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Owen R

Coll. Chir. Feb. 18.
/43.

My dear Sir

I have described those characters of the remains of the great New Zealand Bird which establish its claims to generic distinction at the Meeting of the Zoological Society, January 24th. & the account will appear in the

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proceedings. When the 2d box arrives I shall then proceed with the detailed description of the whole series, build up my bird, and indicate its probable food & habits.

I am glad you promise to discuss with me those of Mylodon, the only ground for dissatisfaction which I feel is that hitherto every body has agreed with me in the rigging & giving theory and until one has been opposed he does not know his strength.

My first paper on the New Zealand Struthioid is printed, with a plate, in the Transact: of the Zoolog! Society for 1839-40. I am sorry I have not a copy left, but the Chief-justice of N.Z. & the Bishop's

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1843

party took all my Stock.

Mrs Owen joins in best
respects with yours
most truly,
Richd Owen

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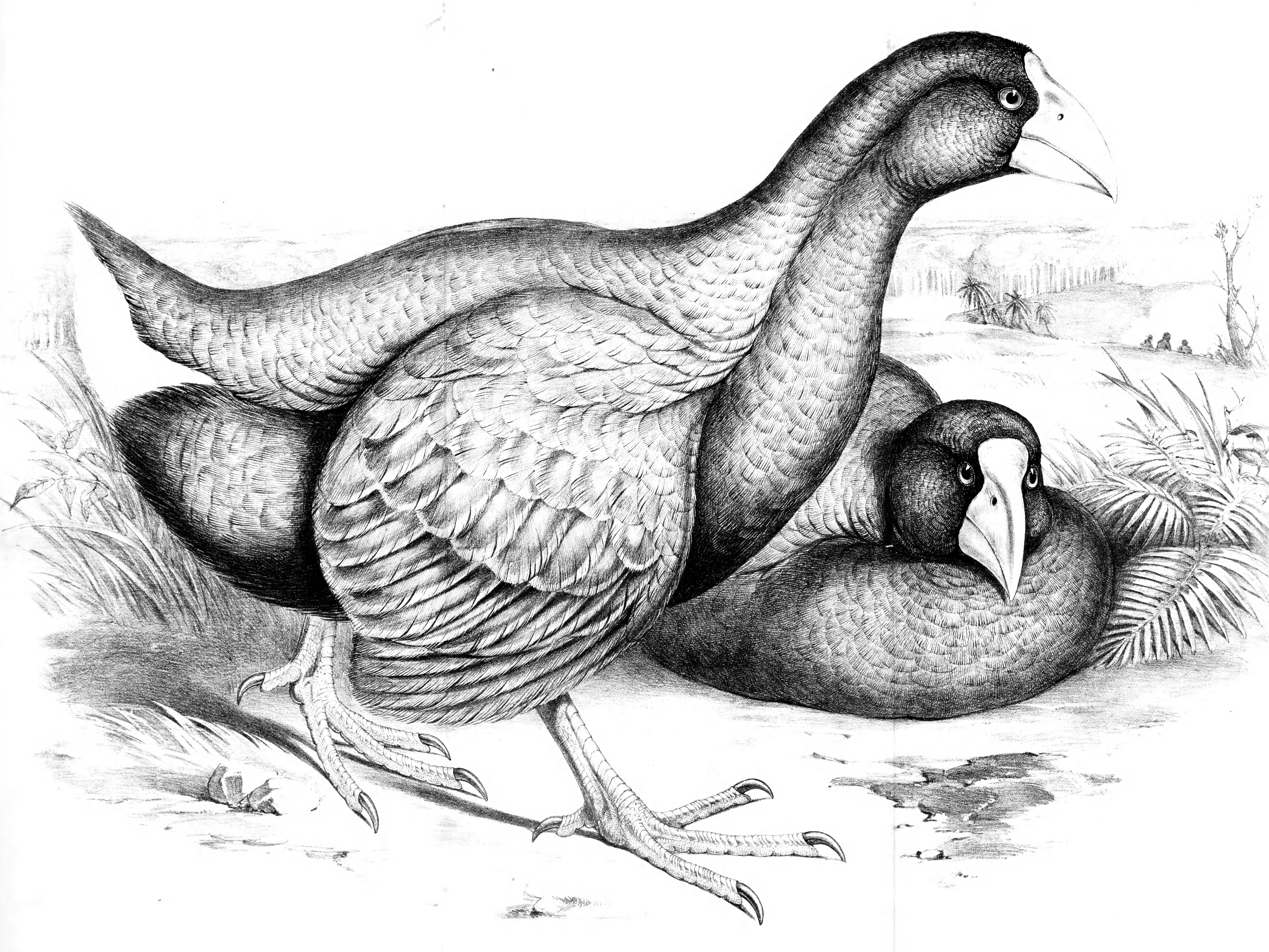

[illegible]

NOTORNIS MANTELLI. *Owen*

Hullmandel & Walton Imp.

MEMOIRS

ON THE

EXTINCT WINGLESS BIRDS OF NEW ZEALAND;

WITH AN APPENDIX

ON THOSE OF

ENGLAND, AUSTRALIA, NEWFOUNDLAND, MAURITIUS, AND RODRIGUEZ.

BY

RICHARD OWEN, C.B., F.R.S.

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE, ETC.

VOL. I. TEXT.

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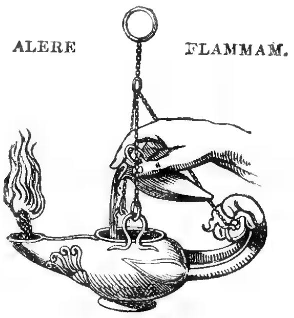

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PREFACE.

THE advantage of attention to any object of Natural History, however unattractive, if it be not a recognizable or previously known specimen, is exemplified in the fragment of bone (Plate, p. 73) which is the foundation of the present work.

It was brought for sale to the College of Surgeons in 1839 by an individual* who stated that he had obtained it in New Zealand from a native, who told him that it was the bone of a great Eagle; and for this specimen he asked the sum of ten guineas.

*Mr Rule M.R.C.S for a narration of negotiations for this purchase see Owen's review of his own labours. Quarterly Review. Vol 90.

The Maori knew nothing of Eagles?

I assured him that he had been misinformed; that the specimen had not the structure of a bone of such a bird of flight; that it was a marrow-bone, like those brought to table wrapped in a napkin.

To further questions as to its locality the vendor replied by showing, amongst other evidences, a jadestone weapon peculiar to the New-Zealanders, which he had also brought from the island, and still seemed to attach so much value to the unpromising fragment, that I consented, being at the time specially engaged, to try to make out the bone if he would leave it with me and call for it the next day.

As soon as I was at leisure I took the bone to the skeleton of the ox, expecting to verify my first surmise; but, with some resemblance to the shaft of the thigh-bone, there were precluding differences. From the ox's humerus, which also affords the tavern delicacy, the discrepancy of shape was more marked. Still, led by the thickness of the wall of the marrow-cavity, I proceeded to compare the bone with similar-sized portions of the skeletons of the various quadrupeds which might have been introduced and have left their remains in New Zealand; but it was clearly unconformable with any such portions.

In the course of these comparisons I noted certain obscure superficial markings on the bone, which recalled to mind similar ones which I had observed on the surface of the long bones in some large birds. Thereupon I proceeded with it to the skeleton of the Ostrich. "The bone" tallied in point of size with the shaft of the thigh-bone in that bird, but was markedly different in shape. There were, however, the same superficial reticulate impressions on the Ostrich's femur which had caught my attention in the exhaustive comparison previously made with the mammalian bones.

In short, stimulated to more minute and extended examinations, I arrived at the conviction that the specimen had come from a bird, that it was the shaft of a thigh-bone, and that it must have formed part of the skeleton of a bird as large as, if not larger than, the full-sized male Ostrich, with this more striking difference, that whereas

not in paper.

the femur of the Ostrich, like that of the Rhea and Eagle, is "pneumatic," or contains air, the present huge bird's bone had been filled with marrow, like that of a beast.

When its owner called the next day I told him, with much pleasure, the result of my comparisons, and assured him that I would recommend the purchase of the bone, at the price asked, to the "Museum Committee."

I regret to relate that, notwithstanding my testimony, the purchase of the unpromising fragment was declined; and it was not convenient to me, in 1839, to pay the sum out of my own pocket. I promised, however, to commend the specimen to other possible purchasers, one of whom I found, through my friend Mr. Broderip, F.R.S., in Benjamin Bright, Esq., then M.P. for Bristol[1].

Meanwhile the vendor permitted me to make the drawings which are lithographed in the Plate, p. 73; and these drawings, with my descriptions and conclusions, were submitted to the Zoological Society of London, November 12th, 1839[2].

I was not surprised that there was some hesitation in the "Publication Committee" as to the admission of the Paper with the Plate into the 'Transactions.' The bone was not fossilized; it might have come from a kind still existing. But a bird larger than an Ostrich, belonging to a "heavier and more sluggish species," could hardly have escaped observation in so limited a tract of dry land as New Zealand.

Moreover, after arriving at the conviction that "the bone" was part of a huge terrestrial bird, I still felt some uncertainty as to the alleged "habitat."

At that date the largest known land-bird of the islands of New Zealand was the *Apteryx*; and even its existence had begun to be doubted[3]. Accordingly the Earl of Derby, then President of the Zoological Society, who possessed the unique skin which had been brought by Captain Barclay from New Zealand in 1812, and had been figured by Dr. Shaw in his 'Naturalist's Miscellany'[4], transmitted the specimen to the Society, and confided it for re-examination and description to William Yarrell[5].

Now this bird was barely the size of a Pheasant; and "the bone" indicated a bird as big as an Ostrich.

But the Ostrich has the continent of Africa for its home; the Rhea roams over South America, the Emu over Australia; Casuarius has not only New Guinea but North Australia, and some neighbouring islands, as its "habitat."

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[1] For the acquisition, many years later, of this specimen by the British Museum, see p. 149.

[2] Proceedings of the Zoological Society of London, part vii. 1839, p. 169. Transactions of the Zoological Society, vol. iii. p. 29.

[3] Temminck, in his 'Analyse du Système Général d'Ornithologie,' relegates the *Apteryx* and *Didus* to a terminal group under the name of "*Inertes*;" and Lesson asks:—L'*Apteryx* de M. Temminck ne seroit-il pas fondé sur les pièces de Dronte [*Dodo*] conservées au Museum de Londres?" ('Manuel d'Ornithologie,' vol. ii. p. 211.)

[4] Vol. xxiv. "Ferruginous-grey *Apteryx*."

[5] Trans. Zool. Soc. vol. i. p. 71.

The misgivings of Vigors and some other of my zoological contemporaries were as to the possibility of a terrestrial bird, of the size I supposed, having been able, at any time, to find subsistence in so small a tract as New Zealand. see Vigors' letter to Swainson.

That island, moreover, had been visited by accomplished naturalists; and the only evidence of a wingless bird which they had been able to obtain there, were fragments and feathers of a small one called "*Kivi-kivi*" by the natives, who hunted it by night with torches and dogs. M. Lesson accordingly refers the evidences of this bird brought from New Zealand by the circumnavigatory vessel 'La Coquille,' in 1828, to the *Apteryx australis* of Shaw[1]. Similar evidence is given by M. D'Urville[2] and MM. Quoy and Gaimard[3].

The interpretation of a single fragment of bone seemed to my more experienced seniors too narrow a foundation for the inference "that there had existed, if there does not now exist, in New Zealand, a struthious bird equal in size to the Ostrich"[4]. Nevertheless I urged that it was not an Ostrich, consequently not any then known species of bird, and that it might as well have come from New Zealand as anywhere else.

Ultimately the admission of this paper into the 'Transactions,' with one plate, was carried at the Committee, the responsibility of the paper "resting exclusively with the author."

On the publication of the volume in 1838 9–40, one hundred extra copies X of the paper were struck off; and these I distributed in every quarter of the islands of New Zealand where attention to such evidences was likely to be attracted. Impossible & untrue and if it had been distributed it contained no information beyond or even equal to that universally known through the islands, and in England since the publication of Polack's book in 1838.

In this distribution I was efficiently aided by Colonel William Wakefield, at that period zealously carrying out in New Zealand the principles of colonization advocated by his brother Mr. Edward Gibbon Wakefield; by J. R. Gowen, Esq., a Director of the then recently established "New-Zealand Company;" by my friend Sir William Martin, the first Chief Justice; and by the Right Rev. Dr. Selwyn, the first Bishop of the islands. see Owen's note 1843.

The confirmatory response, anxiously expected through the years 1840, 1841, and 1842, at length arrived, in the letter from the Rev. William Cotton, M.A.[5], in that from Colonel Wakefield, cited at p. 109, and in the collections of bones transmitted by the Rev. William Williams, and received in 1843 by the Rev. Dr. Buckland, at Oxford, and by Dr. (afterwards Sir John) Richardson, at Haslar Hospital.

These specimens, generously confided to me for description, form the subject of the

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[1] Zoologie de la Coquille, tom. i. p. 418.

[2] Voyage de l'Astrolabe, tom. ii. p. 480 (1832).

[3] Ib. 'Zoologie.' "Il nous a été impossible de nous procurer le singulier oiseau qu'a figuré Shaw sous le nom d'*Apteryx australis*. Nous avons rapporté le manteau d'un Chef qui était recouvert des plumes de cet oiseau que les Zélandais de la Baie Tolaga connaissent sous le nom de '*Kiwi*'" (tom. i. p. 158).

[4] Proc. Zool. Soc. *ut supra*, p. 171.

[5] Proc. Zool. Soc. part xi. 1843, p. 74.

X It was his next not this paper which was so distributed
Dinornis part I. 1843.

paper communicated to the Zoological Society, November 28th, 1843, and of the first "Memoir on the Genus *Dinornis*" in the present work.

To this Memoir is prefixed one "On the Anatomy of the *Apteryx*," which, notwithstanding the inferiority of size, modified structure of the palate, and different proportions of the beak (compare Pl. VII. fig. 2, with Pl. CXIV. fig. 1), is the living bird which is the nearest of kin to the extinct Moas.

As expressions in the present collection of "Memoirs" occasionally occur on ornithological problems which have since been solved, notes of the dates of such papers may here be given. [illegible]

Page 1, containing the remark on the Dodo, was printed in 1838; p. 41, on the skin-muscles of Birds, in 1842. In the "Memoir on the Genus *Dinornis*" of 1843, p. 73, reference is made to the initial paper of 1839. Since that date materials for the present volume have reached me year by year, and have received such notice as I deemed might stimulate to further research.

That the bird I had pictured in imagination, and afterwards, on acquiring sufficient evidence of specific characters, called *Dinornis struthioïdes*, was not the sole representative of its genus, and was far from being the largest, were facts for which I was not prepared. It has been some satisfaction to me to find that eminent ornithologists have recently added one or two species to the *Rhea americana*; and one may well imagine that the more numerous and diversified kinds of *Dinornis* exhibited as well-marked superficial characters as are shown by the six admitted living species of *Casuarius*, the osteological distinctions of which are less marked than those on which I have founded fifteen species of *Dinornis*.

I here repeat my hearty thanks to the contributors of the subjects of the several Memoirs in which those species are characterized, and acknowledge my deep obligations to the Zoological Society of London for the favourable medium of making known successive discoveries of the extinct Birds of New Zealand in their 'Proceedings' and 'Transactions,' and for the liberal permission to avail myself of the plates given in those publications for the purpose of the present work.

With pleasure, also, I embrace this opportunity of expressing my sense of the value of the co-operation of my friend Mr. JAMES ERXLEBEN, the accomplished Artist to whom this work owes the chief part of its Illustrations.

CONTENTS.

APPENDIX.

FRONTISPIECE.

Notornis mantelli, nat. size: from the living bird, noticed p. 436; previously indicated by Fossil Remains, pp. 173–178.

SUBJECTS OF WOODCUTS.

178, + 438

ERRATA.

Page 109, *for* Plate XVIII. *read* Plate XVII.
110, *for* Plate XVIII A. *read* Plate XVIII.
111, *for* Plate XVIII A. read *Din. casuarinus.*
111, 11 lines from bottom, *for* young *Dinornis struthioïdes* read *Dinornis casuarinus.*
112, 4 lines from top, *for Dinornis* read *Aptornis.*
112, 12 lines from top, *for Dinornis* read *Aptornis.*
199, 11 lines from top, *for* pp. 151, 172 *read* pp. 173–178.
459, 10 lines from top:—My friend and valued correspondent, Lady Martin, wife of the first Chief Justice of New Zealand, writes to me, "I am surprised to see 'taiaha' translated as 'axe' or 'adze.' We have seen and handled many 'taiahas,' and always heard the name given to a wooden spear. These spears were often well carved. An axe is ordinarily called 'toki.'"
459, line 13, *for* "panetao" *read* "pounamu."
459, line 20, *for* "tutal" *read* "tutai:" the Maoris have no *l* sound.

MEMOIR

ON THE

APTERYX AUSTRALIS.

IF the Apteryx of New Zealand were to become extinct and all that remained of it after the lapse of one or two centuries for the scrutiny of the Naturalist were a foot in one Museum and a head in another, with a few conflicting figures of its external form,—one representing it in the attitude of a terrestrial Bird, another, like that in Dr. Shaw's Miscellany[1], portraying it erect, like a Penguin[2],—the real nature and affinities of this most remarkable species would be involved in as much obscurity, and would doubtless become the subject of as many conflicting opinions among the Ornithologists of that period, as are those of the Dodo at the present day.

That the opportunities of acquiring a knowledge of the organization of the extinct Bird once inhabiting the island of Mauritius should be now irrevocably past, is, I need not say, a subject of the deepest regret to every one interested in the advancement of zoological science: whether he be engaged as a systematic naturalist in unravelling the intricacies of the natural system; or as a physiologist, in determining the relations which subsist between structure and habits; or as a philosophical anatomist, in investigating the principles which regulate the deviations from a typical standard of organization, and which always receive their most striking illustrations from the aberrant forms at the confines of a great natural group.

The aim of the present memoir is to prevent the recurrence of similar regrets in reference to the *Apteryx Australis*, by securing, before its extinction, a record of its organization, adequate to the several applications above-mentioned.

In the year 1833 the only part of the Apteryx which existed in Europe was the stuffed skin in the Museum of the Earl of Derby; this was the original specimen on which the genus was founded by Dr. Shaw[3]; but many years having elapsed without any additional evidence of the bird having reached Europe, it began to be questioned, as in the case of the Dodo, whether the species had ever existed. At this time the original and unique specimen of the *Apteryx* was transmitted to the Zoological Society and submitted to the free inspection of the Members by their Noble President, and the results of a minute and accurate examination of this precious evidence of the rarest and most sin-

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[1] Naturalist's Miscellany, pl. 1057, 1058, vol. xxiv. 1813.

[2] Whence the name of *Apterous Penguin* applied to the *Apteryx* by Dr. Latham, General History of Birds, vol. x. p. 394.

[3] *Loc. cit.*

7

gular of Birds were recorded by Mr. Yarrell in the first volume of the Transactions of the Zoological Society[1].

Mr. Yarrell at the conclusion of his excellent description expresses "a hope, that the zeal and liberality of the numerous friends and corresponding members of the Society in that part of the globe inhabited by the Apteryx directed to the attainment of this object will yet be successful, and enable us at some future period, perhaps not far distant, to supply the deficiencies which at present exist in our knowledge of the natural history of the Apteryx[2]." This hope has been fulfilled, and the appeal made by the able ornithologist just quoted has been satisfactorily responded to.

The same Noble Cultivator and Patron of zoological science, to whom Ornithologists are indebted for the means by which the true external characteristics of the *Apteryx australis* have been established, has also liberally contributed the materials on which has been founded the chief part of the account of its internal anatomy contained in the present memoir.

The trunk of a male *Apteryx* containing the *viscera*, and extremely well preserved for anatomical investigation, was transmitted by the Earl of Derby for that purpose to the Zoological Society in March 1838. Some months afterwards the abdominal *viscera*, with the bones and tendons of the feet of a female *Apteryx*, were liberally presented to me by Dr. Logan, R.N., through the friendly intercession of Sir Wm. Hooker. Subsequently I received the entire body of a male *Apteryx*, preserved in spirits, from my esteemed friend Mr. Geo. Bennett of Sydney, N. S. Wales, a zealous and valuable Corresponding Member of the Zoological Society. These are the materials from which the following descriptions have been taken.

The Apteryx presents such a singular and seemingly anomalous compound of characters belonging to different orders of Birds, as may well make the naturalist pause before he ventures to pronounce against the possibility of a like combination of peculiarities in the historical Dodo. It seems, as it were, to have borrowed its head from the Longirostral *Grallæ*, its legs from the *Gallinæ*, and its wings from the *Struthious* order. It is clothed with a plumage having the characteristic looseness of that of the terrestrial birds deprived of the power of flight; its feathers resemble those of the Emeu in the general uniformity of their size, structure, and colour, but they are more simple than in any of the tridactyle *Struthionidæ*, as they want the accessory plumelet[3]. The skin of the *Apteryx* is remarkably thick and strong as compared with that of most other birds; it is fully a line in thickness along the back, and gradually diminishes to half a line along the under part of the neck and trunk. A great quantity of fat, of the

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[1] Description, &c. of the *Apteryx Australis* of Shaw, by W. Yarrell, F.L.S., Zool. Trans. i. p. 71. 1833.

[2] *Loc. cit.* p. 75.

[3] Pl. I. fig. 5.

soft oily kind usually found in Birds, is accumulated beneath the skin along each side of the spine, about the rump, beneath the abdomen, and more especially in front of the *sternum*, where it fills up the depression below the root of the neck, which is occupied by the crop in the Gallinaceous Birds. These præpectoral masses of fat are supported by a muscle arising from the *sternum* and expanding over the sternal aspect of the neck: there is no fat deposited beneath the skin covering the rest of the neck; this thinner integument adheres through the medium of a close cellular tissue to a cutaneous muscle with transverse fibres, which surrounds the whole of the neck, and will be subsequently described.

When the trunk is stript of its plumage, the body of the *Apteryx* presents the form of an elongated cone gradually tapering forwards, from the broad base formed by the haunches, to the extremity of the attenuated beak. The wings appear as two small crooked appendages projecting about an inch and a half from the sides of the thorax, and terminated by a curved, obtuse, horny claw, three lines long[1]: the *antibrachium* is retained in a state of permanent flexion by the surrounding integument of the wing; and it cannot be brought by forcible extension beyond an angle of 45° with the *humerus*. Nine quasi-quill-plumes, not exceeding in length the ordinary body-feathers, but with somewhat thicker shafts, are arranged in a linear series along the ulnar margin of the *antibrachium*; the terminal ones are the largest, and in one specimen they presented a structure differing from that of the ordinary plumes, consisting of a shaft, from which radiated a series of flattened horny filaments of nearly equal length.

The *podotheca* commences just above the ankle-joint (*suffrago*) by the development in the cuticle of small scales (*squamæ*); these are smallest at the bend of the joint, where they are arranged in transverse rows; they increase in size as they descend, and at the eighth, ninth, or tenth row the two middle scales begin to enlarge and assume the character of *scutulæ*: a row of these *scutulæ* extends down the fore part of the *tarsus*; most of them are bipartite, but a few are entire: a double row of smaller *scutulæ* extends down the middle of the back part of the *tarsus*, as far as the base of the innermost toe: the rest of the *podotheca* is formed by a reticulation of scales, somewhat larger on the inner than on the outer side. There is a large convex plantar cushion just behind the divergence of the three anterior toes: these differ from the toes of the typical *Gallinæ* in not being connected at their base by an intervening membrane; they are on the contrary quite free, as in the tridactyle *Struthionidæ*; a row of entire *scutulæ* extends along the upper surface of each toe; the sides and under part are covered with small rounded scales, which diminish in size to the ends of the toes. The length of the *tarsus* and of the toes in the largest male specimen of the Apteryx, transmitted to me in spirits, corresponds with that of the specimen described by Mr. Yarrell; the *tarsus* being 3 inches in length, the middle toe 2 inches 4 lines, the lateral ones each 1 inch and 5 lines.

The head of the Apteryx is broad, slightly depressed, and very regularly convex above.

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[1] Pl. I. fig. 4.

The opening of the eyelids is situated immediately behind the vertical line touching the angle of the gape, and about three lines above that angle; it is 4 lines in length: the lower lid is most developed, as in other birds; the upper one is fringed with a row of pretty stiff black *cilia*. The external auditory aperture is situated half an inch behind the eye, and is also a horizontal elliptical fissure, 4 lines in length, formed by a tumid fold of integument, and defended by short and strong ciliiform plumelets.

The weight of the male Apteryx transmitted to me by Mr. Bennett, and which had all the appearances of a mature bird, was, without its plumage, 3 lbs. 6 oz. 12 dr. avoirdupoise; its total length, from the extremity of the beak to that of the outstretched leg, was 28 inches and 8 lines; from the extremity of the beak to that of the *coccyx*, 19 inches; the length of the trunk was 7 inches; the length of the neck, head and beak included, was 12 inches; that of the beak, from the gape to the point, 4 inches and 8 lines; the breadth of the beak at the gape, 1 inch; its depth or vertical diameter at the same part, 7 lines. The different proportions of these latter dimensions to the length of the beak, as compared with those in the specimen described by Dr. Shaw and Mr. Yarrell, are considerable; the length of the beak in that specimen, from the gape to the point, being 6 inches and three quarters. This difference has led me to compare together very minutely the different specimens of the Apteryx at present in the Museum of the Zoological Society and in that of Mr. Gould, particularly with reference to the condition of the beak. Of these specimens, which are five in number, two present proportions of the beak, corresponding nearly with those of the originally described specimen[1]; the other three have the shorter and weaker beak of the male Apteryx here described[2]. The following are the admeasurements taken from these specimens:

LENGTH OF THE BEAK FROM THE GAPE TO THE POINT.

Dr. Shaw's.		Mr. Gould's.		Zool. Soc. No. 1.		Mr. Bennett's Male.		Zool. Soc. No. 2.		Zool. Soc. No. 3.	
Inches.	Lines.	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.
6	8	6	4	6	3	4	8	4	6	4	6

Thus we have a series of three longer-billed and three shorter-billed specimens of the Apteryx: dissection has shown one of the latter to be of the male sex; it remains to be proved whether the longer bill is peculiar to the female. At present it may be questionable whether this difference be dependent on a difference of age, of sex, or of species. But I would observe, that on the first hypothesis it might be expected that the bill would have been smaller in all its dimensions, and that there would have been a want of correspondence in the size of other parts, as of the feet[3]. This, however, is not the case, but on the contrary, the very close correspondence between the short- and long-billed specimens in all other particulars indicates the difference in the length of the beak to be not a specific one. If, therefore, it should actually be found to be a sexual character, it will form another anomaly in the organization of the Apteryx; for

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[1] Pl. I. Fig. 1.

[2] Pl. I. Fig. 2.

[3] The general dimensions of Dr. Shaw's specimen being taken from a dried and stuffed skin are liable to inaccuracy; Dr. Shaw assigns to it, from the tip of the bill to the extremity of the body, about 30 inches.

I am not aware that in any other species of bird there is the same difference in the relative length of the bill, as compared with its breadth, in the two sexes[1].

The soft integument of the head is continued over the base of the bill, and extended along each side, in the form of a narrow angular process, as in the larger Struthious birds. The lateral and a greater portion of the upper part of this integument are covered with short stiff plumes, directed forwards, with long slender black bristles intermixed, and projecting in various directions. The naked part of this integument or *cere*[2] presents a peculiar form, being deeply emarginate both before and behind: the middle portion measures 1½ line in the longitudinal diameter; that of each lateral portion is 9 lines: the transverse diameter of the *cere* is 4 lines; from the gape to the *apex* of the lateral process of plumed integument is 1 inch 8 lines. From this *apex* two narrow grooves extend along the side of the upper mandible, nearly parallel with the *tomia*; the upper groove is continued into a subcircular furrow sculptured on the deflected truncate tip of the mandible; the lower groove leads into the external nostril[3], which forms the dilated termination of this groove; the nostrils, as is well known, are most singularly situated, within one-eighth of an inch of the extremity of the slender elongated mandible.

An angular process of plumed and bristled integument, narrower than that above, extends forwards upon each side of the lower mandible to the distance of 8 lines from the gape. A groove is continued forwards from the *apex* of this process, and expands into a shallow depression as it proceeds. The lower mandible becomes gradually narrower and flatter to its *apex*; its entire length in the male was 5 inches 3 lines; each *ramus* is articulated by two trochlear cavities to two corresponding convexities on the *os quadratum*; from the posterior extremity to the point of confluence of the two *rami* measures 3 inches; from this point two linear impressions extend forwards, slightly diverging from each other, until about half a line from the tomial margin, nearly parallel with which they are continued to the end of the mandible. This part is obtusely rounded, and is opposed to the posterior concavity of the deflected and expanded tip of the upper mandible. Thus when the Apteryx rests its head upon its beak, the extremity of which then presses upon the ground,—a not unusual posture, as I am informed,—the superincumbent weight is transferred by both mandibles to their proximal extremities: when, also, the beak is thrust into the ground in quest of food, the force of both jaws is concentrated upon the smooth and dense wedge-shaped extremity of the upper mandible, and the earth is less liable to be forced between the mandibles than it would have been if the anterior opening had not been defended by the deflected tip of the upper one.

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[1] In other classes we meet with examples of a considerable difference in the development of the jaws as a sexual character; thus, in Mammalia the jaws of the male Cachalot have more than twice the length, both relative and absolute, of those of the female. In Insects the *Lucani* are familiar examples of a still more disproportionate development of the mandibles in the male; in the Apteryx the difference in the development of the jaws, if sexual, is the reverse, the excess being in the female, and this would correspond with the sexual superiority in size and strength in the females of the Raptorial Birds.

[2] Pl. I. *a*. Fig. 2.

[3] Pl. I. *a*. Fig. 1.

If the beak of the *Apteryx* be compared with that of the *Ibis* and *Rhea*, it will be found that its plan of construction is precisely that of the Struthious Bird, and that the resemblance to the grallatorial beak is confined to the elongated form and slenderness of its produced anterior part. In the *Ibis*, for example, the beak is compressed from its very commencement; in the *Apteryx* it is depressed at its base, as in the *Rhea*. There is no production of integument, either plumed or naked, upon the base of the bill of the *Ibis*, while in the *Rhea*[1] we find precisely the same structure, but on a magnified scale, as that above described in the *Apteryx*; the naked *cere* is deeply emarginate, both before and behind; the plumed integument has many black *setæ*, but shorter and finer than in the *Apteryx*, mingled with the short and stiff feathers. In the *Ibis* the external nostrils are pierced in the very base of the beak; a groove is continued from each nostril to the end of the mandible; the same grooves are seen in the *Rhea*, but here the nostrils open at the anterior angle of the lateral processes of plumed integument, which are extended along the sides of the base of the bill, as in the *Apteryx*. In another Struthious genus, the *Cassowary*, the nostrils are situated still more forwards, and are pierced, as in the *Apteryx*, in the horny sheath of the bill itself; there is no other Bird which approaches nearer to the *Apteryx* in the anterior position of the nostrils than does the *Cassowary*; the peculiar modification of the base of the beak in this Bird obscures, as it were, the resemblance which we might otherwise have been able to trace in that part. The *Emeu* and *Ostrich* correspond with the *Rhea* and *Apteryx* in the modifications above noticed, in the base of the upper mandible. If we examine the lower mandible of the larger *Struthionidæ*, we perceive a modification of its inferior surface, which distinguishes it from that of any Gallinaceous or Grallatorial Bird; in the *Ostrich* the tip is formed by a raised quadrate portion, separated by two lateral parallel grooves from the rest of the *gnathotheca*; in the *Rhea* the corresponding raised median piece is longer and narrower than in the *Ostrich*, and the lateral boundary-lines converge backwards to the angle where the *symphysis menti* commences. In the *Apteryx*, notwithstanding the modification by which the bill is transformed from a granivorous to an insectivorous instrument, we find a middle piece marked out, as in the *Rhea*, by two grooves diverging forwards from the angle of confluence of the *rami* of the jaw[2]. The lower mandible of the *Ibis* offers no trace of this character, but is traversed longitudinally by a single mesial groove.

In the Apteryx a narrow membranous fold or ridge is continued from each angle of the gape obliquely forwards and inwards upon the slightly convex under or palatal surface of the upper mandible, and these ridges are gradually lost about 8 lines in front of the posterior apertures of the nostrils; these apertures[3] present the form of two linear slits, 4 lines in length, situated close together, parallel with the axis of the beak, and 4½ inches from its extremity, in the male: the common opening of the Eustachian tubes[4] is situated two lines behind the posterior *nares*. From the anterior part of these aper-

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[1] Pl. I. Fig. 3.
[2] Pl. VII. Fig. 7.
[3] Pl. III. *a*. Fig. 1.
[4] Pl. III. *b*. Fig. 1.

tures a narrow ridge is continued forwards along the middle line of the palatal surface of the beak to its deflected extremity: a mesial groove, corresponding with the above ridge, runs along the flattened upper surface of the elongated *myxa* of the lower mandible.

There is the same structure on the inner surface of the upper and lower mandible in the Ostrich and Rhea. In these, however, the palatal surface of the upper mandible is slightly concave; but in the Apteryx the opposed surfaces of the upper and lower mandibles produce, when pressed together, uniform and entire contact, and, as Mr. Yarrell has observed, are well adapted for compressing or crushing such substances as may be selected for food: the coadapted ridge and groove above described must add somewhat to the power of retaining such substances. To judge from the feeble development of the muscles of the jaw, and their disadvantageous place of insertion, the force of the nip of the mandibles, however, cannot be very great; and with this knowledge of the structure of the bill, I was the less surprised to find large soft-bodied Lepidopterous larvæ entire in the stomach of Mr. Bennett's male Apteryx.

There are two small temporal muscles, one superficial, the other deep-seated, which cross each other obliquely: the superficial and posterior muscle is 4 lines broad and 1 inch long: it is inserted by a round tendon into the coronoid edge, and by fleshy fibres into the external depression beneath that edge, extending as far forwards only as two-thirds of an inch from the joint of the jaw. The deep-seated temporal muscle sends its fibres to be inserted more vertically into the coronoid margin. A masseter, which is connected with a remarkably strong *orbicularis palpebrarum*, is inserted still nearer the joint, below the *fossa* for the insertion of the temporal muscle, and external to it. There is a fourth muscle employed in closing the bill, having a similar direction of its fibres to those of the masseter, but situated on the inside of the temporal muscles: it extends from the pterygoid bone downwards, to be inserted fleshy into the inside of the coronoid margin of the lower jaw. This bone admits of slight protraction and retraction, the muscles performing which are the external and internal pterygoid, on each side. The external pterygoid arises by a broad and flat tendon from the pterygoid plate, external to the posterior *nares*, and expands as it proceeds backwards and outwards, to be inserted into the inflected posterior angle of the lower jaw. The internal pterygoid arises from the body of the sphenoid, behind the posterior *nares*, and contracts as it proceeds more directly outwards to be inserted into the angle of the lower jaw, above the preceding. The bill is opened by the analogue of the *biventer maxillæ*, which is here a stout, short, square-shaped fleshy muscle, deriving its origin from the ex-occipital process, and descending vertically, to be attached to the broad posterior angle of the lower jaw: from its close situation to the centre of motion this muscle can divaricate the tips of the mandibles about two inches. The movements of the jaw are regulated, and its joints strengthened, by several ligaments: one of these ligaments is interarticular, and passes directly between the jaw and *os quadratum*, in the interspace of the double condyle: another is external, and passes from the upper and outer angle of the *os quadratum* obliquely forwards to the lower and posterior margin of the external coronoid depression: a strong posterior ligament descends from the ex-occipital process to the posterior angle of the jaw. These strong ligaments are an essential part of the mechanism of a beak which is destined to be forcibly thrust into the ground, and used in a variety of ways, to overcome considerable resistance.

The posterior expanded surface of the palate is quite smooth in the Apteryx, as in the larger *Struthionidæ*, in which the ridges and *papillæ*, commonly present in other birds, are altogether absent.

The tongue[1], as was conjectured by Mr. Yarrell, is short, much shorter indeed than the interspace of the united *rami* of the lower jaw; it nevertheless presents a greater relative development than in other Struthious birds. It presents a compressed, narrow, elongated, triangular form, with the *apex* truncate and slightly notched; the lateral and posterior margins entire: it is 8 lines in length, 4 lines broad at the base, 1 line across the *apex*. The anterior half consists of a simple plate of a white, elastic, semitransparent, horny substance, gently concave above; behind this part, the exterior covering, which is lost in, or blended with, the horny plate, gradually becomes distinct, and assumes the character of a mucous membrane, and is pitted with several very minute glandular *foramina*: this membrane is reflected over the posterior margin of the tongue, forming a crescentic fold, with the concavity towards the *glottis*; but here, as well as on every other part of the tongue, it is devoid of spines or *papillæ*. This fold can be brought back by the retractors of the *os hyoides*, so as to cover the *glottis*; in which movement the *uro-hyal* process plays in a cellular sheath beneath the *larynx*, and its office seems to be to give steadiness to the protractile and retractile movements of the tongue. The superficial and principal protractor of the tongue represents the *genio-hyoideus*, its two lateral halves being separated and removed from the *symphysis* to within an inch of the angle of the jaw, whence its fibres pass almost directly backwards, and converge, to be inserted into the extremity of the bony *cornu* of the *os hyoides*. The *mylo-hyoideus* arises from the inner side of the lower jaw, commencing posteriorly about an inch from the angle, and extending forwards to within the same distance of the *symphysis*; the fibres become gradually fewer as they are placed more forwards; they meet to be inserted at a middle tendinous line posteriorly, and are separated anteriorly by a tendon about a line in breadth: these tendons are attached to the body of the *os hyoides*, and retract it: a few tendinous threads connect also the posterior margin of the muscle with the anterior part of the upper *larynx*. On the removal of this muscle two deeper-seated protractors of the tongue are brought into view; they arise by a very thin aponeurosis from near the angle of the jaw, and pass directly backwards, to be inserted into the base of the *cornua*. These muscles adhere closely to the membrane, filling up the interspace of the *rami* of the lower jaw. The cartilaginous extremities of the *cornua* of the *os hyoides* curve upwards, and terminate about a line behind the angles of the jaw.

[1] Pl. III. Figg. 1 *c*. & 2.

The lining membrane of the *pharynx*, behind the *glottis*, forms two elongate, square-shaped, smooth, thick, and apparently glandular folds or processes, the obtuse free margins of which project backwards, like lappels, into the *pharynx*[1]; beyond which the lining membrane is produced into close-set, narrow, somewhat wavy, longitudinal folds.

The *œsophagus* is continued down the right side of the neck, behind and a little to the right of the *trachea*, through the *thorax* and *diaphragm* to the *proventriculus*, without forming any partial dilatation or *crop*.

The upper extremity of the *œsophagus* is rather wider than the rest of the tube, measuring from half an inch to an inch in diameter, according to its state of contraction: it gradually diminishes to a diameter which I found in one specimen to be 3, in another 6 lines, and continues, without variation of size, to the *proventriculus*. The *œsophagus* is connected somewhat closely to the *trachea*, and by a looser cellular tissue to the surrounding parts. The muscular coat of the *œsophagus* is about half a line in thickness; its external fibres are arranged circularly; its internal ones form a longitudinal stratum. The ultimate muscular fibres are smooth, slightly wavy, and reticularly intermixed, but with a definite course. The internal membrane in the contracted *œsophagus* is disposed in narrow and slightly wavy longitudinal *rugæ*, which become more close-set and strongly marked at the lower part of the canal: when viewed with a magnifying power the whole internal surface presents a delicate reticular structure. The length of the gullet is 9 inches.

The *proventriculus*[2] is a narrow elongated cylindrical cavity in the *axis* of the *œsophagus*, of which it is an immediate continuation. In one specimen it measured 1 inch 2 lines in length and half an inch in diameter, in another it was 1½ inch in length and 1 inch wide. The gastric glands are developed around its whole circumference, and are closely packed together; they are narrow elongated follicles, from 1½ to 2 lines long, mostly bilobed, but sometimes more subdivided at their cæcal or outer extremities[3]. The glandular *parietes* of each follicle consists of minute *tubuli* placed at nearly right angles with the central cavity. The muscular coat covering the glands is somewhat thicker than in the membranous part of the gullet, which is chiefly caused by the increase of the outer circular stratum of fibres, by the action of which the secretion of the glands is squeezed out into the cavity of the *proventriculus*. The longitudinal *rugæ* of the lining membrane gradually subside at the entry of the *proventriculus*, where they run into each other, and so form a general reticulate surface, in the meshes of which the orifices of the gastric glands are situated.

The *epithelium* lining the glandular part of the stomach is gradually condensed towards its lower part into a cuticle, which, as it passes into the muscular compartment, assumes a brown colour and a callous hardness, and forms a stratum about one-third of a line in thickness. In the *Cassowary* and *Emeu* the *proventriculus* is marked off

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[1] Pl. III. *e*. Fig. 1.

[2] Pl. IV. & V. *a*.

[3] Pl. V. fig. 2 & 3.

from the stomach by a circular strip of *epithelium*, whiter and thinner than the rest, from one to two lines in width: the structure is well shown in Plates LI. and LII. of the 'Comparative Anatomy' of Sir Everard Home. The *Apteryx*, though resembling these large Struthious birds in the arrangement of its gastric glands, does not participate with them in this structure. The muscular stomach[1] does not present the characteristic sub-compressed shape of a gizzard, but resembles, in its regular oval-rounded form, the membranous stomach of carnivorous birds. In its contracted state it appears small for the size of the bird, not exceeding 1 inch 10 lines in length, and 1 inch 3 lines in its greatest diameter; but in the specimen in which I found the stomach distended with food it measured 2½ inches in length, and 2 inches across at the widest part. The muscular fibres are not arranged in the well-defined masses called *digastrici* and *laterales* in the true gizzard, but radiate from two tendinous centres of an oval form, measuring about two-thirds of an inch in the longest diameter. The muscular coat when contracted is thickest at the upper part of the cavity, where its depth is about 3 lines: in the bulging part at the upper end of the gizzard from which the *duodenum* is continued, the muscular coat is about 1 line thick. The inner surface of the contracted stomach (*b*, Pl. V.) presented two protuberances at its posterior part, one near the lower and the other near the upper end: the latter is so situated with respect to the cardiac and pyloric openings that it would tend more or less completely to close those openings when the circular fibres at the upper part of the gizzard were forcibly contracted. There was no appearance of these internal projections in the dilated stomach of the second *Apteryx* dissected by me.

A narrow pyloric passage, of about 3 lines in length, leads from the left side of the upper extremity of the muscular stomach into the *duodenum*[2]. The *pylorus* is defended by a transverse crescentic ridge of the lining membrane; there is no distinct *sphincter*. The cuticle is continued into the *duodenum* about 3 lines beyond the *pylorus*, but there is no dilatation of this part constituting a pyloric pouch as in the *Emeu* and *Ostrich*.

Before proceeding with the special description of the intestinal canal, the general disposition of the abdominal *viscera* may be mentioned, as they appear upon removing the abdominal muscles.

The *peritoneum* consists of an external strong fibrous and an internal serous layer.

The abdominal cavity[3] is divided by peritoneal partitions into three compartments, which contain, besides the ordinary *viscera*, only a little fluid; and when the thoracic cells were inflated from the *trachea* no air passed into the abdominal cells or their interspaces. The two upper compartments contain the right and left lobes of the liver, which are separated from each other by a strong mediastinal process of *peritoneum*: the *ligamentum latum* in *Mammalia* seems to be the representative of this broad process. Each hepatic cell communicates with the single large inferior compartment of the *abdomen* by a round aperture situated close to the ribs; this lower compartment was

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[1] Pl. IV. & V. *b*.

[2] Pl. IV. & V. *c*.

[3] Pl. II.

partly divided into two lateral ones by the stomach, and the omental process continued from it to the lower or posterior margin of the *hepatic septum*.

A great quantity of adipose matter was accumulated, in one specimen, beneath the *peritoneum*. The two lobes of the liver occupied as usual the anterior part of the abdominal cavity, extending from above the notches of the *sternum* to midway between the *sternum* and the *cloaca*. The stomach was entirely concealed by the large omental adipose process above-mentioned, by dividing which and separating the divided portions (as in Plate III. fig. 3, *a*, *a*,) as much of the stomach was exposed as projects between and beyond the lobes of the liver. The space between the stomach and *cloaca* was occupied by long and simple loops of intestine, extending obliquely, and nearly parallel with each other, from the upper and right to the lower and left side of the *abdomen*. In one specimen these loops were concealed, like the stomach, by omental processes, thickly charged with fat (*b*, *b*,) ; each loop also included between the layers of its narrow mesentery one or two thick processes of fat (*c*, *c*,), except the duodenal loop, the interspace of which was occupied as usual by the two lobes of a narrow elongated *pancreas*, the pointed extremity of the anterior lobe of which extended freely beyond the bend of the *duodenum*, as represented in the figures (Pl. II. & III. fig. 3, *d*.). In one specimen the *duodenum* formed the longest and most anterior loop (*e*, Pl. II.). Below or posterior to it lay the first loop of the *jejunum*, (*f*, Pl. II.) and immediately below this appeared the dilated end of the *rectum* (*g*, Pl. II.). In a second *Apteryx* (Pl. III. fig. 3.) I found that four loops of intestine, including the *duodenum*, were immediately exposed by dissecting away the omental processes: on raising these loops the *rectum* was seen extending forwards about 2 inches along the mesial line, and then receiving the *ileum* and the extremities of the two *cæca*. Only the anterior half of the *rectum* has an entire investment of *peritoneum* ; at its posterior or lower half that membrane leaves the abdominal *parietes* on each side of the *rectum*, and gradually advances upon the anterior part of the gut.

The lobes of the liver require to be divaricated and raised, and the stomach and its omental processes to be drawn aside, in order to trace the disposition of the whole intestinal canal. The duodenal loop, which in one specimen was about 4 inches, in another 5 inches in length, extends in a curved direction from the stomach to the right side of the *abdomen*, curves obliquely across the lower surface of the *abdomen* to the posterior and left side, and returns upon itself: the anterior half of this loop is closely attached to the other coils of the intestine ; the rest of the *duodenum* is suspended freely in the *abdomen*. The intestine, after having formed the duodenal loop, bends abruptly upon itself backwards and to the right, and then forms a second loop, $3\frac{1}{2}$ inches long, which continues straight down the right side of the *abdomen* ; its extremity is seen at Pl. III. fig. 3, *f*. Three similar but somewhat shorter loops are then formed to the left of the preceding, after which the intestine returns to near the commencement of the *duodenum*, behind the stomach and close to the root of the mesentery, whence it descends to form a fifth long loop, situated at the left side of the *abdomen*, behind the others, and then becoming looser, after a short convolution, terminates in the *rectum*. The *cæca* in one specimen measured each five, in another six inches in length; they are attached to the last folds of the *ileum*: their tunics are thinner than those of the rest of the alimentary canal. The adipose processes developed beneath the *peritoneum* investing the *ileum* and *cæca*, are smaller and more detached than those connected with the preceding intestinal loops, and assume the appearance of "*appendices epiploicæ*[1]."

In one *Apteryx* I found a very short *cæcum*,—the remnant of the *ductus vitello-intestinalis*,—attached to about the middle of the small intestine[2]; and in the *viscera* of the small female *Apteryx* transmitted to me by Dr. Logan, there extended from the same relative position of the intestinal tube an obliterated duct three lines in length, which expanded into a still persistent *vitelline sac* of a subglobular form, about an inch in diameter, but collapsed and with wrinkled *parietes*. These presented a moderate degree of thickness in the moiety of the *sac* next the duct, but became gradually thinner to the opposite side. The interior of the *sac* was lined with a stratum of a yellowish substance resembling adipocere, and contained many small wavy filamentary vessels, converging to the commencement of the duct, and evidently remains of the *vasa lutea*. A small branch from the mesenteric artery, the remnant of the *omphalo-mesenteric*, and a minute corresponding vein, accompanied the pedicle of the *sac* (Pl. V. fig. 1, *s*, *t*.).

In the large male *Apteryx* the intestinal canal measured four feet, independently of the *cæca*, which were each six inches in length: the *rectum* was four inches long.

The general diameter of the small intestines in the specimen first dissected was three lines; in the male *Apteryx* with the full stomach their diameter was five lines: they slightly diminish in size as they approach the *rectum*. In the *duodenum* the mucous membrane is beset with extremely fine *villi*, about one line in length; towards the end of the *duodenum* these *villi* are converted into thin zigzag longitudinal

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[1] These processes and the return of the small intestine, in the latter part of its course, to the *duodenum* and root of the mesentery, give to the part continued thence to the *rectum* a resemblance to the *colon* in *Mammalia*. The learned Editor of the excellent edition of Cuvier's *Leçons d'Anatomie Comparée*, now in course of publication, is disposed to consider all that part of the small intestine which intervenes between the single vitelline *cæcum* (in those birds which have it) and the double ordinary *cæca*, as representing the *colon*: and the analogy of the *colon* of the *Hyrax*, which is similarly bounded at its commencement by a single *cæcum*, and at its termination by a double one, is undoubtedly very close. If, however, we are guided by the analogies afforded by the other oviparous classes, with which birds present so close a conformity of general structure, and in which the *colon* is always short, wide, generally straight, and in some, as *Python*, *Testudo*, *Iguana*, marked off, or commencing by a single *cæcum*, as in *Mammalia*, there can be no question in that case but that the part of the intestinal canal in Birds corresponding to the *colon* of Reptiles, is that which succeeds the entry of the two *cæca*, and which, from its shortness and straightness, is usually called the *rectum*. In the *Ostrich*, however, it is long and convoluted, and is provided with transverse *valvulæ conniventes*. A similar structure in a less degree is present in the *colon* of the *Iguana*.

[2] Pl. IV. *d*.

folds, which are continued, but with gradually diminished breadth, to the end of the *ileum*. The *cæca*[1], at their commencement, are wider than the *ileum*, and go on slightly increasing in capacity to near their blind extremities, where they suddenly taper to an obtuse point. The diameter of each *cæcum*, at its widest part, was five lines in the first, and six lines in the second dissected *Apteryx*. To the naked eye the lining membrane of the *cæca* presents a smooth surface; viewed with a lens, it is disposed in very fine longitudinal zigzag lines, which are replaced towards the extremities by very minute points. The lining membrane of the *rectum* is beset with minute short *villi* or points, together with *glandulæ solitariæ*, which become numerous and large at the terminal half of the *rectum*[2]: the lining membrane of this intestine, when it is contracted, is thrown into longitudinal folds; but there is no trace of the transverse or spiral *valvulæ conniventes* which so peculiarly characterize the *cæca* and *rectum* of the *Ostrich* and *Rhea*: in this respect the *Apteryx* resembles the *Cassowary* and *Emeu*. The *rectum* communicates with the uro-genital dilatation by a small semilunar aperture, which, when contracted, appears as an oblique fissure, and from the produced valvular margin of which several short *rugæ* radiate. The urinary compartment of the *cloaca* is not expanded into a large receptacle as in the *Ostrich*, but offers the same proportional size as in the *Emeu* and *Cassowary*: it measures about two-thirds of an inch in length and the same in diameter. The *ureters* terminate by oblique valvular apertures[3] immediately beyond the abovementioned membranous fold, at the back part of the cavity, and about two lines apart. The *vasa deferentia* terminate, as in other Struthious birds, by two elongated *papillæ*[4] nearer the anterior part of the uro-genital cavity. This cavity is separated from the external compartment of the *cloaca* by a broader and stronger fold than that which divides it from the *rectum*, and the angles of this fold are lost upon the sides of the *penis*[5], which projects into the external compartment of the *cloaca*. This compartment is continued behind the uro-genital passage in the form of a large and wide *bursa Fabricii*[6], which, in the larger *Apteryx* dissected by me, was partly divided by a crescentic vertical fold, extending forwards from its upper and back part.

The stomach, in Lord Derby's *Apteryx*, contained only a greenish-yellow pulpy substance, and numerous filamentary bodies, amongst which were some legs of insects and a few pebbles. The small intestines were contracted, and contained only a little pulpy material like that in the gizzard, but of a darker colour. The *cæca* were distended with a greater quantity of a similar but more fluid matter, in which parts of the legs of insects, apparently orthopterous, were again discernible. In the male *Apteryx* transmitted by Mr. Bennett, the stomach was distended with insects of various orders, which seemed to have been recently swallowed. There were four *larvæ*, between two and three inches in length, belonging to some species of the *Lepidopterous* order, probably of subterraneous habits; five *larvæ* of some of the *Scarabeidæ*, perfect; some mature *Coleoptera*; parts of

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[1] Pl. IV. *e, e*.

[2] Pl. IV. *f*.

[3] Pl. IV. *g*.

[4] Pl. IV. *h*.

[5] Pl. IV. *i*.

[6] Pl. IV. *k*.

small species of the Locust tribe; one *Elater*; and one Spider, quite perfect; with a few hard seeds and small pebbles[1]. There was also some muddy fluid loaded with the black particles of the earth probably swallowed along with some of the insects. The small intestines contained portions of insects floating in a larger quantity of the black fluid: the *cæca* were distended exclusively with a thin blackish-brown pulpy fluid, in which only extremely minute portions of the legs of insects could be detected.

The *liver*, in the larger male *Apteryx*, weighed 7 drachms, 35 grains, avoirdupoise; it consisted, as usual, of two large lobes, connected by a narrow isthmus, with their thin anterior edges advancing forwards on each side of the *proventriculus*, and meeting in front and a little to the left of the middle line. The right lobe[2] is the longer, of a subtriangular figure; the left[3] is of a subquadrate form. The two lobes are even and smooth on their posterior and outer surfaces, but present irregular furrows and projections on their inner surface. They are traversed here transversely by a broad portal fissure occupied by the vessels and ducts. In two of the specimens there was a gall-bladder, as in the *Emeu* and *Cassowary*; in the third it was wanting, as is usually the case with the *Rhea* and *Ostrich*. In the large male the gall-bladder adhered by its whole length to the omental process covering the stomach; in the other *Apteryx* it was free, and depended by its *cervix* from the inner margin of the right lobe of the liver; in this specimen[4] it was an inch and a half in length, and received two short cyst-hepatic ducts at its *cervix*, each nearly a line in diameter: these ducts, with the serous membrane reflected upon them, and the nutrient vessels of the gall-bladder, formed the only medium of connexion between the gall-bladder and the liver. A cystic duct was continued, in length rather more than two inches, to half-way between the lower bend and the termination of the *duodenum*. The hepatic duct is formed by two branches, one from each principal lobe, which unite together to the left of the cystic duct; it runs parallel with, and terminates a few lines below the cystic: both ducts are longer than usual. The lining membrane of the gall-bladder presents chiefly longitudinal *rugæ*, with smaller transverse lines in the interspaces. In the *Apteryx* without a gall-bladder there were two long ducts terminating in the same part of the *duodenum*; of which the one corresponding to the cystic (Pl. V. *o*, fig. 1.) was very slightly dilated at its origin, where it was formed by the confluence of two ducts.

The *pancreas* (Pl. IV. & V. *q*, fig. 1.) consisted, as usual, of two elongated subtrihedral lobes, lodged chiefly in the anterior part of the duodenal interspace. One of the lobes extended upwards and to the right as far as the spleen. The secretion was carried by two short and thick ducts, which terminated, close to the hepatic and cystic, and alternating with them upon a small longitudinal ridge of the duodenal lining membrane.

The spleen in one *Apteryx* was about the size and form of a hazel-nut (Pl. IV. *r*,): in the large male with the full stomach it was smaller and flatter: it was round, and an

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[1] I am indebted to Mr. Waterhouse for the determination of the above insects.

[2] Pl. IV. *l*.

[3] Pl. IV. *m*.

[4] Pl. IV. *n*.

inch in diameter in the specimen without the gall-bladder. In the larger *Struthionidæ* the organ generally presents a longer and more compressed figure.

In considering the physiological relations of the structures which have just been described, we shall be able to trace the same interesting correlation between their different modifications and the nature of the organic substances which it is their office to assimilate, as is illustrated in other known and more striking peculiarities in the digestive organs of birds. Animals which are destined to subsist exclusively on insects usually present the chief prehensile and preparatory parts of the digestive system, whether it be the beak, as in the Ibis, or the tongue, as in the Ant-eaters and Woodpecker, of a long and slender shape; in the present species we find a pair of Struthious mandibles lengthened out and made slender for this purpose. The beak, thus organized to seize and transmit to the gullet objects of small size, is succeeded by a muscular canal of moderate and uniform width; and the food being of an animal nature and swallowed in small quantities, with successive intervals, as it is caught, the *œsophagus* is not required to be modified to serve as a reservoir, either by a general width or partial dilatation. The *proventriculus* of the *Apteryx* is of a small relative size as compared with that of the *Ostrich*; its glands are also more simple in their structure, and are not aggregated into a circumscribed mass as in the *Rhea*. The stomach has its muscular coat more equally but less strongly developed than in any of the vegetable-feeding *Struthionidæ*; and the small size of the cavity, as well as the moderate strength of its *parietes*, bespeaks a structure adapted for the bruising and chymification of animal substances presenting, as do worms and the larvæ of insects, a moderate resistance.

The length of the intestines and the size of the *cæca*, both of which somewhat exceed those in the slender-billed Insectivorous Waders, indicate that the *Apteryx*—which, by being denied the power of flight, is confined to a more restricted range in quest of food—is designed to possess every needful and practicable advantage in extracting from its low-organized animal diet all the nutriment that it can yield.

The lacteal absorbents in the *Apteryx* in which the digestive system before death had been actively engaged in the assimilation of a full meal of insects, were plainly visible, and in many parts of the mesentery presented an opake white colour.

There was an absorbent gland, about the size of a hazel-nut, in the mass of fat below the root of the neck.

Circulatory and Respiratory Systems.

The heart is surrounded by a wide and thin *pericardium*, which is attached to the concave side of the *sternum* and to the margins of the anterior wide fissure of the *diaphragm*, through which the ventricular portion of the heart protrudes into the *abdomen*, in the posterior concave interspace of the two great lobes of the liver. (Pl. VI., fig. 1, *a*.) It requires only that a central *aponeurosis* should have been continued from the anterior margins of the *diaphragm* between the heart and liver, to have completely separated from the *thorax* the proper abdominal *viscera*, as in the *Mammalia*; for, as will be presently described, the respiratory organs are confined entirely to the *thorax*.

The heart presents the usual ornithic form of a somewhat elongated cone, terminated by an obtuse rounded apex, produced beyond the projection formed by the right ventricle. The *pericardium*, after being reflected upon the origins of the great vessels, passes directly from the peripheral surface of the auricles upon the ventricles, so that there are no freely projecting auricular appendages. In one *Apteryx* I found much fat developed in the angle between the auricles and ventricles, beneath the *pericardium*. The right auricle appeared, when distended, of an uncommon size. The three veins terminated in it in the usual manner, but the inferior *cava* has a much greater relative capacity than either of the superior *cavæ*, in consequence of these having to return to the heart little more than the proportion of venous blood brought back by the jugular and internal thoracic veins in other birds.

The auricles of the heart do not present any peculiarity of structure which is not met with in other birds; the resemblance to the *Emeu* in the disposition of the valves of the right auricle is very close. The great inferior *cava*, (Pl. VI. *b*, fig. 3,) the trunk of which is extremely short, opens into the *sinus venosus* close to the termination of the left superior *cava* (*c*, fig. 3.); the intervening membrane is slightly produced in a valvular form: the coronary vein of the heart terminates in the left superior *cava*, just before it opens into the auricle. The right superior *cava* (*d*, fig. 3.) opens as usual into the upper part of the *sinus*. The tunics of the superior *cavæ* are remarkably strong. The *sinus* is divided, as in other birds, from the proper auricle by two semilunar valves, one large and anterior, the other smaller and posterior (*e* and *f*, fig. 3.). The lower horn of each valve is fixed to the floor of the auricle, the upper or anterior horn of the anterior valve is attached to a strong muscular column, which traverses the upper and anterior wall of the auricle; the extremity of the posterior valve is in like manner continued into a muscular band from the back part of the auricle. From these attachments it is obvious that the valves, during the action of the muscular *parietes* of the auricle, will be drawn together, and their power to resist regurgitation into the *sinus* will be increased, as the action of the muscles to overcome the resistance of the contents of the auricle is greater.

The posterior valve which forms part of the boundary of the *foramen ovale* seems to be represented in *Mammalia* by the muscular ridge called the *annulus ovalis*; the anterior valve is obviously the analogue of that called *Eustachian* in *Man* and *Mammalia*.

The principal deviation from the ornithic type of the structure of the heart is presented in the valve at the entry into the right ventricle (Pl. VI. *g*, fig. 3.). This is characterized in birds by its muscularity and its free semilunar margin. In the *Apteryx* it is relatively thinner, and in some parts semitransparent and nearly membranous: a process moreover extends from the middle of its free margin, which process is attached by two or three short *chordæ tendineæ* to the angle between the free and fixed *parietes* of the ventricle. We perceive in this mode of connection an approach in the present bird to the mammalian type of structure analogous to that which the *Ornithorhynchus*, among *Mammalia*, offers, in the structure of the same part, to the class of birds; for the right auriculo-ventricular valve in the *Ornithorhynchus* is partly fleshy and partly membranous. The dilatable or free *parietes* of the right ventricle were about $\frac{1}{20}$th of an inch in thickness, those of the left were $\frac{1}{8}$th of an inch thick.

There was nothing worthy of note in the left auricle (fig. 2 and 3 *h*,) or in the valves interposed between it and the left ventricle: the two membranous flaps presented the usual inequality of size characteristic of the mitral valve in birds.

The *aorta* divides as usual, immediately after its origin, into the ascending and descending *aortæ*: the ascending *aorta* as quickly branches into the *arteriæ innominatæ* (*d*, fig. 2.), which diverge as they ascend and give off the subclavians in the form of very small branches; they are then continued, very little diminished in size, as the carotids; each carotid divides or gives off a large vertebral artery before passing out of the *thorax*; they then mount upon the neck, converge and enter the inferior vascular canal of the thirteenth cervical *vertebra*, and are continued in the interspace of the *hæmapophyses* to the fourth cervical *vertebra*: here they emerge from the subvertebral canal, and passing through the interspace of the *recti capitis antici*, they again diverge, and when opposite the angle of the jaw, give off occipital, internal carotid, large palatine, and other branches, as in the *Emeu*. The principal difference observed in the *Apteryx* was the equality of size in the carotids: in the *Emeu* I found the right carotid larger than the left.

The descending or third primary division of the *aorta* (*k*, fig. 2.) presents in the *Apteryx*, as in the *Emeu* and other *Struthionidæ*, more of the character of the continuation of the main-trunk than in the rest of the class, in consequence of its greater size and thicker tunics, which relate of course to the diminished supply of blood transmitted to the rudimental anterior extremities; and the increased quantity required to be sent to the powerfully developed legs. The *aorta* arches over the right *bronchus* as usual, and is continued down the *thorax* to the interspace of the *crura* of the *diaphragm*, through which it passes into the *abdomen* in a manner remarkably analogous to that which characterizes the course of the *aorta* in the *Mammalia* (Pl. VI. *n*, fig. 1). The *Apteryx*, in fact, seems to be the only bird in which the limits of thoracic and abdominal *aorta* can be accurately defined. But, in thus establishing this distinction, we observe a remarkable difference from the mammalian arterial system, in the fact, that some large and important branches, which in the latter are given off from the abdominal *aorta*, arise in the present bird above the *diaphragm*, through which they pass by distinct and proper apertures to the abdominal *viscera* which they are destined to supply. These branches are the *cœliac axis* (Pl. VI. *l*, fig. 1.), and the great or superior *mesenteric* artery (*m*, fig. 1.). Besides these branches, the thoracic *aorta* gives off the bronchial and intercostal arteries above the *diaphragm*. The latter are three or four in number, which divide and form the usual plexiform *anastomoses* round the heads of the ribs, with branches of the vertebral arteries; from which *plexuses* the proper intercostal branches are continued. The *cœliac axis*, having perforated the *diaphragm*, divides and supplies the stomach, liver, and spleen in the usual manner. The mesenteric artery offers nothing unusual in its mode of distribution. The *diaphragm* is itself supplied by branches from the intercostal *plexuses*, and there are no proper phrenic arteries.

The first branch which the *aorta* sends off, after having entered the *abdomen*, is the spermatic artery (Pl. VI. *o*, fig. 1.); this was of moderate size in the large male *Apteryx*, and soon divided into two branches, which were distributed respectively to the corresponding *testis* and supra-renal gland.

The *aorta* having reached the first lumbar or sacral *vertebra*, sends off the femoral arteries (*p*, *p*, fig. 1.), which are of equal size with the ischiadic arteries afterwards given off. The femoral is continued outwards on each side at right angles with the *aorta*, sends a small branch to the upper lobe of the kidney and passes out of the *pelvis*, not through a notch or *foramen*, as in most other birds, but simply over the margin of the iliac bone. It is continued upon the thigh, covered by the wide and strong *sartorius*, where it divides into two principal branches, of which one is distributed to the *sartorius*, *gracilis*, *vasti*, and other muscles at the anterior and upper part of the thigh; and the second branch is continued to the knee-joint, where it ends by forming *anastomoses* with the ischiadic. The *aorta* next sends off a pair of renal arteries (*q*, *q*, fig. 1.) of moderate size, beyond which it may be said to resolve itself into the ischiadic (*r*, *r*,) and sacro-median arteries (*s*, fig. 1.). The ischiadic branches are not here, as in most other birds, the main arteries of the hinder extremities; they do not exceed the femorals in size, and are principally expended upon the muscles of the leg: they escape from the *pelvis* as usual by the ischiadic *foramina*, and are continued down the back part of the thigh external to the *adductor magnus*, covered at first by the broad *biceps cruris*, and afterwards continued between the *biceps* and the *vastus externus* to the outer side of the popliteal space: here the artery accompanies the ischiadic nerve and the strong tendon of the *biceps* between the two heads of the *gastrocnemius externus*, and through the tendinous trochlear loop connected with that muscle, where it divides, and is finally distributed as in other birds.

The sacro-median artery, after sending off a small branch to the *rectum*, divides into the genital or hypogastric and the coccygeal arteries.

I did not observe any modification of that condition of the venous system which usually characterizes the class of birds.

The inferior *cava* does not perforate the *diaphragm*, but enters the posterior part of the *pericardium* just above the anterior fissure of the *diaphragm*: it receives, close to its termination, the two large hepatic veins. There exists the same disposition of the renal veins which regulates the quantity of blood transmitted to the lungs or to the liver respectively, as in other birds. This disposition has been erroneously supposed to indicate that the urine was secreted from the venous blood in birds, as in reptiles and fishes; but the end attained by the venous *anastomoses* in question bears a much closer relation to the peculiar necessities and habit of life of the bird, and, so far as I know, has not hitherto been explained. There is no class of animals in which there may be, at any two brief and consecutive periods of existence, a greater difference in the degree of energy and rapidity with which the respiratory functions are performed, than in birds. When the bird of prey, for example, stimulated by a hungry and an empty stomach, soars aloft and sweeps the air in quest of food, the muscular energies are then strained to the utmost, the heart beats with the most forcible and rapid contractions to propel the current of blood along the systemic arteries, and the pulmonary vessels require the greatest possible supply of blood to serve the heart with the due quantity of arterialized fluid: the digestive system, on the other hand, is in a state of repose, and we may conceive the portal circulation to be at its lowest ebb.

But when the *Eagle* is glutted with his quarry and reduced to a state of stupor, there is a reverse condition of the two great systems which propel the venous blood from trunks to branches: the animal functions are now at rest, while the organic powers concerned in the assimilation of the food are in full play, and the portal or hepatic circulation now demands as great a supply as did that of the lungs under the previous condition.

The venous system of the kidneys is so arranged in birds that it can be distributed either to the portal system by the mesenteric vein, or to the pulmonary system by the *vena cava* and right side of the heart, according to the degree of rapidity with which the pulmonary or portal systems of veins are respectively emptied, or in other words, according to the activity with which the circulation in each of these systems may be going on at two different periods. The arrangement is as follows: the venous blood of the kidney is collected into a venous reservoir or trunk extending longitudinally through the substance of the gland, and more or less subdivided at its anterior or thick part in most birds; here it communicates by one or more large *anastomoses* with the iliac vein, which, after a short course, unites with its fellow to form the trunk of the *vena cava*; at the posterior or lower end of the kidney the renal vein emerges, and after receiving some small veins from the *cloaca*, joins the vein from the opposite kidney, and the common trunk, thus formed, then bends forwards, enters the folds of the mesentery of the *rectum*, and becomes the commencement of the mesenteric veins, receiving the blood from the *rectum* and *cæca*. Thus, when the circulation of the portal system is unusually active, the current of the venous blood of the kidneys will naturally tend towards the lower outlet into the mesenteric vein; but when, on the other hand, those causes are in operation which accelerate the current of venous blood through the *vena cava*, we may reasonably suppose that a greater quantity of the renal blood will flow by the anterior outlets into that great channel.

In the extreme case of the raptorial bird above-quoted, the advantage of such an arrangement appears sufficiently obvious to justify the teleological hypothesis here proposed; and in the rest of the class the like benefit may result from this arrangement of the renal veins to a degree corresponding with the necessity for it which may exist.

In the *Apteryx* the great renal vein (*s*, Pl. IV.) is not imbedded in the substance, but is continued along the anterior or under-surface of the kidney, receiving the blood from the lobules of the gland by many oblique but wide openings; the venous trunks of the two kidneys anastomose, as in other birds, posteriorly, to form the commencement of the mesenteric vein (*t*, Pl. IV.); and, anteriorly, after receiving the iliac veins, they unite to form the *vena cava* (*u*), and thus complete the great *circulus venosus renalis*. The modifications of this part of the venous system were less important than I had been led to anticipate in a bird whose comparatively limited powers of locomotion must be attended with less partial and excessive action of the respiratory system than in birds of flight.

The organs of respiration in birds are so eminently characteristic of that class, and so obviously framed with especial reference to the faculty of aerial progression, that in the *Apteryx*—a bird of nocturnal and burrowing habits, and of which the wings are reduced to the most rudimental condition,—the examination of the associated modifications of the respiratory system promised to be replete with peculiar interest. It was, in fact, the first point to which I directed my attention, and having made a preparatory inflation of the pulmonary organs by the *trachea*, I proceeded to open the *abdomen*, and displaced the *viscera* with great care; but, as has been already stated, there was not any trace of the extension of air-cells in the interspaces of the abdominal *viscera*; and the whole of them having been removed, I was not less gratified than surprised to find a complete and well-developed *diaphragm* separating the abdominal from the respiratory cavity. This *septum* did not present any large openings corresponding to those by which the air is continued into the *abdomen* in the other Struthious birds, but was here perforated only for the transmission of the *œsophagus* and large blood-vessels.

The *diaphragm* of the *Apteryx* differs from that which characterizes the class *Mammalia* in the following points; first, in the greater relative extent of the anterior or poststernal interspace; secondly, in the greater proportion of tendinous or aponeurotic tissue which enters into its composition; thirdly, in being perforated by three different large arteries, and not by the *vena cava* or *splanchnic* nerves; and lastly, in the different relative positions of the œsophageal and aortic openings. The plane of the *diaphragm* is more horizontal, or rather more parallel with the axis of the trunk, than in the *Mammalia* generally; but some of the aquatic species, as the *Dugong*, present a position of the *diaphragm* almost similar to that of the *Apteryx*.

The origins of the vertebral or lumbar portion of the *diaphragm* are by two well-developed *crura* (Pl. VI. *α*, fig. 1.), which are attached to slight prominences on the sides of the last *costal vertebra*: these *crura* are almost entirely tendinous; they expand as they advance forwards, and distribute their aponeurotic fibres in a manner remarkably analogous to the disposition of the fleshy fibres of the lesser muscle of the *diaphragm* in *Mammalia*. The mesial fibres decussate in front of the *aorta*: the lateral ones arch outwards; the rest diverge, to constitute the great central tendon. Here they cross each other in various directions, and form distinct and regular decussations around the orifices through which the cœliac artery, with the anterior *splanchnic* nerve, (Pl. VI. *l*,) and the mesenteric artery and nerves (Pl. VI. *m*,), pass into the *abdomen*: the most notable decussation is formed by two broad bands, immediately behind the large œsophageal aperture, which is separated only by a very narrow transverse chord from the anterior fissure through which the *pericardium* protrudes, and the inferior *vena cava* passes: the two broad decussating bands expand, to form the anterior boundary of the *diaphragm*, and are inserted into the lateral processes of the *sternum*.

The muscular or costal part of the *diaphragm* is formed, as in the *Ostrich*, by a number of separate, broad, and thin *fasciculi*, which come off from the third, fourth, fifth, sixth, and seventh vertebral ribs, near their junction with the sternal ones: these *fasciculi* expand, and are gradually lost upon the dorsal surface of the aponeurotic part of the *diaphragm*, but do not form a continuous expanse of muscle, nor constitute the entire thickness or substance of the *diaphragm* at any point: they are, consequently, invisible on the abdominal side of the *diaphragm*; and the aponeurosis of the *diaphragm*, together with the almost aponeurotic cellular layer of the *peritoneum*, with which it is continuous, requires to be reflected inwards, as at Pl. VI. β. β. fig. 1., to bring the digitations representing the great muscle of the *diaphragm* into view.

The existence of a *diaphragm* in a rudimental condition in birds has long been recognized: Hunter left a beautiful figure of the costal portion of the *diaphragm* in the *Ostrich*, which has been published in the second volume of the Catalogue of his Physiological Collection, Pl. XXVI. In this, as well as in the other large Struthious birds, there is also a *pars vertebralis* or analogue of the lesser muscle of the *diaphragm*, which rises by two tendinous *crura* from the last dorsal *vertebra*, and in the *Emeu* by a double origin on each side. Nevertheless their *diaphragm* is incomplete; first, by reason of an arrest of its centripetal development, which leaves a permanent defect of union in the mesial plane; and secondly, by the large perforations for the abdominal air-cells.

The mechanism of respiration in the *Apteryx* is essentially the same as in other birds; and a more muscular *diaphragm* than it possesses would be unnecessary as a part of that mechanism. The abdominal surface of the *diaphragm*, as in the *Mammalia*, is principally in contact with the liver, spleen, and stomach; but its thoracic surface, as we have already seen, does not support the heart, and it is separated from the lungs by the interposition of a series of small but well-marked air-cells. There is no thoracic serous *sac* or *pleura*.

Thus, although the respiratory organs are confined to the chest, and the *Apteryx* offers the only known instance in the feathered race of a species in which the receptacular part of the lungs is not continued into the *abdomen*; yet the Struthious type is strictly preserved, and the course of development has only been restricted, not changed.

The lungs, in fact, present all the peculiarities which characterize the class of Birds. They are fixed to the posterior part of the chest, and imbedded in the interspaces of the ribs, presenting a free anterior surface, slightly concave, extended on a plane nearly parallel with the axis of the trunk, and perforated by large apertures, through which the air passes from the bronchial tubes into the air-cells.

Each lung (Pl. V. figg. 4. & 5.) presents an irregular sub-compressed trihedral figure, broader anteriorly, and gradually contracted towards the posterior extremity, which is thin and rounded off: it is smooth and concave below; smooth and convex above, and outwardly; deeply indented along the upper or dorsal angle with six notches; the intermediate portions occupying the interspaces included between the second and the ninth ribs, and each sending off a small process. In the number of these posterior processes or lobes the *Apteryx* resembles the *Emeu*; in the *Cassowary* there are eight lobes; in the *Ostrich* and *Rhea* there are only five lobes in each lung.

The bronchial divisions of the *trachea* enter the lungs about one-fifth of their length from the anterior end, and almost immediately divide into four principal branches; one, a small branch (*a*, fig. 5.), is lost in the substance of the anterior part of the lung; a second, the largest branch (*b*, fig. 5.), runs down the concave surface, near to and parallel with the dorsal margin, and supplies the rest of the respiratory portion of the lung; the third branch, which is small, perforates the anterior part of the lung, and opens into the anterior air-cell; the fourth branch (*c*, fig. 5.) runs down the middle of the concave surface of the lung, and terminates by three successive orifices in the three inferior air-cells. The inner surface of this bronchial tube presents a great contrast with that of the second, which runs parallel with it, in the paucity of the *foramina* which it presents for the passage of air into the substance of the lung; these being extremely numerous in the second, as shown in the figure.

The pulmonary tissue is as compact, as vascular, and presents the same peculiar spongy texture as in other Birds. A stratum of fat was developed under the *pleura*, along the anterior margin of each lung. The first or most anterior of the air-cells interposed between the lung and *diaphragm* is the smallest; the second the largest; this and the third present a cuboid figure: the *parietes* of these cells consist of an extension of the delicate mucous membrane of the air-passages, and an external thin layer of cellular tissue, by which they adhere to the *diaphragm*: the anterior air-cell on each side protrudes a little way through the anterior aperture of the thorax. (See Pl. V. fig. 4.)

The *larynx* and *trachea* resemble, in the simplicity of their structure, those of the other Struthious birds. The upper larynx is not defended by any rudimental *epiglottis*, nor provided with retroverted spines or *papillæ*. The *glottis* (Pl. III. *d*, fig. 1.) is a long and moderately wide aperture: below the external or superior lips of the *glottis*, and within the *larynx*, there are two thinner membranous folds: a small but elongated process projects from the middle line of the under or anterior part of the upper *larynx*, towards the *rima glottidis*. Behind the *glottis* there are two square-shaped tumid processes, with their free margins directed backwards into the *pharynx*; their texture is more glandular than the surrounding mucous membrane. The *trachea* corresponds in length with the neck, and preserves a nearly uniform diameter throughout its course; it consists of small and entire cartilaginous rings,—in one specimen, 120,—in another, 130 in number,—alternately overlapping and being overlapped at the sides when the tube is relaxed: they are also alternately narrower on one side and the other, but in a slight degree: they become gradually smaller to the last twenty rings, which are not connected so closely and rigidly together as in the *Ostrich* and *Emeu*. Remembering the cervical air-sac which projects through the ovate aperture discovered by Fremery[1] in the anterior part of the *trachea* of the *Emeu*, and situated, as that accurate observer describes, between the fifty-third and sixty-second cartilaginous rings, I examined with care the *trachea* of the *Apteryx*, but without detecting any trace of an analogous structure in either sex.

There is no lower *larynx*. The last two tracheal rings increase in breadth, and the bronchial rings are continued from them with only a slight diminution of thickness: a membrane closes the *trachea* below, and completes the bronchial rings at their under part: near the termination of the *bronchiæ* the cartilaginous hoops are incomplete above as well as below. Both circular and longitudinal muscular fibres enter into the structure of the short bronchial tubes.

The *sterno-tracheales* muscles (Pl. V. *a*, fig. 4.; Pl. III. *g*, fig. 3.) arise, one from the inner surface of each coracoid bone.

It is plain, from the fixed condition of the lungs, and from the space between the lungs and *diaphragm* being occupied by air-cells, that inspiration could not be effectually performed by the action of the *diaphragm* alone: but the structure and mobility of the anterior *parietes* of the thorax indicate that it takes place in the *Apteryx*, as in other birds, by the *sternum* being depressed, and the angle between the vertebral and sternal ribs being increased.

All the triangular muscles which converge to be inserted into the costal processes thus become muscles of inspiration, and more especially those which represent the *serratus magnus anticus*, and which act from the true ribs as a fixed point below, upon the *scapula* above; for by drawing down that bone they bear upon the *sternum*, through the medium of the coracoid; and hence the necessity of strong and well-developed coracoid bones in a bird that otherwise could derive no particular advantage from the fixation of the *scapula*. The adherence to the ornithic type in the characteristic part of the osseous structure due to the *sternum*, *coracoids*, and *scapulæ*, is thus not merely explicable

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[1] De Casuario Novæ Hollandiæ. 8vo. 1819.

on the theory of unity of plan, but relates in the *Apteryx* to the exigences of respiration with fixed lungs and large air-cells.

Renal and Genital Organs.

The kidneys[1] of the *Apteryx* are situated symmetrically, and lodged, as in other birds, in the irregular hollows of the back part of the cavity of the *pelvis*; their posterior surface presents corresponding projections; the anterior surface is smooth and almost flat: the mesial edges of the kidneys are nearly straight and parallel, and very close to each other, but do not coalesce at any part; the outer edges are notched. Each kidney measures 3 inches in length, 11 lines across the broadest part, which is one-fourth from the anterior extremity, and 4 lines at the thickest part. It is divided into five lobes by oblique fissures, extending into the posterior surface of the gland: the middle lobe is the largest. These lobes appear to have a compact and even surface, but their cerebriform convolutions can be readily unravelled. The weight of both kidneys is 2 drs. 36 grs. avoirdupoise. The tortuous *ureter* (*w*, Pl. IV.) emerges from the inner side of the posterior extremity of the kidney, and after a course of an inch and a half, terminates, as above described, in the upper and back part of the uro-genital cavity.

The supra-renal bodies (*x*, *x*, Pl. IV.) were of an oval form, and yellow colour; of a homogeneous texture; each 3 lines in length, and adhering closely to the *vena cava* (*u*).

The male organs of generation consist of two pretty equally developed *testes* (*y*, *y*, Pl. IV.) situated on the sternal aspect of the atlantal extremities of the kidneys, and on each side of the *crura* of the *diaphragm*. They were of a subcompressed oval figure, with a somewhat angular external margin, about 1 inch in length and 8 lines in breadth in the largest male *Apteryx*; but the dimensions of these glands are of course liable to vary according to the season or state of sexual excitement. Thus in the younger male *Apteryx* they were subcompressed, subtriangular bodies, imbedded in the sternal and lateral aspects of the supra-renal bodies, and not exceeding 5 lines in length. The *vasa deferentia* (*z*, *z*, Pl. IV.) are formed by the union of numerous most minute efferent *tubules*, which pass from the *testes*, without forming an *epididymis*, into a soft amorphous substance, of a gray colour, which lies between the *testes* and the bright yellow supra-renal body. Some of the efferent *tubules* are lost in the gray substance, which seems to be the remnant of the *corpus Wolffianum*; but the greater part perforate that body, and proceed to form the *vas deferens*. This tube is continued in the usual transversely undulated course, along the sternal aspect of the kidneys, and towards their mesial margins, to the urethro-sexual compartment, and terminate each on a prominent *papilla* (*h*, *h*, Pl. IV.), situated in the uro-genital cavity, four lines below, and to the outer side of the urethral outlets, and three lines above the sides of the crescentic fold which separates the uro-genital from the vestibular compartment of the *cloaca*. The cresses or

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[1] Pl. IV. *v*, *v*.

angles of the fold are continued into the margins of the *penis*, which projects from below the external orifice of the urethro-sexual cavity into the vestibular or outer compartment of the *cloaca*. The *penis* rapidly diminishes to a point, and its extremity is spirally retracted; when stretched out, the whole length of the intromittent organ is 1 inch and a half in length; but this, doubtless, falls short of the dimensions of the *penis* in the recent and erect condition. An urethral groove traverses the upper, or what, if the *penis* were drawn out of the *cloaca* and bent forwards along the *abdomen*, would be its under surface, by an urethral or rather seminal groove, which is continued to the end of its spiral extremity: the margins of this groove are not beset with *papillæ*, but simply wrinkled transversely, as in the *Emeu* and *Ostrich*. The two lateral cavernous *crura* of the *penis* are attached to the membranous *parietes* of the uro-genital cavity, and to a retractor or erector muscle which comes off from the inner surface of the lower edge of the *ischium*: one of these muscles is represented at Pl. III. *n*, fig. 3. The base of the *penis* is drawn towards the *coccyx*, and the veins quitting the *corpora cavernosa* are compressed by a second pair of muscles (*o*), narrower but thicker than the erectors, which arise from the *fascia* at the sides of the *coccyx*, pass downwards along the sides of the *vestibule*, and meet at a tendinous *raphé* on the *dorsum penis*. Immediately above the base of the *penis*, on each side, there is a considerable *plexus* (*p*) of both arteries and veins, with which also many filaments of nerves are intermingled. The last-described muscles cross over the base of this *plexus* in their course to the *penis*, and would doubtless impede, if not arrest, the current of blood in the veins; they might be termed, therefore, "*compressores venarum penis*," as they fulfil the same office as the *compressores* described by Douglas in the *Dog*. In this office of maintaining the erect and turgid state of the intromittent organ, the *compressores* are aided by two broad sphincters: the internal one (Pl. III. *q*, fig. 3.) rises from the sides of the *coccyx*, and more immediately surrounds the *cloaca*, meeting its fellow at the middle line of the inferior surface: the external sphincter (*r*) closes principally the external compartment of the *cloaca*.

The female organs in the specimen dissected presented their full functional development. The left ovarium was, however, too much decomposed to admit of any accurate observation of its structure being made: it consisted of an irregular and obscurely divided mass, of about three inches in length by two in thickness: the largest yelks appeared to have been about one inch in diameter. There was a perfectly distinct right ovarium situated in front of the corresponding supra-renal gland; it consisted of an irregularly oval flattened body, with a slightly granulate surface, nine lines long, six lines wide, and about one line in thickness. The part of the *cloaca* where a rudimental right oviduct, supposing one to have been present, might have terminated, was cut away.

The left oviduct was of large size, and from the condition of the lining membrane of the calcifying segment or *uterus*, seemed to have been exercising its function a brief period before death. The whole length of the oviduct was thirteen inches; it was disposed in three principal convolutions, and its connexions were as usual in birds. It commences with a thin slit-like mouth, with entire margins, two inches in width, but soon contracts to a diameter of ten lines; it thence proceeds to expand very gradually to the width of an inch, and is thus continued to the uterine or terminal segment: this portion is two inches and a half in length, and one inch and a half in diameter: its inner surface was studded with slightly arborescent calcifying follicles, arranged in transverse rows. The lining membrane of the principal part of the oviduct was thrown into longitudinal *rugæ*; the tube communicated with the *cloaca* by a short, contracted, and oblique canal and orifice, with tumid margins. Both the upper and lower *mesometries* presented the usual radiated muscular structure.

Osseous System.

The skeleton (Pl. VIII.) of the *Apteryx* exhibits, but in a less degree than the entire bird, the Struthious disproportion between the anterior and posterior extremities, and it shows that all the ordinary bones of the wing exist, though in their feeblest state of development.

With the exception of the parts of the skeleton concerned in the formation of the nasal and auditory cavities, none of the other bones of the *Apteryx* are perforated for the admission of air, nor do they exhibit the pure white colour which characterizes the skeleton in other birds. In their tough and compact texture they resemble the bones of the *Lizard* tribe.

The skull (Pl. VII. figg. 1, 2, 5.) of the *Apteryx* is chiefly remarkable for its smooth, expanded, elevated, pyriform cranial portion, the total absence of supra-orbital ridges, the completeness and the thickness of the inter-orbital *septum*, the great development of the *ethmoid*, the small size of the lacrymal bones, and the expansion of the nasal cavity behind these bones. The combination of the depressed with the elongated and slender form of the beak is of course as well marked in the skull as in the entire head already described.

The *occipital* region of the *cranium* has a pretty regular semicircular contour, and differs from that of other Struthious birds in the greater relative extent of its base, and in the comparatively slight lateral sinuosities due to the temporal depressions. The single hemispherical tubercle in the *basi-occipital*, for the articulation with the *atlas*, has not the vertical notch at the upper part observable in the *Ostrich* and *Emeu*, but is entire as in the *Rhea*; and the plane of the *occipital foramen* has the same aspect as in that bird, in which it is more nearly horizontal than in the *Ostrich*. The *supra-occipital plate* forms a somewhat angular projection, corresponding with the small *cerebellum* within, and is bounded on each side by a vertical vascular groove, terminated by a *foramen* above and below: external to these grooves the ex-occipitals extend outwards and downwards, in the form of obtuse processes, compressed in the antero-posterior direction, slightly convex behind and concave in front, where they form the back part of the wide *meatus auditorius externus*. All the parts of the occipital bone were anchylosed together, and also to the surrounding bones.

The angle between the posterior and superior regions of the *cranium* is scarcely produced into a ridge. The superior region is smooth and regularly convex ; it is separated from the temporal depressions by a narrow ridge, a little more marked than the occipital one. The sagittal suture runs across a little behind the middle of the upper part of the *cranium* : the left half of this suture, with the frontal suture, was persistent in one *cranium* of the *Apteryx*, which I extracted from a dried skin in Mr. Gould's Museum ; but all the sutures were obliterated in the skull of Mr. Bennett's male specimen. The persistent sutures were more denticulated than those in the skull of a young *Ostrich* with which I have compared them.

The superior is continued into the lateral regions of the *cranium* by a continuous curvature, so that the upper part of the small orbital cavity is convex, and its limits undefinable, there being no trace of supraorbital ridge or antorbital or postorbital processes : this structure is quite peculiar to the *Apteryx* among birds, but produces a very interesting resemblance between it and the monotrematous *Echidna*. The temporal bone sends forwards a short and slender *zygomatic* process, which in its small relative development resembles most that of the *Rhea* among the larger *Struthionidæ*.

The frontal bones gradually contract to their junction with the nasal bones, between which there is the trace of a small part of the *ethmoid* bone. The narrow frontal region of the skull is traversed by a mesial longitudinal depression.

The *ethmoid* bone is remarkably expanded in the *Apteryx*, and its cells, instead of being restricted to a narrow vertical *septum* of the orbits, as in the diurnal *Struthionidæ*, occupy not only the ordinary orbital space, but extend outwards for more than two lines beyond the lateral boundaries of the anterior part of the *frontals*. A small process extends from the *frontal* to the side of the expanded *ethmoid*, anterior to the *orbital foramina*, which are distinct, and remarkably wide apart, and the expanded *ethmoid* is also supported anteriorly by a similar anchylosed conjunction with the lacrymal bone. The entire breadth of the *ethmoid* is 9 lines. The nearest approach to this peculiar structure of the *Apteryx* is made by the *Ostrich*, in which the interorbital *septum*, though much thinner than in the *Apteryx*, is also occupied by *ethmoidal* cells, and is thicker than in any of the other large *Struthionidæ*. The *Ibis* (*Numenius arcuatus*, Cuv., Pl. VII. figg. 3 & 4.) offers a striking contrast with the *Apteryx* in this respect, the interorbital osseous *septum* being almost entirely absent. In all the other parts of the *cranium* already noticed it also differs widely from the *Apteryx*. In the posterior region of the skull of the *Ibis* the bony covering of the *cerebellum* is in great part defective : in the superior part the cranial *parietes* above the cerebral hemispheres form two convexities, separated by a middle longitudinal depression, and the narrow space between the supraorbital ridges is occupied by the impressions corresponding to the nasal or supraorbital glands: the whole *cranium* also is much higher and shorter in proportion to its breadth than in the *Apteryx*. The *Ibis*, in thus differing from the *Apteryx*, deviates also from the other *Struthionidæ*.

At the base of the skull we find in the *Apteryx* all the peculiarities characteristic of the *Struthious* birds. The body of the *sphenoid* sends outwards on each side two processes, of which the posterior abuts against the tympanic bone, and the anterior one, by a flattened oval articular surface against the *pterygoid* bone: the latter processes exist, but are much more feebly developed, in the *Ibis*: in most other birds, including the *Grallæ*, they are wanting: they are well developed in the Lacertine *Sauria*. A compressed vomerine process is continued forwards from the anterior part of the *basisphenoid*, and this process is anchylosed to the under part of the expanded and cellular *ethmoid*.

In the interior of the *cranium* the olfactory depressions are seen to be proportionally larger than in other birds, and the olfactory nerve, instead of being continued along the upper part of an interorbital septum by a bony canal or groove to the nasal cavity, immediately passes, by many perforations, through a cribriform plate to the complex and extensive pituitary surface of the *ethmoid* bone.

The optic *foramina* are distinct both internally and externally, and are half an inch apart; they are perforated, not in the *sphenoid ala*, but in the inflected margin of the frontal bone. In these peculiarities the *Apteryx* differs from all the rest of its class: each optic *foramen*, however, transmits not only the optic nerve and ophthalmic artery, but also the third, fourth, first branch of the fifth and sixth nerves, as in most other birds. Of these nerves the fifth is the largest, and it is continued forwards to the nasal canal, through two *foramina*, one circumscribed externally by the process already mentioned, which extends from the frontal to the *ethmoid*; the other by the corresponding process of the *lacrymal*. The pituitary *fossa*, or *sella turcica*, is a very deep semi-oval depression; the common internal orifice of the two carotid canals communicates with its posterior part. On each side of the anterior part of the floor of the *cranium*, which supports the *medulla oblongata*, there is an oblique slightly curved groove, terminated at its anterior extremity by the *foramen rotundum*, at its posterior by the *foramen ovale*. These *foramina* are situated between the basilar and alar elements of the *sphenoid*; they are nearly of equal size, and are relatively larger than in the diurnal *Struthionidæ*. The *foramen rotundum* is not only distinct, but is further apart from the *foramen opticum* than in any other bird. The petrous bone projects internally in the form of a thin semicircular plate of bone, commencing at the *foramen ovale* and extending backwards to the *foramen auditorium internum*, which it overhangs: this plate gives attachment to the *tentorium*. There is not any corresponding bony ridge developed from the upper wall of the *cranium* in the line of origin of the *falx*, as in many of the Gallinaceous birds. The anterior or cerebral division of the cranial cavity is larger in proportion to the posterior than in most other birds.

Of the bones more immediately concerned in the formation or motion of the jaws, that element of the temporal may be first described which in birds is always moveable and articulated at once with the *cranium* and both the upper and lower jaws.

The *tympanic* bone is of a subcompressed trihedral form, and sends forwards into the orbit a longer and slenderer process than in the larger *Struthionidæ*: its upper articular surface is a transversely extended convex condyle, which plays in a corresponding cavity internal to the base of the zygomatic process. The opposite extremity is expanded, and presents two distinct articular convexities for the lower jaw, the inner one being the largest: above the external convexity there is a small but deep depression for the reception of the deflected extremity of the jugal bone.

The posterior extremity of the *pterygoid* bone is securely wedged in between the orbital process of the tympanic and the transverse process of the sphenoid: as it advances forwards it expands, as in the other *Struthionidæ*, into a thin plate of bone, which is bent upon itself with its concavity turned inwards, and is continued by anchylosis into the palatine bones, so that the limits between them cannot be defined.

The *palatine* bones are in like manner confluent with the maxillaries. They are pierced by two narrow elliptical posterior nasal *foramina*, about 3 lines in length, over which the exterior margin of each palatine bone arches from without inwards, and these overarching *laminæ* gradually approximate, as they advance forwards, and meet about one inch anterior to the nasal *foramina*, from which an imperforate plate of bone, impressed with a narrow median fissure, and composed of the confluent palatal processes of the maxillary and intermaxillary bones, is continued to the end of the beak. The limits between maxillary and intermaxillary bones are indicated by two fine oblique lines, commencing at the outer margin of the roof of the mouth, about 2½ inches from the apex of the beak.

The *jugal* style, which in the *Ostrich* may be separated in the full-grown bird into a zygomatic and malar portion, consists in the *Apteryx* of a single slender compressed twisted bone, anchylosed with the maxillary bone in front, and terminated behind by an obtuse deflected extremity, which is received into a corresponding vertical cavity in the upper part of the outer process of the tympanic bone. By this mode of attachment the tympanic bone offers increased resistance to the pressure transferred to it by the lower jaw, at the same time that it gives additional strength to the upper mandible. It is continued backwards in the same line with the upper maxillary bone as in other *Struthionidæ*, and is not bent downwards at its junction with the maxillary as in the *Ibis* and other *Grallæ*.

The *superior maxillary* bone presents the singular form of a nearly perfectly flat elongated triangular plate of bone, which is imperforate, and is continued by uninterrupted ossification with the intermaxillary. The *Rhea* among the *Struthionidæ* makes the nearest approach to the *Apteryx* in the structure of this part of the skull; but the maxillary plate is perforated by large *foramina*, and sends upwards on each side a process to join the lacrymal. In the *Ibis* the superior maxillary bones are in the form of slender round styles, having a wide interspace between them. In the *Apteryx* the small lacrymal bones are represented by two compressed plates of bone descending obliquely forwards from the anterior extremities of the frontals, and are articulated below to a small depression in the maxillary plate. They are each pierced by a single small foramen. The frontal, nasal, and intermaxillary bones form one continuous bony piece, too strong to admit of any elastic yielding movement between the upper jaw and *cranium*. The nasal and the upper or mesial portion of the intermaxillary bones form an elongated depressed narrow process, convex above, and with the outer margins bent inwards beneath the long nasal passages, of which they form the outer and part of the lower boundaries.

The lower jaw[1] presents all the usual ornithic characters with the Struthious modifications traceable in the individual peculiarities. The transversely expanded angular and articular extremities offer the inwardly extended process for the attachment of the *pterygoïdei* muscles: the superior transverse plate behind the articular surfaces is thin and concave towards the *meatus auditorius externus*, and is lined by the mucous membrane of that passage, of which it forms part of the bony parietes. There are two distinct narrow oblique articular surfaces, concave in the longitudinal and convex in the transverse directions; the internal one is the largest, and behind this there is a small excavation[2] into which a small process of the air-sac lining the *tympanum* is continued; and this is the only part of the skeleton not immediately concerned in the formation of the organs of hearing or smelling into which air is admitted. The entry to the air-cells in the lower jaw of the *Ostrich* is situated in the part corresponding to the above depression or *sinus* in the jaw of the *Apteryx*. Traces of the compound structure of the lower jaw are very evident in that of the *Apteryx*, and the limits of the angular, articular and coronoid pieces may be in part defined. There is a linear vacancy, bounded by the surangular and angular pieces behind, and by the bifurcate commencement of the mandibular or dentary piece in front: the surangular is compressed, and sends upwards a very slightly elevated coronoid ridge. A second narrower fissure occurs between the thick opercular or splenial element and the upper fork of the mandibular piece. The opercular piece reaches to the posterior part of the *symphysis* as in the *Ostrich*, and the rest of the lower jaw in front of this part is formed by the two anchylosed mandibulars. In the extent of this anchylosed *symphysis* the *Rhea* makes the nearest approach to the *Apteryx* among the *Struthionidæ*, and the two impressions which diverge from the back part to the front of the *symphysis* are present in both the *Rhea* and *Emeu* as in the *Apteryx*. The lower jaw of the *Apteryx* differs from that of the *Ibis* in its greater posterior expanse, its more depressed form, the lower coronoid plate, the narrower fissure between the angular and surangular pieces, and the absence of the mesial furrow, extending in the *Ibis* to the end of the *symphysis*.

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[1] Pl. VII. Figg. 6. & 7.

[2] Pl. VII. Fig. 6. *a*.

The relations of the modifications of the skull of the *Apteryx* to its peculiar habits and kind of food are well marked and very easily traced; those which concern the maxillary portions have already been noticed in the account of the digestive system, and I need only add here that the anchylosed condition of all the parts concerned in the formation of the upper mandible is more complete than in the larger *Struthionidæ*, and relates to the greater force with which the beak is used in obtaining the food.

The nocturnal habits of the *Apteryx*, combined with the necessity for a highly developed organ of smell, which chiefly compensates for the low condition of the organ of vision, produces the most singular modifications which the skull presents, and we may say that those cavities which in other birds are devoted to the lodgement of the eyes, are here almost exclusively occupied by the nose.

The spinal column is relatively stronger, especially in the cervical region, than in the larger *Struthionidæ*: it consists of fifteen cervical, nine dorsal, and twenty-two remaining *vertebræ* in the lumbar, sacral, and caudal regions.

The dorsal *vertebræ* are arranged in a straight line, and slightly increase in breadth to the seventh; the transverse processes of the eighth and ninth suddenly diminish. The third, fourth, fifth and sixth dorsal *vertebræ* are slightly anchylosed together by the contiguous edges of their spinous processes; the seventh, eighth and ninth are overlapped by the iliac bones; but notwithstanding this partial anchylosis, the synovial articulations, both between the bodies and oblique processes, are retained in all the dorsal *vertebræ*, and a slight, yielding, elastic movement is permitted between those *vertebræ*: the body of the last dorsal *vertebra* is anchylosed to the *sacrum*. The breadth of the bodies of the dorsal *vertebræ* diminishes, and their length increases very gradually from the first to the fourth; thence the bodies become broader and shorter in the same degree to the *sacrum*. A short obtuse process is sent off obliquely forwards from the inferior surface of the body of each of the first four dorsal *vertebræ*; the corresponding surface of the succeeding ones is smooth and slightly concave from side to side. The articulation between the bodies is by the adaptation of a surface slightly concave in the vertical and convex in the transverse direction at the posterior end of one *vertebra* to opposite curves at the anterior end of the succeeding one. Close to the anterior surface on each side there is a hemispherical pit for the reception of the round head of the rib: this articular pit is supported on a process representing the inferior transverse process, except in the three middle dorsal *vertebræ*. The transverse processes are broad, flat, and square-shaped, with the anterior angle obliquely cut off to receive the abutment of the tubercle of the rib, except in the second and third, in which a small process is sent down for the same purpose from the under surface of the transverse process: the transverse processes of the three last dorsal *vertebræ* abut against the under or inner surface of the *ilia*, and are probably anchylosed thereto in old birds. The nerves issue from the interspaces of the *vertebræ* above the articulation of the heads of the ribs. The transverse processes are not connected together by extended long splints, but are quite detached from each other, as in Struthious birds. The oblique processes offer no peculiarity; a process is continued backwards from the upper part of those belonging to the first and second dorsal *vertebræ*. The spinous process arises from the whole length of the arch of each *vertebra* ; it is truncate above, and with the exception of the first, is of the same breadth throughout : all the dorsal spines are much compressed, the middle ones being the thinnest, slightly expanding at their truncate extremities, especially the three anterior ones, the first spine being notched behind to receive the contiguous angle of the succeeding one : below this there is a considerable interval between these two spines, but the rest of the spines are in contact throughout, and are probably more anchylosed in the older birds than was observed in the specimen here described. The length of the dorsal region of the spine is 4 inches.

The length of the vertebral column behind the dorsal *vertebræ* included between the *ossa innominata* is 3 inches. The first four sacral *vertebræ*[1] send outwards inferior transverse processes which abut against the *ilia*, and progressively increase in length and thickness. The breadth of these *vertebræ* also gradually increases ; but it diminishes in the four succeeding *vertebræ*, in which the inferior transverse processes are wanting : then the ninth and tenth sacral *vertebræ* send outwards each a pair of strong inferior transverse processes to abut against the inner surface of the *ossa innominata* immediately behind the *acetabulum* : the anchylosis of the bodies is continued through the four succeeding *vertebræ*, which are of a very simple structure, devoid of transverse or oblique processes, becoming gradually more compressed and more extended vertically, so as to appear like mere bony *laminæ* ; the line of the articulation between the bodies of these posterior sacral *vertebræ* is obvious, but their spines coalesce to form a continuous bony ridge, which is closely embraced by the posterior extremities of the *innominata*. The *foramina* for the nerves are pierced in the sides of the bodies of the sacral *vertebræ* ; they are double in the anterior ones, but single in the posterior compressed *vertebræ*, where they are seen close to the posterior margin.

There are nine caudal *vertebræ*, which are deeper, and project farther below the posterior portions of the iliac bones than in the other Struthious birds : these *vertebræ*, as they descend, progressively increase in lateral and diminish in vertical extent ; the spinal canal is continued through the first five, and they are all moveable upon each other, excepting the two last, which combine to form a *vertebra* analogous to the expanded terminal *vertebra* in other birds, but which here exceeds the rest only in its greater length, and gradually diminishes to an obtuse point. In the *Ostrich* the corresponding *vertebra* is expanded for the support of the caudal plumes, but in the *Apteryx* it offers the same inconspicuous development as in the *Rhea* and *Emeu*.

The cervical *vertebræ* present all the usual ornithic peculiarities. Their general form and proportions are shown in the figure (Pl. VIII.). The single inferior process for the attachment of the complicated *longus colli anticus* is present in the three last *vertebræ*.

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[1] See Pl. IX.

The inverted bony arch for the protection of the carotid arteries is first seen to be developed from the inner side of the inferior transverse processes of the twelfth cervical *vertebra,* but the two sides of the arch are not anchylosed together ; the interspace progressively increases in the eleventh, tenth, and ninth *vertebræ*, and the groove widens and is lost at the fifth *vertebra*. The spinous process is thick and strong in the *vertebra dentata*, but progressively diminishes to the seventh cervical *vertebra*, where it is reduced to a mere tubercle ; from the eleventh it progressively increases to the last cervical, in which it presents the strong quadrate figure which characterizes the same process in the dorsal *vertebræ*.

The large canal on each side for the vertebral artery and sympathetic nerve is formed by the anchylosis of a rudimental rib to the extremities of an upper and lower transverse process ; the costal process diminishes in size in the anterior cervical *vertebræ* : it is wanting in the *dentata*, though an arterial canal of very small size is present on each side of that *vertebra*. In the *atlas* there are two small inferior transverse processes, but no canal. The superior or neurapophysial bony arch increases in extent as the cervical *vertebræ* approach the head, and in the third, fourth, and fifth *vertebræ* this part is perforated by a small *foramen* on each side. The spinal chord is least protected by the *vertebræ* in the middle of the neck, where there is the greatest extent of motion : there is a depression on the anterior and posterior parts of the spine in the second, third, fourth, and in the last six cervical *vertebræ.*

The length of the cervical region of the spine is 7 inches.

The close resemblance of the Bird to the Reptile in its skeleton is well exemplified in the young *Ostrich*, in which even when half-grown the costal appendages of the cervical region of the vertebral column continue separate and moveable, as in the *Crocodile*. I have already observed that they were anchylosed to the first fifteen *vertebræ* in the *Apteryx*. The first dorsal rib is a slender style about an inch in length ; the rest are remarkable for their breadth, which is relatively greater than in any other bird ; the *Cassowary* in this respect approaches nearest to the *Apteryx*. The second, third, fourth, and fifth ribs articulate with the *sternum* through the medium of slender sternal portions ; that of the sixth also reaches the *sternum*, but is attached only to the sternal rib anterior to it, and a considerable interspace exists between its unattached extremity and that of its corresponding vertebral rib. In the first simple and floating rib, the part corresponding to the head and neck, as usual, is not developed, and it is attached to the transverse process by the part analogous to the tubercle. In the second rib a short and strong *cervix*, terminated by a hemispherical head, is given off below and in front of the tubercle, and works in a corresponding socket at the anterior margin of the *vertebra*. The head and tubercle, with the points of the *vertebræ* to which they are attached, intercept large *foramina* corresponding to the vertebral *foramina* in the cervical region. Immediately below the tubercle the rib suddenly expands, and then gradually narrows to its lower end : the neck of the rib increases in length in the third and fourth pairs and diminishes in the last two ; the sixth rib begins to lose its breadth, and the rest become narrower to the last. The bony appendages to the vertebral ribs are developed in the second to the eighth inclusive: they are articulated by a broad base to a fissure in the posterior margin of these vertebral ribs a little below their middle part; those belonging to the third, fourth, fifth, and sixth ribs are the longest, and overlap the succeeding rib: these processes are not anchylosed in the specimen described. The *Rhea* comes nearest to the *Apteryx* in the size of these costal appendages. The first four sternal ribs are transversely expanded at their sternal extremities, which severally present a concave surface lined with smooth cartilage and synovial membrane, and playing upon a corresponding smooth convexity in the costal margin of the *sternum*, which thus presents four true enarthrodial joints with capsular ligaments on each side. This elaborate structure is not, however, peculiar to the *Apteryx* among birds, but relates to the importance of the movements of the sternal ribs, which are the centres upon which the respiratory motions hinge,—the angles between the vertebral and sternal ribs, and between these and the *sternum*, becoming more open in inspiration when the *sternum* is depressed, and the contrary when the *sternum* is approximated to the dorsal region in expiration.

The *sternum*—the main characteristic of the skeleton of the bird—is reduced to its lowest grade of development in the *Apteryx*. In its small size, and in the total absence of a keel, it resembles that of the Struthious birds, but differs in the presence of two subcircular perforations on each side of the middle line, in the wide anterior emarginations, and in the much greater extent of the two posterior fissures.

The anterior margin presents no trace of a manubrial process as in the *Ostrich*: on the contrary, the wide interspace between the articular cavities of the coracoid is deeply concave: in the extent of this interspace the *Rhea* most resembles the *Apteryx*, but its contour is almost straight; in the *Cassowary* the space is narrower but is deeply notched. The articular surface for the coracoid is an open groove, which in the fresh state is covered with articular cartilage: external to this groove the anterior angles of the *sternum* are produced into two strong triangular processes with the *apex* obtuse. The costal margin is thickened, and when viewed anteriorly, presents an undulating contour, from the presence of the four articular convexities for the sternal ribs and the intermediate excavations. The *sternum* of the *Emeu* presents a similar appearance. The breadth of each sternal perforation is nearly equal to that of the intervening osseous space; in the specimen described they were not quite symmetrical in position. The extent of the posterior notches is equal to one half the entire length of the *sternum*: the external boundaries of these notches curve towards each other: there is also a slight want of symmetry in the form, position, and extent of these notches, as may be seen in the figures (Pl. IX. Fig. 2 & 3.)

The *scapula* and *coracoid* are anchylosed[1]: a small perforation anterior to the articular surface of the *humerus* indicates the separation between the coracoid and rudimental clavicle, of which there is otherwise not the least trace.

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[1] Pl. IX. fig. 4.

The *coracoid* is the strongest bone: its inferior expanded extremity presents an articular convexity, adapted to the sternal groove before described.

The *scapula* reaches to the third rib: it is a simple narrow plate of bone, slightly curved and expanded at both ends, but chiefly at the humeral articulation. Its length is one inch.

The *humerus* is a slender, cylindrical, styliform bone, slightly bent, 1 inch 5 lines in length; slightly expanded at the two extremities, most so at the proximal end, which supports a transverse oval articular convexity, covered with smooth cartilage, and joined by a synovial and capsular membrane to the scapulo-coracoid articulation. A small tuberosity projects beyond each end of the humeral articular surface. The distal end of the *humerus* is articulated by a true but shallow ginglymoid joint with the rudimental bones of the *antibrachium*, and both the external and internal condyles are slightly developed.

The *radius* and *ulna* are almost straight cylindrical slender bones, each 9 lines in length. A feebly developed *olecranon* projects above the articular surface of the *ulna*. There is a minute carpal bone, two metacarpals, and a single phalanx, which supports the long curved obtuse alar claw. The whole length of this rudimental hand is 7 lines, including the claw, which measures 3 lines and a half. A few strong and short quill-feathers are attached by ligament to the *ulna* and *metacarpus*.

The *iliac* bones in size and shape resemble those of the Struthious tribe: the length is 4 inches and 3 lines. The outer surface presents a slight concavity anteriorly, which gradually passes into a convexity posteriorly, the two surfaces not being separated by the transverse elevation observable above the *acetabulum* in the four large Struthious birds. A distinct epiphyseal piece of bone, of a compressed and triangular form, is wedged in between the posterior extremity of the *ilia* and the first three caudal *vertebræ*.

The *ischium* extends backwards, parallel with the *sacrum*, in the form of a thin plate of bone which slightly expands to its free extremity, which is truncated.

The pubic element is a slender bony style, connected by ligament to the end of the *ischium*, but attached by bone at its acetabular extremity only. A short pointed process extends from the anterior margin of the origin of the *pubis*. In comparing the *pelvis* of the *Apteryx* with that of the large Struthious birds, we find that the *ischia* do not meet below the *sacrum* as in the *Rhea*, but are more distant from that and the iliac bones than in any of the Struthious birds; the pubic bones are not joined together at their distal extremities as in the *Ostrich*; the extremities of the *ischia* are not anchylosed to the superincumbent *ilia* as in the *Cassowary*. It is the *Emeu* which comes nearest to the *Apteryx* in the structure of the *pelvis*, but it also differs in the complete bony boundary of the *foramen* which transmits the tendon of the *obturator internus*, and which is completed posteriorly by ligament in the *Apteryx*.

The *acetabulum* communicates, as usual, by a wide opening with the *pelvis*: a surface covered with a cushion of thick cartilage is continued from its posterior and upper part.

The fibrous capsule of the hip-joint is very strong; the synovial membrane is reflected from it upon the upper margin of the *trochanter* and upper part of the short neck of the *femur*; and also upon the ligamentous bridge continued from the upper and extended margin of the *acetabulum*, to its anterior part. The *ligamentum teres* is very large, but short; it consists of an infundibular process of synovial membrane, reflected from the circumference of the acetabular perforation to that of the depression on the head of the *femur*; and this synovial sheath incloses two distinct ligaments, which are twisted about each other like the crucial ligaments of the knee-joint. One of the ligamentous bands passes from the upper margin of the acetabular perforation to the lower edge of the femoral depression; the other comes off from the under part of the acetabular perforation, and winds round the back part of the preceding, to be inserted into the upper part of the femoral depression.

The *femur* has the usual characters of that bone in the class of birds. Its small round head is supported on a very short and thick neck, placed at right angles to the great and single *trochanter*: it presents at its superior part a large depression for the strong and complex *ligamentum teres*. The shaft of the *femur* is slightly bent, with the convexity forwards, which is increased by a thickening at the anterior part of the middle of the shaft. The *condyles* are separated by a wide and deep groove anteriorly, and by a triangular depression behind. The outer one is the largest, and is grooved externally, for the articulation of the head of the *fibula*: the inferior compressed border of the *condyle* is wedged in between the *tibia* and *fibula*. The length of the *femur* is 3 inches 9 lines. The *tibia* is five inches in length. Two angular and strong ridges are developed from the anterior part of the expanded head of the *tibia*; the external one affords attachment to *fascia*, and to the expanded tendon of the *rectus femoris latissimus*: the internal ridge has affixed to it the ligament of the small cartilaginous *patella*. The knee-joint is remarkably complicated. The internal lateral ligament is broad and thin; it gives origin to part of the *soleus*, and is attached to the internal semilunar cartilage. This fibro-cartilage divides at its anterior extremity into three ligaments: of these one is broad and thick, and goes to the posterior surface of the rotular cartilage; it represents the *ligamentum mucosum*; the other two ligaments are inserted at the interspace of the *condyles*. Beneath the internal semilunar cartilage a very strong ligament arises from the inner edge of the *tibia*, and is also attached to the interspace of the *condyles*. A strong external lateral ligament extends between the outer *condyle* and the head of the *fibula*: beneath or within this there is a second ligament, which passes from the outer *condyle* to the external semilunar cartilage. A thick ligament extends from the anterior parts of this cartilage to the back part of the *ligamentum patellæ*. From the back part of the external semilunar cartilage a posterior crucial ligament extends to the condyloid interspace; lastly, a strong ligament arises from the fore part of the head of the *tibia*, and passes upwards and backwards to be inserted, with the preceding ligament, into the back part of the interspace of the *condyles*. The head of the *tibia* sends down an angular ridge posteriorly: the shaft of the bone is rounded, slightly compressed, converging to a ridge externally, to which ridge the *fibula* is attached in two places, beginning half an inch below the head of the *fibula*, and continuing attached for 10 lines; then again becoming anchylosed, after an interspace of 9 lines. In one specimen I found the *fibula* also anchylosed to the *tibia* by its expanded and thick proximal extremity: it quickly diminishes in size as it descends, and gradually disappears towards the lower fourth of the *tibia*. The distal end of the *tibia* presents the usual trochlea form, but the anterior concavity above the articular surface is in great part occupied by an irregular bony prominence.

There is a small cuneiform tarsal bone wedged into the outer and back part of the ankle-joint. The anchylosed *tarso-metatarsal* is a strong bone, 2 inches 3 lines in length; the upper articular surface is formed by a single broad piece. The original separation of the metatarsal bone below into three pieces is plainly indicated by two deep grooves on the anterior and posterior part of the proximal extremity: the intermediate portion of bone is very narrow anteriorly, but broad and prominent on the opposite side. The bone becomes flattened from before backwards, and expanded laterally as it descends, and divides at its distal extremity into three parts, with the articular pulleys for the three principal toes.

The surface for the articulation of the fourth, or small internal toe, is about half an inch above the distal end, on the internal and posterior aspect of the bone. A small *ossicle*, attached by strong ligaments to this surface, gives support to a short *phalanx*, which articulates with the longer *ungueal phalanx*.

The number of *phalanges* in the other toes follows the ordinary law, the adjoining toe having three, the next four, and the outermost five *phalanges*. The relative size and the forms of these bones are shown in the figures of the skeleton (Pl. VIII.).

Organs of Sense.

The requisite particulars regarding the nervous system of the *Apteryx* will be subsequently described. The cavity of the *cranium* indicates the brain to have been proportionally larger than in the diurnal *Struthionidæ*.

Of the organs of special sense, the ear, as we have already seen, resembles that of the larger *Struthionidæ* in the development of the external passage: the structure of the internal organ was conformable to the typical condition of this part in Birds.

The eye, on the contrary, presented a remarkable deviation from the construction which characterizes the feathered class, in the total absence of the *pecten* or *marsupium*. We may conceive that this modification relates to the nocturnal habits and restricted locomotion of the present singular species. The eye-ball is relatively much smaller than in other birds; its antero-posterior diameter is three lines; its transverse diameter four lines. The *cornea transparens* is very convex, and two lines in diameter. The *sclerotic* is thin, but the margin supporting the *cornea* is strengthened by a circle of small osseous plates. The *choroid* is a delicate membrane; its pigment is of a light brown colour. The ciliary processes commence at the ciliary ring, each process having at its origin a slight linear rising, which becomes gradually wavy and tortuous as it approaches the lens, anterior to the circumference of which it projects freely to a small extent. The *iris* in the specimen examined was one-third of a line in breadth. The optic nerve terminates by a small round aperture. The lens is two lines in breadth, and nearly one line at the thickest part, being thus more convex than in other birds. The external appendages of the eye presented no peculiarities, except the very great strength of the *orbicularis palpebrarum*; the *membrana nictitans* had the usual trochlear muscles: its free margin was black.

The singularly long and narrow nasal passages are closed and defended externally by the inflected outer margins of the nasal and upper process of the long intermaxillary bones. The relative extent and complexity of the turbinated bones, and the capacity of the posterior part of the nasal cavity exceed those of any other bird; and the sense of smell must be proportionally acute and important in the economy of the *Apteryx*.

Affinities of the Apteryx deducible from its Anatomy.

On a review of the preceding details of the organization of the *Apteryx*, it will be seen that, commencing with the skeleton, all the leading modifications of that basis of its structure connect it closely with the Struthious group. In the diminutive and keel-less *sternum* it agrees with all the known Struthious species, and with these alone. The two posterior emarginations which we observe in the *sternum* of the *Ostrich* are present in a still greater degree in the *Apteryx*; but the feeble development of the anterior extremities, to the muscles of which the *sternum* is mainly subservient as a basis of attachment, is the condition of a peculiarly incomplete state of the ossification of that bone of the *Apteryx*; and the two subcircular perforations which intervene between the origins of the pectoral muscle on the one side, and those of a large inferior dermo-cervical muscle on the other, form one of several unique structures in the anatomy of this bird. We have again the Struthious characters repeated in the atrophy of the bones of the wing, and the absence of the clavicles, as in the *Rhea*[1]. Like testimony is borne by the expansively developed *iliac* and *sacral* bones, by the broad *ischium* and slender *pubis*, and by the long and narrow form of the *pelvis*. We begin to observe a

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[1] In the *Ostrich* the clavicles are undoubtedly present though anchylosed with the *scapula* and *coracoids*, and separate from each other. In the *Cassowary* and *Emeu* they exist as separate short styliform bones.

deviation from the Struthious type in the length of the *femur*, and a tendency to the gallinaceous type in the shortness of the *metatarsal* segment: the development of the fourth or inner toe may be regarded as another deviation; but it should be remembered that in the size and position of the latter the *Apteryx* closely corresponds with the extinct Struthious *Dodo*. The claw on the inner toe of the *Apteryx* has been erroneously compared with the spur of certain *Gallinæ*, but it scarcely differs in form from the claws of the anterior toes.

In the broad ribs (see the *Cassowary*), in the general freedom of *anchylosis* in the dorsal region of the vertebral column, and the numerous *vertebræ* of the neck, we again meet with Struthious characters; and should it be objected to the latter particular, that some *Palmipeds* surpass the *Ostrich* in the number of cervical *vertebræ*, yet these stand out rather as exceptions in their particular order; while an excess over the average number of cervical *vertebræ* in birds is constant in the *Struthious* or *Brevipennate* group. Thus in the *Cassowary* 19 *vertebræ* precede that which supports a rib connected with the *sternum*, and of these 19 we may fairly reckon 16 as analogous to the cervical *vertebræ* in other birds. In the *Rhea* there are also 16 *cervical vertebræ*, and not 14, as Cuvier states. In the *Ostrich* there are 18, in the *Emeu* 19 cervical *vertebræ*. In the *Apteryx* we should reckon 16 cervical *vertebræ* if we included that which supports the short rudimental but moveable pair of ribs. Of the 22 true grallatorial birds cited in Cuvier's Table of the number of Vertebræ, only 9 have more than 14 cervical *vertebræ*; while the *Apteryx* with 15 cervical *vertebræ*, considered as a Struthious bird, has the fewest of its order. Its neck is relatively shorter, in correspondence with the shorter legs; the *Cassowary*, among the *Struthionidæ*, comes nearest to the *Apteryx* in these proportions.

The free bony appendages of the ribs, and the universal absence of air-cells in the skeleton, are conditions in which the *Apteryx* resembles the *Aptenodytes*, but here all resemblance ceases: the position in which the *Apteryx* was originally figured[1] is incompatible with its organization.

The modifications of the skull of the *Apteryx*, in conformity with the structure of the beak requisite for obtaining its appropriate food, are undoubtedly extreme; yet we perceive in the *cere* which covers the base of the bill in the entire *Apteryx* a structure which exists in all the Struthious birds; and the anterior position of the nostrils in the subattenuated beak of the *Cassowary* is an evident approach to that very singular one which peculiarly characterizes the *Apteryx*. With regard to the digestive organs, it is interesting to remark, that, with the exception of the *Ostrich*, the thickened muscular *parietes* of the stomach of the granivorous Struthious birds do not exhibit that apparatus of distinct *musculi digastrici* and *laterales* which forms the characteristic structure of the gizzard of the gallinaceous order: thus the *Apteryx*, in the form and structure of its stomach, adheres to the Struthious type. It differs again in a marked degree from the

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[1] Shaw's Miscellany, xxiv. pl. 1075.

Gallinæ in the absence of a crop. With respect to the *cæcal* appendages of the intestine, though generally long in the *Gallinæ*, they are subject to great variety in both the Struthious and Grallatorial orders: their extreme length and complicated structure in the *Ostrich* and *Rhea* form a peculiarity only met with in these birds. In the *Cassowary*, on the other hand, the *cæca* are described by the French academicians as entirely absent. Cuvier[1] speaks of " un cæcum unique " in the *Emeu*. In my dissections of these Struthious birds I have always found the two normal *cæca* present, but small; in the *Emeu* measuring from three to five inches long, and half an inch in diameter[2]; in the *Cassowary* measuring about four inches in length. The presence of two moderately developed *cæca* in the *Apteryx* affords therefore no indication of its recession from the Struthious type: these *cæca* correspond in their condition, as they do in the other Struthious birds, with the nature of the nutriment of the species. It is dependent on this circumstance also, that in the grallatorial bird (*Ibis*), which the *Apteryx* most resembles in the structure of its beak, and consequently in the nature of its food, the *cæca* have nearly the same relative size; but as regards the *Grallæ*, taken as an order, no one condition of the *cæca* can be predicated as characteristic of them. In most they are very small; in many single.

What evidence, it may next be asked, does the generative system afford of the affinities of the *Apteryx*? A single, well-developed, inferiorly grooved, subspiral intromittent organ attests unequivocally its relations to the Struthious group; and this structure, with the modifications of the plumage of the respiratory organs and of the skeleton, lead to the same conclusion as that at which Mr. Yarrell[3] and myself had arrived[4], from a study of the external organization of the *Apteryx*, viz. that it must rank as a genus of the cursorial or Struthious order. In deviating from the type of this order the *Apteryx* manifests a tendency in the structure of the feet to the *Gallinæ*, and in the form of the beak to the *Grallæ*; but it cannot, without violation of its natural affinities, be classed with either.

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[1] *Leçons d'Anat. Comp.* 1836. iv. p. 291.

[2] The accurate Fremery speaks of " *cæca intestina* duos pollices tantum longa, dimidium lata," in the *Emeu* dissected by him, loc. cit. p. 76.

[3] Loc. cit., p. 72.

[4] Art. *Aves*, Cycl. of Anat. and Phys., i. 1836, p. 269.

1849 Trans Zool Soc. Lond 3: 277–301

MUSCULAR SYSTEM.

THE former part of this memoir on the Anatomy of the *Apteryx australis** includes the description of the osteology and splanchnology, with the male organs of generation; the present part is devoted to the illustration of the myology of the same rare and anomalous bird. The specimens which I have dissected for that purpose were afforded me by the Earl of Derby, President, and by Mr. George Bennett, F.L.S., of Sydney, Corresponding Member of the Zoological Society, to whom I am much indebted for such valuable opportunities of completing this monograph on the Apteryx.

The muscular system offers a subject of peculiar interest to the Comparative Anatomist when studied in a species which, in its general proportions and habits of life, deviates in so extreme a degree from the rest of the circumscribed and well-marked class to which it belongs. It is also a department of the anatomy of birds which, from the minute attention and length of time required for its accurate investigation, has been commonly passed over in anatomical monographs of species, but which the rarity of the *Apteryx* and the excellent state of preservation of the specimens dissected have both stimulated and enabled me to pursue with a degree of care which will be found, I trust, if tested by subsequent dissection, to have left little to be added to the myology of the species.

In the application of the facts detailed to the higher generalizations of the philosophy of organized bodies, it will be found that the unity of the ornithic type is strictly preserved, though under the extremest modifications; the characteristic peculiarities, for example, of the muscles of the spine and those of the wing, are all present, but the proportionate development of these classes of muscles is reversed, the spinal muscles being at their maximum, the alar muscles at their minimum of development. Very interesting peculiarities are likewise manifested by the muscles of the skin, with which I propose to introduce the details of the muscular system of the small Struthious bird of New Zealand.

Muscles of the Skin.

No detailed description of the muscles of the skin in Birds has been given either in the systematic works on Comparative Anatomy, or in particular treatises; these muscles appear indeed in general to be too irregularly or too feebly developed to have attracted

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* Transactions of the Zoological Society, Vol. II. Part 4, p. 257.

much attention: brief notices are recorded of some peculiarly developed cutaneous, or rather cuticular, muscles, as those which spread the plumes of the Peacock, erect the hackles of the Cock, and make each individual feather stand on end in the web-footed birds*; the compressors of the subcutaneous air-cells are noticed in the anatomical account of the Gannett (*Sula Bassana*†); and a more constant cutaneous muscle, viz. that which supports the crop in Gallinaceous birds, is briefly mentioned and figured by Hunter‡.

In the *Apteryx*, however, the true cutaneous system of muscles presents a more distinct and extensive development than has hitherto been met with in the class of Birds —a condition which is evidently connected with the peculiar thickness of the integument, and probably with the burrowing habits of this species, which thereby possesses the power of shaking off the loose earth from its plumage, while busy in the act of excavating its chamber of retreat and nidification.

Constrictor colli (Pl. X. XIII. *a*).—The whole of the neck is surrounded by a thin stratum of muscular fibres, directed for the most part transversely, and extending from an attachment along the median line of the skin at the back of the neck, to a parallel *raphe* on the median line of the opposite side: this muscle is strongest at its commencement or anterior part, where the fibres take their origin in a broad fasciculus from the outer part of the occipital ridge; these run obliquely downwards and forwards on each side of the neck, but are continued uninterruptedly with those arising from the dorsal line of the skin above mentioned; the direction of the fibres insensibly changing from the oblique to the transverse. The outer surface of this muscle is attached to the integument by a thin and dense layer of cellular tissue, devoid of fat; the under surface is more loosely connected with the subjacent parts by a more abundant and finer cellular tissue.

Use.—To brace the cervical integument, raise the neck feathers, and in combination with the following muscle to shake these parts.

Sterno-cervicalis (Pl. X. *b*).—*Origin.* Fleshy, from the posterior incurved angular process of the sternum, from the ensiform prolongation and middle line of the outer and posterior surface of the same bone. *Insertion.* The fibres pass forward, and, diverging in gently curved lines, ascend upon the sides of the broad base of the neck, and are inserted by a thin but strong fascia into the median line of the dorsal integument. This muscle is a line in thickness at its origin, but becomes thinner as it expands; the anterior part is covered by the posterior fibres of the *constrictor colli*.

Use.—To retract the skin of the neck, and brace that portion which covers the base of the neck; when these are the fixed points, it will depress and protract the sternum, and thus aid in inspiration.

Obs.—In its position and the general course of the fibres, this muscle is analogous to

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* Nitzsch, art. *Dermorhynchi*, Ersch und Grüber's Encyclopedie.

† Proceedings of the Zoological Society, 1832, p. 91.

‡ In description of pl. 10, vol. i. of Physiological Catalogue of Hunterian Collection, 4to. 1833–1841.

that which supports and assists in emptying the crop in the common Fowl; but the œsophagus presents no partial dilatation in the *Apteryx*, and the situation of the crop is occupied by a large mass of fat enclosing one or two absorbent glands (Pl. XIII. *a'*).

Sterno-maxillaris (Pl. XIII. *c*).—This muscle appears at first view to be the anterior continuation of the preceding, but is sufficiently distinct to merit a separate description and name. *Origin.* Fleshy; from the anterior part of the middle line of the sternum. *Insertion.* It passes directly forwards along the under or anterior part of the neck, expanding as it proceeds, and gradually separating into two thin symmetrical fasciculi, which are insensibly lost in the integument covering the throat and the angle of the jaw. It adheres pretty closely to the central surface of the *constrictor colli*, along which it passes to its insertion.

Use.—To retract the fore-part of the skin of the neck, and also the head. Each lateral portion acting alone would incline the head to its own side: the whole muscle in action would bend the neck; but the movements of the head and neck are more adequately and immediately provided for by the appropriate deeper-seated muscles, and the immediate office of the present muscle is obviously connected with the skin. Nevertheless, in so far as this muscle acts upon the head, it produces the same movements as the *sterno-mastoideus* in Mammalia; and it is interesting to observe, that in the long-necked Ruminants (as the Giraffe) the sterno-mastoid muscles arise by a common origin, and the insertion is by an extended fascia into the angles of the jaw: I consider, therefore, that the *sterno-mastoideus* is represented by the *sterno-maxillaris* in the *Apteryx*.

Dermo-transversalis (Pl. XIII. *d*).—The skin covering the dorsal aspect of the lower two-thirds of the neck, besides being acted upon by the *constrictor colli*, is braced down by a thin stratum of oblique and somewhat scattered fibres, which take their origins by fasciæ attached to the inferior transverse processes of the sixth to the twelfth cervical vertebræ inclusive; the fibres pass obliquely upwards and backwards, and are inserted by a thin fascia into the median line of the skin, covering the back of the neck.

Platysma myoides (Pl. X. *e*).—The representative of this cutaneous muscle is a thin triangular layer of muscular fibres, taking their origin from the outer side of the ramus of the jaw, and diverging as they descend to spread over the throat, and meeting their fellows at a middle *raphe* of insertion beneath the upper larynx and beginning of the trachea, which they thus serve to compress and support.

Dermo-spinalis (Pl. X. *f*).—*Origin.* By a thin fascia from the ends of the spinous processes of the three anterior dorsal vertebræ. *Ins.* The fibres slightly converge to be attached to the integument covering the scapular region.

Dermo-iliacus (Pl. X. *g*).—*Origin.* Fleshy, from the anterior margin of the ilium. *Ins.* The fibres pass forwards and slightly converge to be inserted into the scapular integument.

Dermo-costalis (Pl. X. *h*).—A muscle resembling the preceding in form. *Origin.* Fleshy, from the costal appendages of the seventh and eighth ribs. *Ins.* The fibres pass forwards and join those of the preceding muscle, to be inserted into the scapular integument.

Obs. The three preceding muscles are broad and thin, but well-defined; they would appear to influence the movements of the rudimentary spur-armed wing through the medium of the integument, as powerfully as do the rudimental representatives of the true muscles of that extremity.

There are also two muscles belonging to the cutaneous series, and inserted directly into the bones of the wing. One of these, the *Dermo-ulnaris* (Pl. X. *i*) is a small, slender, elongated muscle, which takes its origin from the fascia beneath the *dermo-costalis*; its fibres pass backwards, and converge to terminate in a very slender tendon which expands into a fascia, covering the back part of the elbow-joint.

Use.—To extend the elbow-joint and raise the wing.

The *Dermo-humeralis* (Pl. X. *k*) is also a long and narrow strip, deriving its origin from scattered tendinous threads in the subcutaneous cellular tissue of the abdomen: it passes upwards, outwards and forwards, and is inserted fleshy into the proximal part of the humerus, which it serves to depress*.

MUSCLES OF THE TRUNK.

A. On the Dorsal Aspect.

The muscles on the dorsal aspect of the vertebral column in Birds have only of late years received any attention from Comparative Anatomists: they have been mentioned rather than described by Tiedemann and Meckel: Carus has given a side-view of the superficial layer of muscles in the Sparrow-hawk; their best description is contained in the second edition of the 'Leçons d'Anatomie Comparée' of Cuvier.

The muscles of the back are in general so feebly developed in birds of flight, that they were affirmed by Cuvier to be wanting altogether in the first edition of the 'Leçons:' and this is almost true as respects their carneous portion, for they are chiefly tendinous in birds of flight. In the Struthious birds, and in the Penguin, in which the dorsal vertebræ are unfettered in their movements by anchylosis, these muscles are more fleshy and conspicuous; but they attain their greatest relative size and distinctness in the *Apteryx*.

From the very small size of the muscles which pass from the spine to the scapula and

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* In Mammalia the cutaneous muscles form a more continuous stratum than in the *Apteryx* and other birds, and hence have been grouped together under the common term *panniculus carnosus*; they have also, in general, both their origins and insertions in the integument; but in Birds, in which the integument supports so extraordinary an abundance of the epidermic material under the form of feathers, the muscles destined to its especial motions require a more fixed attachment from which to act. The Rhinoceros, in which the integuments, from the thickness and density of the corium, are in a similar condition as regards the resistance to be overcome by the skin-muscles, presents an analogous condition of its *panniculus carnosus*, having it divided into several distinct muscles, most of which take their origin from bone or fasciæ attached to bone.

humerus in the *Apteryx*, the true muscles of the back, which correspond to the second layer of the dorsal muscles in Man, become immediately visible on removing the dorsal integuments and fasciæ; they consist of the *sacro-lumbalis*, *longissimus dorsi*, and *spinalis dorsi*. The first two muscles are blended together at their posterior origins, but soon assume the disposition characteristic of each as they advance forwards.

The *sacro-lumbalis* (Pl. XI. XII. *l*) is a strong and fleshy muscle, six lines in breadth, and three or four lines in thickness: it is, as usual, the most external or lateral of the muscles of the back, and extends from the anterior border of the ilium to the penultimate cervical vertebra. *Origin.* By short tendinous and carneous fibres from the outer half of the anterior margin of the ilium, and by a succession of long, strong, and flattened tendons (Pl. XII. *l* 1–*l* 5) from the angles of the fifth and fourth ribs, and from the extremities of the transverse processes of the third, second, and first dorsal vertebræ; also by a shorter tendon (*l* 6) from the transverse process of the last cervical vertebra; these latter origins represent the *musculi accessorii ad sacro-lumbalem*; to bring them into view, the external margin of the *sacro-lumbalis* must be raised, as in Pl. XII. fig. 2. These accessory tendons run obliquely forward, expanding as they proceed, and are lost in the under surface of the muscle.

Insertion. By a fleshy fasciculus with very short tendinous fibres into the angle of the sixth rib, and by a series of corresponding fasciculi, which become progressively longer and more tendinous, into the angles of the fifth, fourth, third and second ribs (Pl. XI. *l**), and into the lower transverse processes of the first dorsal and last two cervical vertebræ: the last insertion is fleshy and strong; the four anterior of these insertions are concealed by the upper and outer fleshy portions of the *sacro-lumbalis*, which divides into five elongated fleshy bundles (Pl. XI. *l***), inserted successively into the upper transverse processes of the first three dorsal and last two cervical vertebræ. These last insertions seem to represent the continuation of the *sacro-lumbalis* in Man, which is termed the *cervicalis descendens* or *ascendens*.

Longissimus dorsi (Pl. XI. XII. *m*).—This muscle is blended posteriorly both with the *sacro-lumbalis* and the *multifidus spinæ*, and anteriorly with the outer portion of the *spinalis dorsi*. It extends as far forward as the thirteenth cervical vertebræ. *Origin.* From the inner or mesial half of the anterior margin of the ilium; from a strong aponeurosis attached to the spines of the eighth, seventh and sixth dorsal vertebræ; and from the transverse processes of the sixth, fifth, fourth and third dorsal vertebræ. *Ins.* The carneous fibres continued from the second origin, or series of origins from the spinous processes, incline slightly outward as they pass forward, and are inserted into the posterior articular processes of the first three dorsal vertebræ, receiving accessory fibres from the *spinalis dorsi*. The fasciculi from the transverse processes incline inwards, and are also inserted into the posterior oblique processes of the vertebræ anterior to them; they receive fibres from the iliac origin, and soon begin to form a series of oblique carneous fasciculi, which become more distinct as they are situated more anteriorly; they are at first implanted in the vertebra next in front of that from which they rise, and then into the vertebra next but one in front (m^*) : the most anterior of these tendons of insertions, to which can be traced any of the fibres of the main body of the *longissimus dorsi* (reflected back in Pl. XII. fig. 1, *m*) is that which is implanted into the thirteenth cervical vertebra (m^{**}) ; it is this fasciculus which is joined by the first or most posterior of the *fasciculi obliqui* of the *longus colli posticus* (*o* 1) which is detached and reflected upwards in fig. 1. Pl. XII.

Obliquus colli (Pl. XI. XII. *m* 1—9).—A series of oblique carneous fasciculi, evidently a continuation of, or part of the same system with those in which the *longissimus dorsi* terminates anteriorly, is continued between the upper transverse process of one cervical vertebra to the posterior oblique processes of the next vertebra but one in advance, as far forward as the fourth cervical vertebra. This series of muscles seems to represent the *transversalis colli*†, which is the anterior continuation of the *longissimus dorsi* in Mammalia, but it differs in being inserted into the oblique, instead of the transverse processes. In the direction of their fibres these fasciculi resemble the *semispinalis colli*, but they are inserted into the oblique processes instead of the spines of the vertebræ. There are no other muscles with which they can be compared in the Mammalia than these two, with neither of which, however, do they precisely correspond ; they seem clearly to represent the second series of oblique muscular fasciculi in the trunk of Fishes, but to avoid the expression of an incomplete or false analogy, I shall term them collectively the *fasciculi obliqui*.

The *fasciculi obliqui* which rise from the first two dorsal and five lower cervical vertebræ are joined near their tendinous terminations by corresponding oblique fasciculi (*o* 1—8) of the *longus colli posticus*, and the strong round tendons continued from the points of convergence of these fascicles are inserted successively into the posterior oblique processes of the twelfth to the sixth cervical vertebra inclusive ; the two fasciculi next in succession receive no accessory fibres from the *longus colli posticus* ; the anterior one (*m* 9) derives an extensive origin from the upper transverse processes of the eighth, seventh, and sixth cervical vertebræ. It must be observed, however, that the whole of each fasciculus is not expended in the strong round tendinous insertion above described ; the portion (m^*, fig. 1. Pl. XII.), which arises from the anterior ridge of the transverse process, passes more directly inwards than the rest, and is attached to the tendon which terminates the fasciculus immediately behind ; at the middle of the neck these accessory fibres approach to the character of distinct origins. The tendons of insertion, moreover, severally receive accessory fleshy fibres (*n n*, fig. 1. Pl. XII.) from the base of the oblique

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† It is the '*grand transversaire*' of Cuvier, *loc. cit.* p. 282 ; but he describes it as passing from the anterior articular process of one vertebra to the posterior articular process of the next in front. Meckel, who calls this muscle '*intertransversalis cervicis*,' follows Cuvier in the description of its attachments, and adds, that it is a continuation of the outer division of the '*extensor communis dorsi*' (*sacro-lumbalis*). In the Apteryx it is plainly a continuation of the inner division or *longissimus dorsi*. See Vergleich. Anatomie, Th. 3. p. 294.

processes of the two vertebræ next behind; and thus they become the medium of muscular forces acting from not less than five distinct points, the power of which is augmented by each tendon being braced down by the oblique converging series of muscles immediately anterior to it. The fasciculus from the eighth cervical vertebra, besides its insertion by the ordinary tendon, sends off externally a small pyramidal bundle of muscular fibres (Pl. XI. *n**), which soon terminates in a long and slender tendon which is inserted into the oblique process of the third cervical vertebra. Corresponding portions of muscle (Pl. XI. & XII. *n***) are detached from the two anterior fasciculi, which converge and terminate in a common slender tendon inserted into the posterior oblique process of the fourth cervical vertebra; and thus terminates this complex muscle or series of muscles.

Longus colli posticus (Pl. XI. & XII. fig. 1. *o* 1—9).—The most internal or mesial of the superficial muscles of the dorsal aspect of the thoracic and cervical regions, called *cervicalis ascendens* by Meckel, and compared in part with the *spinalis dorsi* by Cuvier, cannot be the representative of either of these muscles, since they both (*l*** & *p*) co-exist separately with it in the *Apteryx*. At its posterior part the muscle in question seems to be rather a continuation of the *longissimus dorsi*; its mesial and anterior part offers a strong analogy with the *biventer cervicis*; it appears to me to be evidently the analogue of the first, or mesio-dorsal series of oblique fibres of the muscular system in Fishes, but I shall adopt the name of the *longus colli posticus* applied to it by Cuvier[†]. It commences by long and slender, but strong, subcompressed tendons from the spines of the sixth, fifth and fourth dorsal vertebræ (Pl. XII. *o*): these tendons gradually expand as they proceed forwards and downwards, and send off from their under surface muscular fibres which continue in the same course, and begin to be-grouped into distinct fasciculi at the base of the neck: the first of these bundles (*o* 1) joins the fasciculus of the *longissimus dorsi* (*m***), which is inserted into the posterior articular process of the thirteenth cervical vertebra; the succeeding fasciculi derive their origins from a broad and strong aponeurotic sheet attached to the spines of the fourth, third and second dorsal vertebræ: the second to the eighth fasciculi inclusive are compressed, broad and fleshy, and are inserted in the strong round tendons described in the preceding muscle, and attached to the oblique processes of the twelfth to the sixth cervical vertebræ inclusive: the ninth fasciculus (*o* 9), which forms the main anterior continuation of the *longus colli posticus*[‡], is larger than the rest, and receives, as it advances, accessory fibres from the spinous processes of the seventh (o^{x}) to the third cervical vertebræ inclusive, and is inserted, partly fleshy, partly by a strong tendon, into the side of the broad spine of the *vertebra dentata*. A slender fasciculus is detached from the mesial and dorsal margin of the *longus colli posticus*, near the base of the neck, which soon terminates in a long round tendon (o^{xx}): this tendon is braced down by short aponeurotic fibres to the spine of the fifth, fourth, third and

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[†] Leçons d'Anat. Comp., 2nd edit. vol. i. p. 284.

[‡] '*Accessoires du long postérieur du cou,*' Cuvier, *loc. cit.* p. 284.

second cervical vertebræ inclusive, immediately beyond which it again becomes fleshy, and expands to be inserted into the occipital ridge: this portion is the *digastrique* or *biventer capitis* of Cuvier.

Spinalis dorsi (Pl. XII. fig. 1. *p*).—The displacement of the dorsal portion of the preceding muscle and the *longissimus dorsi* brings into view the *spinalis dorsi*, which is a well-developed and distinct muscle in the *Apteryx*. *Origin.* By two long, narrow, flattened tendons (*p*, 1 & 2.) from the spines of the eighth and seventh dorsal vertebræ: these pass obliquely downwards and forwards, expanding as they proceed, and terminate in two fasciculi of muscular fibres: the posterior bundle passes forwards beneath the anterior one, and inclining inwards and upwards, divides into two portions, inserted by long tendons into the spines of the second and first dorsal vertebræ (*p* 1*) ; it then sends a few fibres forwards to join the outer and anterior fasciculus, which is partly inserted by a slender tendon into the spine of the last cervical vertebra: the rest of the fibres of the second fasciculus join the portion of the *longissimus dorsi* (*m*) which is implanted into the posterior oblique process of the last cervical vertebra. The three inserted tendons of the *spinalis dorsi* are also the medium of attachment of fibres continued from the *multifidus spinæ*, beneath them.

Multifidus spinæ (Pl. XII. fig. 1. *q*).—The series of muscles so called arises by fleshy fibres from the transverse processes of the five last dorsal vertebræ, which pass upwards, forwards and inwards, to be inserted by four flat tendons into the spines of the seventh to the third dorsal vertebræ inclusive, and by the tendons of the *spinalis dorsi* into the two anterior dorsal spines.

Obliquo-spinales (Pl. XII. fig. 3. *r*).—The removal of the *multifidus spinæ* brings into view a series of long, narrow, flat tendons, coming off from the spines of all the dorsal vertebræ, and slightly expanding as they proceed forwards and obliquely downwards and outwards; they become fleshy half-way from their origin, and are inserted into the posterior oblique and transverse processes of the six anterior dorsal vertebræ, and into the posterior oblique processes of the three last cervical vertebræ.

Interspinales (Pl. XII. fig. 3. *s*).—The *interspinales* muscles do not exist in the region of the back, unless we regard the preceding oblique fibres as a modified representation of them. The most posterior fasciculus of muscular fibres, which is directly extended between the spinous processes, commences at the interspace of the spines of the two last cervical vertebræ, and the series is continued as far as the *vertebra dentata*.

Interarticulares (Pl. XII. fig. 3. *t*).—The muscles which form the more direct continuation of the *obliquo-spinales* are continued from the posterior oblique or articular processes of one vertebra to the posterior articular process of the next in front.

Obliquo-transversales (Pl. XII. fig. 3. *v*).—A third series of deep-seated intervertebral muscles is situated external to the preceding, and passes obliquely between the upper transverse process and the posterior articular process of the vertebra in front. These fasciculi appear to be a continuation of the *multifidus spinæ* in the neck.

Intertransversales (Pl. XII. fig. 3. *w*).—These are two series of short carneous fasciculi passing the one between the upper, and the other between the lower transverse processes.

Levatores costarum (Pl. XII. fig. 3. *x*).—The first or most anterior of this series of muscles seems to represent the *scalenus medius* (*x**) ; it arises from both the upper and lower transverse processes of the last cervical vertebra, and expands to be inserted into the first rib, and into the upper and outer part of the second rib. The remaining *levatores* successively diminish in size as they are placed backwards ; they come off from the transverse processes of the first six dorsal vertebræ ; those from the first and second expand to be inserted into the rib attached to the same transverse process and to the one next behind ; the rest have a single insertion : the angle and the part of the rib immediately beneath are the situations of their attachments.

Complexus (Pl. XI. XIII. fig. 1. *y*).—This strong triangular fleshy muscle arises from the articular and upper transverse processes of the fourth, third and second cervical vertebræ, and gradually expands as it advances forwards to be inserted into the occipital ridge, from the outer side of the insertion of the *biventer cervicis* to the mastoid process.

Recti capitis postici.—These small muscles are concealed by the preceding ; they rise successively from the spines of the third, second and first cervical vertebræ, and expand as they advance to be inserted into the occiput.

Trachelo-mastoideus (Pl. XIII. fig. 1. *z*).—This strong, subdepressed carneous muscle arises from the upper transverse processes of the fifth, fourth, third and second cervical vertebræ, and is inserted into the side of the base of the occiput.

B. In Front of the Neck.

Longus colli (Pl. XIII. fig. 2. & XIV. *a*).—This large and long muscle, which appears simple when first exposed, as in Pl. XIII. fig. 2, is found to consist, when unravelled by further dissection, of a series of closely succeeding long, narrow fasciculi, arising from the hæmapophyses of the sixth dorsal to the first dorsal and from the ten posterior cervical vertebræ (Pl. XIV. *a a*) ; and sending narrow tendons (*ib. a**) which increase in length as they are given off more anteriorly, obliquely forwards and outwards, to be inserted into the costal processes of all the cervical vertebræ save the first two : the highest or foremost tendon (*ib. a***) is attached to the tubercle at the under part of the ring of the atlas ; but this tendon is also the medium of insertion of five small fasciculi of muscular fibres (Pl. XIV. fig. 2. *a***) arising from the upper transverse processes of the sixth, fifth, fourth, third and second cervical vertebræ.

The *Rectus capitis anticus major* (Pl. XIV. *b*) is continued, or arises by as many distinct tendons, from the five superior tendons of insertion of the preceding muscle ; these origins soon become fleshy, converge, and coalesce previous to their insertion into the base of the skull.

The *Rectus capitis anticus minor* (Pl. XIV. *c*) is a strong fleshy compressed triangular muscle arising from the anterior part of the body of the first four cervical vertebræ. *Ins.* Base of occiput.

The *Rectus capitis lateralis* (Pl. XI. XIV. *d*) arises from the upper transverse processes of the sixth to the second cervical vertebra inclusive. *Ins.* Side of the base of the skull.

C. *Muscles of the Tail.*

Levator caudæ.—Origin. From the posterior and superior extremity of the ischium. *Ins.* Into the spines of the caudal vertebræ.

Adductor caudæ superior.—This muscle is smaller than the preceding, with which it runs parallel; it rises below from the posterior extremity or tuber of the ischium, and is inserted into the transverse processes of the caudal vertebræ.

Adductor caudæ inferior.—Origin. From the tuber ischii, and the ligament connecting this with the posterior extremity of the pubis. *Ins.* Into the transverse processes of the caudal vertebræ.

Depressor caudæ.—Origin. From the under part of the middle line of pelvis. *Ins.* Into the inferior spines of the caudal vertebræ.

D. *Muscles of the Abdomen.*

Obliquus externus abdominis (Pl. XI. XIV. *e*).—*Origin.* Fleshy, from the second and third ribs, and by a strong aponeurosis from the succeeding ribs near the attachment of the costal processes, and from those processes. *Ins.* The fleshy fibres are continued from this aponeurotic origin to nearly opposite the ends of the vertebral ribs; they run almost transversely, very slightly inclined towards the pubis, to within half an inch of the linea alba, and there terminate, by an almost straight, parallel line, in their aponeurosis of insertion. The fibres of this aponeurosis decussate those of the opposite side, and adhere to the tendinous intersections of the *rectus* beneath. The aponeurosis from the last rib passes to be inserted into a strong ligament extending between the free extremities of the *ossa pubis,* leaving the abdomen behind the last rib, defended only by the *internal oblique* and *transversalis.*

Obliquus internus abdominis (Pl. XIV. *f*).—*Origin.* From the whole of the anterior and outer surface of the pubis; aponeurotic from the upper part, fleshy for half an inch from the lower or ventral extremity: the carneous fibres run longitudinally, and cannot be distinctly defined from the *intercostales* on their outer border, or from the *rectus abdominis* on their inner or mesial border, which forms the medium of the insertion of the internal oblique.

Rectus abdominis (Pl. XIV. *g*).—I give this name to the mesial continuation of the preceding muscle, which arises by a strong, flat, triangular tendon (*g*) from the lower or ventral extremity of the pubis and from the inter-pubic ligament: it soon becomes fleshy; the carneous portion is interrupted by three broad, oblique, but distinct aponeurotic intersections (g*), and is finally inserted into the xiphoid and lateral processes of the sternum and the intervening fascia.

Transversalis abdominis.—A layer of loose, dark-coloured cellular tissue divides the internal oblique from the transverse abdominal, except at its origin from the pubis, and for half an inch anterior to that part.

The *transversalis* then proceeds to derive carneous fibres from the inner surface of the vertebral ribs near their lower third; they pass obliquely upwards and forwards, and terminate by a regular, slightly concave line midway between their origins and the extremities of the ribs; a strong aponeurosis passes thence to the linea alba, but becomes thin at the pubic region, where a mass of fat is interposed between it and the peritoneum.

Diaphragm (Pl. VI.).—This muscle presents more of its normal mammalian character in this than in any other known bird. It is perforated by vessels only, in consequence of the non-development of the abdominal air-cells. The origin corresponding to that of the lesser muscle in Mammalia is by two strong and distinct, short tendinous pillars (*a a*), from the sides of the body of the last costal vertebra; they are united by a strong tendon or fascia, forming the anterior boundary of the aortic passage. The tendinous pillars may be traced forward for some way in the central aponeurosis, expanding without crossing; they are then lost in that aponeurosis, which is perforated by the gastric arteries and veins; decussates and divides anteriorly (at *b*) to give passage to the gullet and the apex of the heart; the aponeurosis expands over the anterior part of the thoracic air-cells, and becomes, at its lateral circumference, the point of attachment of muscular fibres arising from the inner surface of the anterior ribs, and forming apparently a continuation of the *transversalis abdominis*.

Appendico-costales (Pl. XI. *h*).—*Origin.* From the posterior edge and extremity of the costal processes or appendages. *Ins.* They run down to be inserted severally into the rib posterior to that to which the process affording them origin is attached. These processes are supported by strong triangular aponeuroses continued from their anterior and upper margins, severally, to the rib anterior to them.

The muscles of the jaws have already been described in the account of the digestive organs. The following are shown in Pl. XI.: α, *temporalis externus*; β, *temporalis internus*; γ, *biventer maxillæ*; the masseter has been removed, but is shown at η, Pl. XIII. fig. 1. The internal pterygoid muscle is shown in Pl. XIV. at ϵ; the external pterygoid at ζ.

Some of the muscles of the tongue, which are described in the first part of this memoir (p. 8), are delineated in Plate XIII. fig. 1.

The strong *orbicularis palpebrarum* has been divided and reflected forwards at δ, Pl. XI.; it is shown *in situ* at fig. 1. Pl. XIII.

MUSCLES OF THE ANTERIOR EXTREMITY.

Serratus magnus anticus (Pl. XI. XIII. *i*).—This muscle consists of three portions; the first and anterior portion (Pl. XIII. fig. 2. *i*) arises by a short, strong aponeurosis from the last cervical rib, and is inserted into the lower edge of the anterior two-thirds of the scapula: the second and middle portion arises from the lower end of the second vertebral rib, near the attachment of the costal process, and from the anterior margin of the same rib, and is inserted into the lower edge of the posterior two-thirds of the scapula: the third, posterior and smallest portion (Pl. XI. *i*) rises from the costal process of the third rib, and ascends to be inserted into the posterior extremity of the scapula.

This muscle is a direct inspirator: by drawing down the scapula it depresses the sternum through the medium of the strong coracoideum, increases the angle between the vertebral and sternal ribs, and dilates the thoracic air-cells.

Levator scapulæ (Pl. XI. XIII. *k*).—This seems to be the most anterior portion of the series of muscles which constitute the *serratus magnus*. *Origin.* Two flat fleshy strips from the inferior transverse and costal processes of the last and penultimate cervical vertebræ. *Ins.* Into the inner and upper side of the middle third of the scapula. It depresses as well as draws forwards the scapula, and thus aids the *serratus* in the action of inspiration.

Serratus anticus minor.—*Origin.* From the outer part of the costal process of the sternum. *Ins.* Into the posterior part of the base of the coracoideum.

Trapezius (Pl. XIII. *l*).—This flattened oblong quadrilateral muscle arises from the fascia, extending upon the back from the spinous processes of the posterior cervical vertebræ, and is inserted into the conjoined extremities of the scapula and coracoideum.

There is no representative of the *rhomboidei*.

Latissimus dorsi (Pl. XIII. *m*).—This muscle consists, as usual in Birds, of two portions, both of which have their origin from a continuation of the fascia, attached to the spinous processes, which gives attachment to the trapezius: the fibres of the smaller and anterior strip converge to their insertion: the fibres of the posterior and broader strip are slightly twisted, the posterior edge being folded inwards as they also converge to join the preceding, and to be inserted with it into the posterior and inner side of the proximal extremity of the humerus.

Deltoides (Pl. X. XIII. *n*).—This is a single long and narrow triangular muscle, of which the base is attached to the conjoined extremities of the scapula and coracoid, and to the capsule of the shoulder-joint; the apical insertion is into the upper and outer third of the humerus, which this muscle directly raises.

Infraspinatus (Pl. XI. *o'*).—A muscle which may be compared either to the *infraspinatus* or *teres major* comes off from the lower margin of the anterior two-thirds of the scapula, passes behind the shoulder-joint, where it is closely attached to the capsule, and is inserted into the inner and posterior part of the proximal end of the humerus.

Musculi pectorales.—The pectoral muscles, which present their feeblest condition and lowest development in the *Apteryx*, are nevertheless similar in number and arrangement to those which in some birds of flight are known to outweigh all the other muscles of the body.

The *pectoralis major* (Pl. X. XI. XIII. XIV. *p*) is represented by two very thin triangular layers of muscular fibres, the anterior of which is three lines broad at its base, and is attached to the sternum immediately exterior to the perforation of that bone: the second, posterior, and somewhat narrower portion, rises immediately behind the preceding, from the osseous bridge separating the perforation from the notch; the two portions converge as they extend upwards and outwards to unite and be inserted into the anterior and internal surface of the proximal third of the humerus.

The *pectoralis medius seu secundus* (Pl. XI. XIV. *q*) is a similar, thin, feeble, but broader triangular layer of carneous fibres, which arise anterior to the preceding, just below the coracoid socket of the sternum, and converge as they wind over the shoulder-joint to be inserted into the upper surface of the proximal extremity of the humerus, of which they thus become an elevator.

The *pectoralis minor seu tertius* (Pl. XI. XIV. *r*) arises above and between the origins of the *pectoralis secundus* and the anterior strip of the *pectoralis major*, also partly from the coracoid process; its fibres converge to be inserted into the proximal end of the humerus, above and behind the *pectoralis major*.

Coraco-brachialis (Pl. XIV. *s*).—This is represented by two small strips of muscular fibres which rise from the posterior part of the coracoideum, and are inserted, one directly below the other, into the proximal third of the humerus.

Obs.—The close adherence to the ornithic type of the muscular system of the anterior extremity in the *Apteryx* is more especially remarkable as regards the position and course of the *pectoralis medius*, since the physiological conditions of the circumstances attending that muscle are wanting in the *Apteryx*.

Here we have a true bird, exhibiting a remarkable modification of the whole ornithic structure, in reference to exclusively terrestrial life and nocturnal habits; and we learn, from this adherence to a typical organization, in a very rare exception, that the teleological conclusions respecting that typical construction, as it is manifested in the general rule, are in no ways affected by such an exception; because the modification of one part necessarily affects that of many others, perhaps of the whole body. If, for example, the fixation and structure of the lungs require a broad sternum and concomitant modifications of the coracoid and scapula for the mechanical part of the respiratory process, then it may be more convenient for the levator of the humerus to rise below that bone from the sternum, and act in the due direction by a modification of its course; although the locomotion of the bird may in no way be facilitated by the aggregation of muscular substance beneath the centre of gravity, nor the size of the levator be such as to render its particular position a matter of any consequence in regard to that centre.

A minute flexor (Pl. XIII. fig. 2. *t*), wanting the attachment to the scapula which exists in birds of flight, and arising solely from the humerus, glides along the front of that bone, chiefly as a delicate tendon to be attached to the inner part of the head of the ulna.

A single extensor (Pl. XIII. fig. 1. *v*), almost equally tendinous and delicate, arises from the scapula, and represents the 'long extensor' of Vicq. d'Azyr: it is inserted into the rudimental olecranon.

There is a tendinous trace of a flexor (*w*) and extensor (*x*) of the minute monodactyle manus: but the motions of the rudimental wing and its terminal hook would seem to be produced as much by the cutaneous muscles which converge to be inserted into the integument connected with it, as by the feeble representatives of the true wing-muscles above described.

Muscles of the Posterior Extremity.

The most superficial of the muscles on the outer side of the leg is that very broad one which combines the functions of the *tensor vaginæ* and *rectus femoris*, but which, in the opinion of both Cuvier* and Meckel†, is the homologue of the *tensor vaginæ* and *glutæus maximus* (*seu externus*); since however it is exclusively inserted into the leg, I shall describe it with the other muscles moving that segment of the posterior extremity. The removal of this muscle, of the *sartorius*, and the *biceps cruris*, is requisite to bring into view the true *glutæi*.

Glutæus externus (Pl. XI. A).—The external *glutæus* (*glutæus medius* of Meckel) is smaller, as in most Mammalia, than the middle *glutæus*, but is relatively larger in the *Apteryx* than in birds of flight, in which it is described as the *pyriformis* by Cuvier‡. This muscle, however, besides its origin from the outside of the pelvis, overlaps part of the *glutæus medius*, and has its insertion into the femur at some distance below the great trochanter, all of which are marked characteristics of the *glutæus magnus*. *Origin*. It takes its origin from the superior margin of the os innominatum, extends along an inch and a quarter of that margin, directly above the hip-joint, and is chiefly attached by distinct short tendinous threads, which run down upon the external surface of the muscle: it rises also by carneous fibres from the external surface of the os innominatum for three lines below the superior margin. *Insertion*. The fibres converge and pass into a tendinous sheet, beginning on the external surface of the muscle half-way down its course, which ends in a broad, flat, strong tendon, inserted into a rising on the outer side of the femur nearly an inch below the great trochanter. It abducts and raises the femur.

Glutæus medius (Pl. XI. B).—*Origin*. This is the large, triangular, strong and thick muscle, which has an origin of three inches' extent from the rounded anterior and superior margin of the ilium, and from the contiguous outer surface of the bone for an extent varying from an inch to eight lines. *Ins*. Its fibres converge to a strong, short, broad and flat tendon, implanted in the external depression of the great trochanter, having a bursa mucosa interposed between the tendon and the bony elevation anterior to the depression.

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* Leçons d'Anat. Comp. ed. 1836, tom. i. p. 502.

† Vergleich. Anat. 1828, Th. iii. p. 361.

‡ *Loc. cit.* p. 503; it is here called 'pyramidal.'

Glutæus minimus (Pl. XI. c).—*Origin.* It rises below and internal to the preceding muscle from the anterior and inferior extremity, and from one inch and three-fourths of the inferior and outer margin of the ilium, and contiguous external surface, as far as the origin of the *glutæus medius*; also by some fleshy fibres from the outside of the last rib. *Ins.* These fibres slightly converge as they pass backwards to terminate in a broad flat tendon which bends over the outer surface of the femur, to be inserted into the elevation anterior to the attachment of the *glutæus magnus.*

A muscle (Pl. XI. D.) which may be regarded either as a distinct accessory to, or a strip of the preceding one, arises immediately behind it from half an inch of the outer and inferior part of the ilium; its fibres run nearly parallel with those of the *glutæus minimus*, and terminate in a thin flat tendon, which similarly bends round the outer part of the femur, to be inserted into the outer and under part of the trochanter immediately below the tendon of the *glutæus medius.* This muscle and the preceding portion, or *glutæus minimus*, are described by Prof. Mayer* under the names of *Glutæus quartus* and *Glutæus quintus*, in the Cassowary; one of them is absent in most birds.

Use.—All the preceding muscles combine to draw the femur forwards, and to abduct and rotate it inwards.

Iliacus internus.—This is a somewhat short thick muscle, of a parallelogrammic form, fleshy throughout; rising from the tuberosity of the innominatum in front of the acetabulum immediately below the *glutæus minimus*, and inserted at a point corresponding to the inner trochanter, into the inner side of the femur near the head of that bone, which it thus adducts and rotates outwards. This muscle is present both in the Ostrich and Bustard, but Meckel† says it is wanting in the Cassowary.

Pyramidalis.—The same kind of modification which affects the *iliacus internus*, viz. the displacement of its origin from the inner surface of the ilium to a situation nearly external, affects this muscle, which, from its insertion and triangular form, I regard as the analogue of the *pyramidalis.* It arises fleshy from the outer surface of the ischium for the extent of an inch, and converges to a broad flat tendon which is inserted into the *trochanter femoris* opposite, but close to the tendon of the *glutæus minimus*, which it opposes, abducting and rotating the femur outwards.

Adductor brevis femoris (Pl. XI. E).—A small, long and slender muscle arises from the innominatum immediately behind the acetabulum, passes over the back part of the great trochanter, becomes partially tendinous, and is inserted into the back part of the femur in common with the following muscle.

Adductor longus (Pl. XI. XIV. F).—A long, broad and thin muscle, separated from the preceding by the ischiadic nerve and artery. The origin of this muscle extends one inch and a quarter from near the upper margin of the innominatum which is behind the acetabulum; it is joined by the preceding strip, and is inserted into the whole of the lower two-thirds of the back part of the femur.

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* Analekten fur Vergleich. Anatomie: 4to. 1839, p. 12.

† Arch. fur Physiol. xiii. 261.

Adductor magnus (Pl. XIV. G).—This broad and flat muscle has an extensive origin (two inches) from the outer edge of the ischium and the obturator fascia; its fibres slightly diverge as they pass downwards to be inserted into the back part of the lower half of the femur, and into the upper and back part of the tibia.

Obturator internus.—This arises from the inner side of the opposite margins of the pubis and ischium, where they form the posterior boundary of the *obturator foramen*, and from the corresponding part of the *obturator fascia*; the fleshy fibres converge in a slightly penniform manner to the strong round tendon which glides through the notch, separated from the rest of the foramen by a short, strong, transverse, unossified ligament, and is inserted into the posterior part of the base of the trochanter. In its length and size this muscle resembles the corresponding one in the Ostrich and other Struthious birds.

Gemellus.—This is represented by a single small fleshy strip arising from the margin of the *obturator foramen*, close to the emergence of the tendon of the *obturator internus*, with which it is joined, and co-inserted into the femur.

Quadratus.—I consider a broad fleshy muscle which arises from the pubis, below the *obturator foramen*, and which increases in breadth to be inserted into the femur internal and posterior to the obturator tendon, to be the true analogue of the *quadratus femoris*.

Tensor vaginæ and *Rectus femoris* (Pl. X. H).—The largest and most remarkable of the muscles which act upon the bones of the leg is that already alluded to as the most superficial of those on the outer side of the thigh. It has a broad, thin, triangular form, and arises from the spines of the sacrum by a strong but short aponeurosis which soon becomes fleshy; the carneous fibres converge as they descend*, and pass into a thin aponeurosis at the lower third of the thigh: this is closely attached to the muscles beneath (*vastus externus* and *cruræus*), then spreads over the outer and anterior part of the knee-joint, is inserted into the patella, and into the anterior process of the head of the tibia.

Owing to the great antero-posterior extent of the origin of this muscle, its anterior fibres are calculated to act as a flexor, its posterior ones as an extensor of the femur; all together combine to abduct the thigh and extend the leg, unless when this is in a state of extreme flexion, when a few of the posterior fibres glide behind the centre of motion of the knee-joint.

Sartorius (Pl. X. XIV. I).—The origin of this muscle is characterized by an unusual extension, like that of the preceding, with which it is posteriorly continuous: it comes off aponeurotic, from the anterior and superior margin or labrum of the ilium; the fibres soon become fleshy, and the muscle diminishes in breadth and increases in thickness as it descends: it is inserted by short and strong tendinous filaments obliquely into the

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* They are not divided into a superficial and deep layer, as in the Ostrich, but form a simple stratum, as in the Cassowary. Meckel regards the rectus as entirely wanting in the Cassowary, supposing, with Cuvier, the present muscle to be the analogue of the *glutæus maximus* and *tensor vaginæ* united. He says that Professor Nitzsch observed a like absence of the *rectus femoris* in the Emeu. Cuvier calls that muscle ***rectus anticus femoris***, which is described in this monograph as the '*pectineus*.'

anterior part of the tendon of the broad rectus, and into the anterior and inner part of the head of the tibia. Its insertion is partly covered by the internal head of the *gastrocnemius*.

It bends and adducts the thigh, and extends the leg.

The homologue of the *Biceps flexor cruris* (Pl. X. XI. K) is a unicipital muscle, corresponding with the *rectus extensor* in the characteristic modification of its extended origin, in relation to the great antero-posterior development of the pelvic bones: it is exposed by the removal of the *rectus*. *Orig.* By a broad and thin aponeurotic tendon, which at first is confluent with that of the *rectus* but soon becomes distinct, from the posterior prolongation of the ilium: there is no second head from the femur. *Ins.* The fleshy fibres converge as they descend along the back and outer part of the thigh, and finally terminate in a strong round tendon, which glides through a loop (*x*) formed, as in the common Fowl, Ostrich, &c., by a ligament extended from the back of the outer condyle of the femur to the head of the tibia, and is inserted into the process on the outside of the fibula one inch from its proximal extremity. By means of the loop the weight of the hinder parts of the body is partially transferred, when the leg is bent, to the distal end of the femur; and the biceps is enabled, by the same beautiful and simple mechanism, to effect a more rapid and extensive inflection of the leg than it otherwise could have produced by the simple contraction of its fibres.

Semimembranosus (Pl. XI. XIV. L).—*Origin.* From the side of the coccygeal vertebræ, and from the posterior end of the ischium; it crosses the superficial or internal side of the *semitendinosus*. *Ins.* Into the fascia covering the *gastrocnemius* and the inside of the tibia: through the medium of the fascia it acts upon the tendon (R*) of the internal *gastrocnemius*.

Semitendinosus (Pl. XI. XIV. M).—This muscle arises from the posterior and outer part of the *sacrum* and the aponeurosis connecting it with the *ischium*: it is a flattened triangular muscle, which receives the square *accessorius* muscle (N) from the lower and posterior part of the femur. It gradually diminishes as it descends, and having passed the knee-joint, sends off at right angles a broad and square sheet of aponeurosis, which glides between the two origins of the *gastrocnemius internus*, and is inserted into the lower part of the angular ridge continued from the inside of the head of the tibia. The terminal tendon, continued from the apex of the muscle, then runs along the outer or fibular margin of the internal head of the *gastrocnemius*, and becomes confluent with the tendon of that muscle at R* Pl. XIV.

Cruræus (Pl. XI. XIV. O).—This is a simple but strong muscle: it commences at the upper and anterior part of the thigh by two extremities, of which the outer and upper one, representing the *vastus externus*, has its origin extended to the base of the trochanter; the inner and inferior comes off from the inner side of the femur, beneath the insertion of the *glutæus magnus*; the two portions blend into one muscle much earlier than in the Ostrich. *Ins.* By the ligamentum patellæ into the fore-part of the head of the tibia.

Gracilis (Pl. XIV. P).—On the inner side of the *cruræus*, but more superficially, lies a narrow, compressed, long muscle, which rises by two heads, one from the anterior and upper part of the femur, the other from the os pubis; both soon become blended together and transmit a broad thin tendon to be inserted into the lower and lateral part of the patella with the *cruræus*.

Vastus internus (Pl. XIV. Q).—Two other muscles succeed the preceding, and rise beneath it from the inner and anterior part of the femur; they have a similar insertion, and obviously represent the *vastus internus*. The fibres converge to a middle aponeurosis, which increases to a strong short tendon, inserted into the upper and anterior projection of the tibia.

Popliteus.—This small muscle is brought into view when the superficial muscles of the leg which are inserted into the foot are removed. Its carneous fibres extend from the fibula inwards and downwards to the tibia. It is of relatively smaller extent than in the Cassowary.

Gastrocnemius.—This complex and powerful muscle consists, as in other birds, of several distinct portions, the chief of which correspond with the external and internal origins of the same muscle in the Mammalia. The *gastrocnemius externus* (Pl. X. XI. R) arises by a strong, narrow, rather flattened tendon (R*) from the ridge above the external condyle of the femur, which, about an inch below its origin, becomes firmly attached to the strong ligamentous loop attached by one end to the femur above the preceding tendon, and by the other to the outer ridge of the fibula. This trochlear loop, which is displayed by reflecting down the tendon of the *gastrocnemius* in Pl. XI., is lined by synovial membrane, and supports the tendon of the *biceps cruris*, which glides through it. The carneous fibres of the external *gastrocnemius* come off from the outer side of the tendon, and from the fascia covering the outer surface of the muscles of the leg: they are continued in a somewhat penniform arrangement two-thirds down the leg, upon the inner surface of the muscle, where they end in a strong subcompressed tendon. This joins its fellow-tendon, from the internal *gastrocnemius*, behind the ankle-joint, and both expand into a thick, strong ligamentous aponeurosis (Pl. XI. fig. 2. R), which extends over three-fourths of the posterior part of the tarso-metatarsal bone. The lateral margins of this fascia are bent down under the flexor tendons behind the joint, and become continuous with a strong ligamentous layer gliding upon the posterior surface of the distal condyles of the tibia, and attached to the tendons of the *peroneus* and *tibialis anticus*: the conjunction of the thickened tendons of the *gastrocnemii* with this deeper-seated layer of ligamento-tendinous substance constitutes a trochlear sheath (Pl. XIV. R***) lined by synovial membrane, through which the flexor tendons of the toes glide. The synovial membrane of the ankle-joint is continued upwards half an inch above the articular surface of the bone, between it and the fibro-cartilaginous pulley. Below the joint the margins are inserted into the lateral ridges of the tarso-metatarsal bone, becoming gradually thinner as they descend, and ending below in a thin semilunar edge directed downwards.

The *gastrocnemius internus* (Pl. XIV. R) has two powerful heads, one from the femur, the other from the tibia; the first (R)† arises fleshy from the internal condyle of the femur, expands as it descends, and receives additional fibres from the lower edge of the *accessorius semitendinosi.* About one-fifth down the tibia this muscular origin in the right leg terminated in a flattened tendon (R*), which became attached to the inner side of the tibial portion of the *gastrocnemius internus* (R**). In the left leg the tendon soon divided; one portion passed to the soleus, the other went to join the tibial portion of the *gastrocnemius internus.* The second head, which is separated from the preceding by the insertion of the *semitendinosus,* arises partly from the internal and anterior part of the strong fascia of the knee-joint by short tendinous fibres, which almost immediately become fleshy, and partly from a well-defined triangular surface (R**) on the inner and anterior aspect of the head of the tibia: the fleshy fibres converge, receive the tendinous slip from the femoral portion, and end on the inner side of the muscle in a strong flattened tendon, about two-thirds down the leg: this joins the tendon of the *gastrocnemius externus* (R *e*), and is inserted as described above.

Soleus‡ (Pl. XIV. s).—This is a slender flattened muscle arising from the posterior part of the head of the tibia, the tendon of which joins that of the *gastrocnemius internus,* behind the tarsal joint.

The *Flexor perforans digitorum* (Pl. X. XI. XIV. 1) lies immediately anterior to the external *gastrocnemius*; it arises fleshy from the outer condyle of the femur, below the tendinous origin of that muscle, and terminates in a slender flat tendon half-way down the leg. Its tendon (1) glides behind the tarsal joint through the sheath of the *gastrocnemius,* expands beneath the metatarsus and bifurcates, sending its smallest division to the inner toe, and its larger one to blend with the tendon of the *peroneus longus.*

Flexor perforatus of the outer toe (Pl. X. XI. XIV. 2).—This arises by very short tendons from the proximal end of the fibula, and from the ligament forming the bicipital pulley; it continues to derive a thin stratum of fleshy fibres from the fascia covering the anterior surface of the muscles of the leg: the fleshy fibres terminate half-way down the leg in a flattened tendon, which, after entering the gastrocnemial sheath, pierces the tendon of the first *perforatus* of the middle toe, then runs forward to the outer toe, expands into a thick ligamentous substance beneath the proximal phalanx, and sends off two tendinous attachments on each side, one to the proximal, the other to the second phalanx, and is continued to be finally inserted into both sides of the third phalanx.

Flexor perforatus digitorum (Pl. XI. XIV. 3, 4, 5, 6) is the strongest of the three; it arises fleshy from the posterior part of the distal extremity of the femur, above the external condyle (Pl. XI. 4), and also by a distinct flattened tendon (6), one inch in length,

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† This is described as the *soleus* in the Cassowary, by Prof. Mayer, *loc. cit.* p. 15, but the origin of this muscle is not extended in other animals above the knee-joint.

‡ This is described as the *plantaris* in the Cassowary, by Prof. Mayer, *loc. cit.* p. 14, but the normal origin of that muscle should be sought for above the knee-joint.

from the proximal end of the tibia: this tendon moreover receives the long slender tendon sent off obliquely across the front of the knee-joint from the *pectineus* (T), by which its origin is extended to the pelvis. This accessory tendon perforates the inner fleshy surface of the muscle, and is finally lost about half-way down the carneous part. Before the *flexor perforatus* is joined by the tendon of the *pectineus*, it subdivides posteriorly into four muscular fasciculi. The anterior division receives principally the above tendon, and this division of the muscle becomes wholly tendinous two-thirds down the leg; its tendon (3) passes through the posterior part of the pulley of the *gastrocnemius*, and expands as it passes along the metatarsus: a thick ligamentous substance is developed in it opposite the joint of the proximal phalanx of the second toe, into the sides of which it is inserted, dividing for that purpose, and giving passage to the two other flexor tendons of that toe. The second portion of the present muscle terminates in a tendon (4) situated behind the preceding, which passes through a distinct sheath behind the tarsal joint, expands into a sesamoid fibro-cartilage beneath the corresponding expansion of the previous tendon, which it perforates, and then becomes itself the perforated tendon of the second phalanx of the second toe, in the sides of which it is inserted. The third portion of this muscle ends in a somewhat smaller tendon (5) than the preceding, which forms the second *perforatus flexor* of the third or middle toe. The fourth and most posterior portion soon becomes a distinct muscle; its fleshy fibres cease on the inner side, one-fourth down the leg, but on the outside they are continued three-fourths down the leg; its tendon (6) passes through the gastrocnemial pulley behind the ankle-joint, and divides to form a sheath for the *flexor perforatus* of the fourth toe; it is then joined by the tendon of the *peroneus* (7), which passes through a pulley across the external malleolus, and finally becomes the perforated tendon of the first phalanx of the middle or third toe.

Pectineus (Pl. XI. XIV. T), (*Rectus anticus femoris* of Cuvier* and Meckel†).—This is a long, thin, narrow strip of muscle arising from the spine of the pubis, anterior to the acetabulum, and passing straight down the inner side of the thigh; it degenerates into a small round tendon near the knee, which tendon traverses a pulley, formed by an oblique perforation in the strong rotular tendon of the extensors of the leg, and thus passing across the knee-joint to the outer side of the leg, finally expands, and is lost in the *flexor perforatus digitorum* last described. It is this muscle which causes the toes to be bent when the knee is bent.

Peroneus longus (Pl. XI. XIV. 7).—*Origin.* Tendinous from the head of the tibia, and by carneous fibres from the upper half of the anterior margin of the tibia; these fibres pass obliquely to a marginal tendon, which becomes stronger and of a rounded form where it leaves the muscle. The tendon gives off a broad, thin, aponeurotic sheath to be inserted into the capsule of the tarsal joint; it is then continued through a synovial pulley on the side of the outer malleolus, and is finally inserted or continued into the perforated tendon of the middle toe (6).

* Leçons d'Anat. Comp. ed. 1836, p. 523.

† Vergleich. Anat., Th. iii. p. 365.

Tibialis anticus (Pl. XI. XIV. 8).—This muscle is overlapped and concealed by the peroneus; it arises partly in common with that muscle, and partly by separate short tendinous threads from the outer part of the head of the tibia; it gradually becomes narrower, and finally tendinous two-thirds of the way down the leg; its strong tendon glides through the oblique pulley* in front of the distal end of the tibia, expands as it passes over the ankle-joint, and is inserted into the anterior part of the proximal end of the tarso-metatarsal bone, sending off a small tendinous slip to the aponeurosis covering the extensor tendons of the toes, and a strong tendon (8′) which joins the fibular side of the tendon of the following muscle.

Extensor longus digitorum (Pl. XIV. 9).—This lies between the *tibialis anticus* and the front and outer facet of the tibia, from which it derives an extensive origin; its tendon commences half-way down the leg, runs along the anterior part of the bone, first under the broad ligamentous band representing the anterior part of the annular ligament, then through a ligamentous pulley, and inclines to the inner or tibial side of the anterior surface of the metatarsal bone, where it expands and divides into three tendons. Of these the innermost is given off first, and subdivides into two tendons, one of which goes to be inserted into the base of the last phalanx of the second toe; the other portion is principally inserted into the middle toe, but also sends off a small tendon to the inner side of the proximal phalanx of the second toe. The second tendon is inserted by distinct portions into the second, third and last phalanges of the middle toe. The third tendon supplies the outer toe.

Extensor brevis digitorum (Pl. XIV. 10).—A small extensor muscle arises from the insertion of the *tibialis anticus*, and sends its tendon to the outer side of that of the great *extensor digitorum*.

Extensor pollicis brevis (Pl. XIV. 11).—An extensor of the small innermost toe arises from the upper and inner side of the tarso-metatarsal bone.

Peroneus medius, Cuv., *Accessorius flexoris digitorum*, Vicq. d'Azyr (Pl. XI. XIV. 12). —This strong penniform muscle arises fleshy from nearly the whole of the outer surface of the fibula, also from the posterior part of the tibia and the interosseous space; the tendon of the biceps perforates its upper part in passing to its insertion. It ends in a strong flat tendon at the lower third of the leg, which tendon runs through a particular sheath at the back part of the tarsal pulley, becomes thickened and expanded as it advances forwards beneath the tarsus, joins the tendon of the *flexor perforatus* (1), and forms with it the expansion which finally divides into three strong perforating tendons, which bend the last joints of the three long toes.

In the outer, or fourth toe, both the *perforans* and *perforatus* tendons are confined by a double annular ligament; the exterior one being continued from the adjoining toe, the inner and stronger one from the sides of the proximal phalanx of the outer toe.

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* This is ossified in the Bustard and most true *Grallæ*.

The second and third toes have two perforated tendons; one inserted into the sides of the first, and the other into the sides of the second phalanx.

On a review of the details of the Muscular System above recorded, it will be seen that the analogies of the muscles on the dorsal aspect of the spine with those of Man and the Mammalia, are, in consequence of their unusually strong and distinct development in the Apteryx, more clearly traceable than their condition in other birds perhaps admits of. The same character of the muscles of the hind-extremity has led, as I believe, to a more accurate determination of them than had been adopted by former Comparative Anatomists, among whom the honoured names of Cuvier and Meckel call for a more detailed statement of the grounds on which I have ventured to dissent from views, so sanctioned, than has been given in the descriptive part of the present monograph.

The chief modification of the skeleton of the hind limb of Birds, in respect of size and proportion, is manifested in its central segment; the ossa innominata being anomalously expanded in order to include, as it were, in their grasp the whole of the very long sacrum required for the support of the horizontal trunk upon a single pair of extremities. The principal modification of the muscles of the leg attached to the ossa innominata might be expected, therefore, to be found in their origins. In the attachment of the fibres of a superficial muscle to the aponeurosis, continued from the outer part of the thigh, over the knee-joint, to the head of the tibia, we recognize the corresponding insertion of the *tensor vaginæ femoris* of Man and Mammalia; and no Comparative Anatomist appears to have thought the anomalous development and extensive origin of this muscle, in Birds, to be any objection to the homology indicated by its insertion, which is the attachment that mainly governs the function of a muscle. Now besides the attachment to the femoral fascia, we find this broad superficial muscle, and especially its middle and posterior fibres, terminating in a strong tendon, implanted into the upper part of the patella, and receiving fibres from the *cruræus* and *vasti* muscles which it immediately covers, and with which it concurs in constituting a *quadriceps extensor* of the leg. Here, therefore, we perceive the normal insertion, the normal function, and the true relative position of the *rectus femoris*: and shall we reject these concordances on account of the modification of unusually extended origin? By parity of reason, we ought to reject the admitted homology of the *tensor vaginæ*; and not only of this, but also of the *sartorius* and *biceps cruris*, both of which have undergone equal or greater modifications of origin in the class of Birds. It is true that the *glutæus maximus* is the most superficial of the outer muscles of the thigh in Man and Mammalia, and that it has the most extensive origin and largest size in Man; but superior size and extensive origin are far from being the characters of the *glutæus externus* in the lower Mammalia, in which it much more frequently manifests the proportions, as compared with the *glutæus medius*, which the muscle to which I have assigned the name of *glutæus externus* in the Apteryx, presents. But if the *rectus femoris* has undergone, as I believe, a similar modification of origin to that which characterizes the *tensor vaginæ*, *sartorius* and *biceps*, it would, by its extension along the spines of the sacrum, cover and mask the true *glutæus externus*, which arises from part of the outer surface as well as from the crista of the ilium ; and by the same modification of the *rectus*, that connection between the *tensor* and *glutæus*, which is present in some quadrupeds, would be severed ; while the more common close proximity of origin of the *rectus* and *tensor* is maintained. Already, in the Kangaroo, we find the origin of the *rectus femoris* extending from above the acetabulum higher up than usual upon the iliac bone. If, therefore, the great superficial muscle in question does not include the *rectus femoris* with the *tensor vaginæ*, then, with the evidence of the true *glutæus externus* in the muscle A Pl. XI. of the Apteryx, I should feel bound to regard it as an enormous development of the *tensor vaginæ* alone.

Meckel assigns as his reason for regarding the muscle which I have called *glutæus externus* to be the *glutæus medius*, that its origin and relations to the other levators and abductors of the thigh are absolutely the same as the *glutæus medius* in Mammals*. It is, he says, covered by the *glutæus maximus*, meaning H Pl. X., or the great 'pyramidal' of Vicq. d'Azyr ; but we are not bound to admit, in the absence of proof, the assumption that the great pyramidal of Vicq. d'Azyr is the *glutæus maximus* ; and until this be satisfactorily proved the argument is of no weight. I have already given reasons for regarding the *glutæus externus* of Meckel as the combined *tensor vaginæ* and *rectus femoris* : the true *glutæus externus* is hidden in most birds, by the extraordinary extension of the origin of the *rectus extensor cruris* on one side, and of the *biceps flexor cruris* on the other ; but though covered, the *glutæus externus* is the outermost of the three *glutæi* which are recognizable in the 'Apteryx.' The more posterior position of its origin and its lower insertion, together with its inferiority of size as compared with the muscle which I have called *glutæus medius*, are characters which the *glutæus externus* of the Apteryx has in common with that muscle in most Mammalia, and especially in the genera *Macropus* and *Dipus*, which most resemble Struthious birds in the proportions and functions of their locomotive extremities.

To attempt to conceive this muscle to be the homologue of the *pyriformis* involves so anomalous an inversion of position in respect of the pelvis, of relations to other muscles inserted into the proximal part of the femur, and of both origin and insertion, as can only be accounted for by the difficulty in which Cuvier, having recognized the true *glutæus medius*, found himself in respect to the homologue of the *glutæus externus*, having applied the name of that muscle to the expanded *tensor* and *rectus*, by which it is covered.

The remarkable concordance of the muscles of the rudimental wing in the Apteryx

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* *Loc. cit.* p. 352.

with those in ordinary birds of flight, has been already pointed out. Nor is the correspondence less remarkable in the muscles of the leg and foot, especially as manifested in the condition of the 'perching muscle' (*pectineus*), in which it could hardly have been anticipated. The strong flexors and extensors of the leg and toes are strictly adapted to the exigencies of a bird which obtains probably most of its nourishment from the earth by means of feet resembling those of the *Gallinacea*, and which owes its safety to the speed with which it runs by means of legs which have the proportions of those of the Struthious tribe; and which, finally, is reported to seek concealment and to incubate in subterraneous burrows.

Female Organs of the Apteryx australis.

The trunk of a specimen of this species, transmitted to me from New Zealand by the lamented botanist Mr. Cunningham, having proved to be that of a female, enables me to complete this anatomical monograph, by the description of the organs of generation in that sex. These consisted of two ovaria and one oviduct. The right ovarium was, as usual in Birds, in an atrophied state, and situated in front of the corresponding suprarenal body, attached to that body and the adjoining trunk of the *vena cava*. It was a small, flattened, minutely granular body, measuring eight lines by five lines, and about one line in thickness.

The left ovarium (Pl. XV. *a*) was in a state of full development, of the usual racemose structure, consisting principally of one enormous calyx (*b*), ripe for dehiscence, containing the vitellus of an ovum, which measured three inches in length by two inches in breadth, indicating an unusually large egg for the size of the bird. All the other calyces were comparatively small, and the greater number of minute size.

The oviduct commenced by the usual simple unfringed or entire slit-shaped aperture (*c*), two inches in its long diameter: the tube soon contracted to a diameter of half an inch, with longitudinally plicated walls, indicating its dilatability: it then expanded to an inch diameter, and after slightly contracting, suddenly enlarged, to form the uterine or shell-secreting part (*d*), which was nearly one inch and a half in diameter; here the muscular tunic is thicker, and the lining membrane presents a peculiar character, consisting of transverse, linear, sub-parallel streaks, sending off numerous short processes at right angles, both streaks and processes being of a white colour, relieved by the darker mucous membrane. A magnified portion of this structure is given at fig. 2. This structure occupied nearly two inches of the uterine dilatation, which reassumed the longitudinal plications about one inch before terminating in the uro-genital compartment of the cloaca. The terminal outlet (*e*) is of a narrow elliptical form, with a tumid margin covering a sphincteric arrangement of the muscular fibres.

DESCRIPTION OF THE PLATES.

PLATE I.

Fig 1. Head of a female *Apteryx**.
  a. The external nostril.
2. Head of a male *Apteryx*.
  a. The *cere*.
  b. The ear.
3. Head of a *Rhea Americana*.
  a. The *cere*.
  b. The ear.
4. The external appearance of the rudimental wing of the *Apteryx* when the feathers are removed: it exhibits the form of one of the abnormal small quill-feathers described at p. 3.
5. One of the neck-feathers of the *Apteryx*.

PLATE II.

Abdominal sacs of the *Apteryx*.

a. The right hepatic sac, with a style passing through the aperture of communication with
b. The right enteric sac.
b′. Another style, passing by the side of the stomach, into the left hepatic sac.
c. *Omentum*.
d. The *pancreas*.
e. The *duodenum*.
f. The fold of *jejunum*.
g. The *rectum*.
r. The external *sphincter*.
s. The *penis*.
α. The two portions of the *pectoralis major*.
β. *Pectoralis medius*.
γ. *Pectoralis minor, seu internus*.

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* Since the preceding pages were printed Mr. Cunningham has transmitted to the Zoological Society the skin and the trunk of an *Apteryx*, which proves to be a female, and has a beak measuring from the gape to the tip six inches four lines, thus verifying the conjecture put forth at p. 4, that the difference in the length of the beak is sexual, and that the longer one characterizes the female.

PLATE III.

Fig. 1. Under surface of the head of the *Apteryx,* with the tongue and palate exposed.
  a. The posterior nasal apertures.
  b. The common opening of the Eustachian tubes.
  c. The tongue.
  d. The *glottis.*
  e. The glandular processes of the pharyngeal membrane.

2. The inferior surface of the tongue and hyoid-bone, with the commencement of the *œsophagus* and *trachea.*

3. Abdominal *viscera in situ.*
  a. Gastric processes of *omentum.*
  b. *Omental* processes covering the intestines.
  c, c. *Omental* processes in the intestinal loops.
  d. The *pancreas,* in
  e. The *duodenal* loop.
  f. The first loop of *jejunum.*
  g. The *rectum.*
  h. The *œsophagus.*
  i. The *sterno-tracheales* muscles.
  j. The carotid arteries.
  k, k. The right and left lobes of the liver.
  n. *Erector penis.*
  o. *Compressor venarum penis.*
  p. Vascular and nervous *plexus.*
  q. Internal *sphincter* of *cloaca.*
  r. External *sphincter.*
  s. *Penis*: a probe is passed beneath it into the *cloaca.*
  t. *Coccygeal* gland.

PLATE IV.

Digestive, Urinary, and Male Generative Organs.

a. The *proventriculus.*
b. The stomach.
c. The *duodenum.*
d. The *vitelline cæcum.*
e, e. The two *cæca.*

f. The *rectum* laid open, showing the large *glandulæ solitariæ*.
g. Bristles inserted into the ureters.
h, *h*. The *papillæ*, on which the *vasa deferentia* terminate.
i. The *penis*.
k. The *bursa Fabricii*.
l. The right,—and *m*, the left lobe of the liver.
n. The gall-bladder: two *cyst-hepatic* ducts are seen entering its *cervix*.
o. The cystic duct.
p. The hepatic duct.
q. The *pancreas*.
r. The spleen.
s, *s*. The renal veins;
t. Their posterior anastomosis, forming the commencement of the portal system of veins; and *u*, their anterior anastomosis, forming the commencement of the inferior *vena cava*, and completing the *circulus venosus renalis*.
v. The kidneys.
w. The ureters.
x, *x*. The *supra-renal* glands.
y, *y*. The *testes*.
z, *z*. The *vasa deferentia*.

PLATE V.

Fig. 1. Part of the digestive system of Dr. Logan's female *Apteryx*.
- *a*. The *proventriculus* laid open, showing the thickness of the glandular coat and the internal surface.
- *b*. The gizzard, showing the internal projections produced by the state of contraction of the cavity.
- *c*. The commencement of the *duodenum*, lined with thick *epithelium*.
- *l*. The liver.
- *o*. The duct corresponding with the cystic.
- *p*. The hepatic duct.
- *q*. The pancreas.
- *r*. The orifices of the pancreatic ducts.
- *s*. The pedicle or obliterated canal of *t*, the persistent vitelline sac.
- *u*. The twig representing the omphalo-mesenteric artery.

2. A section of one of the ordinary bilobate proventricular glands. 3. A quadrilobate proventricular gland. Both twice the natural size.

4. Section of the right lung and air-sacs.

a. The *sterno-trachealis* muscle: bristles are seen passing from the external branch of the *bronchus* into the three anterior air-sacs.

Fig. 5. Front view of both lungs.
- *a*. The anterior or short pulmonic bronchial tube.
- *b*. The posterior or long pulmonic bronchial tube.
- *c*. The bronchial tube of the air-sacs.

PLATE VI.

Fig. 1. A dissection, showing the *diaphragm* of the *Apteryx*.
- *α*. The two *crura* of the vertebral portion or lesser muscle of the *diaphragm*.
- *β*, *β*. Fasciculi of the costal portions of the *diaphragm*.
- *a*. The *pericardium* covering the *apex* of the heart, and protruding through the anterior fissure of the *diaphragm*.
- *b*. The *œsophagus*.
- *l*. The trunk of the cœliac axis protruding through a *foramen* in the expanded central tendon of the *diaphragm*.
- *m*. The mesenteric artery.
- *n*. The abdominal *aorta*.
- *o*. The spermatic artery.
- *p*, *p*. The femoral arteries.
- *q*, *q*. The renal arteries.
- *r*, *r*. The ischiadic arteries.
- *s*. The sacro-median artery.

Fig. 2. Front view of the heart.
- *a*. The right ventricle.
- *b*. The right auricle.
- *c*. The pulmonary artery.
- *d*. The *arteriæ innominatæ*.
- *e*, *e*. The internal thoracic arteries.
- *f*, *f*. The brachial arteries.
- *g*. The carotids.

3. The heart, dissected, to show the interior of the right auricle and ventricle.
- *b*. The inferior *vena cava*.
- *c*. The left superior *cava*.
- *d*. The right superior *cava*.
- *e* & *f*. The semilunar valves, between the sinus and auricle.
- *g*. The right auriculo-ventricular valve.
- *h*. The left auricle.

PLATE VII.

Skulls of *Apteryx Australis* and *Numenius arcuatus*.

Fig. 1. Upper surface of the skull of the *Apteryx Australis*, male.
2. Under surface of the same.
3. Upper surface of the skull of the *Ibis* (*Numenius arcuatus*).
4. Under surface of the same.
5. Posterior surface of the skull of the *Apteryx*.
6. Upper surface of the lower jaw of the male *Apteryx*.
7. Under surface of the same.
8. *Os hyoides*.

PLATE VIII.

Skeleton of the male *Apteryx*, one half the natural size.

PLATE IX.

Fig. 1. Under surface of the bony compages of the thoracic, abdominal, and pelvic cavities, with the *sternum* and sternal ribs removed.
2. Under or external surface of the *sternum*.
    a. The perforations*.
    b. The posterior fissures.
    c. The broad anterior emargination.
    d. The articular notch for the coracoid.
    e. The coracoid.
    f. The rudiment of an acromial clavicle.
    g. The *scapula*.
    h, *h*. The sternal ribs.
3. The upper or internal surface of the *sternum*.
    h. The articular cavities for the sternal ribs.
4. Posterior or internal surface of the anchylosed *scapula* and *coracoid*.

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* In the skeleton of a half-grown *Apteryx* which I have received since the foregoing Memoir was printed, the sternum consists, as in the young Ostrich, of two symmetrical osseous plates, united at the middle line by cartilage. Neither of the lateral halves of this sternum was, therefore, perforated; and the structure of the sternum of the male *Apteryx* represented in Pl. IX. figg. 2 and 3 may prove to be a variety.

PLATE X.

Side view of the superficial muscles of the *Apteryx Australis.*

PLATE XI.

Fig. 1. Side view of the second layer of muscles of the *Apteryx Australis.*
2. *Plantar fascia,* or tendinal sheath formed by the expanded continuation of the tendon of the *gastrocnemii.*

PLATE XII.

Deep-seated muscles of the spine of the *Apteryx Australis.*

Fig. 1. The *sacro-lumbalis* (*l*) and *longissimus dorsi* (*m*) have been dissected off and reflected back, to expose the *spinalis dorsi* (*p*) and *multifidus spinæ* (*q*) : and most of the insertions of the *longus colli posticus* (*o* 1 to *o* 8) have been detached and turned up, to show more clearly the *obliquus colli* (*m*, *m* 1 to *m* 9).
2. The *sacro-lumbalis* ; its outer margin is raised, to show the *musculi accessorii* (*l* 1 to *l* 5).
3. The *obliquo-spinales* and the small deepest-seated muscles of the cervical vertebræ.

PLATE XIII.

Fig. 1. Muscles of the rudimental wing, and side view of the second layer of muscles of the neck.
2. Front view of the second layer of muscles of the neck.

PLATE XIV.

Front view of the muscles of the *Apteryx Australis.*

PLATE XV.

Fig. 1. Female organs of generation, *Apteryx Australis* :—natural size.
a. Rudimental right ovarium.

b. Full-developed left ovarium, with a yolk ripe for dehiscence.
c. Abdominal opening of the oviduct.
e. Probe introduced by the cloacal opening of the oviduct into the uterine or shell-secreting compartment.

Fig. 2 Slightly magnified view of the calciparous lining membrane of that compartment.

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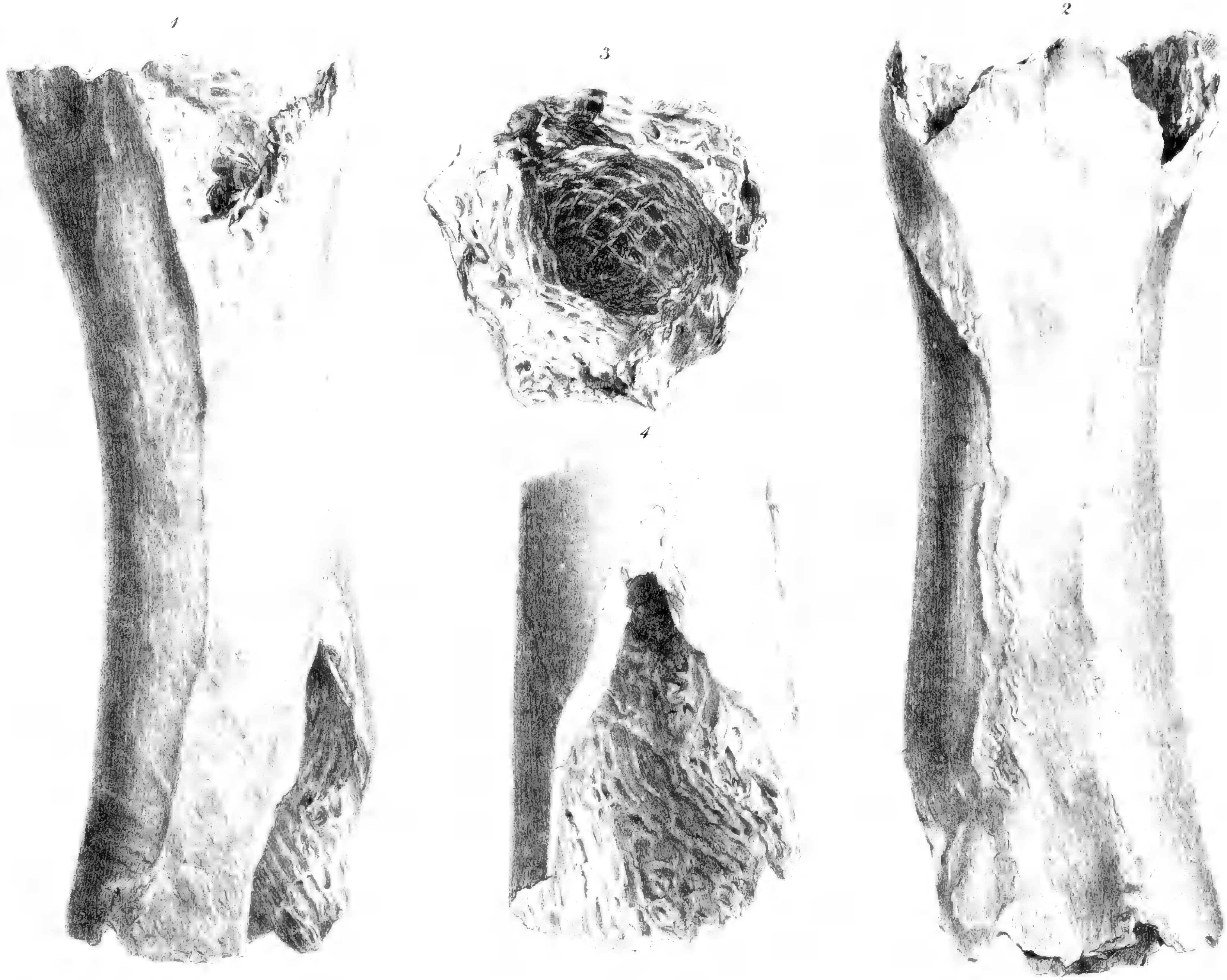

Lithog. from Nature by G. Scharf.

Femur of a Bird from New Zealand.

OWEN 1844
Trans. Zool. Soc. Lond. 3 (3): 235-275

MEMOIR

ON THE

GENUS DINORNIS.

Introduction.

THE brief history of the discovery of the *Dinornis*, a genus of gigantic terrestrial birds, which appears to have become extinct within the historical period in the North Island of New Zealand, like the Dodo in the island of Mauritius, will be found in the Proceedings of the Zoological Society for November 1839, and in the Society's Transactions, vol. iii. p. 32, pl. 3. These papers contain the inferences deduced from the structure of the shaft of a femur, which led to the first announcement of the former existence in New Zealand of a large Struthious bird "of a heavier and more sluggish species than the Ostrich."

As the full development and confirmation of this idea is included in the following pages, I am induced, in vindication of the fruitful principle of physiological correlations, the value of which as an instrument in the interpretation of organic remains there appears a tendency to depreciate in an otherwise estimable osteological work[2], to premise the abstract of my former communication published four years ago:—

"The fragment is the shaft of a femur, with both extremities broken off. The length of the fragment is six inches, and its smallest circumference is five inches and a half. The exterior surface of the bone is not perfectly smooth, but is sculptured with very shallow reticulate indentations; it also presents several intermuscular ridges. One of these extends down the middle of the anterior surface of the shaft to about one-third from the lower end, where it bifurcates; two other ridges or lineæ asperæ traverse longitudinally the posterior concave side of the shaft; one of them is broad and rugged, the other is a mere linear rising.

"The texture of the bone, which affords the chief evidence of its ornithic character, presents an extremely dense exterior crust, varying from one to two lines in thickness; then there occurs a lamello-cellular structure of from two to three lines in thickness. The lamellæ rise vertically to the internal surface of the dense wall, are directed obliquely to the axis of the bone, decussate and intercept spaces which are generally of a rhomboidal form, and from two to three lines in diameter. This coarse cancellated structure is continued through the whole longitudinal extent of the fragment, and im-

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[1] Δεινὸς, *surprising*, ὄρνις, *bird*.

[2] The 'Osteographie' of Prof. De Blainville.

mediately bounds the medullary cavity of the bone, which is about one inch in diameter at the middle, and slightly expands towards the extremities. There is no bone of similar size which presents a cancellous structure so closely resembling that of the present bone as does the femur of the Ostrich; but this structure is interrupted in the Ostrich at the middle of the shaft where the parietes of the medullary, or rather air-cavity, are smooth and unbroken. From this difference I conclude the Struthious bird indicated by the present fragment to have *been a heavier and more sluggish species than the Ostrich*; its femur, and probably its whole leg, was shorter and thicker. It is only in the Ostrich's femur that I have observed superficial reticulate impressions similar to those on the fragment in question. The Ostrich's femur is subcompressed, while the present fragment is cylindrical, approaching in this respect nearer to the femur of the Emeu; but its diameter is one-third greater than that of the largest Emeu's femur, with which I have compared it.

"The bones of the extremities of the great *Testudo elephantopus* are solid throughout. Those of the Crocodile have no cancellous structure like the present bone. The cancellous structure of the mammiferous long bones is of a much finer and more fibrous character than in the fossil.

"Although I speak of the bone under this term, it must be observed that it does not present the characters of a true fossil; it is by no means mineralized: it has probably been on, or in, the ground for some time, but still retains most of its animal matter. It weighs seven ounces twelve drachms, avoirdupois.

"The discovery of a relic of a large Struthious bird in New Zealand is one of peculiar interest, on account of the remarkable character of the existing Fauna of that Island, which still includes one of the most extraordinary and anomalous genera of the Struthious order, and because of the close analogy which the event indicated by the present relic offers to the extinction of the Dodo of the island of the Mauritius. So far as a judgement can be formed of a single fragment, it seems probable that the extinct bird of New Zealand, if it prove to be extinct, presented proportions more nearly resembling those of the *Dodo* than of any of the existing *Struthionidæ*.

"Any opinion, however, as to its specific form can only be conjectural: the femur of the Stilt-bird (*Himantopus*) would never have revealed the anomalous development of the other bones of the leg; but so far as my skill in interpreting an osseous fragment may be credited, I am willing to risk the reputation for it on the statement that there has existed, if there does not now exist, in New Zealand, a Struthious bird nearly, if not quite, equal in size to the Ostrich[1]."

The first letter received by me from New Zealand, confirming this announcement and acquainting me with the existence of the specimens described in the present communication, was written by my friend the Rev. Wm. Cotton, M.A., and has been already published in the Proceedings of the Society[2]. I now subjoin, by Dr. Buckland's permission, the

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[1] Proc. Zool. Soc., November 12th, 1839.

[2] *Ibid.* January 10th, 1843.

letter[1] addressed to him by the Rev. Wm. Williams, a zealous and successful Church Missionary long resident in New Zealand, on the occasion of transmitting to Dr. Buck-

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[1] "Poverty Bay, New Zealand, Feb. 28th, 1842.

"Dear Sir,—It is about three years ago, on paying a visit to this coast, south of the East Cape, that the Natives told me of some extraordinary monster which they said was in existence in an inaccessible cavern on the side of a hill near the river Wairoa; and they showed me at the same time some fragments of bone taken out of the beds of rivers, which they said belonged to this creature, to which they gave the name of 'Moa.' When I came to reside in this neighbourhood I heard the same story a little enlarged, for it was said that the creature was still existing at the said hill, of which the name is 'Wakapunake,' and that it is guarded by a reptile of the Lizard species, but I could not learn that any of the present generation had seen it. I still considered the whole as an idle fable, but offered a large reward to any one who would catch me the bird or its protector. At length a bone was brought from a river running at the foot of the hill, of large size, but the extremities were so much worn away that I could not determine anything as to its proper relationship. About two months ago a single bone of smaller size was brought from a freshwater stream in this bay, for which I gave a good payment, and this induced the natives to go in large numbers to turn up the mud at the banks and in the bed of the same river, and soon a large number of bones was brought, of various dimensions. On a comparison with the bones of a fowl, I immediately perceived that they belonged to a bird of a gigantic size. The bones of which the greatest number have been brought are the three bones of the leg, a few toe-bones, and one claw, which is one inch and a half in length, a few imperfect pelves, and a few vertebræ of different dimensions, and one imperfect cranium, which is small. There are also a few broken pieces, which seem to be ribs. In the case now sent you will receive the largest specimens I have obtained, and also a few of smaller size. The length of the large bone of the leg is two feet ten inches. I have a second case, which I shall send by another vessel, to make sure of your receiving them. If the bones are found to be of sufficient interest, I leave it to your judgement to make what use of them you think proper; but if the duplicates reach you, perhaps one set may with propriety be deposited in our museum at Oxford.

"The following observations may not be devoid of interest:—

"1st. None of these bones have been found on dry land, but are all of them from the bed and banks of fresh-water rivers, buried only a little distance in the mud; the largest number are from a small stream in Poverty Bay, Wairoa, and at many inconsiderable streams, and all these streams are in immediate connexion with hills of some altitude.

"2nd. This bird was in existence here at no very distant time, though not in the memory of any of the inhabitants, for the bones are found in the beds of the present streams, and do not appear to have been brought into their present situation by the action of any sudden rush of waters.

"3rd. That they existed in considerable numbers. I have received perfect and imperfect bones of thirty different birds.

"4th. It may be inferred that this bird was long-lived, and that it was many years before it attained its full size: out of a large number of bones, only one leg-bone now sent is of the size two feet ten inches; two others are two feet six inches, one of which I shall send hereafter. The rest are all of inconsiderable size.

"5th. The greatest height of the bird was probably not less than fourteen or sixteen feet. The leg-bones now sent give the height of six feet from the root of the tail. I am told that the name given by the Malays to the Peacock is the same as that given by the natives to this bird.

"Within the last few days I have obtained a piece of information worthy of notice. Happening to speak to an American about the bones, he told me that the bird is still in existence in the neighbourhood of Cloudy Bay, in Cook's Straits; he said that the natives there had mentioned to an Englishman of a whaling party that there was a bird of extraordinary size to be seen only at night on the side of a hill near there; and that he, with the native and a second Englishman, went to the spot; that after waiting some time they saw the creature at some little distance, which they describe as being fourteen or sixteen feet high. One of the men proposed to go nearer and shoot, but his companion was so exceedingly terrified, or perhaps both of them, that they were satisland the instructive series of rare specimens with which the active spirit and enlightened liberality of their collector have enriched the scientific collections of his native land.

It will be seen from that letter that Mr. Williams had confirmed, by comparison with the bones of the common fowl, the traditional statement of the natives of New Zealand relative to the huge bones which they at different times brought to him, in regard to the class of animals to which they belonged ; he has, therefore, a just claim to share in the honour of the discovery of the *Dinornis*, since, whilst collecting and comparing its osseous remains, he was wholly unaware that its more immediate affinities had already been determined in England.

By means of the specimens first transmitted by Mr. Williams to Dr. Buckland, and generously confided to me by that distinguished Geologist, I was enabled to define the generic characters of the *Dinornis*, as afforded by the bones of the hind extremity[1]: by the favour of a like disposition of Mr. Williams's second and richer collection of bones, and from three additional specimens confided to me, in the same liberal spirit, by Dr. Richardson of Haslar Hospital, evidence has been obtained of six distinct species of the genus, ascending respectively from the size of the Great Bustard to that of the Dodo, of the Emeu, of the Ostrich, and finally attaining a stature far surpassing that of the once-deemed most gigantic of birds.

I shall first enumerate the specimens of the bones which I have examined and compared, then proceed to point out their common generic characters, and finally their specific differences.

List of Bones of the *Dinornis* collected by the Rev. Wm. Williams in Poverty Bay, New Zealand, and transmitted to England.

Nos.
v 1. Middle cervical vertebra.
v 2. Posterior cervical vertebra.
v 3. Posterior cervical vertebra.
v 4. Anterior dorsal vertebra.
v 5. Middle dorsal vertebra.
p 1. Anterior part of pelvis.
p 2. Right os innominatum.
p 3. Fragment of os innominatum.

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fied with looking at him, when in a little time he took the alarm and strode away up the side of the mountain. This incident might not have been worth mentioning, had it not been for the extraordinary agreement in point of size of the bird. Here are the bones, which will satisfy you that such a bird *has been*, and *there* is said to be the living bird, the supposed size of which, given by an independent witness, precisely agrees. Should I obtain anything more perfect you will not fail to hear from me, and in the meantime may I request the favour of your opinion on these bones, and also the information whether any others of similar character have been found elsewhere?

"I beg to remain, dear Sir, your obedient servant,

"*To Dr. Buckland, &c. &c.*" "WILLIAM WILLIAMS."

[1] Proceedings of the Zoological Society, January 10th, 1843.

Nos.		
p 4.	Pelvis, nearly entire.	
p 5.	Ditto, more fractured.	
f 1.	Shaft of femur,	right (one foot four inches long when entire).
f 2.	Femur,	right (one foot one inch long).
f 3.	Ditto,	right, extremities broken.
f 4.	Shaft of femur,	right.
f 5.	Femur,	right.
f 6.	Ditto,	right.
f 7.	Ditto,	right.
f 8.	Ditto,	right.
f 9.	Shaft of femur,	right.
f 10.	Ditto,	right.
f 11.	Ditto,	left.
f 12.	Femur,	left.
f 13.	Ditto,	left, extremities broken.
f 14.	Ditto,	left, ditto ditto.
f 15.	Shaft of femur,	left.
f 16.	Femur,	left.
f 17.	Ditto,	left.
f 18.	Shaft of femur,	left.
t 1.	Tibia,	left (two feet eleven inches long).
t 2.	Ditto,	left (two feet five inches long).
t 3.	Ditto,	left.
t 4.	Ditto,	left.
t 5.	Shaft of tibia,	left (part of).
t 6.	Ditto,	right.
t 7.	Ditto,	right (more broken).
t 8.	Tibia,	right.
t 9.	Ditto,	right.
t 10.	Shaft of tibia,	right.
t 11.	Tibia,	right.
m 1.	Tarso-metatarsal bone,	left (eighteen inches and a half long, five inches across distal end).
m 2.	Tarso-metatarsal bone,	left, ends broken.
m 3.	Ditto,	left.
m 4.	Ditto,	left.
m 5.	Ditto,	left.
m 6.	Shaft of ditto,	left.
ph. 1.	A second phalanx.	
ph. 2.	A third (?) phalanx.	

Total number of bones 47.

The first cursory comparison of the femora, tibiæ, &c. sufficed for the recognition of common characters, by which, notwithstanding their very different sizes, they appeared to be generically related to each other, and were readily distinguishable from their analogues in the skeletons of the existing Struthious birds.

A much closer inspection and cautious consideration were obviously required, in order to determine satisfactorily whether the different-sized bones belonged to different-aged birds of the same species, or to distinct species differing in size. Guided by the seldom-failing law, that distinctive characters are most strongly developed in the peripheral parts of the body, I first collected together and examined the bones of the foot, and fortunately found for comparison three tarso-metatarsal bones of the same side, the left, and of very different sizes.

Metatarsi. (Plates XX *a*, XXVII. and XXVIII.)

I shall first premise the common or generic characters of the tarso-metatarsal bone of the *Dinornis*, and, in detailing the subsequent comparisons of the different-sized bones, shall refer to them, as afterwards to the *tibiæ*, *femora*, &c., by the numbers they bear in the foregoing list, which will obviate much unnecessary repetition.

The tarso-metatarsal bone of the *Dinornis* consists of the tarsal and of three primitively distinct metatarsals blended together, and forming, as usual, a single bone, divided at the distal extremity into three trochlear articulations, for the three toes. The proximal articulation presents two concavities, the inner one the deepest, and the dividing ridge is slightly produced upwards at its anterior termination into a conical obtuse process. At the middle of the back part of the proximal end there are two short and thick longitudinal ridges, divided by a deep round groove for the flexor tendon of the toes: the ridges are supported by a thick longitudinal eminence, which is continued down the middle of the back-part of the bone to a varying distance in the different bones, gradually subsiding as it descends. On each side of the upper part of this median longitudinal eminence there is a foramen, as in most other birds, from which a shallow and narrow longitudinal canal is continued in the larger metatarsi for some distance down the bone: there are no other canals, nor any longitudinal angular ridges at the back part of the metatarsus; nor is there the slightest trace of a surface for the attachment of a hind-toe. On the anterior part of the bone, near the proximal end, there is the usual depression, in which the canals continued from the two posterior foramina terminate by a single foramen: below the depression there is a rough surface, for the insertion of the tendon of the *tibialis anticus*, from which point a median wide and shallow channel extends a certain way down, and divides into two shallower depressions, which diverge to the interspaces of the distal articular condyles: the margins of all these depressions are rounded off, and the general surface of the anterior, as of the posterior part of the metatarsus, is smooth and rounded: this, with the great breadth of the bone as compared with the metatarsi of other *Struthionidæ* and tridactyle *Grallæ*, constitutes the principal generic character of the tarso-metatarsal bone in the *Dinornis*. The interspaces of the three articular terminations are wider, the two lateral ones diverging more, and being of larger size than usual; they have also the median trochlear groove, but not so deep as in the middle articular process.

A section of one of the smaller metatarsals shows the confluent compact walls of the three primitive constituents of the shaft, and the two thin bony partitions dividing the cavity of the bone into the three separate medullary canals, as far down as the middle of the shaft, where they cease, and a common medullary cavity is formed: the lower part of the common medullary cavity is divided by a single septum into two canals, which are continued into the coarse cellular structure of the divisions supporting the articulations of the inner and middle toes, as in most other birds. Pl. XXIX. fig. 5.

The length of the tarso-metatarsal bone in the *Dinornis* is about half that of the tibia, as will be afterwards more particularly demonstrated. In the tridactyle Emeu the tarso-metatarsal bone is as long as the tibia; in the Ostrich and the Bustard it is a little shorter than the tibia. The still shorter proportion which it bears to the tibia in the Apteryx of New Zealand forms a striking resemblance between this bird and the *Dinornis*. But the Apteryx is distinguished from the larger *Struthionidæ* not more by its elongated slender bill than by the presence of a fourth small toe on the inner and back part of the foot, articulated to a slightly raised rough surface of the tarso-metatarsal, about a fourth of the length of that bone from its trifid distal end: the Dodo was also tetradactyle, like the Apteryx. Thus the tarso-metatarsal bone of the *Dinornis* distinguishes that bird generically by its structure from the two last-named *Struthionidæ*, as it does by its shorter and stouter proportions from the Cassowary, the Emeu and the Rhea: the three well-developed anterior toes more obviously distinguish the *Dinornis* from the didactyle Ostrich.

Proceeding now to the comparison of the three most perfect tarso-metatarsal bones of the *Dinornis* with each other, it will be obvious, from the subjoined table of admeasurements, that they differ from each other in their proportions as well as in their size.

Dimensions of the Tarso-metatarsals.

	m 1.		*m* 2.		*m* 3.		*m* 5.		*m* 4.	
	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.
Length	18	6	14[1]	0	12	0	7	0	6	10
Circumference	5	6	4	3	4	3	3	3	3	3
Breadth of distal end	5	1			4	0			3	0
Breadth of middle of shaft	1	11	1	6	1	6	1	5	1	3
Thickness, or antero-posterior diameter of ditto	1	6	1	2	1	1	0	9	0	9

Thus the circumference of the middle of the shaft is as 11 to 37, or less than one-third, in the longest bone (*m* 1)[2]; in the second-sized entire bone (*m* 3)[3] it is a little more than

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[1] According to the probable proportions of the articular extremities, when entire.

[2] Pl. XXVII. fig. 1.

[3] *Ib.* fig. 2.

one-third; in the smallest metatarsal (*m* 4)[1] it is a little more than one-half. Again, the breadth of the distal end of the smallest metatarsal is nearly one-half the length of the bone; in *m* 3 it is just one-third; in *m* 1 it is two-sevenths. The difference is well marked in the proportions of the breadth or lateral diameter of the shaft, as compared with the thickness or antero-posterior diameter, but is less between *m* 1 and *m* 3 than between either of these and *m* 4 or *m* 5. In regard to these smallest-sized metatarsals, they both present differences of configuration when compared with the larger metatarsals, besides those indicated by the admeasurements, which assist in establishing a distinction of species: the distal end of the bone is more suddenly expanded than in the larger specimens; the proximal posterior prominence of the middle division of the metatarsal more rapidly subsides as it descends; there is no longitudinal channel continued downwards from the hole on the inside of this prominence, such channel being as well marked in the larger metatarsals as the outer one: the shallow concavity on the outside of the prominence is relatively broader in the smaller metatarsals. The inner concavity of the proximal articular surface is relatively deeper in *m* 4. The median longitudinal concavity, below the rough depression at the anterior part of the proximal end of the bone, is hardly discernible in *m* 4, but is well marked in *m* 1 and *m* 3. Finally, the small metatarsal, which is but half the length of *m* 3, and but one-third the length of *m* 1, has all the characters of the compound tarso-metatarsal in a fully mature bird: there is no trace of the original separation of the proximal epiphysis; and, with respect to that of the three primitive constituents of the shaft of the bone, it is as obscurely indicated as in other old tridactyle birds, by the two small holes at the back and upper part of the bone. I infer, therefore, from the smallest metatarsals, *m* 4 and *m* 5, which have the same characters and nearly the same size, the former existence of a distinct species of three-toed Struthious bird, differing from the larger species of *Dinornis* in its relatively shorter and broader metatarsus. In this character the present species of *Dinornis* closely resembled the extinct Dodo (*Didus ineptus*, Linn.) of the Isles of France and Rodriguez; and as it could not have been greatly superior in size, I propose therefore to designate it *Dinornis didiformis*. n. sp.

Like the larger species of *Dinornis*, there is not the slightest trace of the articulation of a fourth or posterior toe in the metatarsal of the *Dinornis didiformis*; the generic distinction from *Didus* and *Apteryx* being thus distinctly indicated in all the tarso-metatarsal bones of the present collection.

If the different proportions and configurations of the smallest tarso-metatarsal bones justify the conclusion that they belonged to a particular species of *Dinornis*, by parity of reasoning the same inference must be drawn in regard to the intermediate-sized tarso-metatarsal, *m* 3, which is far from repeating the proportions of the largest bone, *m* 1, as the table of dimensions already referred to demonstrates: *m* 3 is in fact a more robust bone, in proportion to its length; the anterior longitudinal concavity, commencing below the rough depression, is deeper; the channel leading to the cleft between the condyles

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[1] Pl. XXVII. fig. 3—6.

for the outer and middle toes is also relatively narrower and deeper; the posterior commencement of the middle condyle projects further and more abruptly in *m* 3 than in *m* 1; the posterior part of the distal half of the bone is more convex.

These may perhaps be deemed by some Ornithologists to be slight or trivial differences; yet, taken in connection with the greater breadth and thickness of the bone, in proportion to its length, they unquestionably support the conclusions of specific distinction deducible from those proportions.

The Physiologist contending for a difference of age merely in the birds to which the bones *m* 1 and *m* 3 belonged, must be prepared to show that in other large Struthious birds the tarso-metatarsal bones alter in their proportions as well as their size in the progress of growth, and that they are thicker and more robust in the young than in the old birds. The contrary, however, is the case in the Ostrich and the Common Fowl. In the great existing Struthious bird more especially, which offers the most instructive analogy in the present comparison, the tarso-metatarsal bone is relatively more slender in proportion to its length in the young bird than in the old, at least at the period of growth when the tarso-metatarsal bone has attained two-thirds its full size, which is precisely the proportion which the bone of the Dinornis *m* 3 bears in length to the bone *m* 1.

But the comparison with the bones of the young Ostrich brings to light another character, which effectually decides the question of the relation between the two different-sized bones of the Dinornis under consideration. In all birds the tarso-metatarsal bone, as is well known, is an aggregate of several distinct ossicles, the primitive separation of which continues longest in those birds whose respiratory, circulating and muscular energies are least developed. Thus in the Penguins the three metatarsal bones are almost quite distinct from one another throughout life; and in the Ostrich and other *Struthionidæ* deprived of the power of flight, the primitive separation of the metatarsals continues at their extremities to nearly full growth. In the tarso-metatarsal bone of the young Ostrich[1], which is figured to illustrate this condition, and which is rather more than two-thirds the length of the same bone in the mature bird, the tarsal bone, which seems to represent a proximal epiphysis, is still a detached bone, and the posterior channel of the metatarsus deepens and widens as it approaches the proximal extremity, and is finally lost in the two deep and narrow clefts which divide the proximal ends of the three constituent metatarsals from each other.

But the tarso-metatarsal of the Dinornis, *m* 3[2], has all the characters of the bone of not only a mature but an aged bird. The tarsal bone is completely confluent with the upper ends of the metatarsals, and these are blended with each other, as far as their diverging distal condyles. The traces of the proximal separation are limited to a rough depression and a round excavation above it, on the anterior part of the bone, and to the two small perforations on the posterior part, the relics of the original fissures. He, therefore, who would contend that the tarso-metatarsal bone *m* 3 has belonged to a young

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[1] Pl. XXVIII. fig. 1 & 2.

[2] Pl. XXVII. fig. 2.

individual of the same species of Dinornis as that to which the great tarso-metatarsal bone *m* 1 belonged, virtually assumes that the relations which modify the progress of ossification were different in the Dinornis from what they are in the Ostrich, and that a bird which, from the non-extension of the air-cells into the femur, was as poorly endowed with powers of flight as the Apteryx, and consequently possessed of as comparatively low circulating and respiratory energies, must at the same time have enjoyed as rapid an ossification of the skeleton as the Swallow; postulates which, being contrary to known physiological correlations, are inadmissible.

Since, therefore, the tarso-metatarsal *m* 3 combines with the characters of a fully developed bone, a marked difference of size, different proportions, and some minor modifications of form, as compared with the large bone *m* 1, it must indicate a second species of Dinornis, which, as it attained, as will be presently shown, the average height of the
n. sp. Ostrich (*Struthio camelus*), I shall call *Dinornis struthoides.*

That the *Dinornis struthoides* is, in fact, a good and true species, is put beyond all cavil or doubt by the existence of a tarso-metatarsal bone (*m* 2)[1] which is longer than *m* 3, but agrees in the proportions and form of its shaft with *m* 1, and manifests the same characters of immaturity which have been already noticed in the corresponding bone of the young Ostrich. Here, therefore, we actually have, what *m* 3 might have been mistaken for, a bone belonging to a young individual of the gigantic species (*Dinornis giganteus*).

The condition of this young bone demonstrates, what could not indeed be reasonably doubted, that a more tardy ossification coexists in the Dinornis, as in other *Struthionidæ*, with the absence of the powers of flight; and as such a condition in the present bone establishes the maturity of the tarso-metatarsal bone *m* 3, which it exceeds in length, it proves, *à fortiori*, that the smallest tarso-metatarsal, with all the characters of mature age, could not have belonged to a young individual of either of the two larger species. Or, in other words, if the young of the *Dinornis giganteus*, when the shaft of its tarso-metatarsal bone is eleven inches long, manifests evident marks of immaturity, these characters ought to have been more strongly marked in the shorter tarso-metatarsals *m* 3[2] and *m* 5[3], if they had really belonged to young individuals of the largest species. The marks of immaturity in the shaft of the tarso-metatarsal of the young *Dinornis giganteus*, *m* 2, are the gradual deepening and widening of the anterior median channel of the shaft as it approaches the proximal end of the bone, until it divides into the fissures separating the proximal ends of the three constituent metatarsals, which extremities in the specimen are broken off immediately above the point where they begin to coalesce. In a specimen of the tarso-metatarsal bone, *m* 6, of the *Dinornis didiformis*, in which the proximal end is broken off a few lines above the anterior rough depression which indicates the primitive dividing groove, the constituent metatarsals are faintly indicated by

[1] Pl. XXVIII. fig. 3.

[2] Ib. fig. 5.

[3] Ib. figs. 6 & 7.

two diverging lines of a denser cancellous structure, where the unclosed fissures exist in the younger bone. The shaft of the bone *m* 6, which is less than half the length of the mutilated one of the immature *Dinornis giganteus*, equals it in breadth.

Tibiæ. (Plates XXV. and XXVI.)

The chief generic characters of the tibia of the Dinornis are, the broad and wide concavity (Pl. XXVI. *a*) anterior to the proximal articular surface, the great breadth of the ascending wall of bone, *ib. b*, for the implantation of the rotular or extensor tendon, and, at the distal end, the slight anterior production of the lateral ridges of the trochlea. All these characters are very strikingly distinctive when the tibia of the Dinornis is compared with that of the Ostrich; the difference is less, though well marked, in relation to the Emeu or Apteryx. The tibia of the Dinornis differs from that of all known existing Struthious birds in the presence of the canal above the distal trochlea on the anterior and inner side of the bone, formed by the oblique osseous bridge (Pl. XXV. *f*) across the extensor tendon. The affinity of the Dinornis to the Bustard and other *Grallæ* is indicated by this structure. The inner condyle or division of the distal trochlea, *ib. g*, is relatively more produced backwards than in the *Struthionidæ* and *Grallæ* generally.

The anterior crista (Pl. XXV. *c*) at the head of the bone is less developed than usual. The longitudinal ridge (Pl. XXVI. *d*) for the fibula on the proximal half of the bone is well marked; but the fibula has not been anchylosed to it, nor is there any trace of that bone in the present collection. The orifice of the medullary artery (Pl. XXVI. *e*) is close to the termination of the fibular ridge.

Notwithstanding the great length of the largest tibiæ, they are relatively thicker than in the Ostrich and other known long-legged birds; and this character of strength is more marked in the smaller tibiæ. Of the eleven more or less complete tibiæ in the present collection six are nearly of the same size; four of these, *t* 3, *t* 4, *t* 8 and *t* 9 (Pl. XXV. & XXVI. fig. 2.), which are entire and average a length of fifteen inches and two-thirds, do not vary in length to the extent of one inch: the two shafts, *t* 5 and *t* 10, belonged to tibiæ of the same dimensions. The three tibiæ, *t* 1, *t* 2, *t* 6, which are double the dimensions of the foregoing, vary in length five inches, the shortest of the three (Pl. XXV. & XXVI. fig. 1.) being twenty-nine inches in length, the longest thirty-five inches, and the one with incomplete extremities, *t* 6, obviously being of intermediate length. The length of the second long shaft, *t* 7, must have been nearly midway between fifteen and thirty-four inches. The tibia, *t* 11 (Pl. XXV. & XXVI. fig. 5.), is not longer than that of the Great Bustard (*Otis tarda*).

Both this and the tibiæ *t* 3, *t* 4, *t* 8, *t* 9 have the characters of maturity as well marked as in the two largest tibiæ, but I shall at present limit the comparison between *t* 2 and *t* 4, as the respective representatives of the gigantic bones, and of the four tibiæ which present half their dimensions.

A reference to the subjoined table of admeasurements will show that *t* 4 (Pl. XXV. & XXVI. fig. 3.) is thicker in proportion to its length, has relatively broader proximal and distal extremities, and a longer ridge for the attachment of the fibula.

Tibia.	*t* 1.		*t* 2.		*t* 7.		*t* 4.		*t* 3.		*t* 8.		*t* 9.		*t* 11.	
	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.
Length	35	0	29	0	25[1]	0	16	3	15	6	15	4	15	4	8	9
Breadth of proximal end	7	6	6	2	0	0	4	6	4	5	0	0	0	0	2	0
Breadth of distal end	4	0	3	7	0	0	2	4	2	4	0	0	0	0	1	3
Circumference of middle	6	6	5	3	5	0	4	1	4	0	0	0	0	0	1	11
Fibular ridge extends down	13	0	12	0	0	0	7	0	6	10	0	0	0	0	3	6

The anterior ridge *c* at the proximal end of the bone is nearer the middle in *t* 4 than in *t* 2 (Pl. XXV. & XXVI. fig. 1.), the interspace between that and the external ridge being of the same breadth in both, notwithstanding the difference of total breadth. The external proximal ridge curves more abruptly outwards from the shaft of the bone in the small than in the large tibia, whereas the contrary character ought to have been manifested if the difference of size had depended on difference of age, such muscular ridges being more strongly produced in old than in young birds. The shaft of the bone is flatter antero-posteriorly, compared with its breadth, in the small than in the large tibia, and is more nearly triedral, owing to the greater flatness of the inner and anterior surface and the less rounding off of the inner margin. All the four tibiæ of from fifteen to sixteen inches in length correspond in these differential characters, when compared with either of the two gigantic tibiæ; and the two mutilated shafts of the smaller tibiæ equally differ in the subtriedral character from the mutilated shaft of the large tibiæ.

At the distal end of the bone, the angle formed by the posterior contour of the condyles is of a different form in *t* 2 (Pl. XXV. fig. 2.) and *t* 4 (Pl. XXV. fig. 4.): in the latter the outer condyle forms a greater proportional share of the articular surface, and the line of the inner one *g* extends more abruptly backwards.

All the shorter tibiæ, as before observed, present the characters of full maturity; the ridge for the fibula and those at the proximal end of the bone are quite as strongly developed as in the tibiæ of double the length.

In the tibia of a half-grown Ostrich I find the antero-external ridge, which in the adult projects strongly from the head of the bone, in the state of cartilage, the fibular ridge undeveloped, and both articular extremities in a state of epiphysis and incompletely ossified: the same conditions which influence, as has been already remarked, the tardy ossification in the Ostrich must have been still more operative in the Dinornis, in which the absence of air in the femur indicates as low a development of the respiratory system as in the Apteryx.

If this reasoning be admitted to establish the maturity of the bones *t* 3, *t* 4, *t* 8, *t* 9, it equally proves that of the tibia *t* 11 (Pl. XXV. & XXVI. fig. 5.), which bears the

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[1] According to the obvious proportions of the articular extremities when entire.

same proportion to the bone of sixteen inches in length, as this does to that of thirty-five inches. The tibia of eight inches and two-thirds in length, *t* 11, has its articular extremities as completely ossified and confluent with the shaft, and its proximal and fibular ridges as strongly developed, as in the larger tibiæ. The shape of its proximal articulation (Pl. XXVI. fig. 6.) differs more from that of *t* 4 than this does from that of *t* 2; the tibial half is broader from behind forwards than transversely; the anterior ridge at the proximal end is nearer the middle of the bone than in *t* 4, *à fortiori*, nearer than in *t* 2; the inner side of the bone is more rounded or less angular, especially at the proximal half of the shaft; the transverse diameter of the shaft is proportionally less than the antero-posterior one; the posterior notch between the distal condyles is deeper, and the inner condyle (Pl. XXV. fig. 6. *g*) is more compressed laterally, and is produced further backwards. There is no tarso-metatarsal to match the tibia *t* 11: this bone unequivocally establishes a fourth species of cursorial bird, which, from the agreement of the bone in its general characters with the tibiæ of the larger species, most probably belonged to the same genus, *Dinornis*, but did not surpass in size the Great Bustard (*Otis tarda*). I propose, therefore, to name the species to which it belonged, *Dinornis otidiformis*. n. sp.

The distal articular surface of the longest tibia, *t* 1, fits the proximal joint of the longest tarso-metatarsal, *m* 1. There is no tarso-metatarsal bone corresponding with the tibia *t* 2. This bone agrees more closely in its proportions and configuration with *t* 1 than with *t* 4: from the latter it is evidently specifically distinct, but less clearly so from the largest tibia. Yet the difference of size is sufficiently striking; too great, without other evidence, to justify the assumption that it depends on difference of sex; and the mature characters of the shorter bone *t* 2 militate against the supposition of a difference of age. At the proximal extremity the external ridge is relatively less produced but thicker and stronger in *t* 2, and the internal condyle or boundary is broader in *t* 2. In the next section we shall find that there are different-sized femora with equally mature characters which correspond respectively with *t* 1 and *t* 2. These considerations induce me to regard *t* 2 as indicative of a distinct species of Dinornis which must have stood about nine feet in height, and may be provisionally called '*Dinornis ingens*.'

The smallest tarso-metatarsal bones in the present collection, *m* 4, *m* 5, *m* 6, correspond precisely with the tibiæ *t* 3, *t* 4, *t* 8, *t* 9. The proportions of the shaft *t* 7 correspond with those of the intermediate metatarsal, *m* 3.

Femora. (Pl. XXI. XXII. XXIII. XXIV.)

The femur is remarkable for its great strength and the expansion of its extremities: the smallest diameter of the shaft is one-seventh the length of the entire bone. The trochanter *a* is unusually broad, thick and elevated; the distal extremity is still more remarkable for its great size, and especially for the breadth of its rotular concavity *d*.

The shaft is rounded, not compressed and subtriedral as in the Ostrich: in no bird are the muscular ridges and tuberosities so strongly developed on the posterior part of the shaft: the orifice of the medullary artery is at the middle of this surface. The popliteal space is deeply excavated. There is a rough deep oval depression at the upper and back part of the outer condyle. In only one out of eighteen femora are the parietes of the bone deficient at the part where the air is admitted into the interior of the shaft in the Ostrich, Emeu, Rhea, and Cassowary; but in the exceptional instance cited (Pl. XXIX. fig. 1.) the cavity *h* does not lead to the interior of the bone, and may be due to accidental fracture, as there is a similar opening on the opposite side. In all the other femora of the Dinornis the parietes at the back part of the proximal extremity of the bone are entire, as in the Apteryx; and both the weight and cancellous structure of these bones prove the accuracy of the statement made in the description of the original fragment, that the Dinornis retains the medullary contents of the cavities of the femur throughout life, as in the Apteryx, which is the only other known example of a terrestrial bird in which the air is not admitted into any of the bones of the extremities.

The absence of the air-hole and air-canal, the great thickness of the dense bony wall of the medullary cavity of the shaft[1], the tuberosities on the back part of the shaft, the great size of the distal end of the femur, and especially the great breadth of the rotular cavity, constitute the chief generic characters of this bone in the Dinornis.

Dimensions of the Femora.

Femur.	*f* 1.	*f* 2.	*f* 3.	*f* 12.	*f* 13.	*f* 6.	*f* 16.	*f* 8.	*f* 7.	*f* 17.	*f* 10.
	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.	In. Lin.
Length	16[2] 0	13 0	13[2] 0	11 0	9 6	9 4	9 6	8 0	8 0	8 1	0 0
Breadth of proximal end (in the axis of the neck)	0 0	4 10	0 0	4 2	3 5	3 6	3 6	2 10	3 0	3 3	0 0
Breadth (transverse) of distal end	0 0	5 2	0 0	4 3	3 9	3 7	3 7	3 3	3 2	3 6	0 0
Circumference of middle .	7 3	6 1	6 0	5 6	5 1	4 1	4 3	4 0	4 0	4 3	2 1

Of the eighteen femora transmitted to England, eleven of which are more or less complete, and the dimensions of most given in the subjoined table, there is a more regular gradation of size than in the tibiæ and metatarsi; and, as the table demonstrates, a greater correspondence in their general proportions.

Nevertheless it is obvious that there is a similarity of size in a certain number, which, if the maturity of the bones be granted, must therefore indicate particular species. Thus, whether we glance at the series of the bones themselves, or on the table of admeasurements, we have no hesitation in grouping together *f* 6 and *f* 16, the length of which ranges between 9⅓ inches and 9½ inches: *f* 13, though similar in length, is obviously a

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[1] Compare fig. 1 with fig. 2 in Pl. XXIX.

[2] According to the obvious proportions of the articular extremities if entire.

thicker and stronger bone, and yet has more signs of immaturity. We in like manner associate together *f* 7, *f* 8, *f* 17, as not varying beyond a line from the length of eight inches.

In the first four femora, *f* 1, *f* 2, *f* 3, *f* 12, enumerated in the table, there is a more regular gradation of size. The left femur, *f* 12, is eleven inches, and the shaft of a right femur, *f* 4, so precisely corresponds in circumference and other proportions as to leave no doubt as to their similarity in length, and render it highly probable that they belonged to the same bird. The femora *f* 2 and *f* 3 were thirteen inches in length; and the shaft *f* 1 indicates a femur of at least sixteen inches in length.

In an Ostrich the circumference of the femur, of the tibia, and of the metatarsus is respectively five inches three lines, four inches three lines, and three inches seven lines. In an Emeu the circumference of the same bones is respectively three inches seven lines, three inches four lines, and three inches.

From these analogies we may conclude that the shaft of the femur *f* 1, with a circumference of seven inches and three lines, may have belonged to a Dinornis with the largest tibia whose circumference is six inches six lines, and with the tarso-metatarsal bone whose circumference is five inches six lines, the proportionate thicknesses of these bones to each other being intermediate in their degrees to those presented by the same bones in the Ostrich and the Emeu. It must be remembered that the relative length of the femur and metatarsus is very different in the Dinornis from that in existing *Struthionidæ*, the Apteryx excepted; but, according to the above collocation of the femur, tibia and tarso-metatarsus of the largest *Dinornis*, the tarso-metatarsus exceeds the femur in length by 2½ inches in this species, which I have named *Dinornis giganteus*. The femur *f* 2 presents a similar correspondence with the tibia *t* 2; but its excess of length over the tarso-metatarsus *m* 3 renders it very improbable that they could belong to the same species, especially when the difference in their circumference is added, that of the femur being six inches one line, that of the metatarsus four inches three lines; besides, the distal articulation of the tibia *t* 2 is obviously too large for the articulation of the metatarsus *m* 3. The femur *f* 12 offers the required correspondence with the metatarsus *m* 3 of the *Dinornis struthoides*, which exceeds the length of that femur by one inch, and is consequently but a little shorter in proportion than in the largest species.

The tarso-metatarsus is proportionally still shorter in the third species (*Dinornis didiformis*), to which I refer the femora *f* 7, *f* 8, *f* 17, the tibiæ *t* 3, *t* 4, *t* 5, *t* 8, *t* 9, *t* 10, and the tarso-metatarsal bones *m* 4, *m* 5, *m* 6. The tibia, according to this allocation, being, like that of the gigantic Dinornis, little more than twice the length of the femur, we may with great probability associate the shaft of the tibia, which, when restored, gives a length of twenty-five inches, with the femur of the *Dinornis struthoides* measuring eleven inches in length.

The proportions of the three principal bones of the leg in the Ostrich, the Emeu, the

Apteryx and the three species of *Dinornis*, as above restored, are given in the subjoined table.

	Ostrich.		Emeu.		Apteryx.		*D. giganteus*[1].		*D. struthoides*[2].		*D. didiformis*[3].	
							f 1.		*f* 12.		*f* 8.	
	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.
Length of femur ……	11	0	9	0	3	9	16	0	11	0	8	0
Circumference of ditto. .	5	3	3	7	1	0	7	3	4	2	4	0
							t 1.		*t* 7.		*t* 4.	
Length of tibia.	18	6	16	10	5	3	35	0	25	0	16	3
Circumference of ditto. .	4	3	3	4	1	3	6	6	5	0	4	1
							m 1.		*m* 3.		*m* 5.	
Length of metatarsus . .	16	0	15	0	3	3	18	6	12	0	7	0
Circumference of ditto. .	3	7	3	0	0	0	5	6	4	3	3	6

It will be seen that in these three species of Dinornis the united lengths of the femur and metatarsus equal or nearly equal that of the tibia, and that the metatarsus is relatively shorter and thicker as the species decrease in size.

The femur *f* 2 and the tibia *t* 2 of the *Dinornis ingens* have no metatarsus to match them in the present collection: such a metatarsus should be fifteen inches in length. Whether the *Dinornis* with a hind-leg of these proportions be actually a distinct species from the *Dinornis giganteus*, or a smaller individual on account of age or sex, is a question which, though the present evidence induces me to answer in the affirmative, I should be glad to see confirmed by additional specimens.

With respect to the smaller femora, especially those numbered *f* 7, *f* 8, *f* 17, if they had belonged to the young birds of the larger species, their nonage would unquestionably have been indicated by the characters of the bones. The femur of a young Ostrich, bearing the same proportion to that of the adult which *f* 7 bears to *f* 12, has the whole upper surface of the proximal end and all the distal articulation covered with thick cartilage, and the line of the terminal epiphysis is conspicuous, although the uniting ossification has commenced; the trochanterian ridge is rounded off; the surface of the shaft of the bone is smooth; the muscular ridges quite undeveloped. In the small femora of the Dinornis, *f* 7, *f* 8, *f* 17, no trace of the separation of the terminal epiphyses remains; the sculpturing of the articular surfaces is sharp and bold; every ridge and tuberosity indicative of muscular action is as strongly developed as in the largest femora.

The same characters establish the maturity of the femora *f* 6 and *f* 16; *f* 13 has the muscular ridges and prominences less strongly developed. There are no tibiæ or metatarsi which, upon the analogies and proportions adopted for the collocation of the principal bones of the leg in the *Dinornithes giganteus*, *ingens*, *struthoides* and *didiformis*, can be assigned to these femora. Regarding which, therefore, it is first to be inquired whether they belong to immature individuals of *Dinornis struthoides* or to a distinct sex

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[1] Pl. XXX. fig. 1.

[2] Ib. fig. 2.

[3] Ib. fig. 4.

of *Dinornis didiformis*, characterized by superiority of size, or to a distinct species of Dinornis.

Comparing the femora *f* 6, *f* 13 (Pl. XXIII. fig. 1.) and *f* 16 (*Ib.* fig. 2.) with each other, it was obvious that one of them differed in its proportions from the rest, *f* 13 being relatively thicker, as is shown in the plate and in the table of admeasurements. This femur corresponded much more closely with the femur *f* 12 (Pl. XXI. fig. 3.) in its general form, its ridges and tuberosities; but these were less strongly developed, and the manner and extent of abrasion of both proximal and distal articular surfaces would well accord with the supposition of their having been in that cartilaginous or less completely ossified state which characterizes the femur of a bird not quite fully arrived at maturity. The state of development of the muscular ridges and tuberosities forbids the reference of this femur to a very young bird, but supports the conclusion that the bone had belonged to an individual as far advanced in growth as is indicated by the difference in size between it and the femur *f* 12.

The different condition and proportions of the two remaining femora, of 9½ inches in length, *f* 6 and *f* 16, establish their specific distinctions from the femora *f* 13, *f* 12 and *f* 2. Of this I think no doubt can be entertained by any anatomical naturalist who may inspect the plate (Pl. XXIII.) containing the figures of *f* 13 and *f* 16, selected for the comparison, or who may give due consideration to the following statement of their differential characters.

These bones are of equal length but of unequal thickness: the shape of the shaft of the bone is also different; the relative antero-posterior diameter of *f* 13 is much greater than that of *f* 16, especially at the proximal end and trochanterial enlargement of the shaft, and just above the inner condyle: the anterior surface of the proximal part of the shaft presents a shallow equable concavity in *f* 16 which is not present in *f* 13. In *f* 16 a pretty sharp ridge leads from the middle of the posterior surface of the shaft obliquely to the upper and posterior angle of the inner condyle, and the posterior surface of the expanded shaft above the condyles is regularly excavated by a moderate concavity which is continued uninterruptedly into the inter-condyloid depression. In *f* 13 an oblong rough tuberosity, with its long axis parallel with that of the bone, exists in the place where we find the oblique ridge in the other bone, the tuberosity being separated from the upper and posterior angle of the inner condyle by a smooth channel or depression, which leads to an oval depression much deeper and more circumscribed than is the corresponding concavity in *f* 16. The complete development of the muscular ridges and tuberosities, with the better preserved state of the articular extremities, show the femur *f* 16 to be a more mature bone than *f* 13; the differences in proportion and configuration prove it to belong to a distinct species from *Dinornis struthoides*.

We next come to the question whether the femora *f* 6 and *f* 16 belong to the species *Dinornis didiformis*, founded on the femora *f* 7, *f* 8, *f* 17, the tibia *t* 3, *t* 4, *t* 5, *t* 8, *t* 9, *t* 10, and the metatarsi *m* 4, *m* 5 and *m* 6, and whether the femora *f* 6 and *f* 16 represent a sexual superiority of size, or are specifically distinct from the shorter femora.

If the discrepancy of the thickness of the shaft as compared with the length of the bone be sufficiently obvious in femora of equal length, like *f* 13 and *f* 16 (Pl. XXIII.), it becomes still more striking when the more robust proportions are exhibited in a femur of shorter size, which is one of the first differences that strike the eye in comparing *f* 6 and *f* 16 (Pl. XXII.) with *f* 7, *f* 8 and *f* 17 (Pl. XXIV.). The table of admeasurements shows that the femur *f* 17, which is one inch and five lines shorter than the femur *f* 16, has very nearly an equal circumference of the middle of the shaft, and a quite equal breadth of the distal end, the antero-posterior diameter of the condyles being also the same in both. If the comparison of these two femora be pursued into further details, it is seen that the anterior margin of the great trochanter is more produced but narrower in *f* 16 than in *f* 17, that the anterior surface of the shaft is more convex, and that the anterior curve of the outer condyle is shorter in the longer femur: the antero-posterior diameter of the great trochanter and of the shaft, especially of that part leading to the outer condyle, is less in the longer femur. With regard to the configuration of the popliteal space, the same differences exist between *f* 16 and *f* 17 as have been already pointed out between *f* 16 and *f* 13, viz. a circumscribed tuberosity (*d*, fig. 2. Pl. XXIV.) in place of a continuous ridge (*d*, fig. 2. Pl. XXII.), a deeper and smaller instead of a shallower and larger concavity, &c.

In regard to the relation of these differences to sex, it is to be observed, that the male Ostrich slightly exceeds the female in size, and the difference between the two sexes of the Apteryx is relatively greater, yet the femora and other bones of the leg do not differ at all in proportions or configuration, but only in size, corresponding in degree with the rest of the body. I am not, indeed, aware of a single fact in the osteology of existing birds which would justify the conclusion that the differences presented by the femur *f* 16, as compared with *f* 17, were merely sexual. It has already been shown that the differences between *f* 16, as compared with the femora *f* 13 and *f* 12, cannot depend upon nonage, and, *à fortiori*, the femur *f* 16 cannot be regarded as belonging to a young individual of the gigantic species: there remains then only the conclusion that it must represent a fifth distinct species, of which there are neither tibiæ nor metatarsi in the present collection. I venture to surmise that the tibia, and especially the tarso-metatarsus of this species, will be found relatively longer and more slender than in the *Dinornithes struthoides* and *didiformis*: so much may be anticipated from the more slender proportions of the femur, which, moreover, resembles the femur of the Emeu in some of the characters by which it differs from the above species of Dinornis, viz. in the sharper anterior border of the great trochanter, the more equable and deeper concavity between this border and the head of the femur, and in the uninterrupted ridge leading from the middle of the back part of the bone to the inner condyle. The generic characters of Dinornis are, however, manifested in the absence of the air-hole and air-cavity of the femur, the greater robustness of the bone in this the least robust of the genus, the much higher trochanter, the much wider distal extremity, and especially the wider and shallower cavity for the patella. From the equality of size of this femur with that of the Emeu, the species which it indicates may be termed *Dinornis dromæoides.* n. sp.

Pelvis. (Plates XIX. XX. & XX *a.*)

The first portion of the pelvis here described consists of twelve anterior anchylosed vertebræ of the sacrum, with a portion of the right ilium and acetabulum (Pl. XIX. fig. 1.). Of the size of this fine fragment an idea will be given by the subjoined table of its dimensions, compared with those in a full-sized Ostrich.

	Dinornis, p 1.		*Struthio.*	
	In.	Lin.	In.	Lin.
Height of the first sacral vertebra	6	10	4	6
Breadth of the articular surface of the body of ditto	3	4	1	8
Breadth of the seventh sacral vertebra	3	3	1	3
Length of the first seven sacral vertebræ	6	6	6	9

The last admeasurement shows that the anterior part of the sacrum, including the first series of vertebræ provided with double transverse processes on each side[1], is shorter in proportion to its height and breadth compared with the Ostrich; and these proportions are shown to characterize the entire pelvis by the smaller specimen, subsequently to be described. The under surfaces of the first seven vertebræ are flattened, and form a smooth and slightly concave platform in the remaining four. The inferior transverse processes pass out horizontally to the lower border of the ilium, which descends to the level of the under surface of the bodies of the sacral vertebræ. In the Ostrich they ascend obliquely upwards to join the upper transverse processes, before abutting against the lower border of the ilium, which does not descend so low as the bodies of the vertebræ.

In the Ostrich the first two inferior transverse processes of the sacrum retain their primitive condition of detached ribs, and three transverse processes succeed them before the commencement of the os pubis. In the great Dinornis the second sacral rib is anchylosed as a transverse process, and four other processes succeed this before the one which abuts against the beginning of the pubis: this is much thicker and stronger than the preceding ones, and it is succeeded by four confluent sacral vertebræ, which have no lower transverse processes. In the Ostrich the transverse processes of the sixth sacral vertebra abut against the part of the innominatum from which the pubis is continued, and the transverse processes of the four succeeding vertebræ abut against the origin of the ischium, parallel with the lower part of the acetabulum; then a single vertebra without a lower transverse process or sacral rib intervenes before these are again developed, to abut against the posterior part of the acetabulum.

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[1] See description of the sacrum in Birds, in the 'Cyclopædia of Anatomy,' art. Aves, p. 271.

The four ribless sacral vertebræ, which in the Dinornis are interposed between those which send their anchylosed ribs to abut upon the os innominatum anterior to the acetabulum, and those which strengthen in like manner the posterior part of the acetabulum, are very short; their bodies have coalesced into a single mass of bone, smooth and flattened below, rounded at the sides, and only recognizable as distinct bones by the orifices for the nerves at the sides of the anchylosed mass: these orifices are double, as in the sacrum of other birds[1], the two roots of the nerves escaping separately, the motor root issuing by the lower, the sensitive root by the upper orifice.

The upper transverse process of the first sacral vertebra is a broad and thick piece of bone, extending from the body and anterior articular process of the vertebra, and having a deep and smooth excavation at its anterior part: in the Ostrich the corresponding part is much smaller and is reticulated by the bars of bone dividing the orifices by which the air is admitted into the interior of the vertebra.

I shall not swell the extent of the present paper by pursuing farther the description of the structure of the pelvis of the Dinornis, as exhibited in the present striking fragment, but proceed to notice the other specimens of pelvic bones which have been enumerated as forming parts of the present collection.

The large portion of the right os innominatum, including the entire acetabulum (Pl. XX. fig. 1.), must have belonged to a bird of rather smaller size than the one to which the above-described portion of the sacrum belonged. The part of the ilium before and above the acetabulum rises with a steep slope and a slight general concavity to meet its fellow above the spinous crest of the anterior part of the sacrum: behind the acetabulum the outer surface of the ilium is divided into two facets, the upper one nearly horizontal, the lower one vertical, save where it arches out to the flat articular surface behind the acetabulum. The ridge dividing these two facets commences anteriorly above the middle of the acetabulum, and describes a regular curve in its course backwards, the convexity being downwards: in the Ostrich the corresponding ridge forms two curves, meeting at an angle above the prominent articular surface behind the acetabulum, and the convexity of both curves is upwards; from the angle an obsolete ridge extends down to the prominent articulation, and divides the anterior from the posterior vertically concave surfaces of the ilium: in the great Dinornis the corresponding surfaces are uninterruptedly continuous above the acetabular prominence. The posterior wall of the acetabulum (*f*) is incomplete, as in other birds; the smooth articular surface is continued upon an oblong prominence above and behind the cavity. The pubis (*d*), a slender bone, as usual in Birds, springs from a protuberance at the lower part of the acetabulum. The ischium (*e*) is continued more directly from the lower and back part of the cavity: a very slight ridge indicates the posterior boundary of the notch for the tendon of the obturator internus, and the upper border of the notch

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[1] Cyclop. of Anat., art. Aves, p. 271. The Ostrich is the only exception to this rule with which I am acquainted.

is nearly straight. In the Ostrich this part is concave, and a well-developed process extends down, but does not join the pubis at the back part of the obturator notch. The Apteryx resembles the great Dinornis in this part of the pelvis. The ischium becomes compressed and gradually expands vertically as it extends backwards, its lower margin forming almost a straight line. In the Ostrich the ischium maintains its triedral form for a much longer extent and suddenly expands, the lower margin curving down to join the pubis (Pl. XIX. fig. 4. *e*) : there is no indication of such a junction in the present specimen, nor does the superincumbent ilium curve down, as in the Bustard, to join the ischium: both the ischiadic and the obturator notches seem to have been unclosed by bone in the Dinornis as in the Apteryx.

The third specimen of the pelvis of a Dinornis, *p* 4 (Pl. XIX. fig. 2. & Pl. XX. figs. 2 & 3.), is more entire, but much smaller than the foregoing. It seems to include all the sacral vertebræ, which are eighteen in number: seven anterior ones with the lower transverse processes, four without those processes, and seven in which they reappear, extending obliquely outwards and backwards to the line of junction of the ilia with the broad posterior part of the sacrum. The most important feature in the present pelvis is the demonstration of what was obscurely indicated in the foregoing specimen, viz. that the ilia do not, as in existing Struthious birds, including the Apteryx, approximate one another along the whole length of the sharp and narrow ridge formed by the spines of the sacrum, but that they diverge above the acetabula, to give place to a broad horizontal expanse of bone developed from the posterior sacral spines (Pl. XX. fig. 3. *b*), as in the Bustard and most other birds. This surface forms a smooth shallow concavity, perforated as usual by two lateral series of small foramina. From the pelvis of the Bustard that of the Dinornis differs in the greater relative depth and verticality of the anterior plates of the ilia, which meet above to form a ridge, as in the existing *Struthionidæ*: the posterior expanded part of the pelvis is relatively shorter than in the Bustard, and the difference is extreme which this part of the pelvis of the Dinornis presents, as compared with that of the Apteryx[1], the Ostrich, the Emeu, and *à fortiori* the Rhea, in which the ischiadic bones meet, and are united for a considerable extent below the posterior part of the sacrum, which there becomes almost obliterated.

The acetabula are relatively nearer to each other than in the Bustard, but farther apart than in the Ostrich, Emeu, and relatively than in the Apteryx. There is likewise another difference in the relative position of the acetabula as compared with the Ostrich: in this bird those cavities are so situated that their posterior wide orifice exposes to view the neural arches and spinous processes of the intervening sacral vertebræ. In the Dinornis only the lower part of the bodies of the corresponding vertebræ are seen by looking directly into the acetabulum (Pl. XX. fig. 2. *f*), and below these we have the open cavity of the pelvis: the Apteryx and Emeu resemble the Dinornis in this respect: nothing but the cavity of the pelvis is seen on looking directly through the acetabula

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[1] See Zool. Trans. vol. ii. p. 291.

in the Bustard. The body of the third sacral vertebra is carinate below in the Bustard, and none of the vertebræ abut by their transverse processes against the anterior part of the acetabulum.

The smaller pelvis of the Dinornis, *p* 4, when compared with the portions of the larger pelves, *p* 1, *p* 2, presents so many differences besides those of size as to leave no doubt about the specific distinction of the birds to which they belonged.

The first sacral vertebra in the smaller pelvis (Pl. XX. fig. 2.) has a narrower and deeper body, and there is not the deep excavation on the anterior part of the upper transverse process: I do not lay much stress on the fact that the lower transverse processes of the first two sacral vertebræ retain the condition of ribs articulated to depressions at the upper part of the intervertebral spaces (*ib. a*); but every other part of the present pelvis manifests the characters of maturity. These ribs, as well as their anchylosed analogues, the transverse processes which succeed them, come off higher up than in the large pelvis. The lower border of the ilium is thin, and does not form a broad convex surface, increasing the width of the pelvis anterior to the acetabulum, as in the large Dinornis: the four inter-acetabular vertebræ without inferior transverse processes (*ib. b*) are carinate along their under surface, not flattened as in the great Dinornis. The upper facet of the posterior part of the ilium is more horizontal, and forms a right angle with the vertical facet (Pl. XX. fig. 2. *c*): this is also divided from the anterior concave wall of the ilium, as in the Ostrich, by an angle formed by an obsolete ridge: the articular prominence behind the acetabulum is relatively longer in the axis of the pelvis, but less deep in the smaller species. The root of the ischium where it forms the upper part of the obturator notch is concave, and an angular process descends towards the pubis, forming a well-marked posterior boundary to the notch. In this character the smaller pelvis more resembles the pelvis of the Emeu than does that of the larger one; but the ischial process does not quite reach, as in the Emeu, the pubic bone. The ischium resembles, in its gradual expansion and straight direction, that of the larger species, and the more perfect condition of the smaller pelvis proves that the extremity of this bone (*ib. e*) projects freely backwards, as in the Apteryx and Emeu.

The portion of a somewhat smaller pelvis, *p* 5 (Pl. XIX. fig. 3. Pl. XX. fig. 4.), than the preceding is less complete, but manifests characters which prove it to belong to a distinct species of Dinornis, and apparently to an older bird, since the second sacral rib on the left side is anchylosed to the vertebral interspace. This anchylosis sufficiently demonstrates that the smaller pelvis is not of a younger bird than the larger one; and, besides the difference of size, there are the following differences of configuration:—In the smaller pelvis the second and third sacral ribs arise nearer the lower surface of the bodies of the vertebræ, a character by which the smallest pelvis approximates the largest one, from which it differs, in having the bodies of these vertebræ relatively less broad and flat. The extent occupied by the four posterior orifices forming the interspaces of the lower transverse processes of the third to the seventh sacral vertebræ inclusive, is three lines greater in the smallest pelvis, *p* 5, than in the one next in the order of size, *p* 4. The bodies of the four vertebræ without lower transverse processes (*b*) are flatter below in the smallest pelvis than in *p* 4. The vacuity at the sides of these vertebræ, into which the posterior aperture of the acetabulum opens, is relatively much smaller in the *p* 5 than in *p* 4; but the two transverse processes of the twelfth and thirteenth vertebræ which abut against the posterior part of the acetabulum are absolutely much thicker in *p* 5 than in *p* 4. For example, the first of these transverse processes in the larger pelvis *p* 4 is one inch seven lines long and one and a half line broad: in the smaller pelvis it is ten lines long and four lines broad. Such differences are not manifested in the pelvis of individuals of the same species in other birds: they are associated in the present instances with minor differences in the shape of the acetabulum, especially of its posterior and inferior border, and in the relative breadth of the bodies of the posterior sacral vertebræ; the latter, however, might be a sexual difference. Seventeen of the sacral vertebræ are preserved in the specimen *p* 5, and the expanded spinous plate of the posterior ones is more perfectly preserved than in the preceding specimen, *p* 4. The following are some of the dimensions of *p* 4 and *p* 5, compared with those of the pelvis of an Emeu:—

	Dinornis, p 4.		*Dinornis, p* 5.		*Dromaius.*	
	In.	Lin.	In.	Lin.	In.	Lin.
Length of the pelvis	11	0	9	6	15	6
Greatest breadth at post-acetabular protuberance	6	9	5	10	4	0
——— depth at the origin of pubic bones	5	6	5	0	5	0
Breadth of the pelvis at the posterior part of the ilia	3	6	0	0	1	9

After a summary of the characters which the different pelves of the Dinornis present in common, it is obvious that the genus recedes furthest from the Struthious type and makes the nearest approach to the tridactyle *Grallæ* in the structure of this part of the skeleton.

There remains to be determined, to which of the species of Dinornis already established by the bones of the leg, the three specifically-distinct pelves are to be referred. We cannot take the relative lengths of the pelves and femora of existing *Struthionidæ* as a guide, on account of the disproportionate length of the pelvis in them as compared with the Dinornis. The pelvis of the Bustard is also relatively longer than in the Dinornis. The size of the acetabulum is not so good a guide as in Mammalia, because it is always relatively larger than the head of the femur in Birds: thus, although the acetabulum in the portion of the pelvis *p* 2 is larger than the head of the entire femur *f* 2, the size of the post-acetabular articular prominence corresponds sufficiently closely with the articular surface upon the neck and trochanterian enlargement of that femur to render it probable that they belonged to the same species, if not individual. The fragment of the huge pelvis *p* 1 might well have belonged to a Dinornis of the largest stature. The two remaining specimens of pelvis are too small to be adapted to the femur *f* 12, but of the species indicated by that and the tarso-metatarsal bone *m* 3, there appears to be a small portion of a pelvis in the present collection.

This is a part of the right os innominatum, *p* 3 (Pl. XX. fig. 5.), including the posterior and inferior angle of the acetabulum, the origins of the pubis and ischium, which form the obturator notch, and a fractured continuation of the latter bone. The fragment has belonged to a pelvis intermediate in size between *p* 2 and *p* 4, but is nearer the former. From this it differs in the concavity of the upper boundary of the ischiadic notch, and the descending process forming its posterior boundary which almost touches the pubis. The posterior margin of the wall of the acetabulum is straight, and ascends at a right angle with the horizontal ischium. In the larger pelvis, *p* 2, as in the smaller one, *p* 4, this margin curves back at less than a right angle. The ischium is thinner and less convex internally.

The pelvis *p* 4 agrees in the proportions of its acetabula and the form of the posterior articular protuberance with the femora of *Dinornis dromæoides*; and the smaller pelvis *p* 5 offers the same correspondence with the femora of the *Dinornis didiformis*.

If a species of *Dinornis* intermediate in size between the *D. struthoides* and *D. didiformis* had not been indicated by the femora *f* 6 and *f* 16, I must have been led to the same conclusion by the two pelves, *p* 4 and *p* 5, as to the existence of such a species.

Since the foregoing description of the pelvic bones was put into type I have been favoured by William Cotton, Esq., F.R.S., with the view of some specimens of the bones of the Dinornis, very recently transmitted by his son the Rev. Wm. Cotton, M.A., from New Zealand, one of which is a fractured pelvis[1], corresponding in length and in so many other characters with *p* 5, as to lead to the conclusion that it belongs to the same species, and that the differences between them are attributable to sex.

These differences are the following. The bodies of the first two sacral vertebræ in Mr. Cotton's specimen, which I shall call *p* 6, are flatter on their under surface and broader; the form of the anterior articular surface of the first sacral vertebra more nearly resembles that in the largest fragment, *p* 1. The spines of the seven anterior vertebræ and the co-ascending plates of the iliac bones are less elevated in *p* 6. Thus, from the end of the transverse process of the sixth sacral vertebra to the summit of the ilium in *p* 5, is three inches ten lines, whilst in *p* 6 it is only two inches nine lines. The length of the part of the pelvis formed by the first seven sacral vertebræ is precisely the same in both. But whilst the height of *p* 5 is greater its breadth is rather less, especially immediately behind the acetabulum. The expanded horizontal thin plate of bone at the back part of the pelvis, between the diverging iliac bones, is well preserved in Mr. Cotton's specimen.

The breadth of this at the back part of the acetabula is five inches five lines; the breadth at the hinder end of the pelvis is three inches nine lines.

Of the two pelves which correspond in length and in most of the characters by which the one first described differs from *p* 4, we may regard the higher and narrower specimen, *p* 5, as belonging to the male, and the lower and broader one, *p* 6, to the female.

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[1] Pl. XX *a*. fig. 1.

Vertebræ. (Plates XVII. & XVIII.)

Of the five vertebræ in the present collection, only one is of a size which surpasses in a marked degree that of the corresponding vertebra in a full-grown Ostrich ; but all present much stronger proportions, especially of the spinous process, which is unusually robust. The largest vertebra[1], *v* 1, is a cervical one, probably from below the middle of the neck, anterior to those which are distinguished by a median inferior spine.

The following are its dimensions as compared with the twelfth cervical of a full-sized Ostrich :—

	Dinornis.		*Struthio.*	
	In.	Lin.	In.	Lin.
Length, at the middle of the terminal articular surfaces .	2	9	2	2
Breadth, at the middle of the body	1	6		8
Height of the middle of the body	1	1		8
Height from anterior base of spine to the lower part of the anterior articular surface	1	8	1	0
Length of the neural arch	1	9	1	5
Breadth of do.	1	7	0	11

Every process and prominence of this specimen of the vertebræ of the Dinornis is broken off, with the exception of the right posterior oblique process. The texture everywhere presents large reticulate cancelli, which communicate with the outer surface by an orifice on each side the neural arch, behind the upper transverse process.

The body of the vertebra is square-shaped, with a broad and flat, or slightly concave under surface : the anterior part of this surface is divided from the anterior articular surface by a transverse channel, that surface being raised to a higher level. This structure does not exist in the corresponding vertebræ of the Ostrich : it is slightly indicated in those of the Apteryx. The spinal canal presents the usual infundibular expansion at both extremities : it is not larger at its middle contracted part than in the Ostrich. The remains of the base of the spinous process show this to have been almost square-shaped, and much thicker relatively as well as absolutely than in the Ostrich.

Two other vertebræ belong to the base of the neck, and correspond with those few cervical vertebræ at that part which, in most birds, have a median inferior process for the more advantageous origin of the great *longus colli anticus* muscle[2]. These two vertebræ must have come from the same or from closely contiguous parts of the neck ; but they present differences of configuration and proportion which prove that they have not belonged to the same species of Dinornis.

Both manifest the generic massive proportions, the squareness of the body, the great

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[1] Pl. XVII. figs. 1, 2, 3.

[2] None of the cervical vertebræ present this character in the Ostrich or Emeu, but we find it in the last cervical of the Rhea, and in the last three cervicals of the Apteryx and Bustard.

breadth of its under surface, and the thick four-sided spinous process; but one (*v* 2)[1] is broader in proportion to its length than the other (*v* 3). The more slender vertebra[2] has a thicker spinous process, which, at the same time, is more compressed from behind forwards: the cavity behind the spine is deeper and more angular, as is also the notch between the posterior oblique processes. The anterior articular processes are raised higher above the body in the more robust vertebra, *v* 2. The anterior articular surface of the vertebra *v* 3 has a much less vertical extent than in the thicker vertebra; and the inferior spine (*h*) is narrower, but of greater antero-posterior extent, and is situated nearer the posterior part of the body. Both these vertebræ have the orifices at the sides of the neural arch which communicate with the interior loose cancellous structure. These are not present in the Apteryx, the corresponding vertebræ of which in other respects more nearly resemble the present in general form and proportions[3] than do those of the other existing *Struthionidæ*.

The vertebra *v* 4,[4] from New Zealand, transmitted to me by Dr. Richardson, the author of the 'Fauna Boreali-americana,' belongs to the same species as the vertebra *v* 2. It is either the first or second of the dorsal series: the inferior transverse processes manifest part of the concavity for the articulation of the head of the rib, and there is a spinous process (*h*) from the under surface of the body of the vertebra, which, as in the anterior dorsal of the Apteryx, is less broad and flattened than in the anterior cervicals.

Of the difference of the character of this vertebra, as compared with the corresponding one in the Ostrich, the figures[5] give a better idea than can be conveyed by verbal description. The upper transverse processes are continued, as in the first and second dorsals of the Apteryx, from the anterior part of the whole side of the neural arch, not, as in the Ostrich, from near the summit; these processes also, as well as the spinous process, are considerably thicker and stronger than in the Ostrich. In regard to the spinous process, the Dinornis, in the squareness of that part, differs as much from the Apteryx, in which the dorsal spines are compressed laterally and extended antero-posteriorly, as from the Ostrich.

The last vertebra, *v* 5, of the Dinornis in the present collection that remains to be noticed, is from the middle of the dorsal region: it belongs to a smaller species than the preceding; most probably to the *Din. didiformis.*

The body[6] is laterally compressed, and terminates below in a median carina, which has a concave outline: it has the characteristic shortness as compared with the breadth of the vertebræ in this genus; the anterior articular surface[7] is more concave from side to side, and the posterior surface more convex in the same direction than in the corresponding vertebræ of the Ostrich or Apteryx: both these surfaces have an unusual vertical diameter in proportion to their breadth.

[1] Pl. XVII. figs. 4, 5, 6

[2] Pl. XVII. figs. 7, 8, 9.

[3] Pl. XVII. fig. 10.

[4] Pl. XVIII. figs. 1, 2, 3.

[5] Pl. XVIII. figs. 3 & 4.

[6] Pl. XVIII. figs. 6 & 9.

[7] Pl. XVIII. fig. 8.

The following are comparative admeasurements of this vertebra, and a corresponding one of a full-grown Ostrich :—

	Dinornis.		*Struthio.*	
	In.	Lin.	In.	Lin.
Length	1	9	2	0
Depth of anterior articular surface	1	0	0	7½
Breadth, including costal articulations	1	6	2	0
From the lower margin of posterior articular surface to the upper one of posterior oblique process	2	1	1	8

The spinous process of this vertebra is strong and square-shaped[1], and shows, like the preceding dorsal, that there was no blending together of the spines, nor any union by continuous splint-like ossifications, as in many birds, and especially in those that fly. The dorsal region in the skeleton of the Dinornis, by the intervals separating the spinous processes, must have resembled that in the large existing *Struthionidæ*, and have differed from the same part in the Apteryx, in which the dorsal spines are contiguous though not confluent; but the Dinornis surpassed all known birds in the thickness and squareness of its upright spinous processes. Of the length of these processes none of the five vertebræ afford an exact idea, all being more or less fractured.

The spinal canal is proportionally more contracted than in the Ostrich, or even in the Apteryx, where it is rather smaller than usual. This character in the Dinornis indicates, of course, a more slender spinal chord, in which respect it betrays a closer approach to the Reptilia. We may associate, with such a condition of the spinal marrow, less delicate perception, and less energetic muscular action; and the vertebræ thus confirm the induction from the texture of the femur, that the Dinornis was a more sluggish or less active bird than the Ostrich.

CONCLUSION.

Physiological indications of the nature and proportions of the Anterior or Pectoral Members.

Had the Dinornis wings? To this question I was led to give a negative reply after the examination of the first fragment of that bird's bone which came into my hands[2]. It has appeared strange and almost incredible to some, that the cancellous texture of the shaft of a thigh-bone should give, to speak mathematically, the presence or absence of wings. But if the negative had been premature and unfounded, a guess rather than a demonstration, its fallacy might have been exposed by the very next bone of a Dinornis transmitted from New Zealand. A bird of flight has as many wings as legs; it has two humeri as well as two femora, two radii as well as two tibiæ, two ulnæ as well as

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[1] Pl. XVIII. fig. 7.

[2] Absence of the organs of flight is the essential character of a Struthious bird, more especially of one "heavier than the Ostrich."

two fibulæ; the humerus and radius are usually, and the ulna is always, longer and larger than their analogues in the hind extremities; then also there are the two distinct carpal bones, a metacarpus and characteristically modified phalanges. The chances were thus greater that the next bone of an extremity discovered in the alluvium of New Zealand would have been one of the anterior members, had these been developed to serve as wings in the Dinornis. But what is the fact? Eighteen femora, eleven tibiæ and six tarso-metatarsi, with two toe-phalanges, have been consecutively discovered, and not a trace of any part of the osseous framework of a wing: not a fragment of scapula, of humerus, or of the bones of the forearm or hand.

The doctrine of chances thus adds its proof, were such required, to the inferences of physiological correlation, that the Dinornis had no wings. We may next inquire to what extent, short of the faculty of flight, the anterior or pectoral members were developed in this extinct genus, with the same confidence in the laws of correlation as a guide to the determination of this question.

The anterior members present very different degrees of arrested development in the different existing species of the *Struthionidæ*, and always retain, under even their most rudimental condition, the characteristic modifications of form and structure by which they are adapted to serve the office of flight in ordinary birds.

In these, as is well known, the body is made specifically lighter, and in a direct ratio with the powers of flight, by a proportionate extension of the air-cells through the muscular and osseous systems. A much greater proportion of the skeleton is permeated by air in the Swallow than in the Quail.

The Rhea and the Ostrich have the largest and most wing-like anterior members of all the *Struthionidæ*; they use them to aid in their swift progression: throwing their body forwards beyond the centre of support afforded by the hind legs, they partly sustain it by the flapping of the curtailed wings, whilst the legs, to the extent to which they are thus relieved from the act of sustaining, are free to exert additional force in propelling the body: and it may be said of the Ostrich at full speed that half the body flies and half runs. Now we find that in these semivolant *Struthionidæ* the warm and expanded air of the respiratory cavities is freely admitted into the bones of the skull, the vertebræ, the ribs, the sternum, the coracoids, the pelvis and the femora.

In the Emeu and Cassowary, whose pectoral members are much reduced in size, useless for anything like flight, and serving, so far as is known, only for some feeble actions of defence, the air is less freely admitted to the bones of the trunk, but still penetrates the femur.

In the Apteryx the rudimental wings are so minute, that the fact of their retention of the typical structure requires careful dissection for its demonstration: and in this species we find the lungs confined to the thoracic-abdominal cavity, and not extended into any part of the skeleton. The Dinornis presents an intermediate condition between the Apteryx and the Emeu in regard to the extension of the air-cells, which penetrated the vertebral column, as is shown by the pneumatic foramina in the vertebræ, but were not continued into the femora. We may infer, therefore, from the known relations of the development of the air-cells to that of the anterior members in existing *Struthionidæ*, that these were more rudimentary in the Dinornis than in the Emeu, but not quite so minute in proportion to the body as in the Apteryx. The size of the bones on this inference, even in the *Dinornis giganteus*, must have been small enough to prevent any surprise at their not having yet been recovered; especially when it is remembered that no part of the sternum nor any of the ribs, which doubtless surpassed the scapulæ and humeri in size, appear hitherto to have been found.

Stature of the different species of Dinornis. (Pl. XXX.)

The height of the hind leg of the *Dinornis giganteus* in the ordinary standing posture, from the sole of the foot to the upper ridge of the trochanter, being given by the bones of the pelvic extremity in the present collection, the total altitude of the bird may be approximatively determined by the analogies of the existing *Struthionidæ*. In these the neck varies slightly in its relative length, being longest in the Ostrich and Emeu, in which it includes 18 or 19 vertebræ, and shortest in the Cassowary and Apteryx, which have respectively 16 and 15 cervical vertebræ; but in all the species it is of sufficient length to enable them readily to pick up substances from the ground by a slight rotation or bending down of the trunk and pelvis upon the hip-joints.

In estimating the height of the *Dinornis giganteus* by the standard of the Ostrich, I have taken the latter at eight feet four inches, which is the altitude given by the skeleton of one with a tibia two feet in length[1]. The distal end of the metatarsus being raised in the living bird one inch and a half from the ground, the tarso-metatarsal bone, tibia and femur, placed at the angles which they form with one another in the standing posture, rise to the height of four feet four inches; and from the level of the highest point of the femur to the top of the head with the neck erect is four feet. The longest tibia of the *Dinornis giganteus*, with its extremities entire, measures two feet eleven inches: this bone articulated with a femur of sixteen inches and a tarso-metatarsal bone of eighteen inches in length, at angles corresponding to those in the Ostrich, and with an allowance of three inches for the natural angle of the toes and the callous integuments beneath the distal joint of the metatarsal bone, makes the height of the hind leg to the highest point of the femur five feet six inches: from the level of this point to the top of the head, supported upon an erect neck of the same proportions as in the Ostrich, is five feet, making the total height of the *Dinornis giganteus* ten feet six inches. If the tarso-metatarsal bone of the Dinornis had borne the same proportion to the tibia as in the Ostrich, its height would have been nearly twelve feet, but the acquisition of

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[1] The tibiæ of mature specimens of the Ostrich in the Museum of the Royal College of Surgeons measure respectively 1 foot 8 inches, 1 foot 9½ inches, and 1 foot 11 inches in length. The accurate and learned authors of the 'Gardens and Menagerie of the Zoological Society' state that the Ostrich "is generally from six to eight feet in height."—Vol. ii. p. 51.

the tarso-metatarsal belonging to the largest tibia fortunately prevented this error of exaggeration.

But since the Cassowary and Apteryx, as compared with the Ostrich and Emeu, combine shorter tarso-metatarsals with their shorter necks, the Dinornis is much more likely to have resembled these birds than the Ostrich in the proportionate length of its neck, and we know that it resembled the Apteryx much more than the Ostrich in the robust proportions of the cervical vertebræ. In the Apteryx, however, the peculiar length of the bill compensates for the relative shortness of the neck; and until we have proof to the contrary, we must suppose the Dinornis to have had a bill of the ordinary proportions which it presents in the large existing *Struthionidæ*. I, therefore, conceive the Cassowary to offer the best term of comparison by which to calculate the height of the Dinornis. In the skeleton of a full-grown Cassowary[1] the tarso-metatarsal bone measures eleven inches in length: allowing an inch for the callous integuments beneath its distal articulation, the tibia and femur, articulated at the angles natural in the standing posture, rise to the height of two feet nine inches. From the level of the top of the trochanter to the top of the cranial crest is two feet three inches, and to the base of the crest two feet. We have no evidence that the Dinornis had that peculiar defence upon the head, and therefore, from the ground to the summit of the trochanter of the *Dinornis giganteus* being five feet six inches[2], from this level to the top of the head, according to the proportion of the uncrested Cassowary, would be four feet, making the total altitude nine feet six inches. Thus, if we take the average of the altitudes of the *Dinornis giganteus*, as given by the analogies of the existing *Struthionidæ*, we are compelled to restrict our ideas of its height in the ordinary upright posture to ten feet.

The *Dinornis struthoides*[3], with a femur of eleven inches, a tibia of twenty-two inches, and a tarso-metatarsus of twelve inches in length, must have stood, according to the analogies of the Cassowary, six feet nine inches in height; according to those of the Ostrich, seven feet four inches: we may therefore regard its height to have not exceeded seven feet, or to have been about equal to that of a moderate-sized Ostrich, but of a more robust and stronger build. The fragment of the femur first described by me in 1839 belongs to this species.

The *Dinornis didiformis*, with a tibia as long as that of the Cassowary, viz. sixteen inches, but with a femur of eight inches and a tarso-metatarsus of only seven inches in length[4], would, by the analogy of the Cassowary, be a little under four feet in height, or of intermediate size between the Cassowary and the Dodo.

The femur of nine inches in length, with similar proportions of the tibia and metatarsus, which latter would probably be relatively longer, gives the height of five feet to the species which, from its similarity in size to the Emeu, I have called *Dinornis*

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[1] Pl. XXX. fig. 2.

[2] *Ib.* fig. 5.

[3] *Ib.* fig. 3.

[4] *Ib.* fig. 1. The tarso-metatarsal bone of the *Dinornis didiformis* in Mr. Cotton's collection measures seven inches ten lines in length (Pl. XX *a.* fig. 2.); it is in other respects identical in character with the analogous bones described in the text, and indicates a sexual superiority of size.

dromæoides. The tibia of the *Dinornis ingens*[1] indicates that species to have attained the height of nine feet.

Comparison of the bones of the feet of the Dinornis *with the American Ornithichnites.*

In 1836 Prof. Hitchcock[2] published his remarkable discovery of impressions in the New Red Sandstone of the valley of the river Connecticut, Massachusetts, which he conceived to be the foot-prints of birds, the largest belonging to a species with three toes, surpassing the Ostrich in size. The epoch of these impressions is as ancient as that of the Cheirotheria or Labyrinthodont footsteps in Europe, and more ancient than those of the oolites and lias, from which the remains of our most extraordinary extinct reptiles have been obtained: but no fossil bones of birds have been found associated with the Labyrinthodont and Thecodont reptiles, nor with those of the lias or oolites, the Pterodactyles of which were once mistaken for birds. The Wealden is the oldest formation in which true ornitholithes have hitherto been discovered. The ancient foot-prints of the Connecticut sandstones were for the most part supposed to be those of *Grallæ*; but the high geological antiquity of those sandstones, and the inferences which might be deduced from the low character of the air-breathing animal creation, as indicated by fossil bones, of the condition of the atmosphere during the deposition of the oolites, lias and new red sandstones, led me to express a doubt in my report on British Fossil Reptiles whether foot-prints alone were adequate to support the inference that the animals that impressed them actually possessed the highly-developed respiratory organization of a bird of flight[3]. One could hardly in fact venture to reconstruct in imagination the stupendous bird which, on Dr. Hitchcock's hypothesis, must have left the impressions called *Ornithichnites giganteus*; for, before 1843, the only described relic of the extinct New Zealand bird did not warrant the supposition of a species larger than the Ostrich[4].

The species of *Dinornis*, in fact, to which that relic belonged, we now know not to have exceeded seven feet in height, which is the average stature of the Ostrich. But the bones of the *Dinornis giganteus* subsequently acquired demonstrate the existence, at a comparatively recent period, of a bird whose tridactyle foot-prints, as will be presently shown, surpassed the *Ornithichnites giganteus* of Prof. Hitchcock.

The length of this foot-print from its hind part to the extremity of the impression of the claw of the middle toe is sixteen inches; the breadth of the hind part is four inches six lines. The toes were broad and thick, and we may plainly discern that the bird supported itself, like the Ostrich, upon the under surface of the toes, from their extremities to the cushion beneath the distal end of the proximal phalanges; and that in making the impression, the foot did not quite sink as far as the end of the metatarsal bone.

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[1] Pl. XXX. fig. 4.

[2] American Journal of Science and Arts, vol. xxix. No. 2.

[3] Report on British Fossil Reptiles, Part II., Trans. British Association, 1841, p. 203.

[4] Zoological Proceedings, November 1839, p. 170.

The length of a corresponding impression of the foot of the Ostrich is eight inches; the breadth of the posterior part of the impression three inches; the breadth of the distal end of the tarso-metatarsal bone two inches and a half. According to these proportions, the breadth of the distal end of the tarso-metatarsal bone of the tridactyle bird that impressed the *Ornithichnites giganteus* must have been three inches nine lines; but the breadth of the distal end of the tarso-metatarsus of the *Dinornis giganteus* is five inches. According, therefore, to the proportions of the *Ornithichnites giganteus*, the breadth of the hind part of the foot-print of the *Dinornis giganteus* must have been six inches, and its length twenty-one inches and a half.

The genus Dinornis was characterized by a relatively broader foot than the Ostrich, as we know by the tarso-metatarsal bones; and this bone in the *Dinornis struthoides*, the third species in point of size, indicates that its bulky body was supported by feet calculated to leave impressions nearly as large as those of the *Ornithichnites giganteus*. That the toes were as long in proportion to the breadth of the metatarsal bone as in the Ornithichnites, is shown by the two phalanges transmitted by Mr. Williams, the description of which I have reserved for this place.

The largest of these phalanges is 3¼ inches long and 1½ inch broad across the proximal joint. This does not present the median vertical ridge which the corresponding groove in the articular surface of the metatarsal indicates the proximal phalanx to possess, and I regard it, therefore, to be a second phalanx, which, as in the middle toe of the Ostrich, would then differ from the first phalanx in the equable concavity of the proximal articular surface. In the second or outer toe of the Ostrich the median eminence is wanting on the proximal end of the first phalanx, but the want of symmetry in that bone shows that it cannot be the analogue of the phalanx of the Dinornis in question, which is almost quite symmetrical. From this character it may be referred to the middle toe: compared with the second phalanx of that toe in a full-grown Ostrich it is relatively longer, less depressed or flattened, the depth of the bone being equal to its breadth except at the distal articulation, which nevertheless is much less expanded and depressed than in the Ostrich. In this bird the length of the second phalanx of the middle toe is 2¼ inches, the breadth of the distal end is 1½ inch, and its depth at the middle of the bone 8 lines. In the phalanx of the Dinornis the breadth of the distal end is 1¼ inch, its depth at the middle 10 lines. The size of the phalanx of the Dinornis, regarded as the second of the middle toe, agrees well with that of the tarso-metatarsal of the *Dinornis struthoides*. The length of the second phalanx in the *Ornithichnites giganteus* is indicated by the articular eminences in the cast of that impression, and it is a little shorter than the phalanx of the Dinornis above described.

The smaller of the two phalanges has an unsymmetrical figure, and its proximal articular concavity is continuous with an oblique notch which divides the lower border into two tuberosities. This structure is slightly indicated at the corresponding part of the proximal phalanx of the outer toe in the Ostrich, and in the Bustard is as strongly marked in the proximal phalanx of both the outer and inner of the three toes as in the phalanx of the Dinornis. This phalanx measures one inch ten lines in length, one inch two lines across the proximal end, and ten lines across the distal end: the articular surface here is impressed by a vertical groove, as in the proximal phalanges of the outer and inner toes in the Bustard, and it agrees in its general figure with that of the outer toe of the left foot, but is much thicker in proportion to its length. The proximal articulation matches in size with, but is not adapted by its configuration to, the outer trochlea of the trifid metatarsal of the *Dinornis didiformis.* The foot-print of this species was probably about the size of the *Ornithichnites tuberosus* of Prof. Hitchcock.

From the foregoing comparison of the bones of the feet in the different species of Dinornis with the impressions left by the ancient extinct birds of the American continent, it must not, however, be concluded that these were species of Dinornis. Agreement in the size of the foot and number of the toes does not constitute specific or even generic identity in Ornithology, as the living Emeu, Rhea and Cassowary testify; and though we may admit that the discovery of tridactyle terrestrial birds of a size more gigantic even than that indicated by the *Ornithichnites giganteus* and *Ornithichnites ingens* tends greatly to remove the scepticism with which such evidences of the extinct animals of the Triassic period had been previously received, yet the recognized succession of varying vertebrated forms in the interval between that period and the present forbids the supposition that the same species or genus of birds could have maintained its existence throughout the several great changes which the earth's surface has undergone during that vast lapse of time.

We see, in fact, how diversified are the few existing forms of *Struthionidæ*: almost every species now represents a distinct genus. We know that this order has suffered greater diminution within the time of man than any other in the class of Birds, perhaps than any other in the whole animal kingdom. What, then, may not have been the extent and variety of the wingless terrestrial birds in times anterior to man's dominion over the earth!

Already the heretofore recorded number of the *Struthionidæ* is doubled by the six species of Dinornis determined or indicated in the foregoing pages; and both the Maori tradition of the destruction of the 'Moa'[1] by their ancestors, and the history of the extirpation of the Dodo by the Dutch navigators in the Isles of Maurice and Rodriguez, teach the inevitable lot of bulky birds unable to fly or swim, when exposed, by the dispersion of the human race, to the attacks of man. We may, therefore, reasonably anticipate that other evidences await the researches of the naturalist, which will demonstrate a further extent of the Struthious order of Birds anterior to the commencement of the present active cause of their extinction.

And since the texture of the bones of the former gigantic tridactyle *Struthionidæ* of New Zealand proves that they resembled the Apteryx, in the comparatively low

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[1] The Maoris or Aborigines of New Zealand call the Dinornis 'Moa' or 'Movie.'

and reptile-like condition of the respiratory apparatus, we are thereby further justified in admitting the evidence of the co-existence of similar apterous and low organized birds with the cold-blooded and slower-breathing Ovipara, which swarmed in such plenitude of development and diversity of forms during what has been termed the 'Age of Reptiles.'

The remarkable geographical distribution of the birds of the Struthious order, which have no power of transporting themselves to distant isles or continents, either through the air or the ocean[1], irresistibly leads us to speculate on the cause of that distribution, and its connexion with the former extent and importance of the wingless terrestrial birds. Hereupon it may first be remarked that those species, now in existence, which have the least restricted powers of locomotion, enjoy the most extensive range for their exercise.

The Ostrich is spread over nearly the whole of Africa, from the Cape to the deserts of Arabia; beyond which the species is unknown. The Rhea ranges over a great part of the southern extremity of the Western hemisphere. To the Emeu has been assigned the vast mainland of Australia. The heavier Cassowary is limited to a few of the islands of the Indian Archipelago. The Dodo appears to have been confined to the Mauritius and the small adjoining Isle of Rodriguez. The Apteryx still lingers in New Zealand, where alone any specimens of that most anomalous species of the Struthious order have been discovered.

New Zealand was, also, at one period, the seat of a seventh genus of *Struthionidæ*; and it is worthy of remark that the Fauna of no other island, nor of any of the great continents, has yet furnished an analogous example of two distinct genera of that group of birds. Moreover the most gigantic as well as the most diminutive species of the wingless group—always to Ornithologists most remarkable for the great size of its species—formerly occupied their place amid the fern-thickets and turbaries of New Zealand. And, again, the number of the species of *Struthionidæ* in this island equalled that in all the rest of the world, as registered in the catalogues of Ornithology.

Now, since all the larger existing Struthious birds derive their subsistence from the vegetable kingdom, we may hope to receive from the botanist an elucidation of the circumstances which favoured the existence of so many large birds of this order in the remote and restricted locality where alone their remains have hitherto been found. It seems, at least, most natural to suppose that some peculiarity in the vegetation of New Zealand adapted that island to be the seat of apterous tridactyle birds, so unusually numerous in species and some of them of so stupendous a size.

The predominance of plants of the Fern-tribe, and the nutritious qualities of the roots of the species most common in New Zealand, are the characteristics of its Flora which

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[1] The Rhea and Emeu have been seen to take water for the purpose of crossing rivers and narrow channels of the sea; but almost the entire body sinks below the surface, and their progress is slow, as might be anticipated from the absence of the swimming-webs in their feet. See Darwin, 'Voyage of the Beagle,' vol. iii. p. 105.

appear to have been the conditions of the former peculiarities of the Fauna of this island. Some at least of the characters of the skeleton of the Dinornis may well have related to rhizophagous habits. The unusual strength of the neck indicates the application of the beak to a more laborious task than the mere plucking of seeds, fruits, or herbage. The present small Apteryx of New Zealand has a relatively stronger neck than any of the existing *Struthionidæ*, in relation to the needful power of perforating the earth for the worms and insects which constitute its food. Such small objects cannot be supposed to have afforded sustenance to the gigantic *Dinornithes*: but the still more robust proportions of their cervical vertebræ, and especially of their spinous processes,—so striking when contrasted with the corresponding vertebræ of the Ostrich or Emeu,—may well have been the foundation of those forces by which the beak was associated with the feet in the labour of dislodging the farinaceous roots of the ferns that grow in characteristic abundance over the soil of New Zealand[1].

The great strength of the leg, and especially of the metatarsal segment, which is shortened, as in the burrowing Apteryx, almost to the gallinaceous proportions, must have had reference, especially in the less gigantic species, to something more than sustaining and transporting the superincumbent weight of the body, and this additional function is indicated by both the analogy of the Apteryx and the Rasorial birds to be the scratching up the soil.

Thus far, at least, the positive facts justify the attempt to restore, and, as it were, to present a living portrait of the long-lost Dinornis; and, without giving the rein to a too exuberant fancy, we may take a retrospective glance at the scene of a fair island, offering, by the will of a bountiful Providence, a well-spread table to a race of animated beings peculiarly adapted to enjoy it; and we may recall the time when the several species of Dinornis ranged the lords of its soil—the highest living forms upon that part of the earth. No terrestrial Mammal was there to contest this sovranty with the feathered bipeds before the arrival of man[2].

Without laying undue stress on the native tradition of the gigantic Eagle or 'Movie,' cited by Mr. Rule[3], or on that of the great creature of the cavern, called 'Moa,' which first attracted the attention of Mr. Williams to the remains of the Dinornis; and admitting with the cautious scepticism due to second-hand testimony, the tale of the still-existing nocturnal gigantic bird which scared the whaling seamen on the hill at Cloudy

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[1] "New Zealand is favoured by one great natural advantage, namely, that the inhabitants can never perish from famine. The whole country abounds with fern; and the roots of this plant, if not very palatable, yet contain much nutriment." Voyage of the Adventure and Beagle, vol. iii. 'Darwin,' p. 504.

[2] Mr. Darwin says, "It is a most remarkable fact that so large an island, extending over more tnan 700 miles in latitude, and in many parts 90 miles broad, with varied stations, a fine climate, and land of all heights from 14,000 feet downwards, with the exception of a small rat, should not possess one indigenous mammal."—*Loc. cit.* p. 511.

[3] Polytechnic Journal, July 1843.

Bay,—the evidence of the chemical condition of the bones themselves[1], and their alluvial bed, favour the hypothesis of their comparatively recent date. It is not altogether improbable that the species of Dinornis were in existence when the Polynesian colony first set foot on the island; and, if so, such bulky and probably stupid birds, at first without the instinct and always without adequate means of escape and defence, would soon fall a prey to the progenitors of the present Maoris.

In the absence of any other large wild animals, the whole art and practice of the chase must have been concentrated on these unhappy cursorial birds[2]. The gigantic Dinornis, we may readily suppose, would be the first to be exterminated: the strength of its kick would less avail, than its great bulk would prejudice its safety by making its concealment difficult; at all events, the most recent-looking bones are those of the smaller species. The closely allied, but comparatively diminutive Apteryx still survives by virtue of its nocturnal habits and subterraneous hiding-place, but in fearfully diminished and rapidly diminishing numbers. When the source of animal food from terrestrial species was reduced by the total extirpation of the genus *Dinornis* to this low point, then may have arisen those cannibal practices which, until lately, formed the opprobrium of a race of men in all other respects much superior to the Papuan Aborigines of the neighbouring continent of Australia, and very little inferior to the Polynesian natives of the most favoured islands of the Pacific.

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[1] I have been favoured with the following analyses by my friend Thomas Taylor, Esq., author of the Catalogue of the Calculi and other Animal Concretions in the Museum of the Royal College of Surgeons:—

" *Recent Tibia of Ostrich.*	
Animal matter	26·51
Phosphate of lime	65·69
Phosphate of magnesia	0·95
Carbonate of lime	6·22
Sulphate and carbonate of soda, with trace of muriate	0·12
Sulphate of lime, a trace.	
Fluorine, a trace.	
	99·49

Fossil Femur of Dinornis didiformis.	
Animal matter	25·99
Phosphate of lime with phosphate of magnesia	66·19
Carbonate of lime	4·51
Peroxide of iron	2·81
Alumina	0·22
Sulphate, carbonate, and muriate of soda	0·32
Sulphate of lime, a trace.	
Fluorine, a very distinct trace.	
	100·04"

The subjoined comparative analysis, kindly undertaken by Dr. G. Day, also shows the large proportion of animal matter in the bones of the Dinornis:—

	" *Recent femur of Ostrich.*	*Femur of Dinornis struthoides.*
Animal matter	34·86	37·86
Inorganic matter	65·65	62·94
	100·00	100·00"

The superabundance of animal matter in the bone of the extinct bird depends upon its being a marrow-bone, whilst that of the Ostrich contains air.

[2] As the Maoris prize the skin and feathers of the Apteryx for the manufacture of ornamental robes, it might be worth inquiry whether any of the natives preserve remains of their ancestors' dresses composed of feathers of unknown and larger species of birds. Such relics of a Dinornis might in this way be recovered.

ADDENDUM.

J. R. Gowen, Esq., a Director of the New Zealand Company, has obligingly forwarded to me the subjoined indication of a further discovery of the bones of the Dinornis, from a new locality in New Zealand:—

"Extract of a letter from Colonel William Wakefield to J. R. Gowen, Esq., dated Wellington, 19th September, 1843.

"I received lately your letter respecting the Moa, with Professor Owen's notice. I have taken steps to procure some of the bones, which are much larger than the one represented in the sketch. The Rev. Mr. Taylor, of Wanganui, has a large collection of these bones, found in a river between that place and New Plymouth. I have heard several stories of live Moas having been seen; one, that the enormous size (higher than our one-storied houses) frightened the person, an Englishman, who was going to shoot it; but I don't believe any one has seen a live one lately. I intend to make further inquiries amongst the old natives, and send you all I can collect of bones."

DESCRIPTION OF THE PLATES.

PLATE XVIII.

Cervical vertebræ, natural size.

Fig. 1. Front view of a middle cervical vertebra of the *Dinornis giganteus.*

2. Side view of the same, showing the posterior articular process and the outline of the right inferior tuberosity, restored, at *h.*

3. Base view of the same; *h h,* the fractured inferior tuberosities.

4. Side view of an inferior cervical vertebra of a smaller species of *Dinornis* (*Din. struthoides?*): the antero-posterior extent of the single inferior spine is indicated at *h.*

5. Upper view of the same vertebra.

6. Front view of the same vertebra.

7. Side view of a corresponding cervical vertebra of another species of *Dinornis,* of equal size with the preceding: the antero-posterior extent of the inferior spinous process is indicated at *h.*

8. Upper view of the same vertebra.

9. Front view of the same vertebra.

10. Upper view of the thirteenth cervical vertebra of the *Apteryx australis.*

PLATE XVIII *a*.

Dorsal vertebræ, natural size.

Fig. 1. Side view of an anterior dorsal vertebra, of apparently the same species of *Dinornis* as that to which the cervical vertebra Fig. 4 in Plate XVIII. belonged : *c*, the costal articulation ; *h*, the strong inferior spinous process.
2. Upper view of the same vertebra.
3. Front view of the same vertebra.
4. Front view of a corresponding dorsal vertebra in an Ostrich : *h*, the inferior spinous process.
5. Front view of the thirteenth cervical vertebra in the Apteryx : *h*, the inferior spinous process.
6. Side view of a middle dorsal vertebra of a smaller species of *Dinornis* (*Din. dromæoides* ?) : *c*, the costal articulation.
7. Upper view of the same vertebra.
8. Front view of the same vertebra.
9. Under view of the same vertebra.

PLATE XIX.

Front or under views of the Pelvis of three species of Dinornis and of the Ostrich, all reduced to one-fourth the natural size.

Fig. 1. Anterior sacral vertebræ of *Dinornis giganteus*.
2. Pelvis of *Dinornis dromæoides*.
3. Anterior portion of pelvis of *Dinornis didiformis*.
4. Entire pelvis of the Ostrich (*Struthio Camelus*).

The following letters indicate the same parts in each figure :—

a. Anterior sacral vertebra, and its costal articular surfaces in figs. 2 & 3.
b. Middle sacral vertebræ without inferior transverse processes.
c. Os ilium.
d. Os pubis.
e. Os ischium.

PLATE XX.

Back and side views of Pelvis of different species of Dinornis, one-fourth the natural size.

Fig. 1. Right os innominatum of *Dinornis giganteus*.
2. Pelvis of *Dinornis dromæoides*.

Fig. 3. Back or upper view of the same pelvis: *b*, the confluent spines of the posterior sacral vertebræ.
4. Side view of pelvis of *Dinornis didiformis*.
5. Fragment of the pelvis of *Dinornis struthoides*.
f. The acetabulum.

PLATE XX *a*.

Fig. 1. Pelvis of male *Dinornis didiformis*, natural size.
2. Tarso-metatarsal bone of ditto, ditto.

PLATE XXI.

Femora, natural size.

Fig. 1. Back view of femur of *Dinornis ingens*.
2. Lower or distal end of femur of *Dinornis ingens*.
3. Back view of femur of *Dinornis struthoides*.
4. Distal end of femur of *Dinornis dromæoides*.

PLATE XXII.

Femur of *Dinornis dromæoides*, natural size.

Fig. 1. Front view.
2. Back view: *d*, ridge above the internal condyle; *e*, fossa above the external condyle.

PLATE XXIII.

Fig. 1. Side view of femur of a young *Dinornis struthoides*.
2. Side view of femur of *Dinornis dromæoides*.

PLATE XXIV.

Femur of *Dinornis didiformis*, natural size.

Fig. 1. Front view.
2. Back view: *d*, tuberosity above the internal condyle; *e*, fossa above the external condyle.
3. Distal end.

PLATE XXV.

Front views of tibiæ, natural size.

Fig. 1. Tibia of *Dinornis ingens*.

Fig. 2. Distal trochlea of ditto.
3. Tibia of *Dinornis didiformis.*
4. Distal trochlea of ditto.
5. Tibia of *Dinornis otidiformis.*
6. Distal trochlea of ditto.

PLATE XXVI.

Back views of tibiæ, natural size.

Fig. 1. Tibia of *Dinornis ingens.*
2. Proximal end of ditto.
3. Tibia of *Dinornis didiformis.*
4. Proximal end of ditto.
5. Tibia of *Dinornis otidiformis.*
6. Proximal end of ditto.

The following letters indicate the corresponding parts in each figure:—

a. Concavity anterior to the articular condyles.
b. Process for the attachment of the rotular ligament.
c. Anterior crista at the proximal end.
d. Ridge for the attachment of the fibula.
e. Internal condyle or prominence of the distal trochlea.

PLATE XXVII.

Tarso-metatarsal bones, natural size[1].

Fig. 1. Front view of the tarso-metatarsal of *Dinornis giganteus.*
2. Front view of the tarso-metatarsal of *Dinornis struthoides.*
3. Front view of the tarso-metatarsal of a female (?) *Dinornis didiformis.*
4. Back view of ditto.
5. Upper or proximal end of ditto: *a*, the outer concavity; *b*, the inner one.
6. Lower or distal end of ditto.

PLATE XXVIII.

Tarso-metatarsal bones, half the natural size.

Fig. 1. Front view of the metatarsus of a young Ostrich (*Struthio Camelus*).
2. Proximal ends of the three metatarsal bones, which are still separate at this part.
3. Front view of the metatarsus of a young *Dinornis giganteus.*

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[1] The mirror was not used in drawing these bones; they appear, therefore, to belong to the right leg.

Fig. 4. Proximal ends of the three metatarsal bones not united together at this part.
5. Side view of the tarso-metatarsal bone of the *Dinornis struthoides*.
6. Side view of the tarso-metatarsal bone of the *Dinornis didiformis*.
7. A transverse section of ditto, at the part corresponding with the three separate metatarsals of the young *Dinornis giganteus*, fig. 4.

PLATE XXIX.

Internal structure of certain bones.

Fig. 1. Section of the femur of *Dinornis didiformis*, natural size: *h*, an accidental depression at the back of the cervix, not leading into the interior medullary cavity; *i*, the depression in the popliteal space, without any opening into the interior of the bone.
2. Section of the femur of an Ostrich, half the natural size: *h*, the orifice and oblique canal conducting into the interior pneumatic cavity of the bone; *i*, the outlet of the same cavity in the popliteal space.
3. Section of the femur of the *Apteryx*, in which no air is admitted into the medullary cavity; natural size.
4. Section of the tibia of the *Apteryx*, natural size.
5. Section of the tarso-metatarsal bone of *Dinornis didiformis*, natural size: *h*. the obliterated line of union of the tarsal epiphysis.

PLATE XXX.

Restoration of the *Dinornis giganteus*, and scale of altitude of that and other species, according to the standard of the Cassowary.

Fig. 1. The three principal bones—femur, tibia, and tarso-metatarsus—of the hind extremity of *Dinornis didiformis*.
2. Skeleton of *Casuarius galeatus* (Pander & D'Alton).
3. The femur, tibia, and tarso-metatarsus of *Dinornis struthoides*.
4. The femur, tibia, and tarso-metatarsus of the *Dinornis ingens*.
5. The pelvis, femur, tibia, tarso-metatarsus, and restored outline of the *Dinornis giganteus*.

MEMOIR

ON THE

GENUS PALAPTERYX,

WITH

DESCRIPTIONS OF ADDITIONAL REMAINS AND SPECIES OF DINORNIS.

THE publication of the Descriptions of the successively discovered remains of *Dinornis*, in the 'Proceedings' and 'Transactions' of the Zoological Society of London, during the years 1839 and 1843, was speedily followed by the collection in New Zealand, and the transmission to this country of many additional and highly interesting parts of the skeleton; some referable to the species of *Dinornis* therein defined, some to species of which no remains have hitherto been described, and others indicative of the new genus of gigantic wingless Birds, for which I have proposed the name of *Palapteryx*.

The specimens in question have been discovered not only in the 'North Island' of New Zealand, from which those previously described were exclusively obtained, but also from the 'Middle Island,' or as it is sometimes termed, the 'South Island'; and all the bones from this locality are less altered, and appear to be much more recent than those from the North Island. The friendly correspondents through whose kindness I am indebted for the rich additional materials which form the subject of the present memoir, or for information respecting the Dinornis, are Captain Sir Everard Home, Bart., R.N.; the Hon. Wm. Martin, Chief Justice of New Zealand; Sir Wm. Hooker, F.R.S.; the Ven. Archdeacon Williams, Corr. Z.S.; William Swainson, Esq., F.R.S., F.L.S., the distinguished naturalist; Colonel William Wakefield; J. R. Gowen, Esq., a Director of the New Zealand Company; Rev. William Cotton, M.A.; Rev. Richard Taylor, M.A.; the Rev. William Colenso*, M.A.; Dr. Mackellar; and Percy Earl, Esq.

I propose first to describe the bones, the homologues of which have not before been described, and which extend our knowledge of the generic characters of the skeleton of the Dinornis, and afterwards those which characterise additional species.

Amongst the specimens of parts of the skeleton not known when the foregoing memoirs were printed, are two mutilated crania, defective unfortunately in the mandibles, and showing little more than the walls of the cranial cavity; but, nevertheless, highly interesting and instructive. The larger specimen (Plate XVI. figg. 1—4) was obtained by

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* This gentleman has published a very instructive and interesting memoir on the Moa (*Dinornis*) in the Tasmanian Journal, No. VII. 1843, to which the editor has appended an abstract of my memoir in 'Zool. Trans.' vol. iii. p. 32. Mr. Colenso's memoir is reprinted in the 'Annals of Natural History,' August 1844.

the Ven. W. Williams from the bed of a mountain-stream descending to the coast at Poverty Bay, North Island, and is referable by its size to the *Dinornis struthoides*. The smaller specimen (Pl. XXXI. figg. 3—6) was obtained by William Swainson, Esq., from the North Island, probably in the vicinity of the Bay of Islands, and has belonged to a species distinct from the preceding, and agreeing in size with the *Dinornis dromioides*. Both specimens have the ferruginous tint and great weight, arising from infiltration of a salt of iron (peroxide), which characterized the specimens from the North Island described in the former memoir; but the cancelli of the bone contain only a little of the dry powdery alluvium of the streams into which the specimens have been washed.

Cranium.

The cranium referred to *Dinornis struthoides* agrees pretty closely in size with the same part of the skull of the Ostrich, as will be seen by reference to Plate XVI., in which it is figured from four points of view, of the natural size; but it is broader in proportion to its height, especially in the occipital and inter-orbital regions. It is, in fact, remarkably depressed, subquadrate, with two large lateral emarginations for the temporal fossæ (*ib.* 6, 6), and both in size and shape it is more like the corresponding part of the head of the Dodo (*ib.* fig. 5) than that of any existing Struthious species: but the upper surface of the cranium of *Dinornis* is gently and equably convex above, the cerebral hemispheres not raising their bony covering above the level of the rest of the calvarium, as in the Dodo; and the frontal region, though more elevated than in the existing Struthious birds, is less suddenly raised than in the Dodo. The length of the present fossil is three inches, but half an inch at least of the anterior border of the os frontis has been broken away: its breadth across the mastoids is three inches and a quarter, but the breadth across the post-orbital angles appears to have been greater. The breadth between the temporal fossæ, which are large and deep, is two inches five lines; its vertical diameter at the deepest part, from the upper occipital ridge to the under surface of the basi-sphenoid, is one inch and a half. From the occipital region the depth of the cranium gradually decreases to the anterior boundary of the cerebral cavity. The great occipital foramen (fig. 1, 1″) is subcircular, and seven lines in diameter,—that of an Ostrich being five and a half lines across: its plane is vertical, and the single occipital condyle (*ib.* 1) projects freely backwards, upon a short peduncle, beyond the upper margin of the foramen. No existing bird presents this peculiarity: the Dinornis in this respect resembles some of the Chelonian Reptiles. The broad and low occipital surface of the skull slopes forwards as it rises to join the upper surface. This inclination, with the slight depth and great breadth of the occiput, and the almost flat upper surface of the skull, forms the most peculiar features of the present cranium. The occipital region above the *foramen magnum* is divided by three short obtuse vertical ridges into four depressions (fig. 3, *d*), the two median ones being half the breadth of the two lateral ones, which are deeper than usual: each depression is bounded above by a curved border, which does not rise above the level of the calvarium to form a crest, but defines by a festooned line the occipital from the coronal surface. A broad and deep depression separates the condyle on each side from the par-occipital processes (4, 4) which form the posterior boundary of the tympanic cavity (fig. 4, 28). The broad basi-sphenoid descends vertically for a third of an inch below, and at right angles with, the basi-occipital, separated from the condyle by two small but deep depressions; this development of the base of the skull is peculiar to the *Dinornis* among Birds, and resembles that in the Crocodile.

All the sutures of the cranium are obliterated, but the foramen for the third division of the fifth nerve shows that the ali-sphenoid (figg. 2 & 4, 6) ascended, as in other birds, to meet the parietal (*ib.* 7), in order to form the so-called temporal fossa. The upper boundary of each temporal fossa is well-defined, but not elevated into a ridge: a smooth and very slightly convex surface of the cranium, one inch and ten lines in breadth, intervenes between them: a continuation of the same surface, a flattened tract formed by the parietal and mastoid (fig. 3, 8, 8), four lines in breadth, separates the temporal (6) from the occipital fossæ (*d*). A cellular air-diploë, from two to six lines thick, divides the outer from the inner table of the cranium.

The mutilated base of the present specimen exposes the upper border of the pituitary depression, bounded posteriorly by the groove in the basi-sphenoid (fig. 4, 5) common to the converging carotid canals, and anteriorly by the groove which lodged the optic chiasma, and from which the optic foramina (fig. 4, *o*, *o*) are continued outwards and forwards to the orbits (11′, 11′). The outlets of the optic foramina are separated by an interspace of one inch: the Apteryx, amongst existing birds, approaches nearest to the Dinornis in this peculiarity; but the Dodo most probably still more closely resembled the Dinornis in the distinctness of and distance between the external outlets of the optic canals. These foramina, in the present cranium, are smaller than those in the skull of the Ostrich, and indicate it to have had smaller eyes, in which respect it must have resembled the Dodo. The olfactory foramina are subcircular, three lines in diameter, single, on each side, as in other birds, and at the anterior end of the cranial cavity separated by an interspace of two lines: the olfactory cavities (fig. 4, 18) extend backwards behind these foramina, upon the under surface of the cranium, to within four lines of the optic groove, a feature which, with the large size of the olfactory nerves, indicates a development of the organ of smell approaching that most remarkable one in the Apteryx. Of the other outlets of the cerebral nerves, those for the ninth pair (the pre-condyloid foramina, see fig. 1) are alone remarkable for any increase beyond the ordinary size. The foramen rotundum (*n*, *n*, fig. 4) is distinct from both foramen ovale and foramen opticum. The articular depression (fig. 4, 28) for the tympanic or quadrate bone is imperforate, eight lines long, from three to four lines wide, bounded externally by a short angular process of the mastoid.

The form of the inner surface of the cranium shows that the cerebral hemispheres were smooth, low, not rising higher than the cerebellum, but convex and expanded anteriorly: the proportion of the cavity to its great posterior outlet indicates the brain to have been smaller in proportion to the spinal chord than in any Struthious or other existing bird. There is no bony falx: the vertical ridge on the fore-part of the 'os petrosum,' for the attachment of the tentorium, is less produced than in the Apteryx: there are no horizontal ridges of bone continued forwards from the os petrosum to define the fore and upper part of a fossa for the optic lobe on each side, as in the Ostrich and most other birds.

The depressions on the occiput for the insertion of the nuchal muscles indicate the force with which they must have habitually operated upon the head; and the unusual size and depth of the temporal fossæ equally indicate the great strength of the gripe of the bill: such a combination of powerful muscles of the head and the beak accords with the indications which the vertebræ of the neck and the short and strong metatarsi afford, of habits of scratching and uprooting vegetables for food.

Compared with the Ostrich, the occipital condyle is smaller in the *Dinornis* in proportion to the great foramen: the cranium of the Ostrich is narrower, loftier and more convex posteriorly, and much more contracted anteriorly. The form of the cerebral hemispheres must have differed greatly in the two gigantic Struthious birds here compared. In the Ostrich the cerebrum is pyramidal, tapering forwards to a point; in the Dinornis it must have been square-shaped and broadly convex anteriorly.

Amongst the Grallatorial birds the cranium of the Gigantic Crane (*Ciconia Argala*) alone equals the present fragment in size, and resembles it in the expanse and degree of convexity of the upper surface; but it differs, like the Ostrich, in having a more sessile occipital condyle, which is larger in proportion to the foramen: the plane of the foramen inclines in the Argala, as in most other existing birds, from below upwards and backwards; and there is a similar inclination in the plane of the supra-occipital surface, which more nearly than in the Ostrich equals in breadth that of the Dinornis; but it is of greater height. The under part of the occipital condyle is on a level with that of the basis cranii in the Argala, as in most other birds: in the Dinornis it is raised above that level, or rather the level is carried by the above-mentioned development of the basi-sphenoid below it. The supra-occipital crest is more developed in the Argala, and the upper part of the skull is indented anterior to it. The temporal fossæ are much smaller, and more posterior in position, extending to the occipital ridge in the Argala. The optic foramina are more approximated and the cranial cavity is more contracted anteriorly in the Argala. The articular cavities for the quadrate bones are perforated, and more transverse in position in the Argala, as in the Ostrich, than in the Dinornis. The anterior condyloid foramina in both the Argala and the Ostrich are scarcely half the size of those in the Dinornis, and are situated nearer the condyle.

The Apteryx has a more hemispheric occipital condyle than the Dinornis, and the plane of the occipital foramen differs in the same degree from that of the Dinornis, in regard to its slope, as in the Argala and Ostrich: the occiput in the Apteryx is narrower, higher, almost vertical, with the middle part produced backwards into an angular projection and perforated on each side: the upper region of the head is much more lofty and convex than in the Dinornis; the mastoid process is much smaller in proportion to the par-occipital process: the temporal surfaces resemble those in the Dinornis in their antero-posterior extent, but do not impress the sides of the cranium; the orbits are much smaller, and the olfactory cavities much larger in the Apteryx than in the Dinornis; but it is interesting to find the nearest approach to these peculiarities of the existing Struthious bird of New Zealand made by the extinct *Struthionidæ* of the same island.

The cranium of *Dinornis*, referable by its size to the *D. dromioides*, was kindly transmitted, with other bones of the same genus, for my examination by Mr. Swainson*. It has suffered nearly the same kind and degree of mutilation as the larger cranium; the basi-sphenoid, with all the rostral part of the skull, having been broken away; but the supra-orbital ridges and fore-part of the frontal region of the cranium are more entire (Plate XXXI. figg. 4—6). The breadth of the cranium across the mastoids is two inches, seven lines; the length to the anterior border of the os frontis (not entire in the larger specimen) is two inches, eight lines; the breadth across the post-orbital angles is two inches, two lines; the breadth between the temporal fossæ is one inch, nine lines.

The smaller size of the present cranium, as compared with the preceding specimen, does not depend upon the immaturity of the individual: not only are the sutures almost as completely obliterated (and this takes place much later in Struthious birds than in birds of flight), but the ridges defining the attachment of the muscles are as strongly marked, and indicate not only a full-grown but an old bird.

The large size and vertical plane of the foramen magnum; the broad, low, supra-occipital region (figg. 4 & 5, 3), sloping from below upwards and forwards; the almost flat parietal surface (*ib.* 7), continued directly forwards into the broad, downward sloping frontal region (*ib.* 11); the wide and deep temporal fossæ (*ib.* 6); the small orbits (*ib.* 11′) and expanded olfactory chamber (fig. 6, 18);—all repeat the peculiar generic characters of the cranium of *Dinornis* which are exhibited in the larger specimen.

The specific distinction of the smaller cranium is shown by the less produced and sessile occipital tubercle (figg. 4 & 5, 1); by the absence of the two fossæ on the back-part of the descending plate of the basi-occipital; by the wider temporal fossæ, divided behind from the occipital surface by a common ridge (fig. 5, *r*), not by a flattened tract;—and if the value of this difference should seem to be diminished by the known changes in the development of the temporal muscles in the progress of age, it applies in the present instance in favour of the specific distinction of the smaller cranium; for the less

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* In the note accompanying the specimens that eminent Ornithologist says, "They are from the North Island. . . . . . I have no idea that this strange group of Birds is any longer in existence, notwithstanding all the stories of the natives and others. If any may be alive they will probably be found in the Middle Island, which may be almost said to be uninhabited, except on the coast."

extent of the temporal fossa and the concomitant distance of its boundary from that of the occipital fossa, which might be interpreted as characters of immaturity, are present in the larger, not in the smaller cranium; and they are associated also in the larger cranium with a development of muscular ridges and impressions which forbid the supposition that that cranium has belonged to a young individual of the gigantic *Dinornis*. I conclude therefore that the *Dinornis dromioides* had relatively larger temporal muscles and a stronger bite than the *Din. struthoides*. The upper boundaries of the depressions are better defined in *Din. dromioides*, and there is a vertical ridge marking off the anterior third of the depression (*ib.* 6), like that which may be seen in the cranium of the large Storks and some other birds, but of which there is no trace in the cranium of *Din. struthoides*.

The articular surface on the mastoid for the os tympanicum is broader, flatter and shallower anteriorly in *Din. dromioides* than in *Din. struthoides*; and, in both, the lower angle of the mastoid is much less produced below the outer side of the articular cavity than in the Ostrich or Emeu; but the mastoid process in the Apteryx is much less in comparison with the par-occipital process than it is in the Dinornis.

The posterior angles of the supra-orbital ridge (*ib.* 12) are not entire; but the rugged surface has more the character of a sutural than a fractured one; and the presence of distinct posterior frontals in a nearly mature skull of an Emeu (*Dromaius Novæ Hollandiæ*) (*ib.* fig. 1, 12, 12) at the same part, leads me to suspect that these parapophysial elements of the frontal vertebra may have remained permanently separate osseous pieces in *Dinornis*, as in the Reptilia.

The anterior border of the os frontis shows two deep angular depressions (fig. 5, 15) for the articulation of the nasal bones, which are thus proved not to have become anchylosed to the frontals, as in the Apteryx, Emeu, and most other birds, but to have remained distinct throughout life, as in the Turkey and some other *Gallinacea*.

The extent of the supra-orbital ridge is eleven lines, and is, therefore, proportionally much less than in the Emeu or any Struthious bird, except the Apteryx, and apparently also the Dodo: the very slight transverse concavity of the roof of the orbit (fig. 4, 11′) and its longitudinal convexity are characters which are intermediate between those of the Apteryx, where the orbital cavity is singularly small and indistinct, and those of the larger existing *Struthionidæ*, and they combine, with the diameter of the optic canals, to show that the eyes of Dinornis were relatively smaller than in the Emeu and Ostrich.

Part of the inter-frontal suture, usually the last of the proper cranial sutures to disappear, may still be seen in the outer table of the skull of the *Dinornis dromioides*: there is no trace of it in the skull of the *Din. struthoides*.

Tympanic Bone.

The third portion of a skull formed part of a small collection of bones of *Dinornis* from the North Island, transmitted by my esteemed friend the Rev. William Cotton, M.A., whose zealous co-operation in the advancement of the natural history of the remote colony which benefits by his more important labours, deserves the warmest praise.

The portion in question is the left os tympanicum (os quadratum of ornithotomists), with the upper or mastoid articular end broken away, but with the orbital process and inner part of the articular surface for the mandible entire (Plate XXXI. fig. 7). From its size, which is double that of the same bone of the Ostrich (*ib.* fig. 8), it is referable to the *Dinornis giganteus.* In the breadth and flatness of the articular surface (*c*) for the inner division of the mandibular condyle, it resembles the tympanic of the Emeu more than that of the Ostrich; but in the length and slenderness of the orbital process (*a*) it more resembles the Apteryx (fig. 9, *a*) than any other existing Struthious bird. The corresponding process in the tympanic of the Ostrich and Emeu is shorter and broader. The upper articular extremity is wanting in the fossil, but its shape may be judged of by that of the cavity in the skull (Pl. XVI. fig. 4, 28) adapted for its reception. The figures preclude the necessity of further verbal description of the present interesting fragment: if the length of the entire skull bore the same proportion to the os tympanicum in the *Dinornis giganteus* as in the Ostrich or Emeu, it could not be estimated at less than one foot three or four inches in the stupendous extinct wingless bird of New Zealand; but if the form of the beak should have resembled that of the Dodo or approximated to that of the Apteryx, the total length of the skull of the *Dinornis giganteus* would exceed the above-estimated admeasurement.

Vertebræ.

Through the kindness of Dr. Mackellar I have been enabled to compare and describe some remarkably perfect specimens of cervical and dorsal vertebræ of the *Dinornis*, which formed part of a collection of bones obtained by that gentleman in the Middle Island, from a superficial turbary formation on the coast, submerged at high tide, near the settlement at Waikawaite: these specimens are now deposited in the Museum of Natural History of the University of Edinburgh.

The first of these vertebræ (Plate XXXII. figg. 1, 2 & 3) to be noticed is a cervical, with all its parts as sharp and unmutilated as if it had been artificially macerated. From the absence of a neural spinous process, as well as from the longer and more slender proportions of the body, compared with any of those described and figured in the preceding memoir (pp. 97—99), the present vertebra must have come from a more advanced part of the neck, and have belonged to a species at least as large as the specimen in Pl. XVII. figg. 1—3. From the analogy of the Apteryx it might be the eighth or ninth cervical, since in that bird the spinous process begins to be developed in the vertebræ above and below these; but the proportions of the vertebræ and the analogy of the Emeu indicate it to have come from a part nearer the head.

In the length of the posterior zygapophyses or articular processes (Pl. XXXII. z') and the depth of the triangular depression between them, the present vertebra bears more resemblance to the cervical vertebræ of the Emeu than to any in the neck of the Ostrich, the Rhea, or the Apteryx: but the pleurapophysis or process representing the cervical rib (*ib. pl*) is not so pointed or prolonged as in the Emeu; it more resembles that in the Apteryx: the breadth or depth of this process, the large relative size of the canal which it overarches and completes, and the ridges and furrows on the outer surface, bespeak the strong development of the cervical muscles and the great strength of the neck.

The characteristic conformation of the cervical vertebræ in the class of Birds is well-displayed in the present specimen, and the particular modifications characteristic of the Dinornis are better elucidated by the figures than by verbal description.

The next cervical vertebra (Pl. XXXII. figg. 4 & 5), like the foregoing, is from the part of the neck where the neural spinous process ceases to be developed, there being in its place a flat surface (*s*) behind a rough shallow depression for the attachment of the strong, short, elastic ligament: the difference of size and conformation of the present, as compared with the foregoing vertebra, is obviously not such as depends on mere difference of position in the same neck, or in the neck of the same species, but clearly indicates a difference of species in the birds to which they have respectively belonged. The present vertebra may well, from its size, have come from the anterior third part of the cervical series in the *Dinornis giganteus*; the preceding from the corresponding part of *Dinornis ingens*. In assigning the vertebra (Pl. XVII. figg. 1—3, p. 109) to the largest species of *Dinornis*, I was influenced by the ordinary proportions of those bones in other birds: the present specimens prove that the strength of the neck was greater and the cervical vertebræ relatively larger in the genus *Dinornis*, and the above-cited vertebra must be assigned to *Din. ingens* rather than to *Din. gigas.*

The costal process (Pl. XXXII. *pl*) here presents a similar breadth and depth and external sculpturing: the upper and posterior margin is produced into a short obtuse point. From the base of this part a ridge extends obliquely upwards and backwards to that of the posterior zygapophysis or oblique process (*ib.* z'), parallel with the shorter and stronger ridge from the anterior oblique process (*ib.* z) to the base of the spine: between these ridges there is a deep depression opening at the bottom into the cancellous structure of the bone. This *foramen pneumaticum* is not present in the smaller cervical vertebra (*ib.* figg. 1—3). The rudimental spinous process (*ib.* fig. 5, *s*) forms a transverse barrier across the front of the depression between the posterior oblique processes, which depression is broader and more rounded at the bottom than in the preceding vertebra, and is quadrate, not triangular, in the present vertebra.

The largest vertebra in Dr. Mackellar's collection is an inferior cervical one (Pl. XXXIII.), corresponding with that of the smaller species of *Dinornis* figured in Pl. XVII. figg. 7, 8 & 9, in the presence, as in the Apteryx, of a compressed hæmal or inferior spinous process. In this character both species of *Dinornis* more resemble the small existing Struthious bird of New Zealand than the larger species of New Holland. In the Emeu, for example, the inferior spinous process begins not to be developed until the dorsal series of vertebræ, with articular cavities for ribs, commences.

The anterior articular surface of the body (Plate XXXIII. figg. 2 & 3, *a*) bends down upon the under part of the vertebral body, where the lower angles of the reniform surface are produced backwards. The diapophyses or transverse processes (*ib. d*) developed from the base of the anterior oblique processes (*ib. z*) seem not to have been connected by a costal process with the produced margins of the anterior and under part of the body (*a*), but to have been divided from these by an open groove on each side. The perforated depression (*i*, fig. 1) is smaller than in the foregoing cervical vertebra, and the posterior boundary ridge of the foramen pneumaticum is shorter and more obtuse. The base of the superior spine is strongly impressed before and behind by a rough surface for attachment of the inter-spinal elastic ligaments: the antero-posterior extent of this spine (*g*) and of the inferior one (*h*) is shown by dotted lines in fig. 1. Both having been broken off in the specimen, these and the other fractured surfaces of the vertebræ show the very coarse and loose cancellous texture of the bone.

In a similar-sized more perfect posterior cervical vertebra of *Dinornis giganteus*, in the collection of Mr. Percy Earl, obtained from the same deposit and locality, the strong spinous process is entire: it is four-sided and truncate at the summit, four inches high from the fore-part of its base, one inch in the antero-posterior diameter of the base, and ten lines in the transverse diameter.

A fragment of a vertebra, from the same collection, of nearly the same size, and probably a little anterior in position, differs from the preceding in having only a very shallow imperforate depression, where the deep perforated pit exists at the sides of the neurapophyses in the foregoing vertebra: the neural spine has scarcely been developed above the level of the posterior zygapophyses or articular processes in this fragment.

Dr. Mackellar's collection contained two very perfect specimens of dorsal vertebræ of smaller species of *Dinornis*, presenting several peculiarities characteristic of the genus. The first of these (Pl. XXXIV. figg. 1 & 2) is from the middle of the dorsal region of probably the *Dinornis ingens*. It is not carinate inferiorly, as in the corresponding vertebra of the smaller species, figured in Pl. XVII. figg. 6—9, and the lower border of the anterior articular surface of the body is less produced in proportion to that of the posterior surface. The depression leading to the cancellous structure between the transverse and posterior oblique process in the small dorsal vertebra above cited is wanting in the present large one; but the pneumatic foramen (Pl. XXXIV. *f*) between the costal depression (*c*) and transverse process (*b*) is present. The proportionate breadth of the body of the vertebra; the broad outspread oblique processes (*ib.* fig. 2, *z*, *z'*); the thick, obtuse and almost horizontal transverse processes (*ib. b*); the strong spinous process, as broad transversely as antero-posteriorly;—all exemplify the generic characters of the vertebræ of *Dinornis*.

The rough ligamentous tract on the fore and back part of the neural spine is produced into a median ridge (*s*), making the transverse section of the middle of the spine hexagonal; two inches and a half of the spine remain, measured from the bottom of the rough tract; the height would probably have exceeded three inches in the perfect vertebra.

A dorsal vertebra (Pl. XXXIV. figg. 3 & 4) of the same size, and from the same or nearly the same region of the spine, shows the pneumatic foramen between the transverse and posterior articular process, as in the small vertebra (Pl. XVII. figg. 6—9), but not that between the transverse process and the costal depression, as in Pl. XXXIV. fig. 1, *f*: it further differs from that vertebra by the larger proportional size of the zygapophyses (*ib. z, z*) and the somewhat more slender spine (*ib. s*): the ridge continued from the side of the base of the spine to the transverse process (*ib. b*) is sharper.

A middle or posterior dorsal vertebra of a smaller species of *Dinornis* resembles the larger one in the absence of the pneumatic foramen between the posterior oblique and transverse processes, and in the relative size of the posterior and anterior articular processes: the spine is entire, the rough front and back surfaces are not carinate, but convex; the summit of the spine flat and truncate.

The figures in Plate XXXIV. supply the points of comparison omitted in the verbal description, in a better and more applicable form. I suspect one of the larger dorsals to belong to the *Din. ingens*, the other larger one to the *Din. crassus*; the present vertebra may well belong to the *Din. struthoides*.

Sternum.

From the turbary deposit near Waikawaite Mr. Earl obtained nearly an entire sternum (Pl. XXXV. figg. 1—3) of one of the larger, if not of the largest species of *Dinornis*. It appeared to have been fractured by the instruments employed in digging out the bones, and reached me in two pieces, one including the articulations for the sternal ribs (*r, r*) and for the coracoid (*ib.* fig. 2, *c, c*) of the right side, with rather more than half the body of the sternum, and with the border of the right posterior wide notch (*e*) entire, showing its size and shape, but with part of the anterior border and the anterior (*a*) and posterior (*p*) angular processes broken away: the left portion of the same sternum included the two posterior articular surfaces for the ribs and upwards of three inches of the posterior angular process, with part of the entire border of the left posterior emargination (*e*): the base (*x*) of a process from the middle of the posterior border of the sternum indicated the characteristic configuration of this part of the bone. The anterior border (fig. 2), about half an inch thick, and rounded, is shown by the right moiety to have extended almost straight to beyond the middle of the bone. The outer surface of the sternum is gently convex, without the smallest trace of a median crest or keel; the inner surface is slightly concave, deepest near the anterior angles. The main body of the sternum consists of a light cellular layer of bone, with a thin, smooth, compact outer and inner table, the whole averaging three lines in thickness, and thinning off to the posterior margin.

The following are the dimensions of this mutilated but instructive bone:—

	In.	Lin.
Breadth across the articulation of the last rib	9	9
Breadth between ends of posterior angular processes	13	0
Length, or antero-posterior diameter at middle of posterior emarginations	6	0
Thickness at articular margin for ribs	1	0
Length of posterior angular process from middle of emargination	4	0
Extent of costal articular surface	2	6
Extent of coracoid articular surface	1	0

This, the largest sternum which has hitherto been discovered in the class of Birds, is relatively the smallest in proportion to the body, if it belong to the *Dinornis giganteus*. That it belongs to the genus there is no room for doubt, since it was found associated exclusively with the abundant remains of different species of *Dinornis*, and especially with those of *Din. giganteus*. In its small relative size, its shortness as compared with its breadth, its shield-shape and the total absence of a keel, it demonstrates the want of a power of flight in the genus *Dinornis*, and its closer relationship to the Cursorial or Struthious order. The following are comparisons of the present sternum with the modifications of form which that bone presents in the different genera of that strictly terrestrial order.

The sternum of the Ostrich (*Struthio*, Pl. XXXV. fig. 4) is larger in proportion to its breadth; the hind-part is narrower, instead of being, as in Dinornis, broader than the fore-part: the sternum of the Ostrich is more convex, and is a much thicker bone, especially at the middle prominent part of the body of the bone which transmits the weight of the trunk upon the sternal cushion or callosity, upon which the Ostrich rests when prone on the ground. The coracoid grooves (*ib. c, c*) are considerably larger in the Ostrich, extending from the outer angle, close to the middle of the anterior border, which is thin and sharp: the costal articulations (*ib. r*) are broader, much deeper, and occupy a much greater proportion of the lateral borders of the sternum. The posterior angles (*ib. p*) are prolonged backwards, but not so far as in the Dinornis, and there are two emarginations (*ib. e, e*) on each side between the angles and the middle line, to which a cartilaginous, and, in old Ostriches, a semi-osseous xiphoid appendage (*x*) is attached.

In the *Rhea* the sternum (Pl. XXXV. fig. 5) deviates more than in the Ostrich by its greater length, median convexity and posterior contraction, from that of the Dinornis: it further differs in the absence of posterior angular prolongations and the presence of a posterior median marginal notch (*e*); but the coracoid cavities (*c, c*), though considerably larger than in the Dinornis, are more confined to the anterior angles than in the Ostrich.

The coracoid cavities have a similar position, but rather smaller relative size, in the sternum of the Cassowary (*ib.* fig. 6), which however differs as much as that of the Rhea from the sternum of the Dinornis in its greater length as compared with its breadth, and especially in its contraction to the posterior margin, where the angles are rounded off and the middle part slightly produced.

In the Emeu (*Dromaius*) the sternum (*ib.* fig. 7), with the same general form as in the Cassowary, further differs from that of the Dinornis in the approximation of the coracoid grooves (*ib. c, c*) so as to come into actual contact at the middle of the anterior border.

Of the sternum of the Dodo we as yet unfortunately know nothing, although we may as reasonably expect the osseous remains of that extinct bird to reward the search of naturalists and collectors in the islands of Mauritius and Rodriguez, as the similar quest in New Zealand has been followed by the recovery of the bones of the *Dinornis*.

In the *Apteryx* however we find a sternum (*ib.* fig. 8), which, with the same general Struthious characters, very closely corresponds with the particular modifications of that of the Dinornis. It has the same small proportional size to the body; nearly the same superior breadth as compared with the length, the same slight degree of convexity, and the same characteristic expansion and marginal configuration posteriorly. In the sternum of the Apteryx described at p. 34 and figured in Pl. IX. figg. 2 & 3, two small subcircular spaces remained unossified in the body of the sternum; in two more mature specimens which I have subsequently received, ossification has obliterated these spaces, where however the bone is thin and diaphanous, and the sternum presents only the two deep posterior emarginations, bounded by a middle xiphoid prolongation and the two angular elongated processes (*p*, *p*), as in the Dinornis. These processes in the Apteryx are relatively broader, thinner, and are subincurved: in the Dinornis they seem, from the remains of the one on the left side, to be straight, and become thicker and narrower.

The costal articular surface occupies a greater proportion of the lateral margin of the sternum in the Apteryx than in the Dinornis, though it is less than in the Ostrich. The coracoid groove has the same relative position and size in the Apteryx as in the Dinornis, but has a different form: in the small existing wingless bird it is an oblique notch, formed by a small process projecting upward and forward from the outer surface of the sternum near the antero-external angle: in the Dinornis (*ib.* fig. 2, *c*) it is an oblique depression, as if the end of the thumb had been pressed into the same part of the bone when soft. The anterior and lower border of the depression is not produced beyond the level of the bone; but in the example before me it is notched, as if for the passage of vessels to the joint.

Whether the antero-external angle (*a*) is prolonged so far in *Dinornis* as in *Apteryx*, the fracture of that part in the present specimen does not allow to be determined. The anterior margin between the coracoid articulations in the Apteryx is deeply excavated, whilst in the present species of *Dinornis* it is almost straight. Four smooth depressions with three well-marked rough surfaces (r, r', r'') for the attachment of sternal ribs, characterise the anterior two-thirds of each lateral border in the Dinornis. The outer surface of the sternum in the Dinornis shows the impressions of the decussating bands and fibres of the aponeurotic periosteum, with which it was covered when recent.

A part of a young Apteryx, kindly transmitted to me by Dr. Robert Hunter, demonstrates that the sternum is developed, as in other *Struthionidæ*, from two lateral centres, whence the ossification radiates, and converging to the middle line, there produces confluence of the primitively separate halves. We cannot doubt, from the close conformity of the sternum of the adult Dinornis with that of the Apteryx, that it was developed in the same way, and not, as in the *Gallinacea*, from more numerous separate centres, notwithstanding the rasorial proportions of the metatarsus.

Bones of the Extremities.

Although the title of a former Memoir* referred to five species of *Dinornis*, determined from the osseous remains transmitted by Archdeacon Williams from the North Island of New Zealand, a sixth species was indicated in the Memoir itself, under the name of *Dinornis dromioides*, by the characters of a femur†, the only bone of the extremities referable to that species which I at that time possessed.

I have since received from the North Island, by the kindness of Mr. Cotton, two other femora, agreeing in size and characters with the one referred to the *Dinornis dromioides*, together with two tibiæ and a metatarsal bone, of a size in respect of breadth of extremities and circumference of shaft suited to those femora, and differing from the homologous bones in all other known species of *Dinornis* by being more slender in proportion to their length and longer in relation to the femur; thereby approaching more nearly to the proportions of the leg-bones in the Emeu and other large existing *Struthionidæ*, and confirming my conjecture founded upon the characteristic proportions of the femur itself‡.

The species which I have called *Dinornis ingens* was founded principally on the characters of a femur and tibia. I have since received a tarso-metatarsal bone from the North Island, through the kindness of Mr. Colenso, and from the Middle Island there have been transmitted femora, tibiæ and tarso-metatarsals of apparently a more robust variety of *Dinornis ingens*, together establishing most satisfactorily the former existence of at least one species of *Dinornis* of the stature of nine feet.

The richest accessions to the osteology of this extraordinary genus of wingless birds have been made by Mr. Percy Earl, an enterprising naturalist, to whose exertions zoology is indebted for the recovery of the most perfect remains from the soil of New Zealand. These were discovered by Mr. Earl in a turbary deposit on the sea-coast of the Middle Island, near the settlement of Waikawaite. The deposit is overflowed by the sea at high-tides, and had been covered by a bed of sand and shingle; but this bed having been swept away by storm-waves a short time before Mr. Earl's arrival, the black

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* Zoological Transactions, vol. iii. part 3, 1844, p. 235.

† "The femur of nine inches in length, with similar proportions of the tibia and metatarsus, which latter would probably be relatively longer"—(the comparison is with *Dinornis didiformis*)—" gives the height of five feet to the species, which from its similarity of size to the Emeu I have called *Dinornis dromioides*."—*Ib*. p. 264, pl. 22.

‡ *Ib*. p. 252.

bed of peat was exposed, to which Mr. Earl's attention was attracted by observing some bones projecting from its surface. These and many other bones, obtained by digging close to the surface, or at a moderate depth in the peat, all belonged to species of *Dinornis*.

Commencing with the leg-bones referable to known species, I first select for description the femur of the *Din. giganteus*, of which hitherto only the shaft has been described; but I have now had the opportunity of examining four perfect specimens contained in the collections of Dr. Mackellar and Mr. Percy Earl.

The femur of the gigantic *Dinornis* closely accords with the generic characters of the bone, as given in the preceding memoir (pp. 86, 87). The rough surface for implantation of a muscle at the middle of the fore-part of the proximal end is well-marked, and there is an obtuse prominence from the middle of the rotular concavity (Pl. XXXVI. fig. 2, *r*) above the transverse ridge which divides this from the lower inter-condyloid space. The back-part of the proximal extremity of the bone is entire and imperforate, as in the other species of *Dinornis*. Its dimensions are given in the 'Table of Admeasurements': the length precisely accords with that conjecturally assigned to the femur of the Gigantic species in the former memoir (p. 86, Table of Dimensions of Femora, f. 1 and Note*).

The circumference of the middle of the shaft exceeds that of the fragment there described, and indicates the Gigantic Dinornis of the Middle Island to have been a stronger and more robust bird than that represented by the bones from the North Island, described in the former memoir. In Plate XXXVI. the proximal (fig. 1) and distal (fig. 2) extremities of this noble bone are figured of the natural size.

Fine tibiæ of *Din. giganteus* in both Dr. Mackellar's and Mr. Percy Earl's collections supplied, by the perfect state of their articular ends, what was defective in the more ancient and rolled bones from the North Island. The head of the tibia is characterized in Birds by the flat or sinuous, or sometimes slightly convex articular surface (Pl. XXXVII. *a*, *a*) adapted to the inner condyle of the femur, by the large size of the tuberosity (*ib. t*) which divides this from the smaller sloping articular surface applied to the inner side of the outer condyle, and by the 'epicnemial' ridge (*b*), which is commonly broad and more or less produced upwards from the anterior and outer part of the proximal surface of the tibia. From the outer, usually more or less obtuse, angle of the epicnemial ridge a short 'ectocnemial' ridge (*k*) is commonly continued downwards upon the outer part of the shaft: a compressed prominent 'procnemial*' ridge (*p*) is continued further down the fore-part of the shaft of the tibia.

The proximal end of the tibia of the Gigantic Dinornis (Pl. XXXVII. fig. 1) agrees, like

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[*] To facilitate and make more intelligible the comparisons of the tibiæ in the different species of Dinornis and other birds, I have proposed the above names for the well-marked and constant processes and ridges which have not before received any distinct appellations in Comparative Anatomy.

that in the smaller species, with the modifications of the ornithic type presented by most *Grallæ* and *Gallinæ* (*ib.* fig. 4, *Ciconia Argala*), but differs considerably from the corresponding part in the Ostrich (*ib.* fig. 2). In this largest of existing *Struthionidæ* the epicnemial process (*b*) does not rise above the level of the proximal surface of the tibia, but extends directly forwards, sends out a compressed and prominent procnemial ridge (*p*) and a short thick obtuse process (*k*) from its outer side in place of the ectocnemial ridge. In the Dinornis the posterior articular tuberosity (fig. 1, *t*) is divided, by a wider and deeper depression than in the Ostrich, from a smaller anterior prominence to which a fibular ligament is attached (fig. 4, *l*) : this depression in the Dinornis receives the inner prominent division of the outer condyle of the femur ; the posterior tibial tuberosity rising into the space between that and the inner condyle, whilst the fore-part of the outer condyle rests upon the inner side of the ascending tibial ridge : this occasions a closer interlocking of the tibia and femur than in the Ostrich. The only difference in the dimensions of the tibiæ of the *Dinornis giganteus* from the North and Middle Islands is a slight increase of the breadth of the distal end of the more recent and better-preserved bones from the latter locality (see the 'Table of Admeasurements, p. 137.'). I subjoin to the figure of the well-preserved proximal end of one of these tibiæ from the Middle Island, figures of the same parts of the tibia in the Ostrich (fig. 2), Emeu (fig. 3), and Gigantic Crane (fig. 4), all of the natural size.

The tarso-metatarsal bones of the *Dinornis giganteus* from the Middle Island are more generally and sensibly stronger in proportion to their length than the femora or tibiæ, compared with those from the North Island; but I cannot venture to infer from this evidence alone more than a stronger variety of the species : the degree of difference is accurately given in the 'Table of Admeasurements, p. 137.'

A new species might with more reason be founded on the bones of the hind extremity from the Middle Island, which agree in length with those of the *Dinornis ingens*, since they surpass in thickness in a somewhat greater degree their homologues from the North Island. This difference I have not only been able to appreciate with regard to the femur and tibia on which the species *D. ingens* was founded*, but also with regard to the tarso-metatarsal bones, having received one specimen from the North Island, transmitted by Mr. Colenso, which presents intermediate dimensions between the tarso-metatarsal bones referred to *Dinornis giganteus* and *Dinornis struthoides*, and having compared it with three tarso-metatarsals of similar length in the collection of Mr. Percy Earl. These differences will be appreciated by the 'Table of Comparative Dimensions'; but I shall here notice these stronger bones from the Middle Island as belonging to *Dinornis ingens*, var. *robustus*, until other parts of the skeleton, especially the skull, may arrive, although the following differences of form are observable in the homologous bones of the extremities from the two localities.

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* *Loc. cit.* pp. 86, 88.

In the femur of the robust variety of *Dinornis ingens* from the Middle Island, the upper tuberosity of the two posterior ones is nearer the lower than the upper end of the bone; in the femur of the *Din. ingens* from the North Island it is nearer the middle of the shaft. In the *Din. ingens* from the Middle Island the inner contour of the femur descending from the head is less concave: the outer expanded surface of the proximal end of the bone forms an obtuse angle with the posterior surface, not a right angle, as in the *Din. ingens* from the North Island. In the *Din. ingens* from the Middle Island the great trochanterian ridge extends more boldly out, its contour is more convex, and it is relatively larger. The same may be observed with regard to the antero-external prominence of the outer condyle: the length of shaft included between the lower end of the trochanterian prominence and the upper end of the external condyloid prominence is four inches nine lines in the robust variety, and five inches five lines in the femur from the North Island.

The proportions of the tarso-metatarsal bone of the *Dinornis ingens*, as exemplified in the bone (Pl. XL. fig. 1) sent by Mr. Colenso from the North Island, are nearly those of the *Din. struthoides*. In the tarso-metatarsal bone of *Din. giganteus* the antero-posterior thickness of the shaft is greater. The anterior surface of the upper half of the shaft, below the perforated depression, shows a slight longitudinal concavity in *Din. ingens*. Towards the inner side of the posterior part of the lower half of the shaft there is a rough tract of three inches in length, and at its lower end a rough oval depression (*ib. d*), about one inch by nine lines. The surface in the tarso-metatarsal bone of the Apteryx for the attachment of the back-toe occupies the corresponding place: the *Dinornis ingens* therefore, by this mark of resemblance to the Apteryx, may belong to a genus (*Palapteryx*) distinct from *Dinornis*. The accuracy of the reference of the tarso-metatarsal bone, *m* 2, in the preceding Memoir (p. 82) to a young individual of the *Dinornis giganteus*, is well-illustrated by the present bone, in which the shaft, from the perforated proximal anterior depression to the beginning of the clefts of the distal articular trochleæ, is precisely the same as in *m* 2; the tarso-metatarsal in the *Dinornis ingens* manifesting all the characters of age, by complete confluence of its primitively distinct elements, as well as by the strong and rough lateral ridges for ligamentous and aponeurotic attachments; whilst *m* 2, with the same length of shaft, shows, as described in the former Memoir, the still open fissures between the proximal ends of the three constituent metatarsals.

The species, which I have called *Dinornis casuarinus*, is most satisfactorily determined by ten femora, five of the left and five of the right leg; by eleven tibiæ, five of the left and six of the right leg; and by six tarso-metatarsal bones, most of which bones have been obtained from the Middle Island, at the locality and turbary deposit near Waikawaite.

I have figured one of the bones of this species from the North Island in the preceding Memoir, viz. a mutilated femur (Plate XXIII. fig. 1), which I at first regarded as belonging to a young individual of the *Dinornis struthoides*. The acquisition of so many entire femora, tibiæ and tarso-metatarsal bones, evidently belonging, by their proportional size and exact co-adaptation of articular surfaces, to the same species of bird, has enabled me to detect specific characters in the femur and tibia, by which this species, for which I propose the name of *Dinornis casuarinus*, clearly differs from both *Dinornis struthoides* and *Dinornis didiformis*. But I may be permitted to observe, that the reference of the solitary mutilated femur to the young of the *Din. struthoides*, which I am now enabled to correct, was a mistake on the safe side: the caution which refrains from multiplying specific names on incomplete evidence being less likely to impede the true progress of zoological science than the opposite extreme.

The specific characters of *Din. casuarinus* (Pl. XXXVIII.) and its distinction from *Din. dromioides*, with which it most nearly agrees in size, and especially in length, will be most prominently brought out by combining the descriptions of the bones of both species.

The femur of the *Din. casuarinus* very little exceeds that of the *Din. dromioides* in length, but rather more in the circumference of the shaft, and very considerably in the development of the two extremities. The head is relatively larger, as Pl. XXIII. of the foregoing Memoir shows: the tuberosities below the middle of the back-part of the shaft are more developed: the rotular interspace between the condyles is both wider and deeper: the posterior half of the internal condyle is relatively much larger. But both the internal and the external longitudinal narrow ridges are more marked in *Din. dromioides* than in *Din. casuarinus*.

The well-marked differences between the femora of these nearly similarly-sized species will be readily appreciated by comparing Pl. XXXVIII. with Pl. XXII. The specimen figured in Pl. XXXVIII. is rather less than other femora of the same species from the same locality.

The most obvious distinction between the tibiæ of the *Din. dromioides* and *Din. casuarinus*, in the relation of their thickness to their length, is shown in the 'Table of Admeasurements' and in Plate XXXIX. figg. 1 & 2. The tibia of the *Din. dromioides* (fig. 1) is longer and more slender, corresponding with the character of the femur: the interspace between the ectocnemial tuberosity (*k*) and the procnemial crista (*p*) at the proximal end is less than in *Din. casuarinus*, and the procnemial ridge continued down from the crista does not so soon gain the middle of the anterior surface of the shaft, and is continued down the middle to the lower third before it inclines to the inner side: the tendinous groove leading to the osseous bridge (*f*) in front of the distal end is shorter and deeper. The orifice of the canal for the medullary artery is at the same distance from the top in the tibiæ of both species. The antero-posterior thickness of the shaft of the tibia at its proximal third is markedly less in *Din. dromioides* than in *Din. casuarinus*. The difference in the plane and aspect of the surface between the anterior and fibular ridge in the *Din. dromioides* and *Din. casuarinus* is well-marked.

The proportions of the tarso-metatarsus of *Din. dromioides* (Pl. XL. fig. 2) are, as those of the femur led me to conjecture*, more slender, and the bone is relatively longer, not only than in *Din. didiformis*, but also than in any other known species of *Dinornis*, not excepting the *Din. ingens*, to the tarso-metatarsal bone of which the present tarso-metatarsal from the North Island bears the nearest resemblance in general form and proportions, and in the important character of the rough oval surface (*ib. d*) indicative of the attachment of a back-toe, one-fourth from the distal end. Little needs to be added to the 'Comparative Table of Admeasurements,' and to the figures in Plate XL., for the exposition of the specific characters of this bone. In the form of the concavity at the middle of the fore-part of the upper half of the shaft it resembles the tarso-metatarsus of the *Din. struthoides* more than that of the *Din. casuarinus*, in which, as in *Din. crassus*, the same surface below the rough and perforated depression is flat or slightly convex.

The tarso-metatarsal bone of the *Din. casuarinus* (Pl. XL. fig. 3) is remarkable, not only for its great breadth, in proportion to its length, but also, like the femur, for the expansion of the distal end, and especially the production of the inner trochlear division.

On inspecting Mr. Percy Earl's large collection of remains of Dinornis from Waikawaite, it was satisfactory to find with how little difficulty the bones could be selected which belonged to the species which had been named :—

Dinornis giganteus,
——— *ingens*,
——— *struthoides*,
——— *dromioides*.

Of the second of these species, of which I had before seen only the femur and tibia from the North Island, Mr. Earl's collection contained the tarso-metatarsal bones, besides very perfect specimens of femora and tibiæ.

Thus it appears that four species of *Dinornis*, including the three most remarkable for their gigantic stature, were common to both the North and South Islands.

Mr. Earl's collection did not contain any specimen of *Dinornis didiformis* or of *Din. otidiformis*; but after selecting those bones which agreed with the previously determined species, there remained a considerable number of most perfect specimens of femora, tibiæ and tarso-metatarsal bones of unquestionably full-grown individuals, which differed as much in configuration and proportions from the previously determined species as these did from one another. The most abundant remains belonged to the species above

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* "The femur *f* 16 cannot be regarded as belonging to a young individual of the gigantic species; there remains then no other conclusion than that it must represent a fifth distinct species, of which there are neither tibiæ nor metatarsi in the present collection. I venture to surmise, that the tibia, and especially the tarso-metatarsus of this species, will be found relatively longer and more slender than in the *Din. struthoides* and *Din. didiformis*: so much may be anticipated from the more slender proportions of the femur, which moreover resembles the femur of the Emeu in some of the characters by which it differs from the above species of *Dinornis*." —Zoological Transactions, vol. iii. part 3, 1844, p. 252.

defined under the name of *Din. casuarinus*; but the most extraordinary species is that which I propose to call *Dinornis crassus.* It is intermediate in size between *Din. ingens* and *Din. struthoides*: with a stature nearly equal in height to that of the Ostrich, the femur and the tarso-metatarsus (Pl. XL. figg. 4 & 5) present double the thickness in proportion to their length: it must have been the strongest and most robust of Birds, and may be said to have represented the pachydermal type and proportions in the feathered class.

The species described under the name of *Din. casuarinus* combined the stature of the Cassowary with more robust proportions, and especially more gallinaceous character of the feet. The third new species is intermediate in size between the *Din. didiformis* and *Din. otidiformis*, and I propose to name it *Dinornis curtus.* Although the majority of the remains of *Din. casuarinus* have come from the Middle Island, a few specimens have reached me from the North Island. Remains of *Dinornis crassus* have hitherto been found only in the Middle Island, and those of *Dinornis curtus* are at present as exclusively from the North Island.

Of the *Dinornis curtus* I have received from Mr. Cotton the shaft of a femur, a little more complete than that of the *Dinornis otidiformis*, and apparently shorter in proportion to its circumference, but having the same relative superiority of general size, and especially thickness, which is manifested in the tibia and tarso-metatarse of the *Din. curtus.*

The tibia of *Dinornis curtus* (Pl. XXXIX. figg. 3, 4 & 5) resembles that of *Dinornis casuarinus* in the extent and form of the ectocnemial process (*k*); in the distance between this and the procnemial crista (*p*), and in the position and course of the ridge continued thence down the fore-part of the shaft to the inner pier of the distal osseous bridge (*f*). It differs from *Din. casuarinus* and the other larger species of the genus in the lower position of the nutri-arterial foramen, which is nearly half-way between the two ends of the bone. The distal condyles resemble those of the tibiæ of the larger species much more than those of the smaller *Din. otidiformis.* The inner side of the shaft is more rounded, less angular than in *Dinornis didiformis* or *Din. casuarinus*, and the anterior surface slopes more abruptly backwards to the fibular ridge; the surface between the anterior ridge and fibular ridge being convex in *Din. curtus*, but almost plane in *Din. casuarinus.* The outer (fibular) division (*o*) of the distal condyle is less produced forwards than in *Din. didiformis*, but in this respect resembles that in *Din. casuarinus*; its transverse extent is however relatively greater. The tibia, and consequently the whole leg of *Din. curtus*, is shorter in proportion to the femur and the tarso-metatarsus than in the *Din. didiformis* or any other species, except probably the *Din. crassus*, of which only the femur and tarso-metatarsus have yet been obtained.

That *Dinornis curtus* is not the young of *Din. didiformis*, is proved by its tarso-metatarsal bone (Pl. XL. fig. 6). The tarso-metatarsal bone *m* 2, p. 79, [Pl. XXVIII. fig. 3,] proves that the homologous bone of a young *Din. didiformis*, of the size of that of *Din. curtus,* wanting therefore one-fourth of its mature dimensions, as shown in Pl. XXVII. figg. 3 & 4, would exhibit the same imperfect coalescence of the proximal ends of the primitively distinct metatarsals which characterizes the above-cited tarso-metatarsal (*m* 2.) of the young *Din. giganteus.* In the tarso-metatarsal bone of the *Din. curtus,* figured in Pl. XL. fig. 6, the coalescence is as complete as in the corresponding mature bones of all the larger species of *Dinornis.* Besides, it differs from the tarso-metatarsal bone of the *Din. didiformis* not in size only, but in shape and proportions, the shaft being broader in proportion to the length of the bone.

The information derived from the specimens of *Dinornis* transmitted to this country since the publication of my first (1839) and second (1843) memoirs in the 'Transactions of the Zoological Society,' vol. iii., may be summed up as follows:—

Confirmation of the deductions as to the rudimental development of the wings in the genus *Dinornis,* by the discovery of the keel-less sternum, and the evidence it affords of the small size of the coracoid bones.

Confirmation that the species of this essentially terrestrial genus were heavier and more bulky birds in proportion to their height, more powerful scratchers, and less swift of foot than the Ostrich*, but in different degrees, according to the species.

Indications of an affinity to the Dodo in the shape of the cranium; but with evidence of a lower development of the *cerebrum,* whence the Dinornis may be inferred to have been a duller and more stupid bird.

Confirmation of the species—

1. *Dinornis giganteus.*
2. ——— *ingens*
3. ——— *struthoides.*
4. ——— *dromioides.*
5. ——— *didiformis.*
6. ——— *otidiformis.*

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* A correspondent of the 'Polytechnic Journal' for July 1843, commenting on my description of the fragment of the femur of the Movie, in the 'Proceedings of the Zoological Society,' November 1839, objects: "Neither does its femur furnish reason to conjecture that it was swift or slow of foot." (p. 7.) I have not however drawn any absolute conclusion as to the rate of locomotion of the Dinornis. My remark was merely comparative, as respected the Ostrich. In this large existing bird, which is remarkable for both its swift and long-sustained course, the femur is filled with air, like that of a bird of flight. In the fragment of femur which first indicated the genus *Dinornis,* I found the cavity of the bone much smaller than in the Ostrich, with evidence that it had contained marrow; the bony walls being thicker, the cancellous structure more extensive, and the whole bone heavier than in the Ostrich. The femur of the Dinornis therefore did furnish not merely 'reason for conjecture,' but grounds for legitimate physiological conclusion, that that extinct bird was heavier and less swift-footed than the Ostrich.

The proportions of the other bones of the leg which have since arrived establish the accuracy of the conclusion deduced from the structure of the femur; the metatarsal bones being in the Dinornis one-third shorter and thicker in proportion than in the Ostrich, thus rendering the legs more like those of the Apteryx, and consequently more like those of the Gallinaceous birds than in any of the existing large Struthious tribe.

Indications that *Dinornis ingens* and *Din. dromioides* belong to a distinct genus, characterized by a back-toe, for which the name of *Palapteryx* is proposed.

Establishment of the additional species—

7. *Dinornis crassus.*
8. ——— *casuarinus.*
9. ——— *curtus.*

Evidence of well-marked varieties of *Dinornis gigas* and *Din. ingens*, those of the Middle Island presenting more robust proportions than those of the North Island of New Zealand.

The three smaller species, *Din. didiformis*, *Din. curtus* and *Din. otidiformis*, have hitherto been found only in the North Island; the *Din. crassus* seems to have been peculiar to the Middle Island; the other species are common to both Islands; but it would be premature to enunciate any absolute propositions respecting the relations of species to the two chief divisions of New Zealand in the present early period of the inquiry into its extinct Fauna, whilst the evidences appear to exist in such vast abundance and are likelv so richly to reward the zeal of future collectors*.

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* The Rev. Mr. Taylor has favoured me, through Capt. Sir Everard Home, Bart., R.N., with the following note respecting the Dinornis and Apteryx of New Zealand :—

" Whanganui, February 14th, 1844.

"During a journey to Turakina last summer, I was led to the discovery of a large number of the Moa's bones, by accidentally observing a small fragment of a large bone, which, from its extremely cellular structure, led me at once to think it might belong to the Moa. I made the inquiry of a native, who not only confirmed my conjecture, but in reply to the further inquiry, whether such bones were frequently found, told me to look around, and see whether I could not perceive any others. Upon turning a little aside from the path, I noticed several little hillocks formed of bones scattered over the valley; I hastened to them, and so numerous were they that a few minutes sufficed to fill my food-box with choice specimens, emptying out my provision for that purpose, much to the astonishment of the natives, who could not imagine what was my object in loading them with these dry bones: at last they concluded it must be for medicine.

" I found these bones at the mouth of the Whaingaihu, where the sand had drifted over the valley, and I have no doubt there are still many similar heaps covered up by it; each heap was composed of the bones of several kinds of the Moa, as though their bodies had been eaten, and the bones of all thrown indiscriminately together; but such was the friable state they were in, that it was only the larger ones which would bear removal; the bones of the smaller kinds pulverized in the hand, and upon searching below the surface I found the whole one jumbled mass of decomposed bone: the subsoil was a loamy marl, beneath which was a stratum of clay, which chiefly forms the cliffs of this part of the western coast; it contains numerous marine shells, and very closely resembles the gault formation of the east coast of England. I have no doubt it was when that loamy marl was the surface-soil that the Moa lived: although by the river-side it is laid bare, in other parts it is covered by several strata of marine and freshwater deposit. I have found the bones of the Moa in this stratum not only in other parts of the western, but also on the eastern coast at the East Cape and at Poverty Bay, from whence in 1839 I procured a toe of this bird; but I have not heard of its being found north of Turakina.

" I have met with the remains of at least four varieties of the Apteryx family, of which it is highly probable three kinds are still in existence; the Kiwi, which is the smallest, being rather larger than the domestic cock, the male bird having a claw at the termination of its embryo wings; the Kakapo or Tarepo, which is about

No remnant of a *Dinornis* has yet been found in any of the contiguous islands, and I have in vain searched for such in the recent collections of post-pliocene fossils from Australia.

The extraordinary number of Wingless Birds, and the vast stature of some of the species, peculiar to New Zealand, and which have finally become extinct in that small tract of dry land, suggest it to be the remnant of a larger tract or continent over which this singular Struthious Fauna formerly ranged. One might almost be disposed to regard New Zealand as one end of a mighty wave of the unstable and ever-shifting crust of the earth, of which the opposite end, after having been long submerged, has again risen with its accumulated deposits in North America, showing us in the Connecticut sandstones of the Permian period the foot-prints of the gigantic birds which trod its surface before it sank; and to surmise that the intermediate body of the land-wave, along which the *Dinornis* may have travelled to New Zealand, has progressively subsided, and now lies beneath the Pacific Ocean.

the size of a turkey, and from its habits, nature and other circumstances seems so closely to resemble the Dodo, as to lead me to suppose it is the same; and lastly, a bird found in the southern parts of the Middle Island, answering to the Emeu, although perhaps not so high. The gigantic Moa, whose bones are fully as large, though not so ponderous, as those of the Elephant, is extinct, although everywhere traditions of its existence are to be met with, coupled with that of an equally enormous Land-Lizard: this large bird, though perhaps twelve or fifteen feet high, was not tall in proportion to its size. Although the articulations of the bones are many sizes larger than those of the Emeu, I have not yet met with a tibia longer than that of the Emeu of New South Wales."

Capt. Sir Everard Home adds, "I feel little doubt that the Dinornis exists in the Middle Island of New Zealand, which is very thinly inhabited and almost quite unknown; perhaps also in Stewart's Island, where it is said that the Cassowary (Moa?) is to be found."

"H.M.S. North Star, Sydney, April 13th, 1844."

TABLE OF ADMEASUREMENTS OF THE BONES OF THE LEG.

Dimensions of the Femora.

	Din. giganteus.		Din. ingens.				Din. crassus.		Din. struthoides.				Din. casuarinus.				Din. dromioides.						Din. didiformis.						Din. curtus.		Din. otidiformis.	
			v. robustus.		*f* 2.				*f* 12.		*f Colenso.*		*f* 13.		*f* E.		*f* 6.		*f* 16.		*f Taylor.*		*f* 8.		*f* 7.		*f* 17.				*f* 10.	
	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.
Length	16	0	13	9	13	0	12	0	11	0*	12	0	9	6†	10	4	9	4‡	9	6	9	7	8	0	8	0	8	1	0	0	0	0
Breadth of proximal end (in the axis of the neck)	6	0	5	5	4	10	5	0	4	2	4	2	3	5†	3	11	3	6	3	6	3	6	2	10	3	0	3	3	0	0	0	0
Breadth (transverse) of distal end	6	3	5	10	5	2	5	3	4	3	4	4	3	9	4	4	3	7	3	7	3	8	3	3	3	2	3	6	0	0	0	0
Circumference of middle	7	9	7	1	6	1	6	8	5	6	5	6	5	0	4	9	4	1	4	0	3	10½	4	0	4	0	4	3	2	9	2	1

* Perhaps not quite enough allowed for mutilated extremities. † Ib. ‡ Ib.

Dimensions of the Tibiæ.

	Din. giganteus.				Din. ingens.				Din. crassus.	Din. struthoides.				Din. casuarinus.		Din. dromioides.		Din. didiformis.						Din. curtus.		Din. otidiformis.	
	t 1.		*t* E.		*t* 2.		*t* E 1.											*t* 3.		*t* 8.		*t* 9.				*t* 11.	
	in.	lin.	in.	lin.	in.	lin.	in.	lin.		in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.
Length	35	0	35	0	29	0	28	9	......	......		......		19	0	21	0	15	6	15	4	15	4	11	3	8	9
Breadth of proximal end	7	6	7	0	6	2	6	6	......	5	6	5	4	5	6	4	8	4	5	0	0	0	0	3	3	2	0
Breadth of distal end	4	0	4	8	3	7	4	0	......	......		......		2	11	2	8	2	4	0	0	0	0	2	0	1	3
Circumference of middle	6	6	6	6	5	3	6	3	......	5	0	4	8	4	9	4	0	4	0	0	0	0	0	2	9	1	11
Fibular ridge extends down	13	0	13	0	12	0	12	0	......	10	0	10	0	8	6	9	0	6	10	0	0	0	0	4	9	3	6

Dimensions of the Tarso-metatarsals.

	Din. giganteus.				Din. ingens.				Din. crassus.		Din. struthoides.				Din. casuarinus.		Din. dromioides.		Din. didiformis.				Din. curtus.		Din. otidiformis.
	m 1.		*m* E.		*m* E. *v. robustus.*		*Colenso.*				*m* 3.		*m* E.												
	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	
Length	18	6	18	0	14	6	13	9	8	6	12	0	11	6	8	0	10	5	7	0	6	10	5	0	
Circumference at the middle of the shaft	5	6	6	0	5	6	4	6	4	8	4	3	4	2	4	2	3	9	3	3	3	3	2	10	
Breadth (transverse) of distal end	5	1*	6	0	5	6	4	6	4	0	4	0‡	4	5	3	10	3	4	......		3	0	2	5	
Breadth of middle of shaft	1	11	2	2	1	10	1	7	1	10	1	6	1	6	1	7	1	4	1	5	1	3	1	1	
Thickness or antero-posterior diameter of ditto	1	6	1	6	1	5	1	3	1	2	1	1	1	1	0	10	0	10	0	9	0	9	0	7	
Breadth (transverse) of proximal end	0	0	4	6	4	3†	3	6	3	3½	......		3	5	3	0	2	10	......		2	3	1	11	

* The margins being broken and water-worn, the breadth is understated here, as at p. 79. † With a ridge at the middle of inner condyle at proximal end. ‡ Perhaps not enough allowed for water-worn margins of trochleæ.

Average Dimensions of Bones of *Dinornis* in comparison with those of existing *Struthionidæ*.

	Din. giganteus.		Din. ingens.		Ostrich.		Din. crassus.		Din. struthoides.		Emeu.		Din. casuarinus.		Din. dromioides.		Din. didiformis.		Din. curtus.		Din. otidiformis.		Apteryx.	
	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.	in.	lin.
Length of femur	16	0	13	6	11	0	12	0	11	0	9	0	10	2	9	6	8	0	0	0	0	0	3	9
Circumference of ditto	7	3	6	10	5	3	6	8	4	2	3	7	4	9	4	0	4	0	2	9	2	1	1	0
Length of tibia	35	0	28	10	18	6	......		25	0	16	10	19	0	21	0	16	3	11	3	8	9	5	3
Circumference of ditto	6	6	6	0	4	3	......		5	0	3	4	4	9	4	0	4	1	2	9	1	11	1	3
Length of metatarsus	18	6	14	0	16	0	8	6	12	0	15	0	8	0	10	5	7	0	5	0	......		3	3
Circumference of ditto	5	6	5	0	3	7	4	8	4	3	3	0	4	2	3	9	3	6	2	10	......		1	0

DESCRIPTION OF THE PLATES.

PLATE XVI.

Fig. 1. Back view of the cranium of *Dinornis struthioides*.
- 2. Side view of ditto.
- 3. Upper view of ditto.
- 4. Under view of ditto, mutilated.
  - 1. Basi-occipital.
  - 1′. Occipital condyle.
  - 3. Superoccipital plate.
    - *r*. Superoccipital ridges.
    - *d*. Superoccipital impressions.
  - 4. Paroccipital process.
  - 5. Carotid canal in basisphenoid.
  - 6. Foramen ovale in alisphenoid.
    - *n*. Foramen rotundum.
    - *o*. Foramen opticum.
  - 7. Parietal portion of cranium.
  - 8. Mastoid process.
  - 11. Frontal portion of cranium.
  - 11′. Orbital plate of frontal.
  - 12. Postfrontal prominence.
  - 18. Æthmoidal cavities for organ of smell.
  - 28. Articular depression for os tympanicum.
- 5. Upper view of the dried head of the Dodo (*Didus ineptus*), preserved in the Ashmolean Museum at Oxford.
  - *n*. Nostrils. (All the figures are of the natural size.)

PLATE XXXI.

Fig. 1. Upper view of the skull of the Emu (*Dromaius Novæ Hollandiæ*).
- 2. Under or base-view of ditto, wanting the lower jaw and right tympanic bone.
- 3. Side view of cranium of ditto.
- 4. Side view of cranium of *Dinornis dromioides*.
- 5. Upper view of ditto.
- 6. Under view of fore part of cranium of ditto. The small numerals indicate the same parts as in Plate XVI.
- 7. Portion of os tympanicum of *Dinornis giganteus*.

Fig. 8. Os tympanicum of *Struthio camelus.*
9. Os tympanicum of *Apteryx australis.*
  a. Anterior or orbital process.
  b. External or zygomatic process.
  e. Inferior or mandibular articular surface.

PLATE XXXII.

Fig. 1. Side view of an upper or anterior cervical vertebra of *Dinornis ingens.*
2. Front view of the same vertebra.
3. Upper view of the same vertebra.
4. Side view of an upper or anterior cervical vertebra of *Dinornis giganteus.*
5. Upper view of the same vertebra.
  a. Anterior articular surface of the body.
  n. Neural canal.
  pl. Pleurapophysis, or anchylosed cervical rib.
  s. Rudiment of spinous process.
  v. Canal for vertebral artery.
  z. Prezygapophysis, or anterior oblique or articular process.
  z'. Postzygapophysis, or posterior do. do.

PLATE XXXIII.

Fig. 1. Side view of an inferior cervical vertebra of *Dinornis giganteus.*
2. Front view of the same vertebra.
3. Under view of the same vertebra.
  a. Anterior articular surface of the body.
  a'. Its continuation upon the lower part of the body.
  c. Parapophysis, or lower transverse process, from the body of the vertebra.
  d. Diapophysis, or upper transverse process, from the neural arch.
  e. Prezygapophyses.
  f. Postzygapophyses.
  g. Superior or neural spine.
  h. Inferior or hæmal spine.
  i. Pneumatic orifice.
4. Side view of ungual phalanx or claw-bone of a large species of *Dinornis.*
5. Upper view of the same phalanx.
6. Back view or articular surface of the same phalanx.

PLATE XXXIV.

Fig. 1. Side view of a dorsal vertebra of *Dinornis crassus.*
2. Front view of the same vertebra (*minus* the spine).

Fig. 3. Front view of a dorsal vertebra of *Dinornis ingens.*
4. Under surface of the body of the same vertebra.
b. Diapophysis.
c. Costal articular surface.
f. Foramen pneumaticum.
n. Neural canal.
z. Prezygapophyses.

PLATE XXXV.

Fig. 1. Mutilated sternum of *Dinornis giganteus*, half natural size.
2. Anterior border of the same sternum, natural size.
3. Costal border of the same sternum, natural size.
4. Reduced view of the anterior surface of the sternum of the Ostrich (*Struthio camelus*).
5. Ditto ditto *Rhea americana.*
6. Ditto ditto *Casuarius galeatus.*
7. Ditto ditto *Dromaius ater.*
8. Front view of the sternum of *Apteryx australis*, natural size.
a. Anterior angles.
c. Coracoid depressions.
m. Anterior border.
e. Posterior emarginations.
p. Posterior angular processes.
r. Costal articular surfaces.
x. Xiphoid prolongation or appendage.

PLATE XXXVI.

Fig. 1. Proximal end of femur of *Dinornis giganteus*, natural size.
2. Distal end of the same femur, natural size.
r. Rotular surface.
f. Fibular surface.
t. Tibial surface.

PLATE XXXVII.

Fig. 1. Proximal end of tibia of *Dinornis giganteus*, natural size.
2. Ditto ditto *Struthio camelus*, ditto.
3. Ditto ditto *Dromaius Novæ Hollandiæ.*
4. Ditto ditto *Ciconia Argala*, ditto.

a. Inner condyloid surface.
t. Inter-condyloid tuberosity.
b. Epicnemial ridge.
p. Procnemial ridge.
k. Ectocnemial ridge.
l. Fibular ligament (fig. 4).
f. Head of fibula (fig. 4).

PLATE XXXVIII.

Fig. 1. Back view of femur of *Dinornis casuarinus,* natural size.
2. Proximal end of same femur.
3. Distal end of same femur. (The letters indicate the same parts as in Plate XXXVI.)

PLATE XXXIX.

Fig. 1. Front view of tibia of *Dinornis dromioides.*
2. Ditto ditto *Dinornis casuarinus.*
3. Ditto ditto *Dinornis curtus.*
4. Proximal end of the same tibia.
5. Side view of distal end of the same tibia.

(All the figures are of the natural size.)

a. Inner condyloid surface.
t. Inter-condyloid tuberosity.
b. Epicnemial ridge.
p. Procnemial ridge.
k. Ectocnemial ridge.
f. Trochlear bridge and foramen.

PLATE XL.

Fig. 1. Back view of tarso-metatarsus of *Dinornis* (*Palapteryx*) *ingens.*
2. Ditto ditto *Dinornis* (*Palapteryx*) *dromioides.*
3. Ditto ditto *Dinornis casuarinus.*
4. Ditto ditto *Dinornis crassus.*
5. Distal extremity of the same bone.
6. Front view of mutilated tarso-metatarsus of *Dinornis curtus.*

d, figs. 1 & 2, rough surface for attachment of metatarsal bone of back toe.

MEMOIR

ON

BONES OF THE TRUNK AND LIMBS

OF A

GIGANTIC BIRD OF PREY

(*Harpagornis moorei*, Von Haast).

AT p. 108 a speculation is hazarded relative to a condition of extirpation of the now seemingly extinct gigantic wingless birds of New Zealand, which involves the assumption of their continued existence on the islands after the arrival there of mankind. In a subsequent 'section' of the present work (pp. 220, 224) evidence will be submitted of birds, especially young individuals of certain large Moas, having been killed and eaten under circumstances pointing plainly to a Maori race as the cookers and feasters. The advent of such destroyers in islands destitute of herbivorous beasts would first sound the knell of the departure of the huge feathered bipeds incapable of flight.

For how long a period the Dinornithic generations may have roamed unmolested on the plains, hills, and woods of the tract of dry land gradually losing extent, and becoming reduced to the insular conditions and dimensions, such as when it first may have received its Polynesian immigrants, speculation fails to find a basis of estimate. But it might be asked, had the Moas no natural enemies before they became the exciting object of chase to the Maori men?

Having in mind the relation of the existing birds of prey in New Zealand to the other contemporary members of the feathered class, of which the *Apteryx australis* now ranks as one of the giants, it sometimes entered into one's speculations whether the great extinct Apterygians, of which evidence is given in the preceding Memoirs, might have been harried by any raptorial species of analogous or proportional size—whether at least the chicks or young brood of species of *Dinornis* might not have needed the protection of their giant parents against some such enemies.

It was therefore with unusual interest that I received from a valued correspondent, Julius Von Haast, Ph.D., F.R.S., Director of the Canterbury Museum, New Zealand, and of the Geological Survey of that flourishing province, the following announcement of a discovery in the turbary deposits of Glenmark, a locality about forty miles from

Christchurch, Canterbury, of some bones which had been recognized to be those of a huge bird of prey[1], and for which he proposes the generic name of *Harpagornis*.

The bones in question, of which drawings accompanied this announcement, were a left femur, two ungual phalanges, and a rib. Dr. von Haast carries out comparisons of these remains with the answerable bones of existing Raptores, more especially with those of the White-bellied Eagle (*Haliaetus leucogaster*), the Wedge-tailed or Bold Vulture (*Uroaetus audax*), and the Kahu Harrier (*Circus gouldi*, Buller[2], *Circus assimilis*, Gray[3]). The results of these comparisons, notes of which were obligingly transmitted to me along with the drawings, have since appeared in the volume quoted below of the 'Transactions of the New-Zealand Institute.'

In the conclusions arrived at by Von Haast of the nearer affinity of Fuller's great extinct raptorial bird to the small Harrier than to the large Eagle and Vulture now existing in or occasionally frequenting the Islands of New Zealand I concur; but a character will be noted in the course of my descriptions which leads me to place *Harpagornis*, with Falcons and Buzzards, in a subsection of Raptores distinct from that including the Harriers. Of the claims of the great extinct Accipiter to generic as well as specific distinction, confirmatory evidence will be adduced; but a discovery of the skull or beak is still requisite for completing the generic characters and for determining the closer affinities of *Harpagornis* amongst the families of the Accipitres or "Diurnal Raptores" in which the "tibia and tarsus" are not "to all intents equal in length"[4]; but in which the tibia is longer, if not "much longer, than the tarsus"[5].

Pursuing the search for other evidences of his *Harpagornis moorei*, Von Haast writes, "following down the swampy water-course from which these few remains of *Harpagornis* were previously obtained, a further series of bones was discovered, which, on examination, proved to be another portion of the same skeleton described in that first Memoir. The bones obtained were scattered over the bottom of the turbary deposit along the old water-course, 6 feet to 7 feet below the surface, amongst the remains of decaying swampy vegetation. They were mixed up with pieces of drift timber, and with a considerable number of Moa bones, several of them belonging to the larger species (*Dinornis giganteus*, var. *maximus*, and *D. robustus*)"[6].

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[1] "During the progress of excavations undertaken in the month of March of this year on the Glenmark property, Mr. F. Fuller, Taxidermist of the Christchurch Museum, found, amongst a quantity of Moa bones, mostly belonging to specimens of *Dinornis casuarinus*, *crassus*, and *didiformis*, five or six feet below the surface of the swamp, and over a space of about thirty feet square, a few small bones in an excellent state of preservation, which he at once correctly referred to a gigantic raptorial bird."—(Letter *penes me*, of July 1873, since published in the 'Transactions and Proceedings of the New-Zealand Institute,' 8vo, vol. iv. p. 192, pls. 10 & 11.)

[2] 'A History of the Birds of New Zealand,' by Walter Lawry Buller, Sc.D., F.L.S., &c. &c., 4to, part 1, pl. 2, p. 11 (March 1872).

[3] 'Ornithology of the Voyage of H.M.S. Erebus and Terror,' p. 2.

[4] R. Bowdler Sharpe, 'Catalogue of the *Accipitres* in the British Museum,' 8vo, 1874, p. 46.

[5] Ibid. ib. pp. 158 (*Buteoninæ*), 225 (*Aquilinæ*), 350 (*Falconinæ*).

[6] Trans. & Proc. N.Z. Institute, vol. vi. p. 62.

This second 'find' of *Harpagornis*-remains included right and left metatarsus, right and left tibia, right and left fibula, right and left ulna, right and left radius (one fragmentary), right and left scapula, one rib, five phalanges, and four ungual phalanges[1]. A portion of a humerus, "without doubt belonging to this species, was obtained about a mile above Glenmark, from the banks of the Glenmark Creek." "We obtained also the lower portion of a metatarsus from a similar older postpliocene bed situated close to Glenmark; so that there is sufficient evidence that this diurnal raptorial bird existed, like the *Dinornis* and *Palapteryx* species, during a long period in New Zealand"[2]. "Finally, were discovered on the left bank of the Glenmark Creek, near the bottom of the swamp, close to a layer of clay, 7 feet to 8 feet below the surface, a pelvis (fragmentary), right and left metatarsus, right and left tibia, right and left femur, right humerus, right and left ulna, left metacarpal, left scapula, one rib, four phalanges, one ungual phalanx"[3]. These were parts of a skeleton of another *Harpagornis* of smaller dimensions, and, as Von Haast suggests, exemplifying the usual sexual distinction, as to size, in the Raptorial order, the second and smaller series being probably those of a male, the first and larger series those of a female of the huge predatory species.

The wanting parts of the mutilated pelvis from the South Island are fortunately supplied by a perfect specimen of that compound bone of *Harpagornis*, which was included in a series of bones found by Mr. W. A. Low, on the surface-soil under an overhanging rock, in the vicinity of Cowes, in the "Obelisk range of hills," in the province of Otago, South Island, New Zealand[4]. This supplementary series was forwarded by Mr. Low to the Museum at Wellington, where the nature of the pelvis was recognized by Dr. von Haast, to whom it was submitted by the accomplished Director of the Geological Survey of New Zealand, Dr. Hector, F.R.S. Photographs of all the above remains, with admeasurements, have been kindly transmitted to me, from which I have selected the characteristic bones figured of the natural size in Pls. CV., CVI., and CVII. in illustration of the *Harpagornis moorei* of Von Haast.

The raptorial pelvis is characterized by the great proportional extent of its antacetabular part (Pl. CV. fig. 1, *a–f*), by the depth, strong definition, and muscular sculpturing of the surface of the ectiliac fossæ (ib. ib. 62), by the breadth of the ilio sacral disk, by the depth and strength of the ischia between the ischiadic (ib. ib. *m*) and obturator (ib. ib. *q*) foramina, and by the close connexion of the pubis (ib. ib. 64) with the ischium (ib. ib. 63) beyond or behind the obturator foramen. The conformity of the pelvis of *Harpagornis* with that of our Blue Harrier[5] in the foregoing characters

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[1] Trans. & Proc. N.Z. Institute, vol. vi. p. 62.

[2] Ib. ib. p. 63.

[3] Ib. ib. p. 63.

[4] Ib. vol. iv. p. 114. Of this pelvis, Dr. Hector writes:—"It is in wonderful preservation, and is still covered with periosteum, and has the capsular and some other ligaments adherent, while the osseous substance has lost hardly any of the original animal matter which it contained."

[5] *Circus cyaneus*, Bp., *Circus hudsonius*, Vieill. See the beautiful figure of this well-known active raptorial

will be obvious in comparing fig. 1 with fig. 7, both of the natural size; but the difference in relative vertical extent of ilium and ischium, and relative size of the foramen (*m*) is to be noted. The parapophyses of the six anterior sacral vertebræ abut against the ilia near the lower border of those bones. Below this abutment the first and second vertebræ develop the cups for the tubercles of the last two pairs of movable ribs; the cups for the heads of these ribs are on the centrum, below the origins of the parapophyses. These processes in the four following sacrals have coalesced with the ilia. Of the interapophysial vacuities (ib. fig. 2, *d*) the first and second are the largest, the other three smaller ones are subequal.

Four interacetabular sacrals, in which the parapophyses are suppressed to give space to the prærenal lobes, are followed by four postacetabular sacrals, in which the parapophyses are resumed. Of these the first pair are slender, the second and third suddenly expanded, the latter (ib. ib. *u*) apparently bifurcate; the fourth pair are short, and inclined backward; on each side of the sacrum these parapophyses coalesce with each other and with the ilia at their outer ends. The last sacral vertebra (ib. ib. 15) has not coalesced with the preceding, but appears to have been closely joined therewith, as the ends of its short and thick parapophyses combine with those of the fourteenth sacral to abut against the inflected parts of the ilio-ischial deck-like process (ib. ib. *v*). In the number of sacral vertebræ (fifteen) *Harpagornis* agrees with *Falco* and *Circus*, and differs from *Aquila*; in the species of which I have examined the pelvis there are but fourteen sacral vertebræ. The ischiadic foramen (*m*) extends relatively further beyond the postacetabular facet in *Harpagornis* than in *Aquila*; the foramen is relatively less than in *Circus*.

The prærenal or interacetabular fossæ (Pl. CV. fig. 2, *t*) are relatively narrower in *Harpagornis* than in *Aquila* or *Circus*, and more resemble those in *Buteo*. The pubic portion of the acetabulum does not extend so far outward as in *Aquila*. *Buteo vulgaris* and *Falco communis*, as well as *Circus gouldi* and *Circus cyaneus*, resemble *Harpagornis* in the vertically oval figure of the anterior orifice of the neural canal (ib. fig. 3, *n*); in the smaller species figured (*Circus pygargus*, the Ring-tail or Montagu's Harrier) this outlet is circular (ib. fig. 8), as in most species of *Aquila*. The iliac roofs (ib. fig. 3, *f*, *f*) of the long acetabular division of the pelvis are steeper in their slope than in *Circus* (ib. fig. 8) and most Eagles; the ilio-neural openings (ib. ib. o') have consequently, as Dr. Haast has remarked, "a greater vertical than lateral extent." The parts of the pelvis in Pl. CV. are indicated by the same symbols as in that of *Aptornis*[1]. The gluteal processes (ib. fig. 1, *h*) appear to have been broken off in the fossil; they are

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bird in Gould's 'Birds of Great Britain,' folio, part xii. 1867. In no animal does the size become so reduced, in the skeleton, as in the feathered class; with the above plate showing our native 'Harrier' clothed in its plumage, some conception may be formed of the size of the extinct Hawk of New Zealand, magnified according to the proportions of figs. 1, 2, and 6, 7 in Pl. CV.

[1] P. 125; Pls. LXXXIII. & LXXXIV.

more strongly developed in *Circus* and *Buteo* than in *Aquila*. Both first and second sacral vertebræ have well-defined articular surfaces for the head of a rib; and there are indications of a surface for ligamentous attachment of a third free or movable pleurapophysis in the pelvis of *Harpagornis*. The extremity of the long and slender pubis (Pl. CV. fig. 1, 64) has been broken off in the fossil; but doubtless it had similar proportions, when entire, to that element of the pelvis in most existing diurnal Raptorial birds.

Humerus.—This bone appears, as is often the case in fossils, to have lost the terminal angle of the projecting crest (Pl. CVI. figs. 1 & 2, *d*) called 'pectoral' or 'delto-pectoral:' it is restored in dotted outline after the type of that in *Buteo* and *Circus* (ib. figs. 7, 8). The slight outward bend of the shaft beyond or below this process, which distinguishes the great wing-bone in the Buzzards, Falcons, and Harriers from that in the Eagles, is well shown in the photographs, and is noticed by Dr. Haast in the original bone.

The articular head (ib. ib. *a*) is transversely broader, in proportion to the fore-and-aft diameter, in both the extinct *Harpagornis* and in existing Falcons than in Eagles. The pneumatic ridge or crest (ib. ib. *c. p*), extending from the ulnar tuberosity to below the pneumatic orifice, is relatively shorter in *Harpagornis moorei* than in *Aquila chrysaetos*; the breadth of the entire proximal end is relatively greater in the Falcons than in the Eagles. The radial tuberosity (ib. ib. *b*) is more strongly marked in *Harpagornis moorei*. In this huge species the graceful sigmoid bend of the entire humerus is better marked than in the smaller existing Falconines and than in any Eagle; it suggests a greater force in the movements of the wing. The longitudinal line (ib. fig. 2, *e*) along the palmar aspect of the shaft of the humerus is better marked in *Harpagornis moorei* than in the humerus of any existing Raptorial species, though not so developed as to be termed a ridge. In this character the Falcons make the nearest approach (as in Pl. CVI. fig. 8, *e*) to their great extinct confamiliar. In both the line rises to the character of a ridge as it descends to terminate in the palmar prominence (*g'*) of the ulnar epicondyle. The radial epicondylar process (*f*) is characteristically developed in both the recent (fig. 8) and extinct (figs. 1 & 2) Falconines. The condyles themselves (ib. *h*, *i'*) show the usual well-marked modification of that part of the humerus in birds of flight. The radial (*h*) and ulnar (*i*) convexities are strongly marked in *Harpagornis moorei*. The least circumference of the shaft of the present humerus is 2 inches 2 lines; it formed part of the series of the smaller (male ?) *Harpagornis* (*H. assimilis*, Von Haast), and is estimated to have been one inch shorter than the humerus in the female (?*H. moorei*, Von Haast), of which the shaft only was found.

The radius (Pl. CVI. fig. 4) is thicker in proportion to its length, and also in proportion to the ulna, in *Harpagornis*, than in existing Raptores. The ridges and processes indicative of the power of the muscles of flight are strongly marked, especially the tubercle near the proximal end for the insertion of the main tendon of the biceps. The shaft is more bent toward the distal end, as Von Haast has observed, than in existing birds of prey.

The ulna (Pl. CVI. fig. 3) is distinguished from that of the largest Eagles more by its thickness and the expansion of its articular ends than by its superiority in length. The proximal surfaces for both condyles of the humerus bear proportion to their characteristic development in that bone; the 'coronoid' angle (*d*) is well marked. The distal articular convexity (*k*) indicates the extent of the evolutions of the manual part of the wing, with its great 'primary remiges,' in the actions of flight. My photographs showed no indication of the pits and prominences for the 'secondary' and 'tertiary' remiges; and Von Haast expressly states that in the ulna first obtained from the Glenmark alluvium "the quill-knobs are obliterated:" but this may be due to posthumous decay or abrasion; for in the second and smaller examples of ulna obtained from the left bank of the Glenmark creek, "two rows of quill-knobs, and principally the one on the ulnar side, are well seen, as well as the intermuscular ridge on the palmar side and the flat processes for the attachments of muscles "[1].

One metacarpus only, the left, of *Harpagornis* seems hitherto to have been found; it was associated with the series belonging to a smaller individual, and indicative either of a sexual (male) or a smaller variety, or of a smaller but nearly allied species of *Harpagornis*. Von Haast remarks, however, of this compound wing-bone, that "it is not only a little longer than that of *Aquila*" (*audax*?), "but also much stouter in its proportions. This is most conspicuous in the medius metacarpal and the proximal end. The process for the attachment of the index phalanx is broad and heart-shaped; and the two principal intermuscular ridges upon the medius metacarpal enclose a broad and well-defined channel "[2].

Femur.—With the usual characteristics of this bone in the Raptorial order, the femur of *Harpagornis* is remarkable for its greater relative thickness and the greater expanse of its extremities, especially of the distal one. The pneumatic foramen (Pl. CVII. fig. 2, *g*) is large, single, and situated, as usual in the Order, on the fore part of the bone between the prætrochanterian ridge (ib. ib. *f*, *k*) and the supporting base (*d*) of the head (*a*) of the femur; no constriction, like a 'neck,' is present; and the head, from which the articular cartilage was extended along the upper surface of the supporting base to the great trochanter, is as characteristically sessile as in other Raptores. The contrast which the present New-Zealand fossil presents with the femora of the great extinct wingless birds of that island, in the configuration of the proximal end of the femur, may be appreciated by comparing the figures of the femur of *Harpagornis moorei* in Pl. CVI. with those of the femur of *Dinornis gravis* (Pls. XLI. & XLI. A). The ectotrochanterian ridge (*k*) is less convex in contour than in the Golden Eagle (*Aquila chrysaetos*); the hypotrochanterian roughness for the insertion of the intrapelvic muscle, which I have called 'obturator internus' in the *Apteryx* (*ante*, p. 56), has more the form of a ridge in *Harpagornis* than of a tubercle.

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[1] Trans. and Proc. of the New-Zealand Institute, vol. vi. p. 70.

[2] *Tom. cit.* p. 71.

The prætrochanterian ridge (Pl. CVII. fig. 2, *h*) is linear, and may be traced down the middle of the fore part of the shaft; its continuation into the antentocondylar ridge (*n*) is interrupted. This ridge, as well as the antectocondylar ridge (ib. ib. *m*), is well marked, and relatively sharper than in *Aquila*. The rotular channel is broad and deep. The popliteal space (ib. fig. 1, *z*) is shallow. The distal end of the femur is relatively broader transversely than in *Aquila*. The intercondylar ridge (ib. fig. 4, *t'*) is well marked. The backward production of the inner condyle dividing the tibial facet (ib. ib. *x*) from the fibular facet (*y'*), is relatively more produced and sharper. Every character of the femur indicative of muscular force and strength of joint is better marked than in the smaller existing Raptorial birds, although inferior, especially as regards the posterior ridges of the shaft, or 'lineæ asperæ,' to that bone in the huge objects of prey of the *Harpagornis* (Pls. XX.–XXIII.). The least circumference of the femoral shaft in the larger (female?) *Harpagornis* is 2 inches 6 lines, in the smaller (male?) specimen 2 inches 3 lines. The admeasurement in the Table, as in the subject in Pl. CVII., is from the larger specimen of the extinct bird of prey.

Tibia.—This bone in *Harpagornis* corresponds with the femur in its strength, *i. e.* in the proportions of breadth to length of shaft.

The procnemial ridge (Pl. CVII. figs. 5 & 6, *g*) is more produced at its upper part than in the Eagles, but sooner subsides into the lower less prominent ridge (ib. fig. 6, *g'*), which is continued down the fore part of the shaft, inclining toward the innermost of the distal condyles. The depression on each side of the procnemial ridge is well marked; the inner (tibial) one (ib. fig. 6, *l*) is bounded by the low, thick, obtuse 'entocnemial' ridge (ib. ib. *o*), extending from the overhanging inner (tibial) border of the proximal articular facet of that side of the head, obliquely downward and forward to join or be lost in the procnemial ridge. The outer depression (ib. fig. 5, *k*) has the form of a wide vertical channel, and is bounded externally (fibulad) by the ectocnemial process (ib. ib. *h*). The fibular ridge (ib. fig. 5, *m*, *m'*) is well marked; it is relatively more prominent, but is of minor longitudinal extent, than in the Eagles. The ectarticular convexity is smoothly rounded; the rugous facet anterior to it for the 'crucial' ligament, and that attached to the head of the fibula, are well marked. The two distal condyles (ib. fig. 5, *t*, *s*) show a breadth which exceeds by two fifths that of the same part of the leg-bone in the Condor or Lammergeyer. In their proportions, shape, and degree of anterior convexity these condyles exhibit the Falconine characters of this end of the tibia. The præcondylar groove (ib. ib. *p*) is crossed by the osseous bridge (*q'*), as in the 'Diurnal' division of Raptores. The strength of the 'tibialis anticus' muscle (p. 61, Pls. XI., XIV. 8, *Apteryx*) is significantly indicated by the size of the bony canal which was traversed by its tendon.

In the metatarsus (Pl. CVII. figs. 5, 6) of *Harpagornis* the indications of the power of the raptorial foot reach their maximum. This will be evident to any one comparing the above figures with those of the metatarsus of the Golden Eagle (*Aquila chrysaetos*).

From that type the present fossil differs in its greater breadth and thickness in proportion to its length, and especially in the greater strength and outward extension of the condyle for the innermost of the anteriorly directed toes (Pl. CVI. figs. 5, 6, *ii*); the shaft of this composite bone is rather more twisted on its axis, with a greater inclination of the stem of the condyle (*ii*) backward. The 'entocondylar cavity' (ib. fig. 5, *a*) is somewhat deeper and larger than the ectocondylar one (*b*); the intercondylar tubercle (*c*) is large, but little elevated. The ectocalcaneal process (ib. fig. 6, *s*) is a strong and prominent subquadrate plate of bone. The entocalcaneal process (ib. ib. *r*) is, as usual in Raptores, of smaller size. The intervening calcaneal groove or channel (ib. ib. *u*) is of great depth and width. Into the wide and deep antinterosseal depression (ib. fig. 5, *i*) open the entinterosseous and ectinterosseous canals. The small hinder orifice of the latter remnant of the primitive interspace between the ecto- and mesometatarsal elements is shown in fig. 6, at *m*. The ectinterosseous groove is continued down a short way below this orifice. A strong tuberosity (fig. 5, *n*) marks the insertion of the tendon of the 'tibialis anticus.' The entogastrocnemial ridge (*g*) is continued from the entocalcaneal process nearly halfway down the shaft of the metatarsus. The ectogastrocnemial ridge (*x*) and the postinterosseous ridge (*y*) are well developed. The intermuscular ridges on the fore part of the shaft (fig. 5) are equally well marked; the entometatarsal ridge is shown at *q*, the ectometatarsal ridge at *k*. A long groove (*o*) for the 'adductor digiti externi' deepens as it leads to the foramen (*p*), through which the tendon of that small muscle glided to the interspace between the meso- and ectotrochleæ. A strong osseous bridge (ib. fig. 6, *q*) divides the upper and hinder orifice (*p'*) from the intertrochlear outlet of the tendinal canal. The depth and extent of the surface for the ligamentous attachment of the innermost and backwardly directed metatarsal (*i*) bespeak the strength of the toe opposing the forwardly directed digits (*ii* & *iii*) in the grasping actions. The ectotrochlea (*iv*) is, transversely, rather narrower than usual relatively to the other trochleæ; but it is of equal antero-posterior extent. The least circumference of the shaft of the metatarsal of *Harpagornis moorei* is 2 inches; the breadth of the two extremities and the length of the bone are shown in Pl. CVI.

Among the more characteristic evidences of the present extinct gigantic Raptorial are certain claw-bones (ungual phalanges). Assuming this ungual phalanx (Pl. CVII. fig. 7) to correspond with the one which is commonly the largest in diurnal Raptores, viz. that which supports the back toe (digit *i*), a second somewhat smaller claw-bone, discovered at the same time and place, and differing only in a slight inferiority of size, may well be a claw-bone of the toe *iii*. Subsequently a third ungual phalanx was discovered in another part of the Glenmark swamp, of rather less length than the second, but of equal size of basal articulation, and with it the penultimate phalanx of the same toe. On the assumption that the largest claw-bone (Pl. CVII. fig. 7) was that of the 'hallux,' or hind toe (*i*), it may be compared with the homologous bone in the Great Wedge-tailed Eagle of Australia (*Aquila cuneicaudata* of Brehm) or the Bold

Vulture (*Vultur* (*Uroaetus*) *audax* of Latham (ib. fig. 8), and with that in the larger Harrier Hawk of New Zealand (*Circus gouldi*) (ib. fig. 13). In all diurnal Raptores such ungual phalanx is characterized not only by its size, but by its curvature, its gradual tapering to a sharp point, by the depth of the pair of trochlear cavities at the base fitting closely or interlocking with the distal condyles of the penultimate phalanx, and above all by the size and prominence of the lever for the insertion of the flexor tendon of the claw phalanx, which recalls the corresponding development in the retractile claw-bones of the Tiger. The process in question (*b*), in its direction and extent, resembles that in the Falcons and Harriers (fig. 13, *b*) more than that in the Bold Vulture or in the Eagles.

In reference to the evidences which may be adduced from the above-described remains of the more especial or nearer affinities of *Harpagornis* in the diurnal division of the Raptorial order, I esteem as the most important that of the relative length of the metatarsus to the tibia. In the Eagles (*Aquilinæ*, Bd. Sh.), Buzzards (*Buteoninæ*, Bd. Sh.), and Falcons (*Falconinæ*, Bd. Sh.) the superiority of length in the tibia as compared with the metatarsus is greater than in the Harriers and Goshawks (*Accipitrinæ*, Bd. Sh). In the Wedge-tailed or Bold Eagle (*Uroaetus audax*) the tibia is one third longer than the metatarsus. In the Golden Eagle (*Aquila chrysaetos*) the tibia is rather more than two fifths longer than the metatarsus. In our Ring-tail Harrier (*Circus pygargus*) the tibia (Pl. CVII. figs. 11, 12) is rather less than one fourth longer than the metatarsus. In *Harpagornis moorei* the tibia (ib. figs. 5, 6) is rather more than one third longer than the metatarsus (Pl. CVI. figs. 5, 6). By this character the great extinct Raptorial of New Zealand deviates from the Harriers (*Circus*) and Goshawks (*Astur*), and approximates the Eagles and Falcons, and more especially the latter, and also the Buzzards, in some minor modifications which have been pointed out in the descriptions of the bones. The determination of the closer affinity of *Harpagornis* to the shorter-tarsaled groups of Accipitres, or Diurnal Birds of Prey, must, however, await the acquisition of evidence of the skull and beak and of the sternum.

I cannot quit this especially interesting subject, connected with the history of the extinct birds of New Zealand, without a quotation from the paper initiating the quest of their osseous remains. In the "Notice of a Fragment of the Femur of a Gigantic Bird of New Zealand," published in the 'Transactions' of the Zoological Society, I cite the testimony of the person who brought the specimen for sale to the Royal College of Surgeons, and permitted me to describe and figure it, viz. that the natives of the North Island of New Zealand, from whom he stated that he had obtained the bone, "had a tradition that it belonged to a bird of the Eagle kind, but which has become extinct, and to which they gave the name of Movie"[1].

Nonsense — Clarke & Williams were "questing" before this.

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[1] Vol. iii. (1839) p. 29, pl. 3. The specimen in question was submitted for sale, in the first place, to the British Museum; and the vendor was recommended by Dr. Gray to offer it to the Royal College of Surgeons. The price asked (ten guineas) was deemed too high for the fragment by the then "Museum Committee of the

Harpagornis exceeds the Golden Eagle and our native Harrier Hawk more in the length and strength of its legs than of its wings. The anatomical characters of femur, tibia, and especially of metatarsus and ungual phalanges, bespeak a strength and vigour of grasp well-matched, as it would seem, to the bulk of the terrestrial birds on which it preyed. And in regard to these, which the first indication of a leg-bone suggested to be less fleet in movement than the Emu or Ostrich, a corresponding power of wing would be less essential to the predatory Buzzard or Falcon of the Moas than his faculty of holding and mastering them when caught.

Nevertheless it would be rash to infer an inferiority of power of flight, size for size, in the *Harpagornis* over the Eagle, from the minor inequality of length of humerus as compared with that of femur. The proportions, especially of length, of the chief wing-bones in the Humming-Birds, for example, fall short of those in many birds of much inferior powers of flight. The wing, for excellency in its main function, requires also length and strength of primaries, with proportions of those quill-feathers resulting in the elongate and pointed form of wing, such as characterizes Swifts and Humming-Birds.

DESCRIPTION OF THE PLATES.

PLATE CV.

Figs. 1–4. Pelvis of *Harpagornis moorei*. Figs. 5–7. Pelvis of *Circus pygargus*.

PLATE CVI.

Figs. 1–6. Humerus of *Harpagornis moorei*.
Figs. 7–12. Humerus of *Circus pygargus*.

PLATE CVII.

Figs. 1–4. Femur of *Harpagornis moorei*. Figs. 5, 6. Tibia of *Harpagornis moorei*.
Fig. 7. Side view of ungual phalanx of back toe (*i*) of *Harpagornis moorei*.
Fig. 8. Side view of ungual phalanx of *Aquila cuneicaudata*.
Figs. 9, 10. Femur of *Circus pygargus*. Figs. 11, 12. Tibia of *Circus pygargus*.
Fig. 13. Phalanx of back toe of *Circus gouldi*.

College;" and it was purchased, after the publication of my Memoir, by B. Bright, Esq., of Bristol. It has since been presented, with the rest of the "Bright Collection," to the Trustees of the British Museum by Benj. Bright, Esq., the grandson of the founder.

MEMOIR

ON THE

SKULL AND SCAPULAR ARCH

OF THE

DINORNIS ROBUSTUS.

I HAVE been favoured by the kindness of Dr. D. S. Price, of the Crystal Palace, Sydenham, with the opportunity of inspecting a series of bones from the Middle Island of New Zealand, which were obtained under the following circumstances.

"They were found at the bottom of a pit or crevice, about 50 feet deep, in limestone rock, the upper opening of which was scarcely large enough to admit the body of a man, but gradually widening as it descended, measuring at the bottom 30 feet by 4 feet. The opening is on the top of a broken ridge of limestone rock, situated a few miles south of 'Timaru.' There are many such holes in the immediate vicinity, in all of which we found bones."[1]

From this series I have selected for the present Memoir a mutilated cranium and lower jaw of a species of *Dinornis*, which, by its superiority of size over that of "a large kind" described in a former one[2], confirms the accuracy of the reference of that species to the *Dinornis ingens*, and leads me to refer the present specimen to the *Dinornis robustus*. The following are a few comparative admeasurements of the two crania:—

	Dinornis ingens.		*D. robustus.*	
	in.	lines.	in.	lines.
Breadth of cranium across the mastoids	3	8	4	0
Length of cranium from superoccipital crest to premaxillary fossa	2	9	3	7
Breadth, greatest, of premaxillary	2	4	2	10
Breadth of cranium across the temporal fossæ	2	8	2	8

From these dimensions it will be seen that the present cranium, referred to *D. robustus*, differs not only in size but in proportions from that of *D. ingens*, the breadth across the temporal fossæ being the same in both. This difference arises from the greater relative depth of the fossæ in *D. robustus*, indicating more power in the temporal muscles, and is associated with mandibles which are more massive and broader in proportion to their

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[1] Extract of a letter from the finder to Dr. Price.

[2] P. 205, Pl. LII.

length. These and other differences will be readily appreciated by comparing figs. 1 & 2 of Pl. LXII. and fig. 1 of Pl. LXIII. of the present Memoir with Pl. LII. of the Memoir above cited (p. 205).

The mutilation of the two crania is nearly the same in kind and degree; but with the present specimen there is a tympanic bone and the mandible.

The base of the occipital tubercle (Pls. LXII. & LXIII. fig. 1, 1) is 4 lines across, $2\frac{1}{2}$ lines vertically; the foramen magnum (Pl. LXII. fig. 3, *m*) is 7 lines vertically and 6 lines across. The superoccipital, or confluent upper parts of the exoccipitals, slightly overarches the foramen; the middle of the transverse occipital ridge (ib. 3) is 8 lines above the foramen, and extends outward with a slight descent to the paroccipital (ib. 4), having a total transverse extent of 3 inches 3 lines. The broad and low superoccipital surface, so defined superiorly, is divided by a thick, low, median vertical ridge. It shows no cerebellar protuberance, but four rough and shallow muscular depressions, defined by a protuberant part of the middle of each half of the transverse occipital ridge. A venous canal extends from each protuberance to a foramen (ib. *w*) near the middle of the outer depression. The basioccipital (Pl. LXII. fig. 3, 1*j*) descends 5 lines below the tubercle, this vertical part showing a pair of depressions (ib. & Pl. LXIII. fig. 1, *j*); it swells out below on each side into a pair of large smooth tuberosities (ib. 1') with extremely thin walls, covering the pneumatic cellular structure of the bone.

The basisphenoid (Pl. LXIII. fig. 1, 5) probably contributes the anterior part of these tuberosities (ib. *m*), between which it is concave. The Eustachian canals (ib. fig. 1, *e*, *e*), with sharp margins, groove the sides of the basisphenoid, converging as they extend forward, and losing definition as they approach the middle of the fore part of 5. The beginning of the posterior ridge forms the outer boundary of the fossa for the sympathetic and entocarotid foramina (ib. *8*, *c*). The alisphenoid is indicated by the foramen for the third and second divisions of the trigeminal nerve, and by the fossa of the optic lobe on its inner surface. The loss of the outer plate of the connate basi- and pre-sphenoids exposes the pneumatic diploë and the wall (ib. *d*) of the 'sella' or bony cup for the hypophysial appendage of the mesencephalon, which marks the boundary of the second and third cranial vertebræ.

The mastoid (8) is large, thick, and obtuse, excavated below by a single oblong, oblique articular cavity (Pl. LXIII. fig. 1, *u*) for the undivided similarly shaped convex head of the tympanic (ib. fig. 2, *e*); the articular cavity is directed from behind forward and outward. There is no epiphysis upon the border of the tympanic cavity, which is large, and shows several pneumatic foramina besides the stapedial fossa leading to the fenestra ovalis.

The temporal fossa (Pls. LXII. & LXIII. fig. 1, 7'), which excavates the contiguous parts of the alisphenoid, mastoid, parietal, and postfrontal, is narrow and deep, subsiding gradually upon the upper surface of the cranium (Pl. LXII. fig. 1, 7), which is smooth, broad, and slightly convex, for an extent of nearly 2 inches, between the fossæ. The whole cranium is remarkably broad and depressed (ib. fig. 3): its greatest vertical diameter, from the parietal to the basioccipital tuberosity (1′), is 2 inches 3 lines; its breadth across the postorbital processes (Pl. LXII. fig. 1, 12) is 5 inches. Its length from the paroccipitals (ib. 4) to the fore part formed by the coalesced nasals (ib. 15) is 5 inches 2 lines.

The flattened end of the nasal process of the premaxillary (ib. fig. 1, 22′) rests on a shallow elliptical depression of the nasals (ib. 15), which are confluent with the fore part of the frontals (ib. 11). This depression is rounded posteriorly, is 1 inch 3 lines in length and 1 inch in breadth. The rhinal or olfactory fossæ (Pl. LXIII. fig. 1, *n*, 14′) are 2 inches 9 lines in length and 2 inches in breadth, divided by a convex transverse projection of the roof (*n*′) into a larger posterior compartment (*n*) and a smaller and more shallow anterior compartment (14′); both are subdivided by a low median ridge, sharpest and most produced in the posterior compartment. At the back and upper part of each lateral division of this compartment are seen the fine, radiating grooves diverging from the foramina of the cribriform plate (14).

The tympanic (Pl. LXII. 28) is a triradiate bone, with short and strong rays, the lowest being the broadest and thickest. The mastoid condyle (Pl. LXIII. fig. 2, *e*) of the tympanic is 11 lines in long diameter, 3 lines in the short diameter. The stem contracts transversely, expands in the opposite direction, assuming a trihedral shape, widely excavated on the inner facet by the fossa (*g*), terminating in the large pneumatic canal. The anterior or orbital process (*k*) is subcompressed, obtuse, 7 lines in depth, 10 lines in length; it is impressed, externally, by an oval facet for the pterygoid (*pt*). The suddenly and largely expanded lower end presents the usual posterior, narrow, oblong concavity (ib. fig. 3, *i*, *h*) and the anterior, smaller, but similarly shaped convexity (ib. *ï*) placed at a right angle to the foregoing. On the outer side of the lower end is the usual subcircular, deep depression (Pl. LXII. fig. 2, *h*), for the squamosal element of the zygomatic arch.

Mandible.—The articular part of the mandible (Pl. LXIII. fig. 4) is deeply excavated between the articular surfaces (*i*, *i*′) which are adapted to those so marked on the tympanic (fig. 3). An obtuse angular ridge projects from the inner side of the wall of this concavity; a pneumatic canal perforates its base. The ramus, extended forward from the articular end, is divided by two longitudinal fissures into three parts, the upper representing the surangular (Pl. LXII. fig. 2, 29′), the lower the angular (30); and the intermediate portion appears to be the back part of a splenial (31). The surangular developes a low convex ridge, with a rough surface external to it, for the insertion of the temporal muscles. Its fore part is excavated externally, to be overlapped by the upper prong of the dentary element (32′): the angular is more extensively excavated, to be overlapped in a similar manner by the lower prong (32″) of the dentary: this element had not coalesced with the rest of the mandible, and has been drawn forward to show the articular grooves The dentary curves gently down as it approaches the thick symphysis, where it coalesces with its fellow to form a broad external symphysial prominence (32), measuring 7 lines across the back or lower part and 9 lines across the upper border. The length of the symphysis is 1 inch 3 lines. The upper border of the dentary swells outward, increasing in depth as it approaches the symphysis, the surface of which is perforated by the numerous nutritious vessels of the matrix of the horny beak, the thinner hind part of the dentary being smooth. The alveolar border (Pl. LXIII. fig. 4, *b*) is impressed by a shallow groove.

The premaxillary (Pls. LXII. & LXIII. fig. 1, 22) is very broad, depressed, with the usual triradiate division posteriorly; the upper ray (Pl. LXII. fig. 1, 22′) is a backward continuation of the middle raised part of the body of the bone, which expands transversely and becomes flattened from above downwards as it extends backward to rest upon the nasal fossa (15); the sides of this process, before it quits the body of the bone, are concave, as it were pinched in; the least breadth of the upper part of the process is 6 lines. The maxillary processes (22″) are short; both, however, are broken: the breadth of the palatal part of the premaxillary (Pl. LXIII. fig. 1) is 3 inches; it has a small posterior emargination, on the under surface of which is a canal leading forward into the bone: on the upper surface are three similar orifices, also leading forwards. The upper or nasal surface of the plate (22″) of the premaxillary shows a shallow posterior excavation for the support of the palatal part of the maxillary. The alveolar borders of the premaxillary show a shallow multiperforate broad groove (*b*).

After having written the foregoing description of the parts of the skull of the *Dinornis robustus*, from 'Timaru,' and had the Plates LXII. and LXIII. executed, I received the following letter, dated "Dunedin, 15th February, 1864," from Dr. Hector, F.G.S., the accomplished and efficient Provincial Geologist of Otago, New Zealand, informing me of the discovery of "an unusually perfect skeleton of a Moa," which had been "recently found by some gold-diggers in the interior" of that province. "The skeleton," he writes, "was not that of one of the largest-sized Moas, the tibia, for instance, being only 27 inches in length, whereas I have frequently seen them as much as 36 inches." This skeleton Dr. Hector proceeds to describe "as the most perfect I have ever heard of, as all the bones, excepting five or six, are present; and it is further, I believe, a unique specimen in so far that portions of the integuments and feathers still remain attached to the sacrum. There is also a portion of the sole of the foot; and the joints of one leg have their ligaments and interarticular cartilages preserved."

Dr. Hector then proceeds to give the following instructive and valuable account of the geological characters of the locality and district where the discovery was made:—

"The bones were found in one of the large basins which characterize the auriferous region, and lie among the mountains in the interior of the island. These basins are of ancient Tertiary date and of large size, being always partially filled up with a Tertiary deposit that in physical character, and perhaps also in geological age, may be compared to the 'Molasse' in Switzerland. This Tertiary deposit has been partially denuded and then overspread by the dispersed materials derived from ancient moraines that at a later period were thrown down from the neighbouring mountain ridges. A system of lakes then occupied these basins, and indeed over a large area of the province still continue to occupy them. During the gradual drainage of the lakes that occupied these basins, the incoherent materials were shaped into successive terraces that narrowed the basins, and, according to the times of their formation, have more or less relation to the present water-run of the country. Wide ascending valleys, bounded by lake-terraces, were thus formed, and it is in the terraces which were again formed in these valleys that the earliest traces of Moa-bones are to be found.

"I have not visited the Manuherikia Valley, where these bones were found, since their discovery; but I enclose a rough section[1], showing its contour and contents, which I observed nearly two years since on my first arrival in this country.

"As Moa-bones are to be found, however, in every deposit of more recent date than the above, as, for instance, in river-silts and old water-courses, and even in great quantities lying quite exposed on the surface of the plains, I am therefore unable to indicate the precise geological position in the section from which they were extracted. I understand that they were met with in sinking a shaft on one of the terraces through a bed of dry incoherent sand-rock. The plains which I have referred to as existing in the interior have a dry arid climate as compared with the rest of New Zealand, so that they are clothed only with wing-grass, that grows in tufts, or 'tussocks' as they are called. The dry climate and the fact that the bones were imbedded in dry sand prevent our necessarily inferring, from the well-preserved condition of the skeleton, that it is of more recent date than the bones that are usually found; and, moreover, as some parts of the skeleton are quite as much decomposed as the generality of the Moa-remains, it is more natural to suppose that the preservation of the more perishable parts of the remainder of the skeleton has been due to an accidentally favourable position in the soil.

"As this interesting skeleton will no doubt be fully examined and described, and the species determined, by you, when it arrives in England, it is unnecessary for me to transmit to you my notes and measurements of the individual parts of the skeleton. I will preserve them, however, for future reference should the specimen itself be accidentally lost or destroyed.

"I remain, dear Sir,
"Yours very truly,
"JAMES HECTOR, M.D., F.G.S.,
"*Provincial Geologist, Otago, N. Z.*

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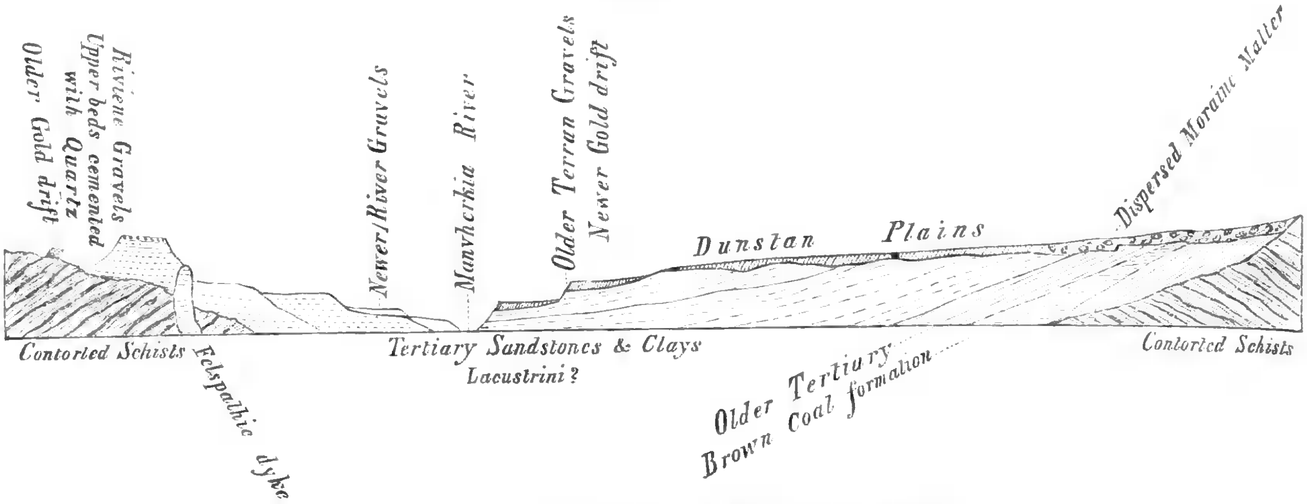
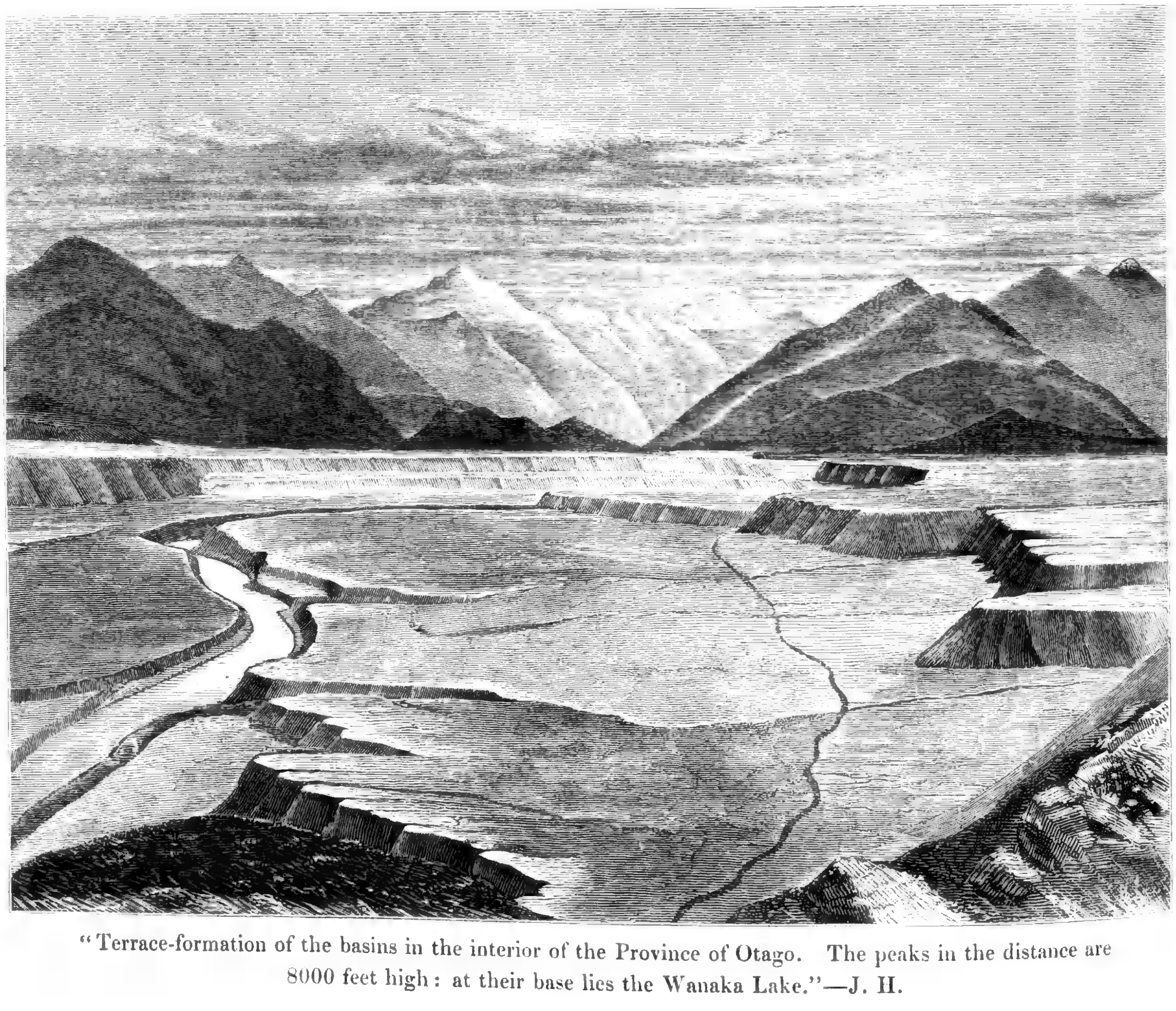
[1] See figure 1, next page.

Fig. 1.



"Section of the contour and formation of Manuherikia Valley."—J. H.

Fig. 2.



"Terrace-formation of the basins in the interior of the Province of Otago. The peaks in the distance are 8000 feet high: at their base lies the Wanaka Lake."—J. H.

"Enclosing—

"Photographic copy of drawing of entire skeleton.

"Photographic copy of drawings of the parts of the skeleton in the state they were found.

"Photographic copy of sketch of the terrace-formation of the Upper Chetha Valley, one of the basins in the interior.

"Sketch-section showing the contour of the Manuherikia Valley, where the remains were found.

"*Professor Owen, F.R.S., British Museum.*"

The cut, fig. 1, is of the "sketch-section of the contour and formation of the Manuherikia Valley" where the bones were found. The cut, fig. 2, is copied from the photograph of the "terrace-formation of the Upper Chetha Valley, one of the basins in the interior."

Sketches with admeasurements of the principal bones were also enclosed, indicating a skull in a more perfect condition than the one I had received from Dr. Price, but of similar size; and, as in the case of the skull, the proportions of the femur, tibia, and metatarse resembled those of *Dinornis robustus*, not those of *D. ingens* or *D. elephantopus*. Besides the sternum and the pelvis of the adult skeleton, there were also sketches of parts determinable as moieties of the sternum, an ilium (8 inches 5 lines long), and an ischium with the pubis (about 6 inches long) of immature birds, which led me to infer that the difference of length of the tibia (27 inches), as contrasted with that of 32 inches[1], might indicate a sexual difference of stature, and that the skeleton from the Manuhirikia Valley was probably that of a female which had perished with her chicks[2].

Dr. Hector finally informed me that these remains were destined by their owner for the Museum at York, where they safely arrived at the latter end of May of the present year. Mr. Thomas Allis, F.L.S., brought some of the bones to London, and kindly submitted them to my inspection, from which I was confirmed in my opinion as to the species. These bones, with photographs of others of the same collection, were exhibited by him to the Linnean Society, June 16th, 1864[3], accompanied by some observations; among the more interesting of which was the announcement of his discovery of the "rudimentary wing-bone, for which he had before sought in vain" ('Proceedings,' p. 52), and which had been long a subject in much request by myself. Mr. Allis, also

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[1] See p. 225: this is the length of tibia of *Dinornis robustus* as compared with that (24 inches) of *Dinornis elephantopus*.

[2] The experienced ornithologist, Dr. P. L. Sclater, favoured me with the remark that, as in the majority of the Struthious birds the male, and not the female, has been observed to incubate, the bones of the *Dinornis* there described might be those of a male. I am not aware that this part of the economy of the Kivi has been determined: if the male of the *Apteryx* rears the young, a similar conclusion as to *Dinornis* would be as safe a one as can be deduced from analogy.

[3] See 'Journal of the Proceedings of the Linnean Society' (Sept. 3), vol. viii. p. 50.

alluding to the still more remarkable evidence of preservation noticed by Dr. Hector, made mention of "a considerable portion of the skin, studded with the quill-parts of the feathers, which are bifid as in the Emu: some of the feathers preserve a portion of the web" (*loc. cit.* p. 51).

I have been favoured by Mr. Allis with copies of the photographs exhibited by him to the Linnean Society, in one of which the bone (fig. 1 of photograph) is described as the "anterior limb of adult." All are referred to the *Dinornis robustus*, although in the text (Proc. Linn. Soc. p. 52) this determination of the species is accepted with doubt. "Dr. Gibson has carefully measured the leg-bones, and does not find them agree in all respects with any described by Professor Owen, though the difference," Mr. Allis suggests, "may possibly be only sexual" (ib. p. 52). Mr. Allis adds the following particular to the history of the finding of this series of bones given by Dr. Hector, viz., "It appears that the skeleton was discovered by some persons who were on a 'prospecting' expedition in search of gold, almost completely buried in a heap of sand, and having beneath it the bones of four young ones."

It does not appear that any portions of the egg-shell were obtained or noticed by the finders.

With the concurrence of Mr. Allis I wrote to the Council of the "Yorkshire Philosophical Society," of which he is Honorary Secretary, requesting the loan for description of certain parts of the skeleton, the discovery of which had been notified to me by Dr. Hector; and I was favoured with the transmission of the skull (Pls. LXIV. & LXV.), the supposed 'anterior limb' or 'rudimentary wing-bone' (Pl. LXIV. figs. 2, 3, 4), and the portion of the foot, with the ligaments, tendons, and tegument.

In the present communication I propose to describe the skull and so-called 'wing-bone.'

Skull of Dinornis robustus, *from Manuherikia.*

This is a little smaller than the one from 'Timaru,' the lower jaw being 7 inches in length, as against 7 inches 6 lines; and this may be accounted for by difference of sex, if not by the range of size of individuals of the same sex. The present skull, like the rest of the skeleton, bears all the marks of mature age.

It supplies the following deficiencies in the skull first described:—the paroccipital, mastoid, and postfrontal processes; the basisphenoid complete, with the pterapophyses; the presphenoid; the prefrontals and anchylosed ossified parts of the olfactory capsules; the lacrymal, nasals, premaxillary entire to the tip, the maxillary, and malosquamosal zygomatic arch of one side.

The occipital condyle (Pl. LXV. figs. 1 & 2, 1) is of a full reniform figure, slightly notched above, and with a shallow groove extending therefrom to the middle of its convexity; its breadth is 5½ lines, its height 3½ lines; it is supported on a short pedicle, contracting below as well as laterally, then quickly expanding to its attached base; its axis is directed backward and a little downward. The occipital foramen (Pl. LXV. fig. 2, *m*) is shield-shaped, expanding to its upper border, which is overhung by the lower transverse superoccipital ridge (ib. 2, 2); the sides also slope toward the margin of the foramen: it is broader than in Pl. LXII. fig. 3, but this I believe to exemplify range of individual variety. The basioccipital descends with a strong curve to its bimammillate (1') inferior line of union with the basisphenoid (ib. fig. 1, 1',5): in the hollow of this curve, at the base of the peduncle, are the two rather unequal venous pits, perforated by small foramina of diploic venules. The precondyloid foramina (*p*) are two in number, on each side of the base of the condyle; they are very small. About one or two lines external to these is the large vagal foramen (*v*), perforating the bone, from within, obliquely downward and outward, and giving passage (in *Apteryx*) to the spinal accessory as well as the respiratory (eighth) nerve. Three lines external and in advance of the 'vagal' is the fossa, perforated anteriorly and inferiorly by the carotid (*c*), and posteriorly by the sympathetic and glossopharyngeal nerves and by a tympanic vein (*s*).

The superoccipital, as in Pl. LXII. fig. 3, is of unusual breadth, and slopes from the lower transverse ridge (2, 2) obliquely upward and forward. From the medial vertical ridge (3) to the paroccipital ridges (4') it is concave: the paroccipital ridge extends from the outer angle of the upper transverse ridge, downward and inward, to the pneumogastric fossa. The ridge is bent backward (ib. fig. 1, 4), and the upper half of the hinder part is thick and rough. The position of the paroccipital diapophysis in the *Dinornis* departs less from that in Crocodiles and Dicynodonts than in any other bird.

On the superoccipital surface a venous groove extends, as in the first-described skull, from near the superoccipital tuberosity downward and outward, and terminates in a foramen penetrating the diploë. The lower superoccipital ridge formed by the exoccipitals (ib. 2) is more bent than the upper one, and its projection is chiefly due to, or shown by, the excavation of the surface of the bone beneath it; the part extending to the upper border of the foramen magnum is nearly horizontal, overhanging that foramen like a pent-house; the ridge laterally subsides about an inch from the paroccipital. Such configuration of the occipital surface (Pl. LXV. fig. 2) is rare in the class of Birds.

The basisphenoid (ib. fig. 1, 5) is square-shaped; its hinder angles swell into the mamillar tuberosities (ib. 1'), which it conjointly forms with the basioccipital, and its anterior ones develope the pterapophyses (ib. 5'): these are about half an inch in length, directed outward, slightly forward and downward, with obliquely truncate ends, presenting a flat, roughish surface upward and outward to abut against the pterygoids. The sides of the basisphenoid are grooved by the Eustachian canals (*e*), which extend from the lower part of the tympanic cavity about a line in advance of the carotid fossa (*c*) forward and inward, gradually subsiding or becoming shallow to near the anterior border of the square basisphenoid platform (fig. 1, 5): the breadth of the Eustachian groove is 1½ line: near the commencement, the hinder wall of the groove shows an oblong vacuity.

The fore part of the basisphenoid platform is impressed by a pair of curved, shallow fossæ, concave forward. The substance of the basisphenoid is pneumatico-cellular: on removing the thin compact crust of the lower surface, as in Pl. LXIII. fig. 1, the wall of the hemispheroid pituitary fossa or 'sella' (Pl. LXV. fig. 1, *d*) is shown, demonstrating the boundary between the basi- and pre-sphenoids.

The lower surface of the basisphenoid platform is gently concave lengthwise and transversely between the produced anterior angles; but, across the mid part, it is concave medially and convex laterally. The lateral margins, forming the lower part or floor of the medial extension of the tympanic cavity, are sharp and jagged, concave lengthwise, between the mammillar (1′) and pterapophysial (5′) productions, where they are impressed by the Eustachian channels. The tract of bone (*r*) from the outside of the mammillar protuberance to the lower end of the paroccipital ridge forms the back part of the beginning of the Eustachian groove (*e*) and the fore part of the carotid fossa (*c*).

The mastoid sends off three processes in many birds, the 'mastoid' process proper (8), the 'post-tympanic' (8″), and the pretympanic (8′). The post-tympanic is the longest in *Dinornis*, and the shortest in *Aptornis*[1] and *Didus*. The pretympanic process is very long in *Notornis* and *Porphyrio*[2].

Internal to the pretympanic process and between it and the post-tympanic, the mastoid forms, by a sharp ridge, the outer and front boundary of the anterior fossa for the condyle of the tympanic bone (28). The mastoid process (8) projects from above the base of the post-tympanic (8″), and is tuberous and rough.

The paroccipital (ib. 4) with the post-tympanic (8″) forms a smooth arch of bone overhanging the membrana tympani: the anterior surface of the paroccipital, forming the back part of this arch, is divided by the narrow ridge for the attachment of the ear-drum into the ectotympanic and entotympanic surfaces.

The tympanic cavity (ib. fig. 1, *t*, *u*) is of a triangular form, bounded externally by this ridge, the post-tympanic process, and the tympanic plate of the mastoid, posteriorly by the paroccipitals (ib. 4), internally by the basisphenoid (ib. 5), and anteriorly by the alisphenoid (ib. 6). The cavity presents a most irregular surface. On the outermost part of the roof, immediately within the ear-drum, is a large oval pneumatic foramen, immediately mesiad of which is part of the single, deep, oblong, smooth, articular cavity (*u*) for the tympanic bone, 10 lines in length and 5½ lines in breadth at its anterior and widest part; whence it extends inward and backward from the mastoid to the paroccipital. Anterior to and mesiad of the articular cavity is a second large oval pneumatic vacuity (ib. fig. 1, *u*) leading to a vertical fossa in the cranial wall, homologous with that wider and more conspicuous 'pretympanic'

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[1] Pl. XLIII. figs. 1–6.

[2] Pl. XLVII. figs. 1 & 7, 8″.

fossa which characterizes the cranium in *Sula* and other *Pelecanidæ*. From the back part of this extends the groove for the tympanic vein leading to the postlacerate fissure[1] (Pl. LXV. fig. 1, *s*). Mesiad of the inner pneumatic foramen is the fossa terminated by the orifices of the vestibular fenestræ (rotunda et ovalis), which are divided by a short subvertical bar. Below the fenestral fossa begins the Eustachian groove (*e*). Anterior to the groove leading to the fenestral fossa are two other large oval pneumatic foramina. The tympanic cavity anterior to these is smooth; but mesially, where it undermines the basisphenoid, it becomes reticulate. The chief part of the floor of the tympanic cavity is membranous.

At the fore part of the base of the pretympanic plate of the alisphenoid (ib. 6) opens the foramen ovale, partly divided into a larger inferior passage for the third, and a smaller upper one for the second, division of the fifth nerve. This foramen is 2 inches 2 lines distant from that of the opposite side, and 8 lines behind the prelacerate fissure[2] (ib. 10). This, as in most other birds, includes the optic foramen, with those for the transmission of the nerves to the orbit, viz. the sixth and fourth and the anterior division of the fifth pair. The optic foramen is on the mesial side of the fissure, and is better defined from the orbital nerves and vessels than in most other birds; a more remarkable peculiarity is the extent of separation of the left from the right prelacerate fissure, the optic foramina being 1 inch 6 lines apart in *Dinornis robustus*.

The optic groove, which extends across the fore part of the sella, from one optic foramen to the other, the floor of which is shown in Pl. LXIII. fig. 1, *m*, defines the coalesced bases of the orbitosphenoidal neurapophyses. These bases rest upon a prolongation of bone from the basisphenoid, suddenly narrower than that part, convex transversely, contracting anteriorly, and called in ornithotomy the 'rostrum' or 'sphenoidal rostrum' (ib. 9).

If we may extend the more general comparisons of the vertebrate endoskeleton to this part of the base of the skull, we should view this 'rostrum' as the anterior continuation of the series of vertebral elements called 'centrums,' but which have been ossified, like the lower cortical or hypapophysial part of the centrum of the atlas, from the capsule of the notochord. The presphenoid, indeed, is only semicylindrical, and offers a close resemblance to the corresponding base of the sacrum, succeeding that which, by its greater breadth and flatness, forms, as a thin floor of bone, the base of the sacral cranium, or neural cavity for the sacral expanse of the myelencephalon, and so closely and instructively repeats the characters of the basioccipital and basisphenoid at the base of the bird's encephalic cranium. To the chambers in which the foremost productions of the myelencephalon expand, this ornithotomical 'rostrum' exists in the relation of a centrum, both developmentally, connectively, and functionally: the coalesced orbitosphenoids and prefrontals have like relations thereto as neurapophyses.

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[1] "Fissura lacera posterior" and "foramen lacerum posterius" of Anthropology.

[2] "Fissura lacera anterior," "foramen lacerum anterius," and "fissura sphenoidalis," ibid.

There is not an interorbital septum in *Dinornis*, as in birds generally; so, if such septum can, on any ground, be regarded as 'the body of an anterior cranial vertebra,' whether 'compressed,' or 'third,' or 'last,' or 'most anterior,'[1] then such 'body' must be denied to the *Dinornis*, and the 'presphenoid' be left without general homological significance. The truth is, however, that the compressed interorbital septum is the result of special ornithic modifications of the general vertebrate type; not, however, common to all the class, but an inconstant feature therein. In such low forms as *Apteryx* and *Dinornis* we see it not: the common vertebrate type is here more closely adhered to. The real 'body,' or representative centrum, of the prosencephalic cranial vertebra is wanting in no bird; it exemplifies its general homological character more clearly where the general vertebrate type is least departed from. Developmentally it is the product of the notochordal capsule, and of a part of such extending anteriorly beyond the gelatinous contents of the chorda, and it may include only the inferior cortical or 'hypapophysial' part of the cervical or dorsal centrum, as in the similarly produced part of the cranial vertebræ in *Cetacea*: but whether it be specially denominated 'sphenoidal rostrum,' 'presphenoid,' or 'vomer,' such median inferior parts of the floor of the osseous encompassings of the foremost parts and productions of the neural axis are in the relation of 'centrums' or 'bodies' to such 'neurapophyses' and 'neural spines.'

As the basioccipital is coalescent with the exoccipitals and basisphenoid, and this again with the alisphenoids, so the forward production of the cranial base is coalescent with the orbitosphenoids, which, by their confluent bases, support the optic groove, and are at the outer end of this groove pierced by the optic foramina. In *Dinornis* the orbitosphenoids coalesce with the antecedent pair of plates to form the walls of the vast rhinal chamber. The presphenoid (Pl. LXV. 9), connate as well as confluent with the basisphenoid, presents the usual ornithic or oviparous condition of a long rostrum, but here may be said rather to resume the usual subcylindrical shape of the vertebral centrums. It is, however, semicylindrical, rounded below from side to side, broad and flattened above, where it coalesces with the laminæ (14) protecting the most anterior developments of the neural axis. It measures from the fore part of the 'pterapophyses' 3 inches 3 lines, contracting to 6 lines across, near its origin, then gradually expanding to a breadth of 8 lines opposite the rhinal apertures, before more gradually contracting to its apex. Its free surface is convex transversely and smooth, consisting of a very thin plate of bone; its substance is highly pneumatic, receiving air from the sphenoidal communications with, or extensions of, the tympanic cavity. Hollow slender columns of bone act as tie-beams on each side, near its confluence with the fore part, connecting the lower and lateral walls with the upper wall of this elongate cranial centrum.

The neurapophysial plates arising from its upper and lateral parts slightly converge posteriorly before bending upward and outward to form the combined optic (*op*) and

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[1] Melville, 'Osteology of the Dodo,' 4to, p. 87 (1848).

prelacerate (*f*) foramina, beneath which there is thus a smooth depression (10) capable of receiving the end of a man's thumb on each side and above the origin of the presphenoid. In advance of these depressions the outer plates of the neurapophyses (Pl. LXV. fig. 1, 14) extend obliquely outward as they rise, forming the sides of the larger rhinal chamber (Pl. LXIII. fig. 1, *n*), and passing uninterruptedly to coalesce with the superorbital expansions of the frontal (neural spine, Pl. LXII. fig. 1, 11). From the upper and anterior half of the presphenoid rostrum, the inner plates of the neurapophyses (14)—foremost terminal ones of the series—converge and coalesce into a vertical wall of bone (Pl. LXV. fig. 3, 14′), thickest, lengthwise, at its middle part and thence gradually thinning off to both posterior and anterior margins, but thinnest vertically at its middle part, and expanding both below and above. Superiorly the expansion attains a breadth of 8 lines, with a flattened upper surface (ib. fig. 3, 14′) supporting the fore part of the nasals (15), which part is overlapped by the premaxillary, and with the under surface forming an arch on each side over the fore part of the rhinal chamber.

The base of each of these neurapophysial plates, prior to their rising to converge and coalesce, developes a strong, thick, dense, and smooth girdle of bone around the orifice of communication between the rhinal chamber and the corresponding nasal passage: the girdle (ib. fig. 1, *g*, *g′*, *g″*) is not entire; about one-sixth is incomplete at its fore part; the orifice it otherwise would encompass is of a triangular form, with the angles rounded off (ib. 19). The hinder side or bar (*g*) is transverse to the skull's axis, and is 1 inch long; the medial side (*g′*) is in the skull's axis, and is 10 lines long; the third side, partly formed by the bending of the outer end of the hind bar, extends obliquely forward and inward for 6 lines, leaving about the same extent of the circumference incomplete at its middle, between the above and the process (ib. *g″*), which extends transversely outward. The inner part of this thick border or girdle is defined from the base of the neurapophysis developing it by a narrow groove; the hind part increases in depth as it extends outward and makes a bold bend forward and inward, with the convexity projecting into the fore part of the orbit, as it bends to form the anterior part of the girdle. There is a small perforation at the convex bend, and the upward continuation of this part of the wall, which is concave forward, becomes as thin as fine paper, subreticulate, and continuous with the delicate bony support of a turbinal (ib. 19). We have here the commencement of the accessory or apophysial part of the neurapophysis, which becomes developed into the most conspicuous part of the ‘frontal antérieur’ of Cuvier, *e.g.* in Reptiles. But in *Dinornis* the ‘prefrontals’ are unwontedly developed in their essential parts, and almost exclusively devoted to the olfactory chamber, which is serially homologous with the orbit and the tympanum, as the antecedent nasal passage conducting the air thereto is the homotype of the meatus auditorius externus in the hinder organ of special sense.

On removing the centrum and lower portions of the neurapophyses of this region of the skull, the rhinal chambers are exposed (as in Pl. LXIII. fig. 1, 14, *n*). These, in transverse vertical section, are of a triangular form, the apex being formed by the bases of the prefrontals where they coalesce with the presphenoid. Each prefrontal divides into an inner or 'medial' and an outer or 'lateral' plate. The lateral plates diverge and bend upward and outward, forming the side-wall of the rhinal chamber, from which the turbinals (middle and posterior, Pl. LXV. fig. 3, 19) are developed; the medial plates coalesce and ascend, forming the rhinal septum (ib. 14', and Pl. LXIII. fig. 1, between *n* and 14), expanding above and partly overarching the rhinal chamber, the main part of the roof of which is formed by the frontals and nasals, with which, however, a thin layer of the prefrontals seems to be blended as it diverges from the upper part of the septum. At the upper and back part of the rhinal chamber this layer of bone (ib. 14) is perforated by numerous minute foramina leading to fine grooves which radiate to conduct the olfactory nerve-filaments to the pituitary membrane.

This 'cribriform plate' is a peculiarity in which the *Dinornis* participates with the *Apteryx*: in birds generally the olfactory foramen is single on each side; sometimes they are blended into one. Cuvier called the combined neurapophyses and sense-capsules, which chiefly form and occupy the rhinal chambers in birds, by the same name which anthropotomists had given to those parts in Man. He rightly determined the bones marked 15, 15', Pls. LXII.–LXV. to be 'nasals,' but those external to them and next the orbit might be either 'anterior frontals' or 'lacrymals'[1]. Cuvier inclined, however, to adopt the latter homology[2], but for a reason which is rebutted by the marked development of the 'posterior frontal' (Pls. LXIV. & LXV. fig. 1, 12) in the *Dinornis*.

The phenomena of development lend no help to the determination of this question; the same spread of blastema, between and expanding transversely in front of the eye-balls, becomes the seat of the histological stages which issue in the bones (14, 15, 73) prior to their mutual confluence in Birds. I doubt if I should have been able to settle this matter, which to some now appears so obvious, if I had not been guided by the light of general homology. That showed me first what was the essential and constant, what the secondary and superadded, growth of the bones called by Cuvier 'frontaux antérieurs' in the Fish and Reptile. The determination of the neurapophysial parts of these bones in Pisces and Reptilia led me to recognize their homologues in all the groups (Batrachia, Aves, Mammalia) in which Cuvier and other anatomists, up to 1844, held the 'anterior frontals' to be absent, or to be represented by the lacrymals. Cuvier was unacquainted

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[1] His able coadjutors and editors, F. Cuvier and Laurillard, retained this opinion:—"Les os externes et plus voisins de l'orbite seraient presque comme on le voudrait, ou des frontaux antérieurs ou des lacrymaux" (Leçons d'Anat. Comp., ed. 1837, tom. ii. p. 580).

[2] "Ce que pourrait faire croire que c'est le frontal antérieur qui manque, c'est que dans les oiseaux il n'y a point de frontal postérieur, et que la paroi antérieure de l'orbite, à l'endroit où le frontal antérieur se trouve ordinairement, est manifestement formée en grande partie par une lame transverse de l'ethmoïde" (*ib.*).

with the term ‘prefrontal,’ nor is it a synonym of ‘anterior frontal.’ By ‘prefrontals’ are meant not only the ‘anterior frontals’ of Cuvier in Fishes and Reptiles, but also his ‘os en ceinture’ in Batrachians and parts of his ‘ethmoïde’ in Birds and Mammals: the term ‘prefrontal’ is the sign of the settlement of a homological question which was far from being an easy one or of obvious attainment when it became my duty to grapple with it in describing the “Osteological Series” of the Museum under my charge in 1843. Notwithstanding the devotion of twelve pages[1] to that subject, by which I believe that now the matter ought to be sufficiently plain, Dr. Melville is unable to understand it. Accepting the choice offered by Cuvier in the skull of birds, he takes the opposite of that to which Cuvier inclined[2]. Seeing that of the three names which Cuvier had given to what I believe to be one and the same bone, two of them were applied to it in pretty equal proportions of the vertebrate series, I balanced for a while whether to adopt ‘ethmoid’ or ‘anterior frontal.’ I considered, however, that by ‘ethmoïde’ Cuvier meant not only the neurapophysial part of the prefrontal, but also the superior portions of the rhinal or turbinal capsules, and that the term, moreover, borrowed from anthropotomy, indicated a structure which, with the two exceptions discovered by me in the class of Birds, was limited to Mammals, and not constant in that class. Inclining, then, to the name referring to the bone in question in Fishes and Reptiles, I constructed a term near enough to it to suggest so much of the homology as was true, but sufficiently distinct from it to show that it was not a synonym, but signified something different and much besides.

In ordinary birds the olfactory nerves, or rather rhinencephalic crura, emerge from the cranium at the upper angle between the hind wall, roof, and septum of the orbit, groove the upper part of the septum as they pass forward to penetrate the prefrontal, and expand into the rhinencephalon, dispersing the olfactory nerves to the turbinal membranes. The frontal olfactory foramen in *Raptores* is smaller than the prefrontal one. Between the Vulture and the Crocodile the difference is that the rhinencephalic crura extend along a common canal above the interorbital space in the Reptile, while in the Bird the ossification of the septum divides the rhinencephalic fossa into two. The bones which hold the neurapophysial relation to the rhinencephalon, anterior to the frontals, are the same or homologous in both *Ovipara*; but in the Bird the secondary peripheral or apophysial developments of the prefrontals are suppressed, as in Batrachians and some fishes (*Xiphias*), in which they form the anterior wall of the

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[1] “On the Archetype and Homologies of the Vertebrate Skeleton,” pp. 46–59.

[2] “The bone which has heretofore been denominated the lachrymal in birds is undoubtedly the homologue of the prefrontal in the cranium of fishes and reptiles. The true lachrymal bone, which is external to the lachrymal duct, exists in certain Saurians and in the *Crocodilidæ*; it does not occur in the higher Vertebrates (*Aves* and *Mammalia*), while the prefrontal only disappears in certain exceptional instances among mammals; in birds and mammals it has erroneously been regarded as the true lachrymal, and is so named by the learned Hunterian Professor: this false homology masks one of the most beautiful instances of the unity of organization,” &c. (‘Osteology of the Dodo,’ 4to, p. 87, 1848.)

orbit, occupying the anterior part of the interorbital space, joining each other at the median line by an extensive vertical cellular surface, and dividing the orbital from the rhinal cavities. In *Apteryx* and *Dinornis* the latter cavities are so developed as to extend backward between the orbits to the cranium, the front wall of which forms the back wall of the rhinal instead of the orbital cavities.

The temporal fossa (Pls. LXII., LXIII., LIV. 7′) is divided by the pretympanic ridge and process of the mastoid (8″) into a posterior compartment (Pl. LXIV. fig. 1, 8) for the posterior 'temporalis' muscle, of a triangular shape, 10 lines broad at the upper part, and an anterior larger and deeper depression (ib. 7′), rounded above, 1 inch 5 lines in breadth, and bounded anteriorly by the broad, triangular, vertically descending postfrontal (ib. 12). These temporal fossæ, as in the less perfect skull (Pl. LXII. fig. 1, 7′), are nearly 2 inches apart on the broad, flattened upper surface of the cranium (7), where the boundary-ridge is scarcely, if at all, defined.

The orbit (Pl. LXIV. *o*) is smaller in proportion to the size of the skull than in most birds, but is much better defined than in the nocturnal *Apteryx*. The bony boundary is formed posteriorly by the convex border of the postfrontal (12′), above and in front of this by the thin superorbital part of the frontal, which is gently wavy; it then curves down as a thicker triangular process (*a*) to form the fore part of the orbital frame. The inner surface of this process developes a low vertical ridge, in part articulated with the outer portion of the rhinal cincture; and the lower part of this ridge is pierced by the lacrymal foramen, indicating the process to be a lacrymal (ib. 73) confluent with the frontal and prefrontal.

The nasal is, in like manner, confluent by its upper border (Pl. LXII. fig. 1, Pl. LXV. fig. 3, 15) with the frontal, its outer descending maxillary process (Pl. LXIV. fig. 1, Pl. LXV. fig. 3, 15′) terminating freely by a slight expansion which rests upon the maxillary (Pl. LXIV. fig. 1, 21). The premaxillary process of the nasal (15) is broad and flat, supported by the prefrontal expanse (Pl. LXV. fig. 3, 14′); it is in great part excavated above by the shallow rough depression for the premaxillary stem (Pl. LXII. fig. 1, 22′), and shows a narrow, thickened, and smooth tract bounding that depression externally or laterally.

The plane of the orbital cavity, so far as it is formed by bone, is directed from behind obliquely forward and upward at an angle of 45° with the axis of the skull, the eyes thus being directed more forward and downward than in birds generally. The downward cast of the eyes relates to the great height of the *Dinornis*, and the position of its food upon the ground. The roof of the orbit shows an oblong shallow depression at its back part for the Harderian gland, and a deeper anterior pit for the lacrymal gland. The fore part of the maxillary (Pl. LXV. fig. 1, 21′) is an oblong, bony, pneumatic capsule, 2 inches in length and 1 inch 3 lines in breadth, flattened below, where the surface is equally divided between the sutural part underlapped by the maxillo-palatal part of the premaxillary (22″) and the free, smooth surface, extending thence the bony roof of the mouth. It is convex above, where it forms a very thin shell of bone; on the outside of this tumid part of the maxillary is the sutural surface for the premaxillary and nasal bones, the latter being the smaller part. The malar process of the maxillary (Pl. LXIV. fig. 1, 21) extends backward from the outer and posterior angle; the inner angle terminates in a point, which was underlapped by the palatine.

Neither palatines nor pterygoids are preserved in the present skull. The maxillary (21), malar (26), and squamosal (27) coalesce to form the usual slender and straight zygomatic arch in birds. This increases in depth and diminishes in thickness at the squamosal part, which shows a feebly convex upper border: its posterior end is thickened to form the convexity adapted to the cup (Pl. LXII. fig. 2, *h*) on the outer part of the tympanic (28).

The modifications of certain parts of the skull of the *Dinornis robustus* are of a nature to throw light on some moot points in the craniology of birds.

Dr. Melville contends that "the interorbital septum in Birds is the homologue of the Mammalian presphenoid"[1]. But of this presphenoid in Pigeons he describes the "ossified portions of the ethmoid, or olfactory capsule," to be processes[2]. Moreover, he admits that the 'interorbital septum' appears on the upper surface of the cranium "behind the premaxillary, and between the nasals," "in the Emu and other Struthionidæ"[3]. It is shown in this exposed position in the Ostrich (art. *Aves*, Cyclop. of Anat. vol. i. p. 274, fig. 127, *l*) as part of the 'ethmoid,' in the Emu (Zool. Trans. vol. iii. pl. 39. figs. 1 & 2, 14) as 'prefrontals,' and in the *Rhea* (Zool. Trans. vol. v. pl. 42) as the 'middle ethmoid' or 'perpendicular ethmoid.'

I have not, however, met with any instance, in any class, in which the 'anterior sphenoid' afforded attachment to 'turbinals' or ossified parts of the olfactory capsule. Anthropotomists describe and figure the homologue of the 'presphenoid' as the "'rostrum'[4] of the sphenoid bone, to which is articulated the vomer and the perpendicular part of the ethmoid."

The 'rostral' form and proportions of the 'anterior sphenoid' in *Cetacea* approach nearer than in most other mammals to those of the 'rostrum of the sphenoid' in Birds and Reptiles. I am unable, therefore, to accept the special homology of the 'interorbital septum' in birds proposed or adopted by Dr. Melville. His views of the "general homology" of the part in question are expressed as follows:—"For reasons which cannot be discussed here, I regard the interorbital septum as the compressed body of the third and last or most anterior of the cranial vertebræ"[5]. But, in this case, we have the body or centrum of a vertebra appearing at the upper surface of a neural arch, and displacing the moieties of a neural spine, projecting, *e. g.*, "between the nasals," as in the Struthious birds already adduced. And beneath this part so

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[1] "Dodo and its Kindred," 'Osteology of the Dodo,' 4to, 1848, p. 87.

[2] Ibid.

[3] Ibid.

[4] 'Anatomy, Descriptive and Surgical,' by H. Gray, 8vo, p. 33, fig. 30.

[5] *Op. cit.* p. 87.

exposed the alleged 'vertebral body' gives off a process "arching over the foramen, for the transmission of the olfactory and ophthalmic nerves"[1]. But this is, surely, a relation rather of a 'neurapophysis' than of a 'centrum' of a vertebral segment.

Some who appeal to developmental phenomena will reject the "general homology" proposed for the interorbital septum by Dr. Melville, on the ground of the non-extension of the 'chorda dorsalis' so far forward in the cephalic blastema of the embryo. I may presume, however, that the arguments for the insufficiency of this ground of objection given in my 'Archetype of the Vertebrate Skeleton' (8vo, p. 6) are held to be conclusive by the learned Professor in Queen's College, Galway. My objections to his view rest on the more decisive and demonstrative homological bases of 'connexion' and 'relative position.'

Mr. Parker confines himself to the question of special homology in regard to the 'interorbital septum' of birds, and points out in it, in the illustrations of his paper on the "Osteology of Gallinaceous Birds,"[2]—*ps*, the 'presphenoid'; *eth*, the 'middle ethmoid' and 'vertical ethmoid'; *prf*, the 'upper prefrontal'; *pe*, the 'perpendicular ethmoid'; *aet*, the 'ali-ethmoid lamina'; *ao* 1, the 'upper antorbital'; *ao* 2, the 'lower antorbital.'

I believe that all these are but parts of the coalesced 'prefrontals,' including a small portion of the rhinal sense-capsule connected therewith; and in regard to the more general relations of homology, I retain my conviction that the 'prefrontals,' under all their modifications as the 'interorbital septum' in birds, are essentially 'neurapophyses,' serially homologous with the 'orbitosphenoids,' and belonging, not to the 'third' cranial vertebra, but to the 'fourth' or most anterior one. The huge eyeballs in most birds press hardly upon the blastemal basis of these poor neurapophyses, interrupting their normal development, and squeezing, so to speak, the rhinal sense-capsules out of all proper position: hence the value of small-eyed birds with mammalian noses, like the *Apteryx* and *Dinornis*, in testing the divers notions which the 'interorbital septum' has raised in the anatomical mind, and in demonstrating the true and essential nature of the part.

But the interorbital septum is not the only stage on which a supposed plurality of bones, with their several denominations, play their parts. Ossification of the blastemal basis of the basisphenoid being stimulated to begin by the channels through which the blood actively and abundantly passes to the rapidly growing brain, a pair of centres, besides the median one, characterize the ossification of this vertebral element in Birds as in many Reptiles. Are these parial ossifications superadded vertebral elements, or indications of two bones calling for special denominations?[3] Considering the varying number of points at which ossification commences in the body of a vertebra in the

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[1] "Dodo and its Kindred," &c., 4to, p. 87.

[2] Zool. Trans. vol. v. p. 149.

[3] 'Basitemporals,' *e.g.*, as proposed in the memoir "On the Osteology of the Gallinaceous Birds," &c., Trans. Zool. Soc. vol. v. p. 176.

different vertebrate classes, the fact did not so weigh with me in considering the serial homology of the vertebral centrums at the base of the skull, and I cannot assign more value to the osteogeny of the basisphenoid in Birds and Lizards than did the embryologist Rathke. The 'pituitary floor' of the 'sella turcica,' which marks the place of the bifurcation of the blastemal capsule of the notochord in the embryo, shows unmistakeably, in the dissection of the base of the *Dinornis* skull (Pl. LXIII. *d*), the boundary-line between basi- and pre-sphenoid. If I understand Mr. Parker, he regards the bones (8) in Pls. LXII.–LXV., which he calls 'temporal' and 'squamosal,' as standing in neurapophysial relation to his 'basitemporals.' Whether 8 be homologous with Cuvier's 'mastoïde' in Reptiles, or with his 'écaille du temporal' in Mammals, is discussed in my work 'On the Archetype,' &c., 8vo, 1848, pp. 29–42. The only additional argument bearing upon this question is based upon the assertion that the bone 8, in Birds, is not ossified in and from cartilage, but is a 'membrane bone' like the squamosal in Mammals. This assertion does not square with my experience. The ossification of no. 8 in Birds, as in Reptiles and Fishes, begins and ends in the cartilage external to the labyrinth. In adducing other reasons for regarding it as the homologue of Cuvier's 'mastoïde' in other *Ovipara*, I should only repeat what I have elsewhere adduced. But I may here remark that, in the quest of the nature and homologies of the bones in the Bird's cranium, the comparison should be made ascensively from the developmental phenomena and anatomical connexions and relations of the parts in the Cold-blooded Vertebrates, rather than descensively from those in Mammals.

§ 4. *Atlas of* Dinornis robustus.

This vertebra consists of the 'hypapophysis' and the 'neurapophyses' in a coalesced state (Pl. LXII. figs. 4, 5, 6): the 'centrum' articulating with the back part of the base of each neurapophysis, having coalesced with the centrum of the succeeding vertebra, is not here present. The hypapophysis (ib. *hy*) is wedge-shaped; the base is convex transversely, with a medial protuberance from its back part and a smaller one on each side: the anterior surface is excavated and smooth, forming the lower two-thirds of the occipital cup (ib. fig. 4); the posterior surface (fig. 5) is plane and roughish for a close attachment to the centrum of the atlas; the upper margin of the wedge is concave transversely, thick and convex longitudinally. The coalesced bases of the neurapophyses send each a process inwards, which is concave anteriorly, contributing the upper third of each side of the occipital cup, and resting in part upon the body of the atlas, which occupies their interspace (fig. 4, *c*). Each neurapophysis then inclines upward and outward, and suddenly expands; it sends a process from its outside downward, which coalesces with the side of the hypapophysis and circumscribes the vertebrarterial foramen (ib. *v*); it sends a larger process backward, with an articular surface (fig. 5, *z*) on its under and inner part for articulation with the prezygapophysis of the axis-vertebra; it is convex externally, with a tuberosity on its outer and hinder surface (fig. 6, z'), and then rapidly diminishes in thickness, curving inward towards its fellow, which it does not quite meet, above the neural canal (Pl. LXII. fig. 5, *n*). The anterior end of the centrum of the atlas occupies the notch (*c*) between the hypapophysis and neurapophysis, completes the occipital cup, and gives attachment to the ligament answering to the 'odontoid' in anthropotomy. The figures of the atlas in Pl. LXII. are of the natural size: the specimen was obtained with the incomplete skull from the fissure at 'Timaru.'

§ 5. *Scapulo-coracoid Arch of* Dinornis robustus.

The existence of such arch in the skeleton of *Dinornis* was inferred, in the Memoir on *Palapteryx* (p. 124), from the articular depressions in the sternum (Pl. XXXV. fig. 2, *c*, *c*); and, by the peculiarly small size, shallowness, and shape of these depressions, I recognized the convex extremity of the bone (Pl. LXIV. figs. 2, 3, 4, *x*), forming part of the skeleton of the *Dinornis robustus* from Manuherikia, as being the sternal end of the coracoid. It presents a rather irregular convexity, of an oval shape, 10 lines by 6 lines in the two diameters, with a rough surface indicative of ligamentous union with the sternal fossa, not of articulation by a synovial joint, as in birds of flight. From the tuberosity (*x*) the bone (52) rises straight, decreasing in thickness and increasing in breadth at its upper end, which is confluent with a much longer and thinner bone (51), forming with the coracoid a widely open angle, and slightly curved in its course. This bone I take to be the 'scapula' confluent with the coracoid, partly from characters of proportion and shape and partly from the analogy of the scapulo-coracoid arch in the *Apteryx*[1]. In this bird the coracoid and scapula are confluent, and present relative proportions as to length like those in *Dinornis*. But the coracoid is relatively much broader in the *Apteryx*; its sternal end is adapted to a long groove, as in most other birds; it also shows a perforation near its scapular end, and a more important difference in the presence of the glenoid cavity for the humerus on the posterior margin of the scapulo-coracoid confluence. There is no trace of such articular cavity in the scapulo-coracoid arch of *Dinornis*, but in place thereof a rough, slightly produced ridge (fig. 4, *r*), to which, if any rudiment of humerus existed, it must have been suspended by ligament. I, however, infer that such appendage of the scapular arch did not exist in the living bird; that the *Dinornis* offers the previously unknown and unique exception to the tetrapodal type in Birds; that the anterior members, like the posterior ones in Cetacea, were represented only by their supporting arch, and that this arch was limbless, as it is in *Anguis* among the Lacertian Reptiles.

The scapula (Pl. LXIV. figs. 2, 3, 4, 51) soon decreases in breadth, from 11 lines at the confluent part (*m*) to 7 lines within an inch from that part, beyond which it more gradually narrows to a breadth of 5 lines at the extremity; the thickness of the bone gradually decreases also from the coracoid confluence (fig. 4, *m*), viz. from 4 lines to

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[1] *Ante*, p. 34, pl. IX. fig. 4, *e*, *f*, *g*.

2 lines, near the free end of the bone. The total length of the scapula is 5 inches; that of the tibia of the same bird is 2 feet 3 inches—a strange disproportion! The scapulo-coracoid arch exists in this huge wingless bird solely in physiological relation as the lever by which the respiratory muscles act to depress the sternum, expand the thoracic air-cells, doubtless developed as in *Apteryx*, and so cause the rush of air by the trachea into the lungs. The open angle at which the coracoid joins the scapula is characteristic of brevipennate birds, and is extreme in *Apteryx* (p. 34, Pl. IX. fig. 4) amongst existing species: but the character was maximized in *Dinornis*.

DESCRIPTION OF THE PLATES.

PLATE LXII.

Fig. 1. Upper view of the skull of *Dinornis robustus*, from the bone-fissure at "Timaru." (The premaxillary is figured about 8 lines too far in advance of the cranium.)

Fig. 2. Side view of the same skull. (The dentary (32, 32′, 32″) is figured about half an inch too far in advance of the surangular (29′) and angular (30), in order to show the articular grooves.)

Fig. 3. Back view of the cranium of the same skull.

Fig. 4. Front view of the atlas-vertebra of a large *Dinornis*.

Fig. 5. Back view of the same vertebra.

Fig. 6. Side view of the same vertebra.

PLATE LXIII.

Fig. 1. Base view of the skull of *Dinornis robustus*, from the bone-fissure of "Timaru." (The premaxillary is figured about half an inch too far in advance.)

Fig. 2. Inner or mesial surface of the left tympanic bone of the same skull.

Fig. 3. The same tympanic bone, viewed from below. e', mastoid condyle; *p*, posterior pneumatic foramen; *q*, antero-internal pneumatic foramen; *k*, orbital process; *pt*, articular surface for pterygoid; *h i*, postero-external condyle, i', antero-internal condyle, for the articular part of the mandible.

Fig. 4. Upper view of mandible of the same skull.

PLATE LXIV.

Fig. 1. Side view of the skull of *Dinornis robustus*, from the skeleton in the arenaceous deposit at "Manuherikia."

Fig. 2. Outside view of scapulo-coracoid bone of the same skeleton.

Fig. 3. Inside view of the same scapulo-coracoid bone.

Fig. 4. Posterior margin of the same bone, showing the ridge (*r*) in place of a glenoid cavity.

PLATE LXV.

Fig. 1. Base view of the skull from the same skeleton of *Dinornis robustus*.
Fig. 2. Back view of the cranium of the same skull.
Fig. 3. Front view of the cranium of the same skull.

(All the figures are of the natural size.)

The figures of the parts of the skeleton of *Dinornis robustus* from "Manuherikia," now in the Museum of the Philosophical Society at York, have been taken by permission of the President and Council of the Society.

MEMOIR

ON THE

GENUS NOTORNIS.

IN a collection of bones of *Dinornis*, obtained by Mr. Mantell from a bed of volcanic ~~ashes~~ at Waingongoro, North Island, New Zealand, in 1847, I detected portions of the skull of a bird about the size of a turkey, with a broad and sloping occiput something like that in *Dinornis*, but with differences which led me to an extensive series of comparisons, resting ultimately in the family of the Coots and Waterhens (*Rallidæ*), as that in which the greatest amount of cranial concordances was discoverable with the fossils in question. It was true that no living species of the Coot family was then known in New Zealand of larger size than the short-winged 'Weeka,' or the Troglodyte Rail (*Ocydromus australis*); but, as the concordances accumulated in the course of comparisons, I gained a conviction that the parts of the skeleton before me, scanty and incomplete as they were, were evidence sufficient that there had existed in New Zealand a bird which might be deemed the giant of the Coots, with so close an affinity to *Porphyrio* as at most to suggest only a subgeneric distinction, which was thereupon indicated by the name *Notornis*[1].

Maori umu
I sent a complete skele

In the cranium of this bird (Pl. XLVII. figs. 7–13) the basisphenoid (fig. 9, 5) is flat and pentangular, as in *Porphyrio* (ib. fig. 3), with the anterior angle projecting below the base of the presphenoid (9): there are no pterapophyses. A slender ridge (fig. 9, 5′) is continued from each paroccipital to the lateral angles of the platform; the

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[1] 'Proceedings of the Zoological Society of London,' January 11th, 1848, part xvi. pp. 1, 7.

posterior angles are hemispheric tubercles (1'') as in *Palapteryx*. The precondyloid holes (*p*, fig. 10) are nearer the carotid holes (*c*, fig. 9) than in *Palapteryx*, opening into the upper part of the same fossa. The occipital region inclines forward as it rises, and is defined above and laterally by a strongly marked ridge (2, 3, fig. 10), which forms a slight angle above the base of the mastoid: the occipital surface is not divided by a median vertical ridge. In *Porphyrio* (figs. 1 & 4) the plane of the occipital foramen inclines from below upward and backward; that of the occipital surface is vertical; it is proportionally narrower than in *Notornis*.

The mastoid (8) gives off a short compressed angular tympanic plate (8, fig. 8). The fractured base (8', fig. 9) of a process answering to that of the true mastoid process in other birds, and marked 8' in the skull of the *Aptornis* (Pl. XLIII. fig. 1), comes off from the lower part of the temporal fossa more in advance of the process 8, and rather as it would seem, from the alisphenoid than the true mastoid. The same peculiarity is repeated in the cranium of the *Porphyrio* (Pl. XLVII. fig. 1, 8'). The articular surface for the tympanic is divided, as in *Aptornis*, into two subcircular cavities (*y*, *y'*, fig. 9) by a pneumatic foramen. The parietal region (7, fig. 8) is singularly flat: the temporal fossæ (between 8 and 12) unusually long; well-defined by the ridge extending from the paroccipital to the postfrontal: this process (fig. 7, 12) is short, obtuse, directed downwards and backwards; broader in *Notornis* than in *Porphyrio*. The temporal fossa is equably divided by an intermuscular ridge (8, fig. 7) probably continued upon a mastoid process as in *Porphyrio* (fig. 1, 8'). The whole inferior border of the temporal fossa is produced as a vertical ridge below the level of the adjoining basis cranii in both *Notornis* and *Porphyrio*, which gives a peculiar character to this part of the cranium. This ridge (fig. 9, 8') bounds the outer side of a large and well-defined muscular impression with intermuscular ridges extending from the anterior tympanic articulation (*y*) to the fore part of the base of the postfrontal (12). There is a similar muscular depression in the *Porphyrio*: in the Maccaw it is much shorter, by reason of the less antero-posterior extent of the temporal fossa. The fore part of the frontal, which extends beyond the cerebral cavity, and appears to have anchylosed with the base of the upper beak, has been broken away, exposing a fine pneumatic diploë (*dl*, fig. 8), and the olfactory outlet (*ol*, fig. 11), which appears to have been common to both nerves; but there is no trace of olfactory chamber at this part, as in *Palapteryx*.

The chief singularity of the cranium, so mutilated, but with the cerebral cavity entire, is its regular four-sided figure; the breadth of the fractured anterior part being almost that of the occipital region, and the extent of the sides being scarcely more than that of the front and back part. This character is very striking as we look upon the almost flat basis cranii (fig. 9), and is well-marked when the cranium is viewed from above (fig. 8), where a smaller flat square platform (7, 11) is defined by the occipital and temporal ridges in the middle of the large square; of which smaller square the anterior boundary is wanting, the platform here sloping gradually down to the base of the bill.

It is in this part of the skull that the *Porphyrio* (Pl. XLVII. fig. 2) most departs from the character of the *Notornis* (*ib.* fig. 8), the parieto-frontal region of the skull (fig. 2 7, 11) being convex and oblong. There are no such cerebral convexities in *Notornis.* The relative extent of the temporal fossa is greater than in any known existing bird, but it is shallow; the *Porphyrio* makes the nearest approach to this character. The optic foramina are blended together, and the orbits, as far as shown in the fossil, are small and ill-defined. The petrosal is proportionally large in the interior of the skull; its central depression (16, fig. 11) is narrow and deep, with an entry of an hour-glass form. The sinus or groove which extends round its fore-part is narrow and deep: the foramen ovale is large; the under surface of the frontals, at their coronal confluence is traversed by a median longitudinal groove, with a parallel broader depression on each side of it. The presphenoid has been of considerable depth; but its fore-part, together with the prefrontals, is broken away.

The base of the upper beak, which was attached to the frontals, is a straight border (15, 22, 22′, figs. 8 & 9) ten lines in extent and half a line thick: the middle two-fourths is formed by the nasal process of the premaxillary (22′), a short linear fissure dividing this on each side from the nasals (15), the outer angles of which bend up. The bony base of the beak of *Porphyrio* presents a similar conformation (fig. 2, 15, 22′). The bony upper mandible of *Nortornis* is a long, inequilateral triangle, subcompressed, very slightly curved down; with a quadrate oblique base (fig. 12), a smooth convex upper border, very gradually narrowing to the pointed apex; the sides almost vertical; the under (palatal) surface (22″, fig. 9) deeply grooved along the middle of its anterior half as far as this extends in the fossil; the groove deepening and widening to the single medial palatal opening (*pl*) of the nostrils. The alveolar borders are entire and sharp, with their inner sides slightly and obliquely grooved. In *Porphyrio* the palatal surface of the premaxillary presents a narrow ridge along the middle of its anterior half; and the excavated surface on each side of this is continued to the sharp alveolar border. The external nostrils in both *Notornis* and *Porphyrio* are of a narrow ovate form, with the great end forwards and the long axis parallel with the upper slope of the beak; they are perforated on each side near the base, quite in the posterior half, of the upper beak. They open into a common excavation at the base of this part, the lateral walls of which in *Notornis* are thin above and thick and cellular below, with two openings at the back of this cellular part leading into it (fig. 12). A thin transverse plate of bone (22′, fig. 12) rises from the lower and fore-part of the external nostrils, spans across the palatal nostril, and ascending perpendicularly with a slight curve backwards, closes the fore-part of the nasal chamber; there is no trace of bony septum dividing this chamber: the under surface of the nasal plate of the premaxillary is almost flat and smooth. The repetition of all the essential characters of this bony upper beak in the *Porphyrio* (figs. 1, 2, 3) is so close, though diminished to the scale of one-half, as to preclude the necessity of reference to any other form of bird in the elucidation of the affinities of *Notornis*. Yet the form, so magnified, is so novel and unexpected, that the singularity of the occurrence of a Coot, so large as is indicated by the fossils here described, makes it incumbent on me to offer a few remarks on the differences observable in those birds that, resembling the *Notornis* in size, come nearest to it in the structure of the beak.

The depth, the degree of compression and the upper convexity of the strong bony basis of the upper bill of *Notornis*, with its almost basal perforation by the nostrils, remind us of some of the characters of the great Maccaw's beak; but, besides the absence of the terminal hook, the superior size of the nostrils, the absence of the bony septum narium in *Notornis*, and the grooved and perforated palatal surface of the premaxillary, are essential deviations from the parrot-type of beak. It approaches more in shape to the upper beak of the Raven, but it is less curved, deeper and more compressed, and the sides are more vertical; the nostrils are also smaller, and the palatine surface of the Raven's premaxillary is entire, gently hollowed out, with a median ridge instead of a groove.

The *Porphyrio* in every particular save size much more closely repeats the characters of the skull of *Notornis*; and the affinity is equally decisively marked in the form and structure of the lower jaw. Of this part of the *Notornis*, the entire ramus of the right side and the whole of the symphysis have been fortunately preserved. The posterior articular expansion presents above an irregular transverse subrhomboidal cavity, with a narrow and long articular surface (*x*, fig. 13, Pl. XLVII.) extending along the outer and hinder border; and the shorter and broader articular surface (*z*) at the fore-part of the deep central depression. The inner angle rises almost vertically: it has a small pneumatic foramen (*pn*): the back part of the enlargement presents an almost flat, irregular, triangular, slightly concave vertical surface; the lower angle (30) curves downwards and forwards below the lower border of the ramus. The surangular (29′, fig. 7) supports a low coronoid process, whose base reaches from the articular enlargement to near the beginning of the sharp alveolar border: its truncated summit has two small depressions on its outer side; they are deeper parts of a more extensive external muscular impression, bounded below by a line reaching nearly to the lower border of the ramus. This border (fig. 12) is smooth, convex, and of uniform thickness; it describes a gentle sigmoid curve, convex on leaving the deflected angle, concave where it joins the symphysis (*s*, fig. 7). The coronoid region has three perforations; the posterior one (*w*) is a small vertical oval, the anterior (*u*) is a longer longitudinal ellipse, and immediately behind this is a linear fissure, which marks part of the lower boundary of the surangular (29′). All the elements and both rami of the jaw have coalesced.

The upper border of the ramus (fig. 13) is convex, and a little thickened between the coronoid and the beginning of the sharp alveolar ridge: this is continued to the point of the symphysis, *s s*, which is more than one-third the length of the jaw; and the alveolar ridges, in gradually converging to the almost pointed termination of the mandible, describe the gentlest curves convex upwards and concave outwards. The lower border of the symphysis (fig. 12 *s s*) is smooth and convex from side to side, and extends in a straight line from the back part of the symphysis obliquely upwards to the apical extremity of the mandible: the upper surface of the symphysis (fig. 13, *s s*) is deeply and almost angularly excavated. The inner surface of the free portions of the rami is smooth and gently concave, with a semicircular ridge extending from the anterior to the posterior subcoronoid perforation If the foregoing characters, of which the details will be excused from the rarity of their subject, be compared with those of the lower jaw of *Porphyrio* represented in figs. 1, 5, 6, Pl. XLVII., the correspondence will be found almost perfect: the lower jaw of *Porphyrio*, however, is not a pneumatic bone and has no perforation for the admission of air.

It is in the comparison of the lower jaw of the *Notornis* that the difference from the Maccaw and the Raven, to which a passing reference was made in the description of the upper jaw, is most strikingly seen. The mandible of the Raven is as much too shallow as that of the Maccaw is too deep; and in neither are the characters of the angle of the jaw or the perforations repeated. And I may briefly state, that after passing in review all the skulls and mandibles of the birds in the Hunterian and some other Metropolitan collections, it is only in the *Rallidæ* or the family of the Coots that I have met with those essential marks of correspondence which have led to the determination of the affinities of the bird to which the present remarkable fossil cranium in Mr. Mantell's collection has belonged.

Besides a species of true *Porphyrio* (*P. melanotus*, Gould) in New Zealand, there exists in that island a peculiar and highly interesting form of the *Rallidæ* in which the wings, although not so rudimentary as in the Apteryx, are nevertheless so restricted in their development as to be useless for the purposes of flight. This bird is the type of the genus *Brachypteryx**,—a genus as characteristic of New Zealand, as is the *Apteryx* itself. In the lower jaw of the Weeka Rail we have the same form of the angular and articular enlargement, with the vertical triangular posterior facet, the short deflected and precurved angle, the posterior smaller and fuller oval perforation (*w*), and the anterior fissure of the coronoid part of the jaw, but not the opening (*u*): the symphysis is shorter, but the rounded under-part ascends obliquely straight to the pointed termination of the mandible. There is the same kind of agreement in the upper jaw: the solid or rostral part of which, anterior to the nostril, has the same essential form, viz., a very slight and equable downward curve, gradually contracting to the point, which is rounded off, while the sides are almost vertical. The palatine surface is deeply exca-

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* This generic term was applied by me to the bird represented by the skeleton (No. 1280) in the Museum of the Royal College of Surgeons, the term 'Brachyptères' having been applied by Cuvier to a family of his Palmipèdes ('Règne Animal,' 1829), vol. i. p. 344. I adopt the term *Ocydromus*, as restricted by G. R. Gray, to the New-Zealand forms of the *Ocydromus* of Wagler.

vated, but the lateral grooves are not defined as in *Notornis*. The differences between the beak of this genus or of *Porphyrio* and that of *Ocydromus* are those of proportion. The whole beak is longer and more slender relatively to the cranium in *Ocydromus*; and this length is gained by the elongation of the nasal part of the beak, or that which is perforated by the external nostrils, and of the part between the coronoid portion and the symphysis in the lower mandible.

One may also follow minor traces of resemblance in the cranial part of the skull of *Ocydromus*, e. g. in the flat square formed by all that part of the basis cranii included between the postfrontals and paroccipitals; in the proportions of the postfrontal and mastoid; in the orbits scarcely at all impressing the under and fore-part of the cranium; and in the relative extent of the temporal fossæ, although the lower boundary of these is not developed into a vertical ridge as in *Porphyrio*. But, on the other hand, *Ocydromus* more resembles *Notornis* in the relative breadth of the occipital region than *Porphyrio* does. The chief characters of the skull by which *Ocydromus* and *Tribonyx* resemble *Notornis*, are participated in by the European, Australian, and African *Rallidæ*; but in the forms and proportions of the upper and lower bones of the beak, the *Porphyrio* of all existing birds makes the nearest apprach to *Notornis*.

Upper mandible of Nestor. Kl

A second, possibly extinct, species of bird indicated by portions of the skull in Mr. Walter Mantell's collection is plainly referable to the family of Parrots (*Psittacidæ*), and particularly to the genus *Nestor*. The bony portion of the upper beak (Pl. XLIV. figs. 11, 12, 13),—the only part of the skull preserved,—by its deep, subcompressed, curved and pointed form, its seeming solidity, pierced by small subcircular nostrils (*n*) close to its base, and impressed by the transverse articular fossæ behind the palatine plate of the premaxillaries for the true palatine bones, attests the family character; whilst the proportional length as compared with the depth, the narrow upper surface to where it suddenly expands above the nostrils to join the cranium, the oblique depression on the outer surface of the beak leading to the external nostril, the very narrow elongated triangular palatal surface, with the median linear notch at its base,—all demonstrate that in this characteristic part of the skull, the New-Zealand bird represented by it most resembled the genus *Nestor*, a singular nocturnal Parrot, at present only known as a denizen of that island; where it is represented by species not inferior in size to the one indicated by the bony portion of the upper beak. By the kindness of Mr. Gould I am enabled to give figures of the upper mandible (figs. 14, 15, 16) of the *Nestor hypopolius* to compare with the fossil.

Notornis Mantelli

Nestor

MEMOIR

ON THE CRANIAL CHARACTERS OF

APTORNIS,

WITH

DESCRIPTIONS OF THE SKULL AND BEAK.

SELDOM has a new idea more rapidly reached its full development than that of the former existence of gigantic terrestrial birds in New Zealand, suggested by the fragment of bone from that island described and figured in the 'Transactions of the Zoological Society' for 1839, vol. iii. p. 29. pl. 3. Three years had scarcely elapsed when other remains, transmitted from New Zealand, led to the determination of one genus of these birds and to the indication of five species, one of the astonishing stature of ten feet, by the characters of bones of the trunk and extremities*. In 1846† a second genus of large terrestrial bird, together with four additional species, and two at least well-marked varieties, were established, principally by specimens of bones of the extremities: different vertebræ, ribs, and a sternum, were at the same time contributed towards the restoration of the entire skeleton of the extinct gigantic bird, and the cranial portions of the skull of two distinct species were described, and compared with that of the Dodo, so far as its characters could then be deduced from the dried head at Oxford‡.

No trace, however, of the beak of either of the genera indicated by the bones of the extremities had then reached England: but in the 'Athenæum' of September 25th, 1847, Dr. Mantell, F.R.S., announced that his son, Mr. Walter Mantell, of Wellington, New Zealand, "in an exploring tour in search of the remains of the colossal Ostrich-like

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* Op. cit. vol. iii. p. 235. pls. 18–30 (1843).

† Tom. cit. p. 307. pls. 38–50.

‡ The casts of the cranium of the Dodo, which the authorities of the Museum of Natural History of Copenhagen have liberally transmitted, and the exposition of the bones of the dried head at Oxford which the Curator of the Ashmolean Museum has caused to be made, permitted the requisite comparisons to be carried further in the Memoir read before the Zoological Society of London, January 11, 1848.

birds which once inhabited New Zealand, and whose bones occur in the alluvial sand and silt of the rivers,"—"had discovered imbedded with the bones, fragments of their eggs;"—that the bones collected and on their way to England amounted to 700 or 800 in number; and included "portions of several skulls and mandibles."

On the arrival of the collection, I was requested by Dr. Mantell to inspect and describe it.

The bones were in a different state from that of any which I had before seen: instead of the deep brown tint, tenacity and heaviness of those from Wairoa, Waipu, and the beds of the streams that run east of the volcanic chain of Tongariro, which had been transmitted by the Ven. Archdeacon Williams, the Rev. W. Colenso and the Rev. Mr. Cotton, in 1843, they were yellowish-grey or fawn-coloured, light and fragile, with their articular surfaces entire and smooth and all their ridges and processes singularly sharp and perfect; most of the fractures being recent and some evidently the result of accident in the transport: all were, however, more or less absorbent from the loss of their animal matter. They have a different aspect also from those remains obtained by Dr. Mackellar and Mr. Percy Earl from the submerged deposits of the shore at Wakewaite in the Middle Island; these are of whitish-grey colour, and though light and friable retain more elasticity, and more of the animal matter; they do not stick to the tongue.

Some portions of a human skeleton, including a clavicle, part of a radius, and a few phalangeal bones, together with half the lower jaw of a Dog, transmitted with the birds' remains, had been reduced by heat to their constituent white earthy matter. Not ~~any of the~~ bones of the *Dinornis* were in this state, though some had been blanched or partially blanched by exposure. All the remains of the extinct birds were dug out of a bed of volcanic ashes at the mouth of the river 'Wanganui,' North Island, New Zealand. They were moist and friable when first exhumed, but soon hardened on exposure to the air.

[illegible]

In proceeding to determine and classify the specimens, I had the same gratification, as at the first inspection of the series of bones brought home in 1846 by Mr. Percy Earl*, in recognizing the specific characters, which had been deduced in the first instance from a few specimens or fragments of bone, perfectly repeated in numerous examples of entire femora, tibiæ and metatarsi. Thus after setting apart, of—

	Femora.		*Tibiæ.*		*Fibulæ.*		*Metatarsi.*	
	Right.	Left.	Right.	Left.	Right.	Left.	Right.	Left.
Dinornis casuarinus . . . . ,	1	1′	1	1	1	1	1	1
——— *didiformis*	9	5	3	2	3	3	1	2
——— *curtus*	0	0	5	3	8	8	2	3
Palapteryx dromioïdes	4	7						
——— *geranoïdes*	10	5	8	8	9	4	7	6
there remained of the *Palapteryx ingens* var. *robustus*	1	1	1	0	2	1		

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* See p. 132.

1940 "[illegible] [illegible] of III"

pandora, *Placostylus (Maoristylus) ambagiosus* [Gastropoda] Powell 1951b 4(2):137.
Paraguraleus [Gastropoda] Powell 1944 3(1):49.
parallelus, *Mimopeus* [Insecta] Watt 1988 25:138.
Paraneonetus [Insecta] Salmon 1948b 3(4,5):305.
paraspiritus, *Placostylus (Maoristylus) ambagiosus* [Gastropoda] Powell 1951b 4(2):137.
parcipictus, *Micrelenchus* [Gastropoda] Powell 1946b 3(2):138.
parkinsoni, *Terebra* [Gastropoda] Cernohorsky & Bratcher 1976 13:137.
parri, *Micantapex* [Gastropoda] Powell 1944 3(1):15.
partinoda, *Mauidrillia* [Gastropoda] Powell 1944 3(1):35.
partula, *Liarea turriculata* [Gastropoda] Powell 1954b 4(5):291.
parvissima, *Morula* [Gastropoda] Cernohorsky 1987a 24:99.
parvula, *Gelechia* [Insecta] Philpott 1930 1(1):7.
parvus, *Mimopeus* [Insecta] Watt 1988 25:128.
patrickensis, *Paryphanta rossiana* [Gastropoda] Powell 1949a 3(6):358.
pauperata, *Sinezona* [Gastropoda] Powell 1933 1(4):193.
paupereques, *Pterochelus* [Gastropoda] Powell 1974 11:199.
penicillus, *Polyplectropus* [Insecta] Wise 1958 5(1,2):57.
perampla, *Rhytida meesoni* [Gastropoda] Powell 1946a 3(2):127.
perarmatus, *Micantapex* [Gastropoda] Powell 1944 3(1):14.
peregrina, *Tolema* [Gastropoda] Powell 1947b 3(3):171.
perforata, *Eatoniella (Caveatoniella)* [Gastropoda] Ponder 1965a 6(2):64.
pergrata, *Selidosema* [Insecta] Philpott 1930 1(1):2.
Perisporochnus [Phaeophyceae] Chapman 1954 4(4):201.
Plectomirtha [Dicotyledonae] Oliver 1948 3(4,5):224.
pleurotomella, *Cryptoborsonia* [Gastropoda] Powell 1944 3(1):43.
pliocenica, *Zelandiella* [Gastropoda] Powell 1931 1(2):102.
ponderi, *Microvoluta* [Gastropoda] Cernohorsky 1975c 12:227.
Pontiolaelaps [Arachnida] Luxton 1984 21:83.
porrecta, *Estea* [Gastropoda] Powell 1933 1(4):201.
Powellisetia [Gastropoda] Ponder 1965b 6(2):104.
praecidecosta, *Estea* [Gastropoda] Ponder 1965c 6(2):144.
prendrevillei, *Scissurella* [Gastropoda] Powell 1933 1(4):193.
prisca, *Risellopsis* [Gastropoda] Powell 1935 1(6):334.
priscus, *Placostylus ambagiosus* [Gastropoda] Powell 1938a 2(3):149.
pritchardi, *Apiotoma* [Gastropoda] Powell 1944 3(1):20.
Proisotomina [Collembola] Salmon 1948a 3(4,5):295.
prolixus, *Hyphalus* [Insecta] Britton 1977 14:85.
protensa, *Ascitellina* [Bivalvia] Powell 1935 1(6):333.
prousei, *Thalassohelix* [Gastropoda] Powell 1952 4(3):164.
prouseorum, *Paryphanta superba* [Gastropoda] Powell 1946a 3(2):109.
Pseudexomilus [Gastropoda] Powell 1944 3(1):61.
pseudoclarae, *Comitas* [Gastropoda] Powell 1944 3(1):18.
pulchra, *Fenestrodaphne* [Gastropoda] Powell 1944 3(1):61.

See p. 173

this copy of book must have belonged
to W. B. D. Mantell!

See opps. p 178
drawing by Mantell?

1848 "On Dinornis, pt. III"
Trans. Zool. Soc. Lond. 3: 345—

and of *Dinornis giganteus* the right and left fibulæ, the proximal end of a left tibia, and both proximal and distal ends of a right tibia of apparently the same bird. In one of the specimens, which is nearly full-sized, the distal epiphysis of the tibia is ununited.

Of the numerous series of vertebræ (250 in number) seven were referable to *Dinornis giganteus*, four to *Palapteryx ingens*, eighteen to *Dinornis casuarinus*, together with twelve others, forming a continuous series of the neck-bones, corresponding with the vertebræ referred to *Palapteryx ingens* in my former Memoir[1].

There are still more complete series of cervical and dorsal vertebræ referable by their size to *Dinornis didiformis*, *Din. curtus*, *Palapteryx geranoïdes*, and to the species indicated in the Memoir of 1843 as *Dinornis otidiformis*.

There are, also, sixteen more or less perfect pelves, referable to at least five species, together with numerous ribs and fragments of ribs.

Amongst the rarer and more instructive parts of this collection are some portions of a sternum of a small species of *Dinornis* or *Palapteryx*, and two nearly entire sternums of the new genus *Notornis*, which belongs to the same family (*Rallidæ*) as the rare *Brachypteryx* or short-winged Rail of New Zealand.

There are not fewer than 190 phalanges of the toes referable to five or six species of *Dinornis*, *Palapteryx* and *Notornis*; and there are eight tarso-metatarsal bones, with the articular surface for a very strong hind-toe, and of a conformation more nearly resembling those of the *Dodo* than those of the *Dinornis* or *Palapteryx*, but shorter and thicker in proportion than in the *Dodo*, and appertaining to the same bird as the tibiæ and femora described in my Memoir of 1843 under the name of '*Dinornis otidiformis*.' The proximal articulation of this remarkable form of tarso-metatarsal exactly fits the distal end of the tibia figured in pl. 26. fig. 5. vol. iii.; and also that of a corresponding fractured tibia in Mr. Mantell's collection, which also contains the proximal end of another tibia, a fibula, an entire femur and distal ends of two other femora of the same species.

The large surface for the hind-toe; the strong calcaneal process, perforated by a complete bony canal for the tendon at the back part of the proximal end of the tarso-metatarsal; the perforation above the interspace between the condyles for the middle and outer toes; and the more posterior position of the condyle for the inner toe,—all concur to indicate the generic distinction of the bird to which it belonged from either *Dinornis* or *Palapteryx*; and I propose to indicate the new genus by the name of *Aptornis*[2]. The present species, *Aptornis otidiformis*, resembles the *Apteryx* in the shortness of the metatarsal as compared with the length of the tibia. Amongst all this collection there is but one bone of a wing—a humerus—which bears the same proportion to the femur referred to *Notornis Mantelli*, which the humerus of the little existing *Brachypteryx* does to its femur.

Aptornis n. gen.

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[1] (Part II.) p. 314. pl. 40. figs. 1 & 3.

[2] By syncope for 'Apterygiornis,' from α priv., πτέρυξ wing, ὄρνις bird.

and of *Dinornis giganteus* the right and left fibulæ, the proximal end of a left tibia, and both proximal and distal ends of a right tibia of apparently the same bird. In one of the specimens, which is nearly full-sized, the distal epiphysis of the tibia is ununited.

Upwards of one hundred phalanges of the toes were referable to five or six species of *Dinornis*, *Palapteryx* and *Notornis*.

Of the numerous species of vertebræ (250 in number) seven were referable to *Dinornis giganteus*, four to *Palapteryx ingens*, eighteen to *Dinornis casuarinus*, together with twelve others, forming a continuous series of the neck-bones, corresponding with the vertebræ referred to *Palapteryx ingens* at p. 121, Pl. XXXII. figs. 1, 2 & 3.

There were still more complete series of cervical and dorsal vertebræ referable by their size to *Dinornis didiformis*, *Din. curtus*, *Parapteryx geranoïdes*, and to the species indicated in the Memoir of 1843 as *Dinornis otidiformis*. There were, also, sixteen more or less perfect pelves, referable to at least five species, together with numerous ribs and fragments of ribs.

Amongst the rarer specimens in this collection were some portions of a sternum of a small species of *Dinornis* or *Palapteryx*, and two nearly entire sternums of the Ralline type, and by size referable to the new genus *Notornis*, which, as we have seen, belongs to the same family (*Rallidæ*) as the *Ocydromus* or short-winged Rail of New Zealand.

Eight tarso-metatarsal bones (Pl. L. figs. 5–8), with the articular surface for a very strong hind toe, and of a conformation more nearly resembling those of the *Dodo* than those of the *Dinornis* or *Palapteryx*, but shorter and thicker in proportion than in the *Dodo*, appertained to the same species as the tibiæ and femora described at pp. 85, 137, under the name of '*Dinornis otidiformis*.' The proximal articulation of this remarkable form of tarso-metatarsal exactly fits the distal end of the tibia figured in Pls. XXV. & XXVI. figs. 5 & 6; and also that of a corresponding fractured tibia in Mr. Mantell's collection, which also contains the proximal end of another tibia, a fibula, an entire femur and distal ends of two other femora of the same species.

The large surface for the hind toe; the strong calcaneal process, perforated by a complete bony canal for the tendon at the back part of the proximal end of the tarso-metatarsal; the perforation above the interspace between the condyles for the middle and outer toes; and the more posterior position of the condyle for the inner toe,—all concur to indicate the generic distinction of the bird to which it belonged from either *Dinornis* or *Palapteryx*; and I propose to indicate the new genus by the name of *Aptornis**. The present species, *Aptornis otidiformis*, resembles the *Apteryx* in the shortness of the metatarsal as compared with the length of the tibia. Amongst all this collection there is but one bone of a wing—a humerus—which bears the same proportion to the femur referred to *Notornis Mantelli*, which the humerus of the little existing *Ocydromus* does to its femur.

With the bones of the birds were associated fragments of large birds' eggs; some

* By syncope for 'Apterygiornis,' from α priv., πτέρυξ wing, ὄρνις bird.

ossified rings of a bird's trachea, about half an inch in diameter (Pl. XCII. fig. 7); several bones, including jaws and teeth, of a large Seal of the genus *Arctocephalus*; and a few bones of a small Dog, besides the calcined bones already alluded to, which include some that have indubitably appertained to a human skeleton. But there is no evidence that the human or canine remains were imbedded, like the bones of the birds and seals, in the deposit of the volcanic sand.

From this extremely rich and interesting addition to the materials for working out the zoological history, past and present, of the distant isles of New Zealand, I select for the subject of the present Memoir the bones of the head and beak of a bird which I am induced, provisionally, to refer to the same genus and species as the limb-bone of *Aptornis otidiformis*.

The largest and most complete specimen (Pl. XLIII. figs. 1, 2, 3) has a broad, depressed, subelongate beak, regularly but moderately curved downwards, resembling a cooper's 'adze' (*doloire*, Fr.), with evidence in the skull of unusual muscular forces for working such beak. A second skull (Pl. XLVII.), of nearly equal size, with a beak more resembling that of the Emeu, and with characters of the skull which deviate less than those in *Dinornis* from the cranial organization of the *Apteryx*, I refer to the genus *Palapteryx*, indicated in the preceding Memoir by certain characters in the bones of the legs approaching those of *Apteryx*. There is a portion of the lower jaw (Pl. XLIV. figs. 1, 2) which from its size may have belonged to the *Palapteryx ingens*, if not to the *Dinornis giganteus*.

The cranial portion of the skull of *Aptornis otidiformis* is intermediate in size between that figured in Pl. XVI. figs. 1–4, and that in Pl. XXXI. figs. 4, 5 & 6, of a preceding Memoir, p. 116; and if the reference of the larger of those crania to *Dinornis struthoïdes*, and of the smaller one to *Dinornis dromioïdes* be correct, the present skull indicates that the genus and species of bird to which it is here referred differed from both *Dinornis* and *Palapteryx* in the greater relative size of the head to the body and legs of the extinct bird.

The cranium of *Aptornis* in its general broad and depressed form, in the pedunculate condyle, in the vertical plane of the foramen magnum (fig. 4, *o*), in the direction from below upwards and forwards of the broad and low occipital surface (fig. 1, 3), in the slight convexity of the parietal region (fig. 2, 7), and in the wide and deep temporal fossæ (fig. 1, *t*, 8″, 12), approaches the characters exhibited by the previously described specimens of the cranium of *Dinornis* (pp. 116–120, Pls. XVI. & XXXI.). But some of these cranial peculiarities of the great extinct wingless birds are exaggerated in the present genus, especially the downward development and abrupt descent of the basioccipital and basisphenoid (fig. 4, 5) and the forward inclination of the occipital surface, which makes the occipital condyle (figs. 4 & 6, 1) the centre of the hinder surface of the skull, and places the occipital foramen (*o*) in the upper half—characters hitherto unknown in the air-breathing Vertebrata, amongst which the *Crocodilia*, perhaps, present the nearest approximation to the peculiar structure exhibited in fig. 4. The extent of the paroccipital, to which the great breadth of the occipital region is due, is characteristic of the *Aptornis*.

The nasal process of the premaxillary, partly overlapped by the nasals, quickly expands, and in its turn begins to overlap the anterior ends of those bones. The upper surface of the premaxillary, at first flat or slightly concave, soon becomes convex, and gradually broader to the fore part of the external nostrils, where it bends down on each side to form their anterior boundary, and joins what may be termed the body of the premaxillary (22, fig. 1). From this part forwards the convexity begins to subside; and the bone very gradually contracts as it extends forwards to terminate in a broad truncated or slightly rounded border.

The palatal plate of the premaxillary extends one inch nine lines entire from the fractured end to the anterior border of the palatal nostril. A well-defined rough alveolar border (*s s*, fig. 3) extends backwards on each side from the premaxillary upon the coalesced maxillaries (*s*′, 21), and terminates by a slightly expanded portion below the anterior boundary of the external nostril (indicated by the dotted line at *n*, fig. 1).

Skull of Palapteryx geranoïdes (?).

The second almost entire cranium (Pl. XLV.) agrees in all the characteristics by which that of *Dinornis* differs from the cranium assumed to belong to *Aptornis* (Pl. XLIII.), viz. in the minor descent of the basioccipital (1, 1″, fig. 4), the square platform of the basisphenoid (5, fig. 3), the higher position of the precondyloid holes (*p*, fig. 4) and their separation from the carotid holes (*c*), the minor development of the paroccipitals (4), the major development of the mastoids (8) and olfactory chambers (18, fig. 3), and especially in the large and single oblong depression (*y*, fig. 3) beneath the mastoid for the single superior condyle of the tympanic. But it shows the palapterygian slenderness of beak.

DESCRIPTION OF THE PLATES.

PLATE XLIII. Aptornis.

Fig. 1. Side view of the cranium and upper mandible of *Aptornis otidiformis*.
2. Upper view of ditto.
3. Under view of ditto.
4. Back view of ditto.
5. Front view of the cranium, showing the surface from which the beak had been broken off.
6. An oblique view of the hinder part of the cranium, showing the two ridges of the downwardly developed basioccipital (1″) and basisphenoid (5′), and the anchylosed stylohyal (38).

Fig. 7. Inner surface of part of the cranium with the pedunculate condyle (1).
8. Under view of the cranium of the Bustard (*Otis tarda*).
9. Oblique view of the hinder part of the same cranium.

PLATE XLIV.

Fig. 1. Back part of ramus of lower jaw of a large *Dinornis* or *Palapteryx*.

2. Upper view of ditto.

3. Back view of expanded end of ditto.

4. Upper view of lower jaw of an Ostrich (*Struthio Camelus*).

5. Side view of ditto.

6. Back view of expanded end of ditto.

7. Under surface of calvarium, showing the cerebral and olfactory cavities of *Palapteryx geranoïdes*.

8, 9 & 10. Views of the os tympanicum of the *Dinornis casuarinus* (p. 126).

Fig. 11. Side view of the upper mandible of a species of *Nestor*.

12. Upper view of ditto.

n, the nostril.

22, the groove behind the upper end of the premaxillary part of the mandible.

13. Under view of ditto.

14, 15 & 16. Corresponding views of the upper mandible of a living species of *Nestor* (*N. hypopolius*).

PLATE XLV. PALAPTERYX.

Fig. 1. Side view of the skull, with lost parts restored in outline, of the *Palapteryx geranoïdes*.

2. Upper view of ditto.

3. Under view of ditto.

4. Back view of ditto.

5. Back view of the extremity of the upper beak.

Fig. 6. Under view of the portion of lower jaw.

7. Upper view of ditto.

8. Outline of head of *Aptornis* as conjecturally restored in 1843 (see pl. 30).

9. Outline of cranium of *Dinornis* reduced to the same proportions.

PLATE XLVI. PALAPTERYX.

Fig. 1. Side view of the cranium of a *Palapteryx*.

2. Back view of ditto.

3. Under view of ditto.

4. Side view of the cranium of a different and larger species of *Palapteryx*.

Fig. 5. Under view of the cranium of a different and larger species of *Palapteryx*.

6. Upper view of a mutilated cranium of apparently the same species, indicating the form and proportions of the cerebrum and cerebellum.

PLATE XLVII. NOTORNIS MANTELLI.

Fig. 1. Side view of the skull of *Porphyrio Sultana*

2. Upper view of ditto.

3. Under view of ditto.

4. Back view of ditto.

5. Under view of lower jaw.

6. Upper view of lower jaw.

7. Side view of skull, with lost parts restored in outline, of *Notornis Mantelli*.

Fig. 8. Upper view of ditto.

9. Under view of ditto.

10. Back view of ditto.

11. Interior of cranium of ditto.

12. Under view of lower jaw.

13. Upper view of ditto.

The homologous bones and parts are indicated by the same numbers or letters in each figure, and are explained and referred to in the text.

MEMOIR

ON THE

GENUS APTORNIS,

WITH A

DESCRIPTION OF THE STERNUM OF

PALAPTERYX AND NOTORNIS,

AND A

RESTORATION OF THE FEET OF

DINORNIS AND PALAPTERYX.

Femur and Tarsometatarsus of Aptornis.

IN the Memoir on the genus *Dinornis*, pp. 73, 83, I described and figured (Pl. XXV. & XXVI. fig. 5) a tibia obtained by the Very Rev. Archdeacon Williams from a fluviatile deposit in the North Island of New Zealand, and referred it provisionally to a species of that genus under the name of *Dinornis otidiformis*[1]. In the subsequent Memoir on the genus *Notornis*, I determined the tarso-metatarsal bone which articulated with that tibia, and pointed out some characters of the tarso-metatarsal bone which indicated the generic distinction of the bird to which it belonged, from the *Dinornis*, and accordingly I proposed for it the name of *Aptornis* (p. 153). In the present Memoir I propose to give the details of the characteristics of the tarso-metatarsal bone of the *Aptornis otidiformis* (Pl. L. figs. 5–8), and to advance the knowledge of the characters of the bones of the leg of this genus and species by a description and figures of the femur (Pl. L. figs. 3 & 4).

The femur of the *Aptornis*, which measures six inches three lines in length, has a straight, strong, subcylindrical shaft, with which the short and thick neck supporting the head stands inwards at right angles. The head is impressed by a large pit for the

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[1] Zool. Trans. iii. Part iii. p. 235. pl. 25. figs. 5 & 6; pl. 26. figs. 5 & 6.

"ligamentum teres." The great trochanter rises above the level of the smooth upper surface continued to it from the head: there is a well-marked ridge which extends from the inner and back part of the shaft of the bone to the upper and back part of the inner condyle; in this character it resembles the femur of the *Apteryx*, as well as in its relative length to the tibia. The inner condyle reaches downwards nearly as far as the outer condyle. The fibular fossa, outside the outer condyle, is well-marked: above it is a deep and rough depression. The fore part of both condyles is more prominent than in the femora of *Dinornis*. There is no pneumatic foramen: the compact wall of the shaft of the femur is between one and two lines in thickness. As compared with the femur of the Bustard, that of the *Aptornis* is thicker in proportion to its length, and longer in proportion to the tibia; and the ridge extending in the Bustard's femur from the middle of the back part of the shaft towards the outer condyle, is not present in that of the *Aptornis*.

The tarso-metatarse of the *Aptornis otidiformis* (Pl. L. figs. 5–8) measures three inches ten lines in length; its proportions in comparison with the tibia and femur resembling those of the *Apteryx*. The ecto- and ento-condyloid cavities at the proximal end of the bone (fig. 6) are deeper than in *Palapteryx* or *Dinornis*, are more equal in size, and are more widely separated by the intercondyloid tract and eminence: these modifications accord with those of the distal end of the tibia figured in Pl. XXV. fig. 6. The intercondyloid eminence is obtuse and relatively higher than in *Dinornis* or *Palapteryx*. The calcaneal processes project further back and blend together in a smooth convex plate behind, converting the groove for the flexor tendons into a foramen which is remarkable for its width: its shape is shown in Pl. L. figs. 5 & 6. Figure 7 shows another character of the calcaneal prominence by which the *Aptornis* differs from the *Dinornis* and *Palapteryx*, viz. in the absence of the buttress-like support formed in those genera by the posteriorly projecting shaft of the mesometatarsal element. The back part of the shaft is even and almost flat, the surface being broken only by one or two narrow intermuscular or intertendinous ridges: just below the best-developed ridge near the inner side of the bone, is the large and well-marked surface for the attachment of the metatarsal bone of the hallux, I. The anterior surface of the tarso-metatarse is convex transversely, slightly concave lengthwise: the distal end of the bone is so equally expanded, that both the inner and outer sides show a nearly equal degree of concavity. A short groove on the outer third of the fore part of the bone leads to the canal which pierces the confluent parts of the outer and middle metatarsals, two lines above the space between the two condyles of those bones: this canal answers to that which in the *Notornis*, *Didus*, *Diomedæa* and many other birds, transmits the tendon of the adductor muscle of the fourth toe (IV). The relative size and position of the condyles of the three coalesced metatarsals are shown in figs. 5 & 8. The middle one advances further in front of the others than in the *Apteryx*, *Palapteryx* and *Dinornis*: each condyle is impressed by a well-marked median groove.

Restoration of the Feet of Dinornis *and* Palapteryx.

In the previous memoirs of the present Work, the remains of the wingless birds of New Zealand, consisting of the cranium and the bony beak[1], of the vertebræ and pelvis[2], of the sternum[3], and the principal bones of the leg[4], have been determined, described, and referred for the most part to different species of *Dinornis* and *Palapteryx*; the rest belonging to the genera *Aptornis* and *Notornis*, the species of which, though they would be called large in comparison with the majority of the actual class of birds, dwindle into insignificance by the side of their stupendous contemporaries.

There chiefly remained to complete our knowledge of the osteology of these apparently extinct forms of the feathered class, the complete restoration of the feet: and when the number of different bones which compose this part of the skeleton of the bird is called to mind, the slight though definite modifications of form that distinguish them, and the chances against the discovery of such comparatively small bones, it will not be matter of surprise that the foot should have been the last of the segments of the limbs to be so reconstructed.

With each successive collection of the remains of the great terrestrial birds of New Zealand, since the arrival, in 1843, of that first transmitted by the Very Rev. William Williams[5], more or fewer toe-bones have, nevertheless, been associated; and, as their numbers increased, their determination became facilitated. Already in the partial restoration of the *Dinornis giganteus* in pl. 30 of my memoir in the 3rd Volume of the Zoological Transactions, in 1843, I had ventured to sketch the probable proportions and disposition of the phalanges in each of the three anterior toes, guided by the analogy of the *Apteryx*, in building up that part on the basis of the few specimens of phalanges that then suggested the probability of such analogy being correct.

Each successive acquisition of additional phalanges has tended to support my original supposition of the general resemblance of the foot of the *Dinornis* to that of the *Apteryx*: and the rich acquisition of remains from Waikawaite in the Middle Island, transmitted, in 1849, by the late Col. Wakefield, has enabled me to recompose the entire skeleton of the foot of three species of *Dinornis* and *Palapteryx*, the largest appertaining to that great bird which I had indicated in my memoir in the 3rd Volume of the Zoological Transactions, in 1846, p. 327, as probably being 'a well-marked variety' of the *Dinornis giganteus*.

No specimens precisely corresponding with the characteristic femur, tibia and metatarse of the *Dinornis giganteus* have, as yet, been transmitted from the Middle Island: the homologous bones of similar size from Waikawaite present more robust proportions; and this difference is not only well-marked in the metatarse of the entire foot figured in Plate XLIX., but is accompanied by a well-marked articular rough depression for the

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[1] pp. 116, 118. [2] pp. 91, 97, 121. [3] pp. 124, 190. [4] pp. 78–90, 127–137.

[5] Trans. Zool. Soc. vol. iii. p. 237.

ligamentous attachment ofthe rudimental metatarsal of the back-toe (hallux), and also by that characteristic bone of the genus *Palapteryx* (fig. 1, I).

The general differences in the proportions of thickness to length will be appreciated by comparing the metatarse of *Palapteryx robustus*, fig. 1, in Pl. XLIX., with the metatarse of *Dinornis giganteus*, Pl. XXVII. fig. 1.

The subject of Pl. XLIX., which was obtained, like most of the bones transmitted by Col. Wakefield, from the recent vegetable deposits at the mouth of the Waikawaite, is in a much better state of preservation than the bones obtained from the more ancient beds of the actual rivers in the North Island, described by the Very Rev. Archdeacon Williams, in the letter quoted at p. 75. The relative age of the present North and Middle Islands of New Zealand, the question of their original union and of the period of their separation—in short, all the geological and geographical deductions from the evidence of their organized fossils—depend for their true solution upon a rigorous comparison and exact determination of those fossils.

The principal dimensions and general form of the tarso-metatarsal bone of the *Palapteryx robustus* are given in Pl. XLIX. fig. 1, where the anterior surface is represented of the natural size; other dimensions are recorded in the text. The compound nature of this bone in birds generally is described at p. 78, and I may here premise that I have applied to the principal elements the names of 'entometatarse' (II), 'mesometatarse' (III), and 'ectometatarse' (IV) respectively, for the convenience of description.

The shaft in *Palapteryx robustus* is subtriedral in its upper two-thirds, subcompressed from before backwards in its lower third, of equal breadth in its middle fourth, and thence expands to both extremities, but more to the inner than the outer side, and in a greater degree at the lower end; so that the inner margin is more concave than the outer one. This difference is not so great in the *Dinornis giganteus*, in which, also, the shaft continues gradually to diminish in breadth towards its lower third.

The proximal articular surface of the metatarse of the *Palapteryx robustus* is divided, as usual, into two concavities, that for the inner condyle of the tibia being the largest and deepest: it is of a triangular form bounded internally by a well-defined edge which extends in a nearly straight line from the anterior internal angle to the posterior angle of the concavity: the anterior external angle is formed by the prominent fore part of the intercondyloid protuberance. The more shallow concavity for the outer condyle is subcircular, its outer boundary being convex and most raised at its middle part; posteriorly the border subsides and the concavity passes into a convexity at that part. The non-articular surface of the proximal end is chiefly behind the concavities and extends upon the upper part of the calcaneal processes: these are, as usual, three in number, the internal and middle ones being most prominent: they are obtusely rounded, and separated by the deep and wide groove for the flexor tendons of the toes: the longitudinal extent of the inner process (the entocalcaneal one, fig. 2, *c e*) measures one inch and a half: its obtuse and thick upper end commences behind and half an inch below the posterior border of the entocondyloid cavity: the process gradually contracts to a point at its lower end, which overhangs the smooth groove continued obliquely downwards and outwards to the foramen formed by the persistent remnant of the interosseous space between the inner (II) and middle (III) metatarsal elements of the compound metatarse.

The mesocalcaneal process (fig. 2, *c m*) is the largest of the three: it is broad and rounded about, slightly grooved down its posterior surface, and supported by the rough posteriorly projecting buttress-like part of the mesometatarse, of which it seems to form the obtuse summit.

The ectocalcaneal process is the smallest: it is separated by a shallow open groove from the mesocalcaneal process: it begins to project half an inch below the posterior convexity of the ectocondyloid surface: its lower part subsides before it reaches the foramen between the ecto- and meso-metatarse. The interval between the two interosseous foramina, which gives the breadth of the mesometatarse at that point, is greater in the *Palapteryx robustus* than in the *Dinornis giganteus*, notwithstanding the greater length of the bone in the latter species.

The anterior intercondyloid protuberance sends a short obtuse ridge downwards and slightly outwards upon the fore part of the upper end of the tarso-metatarse. A large low rough protuberance projects forwards and outwards below the antero-internal angle of the entocondyloid surface; between this protuberance and the opposite angle the anterior surface is gently concave from side to side: the fossa between the proximal ends of the ento- and ecto-metatarsals commences two inches below the intercondyloid eminence: it is a vertical elongated ellipse, bounded behind by the mesometatarse, and below by the rough depression and protuberance, for the insertion of the *Tibialis anticus*. Below this protuberance a broad and very shallow depression extends to near the middle of the shaft, where it is filled up by the advance of the mesometatarse towards the anterior surface of the bone, where it forms a longitudinal prominence, which increases in breadth as it approaches the condyle of the same element: a shallow and longitudinal groove extends on each side of this median eminence to the interspaces between the middle and the lateral condyles. There is no perforation in either of the grooves leading to these interspaces.

The back part of the upper two-thirds of the shaft of the mesometatarse forms a buttress-like prominence extending from the mesocalcaneal process down to the lower third of the common shaft; the upper third of this process is very rugged; the rest is comparatively smooth: the borders of the back part of the common shaft are roughened for the attachment of the strong fascia that bound down the tendons traversing that aspect of the shaft: the rough tract on the inner side terminates in the rough oval depression for the attachment of the rudimental metatarse of the hallux: from the lower border of this depression to the division between the inner and middle condyle measures two inches eight lines; the relative position of the depression being the same as in the *Apteryx*.

The distal trochlear or condyloid extremities of the three coalesced metatarsals terminate at different distances from the proximal ends of the bones, the outer one being the shortest—not the inner one, as in the *Apteryx*; and the middle one, as in most birds, being the longest and the most prominent one anteriorly. The inner trochlea (II) presents a depression on its inner surface and another on its under surface, from which a shallow channel is continued a little way backwards upon the back part of the condyle and forwards upon the broad anterior convex articular surface: this surface slopes obliquely from the outer to the inner margin of the trochlea: the inner part of the hinder surface of the trochlea is the most produced: the outer surface of the condyle presents a wide and deep depression.

The articular surface of the middle trochlea is narrowest at its posterior commencement, gradually expands to its lower and fore part, and contracts, but in a less degree, to its anterior boundary: it describes three-fourths of a circle, and is grooved along its middle, the groove widening towards the posterior part of the bone. The outer portion of the posterior boundary projects from the level of the short stem of the condyle: the anterior boundary rises very gradually but somewhat obliquely from the level of the stem: the sides of the condyle are widely and deeply excavated for the lateral ligaments.

The outer trochlea (IV) has a deep and rough depression on its narrow outer side, and a wider depression on the side next the middle condyle; but it is not impressed on its under surface. The articular surface slopes from the inner to the outer side; it is moderately convex, with a faint median channel at its under part. The fore part of the stem of this condyle presents a transverse groove between two transverse ridges. The outer and hinder border of the trochlea is produced backwards. The rudimental metatarsal of the hallux is figured of its natural size at fig. 1, and in figs 4 and 5, Pl. XLIX.: it is of a rhomboidal form, is subcompressed, with its lower end enlarged and convex for articulation with the proximal phalanx of the hallux. The opposite end of the bone is obliquely truncate and roughened for the attachment of the ligaments which connected it with the similarly rough articular depression on the entometatarse (II). The outer and anterior surface is slightly convex; the inner and posterior surface is concave lengthwise: the bone is slightly twisted upon itself, this character being best shown by the direction of the inner and longer border of the bone. It is longer in proportion to its breadth than in the *Apteryx*, and it doubtless supported, as in that genus, a small proximal phalanx terminated by an ungual one: the convex articular surface is impressed by a shallow longitudinal groove, indicative of a trochlear articulation with the phalanx.

The phalanges of the three anterior toes are present in the same progressively increasing number in the *Palapteryx* as in birds generally. The proximal phalanx (II. 1) of the second toe is distinguished from that of the third (middle) toe by the unsymmetrical form of the proximal articulation, and from that of the fourth (outer) toe by its greater length in proportion to its thickness. The form of the proximal articular surface is given in fig. 3, at II. 1: the outer half of the surface is most extended from before backwards, and its posterior rounded angle is produced, and divided by a groove from the corresponding part of the inner part of the joint. The under surface of the phalanx presents a rough tuberosity near each of these angles, and the inner surface of the inner angle is impressed with a pit for the insertion of the lateral ligament: the under surface of the middle of the phalanx is flattened: the section of the bone at that part would give almost a semicircle with the angles rounded off; but the inner side of the upper convex part of the phalanx is rather more extended and sloping than the outer one. The distal articulation is a convex trochlea describing rather more than a semicircle in the vertical direction, and divided by a wide and deep median channel: the inner moiety of the trochlea is rather the most produced: on each side of the distal end of the phalanx there is a depression for the lateral ligament; it is deepest on the outer side.

The second phalanx of the second toe (II. 2) has its expanded proximal articular surface divided by a submedian vertical ridge into two concavities, the inner one being broader in proportion to its vertical extent than the outer one, which shows reverse proportions: the section of the middle of the shaft is subtriedral with rounded angles; the outer and inner sides converging more to the upper surface than in II. 1, and the inner surface sloping rather more than the outer one: this character distinguishes the phalanx in question from the corresponding one in the other toes (III. 2 or IV. 2). The under surface is flattened, the upper one slightly concave lengthwise. The distal trochlea, divided by the vertical wide groove, is more contracted above than in II. 1. The pits for the lateral ligaments are large and well-marked; that on the outer side is the deepest and has a tuberosity beneath it.

The third or ungual phalanx (II. 3) is three inches in length; it is figured somewhat foreshortened, being viewed as it is naturally bent in Pl. XLIX. It is a subtriedral long cone, bent slightly downwards. The proximal articular surface is shield-shaped with the base downwards; it is nearly equally divided by the vertical ridge which fits into the groove of II. 2: the under surface of the base of the phalanx presents a broad rough surface for the insertion of the flexor perforans tendon; the rest of the under surface is smooth and nearly flat transversely, slightly curved lengthwise. The lateral surfaces converge to an upper smooth convexity, which near the base of the phalanx shows the line of insertion of the expanded extensor tendon. The inner surface is most sloping and most extensive: the upper surface is smooth and convex; each side is impressed by a deep vascular groove extending half way towards the apex of the phalanx. The apex of the claw is pierced by many large vascular canals, for the issue of the vessels supplying the secreting organ of the powerful claw.

The length of the toe II, as given by the three phalanges, is seven inches and a half. The length of the proximal phalanx of the middle toe (III. 1) is four inches and a half;

the form of its proximal articular surface is shown at fig. 3, III. 1. A rough, somewhat prominent tract, of a triangular shape, extends from the lower angles of the proximal surface forwards upon the lateral and under surface of the shaft, over more than one-third of its extent; and they bound a shallow channel which impresses the middle of the under surface of that part of the bone. The section of the middle of the shaft of this phalanx yields a full transverse ellipse, a little flattened at the under part. The upper surface of the phalanx is almost straight lengthwise: there is a slight depression above the upper border of the distal trochlea. This trochlea is more equally divided, and by a less deep median groove, into the two articular convexities, than in the phalanx II. 1: there is a depression at the middle of the under border of the surface, and a deep and large ligamentous depression on each side of the distal trochlea. The second phalanx, III. 2, differs from II. 2, not only by its greater size, but by its more symmetrical form, and by the straight line in which the upper surface extends from the posterior to the anterior trochlea. The inner of the two divisions of the proximal trochlea is rather the largest, but the inequality is less than in II. 2. The distal trochlea is almost symmetrical; the under surface is more deeply notched than in II. 2: the outer of the two impressions for the lateral ligament is the deepest.

The third phalanx, III. 3, has almost a square contour, with three of the sides slightly concave, and the fourth formed by the proximal articular surface slightly produced at the middle: the section of the middle of this phalanx would be nearly a semicircle, the under surface being flat transversely: the pits for the lateral ligaments, near the distal end of the bone, are large and well-marked: the median depression of the distal trochlea is shallower than in II. 2. The proximal surface of the ungual phalanx is consequently marked by a much more feeble median vertical prominence, and it is broader and of a more symmetrical form than that of the ungual phalanx of the inner toe (II. 3); it is very little longer than that phalanx, and in other respects closely resembles it.

The proximal phalanx of the outer toe (IV. 1) is characterized by its unsymmetrical proximal surface and its great breadth in proportion to its length. The proximal articular surface is less expanded in proportion to the shaft than in II. 1. The median concavity of that surface is smaller in proportion to its peripheral convexity: the inner moiety of the surface has a much greater vertical extent than the outer one, its lower angle being produced downwards and backwards, as shown in fig. 3: a deep notch divides it from the corresponding part of the outer surface; a broad rough tract extends forwards from the lower half of the outer surface along half the extent of the shaft: the similar rough tract from the lower angle of the inner part of the proximal articulation is narrower and of less extent. The smooth under surface of the shaft is slightly concave; the upper surface is slightly concave lengthwise, convex transversely. The distal trochlea is divided by a deeper median vertical groove than in III. 1, and the inner convexity is broader, whilst the outer one is the most prominent: the inferior boundary of the distal trochlea is sharply defined and almost straight, not notched in the middle as in III. 1 and II. 1. The second phalanx (IV. 2) is almost as broad as it is long. The inner concavity of its proximal trochlea is the broadest: the upper surface extends straight from the proximal to the distal trochlea, and it is less convex from side to side than in III. 2. The under surface is nearly flat, and presents a ridge near to and nearly parallel with the lower margin of the proximal trochlea. The large and deep pits for the lateral ligaments occupy nearly the whole of the lateral surfaces of the phalanx. The distal trochlea is proportionally broader in comparison with its vertical extent than in III. 2 or II. 2; it is less contracted above than in III. 3, and is also more deeply impressed by the median channel: the inner division is the broadest.

The third phalanx (IV. 3) viewed from above is broader than it is long; but the production backwards of the inferior border of the proximal articulation makes its extreme length rather greater than its breadth: the section through the middle of this phalanx would be nearly quadrate, the upper surface being broader and flatter than in any of the previously described phalanges. The under surface developes a ridge along the outer half of the inferior border of the proximal articulation: the inner concavity of that articulation is the broadest. The ligament-pits occupy the whole lateral surface. The distal articulation is much broader than it is deep, and the median channel is wide and shallow; the inner convexity is the broadest.

The fourth phalanx (IV. 4), besides its smaller size, is shorter above in proportion to its breadth than the preceding (IV. 3): the proximal surface is divided by a less prominent ridge, and the distal one is still more feebly impressed by the median channel.

The ungual phalanx (IV. 5) consequently may be distinguished from that of the other toes by the almost uniform concavity in the vertical direction of its articular surface. It is the smallest of the three; the outer surface is more extensive and is flatter than the inner one. In its lateral grooves and general downward curvature it agrees with the ungual phalanges of the toes III and II.

The ungual phalanges are of great strength: the base of the cone bears the same proportion to its length as in the phalanx which terminates the strongest of the two toes of the Ostrich (III. 4, fig. 7); and it exceeds that in the ungual phalanges of the Rhea and Emeu: notwithstanding which, the claw phalanges of the *Palapteryx* show a degree of downward curvature greater than in the Ostrich or Rhea, and such as is rarely seen except in claw-bones of more slender proportions.

The breadth of the base, or articular surface of the ungual phalanx of the middle toe in the *Palapteryx robustus* is one inch four lines, the length of the phalanx being three inches: the same admeasurements in the ungual phalanx of the inner toe, II, give one inch three lines, and three inches, and in that of the outer toe, IV, one inch one line, and two inches four lines. These proportions, with the downward curvature of the claw-bones, indicate that the powerful claws with which they were sheathed must have been put to uses requiring great force, analogous to those for which the similarly proportioned claw-bones of the *Apteryx* are adapted. In this small species the power of scratching up the soil is exercised to such a degree that it excavates a burrow for its safe habitation: in the larger allied extinct species the rasorial actions would doubtless be restricted to the acquisition of food: and the ascertained structure of the foot thus accords with and bears out the conclusions deduced from the structure of the bones of the neck and head[1].

Bones of the Foot of Palapteryx dromioides.

Amongst the toe-bones of smaller dimensions, which from time to time were transmitted to me, I soon found homologous ones presenting different proportions; and, finally, by means of the rich accession of specimens due to the obliging exertions of Col. Wakefield, I have been enabled to recompose the entire feet of two species characterized by those different proportions of the phalanges. One of these feet is represented in Pl. L., the other in Pl. LI.

As the coalesced metatarsals might be expected to manifest the same general proportions as the toes they sustained, I have referred the more slender phalanges to the *Palapteryx dromioides*, and the more robust ones to the *Dinornis rheides*, the articular condyles of the metatarsi of these species bearing the closest correspondence with the joints of the proximal phalanges to which they have been respectively adjusted in the specimens represented of the natural size in Plates L. & LI.

The metatarse of the *Palapteryx dromioides* shows the articular depression for the small back-toe: but the bones of this toe have not yet reached me.

The proximal phalanx of the inner or second toe, Pl. LI. II. 1, has the contour of the proximal articulation cordiform, the apex being superior, the notched base below: it is more concave than in the *Palapteryx robustus*, and the inner and lower angle is as much produced as the outer one. A well-marked rough surface extends from each of these angles forwards upon the under and outer surfaces of the bone. The vertical channel dividing the distal trochlea is deeper than in the *Palapteryx robustus*, especially at its upper part: the more gradual slope from the upper to the inner side of the bone, as contrasted with the more vertical outer side, is better marked than in the *Palapteryx robustus*. The inner depression at the distal end for the lateral ligament is deeper than the outer one. The second phalanx is characterized by the deep lateral cavities and the prominent median vertical ridge forming the proximal articulation, which is also more nearly symmetrical than in the *Palapteryx robustus*; the inner division is, nevertheless, the broadest. The distal articular surface extends further back upon both the upper and under surfaces of the bone. The ungual phalanx (II. 3) shows the same unsymmetrical character, produced by the more sloping inner side and the more vertical outer side, as the proximal phalanx (II. 1) does: the inner side terminates below in a ridge; the outer one is rounded off into the under surface: this is protuberant near the lateral vascular grooves, which are well-marked. The length and slenderness of the ungual phalanx contrast better with the proportions of the same bone in *Palapteryx robustus*, than do those of the preceding phalanges.

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[1] pp. 107, 180.

The proximal phalanx of the middle toe (III. 1) shows well the characters of length and slenderness: its proximal articulation differs from that in the *Palapteryx ingens* by the absence of any median vertical ridge: it is a single shallow concavity, a little deepened towards the upper part: each angle between the under and lateral surfaces, at the proximal expanded end of the bone, supports a rough triangular prominent surface: the distal trochlea repeats the same character of the deep median cleft as in the phalanx II. 1, but the divisions are more symmetrical: the articular surfaces extend further upon the upper and under surfaces of the bone than in the *Pal. robustus*. The second phalanx (III. 2) has its proximal articulation divided and adjusted by the development of the median prominence to the deeply cleft trochlea of the preceding phalanx: its distal trochlea repeats the deep-cleft character. In the third phalanx (III. 3) the distal trochlea is much less deeply cleft; and the articular surface of the ungual phalanx is correspondingly simplified. This claw-bone (III. 4) repeats the long and slender proportions of that of the second toe: the lower border of each lateral groove is notched, which gives a character something like that shown in the corresponding phalanx of the Ostrich (III. 4, Pl. XLIX. fig. 7).

The proximal phalanx of the outer toe (IV. 1) is shorter and broader in proportion to III. 1 and II. 1 than in the *Palapteryx robustus*: its proximal articulation is more extended transversely, is less notched below and less concave: the inner half has the greater vertical extent, its lower angle being produced downwards: the shaft is depressed and slopes away towards the outer side: the distal trochlea is less deeply cleft than in III. 1 or II. 1.

The second (IV. 2), the third (IV. 3) and the fourth (IV. 4) phalanges repeat the characters of their homologues in the *Palapteryx robustus*, in regard to their shortness and breadth, and the flattening of their upper surface: the under border of the proximal joint of one phalanx underlaps the trochlea of the preceding phalanx, and the distal joint of the fourth phalanx is divided by the median groove to which a median ridge on the proximal joint of the last phalanx is adapted.

The extent of the articular surfaces of all the joints of the toes of the *Palapteryx dromioides* shows a corresponding freedom and extent of motion of those toes.

Bones of the Foot of Dinornis rheïdes.

The bones of the foot restored and figured in Pl. L. fig. 1, accord by their proportions with the tarso-metatarse of the *Dinornis rheïdes*, the distal trochleæ of which are quite adapted to the proximal joints of the proximal phalanges.

The tarso-metatarse of the *Dinornis rheïdes* differs from that of the *Palapteryx robustus*, by the absence of any rudiment of the ectocalcaneal process; by the greater elevation of the entocalcaneal process and its equality of size with the mesocalcaneal process; and by the presence of a tubercle at the middle of the inner border of the inner concavity for the tibia. There is no trace of a depression for the articulation of the back-toe.

The phalanges differ from those of the *Palapteryx dromioides*, not only by their thicker proportions, as shown in Pl. L. fig. 1, but by the less deep divisions of the trochlear surfaces. In the short cuboidal phalanges, 3 and 4, of the outer toe (IV), the distal trochlea presents an almost uniform convexity: and the ungual phalanx of this toe is distinguished from that of the other toes by the uniform concavity of its proximal surface. The greater strength of the toes of the *Dinornis casuarinus* accords with the superior thickness of the tarso-metatarse, compared with that bone in the *Palapteryx dromioides*; and a corresponding difference in the habits of the two birds may be inferred from these differences in the structure of the feet.

Sternum of Palapteryx *and* Notornis.

The most simple form of *sternum* in the class of *Birds* is that which is presented by the terrestrial species deprived of the power of flight, in which, however, the size and especially the breadth of the bone surpass those of the sternum of any of the terrestrial mammals, and relate to the peculiar mode of respiration in the class of Birds. The mechanical part of this function is effected by alternately bringing the sternum nearer to the back and pushing it farther from it, these movements of elevation and depression being performed chiefly upon the synovial joints between the sternal and vertebral ribs; by these movements the large air-cells interposed between the concave surface of the sternum and the lungs, which lungs are fixed in intercostal cavities at the back of the thorax, are alternately expanded and contracted, receiving the air in expansion from the orifices on the sternal aspect of the lungs, and expelling it on contraction through the same apertures back into the lungs; or, if, as is commonly the case, other air-cells be developed beyond the sternum, into those extrasternal cells. The suprasternal or thoracic air-cells being those which are most essential to this mode of respiration, are constantly developed in Birds, and are present in the *Apteryx*[1], where no other extra-pulmonary air-cells exist; in which bird accordingly we find the sternum of greater relative breadth[2] than in any Mammalian animal, notwithstanding the wings are reduced to mere rudiments; the primary and essential relations of the sternum being to the ornithic mode of respiration above described. The other modifications of the sternum in Birds relate to the functions and actions of the anterior extremities. The great extent, however, of its diversity of shape and proportion has not, as yet, been fully or satisfactorily explained on the principle of final causes; but they are characteristic, to a certain degree, of natural groups, and are useful as accessory guides to the natural arrangement and affinities of the class.

The relation of particular forms of sternum to particular genera of Birds is illustrated by those which characterize the different genera of the Struthious family, in which the secondary modifications are superinduced upon a common family type of the bone exemplified by its resemblance to a buckler and the total absence of the keel. They are

[1] Zool. Trans. vol. ii. p. 278. pl. 51. fig. 4.

[2] *Ib.* vol. iii. p. 318. pl. 43. fig. 8.

so constant and well-marked, that the Comparative Osteologist, who had had the opportunity of comparing them, would afterwards readily distinguish the genera *Struthio*, *Rhea*, *Casuarius* and *Dromaius*, by the sternum alone. That bone in the *Apteryx* is still more characteristic of the genus, and it is to this particular modification of the keel-less sternum that the sternum of one or both genera of the gigantic wingless birds of New Zealand makes the nearest approach. This is exemplified in the attempted restoration of the sternum of a large species[1] referred to *Dinornis* prior to the reception of the evidence afforded by the cranium and beak of two genera of large wingless birds in New Zealand. That sternum may, however, belong to the *Palapteryx robustus*: it was obtained, it will be remembered, from the same deposit at Waikawaite in the Middle Island, from which the most abundant and instructive evidences of that species have been had. The restoration was unavoidably imperfect, as regards especially the form and extent of the anterior or costal angles (*a*, Pl. XXXV.), but was sufficiently established to illustrate the nearer resemblance of the sternum in form to that of the *Apteryx* than to that of any of the larger existing Struthious birds.

A much more perfect specimen of the sternum (Pl. XLVIII. figs. 1-4) of a smaller species of the great wingless birds of New Zealand confirms the general accuracy of the restoration attempted in the Memoir on the *Palapteryx* (p. 124), and affords additional illustration of a near affinity to the *Apteryx*. For this reason I refer the sternum in question to the genus *Palapteryx*. Like that of the *Apteryx*, this sternum is remarkable for its shortness in comparison with its breadth, and for the breadth and depth of the two posterior notches. The chief difference is presented by the anterior border, which extends in almost a straight line from one costal angle to the other. These angles are produced into short, broad, subcompressed processes, rounded and thick at their free and expanded ends, and slightly twisted upon their neck, or point of attachment. Only three articular surfaces for sternal ribs are indicated (fig. 3), the intervening fossæ being very shallow; and the whole extent of the costal border is shorter than in the *Apteryx*, and resembles in this respect that in the Gallinæ, Pigeons, and Penguins. The coracoid fossæ are small and unusually shallow; there is a large depression on each side of the fore part of the concave surface of the sternum nearly opposite the coracoid fossæ, the bottom of which is cribriform; numerous small foramina having apparently conducted air from the anterior thoracic cells into the sternum. That bone in the *Apteryx* shows no trace of such depressions. The bone, which is cellular at the thicker parts of the periphery, is very thin and compact at the middle of the body of the sternum.

The posterior border is marked by two deep and wide angular emarginations leaving a broad middle process with two very long and narrow diverging lateral ones; but the extremities of all these processes have been broken away. The chief specific distinction of the sternum in question, which is that of a mature bird, from the sternum figured in

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[1] Vide *supra* p. 124. Pl. XXXV. figs. 1, 2 & 3.

Pl. XXXV., is its smaller size, and the angular form of the posterior notch, which was rounded at the bottom in the larger sternum, as in the *Apteryx*.

A distinct form of sternum, although evidently appertaining to a bird which was deprived of the power of flight, is that which is represented in Pl. XLVIII. figs. 5–8. The specimen is part of the collection obtained by Mr. W. Mantell at Waingongoro, and which was sold by Dr. Mantell to the British Museum; where, for the facilities afforded for describing and figuring the specimen, I feel indebted to the kindness and urbanity of the learned Keeper of the Department, Charles König, K.H., and of his able Assistant Mr. Waterhouse.

Its proportions would justify its reference to a bird of the size of that to which the skull[1], referred in the Memoir on *Notornis*, p. 151, to that genus, has belonged; and although its shape, so far as I at present know, is unique in the class of Birds, I conceive it to be a modification of that type which characterises the Rail and Coot tribe (*Rallidæ*). The grounds for this opinion will, perhaps, be best illustrated if I premise a description of the sternum of that existing species of the family in New Zealand, which, being incapable of flight from the shortness of its wings, I have referred to a genus called *Brachypteryx*.

The sternum of the *Brachypteryx* is almost as remarkable for its narrowness as in the *Apteryx* for its breadth. The anterior border has a deep rounded median emargination, between the projecting borders of which, and the more produced costal angles, the wide coracoid grooves are placed. The costal border occupies one-fifth of the lateral margin of the sternum and presents articulations for five sternal ribs: the narrow posterior border has a deep and moderately wide median emargination and two lateral, very narrow and very deep ones, like fissures, equalling one-third of the entire length of the sternum, the outer border of each fissure being a long slender filiform process. Two ridges commencing on the outer surface of the sternum behind the coracoid grooves, converge to support the fore part of a shallow keel which subsides before it reaches the posterior border of the sternum. The outer surface of the bone is slightly concave between the keel and the costal margins of the bone. The upper or concave surface of the sternum presents two pneumatic depressions behind the coracoid grooves.

The sternum of the *Notornis* (Pl. XLVIII. figs. 5 & 6) resembles that of the *Brachypteryx* in its elongated and narrow proportions, and in the rudiment of a keel which commences by two ridges converging from the inner ends of the coracoid grooves: but the lateral styliform appendages, and consequently the lateral fissures of the posterior part of the bone, are wholly wanting, and the intermediate part of the body of the bone is narrower, and gradually contracts to what seems to have been an obtusely pointed extremity: but this is broken in the specimen. The keel does not project so far from the surface of the bone as in the *Brachypteryx*. The coracoid grooves are more shallow, and the whole sternum, although its general form and proportions are indicative of a bird of the same

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[1] Zool. Trans. iii. p. 366. pl. 56. fig. 7.

natural family as the *Brachypteryx*, shows that the wings were still less developed than in that genus[1]. The costal border exhibits articulations for five sternal ribs (fig. 7) on each side, as in the *Brachypteryx* ; the anterior border shows a wide and shallow concavity, not the deep narrow median notch. There are no pneumatic fossæ on the upper surface. The anterior buttresses of the keel divide the fore part of the anterior surface of the sternum into three parts, as shown in fig. 8, where the coracoid grooves are represented near the fractured anterior or costal angles of the bone.

Bones of the Leg of Notornis.

The genus *Notornis*, of the family of the *Rallidæ*, and most nearly allied to the *Porphyrio*, was established on a skull described and figured in the Memoir on that genus, pp. 151, 172, Pl. XLVII.

To the same genus I refer the femur, tibia and tarso-metatarse about to be described, on account of their similar correspondence with the homologous bones in *Porphyrio*, and their proportional agreement in size with the skull of the *Notornis*.

The specimens were obtained from the North Island of New Zealand, and were transmitted by the Rev. William Cotton, M.A. The femur (Pl. LI. fig. 3) is moderately long and slightly bent with the convexity forwards, as in the *Brachypteryx*. A small head supported on a short and thick neck is impressed on its upper part by a large fossa for the 'ligamentum teres': the apex of the three-sided trochanter is bent upwards and forwards: the broad irregular convex outer surface of the trochanter extends between a concavity at the inner and fore part of the trochanter and a smaller concavity at the back part of the upper surface of the shaft. A narrow intermuscular ridge extends down the middle of the back part of the shaft to the shallow popliteal space, above the inner condyle, as in the *Brachypteryx*: the shaft is nearly cylindrical. The rotular intercondyloid surface is wide and slightly inclined inwards. The fibular notch behind the outer condyle, and the rough fossa above it, closely accord with those of the *Brachypteryx*.

The tibia (Pl. LI. fig. 4) measures seven inches ten lines in length, and like the femur is more slender in proportion to its length than in the *Aptornis*: the proximal articular surface is almost confined to the entocondyloid division, which is very slightly concave in adaptation to the almost flattened broad inferior surface of the inner condyle of the femur: the intercondyloid tuberosity is low. The epicnemial ridge rises much above it, and equals in extent the breadth of the articular surface of the tibia: it forms an angle at the fore part of the middle of the proximal end of the tibia and extends thence obliquely outwards and backwards, where it terminates by meeting at a right angle the ecto-

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[1] Since the memoir in which this passage occurs was printed, the *Notornis* has been discovered alive in the Middle Island of New Zealand, and an entire skin transmitted thence by Mr. Walter Mantell, which was described and exhibited by Mr. Gould at the Meeting of the Zoological Society, November 12, 1850. The wings are too short to serve the purposes of flight, and the feathers show that downy or decomposed character common to those land birds that cannot fly.

cnemial ridge: this is short, and descending obliquely inwards terminates or subsides upon the prominent fore part of the tibia about an inch below its upper angle. The procnemial ridge has an equally short origin, which is oblique and parallel with the ectocnemial ridge: it is broken in the specimen under description, but from the analogy of the *Brachypteryx* probably projects far forwards: where it subsides at the inner side of the tibia there is a tuberosity, from which a low ridge extends bounding internally the fore part of the tibia as far as the canal for the extensor tendon. The fibular ridge is well-marked; it begins on the outer side of the shaft one inch below the epicnemial ridge, extends nearly two inches down the shaft, and after a smooth tract of half an inch, reappears as a rough tract of an inch and a half in extent: a low narrow ridge is continued thence to the outer side of the fossa, lodging the extensor canal. The shaft of the tibia is compressed from before backwards, is smooth and rounded on the inner side which is thicker than on the outer side. The hinder and under part of the distal articular surface is convex from behind forwards, slightly concave from side to side, increasing in breadth as it extends forwards, and bounded laterally by two prominent ridges: the division of this surface into condyles is limited to its fore part, where they project forwards, are of small size, and are divided by a very wide concave interspace, immediately above which is the bony canal for the extensor tendons. The distal end of the tibia is expanded chiefly at its inner side, towards which it seems to be slightly bent.

The tarso-metatarse (Pl. LI. fig. 5) a little exceeds the femur in length: its proximal condyloid cavities are small and widely separated by a large intercondyloid prominence, and a non-articular tract behind extended upon a calcaneal process: the entocondyloid cavity is as usual the deepest. The calcaneal process is simple, imperforate, and subsides eight lines below its upper end upon the back part of the mesometatarse. The concavity on the inner side of the calcaneal process is bounded internally by a ridge continued from a tuberosity behind the entocondyloid cavity about two-thirds down the shaft, below which is the well-marked oval depression for the back-toe (I). A small foramen, indicating the interosseous space between the inner and middle metatarsals, opens into the upper part of the concavity below and at the inner side of the calcaneal process. On the outer side of that process, but at a lower level, is a similar remnant of the primitive space between the middle and external metatarsals: both these foramina unite as usual into a single median foramen at the fore part of the proximal end of the bone. A deep and wide concavity occupies the upper half of the fore part of the tarso-metatarse: it is gradually filled up by the advance forwards of the middle metatarsal element, which is placed as usual rather obliquely between the outer and inner elements. A slight groove between the distal portion of the middle metatarsal and the outer one, leads to the canal for the transmission of the adductor tendon of the fourth toe. The outer and inner trochleæ are nearly of equal extent, the outer one being a little longer or lower: the middle trochlea is the longest as well as largest: it does not advance so far forwards as in the *Aptornis*: each condyle is slightly grooved.

Remains of the Apteryx.

In the fluviatile deposits and in the cavern at the base of Tongariro, in the North Island of New Zealand, bones of the *Apteryx* have been discovered so associated with those of *Dinornis*, *Palapteryx*, *Aptornis* and *Notornis*, as to lead to the conclusion that they had been buried at the same period and were of equal antiquity. Most of these remains, of which a femur (fig. 6), and a tarso-metatarse (figs. 7 & 8) are figured in Pl. LI., agree in size and other characters with the corresponding parts of the existing species (*Apteryx australis*): but amongst the specimens transmitted by Governor Grey from the cavern at Tongariro there is a femur, which agrees in size with that of the smaller species of *Apteryx* figured and described by my friend Mr. Gould under the name of *Apteryx Owenii*[1].

The shaft of the femur of the *Apteryx* is characterized by the convexity of the fore part of the shaft in the direction of its axis, which is due, not only to a slight bending of the whole shaft forwards, but to an enlargement in that direction of the middle of the fore part of the shaft: the trochanter does not rise much above the neck and head of the bone: its anterior border, which is thick and rounded, is produced: the broad outer and back part of the condyle is impressed by coarse irregular grooves and pits. Two intermuscular ridges diverge from the middle of the back part of the bone to each condyle. The fore part of the outer condyle is slightly inclined inwards. There is no 'foramen pneumaticum.'

The tarso-metatarse (figs. 7 & 8) presents the general characters of that compound bone in the *Palapteryx*: but the intercondyloid tubercle is relatively higher, and the inner border of the entocondyloid fossa is more convex: the ectocalcaneal process is also better developed and more distinct from the mesocalcaneal one: the chief tendinous groove lies, however, between this and the entocalcaneal process. The back part of the mesometatarse projects and supports, as a buttress, the mesocalcaneal process: on each side of this are the interosseous foramina which converge as they extend forwards, but open separately into the anterior fossa below the proximal end of the bone. This fossa is relatively larger and deeper than in *Palapteryx* or *Dinornis*, but is not extended so far down the bone as in *Notornis*. The rough articular depression (I, fig. 7) for the syndosmosis of the hallux is well-marked. The meso-metatarse advancing forwards at its lower half, makes a median prominence at that part of the common shaft: the groove between it and the ectometatarse is well-marked, and just before its termination it shows a small perforation from before backwards: this is the most distinctive mark between the tarso-metatarse of the *Apteryx* and that of the *Palapteryx*. The inner condyle is the least produced, the middle one the most, and in a somewhat greater degree than in the *Palapteryx*. The trochlear groove deeply impresses the whole extent of the middle condyle: it is more feebly marked on the lateral condyles, except posteriorly where the lateral border of each is produced backwards.

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[1] Zool. Trans. vol. iii. p. 379. pl. 57.

When the general results of the restoration of extinct species and their relations to existing species of the different continents and islands of the globe are first received, they commonly suggest the idea that the races of animals have deteriorated in respect of size. The more striking phænomena first and most strongly impress the mind, which contrasts, for example, the great Cave-Bears of Europe with the actual Brown Bear, the Megatherioids of South America with the small existing Sloths, and the gigantic Glyptodons with the Armadillos. The huge *Diprotodon* and *Nototherium* suggest a similar contrast with the Kangaroos of Australia; and the towering *Dinornis* and *Palapteryx* with the humble *Apteryx* of New Zealand. But the comparatively diminutive animals of South America, Australia and New Zealand, that form the nearest allies of the gigantic extinct species respectively characteristic of such tracts of dry land, are yet specifically if not generically distinct from them, nor have such small species been more recently introduced. In England, for example, our Moles, Water-voles, Hares, Weasels, Stoats, Badgers and Foxes are of the same species as those that existed when the Hippopotamus swam the rivers, the Hyæna, Bear and Lion lurked in the caves, and the Rhinoceros and Elephant trod the land. So likewise the remains of small Sloths and Armadillos are found associated with the Megatherium and Glyptodon in South America; and the fossil remains of species as diminutive as the present Kangaroos and Dasyures occur abundantly in Australia with those of herbivorous Marsupials as large as Tapirs and Rhinoceroses, and of carnivorous Marsupials as large as the Lion or Tiger. So likewise in New Zealand we find that the small *Apteryx* and *Notornis* have co-existed with the great *Dinornis* and *Palapteryx*.

We have not a particle of evidence that any species of bird or beast that lived during the pliocene period has had its characters modified in any respect by the influence of time or of change of external influences. In proportion to its bulk is the difficulty of the contest which, as a living organized whole, the individual of such species has to maintain against the surrounding agencies that are ever tending to dissolve the vital bond, and subjugate the living matter to the ordinary chemical and physical forces. Any changes, therefore, in such external conditions as a species may have been originally adapted to exist in, will militate against that existence in a degree proportionate, perhaps in a geometrical ratio, to the bulk of the species. If a dry season be gradually prolonged, the large Mammal will suffer from the drought sooner than the small one: if any alteration of climate affect the quantity of vegetable food, the bulky Herbivore will first feel the effects of stinted nourishment: if new enemies are introduced, the large and conspicuous quadruped or bird will fall a prey, whilst the smaller species conceal themselves and escape. Smaller animals, also, are usually more prolific than larger ones.

The actual presence, therefore, of small species of animals in countries where larger species of the same natural families formerly existed, is not the consequence of any gradual diminution of the size of such species, but is the result of circumstances, which may be illustrated by the fable of the 'oak and the reed': the smaller and feebler animals have bent, as it were, and accommodated themselves to changes which have destroyed the larger species. We find, nevertheless, that the same peculiar forms or families of animals exist, and characterize particular portions of dry land, *e. g.* South America, Australia, and New Zealand, at the present day, as at a period long antecedent to Human history or existence; and although many species have perished, there has been no general sweeping away of the peculiar aboriginal land animals of those continents or islands. But just as the smaller Sloths and Armadillos still linger in South America, so the smaller Kangaroos, Wombats, Dasyures, and other Marsupials have continued to exist in Australia, and a few species of the comparatively diminutive wingless birds of the genera *Apteryx* and *Brachypteryx* still dwell in the island where, when probably its extent was far greater, their peculiar families were once much more richly represented and by species on a far larger scale.

DESCRIPTION OF THE PLATES.

PLATE XLVIII.

Fig. 1. Outer or under view of the sternum of a species of *Palapteryx*.
2. Inner or upper view of ditto.
3. Lateral border of ditto.
4. Anterior border of ditto.
5. Outer view of the sternum of *Notornis Mantelli*.
6. Inner view of ditto.
7. Lateral border of ditto.
8. Anterior border of ditto.

All the figures are of the natural size.

PLATE XLIX.

Restoration of the foot of *Palapteryx robustus*.

Fig. 1. Front view of the bones.
i. Detached metatarse of the rudimental hallux.
ii. Distal trochlea of entometatarse, or that of the second toe: its three phalanges are numbered 1, 2, 3.
iii. Distal trochlea of mesometatarse, or that of the third toe: its four phalanges are numbered 1, 2, 3 and 4: a side view of the last is added in outline.
iv. Distal trochlea of ectometatarse, or that of the fourth toe: its five phalanges are numbered 1, 2, 3, 4, 5.

Fig. 2. Outline of the proximal end of the compound tarso-metatarsal bone.
3. Distal ends of the trochleæ of the three metatarsal elements, numbered as in fig. 1: below these are the proximal articulations of their respective proximal phalanges.

Fig. 4. A side view of the metatarse of the hallux, showing its characteristic twist.

5. Back view of the metatarse of the hallux.

6. Distal ends of the trochleæ of the three metatarsal elements of the compound bone of the Cassowary (*Casuarius indicus*): below these are the proximal articulations of their respective proximal phalanges.

7. Outline of the bones of the foot, front view, of an Ostrich (*Struthio camelus*): the homologous phalanges with those of the *Palapteryx* are indicated by the same symbols.

All the figures are of the natural size.

PLATE L.

Restoration of the foot of *Dinornis rheïdes.*

Fig. 1. Front view of the bones. Only the distal ends of the coalesced metatarsals are figured. The bones of the toes are indicated by the same symbols as in Plate XLIX.

2. A side view of the ungual phalanx of the middle toe.
3. Back view of the femur of *Aptornis otidiformis.*
4. Front view of distal end of ditto, with part of the medullary cavity and its compact walls exposed.
5. Back view of the tarso-metatarse of *Aptornis otidiformis.*
6. Proximal end of ditto.
7. Side view of ditto.
8. Distal end of ditto.

All the figures are of the natural size.

PLATE LI.

Restoration of the foot of *Palapteryx dromioides.*

Fig. 1. Front view of the bones. Only the distal ends of the coalesced metatarsals are figured. The bones of the toes are indicated by the same symbols as in Plate XLIX.

2. A side view of the ungual phalanx of the third toe.
3. Back view of the femur of *Notornis Mantelli.*
4. Front view of the tibia of ditto.
5. Back view of the tarso-metatarse of ditto.
6. Side view of the femur of *Apteryx australis.*
7. Back view of tarso-metatarse of ditto.
8. Front view of ditto of ditto.

All the figures are of the natural size.

MEMOIR

ON THE

CRANIUM AND MANDIBLE OF

DINORNIS INGENS,

AND ON THE CRANIA OF

DINORNIS GIGANTEUS,

AND OF SPECIES OF

PALAPTERYX.

FOUR distinct generic types have been pointed out (pp. 151–184) of the cranial organization of the wingless birds of New Zealand:—one referable to an existing genus of Parrot (*Nestor*), peculiar to New Zealand; a second to a bird most nearly allied to the Purple Coots, but of a distinct genus (*Notornis*), represented by a species about the size of a goose: the other two types belonged to much larger birds; one, from its nearer approach to the *Apteryx* and *Emeu*, was referred to the genus *Palapteryx*; the other, which differed in the structure of the back part of the cranium and in the greater extent of the ossified portion of the bill, was referred to *Dinornis* proper.

The present memoir is chiefly devoted to the description of a still larger and more complete skull than any previously described, which in the greater extent of its ossified and deflected upper mandible approaches the *Dinornis* and deviates from the *Palapteryx*, but in the structure of the back and under part of the cranium more resembles the type referred to *Palapteryx*. In regard to its size, as compared with that cranium described (p. 116) and figured in Pl. XVI., and referred to the *Dinornis struthioïdes*, the present cranium would, at least, merit reference by its size to the species called *ingens*, the second in point of stature of those that have hitherto been found in the North Island of New Zealand.

The circumstances under which this at present unique specimen came into my hands are as follows :—

In March 1850 I was favoured by a letter from His Excellency Sir George Grey, Governor-in-Chief of New Zealand, dated Auckland, November 29th, 1849, informing me that he had been "able to procure a number of bones of birds, which were found in a cave in the district which lies between the River Waikate and Mount Tongariro:" and intimating his liberal intention of transmitting them to me. They arrived soon after: and in this collection, which included remains of various species of *Dinornis* and *Palapteryx*, and the cranium of a *Notornis*, I had the extreme pleasure to find, with several smaller crania, the remarkably fine specimen, with the bone of the upper mandible, which forms the subject of Pl. LII. The following are some of the dimensions of this cranium :—

	Pal. ingens (?).		Struthio.	
	inches.	lines.	inches.	lines.
Breadth of the cranium across the mastoids (8, 8)	3	8	3	0
Length of the cranium to the anterior border of the coalesced frontals (11)	4	2	3	2
Breadth across the postorbital angles	4	8	3	1
Breadth across the temporal fossæ	2	8	2	1
Vertical diameter from supraoccipital ridge to basisphenoid	1	11	1	9
Transverse diameter of occipital foramen	0	8	0	6½
Breadth across the paroccipitals (4, 4)	. . .	. . .	1	9
Total length of skull, in a straight line	8	0 (?)	7	0
Total length of premaxillary	4	0 (?)	3	10
Breadth of the middle of the upper beak	2	0	1	8
From the anterior border of the intercommunicating aperture between the nostrils to the end of the premaxillary	2	4	0	10
From the fore-part of the bony palatal opening of the nostrils to the end of the premaxillary	2	3	0	10
Length of the olfactory fossæ in the frontal bone	1	3		
Breadth of the same fossæ	2	0		

The occipital region corresponds very closely with that of the cranium referred to *Dinornis struthioïdes* (Pl. XVI.) and with that conjectured to show the characters of *Palapteryx geranoïdes* (Pl. XLV.), repeating the distinctive characters pointed out at p. 116, by which the large wingless birds of New Zealand differ from the Ostrich, Emeu, Cassowary, and Rhea of the existing class.

The pedunculate occipital condyle (Pl. LII. fig. 1, 1), the descending basioccipital, the square basisphenoidal platform with its two posterior tuberous angles (*ib.* fig. 2, 1''), the extremely broad, low superoccipital region (*ib.* fig. 1, 3), with its inclination from below upwards and forwards, and its subdivision into four depressions, are all well-marked characters in the present skull. The border of the vertical occipital foramen is rounded off, not sharply defined or grooved, as in the crania above-cited. The outer superoccipital depression is separated from the temporal fossa by a smooth non-muscular tract above the mastoid, of four lines in breadth, as in the cranium figured in Pl. XVI. The temporal fossæ are separated from each other by a similar tract upon the parietals (Pl. LII. fig. 1, 7) of one inch eight lines in breadth: this tract is almost flat: two very shallow channels, four lines broad, diverge from the flat parietal surface along the upper part of the skull close to the anterior border of the temporal fossæ and terminate at the upper part of the much-developed and deflected postfrontal (*ib.* 12). Between these shallow impressions the frontal region is slightly convex, but it becomes a little concave at its anterior half, the middle of the fore-part of which is impressed by a sharply-defined shallow channel for the reception of the cranial and of the median branch of the coalesced premaxillaries. The large tympanic fossa, over-arched by the mastoid (*ib.* fig. 2, 8), shows the single oblong deep cavity for the upper condyle of the tympanic bone, with the pneumatic, jugular, and auditory foramina, and the adjacent trigeminal one (*ib. tr*). An arterial canal is continued upwards from the posterior aperture of the carotid canal, and grooves or notches the lower border of the paroccipital. The antero-posterior extent of the temporal fossa (*ib.* fig. 2, 7, *tr*, 12) is one inch eight lines, indicating, with the depth of the same fossa, the great strength of the temporal muscles of this bird. The median part of the roof of the orbit is slightly convex towards that cavity: the lateral part becomes concave by the remarkable downward production of the postfrontal. But, perhaps, the most extraordinary features are the olfactory depressions on the under surface of the frontals, the dimensions of which have already been given. The great extent of these depressions has been dwelt on in previous memoirs as peculiarly characterizing the great wingless birds of New Zealand, and it becomes remarkably striking in the present large cranium. The olfactory foramen opens into the upper part of the posterior third of these cavities, and the grooves which radiate from each foramen indicate the dispersion of the branches of the nerve after its emergence from the cranium. One cannot avoid the inference that the living bird must have been remarkable for its acuteness of smell. The deep circular 'sella turcica' has not increased in the same ratio: there is a special depression at its back part above that which receives the orifices of the entocarotid canals.

The upper and median branch of the premaxillary (*ib.* fig. 1, 22′) slightly expands at its flattened cranial end, but that part is broken away which would have filled the depression on the frontal (*ib.* 22″). Allowing for it according to the proportions of the cranium with the entire lower jaw restored at Pl. XLV., the length of this skull would be about eight inches. But the skull is much shorter in proportion to its breadth than in the existing large Struthious birds, or than in the *Palapteryx* described and figured in Pl. XLV. As the median branch of the premaxillary advances forwards, it decreases in breadth and increases in thickness; its outer margins become rounded, and it sends down from the median line of its inferior surface a ridge (*ib.* fig. 2, *n*), which divides the external nostrils anteriorly, and which rapidly expanding, as it descends, becomes continued into the broad palatal plate of the premaxillary. The back part of the base of the septum presents a triangular depression, on each side of the base of which is a canal, which conducted vessels or nerves into the substance of the bone: the middle line of the upper surface of the median branch of the premaxillary is impressed by a groove leading, also, to a canal which enters the substance of the bone. Where this branch is confluent with the body of the premaxillary, it slightly expands towards its anterior end, and a deep and narrow groove divides it on each side from the body of the bone. This is formed by a strong osseous mass curved downwards, with sharp lateral margins, and richly perforated by vascular and nervous foramina. There is a slight median ridge along the fore-part of the broad, moderately concave, palatal surface (*ib.* fig. 3): and there is a broad shallow channel along each side of the same surface, with numerous large foramina opening into it. The outer border of this groove is sharply defined. Only the anterior border of the naso-palatine foramen is here preserved; a canal is continued forwards from it into the substance of the bone. The apex of the massive, broad, deflected premaxillary seems to have been rather obtuse.

The chief difference which the skull under consideration presents as compared with that figured in Pl. XLV., is the greater relative extent of the osseous body of the premaxillary, and of its downward curvature, in which it resembles in the same degree the skull presumed to be of the *Dinornis* figured in Pl. XLIII.

From the remarkable modifications of the back part of the cranial portion of that skull, its generic distinction from the large skull under consideration is evident; and if we refer the present large cranium to the genus *Dinornis*, distinguished as it is by its superior extent and curvature of the bony beak from the skull referred to *Palapteryx*, then the still more remarkable skull figured in Pl. XLIII. might possibly belong to the genus *Aptornis*, of which the equally remarkable bones of the legs have been described and figured in a preceding Memoir (p. 185). It seems, however, to be too large for those small metatarsi.

The skull of, perhaps, a larger species than the subject of the previous description, is indicated by the hinder half of the cranium (Pl. LIII. figs. 1, 2 & 3), which, by the persistency of the sutures, the absence of the superoccipital and temporal ridges, and the smooth exterior of the bones, has belonged to a young individual of, it may be, the *Dinornis giganteus*. The occipital condyle (*ib.* fig. 2, 1) is larger than in the older skull; the elements of the occipital bone have coalesced: but the lambdoidal suture dividing the superoccipital (3) from the parietals (7), the sagittal suture (*s*), and that dividing the parietals (7) from the mastoids (8), and both these from the alisphenoids, remain. Not any of these sutures are dentated; they are more properly 'harmoniæ': the sagittal is the most irregular or wavy. The particular form of the cranial bones of the *Dinornis* is indicated by these sutures.

The superoccipital (3), as in the skull last described, deviates most, by its great breadth and small height, from that in other birds: the middle and major part of its anterior margin is slightly convex, or subangular forwards, the outer parts notched for the reception of the posterior external angles of the parietals: yet, notwithstanding the little elevation of the superoccipitals, it reaches the level of the upper surface of the cranium, owing to the flatness of the parietals: it slopes forwards at once from the upper border of the foramen magnum. The broad paroccipitals (4) spread outwards and backwards, and nearly attain the level of the upper surface of the cranium.

Each parietal terminates behind in an obtuse angle, which penetrates a corresponding emargination in the superoccipital near its outer angle; and it sends a rounded projection from its anterior border, near its outer angle, which enters a corresponding emargination between the frontal and postfrontal. The outer part of the parietal bends down, forms the bottom of the temporal fossa, and meets the alisphenoid near the lower part of that fossa at a straight longitudinal suture. The tumid mastoid (8) forms the outer and posterior angle of the upper surface of the skull, as in the Crocodile, and is wedged between the parietal, superoccipital, alisphenoid, and tympanic bones, for which latter bone it affords the major part of the glenoid cavity. The apophysary part (8′) of the mastoid descends vertically from its outer side for more than half an inch, external and posterior to the tympanic; the inner side of the base of the process is perforated by the pneumatic foramen supplying air to the cancelli of the cranial walls. In consequence of the non-obliteration of the sutures in the young bird, to which this interesting cranial fragment has belonged, the right mastoid had become detached, exposing the great breadth of its suture with the parietal and alisphenoid; and the pneumatic foramen is exposed. The whole extent of the paroccipital process is preserved on this side. The loss of the frontals and orbitosphenoids from the fragment of skull in question shows the thickness of the cranial walls at the coronal suture (*ib.* fig. 3, *r*), and exposes the cranial cavity, which is here divided into epencephalic, mesencephalic, and prosencephalic chambers. The epencephalic division is entire, is excavated below for the medulla oblongata, and above for the cerebellum, and is perforated behind by the foramen magnum (*fm*). The mesencephalic division (*o*) consists of two small, well-defined, hemispheric pits for the optic lobes, in front of the lower part of the epencephalic chamber. The portion of the prosencephalic division (*p*) above and external to the depressions for the optic lobes is excavated in the alisphenoids and parietals: the thick cancellous walls form a striking contrast to the general character of the cranial parietes in birds. The deep subspherical sella turcica (*t*) sinks down between the mesencephalic pits.

As compared with the cranium of other birds, and particularly with those of the Ostrich and Emeu, the *Dinornis* and *Palapteryx* are remarkable for the forward production and lateral expansion of the upper cranial walls. In the Ostrich, a vertical line dropped from the point of union of the sagittal with the coronal sutures, would fall into the interspace between the basioccipital and basisphenoid: in the Emeu the same line falls behind the sella turcica; but in the *Dinornis*, the same line falls in advance of the sella turcica. In taking the greatest vertical diameter of the cranium of the Ostrich, the points of the compass touch the middle of the frontal region, and the interspace between the pterapophyses[1] of the sphenoid: the dimension is two inches five lines. In the *Dinornis* and *Palapteryx*, the lower point of the compass in this measurement touches the narrow presphenoidal prolongation of the sphenoid, and the dimension does not exceed two inches. As a result of this anterior production of the frontal, it overhangs in a peculiar degree the coalesced prefrontals which are excavated to form the wide chambers of the olfactory capsules, and the upper walls of which chambers coalesce with the overarching part of the frontal.

The cranium, Pl. LIII. fig. 6, exhibits in a remarkably perfect degree the three transverse processes (4, 8, 12) of the three principal vertebræ of the skull, together with the basisphenoidal platform and the pterapophyses (5′) of the sphenoid. This appears to be of the same species as the more mutilated cranium figured in Pl. XLVI. figs. 4 & 5. The paroccipitals (4) are less expanded relatively than in the *Pal. ingens*, and are almost straight vertical plates. The apophysary part of the mastoid (8) is also vertical, straight, and compressed from behind forwards with the outer border a little advanced. Between this and the postfrontal intervenes a wide and deep temporal fossa, much exceeding in its proportional size that of the *Palapteryx* figured in Pl. XLV. fig. 1. The postfrontal (12) is long, three-sided, and curves outwards, downwards and backwards as low down as the mastoid. The pterapophyses (5′) are shorter than in the Ostrich or Emeu, and are depressed. The base of the alisphenoid swells out a little above them.

The cranium, Pl. LIII. fig. 5, is somewhat smaller than that of the *Palapteryx* figured in Pl. XLV.; it more nearly corresponds in size with that figured in Pl. XLVI. fig. 3, but it differs in the greater elevation of the frontal region, which is more marked than in any skull of *Dinornis* or *Palapteryx* I have yet seen. This skull is of a mature bird: all the cranial sutures are obliterated; and we learn from the specimen of the young *Dinornis*, Pl. LIII. fig. 2, that, as in the Ostrich, this obliteration did not take place in these wingless birds until they had nearly arrived at their full size.

The interorbital part of the skull is relatively narrower than in the *Palapteryx* (Pl. XLV.): the temporal fossæ are relatively narrower than in the skull, Pl. LIII. fig. 6. The occipital condyle is more sessile than in the larger species, and the occipital foramen is less vertical, the plane sloping from above downwards and a little forwards. The mastoid is shorter and more pointed, and the pneumatic hole is reduced to a very small foramen behind its base. The interorbital septum is entire and thick; a slender compressed process (Pl. LIII. fig. 5, 14) is sent down from it just behind the large olfactory fossa. The cranial end of the premaxillary, which is bifid as in the Ostrich, has coalesced with the frontal; but they remain distinct from the subjacent prefrontals, which have as usual coalesced together to form the cavities for the olfactory capsules. The septum between these cavities is entire.

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[1] I use this word instead of 'pterygoid processes,' as the latter term has been employed in Anthropotomy to designate the independent bones, called 'pterygoids,' which, in birds, articulate with the pterapophyses.

The skull, of which a vertical section is figured in Pl. LIII. fig. 4, appears to belong to the same species as that figured in Pl. XLVI. fig. 5, and differs from those figured in Pl. LIII. figs. 5 & 6 in the minor development of the mastoid and postfrontal processes. The olfactory chambers (1s) are deep, and the diameter of the single orifice penetrating the upper and back part of the roof of each division of that cavity, indicates the large size of the olfactory nerve. The outer and inner tables of the cranium are seen to be divided by a diploë of air-cells about one and a half line thick; but the extent of the diploë varies much when seen in transverse section.

The epencephalic chamber (*a*, *v*, *c*) is remarkable for its size, rising to the highest level of the prosencephalic one (*p*), and sinking much below it; the mesencephalic fossa (*o*) is comparatively small. The transverse section across the broadest part of the cranium shows that the prosencephalic cavity is far from being of corresponding breadth: a considerable extent of diploë intervenes between that chamber and the base of the postfrontal processes. The outer and inner tables unite without diploë above the highest part of the upper longitudinal elevations of the cerebrum. The inner circumference of the olfactory orifices is partially grooved.

In order to gain some idea of the size of the bird to which the largest cranium belongs, I have compared the diameter of its foramen magnum with that of a lower cervical vertebra and of a middle dorsal vertebra, both referable by their size to the *Dinornis giganteus*, the same comparisons having previously been made in the skeleton of the Ostrich.

	Dinornis. Lines.	*Ostrich.* Lines.
Transverse diameter of the foramen magnum	9	6½
Transverse diameter of middle of spinal canal, lower cervical vertebra .	6½	5
Transverse diameter of middle of spinal canal, dorsal vertebra	7	4½

From the above admeasurements and comparison we might be led to conclude that the skull of the *Dinornis* yielding that of the foramen magnum belonged to a larger species than the vertebræ; but the size of these vertebræ forbids the supposition; for they are larger in proportion to the size of the skull compared, than in the Ostrich. The canal for the spinal chord is, in fact, singularly small in proportion to the bulk of the entire vertebra in *Dinornis* as compared with that in the Ostrich or other birds, and forms, as has been pointed out at p. 99, one of the peculiarities of the large wingless birds of New Zealand. The cervical vertebra, for example, with a spinal canal six and a half lines wide, has a body of four inches in length; whilst that of the Ostrich with a spinal canal five lines in diameter has a body only two and a quarter inches in length; and the dorsal vertebra presents similar relations.

Lower jaw.—An almost entire lower jaw of a *Dinornis* or *Palapteryx*, of rather smaller size than the one of which a large portion is figured in Pl. XLV. figs. 6, 7, closely accords with that portion as far as they can be compared: the symphysial end of the jaw is rounded and short, and impressed below by two parallel longitudinal grooves, *sg*. Each ramus is slightly bent in a sigmoid flexure, concave below at the anterior half, convex at the posterior one. The alveolar border is pierced by vascular grooves and foramina at its anterior part, and obliquely levelled off to an edge behind. There is neither coronoid process nor vacuity in the ramus of the jaw, but only a deep longitudinal groove half an inch long, between the originally distinct 'angular' and 'surangular' pieces, which groove is completely closed up on the inner side by the splenial piece: in this respect the present lower jaw differs from that portion of a very large one ascribed to the *Dinornis* in a preceding Memoir, p. 171, Pl. XLIII. figs. 1 & 2.

The principal articular cavity is the large and deep one that occupies the major part of the expansion at the articular end of the ramus: the second surface for the tympanic is a very narrow strip along the outer border of the expansion, which slightly overhangs that part of the ramus. The angle of the jaw is obtuse. From the proportions of this lower jaw it appears that the ramus, as restored in fig. 1. Pl. XLV., is about half an inch too long, and the whole beak of the *Palapteryx* thus figured must be shortened to that extent.

Humerus.—As the number of importations of the remains of the large wingless birds of New Zealand has progressively increased, the argument deduced from the absence of any bones of the anterior extremity in the first large collection transmitted by the Very Rev. Wm. Williams, has been gaining cumulative force, in proof of the extremely insignificant size of those bones. But, in the collection of remains last transmitted to me by Governor Grey, I found a fragment of a long bone, which I believe to be the proximal half of the humerus. It is three inches and a quarter in length, with an enlarged oblong-ovate, convex articular end; the shaft, at first three-sided, takes an oval transverse section as it recedes, diminishing from the head, and shows a slight ridge on one side, and a rough surface on the opposite for the attachment of small antagonizing muscles. The only other bone in the *Dinornis* with which it is comparable is the fibula; but, in the present specimen, the head is too convex, and has not the lateral concave articular surface which this fibula shows for the tibia. This small humerus may belong to a large species of *Dinornis* or *Palapteryx*; but to whatever sized species it did belong, it is as devoid of those muscular crests and tuberosities indicative of powers of flight, as the humerus of the *Apteryx* is.

A cranium of the *Notornis* in the collection transmitted by Governor Grey exhibits the frontal portion which was deficient in the specimen described at p. 136 in a previous Memoir, in which that genus and its affinities were defined.

The postfrontal processes equally divide the upper region of the skull from the superoccipital ridge to the naso-premaxillary groove: that region is moderately convex: the superorbital ridge is of about the same extent as the temporal ridge; it is somewhat irregular, is grooved posteriorly, and terminates anteriorly in very short antorbital processes directed forwards. The coalesced frontals terminate anteriorly in a moderately thick straight transverse border of nine lines' extent, overhanging the flat smooth platform formed by the coalesced prefrontals: from the outer border of this platform, a bony plate descends and blends with the interorbital septum, half-way down, leaving an interval between the septum and the upper part of the plate, through which the olfactory nerves were continued. The posterior turbinals were attached to the fore-part of these descending plates. The interorbital septum is perforated anterior to the common outlet of the optic nerves, is deeply grooved at its upper part by the olfactory nerves, and is formed below by the presphenoidal prolongation.

In all other respects in which a comparison can be instituted with the less complete cranium of the *Notornis* described in a previous Memoir, the present specimen agrees with it: the part conjecturally restored in Pl. XLVIII. is shown by the present specimen to be correct as to extent.

The number of skulls of full-grown large terrestrial birds of New Zealand that have now been described, clearly indicate at least four species, independently of the one with the remarkable occiput, referred to *Dinornis* proper at p. 154, but more probably belonging to *Aptornis*, and also of that on which the genus *Notornis* was founded. The rich development of the wingless family of birds, not in individual magnitude only, but in the number of species, thus progressively receives additional illustration. Owing, however, to the remains of these great birds reaching England for the most part in a detached or disconnected state,- few portions of the skeleton of one and the same bird having yet been discovered in juxtaposition, or so transmitted to this country, and not any specimen, so far as I can learn, having been found with the head,—the skull can only be restored to the other parts of the skeleton of species already described, conjecturally; and much remains to be done before such conjectures can acquire a degree of certainty. That, however, which is mainly necessary to be done, is to record with accuracy and depict with fidelity the several materials for the reconstruction of these apparently extinct species of large wingless birds as they from time to time reach this country: and the desired result will without doubt in time be gained.

DESCRIPTION OF THE PLATES.

PLATE LII.

Fig. 1. Upper view of the cranium of a large species of *Dinornis* (?).

Fig. 2. Side view of ditto.

Fig. 3. Under view of the premaxillary bone of the same cranium.

PLATE LIII.

Fig. 1. Back view of the mutilated cranium of the young of the *Dinornis giganteus* (?).

Fig. 2. Upper view of ditto.

Fig. 3. Front view of ditto, from which the frontal bones have been separated at the coronal suture.

Fig. 4. Moiety of a vertically and longitudinally bisected cranium of a *Palapteryx* (?).

a, Internal auditory foramina.

v, Foramen for the nervus vagus and a vein.

tr, Foramen for the third division of the trigeminal nerve.

c, Cerebellar fossa.

All these letters are in the epencephalic compartment of the cranium.

o, Mesencephalic compartment lodging the optic lobes: and below these the third ventricle and its hypophysis.

p, The prosencephalic compartment.

(18), Olfactory chamber.

Fig. 5. Side view of the cranium of a *Palapteryx* (?).

Fig. 6. Base view of the cranium of another species of *Palapteryx*.

The letters and figures are explained in the text (pp. 205–213).

MEMOIR

ON THE

BONES OF THE LEG OF

DINORNIS STRUTHIOÏDES

AND

DINORNIS GRACILIS.

IN the Memoir on the genus *Dinornis*, I described (pp. 85–90) two femora of birds from tertiary deposits in New Zealand, agreeing in size with that bone in the Ostrich, and referred them to a species called *Dinornis struthioides*; one of these specimens however consisted only of the shaft; the other and more perfect specimen, figured in Pl. XXI. fig. 3, was mutilated at both its extremities. I have since received, through the kindness of the Rev. Mr. Colenso, M.A.[1], and the Rev. William Cotton, M.A., three entire specimens of femora, ranging between 11 and 12 inches in length, and the shaft of a fourth femur of the *Din. struthioides*, confirming very satisfactorily that species, and completing our knowledge of the anatomical characters of the bone.

The head (Pl. LIV. fig. 2) is rather more than a hemisphere, more prominent than in the Ostrich, and with a smaller proportion cut off, as it were, from the upper and outer part, and roughened for the attachment of the strong 'ligamentum rotundum.' From the upper part of the base of the head, an almost flat, slightly concave, surface ascends, expanding, as it rises, to the broad semicircular ridge which crowns the great trochanter. In the Ostrich that process does not rise above the level of the head of the bone. In the *Din. struthioides* the upper trochanterian platform is broader proportionally than in the *Din. casuarinus*[2]. The anterior surface of the trochanter is also extensive through the continuation outwards of the great process: it is slightly

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[1] The specimen contributed by this gentleman is cited in the table of admeasurements, p. 137.

[2] Pl. XXXVIII. fig. 2.

concave, sculptured by muscular impressions with intervening ridges, and by a defined oval rough tract between the head and the base of the trochanter. The outer convex expanded surface of the trochanter is more strongly marked by the insertions of powerful tendons, surrounding an irregular smooth tract near the centre of the surface. The back part of the upper end of the femur in two of the specimens presents two or three small holes leading into the superficial cancelli, by which it is possible a little air may have been admitted into these cavities; but this is a very feeble representation of the wide orifice and canal at the same part of the Ostrich's femur which conducts directly to the large air-cavity in the body of that bone.

The shaft of the entire femur of the *Din. struthioides* repeats the characters described and figured in the memoir above cited. The fore part of the external condyle begins to rise from the level of the shaft, about one-third from the distal end of the bone, and bends outwards, forwards and downwards, increasing in breadth and convexity, and forming the outer boundary of the characteristic broad rotular surface. The convex fore part of the inner condyle forming the inner boundary of that surface is shorter, and rises more abruptly. The deep oval fossa, above the vertical broad groove for the fibula, behind the outer condyle, is well-marked. The orifice of the medullary artery is at the middle of the back part of the shaft of the femur in two of the specimens.

With regard to the metatarsus of the *Dinornis struthioides*, the same satisfactory confirmation of the species has been received, as in the case of the femur, by the addition of three specimens repeating the characters of the original bone described at p. 81, and figured in Pl. XXVII. fig. 2. One of these specimens, kindly sent to me by J. R. Gowen, Esq., F.G.S., Sec. H.S., was discovered in the tertiary deposits at Waikawaite, Middle Island of New Zealand, and has the two extremities more entire than in the original specimen figured. The middle of the distal trochlea is impressed by a shallow groove running its whole length, and becoming more shallow as it approaches the contracted back part of the trochlea, which terminates abruptly, projecting beyond the level of the back part of the distal end of the bone.

A second of the additional specimens of the metatarsus of the *Din. struthioides* was obtained by the Rev. Wm. Cotton, M.A., at Tarawaite, in the North Island of New Zealand: a third specimen (Pl. LIV. fig. 4) was discovered by Governor Sir George Grey, C.B., in a cave in the district which lies between the river Waikate and Mount Tongariro, in the North Island.

From the same cave Sir George Grey likewise obtained and very liberally transmitted to me, with a most valuable collection of other bones of *Dinornis* and *Palapteryx*, an entire tibia (Pl. LV. fig. 2) agreeing with the portion of shaft, which, from the dimensions given in p. 137, I was induced to refer to the *Dinornis struthioides*, since it differed in its size and proportions from all the tibiæ previously described and referred to other species, but presented similar relations of size to the femur and metatarsus of the *Din. struthioides*, which the previously described tibiæ have presented to the other bones of the leg of the respective species to which those tibiæ have been referred.

I conclude, therefore, that in the tibia transmitted with the metatarsus of the *Din. struthioides* by Sir George Grey, I possess the bone, which I have been so long desirous to obtain in order to complete the leg of the *Din. struthioides.* Like the metatarsus above-cited, it is from the left side, and they appear to have belonged to the same individual bird.

	in.	lin.
The length of this bone is	22	0
The breadth of the proximal extremity . .	5	6
The breadth of the distal extremity	3	2
The circumference of the middle of the shaft .	5	0
The fibular ridge extends down	10	0

This ridge begins, as in the tibiæ of other species of *Dinornis,* below the expanded end of the tibia near the middle of its back part, inclining to its outer side.

In its slender proportions, and the relative positions of the procnemial (*p*) and ectocnemial (*e*) ridges, the tibia of the *Dinornis struthioides* agrees with that of the *D. dromioides.*

Description of the Bones of the Leg of the Dinornis gracilis.

The advantage of additional specimens, as confirming, by the repetition of the same characters, a species previously defined, is still greater in respect of the ground which they afford for the discrimination of a distinct but nearly allied species. Notwithstanding the well-marked differences observable between the femur of the *Dinornis struthioides* (Pl. LIV. fig. 2) and the *Dinornis gracilis* (*ibid.* fig. 1), I might have deemed them due to differences of sex or individuals, had I not had evidence of the fixity of the specific characters of the *Dinornis struthioides* by the successive arrivals of additional specimens of its bones. Attending the hoped-for confirmation from such arrivals, it appeared to be most prudent to refrain from announcing a new species of the rapidly increasing family of the great wingless birds of New Zealand until further evidence might be obtained by corresponding differences in the tibiæ and metatarsi of the two species.

Having had the good fortune at length to receive, through the kind contributions of the Rev. Richard Taylor, M.A., of Wanganui, and of W. E. Cormack, Esq., of Auckland, New Zealand, these additional illustrations of the *Din. gracilis,* I no longer delay the publication of descriptions and figures of them.

Femur.

The bone (Pl. LIV. fig. 1) was obtained at the Bay of Opito, East Coast of the North Island, from beneath a sandy deposit, about three feet below the surface, by Mr. Cormack.

The following are the chief dimensions of this bone :—

	in.	lin.
Length	11	0
Breadth of proximal end in the axis of the neck .	3	8
Transverse breadth of distal end	4	0
Circumference of middle of shaft	4	8

A small portion of the upper ridge of the great trochanter has been broken off: when entire, the femur of the *Din. gracilis* presents the average length of that of the *Din. struthioides*; but it is more slender in proportion, the head is smaller, and is supported by a better marked constriction or neck, especially at its under part. The upper platform of the trochanter is narrower, the anterior border of the trochanter not being extended so far forwards and outwards. The angle between the upper and fore surfaces of the trochanter is a right one, and they meet at a sharp ridge. The rough oval surface between the head of the femur and the base of the trochanter is smaller than that of the *Din. struthioides.* The outer irregular surface of the trochanter is of much less breadth in the *Din. gracilis.* The muscular impressions at the sides of the shaft meet and form a longitudinal ridge along the back part of the middle third of the shaft: they are separated by a tract of half an inch in the *Dinornis struthioides*, and terminate below in two tuberosities. The corresponding ridge formed by the meeting of the vasti-muscles along the fore part of the shaft is shorter in *Din. gracilis* than in *Din. struthioides.*

The most marked distinction, however, is presented by the distal extremity of the bone, which is not only relatively less expanded in the *Din. gracilis*, but the rotular groove is narrower, and is bounded laterally by condyloid eminences of more nearly equal length; the external one not rising so high up, nor describing the sigmoid curve in descending, as in the *Din. struthioides.* The rotular groove in the *Din. gracilis* is impressed by a transversely oval rough depression, at its upper part, with sharp lateral borders, which depression does not appear in any of the femora of the *Din. struthioides.* The popliteal space is triangular and better defined in the *Din. gracilis*; the fibular groove is shorter and less angular, and the rough deep pit above it is smaller. The tibial surface on the inner condyle is relatively smaller.

Tibia.

The same character is repeated on the proximal end of this bone, where the surface applied to the inner condyle is absolutely smaller than in the *Din. struthioides*, although the entire bone, as shown in the subjoined admeasurements, is longer in the *Din. gracilis*: it is also, as the name of the species implies, more slender in proportion to its length.

This bone (Pl. LV. fig. 1) was obtained from beneath a sandy deposit, about two feet below the surface, at a locality between Wanganui and Turakina, North Island of New Zealand, by the Rev. Mr. Taylor.

	D. gracilis. in.	lin.
The entire length of the bone is	23	6
The transverse breadth of its proximal end . .	5	0
The transverse breadth of its distal end . . .	2	10
The circumference of the middle of the shaft . .	4	6
The fibular ridge extends down the shaft . . .	9	6

But this ridge commences nearly three inches below the back part of the proximal end of the bone, nearer the outer side than in the *D. struthioides*: it is interrupted by an oblique smooth tract at the point indicated in the admeasurement, where the medullary artery penetrates the bone; it then reappears about an inch and a half below the interruption, and soon gradually subsides. This second lower part of a fibular ridge is better marked than in the *Din. struthioides.* The relative size and position of the procnemial, *p*, and ectocnemial, *e*, ridges are much the same as in the tibia of the *Din. struthioides* and *Din. dromioides.*

Metatarsus (Pl. LIV. fig. 3).

The difference between the *Din. struthioides* and the *Din. gracilis* is more obvious at first glance in a comparison of their metatarsi than in that of the above-described bones; especially to an eye accustomed to the comparison of the metatarsi of the different species. The superior length and slenderness of that bone in the *Din. gracilis* would at once prevent its being confounded with the metatarsus of the *Din. struthioides.*

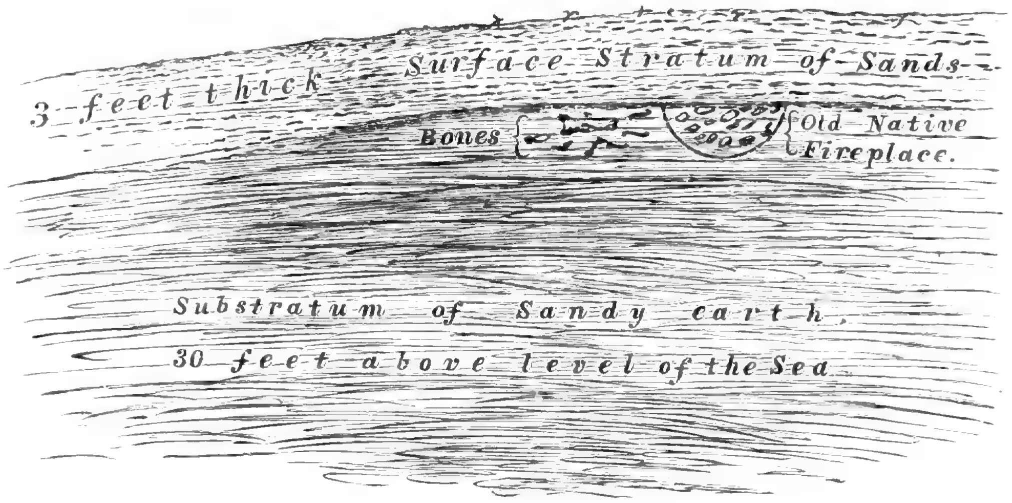
The following are the chief dimensions of the bone in question: those of the extremities being approximative by reason of their worn margins:—

	D. gracilis. in.	lin.
Length of the tarso-metatarsus	13	0
Circumference at the middle of the shaft . . .	4	3
Transverse breadth of proximal end	3	4
Transverse breadth of the distal end	4	3
Breadth of the middle of the shaft	1	7
Thickness or antero-posterior diameter of ditto .	1	2

The depressed surface for the back toe is better marked than in the *Din. struthioides.*

Subjoined is the "Note on the locality" affording the femur of the *Dinornis gracilis*, kindly contributed by W. E. Cormack, Esq.; with a sketch of the section of the strata, of which a woodcut is here given.

"The bone" (Pl. LIV. fig. 1) "of the *Dinornis* now presented to Professor Owen was found in the north part of the North Island of New Zealand, in the month of January 1849. Its *locality* was in a small bay called 'Opito,' at the east extremity of the projecting land between Mercury Bay and Wangapoua, on the east coast, in about the latitude of 36° 40′ S., and fifty miles east from Auckland. The bay is about a mile in length, northerly and southerly, by about half a mile in depth, with high bluff heads or rocky cliffs projecting at each extremity; the semicircular sandy beach inside forming the bay. An irregular strip of low land lies inside of the beach, in some parts fertile, in other parts consisting of downs, and is overlooked in the rear by round hills of from 100 to 300 feet in height. The hills are composed of yellow-white and red burnt earth; very barren, producing stunted fern, and a solitary bush or scrubby tree here and there. Towards the north end of the bay a small brook discharges itself, from a swamp at the foot of the hills in the rear: and at the mouth of the brook a short range of downs runs along the beach to the southward, presenting a line of earthy cliffs, wasting away and forming the shore as they fall down by the washing of the sea at the foot. These cliffs are about from twenty-five to thirty feet in height, and nearly perpendicular. The upper stratum of the cliffs is formed of sand, and is about three feet in thickness, producing the usual arenaceous shrubs, grasses, &c. Underneath, the line of demarcation being very distinct, is a thick stratum or bed of sandy earth, sand predominating: out of this substratum, about fifty or sixty yards south of the mouth of the brook, the *Moa's* bones were exposed, projecting, in consequence of a late falling away of that part of the cliff in which they were imbedded: they lay a foot or more beneath the upper surface of the substratum. At the same spot there was a '*kapura maori*,' or *native cooking fireplace*, dug into the surface of the substratum, and full of stones that



had been once heated (to convey the heat to the food laid upon them),—and left, just as similar cooking-places are left at the present day by the natives;—about two feet from which lay the bones. Close to the fireplace, and similarly imbedded, were bones of smaller birds, and of fishes similar to those found at present in the sea adjacent; all, including those of the *Moa*, having been evidently the remains of the food cooked here at a former period and eaten, as my native attendant remarked, by the then native inhabitants. A part of a leg bone, about two feet in length, apparently belonging to the same leg as this femur[1],—the bone having been broken near the middle (probably in order to be placed more conveniently over the fireplace), was also found close to the femur.

"The antiquity of these remains can only be arrived at by inference. How long it is since the superficial stratum of sand now exhibited at the top of the cliffs overlooking the sea, was formed by water and winds, is a matter of induction for the geologist. The sea is now undoing, and claiming the privilege of, former lacustrine or marine deposits. It would not be difficult to compute, with some shadow of approximation, the time required for the inroad of the ocean into strata of the nature of those described, supposing them to have extended from the summit of the cliffs to the ocean half a mile distant, along a line between the two heads or extremities of the bay: but that period would be conjectural only; for there are rocks, islets, and islands succeeding each other—mile beyond mile,—extending into the surrounding ocean, all of which are, by marine inroad, vestiges only of former rock-formations. Man and the *Moa*, however, were coeval at man's cooking fireplace upon this substratum.

"The mother ocean is altering, in some places very rapidly, the configuration of the coast of New Zealand. It is consuming some parts, and forming others by deposits; and again removing former deposits. In a general view, many parts of the east coast of the North Island are being disintegrated, not to reappear above water for many ages; while on the west coast, downs are not only being formed, stretching into the sea, but superimposing themselves—inland—in some places.

"These shiftings of the outline of the earth's crust are not limited to the sea-coast: for in the interior are many partial and violent settlings of the earth, evidently from earthquakes; submerging, in some instances many feet under the surface of fresh-water lakes, land with the natives' houses, fences, &c. upon it. This has happened in regard to the lake situated some miles from the east bank of the River Waipa, and south-eastwardly from the ruins of the famous sacked Pa (town) called 'Matakitaki.'

"W. E. Cormack,
6, Percy Street, 22nd October, 1850."

"*To Professor Owen,*
Royal College of Surgeons, London."

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[1] It accords with the size of the tibia of the *Dinornis gracilis*.—R. O.

DESCRIPTION OF THE PLATES.

PLATE LIV.

Fig. 1. Front view of the femur of the *Dinornis gracilis.*
Fig. 2. Front view of the femur of the *Dinornis struthioides.*
Fig. 3. Front view of the metatarsus of the *Dinornis gracilis.*
Fig. 4. Front view of the metatarsus of the *Dinornis struthioides.*

PLATE LV.

Fig. 1. Front view of the tibia of the *Dinornis gracilis.*
Fig. 2. Front view of the tibia of the *Dinornis struthioides.*
p. Procnemial ridge. *e.* Ectocnemial ridge.

(All the figures are of the natural size.)

MEMOIR

ON THE

DINORNIS ELEPHANTOPUS.

Mr. Walter Mantell on his return from New Zealand in March 1856, provisionally deposited his very extensive collection of remains of Dinornithic and other Birds, there obtained, in the British Museum, and I gladly acceded to the wishes of that successful and enterprising collector, to devote the leisure at my command to the examination of this interesting and valuable collection. This was shortly after purchased by the Trustees of the British Museum, on my recommendation: the entire skeleton of the species which forms the subject of the present memoir, and which I propose to call *Dinornis elephantopus*, was thereupon recomposed and articulated, and it is now exhibited in the Gallery of Fossil Remains.

In the arrangement of Mr. Mantell's collection, I had advanced as far as the determination of the bones of the leg, and their classification according to their species, when the distinctive characters of one series of these bones irresistibly brought a conviction that they belonged to a species of *Dinornis* that had not previously come under my notice,—a species which, for the massive strength of the limbs, and the general proportions of breadth or bulk to height of body, must have been the most extraordinary of all the previously restored wingless birds of New Zealand, and unmatched, probably, by any known recent or extinct member of the class of Birds.

On a former occasion, I was so much struck by the form and proportions of the metatarsal bone which is referred to the species called *Dinornis crassus*, described at p. 133, and figured in pl. xl. fig. 4, that I alluded to it as "representing the pachydermal type and proportions in the feathered class;" and the bone unquestionably indicated, at the date of that memoir, "the strongest and most robust of birds." But by the side of the metatarsus of the species which is here described, and for which I propose the name of *elephantopus*, the metatarsus of *Dinornis crassus* shrinks to moderate if not slender dimensions. But the peculiarities of the elephant-footed Dinornis stand out still more conspicuously when the bones of its lower limbs are contrasted with those of *Dinornis giganteus*.

I propose, to commence the present Memoir, with the account of the leg- and foot-bones of *Dinornis elephantopus*, to combine with it a notice of the bones of the lower limb of *Dinornis crassus* which have not previously been described, and to bring out the characteristics of both by comparison with the bones of other species, especially those of *Dinornis robustus*.

Femur of Dinornis elephantopus.

Commencing with the femur, I shall premise the following Table of admeasurements of that bone in the three above-named species of *Dinornis*.

Dimensions of the Femur in

	D. robustus.		*D. elephantopus.*		*D. crassus.*	
	in.	lines.	in.	lines.	in.	lines.
Length	14	2	13	0	11	10
Transverse breadth of proximal end	6	0	5	10	4	5
Fore-and-aft breadth of ditto	5	0	4	5	3	9
Transverse breadth of distal end	6	0	5	11	4	7
Fore-and-aft breadth of ditto	4	3	3	9	3	5
Circumference (least) of shaft	7	10	7	9	6	0

The above comparative dimensions exemplify the characteristic proportions of the femur of *Dinornis elephantopus* (Pl. LVI. fig. 1), as shown by its greater thickness and strength. Compared with the femur of *Din. robustus*, this character is remarkably exemplified in the articular extremities (Pl. LVI. figs. 2 & 3). Had these parts alone of *Din. elephantopus* been preserved and submitted to me, I should have scarcely ventured upon a conclusion as to their specific distinction from *D. giganteus*, or its representative on the Middle Island, *D. robustus*, the correspondence of configuration being so close and the difference of size so slight.

The articular surface is continued from the head upon the upper part of the neck (Pl. LVI. fig. 2), expanding as it approaches the great trochanter, along the summit of which it is terminated by a ridge. In both species the surface for attachment of the ligamentum teres is formed, as it were, by a portion of the inner and back part of the hemispheric head, having been cut off obliquely with a slight excavation. The corresponding ligamentous surface in the head of the femur of *Din. crassus* is relatively smaller, less depressed and less defined. The upper and fore part of the trochanter is less produced relatively to the breadth of the supra-trochanterian articular surface in *Dinornis elephantopus*. In this species the subcircular rough surface for the attachment of the *iliacus internus* muscle (fig. 1, *i*) is relatively nearer to the head of the bone than in *Dinornis robustus*: the rugged and thick fore part of the great trochanter descends lower upon the shaft; indeed the shortness of the entire bone seems to depend chiefly on the shaft being relatively shorter in *Din. elephantopus* than in *D. giganteus* or *robustus*. The intermuscular ridge continued from the trochanterian one down the fore part of the shaft bifurcates sooner in *Din. elephantopus*. The depression behind the trochanterian ridge is less deep in *Din. elephantopus*.

The oblique rotular channel is relatively as wide and deep as in *Din. robustus*, but the inner boundary formed by the fore part of the inner condyle is shorter in *Din. elephantopus*. At the back part of the shaft of the femur the medullo-arterial foramen is relatively nearer the proximal end of the bone: the two tuberosities below this are closer together: the two sides (fig. 3, *s* & *t*) of the fibular groove (fig. 3, *r*) are at a more open angle, and the groove is less deep in *Dinornis elephantopus*, the outer side, *t*, being less produced, as compared with *Din. robustus*. The antero-posterior breadth of the outer and inner condyles is equal in *Din. elephantopus*, as it is in *Din. robustus*; but in *Din. crassus* that dimension of the outer condyle exceeds the same dimension in the inner one, and the fibular groove is more open or shallow than in *Din. elephantopus*.

The generic modifications of the femur are, however, very closely preserved in each species, being strictly of the type ascribed to the genus *Dinornis* in p. 85.

Tibia of Dinornis elephantopus.

Dimensions of the Tibia in

	D. robustus.			*D. elephantopus.*			*D. crassus.*		
	feet.	in.	lines.	feet.	in.	lines.	feet.	in.	lines.
Length	2	8	3	2 1	0 9	0 6[1]	1 1	7 6	6[1] 6
Transverse breadth of proximal end	0	7	6	0 0	7 7	5[1] 0	0	6	2
Fore-and-aft breadth of ditto	0	4	9	0 0	4 4	6[1] 3	0	3	6
Least circumference of shaft	0	6	9	0	6	5	0	4	10
Transverse breadth of distal end	0	4	4	0 0	4 4	2 0	0	3	3

The characters of the upper end of the tibia of *Dinornis elephantopus* (Pl. LVI. fig. 5) closely accord with those of the *Din. robustus*, and the difference of size, as exemplified in the foregoing Table, is so slight, that, had this extremity only of the bone reached me, I should most probably have referred it to *Din. robustus*. The almost flat articular surface for the inner condyle of the femur is somewhat less in its shorter diameter: the epicnemial ridge, *k*, is less extended transversely: the ectocnemial ridge, *e*, curves more strongly outward: but there are individual varieties in all these characters in the tibiæ before me. All, however, differ in the earlier subsidence of the ridge continued downward from the procnemial plate, *p*, which ridge is continued in *Dinornis robustus* uninterruptedly to that above the inner division of the distal trochlea. The space between the ecto- and pro-cnemial plates in *Dinornis crassus* is relatively greater than in either of the above larger species: the ridge continued from the procnemial plate is interrupted as in *Din. elephantopus*. The concave fore part of the tibia between the ectocnemial, *e*, and procnemial, *p*, ridges is impressed by irregular vascular grooves. The fibular ridge is interrupted by a smooth tract, in or near which is the orifice of the canal for the obliquely descending medullary artery, in all the

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[1] The extremes of size in a series of several bones are here given.

species of *Dinornis*. The upper division of the ridge is shorter in *Dinornis elephantopus* than in *Din. robustus*, and relatively shorter than in *Din. crassus*. The surface between the fibular ridge and the inner border of the shaft, at the back part, is concave transversely in *Din. elephantopus*, not merely flat as in *Din. robustus* and *Din. crassus;* and, as it descends, it continues longer a flat surface before it changes gradually to a convex one. The oblong rough insertional surface above the inner condyle is relatively shorter and better defined in *Din. elephantopus* than in *Din. robustus*. On the characteristic fore part of the lower end of the tibia, that bone in *Din. elephantopus* repeats all the modifications ascribed to the genus *Dinornis* in my Memoir on the *Gastornis*, or large fossil bird from the Paris eocene[1].

The tendinal canal inclines obliquely inward, parallel with the inner border of the expanding end, near which it is placed (Pl. LVI. fig. 4, *f*) : the bony bridge spans across it from a flattened tubercle developed from the lower part of the outer pier. The outlet of the canal is as wide as in *Din. robustus*; its aspect is obliquely forward and downward. External to the tubercle is an oblique rough depression, relatively narrower and better defined than in *Dinornis robustus*. The inner condyle, *a*, is relatively narrower and more produced forward than in *Din. robustus*, resembling more the proportions of that part in *Din. crassus*. The general form and oblique direction of the wide distal trochlear articulation of the tibia are closely repeated in all the species; the concavity being rather more sharply defined behind in *Din. elephantopus* than in *Din. robustus*. The depression on the entocondyloid surface is less deep in *Din. elephantopus* than in the *Din. robustus*.

The above specific differences, as well as all that I have noticed in the tibiæ of other species of *Dinornis*, are so inferior in degree to those which I have found in closely allied genera, and even in different species of the same genus, of other large land- and wading-birds, as *e. g.* in species of *Ciconia*, and in the existing Struthious genera, as to leave a strong impression on my mind of the generic affinity of the species of wingless birds of New Zealand which I have referred to *Dinornis* and *Palapteryx*, and which species have been divided, with a more liberal imposition of terms, by Dr. Reichenbach, into the nominal genera *Anomalopteryx, Movia, Emeus, Syornis*, &c.; no other facts or characters being assigned for that multiplication of generic names than those which are to be found in the pages or plates of the Memoirs contributed by me to the Zoological Transactions.

Fibula of Dinornis elephantopus.

The fibula o *Dinornis elephantopus* remains, as in other *Dinornithes*, and as in the existing Struthious genera, permanently distinct from the tibia. As a general rule in Birds, the fibula soon becomes anchylosed to the tibia. In the species now defined, it is a straight styliform bone, 14 inches 6 lines in length (Pl. LVI. fig. 6). The head is

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[1] Quarterly Journal of the Geological Society, 1856, vol. xii. p. 210. pl. 3. fig. 2

subcompressed and produced, as if slightly bent, backward. The upper articular surface is convex from before backward, almost flat transversely. The head of the bone is flattened on the inner side; almost flat, but a little convex, on the outer side: the fore-and-aft dimension of this end of the bone is 2 inches 9 lines; the transverse diameter is 1 inch 3 lines. Below the head the bone assumes a trihedral form with the sides convex, gradually tapering and blending into a shape which is elliptic in transverse section, and ending in a point about 9 inches above the ankle-joint. The outer surface of the shaft of the fibula is impressed by two oblong rough surfaces for the insertion of muscles, the upper one 2 inches 9 lines in length. The inner part, which is ridge-like, dividing the fore from the back surface of the bone, presents a rough surface, *r*, *r'*, with a median interruption, for the ligamentous attachment of the bone to the fibular ridge of the tibia.

Metatarsus of Dinornis elephantopus.

Comparative dimensions of the Metatarse of

	D.giganteus[1].		*D.robustus*[2].		*D.elephantopus*[3].		*D.crassus*.	
	in.	lines.	in.	lines.	in.	lines.	in.	lines.
Length	18	6	15	9	9	3	8	8
Transverse breadth of proximal end	4	3	4	6	4	5	3	3
Ditto ditto distal end	5	4	5	3	5	4	3	9
Least ditto of shaft	2	3	2	0	2	5	1	9
Fore-and-aft breadth of proximal end	3	2	3	2	2	10	2	5
Circumference of ditto.	12	0	12	9	12	0	9	3
Least circumference of shaft	6	3	5	3	6	6	4	6
Breadth of middle trochlea	1	10	2	3	2	2	1	8
Length, following the curve	5	9	5	4	5	3	4	0

I had, hitherto, regarded the metatarse of *Dinornis crassus*, described and figured at p. 137, in Pl. XL. figs. 4 & 5, as presenting the most extraordinary form and proportions of all the restored species of huge wingless birds of New Zealand; but it is strikingly surpassed in robustness and in great relative breadth and thickness by the same bone of the present species (Pl. LVII. fig. 1), which chiefly on that account I have proposed to name *elephantopus*. Only in the great Maccaws and Penguins do the proportions of the metatarsus resemble those in this most robust-legged of birds; but the Parrot-tribe present those peculiar modifications of the distal trochleæ, with the strong articulation for the back toe, which relate to the Scansorial modifications of the bird's foot; and the Penguins associate with their broad and short metatarsus a characteristic retention of much of the primitive separation of the three constituent bones. In *Dinornis elephantopus* these elements have become as completely coalesced as in any other species, and the general characters of both proximal and distal ends accord with those in previously described species. On a more special comparison of the metatarse of *Dinornis elephantopus* with that of its nearest congener

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[1] Plate XXVII, fig. 1. [2] Plate XLIX. [3] Plate LVII.

the *Dinornis crassus*, the following differences present themselves. The entocondyloid depression (fig. 2, *e*) is deeper, its fore-and-aft diameter is greater, and its transverse diameter less, than in the ectocondyloid one, *c*; but the breadth of the entocondyloid depression is relatively greater and its depth somewhat less in *Dinornis elephantopus* than in *Dinornis crassus*.

The transverse convexity dividing the two condyloid depressions is relatively broader in *Dinornis elephantopus*; and the rough surface external to the anterior intercondyloid prominence is more strongly marked.

The two calcaneal ridges present an equal prominence in *Dinornis elephantopus*: the ectocalcaneal one, *c e*, is the most prominent in *Dinornis crassus*.

The anterior surface of the metatarsus differs chiefly in the proportions indicated in the "Table of admeasurements," p. 227, from that in *Dinornis crassus*: like most of the metatarsi of that species, one or more vascular foramina occur above the subcircular rough surface of insertion of the *flexor pedis*, which occupies the lower part of the shallow depression on the upper and fore part of the shaft.

Along the lower half of the shaft the median longitudinal and progressively widening prominence, due to the middle of the coalesced metatarsal bones, is rather more marked than in *Dinornis crassus*.

The inner side of the shaft is marked at its upper half by the oblique rough tract indicative of the insertion of the powerful aponeurosis of the gastrocnemial muscles. At the back surface the upper part of the mesometatarse is relatively less prominent than in *Dinornis crassus*.

The two vascular foramina occupy corresponding relative positions. All other notable differences are those of size and proportion.

From the metatarsus of *Dinornis robustus* that of the *Dinornis elephantopus* differs, most strikingly, in its proportions of length to breadth, being little more than half the length, but of nearly equal breadth; the distal trochleæ, however, being relatively less expanded than in *Dinornis robustus*.

The anterior vascular perforation is less than in *Dinornis robustus*: the insertional roughness for the *tibialis anticus* below the foramen is of equal size. The upper half of the fore part of the metatarsus is longitudinally channeled in *Din. robustus*, not in *Din. elephantopus*. The corresponding part of the back part of the shaft is much more prominent in *Dinornis robustus*. The characteristics of the metatarsus of *Dinornis elephantopus* are more strongly manifested in the comparison with that of *Dinornis giganteus*, Pl. XXVII., of which bone it has only half the length, other dimensions being equal or even greater in *Din. elephantopus*.

Of the depression,—which is very faint in *Dinornis robustus*,—for the ligamentous attachment of the rudimental back toe, there is no trace in the metatarse of *Dinornis elephantopus*.

The form of the articular pulleys for the three toes is shown in Pl. LVII. fig. 3.

Toe-phalanges of Dinornis elephantopus.

The bones of the foot I shall compare with those of *Dinornis robustus*, Pl. XLIX., to which they make the nearest approach in size.

Equalling, or nearly equalling, the phalanges of that bird in breadth and thickness, they differ chiefly in shortness, but in a less degree than the metatarsi differ.

These proportional characters of the species are best given and easiest appreciated in the plates (compare the above-cited Pl. XLIX. with Pl. LVII.). A few minor differences, however, may be noticed: the outer portion of the proximal end of the first phalanx of the inner toe, I, II., is broader in proportion to its fore-and-aft diameter in *Dinornis elephantopus*. The inner portion of the proximal end of the first phalanx of the outer toe, I, IV., presents the like difference: the general form of that articular surface, fig. 3, II. & IV., is less triangular and more oval in both the specified phalanges of *Dinornis elephantopus*; the under side being indented as usual in the proximal phalanges of the inner and outer toes.

The modifications in the other phalanges, besides those of size and proportion, are not greater or other than might be expected in different species of the same genus.

Of the very remarkable species of *Dinornis* based upon the powerfully developed limbs, the bones of which are described in the foregoing pages, Mr. Mantell's collection includes five right and eight left femora, three right and four left tibiæ, nine right and fourteen left fibulæ, three right and eight left metatarsi; together with a considerable collection of toe-bones, from which, probably, other entire feet might be reconstructed in addition to the one of the left foot figured in Plate LVII.

There are also two femora and two metatarsi of an immature bird, apparently, by their proportions, from one individual of *Dinornis elephantopus*, Pl. LVIII. fig. 1; to which may also belong the proximal end of a tibia, wanting the articular epiphysis.

The femora, as in other birds, retain the two articular ends, which are simply rougher than in the adult, having been covered by a thicker cartilage; but are not developed upon distinct osseous pieces, as in land mammals.

The proximal epiphysis is wanting in both the immature metatarsi, the left of which is figured in Pl. LVIII. fig. 1, so that they exhibit the separate expanded ends of the three constituent bones, as shown in fig. 1, *a*; which bones terminate in the three prominent trochleæ below. The length of the femur of this young bird is 11 inches, that of the metatarse 7½ inches. They already present the characteristic robustness of the adult bird.

In attempting the reconstruction of the entire skeleton of the *Dinornis elephantopus*, after the structure of the leg and foot had yielded the grounds for determining the species, my first step was the classification of the vertebræ.

Of these bones several hundreds had been collected by Mr. Commissioner Mantell at the spot where the bones of the leg had been found (p. 234).

Upon comparison, the several vertebræ of obviously the same individual or species of

Dinornis, presented good distinctive characters; and many series, of greater or less extent, were formed in the progress of the work; such series belonging, respectively, to the same individual skeleton of a different species of *Dinornis*.

Not to dwell needlessly on the different steps of this work of arrangement, in which I was efficiently aided by Mr. Flower, the experienced Articulator, I may proceed to state, that, after classifying the pelvises according to their size and probable species, one of these, which in general size and in the proportions of acetabulum accorded with the femur of *Dinornis elephantopus*, was found to present a well-marked anterior articular surface both on the centrum and on the fore part of the peculiarly long and strong square-shaped spine; the articular surface on the spine being unusually rugged.

Among the vertebræ previously classed as the 'last dorsal,' was found the one that had articulated with the above pelvis; and that dorsal vertebra terminated a series of seven dorsals, progressively decreasing as they advanced forwards, and indubitably belonging to the same individual bird.

The last dorsal vertebra of the *Dinornis* is characterized by a pair of tuberous processes (hypapophyses) from the under part of the centrum, close to the hind border: in the present skeleton of the *Dinornis elephantopus*, they are an inch apart: this vertebra is also characterized by the height of its spine, which is subquadrate; slightly expanded above; smooth at the sides, but rough at the fore and back parts. The height of this spine is four inches. There is a rudimentary tubercle at the middle of the under surface of the centrum near the anterior border. The articular surface at that end is concave transversely, convex vertically. The parapophysis is a large surface with slightly raised borders near the fore part of the centrum. The diapophysis is short and thick: at its under part is the pneumatic orifice. The proximal end of the rib is strongly bifurcated to articulate with the two processes; it supported an appendage, but does not join the sternum. The above-described vertebra is the seventh dorsal, or the last free vertebra that supports moveable ribs (Pl. LX. D 7).

The sixth dorsal (*ib.* D 6) is narrower and with a spine somewhat shorter than the seventh. The posterior hypapophyses are nearer together: the anterior one is more developed: the spine, besides being shorter, is more compressed; but the diapophysis is longer, and the base of the neural arch is of greater fore-and-aft extent. The rib is stronger and longer; it supported an appendage, but is equally free from junction with the sternum. At the under part of the base of the diapophysis is the large pneumatic opening.

The fifth dorsal (*ib.* D 5) presents a corresponding decrease in transverse and vertical diameter, without any loss of fore-and-aft extent. The posterior hypapophyses have coalesced into a single process: the anterior hypapophysis is a strong ridge, with the fore part a little in advance of the anterior articular surface of the centrum. The shorter and more compressed spine has a somewhat greater fore-and-aft breadth than in the sixth vertebra: its height is not quite three inches.

In the fourth vertebra (*ib.* D 4) the anterior and posterior hypapophyses have coalesced into a single ridge, with a tuberosity on each side of its fore part; the ridge appearing to be a downward continuation or termination of the sides of the compressed centrum. The diapophysis is thicker but shorter than in the foregoing vertebræ: the spine, though shorter and somewhat thinner, has a greater fore-and-aft diameter; it is truncate a-top, like the rest.

The ribs of this and the succeeding vertebra, the fifth, are the largest; they each support a lamelliform appendage articulated to a well-marked surface at the back part, below the middle of the rib. The appendage is three inches in length and one in breadth; ascending obliquely and overlapping the succeeding rib. The sternal portion of the rib of the fourth dorsal joins the sternum.

The third dorsal vertebra (*ib.* D 3) much resembles the fourth; but with a slight diminution of size and a somewhat lower position of the parapophysis: this is associated with a rather longer and more bent-down neck of the rib. The sternal part of this rib joins the sternum.

In the second dorsal vertebra (*ib.* D 2) the inferior ridge is divided by a notch into an anterior and posterior hypapophysis; but the diminished size of the vertebra, the lower parapophysis, with a smaller articular surface for the rib, and shorter diapophysis, distinguish it from a fifth dorsal. The spine is somewhat shorter, and inclines more forward than that of the third dorsal.

In the first dorsal (*ib.* D 1), the hypapophysis is a ridge projecting from rather more than the anterior half of the centrum: the parapophysis has a smaller cup for the head of the rib than in the second dorsal: the diapophysis is proportionately diminished in size: the neural spine is smaller in every dimension, and slopes more forward. There is a small pneumatic foramen below and in front of the diapophysis. The rib, about four inches in length, terminates in a point, and has no sternal portion, nor any appendage.

Besides the seven pairs of ribs from the seven dorsals, there are two pairs from the anterior sacrals, progressively diminishing in size, and the last terminating freely in a point. The first of these sacral ribs was moveably articulated to the first sacral vertebra: the second is anchylosed to the second sacral vertebra.

Thus the *Dinornis elephantopus* had nine pairs of long, conspicuous ribs: the first floating; the second to the fourth pairs inclusive composed of pleurapophysis and hæmapophysis, the latter articulating with the expanded hæmal spine or sternum. The next three pairs had hæmapophyses, or 'sternal ribs' which did not reach the sternum: the eighth and ninth pairs, simple and pointed like the first pair, belong to the first two of the vertebræ that have coalesced to form the long sacrum.

Of the cervical vertebræ there are fifteen, each having its individual character, and with trochlear articular surfaces so clearly or definitely sculptured on the ends of the centrum as to permit of no mistake in the co-adaptation of the vertebræ, successively, from the last or fifteenth, *ib.* C 15, up to the atlas, *ib.* C 1. The size of the articular cup on the fore part of the atlas determined the cranium belonging to the present skeleton of *Dinornis elephantopus.*

In the last cervical, *ib.* C 15, the hypapophysis is a ridge from the front half of the centrum; which centrum is longer, but of less fore-and-aft extent than that of the first dorsal. The short rib is anchylosed to both parapophysis and diapophysis; it is an inch and a half in length, pointed and directed backwards. The spine is smaller in all its dimensions than in the first dorsal.

In the fourteenth cervical, *ib.* C 14, the hypapophysis is a thick sub-bilobed ridge from near the fore part of the centrum, but is extended transversely, not from before backwards. The rib is merely a bar uniting the ends of the two transverse processes: the spine is rather more than an inch long, nearly an inch broad, half an inch from before backwards, and bifurcated, with the two divisions on the same transverse line.

The thirteenth cervical, *ib.* C 13, has a pair of anterior hypapophyses with their tuberous ends approaching and almost meeting each other, so as to complete a hæmal canal. The median cleft of the short spine almost divides it into two processes. The canal circumscribed by the met-, di- and pleur-apophyses, on each side of the vertebra, is large enough to admit the fore-finger. The centrum appears to be larger than in the succeeding vertebræ, because it does not lose in fore-and-aft extent while decreasing in other dimensions.

In the twelfth cervical, *ib.* C 12, the anterior hypapophyses are wider apart: the transverse pair of spines are also more apart, and are shorter than in the thirteenth vertebra.

In the eleventh cervical, *ib.* C 11, the hypapophyses are shorter and wider apart: the neural spine is now a pair of tuberosities.

The under surface of the tenth cervical, *ib.* C 10, is widely grooved, with the hypapophysial tubercles deepening the fore part of the sides of the groove. Slightly converging ridges from the upper part of the posterior zygapophyses represent the neural spine.

These ridges converge as they advance upon the neural arch, in the ninth, eighth, seventh, sixth, and fifth cervicals, in which a low tuberosity on the fore part of each ridge represents the divided neural spine. The under surface of the centrum becomes flatter in the above vertebræ: the hypapophyses are represented by a tubercle on the lower part of each parapophysis.

In the fourth cervical, *ib.* C 4, the pair of tubercles representing the neural spine are onger: in the third cervical they are closer together: in the second they have coalesced to form a single spine, with a deep fossa at its back part: in the atlas, *ib.* 1, the neural spine is obsolete.

The hypapophysis in the third cervical is a single median ridge, as it is also in the axis, or second vertebra: in the atlas it is absent. The hind surface of the body of the atlas is convex, a little hollowed above to receive the odontoid process: the lateral ' vertebral ' canals are defined each by a slender vertical bar of bone. The under surface is produced into a pair of short tubercles at its hind margin and at its front margin; and they project respectively backwards and forwards, not downwards as hypapophyses. The deep anterior cup, which receives the single occipital condyle, is notched at the middle of its upper part. The neural arch expands beyond the breadth of the centrum, and developes only the posterior pair of zygapophyses.

The pelvis of the *Dinornis elephantopus* (Pl. LX. S, 63, 64) is one foot nine inches in length, contrasting extraordinarily with the size of the skull.

Six of the anterior sacral vertebræ have parapophyses with the ribs confluent with them, save in the first: beyond the second vertebra the ribs simply abut against the ilium, with which they are confluent.

The ischium, 63, and pubis, 64, which coalesce with the ilium to form the acetabulum, do not again unite with each other: the notch at the under and fore part of the ischium opens into the long interspace between the two posteriorly extended bones. This part of the pubis, 64, is straight and styliform, 8½ inches in length; slightly expanded, to a breadth of 14 lines, near the end; flattened externally, convex internally, so as to offer a subtrihedral transverse section. The ischium, 63, with an upper and lower notch, having smooth and thick rounded borders, near the acetabulum, expands gradually, and is flattened, into a plate of about three inches of vertical depth, with a truncate termination.

Nine caudal vertebræ, of a transversely subquadrate form, with a contracted neural canal, surmounted by a low transversely extended arch supporting a pair of tubercles, represent the basis of the short tail of the Dinornis.

The last of these vertebræ is as small and simple as in other large birds devoid of the power of flight; showing nothing of that characteristic modification of the terminal coalesced coccygeals in birds of flight, for the support of the rectrices, or steering quill-feathers of the tail.

The cranium, Pl. LIX., is six inches eight lines in length; three inches nine lines across the broadest part, behind the orbits. The post-orbital process is broad, compressed, and descends nearly to the zygomatic arch. The upper mandible is slightly deflected, conical, obtusely pointed, with the external nostrils terminating at the distance of about an inch from the apex of the premaxillary. The upper part of the median nasal process of this bone, together with the nasals, has been broken away. The minor characters of the cranium and of the lower mandible accord generically with those of the *Dinornis*, described in pp. 116 and 206. The chief peculiarity of the skull in the present species is its small size, as contrasted with the pelvis and hind limbs.

The keel-less sternum, Pl. LXI., in its shortness, breadth, and subquadrate form; in the two wide and deep posterior notches; in the unusually small and shallow coracoid fossæ; and in the reduction of the articular pits on the costal borders to three on each side, closely conforms to the type of that instructive bone, in the *Palapteryx* (*Dinornis*), described in pp. 124 and 196.

I have refrained from entering into closer descriptive details of the skeleton of the *Dinornis elephantopus*, because only the plates can convey an adequate idea of its extraordinary proportions to those who have not seen the original itself.

The specimen, as now articulated, stands in the first compartment of the Palæontological Gallery of the British Museum. The articulated hind-limbs of the *Dinornis robustus* —a possible variety of *D. giganteus*—are placed on each side, as in Pl. LXI., to illustrate the characteristic proportions of the two extinct species.

The drawings from which the plates have been engraved were taken from two successful photographic views, corrected, as to the relative size of the parts, from the skeleton itself: I am much indebted for the care and skill which Mr. Erxleben has bestowed on this complex subject.

The first evidence of the *Dinornis crassus* reached me from a turbary deposit at Waikawaite, in the Middle Island; it formed part of the collection there made by Mr. Earl. I have never received any evidence of this species of *Dinornis* from the North Island.

In like manner the bones of the much larger bird, which I have called *Palapteryx robustus* and *Dinornis robustus*, and which I was formerly inclined to regard as not only specifically but generically distinct from *Dinornis giganteus*, appear to be peculiar to the Middle Island; or at least have not, hitherto, been found in any locality of the North Island.

The richer series of illustrations of both *Dinornis robustus* and *Din. crassus* in the collection of Mr. Walter Mantell are from localities in the Middle Island; and the abundant illustrations of *Dinornis elephantopus* are exclusively from one locality in that island: they were obtained at Ruamoa, three miles south of Oamaru Point, or that called the "First Rocky Head" in the New Admiralty Map. This fact might give rise to the idea that the original range or locality of *Dinornis elephantopus* had been a restricted one; unless, at the period when the species flourished, the geographical extent of the Middle Island of New Zealand was widely different from what it now is. Yet Mr. W. Mantell has obtained strong, if not unequivocal, evidence that *Dinornis elephantopus* and *Din. crassus* existed contemporaneously with Maori natives in that island. The bones described in the foregoing pages are in a recent and most perfect condition. They retain the usual proportion of animal matter, and have undergone no mineral change.

They were discovered under circumstances closely resembling those described in a previous Memoir, p. 220, under which the femur of *Dinornis gracilis* was found in the North Island, by Mr. Cormack. Remains of native ovens, with the baking stones, were not far from the chief collection of bones of *Dinornis elephantopus*, discovered by Mr. W. Mantell, in the Middle Island. Both were covered by drifted sand from three to seven feet in thickness. Some of the bones have been scorched by fire.

From the sum of our present information respecting the localities of the several species of *Dinornithidæ*, we may infer that most, if not all, of the species of the North Island were distinct from those of the South Island.

To birds that could neither fly, nor, probably, swim well or far, the channel called Cook's Straits would prove an effectual bar to any migration from one island to another. With each successive addition of materials for the history of this most remarkable family of birds, I feel, nevertheless, impressed with the conviction of how little comparatively we still know respecting them, and how much more is likely, through the enlightened cooperation of active, resolute, and accomplished explorers, such as Mr. Walter Mantell, to be, hereafter, contributed towards a complete history of the New Zealand wingless birds.

DESCRIPTION OF THE PLATES.

PLATE LVI.

(All the figures are of the natural size.)

Fig. 1. Front view of the left femur of *Dinornis elephantopus.*

Fig. 2. Upper view of the head of the same bone.

Fig. 3. Under view of the condyles of the same bone.

Fig. 4. Front view of the left tibia of *Dinornis elephantopus.*

Fig. 5. Upper articular end of the same bone.
k. epicnemial ridge; *p.* procnemial plate; *e.* ectocnemial process; *a.* inner condyle; *b.* outer condyle; *f.* tendinal groove and bridge.

Fig. 6. Left fibula of *Dinornis elephantopus*: the side which is applied to the tibia is shown.

PLATE LVII.

(All the figures are of the natural size.)

Fig. 1. The bones of the left foot of *Dinornis elephantopus*: II., III., & IV. indicate the distal trochleæ of the metatarsus; II. 1, 2, 3, the three phalanges of the inner toe; III. 1, 2, 3, & 4, the four phalanges of the middle toe; IV. 1, 2, 3, 4, & 5, the five phalanges of the outer toe.

Fig. 2. The proximal articular surface of the metatarsus: *e.* the internal, *c.* the external, articular cavity; *c e.* the ectocalcaneal, *m c.* the mesocalcaneal, process.

Fig. 3. The distal trochleæ of the metatarsus: II. that of the inner toe; III. that of the middle toe; IV. that of the outer toe.

Fig. 4. The proximal articular surfaces of the proximal phalanges of the three toes.

Fig. 5. Side view of the ungual phalanx of the middle toe.

PLATE LVIII.

Fig. 1. Front view of the left metatarsus of an immature *Dinornis elephantopus*: *a.* its proximal end uncovered by the tarsal epiphysis.

Fig. 2. Back view of the left metatarsus of an immature *Dinornis crassus.*

PLATE LIX.

The skull of the *Dinornis elephantopus*: nat. size.

PLATE LX.

Side view of the skeleton of the *Dinornis elephantopus*; with a scale of English feet and inches, showing the degree of reduction of the figure, and the natural height of the skeleton, in the ordinary attitude of the bird, viz. five feet six inches.

PLATE LXI.

Fig. 1. Front view of the same skeleton.
Fig. 2. Front view of the right leg and foot of the *Dinornis robustus*.
Fig. 3. Front view of the left leg and foot of the *Dinornis robustus*.

MEMOIR ON THE GENUS CNEMIORNIS.

In the collection of bones, including the skull of *Dinornis robustus*, Ow. (described in the Memoir, p. 151), gathered from the bottom of the fissure in the limestone rock at 'Timaru,' Middle Island of New Zealand, there were remains of smaller birds, the tibia of one of which first attracted my attention by the unusual size of the muscular crests and processes at its proximal end.

A comparison of this tibia with that bone in other birds proved it to belong to a species hitherto unknown, and gifted with legs, if one might judge by the unusual provision for muscular attachments, capable of being applied with greater force than in the rest of the class: for not only did the epicnemial process rise high above the knee-joint, as in *Colymbus*, but both procnemial and ectocnemial plates were as extraordinarily developed.

This tibia was about the size of that in *Aptornis otidiformis*[1] and *Dinornis geranoïdes*; nearly equalling in length, but exceeding in thickness and strength, that of the larger Argalas and Storks; more closely resembling in both proportions the tibia of the Mooruk Cassowary.

With the tibia from Timaru was a femur of proportional size, and fitting thereto as well as the loosely adjusted articular surfaces of the bones forming the knee-joint admit of in birds. There was also a metatarsus more decidedly belonging to the same bird by the closer adaptation to the distal trochlea of the tibia; and the three bones gave a total length of leg of about 24 inches.

A pelvis, by its proportions to this limb, and more especially by the relative size of the acetabulum to the head of the femur, claimed to be entered in the list as part of the same bird. To the fore part of this pelvis fitted the articular surfaces of the back

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[1] The tibia of this species, referred at p. 85, pls. xxv. & xxvi. fig. 5, to *Dinornis otidiformis* (see also Zool. Trans. vol. iii. 1843, pl. xxv. figs. 5 & 6, pl. xxvi. figs. 5 & 6), and the skull referred to *Dinornis casuarinus* (Zool. Trans. vol. iii. pl. lii.), were determined as belonging to the genus *Aptornis* in 1856 (Zool. Trans. vol. iv. p. 62), and have been so labelled in the exhibited series of the fossil remains of birds in the British Museum since that date.

part of one of some dorsal vertebræ belonging to the same backbone; and the characters of size led to the like conclusion in regard to part of the series of cervical vertebræ.

Some portions of ribs had been collected, corresponding in the size and relative position of the capitular and tubercular joints with the answerable articular surfaces on the dorsal vertebræ: the size of the costal articular surfaces on the margins of an otherwise small and keel-less sternum similarly supported the inference that it belonged to the same bird, and that this was one of those singularly numerous feathered species of New Zealand that were without the power of flight.

Finally, there was a humerus which, from the feeble development of its proximal processes, had evidently belonged to some such flightless bird. The size of this bone was, indeed, disproportionately small compared with the tibia, according to the ordinary avian skeleton, but it bore nearly the same proportion to the sternum as does the humerus in *Notornis*, and rather a larger proportion to the leg-bones than in the Emeu. I, therefore, have strong faith in the accuracy of the reference of all the bones from the limestone fissure above enumerated to the same species, if not the same skeleton; the more so, as there were no other bones of other species sufficiently similar in size to the leg-bones, pelvis, and vertebræ, to which the keel-less sternum and feeble humerus could be supposed to belong.

The bird of the Middle Island of New Zealand, about the size of the Mooruk, and now, perhaps, extinct, will be shown, I believe, by the characters of so much of its skeleton as has been obtained, to have been the type of a genus unknown to science; and for which I propose the name *Cnemiornis*[1], indicating the present species by the term *calcitrans*, as being capable of kicking much more violently than the *Apteryx*, after full allowance for difference of size.

Cervical Vertebræ.

Of the cervical vertebræ, some (Pl. LXVI. figs. 1 & 2) present a remarkable expanse of the neural arch (*n*), which may be 2 inches 6 lines across, the smallest transverse diameter of the centrum (fig. 4, *c*) being but 5 lines. In such a vertebra the centrum sends down a short, compressed hypapophysis (ib. *h*) from its hinder part. The length of the centrum is 1 inch 9 lines; it expands, being concave and smooth below, toward the anterior articular surface (figs. 1 & 2, *c*′), and to each side of this expanded part the pleurapophysis (figs. 1, 2 & 4, *pl*) is confluent, completing a vertebrarterial canal (ib. *v*), almost as wide as the neural one (*n*); the prezygapophyses (*z*) are wide apart, looking upward and forward; a horizontal plate of bone (figs. 3 & 4, *iz*) extends from each to the postzygapophysis (fig. 4, *z*′), expanding and forming a slightly thickened, convex

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[1] Κνήμη, tibia, ὄρνις, avis: in composition, *cnemi*, as in "anticnemion," "gastrocnemius," &c., signifying the genus of wingless birds remarkable for the size of the processes of the tibia. For the opportunity of describing this series of bones I am indebted, as for the skull of *Dinornis robustus* from the same locality, to Dr. David S. Price.

border (*d*) before its termination; there is a low and strong tuberosity (figs. 1 & 3, *t*) above each postzygapophysis; at the back of the neural platform is a low, compressed, neural spine (*ns*), the base of which is less than half the length of the neural arch; on each side the spine, at some distance from it, there is a vacuity (*o*) in the neural platform. This vertebra, from the analogy of the cervical region in the skeleton of *Dinornis* and *Casuarius*, has come from the anterior part of the neck, and was probably the third or fourth of the series.

A cervical vertebra (Pl. LXVII. figs. 1 & 2), from the lower or hinder third of the neck, shows a hæmal canal (*h*) beneath the fore part of the centrum (fig. 1, *c'*), formed by the parapophyses (*p*, *p*); the hypapophysis has disappeared from the back part of the centrum (*c''*). The thick and short pleurapophysis (*pl*) shows three longitudinal, shallow, wide grooves; the diapophysis (*d*) forms a thick, obtuse, sub-bifid projection, external to and below the prezygapophysis (*z*), from the back part of which extends a slender bar of bone (fig. 2, *b*) to the side of the centrum, unequally dividing the hinder outlet of the vertebrarterial canal (fig. 1, *v*). The interzygapophysial plates are here wanting, as is also the neural spine, its place being occupied by a chevron-shaped, rough tuberosity (*t*), as in the vertebræ of the bend of the neck, which is concave neurad.

In a cervical vertebra, contiguous or near to the preceding, the posterior aperture of the vertebrarterial canal (*v*) is more equally divided by a horizontal bar of bone.

Other cervicals do not present characters worthy of special notice.

Dorsal Vertebræ.

The bodies of the dorsal vertebræ (Pl. LXVII. figs. 3 & 4) have the usual terminal concavo-convex articulations, the concavity being transverse on the anterior surface (*c'*); the last is compressed, the sides converging below to a ridge, representing a hypapophysis. The neural spine (*ns*) is 1 inch 6 lines in height, 10 lines in fore-and-aft diameter, moderately thick, with a truncate, subexpanded, transversely convex summit; the diapophyses (*d*) are strong, trihedral, being supported by a trihedral buttress (fig. 4, *b*). In the antecedent dorsals, of which seven are preserved—probably the entire number—the lower part of the centrum is produced into a compressed hypapophysis (fig. 3, *hy*); the articular surface for the head of the rib is an oval depression, near the front margin of the centrum, supported upon a slightly produced parapophysis (*p*); the terminal subconcave surface on the diapophysis (*d*), by its distance from the parapophysis, gives the length of the neck of the rib, and enables one to identify, as belonging to *Cnemiornis*, some of the ribs in the promiscuous lot of bones raised out of the fissure at Timaru.

Pelvis.

The pelvis (Pl. LXVII. figs. 5, 6, 7) includes seventeen sacral vertebræ with the coalesced ossa innominata; from which, however, the pubic and ischial bones have been broken off. The bodies of the sacral vertebræ diminish in breadth to the third (fig. 6, *c*), where the sides converge to a ridged inferior termination; they then expand to the seventh, which has a broad, flattened inferior surface, rather concave transversely; beyond this they again contract, and reassume the inferior ridge, to which the flat sides converge and meet at a right angle. The first and second sacral vertebræ show the subcircular, shallow depressions, at the upper and anterior border of the centrum, for the long ribs; the third shows a similar, but much smaller, surface, indicative of a short and loose pleurapophysis which has been lost; the five following vertebræ send parapophysial abutments (*p*, *p*) against the ilia (*i*, *i*), of which the seventh is the shortest and thickest, affording the chief resistance against the pressure from the acetabulum (*a*). The three following vertebræ have no parapophyses: the lateral pairs of orifices for the separate issue of the sensory and motory roots of the sacral nerves are here conspicuous; the parapophyses reappear in the twelfth sacral vertebra, and are continued on to the seventeenth, mostly in the form of broad, thin, antero-posteriorly compressed plates, continuous with the diapophyses, and about an inch in length in the first three, thence gradually diminishing and abutting in a direction upward, outward, and backward against the junction of the ilia with the osseous expansion from the neural spines of the posterior sacral vertebræ (Pl. LXVII. fig. 5, *ns*).

The long iliac bones (fig. 5, 62), as they extend from their anterior border backward, converge, to coalesce with the ridged summits of the spines of the first seven sacral vertebræ, then rapidly diverge to the thirteenth, and again converge to the seventeenth vertebra leaving a rhomboidal space, 4 inches in length and 2 inches in breadth, where the pelvic roof is formed by a thin expanse of bone (*ns*), continued from the neural spines and the upper borders of the diapophyses to the ilia; this part of the roof is straight lengthwise, concave across, with a smooth, medial convexity formed by the summits of the confluent spines, 4 lines in breadth. A few small foramina alone here indicate the primitive division of the sacrum (fig. 5, *o*). The ilia, at their fore part, do not extend outward beyond the parapophysial abutments of the anterior sacral vertebra, but rise, at first concave and then convex, to the summits of the spines; the concavity is bounded by a curved ridge, convex upward. The acetabulum (fig. 7, *a*) is circular, 1 inch 2 lines in diameter, with an irregular, oval vacuity of 11 lines in long diameter; the anterior wall is deepest, having an extent of 8 lines, the posterior wall becomes reduced to 3 lines; the articular surface of the upper part of the cavity is continued upon the superacetabular prominence (*b*), which is applied to that upon the upper part of the femur; the large ligamentous depression upon the head of the femur projected, in the living bird, through the acetabular vacuity. There is a pneumatic fossa above the upper border of the acetabulum: the superacetabular surface is supported by a thick, strong, subtrihedral part of the ilium, strengthened by the three longest abutments (fig. 6, *p*, *p*) of the posterior sacrals. The ischium (fig. 7, 63) contributes the lower and posterior third of the acetabulum: the pubis (64) was attached to about one-fifth of the lower part of the cavity.

Sternum.

The three portions of the sternum of *Cnemiornis* include the right costal border and process (Pl. LXVI. figs. 5 & 6), part of the left (figs. 7 & 8), and the middle part of the bone (fig. 9)[1]. The costal border (*c*) is 3 inches 6 lines in length, and includes seven articular ridges (*h*) for the sternal ribs, the last contracting to the form of a tubercle; and there is also a tubercle of smaller size at the angular beginning of the border. The costal process (*d*) is quadrate, slightly concave on the inner side, convex lengthwise on the outer side, and smooth, as if for some articulation; the pneumatic foramina are at the base of this process, on the inner side of the sternum, and are also seen at the costal border, at the interspaces of the articular ridges. The posterior boundary of what appears to be the short, shallow and narrow coracoid groove (*b*) extends from above these foramina towards the middle line, but apparently not far: the body of the sternum has been broken away from near the base of the costal process. The greatest breadth of the body of the sternum preserved, at the end of the costal border (fig. 5, *c*, *a*), is 1 inch 8 lines; the length of this right portion of the sternum preserved is 4 inches 5 lines, and shows no trace of posterior notch; it is gently convex lengthwise, concave transversely, but in a less degree; and the fore part of the sternum, for more than an inch behind the costal process, shows a shallow excavation. A smaller proportion of the body of the sternum remains connected with the left costal margin: it cannot, therefore, be positively affirmed that the keel was absent, but this may be inferred from the thinness of the sternum at the fractured mesial margins (*a'*) of the two lateral portions. From the sternum of *Notornis* that of *Cnemiornis* differs in the greater extent and different direction of the costal border, the greater number of articular ridges thereon, the presence of the costal process, and the much greater breadth of the body of the sternum.

The middle portion of the body of the sternum (fig. 9) includes a length of 4½ inches, with a breadth of 2¼ inches, of that part of the bone. Its thickness does not exceed 2 lines at the fore and mid part. It is very feebly convex externally, and correspondingly concave on the opposite surface. A pair of shallow muscular surfaces nearly meet at a slightly raised median tract (*s*), convex transversely, and from 2 lines to 3 lines across, extending from the anterior fractured margin about 1 inch along the bone, leaving more than 3 inches beyond free from even this feeble indication of a keel.

Humerus.

The humerus (Pl. LXIX. figs. 7–10), by its small size, slender proportions, and feeble development of the parts at the proximal end, accords with the characters of the sternum, and indicates the incapacity of the *Cnemiornis* for flight: the articular head (*a*) is narrow in proportion to its length, and is not broader or more convex at its middle part, as in birds of flight; its margin projects posteriorly, but anteriorly falls

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[1] These figures have been drawn on the stone, without being reversed.

into a shallow concavity. The inner (ulnar) tuberosity (*c*) rises above the articular surface, slightly projects towards the back (anconal) side of the bone, where it is divided by a groove from the articular head, but there is no excavation below it for a pneumatic foramen. The outer (radial) tuberosity (*b*) is almost obsolete, being represented by the short, thickish ridge continued from the outer end of the head downward and a little forward, with a deepish cavity behind. The pectoral ridge, instead of being continued directly from the tuberosity, as in birds of flight, is represented by a tubercle (*b'*), an inch below this part. There is a shallow, transverse depression (*d*) below the head on the palmar side, and a subsemicircular, slightly concave, smooth surface below that depression. The shaft of the humerus is slightly bent forward; it is subcircular, a little expanded and flattened at the distal end. This shows, feebly developed, the ulnar articular convexity (*f*), and the longer, narrower, and more prominent radial one (*e*); there is a slight ento-condyloid tuberosity (*h*), and a very feebly indicated, transversely concave, anconal depression.

Femur.

The femur (Pl. LXVIII. figs. 1 & 2), about the size of that of *Dinornis geranoïdes* (ib. figs. 5 & 6), differs in being more compressed from behind forward, especially at the proximal end. The head is more sessile; the depression for the round ligament is deeper and larger, and is on the upper part (fig. 2, *a*). The articular 'epitrochanterian' surface (*b*), extended from it to the great trochanter, is more horizontal; that process (*c*) being less elevated, and forming a more abrupt ridge at the outer boundary of the articular surface. There is a low trochanter minor (*d*), for the iliacus internus, about 9 lines below the head, in the femur of *Cnemiornis*, of which no trace appears in that of *Dinornis geranoïdes* (fig. 5). The shaft has an oval, transverse section, with the small end acute, formed by the inner side or border of the shaft: the posterior ridge is nearer this border than in *Dinornis geranoïdes*. The outer condyle (*e*) extends lower than the inner one (*f*) to a degree greater than in *Dinornis*. The rotular fossa (*p*), and that for the head of the tibia, are deeper than in *Dinornis*. There is no pneumatic foramen. The canal for the medullary artery is very small, and perforates the back of the shaft, in one specimen, above the middle. There is a curved, rough ridge above and behind the outer condyle, but not the fossa which impresses this part above the vertical groove for the fibula in *Dinornis geranoïdes* and most other species of *Dinornis*.

As compared with that of *Aptornis* (figs. 3 & 4), the femur of *Cnemiornis* is much thicker in proportion to its length, but resembles it in the ridged character of the trochanter major, in the high position of the depression for the ligamentum teres, which, however, is more posterior in *Aptornis* (fig. 4, *a*), in the more compressed character of the upper part of the bone, and in the approximation of the posterior ridge to the inner side of the shaft; but that ridge is interrupted an inch above the inner condyle in *Cnemiornis*, and is continued sharply to it in *Aptornis*, in which also the outer condyle is less produced downward, and the rotular channel (*p*) shallower and less defined. There is a rough depression above the fibular groove of the outer condyle in *Aptornis*, as in *Dinornis*.

Tibia.

The tibia (Pl. LXIX. figs. 1–5) is about the length of that of *Dinornis geranoïdes*, but, like the femur, is more slender in its proportions, and differs more widely in other particulars. The chief of these is the much greater development of the ectocnemial (*e*) and especially of the procnemial (*p*) processes. The latter is a compressed, rhomboid plate, 1 inch 8 lines in vertical, 1 inch 3 lines in transverse or antero-posterior, extent; it rises an inch and a quarter above the intercondylar tubercle (*i*), and is directed forward and a little outward. The ectocnemial process (*e*) is a thicker plate, of a triangular form, 1 inch 3 lines in the extent of its base, and the same in length; it is divided above from the procnemial plate by a notch in the epicnemial common base (*k*) of the two lamelliform processes. The principal articular entocondylar surface of the proximal end (*d*) is applied to the broad back part of the inner femoral condyle: the ectocondylar surface is on a small mammillar eminence (*t*); a smaller 'intercondylar' tubercle (*i*) projects into the intercondylar space of the femur. A small articular tract, on a prominence (*s*) on the outer side of the tibial head, articulates with the side of the head of the fibula. There is a strong gastrocnemial tubercle (*g*) on the inner side of the shaft, an inch below the produced margin of the entocondylar surface[1], of which tubercle there is no trace in *Dinornis*. The fibular ridge (*h*, *h*) begins opposite the lower end of the gastrocnemial tubercle, and is 1 inch 7 lines in extent, rather thick and prominent, with the surface well defined; the canal for the medullary artery (*o*) begins about half an inch below this ridge, toward the back part of the bone. The fore part of the shaft (fig. 1) is traversed by a low and narrow intermuscular ridge (*m*), commencing from near the base of the procnemial process, and terminating on the inner side of the extensor-tendinal canal, above the bridge (*l*); a similar ridge runs along the outer border of the shaft from its middle to the ectocondylar fossa, near which it bounds outwardly a narrow, longitudinal, tendinal groove. The canal (*f*) of the extensor tendon is crossed by a broad bridge of bone (*l*), is medial in position, not toward the inner side, as in *Dinornis*[2]; its lower outlet is transversely oval, and immediately above the intercondylar fossa (*c*); the anterior convexities of the two distal condyles are more nearly equal than in *Dinornis*: the trochlear canal (*v*) is less deep than in *Dinornis*. There is a well-marked tubercle near the middle of the entocondylar fossa (shown in fig. 5), which is not so developed in *Dinornis*.

As compared with the tibia of *Aptornis*, the most striking differences in that of *Cnemiornis* are seen in the development of the ectocnemial and more especially of the

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[1] The lower head of the 'gastrocnemius internus' rises from this part of the tibia in *Apteryx* (p. 59, pl. XIV. R**).

[2] Pl. XXV. fig. 4 *f*.

procnemial plates; the extensor-tendinal canal is more strictly medial in *Cnemiornis*, and the fore part of the inner distal condyle is less produced and less compressed. The gastrocnemial tubercle (*g*) is wanting in *Aptornis*, as in *Dinornis*.

Fibula.

The fibula (Pl. LXIX. fig. 6), about 6 inches in length, shows the usual subcompressed, convex head, with an articular surface, about 14 lines long by 4 lines broad, slightly curved backward: the head is slightly hollowed on the inner side, moderately convex externally; the shaft gradually contracts to the usual pointed termination about two-thirds down the tibia; it shows the broad, rough, articular surface for the tibia on the tibial border, and two rough tuberosities for tendinous insertions (*u*, *v*) on the outer side of the bone.

Metatarsus.

The metatarsal (Pl. LXX. figs. 1–4), which equals in length that of *Dinornis geranoïdes* (ib. figs. 5 & 6), has less than two-thirds its breadth, but almost equals it in fore-and-aft extent of the proximal end, owing to the greater development of the calcaneal ridge, which is perforated as in *Aptornis*. The inner condylar cavity (fig. 2, *i*) is much less extended from before backward; the anterior intercondylar prominence (fig. 1, *r*) is broader and more produced: the calcaneal process (fig. 1, *c*) extends downward, as a low ridge, to within an inch of the distal trochlea (fig. 3); the calcaneal canal is 10 lines in length, and 4 lines in long diameter. The surface, sloping to the outer condyle, is excavated by three well-marked longitudinal grooves, increasing in width as they approach the outer condyle (*e*); the ridge (*c'*) dividing the two outer grooves is the thickest. The antero-posterior canal, between the outer and middle metatarsal, opens behind at the end of the outermost groove; that between the middle and inner metatarsal opens behind upon the inner side of the base of the calcaneal process; the transverse section of the middle of the shaft is subtrihedral, not transversely oval as in *Dinornis*; the inner trochlea (*ii*) is not produced lower than the outer one (*iv*); the middle trochlea (*iii*) is narrower in proportion to its length, and less produced forward; in each trochlea, and especially the outer and inner ones, the longitudinal canal is deeper than in *Dinornis*; the interspace between the outer and middle trochleæ is the widest, not, as in *Dinornis*, narrowest. The posterior boundary of the middle trochlea is more prominent, projecting further back beyond the shaft than in *Dinornis*. As compared with *Palapteryx*, the metatarse is longer in proportion to its breadth; the calcaneal process in *Aptornis* is shorter, more prominent, and more widely excavated; there are no tendinal grooves on its outer side; the posterior ridge is not continued from it, and is nearer the inner border of the shaft; the inner trochlea is not produced so low as the outer one in *Aptornis*, and there is an antero-posterior canal above the interspace between the outer and middle trochleæ.

DESCRIPTION OF THE PLATES.

PLATE LXVI.

Cnemiornis calcitrans.

Fig. 1. Cervical vertebra, front view.
Fig. 2. Cervical vertebra, back view.
Fig. 3. Cervical vertebra, upper view.
Fig. 4. Cervical vertebra, under view.
Fig. 5. Right costal border of sternum, outer view.
Fig. 6. Right costal border of sternum, marginal view.
Fig. 7. Left costal border of sternum, outer view.
Fig. 8. Left costal border of sternum, inner view.
Fig. 9. Middle portion of sternum, outer view.

(Figs. 5–9 have been drawn without being reversed on the stone.)

PLATE LXVII.

Cnemiornis calcitrans.

Fig. 1. Posterior cervical vertebra, front view.
Fig. 2. Posterior cervical vertebra, back view.
Fig. 3. Middle dorsal vertebra, front view.
Fig. 4. Posterior dorsal vertebra, front view.
Fig. 5. Pelvis, upper view.
Fig. 6. Pelvis, under view.
Fig. 7. Pelvis, side view.

PLATE LXVIII.

Fig. 1. Femur, *Cnemiornis calcitrans*, front view.
Fig. 2. Femur, *Cnemiornis calcitrans*, inner side of proximal end.
Fig. 3. Femur, *Aptornis didiformis*, front view.
Fig. 4. Femur, *Aptornis didiformis*, upper view of proximal end.
Fig. 5. Femur, *Dinornis geranoïdes*, front view.
Fig. 6. Femur, *Dinornis geranoïdes*, upper view of proximal end

PLATE LXIX.

Cnemiornis calcitrans.

Fig. 1. Tibia, front view.
Fig. 2. Tibia, back view.
Fig. 3. Tibia, inner side of proximal end.
Fig. 4. Tibia, upper view of proximal end.
Fig. 5. Tibia, inner side of distal half.
Fig. 6. Fibula, outer side.
Fig. 7. Humerus, outer side.
Fig. 8. Humerus, inner side.
Fig. 9. Humerus, upper view of proximal end.
Fig. 10. Humerus, distal articular surface.

Tibia.

a. Inner distal condyle.
b. Outer distal condyle.
c. Intercondylar fossa.
d. Entocondylar surface.
e. Ectocnemial process.
f. Tendinal groove or canal.
g. Gastrocnemial tubercle.
h. Fibular ridge.
i. Interarticular tubercle.

k. Epicnemial ridge.
l. Bridge of tendinal groove.
m. Intermuscular ridge.
o. Medullarterial orifice.
p. Procnemial process.
s. Fibular articular surface.
t. Ectocondylar convexity.
v. Trochlear canal.

PLATE LXX.

Fig. 1. Metatarsal, *Cnemiornis calcitrans*, front view.
Fig. 2 Metatarsal, *Cnemiornis calcitrans*, proximal surface.
Fig. 3. Metatarsus, *Cnemiornis calcitrans*, back view.
Fig. 4. Metatarsus, *Cnemiornis calcitrans*, inner view of proximal end.
Fig. 5. Metatarsus, *Dinornis geranoïdes*, front view.
Fig. 6. Metatarsus, *Dinornis geranoïdes*, proximal surface.

(All the figures are of the natural size.)

MEMOIR

ON THE

INTEGUMENT OF THE SOLE, AND TENDONS OF A TOE, OF THE FOOT,

OF THE

DINORNIS ROBUSTUS.

THROUGH the liberality of the President and Council of the Philosophical Society of York, I have had transmitted to me for examination the portion of the foot, with the adherent tendons and integuments, of the skeleton of the Moa referred to in the letter of Dr. Hector, F.G.S., quoted at p. 154, which skeleton, having been presented to the Museum of the Philosophical Society, I have been able to determine and refer to the *Dinornis robustus*.

The toe, so preserved, with the tendons, sesamoids, and tegumentary sole-pads (Pl. LXI.), is the inner one (*ii*) of the right foot, and includes the three phalanges, corresponding in size and character with those figured in Pl. XLIX. fig. 1, II. 1, 2, 3, p. 190. To the outer side of the proximal end of the first phalanx the capsule of the joint adheres (Pl. LXI. fig. 1, *e*), whence it is continued upon the same side of that part, inclosing the metatarsal trochlea, and is extended upon the upper part of the sheath of the tendons (*a*, *b*, *c*) and sesamoids (*s*), beneath the joint between that phalanx and the corresponding (innermost) trochlea of the tarsometatarsal. Part of the dried cartilage also adheres at *f* to the proximal articular surface of the phalanx.

The terminal portions of the tendon (*a*), inserted, by means of the sesamoids and their ligaments, into the base of the first phalanx, part of the perforating tendon (*b*, *n*), similarly inserted into that of the second phalanx, and part of the upper or innermost perforating tendon (*c*), which is continued to that of the last phalanx, are here preserved.

The largest portion of the sole-skin includes the pad (ib. fig. 2, *d*, *d'*) beneath the trochlear division of the metatarse answering to the above toe, with part of that which extended beneath the middle trochlea, but wanting the outer portion. The under surface of so much as remains of this 'heel-pad' measures 3 inches 8 lines by 3 inches

6 lines. The margin (*d′ d′*) towards the missing outer heel of the pad shows abrasion; but where the under surface is entire, it is beset with large papillæ, having a tendency to a circular arrangement about a smoother space, which seems to have received the chief pressure of the inner trochlea. On the inner or tibial side of the pad (*d*) the papillæ increase in breadth and number, and are aggregated in the form of penta- or hexa-gonal oblongish scales, about 2½ lines in long diameter, diminishing in size (and chiefly in breadth) at the inner margin of the pad.

The skin becomes thinner and smooth at the part yielding to the bend of the toe upon the metatarse (ib. fig. 1, *h*), and that to an extent and with a degree of infolding in the dry integument which indicate great flexibility of the toe.

In advance of this, beneath the expanded ends of the first and second phalanges, the skin thickens and spreads into a second broad flat pad (*i*) beset with coarse scattered papillæ.

A short smooth tract (*k*) below the middle of the second phalanx intervenes between the second (*i*) and the third (*l*) papillose pad, which latter is beneath the joint between the second and third phalanges; the papillæ are here longer and more close-set, the transverse extent prevailing in most.

All the papillæ are formed, or covered, by thick epidermal matter as hard as horn. It is, however, together with the more gelatinous matter of the tendons and tendinous sheaths, soluble; and, unless the remains of the bird had been buried in very dry sand, not exposed to rainfall, it can hardly be supposed that it would have resisted for many years the action of moisture.

DESCRIPTION OF THE PLATE.

PLATE LXXI.

Fig. 1. Inner-side view of the inner toe (*ii*) of the right foot, *Dinornis robustus*, Ow.
Fig. 2. Under view of the same toe.
Fig. 3. Proximal end of first phalanx of the same toe, with appended integument, tendons, &c. Natural size.

MEMOIR

ON THE

DINORNIS MAXIMUS.

IN the letter of the date of February 15th, 1864, in which Dr. Hector, F.G.S., Provincial Geologist of Otago, New Zealand, communicated to me the particulars of the discovery of the almost entire skeleton of the *Dinornis*, of which the skull and scapulo-coracoid arch are described (pp. 151–172), he remarked that "The skeleton was not that of one of the largest-sized Moas, the tibia, for instance, being only 27 inches in length, whereas I have frequently seen them as much as 36 inches."[1]

The tibia of the specimen in the British Museum, which is the type of my *Dinornis robustus*, measures 32 inches in length; and it is probable that the difference in the length of the tibia of this specimen and that of the skeleton at York (27 inches) indicates the range of size as exemplified in individuals of different sexes of this species.

I have, however, for some years, been cognizant of a species of *Dinornis* from the Middle Island of New Zealand, having a tibia rather exceeding the length stated by Dr. Hector, and of a thickness proportionally the same as in *Dinornis robustus.* In 1858 the Duke of Argyll favoured me by sending for my inspection a tibia of this size, together with a femur and metatarsus of like proportions, and purporting to be of the same limb of a *Dinornis*, which bones had been transmitted to His Grace from the Middle Island, New Zealand, by the Rev. Dr. Lillie. With the liberal permission of the Duke, casts were taken from these bones for the British Museum, which have been exhibited in the Palæontological Gallery as of the "*Dinornis giganteus*, var. *maximus*."

In 1861 I was favoured by Henry Joseph, Esq., with an inspection of a femur of a *Dinornis* of the dimensions of that of *D. maximus*, which had been found beneath drift-sand at Otago, New Zealand.

In 1863 Professor Tennant, F.G.S., was so kind as to bring for my inspection the shaft of a femur of a *Dinornis*, from New Zealand, locality not stated, of the general dimensions of the two above specified, but heavier from some infiltration of mineral matter, and rather more robust. The least circumference, *e. g.*, of the shaft of the femur in Dr. Lillie's and Mr. Joseph's specimens was 8 inches $1\frac{1}{2}$ line; in Professor Tennant's specimen it was 8 inches 9 lines.

In March, 1867, I was favoured by Major J. Michael, of the Madras Staff Corps, with

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[1] Page 154.

the opportunity of inspecting the femur, tibia, and metatarse figured in Plates LXXIX. and LXXX., of the natural size, which had been discovered in August, 1865, on the Glenmark Estate of "Kermode & Co.," about forty-five miles from Christchurch, Canterbury Settlement, Middle Island, New Zealand. They were discovered, in the course of running a drain across a bog or swamp, about 4 feet below the surface, in such juxtaposition as to lead to the inference that they were bones of the same leg (the left); and their dimensions a little exceed those of the bones on which I had previously founded the variety or species *Dinornis maximus*. They are such, indeed, as to lead me to believe that the proposed specific term may be a safe one. I can hardly conceive that any bones as much larger than these as they are in comparison with *Dinornis giganteus* remain to be discovered in New Zealand—that land of these strange giants of the feathered class.

To have evidence of a bird as large as the Ostrich of Africa, from so comparatively small a tract of territory, seemed to me in 1839 the most wonderful result of the determination of the bone figured in plate III., Volume III., of the 'Zoological Transactions.' When I subsequently received a femur surpassing in length that of the struthioid species (*Dinornis struthioides*[1]) by 2 inches, I called the species *Dinornis ingens*[2]; then receiving a femur of the length of 15 inches, with other leg-bones to match, I proposed for it the term *Din. giganteus*[3]. Leg-bones equalling those of *Dinornis giganteus* in length, but in all cases exceeding them in thickness, and from an island where bones of the true *Dinornis giganteus* have never been found, represent the species called *Dinornis robustus*[4]; and now, having almost exhausted the vocabulary of terms expressive of hugeness, I venture on the superlative for the species represented by the bones which form the subject of the present Memoir.

Femur. (Plate LXXIX. fig. 1.)

This presents all the generic characters of that bone in *Dinornis*[5]. The roundness of the shaft, the thickness of the walls of the medullary cavity, the absence of pneumatic foramina, the thickness of the shaft, and breadth of the articular extremities, especially of the distal one, in proportion to the length of the bone, the tuberous "lineæ asperæ" on the back of the shaft (Pl. LXXIX. fig. 1), the production of the anterior intermuscular ridge from the lower end of the longitudinally extended thick and rugged pretrochanterian ridge, the rough, deep, well-defined fossa at the upper and fore part of the femoral shaft, the still deeper ecto-gastrocnemial fossa, and the very wide rotular channel—each and all of these Dinornithic characters of the avian femur are strongly marked in the present species. The surface, on the head of the femur, for the attach-

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[1] Pl. XXI. fig. 3. (Length 10″.)

[2] Pl. XXI. fig. 1. (Length 12″.)

[3] Pl. XXX. fig. 1. (Length 15″.)

[4] Page 224. (Length 14″ 6‴.)

[5] Page 85.

ment of the ligamentum teres is as if a slice of the convexity had been cut off obliquely from its most prominent part backward and a little upward, so that no part of this surface appears in a direct front view; and it is slightly, if at all, depressed: part of this large flat surface had been broken away in the specimen figured (Pl. LXXIX. fig. 1).

In the few femora of the general size attributable to *Din. maximus* there are variations in the relations of the circumference of the shaft to the length of the bone, and in one instance (the femur from Mr. Joseph) in the proportion of the breadth of the distal end. In the instance (Mr. Joseph's) where this end of the bone is narrower, the back part of the inner condyle is much narrower, and is more convex and more backwardly produced. The form of the popliteal space also differs. In Plate LXXIX., and the majority of femora of *Dinornis*, it is a deep oblong oval pit, definitely excavated, the larger end toward the inner posterior tuberosity of the "linea aspera," and deepening to the back ridge of the inner condyle, which extends toward the outer one. In the femur from Mr. Joseph the depth of the popliteal pit is due to the backward projection of the condyles and their uniting posterior ridge, dividing the popliteal from the inferior intercondylar fossa, which is unusually deep. The modification of the distal end of the less robust femur (from Mr. Joseph) is, indeed, such as to suggest a specific difference. The trochanter, also, rises more abruptly, is higher, and the outer ridge of the antero-superior pit is unusually prominent.

Tibia. (Plate LXXX.)

Of the tibia (Pl. LXXX.) there need only to be given the dimensions, taken in accordance with those which have been previously recorded of the *Dinornis giganteus* and other species[1]. All the characters of the bone which distinguish it generically as of *Dinornis* are closely repeated in the present specimen.

Metatarsus. (Plate LXXIX. figs. 3 & 4.)

The same remark applies to the metatarse (Pl. LXXIX. fig. 3); but between that bone in Major Michael's series and the one in Dr. Lillie's there are differences of proportion (probably within the limits of individual variety), which may be mainly appreciated by comparison of the outline of the latter (fig. 4) added to the Plate (LXXIX.) which contains the finished lithograph of Major Michael's specimen (fig. 3).

Dr. Lillie's specimen is longer and more slender, but with a greater transverse expansion of the distal end. The back part of the middle articular trochlea at the distal end projects more abruptly in Dr. Lillie's specimen; but the generic characters of the metatarsus of *Dinornis* are closely maintained in both specimens.

Subjoined are dimensions of the three chief bones of the hind limb of the present enormous species (*D. maximus*), together with those of the same bones in *Dinornis giganteus*.

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[1] Page 83.

Dimensions of Femur.

	Dinornis maximus.						*Din. giganteus.*	
	Major Michael's.		Dr. Lillie's.		Mr. Joseph's.			
	in.	lines.	in.	lines.	in.	lines.	in.	lines.
Length	18	3	17	0	18	0	16	0
Breadth of proximal end, in the axis of the neck, or transverse diameter	6	6	6	3	6	2	6	0
Breadth of antero-posterior diameter	6	0	5	6	4	7	5	6
Breadth of distal end, transverse diam.	7	6	7	0	6	9	6	3
Circumference of middle	9	6	8	9	8	0	7	9

Dimensions of Tibia.

	Dinornis maximus.		*Din. giganteus.*	
	in.	lines.	in.	lines.
Length	39	0	35	0
Breadth of proximal end	8	6	7	6
Breadth of distal end	5	0	4	0
Circumference of middle	8	6	6	6
Tibular ridge extends down	20	0	13	0

Dimensions of Metatarse.

	Dinornis maximus.				*Din. giganteus.*	
	Major Michael's.		Dr. Lillie's.			
	in.	lines.	in.	lines.	in.	lines.
Length	20	0	21	6	18	6
Circumference of middle of shaft	8	4	6	4	5	6
Breadth of middle of shaft	3	0	2	7	1	11
Breadth, transverse, of distal end	6	9	7	3	5	1
Breadth, transverse, of proximal end	5	6	5	3		

DESCRIPTION OF THE PLATES

PLATE LXXIX.

Fig. 1. Femur, back view, *Dinornis maximus*: nat. size.
Fig. 2. Femur, back view, Turkey (*Meleagris gallopavo*): nat. size.
Fig. 3. Metatarsus, front view, *Dinornis maximus* (Major Michael's specimen): nat. size.
Fig. 4. Metatarsus, front view, *Dinornis maximus* (outline of Dr. Lillie's specimen): nat. size.
Fig. 5. Metatarsus, front view, Turkey (*Meleagris gallopavo*): nat. size.

PLATE LXXX.

Fig. 1. Tibia, front view, *Dinornis maximus*: nat. size.
Fig. 2. Tibia, front view, Turkey (*Meleagris gallopavo*): nat. size.

MEMOIR

ON THE

MODIFICATIONS OF THE STERNUM

IN THE

GENUS DINORNIS.

IN November 1867 I was favoured by a note from HENRY SUMPTER, Esq., requesting me to inspect a collection of bones which he had received from a correspondent at Christchurch, Canterbury Settlement, in the South (or Middle) Island of New Zealand.

It appeared that the bones had been obtained from the extensive swamp or bog at Glenmark, about forty miles from Christchurch; they consisted of a considerable proportion of the skeleton of the *Dinornis elephantopus*, of a less complete series of the bones of *D. rheïdes*, including bones of the foot, corresponding with those figured in Pl. L. fig. 1. There were also a few bones of *D. crassus*. In this collection I saw, for the first time, specimens of sterna, entire, of these large wingless birds of New Zealand.

Sternum of Dinornis elephantopus, *Ow.*

The collection of bones of *Dinornis elephantopus* includes a sternum (Pl. LXXII.), wanting only the margin of the anterior border with the costal processes: the costal tracts (d, *c*, c, fig. 2, *m*, *n*, *o*) are nearly entire; and a great part of the lateral processes (fig. 1, *h h*) are preserved, showing that these diverged from the sternal body at a more open angle than was given in the restoration of the bone from the fragments accompanying the skeleton figured in Pl. LXI., such restoration being guided by the analogy of the more perfect sternums referable to the genus *Dinornis* (Pl. XXXV.) or *Palapteryx* (Pl. XLVIII.).

In the transverse extent and straightness of the anterior border (fig. 1, *b b*), the small and feebly marked coracoid depressions limited to the outer angles of that border (*d d*), and in the pair of wide and deep posterior vacuities (*f f*), this sternum exhibits the general Dinornithic modifications of the type of the bone presented by the *Apteryx* (Pl. IX.), and noted at p. 197.

The body of the sternum in *Dinornis elephantopus* is unusually flattened; the upper or inner[1] concavity (Pl. LXXII. fig. 1) is limited to the fore part of the disk, and is due chiefly to the upward or backward bending of the anterior border, slightly deepened by the ill-defined pneumatic fossæ (ib. *pn pn*) near the costal border (*c c*). As the sternum recedes backward the inner concavity changes to a convexity, both lengthwise and transversely, the broad mesial process (ib. *g*) rising into a low obtuse ridge (ib. *r*) along the mid-line of the inner surface.

The outer surface of the bone offers a corresponding convexity at the fore part, and concavity both lengthwise and across in the rest of its extent; and this concavity is continued along part of the origins of the lateral processes. The thickness, or rather thinness, of this flattened sternum varies from $\frac{1}{4}$ to $\frac{1}{8}$ and $\frac{1}{16}$ of an inch.

The costal border is traversed by two oblique parallel articular ridges (fig. 2, *m n*), with shallow intervening and contiguous depressions (ib. *o o o*). The lateral process (*h*) retains, anteriorly or externally, the thickness of the lower part of the costal tract, diminishing in thickness towards the posterior border, which there has a breadth of 6 lines; the inner or posterior surface of the process is impressed by a shallow groove lengthwise, and, after an extent of about 3 inches from the sternal body, the process appears to be twisted upon itself from before backwards, the inner border of the outer surface becoming the inner ridge-like border of the process itself, which is then compressed from without inwards, instead of from before backwards as at its basal half. This twist is more notable in the right process (*h*) than in the left one (*h'*), a greater proportion of which is preserved. Dimensions of different parts of this sternum are given in the Table of Admeasurements, p. 261.

Sternum of Dinornis rheïdes. (Plates LXXIII. & LXXIV.)

The sternum of *Dinornis rheïdes* is of the long and slender type, with the minor degree of divergence of the lateral processes. The body of the sternum is cleft for more than half its extent by a pair of posterior notches (*f f*) of a narrow angular form with the apex rounded off, leaving a long and narrow mesial process (*g*), which, in the specimen described, is notched at its rounded extremity, and has a small unossified vacuity about an inch anterior thereto. The entire part of the sternal body is moderately convex in every direction externally (Pl. LXXIII.), and correspondingly concave within (Pl. LXXIV.). On the inner surface it is impressed by two special deeper hollows (Pl. LXXIV. *n n*) just behind the anterior border and near the base of the costal processes (*d d*): these pneumatic depressions are perforated by several small foramina conveying air from the air-cells which occupied them into the cancellous texture of the thicker parts of the sternum. Neither the Ostrich nor Cassowary shows such pneumatic

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[1] In the following descriptions I term the surface of the sternum which, in its natural position, is upward, or toward the cavity of the body, internal or "inner" surface; the opposite one, which looks downward and is toward the pectoral muscles, I call the external or "outer" surface.

depressions and foramina, their sternum receiving air exclusively from the intercostal fossæ, whilst these in *Dinornis* are imperforate (Pl. LXXIII. fig. 2, *o o o*).

The anterior border of the sternum of *D. rheïdes* (Pl. LXXIV. fig. 4) is straight, no part projecting forward as "manubrium" or receding; it is slightly and equably curved transversely toward the chest (as shown at *a*, fig. 4); it is strongly bent from without inward, or from below upward, where it terminates by a narrow subobtuse margin, overhanging, in the vertical position of the bone, the pneumatic depressions and the general concavity of the inner surface. This margin is continued on into each costal process (figs. 3 & 4, *d d*), which extends upward and outward in the same slight transverse curve for rather more than an inch beyond the costal border, with an antero-posterior thickness, at the middle, of 9 lines, and with an obtuse and apparently slightly expanded termination, which, however, is not quite entire in the specimen.

The coracoid depressions (fig. 4, *b b*) are feebly defined by a transverse concavity occupying the fore part of the costal process, not extending mesially much beyond the line of the outer or lower border of the costal tract (fig. 4, *c c*). This tract (Pl. LXXIII. fig. 2) shows ridges for the articulation of two sternal ribs, the anterior one (*m*) being bituberculate, as in the Ostrich; the posterior and shorter ridge (*n*) is simple: three intercostal fossæ (*o o o*) are defined by these ridges; the anterior and largest has a somewhat irregular surface, the two following are smoothly concave.

The sternum, which is 1 inch across the first fossa, contracts to a thickness of 4 lines at the end of the third fossa. The length of the costal tract is $2\frac{1}{2}$ inches. The outer border of the lateral process (*h*) continues obtuse but decreasing in thickness to about one-third from the lower end, where it becomes a ridge: the inner border is a sharper ridge through the whole extent. The length of each lateral process is 6 inches, the average breadth 6 lines, being very little more at its commencement.

The length of the sternum in a straight line along the middle is 9 inches: the lateral processes (*h h*) extend about an inch beyond the middle one (*g*); this, halfway from its commencement, measures 2 inches across.

The breadth of the sternum at the ends of the lateral notches (*f f*), or origins of the lateral processes, is 5 inches 6 lines; the breadth of its fore part, including the costal processes (*d d*), in a straight line is 7 inches.

The middle of the entire part of the sternum is reduced to the thinness of cartridge-paper; it gains a little in thickness at the median process; but this thins off again to the end.

The outer surface is marked by fine lines, indicative of aponeurotic insertions; the inner surface is for the most part smooth and polished.

Longitudinally both median and lateral processes have a slight outward or downward flexure, giving a gentle sigmoid contour to the bone in that direction, as in fig. 2, Pl. LXXIII.

The second sternum of *Dinornis rheïdes* in the collection examined at Mr. Sumpter's shows the same general specific characters as the one above described, with individual differences due to degrees of ossification of the posterior half of the sternum.

The lateral notch, measured along the border formed by the lateral process, is 5 inches 3 lines; the length of the mesial process along the median line is 3 inches 3 lines, the breadth of that process across its middle part 2 inches 3 lines; it is thus shorter and broader than in the first described specimen (Pls. LXXIII. & LXXIV.). The lateral processes, about 5½ inches in length, are rather broader than in figs. 1 & 3, but diverge at a corresponding angle. The more essential characters afforded by the costal tracts and processes, the coracoid depressions, and pneumatic fossæ, with the general outward convexity and inward concavity of the entire part of the sternal body, exemplify the specific identity of these bones.

Thus the specimens of sternum in Mr. Sumpter's collection show two well-marked modifications of the Dinornithic or Apterygian type of sternum, which type may be characterized as "subquadrate, keelless, more or less flattened, with a pair of deep and wide posterior notches, and with small and remote coracoid pits." The characteristic which differentiates *Apteryx* is the anterior emargination: in *Dinornis* the different degrees of divergence of the lateral processes, involving corresponding differences in the breadth of the sternum, appear to be the best-marked modifications, though not the only ones; but before referring to these I may note the concurrence of the broad modification with the peculiar robustness of the legs and breadth of pelvis in *Dinornis elephantopus.* The chief minor modification, after the difference of divergence and breadth, is that shown by the costal tract in a fragmentary sternum obtained by Mr. Percy Earl from the turbary at Waikawaite, and referred by me to "one of the larger, if not of the largest, species of *Dinornis*" (p. 124). The costal tract occupies a relatively greater extent of the lateral border of the sternum between the coracoid and lateral processes, and shows in that extent three articular transverse ridges (Pl. XXXV. fig. 3, r' r'' $rr r'''$). The anterior border (ib. fig. 2) exceeds in extent that in *Dinornis elephantopus*, but is less thick; the lateral processes are more slender, with a narrower base and minor degree of divergence, so far as can be judged from the proportion of the process preserved and figured in pl. 43. fig. 1, *p*.

The more perfect sternum of the smaller species of *Dinornis* described (p. 197) and figured in Pl. XLVIII. figs. 1–4, is of the same type as that of *Dinornis rheïdes.* Its somewhat smaller size, with the more acute termination of the posterior notches, and greater prominence of the mid part of the outer surface of the sternum anteriorly, as shown in fig. 4 of the plate above cited, induced me to regard it as having come from a different species, which is very probably the *Dinornis casuarinus*, leg-bones of which have also been obtained from deposits south of Otago, Middle Island, where the sternum (Pl. XLVIII. figs. 1–4) was found.

At the beginning of the work of determination of the remains of wingless birds from New Zealand I found two generic types of skull, and referred in 1848 one of these to *Dinornis*, the other to *Palapteryx*. I subsequently discovered a type of leg and foot generically distinct from those which had been referred respectively to *Dinornis* and *Palapteryx*; and for that type I proposed the genus *Aptornis*, to which genus I was then led to refer the very remarkable skull figured in Pl. XLIII.

Successive evidences of cranial characters of different species of *Dinornis*, from the largest downwards, were far from showing the distinctions which, in the skull of *Aptornis*, had originally led to a generic division of the larger extinct wingless birds of New Zealand; and accordingly, retaining the name *Dinornis* for the *D. giganteus* and allied species to which, as originally known by vertebræ, pelvis, and limb-bones, that generic name had been applied, I was driven, after ascertaining their true cranial characters, to rest the distinction of *Palapteryx* on the presence of the small back toe, determined in the large robust species of the Middle Island (*Palapteryx robustus*), and its seeming absence in the more slender *Dinornis giganteus* of the North Island. Subsequently I was led to doubt the generic value which had been assigned to that reduced, not to say abortive, digit, probably variable as to its existence; and I gave up the application of the character, from the consideration that the ligamentous attachment might fail to leave sufficient indication on the metatarsal bone in some cases. The range of variation in the cranial characters of species unequivocally of either *Dinornis* or *Palapteryx* did not appear to me to support a continuance of those generic sections; and of late years I have, therefore, practically dropped "*Palapteryx*," and described additional facts and evidences of these extinct birds under the old generic term *Dinornis*.

No doubt, apart from the Apterygian character of the back toe (*i*, fig. 1, Pl. XLIX.), if even it had been determined without question to be constantly present in certain species and absent in others, the singularly massive proportions of the limb-bones in such species as *D. elephantopus* and *D. crassus* might lead one, prone to generic sections, to found a genus for such strong-limbed birds. But *D. robustus* and *D. maximus*, with the series of Moas dwindling to a form smaller than any which I have yet described, but equally worthy of being named, illustrate the transitional steps in the derivation of such species, due to inherent tendencies operating independently of individual volitions, and under circumstances affording no obvious or intelligible selective influences. Guided, however, by the Linnean methods of making known these animated forms, and accepting genera as they stand in natural families of modern ornithological systems, the two well-marked modifications of sternum which I have now been enabled to describe might justify the restitution of the term *Palapteryx* to such thick-limbed kinds as *Pal. elephantopus*, *Pal. crassus*, and *Pal. robustus*.

In a collection of bones transmitted by Dr. Haast to the Royal College of Surgeons, and which were submitted, by his request, to my examination, there was a lot marked "no. 16, fragments of sternum of *Dinornis crassus*," and associated with a portion of the skeleton ascribed to the same species. This lot contained portions of sternums of three or more species of *Dinornis*, and probably included all the parts of that rare bone which had been obtained in this collection from the swamp at Glenmark.

One of the fragments (no. 1), including the left anterior angle wanting the costal process, affords the means of comparing the anterior and costal borders with the sternum of *Dinornis rheïdes*. The costal border shows a proportion of extent from without inward double that in *D. rheïdes*; it is of a more definite triangular form, with the base forming the inner or upper border of the tract, and the apex obtuse; it is traversed by two oblique continuous ridges for the attachment of the sternal ribs, the second of nearly equal extent with the first, which is not divided as in *D. rheïdes* and the Ostrich. The anterior border is bent upward or inward like that in *D. rheïdes*, but terminates in a much thicker margin than in *D. rheïdes*; the convex bend inclines towards the costal border, is not so abruptly continued into it as in *D. rheïdes*: there is no definite pneumatic depression; the pneumatic foramina extend over a greater proportion of the fore part of the upper or inner concavity. The whole bone, so far as preserved in this fragment, is thicker than the corresponding part of *D. rheïdes*, and may well, therefore, have formed part of the sternum of the more robust species of *Dinornis* to which it is ascribed by Dr. Haast.

A second corresponding fragment of a sternum (no. 2), in which the costal process is preserved, has a costal border resembling in shape that in *D. rheïdes*; but both articular surfaces are undivided, the lower one being more extensive and broader than in *D. rheïdes*, not projecting as a ridge. The depression between the surfaces is much less extensive and less deep than in *D. rheïdes*; the costal process is broader but thinner, directed more outwardly than in *D. rheïdes*, from which it shows the more important difference of a deeper and much better-defined coracoid depression, of which the anterior boundary is partially produced as a ridge, and the posterior or upper one is plainly defined. The articular surface, broadest externally, is concave from before backward, slightly convex transversely, but with a small special depression at the narrower median end; there is also a pneumatic hole near the front ridge. The costal process has an obtuse, convex termination. The pneumatic depression on the anterior inner surface of the sternal body is more definite than in *D. crassus*, but is wider and less deep than in *D. rheïdes*. This portion of sternum shows characters specifically distinct from those in the two species named.

A third fragment of sternum in the lot, no. 16, includes the costal process and border of the right side of that bone. The process is entire, of a different shape from that in either *D. rheïdes* or *D. crassus*, the anterior margin being obliquely truncate toward the narrower but obtuse apex. There is a well-marked distinction from no. 1 in the absence of any defined coracoid depression; and sufficient of the body of the bone is preserved to show the absence of a pneumatic depression, such as exists in *D. rheïdes*. The external convexity leading to the anterior border is less abruptly defined than in *D. rheïdes*. The two articular tracts on the costal border are narrow, oblique, and continuous as in *D. crassus;* but the shape of the tract is like that in no. 1 and in *D. rheïdes.*

A portion of the right side of a sternum, which appears to be part of the same bone as no. 1, shows a continuation of the lateral process in the same direction relative to the contour of the costal border as in *D. rheïdes.* A corresponding portion of another sternum, no. 6 in lot 16, shows a divergence of the lateral process from the line of the costal border like that in the sternum of *D. robustus*, *D. elephantopus*, and probably also *D. crassus*, to which nos. 2 & 5 may have belonged. Assuming that nos. 1 & 3 are parts of the same sternum, it is certainly of another species, which probably may be *D. casuarinus;* the portion no. 4 belongs to a different species, and the portion no. 6 to a different individual of, perhaps, *D. crassus;* but four distinct birds, at least, must have contributed the fragments of sternum ascribed to the skeleton of *D. crassus* in Dr. Haast's list.

A more important contribution to the reconstruction of the extinct wingless birds of New Zealand has been made by the eminent State Geologist of Canterbury Settlement, by a series of photographs of skeletons obtained from the Glenmark Marsh, and preserved articulated in the Museum at Christchurch. From the front view of that of the *Palapteryx robustus* I infer that the remark, that "the attempted restoration of the sternum of a large species referred to *Dinornis* may, however, belong to *Palapteryx robustus*" (p. 197), is correct. The divergence of the lateral processes, though less than in *Palapteryx elephantopus* and *Pal. crassus*, is greater than in *Dinornis giganteus* and *D. rheïdes.* To this series of photographs I propose to return in a subsequent Memoir, after completing the comparison of the collection of Dinornithic remains transmitted by Dr. Haast.

Admeasurements of Sternum.

	Dinornis elephantopus.		*D. crassus?*		*D. rheïdes.*	
	in.	lines.	in.	lines.	in.	lines.
Length, along mid line, from the anterior border to the end of the median process	10	0 [1]	9	0	9	0
Extreme breadth, across the lateral processes in a straight line	16	0	13	0	8	0
Breadth of body from fore part of the costal tracts	8	0	7	0	5	6
Length of costal tract	2	3	1	7	2	4
Antero-posterior breadth of ditto	1	5	1	2	0	10
Antero-posterior extent from anterior border to apex of posterior notch	5	6 [2]	4	6	4	5
Breadth between apices of posterior notches	8	6	6	0	4	0
Length of median process	5	0 [3]	4	0	5	0
Breadth of mid part of ditto	4	6	3	6	2	0
Length of lateral process, following the curve of anterior border	7	0	6	0	7	6
Breadth of base of lateral process	2	9	2	0	0	10
Breadth of middle of ditto	1	2	1	0	0	6

DESCRIPTION OF THE PLATES.

PLATE LXXII.

Fig. 1. Sternum, inner or back view, of *Palapteryx elephantopus*: nat. size.
Fig. 2. Costal border and lateral process of the same: nat. size.

PLATE LXXIII.

Fig. 1. Sternum, outer or front view, of *Dinornis rheïdes*: nat. size.
Fig. 2. Profile view, right side, of the same sternum.

PLATE LXXIV.

Fig. 3. Sternum, inner or back view, nat. size, of *Dinornis rheïdes.*
Fig. 4. Anterior or upper border of *Dinornis rheïdes*: nat. size.

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[1] The end of the median process is not entire; one, or even two inches may be wanting.

[2] This is on the left side; the extent is less on the right side, where the notch is deeper and is terminated by a narrower curve.

[3] Subject to addition from the part wanting.

MEMOIR

ON THE

MODIFICATIONS OF THE SKULL

IN THE

GENUS DINORNIS.

IN the Memoir on the skeleton of *Dinornis elephantopus*, the skull is briefly noticed (p. 233). Subsequent acquisitions of specimens of that part, in some respects more complete, enable me to better appreciate its specific characters and to bring them out by comparisons with those of the skull of *Dinornis robustus*, described pp. 151–169. I also avail myself of these grounds to determine and elucidate the cranial characters of some other species of *Dinornis*, as well as those of a seemingly dinornithoid gigantic bird which, like *Gastornis parisiensis*, existed in our own part of Europe at a remote tertiary period.

Skull of Dinornis elephantopus. (Plate LXXVII.)

The cranium of *Dinornis elephantopus* equals in length that of *D. robustus*[1], but is inferior in breadth and more convex both longitudinally and transversely, especially the latter, at the interorbital region (fig. 3, 11). The entire skull of *D. elephantopus* is shorter than that of *D. robustus*, by reason of the relatively shorter premaxillary and mandibular bones.

The occipital condyle (Pl. LXXVII. figs. 2, 4, 1) is a hemispheroid with a small proportion truncate above, from the middle of which surface a groove extends to the centre; its breadth is 4½ lines, its vertical diameter 4 lines.

The occipital foramen is in one skull subcircular, in others shield-shaped, as in the second specimen of *D. robustus* (Pl. LV. fig. 2). The lower transverse superoccipital ridge (Pl. LXXVII. fig. 2, 2), which overhangs the foramen, subsides upon the exoccipitals sooner than in *D. robustus*. The basioccipital descends proportionally lower to its bimammillate union (ib. figs. 2, 4, 1′) with the basisphenoid. There is one small precon-

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[1] Measured from the superoccipital protuberance to the premaxillary depression on the nasals; comp. Pl. LXXVII. fig. 1 with Pl. LXIV. fig. 1.

dyloid foramen on each side the base of the peduncle of the condyle. The vagal (ib. *v*), carotid (ib. *c*), and sympathetic canals have the same relative position as in *D. robustus*. The superoccipital is much less broad and is more arched than in *D. robustus*; its median vertical ridge (ib. fig. 2, 3) is less prominent in the present specimen, subsiding halfway down towards the foramen magnum. The paroccipital ridge takes the same course, but is not bent backward as in *D. robustus*; its lower angle (ib. fig. 2, 4) is divided by a notch from the carotid fossa. The paroccipital process is more contracted toward its lower end. The basisphenoid resembles in shape that in *D. robustus*, but the pterapophyses[1] (ib. fig. 4, 5′) are relatively shorter; the oblique eustachian grooves (ib. *e*) are well marked. There is a median venous foramen, in two skulls, between the origins of the pterapophyses, in one skull accompanied by a groove (ib. fig. 4, 5).

The crenate transverse occipital ridge, answering to that marked *d d*, Pl. XVI. fig. 3, instead of two, shows three curves on each side of the median vertical ridge (Pl. LXXVII. fig. 2, 3), answering to as many insertions of nuchal muscles. In advance of this ridge, upon the upper surface of the cranium (ib. fig. 3), is a second transverse ridge (ib. 7), not parallel with the former, but with a greater bend convex forward; it is formed in the same way, viz. by the rise of the outer surface in advance of the depression for muscular insertion. This second ridge is from 5 to 7 or 8 lines in advance of the first; it seems to correspond with the place of the lambdoidal suture in the young bird, here and in other adult skulls quite obliterated.

The mastoid process (fig. 1, 8) is as long as in *Dinornis robustus*. The premastoid (ib. 8′) is a ridge produced into a short point; the intervening concavity gives attachment to the postcrotaphyte fascicule or muscle. A longitudinal ridge extends from above the base of the mastoid, backward, overhanging somewhat the tympanic fossa, and joining the outer margin of the paroccipital at a right angle; to a ridge within this border, part of the ear-drum was attached, and the ridge, before it subsides, indicates the ecto- and entotympanic surfaces of the paroccipital (ib. 4). The tympanic cavity is formed as described in *D. robustus*, as is also the articular cavity for the tympanic bone. The characters of the "foramen ovale" and "prelacerate fissure," with its divisions into the optic foramen and those for the fourth nerve, the anterior division of the fifth, and the sixth nerve, are as in *D. robustus*. The right and left optic foramina are 7 lines apart; at the intervening space are the deep fossæ impressing the upper part of the sides of the beginning of the presphenoid (fig. 4, 9) and confluent orbitosphenoids (ib. 10).

The temporal fossæ are well defined, are similar in shape to and quite as large as those in *Dinornis robustus*: the least interspace between their upper ridges is 2 inches; but this varies a little in different specimens. The posterior division of the temporal

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[1] Trans. Zool. Soc. vol. iii. p. 351 (January 1848), and Osteol. Catal. Mus. Coll. of Surgeons, p. 303, no 1601: my "pterapophysis" is the "éminence particulière qui provient du sphénoide" of the Leçons d'Anat. Comp., ed. 1835, tom. iv. prem. partie, p. 111.

fossa (Pl. LXXVII. fig. 1, 8 8′) is smaller relatively to the anterior division (ib. 7) and to the entire cranium than in *D. robustus.*

On the upper part of the cranium (ib. fig. 3) a rough surface extends forward from the upper normal transverse occipital ridge for about half an inch at the mid line; it is defined by a slight elevation of the anterior, smoother upper intertemporal surface of the cranium, simulating a second upper transverse ridge (7) as before described.

The postfrontal or postorbital processes (Pl. LXXVII. figs. 1–4, 12) are as broad as in *D. robustus*, consequently are relatively broader in proportion to the orbits and skull in *D. elephantopus* than in *D. robustus*: they are bent in their descent less obliquely backward. Upon the under surface of the roof of the orbits there is a well-marked oval depression, 3 lines in long diameter, posteriorly (ib. fig. 4, *l*), and a number of smaller more irregular depressions and foramina anterior thereto.

The presphenoid (ib. fig. 4, 9) is compressed and is angular at the interorbital extent of its under surface, instead of being convex as in *Dinornis robustus.* The depression above the base of the presphenoid and below the optic foramen is narrower than in *D. robustus.* The posterior part of the "girdle" is not transverse to the axis of the skull but is inclined from the mid line outward and forward; and the presphenoid is deeper as well as narrower below the "girdle."

The prefrontals (ib. figs. 1 & 4, 14), anterior to the orbitosphenoids (ib. 10), and continuous therewith, diverge from their basal confluence with the presphenoid (ib. 9), upward and outward; the part of their primitive blastema, interposed between the olfactory capsules, retains its unossified state at the hinder part of those cavities, save to the extent of one or two lines at the upper part, where a thin septal crest projects to the same extent from the expanded layer of the prefrontal, coalesced with the anterior wall of the cranium formed by the frontals and nasals. The posterior wall of the rhinal cavity is perforated by numerous olfactory nerve-filaments so as to form a "cribriform plate"[1]. At the fore part of the orbit the outer plate of the prefrontal bends downward, outward, and forward toward the lacrymal (Pl. LXXVII. figs. 1 & 5, 73), with which it forms the anterior wall of the orbit, chiefly convex thereto; the inferior border of this antorbital wall is continuous with the semicircular frame or "girdle" of bone[2] supporting a thin subreticulate ossified part of the olfactory capsule, forming a concavity looking or opening forward, and leaving a passage to the interorbital part of the olfactory cavity between its convex surface and the median part of the prefrontal. This median part, answering to the "lamina perpendicularis ethmoidei" of anthropotomy, the partial ossification of which at the upper and back part of the olfactory chamber has already been noticed, has undergone the ossifying process about half an inch in advance of the cribriform plate, for about an inch and a half along the base, which expands upon the fore part of the presphenoid; contracting as it rises to form the thin bony septum, it

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[1] "This cribriform plate is a peculiarity in which *Dinornis* participates with *Apteryx*," *ante*, p. 164.

[2] "Cingulum olfactorium," *ante*, p. 163, Pl. LXV. fig. 1, *g*.

expands superiorly, especially at the hinder part, forming the platform supporting the nasals (ib. fig. 5, 15), and decreases vertically as it extends forward. The "girdle" divides the part of the olfactory cavity, partially partitioned by the bony septum, from the hinder expansion, where that septum is wanting. The undivided olfactory cavity extends backward beneath the fore part of the cranial cavity as far as the back part of the orbits. The outer layer of the prefrontal projects from beneath the angle between the nasal and frontal, or lacrymal, very much in the ordinary position of the external part of the prefrontal in Reptiles and Fishes.

The nasals (ib. figs. 1, 3, 5, 15) are confluent posteriorly with the frontals (ib. 11), below with the upper expanded plates of the prefrontals (ib. fig. 5, 14), externally with the lachrymals (ib. 73), and internally or mesially with each other as far as the prefrontal confluence, in advance of which their median suture persists. The maxillary process (ib. fig. 5, 15′) appears to be shorter, and the premaxillary part (ib. 15) longer and more pointed than in *Dinornis robustus*. The smooth shallow depression (ib. fig. 3, 15) on which the premaxillary glides is narrower than in *D. robustus*; the raised, usually rough, surface external thereto contracts in breadth to near the pointed fore end of the bone, the upper part of which is smooth.

The cranium is longer in proportion to its breadth than in *D. robustus*. The occipital region is relatively of less extent vertically and transversely, and its middle part more completely overhangs the basioccipital condyle. The transverse extent of the cranium between the descending antorbital processes is markedly inferior in *D. elephantopus*, the vertical extent at the mid line being somewhat greater than in *D. robustus*.

The tympanic (ib. fig. 1, 28) differs from that of *Dinornis robustus* (Pl. LXII. fig. 2, 28, Pl. LXIII. figs. 2 & 4) in the less-concave upper border of the orbital process (*k*) and in the smaller cavity (*h*) for the squamosal.

The posterior articular surface of the squamosal presents a convexity at the back part of the inner surface of the bone, fitting into the depression of the tympanic, and a concavity in advance adapted to the convexity on the tympanic process in front of the depression. The low obtuse ascending malar process to meet the postfrontal is better defined than in *D. robustus*.

Perhaps the best and most recognizable distinction between *Dinornis robustus* and *D. elephantopus* is in the not only absolutely but relatively smaller size of the mandibular parts of both upper and lower jaws in the latter species. The beak was shorter, more slender, and less obtusely terminated. The premaxillary with the most entire nasal process in my present series gives a total length of 3 inches 3 lines (ib. fig. 1, 22, 22′); that process expands posteriorly to a breadth of 6 lines (ib. fig. 6); but in the largest skull (belonging to the skeleton described in vol. iv.) the nasal articular surface indicates a rather broader process. As it advances the nasal branch loses breadth as it gains in depth, and is impressed at its narrowest part by a longitudinal groove. The lateral margins, as the branch contracts, bend downward and inward and meet to form the prenarial septum (ib. fig. 1, *s*), from the free margin of which to the tip of the beak measures 1 inch 7 lines.

The rough punctate surface sheathed by the horny bill passes rather gradually behind into the smooth septal plate. The maxillary branches (ib. figs. 1, 6, 22″) diverge backward at a more acute angle than in *Dinornis robustus*. The alveolar channel (ib. fig. 7) is much narrower; the intervening palatal tract is slightly concave without the median ridge. From the tip to the palatal fissure measures, in one specimen, 1 inch 5 lines; from the tip to the end of the maxillary process is 2 inches 5 lines; the breadth of the palate there is 1 inch 7½ lines.

The symphysial or rostral end of the lower jaw (ib. figs. 8 & 9) agrees with its homotype above in its smaller size, more slender and pointed proportions, as compared with that in *D. robustus*. The outer median tract defined by the parallel grooves (fig. 8) is 10 lines in length by 3 or 3½ lines in breadth. The upper or inner smooth surface of the symphysis (fig. 9) is deeper as well as narrower than in *D. robustus*.

Of the constituent elements of the mandible, the fore part of the splenial and the hind branches of the dentary retain their distinctness; the rest are welded together with the usual indications of the longitudinal fissure and foramina of the primitive separation.

The articular expansion of the mandible presents a narrow outer articular tract rising longitudinally into an open angle, and a broader inner and anterior surface, deeply concave transversely, almost level from before backwards, forming the anterior half of the digital cavity or depression, the posterior half of which is non-articular, and, in one specimen, is perforated by a small pneumatic foramen. The angle of the jaw is obtusely rounded, and from it arise, diverging upon the back part of the ramus, two obtuse ridges bounding a shallow transverse concavity; the outer ridge is most produced, especially at its termination.

The mandible, in proportion to the cranium, is relatively shorter, and of less vertical thickness than in *D. robustus*.

Skull of Dinornis crassus. (Plate LXXVI.)

In the extensive collection of dinornithic remains from Ruamoa, Middle Island, purchased of Mr. Walter Mantell[1] in 1846 by the Trustees of the British Museum, were many skulls which could only be approximatively referred to their respective species according to characters of size and proportion; and it was not until my reconstruction of the skeleton of *D. elephantopus*, described in vol. iv. of Trans. Zool. Soc. p. 159, that, besides the skull fitting the atlantal cup of the vertebral column of that skeleton, and apparently of the same individual, I could refer three other specimens[2] of more or less mutilated crania, giving materials for the foregoing description, to the same species.

Other skulls, next in inferiority of size, seemed probably from their number to belong

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[1] *Ante*, p. 234.

[2] Nos. 32200, 32202, 32205 of the 'Register,' Geological Department, British Museum.

to the species, *D. crassus*, of which many individuals were indicated by limb-bones obtained from the same locality and deposit. Finally, in the collection recently transmitted from Christchurch, Canterbury Settlement, Zew Zealand, by Dr. Haast, are two skulls of corresponding dimensions and characters, one of which is referred by that accomplished geologist (and, I believe, rightly) to *Dinornis crassus*, of which species series of limb-bones form part of the same collection, obtained from the swamp at Glenmark, which has proved so prolific in evidences of these extinct gigantic birds.

With this confirmation I proceed to add to the subjoined figures of the skull of *Dinornis crassus* (Pl. LXXVI.) notes of the principal differences which it presents in comparison with the skull of *D. elephantopus*.

The skull of *Dinornis crassus*, besides its proportional difference of size, chiefly shown in minor length, is distinguished from that of *Dinornis elephantopus* by a less-convex calvarium, relatively narrower and deeper temporal fossæ, and above all by shorter and terminally broader and more obtusely rounded upper and lower mandibles.

In breadth of superoccipital surface (Pl. LXXVI. fig. 4, *d d*) *Dinornis crassus* almost equals *D. elephantopus* (Pl. LXXVII. fig. 2); but it has a sharper, more deeply defined supplementary upper transverse superoccipital ridge (ib. fig. 2, 7), and this is nearer to the normal (more or less wavy) upper transverse ridge (that, viz., which is marked *d d* in fig. 4, and in Pl. XVI. figs. 3, 4, *Dinornis struthioïdes*).

The occipital condyle and foramen (Pl. LXXVI. fig. 4, *m*) differ from those of *Dinornis elephantopus* both in size and shape; a larger proportion of the tubercle is truncate above. The basioccipital descends more abruptly and relatively lower to the "platform," the tuberosities forming the hinder angles of which are well produced but more ridged, less mammilloid, than in *Dinornis elephantopus* or *D. robustus*. The sphenoidal platform (ib. fig. 3, 5) is less deeply impressed, less constricted laterally, by the eustachian grooves; and its under surface is flatter, less irregular. The thick paroccipital border of the tympanic fossa is subangular, with a superincumbent prominence connecting the paroccipital (ib. fig. 1, 4) with the mastoid (ib. 8), rather more marked than in *Dinornis elephantopus*. The mastoid and the premastoid ridge and fossa retain the type of *D. elephantopus*; but the temporal fossa (ib. 7) has less than half the antero-posterior breadth, with equal depth: a tract of from 2 to 3 lines intervenes between the superoccipital and temporal depressions (ib. fig. 2). The hind part of the postfrontal (ib. fig. 1, 12) is more deeply excavated by the temporal fossa, and thereby has a sharp margin from the origin of the process, that margin being thick and obtusely rounded as in *Dinornis elephantopus*. The antero-inferior boundary-ridge of the temporal fossa is continued from the underside, not the hinder part, of the base of the postfrontal. There is every sign of the vigorous action of the temporal muscles, although they were relatively smaller, and absolutely much smaller, than in *Dinornis elephantopus*. The orbit is not much less than in that larger species. In one skull of *Dinornis crassus* the presphenoid is more carinate than in another.

The premaxillary (Pl. LXXVI. figs. 1, 2, 3, 22), with the best-preserved nasal process (22′), gives a total length therealong, in a straight line, of 2 inches 7 lines, the length of the process from the point of trifurcation (or the back part of the prenarial septum) being 1 inch 6 lines. The rostral part of the bone contracts behind, rather gradually, to form that septum (ib. fig. 1, *s*), which is much narrower, or less produced backward, than in *Dinornis elephantopus*. The mid tract of the rostral part (ib. fig. 2, 22), defined by the pair of grooves, is broader and flatter than in *Dinornis elephantopus*. The sides slope from the grooves less vertically to the alveolar margin; and the end of the beak is more obtusely rounded: it is broader, flatter, and shorter than in *Dinornis elephantopus*. The palatal surface of the premaxillary (ib. fig. 3, 22) presents a gentle concavity, without median ridge or groove; and the bony roof of that part of the mouth is continued entire further back in relation to the prenarial septum.

The palatal part of the maxillary (ib. 21′) is gently convex from side to side, and sends back a short three-sided process for the articulation or attachment of the fore end of the palatine (ib. 20).

Two of the skulls of *Dinornis crassus*, from the morass at Ruamoa, in the Walter-Mantellian series, had fortunately been packed up with the fine dark mud dried and hardened about them. On carefully picking this matrix away from the palatal surface I exposed a pair of long, rather narrow, and slightly bent plates of bone (ib. fig. 3, 13), with their concave side applied to the presphenoidal rostrum (ib. 9), which they underlapped by their anterior third part, where their median edges come into contact. On being freed from the matrix, these laminæ fell apart: and I do not think that any confluence here of the pair of plates was ruptured in their exposure; but the delicacy and extreme fragility of the plates may leave this an open question at present. I doubt whether the entire length of either plate is shown, as, in the skull presenting them, the upper mandible and the fore part of the presphenoidal rostrum has been broken off. Of that on the right side a length of 1 inch 9 lines is preserved, of the left lamina 1 inch 6 lines. Both begin, behind, by an obtuse narrow end, and, converging, quickly expand to a breadth of 4 lines, which is retained for the course of an inch, when the lamella gradually narrows, and at their anterior divergence more quickly, to a point. The inner concavity and the outer convexity, which are moderate, rule in the transverse direction of the plate. Lengthwise the plate posteriorly is slightly concave, and then more slightly convex, where the plates converge anteriorly. The lower margin is straight, the upper and outer one convex in the degree of the expansion of the plate. These lamellæ (Pl. LXXVI. fig. 3, 13) are homologous with the pair, confluent anteriorly, and underlapping the rostrum in the Emu (*Dromaius ater*), determined (in my Second Memoir on *Dinornis*, 1846) as the vomer, and figured, with its symbolic number (13) in Pl. XXXI. fig. 2.

On the right side of the palate in the skull of *Dinornis crassus* with the divided vomer I found a more sinuously bent plate of bone in contact at its fore and inner surface with the hind end of the vomerine plate, extending some way forward parallel therewith, and continued backward, beyond the vomer, diverging, with gain of thickness and loss of breadth, to abut against the pterygoid facet of the tympanic. This bone (ib. fig. 3, 24) is the "pterygoid." External and superior to it was the hind end of the palatine (ib. 20), which there has a breadth of 5½ lines, the inner angle of which is rather thickened where it touched the vomer. From the outer, thinner and sharper angle the margin of the plate, which is the lower and outer one, is straight, slightly thickened, and, after advancing for one inch, expands, becoming again lamelliform. This end, however, is not entire, and seems to have been broken away from some attachment. The hind plate, which, after a slight transverse convexity from the hinder and outer angle, bends upward and inward, expands to a breadth of 7 lines at a distance of 9 lines from the hinder and inner angle; it then contracts with a thin wavy border to the fore end of the outer thicker border, which is there as it were twisted inward upon or beneath it. The entire plate then shows a twofold sinuous disposition with the concavity of the major part turned downward and inward. It bounds the inner, posterior or palatal nostril, and is homologous with the palatine (20, fig. 2, Emu, Pl. XXXI.).

In the second skull of *Dinornis crassus*, yielding evidence of palatal structure, the palatals were found with the anterior, expanded, inwardly twisted end of the straight outer tract in contact with the palatal plate of the maxillary. This plate (ib. fig. 3, 21'), in form and proportion resembling that in *Dinornis robustus* (Pl. LXV. fig. 1, 21), together with the attached portion of the body of the maxillary, had been slightly displaced on both sides by a superincumbent pressure of matrix, the skull seeming to have rested on the calvarium, palate upwards. No trace of the delicate vomerine plates had been preserved in this skull. But, together with the tympanic, pressed forward to the horizontal position, with the mastoid condyle slightly dislocated, there was exposed in the space between the orbital process of the tympanic and the pterapophysis of the basisphenoid, extending obliquely inward between the hind part of the palatine and the base of the presphenoid, the pterygoid bone, corresponding in shape with that above described. This bone had its thick, narrow, subtrihedral end directed toward the pterygoid articular facet of the tympanic, and its lamellate fore end joining both vomer and palatine. Retaining its attachment to the tympanic on the left side, where that bone has been pressed more outward than on the right, the pterygoid has been dragged away from its anterior connexions, and lies above and to the outside of the left palatine.

In the general proportions and connexions of the above-described bones, readjusted as nearly as their condition permitted in their natural places, as in Pl. LXXVI. fig. 3, they defined the posterior nostrils (palato-nares) and the pterapophysial vacuities (those between the rostrum and pterygoids bounded behind by the pterapophyses), in form and extent most nearly corresponding with that part of the skull in the *Apteryx* (Pl. VII. fig. 2). The two moieties of the vomer are in contact beneath the rostrum for nearly the same relative extent in *Apteryx* as in *Dinornis*; and the confluent anterior part of the vomerine lamellæ in *Apteryx* probably indicates the true condition of the vomer in *Dinornis*. In *Dromaius* the non-united halves of the vomer diverge posteriorly in a greater degree than in *Apteryx* or *Dinornis*, exposing a greater proportion of the rostrum. The obliquely and mesially concave palatal plates converge anteriorly, not so much or so soon in *Dinornis* as in *Apteryx*, but more quickly than in *Dromaius*, defining more completely a smaller pair of bony palato-nares. It is most probable that the detached representatives of "palatines" worked out of the matrix, in the first specimen, were the parts broken away from the anchylosed union of those bones with the palatal plates of the maxillary anteriorly, and with the pterygoids behind.

In *Struthio*, *Rhea*, and *Casuarius* the pterygoid coalesces with the palatine earlier than it does in *Dromaius*. A greater proportion of the vomer is cleft posteriorly in *Dromaius* than in *Rhea*. Upon the whole *Dromaius*, among the larger existing *Struthionidæ*, makes the nearest approach in palatal structure to *Dinornis* and *Apteryx*. This closer affinity is shown in the form of the basioccipito-sphenoidal tract and its relation to the pterapophyses. In *Rhea*, which, after *Dromaius*, comes next in palatal conformity, the tract in question sinks abruptly below the level of the pterapophyses, which seem to diverge at almost a right angle from the base itself of the rostrum. In *Dromaius* the pterapophyses diverge from the fore part of the tract itself, which is on the same level with the back part of the tract, and, as in *Dinornis*, only distinguished therefrom by the lateral constrictions or grooves due to the pressure of the Eustachian tubes.

The appreciation of the near affinities, among *Struthionidæ*, of *Dromaius* to *Dinornis* and *Apteryx* led me to select the skull of the Emu to illustrate that of the Moa in my first attempts to restore that complex and instructive part of the skeleton of the huge extinct New-Zealand apterous birds[1].

The results of the above exposition of palatal structure in the skulls of *Dinornis crassus* have enabled me to restore, from cranial fragments in the Walter-Mantellian series, not only the pterygoids and portions of the palatines of *Dinornis crassus*, but also those of the *Dinornis ingens* as figured in Pl. LXXXII. fig. 3.

In *Dinornis crassus* the malar process of the maxillary (Pl. LXXVI. fig. 1, 21), the malar (ib. 26), and squamosal (ib. 27) have coalesced into a styliform zygoma 2 inches 2 lines in length. The malar rises as a low, obtuse ridge toward the postfrontal; the squamosal has a rough elliptic surface at the inner side of its hinder end, which projects inward to an obtuse point effecting the "gomphosis" with the tympanic (28). This bone (Pl. LXXVI. figs. 5 & 6), in relation to the shorter mandible, is relatively as well as absolutely smaller than in *Dinornis elephantopus*; the orbital process (*k*) is more triangular, has a broader base than in *Dinornis elephantopus*: this process is more

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[1] Most of the notable modifications of the palate and pterygo-palatine arches have since been figured by Eyton in the rich storehouse of the bony structures of birds, entitled 'Osteologia Avium,' 4to, London, 1864–67.

produced, with a narrower base, in *D. robustus* (Pl. LXIII. fig. 2, *k*). The pterygoid and pterapophysial (*pt*) articular surfaces are well marked.

The mandible (Pl. LXXVI. fig. 1, 29, 32, and figs. 7, 8, 9), nearly 5 inches in length, has a more irregular upper border than in most Moas, owing to the deeper emargination between the coronoid process of the surangular (29') and the alveolar border of the dentary (32'). The posterior triangular fossa is deeper and better-defined than in *Dinornis elephantopus*; its upper and outer angle is more produced; the expanded articular part is longer in proportion to its breadth. But the chief and most recognizable modification is at the rostral or symphysial end (figs. 8, 9), which is more expanded, more obtuse, and shallower above (fig. 9) than in *D. elephantopus*—conforming in shape to that of the premaxillary.

Skull of Dinornis rheïdes, *Ow.* (Plate LXXV.)

With the sternum and limb-bones of *Dinornis rheïdes*, in the collection of H. Sumpter, Esq., of which the former bone is described, pp. 255–258, there was a cranium and mandible proportionate in size. In the collection of Moa-remains brought by Mr. Walter Mantell from Ruamoa there were, with limb-bone evidences of *Dinornis rheïdes*, two skulls, more or less entire, which so clearly agree with that above-mentioned that I refer them to the same species; and this species I believe, on this evidence, to be *D. rheïdes*.

The cranium is narrower in proportion to its length than in *D. crassus*. The superoccipital so projects at its midpart as to conceal the condyle from view, looking directly upon the calvarium: comp. Pl. LXXV. fig. 3, with Pl. LXII. fig. 1, *D. robustus*. From this structure the plane of the occipital foramen (Pl. LXXV. fig. 2, *m*) is less vertical, inclining from above downward and a little forward to the condyle. From the prominent upper border of the foramen the superoccipital plane inclines from below, upward and forward, at an angle of 50° with the basi-presphenoidal axis. If the occipital plane be understood as the hind wall or face of the skull from the basioccipital mammillæ (ib. 1') to the superoccipital crest (ib. 3), such plane lies nearly at a right angle with the basi-presphenoidal axis. But in the present and some other dinornithine skulls it describes a convex curve vertically, of which the upper border of the foramen magnum is the most prominent part (ib. fig. 1, 437). The basicranial axis is usually understood to traverse the lower border of the occipital foramen, and it would then be out of the parallel of that of the basi-presphenoidal tract or axis.

The occipital condyle forms rather more than half a hemisphere, truncate above, from the mid part of which a slight depression or dimple extends toward the middle of the condyle. The crenate ridge (3) and the more advanced upper transverse superoccipital ridge (fig. 3, 7) are approximate; both the mid vertical and transverse ridges of the superoccipital are less strongly marked than in *D. crassus*, *D. elephantopus*, and *D. ro-*

bustus. With other smaller kinds of Moa, *D. rheïdes* exemplifies the less-mature age of the larger kinds in the minor indications of muscular force. The paroccipital part of the occipital surface bulges rather more abruptly outward and backward than in the larger crania above described, leaving a correspondingly deeper depression between that part (Pl. LXXV. figs. 2, 3, & 4, 4) and the superoccipital tract (ib. 3). The masto-paroccipital wall of the tympanic chamber (ib. figs. 1 & 4, 4, 8) has a less angular, more arched, border than in *D. crassus*. The basioccipital mammilloid tuberosities (Pl. LXXV. figs. 2 & 4, 1′ 1′) are less prominent. The posterior walls of the Eustachian canals (fig. 4, *e*) in one skull of *Dinornis rheïdes* are continuous, appearing to define the basioccipital from the basisphenoid, with a median emargination; but this is less marked in the two other crania of the same species. All show, more or less strongly, the remnant of the basisphenoidal mid vertical canal between the bases of the pterapophyses (5′).

The alisphenoid (fig. 4, 6) swells out into an oblong tuberosity below the "oval hole"; a deep notch, with a small venous perforation, divides the swelling from the pterapophyses (5′). The tuberosities are more prominent in *Dinornis rheïdes* than in *D. elephantopus* or *D. crassus*[1]; they correspond with the mesencephalic fossæ, but are pneumatic, and due exclusively to the outer table and subjacent diploë.

The orbitosphenoids (ib. 10) are as unmistakably indicated (in birds) by their essential characters as transmitters of the optic nerves, as are the alisphenoids by the oval foramina; no separate ossification of the descending orbital plate of the frontal in a young Grouse, or Goose, or other bird could be mistaken for an orbitosphenoid by any anatomist, save one constitutionally incompetent to appreciate or comprehend the grounds upon which true homology is determinable.

The presphenoid (fig. 4, 9) rostral in shape, as in all birds and most mammals, is of great length, as in other *Dinornithes* and the *Struthionidæ* generally; it is compressed behind its mid part, and again expands to a breadth equalling that of its hind part in *D. rheïdes*: the under surface is subcarinate where compressed, transversely convex where expanded; it terminates as usual, in a point. At its base it is confluent, above, with the orbito-sphenoids, and in advance of these with the prefrontals; the line of confluence with the latter extends outward in the form of a shelf, or transversely horizontal plate, with an obtuse terminal angle on each side (9″); on this plate rests the olfactory hoop (*cingulum olfactorium*).

The prefrontals retain the characters of those in the previously described species, making no show (as they do in *Struthionidæ*[2]) upon the upper surface of the cranium. The confluence of the nasals with the frontals, prefrontals, and lachrymals is very complete; the cleft between the nasals (fig. 3, 15) persists anteriorly.

Both nasals and frontals were unfortunately wanting in that instructive portion of the cranium of the young Gigantic Dinornis figured in Pl. LIII. figs. 1, 2, 3. I have

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[1] They are still more prominent in *D. gravis*, to be afterwards described.

[2] Pl. XXXI. fig. 1, 11 (*Dromaius*).

found the nasal confluent with the frontals in all other specimens of skulls of more or less adult birds; they are planed off, as it were, above, to let in the nasal process of the premaxillary. Such depressed articular surface (Pl. LXXV. fig. 3, 15) does not reach further back than the transverse parallel of the lachrymal part of the orbits.

The prosencephalic part of the cranial cavity makes a prominence above the general level of the calvarium. The postfrontal (ib. fig. 1, 12) is nearly vertical. The temporal fossa is narrow antero-posteriorly compared with that in *Dinornis elephantopus*, but is relatively wider than in *D. crassus*: a postcrotaphyte fossa is defined by a short, premastoid, pointed process[1]. The mastoid process (fig. 1, 8) is long, subcompressed from before backward, and pointed.

The rostral part of the premaxillary (ib. 22) is relatively longer than in *D. crassus* or *D. elephantopus*, shorter than in *D. robustus*; it is minutely perforated, showing a cork-like surface; that of the nasal process (22') resumes the usual smoothness, as does the premaxillary part of the internarial septum (*s*). The premaxillary is more suddenly pinched in, as it were, laterally, to form this septum, than in any of the above species; its fore-and-aft extent is two-fifths that of the premaxillary prior to its trifurcation. The entire portion of the bone forming the end of the upper mandible is slightly deflected, and terminates subacutely. The upper median tract is defined by a well-marked, though shallow and narrow, groove on each side, ending about four lines from the apex. The palatal surface shows a low, narrow or linear median ridge, and two wider marginal or alveolar grooves; between these grooves the surface is transversely concave at the middle, and convex on each side. At about an inch from the apex the mid ridge subsides, and the bifurcation of the palato-maxillary processes begins; the fissure is relatively longer and narrower than in *Dinornis robustus*. The narrow base, or beginning, of the nasal process (fig. 1, 22') shows a linear mid furrow on its upper surface, which disappears as the process flattens and expands; the under surface of the process shows a low mid ridge, against which the margins seem to be bent or folded inward to form the front part of the internarial septum. The hind free concave margin of this septum shows the fissure left between the inflected laminæ, which diverge below to form the upper surface or layer of the palatal part of the premaxillary. At the place of divergence, above the lower palatal layer, are the mid fossa and two lateral nervo-vascular canals conveying the trunks of the many ramifications which emerge at the perforations of the cork-like outer surface to constitute (or help thereto) the periosteal formative bed of the upper horny mandible.

The maxillary is broadest anteriorly, where it sends inward from its lower part the contribution to the roof of the mouth called "palatal plate or process of the maxillary," answering to the same processes in the Crocodile and in Mammals. The upper plate of this fore part of the bone swells into an oblong convex dome, roofing a sinus

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[1] The homologue of the ridge bisecting the temporal fossa, and produced beyond the ordinary mastoid in *Aptornis* (Pl. XLIII. figs. 1, 8').

answering to the "maxillary" one or "antrum"[1] in Mammals, with a small subtriangular aperture posteriorly, which looks backward and downward: the longest diameter of this aperture is 4 lines; the sinus is elsewhere closed: its length is 1 inch 2 lines, its height 8 lines, and its breadth the same. The inner wall developes a slightly arched ridge, which abuts upon the presphenoid below the rhinal plate or "shelf" (fig. 4, 9′). The outer side or wall of the antrum is impressed lengthwise by the termination of the alveolar branch of the premaxillary (fig. 1, 22″): the palatal plate of the maxillary, forming the floor of the antrum, is underlapped anteriorly by the palatal plate of the premaxillary, and abuts by its median margin upon the fore part of the vomer. The maxillary or descending branch of the nasal, with the contiguous part of the rhinal capsule, articulates with the outer and back part of the antrum. Below this, and external to the antral orifice, the maxillary contracts to the slender subtrihedral bar passing backward and outward to coalesce with the slender malar (fig. 1, 26). The under facet of the maxillary is impressed with the backward prolongation of the alveolar channel.

Thus the maxillary manifests its true nature and homology with the bone so called in the Mammal, in the clearest and most unmistakable manner in *Dinornis*. In all birds it retains the more essential and constant characters of 21 in Mammals and Reptiles. It continues backward the roof of the mouth from the premaxillary palatal process; it continues backward the alveolar process or border, from that grooved border of the premaxillary; it sends off the zygomatic process, to which the malar articulates, such part of this malar, prior to anchylosis, being overlapped, as is usual, by the maxillary, as the malar itself is overlapped by the zygomatic part of the squamosal.

Accordingly our great masters in Comparative Osteology (CUVIER[2], MECKEL, GEOFFROY ST.-HILAIRE) have unhesitatingly recognized the nature of this bone, which only one prone to mystify what is clear, and to complicate what is simple and plain, could have persuaded himself to contradict by "vicarious" fancies[3]. The usual extreme ornithic modification of the bone is manifested in *D. rheïdes* as in *D. robustus* (Pl. LXV. fig. 1, 21 21′). The malar (26), with which it has coalesced, is remarkable in *D. rheïdes* (at least I have not found the character in the larger dinornithic crania with the

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[1] The corresponding part of the maxillary is described in *Dinornis robustus* as "an oblong, bony, pneumatic capsule, 2 inches in length and 1 inch 3 lines in breadth, flattened below," &c. (*ante*, p. 156).

[2] "*L'os jugal* réunit, comme dans les mammifères, les parties latérales du crâne à la face, par le temporo-articulaire [my "squamosal"], et le sus-maxillaire se joint à ces deux os par une articulation serrée, qui les force de suivre ses mouvements en avant et en arrière. Les os *palatins* ont une articulation à peu près fixe ou très-mobile avec les os sus-maxillaires," &c. (Leçons d'Anat. Comp. ed. 1835, tom. iv. p. 112). Cuvier's "sus-maxillaire" is my "maxillary"; his "sous-maxillaire" I call "mandible."

[3] The "maxillary" is, or rather was, the "prevomer" of Parker, who calls it "the splint-bone which is vicarious of the maxillary in the Bird-class" (Trans. Zool. Soc. vol. v. p. 233). His rectification of opinion (Trans. Zool. Soc. vol. vi. p. 502) is based on a distinct ground for the acceptance of homology, viz. "authority." It is in his case a praiseworthy ground, and needs only a choice of the proper one to lead him to a true view of other particulars of the osteology of birds in which he has gone astray.

zygomatic arch) by the extent of the process sent upward to meet the descending postfrontal (12).

The tympanic bone (figs. 9, 10) shows the single mastoid condyle (*e*) as in *D. robustus*, *D. crassus*, and probably all *Dinornithes*: it is here divided by a low mid-linear ridge at the fore part; and the divisions very slightly project behind, on each side a shallow mid depression. The stem is subcompressed obliquely from before backward, the hind surface inclining rather outward; both outer and inner sides converge to a sharp concave posterior margin, the stem becoming thus three-sided with the anterior surface narrower than the outer and inner ones. The latter shows a subcircular pneumatic foramen (fig. 10) ½ inch below the condyle, and not situated in so large and definite a depression as in *D. robustus* (*loc. cit.* pl. 54. fig. 2, *g*). The posterior margin shows part of the groove and ridge for the attachment of the tympanic membrane. The orbital process (*k*) shows the facet (*ps*) for the pterapophysis, but not supported on so well-marked a prominence as in the larger species of *Dinornis*. The surface for the pterygoid is at the fore part of the inner convex condyle (*i*) for the mandible. The two mandibular surfaces, postconcave and preconvex, are similar to those shown in pl. 54. fig. 3, *h i*, *tom. cit.* External to the mandibular process is the usual subhemispherical cavity (fig. 9, *h*) for the squamosal (fig. 8, 27).

The mandibular rami coalesce, as in other *Dinornithes*, by a short symphysis sloping from above downward and backward (Pl. LXXV. fig. 5). Each ramus describes a gentle sigmoid curve, best marked at the lower border, which is convex at the hinder, concave at the fore half of the mandible (ib. fig. 1, 29 32).

The back part of each ramus forms an expanded triangular surface (Pl. LXXV. fig. 6, 29), deeply concave from the outer to near the inner side, which is formed by a narrow, vertical, convex tract; the vertical ridge or plate of bone extending forward from this tract divides the concavity (fig. 7, 29) for the insertion of the pterygoid muscles from the interarticular depression (fig. 5, *i*). At the fore part of this depression is the transversely concave facet for the convex lower condyle of the tympanic. The plate of bone extending forward from the outer side of the mandibular base expands and forms along its upper part the oblong articular surface (fig. 5, *i*) adapted to the outer and lower condyle of the tympanic. The inner plate, which is sharp above, subsides at the fore part of the fossa (*b*); the surangular part of the ramus (fig. 7, 29) is continued from the outer articular surface. The angular piece (fig. 1, 30), smooth and broadly convex posteriorly, rapidly contracts to a vertical lamella, which is excavated at the outer part of its anterior half for reception of the lower division of the dentary (32), along which it is continued internally as a flat thin lamella, below and parallel with the splenial (figs. 1 & 7, 31), and terminating in a point about an inch from the fore end of the mandible. The surangular (29), coalescing or connate posteriorly, like the angular (30), with the articular element, bounds the outer ramal depression above and terminates forward by penetrating the upper division (32') of the dentary, with which it thus unites as by a species of gomphosis. The splenial (fig. 7, 31), conversely with its condition in *Alca impennis* and many other birds, has coalesced posteriorly with the angular and surangular, and terminates in a free point anteriorly, being lodged, behind, between the angular and surangular, where it closes internally their interspace, and anteriorly between the two divisions of the dentary. Of these the lower (figs. 1 & 7, 32″), as in *D. robustus* and *D. crassus*, is longer than the upper one.

The outer surface of the unbranched part of the dentary and the symphysial part determining the contour of the lower mandible repeat pretty closely the characters described and figured in *D. robustus*. The alveolar groove (fig. 5, *b*) is narrow and multiperforate.

The length of the cranial cavity is 2 inches, its extreme breadth (across the hind third of the prosencephalon) is 1 inch 8 lines, its extreme height (behind the sella near the fore part of the epencephalon) is 1 inch 2 lines; and these admeasurements give almost accurately the dimensions of the brain in a bird which, weight for weight, equalled or surpassed the *Rhea americana*. The cavity is nearly equally divided lengthwise between the ep- and pros-encephala. A low tentorial ridge forms the boundary, arching from above, vertically, along the side walls of the cavity, interrupted at the fore part of the petrosal sinus, and subsiding on the floor of the cavity, after bounding anteriorly the triangular depression for the optic lobe. From the lower and back part of this depression is continued the canal for the main part of the trigeminal nerve (foramen ovale) traversing and determining the alisphenoid neurapophysis. The upper semicircular canal bounds below and gives the arched curve to the petrosal sinus. The roof of the epencephalic chamber is less arched from before backward than in most birds, owing to the hinder position and almost verticality of the foramen magnum and to the degree in which the superoccipital inclines forward to join the parietals. The tentorial ridge shows no trace of the tumid swelling which characterizes it in the *Didus ineptus*[1]. At the lower lateral part of the epencephalic wall is the multiperforate shallow depression receiving the acoustic nerve. Behind this is the canal for the vagal nerve and entojugular vein: below this opens the small precondyloid foramen. The prosencephalic chamber has its side and upper walls divided by a long, low, smooth, broad rising, which arches, from the tentorial ridge above the fore part of the petrosal sinus, obliquely forward and a little downward, subdividing at the rhinencephalic chamber: it indicates a corresponding longitudinal furrow of the cerebral hemisphere.

In all *Dinornithes*, and in the ratio of their size, the walls of the cranial cavity are thick, mainly through the abundance of largely cellular diploë interposed between the thin and compact outer "table" and the thicker compact inner table of such walls. This is shown in the section of the cranium figured in Pl. LIII. fig. 4, also in the specimen with the outer table of the calvarium removed, in Pl. XLIV. fig. 6, and in the specimen with the outer table removed from the basis cranii, ib. fig. 5. The thickness

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[1] Owen, Memoir on the Dodo, Zool. Trans. vol. vi. p. 71, pl. 23. fig. 1, *o*.

of the cranial walls is strikingly shown at the lines of suture, or rather "harmonia," of the cranial bones in the skull of a young individual of *Dinornis giganteus* (Pl. LIII. fig. 3, *r*), in which the extension of the compact table from the outer to the inner surface of the cranial bone is shown along the harmonial surface: such continuous plate becomes absorbed after the confluence of the cranial bones is completed; and the diploë then gives free and uninterrupted passage to the air through the thick walls of the skull. Consequently the inner table alone is moulded upon the brain, the most prominent upper parts of which (at the prosencephalon), though sometimes obliterating the diploë, as is partially the case in *Dinornis rheïdes*, rarely (as in that species) pushes the outer table above its level so as to indicate the whereabouts of the cerebral hemispheres. The breadth as well as length of the fronto-nasal roof of the skull (Pl. LXXV. fig. 3, 11) anterior to the prosencephalic risings (if these happen to be marked) are characteristic features of *Dinornis*; and I may add that, among other distinctive characters noted in former Memoirs, *Dinornis* differs from the *Struthionidæ* in the upper expansion of the coalesced prefrontals being covered by the nasals and not appearing at the upper surface of the skull, in the absence of an expanded outer plate of the lacrymal, and in the almost equality of breadth of the occiput with the postorbital part of the skull.

Of the Cranial Cavity of Dinornis giganteus. (Plate LXXVIII. fig. 9.)

With some parts of the skeleton of a *Dinornis giganteus* presented to the British Museum by Mr. Luxmore, including most of the vertebræ and pelvis, was the cranium, with some other fragments of the skull, all much abraded or fractured. The locality of these remains is unknown. The thick and coarse-celled diploë of the cranial walls was extensively exposed; and it seemed to me that the best use to make of the specimen was to expose in it by a vertical longitudinal section the extent, shape, and other characters of the cranial cavity in that species.

These, therefore, I propose to compare with those detailed in the foregoing account of *D. rheïdes*.

The length of the cranial cavity is 2 inches 8 lines, the breadth 2 inches 5 lines, the height 1 inch 4 lines, the measurements being taken at the same points as in the cranium of *D. rheïdes*. The cavity is unequally divided by the vertical tentorial ridge, the prosencephalon being longer in proportion to the cerebellum than in *D. rheïdes* or the species figured in Pl. LIII. fig. 4. The tentorial ridge is interrupted, as in those species, by the passage of the longitudinal into the lateral or petrosal sinus. Beneath this the petrosal wall of the labyrinth makes a greater prominence than in the smaller Moas above cited. The mesencephalic fossa (Pl. LXXVIII. fig. 9, *m*) is not larger than in them, is consequently relatively smaller, especially to the prosencephalic one (*p*) in *D. gigas*. The foramen ovale is more oblong, and at the upper part of the side of the cavity. The prelacerate and optic foramina present the same size and position as in *D. rheïdes*, indicating, together with the size of the mesencephalon, relatively smaller eye-balls in *D. gigas.* The sella (*s*) is somewhat deeper, but not larger in other dimensions; it is perforated behind by the entocarotid canal. The prosencephalic wall has the same configuration (indicative of the longitudinal indent of the cerebral hemisphere) as in *Dinornis rheïdes.* The rhinencephalic fossæ (*r*) are a pair divided by an obtuse longitudinal ridge representing a "crista galli" 2½ lines thick; each fossa is elliptic, 5 lines by 4 lines in long and short diameters, with from eight to ten perforations, the largest leading from the outer side of the cavity. The cribriform plate is extremely thin.

Skull of Dinornis casuarinus, *Ow.* (Plate LXXVIII. figs. 1–8.)

The relations of locality affecting the sternum and limb-bones of *D. rheïdes*, and the sole cranium therewith collected and transmitted to Mr. Sumpter, without a trace of any determinant bone of *Dinornis casuarinus*, solved the doubt which had long troubled me in regard to the skull, which, in respect to general size, might seem to belong to either of two such nearly matched species. It was with lively satisfaction, therefore, that I saw in a series of bones belonging to one and the same skeleton of a *Dinornis casuarinus* from the famous Glenmark swamp, submitted for exchange to the Geological Department of the British Museum, in the course of the present year, by William Reeves, Esq., that the skull presented, with a general correspondence of size in the cranial part (Pl. LXXVIII. figs. 2, 3), unquestionable specific differences throughout from that of *Dinornis rheïdes*, and more especially in the forms and proportions of the mandibular parts of both upper and lower jaws (ib. figs. 4–8).

The occipital surface (ib. fig. 3) almost exactly repeats the dimensions of the same in *Dinornis rheïdes*, but with the following differences:—

The basioccipital descends more abruptly and vertically, the vagal and carotico-sympathetic foramina are larger, the tuberosities (ib. fig. 3, 1′) are less prominent or defined at the back part of the basioccipito-sphenoidal quadrate surface or "platform." The upper border of the foramen magnum is much thicker, and is channelled, as if for a venous sinus. The superoccipital rises above the foramen, as a triangular tuberosity (ib. fig. 2), to the level of the calvarium. The superoccipital depressions, having this tuberosity intervening instead of a vertical crista, are wider apart. The ridges descending from above the foramen magnum, and diverging to the paroccipitals, are broader and more pronounced; they define, with the back part of the basioccipito-sphenoidal surface, a triangular area, from near the centre of which projects the occipital condyle. There is a similar depression to that in *D. rheïdes* on each side of the superoccipital surface, below and external to which bulge out the paroccipitals; the ends of both processes are broken away. I hesitate on this account to express the belief that the paroccipital part of the tympanic fossa has less antero-posterior extent than in *D. rheïdes.* The articular cavity for the tympanic extends further inward from the base of the mastoid process. The premastoid ridge is less produced than in *D. rheïdes*; the temporal fossa is encroached upon by a vertical longitudinal rising midway between the premastoid ridge and the postfrontal. The antero-posterior extent of the temporal fossæ and the calvarian interval between them are alike in both species. But it is in advance of this part of the skull that the greater differences begin. The orbits are smaller; the breadth of the cranium across the postorbitals is less; the fore part of the cranium is modified for the support and attachment of a much weaker and shorter mandible.

The premaxillary part (Pl. LXXVIII. figs. 4, 5, fig. 1, 22) of this mandible is fortunately nearly entire. The anterior undivided mandibular part of the base is much smaller and shorter in proportion to the nasal process. The perforated irregular surface in relation to the bill-sheath contracts posteriorly more gradually between the nasal and maxillary branches to form the smoother prenarial septum; and this is relatively of much less extent than in *D. rheïdes.*

The palatal surface of the premaxillary in *D. casuarinus* (ib. fig. 5) is flatter and less bent; the marginal alveolar grooves are shallower. The mid furrow upon the narrower beginning of the nasal process is long and deep; it disappears upon the hinder flattened part of that process.

The tympanic (Pl. LXXVIII. figs. 1, 28 & 13), like the mandible it supports, is markedly less than in *D. rheïdes.* There is less indication of a division of the single condyle that crowns the antero-posteriorly compressed mastoid branch (*e*); the orbital or pterygoid branch (*k*) is broader and shorter, more convex outwardly, more concave at the inner side, with a better-marked and more prominent pterapophysial facet (*p*). The pneumatic depression, though smaller, is better defined, extending from the foramen upward to the inner side of the mastoid condyle.

The rami of the lower jaw (fig. 6) are more delicate and slender in proportion to their length than in *D. rheïdes.* The back part of the ramus is less expanded, the outer border of its concavity is thicker and more obtuse, the inner one is less thick, the two borders, which meet at the lower angle, being more alike in character. The articular surfaces and intervening vacuity offer no notable modification. The outer depression between the angular and surangular retains posteriorly a small vacuity leading obliquely upward to a foramen on the inner side of the ramus, grooving the base of the low obtuse coronoid process. The splenial element (31) has coalesced behind, not anteriorly; the dentary has coalesced with both the angular and surangular. The outer mid tract of the symphysis (fig. 7) is defined, as in other species, by a pair of parallel grooves.

The more characteristic leg-bones of the specimen to which the above-described skull belongs, agree pretty closely in size with the type specimens[1], but are rather more slender as in the smaller variety of *Dinornis casuarinus* in Dr. Haast's admeasurements, the following being the length of—

	in.	lines.
Metatarse	8	5
Tibia	18	3

The difference between Dr. Haast's larger and smaller sizes is only such as might be

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[1] Femur, Pl. XXXVIII. figs. 1–3; tibia, Pl. XXXIX. fig. 2; metatarse, Pl. XL. fig. 3.

explicable, as Dr. Haast suggests, as a sexual character; the specimen noted as yielding "the smallest size" is, as Dr. Haast remarks, of a bird not quite full-grown.

The difference in the proportions of the leg-bones between *Dinornis rheïdes* and *D. casuarinus* is greater in respect of robustness than of length, yet not in such a degree as to make the decision come to as to their specific distinction one lightly arrived at, or without well weighing many particulars. In the memoirs defining these species I troubled the Society mainly with the results, omitting particulars of the processes leading thereto. But I could not have ventured to anticipate that a certain comparative slenderness of the hind limbs would have been associated with a beak shorter and weaker in the degree demonstrated by the skull of *D. casuarinus* above described.

Skull of Dinornis gravis, *Ow.* (Plate LXXXI.)

Many characteristic parts of the skeleton of the same individual bird were obtained by William Fenwick, Esq., at the Kahamin River, Middle Island, New Zealand, and were presented by that gentleman to Miss A. Burdett Coutts.

Dinornis gravis was of about the same stature as *D. rheïdes*, and as the characteristics of cranial structure will be better appreciated in both birds by contrast and comparison, I give a description of the skull of the new species in the present Memoir.

Dinornis gravis presents the shortest mandible in proportion to the breadth of the skull that I have yet observed in that genus. The breadth of the occiput being equal to that of *Dinornis crassus*, the occipital condyle and foramen magnum are less, especially the latter (comp. fig. 4, Pl. LXXXI., with fig. 3, Pl. LXXVI.). The superoccipital tract slopes more forward, is more continuous with the general longitudinal upper convexity of the cranium. The basisphenoidal platform is longer in proportion to its breadth; it shows a large central orifice of a canal extending upward and backward. The alisphenoidal tuberosity (fig. 4, 6) is more prominent and divided from the pterapophysis by a deeper and narrower fissure. The foramen ovale is divided by a better-marked bar into an upper smaller and lower larger division. The paroccipital bends down from the mastoid more abruptly, at a right angle to the connecting ridge, in order to form the back part of the tympanic fossa. The temporal depression is relatively smaller, especially in antero-posterior diameter; an extent of 1 inch 9 lines intervenes at the upper part of the cranium between these fossæ (fig. 3). The postorbital process is triangular, more rapidly decreasing in breadth as it descends, and its outer plane is directed more backward, less outward, than usual. The presphenoidal rostrum, 2 inches 8 lines in length, is compressed at its middle part below, expanded and convex before and behind this ridge, pointed anteriorly and confluent throughout its upper extent with the prefrontals and orbito-sphenoids. The "shelf" (Pl. LXXXI. fig. 4, $9''$) extends further outward than in *Dinornis crassus* or *D. rheïdes.* A broad vertical lamina, continued from the lachrymal and the olfactory girdle, descends external to the posterior olfactory orifice almost to the level of the presphenoid, forming the anterior wall of the orbit. The fronto-nasal articular tract for the median process of the premaxillary is 1 inch 7 lines in length and 6 lines in breadth (fig. 3); there is no distinct orbital process of the nasal.

The mandible of *D. gravis*, 4 inches 4 lines in length, is 2 inches 9 lines across the condyles, 1 inch 3 lines in breadth opposite the back part of the symphysis, which is only 7 lines in length (fig. 6). The splenial bends inward anteriorly toward the symphysis, its pointed end terminating in the groove at the back part of the symphysis: it has coalesced throughout its length with the other elements of the lower jaw. The form of the symphysial or rostral part of this lower jaw (Pl. LXXXI. fig. 6) indicates a corresponding breadth and obtuse termination of the short rostral part of the premaxillary. The type of beak of *D. crassus* is that which is exemplified in *D. gravis*. In size of head *D. gravis* most resembled *D. rheïdes*; but the degree in which specific characters are exemplified may be satisfactorily appreciated by contrasting their respective mandibles in the figures 5 and 6 of Pl. LXXXI.

Skull of Dinornis ingens, *Ow.* (Plate LXXXII.)

To Pl. LII. (pl. 23, vol. iv. of the Transactions of the Zoological Society), representing the most perfect skull of a *Dinornis* which had come to my hands at the date of my fifth Memoir (Nov. 12, 1850, p. 59), I added a note of interrogation to the name of the species to which such skull was, with that expression of doubt, referred.

This skull and many other bones, including limb-bones of *Dinornis ingens*, were discovered in 1849 in a cave in the district which lies between the river Waikata and Mount Tongariro, in the North Island of New Zealand; they were obtained and liberally transmitted to me by Governor Sir George Grey in 1850.

Successive receptions of Moa-remains, especially those with which the British Museum has been enriched by the laborious collectings of Mr. Walter Mantell, have added evidence of the general fixity of the characters of the above-described skull as belonging to an adult individual of a large and well-defined species; and the recent additional confirmation of its appertaining to the *Dinornis ingens*, published in the Palæontological part of the Circumnavigatory Expedition of the 'Novara,' induces me no longer to defer the publication of the description and figures of the more perfect materials at my command for the restoration of this instructive part of the skeleton of that species.

The portion of skull referred by Dr. Gustav Jaeger to *Dinornis* (*Palapteryx*) *ingens*, in the above-cited work (4to, p. 307, Taf. 25, 26), consists of the cranial part only, wanting both upper and lower mandibles. The locality where the specimen was discovered is not noted; it is stated to have formed part of the rich collection of remains of *Dinornis* obtained by Dr. v. Hochstetter during the stay of the Expedition of the Imperial Austrian frigate 'Novara' at New Zealand[1].

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[1] "Unter der reichen Sammlung von Moa-Resten, welche Professor Dr. v. Hochstetter bei Gelegenheit der Expedition der k. k. österreichischen Fregatte Novara aus Neu-Seeland nach Wien brachte, befindet sich ein Schädel," &c., p. 307.

Dr. Hochstetter, however, was so fortunate as to have presented to him the parts of the skeleton of one individual Moa, determined by proportions of the leg-bones to be *Dinornis ingens*, which had been discovered in a limestone cavern on the right bank of the Aorere River, in the Province of Nelson, New Zealand, in which, with the cranium, were the two tympanic bones ("Quadratknochen") and both upper and lower jaws. Unfortunately no other figure of this skull is given, save that (much reduced in size, as seen obliquely from below) in the plate of the restored skeleton. It shows, however, as may be seen in the copy added to Pl. LXXXII. fig. 4, the main characteristic distinctions of the skull of *Dinornis ingens* given in Pl. LIV., viz. the wide temporal fossæ, the long rostral portion of the premaxillary, and the extent of the prenarial septum. Further conformity is shown by the following admeasurements:—

	Dinornis ingens[1].		*'Novara' specimen*[2].	
	in.	lines.	in.	lines.
Breadth of the cranium across the mastoid	3	8	3	8
Breadth of the lower end of paroccipitals	2	10	3	0
Breadth of the lower end of postorbitals	4	0	4	2
Antero-posterior diameter of temporal fossa	1	6	1	6
Antero-posterior diameter of posttemporal division of temporal fossa	0	5½	0	6
Breadth of intertemporal tract	1	8	1	9

I have found no such degree of conformity between skulls of distinct species of *Dinornis* as is here exemplified.

The length, of "about eight inches," assigned to the entire skull of *Dinornis ingens* (p. 207) was estimated on the supposition that the nasal process of the premaxillary (Pl. LII. 22′) had lost more from its free end than I now know to have been the case; that described skull would not be more than from two to four lines longer than the more perfect specimen figured in Pl. LXXXI. The superoccipital transverse ridge (ib. fig. 2, *d*, *d*) shows two curves on each side the vertical ridge (3), the outer one being the widest, as in *Dinornis struthoïdes* (Pl. XVI. figs. 1, 3); the occipital condyle (1) is less pedunculate; the temporal fossæ (fig. 1, 7) are wider, with a different contour; and the prosencephalic chamber is more prominent on the upper surface of the cranium; the smooth tract between the temporal and occipital muscular fossæ is also narrower in *Dinornis ingens* than in *D. struthoïdes*. The mastoid (Pl. LXXXII. fig. 1, 8) is produced as a slender process about five lines below the masto-tympanic articulation; the premastoid ridge (ib. 8′) seems more definite than in *D. struthoïdes*. The postfrontal process (12) is relatively longer than in *Dinornis robustus*; the zygomatic arch (26 27) sends upward a more definite process toward the postfrontal. The rostrum (22 32) accords with the type of that in *Dinornis robustus* (Pl. LXIV. fig. 1), but is rather narrower and less obtuse.

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[1] Pl. LII., and p. 281, Pl. LXXXI.

[2] 'Novara' Expedition, Abth. Palæontologie, Taf. xxv. xxvi. (Dr. G. Jaeger's specimen).

The figures, of the natural size, in Pl. LXXXII., in which each bone bears its symbolic number, with similar figures in the present and former Memoirs of other species of *Dinornis*, give grounds of comparison which preclude the necessity of further verbal notice of details. One notes with interest that a species with comparatively long and slender limbs in the present wingless genus has a more lengthened beak (e. g. *Dinornis ingens*) than *Dinornis crassus*, and that the diploë of the cranial walls is less thick, showing the more than usually domed character of the cranium[1] in this broad and flat-headed group of extinct birds. The range in the length of the rostral part of the premaxillary exemplified by *Dinornis crassus* and *Dinornis ingens*, indicates a ground of derivative variety in which the existing *Apteryx* exemplifies a maximized degree. But, unless this gain was sudden in the dwarf species, the intermediate steps should be numerous, and have not yet been observed.

In the 'Bericht über einen fast vollständigen Schädel von Palapteryx,' Dr. Gustav Jaeger compares his specimen with the several figures of the skulls of New-Zealand extinct wingless birds given in the 3rd volume of the 'Transactions' of the London Zoological Society, pls. 38, 39, 52, 53, 55, but appears not to have been cognizant of the Memoir in the 4th volume (p. 205), in which not only is the most complete skull of a Moa described and figured which had, at that date (1850), been obtained, but also one belonging to the same species as that to which Dr. Jaeger is finally led to refer the subject of his description. (See "Erklärung der Tafel xxv., Schädel von *Palapteryx ingens*, Ow.," at the close of the Memoir.)

The chief aim of the comparisons of the accomplished Director der Wiener Thiergartens is to show that his specimen exemplifies the generic characters of *Palapteryx* by contrast with those of the skull referred, erroneously, by me to *Dinornis casuarinus*, in my third Memoir (1848), p. 445, pl. 52. vol. iii. Trans. Zool. Soc. That skull I now believe to have belonged to the *Dinornis otidiformis* of the first Memoir (p. 73), founded on a *tibia* (Pls. XXV., XXVI. fig. 5), but recognized by the subsequent acquisition of the metatarsal as a distinct genus, *Aptornis*, belonging to a distinct family, perhaps order, of birds from that to which *Dinornis* belongs. Upon that rectification I lost the best ground on which I had previously based the generic distinction of *Dinornis* from *Palapteryx*; and now there remain the degree of development of the abortive and functionless back toe, which I cannot regard of generic importance, and the proportions of sternum, limb-bones, and rostral part of the beak-bones, all more or less gradational. With the breadth of trunk concomitant with limbs so robust and divergent as in *D. robustus*, *D. elephantopus*, and *D. crassus*, the sternum is broad in proportion to its length, and the side processes more divergent; yet the dinornithic type of that bone is closely kept.

The robuster-limbed and broader-bodied Moas, however, do not all show the short,

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[1] This character of the skull of *Dinornis ingens* is somewhat exaggerated in Dr. Gustav Jaeger's figure (Taf. xxv. *op. cit.*), through the view in fig. 1 not being a direct profile but looking obliquely on the calvarium.

broad, obtuse form of beak; and I confess that the general conformity of cranial structure under the modifications illustrated in the present Memoir do not promise an advantage, by drawing a line which must be more or less arbitrary in whatever direction, equivalent to the imposition of two names for such divisions of a group of species so natural and closely allied as I would at present indicate by the sole generic name *Dinornis*.

On the Cranium of a Gigantic Bird (Dasornis[1] londinensis, *Ow.*) *from the London Clay of Sheppey, Kent.*

The study and foregoing illustrations of the cranial structure of the recently extinct species of large terrestrial birds, induce me no longer to defer communicating similar evidence of one which passed away at a much more remote period of geological time. This evidence is the cranial part of the skull, which has been reduced by rough usage of the elements to a similar state with that of the cranium of *Dinornis giganteus* above described (p. 277). Very little of the outer table of the walls of that cavity is preserved; and much of the thick pneumatic diploë is exposed, not only along the upper (parieto-frontal) walls, but at the back and base of the cranium.

To this state it appears to have been brought, probably in its transport seaward by the mighty eocene river, prior to petrifaction in the mud with which it finally became enveloped. In the mass of such matrix, converted into petrified "London clay," of which geological formation the Isle of Sheppey now mainly consists, this cranium was gathered with other eocene fossils, and was obtained from a local collector by the Earl of Enniskillen, F.R.S., to whom I am indebted for the opportunity of describing it, and to Mr. Davies, of the Department of Geology, for first calling my attention to the specimen in a collection of Sheppey fossils which Lord Enniskillen had sent (for determination) to the British Museum.

In size this cranium equals that of the *Dinornis giganteus*; its proportions are also dinornithic, exemplified in the great breadth, small height, and forward slope of the occiput, in the flatness of the calvarium—with all the indications, in short, of low cerebral development. But there are well-marked differences as compared with *Dinornis*. The occipital condyle exceeds in size by 1 line that of *Dinornis robustus* in both vertical and transverse diameters; its shape is almost the same; and it is similarly impressed along the middle of its upper half by a vertical groove deepening, and in the fossil slightly expanding, to the end. This latter character is more marked in *Dinornis elephantopus* than in *D. robustus*; but the groove goes lower, and the hemisphere is more truncate above in *D. elephantopus*.

The condyle in the fossil shows, under the pocket-lens, the same fine punctate diploë, or cellular structure, as does the condyle in *Dinornis*, when the thin, smooth outer coat

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[1] δάσος, a thicket (in reference to the abundance of fossil fruits and other arboreal evidences associated with the remains of the large bird).

has been rubbed off. The foramen magnum is rather smaller, especially across, than in *Dinornis giganteus* or *D. robustus*; it resembles in shape that of the specimen of the latter species from the limestone fissure at Timaru, figured in Pl. LXII. fig. 2, *o*. The foramen has been overtopped, not by so sharp or narrow a penthouse as in *Dinornis robustus*, but by a thicker prominence of the combined ex- and super-occipitals, like that in *Casuarinus*, in *Dromaius*, and in *Dinornis gravis*. The abrasion of this part, and of the arc thence curving down to each paroccipital, exposes the diploë at many parts; where the outer table remains it shows the arched ridge to be broader and more smoothly rounded than in *Dinornis robustus*, more like that in *Dinornis elephantopus*; but the descending curve is less, the arch is wider, spanning more transversely to the paroccipitals: in the degree of transverse and vertical concavity of the area below the exoccipital arch *Dasornis* resembles *Dinornis robustus* rather than *Dinornis elephantopus*, in which the area is more depressed. The vagal foramina in this area, of which the right is plainly recognizable, open rather nearer the condyle than in *Dinornis*. In a direct upper view the condyle is visible, as in *Dinornis struthoïdes* and *D. dromioïdes*. It is plain from what remains of the basi-occipital tuberosities that they were developed from a tract not descending below the condyle in a degree beyond that in *Dromaius*; otherwise they resemble those protuberances in *Dinornis* in size and position. The superoccipital surface inclines from below forward in a degree as great as in *D. struthoïdes* and *D. dromioïdes*—consequently more so than in the larger Moas, much more so than in any of the existing *Struthionidæ*, or in any aquatic or other known living bird.

Notwithstanding the degree of abrasion of the transverse superoccipital ridge, there is evidence of the two outer and larger curves, convex forward, continued as in *Dinornis struthoïdes* to the paroccipital ridges. These were inclined backward, as in *Rhea* and *Dinornis*; but to what degree, or how far the ridges descended, the broken specimen gives no information.

Against an indication of a short pterapophysis, on the right side, part of what is plainly a pterygoid abuts by its hinder end; this lamelliform bone extends forward and, as in *Rhea*, slightly outward, and joins a similar fragment of a lamelliform palatine which has been pressed upward into the orbit, above the level of the presphenoidal rostrum Of this rostrum, a length of nearly two inches is continued forward from the basisphenoid; its wide-celled pneumatic structure is exposed, as one sees in similarly abraded *Dinornis*-skulls. To the left of the anterior broken end of the rostrum, in the same relative position as in *Dinornis robustus*, is a portion of the hind part of a broad palatal plate of the premaxillary; and suturally connected therewith is the palatal process of the maxillary, fractured across where it was contracting and thickening to join the palatine bone.

On the left side of the cranium, part of the smooth upper surface is continued upon a process arching downward, which I regard as homologous with the postfrontal in *Dinornis*; the broken termination shows a fore-and-aft breadth of 5 lines, a transverse thickness of 2 lines; and the fracture exposes the same open pneumatic diploë as in *Dinornis*. This process is distant from the back part of what remains of the paroccipital process 1 inch 3 lines. It is consequently nearer that process, being more backwardly situated, than in *Dinornis robustus* or *D. elephantopus*. But the Moas differ among themselves in this respect, according to, or with concomitant differences in, the antero-posterior extent of the temporal fossæ. Thus *Dinornis rheïdes* more resembles *Dasornis* in this respect. But in the proximity of the postfrontals to the occiput *Dasornis* still more nearly resembles *Struthio*; and the resemblance extends to a concomitant large expanse of the superorbital arch.

Again, we find in what is preserved of the fore part of the cranium a marked departure from the dinornithic type, and an adhesion as well marked to that of existing *Struthionidæ*. The fore half of the interorbital part of the frontals is contracted, as in *Rhea* and *Dromaius*, and is concave transversely, as in *Rhea*. To its sides articulate the broad hind parts of a pair of bones which I regard as homologous with the two distinct nasals in *Rhea* and *Struthio*. These parts of the nasals, beginning narrow, or by a point, behind, rapidly expand and meet as they advance, so as to give a pointed form to the included part of the calvarium. Whether this part be the frontal, or an exposed surface of the connate prefrontals, the abraded surface of the bone does not permit to be defined with certainty.

The structure of this interesting fossil, as far as it can be defined, shows it to be of a bird; its configuration and proportions exemplify combinations of dinornithic and modern struthious characters. What the mandibles may further prove, time, we will hope, may discover. But this I anticipate with confidence, that further acquaintance with the osseous structure of *Dasornis* will show it to be no exception to the flightless and terrestrial nature of all other known birds of like hugeness.

The present evidence of such a bird in so old a tertiary deposit as the London Clay at once recalled the discovery of the limb-bones of an equally gigantic bird by M. Gaston-Planté (tibia) and by Professor Hébert (femur) in the lower conglomerate of the eocene plastic clay at Meudon, near Paris. For the conclusions to which the study and comparison of these bones led me, I would refer the palæontologist to the Memoir quoted below[1], to which M. Alphonse Milne-Edwards has done me the honour to refer[2]. I will only add that the main part of the shaft of the fibula of *Gastornis* has been more recently discovered in the same formation at Passy, near Paris[3], which exhibits as extensive a con-

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[1] "On the Affinities of the large Extinct Bird (*Gastornis parisiensis*, Hébert), indicated by a fossil femur and tibia discovered in the lowest eocene formation near Paris."—Quarterly Journal of the Geological Society of London, vol. xii. p. 204, pl. 3 (1856). I am glad to find, carefully reperusing this Memoir, that it affords no ground for the difference alleged to exist between myself and the accomplished writer of the following remarks:—"Je ne puis partager l'opinion de M. Owen relativement aux rapports qui existent entre le *Gastornis* et les oiseaux du groupe des Rallides."—Alphonse M.-Edwards, Recherches Anatomiques and Paléontologiques pour servir à l'Histoire des Oiseaux Fossiles de la France, 4to, p. 172.

[2] *Op. cit.* p. 167.

[3] *Op. cit.* pl. 29. figs. 3 & 4.

nexion with the tibia, and proportions almost as massive and robust as the fibula of *Dinornis*, like which genus, *Gastornis* will probably prove to be tridactyle and terrestrial. It is possible (one cannot venture to say more) that the cranial fragment here described may belong to the same genus as the Parisian eocene large bird[1].

DESCRIPTION OF THE PLATES.

PLATE LXXV.

Dinornis rheïdes.

Fig. 1. Side view of skull.
Fig. 2. Back view of cranium.
Fig. 3. Top view of cranium.
Fig. 4. Base view of cranium.
Fig. 5. Top view of mandible.
Fig. 6. Back view of left ramus of mandible.
Fig. 7. Inner view of left ramus of mandible.
Fig. 8. Inner view of right zygomatic arch.
Fig. 9. Outer view of right tympanic.
Fig. 10. Inner view of right tympanic.

PLATE LXXVI.

Dinornis crassus.

Fig. 1. Side view of skull.
Fig. 2. Upper view of skull.
Fig. 3. Under view of skull.
Fig. 4. Back view of cranium.
Fig. 5. Inner surface of tympanic.
Fig. 6. Outer surface of tympanic.
Fig. 7. Inner surface of mandibular ramus.
Fig. 8. Under view of mandibular ramus and symphysis.
Fig. 9. Upper view of mandibular ramus and symphysis.

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[1] In the Memoir quoted by M. Alphonse Milne-Edwards, the following 'Rapports' between *Gastornis* and *Dinornis* are thus indicated :—" Interesting, unquestionably, is the median position of the supratendinal bridge in *Gastornis* ; and it would indicate affinities to the Swan and Goose, were not the same bridge equally medianly situated in the Gallinule, the *Notornis*, the Raven, some Accipitrine birds," &c. "The inclination of the canal to the inner side, and the position of the lower outlet to the left of the median plane, in *Gastornis*, while it is a departure from the Anserine type, is an approximation to the Gallinaceous and Dinornithic structures."—*Quarterly Journal of the Geological Society*, vol. xii. p. 215. And, again, " In the aspect of the lower outlet of the tendinous canal the *Gastornis* more resembles the known larger wading and land birds and the *Dinornithidæ* than it does any aquatic bird."—*Ib.* p. 216. " The proportions of the tibia, its thickness *e. g.* in proportion to its length, would plainly show that the Parisian eocene bird had more robust and shorter legs than the typical waders, and probably was, as other birds of like dimensions, better adapted for terrestrial life."—*Ib.* p. 216.

PLATE LXXVII.

Dinornis elephantopus.

Fig. 1. Side view of skull (wanting zygoma).
Fig. 2. Back view of cranium.
Fig. 3. Upper view of cranium.
Fig. 4. Under view of cranium.
Fig. 5. Front view of cranium.
Fig. 6. Upper view of premaxillary.
Fig. 7. Under view of premaxillary.
Fig. 8. Under view of symphysial end of mandible.
Fig. 9. Upper view of symphysial end of mandible.

PLATE LXXVIII.

Dinornis casuarinus.

Fig. 1. Side view of skull (wanting zygomatic and palato-pterygoid arches).
Fig. 2. Upper view of cranium.
Fig. 3. Under view of cranium.
Fig. 4. Upper view of premaxillary.
Fig. 5. Under view of premaxillary.
Fig. 6. Inner side of left mandibular ramus.
Fig. 7. Under view of symphysial end of mandible.
Fig. 8. Upper view of symphysial end of mandible.

Dinornis giganteus.

Fig. 9. Vertical longitudinal section of cranium.
Fig. 10. Inner side of right mandibular ramus, mutilated.
Fig. 11. Under surface of symphysial end of mandible.
Fig. 12. Upper surface of symphysial end of mandible.
Fig. 13. Inner side of left tympanic of *Din. casuarinus.*

PLATE LXXXI.

Dinornis gravis.

Fig. 1. Side view of skull.
Fig. 2. Back view of cranium.
Fig. 3. Top view of cranium.
Fig. 4. Base view of cranium.
Fig. 5. Top view of symphysis mandibulæ.
Fig. 6. Top view of symphysis mandibulæ of *Dinornis crassus.*

PLATE LXXXII.

Dinornis ingens.

Fig. 1. Side view of skull.
Fig. 2. Back view of cranium.
Fig. 3. Base view of skull (minus mandible).
Fig. 4. Reduced side view of skull (*ex* Jaeger, *loc. cit.*).

All the figures are of the natural size; the numerals and letters are explained in the text.

MEMOIR

ON THE

GENUS APTORNIS.

Species 2. APTORNIS DEFOSSOR.

§ 1.

THE Rev. RICHARD TAYLOR, M.A., to whose valuable cooperation in advancing the Natural History of New Zealand, the field of his devoted missionary labours, I have had occasions to testify[1], was so obliging as to submit to my inspection, on his recent return to England, a skull, femur, tibia, and fibula, which I recognized, with intense interest, to belong to that very rare and singular genus of extinct New-Zealand birds the *Aptornis*. Mr. Taylor favoured me with a copy of the following "entry" from his note-book relative to these bones:—"They were discovered in a cave of soft sand about fourteen miles from Oamaru, which was filled with birds' bones. The peculiarity of this skull is its massiveness, very small brain-receptacle, and width of bill: it appears to be allied to the *Notornis*, but of a much larger size."—July 1st, 1863.

It will be seen in the course of the following descriptions that these bones belong to that ornithic form first indicated by a tibia referred to a *Dinornis otidiformis*[2], but subsequently shown by metatarsal and cranial characters to represent a distinct genus, for which I proposed the name *Aptornis*[3].

The generic characteristics of both skull- and leg-bones are closely repeated in the present specimens; but, as shown in the "Table of Admeasurements" (p. 315), they are larger than those parts of *Aptornis otidiformis*. This increase of size is also associated with some modifications of form and proportion. The original (smaller) specimens, on

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[1] From the period, viz., of my Memoir on the first general collection of *Dinornis*-remains (of November 1843, p. 73). "The Rev. Mr. Taylor, of Wanganui, has a large collection of these bones, found in a river between that place and New Plymouth" (pp. 109, 115, 135). This locality is in the North Island, where the smaller species of *Aptornis* was found. Mr. Taylor has recorded the results of long experience and observation in his work 'On New Zealand and its Inhabitants,' 8vo.

[2] P. 85.

[3] P. 185. In the 'Revue Zoologique' for October 1848, M. de Selys-Longchamps proposed the minor abbreviation "*Apterornis*" for some, then vaguely indicated, extinct birds of the Mascarene Islands.

which the genus was founded, are of a mature bird[1]; and accordingly I propose to refer the bones under description to an *Aptornis defossor*.

§ 2. *Skull of* Aptornis defossor. (Plate LXXXIII. figs. 1–3, Plate LXXXIV. figs. 1–4 & 6–8.)

The skull, as Mr. Taylor remarks, may be said to be massive, the cranial walls are thick, much of its osseous substance is compact, and there is the full amount of confluence of the bones of the head observed in birds. The beak is moderately down-bent, and terminated by a transverse subtrenchant margin, in both upper and lower jaws. The length of the part of the skull anterior to the orbit exceeds the rest by one-eighth; the fore-and-aft extent of the orbit is rather less than one-fifth that of the entire skull. The cranium, viewed either from above or below (Pl. LXXXIII. figs. 2 & 3), offers a subquadrate form. The breadth of the occiput at the paroccipitals (4, 4) equals that of the cranium at the postfrontals (12, 12), a character to which the skull in *Notornis* and *Dinornis* offers the nearest approach. The occipital region (Pl. LXXXIV. fig. 1) extends below the foramen magnum (*o*) further than above it—a proportion unique in the class *Aves*.

Those most conversant with the osteological features of birds will best appreciate the singular and exceptional characters above defined. The external bony nostrils (Pl. LXXXIII. fig. 1, *n*) are large and triangular, or oval-elongate, with the upper, small end almost pointed. No groove or furrow is continued forward from them. The interorbital septum (ib. fig. 1, *o*) is entire; the temporal fossæ (*t*) are deep, though wide apart above (ib. fig. 2, 7); they are over-arched externally by an upper zygoma (ib. fig. 1, 8′-12), as in Crocodiles. The cerebral bosses are hardly raised above the level of the interorbital region (ib. fig. 2, 11).

The occipital tubercle (Pl. LXXXIV. fig. 1, 1) is hemispheroid, 5 lines in transverse diameter, feebly impressed by a small pit at the middle of its upper half. The basioccipital advancing from the condyle about two lines, then curves downward, and, with the basisphenoid, forms a subquadrate almost vertical plate, inclined somewhat forward, below, with the lower angles produced and swollen to form a pair of oblong convex tuberosities (Pl. LXXXIII. fig. 3, *l*′, Pl. LXXXIV. fig. 1, 5′, 5′).

The vertical surface of this descending part of the occiput is concave across, but less deeply than in *Aptornis otidiformis*[2], the lateral margins not being so produced backward, especially at their upper part. In both species they form angular lamelliform processes, each defending the inner side of the corresponding vagal fossa (ib. fig. 1, *v*). Three minute precondyloid foramina, in a vertical line, range on each side of the base of the condyle. The depth of the basioccipito-sphenoidal ("basilar") tract, from the under part of the condyle to the middle of its under surface, measures 1 inch 2 lines, to

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[1] The anchylosis of the stylohyal in the original skull (Pl. XLIII. figs. 3 & 6, 38) indicates it to have come from an old bird.

[2] Pl. XLIII. fig. 4.

the end of the tuberosity 1 inch 4 lines; the breadth of the tract is 1 inch ½ line: in the centre of the tract is a small venous foramen. The tuberosities bend forward and inward; each is indented by an oblique channel; and from each a ridge continuing the convergence is lost after 3 lines course upon the fore part of the basisphenoid. This curves upward and contracts to a median ridge slightly produced, as a compressed process, projecting about 2 lines forward freely below the base of the presphenoid (Pl. LXXXIII. fig. 3, 9). The occipital foramen (Pl. LXXXIV. fig. 1, *o*) is vertically elongate, with a small process on each side, projecting inward and forward from the junction of the lower with the middle third, as in *Aptornis otidiformis*[1]. The vertical diameter of the foramen is 7 lines, the transverse one 5½ lines, the foramen being relatively smaller than in *Aptornis otidiformis*. As in that species, the occipital surface, as it rises from the foramen magnum, slopes forward to the superoccipital ridge (Pl. LXXXIII. fig. 2, 3).

From the under and inner base of the paroccipital an irregular ridge or bar of bone (Pl. LXXXIII. figs. 1 & 3, 4′) passes downward and inward, forming the outer side of the vagal fossa, and bending forward into and abutting against the smooth deep channel outside the descending basicranial tract (1-5), where it terminates like an adherent process, with a rough tuberous ending. It was to the left of these productions (Pl. XLIII. fig. 6, 4′) of the paroccipital, which might be called "styloid processes," that the proximal element of the hyoid arch (stylohyal, ib. 38) was anchylosed in the skull of *Aptornis otidiformis*: this is significant of the arbitrariness of the ascription of the tympanic or quadrate bone to that arch. The hind part of the base of the alisphenoid is more produced and tuberous outside the end of the hyoid process of the paroccipital in *Aptornis defossor* than in *Apt. otidiformis*. Between this process and the expanded base of the alisphenoid there is a groove-like extension of the tympanic cavity.

The alisphenoid expansion is pneumatic; in advance of that swelling are two wide pneumatic openings; and two lines in advance of these is the foramen ovale.

The mastoid in mammals is characterized by its early ossification, the centre or centres appearing in the primordial or protocranial cartilage containing the acoustic vesicle. In this developmental relation Cuvier's "temporal" in birds agrees with the mammalian mastoid. Mr. Parker admits that the mastoids are already ossified at the "time that the parietals are small ovoid patches;" but he cannot apparently bring himself to state that his "squama temporis" in the chick is ossified in and from the protocranial cartilage, including the labyrinth. The "squama temporis" in the human embryo is ossified in a membranous basis, like the parietal; the base of the zygoma alone shows cartilage. The condition of the mammalian squamosal in Monotremes, in which it is almost reduced to its zygomatic part, shows well the homologous bone in birds. The mastoid, connate, as usual in birds, with the petrosal, here joins the alisphenoid, pushing inward, between the pneumatic vacuities and the canal for

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[1] Pl. XLIII. fig. 4, *o*.

the third division of the trigeminal nerve, to form the articulation for the double condyle of the tympanic. The cavity is oval, directed from behind, forward and outward; the postero-internal division is the largest and shallowest; the antero-external one is the deepest, and is hemispheroid. The articulation is close and deep, whereby, with a peculiar suspensory structure, the tympanic is retained on the right side of the present skull, where the surrounding parts of the cavity are entire. Between the articular cavities for the tympanic and the paroccipital are the large pneumatic vacuities; and behind them is a smooth, transversely extended deep fossa. This is partially bounded externally by the normal mastoid process, but is continued outward, contracting into the groove between the mastoid (Pl. LXXXIII. fig. 1, 8) and the mesomastoid (8′) process. This process has contracted a filamentary bony union with the expanded base of the alisphenoid, the filament passing behind the neck of the tympanic, and helping to suspend and maintain it *in situ*. But the great characteristic of this part of the skull of *Aptornis* is the large size and advanced position of the premastoid process (ib. 8*). This diverges, like the two hinder ones, from the common diapophysial basis, developed in and from the primordial cranial cartilage, and retaining all the guiding homological characteristics of the Crocodile's mastoid. The process (8*), repeating the zygomatic development thereof, is three-sided; the fore and hind sides are broadest, and meet externally at a sharp ridge directed downward and forward, bisecting the temporal fossa, but leaving the hinder division widest. Near its lower end the premastoid contracts a bony union with the postfrontal (12) as in *Aptornis otidiformis*, but with a shorter, broader, and more compressed free termination beneath that union. The inner, narrow side of the premastoid process presents a rough surface for apparently ligamentous union with a process from the outer side of the tympanic.

The basisphenoid is pierced anteriorly by the outlets of the Eustachian canals, continued into each other by converging channels, underlapped by the process (Pl. LXXXIII. fig. 3, *m*), which is compressed and slightly produced downward. Above the Eustachian channels the basisphenoid contracts, and is produced into the presphenoid, first sending off on each side a small, horizontally compressed ridge or plate representing a "pterapophysis," but without an articular surface. If it is joined at all to the pterygoid, it must be only by ligament.

Each orbito-sphenoid shows three small foramina in a transverse line, representing the "prelacerate fissure," behind the large optic foramen. The optic foramina are barely two lines apart anteriorly. Beneath them the connate orbito-presphenoid is impressed by a smooth, oblong cavity, and is continued forward, confluent with the prefrontal, as an entire but thin "interorbital septum," expanding anteriorly to form the back part of the olfactory chamber. The rhinal platform (Pl. LXXXIII. fig. 3) is subcompressed vertically.

The olfactory chambers do not extend backward beyond the "platform;" they are subspherical, half an inch in diameter, divided by a thin but complete septum, and perforated each by a single olfactory foramen a little external to their hind walls.

They are wholly anterior to the cerebral cavity. Their condition in *Aptornis otidiformis* (Pl. XLIII. fig. 5, 18) is closely repeated in *Apt. defossor*.

The cranial cavity, exposed in the present specimen by an opening on the left side (which may have been made to extract the brain), shows a slight falcial ridge; and about half an inch outside this, runs a less marked parallel ridge, indicative of a longitudinal sulcus on the surface of the cerebral hemisphere. The under parts of the anterior cerebral lobes were divided from each other by a short ridge continued forward from above the common intracranial beginning of the optic foramina. A well-marked curved "tentorial" ridge marks the boundary between the prosencephalic and the combined mes- and ep-encephalic divisions of the cranial cavity. The "sella" is small and moderately deep. There is a well-defined, oblong, rough depression for the "Harderian gland" at the back part of the orbit.

The nasal bones (Pl. LXXXIII. figs. 1 & 2, 15) seem to touch each other at their postero-internal angles, whence they diverge, and are distinct from each other in the rest of their course. They coalesce with the frontal; but the fronto-nasal suture seems traceable, forming a strong curve convex backward, touching the transverse parallel of the middle of the superorbital ridge, and thence curving forward to the antorbital process, where a portion of the suture is persistent: it is possible that this curved line may indicate the limit of a frontal expanse of the nasal. At one inch and a quarter from the hindmost part of the nasal, that bone bifurcates into its maxillary (*b*) and premaxillary (*a*) branches.

The maxillary branch (Pl. LXXXIII. fig. 1, *b*) is a long, straight, narrow, subdepressed rod, a little wider midway, and coalescing with the nasal process of the maxillary (ib. 21) too closely for any trace of the original distinction.

Although the nasal branch of the premaxillary (22′) has coalesced with the nasals, the line of original distinction is traceable, and shows the premaxillary branch of each nasal (ib. fig. 1, *a*) to have become soon overlapped by the premaxillary, and to have extended forward from the bifurcation of the nasal nearly two inches, each slightly inclining toward its fellow, underlapping and strengthening that part of the bony arch of the upper mandible.

The palatine plate of the maxillary (Pl. LXXXIII. fig. 3, 21′) underlaps that of the premaxillary (22″), filling the interval between it and the dentary part of the premaxillary. The line of suture is apparent; it is transverse and convex forward, nearly in the same relative position to the prepalatine vacuity as in *Dinornis*[1]. This vacuity is continued backward between the maxillaries (ib. 21′), and then between the palatines (ib. 20), and is continuous with the palato-nares (ib. *e*, *e*).

The palatines (20), at their upper and mesial beginnings, extend backward, parallel to each other, for an inch or more on each side of the vomer and the fore end of the presphenoid. Their contiguous sides in this extent are nearly straight, with an interval of

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[1] See *Dinornis ingens*, Pl. LXXXII. fig. 3, 22″, 21.

from one to two lines. From this type connexion or origin each arches obliquely upward and outward, in a degree increasing from behind forward, where opens the base of a semiconical cavity so formed, the thin lamellar wall of which is continued down into the posterior one of the palatal nostril. The cavity above this opening is divided by a horizontal portion into two *culs-de-sac.* From the walls of this cavity two plates are continued, one median, the other lateral. The median one projecting, where the palato-narial cavity begins to expand, from the common posterior plate or body of the palatine, descends vertically and abruptly, for 5 lines, gradually losing depth and gaining breadth at the level of the roof of the mouth, where it extends forward on each side the midpalatal vacuity for about one inch, coalescing with the maxillary, but leaving a trace of the original separation; the median side of the median plate is convex; the outwardly curved free border is somewhat thickened; the outer concave side of the plate and the oblique longitudinal channel between the median and lateral descending plates of the palatine have a rather rough surface. The outer or lateral lamella, continued from the outer wall of the palato-narial *cul-de-sac*, extends downward and outward in a less degree than does the median plate, and without thickening of the free border, but expanding horizontally, as it advances, to coalesce with the base of the malar process of the maxillary. The interlamellar channel, with a general breadth of 4 lines, gradually deepens as it retrogrades, until the inner plate suddenly ceases; the outer plate then contracts, becomes horizontal, and converges to unite with that of the opposite palatine behind the palato-nares. The inner wall of the palato-narial *cul-de-sac* is continued forward, contracting to a styliform process, which is, indeed, the fore end of the articular origin of the complex cranial pleurapophysis—such origin extending backward, as above described, from its own to the succeeding centrum, as the head of a rib is apt to do.

At the opposite end the palatine, as above described, bifurcates to effect two junctions with its hæmapophysis, the maxillary—one with its outer or dentary border, the other with its inner or palatal productions.

The short maxillary (Pl. LXXXIII. 21) presents or radiates, as usual in birds, its premaxillary, palatine, nasal, and malar productions. Posteriorly, between its palatine, nasal, and malar rays, it expands into a sort of rudimental "antrum" consisting of two low, shallow, pneumatic fossæ divided by a horizontal shelf, concave backward; and from the lower division goes a small oblique communication with the fore part of the hypo-palatine channel, just showing where the maxillary contributes to and continues the fore part of that channel. The small foramen answers to the commonly larger (palato-maxillary) vacuity at this part of the roof of the mouth. The nasal process of the maxillary preserves part of its posterior margin free; the rest is intimately blended with the long maxillary style of the nasal (ib. fig. 1, *b*) above described. The anterior transversely expanded part of the maxillary is intimately blended with and contracts above to be wedged between the maxillary and palatal parts of the premaxillary. These are the true or type beginnings, or basis, of that "hæmal spine." They speedily coalesce as they extend forward into a horizontal plate half an inch broad (Pl. LXXXIII. fig. 3, 22″); it is slightly concave, with an irregular surface below, more concave and smooth above; it has a thickish, smooth median margin, and a rough outer one rapidly rising as it advances to be continued into the nasal branch of the premaxillary.

The anterior part or "body" of the bone (ib. figs. 1 & 2, 22) is 2 inches 9 lines in length, 1 inch 3 lines in breadth at the base, whence the branches radiate, thence tapering to an anterior, depressed, slightly rounded terminal trenchant edge half an inch broad. The upper surface for about an inch from this end is smooth; each lateral margin is rough, and gains in thickness as it recedes, forming a convex, non-canaliculate dentary border, 2 inches 5 lines long, about 1½ line thick, continued, contracting, for about 6 lines, upon that of the maxillary. The rough surface gradually extends upon the outer side of the premaxillary to a breadth of 3½ lines, where it is arrested by a very shallow smooth impression, above which open six or eight conspicuous nervo-vascular foramina in an irregular longitudinal series. Here the sides of the premaxillary are more rapidly continued into the upper surface; the arch or transverse convexity not being a regular curve.

The palatal surface of the premaxillary (ib. fig. 3, 22′) is concave lengthwise, but more so across, especially midway between the fore and hind end of such surface. It is divided lengthwise into three tracts—one median, becoming concave and smooth at its posterior half, and two lateral, similarly concave, but irregular of surface. They deepen forward into narrow grooves, from which nervo-vascular canals pass into the substance of the bone; and the grooves grow more shallow as they extend to the almost trenchant termination of the upper beak. The fore part of the common midpalatal vacuity is half an inch in advance of the fore part of the outer bony nostril; and the ridge from the upper mid tract of the premaxillary part of the roof of the mouth extends half an inch in advance of the palatal vacuity before it rises to the upper plate of the premaxillary. The vacuity of the premaxillary, which is an anterior extension of the common nasal cavity, becomes divided only along the anterior half of the outwardly seeming solid part of the premaxillary. From the apices of the long conical cavities, so separated and extended toward the fore end of the upper beak, one or two canals are continued outward, forming by their termination the anterior of the conspicuous nervo-vascular canals above noted. The nasal branch (22′), 2 inches 8 lines in length, gradually loses breadth as it recedes, viz. from 11 lines to 7 lines between the bifurcating part of the nasals, then more rapidly to its cranial termination, which is nevertheless broadly rounded, where it overlies the smooth and free prefrontal, coalescing by its periphery with the frontals and nasals. The premaxillary processes of the latter underlap the premaxillary, the margins of which appear thickened by bending down to the nasal coalescence; the under surface of the internarial part of the premaxillary is reticulate. This part of the long arch of the base of the beak is strengthened by the pair of longitudinal ridges due to the produced premaxillary processes of the nasals.

The tympanic[1] (Pl. LXXXIII. fig. 1, 28, Pl. LXXXIV. figs. 2, 3, 4) has its mastoid end expanded and divided into two convex condyles (figs. 2 & 4, *k*), corresponding in form and relative size to the cavities for their reception above mentioned. The inner, larger, oblong condyle is more convex lengthwise than transversely; the outer, smaller condyle is subhemispheric; they are connected by a narrow tract, forming the upper part of a pneumatic foramen which divides the condyles from each other posteriorly. The stem of the condyles, subcompressed, from 3 lines to 4 lines in length, quickly expands as it descends, sending off anteriorly a broad, thin, compressed, triangular, obtusely pointed orbital plate (ib. *e*), and downward and backward outswelling in every direction, but chiefly antero-posteriorly, to form an unusually large lower end (*i*), the anterior half of which affords the single articular surface (Pl. LXXXIV. fig. 3, *i*) for the mandible. On the outside of the base of the articular stem is the process with the flat articular surface (fig. 4, *f*) for the premastoid; on the outside of the mandibular articular expansion is the articular cavity (ib. *h*) for the squamosal. The orbital plate is widely excavated internally; and the lower border of the cavity sends off the small hemispherical articular tubercle (fig. 2, *g*) for the pterygoid. Thus there are not fewer than five articular facets on this singularly modified homologue of the element or "process of the tem-

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[1] In regard to the homology indicated by this name, I have no better reason for breaking a silence which an accuser might call obstinate, save the following, which I give for what it is worth. Prof. Huxley states (Proc. Roy. Soc. Nov. 18, 1858), with the emphasis of italics, and a repetition of negatives, implying sense of the insecurity of his ground, "that the tympanic of the mammal does *not* articulate with the lower jaw, nor with the pterygoid, nor with the jugal or quadrato-jugal;" and so trite a statement of a commonly known fact would have remained unnoticed by me if it had not been quoted, in a former volume of the 'Transactions of the Zoological Society,' with commendation, as if it were a novel contribution to the elements for determining the homology of that bone in other vertebrates. Mr. Parker puts this statement, which he rightly characterizes as "very true," in the van of his arguments for opining "that the quadratum of birds is the homologue of the mammalian incus" (Trans. Zool. Soc. iv. p. 316).

But the "incus" "of the mammal does *not* articulate with the lower jaw, nor with the pterygoid, nor with the jugal, or quadrato-jugal." What is more, also, and what Mr. Parker's guide was careful to be silent upon, is this, viz. that the incus of the mammal does *not* articulate with the mastoid, or with the squamosal, nor does it support the membrana tympani or any part thereof. No doubt the tympanic of the mammal is reduced in divers degrees in that class; but it always retains those relations with the mastoid and squamosal, and performs that function in reference to the ear organ, which characterize it under all its subordinate and accessory developments in Birds, Chelonians, Crocodiles, and other air-breathing vertebrates. The averment that "Professor Owen, once wrong, goes far astray" (Parker, ibid. p. 304), does not affect the facts nor the legitimate deductions from them which guide to a recognition of the homology of the tympanic, the mastoid, and the squamosal—at least by one bent "on *ascertaining*, instead of pleasantly *supposing*, the true nature of an anatomical element" (Parker, ib. p. 271). The case is this: the negative argument tells as strongly against the incus or other member in the chain of ossicles or gristles connecting the membrana fenestræ vestibuli with the membrana tympani, as it does against the tympanic, whilst the positive evidence is exclusively in favour of the tympanic.

One use of homology or "namesakeism" is to rid anatomy of different names for the same thing. Why do not those who believe the "quadratum" to be the "incus" or the "malleus" call it one or the other in the bird and hæmatocrya, or else call the mammalian otosteal of their choice "quadratum"?

poral bone" reduced, in human anatomy, mainly to the support of the tympanic membrane. The feebly marked groove and ridge on the hind concavity of the tympanic intimates the degree in which the function in relation to the organ of hearing is exercised in the ornithic modification of the air-breathing vertebrate tympanic bone. The vertical length of the present tympanic is 1 inch 2½ lines; the long diameter of the distal articular surface is 1 inch; it is slightly convex, but by a downward production of the middle of the outer border is there made concave transversely at the outer half.

The mandible of *Aptornis* presents in profile (Pl. LXXXIII. fig. 1, 29–32) a series of graceful curves. By the downward production of the angle (30) and the elevation of the articular surface (29), it is curved for a short way with the concavity below, then becomes concave above for a longer extent, and finally is again bent with the concavity downward. The extent of the symphysis (Pl. LXXXIV. figs. 6, 7, 32) is 2 inches, following the curve, rather more than one-fourth the length of the mandible; its upper surface (ib. fig. 6, 32) is longitudinally convex, transversely concave, deepening, as it widens, backward. The hinder half of this concavity is smooth; the fore half shows two parallel longitudinal nervo-vascular tracts, with canals leading forward and opening upon the outside of the symphysis near the end; this has a horizontal, subtrenchant, slightly convex border. The dentary margins are rather sharp as they extend backward for an inch and a half, then begin to thicken into a convex border, 1½ line across, which border again contracts before it is lost in the thick hinder half of the ramus. The outside of the trenchant margin of the symphysis is indented by a delicate line. An oblique groove, beginning about the middle of the outside of the ramus, indicates the junction of the dentary (Pl. LXXXIII. fig. 1, 32*) with the angular element (30), which is further denoted by a ridge continued backward from the groove. A fissure on the upper border of the ramus, half an inch in front of the articular surface (Pl. LXXXIV. fig. 6), sinks into the substance of the bone as it advances, and opens by a shorter fissure upon the inner surface of the ramus nearly two inches from the angle. The tract between the two fissures probably included the hind end of the splenial. Save at these indications all the elements of the mandible are fused into one bone of a strong, compact osseous tissue, as in a few other strong-billed birds[1]. The articular surface is single (Pl. LXXXIV. fig. 6, 29) with the moderate convexities and concavity of its undulated surface answering to those on the tympanic. The fore-and-aft diameter of this surface of the mandible is 7 lines, the transverse diameter is 7½ lines. I never saw a mandibular condyle of an oviparous Vertebrate in which so large a proportion was convex. Behind the articular surface there is a very small and not deep fossa; internal thereto the bone extends obliquely upward and inward into an irregular conical process, attached by ligament to the posterior non-articular part of the mandibular end of the tympanic. The outside of the ramus, below the articular surface, is strengthened by a tuberous ridge, between which and the angle is a broad oblique channel. There is no "coronoid" elevation; the ramus rather loses than gains

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[1] *Ramphastos, Buceros, Psittacidæ, Balæniceps.*

vertical extent from the symphysis, where it is 6½ lines, to the articular end; but the thickness of the rami, with the outer angular ridge and the curvatures, indicate adaptations for strength in relation to powerful applications of the beak. And this accords with the massive character of the cranium, the extraordinary lever afforded by the transfer of the attachments of the recti capitis laterales[1] to the large basilar tuberosities carried down to so exceptional an extent below the bony junction of the head with the neck.

The skull of *Aptornis* offers many and well-marked differences compared with that of *Dinornis*. The occipital condyle is larger, more hemispheroid, more prominent; the foramen magnum is narrower in proportion to its vertical extent (comp. fig. 2. pls. 10, 12, 15, with fig. 1. Pl. LXXXIV.); the paroccipitals are more outwardly and less backwardly extended, the breadth there across exceeding that at the mastoids or at the postfrontals; in this particular *Aptornis* resembles *Apteryx*[2] and *Notornis*. But the angle or protuberance (Pl. LXXXIV. fig. 1, *t*) for the insertion of the portion of the "longus colli posticus" called "biventer capitis"[3] is more developed than in any bird[4]. The linear depression, indicative of the "coronal suture," is more marked than in *Dinornis*.

The mastoid process is smaller, but the premastoid much larger; and it adds by its bony union with the postfrontal another to the few exceptions (*Tetraonidæ*, *Crax*, *Lophophorus*, and some *Psittacidæ*) in which the Crocodilian character is repeated in the class of Birds.

The "rhinal chambers"[5] are much smaller, absolutely and relatively, than in *Dinornis*[6], and receive the olfactory nerves each by a single foramen instead of by several foramina.

The basilar tract descends much lower before developing the tuberosities for the "recti capitis laterales;" and these tuberosities are larger, indicative of the great strength of those muscles and of the other "recti" inserted into the marginal ridges and broad, deep, rough intervening surface of this extraordinary development. The basisphenoid contracts to a triedral process beneath the converging Eustachian channels, not present in *Dinornis*, and the surface in advance of the basilar tuberosities is more vertical and compressed in *Aptornis*. The pterapophyses are rudimental and devoid of articular surface. The mastoidal articular cavity for the tympanic is divided or double, instead of being single as in *Dinornis*[7]; the upper condyle of the tympanic is correspondingly modified. The tympanic has a premastoid process and articulation, not present in *Dinornis*; the squamosal articular cavity is not pedunculate; the surface for the mandible is single, not double as in *Dinornis* and most birds.

The beak is more elongate, more decurved, more depressed terminally; the outer

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[1] P. 50, Pl. XIV. *c*, *d*.

[2] Pl. VII. fig. 5.

[3] Pls. XI. & XII, *o***.

[4] This has no relation whatever with the superior or any other of the semicircular canals; it answers to the thickened part of the superoccipital ridge marked *ep* in *Balæniceps* (Trans. Zool. Soc. vol. iv. pl. 65. fig. 3).

[5] Pl. XLIII. fig. 5, 18.

[6] Pl. LXIII. fig. 1. *n*.

[7] Ib. fig. 1, *u*.

wall of the premaxillary extends so far back, before the divergence of the maxillary and nasal branches, as to hide from view the prenarial septum and convert the cavity on each side into a fossa. This septum is exposed in *Dinornis*[1]; and a shallow depression on each side represents the cul-de-sac of *Aptornis*.

The nasal branch of the premaxillary coalesces with the frontals and nasals. The maxillary branch of the nasal is longer, and directed more forward, leaving a larger antorbital vacuity (Pl. XL. fig. 1, *v*) in *Aptornis*. In *Dinornis*, as in *Apteryx*, the maxillary branch of the nasal descends anterior to and in connexion with the lacrymal[2], leaving no antorbital vacuity distinct from the external nostril. The mandible, besides the difference in shape and articulation, has the angle deflected.

It is instructive to find in the cranial organization of *Aptornis* these evidences of family distinction from *Dinornis* repeated in the second species of the genus, although the fact was more plainly and decisively shown by the leg-bones (p. 185).

In the downward production of the basilar platform *Aptornis* differs from *Notornis* more than it does from *Dinornis*; it differs from *Notornis* and all Coots (*Rallidæ*) in the development of the premastoid process and its junction with the postfrontal; from the same group it differs in the adze-like form of the bill, which is commonly in Coots, as in *Notornis*, not only pointed but straight; *Aptornis* further differs in the entire, imperforate structure of the mandibular ramus, and more especially in the absence of the outer narrow second synovial articular surface for the tympanic. When to these well-marked differences we add the form and proportions of the metatarsus of *Aptornis*[3], the ornithologist might be pardoned for pausing before referring the present remarkable genus to the *Rallidæ*.

In *Aptornis*, e.g., the metatarsus is but three-fifths the length of the femur; but it is quite as broad as that bone at the middle of the shaft, and both articular ends expand to corresponding proportional dimensions.

The two upper articular surfaces of the metatarsus are very nearly on the same level, the inner one being rather the higher; and the intermediate eminence is broad and high. The calcaneal process is abruptly prominent, and is perforated, the outer and inner crests having coossified around the flexor tendons; such structure has not been seen in any Coot. The outer and inner calcaneal crests are distinct in *Rallidæ*—the outer one being most produced, but subsiding more gradually to the level of the shaft of the metatarsus than in *Aptornis*.

Yet the following correspondences of cranial structure show, unequivocally, a closer affinity of *Aptornis* to *Notornis* than to *Dinornis*. The basilar (basioccipito-sphenoidal) platform is pentagonal, the anterior angle projecting below the base of the rostral pro-

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[1] Pl. LXXV. fig. 1, *s*.

[2] Pl. LXIV. fig. 1, 15″. In the specimen figured in Pl. VII. the suture between the nasal process and the lacrymal was obliterated, and both were referred to the lacrymal (p. 30).

[3] Pl. L. figs. 5, 6, 7, 8.

duction[1]; the Eustachian canals have a corresponding adjustment. The pterapophyses are obsolete in both *Aptornis* and *Notornis*. The articular cavities for the tympanic are two in each mastoid, similarly divided by a pneumatic slit. *Notornis* has muscular productions from the outside of the mastoid, answering to the mastoid process—the midmastoid and premastoid ones; but the two latter are mere ridges, or, if the premastoid be produced, it ends freely in a point, as in smaller Coots[2]. The nasal branch of the premaxillary coalesces with the nasals and frontals in *Aptornis* and *Notornis*. The maxillary branch of the nasal is similarly directed, leaving an antorbital vacuity, with a long oval nostril, almost pointed at the upper, smaller end. The ossification of the fore part of the premaxillary hides from view the prenasal septum. In the mandible the angle is deflected in *Ocydromus*, *Porphyrio*, and *Notornis* as in *Aptornis*. The variation of palatal structure might be a bar to an approximation of *Aptornis* to *Notornis* and smaller Coots, were it not such in other families, united by sounder ties of organic character, as to show its low taxonomic value.

From another point of view the peculiarities of the skull in *Aptornis* may be considered in relation to the food of the bird and the work to which its long adze-like beak was put.

I infer this work to have involved frequent strong and deep thrusts into the ground, and that the quest was for animal, not vegetable matters. I have heard casually and vaguely of the great number, size, and unusual colour of the earthworms of New Zealand; and it is probable that a rich field here remains to be explored by the helminthologist.

The strange appearance of the parasitic cryptogam, *Sphæria*, sp., when it has achieved its growth at the cost of the caterpillar infested, has made us familiar with the burrowing habits of at least two species of New-Zealand Nocturnal Lepidoptera (*Cheiragria virescens* and *Cheir. rubroviridens*) at the larval stage of their existence. Such larvæ and earthworms were probably part of the food of *Aptornis*.

The cranial part of the skull may be regarded as the base or handle in which the digging adze was set; its expansion, radiating from the occipital condyle as a centre (Pl. LXXXIV. fig. 1, 1), speaks decisively, by its superficial accentuation, to the size and power of the muscles therein implanted: the special development of the leverage-tract below the centre of motion relates to adequate fixation of the muscular powers that were to strike down the adze into the soil.

The muscles working the beak as part of the head are better developed in the ground-piercing *Apteryx* than in most birds, as will be estimated by the myotomist who may compare therewith the muscles in a fowl answering to those called rectus capitis anticus major (p. 49, Pl. XIV. *b*), rectus cap. ant. minor (p. 50, Pl. XIV. *c*), rectus cap. lateralis

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[1] Pl. LXV. fig. 11.

[2] In a *Porphyrio smaragnotus* I have seen the tendon of each crotaphyte muscle ossified, and extending from a part of the temporal fossa answering to the "midmastoid" as far as its insertion into the mandibular ramus.

(Pls. XI. & XIV. *d*), biventer capitis (Pl. XII. *o***), complexus (Pls. XI. & XIII. *y*), and trachelo-mastoideus (Pl. XIII. fig. 1, *z*). The developments of cranial bone for the insertions of the corresponding muscles in *Aptornis* indicate a fourfold increase of force and size, and bespeak corresponding power with which the beak was driven through the surface and the soil displaced. For this application it was requisite that the lower jaw should be held firmly in contact with the upper one, that both might penetrate as one instrument with a common sharp-edged extremity; hence the evidence of unusual extensions from the main cranial diapophyses of the bony processes giving origins to the muscles working the cranial rib, *i. e.* drawing up the mandible and holding it in close contact with the maxilla, as in that action of the corresponding muscles of the strong man who in a determined and vigorous effort sets his teeth.

Underlying all these exaggerations of apophysial outstandings, we nevertheless discern a "porphyrian platform"—so much more essential resemblance to the cranial characteristics of the Coots, especially the larger kinds, whose craniology is illustrated in Plate XLVII. as to conclude *Aptornis* to have been (if one may not speak of it as present in the living creation) a gigantic modified "Ralline." The down-bending of the mandible, it is true, is not seen in *Notornis* or *Porphyrio*; but in the "Poule rouge au bec de Bécasse" of the Mascarene Islands (for a knowledge of which we are indebted to Von Frauenfeld's publication of the coloured drawing, from the life, preserved in the library of the Emperor Francis I.) one sees a curve of beak like that of *Aptornis*. The mandible of this probably extinct Mauritian bird, which has been obtained, with bones of the Dodo, from the famous "Mare aux Songes," shows also, in the figures given by M. Alphonse Milne-Edwards[1], the deflected angle answering to 30 in *Porphyrio* (fig. 1. Pl. XLVII.) and *Notornis* (ib. fig. 7), also the small "prearticular foramen" (ib. ib. figs. 1 & 7, 10). The larger vacuity (ib. ib. *u*) is almost reduced to the state of obsolescence which characterizes the more consolidated and more powerful mandible of *Aptornis* (comp. fig. 4 with the mandible in fig. 1, Pl. LXXXIII.). The extent of symphysis, with its canaliculate upper surface, is interestingly similar in *Aphanapteryx* (Pl. LXXXIV. fig. 5) and *Aptornis* (ib. fig. 6), and I concur in the conclusions to which M. A. Milne-Edwards has been led as to the "analogies of *Aphanapteryx* with the Rails"[2]. In speculating on the origin of the much larger extinct(?) brevipennate Rallines of New Zealand, it may be remembered that our own Coots and Waterhens are poor fliers compared with most water-birds.

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[1] "Researches into the Zoological Affinities of *Aphanapteryx*," in 'The Ibis' for July 1869.

[2] Ibis, 1869, p. 267. By a curious coincidence, at a later period of the year (1848) in which I proposed a diminutive of "*Apterygiornis*" for the large extinct Coot of New Zealand, the accomplished Belgian ornithologist, M. de Selys-Longchamps, was moved to propound a minor diminutive of the same term for some loosely indicated Mascarene birds, one of which we now know to have been an extinct Coot of the Mauritius. Without entering into the question of the degree of synonymy of *Aptornis* and *Apterornis*, the priority of proposition of the first will, I apprehend, secure it for the main subject of my present Memoir.

§ 3. *Pelvis of* Aptornis otidiformis. (Plate LXXXV. figs. 1–3; Plate LXXXVI. figs. 1–4.)

My materials for the description of this instructive part of the skeleton are derived from the smaller species (*Apt. didiformis*), and were obtained from Wanganui, North Island of New Zealand.

Referring for the definition of the bone called "sacrum" to my 'Anatomy of Vertebrates,' "Aves," vol. ii. p. 29, I find it most convenient to adhere to the character of "confluence of vertebræ in connexion with the pelvic arch." In the 'Archetype &c. of the Vertebrate Skeleton' are discussed the characters by which the homologies of the twenty "sacral vertebræ" of the Ostrich *e. g.* with the lumbar and caudal vertebræ of Reptiles and Mammals may be determined; therefore I need not be misunderstood if, to make plain, or easily comprehensible, the characteristics of the pelvis of the extinct ground-birds of New Zealand, I continue to speak of such confluent series of vertebræ as "sacrum."

In *Aptornis* the sacrum includes nineteen vertebræ (Pl. LXXXV. fig. 2, *s* 1–19). The under surface of the confluent centrums shows well-defined modifications: it is pinched into a median ridge in the first three; the ridge is then, as it were, scooped off, leaving a smooth concave surface or mid channel along the next six centrums, beginning and ending in a point (fig. 2, *c c′*). From the hind point (*c′*) a broadish obtuse ridge runs along the next seven centrums, which gradually lose breadth. The seventeenth centrum suddenly expands; and those of the eighteenth and nineteenth have the form of broad depressed plates moderately concave across; the lateral confluent productions of the vertebræ being defined by two pairs of small vertical canals.

The pleurapophyses of the first and second sacral vertebræ retain their moveable joints. The cup for the head of the rib (Pl. LXXXV. fig. 1, *pl, pl*) is oval, with the small end upward, rather deep, well defined, and supported on an eminence at the upper part of the centrum, nearer the fore end in the first than in the second sacral. The surface for the "tubercle" is small, flat, cut obliquely at the fore part of the end of the diapophysis, which expands above to contract bony union with its successor and with the overlying ilium (62). The unossified space left between the first and second sacral diapophyses constitutes the foremost of the "interdiapophysial holes" (Pl. LXXXV. fig. 2, *i d′*). The third pleurapophysis (ib. *pl*) is short, straight, expanded, and confluent at both ends, broadest at that which underlies and is soldered to the ilium, beyond which it does not extend. The fourth is still shorter, and abuts as a parapophysis against the distal end of the third, with an extensive bony union above with the diapophysis of its own vertebra. The fifth, sixth, and seventh parapophyses lose length, gain breadth, and abut, with complete confluence, against the ilium a few lines from its lower margin; the seventh blends with a smooth ridge-like thickening of the lower border of the acetabulum as it passes to be continued into the origin of the ischium (63).

There then follow three sacrals without "parapophyses;" a side view of these, defined by the double intervertebral foramina, is given from a fragment of a second pelvis at fig. 3, Pl. LXXXVI. In the eleventh sacral the lower process is suddenly resumed, passing obliquely outward and backward, straight to its confluent abutment against the postacetabular wall of the ilium; from this a continuous plate of bone curves inward and backward, with the lower margin bending forward to receive the expanded ends of the shortening parapophyses of the twelfth, thirteenth, and fourteenth, as well as of the eleventh, sacrals. The lower processes of the succeeding vertebræ are more or less broken away. The curved and bent lamelliform process of the ilium divides the inter-acetabular renal fossa from the ilio-ischial fossa behind. This (Pl. LXXXV. fig. 2, *r*) is remarkable for its size, depth, and smooth surface, so far as it is preserved.

Fracture of the fore part of the right ilium exposes the neural spine of the first sacral (fig. 2, *n s*). It is directed upward and forward, is 1 inch 5 lines in height, 7 lines from before backward, where it becomes free; and it terminates in a slightly expanded truncate border, which has contracted no anchylosis with the over-arching confluent iliac bones. The anterior articular surface of the first sacral (Pl. LXXXV. fig. 3, *c*) is, as usual, concave transversely, convex vertically, but almost bilobed in form from a shallow emargination below and the down-sinking of the neural canal above; its breadth is 11 lines, its mid vertical diameter but $3\frac{1}{4}$ lines. The neural canal is circular, $2\frac{1}{2}$ lines in diameter. The prezygapophyses (ib. *z z*) look upward, inward, and rather forward; they are each 6 lines in diameter; together, an inch across their outer margins. The fore part of the base of the spine is impressed with a rough laterally ridged surface for the interneural ligament. The beginning of the inferior ridge represents a short "hypapophysis" in the front view (Pl. LXXXV. fig. 3, *h*). The vertical extent of the fore part of the first sacral is 2 inches 3 lines; from the lower ridge to the upper part of the coalesced ilia is 2 inches 6 lines. The extreme breadth of the fore part of the pelvis, which is that of the first sacral across its diapophysis, is 1 inch 11 lines. The neural canal of the sacrum expands, as usual, as it extends backward, chiefly transversely (Pl. LXXXVI. fig. 4, *n*), then contracts to the diameter shown at *n*, fig. 1, Pl. LXXXV.

The ilia (Pl. LXXXV. fig. 1, 62), anterior to the acetabulum, ascend from their outer margins and converge rapidly to contact and partial confluence with the bases or mid parts of the sacral spines, above which they coalesce and form a ridge, the contour of which describes a moderate convex curve from before backward. The ridge, which is about 4 lines across anteriorly, narrows as it recedes. The outer surface of the preacetabular part of each ilium is uniformly concave, and the concavity is continued, contracting, above the acetabulum (*a*). The "gluteal ridges" (Pl. LXXXV. fig. 1, *g*), which divide the concave tract (62) from the expanded convex or undulated tracts of the ilia, called "pelvic disk" (*r r*), rise as they recede and diverge, terminating rather abruptly 2 inches 3 lines from their origin; they recommence, to be continued with partial thickening to the hind end of the coalesced ilium and ischium, dividing its horizontal from its vertical surface.

The "pelvic disk" is deeply impressed along the middle of its anterior half, the channel or groove contrasting with the iliac ridge in advance. The bottom of the channel is entire, slightly widening as it recedes and descends, when the depressed spineless upper surface of the neural arches of the last three sacral vertebræ come into view at *n*, fig. 1, Pl. LXXXV., between the hind parts of the ilia. The sloping sides of the interiliac groove are pierced each by three interneural foramina. The fore part of each side of the pelvic disk is convex transversely; but this changes to a concavity as it recedes.

Of the ischial and pubic elements the broken origins are preserved at 63, 64, Pl. LXXXV. fig. 1, Pl. LXXXVI. fig. 2. That of the pubis has a long diameter of 5 lines, where it extends from below the acetabulum. Where the ischium becomes free, half an inch below the postacetabular facet, it is 4 lines by 2½ lines in thickness.

This facet (ib. *b*) is a more continuous part of the general acetabular cavity than usual. Including it therein, the long diameter (from before backward) measures 1 inch 5 lines; the vertical diameter of the acetabulum proper is barely 1 inch; the acetabular vacuity (ib. *a*) has a diameter of half an inch; its margin projects, as usual, into the prerenal or interacetabular fossa. The vertical diameter of the postacetabular facet is 6½ lines. Between the margin of the acetabulum and the free part of the ischium (63) is a well-defined (antischial) fossa (Pl. LXXXVI. fig. 1, *e*). The ischial foramen is subcircular, 8 to 9 lines in diameters. On the right side a distal part of the ischium, coalescent with the ilium, is preserved, descending vertically at right angles with the area of the "disk," and effecting, by an inwardly extended plate (Pl. LXXXV. fig. 2, *v*) underlying part of the postrenal fossa, a bony union with the depressed terminal sacral vertebræ (ib. 19). The degree of coalescence of the sacrum and iliac bones is such as to reduce the ilio-neural canals to small separate spaces (Pl. LXXXVI. fig. 4, *i d*), into which the interdiapophysial foramina (fig. 2, *i d*) open.

The pelvis of *Aptornis* differs from that of *Dinornis*[1] in its greater length relatively to the breadth, in its less sudden and minor expansion behind the acetabula, in the inferiorly carinate anterior centrums, in the more sudden expansion of the hindmost centrums, in the more convex contour and sharper upper ridge of the coalesced preacetabular plates of the ilia, in the deeper and narrower channel dividing the postacetabular parts of the same bones, in the relatively narrower interval between the postacetabular parts of the ilium and ischium, and in the relatively smaller ischial foramen[2]. The rather sudden down-sinking of the preacetabular iliac ridge into the superacetabular iliac channel is also very significative of the distinction of ordinal groups between *Aptornis* and *Dinornis*.

Aptornis agrees with *Apteryx* in the proportional extent of the antacetabular part of

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[1] Compare Pl. LXXXV. figs. 1 & 2, and Pl. LXXXVI. figs. 1–4, with Pls. XIX., XX., XX. *a*, p. 91.

[2] Compare Pl. LXXXVI. fig. 1., with Pl. XX. figs. 1 & 2.

the ilium[1], but offers the same differences, and some of them exaggerated, which have been noted in the pelvis of *Dinornis*. In the general proportions, as in size of pelvis, the correspondence between *Aptornis* and *Cnemiornis*[2] is closer than between either of them and *Dinornis*; but there are differences of at least generic value.

The anterior sacral centrums are relatively broader and less deep in *Aptornis*; there is no increase of breadth or expansion in the seventh or contiguous antacetabular ones, as in *Cnemiornis*; the narrowing is continuous, though quicker, after the seventh, in *Aptornis*, as far as the sixteenth, when the sudden expansion takes place. In *Cnemiornis* there is no indication of such expansion of terminal sacral centrums; they continue narrow and ridged below from the twelfth to the seventeenth. The breadth of the anterior sacral vertebra across the costal pits of the centrum in *Cnemiornis* is 7 lines, in *Aptornis* it is 13 lines; but the height of this vertebra must have been the same, or nearly so, in both. There are surfaces for the articulation of a third pair of free sacral ribs in *Cnemiornis*; but these do not exist in *Aptornis*. The concavity of the preacetabular part of the ilium in *Cnemiornis* is bounded above by a curved ridge, leaving a flatter tract between it and the summit of the bone; but there is no trace of this division of the bone in *Aptornis*. The posterior, horizontal iliac tract is divided by a median convex ridge in *Cnemiornis*, but by a deep median furrow in *Aptornis*. In that genus there is no trace of the superacetabular pneumatic fossa as in *Cnemiornis*, in which the acetabulum is relatively larger, its vacuity wider, its distinction from the posterior flat facet greater. The antischial depression of *Aptornis* is not repeated in *Cnemiornis*. In this genus there is no indication of the smooth, large, deep, hemispherical postrenal fossa on the under surface of the ilium which characterizes *Aptornis*; neither is there an iliac lamella bounding behind the interacetabular renal fossa.

In both genera there are indications of similarity of the pelvis to that in *Rallidæ*; there is the length of the antacetabular part and its steeply inclined roof-like iliac plates, the great reduction of the iliac fossæ through the non-extension, or slight extension, of the ilia beyond the sacral diapophyses; but this affinity is more marked in *Aptornis*, as by the development of the postrenal ischial lamellæ (Pl. LXXXV. fig. 2, *v*) and the small and round ischiatic foramen.

§ 4. *Notice of a mutilated Pelvis of* Notornis.

I have long entertained hopes of receiving, through the friendly cooperation of some collector of natural-history objects in New Zealand, materials for a monograph on the osteology of *Notornis*[3]; but, so far as I know, only a very few skins of that still lingering species of Ground-Coot have hitherto reached Europe.

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[1] Compare Pl. LXXXV. fig. 1, 62, with Pl. VII., p. 35.

[2] Compare the figures in the present Memoir with figures 5, 6, 7, Pl. LXVII.

[3] *Notornis* is affirmed to be living in considerable numbers in some districts on the west coast of the Middle Island (Mackay in 'Ibis,' 1867, p. 144).

I no longer delay, therefore, to communicate a description of a very mutilated portion of pelvis received from the sand-beds at the embouchure of the Wanganui river, North Island of New Zealand, in the same brittle but unpetrified state as the parts on which the genus *Notornis* was originally founded[1], under the impression of its being extinct, as in the North Island of New Zealand it actually is.

I am led to refer the specimen about to be described to that genus by reason of the relation of its size to that of the skull described and figured in the under-cited Memoir, and also to the size of the femur and tibia described and figured in a subsequent Memoir[2].

This portion of pelvis includes thirteen confluent sacral vertebræ, the rest being broken off from the hind end of the series.

The first sacral offers the usual articular surfaces on the prezygapophyses (Pl. LXXXV. fig. 6, *z*) and on the fore part of the centrum, the transverse concavity of the latter (ib. *c*) being deep, the vertical convexity slight. A circular costal pit (ib. fig. 6, *pl*) impresses each side of the centrum and each diapophysis. A large pneumatic foramen opens at the base of each diapophysis. The neural spine, moderately compressed and high, is confluent at top with the iliacs: the vertical length of the vertebra is 1 inch 5 lines; the transverse diameter across the diapophyses is 1 inch. The sides of the centrum converge below to a tract from 1½ line to 2 lines in breadth (Pl. LXXXV. fig. 5, *c*). The second sacral has no free rib; its transverse process, directed outwards, contracts an extensive anchylosis with the ilium; the centrum, expanding backward, has a broader convex under surface. That of the third sacral continues the expansion with a broad, smooth, convex under surface; the lamelliform transverse processes incline forward to their terminal coalescence. The more expanded fourth sacral centrum has a broad, flat under surface, on a level with which the thick, short parapophyses pass directly outward. Those of the fifth and sixth sacrals have a like position, size, and direction. The breadth of the flat lower surface is here half an inch. The four succeeding vertebræ are "interacetabular," have no parapophyses; the inferiorly flattened centrums gradually lose breadth, and are defined by the nerve-canals in pairs, as usual, opening obliquely backward, and progressively decreasing in size from the seventh to the eleventh (Pl. LXXXVI. fig. 9, *c*, 7–11). In this and the succeeding centrums the parapophysis reappears, but is broken away in each of the remaining sacrals.

As much of the iliacs remain as have coalesced with the neural arches of the thirteen sacrals here preserved. They meet and form an obtuse continuous smooth ridge above the first five sacrals, from which ridge the bones slope, like the sides of a steep roof, to their lower, fractured margin. The longitudinal contour above (ib. fig. 9) is slightly convex, then rather abruptly sinks to the lower level of the expanded neural arches of the seven or eight hinder vertebræ, describing a concavity, which again becomes convex in a slight degree. Here the upper surface is almost flat, with a feeble mid linear

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[1] P. 173, Pl. XLVII.

[2] Pl. L. figs. 3 & 4.

rising; where this rises to the anterior convexity there is a linear slit on each side, leading to the "ileo-neural" vacuities.

Fragmentary as is this portion of pelvis, it permits of the deduction of some characters which support the reference of it to the porphyrian genus *Notornis*. The antacetabular portion included, as I am led to infer, at least half the total length of the pelvis. In this respect it resembles *Apteryx*[1]; but the superior contour of the coalesced iliacs in that bird is convex. The undulated contour of the same part of *Notornis* rather exaggerates that in *Aptornis* (Pl. LXXXV. fig. 1), and still more so what is more feebly shown in *Tribonyx* and some other Rallines, viz. *Gallinula nesiotis*, Scl., *Porphyrio*, sp., and *Ocydromus*, sp. But in none of these is the undulation so strong as in *Notornis*. In *Gallinula nesiotis* I observe the same slit-shaped outlets of the ilioneural canals on each side the descending mid ridge of the coalesced ilia.

The character of the under surface of the antacetabular centrums in *Notornis* (Pl. LXXXV. fig. 5) agrees with that in species of *Gallinula* and *Porphyrio*. The ridge-like shape of the same part in *Aptornis* and *Cnemiornis* finds a partial resemblance in the first and, sometimes, second sacral centrums of species of *Fulica*. Only the first sacral supports, as in *Notornis*, moveable ribs in *Gallinula nesiotis* and *Porphyrio cœlestis*; but in some species of *Fulica* both first and second sacrals have moveable ribs, as in *Aptornis* and *Cnemiornis*. In the vertebræ which I have called "interacetabular," though they are partly in advance of the internal openings of those articular cavities, *Notornis* resembles *Aptornis* and many existing Rallides, in the absence of transverse processes; the neurapophyses rise, from above the double nerve-holes, as vertical walls slightly expanding to be lost in the flat iliac roof of that part of the pelvis. In *Cnemiornis* oblique ridges extend from the neurapophyses of those vertebræ, strengthening, as buttresses, the support of the superincumbent bony roof[2].

§ 5. *Femur, Tibia, and Fibula of* Aptornis defossor.

Femur.—The difference in the size of this bone, as compared with the femur of *Aptornis otidiformis*, is given in the "Table of Admeasurements" (p. 315), and may be seen by comparing fig. 5. Pl. LXXXVI. with those cited below[3]. The differences which the femur of *Aptornis* presents, as compared with that of *Dinornis*, are repeated, and in some respects exaggerated, in *Apt. defossor*: the straight subcylindrical character of the proportionally longer and more slender shaft in *Aptornis* is better marked in the present species. That of *Apt. didiformis*, viewed in profile, as in the figure of the femur of the larger species given in Pl. LXXXVI., shows a slight bend, convex forward; this is due to a minor diminution of fore-and-aft diameter in the lower part of the shaft, and to a relatively greater fore-and-aft diameter of the outer condyle in *Apt. defossor*. The "well-marked ridge," extending down the back part of the shaft, and inclining to terminate in the border of the inner condyle, is repeated in the present species. In

[1] Pl. VII.

[2] Pl. LXVII. fig. 6.

[3] Pl. L. fig. 3; Pl. LXVI. fig. 3.

Dinornis the corresponding ridge is more median or even tends toward the outer side of the back surface of the femoral shaft, and ends abruptly in a tuberosity, usually one of a pair, at the lower third of the shaft, from the innermost of which extends the ridge to the inner condyle. This condyle in *Dinornis* does not reach so low as the outer one; and the terminal distal line is oblique, indicative of the greater angle at which that end diverges from the hip-joint to rest on the tibia of the robuster-bodied bird. In *Apt. defossor*, as in *Apt. didiformis*, the inner condyle more nearly equals in vertical extent the outer one, yet in a somewhat minor degree in the larger species. In both, the fore part of the two condyles is less prominent, and the rotular groove less deep, than in the femur of *Dinornis*. The head of the femur is more truncate or depressed in *Aptornis*, through the relatively larger size of the ligamentous pit, than in *Dinornis*. The lower part of the head is more produced downward in *Aptornis*; and a short ridge from the under and back part of the head (*Apt. otidiformis*), or of the neck near that border of the head (*Apt. defossor*) (Pl. LXXXVI. fig. 6), extends downward and rather backward for 6 or 8 lines. Of this ridge there is no trace in *Dinornis*. A broader parallel ridge or rising extends about the same distance from along the back part of the supracervical articular surface: this extension from the head of the femur is more convex from before backward in *Aptornis* than in *Dinornis*. Of the pneumatic fossa, which in some species or individuals of *Dinornis* breaks the surface below the back part of the supracervical surface, there is no trace in either species of *Aptornis*.

For the characters of the femur of *Aptornis* as compared with that of *Cnemiornis*, reference may be made to p. 243, Pl. LXVIII. They are as well marked in *Apt. defossor* as in *Apt. otidiformis*.

Tibia.—The importance of such distinctive characters as "the tibial half of the proximal articulation is broader from behind forwards than transversely," "the anterior ridge at the proximal end ['procnemial ridge'] is nearer the middle of the bone," "the more rounded or less angular inner side of the shaft," "the proportionally greater antero-posterior thickness of the shaft," "the deeper posterior notch between the distal condyles," "the more compressed and more backwardly produced inner condyle," could not be fully estimated in the solitary tibia of the smaller species first described[1]. In the absence of a femur or of a tarso-metatarsal bone to match this tibia, I could only venture to affirm that "it unequivocally established a fourth species of cursorial bird" in the series of tibiæ first received from New Zealand. The subsequent acquisition of the femur, the "tarso-metatarsal"[2], and the skull of the *Dinornis otidiformis* of 1843 impresses one instructively with the value of such seemingly insignificant modifications of the chief leg-bone, and the need of close scrutiny and comparison of every character thereof in solitary fossil specimens.

The somewhat more perfect tibia of *Aptornis defossor* (Pl. LXXXIV. fig. 9, and Pl. LXXXVI. fig. 8) than that of *Apt. otidiformis* (Pl. XXV. fig. 5) yields other

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[1] P. 83, Pls. XXV., XXVI.

[2] Pl. L.

differences between *Aptornis* and *Dinornis*, in this bone, than are noted at p. 85. The bony canal for the tendon of the "tibialis anticus" and "extensor longus digitorum pedis"[1], is nearer the middle of the anterior surface. The ridge forming the inner wall of the groove thereto leading is longer and sharper, the bony bridge (Pl. LXXXIV. fig. 9, *f*) is broader, the fibular ridge (*h*) is more prominent and more lateral. In most of these characters may be discerned a significant resemblance to the tibia of *Notornis*[2]. In the median position and breadth of the "extensor tendon bridge" (*f*), in the development of the inner wall of the groove, in the outer position and prominence of the fibular ridge, similar affinities are indicated in the tibia of *Cnemiornis*; but the exaggerated development of ectocnemial and procnemial ridges in that genus only comes out the stronger in the comparison with *Aptornis* (Pl. LXXXIV. fig. 9, and Pl. LXXXVI. fig. 8, *p*, *e*). As in *Apt. otidiformis*, the tendinal canal is less strictly median in *Apt. defossor*, and the fore part of the inner distal condyle is more produced and more compressed, than in *Cnemiornis*.

The fibula of *Aptornis defossor* (Pl. LXXXIV. figs. 10, 10 *a*) is 6 inches in length, has the usual subcompressed head, with the convex elongate articular surface for the groove of the outer femoral condyle; the proximal end is slightly hollowed on the inner side, in a minor degree convex on the outer side; the shaft, gradually tapering as usual to a pointed end, which seems to have contracted a second junction with the tibia, shows also the two rough surfaces for tendinous attachments, but less strongly marked than in *Cnemiornis*.

§ 6. *Femur of* Notornis.

The acquisition of a second, somewhat more perfect specimen of the femur of *Notornis*, from Waingongoro, in the North Island of New Zealand, induces me to repeat and develope a description of the bone with special reference to the illustration of the Ralline affinities of *Aptornis*. The femur of *Notornis* (Pl. L. fig. 3), in the proportions of length to thickness of shaft, in the degree of curvature, and of torsion on the axis, resembles that in smaller existing Rails and Coots more closely than does the femur in *Aptornis* or *Cnemiornis*.

The head shows the same free and sharp downward production of its lower margin, the same proportion and position of the depression for the round ligament as in *Aptornis*, the same form and degree of extension of the articular surface upon the neck, the same transverse convexity of that surface. The great trochanter rises higher than this surface, but is relatively less elevated than in *Aptornis*; it is relatively as broad; the anterior border is rather more sharply produced, and is brought more to the front surface of the bone. A linear ridge is continued therefrom down three-fourths of the shaft, inclining toward its inner side. A tuberosity projects below the base of the trochanter at the outer side of the bone, from which goes a linear ridge along the back

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[1] Pl. XIV. 8, 9.

[2] Pl. L. fig. 4.

part of the shaft, toward the outer side; a second linear ridge, commencing lower down, runs along the back of the shaft towards the inner side as far as the popliteal space; between these ridges, near halfway down the bone, opens the canal of the medullary artery. The distal end is less expanded than in *Aptornis* or *Cnemiornis*. The rotular channel, though wide, is relatively deeper and narrower than in *Aptornis*, and the inner border is more produced. A small tuberosity projects external to the upper end of the outer border: this may be individual. The popliteal space shows no definite fossa, and its surface is irregular. The fibular articular groove is deeper, with a better-defined and produced outer border. As in the thigh-bone of the *Rallidæ* generally, there is no pneumatic foramen.

§ 7. *Metatarsus of* Aptornis defossor.

In general form and proportions this bone resembles that in *Aptornis otidiformis*: the superiority of size is shown in the "Table of Admeasurements," and in figs. 1–4, Pl. LXXXVII. As compared with *Dinornis* (ib. figs. 7–10), the metatarsal of *Aptornis defossor* shows the same greater depth and nearer equality of size of the two condylar cavities (ib. fig. 4), with the broader and loftier intercondylar tract, as in *Apt. otidiformis*[1] (ib. fig. 6), the same superior prominence and perforation of the calcaneal process (ib. figs. 2–4, *c*, *c'*), the same flattening of the back part of the shaft through the non-projection there of the upper half of the mid metatarsal element, also the presence of the canal (ib. *t*) for the tendon of the "adductor digiti externi." The inner (entotibial) condylar cavity is on a rather higher level than the outer (ectotibial) one, is rather deeper, rather less from before backward. The cavity at the upper part of the front surface of the metatarsal shaft is relatively less deep than in *Aptornis otidiformis*; it is not continued so low down upon the shaft; but the anterior outlets of the interosseous canals open separately at its bottom, and the ridge at the inner border for the insertion of the corresponding part of the tendon of the "tibialis anticus" is strongly marked and defined. In *Dinornis* the interosseous canals converge from behind forward to a common orifice (*o*, fig. 7) at the bottom of the shallow upper and anterior depression. In one specimen of metatarsus of *Aptornis defossor* the groove (*t*, fig. 1) for the tendon of the "adductor digiti externi" deepens as it approaches the interspace between the middle and outer digital trochleæ, and perforates the bone above that interspace; in another it deeply grooves the interspace, but is not crossed by the bony bridge at the fore part of the interspace. A similar variety is shown by one of three specimens of metatarsus in *Apt. otidiformis*. Where the bridge exists, the tendinal canal opens in the interval or chink between the two trochleæ; but there is commonly another canal, continued from the "adductor groove," which traverses the bone backward and opens into the lower concavity of the posterior surface of the metatarsal above the interval between the outer (IV) and middle (III) trochleæ, as at fig. 2, *h*, Pl. LXXXVII., and in vol. iv. pl. 3. fig. 5, *Apt.*

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[1] P. 200.

otidiformis. Now, this orifice is not present in one of three metatarsi of *Apt. otidiformis*, nor in one of the two metatarsi of *Apt. defossor*. Neither the vertical nor the fore-and-aft canals are present in *Dinornis*: I have once seen the latter canal, as an exception, in *Apteryx*.

At the back part of the shaft *Aptornis defossor* shows a perforate calcaneal process (Pl. LXXXVII. figs. 2, 3, *c*), relatively longer vertically than in *Apt. otidiformis*: the ridge on the inner side of each side-wall (fig. 4), indicating the portions of the canal traversed respectively by the tibialis posticus (*e'*) and the "flexor longus digitorum" (*e*), is better marked, and the bony canal is less contracted posteriorly, than in *Apt. otidiformis*. The postinternal longitudinal crest is shorter and more produced in *Apt. defossor*; the fossa internal to its upper part, for the origin of the "flexor brevis hallucis," is well defined, as is the surface below the crest for the attachment of the metatarsal of the hallux (fig. 2, I). The longer surface at the outer and back part of the metatarsal for the insertion of part of the strong gastrocnemial sheath-like tendon is strongly marked. Every thing bespeaks the force with which this massive metatarsal was worked in *Aptornis*. The proportions and disposition of the distal trochleæ in *Apt. otidiformis* (fig. 5) are closely repeated in the larger species (fig. 1, *a*); the inner one (fig. 2, II) does not terminate at a higher level than the outer one (ib. IV); the cleft between the outer and middle trochleæ is deeper and anteriorly wider than the inner cleft, in both species of *Aptornis*. The outer trochlea in *Dinornis* (fig. 8, IV) is shorter than the inner one (ib. II).

To exemplify the generic, or family, or ordinal distinction between *Aptornis* and *Dinornis*, I take the present opportunity to figure the metatarsus of the species coming nearest to *Aptornis* in size[1], viz. *D. curtus* (Pl. LXXXVII. figs. 7–10), first indicated by the mutilated bone described and figured in Pl. XXXIX. fig. 6.

The metatarsus of *Aptornis defossor*, above described, formed part of the extensive series of remains brought by Mr. Walter Mantell from Ruamoa, Middle Island of New Zealand, and purchased by the British Museum in 1856 (pp. 223, 234). Deeming, then, that it might prove to belong to a larger variety of the *Aptornis otidiformis* of the North Island, I concluded to wait for further evidence, which the bones brought from the same neighbourhood (Oamaru) by Mr. Taylor have now given. The tibia (Pl. LXXXIV. fig. 9) fits this metatarsus (Pl. LXXXVII. fig. 1) as well as the tibia of *Apt. otidiformis* (Pl. XXV. fig. 5) fits the metatarsus figured in Pl. L. fig. 5.

On comparing the metatarsus of *Aptornis* with that of *Notornis*, *Ocydromus*, or *Tribonyx*, the bone[2] would seem, at first sight, to drive the extinct genus far away from the Ralline waders: the occiput of *Aptornis* hardly presents more marked differences from that in any known recent Ralline's skull.

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[1] Unless the small bone (Pl. LXXXIV. fig. 7) should indicate an established breed of that inferior size, meriting a distinctive name, and should not belong to a female or somewhat dwarfed individual of *D. curtus*.

[2] Pl. L. figs. 5–8; and Pl. LXXXVII. figs. 1–6.

I discern, however, a certain harmony in the departures from type thus presented by the two extreme parts of the skeleton of *Aptornis*—an associated relation to the needs and habits of this most strange brevipennate bird. On the functional hypothesis of the large and long adze-like bill of *Aptornis*, as being designed and used for the purpose of feeding its great body with earthworms and burrowing grubs, the delving-instrument may have needed another one to clear off the broken-up surface and to help in the unearthing quest. What, then, we may ask, would be the modifications superinduced, say, upon the Ralline type, if indeed such type-characters be not predicable of a wider range of the "precocious birds"?

In the first place, the foot, if it is to be used, with due vigour, in scratching up and scraping away soil, must be brought near to the bending powers; their force must not be wasted upon long tendons traversing a stilt-like metatarsus before they can be inserted into the toes. The shortness of that segment in proportion to the tibia is accordingly notable in scratchers (*Rasores*, *Gallinæ*) as compared with waders (*Grallæ*).

The metatarsus is less remarkable for its length in most *Rallidæ* than in waders generally; but that of *Aptornis* is reduced to shorter proportions than have been seen in any known grallatorial or, even, rasorial bird. In some of the Grouse-tribe the metatarsus may be reduced to one-half the length of the tibia; but in *Aptornis* it is less than half. In strength or robustness it loses nothing in this comparison with *Gallinæ*, rather gains; the transverse diameter of the middle (narrowest part) of the shaft of the metatarsus in *Aptornis* is equal to, or exceeds, that of either the tibia or the femur.

For the strength of a "double joint," equality of the two condyles, and of their cups, may be a condition, as well as prominence and depth of interlocking; and both ecto- and entotibial cups on the proximal articular surface of the metatarsus in *Aptornis* are almost on the same level: the outer one (ectotibial) is rather the lowest; and this may be deemed significant of its porphyrian affinity, seeing that the level of this surface is conspicuously lower, in Coots, than that of the inner (ento-tibial) cup; and this cup, though higher, is deeper than the outer one, as in *Rallidæ* generally. The intervening rise of the proximal surface, however, which, as it passes into the joint between the condyles of the tibia, is called "intercondylar," instead of being low, as in *Rallidæ*, is raised considerably; but this is in more direct relation with the strengthening of the ankle-joint than is the equality or level of the two cups and balls.

The perforate condition of the strongly produced calcaneal process seems, with the shortness and thickness of the metatarsus, to speak for the rasorial affinities of the bird to which it belongs. But there are no longitudinal grooves upon either the back or the sides of the perforate calcaneal process in *Aptornis*. If the ento- and ecto-calcaneal plates of *Notornis*[1] or of *Porphyrio* were united by coossification of their free borders, the condition of the calcaneal process in *Aptornis* would be produced. One can see the advantage of a complete bony pulley for the traversing tendon of the flexors of the

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[1] Pl. L. fig. 3.

toes[1]; and this was a strong one in *Aptornis*, with a pulley to match. The base of the perforated process equals half the transverse diameter of the proximal end of the metatarsus, outstanding a little to the outer side of the middle of the hind part of that surface, slightly deflected at the end. The inner wall has a longer base of origin than the outer one. There is a feeble indication of the parts of the canal respectively traversed by the "perforans" and "perforatus" tendons, but no outside grooves; and the difference from the gallinaceous metatarsus is shown by the non-continuation of the entocalcaneal plate with the postinternal crest on the shaft of the bone, giving attachment to one of the divisions of the sheath-forming insertional tendon of the "gastrocnemius externus"[2].

The beginning of the postinternal crest is separated from the entocalcaneal process by a canal about $1\frac{1}{2}$ line wide, into which opens the antero-posterior (interosseous) canal between the inner and middle metatarsal elements. The surface on the inner side of the postinternal crest for the origin of the "flexor brevis pollicis" is extensive and well marked, according with the size of the digit indicated by the hallucial articular surface (Pl. LXXXVII. fig. 5, I). The anterior surface of the metatarsus is impressed, near the tibial articulation, with a deep fossa, into which open the two "interosseous" tubular canals; beneath these are surfaces for the origins of the "extensor pollicis brevis" and "adductor digiti externi;" and the inner side of the fossa is produced into a short ridge, into which the tendon of the "tibialis anticus"[3] is in part inserted. Midway down the fore part of the shaft begins the groove for the "adductor digiti externi," the tendon of which glides through the canal above the interval between the middle and outer trochlear condyles, which canal is present in the *Notornis* and Coots, though by no means peculiar to them. It is one of the well-marked distinctions between the metatarsus of *Aptornis* and of *Apteryx*, this latter bird agreeing with *Dinornis* in the absence of the intertrochlear canal.

The surface below the postinternal crest indicates a strong and large back toe (hallux, Pl. LI. fig. 7, I); but *Notornis* and the Coots have this in common with the *Rasores*. The trochleæ of the digits II & IV descend almost to the same level; IV is, perhaps, rather the lowest; in *Notornis* and the Coots it is more decidedly so. The mid condyle is more advanced and more produced in *Aptornis*, as is usual in *Grallæ* and *Gallinæ*, and as it is, indeed, in *Apteryx* and *Dinornis*. The interval between the toes III & IV in *Aptornis* is wider and deeper than that between III & II. The grooved or trochlear character of each condyle is well marked.

On the whole, the inference seems legitimate that we have in the metatarsus of *Aptornis* a bone extremely modified for "rasorial" functions upon a porphyrian or "ralline" type.

[1] "Myology of *Apteryx*," pp. 41–70, Pls. XII., XIV., 1, 3, 1, 5, 6.

[2] Pl. XIV. R***.

[3] Ib. 8.

Table of Admeasurements.

	Aptornis defossor.		*Aptornis otidiformis.*	
	in.	lines.	in.	lines.
Skull.				
Length	7	2	6	2
Breadth (across paroccipitals)	3	3	2	9
Breadth (across postfrontals)	3	2	2	10
Breadth (across temporal fossæ)	2	3	1	1
Breadth of base of upper mandible at fore part of orbit	1	6	1	3
Breadth of middle of upper mandible	1	4	1	1
Breadth of fore end of upper mandible	0	7	0	6
Length of cranium to coalesced premaxillary	2	6	2	2
Length of premaxillary	5	0	4	3
From the fore part of external nostril to the end of the premaxillary	2	9	2	3
From the superoccipital ridge to the lower border of the fore basilar tuberosities	2	6	2	1
Femur.				
Length	7	6	6	2
Breadth of proximal end, in the axis of the neck	2	2	1	9
Breadth of distal end, across the condyles	2	2	1	9
Circumference of middle of shaft	2	9	2	3
Tibia.				
Length	10	3	8	9
Breadth of proximal end	2	3	1	9
Breadth of distal end	1	10	1	3
Circumference of middle of shaft	2	6	1	11
Metatarsus.				
Length	4	4	3	10
Breadth (transverse) of proximal end	1	8	1	5
Breadth (transverse) of distal end	1	9	1	6
Breadth (transverse) of middle of shaft	0	11	0	8
Breadth from fore part of proximal end to back part of calcaneal process	1	6	1	4

DESCRIPTION OF THE PLATES.

PLATE LXXXIII.

Aptornis defossor.

Fig. 1. Side view of skull.
Fig. 2. Top view of skull.
Fig. 3. Base view of skull (without mandible).
Fig. 4. Side view of mandible of *Aphanapteryx* (*ex* A. Milne-Edwards, 'Ibis,' July 1869).

PLATE LXXXIV.

Aptornis defossor.

Fig. 1. Back view of cranium.
Fig. 2. Inner side view of tympanic bone.
Fig. 3. Mandibular articular surface of tympanic bone.
Fig. 4. Outer side view of tympanic bone.
Fig. 4 *a*. Hind view of palatines.
Fig. 5. Upper view of mandible of *Aphanapteryx* (*ex* 'Ibis,' &c.).
Fig. 6. Upper view of mandible.
Fig. 7. Under view of mandible.
Fig. 8. Hind surface of ramus of mandible.
Fig. 9. Front view of tibia.
Fig. 10. Side view of fibula.
Fig. 10 *a*. Upper end of fibula.

PLATE LXXXV.

Aptornis otidiformis.

Fig. 1. Pelvis, from above, or dorsal aspect.
Fig. 2. Pelvis, from below, or ventral aspect.
Fig. 3. Pelvis, from before, or front view of first sacral vertebra and iliac bones.

Cnemiornis calcitrans.

Fig. 4. Front view of mutilated first sacral vertebra and iliac bones.

Notornis mantellii.

Fig. 5. Fore part of sacrum and iliac bones, from below.
Fig. 6. Front view of first sacral vertebra and iliac bones.

PLATE LXXXVI.

Aptornis otidiformis.

Fig. 1. Side view of pelvis.
Fig. 2. Side view of neural spine of first sacral vertebra.
Fig. 3. Side view of middle sacral vertebræ.
Fig. 4. Section of fourth sacral vertebra and confluent parts of iliac bones.

Aptornis defossor.

Fig. 5. Outside view of right femur.
Fig. 6. Back view of proximal end of right femur.

MEMOIR

ON THE

EGGS OF SPECIES OF DINORNIS.

IN 1843 the Rev. Richard Taylor, of the Missionary Station at Wanganui, visiting the shore of the coast of Waimate, near the river Waingongoro, found a sandy plain covered with a number of little mounds, entirely composed of Moa bones: "it appeared," he writes, "to be a regular necropolis of the race"[1]. Here fragments of shells of some large egg were first met with. "When I next visited Waingongoro, expecting to carry off another load of Moa bones, I found, to my surprise, that they had disappeared. I afterwards heard that Mr. Mantell had passed that way after me, and had cleared the place of all worth taking"[2].

The collection so obtained by Mr. Mantell was purchased by the British Museum (*antè*, p. 223); and, after the determination of the species of *Dinornis* represented by the bones, I proceeded to compare the numerous fragments of egg-shell. These had previously yielded the following generic character:—"The shell in *Dinornis* is not only absolutely thinner, but relatively much thinner than in the Ostrich, and, *à fortiori*, than in the *Æpyornis*. The air-pores also have a different form, being linear, not rounded; and the external surface is smoother. In the smoothness and thinness of the shell the egg of *Dinornis* resembles that of *Apteryx*." But, "viewed under a moderately magnifying power, the surface of the egg of the *Apteryx* presents a very fine fibrous or spicular character; the raised lines, like spiculæ, crossing in opposite directions, the air-pores scattered here and there, and barely perceptible to the human eye"[3].

After a general comparison and sorting of the shell-pieces and fragments, they indicated eggs of two, if not three sizes. That to which the most numerous fragments

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[1] Transactions of the New-Zealand Institute, vol. v. 1872, p. 98.

[2] *Loc. cit.* p. 99.

[3] Proceedings of the Zoological Society of London, Part xx. 1852, p. 12. See also NATHUSIUS, 'Zeitschrift für wissenschaftliche Zoologie,' 8vo, 1871, to whom I transmitted portions of the egg-shell of *Dinornis* for the purpose of his memoir.

were referable gave grounds for an estimate of size of the entire egg. The convex surface showed two degrees of curvature, one indicating the length, the other the breadth of the egg. The direction of the linear air-pores ran mainly in that of the long axis of the egg, as inferred by the major curve. A few fragments, by shorter curves coinciding with the direction of the air-fissures, indicated proximity to one or other of the ends of the egg.

A comparison with corresponding curves in answerable portions of an egg of an Ostrich led me to the conclusion as to comparative size, which is illustrated in Plate XC. The middle circle, inclosing the words *Struthio .... Struthio*, gives the extreme transverse girth, the dotted line of the middle oval, inclosing > *Struthio* >, gives the longitudinal girth, of the egg of the Ostrich. The outer circle, inclosing "*Dinornis .... Dinornis*," gives the extreme transverse girth, the outer oval, in dotted line, gives the extreme longitudinal girth, of the egg of a Moa. Guided by the proportion of the number of shell-fragments indicating the same species of bird to that of the number of bones referable to one species, I was led to the conclusion that the form and dimensions of the egg of *Dinornis elephantopus* had thus been worked out. The portions of egg-shell, indicating by their curvatures a smaller kind of Moa, were of larger size; and long and patient attempts at fitting them together were ultimately rewarded by a reconstruction of one of the eggs, now in the British Museum, the most perfect side of which is figured in Plate CXV.

As the Mantellian collection, besides its illustrations of the then new species *Dinornis elephantopus* (p. 223), included many specimens confirmatory of *Dinornis crassus*, previously indicated by bones discovered by Percy Earl, Esq., at Waikawaite (p. 132), it seemed probable that the smaller egg belonged to that smaller species.

In the Plate CXV. are given illustrations of the structure of the egg-shell: fig. 2 shows the markings on the outer surface, nat. size; fig. 3 the same, magnified three diameters; fig. 4 shows the thickness of the shell of the egg of *Dinornis elephantopus*; fig. 5 a portion magnified three diameters, to show the proportions of the inner and outer layers of the shell.

Such was the degree of knowledge of the egg-characters of *Dinornis* to which I had got in 1856.

In the year 1865 an egg of a *Dinornis* was sent from New Zealand to London, and was submitted to my inspection. A small portion of the shell had been broken away at one side of the egg; but the pieces were transmitted. The egg measured 10 inches in length and 7½ inches in breadth; the shell was $\frac{1}{12}$ of in inch in thickness. showed the external linear air-pores and the smooth inner layer characteristic of the *Dinornis* egg-shell; but the shell in this instance had been stained of a dirty brownish colour, probably from the decomposition of the body of the native with which it had been buried, added to the natural colour of the grave-soil.

Judging from the degree of superiority of size of this egg in comparison with that of the *Dinornis elephantopus*, and deeming it probable that some slight variation of breadth to length in the egg might accord with a similar modification of robustness to height of the body in the species, I inferred that the specimen was the egg of *Dinornis ingens*. As such it was offered for sale by auction, 24th November, 1865.

The 'Note of Sale' stated that "A man in Mr. Fyfe's employment at Kai Koras was digging the foundation of a house; and when on the side of a small mound, he suddenly came upon the egg in question and the skeleton of a man, supposed to be a Maori. The body had evidently been buried in a sitting posture; and the egg must have been placed in the hands, as, when found, the arms were extended in such a manner as to bring the egg opposite the mouth of the deceased." In corroboration of this story I received from J. Davies Enys, Esq., of Christchurch, New Zealand, the following Note:—" I beg to state that, being on a visit to the Kaikouras at the latter end of 1861, I was shown by Mr. Fyfe the Moa-egg, together with a human skull and a blackstone adze, which he kept in a box together, as having been found together when digging the foundation for a Store close to his house. Mr. Fyfe observed at the same time that he had only preserved the skull of the skeleton with which the egg was found, and that the Maories had no traditions whatever of a burial-place in that locality, although one of their Pas is situated about a mile from the spot..... Since writing these notes, I have asked Mr. John Innes, who was living at a station in the neighbourhood shortly after the time the egg was found, if he remembered the circumstances under which it was discovered. He entirely confirms the correctness of the account I have given, and adds that the egg was found in the early part of the year 1860, or at the end of 1859"[1].

The unique subject of this communication was purchased by George Dawson Rowley, Esq,, F.Z.S., and is now in his Museum of Ornithological Treasures at Chichester House, East Cliff, Brighton. I am indebted to him for the opportunity of figuring the specimen in Plate CXVII. of the present work.

In 1866 two eggs were discovered in the alluvial sandy loam of the "Upper Clitha Plains, Otago." The first was 2 feet from the surface, the second about a foot apart, and 3 inches deeper. Of the first and most perfect egg, pieces were extracted which, when fitted together, made nearly one complete side of the egg, from which its dimensions were estimated at—long diameter 8·9 inches, short diameter 6·1 inches"[2]. The egg-shell had been eroded by the solvents of the soil; but on the granular surface so produced the characteristic linear pores were distinctly visible. A portion of shell yielded 0·9 per cent. of organic matter, that of a recent Emu's egg yielding 7·89 of organic matter[3]. The Moa's egg-shell had thus not been long enough in the soil to part with all its soluble constituent, though much, doubtless, had been dissolved. The second egg was too far decomposed to admit of removal.

[1] See also Mr. Enys's letter in the 'Christchurch Press' of August 3rd, 1871.

[2] Hector, Dr. J., F.R.S., 'Proceedings of the Zoological Society,' 1867, p. 991.

[3] Ibid.

Supposing the two eggs to have been laid in superficial dry soil, as in the oviposition of the Ostrich, they might have been subject to some amount of incubation before the surface was overflowed and the 2 feet of alluvium was accumulated above them. That this had been the case was proved by the discovery, in the first egg, of bones of an embryo chick. These were of a brown colour, of a light spongy texture, adhered to the tongue through loss of organic matter, and were free from traces of membrane or ligament. Of the long bones of the hind limb the shaft only was ossified[1].

Of a somewhat more advanced embryo from an egg of a *Dinornis crassus*, one half of the sternum was obtained (Plate CXV. fig. 8), showing the ossification of that bone, as in *Apteryx*, from two lateral centres. The pelvis of the same embryo showed a confluence of pubis and ischium at their acetabular ends, the ilium being distinct (ib. fig. 6). The scapula and coracoid had coalesced (ib. fig. 7) at this early period, and showed no trace of glenoid cavity for a humerus

Among existing birds I infer, from characters of the sternum, scapular arch, conformity of number of cervical and dorsal vertebræ, structure of pelvis and of caudal vertebræ, character of bones of the hind limbs, palatal and other modifications of the beak and cranium of the *Apteryx*, that the wingless Kivis are most nearly allied to the extinct family of *Dinornithidæ*.

In comparison with the existing *Struthionidæ*, the *Apteryx* lays a much larger egg in proportion to its size (Plate XCIX. fig. 2); and in the thinness of the shell it more closely resembles that of *Dinornis*, though the air-pores are minute and indistinct. The Kivi lays but one egg at the season of oviposition; it is usually placed in leaves or moss in a dry nook or hollow at the root of a tree. Evidence has been obtained from New Zealand that the *Apteryx* breeds twice a year, and, if fortunate, rears two chicks in that period, one at each half-yearly sitting. The discovery of the two Moa-eggs at Otago may indicate that the *Dinornis* laid and sat on two eggs at the breeding-period. The large relative size of the egg also points to such limited number for each sitting.

From the relative size of the egg of the *Apteryx* to its pelvis, and a like relation in *Dinornis crassus*, *D. elephantopus*, and *D. ingens*, I have hazarded in fig. 1, Plate XCIX. a scheme of the egg of *Dinornis maximus*. The confirmations which have favoured the previsions of size and shape of extinct Moas, before their skeletons were discovered, encourage me in the belief that a future find of the egg of the hugest kind of Moa may show that its estimated size has not been exaggerated.

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[1] Proc. Zool. Soc. 1867, p. 991; and Transactions of the New-Zealand Institute, vol. v. 1872, p. 10, pl. vi.

MEMOIR

ON THE

APTERYX AUSTRALIS.

NERVOUS SYSTEM.

I AVAILED myself of the section of the mutilated cranium of *Dinornis giganteus*, described and figured in Pl. LXXVIII., to take a cast of the cavity (Pl. XCI. figs. 11, 12, 13), which affords an instructive representation of the brain of that species.

As the Memoirs on the bones of *Dinornis* were preceded by a description of the osteology and myology of *Apteryx*, so I propose in the present Memoir to communicate some notes and figures made in the year 1848 from dissections of the brain and certain nerves of the head of the *Apteryx australis*, which I kept back until I was able to get satisfactory evidence of the brain of the *Dinornis*, with a view to bringing out the characteristics of which my investigations of that organ in the small surviving representative of the gigantic *Dinornithidæ* of New Zealand were mainly conducted.

§ 1. *Brain of* Apteryx.

The brain of the *Apteryx australis* (Pl. XCI. figs. 1–10) is of an ovate subdepressed form, $1\frac{1}{2}$ inch in length, 1 inch 3 lines in breadth; the cerebral hemispheres (*a*) overlap the optic lobes and four-fifths of the cerebellum (*c*); they are defined anteriorly from the olfactory lobes (fig. 2, *r*) by a curved linear depression (a'), convex forward.

Thus, as in most Mammals, three of the primary cerebral vesicles, or divisions of the brain, are exposed by removal of the calvarium, whilst no part of the mesencephalon comes into view.

At the base of the brain (ib. fig. 3) the myelon (*m*) expands into a long macromyelon (*d*). This shows on each side the small pneumogastric swelling (*v*), and the larger trigeminal one (*tr*); it then expands vertically, as well as laterally, at *d*, for the grey centres in connexion with the "crura cerebri" (fig. 4, *k*), the smaller fascicules diverging to the cerebellum and the mesencephalon. The length of the macromyelon ("oblong medulla" of Anthropotomy) is half an inch, its extreme breadth 4 lines; the under surface is impressed by a median line or furrow for the basilar artery (fig. 3, *e*), which is formed, as in birds generally, by the two "arteriæ communicantes" (*f*) sent backward from the cerebral divisions of the entocarotids (*g*). The basilar artery transmits or receives the branches from the vertebral arteries (*h*). A division of the macromyelon, defining a "pons," is not more definitely marked than in most other birds.

The cerebellum (Pl. XCI. figs. 1 & 2, *c*) is of a subcompressed, subconical shape; it gives 6½ lines in vertical, 5 lines in transverse diameter, and 6 lines in antero-posterior extent at the base. A rudimentary appendage or prominence represents the side lobes: the superficies is multiplied by about fifteen transverse folds, averaging 1½ line in depth; their grey and white matters are shown in the section (ib. fig. 6, *c*). About seven of these folds are visible on the exposed surface of the cerebellum (figs. 1, 2, *c*). A short fissural trace of the primitive cavity (ib. fig. 6, *c'*) communicates with the macromyelonal one, called "fourth ventricle."

The distinctive peculiarity in the base view of the brain in *Apteryx* is the small relative size of the optic lobes (figs. 3 & 4, *b*). M. Dareste was struck with the peculiarity in the specimen of the brain of an *Apteryx* in the Museum of Comparative Anatomy in the Garden of Plants. He speaks of the optic lobes as "à peine visible à l'extérieur"[1], and justly notices this confirmation by comparative anatomy of the relation of the optic lobes to vision, which relation MM. Flourens and Mayer had inferred from physiological experiment.

The optic lobes, reduced as they are in *Apteryx*, adhere, however, to the ornithic type by the degree in which they have diverged laterally from each other in the course of the brain's acquisition of its mature characters[2]; they are ovate and subdepressed. The optic thalami (ib. fig. 4, *i*) form a larger and more definite tract than in other birds, and contribute in a greater degree to the "radix optica," or chiasma.

The cavity or ventricle of the small optic lobe is shown in the section (fig. 6, *b'*), and in the base view (fig. 4, *b'*), in which the macromyelon, removed by a transverse section through the back parts of the optic lobes (*b b'*) and the "crura cerebri" (*k*), exposes the rudimental hippocampal enlargements (*l*) and the fissures (*m*) by which the artery of the "choroid plexus" penetrates the lateral ventricle.

The cerebral hemispheres (*a*, *a'*, figs. 1 & 2) are smooth: a feeble indent at the side of the base indicates the "Sylvian fissure," which receives a branch of the cerebral entocarotid (fig. 3, *g*); there is a more feeble indication of a mid longitudinal tract at the upper and hinder part of the hemisphere (fig. 2, *a*), and still more feeble indication of a transverse frontal depression marking off, as it were, an anterior lobe (ib. *a'*). The structure of the hemisphere adheres closely to the avian type. Each "crus" expands and commingles its white fibres with grey matter to form a large ganglion or "corpus striatum" (fig. 5, *n*), from the outer side of which the neurine, chiefly of the white

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[1] Annales des Sciences Naturelles, Zoologie, 1856. His notice of this specimen is as follows:—"Le cerveau de l'*Apteryx*, tel que je l'ai entrevu au travers de ses membranes, m'a paru présenter des particularités intéressantes. Malheureusement je n'ai pu obtenir l'autorisation de le disséquer, ou même seulement de le dépouiller de ses membranes."—*Tom. cit.* p. 50.

[2] Anat. of Vertebrates, vol. ii. p. 119.

fibrous kind, expands, ascends, and arches inward over the great ganglion, becoming thinner as it approaches the median line, where it descends in contact with the corresponding part of the opposite hemisphere as a thin film forming the inner or median and the posterior wall of the "lateral ventricle" (Pl. XCI. figs. 7 & 8, *a''*). This is exposed by a longitudinal section of the thicker part of the roof (*a'* in fig. 5, and in Pl. XCII. fig. 2), the smooth ventricular surface of the ganglion being shown at *n*. In Pl. XCI. fig. 7, the thin inner wall of the ventricle (*a''*) is exposed by removal of the "corpus striatum" and the thicker part of the ventricular wall (fig. 5, *a'*). The "corpus striatum" is impressed by equidistant transverse vascular linear grooves.

Figure 10 shows a vertical transverse section of the hemispheres, where they are united by the "anterior commissure" (*o*): the depth of the interhemispheral fissure (*p*) is seen below the commissure; and the shape of the section of the ventricular cavity is shown at *q*. A similar section, 3 lines in advance (fig. 9), shows the ventricle (*q*) shrunk to the under and inner surfaces of the hemisphere. The section across the base of the rhinencephalon (fig. 8) exposes the continuation of the ventricle (*q*) into that foremost primary division of the brain.

The rhinencephalon (figs, 1 & 2, *r*) is as remarkable in the present singular bird for its large size as is the mesencephalon (fig. 5, *b*) for the smallness of its principal elements. The mammalian proportions of the rhinencephalon (figs. 3, 4, *r*) involves the development of the fore part of the prosencephalon, including those continuations of fasciculi of white with grey matter forming the "crura rhinencephali," the homologues of what are described in Anthropotomy as the "roots of the olfactory nerves." It is that which gives rise to the semblance of "anterior lobes" of the hemispheres on the upper surface of the brain of the *Apteryx* (fig. 2, *a'*), and to the tumid tracts below continuing the hemispheres in advance of the chiasma and its minute optic nerves (figs. 3 & 4, *a a*). The prosencephala (fig. 1, *a*) overhang about two-thirds of the rhinencephala (ib. *r*). One may distinguish at the under part of the hemispheres an outer and an inner division of the "crura rhinencephali" (ib. *r'*) by feeble degrees of prominence; but they are not divided, as in Mammals, by a "perforate tract," or by the definite superficial fascicle of white fibres.

§ 2. *Cerebral nerves of* Apteryx.

The rhinencephala occupy special compartments or fossæ at the fore end of the cranial cavity. The olfactory nerves (Pl. XCI. fig. 2, *s*) perforate the anterior and inferior wall of the rhinencephalic chamber by several foramina, but are closely invested and united by the neurilemma, especially along their upper surface, so as to appear, for an extent of 8 or 9 lines, each as one large olfactory nerve. From the underpart of these fasciculi, filaments pass down to the broad ethmoturbinals (fig. 1, *ae*); the rest of the nerves are dispersed upon the septum narium and the middle turbinals (ib. *ai*), which seem to prolong forward and to make one huge mass with the ethmoturbinals of convolute bony laminæ covered with highly vascular pituitary membrane. The smaller and more remote anterior turbinal (ib. *ao*), rarely ossified, receives its nerves from the nasal branch (*x*) of the trigeminal.

The optic nerve is but one-fifth of a line in diameter, and about half an inch in length (Pl. XCI. fig. 4, *t*): its course to the eyeball is shown by dividing and reflecting the "obliquus superior" (Pl. XCII. fig. 2, *o*), the "rectus superior" (ib. *r*), and the naso-maxillary division of the trigeminal nerve (ib. *w*).

The fifth or trigeminal nerve (Pl. XCI. fig. 1, *tr*) arises from the ganglionic enlargement of the macromyelon in connexion with or covered by the fibres of the transverse crus of the cerebellum. After a course of a line and a half, in which it leaves the cranium, it divides into two. The upper division (Pl. XCI. fig. 1, *w*) passes forward, ascending obliquely, traverses the orbit, diving beneath the "rectus superior" (Pl. XCII. fig. 1, *r*), and the "obliquus superior" (ib. *o*), sending a filament here to the ciliary ganglion: it then, emerging at the upper and fore part of the orbit, subdivides. Prior to its subdivision it rests internally on the dura mater, closing an unossified part of the cranial wall external to the large rhinencephalic fossa. The branch (Pl. XCI. figs. 1 & 2, *x*, and Pl. XCII. figs. 1 & 2, *x*) here reenters, as it were, the cranium, and emerges external to the cribriform plate by a canal larger than any of the olfactory foramina. The canal perforates the lacrymal bone, then grooves the outside of the turbinal mass (*ae*), and next perforates the base of the maxillary branch of the nasal: afterwards, inclining mesiad and sinking into the naso-premaxillary cavity, it gives branches to the anterior turbinal (ib. *ao*), attaching itself to the septum narium, near the lower margin, and becoming lost upon the septal membrane.

The branch (Pl. XCI. figs. 1 & 2, *y*) passes more directly forward, impresses the outer side of the upper (*ae*) and middle (*ai*) turbinals, and is continued more superficially beneath the horny sheath of the beak as far as the terminal disk perforated by the nostrils; it is diminished by filaments given off to the formative membrane and softer layer of the sheath to its termination at the tactile disk. The division corresponding to that called "third division," or "inferior maxillary nerve" (fig. 1, 6), sends off two nerves to the muscles of the mandible; these are derived from the non-ganglionic origin of the trigeminal: the main part, from the ganglion, is continued forward, sending off a branch to the outer tegument at the base of the mandible; it then enters the mandibular canal (fig. 1, *z*), and is continued forward to the end of the mandible.

The "eighth" nerve arises by two sets of roots from the same macromyelonal tract—the anterior set of three (Pl. XCI. fig. 1, 1), and the posterior one of two filaments (ib. 2): these combine in passing out of the skull, and emerge at the "vagal" foramen, whence the nerve (ib. 3) is continued further than usual before swelling into the ganglion and dividing into the glossopharyngeal (ib. 4) and the pneumogastric (ib. 5; see also figs. 1 & 2 in Pl. XCII.). I need not go into the further distribution of these nerves, as they cease to mark any part of the skeleton.

Between the origins of the trigeminal and vagal nerves in Pl. XCII. figs. 1 & 2, are shown that of the "portio dura" of the seventh pair, and the origin of the acoustic nerve.

§ 3. *Cranial Cavity of* Apteryx.

I may here supplement a former Monograph on the Osteology of the *Apteryx* by a notice of the characters and foramina seen in the interior of the cranium. The largest of the foramina is the foramen magnum, which looks downward and backward. The cerebellar protuberance of the occiput projects a little beyond the foramen; it is bounded on each side by a venous canal, which, emerging from the cranium behind the petrosal, grooves vertically the occiput, and again pierces the bone at the upper margin of the foramen magnum. In most skulls of the *Apteryx* the right of these canals with its upper and lower holes is larger than the left. Near the lower border of the great foramen, on each side the condyle, is a minute "precondylar foramen;" in advance and external thereto is the larger "vagal" fossa and foramen. Above this are the minute foramina conducting the acoustic filaments to the labyrinth. These are overarched by a remarkable development of bone within the "tentorium," forming in the dry skull a nearly horizontal plate, 3 lines by 1 line, terminating mesíad in a rounded and slightly thickened border. Beneath the back part of this plate is a large venous foramen. The superior semicircular canal raises a well-defined prominence on the petrosal platform continued into the above-described plate. The macromyelonal fossa is wide and moderately deep. It is bounded anteriorly by the posterior ridge of the trigeminal fossa and by the intervening hind wall of the sella. The foramen ovale leads from the back part, and the foramen rotundum from the fore part, of the fossa. The sella is deep and hemispheroid; it is tapped behind by the entocarotids. The chiasmal tract rises vertically from its fore part with an irregular aperture on each side larger than is needed for the optic nerves. The chief peculiarity of the cranial cavity is the enormous rhinencephalic fossa, divided by the "lamina perpendicularis." The dura mater closing these fossæ is not ossified, so that in the dry skull the turbinals, upon which the olfactory nerves perforate the membrane to ramify, are here exposed. The cranial walls show a thin pneumatic diploë above the paroccipitals, but in the rest of the section they are thin and compact.

MEMOIR

ON THE

BRAIN, LARYNX, AND TRACHEA

IN THE

GENUS DINORNIS.

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§ 1. *Brain of* Dinornis.

RETURNING to the brain of the *Apteryx*, the side view (fig. 1) is contrasted (in Pl. XCI.) with that of the *Dinornis* (fig. 11), the upper view (fig. 2) with fig. 12, and the under view (fig. 3) with fig. 13.

The *Dinornis* differs in the minor relative size of the cerebrum to the cerebellum, which latter (figs. 11 & 12, *c*) rises wholly behind and uncovered by the hemispheres (*a*). The cerebrum appears to be broader, because it is so much shorter, relatively, than that of the *Apteryx*; its upper surface is much more accentuated. A broad and high longitudinal tract (*a*), next the mid line, is divided from the outer part of the hemispheres; and this is partially subdivided into a posterior (*a''*) and anterior (*a'*) portion by a shallow depression answering to the "Sylvian fissure."

The optic lobes (ib. figs. 11, 12, 13, *b*, *b*) are, relatively as well as absolutely, larger than in *Apteryx*, corresponding with the indications, given by the orbits or bony beds, of the larger and better-developed organs of vision in *Dinornis*, the species of which we may conclude to have been diurnal; they are visible in the upper view (ib. fig. 12, *b*, *b*) as well as in the side view (ib. fig. 11).

No demarcation of a "pons" can be satisfactorily traced on the cast; but the trigeminal swelling is plain. The length of the macromyelon is 11 lines, its breadth is 9 lines.

The cerebellum shows a pair of low lateral lobes (ib. fig. 11, *c'*) at its fore part, and behind this the depression answering to the upper semicircular canal. The length of the cerebellum is 1 inch 2 lines, its breadth at the lateral lobes is 1 inch. The vertical diameter of the epencephalon (ib. *c*, *d*) is 1 inch 4 lines; the breadth of the mesencephalon (fig. 13, *i*, *b*), taken outside of the optic lobes, is 1 inch; the length to the fore part of the chiasma is 8 lines; each optic nerve (*t*) has a thickness of 2 lines. The breadth of the cerebrum (fig. 12, *a*, *a''*) is 2 inches 2 lines; its length is 1 inch 7 lines; its depth, or vertical diameter, is 1 inch 1 line. The breadth of the rhinencephalon (*r*) is 8 lines; the length of each lobe in advance of the cerebral hemisphere is 2½ lines. They are relatively less than in *Apteryx*.

The hypophysis, as represented by the cast of the "sella" (ib. figs. 11, 13, *y*) is of considerable size; there is an indication of a better-developed pineal gland (ib. fig. 12, *p*) than in the *Apteryx*.

§ 2. *Trachea of* Apteryx, Struthio, *and* Casuarius.

In the *Apteryx australis* the trachea has a nearly uniform diameter throughout its extent; the rings, from 120 to 130 in number, are entire and cartilaginous. When the windpipe is relaxed the rings alternately overlap, and are overlapped by, each other at their sides, appearing to be alternately narrower on one side than on the other; but when the tube is stretched this appearance is lost, though not wholly, the rings then showing a slight difference of breadth in the axis of the tube at their sides. They become gradually smaller in circumference and diameter in the last twenty, which are less closely attached together than in the Ostrich and Emu.

In the trachea of the Cassowary the rings, mostly entire as in other birds, vary in depth, *i. e.* in the diameter of the hoop parallel with the length of the tube, and they correspondingly vary in thickness (Pl. XCII. fig. 5). Their excess in these diameters is shown at about one-fourth down the trachea; they become narrowest and thinnest at the terminal tenth part of the tube, where a solution of continuity of the ring begins to show itself along the mid line of the back part of the tube. The incomplete rings of the bronchi resume the dimensions of those at the beginning and middle of the trachea.

In the Ostrich the bronchial rings are more slender than any of those of the trachea, and rapidly diminish in size as they approach the lungs.

In both Ostrich and Cassowary the tracheal rings examined by me were gristly, or were hardened with a very small proportion of bone-earth.

§ 3. *Trachea of* Dinornis crassus.

The more completely ossified state of the tracheal rings of *Dinornis* has led to their preservation in more than one species; and I have received from time to time specimens of such rings more or less closely associated with parts of the skeleton, in largest numbers with that collection of *Dinornis* remains obtained by Mr. Walter Mantell from the fine dark soil, or morass, at Ruamoa, Middle Island of New Zealand, and purchased for the British Museum (p. 223).

In working out this matrix from the base of the skulls of *Dinornis crassus*, described in a former Memoir (pp. 262–284), I detached from beneath the position of the palatonares a group of four bony hoops or rings of an oval form, averaging 9 lines in long diameter, 7 lines in short diameter; the depth of the rim of the bony hoop varied from one line to half a line; its thickness was about a quarter of a line. The outside of the ring is convex and finely rugose; the inside is less convex and smooth.

I cannot hold it as certain, that, because these slender rings were found at or near the position of the upper larynx, therefore they were from the beginning of the windpipe; for the dislocation of the parts of the skeleton in all the individuals so represented in the marshes of Ruamoa, as far as can be gathered from the account given by Mr. Mantell, might well admit of displacement of parts of the bony trachea: but I think it very likely that they are upper tracheal rings.

Admitting this doubt as to their precise position in the windpipe, still the probability is so great that tracheal rings preserved in contact with parts of the skeleton were parts of the same bird, that the rings here described may be reasonably referred to the *Dinornis crassus.*

There is, moreover, a significant degree of correspondence between the number of tracheal rings of the type of those attached to the skull, but collected without note of precise relations, probably scattered in the matrix, and the number of individuals of *Dinornis crassus* indicated by bones of the skeleton; that is to say, both tracheal rings and skeletons or bony evidences of *D. crassus* are amongst the most plentiful of the species there found.

The rings or hoops, upwards of 150 in number, provisionally referred to *Dinornis crassus*, are associated together by the character of shape and size. In general they are less slender than those cemented to the skull-base; but they present a certain range in the thickness, especially the depth, of the wall of the ring. The extreme of the latter, or breadth in the axis of the windpipe, is 3 lines, as at fig. 2, *b*, Pl. XCIII.; but this is partial, the hoop decreasing to 2 lines and $1\frac{1}{2}$ line at part of the circumference, in a few at the small ends of the ellipse, or the lateral parts of the hoop; the more common breadth is from 2 lines to $1\frac{1}{2}$ line (Pl. XCIII. fig. 1, *d*); those found at the base of the skull, and inferred to be from the upper part of the windpipe, were 1 line, decreasing partially to $\frac{1}{2}$ a line, in depth. There is less range of thickness in the elliptical rings of *Dinornis crassus*, as, *e. g.* from $\frac{1}{10}$ to $\frac{1}{8}$ of a line, seldom getting to $\frac{1}{6}$ (ib. figs. 1 & 3). There is a certain range of size and of shape of the ellipse: thus, in fig. 1, *a*, *b*, exceptional instances of subcircular rings are figured; in fig. 3, *a*, *b*, the long axis is 10 lines, the short one 9 lines; in fig. 3, *c*, the long axis is $11\frac{1}{2}$ lines, the short one 8 lines. Most of the rings have intermediate proportions; in a few the ellipse is less regular, one side inclining to flatness. There is a variety also in the configuration of the surfaces of the hoop; instead of the outer surface being convex from the upper to the lower margins, as in the slender rings detached from beneath the skull, it is flat, especially in the broader varieties, in which the inner surface preserves a slight convexity in the same course; in some rings the outer surface is slightly concave from edge to edge (as in fig. 2, *b*).

Of the tracheal rings referred to *Dinornis crassus* some are preserved in groups, cemented in their consecutive arrangement upon and by the matrix. These groups include one of seven rings (fig. 4), two of six rings, one of five rings (fig. 5), two of four rings with part of a fifth (fig. 6), as many of three rings, and more of two rings so kept in natural sequence. In three instances of the "two rings" these show broader and narrower parts of the outer surface, alternating, the extremes being at the small ends of the ellipse, or at the sides of the tube. This character has been noted in recent birds, especially in the Waders[1], the appearance being that presented by the tracheal rings of the present extinct Moa (fig. 7, *a*, *b*, *c*); but the analogy of *Apteryx* (*anteà*, p. 326) led me to test the relation of the appearance to reality.

Succeeding in working out the cementing matrix in one instance, and exposing the inner surfaces of the two interlocked rings, I found, as I had anticipated, that the outward appearance was due in some degree to intussusception, the inner surface being broader where the outer surface was narrower, and *vice versâ*. Nevertheless a slight inequality of breadth is shown in some detached rings at the ends of the ellipse; and it may indicate that they come from a part of the windpipe situated where it was subject to most flexure in the bendings of the bird's neck.

§ 4. *Larynx of* Dinornis crassus?

The portion of a thin, hollowed, shield-shaped piece of bone (Pl. XCIII. fig. 8, *a*, *b*) I take to belong to the upper larynx, and to be part of the thyroid element. To its lower border has coalesced, as is sometimes found in existing birds, the first tracheal bone or hoop (*c*), which, as usual, is incomplete; the coalescence is limited to the two ends of this half ring; the slit of separation between it and the thyroid is 9 lines in extent, giving the breadth of this slender bone as half a line; it projects anteriorly like a folded lower border in advance of the actual lower border of the thyroid, which is the more prominent part on the inner or concave side of the thyroid. One might expect the rings near to or following this to have similar slender proportions, like those worked out of the matrix beneath the skull of *Dinornis crassus*; lower down the windpipe they gained in depth.

From another mass of matrix, exhibiting a portion of a broad tracheal ring, I worked out the part of the expanded terminal one, to which, in the entire or recent state of the parts, the bronchi are attached; it answers to that supporting the cross bar shown at *t*, fig. 103, 'Anatomy of Vertebrates,' vol. ii. p. 222, in the Raven, and ranks among the parts of the lower larynx. The specimen shows the contiguous portions of two cavities, meeting at a sharp straight ridge (fig. 9, *a*), 8 lines in extent, which was produced into the cavity of the trachea, dividing the tube from before backward; the concavities on

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[1] "They are alternately narrower at certain parts of their circumference and broader at others; and in these cases the rings are closely approximated, as it were interlocked. This structure is most common in the Grallatores, where the rings are broadest alternately on the right and left sides."—*Anat. of Vertebrates*, ii. p. 219.

each side are the beginnings of the divisions or the continuations of the trachea into the bronchi. The margins of the expanded bone, continued from one (probably fore) end of the dividing ridge, are rather thickened. Cemented by the matrix to this part of the lower larynx was one, probably the first, of the bronchial bones (fig. 9, *b c*); it is incomplete, varying in breadth from 2 lines to nearly 3 lines, and may have surrounded two-thirds or three-fourths of the bronchus. At the broader part the outer surface is rather convex from the upper to the under margin; at the narrower part this surface is concave. It seems to answer to that part of the lower larynx figured at *a*, fig. 103, *tom. cit.* p. 222.

§ 5. *Trachea of* Dinornis rheïdes ?

To a smaller species of *Dinornis*, probably *D. rheïdes*, I refer a series of rings, about 80 in number, similar in shape and general character to those of *Dinornis crassus*, but of a smaller size (Pl. XCIII. figs. 10–12).

The range of variety of size is here rather less. The largest ring yields, in long diameter, 9 lines, in short diameter 7 lines (fig. 11); the smallest gives 7 lines and 6 lines in the same diameters (fig. 10). The average, or common size, is 8 lines in long and $6\frac{2}{3}$ in short diameter (fig. 12); the ellipse is more perfect and constant in the rings of this species, and the concavity from edge to edge of the outer surface of the hoop is more constant and more marked than in *Din. crassus.* The depth of the hoop is greater, relatively, and is maintained through a greater extent of the windpipe, as it seems; this dimension is 2 lines, with slight change at parts of the circumference.

Of this species there is one specimen of a sequence of four rings in the same portion of matrix (fig 12), another piece with three rings, and three or four with two rings. The extreme of depth of hoop is reached at part of the circumference of the ring (fig. 11, *a*, *b*).

§ 6. *Trachea of* Dinornis elephantopus ?

The tracheal rings of the third series are remarkable for their great breadth and thickness. There are about 80 of these, of a full elliptical, subcircular, or circular shape, with an average diameter or long diameter of 9 lines. The specimen figured (Pl. XCIII. fig. 13, *a*, *b*) shows the average size or common character of these strong, broad, well-ossified tracheal rings. The exterior surface is rugose, the inner one smoother, both surfaces straight or even from one margin to the other; the margins are flat, as if made by a clean cut, and show irregular perforations, probably vascular, of the osseous tissue. The thickness of the hoop is rarely uniform, the difference being, in several rings, as great as in that figured in 15, *a*; there is also, occasionally, a variety in the breadth at different parts of the circumference of the hoop, though rarely to the extent shown in fig. 16, which, from its small size, may possibly be a bronchial hoop.

§ 7. *Trachea of* Dinornis ingens?

About 70 tracheal rings show an average of size and shape as in that of fig. 17,*a*,*b*,*c*; the extremes in regard to depth of hoop, in this series, are given in figs. 19 & 20. The bone, in all, is of unequal thickness, longitudinally rugose, but unequally so, on the outer surface, smooth within (fig. 18, longitudinal section). On the rougher part of the ring the bony substance stands out in the form of granules or ridges, the latter running in the direction from one margin to the other (figs. 19 & 20, *b*, *b*). These margins (figs. 17 & 19, *a*) are flat or "truncate," as in the smaller rings (figs. 13–15, *a*) of the present robust type; but here the margin is more uneven, with risings and depressions, somewhat irregular, but on the whole at right angles to the outer and inner surfaces.

In this series were specimens of two partially confluent rings, or of a broad hoop twisted upon itself spirally, so as to simulate two hoops. Of these specimens one is represented at fig. 21, *a*, *b*, a second at fig. 22; fig. 23 shows more plainly a partial confluence of the two bony rings. Seven rings of the average size of those provisionally attributed to *Dinornis ingens* (Pl. XCII. fig. 6) occupy an extent of the trachea equalling that which includes thirty-nine in *Casuarius galeatus* (ib. fig. 5).

§ 8. *Trachea of* Dinornis robustus?

I have finally to notice the largest specimens in the present collection, which exemplify the most extraordinary degrees of thickness and strength of bone which have been hitherto observed in the windpipes of Birds.

I think it not improbable that an osseous hoop like that represented in Pl. XCIII. fig. 24, *a*, *b*, might, if received as a solitary fossil, have passed rather for a section of the shaft of a pneumatic limb-bone, being as large, for example, as such section of the femur of a Cassowary, but thicker in the walls. He must have been a bold, as well as acute, palæontologist who would have pronounced it one of the rings of a bird's windpipe. I have now, however, received upwards of thirty specimens, averaging the dimensions of that of fig. 24. They are, most of them, rather more elliptical, less circular, than the smaller hoops of a like type (figs. 17–23). The long diameter averages, as in fig. 24, 1 inch 2 lines, the short diameter 1 inch, outside measure; the area, which is a more regular ellipse, gives 10½ lines and 9 lines in the two diameters. The breadth, or we may now say the length, of the hoop's wall, *i. e.* from the upper to the lower margin, averages 9 lines and 7½ lines, not being uniform all round; the difference of thickness is greater, viz. from 2½ lines to ½ a line (fig. 24, *a*, and fig. 32).

The contrast between the outer and the inner surfaces of the tracheal hoops in *Dinornis* becomes greater as these increase in size. In the present series, which may belong to *Dinornis robustus*, the irregular longitudinal striation prevails over the external surface of the bone; but there are other characters.

At one or two parts of the circumference a part of that surface (figs. 24, 26, 28, ×) projects beyond the rest, usually from the middle third part between the upper and lower borders; these elevations, or the elevation, if it be single or continuous, are limited to one side of the hoop, and to that which is most convex or least flattened. The degree of elevation is slight, from a fourth to a sixth of a line; the surface is smoother than the parts above and below. These elevations I take to indicate the interval between the surfaces of insertion or attachment of fibrous substance connecting one ring to the next in a more special manner than the general external investment of the hoops, the fibrous character of which may be indicated by the general longitudinal striation of the external surface. The smoother part of that surface is usually opposite the side showing the broad and low elevation. Besides the foregoing accentuations of the outer surface, many of the hoops show coarser granulate outgrowths at the rougher part of the bone.

In almost all of the present series of rings the longitudinal lay of the outer surface, from one margin to the other, if it is not straight, tends rather to convexity. The longitudinal lay of the smooth inner surface is more uniformly straight; but there is a feeble transverse rise, or linear impression, indicative of a tract on the inside corresponding to the elevation on the outside of the hoop.

In the present, as in the preceding series, there are differences of length, breadth, and thickness of the wall of the hoops; the two extremes of the first dimension are shown in the subjects of figures 25 & 26. There are also six instances of confluence of two hoops; in no received example is co-ossification of the tracheal rings carried further. Fig. 27 shows two of the shorter variety of hoops coalesced at the flatter and rougher half of their circumference (*b*), the activity there of the ossifying process being further exemplified by an unusual degree of granulate outgrowths simulating an exostosis: the more convex part of each hoop (*a*), where the line of separation remains open, is comparatively smooth. The two rings (Pl. XCIII. fig. 28, *a b*) have completely coalesced—the original separation, showing them to have been of the long variety, being feebly, though sufficiently, indicated. These also show a markedly flatter side of the ring where the bone is thickest and most irregular. It is to this increase of osseous substance that the flattening is due, the smooth inner surface of the same part following the course of the elliptical section of the air-passage. Lengthwise these anchylosed hoops show a greater longitudinal convexity of the smoother side, and a more feebly longitudinal concavity of the opposite side; but this indication of a bend of the windpipe is better marked in the next anchylosed pair of hoops (fig. 29), although they are shorter, showing the common size. In these, at the convex part of the bend, the coalescence is incomplete.

Figure 30 shows two coalesced rings, where the hoops thin off behind and the bony texture is exposed by abrasion. This texture is coarse, and, with the character of the truncate margins and of the rough parts of the outer surface, gives the hoops or cylinders a cork-like appearance.

Sections of these tracheal rings (fig. 31, *D. ingens*?, and fig. 32, *D. robustus*?) show the varying thickness of the bone at opposite parts of the cylinder, the smoothness of the inner surface, and the denser character of the osseous texture at the thicker part of the wall of some of the rings.

§ 9. *Trachea of* Aptornis defossor.

With a sternum, pelvis, and some other parts of the skeleton of *Aptornis defossor*, more entire than those described in my Memoir No. XV., and subsequently received, were a few rings of the trachea, of elliptical shape, averaging 7 lines and 5 lines in the two diameters (Pl. XCII. fig. 7), with a depth of the hoop of 1½ line. These rings show a pair of narrow notches, one at the upper, the other at the lower margin, at opposite sides of the hoop, at its shorter diameter (ib. *a*, *c*). In the instance of two of these rings in connexion, the partial and reciprocal overlapping or intussusception was defined by or took place at these notches (ib. *b*).

MEMOIR

ON THE

APTERYX AUSTRALIS.

SUPPLEMENT TO MUSCULAR SYSTEM.

§ 1. *Muscles of the Mandible and Hyoid of the* Apteryx.

THE illustrations of the myology of the *Apteryx* in my second Memoir on this bird[1] were mainly devoted to the muscles of the trunk and limbs; I now, therefore, supply figures (Pl. XCII. figs. 1–4) in which are shown some muscles of the eye, the jaw, and the tongue, either undescribed or briefly referred to in that Monograph.

The origin of the "constrictor colli" (Pl. X. *a*), by a "broad fasciculus from the outer part of the superoccipital ridge" (ib. p. 42), is shown at *a*, fig. 3. It is reflected back, to expose the homologue of the "biventer mandibulæ" (γ), a powerful muscle which arises tendinous from the outer and anterior marginal ridge of the paroccipital, swells into a fleshy belly, which again contracts to its insertion into the slightly deflected angle of the mandible.

The external or posterior "temporalis" (α) and the internal or anterior "temporalis" (β) have their origins exposed in fig. 3, Pl. XCII., and their entire course shown in fig. 4, ib. The external muscle derives its origin from the lower and lateral part of the parietal as far back as the mastoid (8)[2]. The origin of the internal portion continues the curved line forward from the parietal to the postfrontal. The fibres of the external portion pass obliquely forward, external to those of the anterior portion, to be inserted into the fore part of the outer surface of the marginal coronoid elevation of the mandible. The fibres of the anterior portion (β, fig. 4) descend less obliquely, and more directly embrace, by their insertion, the long and low, sharp, straight coronoid ridge in *Apteryx*; the hinder fibres descend vertically, and are continued backward to the hind end of the ridge. Both portions, like the more collective mass of carneous fibres of the temporal in Man and Mammals, pass behind the horizontally extended arch of

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[1] (Muscular System) p. 41, Pls. X.–XV.

[2] As in Man, the temporal muscle is described as extending its origin "from the curved line on the frontal and parietal bone above to the mastoid portion of the temporal behind."—GRAY's '*Anatomy, Descriptive,*' &c., 8vo, 1858, p. 200. The "temporalis externus" in birds answers to the posterior portion of the mammalian "temporal muscle."

bone formed by the zygomatic portions of the squamosal (27) and the malar (26). This relation I deem worthy the attention of the unbiased student of the homologies of the bones marked respectively 8, 27, 26, in fig. 4, and in the illustrations of the skulls of *Dinornis* &c. in preceding Memoirs. If the hind end of 27, where it joins the tympanic (28) as in Man and Mammals, were to expand into overlying junction with the mastoid (8) and parietal (7), it would also contribute to the surface of origin of the temporalis muscle. By adopting the homology propounded by Cuvier and Hallmann of the bone (8) as with the "temporal" or "squamosal" of Mammals, the anatomist falls into the necessity of introducing a new bone into the cranium of the bird, and of completing its zygomatic arch by a "quadrato-jugal."

From the posterior third of the lower border and inner surface of the zygomatic arch rises the masseter muscle (*η*, fig. 3, Pl. XCII.), answering, in regard to its origin and the forward inclination of the fibres as they descend, to the deep portion of the mammalian and human masseter: the insertion is into the lower half of the outer side of a short tract of the mandible behind the insertion of the "temporal" muscles.

The "orbicularis palpebrarum" (fig. 3, *c*) sends some of its hinder superficial fibres over the part of the zygoma giving origin to the masseter, which are lost in the superficial fascia of that muscle. I noted the great strength of the "orbicularis palpebrarum" in my first Memoir on the *Apteryx australis* (p. 38). In fig. 3 a bristle is represented passing through the "punctum lacrymale" and along the lacrymal duct into the nasal chamber, where it terminates between the second and third turbinals. In fig. 4 are shown three of the ligaments of the lower jaw. The "occipito-mandibular ligament" (*m*) is attached above to the paroccipital ridge (4), crosses the back part of the "membrana tympani," but behind the "meatus auditorius," to be fixed into the external and posterior articular ridge of the mandible. The "tympano-mandibular" ligament (*n*) is attached above to the back part of the articular cup for the "squamosal," and below to the anterior and external articular ridge. The "zygo-mandibular ligament" (*o*) is attached to the slightly expanded hind end of the zygomatic element or representative of the squamosal, and below to the outer side of the mandible between the temporal and masseteric insertions; some fibres of the masseter are derived from both these ligaments, respecting which I may quote the remark from my first Memoir on *Apteryx*, "that they are an essential part of the mechanism of a beak which is destined to be forcibly thrust into the ground, and used in a variety of ways to overcome considerable resistance" (*tom. cit.* p. 264).

The short struthious tongue of the *Apteryx*, described at p. 8 of the first Memoir, is shown at *l* in fig. 1, Pl. XCI. The "mylo-hyoideus" muscle is reflected from its origin (at *h*, fig. 3, Pl. XCII.) to expose the "genio-hyoid" muscle, which arises from the inner and under part of the mandibular ramus, nearer the angle than the symphysis, and sends backward its fibres to embrace the "thyrohyal" element (*k*) of the tongue-skeleton to near the free hind extremity; the pair tend to protrude or draw forward the tongue. In fig. 3 are also shown the circular fibres of the pharynx and beginning of the œsophagus (*f*), also the commencement of the trachea (*g*).

The portion of the cutaneous system of muscles for which I retained the old term "platysma myoides" (p. 43, Pl. X. *e*), has its rather strong, but flattened, tendinous origin from the external ridge of the hinder surface of the mandible, shown in fig. 3, and the expansion of its thin sheet of carneous fibres (at *e*) inserted into the skin covering the throat. This pair of muscles must tend, acting together, to support and compress the upper larynx and pharynx.

In both figures (3 & 4) are shown the inserted portions of the "longus colli posticus" (*o***), of the "complexus" (*y*), of the "trachelo-mastoideus" (*z*), and of the "rectus capitis lateralis" (*d*). Full descriptions and figures of these muscles are given in Memoir II., on the *Apteryx*, pp. 46–50, Pls. X–XIV.

DESCRIPTION OF THE PLATES.

(All the figures are of the natural size.)

PLATE XCI.

Apteryx australis.

Fig. 1. Side view of the brain, *in situ*, with dissection of nerves and of organ of smell.
Fig. 2. Upper view of the brain, *in situ*, with olfactory and trigeminal nerves.
Fig. 3. Base of brain, with cerebral arteries and origin of nerves.
Fig. 4. Base of brain, the cerebellum exposed by removal of the macromyelon.
Fig. 5. Side view of the brain, dissected to show the corpus striatum, *n*.
Fig. 6. Section of cerebellum, *c*, and of part of cerebrum.
Fig. 7. Cavity of the lateral ventricle of the brain.
Fig. 8. Section of rhinencephala, showing their ventricle, *q*.
Fig. 9. Section of the fore part of prosencephala.
Fig. 10. Section, showing the anterior commissure, *o*.

Dinornis giganteus.

Fig. 11. Side view of brain.
Fig. 12. Upper view of brain.
Fig. 13. Base view of brain.

The brain is represented by a cast of the cranial cavity.

PLATE XCII.

Fig. 1. Dissection of the brain, of the fifth, seventh, and eighth nerves, and of the muscles of the eyeball of *Apteryx australis.*

Fig. 2. Further dissection of the same parts, with the course of the optic nerve.
Fig. 3. Dissection of the muscles of the mandible and tongue of *Apteryx australis*.
Fig. 4. Ligaments and muscles of the mandible of the same.
Fig. 5. Portion of the trachea of the Cassowary (*Casuarius galeatus*).
Fig. 6. Portion of the trachea, including seven tracheal rings of *Dinornis* (*ingens*?).
Fig. 7. Tracheal rings of *Aptornis defossor*.
Fig. 8. Stones from the gizzard of *Dinornis elephantopus*[1].

PLATE XCIII.

Fig. 1. Tracheal rings of *D. crassus*: *a*, *b*, *c*, varieties, full view; *d*, oblique view, from near the head.
Fig. 2. Side views of (*a*) large ring and (*b*) small ring, showing inequality of depth of hoop.
Fig. 3. Full view of subcircular rings, *D. crassus*.
Fig. 4. Group of seven tracheal rings, *D. crassus*.
Fig. 5. Group of five tracheal rings, *D. crassus*.
Fig. 6. Group of four tracheal rings, *D. crassus*: *a*, front view; *b*, side view.
Fig. 7. Groups of two rings, showing appearance of alternate breadth and narrowness of parts of hoop: *a*, front view; *b*, back view; *c*, side view.
Fig. 8. Part of ossified "thyroid cartilage" of upper larynx of *Dinornis crassus*: *a*, outer surface; *b*, inner surface.
Fig. 9. *D. crassus*: *a*, part of the chief bone of the lower larynx; *b*, *c*, upper bronchial ring.
Fig. 10. Tracheal rings of *Dinornis rheïdes*: *a*, *b*, *c*, varieties, in full view; *d*, oblique view.
Fig. 11. Broad variety of tracheal rings, edge views: *a*, broader side; *b*, narrower side.
Fig. 12. Group of four tracheal rings, *D. rheïdes*.
Fig. 13. Tracheal ring of *Dinornis elephantopus* (?): *a*, full view; *b*, side view.
Fig. 14. Broader variety of tracheal ring of the same species.
Fig. 15. Narrow variety of tracheal rings of the same species: *a*, full view; *b*, side view.

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[1] These pebbles constitute about one-third of the heap of such found within the space encompassed by the ribs and sternum of the skeleton of *Dinornis elephantopus* exhumed from the bog at Glenmark, Canterbury Settlement, Middle Island, New Zealand, of which the sternum is described, p. 254, Pl. LXXII. No such pebbles occur, naturally, within a distance of thirty miles of that locality.

I submitted them to the examination of the experienced officers in the Department of Mineralogy, British Museum, and append the following note from Thomas Davies, Esq., Assistant in that Department:—

"The pebbles supposed to have been contained in the gizzard of the *Dinornis* consist exclusively of varieties of quartz more or less crystalline or compact—sometimes amethystine, and also approaching in texture and colour the black cherty variety called Lydian stone or Basanite; the two latter, however, are apparently of more exceptional occurrence. All are much worn, preserving little trace of their original fragmentary outline."

I have received pebbles smoothly rounded by the triturating work of the gizzard of the *Dinornis*, from other localities (Rangiora), under similar relations to the skeleton; their significance in association with bones of the trunk has probably been overlooked.

Fig. 16. Side view of bronchial ring? of the same species.
Fig. 17. Tracheal rings of *Dinornis ingens* (?): *a*, full view; *b*, front view; *c*, back view.
Fig. 18. Inside view of a tracheal ring of *Dinornis elephantopus* (?).
Fig. 19. Broad variety of tracheal rings of *Dinornis ingens* (?).
Fig. 20. Narrow variety of tracheal rings of *Dinornis ingens* (?).
Fig. 21. Two partially united tracheal rings of *Dinornis ingens* (?).
Fig. 22. Two partially united tracheal rings of *Dinornis ingens* (?), simulating a spiral.
Fig. 23. Two partially united tracheal rings of *Dinornis ingens* (?), simulating a spiral.
Fig. 24. Tracheal rings of *Dinornis robustus* (?): *a*, full view; *b*, back view; *c*, front view.
Fig. 25. Narrow variety of tracheal rings of *Dinornis robustus* (?).
Fig. 26. Broad variety of tracheal rings of *Dinornis robustus* (?).
Fig. 27. Two partially confluent rings of *Dinornis robustus* (?): *a*, smooth united part; ×, rough anchylosed part.
Fig. 28. Two confluent rings of the broad variety of *Dinornis robustus* (?).
Fig. 29. Two partially confluent rings of *Dinornis robustus* (?).
Fig. 30. Inside view of two confluent rings of *Dinornis robustus* (?).
Fig. 31. Longitudinal section, showing inner surface of two confluent rings of *Dinornis ingens* (?).
Fig. 32. Longitudinal section of a tracheal ring of *Dinornis robustus* (?).

RESTORATION

OF

APTORNIS DEFOSSOR.

THE nearly complete sternum and pelvis of *Aptornis defossor* about to be described, in addition to the evidences of that bird given in a preceding Section[1], afford grounds for attempting a restoration of the skeleton of this extinct species (Pl. XCIV.).

The sternum, figured of the natural size in Pl. LXXXIX. figs. 2, 3, 4, presents a close family, if not generic, resemblance to that described and figured in Pl. XLVIII. figs. 5–8, in my first Memoir on the genus (p. 185), with regard to which, recognizing in it unequivocal characters of a Ralline type, closely resembling that of the wingless Wekas (*Ocydromus*), but of much larger size, I had doubts whether to refer the bone to the *Notornis* (subsequently recognized as a still existent species), or to the still larger *Aptornis otidiformis*, which is most probably extinct.

In *Tribonyx ventralis* the length of the sternum is 2 inches, that of the femur is 2 inches 3 lines. In *Ocydromus australis* the length of the sternum is 2 inches, that of the femur is 2 inches 8 lines. In *Notornis*[2] the length of the femur is 4 inches 10 lines; in *Aptornis otidiformis*[3] the length of the femur is 6 inches 3 lines. The length of the sternum described p. 198, and figured in Pl. XLVIII. figs. 5–8, is 4 inches 6 lines, measured from the foremost part of the coracoid groove to the tapering hind end, which is not entire. I do not suppose, however, that the missing portion would exceed 6 lines in length; and it might probably be less. An addition of 4 lines would make the sternum in question equal in length to the femur of *Notornis*, and 1½ inch shorter than the femur of *Aptornis otidiformis*. I select the femoral bone of the hind leg for this test comparison, because it varies less in proportion to the trunk or general size of the bird than the more distal elements of the limb. A comparison of the metatarsus of *Notornis* with that of *Aptornis* instructively illustrates this principle[4].

The contiguity of the bones, when discovered, of *Aptornis defossor* here described enables me to refer with confidence the sternum to that species, most probably to the

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[1] P. 290.

[2] Pl. LI. fig. 3.

[3] Pl. L. figs. 3 & 4.

[4] 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 200, note, p. 202.

same individual as the pelvis; and the comparison of the sternum with the femur described (p. 308) and figured Pl. LXXXVI. figs. 5, 6, 7, gives the following proportions of length:—sternum 6 inches 6 lines, femur 7 inches 6 lines. The length of the sternum is here taken from the fore border of the coracoid groove to the tapering hind end, which is all but entire.

The inferiority of size of the sternum figured in Pl. XLVIII. figs. 5–8 to the sternum of *Aptornis defossor* is greater than that of the femur of *Aptornis otidiformis* as compared with that of *Apt. defossor.* But the relative size of the smaller sternum to the femur of *Aptornis otidiformis* is more like the relative size of the sternum of *Aptornis defossor* to the femur of that species than is the relative size of the smaller sternum to the femur of *Notornis.* Seeing therefore, in the two existing Rallines here compared, that as the wings decrease and the legs increase in size the sternum becomes shorter in proportion to the femur, I am inclined to believe that the smaller sternum (Pl. XLVIII. figs. 5–8) has belonged to *Aptornis otidiformis* rather than to *Notornis.* This view derives further support from the fact that, with the decreasing relative size to the femur, there is a progressive simplification of the sternum in the recent Rallines (*Tribonyx*, *Ocydromus*), by which the still more simple type of the bone in *Aptornis defossor* is approached. The slender lateral processes, for example, in *Tribonyx ventralis* come off immediately behind the costal border, diverge and extend backward beyond the body of the bone, with slightly expanded terminations. In *Ocydromus australis* the slender lateral processes come off at some distance from the costal borders, near the hind part of the body of the sternum, are consequently much shorter, and have no terminal expansion. The keel, which is well developed in *Tribonyx ventralis*, is much reduced in *Ocydromus australis*[1]; it is almost obsolete in *Aptornis defossor.*

As the wings of *Notornis* are relatively less than those of the Weka, and the legs relatively larger, it is not likely that the sternum would bear the same proportions of length to the femur as the sternum figured in Pl. XLVIII. figs. 5–8 bears to the femur figured in Pl. LI. fig. 3. Whether, however, the sternum of the smaller species of *Aptornis* would be shorter in proportion to the femur than it is in *Aptornis defossor* may be questioned.

Demonstration on this point still waits the acquisition, so long desiderated, of the entire skeleton of *Notornis.*

This, at least, is certain, that the larger sternum, belonging to *Aptornis defossor*, repeats all the generic characters of that of which the reference oscillates between *Aptornis otidiformis* and *Notornis mantelli.*

As in it, the present larger sternum is of an elongate triangular form, the base anterior and concave, the curve of the emargination being interrupted by the pair of prominences (Pl. LXXXIX. fig. 2, *a*, *a*), from which the faint beginnings of the keel

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[1] Descriptive Catalogue of the Osteological Series, Mus. Coll. of Surgeons, 4to, 1853, p. 238. no. 1280 (*Brachypteryx*).

converge as they retrograde to the thick low ridge (ib. *s*, *s*) representing that part of the sternum in birds of flight. The body of the sternum describes a slight curve lengthwise to the tapering end, with the convexity downward or outward (ib. fig. 4); the general transverse lay of the outer surface of the sternum is slightly convex; but between the keel-ridge and the lateral margin the surface is feebly excavated. The ridge (ib. *s*, *s*) expands and subsides about an inch and a quarter from the hind end.

In the smaller sternum (of *Aptornis otidiformis*?) the initial ridges converging from the anterior tuberosities to the sternal ridge are better defined by the excavation of the surface outside them than in *Aptornis defossor*, and the ridge expands into a transversely convex prominent tract, which is continued to the broken end (as shown in fig. 5. Pl. XLVIII.); it consequently extends further back than in *Aptornis defossor*, apparently not leaving a terminal flattened tract of the outer surface of the bone, such as is shown in fig. 2. Pl. LXXXIX., near the end of the sternum. The costal border in *Aptornis defossor* forms two fifths of the lateral border of the sternum, and presents articular surfaces (ib. fig. 4, *c*, *c*) for five sternal ribs. The foremost surface is a narrow ridge, crossing obliquely the costal surface close to the articular groove for the coracoid. This surface appears to be obliterated by anchylosis of the coracoid to the sternum on the right side (ib. fig. 2, *d*); and the left side shows a fracture at the part corresponding to the smooth deep coracoid groove in the sternum of *Apt. otidiformis* (?). The coracoid union with the sternum is restricted to as small an extent, relatively, of the anterior border or base of the bone as in *Apt. otidiformis* (?).

The second, third, and fourth articular surfaces for the sternal ribs are ridges with extensive intervening smooth and imperforate cavities (Pl. LXXXIX. fig. 4, *c*, *c*). The last or hindermost articulation is a small subcircular cavity with a raised border. The costal border contracts from the third ridge backward. The non-articular side-border of the sternum contracts as it recedes to a rather sharp edge, the two sides converging to a nearly pointed end. There is no trace of the lateral fissures and slender processes characterizing the sternum of *Ocydromus* or *Tribonyx*. A very shallow tract (ib. fig. 2, *r*) for the insertion of muscle is bounded by a feeble ridge (ib. fig. 2, *t*, *r*) 8 lines behind the anterior border of the sternum, which tract is less smooth and even than the rest of the outer surface of the bone.

At the fore part of the inner or upper surface the sternum is strengthened by a transverse prominence or bar (ib. fig. 3, *b*), which expands as it subsides at each end upon the inner part of the costal tract. This bar is further from the anterior border, and consequently more internal in position, than is the corresponding ridge in the sternum of *Apt. otidiformis* (?), where it seems to form the upper or convex border of a thickened anterior margin of the sternum (Pl. XLVIII. fig. 8). A shallow excavation of the inner surface of the sternum is bounded by a curved border (Pl. LXXXIX. fig. 3), concave forward, nearly midway between the fore and hind sides of the sternum. The corresponding part of the inner surface of the sternum of *Aptornis otidiformis*, or of *Notornis*, is not so defined, but is undulated by a rising, convex lengthwise, parallel with the mid third of the costal borders.

The figures of the sternum of *Aptornis defossor* in Pl. LXXXIX., being of the natural size, preclude the necessity of further admeasurements.

There is no pneumatic perforation in any part of the sternum, which agrees, in this respect, with that provisionally referred to the smaller species of the genus.

The generic distinction between *Aptornis* and the extinct gigantic Ralline bird called *Cnemiornis* is strongly expressed by the sternum. In *Cnemiornis* the ridged representative of the keel[1] subsides much nearer the fore part of the bone; the costal border is relatively longer, and includes articular surfaces for seven sternal ribs; the body of the bone appears to retain its breadth for a greater extent as it recedes than in *Aptornis defossor*. The portions of sternum picked up with the other bones of *Cnemiornis* enable the above comparisons to be instituted, but they are not sufficient to give a satisfactory idea of the shape of the entire sternum in that genus.

The pelvis of *Aptornis defossor*, figured of the natural size in Pl. LXXXIX. fig. 1 and Pl. LXXXVIII., exhibits a slight deformity or departure from the normal symmetrical figure at its fore part, which is somewhat bent to the right—the twist, which chiefly affects the neural spine and ilia, being most conspicuous when the bone is viewed from the front and from below, as in fig. 2. Pl. LXXXVIII. It is doubtless an individual variety, and indicates the bird from which it was derived to have been aged.

The articular surface of the centrum of the first sacral vertebra (Pl. LXXXVIII. fig. 2, *s* 1) is transversely extended, measuring in that diameter 1 inch 4½ lines, the vertical diameter at the middle being 5 lines; but this extends to 7 lines on each side beyond the neural canal, which is circular, and only 3½ lines in diameter at its anterior outlet. The prezygapophyses (Pl. LXXXIX. fig. 1, *z*) are large, with their outer borders bent strongly forward; the right is the largest, partaking of the asymmetry above noticed. The articular surface, concave transversely, is vertically plane, or rather convex. The fore part of the neural spine shows a rough surface for ligamentous attachment along the lower half of its extent; this surface expands to a breadth of 4 lines, then contracts to a point, beyond which the spine presents a sharp anterior margin to near the summit, where it again expands and coalesces with the contiguous parts of the iliac bones. A deep and narrow ilio-neural fissure extends backward on each side the spinal plate.

The neurapophysis, developing the zygapophyses, is coextensive with the centrum, and expands beyond that element into a broad depressed diapophysis, confluent above with the ilium (Pl. LXXXVIII. fig. 2, *i*): this process forms at its hinder angle a roundish flat surface (Pl. LXXXIX. fig. 1, *d*) for the tubercle of the first free sacral rib. The articular surface for the head of that rib is large and flat on the left side (ib. fig. 1, *pl*), but is small on the right side, partaking of the asymmetry above noticed. The under surface of the centrum is carinate; the keel beginning 2 lines behind the

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[1] Pl. LXVI. fig. 9, *s*.

lower border of the articular surface. The keel runs to the third sacral centrum (Pl. LXXXVIII. fig. 2, *c*), where it begins to expand, as in *Aptornis otidiformis* (Pl. LXXXV. fig. 2).

The surface for the head of the second sacral rib is small, subcircular, concave, and produced. The succeeding pleurapophyses (Pl. LXXXVIII. *pl*) are represented by short thick parapophyses abutting against the lower border of the ilia, to the fifth (seventh, including the moveable ribs) pair, which abuts against the part to which the head of the pubis is anchylosed (ib. fig. 2, 64). There are consequently six pairs of interapophysial vacuities (ib. *id. id.*) at the antacetabular part of the pelvis. The mid tract beneath the centrums gains a breadth of ½ inch at the seventh vertebra, beyond which it contracts to a point at the fourteenth.

The sacral centrums maintain their breadth to the seventh vertebra, contract at the eighth, but between the acetabula maintain a breadth of 9½ lines to the eleventh vertebra, beyond which they contract to the fifteenth, and again expand at the seventeenth (17) to a breadth of 5 lines, which they retain, below, to the twentieth vertebra. The last three of them (*n*, *n*, fig. 1, Pl. LXXXVIII.) are caudals, which, like the dorsal and lumbar vertebræ at the other end of the pelvis, have become "sacral" by anchylosis.

In the three interacetabular sacrals (ib. fig. 2, *c'*) the parapophyses are, as usual, suppressed; there is, however, a filamentary representative of one of those processes from the left side of the eighth sacral centrum. The parapophyses reappear at the eleventh sacral (ib. *p*, 11), where they are long and slender, and combine at their distal ends with those of the twelfth, thirteenth, and fourteenth sacrals to form a plate or screen of bone (ib. *u*), dividing the interacetabular depression (*t*) from the postacetabular or postrenal one (*u*). The parapophyses of the fourteenth (ib. fig. 2, 14), fifteenth, and sixteenth sacrals increase in breadth, and bend or arch outward and upward to form the lower and lateral walls of a passage or cavity on each side of the crest formed by the continuous or confluent neural spines of the corresponding vertebræ. These "ectoneural" canals are partially divided above by diapophysial or upper transverse plates, arching from the neuro-spinal crest to the inner surface of the plate or ectoneural side-wall.

The civil engineer might study, perhaps with advantage, the disposition of the several buttresses, beams, and arched plates of bone which support the iliac roof of the pelvis, and strengthen the acetabular walls receiving the pressure of the thigh-bones, in this large and powerful Wood-hen.

The unusual depth and width of the excavation at the postacetabular part of the pelvis, the hind part of which excavation is partitioned off from the general pelvic cavity by a deck, as it were, of bone (ib. fig. 2, *v*), extending from the ischium and confluent part of the ilium inward or mesiad to join the hinder sacral vertebra (ib. *c*, 17), led me to examine the pelvic viscera in a recent Ralline (*Rallus aquaticus*) with a view to determine the nature of the contents of the homologous ilio-ischial postacetabular excavation in that bird.

On a first view of the pelvic viscera, as exposed by removal of the intestines, the kidneys appear to be chiefly developed anteriorly, the broad lobes there extending beyond the ilia with a convex border covering, or lying in contact with, part of the iliac origins of the abdominal muscles. The length of these anterior renal lobes equals that of the antacetabular part of the pelvis in *Aptornis defossor*; the second lobes, commencing mesiad of the anterior ones, acquire their greatest breadth where those terminate, but are here much narrower than the anterior lobes. Thence the middle lobes contract transversely to a point, underlapping the narrow posterior lobes, which seem to end where the ischia join the sacrum, and to blend with each other; but it is merely close contact, they are distinct[1].

On each side of the hind part of the kidney is the belly of the "obturator internus" or postrenal muscle, which underlies the inferior opening of the ilio-ischial excavation.

This muscle being removed, the renal substance is found to pass "neurad," expanding to a breadth equal or superior to that of the anterior lobes, with much greater depth or thickness in the neuro-hæmal or dorso-ventral direction; and this the true posterior renal lobe is shown, by a vertical longitudinal section of the side of the pelvis, to fill the whole of the great posterior ilio-ischial cavity, extending from the partition bounding posteriorly the interacetabular cavity backward to above and beyond the ischio-iliac deck-like plates (Pl. LXXXVIII. fig. 2, *v*).

The vertebræ numbered 19, 20 in Pl. LXXXVIII. fig. 2 are homologous with the first two free caudals in *Rallus aquaticus* and *Ocydromus australis*. The parapophyses of the seventeenth and eighteenth sacrals expand, coalesce (a small foramen intervening), and unite with the "deck" (*v*), of which they form the inner beginning. The parapophyses of the first caudal in *Rallus* abut against the ilia, leaving a small intervening foramen between them and the antecedent parapophyses. The homologous foramina are seen on each side of the vertebra 19 in fig. 2. Pl. LXXXVIII.

From these foramina each ilium extends backward 2 inches. The free terminal ends bend slightly toward each other, leaving an interval of 9 lines; they are obtusely rounded. Externally each is strengthened by a vertical ridge (Pl. LXXXIX. fig. 1, *l*).

The entire length of the ilium, following the upper curve, of *Aptornis defossor* is 12½ inches, equalling that of the same part of the pelvis in *Casuarius bennettii*. This length is pretty equally divided by the mesial beginnings of the "gluteal ridges" (Pl. LXXXVIII. fig. 1, *g*).

The fore half of the ilium repeats very closely the characters of that part in *Aptornis otidiformis*[2]. The upper curve is greater in *Aptornis defossor*; the gluteal ridge is stronger, runs more outward, and ends by an obtuse process (Pl. LXXXIX. fig. 1, *h*). The rest of the pelvic disk (Pl. LXXXVIII. fig. 1, *r*, *r*) is bounded externally by the

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[1] In my 'Anatomy of Vertebrates,' the statement (vol. ii. p. 227) that "the kidneys are more or less blended together at their lower extremities in the Coots (*Fulica*)" will probably bear the above explanation.

[2] Pl. LXXXV. fig. 1, Pl. LXXXVI. fig. 1.

strongly produced ridge overhanging the vertical postacetabular plate (Pl. LXXXIX. fig. 1, 62, *l*) of the ilium, which coalesces with the similarly vertical expanding plate of the ischium (ib. 63). The foramen (ib. *m*) between the ilium and beginning of the ischium is a full ellipse or oval. The ischium developes downward a ridge, behind the obturator notch (*q*); but this does not meet the ridge reciprocally directed upward from the pubis (ib. 64): there are impressions of the attachment of a strong fibrous sheet which closed the obturator groove behind; and this sheet becomes a thin plate of bone in old individuals of some existing Rallines (*Tribonyx ventralis*, *Ocydromus australis*).

The proportions and form of so much of the pubis (64) as is preserved adhere to the ralline type of that bone; but the tubercle, prominent below the fore part of the bone in most existing Rallines, is not developed in *Aptornis*.

I have restored, in outline (Pl. XCIV.), the parts of the ischium and pubis broken away from the otherwise complete and truly singular and interesting form of pelvis in *Aptornis defossor*. It may aid in future comparisons of this most complex of bones to subjoin a list of the parts of the pelvis, conveniently indicated by names, with the symbols used to indicate them in Pls. LXXXVIII. and LXXXIX.

The specimens of *Aptornis defossor* above described are from a cavernous fissure at Timaru, Canterbury Settlement, South Island of New Zealand. I am indebted to Dr. D. S. Price, of the Crystal Palace, Sydenham, for the much valued opportunity of describing, comparing, and figuring them.

Parts of the Pelvis of Aptornis defossor, *Ow.*

a. Acetabulum (the letter marks, in Pl. LXXXIX. fig. 1, the inner aperture).
b. Postacetabular facet.
c. Centrum (marking, in Pl. LXXXVIII. fig. 2, the ridged underparts of the first and second sacral vertebræ).
c'. Centrum (marking the unridged underparts of succeeding centrums).
d. Diapophysis (marking, in Pl. LXXXIX. fig. 1, the diapophysial articular surface).
e. Subacetabular fossa.
f, *f*. Antacetabular part of ilium (Pl. LXXXVIII. fig. 1).
g. Gluteal ridge. *h*. Gluteal process (Pl. LXXXIX. fig. 1).
i. Ilium (marking, in Pl. LXXXVIII. fig. 2, the part anchylosed with and overhanging the foremost diapophysis).
id. Interdiapophysial vacuities (marking the six anterior ones).
l. Postiliac tuberosity. *m*. Ischiadic foramen.
n. Neurapophysis; *n'* in Pl. LXXXVIII. fig. 1, is the fore part, *n** the hind part, of the neurapophysial crest. *o*. Ilio-neural orifices.
p. Parapophyses, } both combine to separate, below, the interdiapophysial vacuities:
pl. Pleurapophyses, } in Pl. LXXXIX. fig. 1, *pl* marks the articular surface for the head of the first sacral rib.

q. Obturator notch. *r*. Pelvic disk.
s. Sacral vertebræ (*s* 1, in Pl. LXXXVIII. fig. 2, marking the anterior articular surface of the first centrum).
t. Interacetabular cavity. *u*. Postrenal cavity.
v. Ilio-ischial plate or deck-like production.
z. Prezygapophysis (marking, in Pl. LXXXIX. fig. 1, that of the first sacral vertebra).
1-20 indicate the sacral vertebræ from before backward.
62. Ilium. 63. Ischium. 64. Pubis.

In the restoration of the skeleton (in which I have taken the vertebral formula of *Ocydromus*) the *Aptornis defossor*, with the neck bent and head supported as in the ordinary standing position of the bird, would be about 3 feet in a straight line from the top of the head to the soles of the feet; the length, in a straight line, from the end of the beak to that of the tail would be about 2 feet 10 inches. The chief departure from the ordinary form of the Coots is seen in the shorter and more robust proportions of the tibiæ and metatarsal segments of the legs, in which feature *Notornis*, amongst recent Rallines, offers the nearest approach to *Aptornis*.

DESCRIPTION OF THE PLATES.

PLATE LXXXVIII.

Fig. 1. Upper view of pelvis of *Aptornis defossor*, nat. size.
Fig. 2. Under view of pelvis of ditto, nat. size.

PLATE LXXXIX.

Fig. 1. Side view of pelvis of *Aptornis defossor*, nat. size.
Fig. 2. Front or under view of sternum of ditto, nat. size.
Fig. 3. Back or upper view of sternum of ditto, nat. size.
Fig. 4. Side view of sternum of ditto, nat. size.

PLATE XCIV.

Fig. 1. Restoration of skeleton of *Aptornis defossor*. $\frac{1}{4}$th nat. size.
Fig. 2. Skeleton of *Ocydromus australis*. $\frac{1}{4}$th nat. size.

MEMOIR

ON THE

DINORNIS GRAVIS.

THE bones described and figured in the present Memoir were discovered in the bed of the Kakamai river, South Island, New Zealand, by William Fenwick, Esq. I am indebted to the kindness of the Baroness Burdett Coutts for the loan of the specimens.

The seventeen species of terrestrial birds, incapable of flight, defined in previous Memoirs of this work were, for the most part, originally characterized by bones of the hind limbs. They have, however, received subsequent confirmation, either by the discovery of other parts of the skeleton, or by the repetition of the characters in additional specimens of femur, tibia, and metatarsus, or by both classes of evidence.

Of *Dinornis casuarinus*, for example, in the year 1846, I had had under inspection ten femora, eleven tibiæ, and six metatarsi. At a later period I was able to add the cranial characters to seven of the species of *Dinornis* and to two of the species of *Aptornis*, originally indicated by leg-bones[1], and at the same time to propose a distinct species of *Dinornis*, as represented by the skull[2], of which species the characters of the leg-bones are now given. Dr. Hector has vindicated the generic distinction of *Cnemiornis*, and shown it to be a flightless water-fowl.

I have much confidence, therefore, that the remains of the singular wingless birds of New Zealand described and figured in this work as the types of such extinct species will be matched and recognized in the way and degree in which many of them have been confirmed by the able naturalist Dr. Haast, F.R.S., Government Geologist of the Province of Canterbury, in the instructive paper quoted in a subsequent part of the present Memoir.

The term *gravis*, applied to the species which is its subject, referred to the weight of the bird, as indicated by the proportions of a bone of the hind limbs; and its appropriateness will be, perhaps, admitted, on due consideration of the characters of the pelvis, femora, tibiæ, and metatarsi about to be described.

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[1] The tibia, *e.g.* (p. 85, Pl. XXVI. fig. 5), of *Dinornis* (afterwards *Aptornis*) *otidiformis*.

[2] *Ante*, p. 280, Pl. LXXXV.

I begin with the metatarsus (Pl. XLII. *a*), as this bone usually yields the best characteristics of the kind of Moa to which it belonged.

In length it comes nearest to the metatarsus of *Dinornis casuarinus*[1], in breadth to that of *Dinornis crassus*[2]; it is, however, shorter by half an inch than the former, and broader by five lines than the latter; and as *Dinornis crassus* was differentiated from *Din. casuarinus* by the greater relative breadth of the metatarsus, this differential character applies still more strongly to the present species, inasmuch as the entire bone is shorter than that of *Dinornis casuarinus*, instead of being longer as is the metatarsus of *Dinornis crassus*.

The length of the metatarsus in *Dinornis gravis* is 7 inches 9 lines, the least breadth of the shaft is 2 inches 1 line, the breadth of the proximal end is 3 inches 2 lines or 3 inches 3 lines, that of the distal end is 4 inches 2 lines, the thickness or antero-posterior diameter of the middle of the shaft is 1 inch, its circumference is 5 inches.

A comparison of these dimensions with those of the two species of *Dinornis* to which the present comes nearest, in the Table of Admeasurements, p. 356, will exemplify the chief metatarsal characteristics of *Dinornis gravis*.

In general configuration, as in robustness of proportion, though exceeding in the latter respect, the present metatarsus most resembles that of *Dinornis crassus*. I note the following differences, which are repeated in specimens of the metatarsus from two individuals of *Din. gravis* from remote localities in the South Island of New Zealand. The intercondylar rising (Pl. XLII. *a*, figs. 1, 3, *c*) is but slightly developed anteriorly in any *Dinornis*, but it has more claims to be considered a "process" in *Din. gravis* than in *Din. crassus*; the entometatarsal tuberosity (ib. figs. 1 & 3, *e*) is more prominent, and is longer.

In the antinterosseal depression (ib. fig. 1, *i*) the upper common anterior orifice (ib. *n*) of the interosseal canals is less speedily divided into the entinterosseal (ib. fig. 2, *l*) and ectinterosseal (ib. *m*) canals than in *Dinornis crassus*; the rough depression below for the *tibialis anticus* (ib. fig. 1, *o*) is deeper and better-defined for its size in *Dinornis gravis*.

The calcaneal groove (ib. figs. 2, 3, *u*) is narrower and deeper in *Din. gravis*; and the entocalcaneal process (ib. ib. *r*) is rather less prominent. The outer depression on the ectocalcaneal process (ib. *s*) is better marked, and in one metatarsal specimen of *Din. gravis* appears as a shallow longitudinal groove.

The posterior orifice of the entinterosseal canal (*l*) does not open into a depression of the bone; that into which the ectinterosseal canal (*m*) opens is wide and shallow. The interval between these two orifices in one of the specimens is greater in *Din. gravis* than in the longer metatarsus of *Dinornis crassus*; in the other it is as great.

As in *Dinornis crassus*, the places of insertion of the strong ligamentous aponeurosis formed by the confluence of the tendons of the *gastrocnemius internus* and *gastro-*

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[1] *Ante*, p. 131, Pl. XL. fig. 3.

[2] *Ante*, p. 133, Pl. XL. fig. 4.

cnemius externus are less longitudinally extended, less ridge-like, and are more concentrated, broader, and better marked than in *Apteryx australis*[1].

The entogastrocnemial surface (Pl. XLII. *a*, fig. 2, *g*) begins behind the entometatarsal tuberosity, and runs downward and backward to near the mid length of the bone; it becomes more defined as it descends, retaining a breadth of about 3 lines, before it suddenly expands into a rough tract of a semioval shape, about 2 inches long by 6 or 7 lines in extreme breadth. This surface terminates about an inch and a half above the hind end of the articular surface of the inner condyle (II). The lower part of this surface indicates the position (ib. fig. 2, I) of the ligaments which would attach the metatarsal rudiment of a back toe to the main bone, if such toe existed in *Dinornis gravis*.

The ectogastrocnemial tract (ib. fig. 2, *x*) is at the outer part of the hind surface, and on the lower or distal half of the shaft, of the metatarsal. It is of a semioval form, 1 inch 9 lines in length, 7 lines in extreme breadth, and is divided from the back part of the articular surface of the outer trochlea (IV) by a smooth tract about 4 lines in breadth. A narrow, oblong, rough tract at the proximal part of the shaft behind the ectometatarsal ridge (ib. fig. 2, *k*) may serve also for gastrocnemial insertion; but it is divided from the lower ectogastrocnemial tract by a smooth surface of the mid part of the metatarsal, about an inch and a half in extent in one instance, and two inches in the specimen figured in Pl. XLII. *a*. The narrow tract from the entogastrocnemial tuberosity (*g*) is more feebly marked, if it be discernible, in *Dinornis crassus*. The ectogastrocnemial surface is also less defined, and is continued upwards as a more or less conspicuous ridge to within a few lines of the ectometatarsal rough surface in *Dinornis crassus*.

The fore part of the entotrochlea (fig. 1, II) is broader relatively to the hind part in *Dinornis gravis* than it is in *Dinornis crassus*. The outer side of the fore part of the ectotrochlea (IV) is more convex or tuberous, and is less defined from the ectotrochlear fossa than in *Dinornis crassus*.

The interspaces of the trochleæ are narrower in *Dinornis gravis*; and this character is the more easily seized, inasmuch as the breadth of the three trochleæ is almost the same in the two species, notwithstanding the difference in the length of the metatarsi.

Dinornis gravis had a stronger and stouter foot, relatively, than *Dinornis crassus*; and the muscular force working it was more powerful, as is indicated by the insertional ridges and tracts (*g*, *y*, *x*).

In a metatarsus of *Dinornis crassus* 8 inches 6 lines in length the greatest breadth of the mid trochlea is 1 inch 8 lines; in a metatarsus of *Dinornis gravis* 7 inches 9 lines in length the greatest breadth of the mid trochlea is 1 inch 10 lines.

The general characters of the bone, with the disposition and aspects of the distal

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[1] Pls. X. & XI. B.

trochlea, are much alike in the two species; but the differences above defined impress me with the conviction that ornithologists would find the birds to which the metatarsi of *Din. crassus* and *Din. gravis* belonged, if they had them entire to compare, to be distinct species.

The number of the living species of *Casuarius* which have of late years been discovered in detached remnants of the great Australasian continent, show much more striking differences in plumage and dermal appendages than could have been suspected from any differences which are discernible in the bones of the legs; and these differences, when most distinct, are less marked than those above demonstrated in the metatarsals of the species of *Dinornis* which least differ in general size.

The tibia of *Dinornis gravis* (Pl. XLII.), in comparison with that of *Dinornis crassus*, which it most resembles, has a stronger or thicker shaft in proportion to its length[1]. The character of the metatarsal bone of *Dinornis gravis* is here repeated, but in a minor degree. For the rest, the modifications of the dinornithic character of the tibia which the stouter-legged species (*D. robustus*, *D. elephantopus*, *D. crassus*) present are closely repeated in the tibia of *D. gravis*.

The articular surface (Pl. XLII. fig. 3, *a*), adapted to that of the inner condyle of the femur, is large, shallow, semioval in shape, with the small end turned forward. The ectocondylar surface of the tibia (ib. *b*) is comparatively small, in the form of a tuberosity, the outer and hinder half of which is applied to the inner side of the ectocondylar ridge which divides the tibial from the fibular part of the articular surface at the distal expansion of the femur. The intercondylar channel (*c*) is wide and shallow, and slightly expands as it curves from behind, forward and outward, to the ectocnemial cavity. Anteriorly it is bounded by the low, rough, intercondylar eminence (ib. *d*) for the attachment of the crucial ligaments. The epicnemial channel (*f*) is smooth, broad and shallow.

The rotular or epicnemial ridge (*e*) bounds the anterior and outer half of the proximal expansion of the tibia. The upper end of the procnemial ridge (ib. fig. 1, *g*) forms the low obtuse angle of the epicnemial ridge; the outer continuation of this ridge forms the upper border of the ectocnemial process (*h*).

The suprafibular facet (ib. fig. 2, *l*) is triangular, rough, almost flat. A smooth tract, one inch in extent, divides it from the fibular ridge (*m*), which is four inches in extent and terminates nearly eight inches below the summit of the epicnemial ridge.

The procnemial ridge (ib. fig. 1, *g*) is continued uninterruptedly down the fore part of the shaft with as much inward inclination as makes it, at the lower third of the bone, the inner boundary (g') of the "extensor groove" (ib. *p*). The ectocnemial process or ridge (ib. *h*) is much shorter and thicker, subsiding four inches below the summit of the epicnemial ridge, but extending outward two inches from the suprafibular facet (fig. 2, *l*), and having a thick, smooth border curving to the shaft below its pointed

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[1] See Table of Admeasurements, p. 356.

end. The intercnemial surface (ib. fig. 1, *k*), slightly concave across at its upper part, becomes almost flat below. The ectocnemial surface (ib. fig. 2, *i*) is uniformly and more deeply concave across; it is 1½ inch in width.

There are (pneumatic?) foramina (ib. fig. 2, *j*, *j*) behind and below the intercondylar surface.

A low longitudinal ridge bounds internally the posterior flat tract of the upper half of the shaft, and opposite the fibular ridge inclines forward and to the inner side of the shaft. The medullarterial orifice (ib. fig. 2, *n*) is on the inner side of the fibular ridge, one inch above its end.

As the shaft descends the flatness of its back part gradually becomes convex across, and loses the rough reticulate shallow markings indicative of muscular origin. The ridge (*g'*) continued from the procnemial process, longitudinally and pretty equally bisects a great part of the anterior surface of the shaft, and gives the three-sided character to that part of the bone. On the inner and anterior part of the tibia, 3 inches from the proximal end, is a rough low ridge and surface (ib. fig. 1, *o*), answering to the stronger prominence in the *Cnemiornis* (marked *g* in fig. 1, Pl. LXIX.).

The extensor canal (Pl. XLII. fig. 1, *p*), its bridge (*q*), and lower outlet (*r*) repeat or retain the dinornithic characters[1]. The tuberosity from the outer pier of the bridge is strongly developed. A flat, rough surface, 3½ inches in extent, pointed above and broadening to 10 lines below, marks the inner side of the distal end of the shaft. On the other side of that part is a rough, narrow surface, suggesting a third attachment of the pointed end of a long and slender fibula. The configuration of the distal trochlear articulation closely adheres to the dinornithic pattern. The shallow pit receiving the ectocondylar convexity is well defined.

The epicnemial process is developed as an epiphysis; it retains this character in the tibia, 14 inches in length, of a young Emu (*Dromaius novæ-hollandiæ*), and includes the commencement of the procnemial and ectocnemial ridges; it might pass for a distinct bone (the patella), as the distal epiphysis (ib. fig. 4, *a*, *v*) has been conjectured to represent an astragalus; but the cartilaginous homologue of the patella in *Dromaius*, which plays upon the rotular groove of the femur, is ossified in some birds, notably in the Penguins and Loons (*Colymbus*), in which the development of the epicnemial process is in excess[2], and with which the true patella coexists.

The distal epiphysis (Pl. XLII. fig. 4) has effected a closer union with the shaft of this tibia, agreeably with the law of its relation to the course or direction of the medullary artery; the portion of the shaft developed epiphysially (ib. *a*) with the trochlear articulations (*b*) ascends nearly three inches up the fore part of the diaphysis, and develops the groove and process for the ligamentous bridge of the "tibialis anticus" tendon.

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[1] These are shown, in contrast with those in the tibia of *Gastornis parisiensis*, in the 'Quarterly Journal of the Geological Society,' 1856, pl. iii. figs. 1 & 2, p. 204.

[2] Owen, 'Anatomy of Vertebrates,' vol. ii. p. 83. fig. 34, *l*.

Femur.—In no specimen that has hitherto reached me are the dinornithic modifications of the femur more definitely and strongly marked than in the present example (Pls. XLI. & XLI. A.), in which the effects of the usual posthumous abrasion are limited to the articular prominence of the head, and to parts of the margin of the trochanter and hinder projections of the outer condyle. I propose, therefore, to take the opportunity of noting the characters more in detail than has been done in previously figured, less complete, and commonly larger specimens.

The head (*a*) of the femur, in all the species of *Dinornis*, is less sessile than in birds generally; but the part supporting it has more the character of a neck in the present species than in *Dinornis giganteus*[1], in *Dinornis casuarinus*[2], or in *Dinornis maximus*[3]. The constriction affects the entire circumference, but is deepest, as usual, anteriorly, the head being turned rather forward as well as projecting inward; the axis of the head and neck also slightly inclines upward. The head forms more than a hemisphere. From the neck (*d*), or constriction, the bone rapidly expands to the great trochanter (*f*) and shaft. The articular surface is continued from the head upon the anterior two thirds of the upper part of the trochanter (Pl. XLI. A. fig. 2, *c*), and is defined by a linear boundary from the non-articular part. Three surfaces may be noted in the enormous trochanterian enlargement of this femur—the upper (epitrochanterian) subdivided as above, the anterior, and the postero-external.

The anterior, or "pretrochanterian," surface (Pl. XLI. fig. 1, *g*) is bisected by a low linear ridge (*h*), which, rising about an inch below the angular summit, passes downward and inward, and subsides (at *h'*) on the inner side of the shaft above the expansion of the inner condyle.

The pre- meets the post-trochanterian tract at an acute angle (*i*); the latter surface is traversed vertically by a rough, broad tract, commencing about an inch from the summit of the trochanter, and gradually approaching the anterior angle as it descends, below which the ridge bends forward, and terminates in the ectotrochanterian tuberosity (Pl. XLI. fig. 1, *l*).

The rough tract defines a narrow ectotrochanterian surface from the broader post-trochanterian surface (Pl. XLI. A. fig. 1, *m*). On this surface are two rough oval shallow depressions for muscular insertions; the upper one (Pl. XLI. A. fig. 1, *n*, for the "abductor femoris") is 10 lines below the epitrochanterian ridge, and measures 15 lines by 10 lines: half an inch below and rather in advance of this is the second depression, of rather smaller size, but with a more irregular surface (ib. ib. *o*, for the "quadratus femoris"). From this surface several longitudinal striæ descend vertically, and are continued by one principal linear ridge down the outer side of the shaft to within an inch of the ectocondylar fossa (ib. *k'*). A rough tract is continued from the lower gluteal surface obliquely downward and backward, contracting to the strongly marked ridge (Pl. XLI. A. fig. 1, *p*). To this ridge converges an inner less prominent oblique

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[1] Pl. XXXVI. fig. 1.

[2] Pl. XXXVIII. figs. 1, 2.

[3] Pl. LXXIX. fig. 1.

ridge (ib. *q*) commencing at the inner side of the shaft, one inch below the neck. The two oblique ridges are divided by a smooth interspace 4 lines in breadth, below which is the orifice of the medullary artery (ib. *r*). On each side of this orifice the lineæ asperæ are, as it were, resumed, and descend slightly diverging,—the outer one (ib. p') gradually subsiding near the ectocondylar pit (*k*); the inner one (ib. *q*) descends an inch and a half below the arterial orifice to form the tuberosity, q'. Internal to this rises a second rough tuberosity (ib. q''), continued by a ridge to within an inch of the hind angle of the inner condyle (ib. *u*).

From the ectotrochanterian tuberosity (Pl. XLI. fig. 1, *l*) the strong ridge bisecting the fore part of the mid third of the shaft is continued down near the mid line of that surface. Six inches below the upper end of the femur this ridge, which divided the attachments of the "vastus externus" and "vastus internus" muscles, bifurcates, its divisions diverging to the upper end of the condylar risings (ib. *u*, *y*), but subsiding before attaining these.

At the lower part of the pretrochanterian surface, midway between the head and the ectotrochanterian tuberosity, is the rough surface, partly prominent, partly depressed (Plate XLI. fig. 1, *s*), which seems to represent the small trochanter in Mammals.

The rotular cavity or channel (ib. fig. 1, *t*), 2 inches across and 1$\frac{1}{4}$ inch in depth, shows no trace of the rising marked in that part of the femur of *Dinornis giganteus*[1]. The anterior intercondylar ridge dividing the rotular fossa (*t*) from the intercondylar one (Pl. XLI. A. fig. 1, *v*, v') is sharp. The intercondylar fossa is partially divided into two depressions, the inner one (ib. *v*) being the deepest, the outer one (v') the largest. These are divided from the popliteal cavity (Pl. XLI. A. fig. 1, *z*) by the post-intercondylar ridge (ib. *w*), which is well marked, but shorter, thicker, and more rounded than the anterior one (Pl. XLI. fig. 2, t').

The entocondylar articular surface (ib. u') has the usual relative size and shape[2].

The ectocondylar surface for the tibia (ib. *x*) is comparatively small, measuring 1 inch 9 lines by 1 inch in extent; it is continued over the ridge-like posterior projection of this part of the condyle to that on the concavity or groove for the head of the fibula (Pl. XLI. A. fig. 1, *y*), which groove is feebly divided into an upper (y') and lower (y'') tract.

The popliteal space (ib. fig. 1, *z*) has the usual dinornithic depth, shape, size, and oblique direction. It is rugous; and some small foramina at its deepest part are the sole representatives of a pneumatic system, though probably related only to the transmission of vessels.

The contrast is striking, in placing by the side of the above-described bone the femur of any of the species of large existing Struthious birds, in regard to every indication of the strength and vigour of application of the hind limbs. The chief results of the comparison of the femur of *Dinornis* with that of *Struthio* were recorded in the Memoir

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[1] Pl. XXXVI. fig. 2, *r*.

[2] Pl. XXXVIII. fig. 3, *t* (*Dinornis casuarinus*).

on the first received collection of bones from New Zealand[1]. But the femur of the Emu (*Dromaius*), though still smaller than that of the Ostrich in comparison with the gigantic species of *Dinornis*, is less different in shape. The shaft of the bone is rounder than in the Ostrich; but the antero-posterior diameter of that part is less than in *Dinornis*. There is no trace of the bifurcate ridge on the fore part of the shaft, and very feeble indications of "lineæ asperæ" on the back part; of the tuberosities there developed in *Dinornis* no rudiment even is present in existing Struthionidæ. The medullarterial canal is very minute in *Dromaius*, as in other pneumatic femora; and the associated large air-hole at the back part of the upper end of the femur significantly differentiates *Dromaius*, as it does the other large existing Struthionidæ, from *Dinornis*. The head is sessile; one cannot predicate a cervix in the femur of *Dromaius*; the trochanter hardly rises above the level of the head; the back of the trochanter is scarcely at all accentuated, chiefly shows a smooth, feeble concavity; there are no gluteal rugosities, no trace of a lesser trochanterian place of muscular attachment. The popliteal cavity is a shallow groove, not bounded by any post-intercondylar ridge from the intercondylar space. The distal expansion is relatively much less than in *Dinornis*; the inner condyle is much narrower. The tibial part of the outer condyle has relatively more longitudinal extent in *Dromaius* than in *Dinornis*; it rises well above the fibular division, which is relatively shorter than in *Dinornis*, where it equals in that dimension the tibial prominence. But the fibular division projects more outwardly in *Dromaius*, is broader in proportion to its length, and more generally convex. There is no trace of the rough pit for ligamentous or muscular attachment above the fibular division of the outer condyle which so markedly distinguishes the femur of *Dinornis*.

The antero-posterior extent of the outer condyle is much greater than that of the inner condyle in *Dromaius*; the difference is less in *Dinornis giganteus*[2], *Din. casuarinus*[3], and *Din. didiformis*[4]. The antero-posterior dimension of the outer and of the inner condyle are nearly the same in *Dinornis gravis*.

The pelvis of *Dinornis gravis* is characteristically massive and ponderous, and accords in shape with those figured in Plates XIX. & XX. of the first Memoir[5].

The upper and outer bony wall of the hinder expansion, beyond the gluteal ridges, is better preserved than in figure 3, Plate XX.

Eight coalesced vertebræ with combined par- and pleur-apophyses precede the three interacetabular vertebræ, in which those processes are wanting. The bodies of these are broader and flatter below than in the subject of figure 2, Pl. XIX. After the above eleven sacrals follow six vertebræ with par- and pleurapophyses again abutting against the iliac walls.

The first sacral has, on each side the centrum, a circular cup for the head of a free

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[1] *Ante*, p. 73.

[2] Pl. XXXVI. fig. 2.

[3] Pl. XXXVIII. fig. 3.

[4] Pl. XXIV. fig. 3.

[5] *Ante*, p. 73.

rib, behind which cup is a large pneumatic foramen. The ribs of the seven succeeding sacrals are anchylosed and short, abutting against and coalescing with the closely grasping plates of the antacetabular parts of the ilia. The interpleural vacuities of the eight anterior sacrals rapidly decrease in size to the fifth, and again slightly expand in the last two. The first three pairs of anchylosed ribs incline forward; the next three pairs are transverse; the last of this series curves slightly backward, commencing that curve which is carried out by the proximal ends of the ischia. Both ischia and pubes in the present specimen are broken away from their origins at the acetabulum. The following are the dimensions of this pelvis:—

	in.	lin.
Length (fore ends and hind ends of ilia broken off)	14	0
Breadth (behind acetabula, where the prominences are abraded)	8	6
Height of first sacral (summit of spine broken off)	5	0
Breadth of first sacral	4	0
Diameter of circular orifice of neural canal of first sacral	0	4
From fore part of first sacral to postacetabular angle of ilium	9	4
Breadth of "pelvic disk"[1]	7	0
Vertical diameter of acetabulum	2	3
Length of first eight sacral vertebræ	6	4
Length of last nine sacral vertebræ	7	0

It may be convenient for future comparers of the hind-limb bones of *Dinornis* to have, in a tabular form, the principal dimensions of the femur, tibia, and metatarsus of the several species at present defined and named. In this table are given references to the figures of the type specimens affording the dimensions; and there are added remarks and dimensions by Dr. Haast, F.R.S., the latter of bones obtained from the swamp of Glenmark, and which are referable to the above species of *Dinornis*.

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[1] *Ante*, p. 304.

TABLE OF ADMEASUREMENTS OF THE BONES OF THE LEG OF THE KNOWN SPECIES OF *DINORNIS*.

The letter H. refers to the admeasurements given by Dr. Haast in the "Memoir" cited, note 2, p. 362.

Dimensions of the Femur.

	Din. curtus.		Din. geranoïdes.	Din. didiformis.			Din. dromioïdes.		Din. rheides.	Din. gracilis.		Din. gravis.			Din. casuarinus.	
	f 3	*f* 4	4	6 *f* 8.	*f* 7.	*f* 17.	9 *f* 16.	*f Taylor.*		13	H.		15 H.	H.	*f* 13.	18 *f* E.
	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.
Length	6 0	5 6	6 3	8 0	8 0	8 1	9 6	9 7	9 0	11 6	11 4	11 0	10 8	9 3	9 6*	10 4
Breadth of proximal end (in the axis of the neck)	2 3	2 0	2 3	2 10	3 0	3 3	3 6	3 6	3 0	3 8	......	4 3	...	...	3 5*	3 11
Breadth (transverse) of distal end	2 5	2 2	2 9	3 3	3 2	3 6	3 7	3 8	3 6	4 0	......	4 7	...	...	3 9	4 4
Circumference of middle	2 9	2 7	3 2	4 0	4 0	4 3	4 0	3 10½	3 9	4 8	......	5 8	6 0	5 3	5 0	4 9

* Perhaps not quite enough allowed for mutilated extremities.

Dimensions of the Tibia.

	1 *t* 3¹.	*t* 4.		7 *t* 3.	*t* 8.	*t* 9.	10			14	H.		16	H.	19	
Length	11 3	11 0	14 0	15 6	15 4	15 4	21 0	.....	17 0	23 6	23 0	17 3	16 7	15 7	18 7	.....
Breadth of proximal end	3 3	3 1	3 0	4 5	......	......	4 8	......	4 6	5 0	......	5 4	......	......	5 6	.....
Breadth of distal end	2 0	1 10	2 9	2 4	......	......	2 8	......	2 6	2 10	......	3 2	......	......	2 11	.....
Circumference of middle	2 9	2 7	......	4 0	......	......	4 0	......	4 0	4 6	......	4 9	5 0	4 4	4 9	.....
Fibular ridge extends down	4 9	4 7	......	6 10	......	......	9 0	......	8 0	9 6	......	6 6	......	......	8 6	.....

Dimensions of the Metatarsus.

	2 *m* 3.	3 *m* 4.	5	8			11			12	H.	17			20	
Length	5 0	4 6	6 0	7 0	6 10	......	10 5	......	9 0	13 0	12 6	7 9	7 9	7 4	8 0	......
Circumf. at the middle of the shaft	2 10	2 6	......	3 3	3 3	......	3 9	......	4 6	4 3	......	5 0	9 8	4 5	4 2	......
Breadth (transverse) of distal end	2 5	2 1	3 0	......	3 0	......	3 4	......	3 9	4 3	......	4 1	......	......	3 10	......
Breadth of middle of shaft	1 1	1 0	1 5	1 5	1 3	......	1 4	......	1 10	1 7	......	2 0	......	......	1 7	......
Thickness or antero-posterior diameter of shaft	0 7	0 6	......	0 9	0 9	......	0 10	......	1 0	1 2	......	1 0	......	......	0 10	......
Breadth (transv.) of proximal end	1 11	1 9	2 3	......	2 3	......	2 10	......	3 9	3 4	......	3 1	......	......	3 0	......

Dimensions of the Femur.

	Din. crassus.	Din. elephantopus.		Din. struthioides.		Din. ingens.		Din. giganteus.			Din. robustus.		Din. maximus.	
		22	H.	25 *f* 12.	*f Colenso.*	28	*f* 2.	31	H.			H.	33	H.
	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.
Length	12 0	13 0	12 8	11 6*	12 0	13 9	13 0	16 0	16 5	......	14 2	14 6	18 3	18 4
Breadth of proximal end (in the axis of the neck)	5 0	5 10	......	4 2	4 2	5 3	4 10	6 0	......	......	6 0	......	6 6	......
Breadth (transverse) of distal end	5 3	5 11	......	4 3	4 4	5 10	5 2	6 3	......	......	6 0	......	7 6	......
Circumference of middle	6 8	7 9	......	5 6	5 6	7 1	6 1	7 9	.....	......	7 10	.....	9 6	9 6

* Perhaps not quite enough allowed for mutilated extremities.

Dimensions of the Tibia.

		23		26		29 *t* 2.	*t* E 1.	*t* 1.	*t* E.	H.		H.	34	H.
Length	19 0	24 0	21 6	22 0	21 2	29 0	28 9	35 0	35 0	34 0	32 3	30 4	39 0	39 2
Breadth of proximal end	6 2	7 5	7 0	5 6	5 4	6 2	6 6	7 6	7 0	......	7 6	......	8 6	......
Breadth of distal end	3 3	4 2	4 0	3 2	3 1	3 7	4 0	4 0	4 8	......	4 4	......	5 0	......
Circumference of middle	4 5	6 5	6 5	5 0	4 8	5 3	6 3	6 6	6 6	......	6 9	......	8 6	8 7
Fibular ridge extends down	10 0	11 6	11 0	10 0	10 0	12 0	12 0	13 0	13 0	......	12 0	......	20 0	......

Dimensions of the Metatarsus.

	21	24		27 *m* 3.	*m* E.	30 *m* E.	*Colenso.*	31 *m* 1.	*m* E.	H.	32	H.	35	
Length	8 6	9 8	9 3	12 0	11 6	14 6	13 9	18 6	18 0	18 9	15 9	16 2	20 0	21 6
Circumf. at the middle of the shaft	4 8	4 8	4 6	4 3	4 2	5 6	4 6	5 6	6 0	......	5 3	......	8 4	6 4
Breadth (transverse) of distal end	4 0	5 6	5 4	4 0*	4 5	5 6	4 6	5 1	6 0	......	5 3	......	6 9	7 3
Breadth of middle of shaft	1 10	2 8	2 5	1 6	1 6	1 10	1 7	1 11	2 2	......	2 0	......	3 0	2 7
Thickness or antero-posterior diameter of shaft	1 2	......	.....	1 1	1 1	1 5	1 3	1 6	1 6	......	......	......	......	......
Breadth (transv.) of proximal end	3 3½	4 8	4 5	......	3 5	4 3†	3 6	0 0	4 6	......	4 6	......	5 6	5 3

* Perhaps not enough allowed for water-worn margins of trochleæ.

† With a ridge at the middle of inner condyle at proximal end.

The bone of which a side view is given in pl. 20. *a*, and there ascribed to *Din. didiformis*, is a metatarsal of *Din. casuarinus*.

1 Pl. XXXIX. figs. 3, 4, & 5. *t* 3¹ Ibidem.

2 Pl. LXXXVII. fig. 8 (compare with the first indication of this species, Trans. Zool. Soc. iii. pl. 48. fig. 6).

3 Pl. LXXXVII. fig. 7.

4 Pl. LXVIII. figs. 5, 6.

5 Pl. LXX. figs. 5, 6.

6 Pl. XXIV.

7 Pl. XXVI. figs. 3, 4.

8 Pl. XXVII. fig. 3.

9 Pl. XXII.

10 Pl. XXXIX. fig. 1.

11 Pl. XL. fig. 2.

12 Pl. L.

13 Pl. LIV. fig. 1.

14 Pl. LV. fig. 2.

15 Pl. XLI.

16 Pl. XLII.

17 Pl. XLII. A.

18 Pl. XXXVIII.

19 Pl. XXXIX.

20 Pl. XL. (See also pl. 20. *a*, fig. 2, wrongly ascribed to *Din. didiformis*.)

21 Pl. XL. figs. 4 & 5.

22 Pl. LVI.

23 Ibid. figs. 4 & 5.

24 Pl. LVII. fig. 1.

25 Pl. LIV. fig. 2.

26 Pl. LV. fig. 1.

27 Pl. LIV. fig. 4.

28 Pl. XXI. fig. 1.

29 Pl. XXV. fig. 1, pl. 26. fig. 1.

30 Pl. XL. fig. 1.

31 Pl. XXVII. fig. 1.

32 Pl. XLIX. fig. 1.

33 Pl. LXXIX. fig. 1.

34 Pl. LXXX.

35 Pl. LXXXIX. fig. 3.

Addition to Note **5**, p. 356.

The dimensions of the tibia and metatarse of the "smallest size" of *Dinornis didiformis* in Dr. Haast's list of bones from Glenmark swamp agree with those of the present species (*D. geranoïdes*); but the femur therewith associated has the length (9 inches) of a large variety of *D. didiformis.—Trans. New-Zealand Institute*, vol. i. 1869, p. 83.

Addition to Note **8**, p. 356.

Tibia and metatarsi identical, or nearly so, in size and shape with those of the present species are referred thereto by Dr. Haast (*loc. cit.*); but the femur associated therewith in the list of specimens from the Glenmark swamp is an inch longer than that of *D. didiformis* from the North Island. Does this indicate an established variety in the South Island?

Addition to Note **9**, p. 356.

Unless the femur, 9 inches 6 lines in length, referred to "No. 4, *Din. didiformis*, largest size," in Dr. Haast's list (*loc. cit.* p. 83), belongs to a *Dinornis dromioïdes*, that species has not yet been met with out of the North Island. The tibia, 15 inches 6 lines in length, and the metatarsus, 7 inches 5 lines in length, which Dr. Haast associates with this femur, would rightly come under the head of *Din. didiformis*.

Addition to Note **14**, p. 356.

"No. 10. *Dinornis gracilis*, Owen. Of this elegant species three more or less complete specimens were found amongst the exhumed bones, which agree in every respect with Professor Owen's figures. For comparison, I shall give the measurements of the best-preserved specimen:—

"No. 10.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
"Metatarsus	12·6	10·3	4·6	12·0
Tibia	23·0	13·9	4·7	11·3
Femur	11·4	11·3	5·4	12·7"

Haast, *loc. cit.* p. 84.

Addition to Note **17**, p. 356.

To this species I refer "No. 17, *Dinornis* . . . . (?)," in Dr. Haast's List (*loc. cit.* p. 87): on which he remarks:—"A species smaller than No. 16, but partaking still of the same character.

"*Measurements.*

"No. 17.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
"Metatarsus	7·4	7·5	4·5	10·3
Tibia	15·7	14·4	4·4	9·5
Femur	9·3	10·5	5·3	11·4"

The specimens from the Glenmark swamp, referred to under "No. 16, *Dinornis crassus*," agree best with *Dinornis gravis*. Dr. Haast remarks:—"Of this species we obtained ten more or less complete specimens, so that I had ample material to assure myself of the correctness of its specific character.

"*Measurements.*

"No. 16.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
"Metatarsus	7·9	9·0	4·8	11·1
Tibia	16·7	14·2	5·0	10·6
Femur	10·8	12·9	6·0	15·3

"The metatarsus is shorter than Professor Owen's *crassus*, the circumference larger, but the proximal end is somewhat smaller.

"The tibia is smaller, but again thicker than Professor Owen's *crassus*.

"The femur is also shorter, whilst the circumference is the same as Professor Owen's species. An examination of the general character shows that it is a somewhat smaller but stouter bird than Professor Owen's *crassus*."—*Loc. cit.* p. 86.

Addition to Note **21**, p. 356.

To this species I should refer the specimens of which Dr. Haast gives the following average size of the leg-bones of fifteen specimens obtained from the Glenmark swamp:—

"No. 11.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
"Metatarsus	8·8	9·2	5·1	10·8
Tibia	18·7	14·9	4·8	10·5
Femur	11·0	12·4	5·6	13·0"

And on which he remarks:—"When examining the metatarsus of this subdivision, I found that it corresponded best with one figured by Professor Owen as *crassus* (pl. 48, p. 324, vol. iii. Trans. Zool. Soc.), although the measurements of *crassus* given by Professor Owen further on in his excellent Memoirs differ slightly from the specimen in question, and, as it appears to me, from his own figured metatarsus."—*Loc. cit.* p. 82.

This difference applies to figure 3 in plate 48 of the Memoir cited, but not to figure 4 in that plate.

Addition to Note **24**, p. 356.

"*Dinornis elephantopus*, Owen. Of this remarkable species bones of at least nine, more or less complete, individuals were exhumed, of which four were of the same size as those figured by Professor Owen, while the five others decrease gradually to the size of No. 13, without my being able to find any line of demarcation between them. Of one of these large specimens, which were found together in their natural position, I give here the measurements; they represent, at the same time, the character of the three large specimens excavated.

"Among the Glenmark bones the metatarsus is generally of larger dimensions than Professor Owen's, according to his measurements; the tibia between the two measurements he gives; the femur is also slightly smaller than the one Professor Owen figures:—

"No. 12.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
"Metatarsus	9·8	12·3	6·8	15·2
Tibia	22·8	18·7	6·3	14·5
Femur	12·8	15·5	7·7	17·4

"There is, then, a distinct break between No. 13 (*Din. elephantopus*, smaller size) and the next size, No. 16, *Dinornis crassus* (?)."—Haast, *loc. cit.* p. 85.

Addition to Note **27**, p. 356.

This species appears to be represented by a somewhat stronger variety in the South Island, and to have been rare there. In the series of bones obtained from the Glenmark swamp, Dr. Haast remarks:—

"No. 7. *Dinornis*, sp. We possess only the three principal bones of one leg, and odd bones of two other specimens; they are larger, and slightly thicker, than those of *Dinornis struthioïdes*.

"On the other hand they are much smaller than those of *Palapteryx ingens*. There is no dent or depression on the back of the metatarsus for the attachment of the back metatarsal trochlea. This bird was bow-legged, and resembled most *Dinornis struthioïdes* in its principal characteristics, although of larger dimensions.

“ No. 7.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
“ Metatarsus	12·9	10·8	4·7	13·2
Tibia	24·8	14·8	5·2	12·7
Femur	12·3	14·3	6·4	14·8

“ The bones belong evidently to adult birds (three specimens).”—*Loc. cit.* p. 84.

Addition to Note **30,** p. 356.

This species, common in the North Island, seems to have been rare in the South Island. Dr. Haast remarks :—

“ No. 8. *Palapteryx ingens*, Owen. We obtained only portions of one single specimen from Glenmark, which agree closely with the figures and measurements given by Professor Owen. It is remarkable that there were no more, considering the large quantities of bones of other species dug out.

“ Well-preserved parts of another of the same were obtained at Heathcote, near the foot of Banks's peninsula, from a drain five or six feet deep, cut in sandy loam (silt); the bones are a little smaller than Professor Owen's figure, but they are larger than those found in a cave in the province of Nelson, and from which Dr. Jaeger, in Vienna, constructed his cast.

“ For comparison I append the measurement of the Heathcote specimen :—

“ No. 8.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
“ Metatarsus	15·1	11·5	5·7	13·6
Tibia	29·5	17·6	6·0	15·0
Femur	14·2	12·5	7·6	17·0

“ The metatarsus has the hollow for the attachment of the back *trochlea* well marked ; and the general character of the bones shows clearly that they belonged to a well-developed strong (male ?) bird.”—*Loc. cit.* p. 48.

Addition to Note **31,** p. 356.

This species is represented in the South Island by a variety with rather thicker limb-bones, as indicated by the third of Dr. Haast's admeasurements.

“ No. 20. *Dinornis giganteus.* Bones were obtained belonging to six distinct birds of this species, one of the most perfect of which, when articulated, measured 9 feet 10 inches.

“ The character of its bones is identical with those given by Professor Owen, except in some small details.

“ No. 9.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
“ Metatarsus	18·9	13·1	6·8	16·6
Tibia	34·0	21·0	6·9	17·5
Femur	16·5	16·1	8·7	18·6”

Loc. cit. p. 88.

Addition to Note **32,** p. 356.

“ **No. 21.** ***Dinornis robustus*****,** Owen. The measurements given are those of the specimen articulated for the

Canterbury Museum. Besides which we obtained a few bones belonging to another bird very little inferior in size. Both correspond well with the figures and descriptions of Professor Owen :—

" No. 21.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
" Metatarsus	16·2	12·6	6·2	15·2
Tibia	30·4	19·1	6·8	14·5
Femur	14·6	15·5	7·7	17·5"

Loc. cit. p. 88.

Addition to Note **35,** p. 356.

The confirmation and acceptance of this species by the accomplished geologist and naturalist in charge of the Canterbury Museum gave me much satisfaction. Dr. Haast writes :—

" No. 18. *Dinornis maximus*, Owen? Of this species we obtained the perfect pelvis, the right femur, tibia, and fibula, and the first two dorsal vertebræ, lying still in their original position. We dug all round these bones, but our researches were not rewarded by finding any more remains belonging to the same specimen. A fragment of a metatarsus, however, which was lying in a drain not far from the spot, seemed, from its size, to have belonged to this or to a similar bird.

" I may here observe that, judging from the size of the two dorsal vertebræ, still larger specimens of *Dinornis* are entombed in the same swamp, because we obtained a nearly complete neck of one of still larger dimensions than that belonging to No. 18, the other portions of which have not yet been found.

" *Measurements.*

" No. 18.	Length of bone.	Girth of proximal end.	Girth of shaft, thinnest part.	Girth of distal end.
	inches.	inches.	inches.	inches.
" Metatarsus	....	....	8·1	
Tibia	39·2	22·5	8·7	17·6
Femur	18·4	19·0	9·6	21·7

" The metatarsus, of which, as before observed, we have only a fragment, is remarkably flat and broad, and does not narrow towards the middle, as in *Din. giganteus*; when restored according to the metatarsus belonging to No. 19, it would be about 23 inches long. We obtained also parts of a specimen of No. 19, which have all the characteristics of this species, but somewhat smaller in all dimensions. The tibia is remarkably thick round the shaft, and presents altogether a very different appearance from that of *Din. giganteus*."—*Loc. cit.* p. 87.

In the preceding Table five species have leg-bones proportionally thick ; these strong-limbed Moas are represented by *Dinornis gravis, Din. casuarinus, Din. crassus, Din. elephantopus*, and *Din. robustus*. Six species have leg-bones proportionally thin ; these are:—*Dinornis didiformis, Din. dromioïdes, Din. gracilis, Din. struthioïdes, Din. ingens*, and *Din. giganteus*.

Dinornis rheïdes is intermediate in the strength or thickness of the limb-bones.

Two species are notable for their small size, viz. *Dinornis geranoïdes*, and *Din. curtus*; one species for its great size, even in a genus of giants, viz. *Dinornis maximus*. Of the bones referable by length to this species, two varieties are indicated by metatarsals[1]; the longer and more slender form, contributed by Dr. Lillie (*ante*, p. 252), I have now reason to suspect may prove to be a variety so well established and so characterized by concomitant modifications in other parts of the skeleton as to need, for convenient reference, a distinct name, for which that of *Dinornis altus* may be accepted.

In comparing the skulls, indicative of eight or nine of the fifteen species of *Dinornis* characterized by limb-bones, we see that they differ in the relative length of the beak[2], and in that of the terminal osseous part of the upper mandible[3] to the rest of the skull in the sharper or more obtuse termination of both mandibles[4], in the relative antero-posterior extent of the temporal fossæ[5], in the relative flatness or transverse convexity of the cranium[6], in the longitudinal contour of the upper part of the skull[7], and in a few such minor particulars as the breadth and direction of the postorbital process.

The sternum of *Dinornis*, whilst conforming to the apterygian type[8], shows two well-marked modifications thereof—in the proportions of breadth to length, and in the degree of divergence of the lateral processes[9].

The back toe (*hallux*, *i*) was a small functionless appendage to the foot in the best-developed condition in which it has been found[10]. The trace of the ligamentous attachment to the functionally developed metatarsus is feeble in the species in which the existence of this toe is most certain. It cannot be inferred to have been wholly absent in the cases in which the connecting ligaments have left a less definite trace or where such is undistinguishable. I have therefore felt obliged to abandon this ground of generic distinction[11].

One is naturally disposed to group together the thick-legged or strong-limbed species of the South Island represented by the five above cited. It would seem that the broader type of sternum was associated with such proportions of the limb-bones in those species. If such association should be proved and found to be constant, and if, in like manner, the narrower form of sternum shown in *Dinornis rheïdes* should be found to prevail in the six slender-limbed species, we shall have the same ground for restricting to them the old generic term. If it could be shown that *Palapteryx*, as

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[1] Pl. LXXIX. figs. 4 & 5.

[2] Compare Pl. LXIV. fig. 1 (*Dinornis robustus*) with Pl. LXXVIII. fig. 1 (*Dinornis casuarinus*).

[3] Compare Pl. LXXXII. fig. 1 (*Dinornis ingens*) with Pl. LXXVI. fig. 1 (*Dinornis crassus*).

[4] Compare Pl. LXXVI. figs. 2, 3, 8, & 9 (*Dinornis crassus*) with Pl. LXXVII. figs. 6–9 (*Dinornis elephantopus*).

[5] Compare Pl. LXII. fig. 1 (*Dinornis robustus*) with Jaeger, Paläontologie der Novara Expedition, art. vi. Bericht über einen fast vollständigen Schädel von *Palapteryx ingens*, Taf. xxvi. fig. 2.

[6] Compare Pl. LXXVII. fig. 2 (*Dinornis elephantopus*) with Pl. LIII. fig. 1 (*Dinornis giganteus*).

[7] Compare Pl. LXIV. fig. 1 (*Dinornis robustus*) with Pl. LXXVI. fig. 1 (*Dinornis crassus*), or with Pl. LXXVIII. fig. 1 (*Dinornis casuarinus*).

[8] *Ante*, p. 34, Pl. IX. figs. 2 & 3, and p. 254.

[9] Compare Pl. LXXII. fig. 1 (*Dinornis elephantopus*) with Pl. LXXIII. fig. 1 (*Dinornis rheïdes*).

[10] Pl. XLIX. figs. 4 & 5 (*Dinornis robustus*).

[11] *Ante*, p. 283.

above defined, had the hallux, and that *Dinornis*, as above restricted, had it not, the grounds of the generic or subgeneric division would be strengthened.

But when we come to consider the species manifesting the cranial modifications above specified, we find what would otherwise afford the most satisfactory generic character failing us. *Dinornis robustus* resembles most *Dinornis ingens* in the form and proportions of skull and beak. *Dinornis elephantopus*, which most closely resembles in limb-characters and sternum *Dinornis crassus*, most differs from that species in the form and proportions of the mandibles.

But much yet remains to be recognized as to the cranial characters of the species of *Dinornis* indicated by other parts of the skeleton. No skull of any of the species represented by remains in the North Island has yet been found at all comparable in the state of its preservation or entireness to those discovered in the South Island. The North-Island Moa-bones, as I have before had occasion to remark, are more mineralized, or more changed from their recent state, than those from the swamps and turbaries of the South Island. The least incomplete of the crania from the North Island is that figured in Pl. XLV. (p. 206), where it is provisionally referred to *Dinornis geranoïdes*.

Many years may elapse before examples of the skeleton of the slender-limbed species of the North Island are found in such proportion and juxtaposition as to warrant confidence in the ascription to each of its cranial characteristics. The inferential restoration of some of the South-Island Moa-skeletons, in respect at least of the skulls, may need rectification as the result of more fortunate discoveries.

In the present condition therefore of our information respecting the extinct Moas, I deem the means of imparting it to be satisfied by the use of one generic term, with a grouping together of the species on the ground of well-marked differences of thickness in relation to length of femur, tibia, and metatarsus, and more especially as shown by the last-named bone.

DESCRIPTION OF THE PLATES.

Femur of Dinornis gravis. Nat. size.

PLATE XLI.

Fig. 1. Front view.
Fig. 2. Lower articular surface.

PLATE XLI. A.

Fig. 1. Back view.
Fig. 2. Upper articular surface.

In both Plates.

a. The head.
b. The depression for ligament (part of).
c. The trochanterian articular surface.
d. The neck.
e. Non-articular surface.
f. Epitrochanterian ridge.
g. Pretrochanterian surface.
h. Pretrochanterian ridge.
i. Angle between trochanterian surfaces.
j. Ectotrochanterian surface.
k. Ectotrochanterian ridge.
l. Ectotrochanterian tuberosity.
m. Post-trochanterian surface.
n. Upper gluteal surface.
o. Lower gluteal surface.
p. Linea obliqua longitudinalis superior externa; *p'*, inferior ditto.
q. Linea obliqua longitudinalis superior interna; *q'*, inferior.
q''. Entocondylar branch.
r. Medullarterial orifice.
r'. Entocondylar branch.
s. Small trochanterian surface.
t. Rotular channel.
t'. Anterior intercondylar ridge.
u'. Entocondylar surface.
v. Intercondylar fossa.
w. Posterior intercondylar ridge.
x. Ectocondylar surface for tibia.
y. Fibular surface.
z. Popliteal space.

PLATE XLII.

Right tibia. Nat. size.

Fig. 1. Front view.
Fig. 2. Back view.
Fig. 3. Upper articular end.
Fig. 4. Lower epiphysis of tibia of *Dromaius.*

a. Entocondylar surface.
b. Ectocondylar surface.
c. Intercondylar canal.
d. Intercondylar eminence.
e. Rotular (epicnemial) process.
f. Epicnemial channel.
g. Procnemial ridge.
h. Ectonemial ridge.

i. Ectocnemial cavity.
j. Pneumatic orifices.
k. Intercnemial cavity.
l. Suprafibular surface.
m. Fibular ridge.
n. Orifice of medullary artery.
o. Gastrocnemial surface.
p. Extensor groove.
q. Extensor bridge.
r. Extensor bridge, lower outlet.
s. Entocondyle.
t. Ectocondyle.
u. Intercondylar space.
v. Trochlear canal.

PLATE XLII. *a*.

Left Metatarsal. Nat. size.

Fig. 1. Front view.
Fig. 2. Back view.
Fig. 3. Upper, or condylar end.
Fig. 4. Lower, or trochlear end.

a. Entocondylar cavity.
b. Ectocondylar cavity.
c. Intercondylar process.
d. Intercondylar tract.
e. Entometatarsal ridge or tuberosity.
f. Ectocondylar ridge.
g. Entogastrocnemial ridge.
h. Antero-superior ridge.
i. Antinterosseal depression.
k. Ectometatarsal tuberosity.
l. Entinterosseal canal.
m. Ectinterosseal canal.
n. Antinterosseal canal.
o. Fossa of tibialis anticus tendon.
p. Entotrochlear ridge.
r. Entocalcaneal process.
s. Ectocalcaneal groove.
u. Calcaneal groove.
v. Postinternal surface.
w. Postexternal surface.
x. Ectogastrocnemial surface.
I. Hallucial surface.
II. Entotrochlea.
III. Mesotrochlea.
IV. Ectotrochlea.

RESTORATION

OF

CNEMIORNIS CALCITRANS.

IN a preceding Memoir[1] this genus of the extinct flightless birds of New Zealand was founded upon portions of the skeleton, including some vertebræ of the neck[2], the pelvis[3], portions of the sternum[4] indicative of the rudimental state of the keel and consequent incapacity of the bird for flight, a femur[5], a tibia[6], a metatarsus[7], and a humerus[8] described as belonging "to some such flightless bird," and provisionally referred to the species represented by the first-named bones[9].

The resemblance of the tibia in certain characters to that of a natatorial bird (*Colymbus*) was pointed out; but there were other features of the bone which checked the choice of the family. The minor degree of inward extension of the inner distal condyle (*tom. cit.* Pl. LXIX. fig. 1, *a*), as compared with that characteristic of *Anatidæ*—still more the out-springing of the inner trochlear joint at the distal end of the metatarsus (*tom. cit.* Pl. LXX. fig. 1, ii, and fig. 3, iv) below the level of the interval between the other two trochleæ, instead of the inner trochlea rising from a higher level than the origin of the other two trochleæ, together with the absence of any backward production of the inner trochlea beyond the plane reached by the other two trochleæ, were characters which, in the then (1865) inability to extend my comparisons of these bones with their homologues in the Anatidæ, so as to include the rare Australian form *Cereopsis*, counselled reticence as to positive statement of the Anserine affinities of *Cnemiornis*, the cranial grounds for determining the family affinities of the genus being wanting.

These grounds have since been supplied by an esteemed and accomplished correspondent, James Hector, M.D., F.R.S., Government Geologist of the province of Wellington, New Zealand, from whom, in September, 1873, I received outline figures and brief notes of *Cnemiornis* in addition to those given in the preceding Memoir (p. 238), or

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[1] P. 238.
[2] Ib. Pl. LXVI. figs. 1–4, Pl. LXVII. figs. 1 & 2.
[3] Pl. LXVII. figs. 5, 6, 7.
[4] Pl. LXVI. figs. 5, 6, 7, 8.
[5] Ib. Pl. LXVIII. figs. 1 & 2.
[6] Ib. Pl. LXIX. figs. 1–5.
[7] Ib. Pl. LXX. figs. 1–4.
[8] Ib. Pl. LXIX. figs. 7–10.
[9] Ib. p. 239.

in a more perfect state than were some of those bones—as, *e. g.*, the sternum and pelvis therein described and represented. The most instructive additional bones of this second series were an almost entire skull and a humerus, the latter showing that the bone referred to *Cnemiornis* in the description of Pl. LXIX. (p. 247) must have belonged to some other, apparently similar-sized, flightless bird, which I deem to have been probably an *Aptornis*, inasmuch as a few bones referable to that genus were included in the collection sent to me in 1864 from Timaru. For this instructive accession to the evidences of *Cnemiornis* (pp. 239–245) ornithology is indebted to the Hon. Captain Fraser, F.R.G.S., who has consigned an account of the cave in which the bones were discovered to the 'Transactions of the New-Zealand Institute,' vol. v. (1872)[1].

The 'Notes' by Dr. Hector on these remains, now in the Museum of the Wellington Philosophical Society, have been published in the 'Proceedings of the Zoological Society of London,' Part I. 1874.

Having since had the opportunity of examining portions of two crania, certain ribs, humeri, and a metacarpus of other individuals of *Cnemiornis*, I can testify to the accuracy of the figures of those bones given by Dr. Hector; and to his 'Notes' my later acquisitions enable me to add descriptions and figures of an ulna and an almost entire coracoid of *Cnemiornis*. The more perfect of my two skulls includes also the roof and fore (lacrymal) part of the orbits, wanting in Dr. Hector's figure: and I believe, therefore, that a description of these specimens confirming Dr. Hector's demonstration of the former existence of a very large, not to say gigantic, Anserine bird in New Zealand will not be unacceptable, inasmuch as in their description comparisons will be made with the skulls of other Lamellirostrals, more especially of the flightless Duck (*Tachyeres*[2] *brachypterus*, Latham) of Magellan's Strait, and of the *Cereopsis cinereus* of Australia. The latter bird is notable among Anserines for the length of its legs and shortness of its bill; and it appears to me more terrestrial in its habits than most of its living congeners.

Skull.

The occipital surface of the skull of *Cnemiornis* is remarkable, in the present comparative series, for its breadth, especially at its base, here due to the outward expansion of the paroccipitals (Pl. CI. fig. 2, 4, 4), in which feature the skull of *Tachyeres* is

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[1] 'A description of the Earnsclough Moa-Cave,' p. 102. (This cave is in the interior of the province of Otago.)

[2] The generic name *Micropterus*, applied by Lesson in 1831 to the *Anas brachyptera* of Latham, was bespoken by Lacépède, in 1802, for a genus of Fishes. *Microptera* was applied by Gravenhorst, in the same year, to a family of pentamerous Coleoptera, and by Robin, in 1830, to a genus of Diptera. *Micropteryx* was given by Hübner, in 1816, to a genus of Lepidoptera, and by Agassiz, in 1829, to a genus of Fishes. The name above proposed for a subgeneric type of Anatidæ, as well-marked as any of those to which terms indicative of such distinction have been applied, is derived from ταχυήρης, swift rower, and relates to the characteristic movements of Latham's species in water, which has obtained for it, from navigators, the name of "Steamer Duck."

more like it than is that of *Cereopsis* (ib. fig. 7). It resembles more the latter Anserine in its complex ossification. *Cnemiornis* differs from both those genera and most other Anserines in the greater breadth of the cerebellar prominence (ib. 3) along the middle of the superoccipital tract, and in its greater slope forward as it rises from the foramen magnum (compare fig. 1, 3, with fig. 6, 3, Pl. CI.). A narrow mesial tract slightly projects from the convex prominence in *Cnemiornis*; it answers to the sharper ridge (3) in *Cereopsis* (ib. fig. 7, 3). The foramen magnum has a relatively longer vertical diameter in *Cnemiornis* than in *Cereopsis* or *Tachyeres*. In the vertical extent of the basioccipital[1], beneath the condyle (ib. fig. 7), *Cereopsis* comes nearer to *Cnemiornis* than does *Tachyeres*. A greater proportion of the parieto-frontal expansion of the cranium appears in the direct back view of the skull in *Cereopsis* than in *Cnemiornis*—the brain being smaller relatively, and the muscular impressions more extensive, in the larger extinct Anserine.

The extent of the insertion of the portion of the "longus colli posticus" (*ante* pp. 47, 283, Pls. XI. & XII. *o***), impressing the sides of the cerebellar protuberance, and leaving a convex ridge on each side the mid tract, dividing the occipital from the parietal surface, gives greater breadth to the upper part of the occiput, so defined, in *Cnemiornis* than in *Cereopsis*; the insertions of the "complexus" (p. 49, Pls. XI. XIII. *y*) leave the deeper impressions (Pl. CI. fig. 2, *y y*) bounded by the lateral ridges; and these are more distinct from the "biventer" impressions than in *Cereopsis*.

The basioccipital protuberances (ib. figs. 2, 4, 1′) are more developed than in any known Anserine, though they are well marked in *Cereopsis* (ib. fig. 7, 1′) and indicate great size and power of the "recti capitis laterales" muscles (*ante* p. 50, Pls. XI. XIV. *d*). In the deep chink-like fossa between the protuberances and the paroccipitals open the canals giving passage to the hypoglossal and vagal (fig. 2, *v*) nerves and the paroccipital foramen (ib. *p*) (perforating the base of the paroccipital and opening into the tympanic cavity). The paroccipitals (figs. 1–4, 4), giving insertion to the "trachelo-paroccipitales" (Pl. XII. fig. 1, *z*), are subcompressed, and do not descend below the basioccipital protuberances.

The basisphenoidal fossa (Pl. CI. figs. 4 & 9, 5), the floor of which is formed by a short triangular lamelliform process, receives on each side a (vascular?) canal from the tympanic cavity. On each side of the fore part of this fossa the entocarotid canals (ib. ib. *e c*) are exposed in *Cnemiornis*, which converge to terminate at the back part of the deep "sella." Of these canals there is only a minute indication in *Cereopsis*. In advance of them the basisphenoid contracts and develops the pair of pterapophyses (ib. ib. 5′), here, as in other Anserines, well marked, but sessile; they are a long ellipse in shape.

The base of the alisphenoid swells out, external to the entocarotid opening, to

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[1] The "fontanelles" "due to original arrest of ossification between the exoccipital and mastoid" (Anat. of Vertebrates, tom. ii. p. 49), are obliterated in both *Cnemiornis* and *Cereopsis*.

augment the tympanic cavity, with which such "bulla" communicates by an aperture (Pl. CI. fig. 1, *t a*) below the inner articular facet for the tympanic. The tympanic cavity opens upon the basis cranii by a wider aperture (ib. fig. 4, *t b*), directed outward and forward as well as downward, of a transversely elliptical form, which seems to be bisected at a higher level by the process of bone (from the alisphenoid), forming the inner articular cavity for the inner division or condyle of the head of the tympanic. A vacuity divides this from the outer articular cavity, which looks inward and a little downward.

The prebasal aperture of the tympanic cavity (ib. fig. 4, *t b*) is bounded behind by the bar of bone extending, as in *Cereopsis* and *Aptornis*[1], from the side of the basisphenoid (ib. figs. 1 & 4, 5*) to the mastoid process (ib. fig. 1, 8'). This bar bounds the fore part of the lateral opening of the tympanic cavity (ib. figs. 1 & 4, *t l*). The inner wall of this cavity is perforated by two openings leading to the pneumatic cancellous structure of the cranial walls. The paroccipital forms the hinder wall of the tympanic cavity, and is continuous by the thin plate forming the lower part of the inner wall of the cavity with the basisphenoidal pier of the vertical "sphenomastoid" bar or arch (fig. 1, 5'-8').

The sphenoidal tympanic bulla is homologous with that in the Marsupial genus *Peragalea*[2]. Anterior to it opens the foramen ovale (figs. 1 & 4, 6), divided, on one or both sides, by a slender bar between the issue of the motory and larger sensory parts of the third division of the trigeminal nerve. Five lines in advance and mesiad of this is the "foramen rotundum;" and two lines in advance of this is the larger elliptic foramen for the optic nerve (ib. fig. 1, 10) and first division of the trigeminal.

On the inner surface of the cranium the petrosal is impressed above the cribriform depression, representing the "foramen auditorium internum" by a very deep vertically elliptical fossa, answering to the "appendicular fossa" in that part of the epencephalic chamber of certain Marsupialia[3]. The side walls of the epencephalic compartment are from 9 lines to 5 lines in thickness, and are occupied by air-cells; the walls of the prosencephalic compartment are thinner, but still with a pneumatic diploë.

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[1] In the description of the sphenomastoid part of the skull of *Aptornis defossor* it is stated:—

"The articulation is close and deep, whereby, with a peculiar suspensory structure, the tympanic is retained on the right side of the present skull, where the surrounding parts of the cavity are entire." The structure is described as follows:—"This process" (the mesomastoid) "has contracted a filamentary bony union with the expanded base of the alisphenoid, the filament passing behind the neck of the tympanic, helping to suspend and maintain it *in situ*."—P. 293, Pl. LXXXIII. fig. 1, 8'.

[2] *Perameles lagotis*, Art. Marsupialia, Cycl. of Anatomy, vol. iii. p. 274, fig. 96.

[3] "The petrous bone in the Kangaroo, Koala, and Phalanger, is impressed above the 'meatus auditorius internus' by a deep, smooth, round pit, which lodges the lateral appendage of the cerebellum."—Art. Marsupialia, *ut supra*. p. 274. This is the "appendicular fossa;" the "floccus" of Reil is a different part of the cerebellum.

The greatest breadth of the cranial cavity is at the lateral depressions for the optic lobes, where it is 1½ inch across; the greatest vertical diameter is 1¼ inch; the length of the cavity is 1 inch 9 lines; it is short, therefore, in proportion to its breadth and height. In the proportion of the mandibular to the cranial part of the skull, *Cnemiornis,* as is shown in Pl. CI. fig. 1, most nearly resembles *Cereopsis* (ib. fig. 6) among Lamellirostrals.

There are no sutural indications of the limits of the parietals. The occipital surface, which, from its upper slope, appears in the view of the skull given in ib. fig. 3, through its more vertical position in *Cereopsis* does not there appear (ib. fig. 8); but a parietal tract (ib. ib. 7) is indicated in *Cereopsis* by the more marked and definite rise of the "frontal" covering (ib. ib. 11, 11) of the cerebral hemispheres. This difference is shown also in the profile views (fig. 1, 3-7, *Cnemiornis*; and fig. 6, 3-7, *Cereopsis*), in Pl. CI.

The "crotaphyte surface" (ib. fig. 6, *t*) is small and feebly indicated in *Cereopsis*; the postcrotaphite surface (ib. *p c*) is better marked. In *Cnemiornis* both crotaphite (ib. fig. 1, *t*) and postcrotaphite (ib. *p c*) surfaces are better defined by intermuscular ridges.

The "processes" of the mastoid are limited to that (8') which passes behind the joint for the tympanic to coalesce with the basisphenoidal extension (5') in *Cnemiornis,* as in *Cereopsis* and *Aptornis*; but in *Aptornis* there is a second, longer and stronger process of the mastoid, which descends external and anterior to the tympanic articulation [1].

The postfrontal is a long and strong trihedral process, terminating obtusely in *Cnemiornis* (ib. fig. 1, 12), but extending forward to coalesce with the backwardly produced lacrymal in *Cereopsis,* in which anserine the bony rim of the orbit is thus completed (ib. fig. 6, 73-12).

The lacrymal is long, and directed backward as well as downward, in *Cnemiornis* (ib. fig. 1, 73), but terminates half an inch from the end of the postfrontal, leaving the lower part of the rim of the orbit incomplete to that extent. The hind part of the base of the postfrontal is deeply impressed by an oblong fossa (ib. fig. 4, 1) in *Cnemiornis*; and this fossa is well defined, though less deep, in *Cereopsis.*

The upper part of the orbital rim, or frame, is more complete, better defined, in *Cnemiornis,* and is separated by a smooth upper tract of about 2 lines from the depressions for the superorbital mucous glands (ib. fig. 3, *m m*), which depressions are absolutely as well as relatively larger in *Cereopsis,* and cause by their pressure, combined with that of the eyeball from below, absorption of parts of the upper orbital border. The interspace between the glandular fossæ is gently concave across, but undulated by a feeble mesial rising of the frontal.

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[1] It is referred to in Dr. Hector's Paper as the "premastoid arch;" but the process effects no junction with any outstanding part of the basis cranii.

The prefrontals (Pl. CI. fig. 12, 14), perforated in Birds, as in all other Vertebrates, by the olfactory nerves, expand from their coalescence with the presphenoid (ib. fig. 4, 9) to articulate above with the fore part of the frontals and to give support to the lacrymals. They form the fore part of the rhinencephalic cavity, and contribute to the hind part of the walls of the olfactory cavity, of which they there commence the "septum," by their mutual coalescence.

Each olfactory nerve passes from the rhinencephalic to the olfactory chamber by a single canal (fig. 12, *ol*), the right and left nerve forming a pair separated by the base of the "septum," and indicating the primitive quality of the neurapophyses of the third cranial vertebra (ib. 14).

The frontals are truncate anteriorly (ib. fig. 3, 11, 11′) and present two transversely elongate convexities or condyles (fig. 11, *h*, *h*) for articulating with the nasals; external to which junction the nasals (fig. 3, 15) expand slightly to form a convexity (fig. 12, *k*) articulating with a concavity at the fore part of the base of each lacrymal. A pair of short fine fissures (fig. 3, 22) indicate the proportion which the premaxillary contributes to the naso-frontal joint.

A similar indication in *Cereopsis* (ib. fig. 8) bespeaks a relatively broader nasal process of the premaxillary. The bifurcation of the nasal at *a*, *b* (figs. 1, 3, 6, 8) to form the hind border of the external nostril has the angle rounded at the apex in *Cnemiornis* (fig. 1, *n*); it is notched and irregular in *Cereopsis* (fig. 6, *n*); the nostril is large and ovate in both, but with the anterior end larger and more definitely marked and rounded in *Cnemiornis*.

The internarial tract of the upper mandible is almost flat in *Cnemiornis* (fig. 3, *c*), but is convex, raised into an arch, in *Cereopsis* (fig. 8, *c*). The definition of the broad, short, rostral part (figs. 1, 3, 6, 8 *d*) of the premaxillary is well defined in both; but the defining channels at the sides of the base of such rostral part are deeper, and are bounded by a ridge behind, in *Cnemiornis*. The "rostrum" is pitted by the usual vascular impressions and foramina relating to renewal of the horny beak-sheath in both Anserines.

On the bony palate a median "prepalatal" vacuity exposes the anterior extremity of the vomer (fig. 4, 13) at a higher level. At a lower one, behind the vacuity, is the orifice of a longitudinal "palato-vomerine" canal (figs. 4, 11, *e*), running backward between the bony palate and the vomer. The prepalatal vacuity is represented in *Cereopsis* by a depression (fig. 9, 13), into the back and deep part of which the palato-vomerine canal (ib. *e*) opens. The extent of median coalescence of the palatal plates of the maxillaries (? if this be not due to the vomer), behind the palato-vomerine foramen, is relatively the same in *Cnemiornis* and *Cereopsis*.

The palatal vacuity is present in *Tachyeres brachypterus* and most Lamellirostrals, is largest (so far as I have seen) in *Carina moschata*, is reduced to a fissure in some skulls of the Common Goose, and is exceptionally obliterated in *Plectopterus gambianus*, as it is in *Cereopsis*.

The hind part of the bony palate is emarginate in *Cnemiornis* (Pl. CI. fig. 4), but less deeply than in *Cereopsis* (ib. fig. 9); its outer angles extend backward and upward, internal to the palatines, and are continued into the swollen pneumatic or "antral" ends of the maxillaries, the outer wall of which is cribriform, or reticulate, in *Cnemiornis* (ib. fig. 10, 21*). The anterior, horizontally lamellate, ends of the palatines (fig. 4, 20) coalesce with the maxillaries (ib. ib. 21) between the "antero-palatal" plates and the angle to which the expanded end of the jugal style (ib. fig. 7, 26) is attached.

From these attachments the palatines (20), retrograding, lose transverse and gain vertical extent, and this suddenly at their hind ends, from the upper and inner side of which a "nasal lamella" extends inward and forward to meet its fellow, and circumscribe there the palato-naris (ib. figs. 4 & 9, *f*). A ridge along the inner side of the free part of the palatine (ib. ib. 20′) seems to mark the inner boundary of the palatal surface; below this the "nasal" plate extends, with a concave surface next the meatus, to the terminal expansion; the outer surface is smooth and convex.

The bony palate anterior to the vacuity (fig. 4, 13) is divided into three longitudinal channels, of which the median one is deepest; but all gradually shallow to the common palatal level close to the broad terminal alveolar or rostral border.

From the conformity with *Cereopsis* of the articular cups for the bicondylar head of the tympanic, we may infer a similarity of that bone in *Cnemiornis*; and a like conformity of the pterapophyses (ib. figs. 4 & 9, 5′) supports the same inference in regard to the pterygoids, and strengthens that in regard to the tympanic. Both these skull-bones are wanting in my specimens of *Cnemiornis*, as in that of Dr. Hector.

The mandible of *Cnemiornis* shows the lamellirostral character of the ectocoronoid articular process (ib. figs. 1, 5, *g*). The ordinary coronoid (ib. *q*) is higher than in *Cereopsis* (ib. fig. 6, *q*), and has an angular form. The alveolar border of the dentary between the coronoid and the punctate symphysial end is smooth, rather swollen, and, as it were, bent over to the outer side of the mandible, where it overhangs the more depressed lower part of that surface. This is relatively deeper than in *Cereopsis*, the whole mandible being deeper and broader in proportion to its length, and with the fore end more squarely terminated.

The articular channels (fig. 5, *w*, *x*) for the tympanic are divided or defined by a longitudinal ridge, as in *Cereopsis*. The outer groove (*w*) is partly supported by an ectarticular process; the inner one (*x*) by a longer entarticular process, which bends upwards and terminates in a swollen apex. The angular process (30) is relatively shorter and deeper in *Cnemiornis* than in *Cereopsis* and Anserines generally. The oblique suture between the subangular (29) and dentary (32) is traceable in *Cnemiornis* as in most other Lamellirostrals. In the transverse joint between the nasal base of the upper mandible and the fronto-lacrymal apex of the cranium, and in the spheno-mastoid bridge crossing the tympanic cavity, *Cereopsis* agrees with *Cnemiornis*.

Vertebræ.

Of the cervical vertebræ of *Cnemiornis* I have now as many as exemplify the usual modifications of their size, shape, and processes in this part of the spinal column of birds, also the general characteristics of such part in Lamellirostrals by a number of vertebræ above the average in the feathered class; but the precise sum of cervicals waits a better opportunity of obtaining the skeleton of the same individual than has hitherto offered, and one knowingly availed of[1].

The main modification of the cervicals of *Cnemiornis*, as compared with those of other Natatores, is the greater extent of ossification of the neural arch. The parial hypapophyses also converge in the eleventh cervical to contact at their free ends; and those in the twelfth cervical have coalesced to form a complete inferior bony arch or ring. This structure I have not observed in any other Anserine or Lamellirostral species[2].

Both characteristics of *Cnemiornis* are shown in the figures of the cervical vertebræ in the previous Memoir on the genus. The views chosen for this purpose gave, accordingly, the upper[3], the under[4], with the fore[5] and hind[6], surfaces of the vertebræ. In the present paper I therefore give a side view (Pl. CII. fig. 6), and, for comparison with fig. 1, Pl. LXVI., a corresponding view of the homologous cervical in *Cereopsis* (Pl. CII. fig. 7) and *Tachyeres* (ib. fig. 8).

The cervical vertebræ in Anserines, which have a single hypapophysis at the hind part of the centrum, beneath the hind articular surface, are the two or three which follow the axis. After a certain number without lower processes a pair of præhypapophyses (ib. figs. 7 & 8, *ph*) begin to project from beneath the costal arch, approach each other in succeeding vertebræ without coalescing, and gain the under surface of the centrum as they lengthen. They then usually abruptly cease, and are replaced by a single hypapophysis at the middle of the fore half of the centrum; and this is continued, usually with decreasing length or suppression, to the dorsal series, where, after the first, the hypapophysis reappears with increased length.

The cervical vertebra of *Cnemiornis* the subject of figs. 1–4, Pl. LXVI., answers by the position of its hypapophysis to the third or fourth cervical in *Cereopsis* and *Tachyeres*. My present series shows it to be the fourth, and also includes the third cervical, of which I give a side view in Pl. CII. fig. 1, with a similar view of the homologous vertebra in *Cereopsis* (ib. fig. 2) and *Tachyeres* (ib. fig. 4).

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[1] Twelve cervical vertebræ were collected by the Hon. Capt. Frazer in the Earnscleugh Cave, and are attributed to the same individual bird by Dr. Hector.

[2] It occurs in other groups of Aves; the illustration in my 'Anatomy of Vertebrates,' vol. ii. p. 40, fig. 25, is from a Pelican.

[3] Pl. LXVI. fig. 3. [4] Ib. fig. 4. [5] Ib. fig. 1. [6] Ib. fig. 2.

Besides size, the chief difference is in the greater relative breadth of the entire vertebra, and more especially of the neural arch (as shown in fig. 3, Pl. LXVI.). This breadth is due in the anterior fourth of the cervical region to a diapophysial ridge extending from the side of the præ- to that of the post-zygapophysis, near which the ridge (ib. fig. 1, *a*) stands out furthest, and has its margin thickened and roughened for tendinous attachment. In the middle third of the cervical region the diapophysis loses in antero-posterior extent of origin, but gains in length, or outstanding, and in greater thickness of its free border for muscular attachment. The eighth cervical, for example, is here 2½ inches in breadth. The outer surface of the base of the anchylosed cervical rib is strongly sculptured by irregular longitudinal ridges and furrows.

No Anserine comes near to *Cnemiornis* in this respect. Its cervical vertebræ recall the proportions of those in *Megaceros*, and have a like relation to the muscular powers brought to bear upon the head. In the extinct Anserine this probably related to the gripe and tug exercised by the broad, short, but strong beak upon the vegetable growths torn up for food.

The third cervical (Pl. CII. fig. 1), like the fourth, is broader than it is long. The hypapophysis is represented by a sharp ridge, 8 lines in length, at the hinder half of the centrum, terminating in a short tuberosity (ib. *hy*) projecting beyond the hinder articular facet. The parapophysial plate extends from the lower angle of the anterior articular surface of the centrum to the hinder half of that element, ascending upon its side, and forming the floor (ib. *p*) of a vertebrarterial canal, 10 lines in length, and 8 lines in diameter at the hinder outlet (*v*). The end of the rib-element (ib. *pl*) forming the outer wall of the canal is broken off. In the fourth cervical the neural spine is entire; it is also short and rounded, as in the third (fig. 1, *n s*); and more of the pleurapophysis is preserved. The hypapophysis has its base shortened to an extent of 5 lines; but its apex extends downwards, 3 lines below the hinder articular facet (*h*, fig. 2, pl. 63, *tom. cit.*).

The side view of the twelfth cervical vertebra (ib. fig. 6) shows the division of the hinder part of the vertebrarterial canal into two foramina (ib. *v*, *v'*) by the bony bar passing from the pleurapophysial plate backward and downward to the lower part of the side of the centrum. In *Cereopsis* (ib. fig. 9) and *Tachyeres* (ib. fig. 10) the vertebrarterial canal of the answerable vertebra has also two hinder outlets (*v* & *v'*); but the dividing bar passes from the hind border of the rib-plate upward to coalesce with the neural arch, and the upper outlet (*v'*) is much less than the lower one (*v*). The diapophysis (ib. fig. 6, *d*) projects freely, in *Cnemiornis*, above the longitudinal ridges: these alone mark the rib-prominence below the præzygapophysis in *Cereopsis* (ib.fig. 9) and *Tachyeres* (ib. fig. 10).

The vertebræ bearing freely-movable ribs are nine in number in *Cnemiornis*, of which the last three are anchylosed with the sacral mass. The rib of the first dorsal is free at the distal end; the centrum has a hypapophysial tuberosity at its fore part, the size of which is not definable by reason of fracture. The breadth of the anterior articular surface of the centrum is 1 inch 7 lines; its height at the middle is but 5 lines; this bilobed character is more strongly shown in the next.

The second dorsal presents a structure which seems not to have hitherto been noted in birds. Besides the median process (hypapophysis) (Pl. CII. fig. 11, *hy*) from the fore part of the under surface of the centrum, there is a pair of processes (ib. ib. *hl*, *hl*) from the sides of that part of the centrum, which part extends vertically below the anterior articular surface (ib. fig. 11, *c*, *c*) for an extent of from 2 to 5 lines, and is festooned below by the emarginations between the origins of the median (*hy*) and lateral (*hl*) inferior processes. This character is rudimentally indicated in the first dorsal vertebra of *Cereopsis* (ib. fig. 13, *hy*, *hl*); the processes (*hl*) are broader and more transversely extended in *Tachyeres* (ib. fig. 14). The articular surface for the tubercle of the rib is supported in *Cnemiornis* by a distinct process (ib. figs. 11 & 12, *dt*) from the under part of the base of the diapophysis (*d*). The process is feebly indicated in *Cereopsis* and *Tachyeres* (ib. fig. 14, *dt*). The length of the second dorsal vertebra in *Cnemiornis* from the postzygapophysis (z') to the broken end of the mid hypapophysis (*hy*) is 2 inches 4 lines. The length between the same points of the corresponding vertebra in *Cereopsis* is 1 inch. The rib has a short, straight sternal portion tied by ligament to the anterior small tubercle of the costal border of the sternum.

In the third dorsal (ib. figs. 15, 16) the hypapophysis (*hy*) extends its base the whole length of the centrum, and curves forward as it narrows to a trituberculate end, the mid tubercle projecting beyond the lateral pair (ib. fig. 16, *hl*, *hl*), and also beyond the vertical parallel of the joint between the third and second dorsal centrums. The upper spine (ib. fig. 15, *n s*) also curves forward, its anterior apex reaching the same vertical parallel as that below (*hy*). One or two longitudinal ridges strengthen the neural spine near its summit. The hypapophysis of the fourth dorsal (ib. fig. 17, *hy*) has a less extensive base, but equal length; it is also curved forward, as is the neural spine; but this is longer, and gains more antero-posterior breadth toward its truncate summit.

The fifth and sixth free dorsals cease to develop hypapophyses; their neural spines continue to gain in antero-posterior breadth. The principal pneumatic aperture in the dorsal vertebræ of *Cnemiornis* is at the base of the diapophysis (ib. figs. 15, 17, *d*), between the articular surfaces (ib. *pl* and *dt*) for the bifurcate head of the rib; in the cervical vertebræ it is at the base of the neural arch.

The ribs, both vertebral and sternal, increase in length; and epipleural appendages are attached to the former from the second to the seventh pair.

The chief things notable in the dorsal vertebræ of *Cnemiornis*, as compared with *Cereopsis* and existing Anserines, are the great breadth of the centrum in proportion to the length, the minor fore-and-aft extent of the neural spines in proportion to their height, the forward curvature of both upper and lower spines, and, above all, the absence of the osseous splints which connect together the summits of the neural spines and the diapophyses of a greater or less proportion of the dorsal series in all living and volant Lamellirostrals. The vigorous actions of flight need corresponding fixedness in the complex congeries of bones forming the centre whence the muscular forces converge to work the wings.

In Lamellirostrals, as in most other birds[1], the vertical convexity and transverse concavity of the anterior articular end of the centrum (Pl. CII. fig. 11, *c*, *c*) closely clasps the posterior surface with reverse curvatures of the next centrum before it; and this double interlocking runs throughout the series of movable dorsals. The zygapophysial surfaces (ib. *z*, *z′*) are large, and strongly connect together the neural arches of the dorsals. The pleurapophyses have two cup-and-ball joints with their vertebra, widely separate upon the bifurcate ends of the ribs. The bony hæmapophyses, or sternal ribs, have, for the most part, bilobed articular ends for a double joint with the costal border of the sternum (Pl. CIII. fig. 3).

Cnemiornis retains all these modifications, but has not the superadded strength gained by the bony beams passing from parts of one dorsal vertebra to the next; to which, in birds of strongest and swiftest flight, is superadded continuous anchylosis of certain neural spines of the segments of the thorax. *Cereopsis* shows the splint-like ossifications of the tendons of muscles inserted into the diapophyses and neural spines of the free dorsals; and this retardation of the ordinary Lamellirostral structure coexists with a development of wing, endowing the Australian Goose with the power of flight.

Sternum.

The sternum of *Cnemiornis* (Pl. CIII. figs. 1, 2, 3) is of an oblong-quadrate form, 7 inches long by 4 inches broad at the middle of the bone, expanding to 4 inches 9 lines in the present specimen across the anterior border.

This border shows three wide and shallow emarginations, the median one between the advanced angles (*a*, *a*) of the inner wall of the coracoid groove (*b*), the lateral ones between these and the costal processes (*d*, *d*), near which the emargination deepens.

From the median end of the outer wall of each coracoid groove the anterior ridged origins (*c*, *c*) of the keel converge backward to form the low, rather broad and flat beginning (*s*) of this instructive process. Its extreme depth or projection from the plane of the sternum does not exceed 3 lines; the breadth of its free border is 4 lines; and this is flat and roughened by transverse striæ for aponeurotic attachments. It loses breadth and depth as it retrogrades, and subsides (at *s′*) about 3 inches from the origins. Beyond the keel the body of the sternum retains somewhat of the convexity, transversely and lengthwise, which characterizes in a greater degree the carinate part of the sternum; but the terminal third of the bone becomes almost flat. It is truncate posteriorly, with

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[1] The exception, in *Aptenodytes*, is figured in 'Phil. Trans.' 1851.

rounded angles, retaining a breadth of 3 inches 3 lines at this end, which is devoid of the pair of notches characterizing, as a rule, the Anserine sternum[1].

Cnemiornis follows the rule of keelless, or rudimentally keeled, breast-bones of flightless fowl in the integrity of the bony shield. The length of each coracoid groove is 1 inch 6 lines, the greatest depth $1\frac{1}{2}$ line. From near the lateral end of the outer wall the pectoral ridges extend backward, slightly converging, but cease to be traceable after a course of 2 inches. The costal process (*d*) is quadrate, relatively thicker and more produced than in *Cereopsis* or *Tachyeres*. The outer surface, defined by a low curved ridge, is so smooth as to have suggested the remark at p. 242. The inner surface of the base of both right and left of these processes shows a large reticulate pneumatic vacuity.

The costal border indicates the same degree of longitudinal curve, convex outward, of the coextensive part of the breast-bone as in *Cereopsis*; but is relatively more extensive, and is traversed obliquely from within outward and backward by seven articular prominences for the sternal ribs. The five anterior of these are ridges expanded at the ends into articular tubercles; the sixth and seventh are represented by the inner tubercle only. A smaller tubercle (ib. fig. 3, *h* 1), in advance of the broad ridges, may afford attachment to the hæmapophysis of the second free rib. The breadth of this surface is shown in fig. 3. *Cereopsis* has but five articular prominences on each costal border. *Tachyeres* has seven, as in *Cnemiornis*. The outer surface of the sternum near the costal border is feebly concave transversely, before swelling into the convexity producing the hollow cavity of the anterior half of that bone next the thoracic abdominal cavity.

It would seem that a comparison with the view of tracing affinity within the limits of the Lamellirostaal group could not profitably be made between the almost keelless breast-bone of *Cnemiornis* and the deeply keeled ones in all existing members of such group; for even the sternum of the flightless Steamer-Duck has "the great development of the keel" which the experienced ornithologist Eyton adds to his osteological characters of the family Anatidæ[2]. However, there is a greater convex curve of the free border of the sternum in *Cereopsis*[3] than in *Anser cygnoïdes*[4] or in *Tachyeres*; and, in a small degree, this approximates *Tachyeres* and *Cereopsis* to *Ciconia*.

Limb-Bones.

The coracoid (Pl. CIII. figs. 4–7) accompanying the collection of *Cnemiornis* bones now described, is of the left side, and wants only the terminal expansion fitting to the

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[1] Eyton, 'Monograph on the Anatidæ,' 4to, 1838, pl. 1. figs. 7–11. *Clangula* (fig. 4) and *Fuligula* (fig. 5) agree with the Goosander (*Mergus serrator*) in the conversion of these notches into foramina. *Cereopsis* and *Tachyeres* adhere to the anserine type.

[2] Eyton, in his classical Monograph (4to, 1838, p. 5), follows Vigors in making "Anatidæ" (which suggests rather the tribe or subfamily of Ducks) the equivalent of Cuvier's well-conceived term "Lamellirostres."

[3] Id. Supplement to 'Osteologia Avium' (4to, 1869), pl. ii. *Cereopsis*.

[4] Ib. pl. 3.

sternal groove. The length of the bone which includes the beginning of this expansion is 3 inches 6 lines; the entire bone would be about 4 inches 6 lines in length. The extreme breadth at the middle of the shaft is 4½ lines. It is thus weaker and more slender than in *Cereopsis*, and longer in proportion to its sternal breadth than in *Tachyeres*. It also differs from the coracoid in these and other Lamellirostrals in the very slight production of the tuberosity *c* in advance of that (*b*) supporting the the articular surface (*a*) for the humerus. The tuberosity *c* is divided from *b* by a shallow groove (*d*) of less than half the width of the homologous one in *Cereopsis*; and the tuberosity *b* is not present in *Cereopsis*, or is represented (as in fig. 8, *b*) only by the produced margin of the relatively larger and deeper facet for the humerus. The process (*e*) joining the median facet of the scapular articular expansion is more produced, more terminally expanded, both lengthwise and transversely; the latter expansion inclines, as a curved lamella, toward the inner or anterior division of the tuberosity *c*, in advance of the humeral joint.

From the low scapular process in *Cereopsis* (Pl. CIII. fig. 8, *e*) a ridge of bone (ib. *f*) extends down to the middle of the coracoid, where it blends with the mesial border, leaving a narrow oblong interspace, 4 lines in length, near that border. This character is not present in the coracoid of *Tachyeres*. Such a vacuity (ib. fig. 5, *f*) exists in the coracoid of *Cnemiornis*; but its filamentary boundary is not continued from the scapular process (*e*, *e'*); it forms part, or is a continuation, of the sharp mesial border of the shaft of the bone; and the vacuity is a perforation of such border.

An intermuscular ridge (ib. fig. 5, *g*) is continued in *Cnemiornis* more directly from the tuberosity (*c*), but sooner subsides upon the shaft than in *Cereopsis*; it is resumed at the lower third of the shaft, but nearer the lateral border, and bounds the fore part of a flat, roughish, elongate tract, which has a continuation of the lateral border (ib. fig. 7, *j*) for its hinder boundary. Above this tract, the shaft of the coracoid is thicker in *Cnemiornis* than in *Cereopsis* and other Anserines. The hind surface of the sternal half of the coracoid is feebly concave; the sternal articular expanded end has been broken away in my specimen.

Although this coracoid is more slender, in proportion to its length, than in *Cereopsis*, it is thicker, and less flattened from before backward toward the sternal expansion. This proportion is still more characteristic of the coracoid of *Cnemiornis*, in comparison with that of *Tachyeres*, in which the whole shaft is more flattened than in *Cereopsis*.

The strength of the bone in *Cnemiornis* relates to its office in depressing the sternum in the respiratory movements of the bird.

In describing the humerus (*ante* pp. 242, 243) forming part of the collection of bones including a skull of *Dinornis robustus* and part of one of *Aptornis*, together with the tibia and other bones on which was founded the genus *Cnemiornis*, I stated that, "from the feeble development of its proximal processes," such humerus "had evidently belonged to some such flightless bird," and that "it bore nearly the same proportion to the sternum as does the humerus of *Notornis*."

As the humerus associated with a nearly entire skeleton of *Cnemiornis*, discovered by the Hon. Capt. Frazer in the interior of the province of Otago, New Zealand, presents clearly distinctive characters from the one figured in Pl. LXIX. figs. 7–10, I am now disposed to believe that it may prove to be the humerus of an *Aptornis*, probably *Aptornis defossor*.

Dr. Hector remarks that, in the humerus of *Cnemiornis*, "the tuberosity (XI *b*) representing the pectoral ridge is not so wide" as in that above described and figured by me. I am in some doubt as to the dimension referred to, whether, viz., the "width" of the pectoral process is meant for its basal extent, or the degree in which it projects from such origin. The marked and unequivocal distinction is that, in the humerus of *Cnemiornis*, of which I have had under inspection a right and left (Pl. CIV. figs. 1–6) since the reception of Dr. Hector's Memoir, the pectoral ridge (*d*) is continued directly from the ecto-tuberosity (outer or radial tuberosity), whereas in *Aptornis* (Pl. LXIX. fig. 7, *b*′) it is divided from that tuberosity (ib. ib.) by a shallow concavity nearly 1 inch in length.

The ento-tuberosity (inner or ulnar one) in *Cnemiornis* (Pl. CIV. figs. 1 & 2, *c*), instead of rising above the convex articular head (*a*) of the humerus as in *Aptornis* (?), does not attain its level; its expansion below such tuberosity for a pneumatic fossa (fig. 3, *p*), with its cribriform plate, is a more conspicuous distinction, as Dr. Hector has shown.

Notwithstanding, however, the several approximations which these characteristics of the humerus of *Cnemiornis* make to that bone in birds of flight, the almost keelless condition of the sternum, together with the dwarfed proportions of the humerus in comparison with those of the bones of the leg, the pelvis, vertebræ, and skull, confirm the conclusion, in which Dr. Hector accords with myself, that *Cnemiornis* was unable to fly.

The existence of the Flightless Duck (*Tachyeres brachypterus*; *Anas brachyptera*, Latham) has long been known; but the humerus in that species is as long as the tibia, and the power of flight is enjoyed by the young bird, and only lost when the bulk and weight of the adult frame is acquired[1]. It can hardly be supposed that flight was enjoyed at any age in a lamellirostral palmiped with a humerus of only half the length and less than half the thickness of the tibia.

It is half an inch less in absolute length than the humerus of *Cereopsis*; but the circumference of the shaft is one fourth greater in *Cnemiornis* (it is 1 inch 6 lines in *Cereopsis*, 2 inches in *Cnemiornis*); and the muscular impressions are throughout stronger.

The groove between the head (Pl. CIV. figs. 1–3, *a*) and the entotuberosity (*b*) is less deep in *Cnemiornis*: the pectoral ridge (*d*) is rather less produced, and is not so

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[1] As observed by Dr. Cunningham (Zool. Trans. vii. p. 493, pl. 60. fig. 43, humerus; pl. 62. fig. 62, tibia).

much bent forward. The ectocondyle (Pl. CIV. fig. 6, *e*) is broader in proportion to its length, the entotuberosity (ib. fig. 5, *c*) is more produced backward, and the pneumatic ridge (fig. 1, *o*) is more produced inward, in the humerus of *Tachyeres* than in that of *Cereopsis* and *Cnemiornis*. In these characters of the bone, the extinct flightless Anserine of New Zealand more resembles the Australian than the Magellan genus.

The ulna in my present illustrations of *Cnemiornis* belongs, like the coracoid, to the left side. It is entire (ib. figs. 7 & 8), is relatively shorter, but much thicker, than the ulna of *Tachyeres*, and is absolutely shorter, and relatively much shorter and thicker, than is the ulna of *Cereopsis*. It exceeds these bones in both species, as well as in any other existing Lamellirostral, in the definition and prominence of the parts of the exterior and convex surface of the shaft for the attachment of "secondary" quill-feathers and the "tectrices primæ." These marks are of two kinds, cavities and prominences. The cavities (fig. 7, *h*), fourteen in number, extend in a single series along the entire shaft: they are elliptical in shape, about 3 lines by 2 lines in dimension, more feebly impressed along the middle and distal end of the shaft, some touching each other, others with intervals of half a line or a line. The prominences (ib. *i*, *i*) are developed from a ridge, external to the cavities, beginning one fourth of the bone's length from its humeral end, and terminating opposite the penultimate cavity. The prominences, nine in number, are from 2 to 3 lines apart. The ridge (fig. 8, *c*) extending the articular cavity for the ulnar condyle of the humerus, and overhanging the surface of attachment of the "brachialis internus" is more produced and extensive than in *Cereopsis*. The olecranon (*e*) is relatively rather more produced; the rest of the proximal surface (fig. 9) closely accords with the anserine type. The surface (*f*) for the attachment of the lateral ligament, and the larger one below (*g*) for the insertion of the "brachialis anticus," are well defined; but the latter is less deep than in *Cereopsis*. Both articular terminal ends are less expanded in proportion to the shaft, and especially so the distal end, than in *Cereopsis*. The radial prominence is less produced.

My specimen of the composite bone called "metacarpus" (ib. fig. 10) is rather larger than the one figured by Dr. Hector, agreeing in this respect with the associated humerus. Like that wing-bone also, it is characterized by its breadth and thickness, which, in proportion to the length of the metacarpus, are much greater than in *Cereopsis* or *Tachyeres*.

The number and nature, or homologies, of the constituents of this bone were determined by its analysis in a young Ostrich, in my work 'On the Nature of Limbs' (1849), and in the description of the specimen No. 1367 in the 'Catalogue of the Osteological Specimens in the Museum of the Royal College of Surgeons' (4to, p. 265). The metacarpus in the Bird consists, like the metatarsus, of three metacarpal bones coalesced with each other and with part of the carpus. As the latter element is mainly and more directly in articular relation of support to the "medius" metacarpal (Pl. CIV. fig. 10, *m*, III), and at the same time presents a convex articular surface to the two non-confluent carpals of the proximal row, it answers to the "os magnum" (ib. fig. 10, *m*). The base of the metacarpal coalesced therewith is indicated, on the palmar side, by the prominence (III). The stunted "index" metacarpal (II) has coalesced by its entire length with the contiguous base of the "medius" metacarpal (III), and its supporting carpal (*m*). The head of the "annularis" metacarpal is likewise indicated by the prominence (IV) on the sternal side, where it has coalesced with the contiguous part of the base of the "medius" (III). From this attachment the shaft of IV bends slightly ulnad, and then runs parallel with an interspace about 1½ line in breadth to near the distal end, which again coalesces with that of the "medius." This coalescence is chiefly along the thenal side of the bones; on the opposite, anconal, or dorsal side the primitive separation is shown by a groove.

The head of the index metacarpal (fig. 10, II) is more tumid, but less extended radiad, in *Cnemiornis* than in *Cereopsis*; and the distal articulation (II') for the proximal phalanx of the index digit is less definite: such rudiment of that finger (commonly called the "thumb" by ornithologists) was probably tied by ligament to its metacarpal.

The tendinal groove impressing lengthwise the anconal surface of the shaft of the mid metacarpal is less marked in *Cnemiornis* than in *Cereopsis*. The distal articulation (fig. 11) is similar in both: it is quadrate, flattened on the radial half, and swelling into a condyle on the ulnar half. The distal articular surface of the "annularis" metacarpal (IV') shows more of the typical form, viz. two narrow condylar convexities, with a trochlear depression between them.

I have not recognized phalanges in either series of *Cnemiornis* remains which have reached me, and have restored them in the figure of the entire skeleton (Pl. XCV. fig. 1) according to the analogy of *Cereopsis*—the radial digit or index (II) being represented by a proximal phalanx, the median digit (III) by three phalanges, and the annular digit (IV), again, by the proximal phalanx only.

To the characters of the pelvis described and figured in my former monograph I am able to add, through Dr. Hector's description, the configuration of the entire part, as shown in the restoration of the skeleton (ib. fig. 1). The ischium, of which the slender continuation from the acetabulum was shown in fig. 7, 63, of Pl. LXVII., loses thickness and gains vertical breadth as it recedes, and, coalescing with the hind end of the ilium, circumscribes a great ischiadic foramen, of an oval figure, nearly 3 inches long by 1 inch deep. The pubis unites with the end of the ischium, a "foramen ovale" intervening nearly 5 inches in length and 10 lines at the broadest part, with the canal for the passage of the "obturator internus" tendon[1], indicated, as usual, by a low process rising from the upper border of the pubis, and a corresponding one descending from the opposite part of the beginning of the ischium. Both processes are present in *Cereopsis*, as in *Cnemiornis*; but only the upper or ischiadic one marks out the "obturator" notch

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[1] "Myology of Apteryx," *ante* pp. 41-64, Pls. X.-XV.

in *Tachyeres*[1]. A second small vacuity weakens the ilium above the hind part of the ischiadic foramen in *Tachyeres*, as in the White-eyed Pochard (*Anas leucophthalmus*)[2]; but this character is not present in *Cnemiornis* or in *Cereopsis*. The proportion in length of the preacetabular to the postacetabular parts of the pelvis is greater in the two last-named genera than in *Tachyeres*.

I have nothing to add to the characters of the femur, tibia, and fibula illustrated in a previous Section (pp. 243–245). The excessive development of the combined pro- and epi-cnemial processes, which suggested the affinity or resemblance to *Colymbus*, we now know to have been possessed by a species of another family of web-footed birds. The great extinct Anserine of New Zealand may have kicked its way through the dense element with a vigour and speed that would have arrested the attention of navigators more strongly, perhaps, than such action in the smaller non-volant Lamellirostral which has thereby got the name of "Steamer Duck."

The three digits whose metatarsal bones coalesce to form the "metatarsus" in birds are homotypes of the three metacarpals similarly fused together in the wing, viz. the second, third, and fourth. The first, sometimes wanting, but more commonly present, keeps its rudimental metatarsal element free in all species with the back toe. The rough slightly depressed surface above the entotrochlea shows the usual anserine position of attachment of the back toe in *Cnemiornis*.

The metatarsus of *Cnemiornis* (Plate CIV. fig. 12) yields well-marked evidence of its closer affinity to *Cereopsis* than to *Tachyeres* or other Lamellirostral genera. In these the entotrochlea, or that distal condyle which supports the second or innermost[3] of the three anterior toes, is given off from the composite bone at a higher or more proximal level than the other two trochlear condyles (ib. fig. 14, II): it also projects much more backward than the other condyles. In *Cereopsis* the entotrochlea (ib. fig. 13, II) comes off at a lower level, nearly that of the ectotrochlea, and projects but a short way behind the line attained by the hind part of the mesotrochlea, this terminating a little behind that reached by the ectotrochlea. Thus, in *Cereopsis*, the three trochleæ are more in accordance with the ordinary pattern in non-natatorial birds; and this is precisely the character by which *Cnemiornis* departs from the web-footed order in the

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[1] According to Mr. Smit's figure of the pelvis of the Steamer Duck in Trans. Zool. Soc. vol. vii. pl. 62. fig. 59: the originals, collected at the cost of the nation in a Government expedition, have not found their way to the National Museum of Natural History. On special application to the naturalist of the expedition of H.M.S. to the Magellan's Strait, some bones of an immature *Tachyeres* have been sent by him to the British Museum since the penning of the present paper.

[2] *Nyroca*, Flem.; see Eyton, 'Monograph on the Anatidæ,' 4to, 1838, p. 63, and plate.

[3] M. Alphonse Milne-Edwards, describing the metatarse of *Cereopsis* in his 'Recherches pour servir à l'histoire naturelle des Oiseaux Fossiles,' 4to, 1867, writes of the "trochlées digitales:"—"l'externe, au lieu d'être fortement rejetée en arrière, comme dans les autres Anatides; se trouve presque sur le même plan que la médiane" (p. 80). I find the "ectotrochlea" (supporting the outer five-jointed toe) to have its hind border a little anterior to the plane of that of the mesotrochlea, while the entotrochlea projects as much behind that plane, but in a markedly less degree than does the internal trochlea in *Tachyeres* and other Anatidæ.

structure of its metatarse. The entotrochlea comes off at the same transverse line with the ectotrochlea (Pl. LXX. figs. 1 & 3), and shows but a feeble trace of the anserine backward production of the internal trochlea, as shown in the side view of the bone given in the present Section (Pl. CIV. fig. 12). The metatarse in *Tachyeres* conforms to the rule in Anatidæ, the innermost digital trochlea not only diverging from the confluent shafts at a higher level but being produced more backward than the other two trochleæ (as shown in the side view given in fig. 14, Pl. CIV.).

Conclusion.

The sum of the comparisons instituted in the foregoing descriptions of parts of the skeleton of *Cnemiornis* with corresponding parts in *Cereopsis* and in *Tachyeres* weighs strongly in favour of the nearer affinity of the non-volant Anserine of New Zealand with the feebly flying Goose of Australia than with the non-volant Duck of Magellan's Strait. This is more especially exemplified in the pelvis, the metatarsus, and the skull. The characters of shortness, breadth, and obtuseness of the beak which generically distinguish *Cereopsis novæ hollandiæ* were exaggerated in *Cnemiornis*, and lead me to infer a similarity of diet and terrestrial habits[1] in the gigantic goose of New Zealand.

In the 'American Journal of Science and Arts,' vol. xlix. no. 146, March 1870, Professor O. C. Marsh reports the acquisition, from "the greensand of New Jersey," of "a portion of the shaft and distal extremity of a left tibia which indicates a species, apparently, of a swimming bird nearly as large as the common wild Swan (*Cygnus americanus*, Sharpless)" (p. 206). "The condyles of the distal end are broader anteriorly than deep, the inner condyle being more prominent in front, and the outer one projecting somewhat further behind. The intercondyloid space is wider than either condyle." "The supratendinal bridge is well ossified;" "it is submedian in position, straight, transverse, of moderate width, and spans a deep and well-defined canal, which was traversed by the extensor tendon of the toes." "The under trochlear surface is but slightly concave transversely, and has a faint median elevation, as in the tibia of the Swan." But this elevation is present in birds of other genera, families, and orders: it is shown in many of my illustrations of the bone; and I may refer to Pl. XLII. fig. 2, where it is indicated in the tibia of *Dinornis gravis* by the letter *u*. With regard to another alleged anserine character, I may remark that in every bird with the "supratendinal bridge well ossified," I have found it spanning a canal that might be called "deep and well-defined," and "which was traversed by a tendon;" but this I have found to be, in Anserines as in other birds, the tendon of the "tibialis anticus" (*ante*

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[1] Mr. Yarrell has recorded his observation that the *Cereopsis*, like the semipalmated Goose, "passes much of its time on land," 'Proceedings of the Committee of Science and Correspondence of the Zoological Society of London,' 8vo, p. 25 (January 1831).

p. 61, Pl. XIV. 8)[1], not "the extensor tendon of the toes." Professor Marsh admits that the lower part of his fossil tibia "has little of the marked inward curvature characteristic of swimming birds, but is so straight that its median plane, if continued, would divide the trochlear surface nearly equally" (ib. p. 207). He further states that "the outer margin of the canal is low and obtuse, as in most of the Gallinaceous birds" (ib. p. 206), that "on the lower surface of the inner condylar ridge there is a shallow notch, resembling in shape and position that in the tibia of some Gulls" (ib.), and that "the shaft curves forward slightly just where it begins to expand above the lower condyles, closely resembling in this respect the tibia of the Turkey" (ib. p. 207).

Nevertheless on this portion of bone is founded the genus *Laornis,* of the order Natatores, bearing "a strong resemblance in many respects to the Lamellirostres and also to the Longipennes, but differing essentially from the typical forms of both these groups."

With all respect to the learned Professor of Paleontology in Yale College, I would express the strong wish felt, with myself, by many of my fellow labourers in that science, that he would accompany his descriptions, notices, and names of new genera and species of extinct animals with figures, of the natural size, of the fossils on which such are founded. Casts would be still more acceptable for European comparisons. In relation to the subject of the present memoir it is plain that if the fossil tibia, "nearly as large" as that of a Wild Swan, prove to be really anserine, it cannot be referred to the genus *Cnemiornis* of 1865.

The species representing this anserine genus was about the same size as, or, rather, exceeded, its contemporary, also now extinct, the ralline *Aptornis defossor.* Both equalled in bulk the smaller species of Cassowary. The height of the back of *Cnemiornis* above the ground probably exceeded 2 feet; and the length of its body from beak to tail must have been at least 3 feet.

DESCRIPTION OF THE PLATES.

PLATE CI.

Fig. 1. Side view of skull of *Cnemiornis.*
Fig. 2. Back view of ditto.
Fig. 3. Upper view of ditto.
Fig. 4. Under view of ditto.
Fig. 5. Upper view of mandible.
Fig. 6. Side view of skull of *Cereopsis.*
Fig. 7. Back view of ditto.
Fig. 8. Upper view of ditto.
Fig. 9. Under view of ditto.
Fig. 10. Upper view of mandible.
Fig. 11. Back view of base of maxilla of *Cnemiornis.*
Fig. 12. Prefrontal portion of cranium of ditto.

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[1] See also 'Anat. of Vertebrates,' ii. (1866) p. 108, and Alphonse Milne-Edwards, 'Oiseaux Fossiles de la France,' 1867, 4to, pl. 7. figs. 1 & 2, 13, 13' (tibial antérieur).

PLATE CII.

Fig. 1. Side view of third cervical vertebra, *Cnemiornis calcitrans.*
Fig. 2. Idem of ditto, *Cereopsis.*
Fig. 3. Under view of ditto, ditto.
Fig. 4. Side view of ditto, *Tachyeres brachypterus.*
Fig. 5. Under view of ditto, ditto.
Fig. 6. Side view of twelfth cervical vertebra, *Cnemiornis calcitrans.*
Fig. 7. Front view of twelfth cervical vertebra, *Cereopsis.*
Fig. 8. Idem of ditto, *Tachyeres brachypterus.*
Fig. 9. Side view of ditto, *Cereopsis.*
Fig. 10. Idem of ditto, *Tachyeres.*
Fig. 11. Front view of second dorsal vertebra, *Cnemiornis calcitrans.*
Fig. 12. Under view of ditto, ditto.
Fig. 13. Front view of ditto, *Cereopsis.*
Fig. 14. Under view of ditto, *Tachyeres.*
Fig. 15. Side view of third dorsal vertebra, *Cnemiornis.*
Fig. 16. Front view of ditto, ditto.
Fig. 17. Side view of fourth dorsal vertebra, ditto.

PLATE CIII.

Fig. 1. Under view of sternum, *Cnemiornis.*
Fig. 2. Front border of ditto.
Fig. 3. Costal border of ditto.
Fig. 4. Inner view of coracoid.
Fig. 5. Outer view of coracoid.
Fig. 6. Scapular end of ditto.
Fig. 7. Side view of ditto.
Fig. 8. Outer view of coracoid, *Cereopsis.*

PLATE CIV.

Fig. 1. Anconal view of humerus, *Cnemiornis.*
Figs. 2 & 3. Views of proximal half of ditto.
Fig. 4. View of distal half of ditto.
Fig. 5. Proximal articular end of ditto.
Fig. 6. Distal articular end of ditto.
Figs. 7 & 8. Views of left ulna, ditto.
Fig. 9. Proximal articular end of ulna.
Fig. 10. View of metacarpus.
Fig. 11. Distal articular end of ditto.
Fig. 12. Side view of metatarsus.
Fig. 13. Idem, *Cereopsis.*
Fig. 14. Idem, *Tachyeres brachypterus.*

N.B. All the figures of the preceding Plates are of the natural size.

PLATE XCV.

Fig. 1. Restored skeleton of *Cnemiornis calcitrans.*
Fig. 2. Skeleton of *Cereopsis*, reduced to the same scale.

RESTORATION

OF

DINORNIS GRAVIS.

IN preceding Memoirs the characters of a species of *Dinornis* distinct from those at that date determined were deduced from the skull (p. 280, Pl. LXXXI.) and principal bones of the hind limb (p. 347, Pls. XLI. XLII.).

Subsequent discoveries of answerable bones in other localities have exemplified repetitions, not to say constancy, of the differential characters above pointed out; and in the Glenmark Swamp these bones were found associated with so large a proportion of the skeleton, as to permit that framework of the extinct bird to be articulated. From the specimens above alluded to, aided by photographs of the articulated skeleton kindly transmitted to me by Dr. von Haast, F.R.S., and reproduced in Plate CX., I am enabled in the present section to supplement my former evidences of the species.

As regards the free and movable vertebræ, or those between the skull and pelvis, the numerical formula of *Dinornis gravis* is that of the genus, viz. 15 cervical, 7 dorsal; and of the latter, the hæmapophyses (sternal ribs) of the second and third dorsals join directly their coalesced spines. This mass, called 'sternum,' shows the dinornithic characters of the bone—the straight anterior border between the costal processes, the short costal tract, the small and ill-defined coracoid depressions, the pair of deep and wide hind notches, with the smaller median notch. In the costal tract two ridges for articulation with sternal ribs divide the intercostal depressions. The parts of the sternum circumscribing externally the hind notches, which boundaries represent the backward continuation of the outer marginal portions of the body of the sternum, are reduced by the extent of the unossified portions of the body of the bone to the character of processes, and are defined as 'lateral processes' in preceding Memoirs[1]. These in *Dinornis gravis* are more slender in proportion to their length than in *Dinornis robustus*, but less so than in *Dinornis rheïdes*; in this respect, as in their degree of

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[1] They are homologized with the xiphoid appendage of the mammalian sternum by Prof. Mivart, and termed by him the 'lateral xiphoid processes' in his Memoir on the axial skeleton of the Ostrich, Trans. Zool. Soc. vol. viii. p. 447.

divergence, they are intermediate between *Dinornis ingens* and *D. robustus.* The extremes of sternal modifications and the intermediate gradations in the Dinornithidæ are exemplified in the cut, fig. 35, p. 419.

The pelvis of *Dinornis gravis* includes a sacrum of seventeen vertebræ, of which the two anterior ones support movable ribs.

The axis vertebra has a low antero-posteriorly extended neural spine, and a somewhat more produced but thinner and axially shorter hypapophysis from the hinder part of the under surface of the centrum.

In the third cervical the neural spine is bifid, and the hypapophysis is reduced in size. This process disappears in the fourth cervical; and processes for muscular attachments from the under surface of the centrum begin to be developed from the attached base of the parapophysis at the sixth cervical. They form a pair of processes which, as the cervical vertebræ recede in position, approximate and seem to be represented in the fourteenth cervical by a single low hypapophysis in the centre of the under surface of the vertebral body. The serial homologue of this process recedes in position and gains in length in the last cervical, here resuming the character it manifests in the second and third of the cervical series. The hypapophysis gains in length both longitudinally and vertically in the first dorsal; in the fourth the base of the process is coextensive with the under surface of the centrum; in the fifth dorsal it subsides midway, and on the sixth the hypapophysis disappears.

The length of the dorso-sacral series of vertebræ, which represent the vertebræ of the trunk, equals that of the combined tibia and metatarse. In *Dinornis casuarinus* and *Dinornis gracilis* the trunk-series is shorter than those limb-bones: in *Dinornis elephantopus* and *Dinornis crassus* the reverse proportions obtain.

Since the above notes were written I have been made acquainted, through the kindness of Capt. F. W. Hutton, C.M.Z.S., with the discovery of additional evidences of the present species of *Dinornis* in a swamp near Hamilton, province of Otago, South Island.

Of these remains, now in the Museum of Natural History, Otago, Capt. Hutton writes:—"*D. gravis* also appears to me to be a good species, although the tibia approaches very closely to that of *D. casuarinus*, but is more robust, the length being only about three and a half times the circumference of the middle of the shaft, while in *D. casuarinus* it is more than four times the circumference. The measurements, however, given by Dr. Haast (Trans. N. Z. Inst. i. p. 86. no. 13) of bones found *in situ* in the Glenmark Swamp appear to connect *D. gravis* with *D. crassus.* In the swamp at Hamilton the bones were so confusedly mixed together that in the whole collection I have only two leg-bones that I am absolutely certain belonged to the same bird. They belong, I consider, to *D. gravis*, although larger than those figured by Professor Owen; their dimensions are as follows:—

	Metatarsus. inches.	Tibia. inches.
" Length	8·25	18·5
Circumference at middle	6·0	5·25
Breadth, proximal	3·7	5·6
" middle	2·33	—
" distal	4·9	3·0
Thickness, middle	1·2	—"[1]

Additional discoveries reaching the able hands of such observers as Dr. Haast and Capt. Hutton will lead, most probably, to the desirable knowledge of the extent of variation in the species by them recognized and confirmed; and there seems to be a probability of the determination of the sexual characters of such established species, as exemplified by size and strength of the limb-bones.

The height of the skeleton in the ordinary easy standing position of the bird is 4 feet 2 inches; the length of the trunk (dorsal and sacral series of vertebræ) is 2 feet 3 inches; the length of the hind limb, following the angles of the segments, is 3 feet 7 inches; the total length from point of beak to end of tail, following the curves, is five feet 6 inches.

DESCRIPTION OF THE PLATE.

PLATE CX.

Fig. 1. Side view of the skeleton of *Dinornis gravis.*

Fig. 2. Front view of the same skeleton. (From photographs of the articulated skeleton in the Museum of Natural History, Christ Church, province of Canterbury, South Island of New Zealand.) The scale introduced in the Plate exemplifies the admeasurements above given.

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[1] Trans. New Zealand Institute, vol. vii. 1875, p. 275.

RESTORATION

OF

DINORNIS ROBUSTUS.

Of the species *Dinornis robustus*, the numerous evidences accumulated in the Museums of Wellington, of Christchurch, and of Otago have confirmed the conclusion from the first received remains (*ante* pp. 127, 151, 187). The chief materials of the restored skeleton figured in Plate XCVI. were obtained by Edmund Gibson, Esq., of Oawaru, Dunedin, South Island of New Zealand, from some 'gold-prospectors,' by whom it was discovered. They came upon the bones " imbedded in a drift of almost impalpable sand overlying the 'older gold-drift' in the Manuherikia valley " (*ante*, p. 156). The parts of the bones where the overlying sand was not of sufficient depth to protect them from atmospheric influences were bleached and weather-worn ; but the more deeply imbedded bones and parts of bones seemed " as fresh as if the bird had only been killed a few months; on several of them cartilages and ligaments were remaining, while on the sacrum there was a large piece of skin set with feathers. The skeleton was accompanied by several bones of the young bird, and by fragments of the shell of the egg, thus indicating that the parent bird was brooding over its young when overwhelmed by the sand-drift "[1].

Of the skeleton of this bird, the sex of which, considering the share of incubation which the male takes in some large existing *Struthionidæ*, cannot be confidently inferred, the cranium (Pls. LXIV. and LXV.), scapulo-coracoid arch (Plate LXIV. figs. 2, 3, 4), integument of the foot (Plate LXXI.), and remains of the feathers (Plate CXIV. figs. 7–9) are described in other sections of this work (pp. 248, 262).

By means of additional materials I estimate the number of the cervical vertebræ, five or six of which are wanting at the beginning of the series in the York specimen, to be fifteen. Their characters and modifications closely accord with those detailed in the description of that part of the skeleton of *Dinornis maximus*.

The dorsal vertebræ are seven in number, of which the ribs of the second and third

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[1] Notes accompanying the bones which were transmitted by Mr. Gibson to his brother, Dr. Gibson, of York, by whom they were presented to the Museum of the Philosophical Society of that city.

distinctly and separately articulate with the sternum; those of the fourth dorsal less distinctly than is shown in Plate XCVI. As a rule, I believe their sternal portions join those of the third pair, as the sternal portions of the fifth pair are terminally attached to those of the fourth pair.

The sternum (Plate XCVI. figs. 2 and 3) shows two well-defined ridges for the articulation of sternal ribs on each of the short costal borders. The angle in advance is feebly notched for the articulation of the coracoid, which, with the confluent scapula, is indicated *in situ* in the side view of the sternum in figure 1. The anterior surface of the sternum is shown in figure 2, and the under or outer surface in figure 3. The lateral processes are less slender and more divaricated than in *Dinornis rheïdes* (Plate LXXIII.), more slender and less divaricated than in *Dinornis elephantopus* (Plate LXXII.). The lateral notches are shallower and wider than in *D. rheïdes*, deeper and narrower than in *D. elephantopus*. The postmedial notch is well marked, but there is no foramen or vacuity in the body of the sternum of *Dinornis robustus* as in that of *Dinornis rheïdes* (at least in the subject figured in Plates LXXIII. and LXXIV.). On the whole, the sternum of *D. robustus* most resembles that of *D. maximus*; but its ossified portion, or body, is longer in proportion to its breadth, as are the lateral and middle processes, if we may so call the portions bounding the two angular unossified tracts of the sternum. The notch at the apex of the mid-production is deeper and shallower than in *D. maximus*. The sternum of *D. giganteus* and *D. ingens* I have not seen.

The sacrum of *Dinornis robustus* (Plate XCVI. fig. 4) includes, as in *D. maximus* (Plate CXIV. fig. 2), seventeen vertebræ. Of these the ribs of the first and second retain the movable joints with the centrum; those of the third sacral are anchylosed and shortened; those of the fourth are still shorter, and terminally coalesce with the antecedent ribs and with the ilium. After the eighth sacral the ribs are suppressed; they are resumed (as parapophyses) in the eleventh and following sacrals.

The portion of the Moa chick's skeleton found with that of the (seeming) parent included, with some other parts, the pelvis, sternum, and scapular arch.

The sacrum, of which the structure in the mature bird is described in a larger species (p. 420), is formed, not only by certain caudal vertebræ, united with one another and with an antecedent sacral, but by anterior vertebræ bearing, as in the 'dorsal' ones, free ribs, and by others having shorter coalesced ribs, as in 'lumbar vertebræ.' If a name should be required by anatomy for the vertebræ massed together in the full-grown bird to form the 'sacrum' and anthropotomically 'sacral,' by the character of such anchylosis, then 'dorso-sacral,' 'lumbo-sacral,' 'sacral proper,' as well as 'urosacral,' are terms needed to express correctly the vertebræ which go "to form the 'sacrum' of a bird"[1]. The ilium, ischium, and pubis of the right side of the immature pelvis are figured in Plate CXV. fig. 6. The ischium and pubis have coalesced; the ilium retains its distinct-

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[1] See Proc. Zool. Soc. April 11, 1867, p. 422, and the supposed osteological characters of *Dinornis*, p. 423.

ness. The ischium sends upward a short and thick acetabular process above the fore end, which expands to contribute to the articular cup for the femur. The lower part of this expansion has coalesced with the acetabular end of the pubis. The inferior process of the ischium, marking off the anterior portion of the 'obturator vacuity' for the passage of a tendon, is feebly indicated: behind this the ischium is laterally compressed and vertically expanded; the pubis retains its styliform character to the hinder end. This, in the adult bird, coalesces with that of the ischium; but the ischium does not coalesce with the hinder end of the ilium, as it does in the Emu (*Dromæus*). The ischiadic notch remains open, as in *Apteryx* (comp. Plate XCVI. fig. 1, with Plate VIII.).

The collected bones of the same immature *Dinornis robustus* included the left moiety of the sternum, to the figure of which, in Plate CXV. fig. 8, I have added in outline the entire bone as indicated at this period. I infer that, as in the *Apteryx* (p. 69), the sternum is ossified from two centres, forming a pair, from which, as they coalesce at the middle line, ossification extends into the postmedial portion, simulating a 'xiphoid cartilage.' The ossified half of the sternum of the chick of *D. robustus* showed the costal process, the costal border, and the lateral process. The scapula and coracoid of the same chick had coalesced (ib. fig. 7; the longer scapular portion is inadvertently turned downward); and it is not devoid of significance to note that the proportion of this arch to the sternum is greater in the chick or embryo than in the adult bird. It would seem that the development of the support of the wing-bone was arrested.

The skeleton of *Dinornis robustus*, as restored in Plate XCVI., shows a height of 8 feet 6 inches; but the trunk is raised, and the neck outstretched somewhat beyond the pose of easy station. In such a position as that of the skeleton of *Dinornis rheïdes* (Plate CIX.) the *D. robustus* would barely reach 8 feet in height.

DESCRIPTION OF THE PLATE.

PLATE XCVI.

Fig. 1. Side view of the skeleton of *Dinornis robustus*.
Fig. 2. Front border of sternum, with two sternal ribs of the left side.
Fig. 3. Under or outer surface of the sternum, with two right and one left sternal ribs.
Fig. 4. Under or inner surface of the pelvis.

(All these figures are reduced to the scale of feet and inches in the margin.)

RESTORATION

OF

DINORNIS MAXIMUS.

THE indications in a former section (pp. 250–253) of an established form of *Dinornis* surpassing in size those to which the names *Dinornis giganteus* and *Dinornis robustus* had been applied have been strengthened by later discoveries, which equally justify the term *maximus*, and have contributed to the present restoration of that huge species or propagable variety.

Osseous remains, agreeing in their dimensions or proportions with those figured in Plates LXXIX. and LXXX., have been disinterred, chiefly from that notable locality "Glenmark Swamp," in the province of Canterbury, New Zealand; and the abundance of the evidences of this hugest of known birds (recent or extinct) afforded Dr. Haast the materials for a proposition of exchange, in effecting which I obtained a series of bones of the *Dinornis maximus* which permitted the articulation of the skeleton figured in Plate XCVII., and now in the National Museum of Natural History.

In the present summary of the osteology of the species I shall supplement the former Memoir by details of the vertebral structures. These I propose to combine with comparisons of the homologous bones in the largest living wingless bird, *Struthio camelus* —to which end the admirable and usefully illustrated monograph by Professor Mivart, F.R.S., "On the Axial Skeleton of the Ostrich"[1], lends peculiar facilities.

In these comparisons I adopt most of the technical terms of aspect and position proposed by Prof. Mivart, in addition to my own, and I subjoin, for the convenience of students, their vernacular equivalents:—

preaxial = fore, anterior;
postaxial = back, hind, posterior;
dorsal or *neural* = upper;
ventral or *hæmal* = lower, under;
neurad = upward;
hæmad = downward;

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[1] Trans. Zool. Soc. vol. viii. p. 385.

antero-posterior or *prepostial* = longitudinal, fore-and-aft;
dorso-ventral or *neuro-hæmal* = vertical, high, deep;
lateral = side.
medial = relating to the middle line or mid-vertical longitudinal plane of the body.

ATLAS, or FIRST, VERTEBRA (natural size).

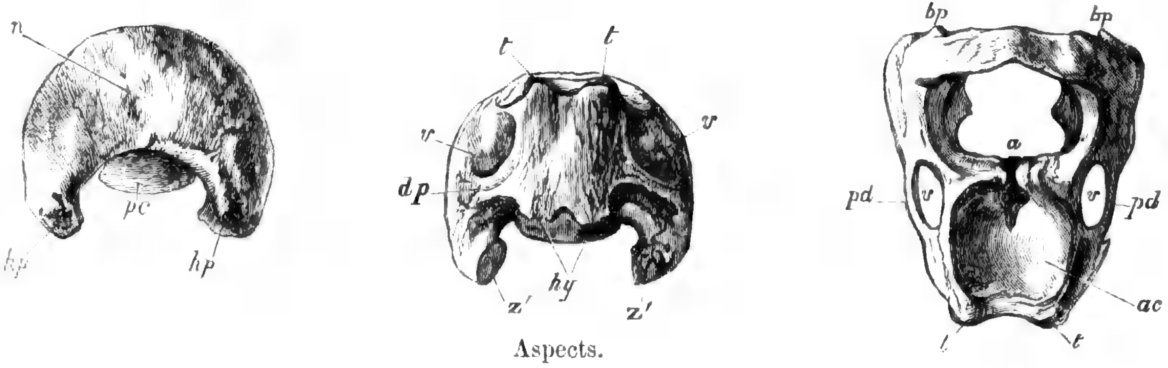

Fig. 1. Fig. 2. Fig. 3.

Aspects.

Fig. 1, neural (or dorsal); 2, hæmal (or ventral); 3, preaxial.

The atlas vertebra of *Dinornis robustus* is described and figured (p. 169, Pl. LXII. figs. 4, 5, 6). To the three figures there given, answering to the 2nd, 3rd, and 4th in Mivart's Memoir[1], I here add views of the neural or dorsal, fig. 1, of the hæmal or ventral, fig. 2, and of the 'preaxial,' fig. 3, surfaces of the atlas of *D. maximus*, to complete the comparative illustrations of the bone in the genus *Dinornis*.

The preaxial articular cup (fig. 3, *ac*) for the occipital condyle is formed in great part by the hypapophysis (simulating the centrum), the neural vacuity being supplied by the true centrum of the atlas ('odontoid process,' fig. 4, *ca*): the sides of this vacuity are formed by a pair of articular surfaces developed on the atlantal neurapophyses, homotypal with the prezygapophyses in the succeeding vertebræ. The vacuity is progressively encroached upon by the growth of the prezygapophyses, and, in the atlas of the aged individval of *Dinornis maximus* (fig. 3), it is reduced to the chink *a*. The neurapophyses have met and coalesced above the neural canal, which was not the case in the atlas of the younger, but full-grown, subject of *D. robustus* (*loc. cit.*).

Assuming the atlas of *Struthio camelus*[2] to have been from a full-grown and mature individual, a similar confluence of the neurapophyses having taken place, the following differences are chiefly notable between it and the corresponding vertebra of *Dinornis maximus*. In the Ostrich the antarticular vacuity (not marked in Mivart's figures), answering to *a* in fig. 3, remains much more widely open; the hypapophysial surface

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[1] *Tom. cit.* p. 388.

[2] *Tom. cit.* p. 388, figs. 2–6.

(*ac*) is less deep in proportion to its breadth; its lower border has not the pair of low tubercles (fig. 3, *t*, *t*); the hæmal surface of the hypapophysis is produced downward and backward into the *quasi*-hæmal spine, *hy* (Mivart, figs. 2–7); this is not present in *Dinornis*, but is replaced by a pair of low tuberosities, fig. 2, *hy* (which productions served for the attachment of the 'longus colli'[1]), as in *Apteryx*, but are variable. The difference between *Dinornis* and *Struthio* in the relative size of the vertebrarterial foramina *v* is well marked; the larger size of the canal in *Dinornis* relates to its better-developed brain: the roof of the neural canal is relatively less extended from before backward in *Struthio*; it is convex, rough or irregular in surface, with a feeble indication of a medial ridge at the fore part in *Dinornis* (fig. 1, *n*), and with a hyperapophysis (ib. *hp*) as a low tuberosity above each postzygapophysis.

The postaxial articular surface presents, in *Dinornis*, a subquadrate convexity, and is not flat transversely in the present species or individual: the upper shortest border is moderately concave; the lower longest border is framed, as it were, by a backwardly extended ridge, of which the pair of tubercles (fig. 3, *t*, *t*) form part. The postzygapophysial facets (*z′*, *z′*, fig. 2) look more obliquely backward than in *Struthio*, where their aspect is almost wholly inward or 'mediad.'

In the general though slight convexity of the postaxial articular surface of the atlantal hypapophysis, in the slenderness of the pardiapophysial bar (fig. 3, *pd*), defining outwardly the vertebrarterial canal, and in the parial disposition of the hypapophysial tubercles, the atlas of *Dinornis elephantopus*[2] in the main agrees with that of *D. robustus* and *D. maximus*.

In *Struthio* the neural arch has a less relative antero-posterior breadth, and the same proportional difference prevails in the *quasi*-centrum; the processes, *t*, *t*, in fig. 2, are not developed; the preaxial cup has a wider upper emargination.

The length of the axis in *Dinornis maximus* (fig. 4) is about four times that of the atlas, and equals about 2½ inches. The preaxial surface of the centrum (fig. 5, *cx*) is twice as broad as high, and is concave transversely, but less deeply than it is neuro-hæmally. It is not prolonged neurally, as in the Ostrich, "on to each side of the base of the odontoid process"[3]; a slight non-articular concavity separates it on each side from the convex articular surface on the under part of the odontoid (figs. 4 and 7, *ca*, *o*). This surface is convex, narrower and more produced than in the Ostrich[4]. The postaxial surface (figs. 4 and 6, *pc*) has reverse proportions to the preaxial one, the longest diameter being vertical. It is divided into a pair of narrow vertically concave facets by a still narrower medial tract, the transverse contour being thus rather angular than, as in *Struthio* and most birds, convex. The under border is nearly straight, and the transverse extent of the neural margin slightly exceeds that of the hæmal one.

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[1] P. 49, Pl. XIII. fig. 2 and Pl. XIV. *a*.

[2] P. 232.

[3] Mivart, *loc. cit.* p. 391.

[4] Ibid. fig. 12, *o*.

The articulation slopes downward and backward. The hypapophysial process (figs. 4, 5, 6, 7, *hy*) is relatively more produced hæmad than in *Struthio*, and descends vertically and slightly backward from the postaxial surface, thus adding to the length of the vertebra.

AXIS, or SECOND, VERTEBRA (natural size).

Fig. 4.

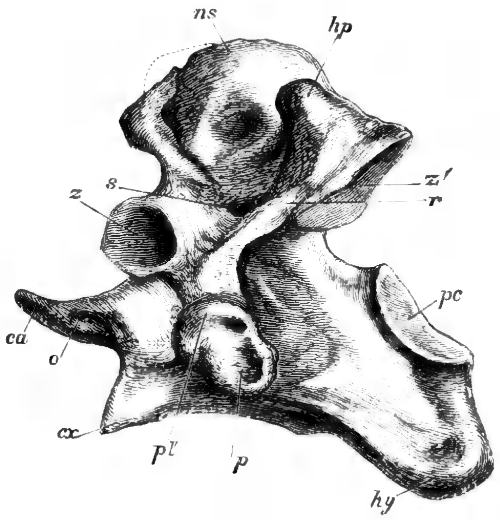


Fig. 5.

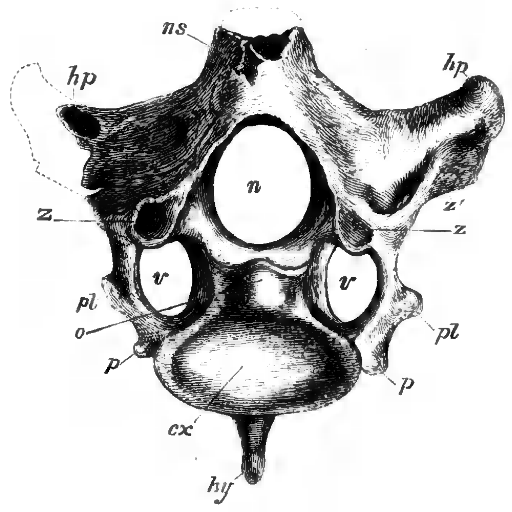


Fig. 6.

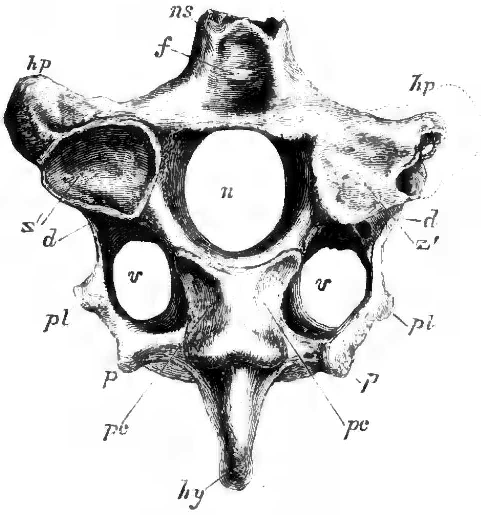
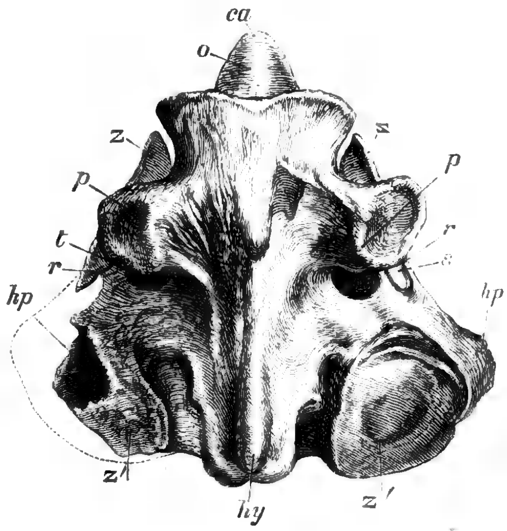


Fig. 7.



Aspects.

Fig. 4, lateral ; 5, preaxial ; 6, postaxial ; 7, hæmal (or ventral).

The neural canal (figs. 5 & 6, *n*) is half the length of the entire vertebra, and its width is nearly one third of the breadth. Its area is a full ellipse with the long axis vertical, not transverse as in *Struthio*.

The ridges on the fore part of the hæmal surface of the centrum in *Struthio*[1] are not present in *Dinornis maximus* or in *D. robustus.* The parapophysis is represented by the short obtuse ridge, *p*, figs. 4 & 7; the pleurapophysis (ib. *pl*) by a similar one above, near the middle of the outer wall of the vertebrarterial canal, *v*. From the diapophysial plate (fig. 6, *d*), completing that wall above, a ridge (fig. 4, *r*) extends backward to the postzygapophysis, *z′*; this ridge circumscribes externally the vertical canal (figs. 4 & 7, *s*). On the medial side of this canal is the pneumatic orifice (fig. 7, *t*), leading to the cancellous part of the neurapophysis. The canal *s* is not noted in *Struthio*, and in place of one large hole there are irregular pneumatic foramina[2]. The postzygapophysis is thrice the size of the prezygapophysis, but the antero-posterior hardly if at all exceeds the transverse diameter; its aspect is as in *Struthio* and birds generally. The hyperapophysis (figs. 4 & 6, *hp*) is relatively more prominent than in *Struthio.* The neural spine gains thickness as its base extends backward; its summit is broken off in my specimen, exposing the wide-celled pneumatic texture.

In *Dinornis elephantopus* the hyperapophyses (fig. 5, *hp*) are relatively larger and higher; the prezyapophyses are relatively less.

The odontoid process (figs. 4 & 7, *ca*) is less than half the size of the atlantal hypapophysis; its free extremity is obtusely rounded.

The third cervical vertebra, as in *Struthio* and birds generally, gains a transverse breadth of the neural arch, anteriorly, with concomitant size of the prezygapophyses (fig. 11, *z*), fitting the postzygapophyses of the axis. From this gain results a quadrate form of the roof of the vertebra; but, from the less relative length or greater breadth of this part in *Dinornis*, the roof (fig. 11) is a transverse quadrilateral, not so oblong as in *Struthio*: in both birds the angles are rounded off[3].

The centrum is a horizontal wedge, with the edge anterior, concave, and formed by the neural border of the preaxial articular surface (fig. 9, *ac*), which, broad and concave transversely, is short and almost flat vertically, but here slopes from the vertical so much backward that it is on a plane with the contour of the hæmal surface of the centrum, as carried back by the hypapophysis (*hy*), and forms a very open angle, with the base-line extended from its hæmal border to the same border of the postaxial surface. Hence, in a direct front view (fig. 9), a little more than the concave fore border of the preaxial surface (*ac*) is seen: while the whole surface is fully in view in the under view of the vertebra (fig. 10, *ac*). It looks almost wholly downward (hæmad) in *Dinornis*, not obliquely downward and forward (hæmo-preaxiad) as in *Struthio*[4]. The postaxial surface (fig. 8, *pc*) much resembles that of the axis vertebra: its transverse contour is sinuous, a medial convexity dividing two concavities; the aspect is more upward than backward; the vertical exceeds the transverse diameter, but in a minor degree than do the reverse proportions of the preaxial surface.

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[1] Mivart, *loc. cit.* p. 391, fig. 12. *t.*

[2] Ib. *loc. cit.* p. 393.

[3] Ib. *loc. cit.* p. 395, fig. 15.

[4] Ib. *loc. cit.* p. 394.

THIRD VERTEBRA (natural size).

Fig. 8.

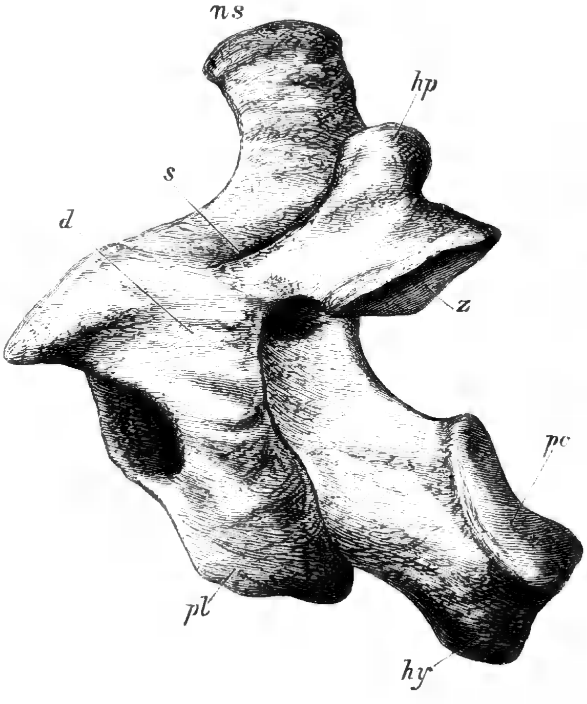


Fig. 9.

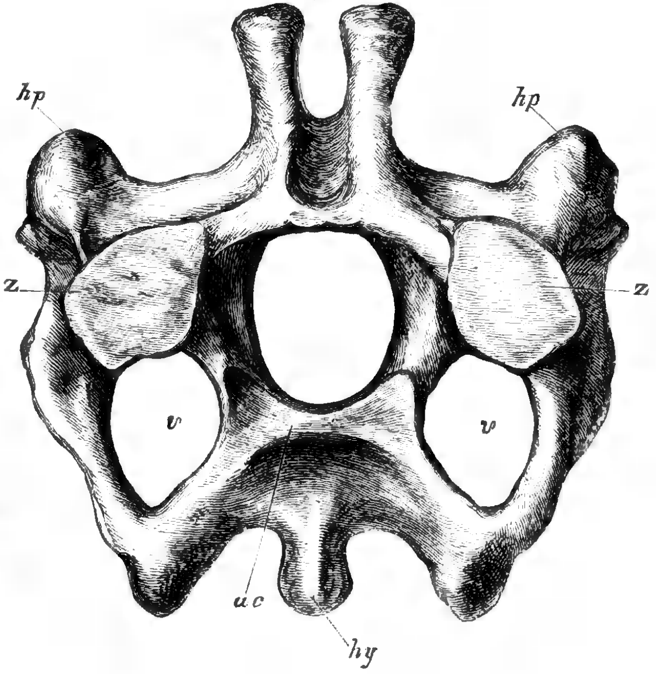


Fig. 10.

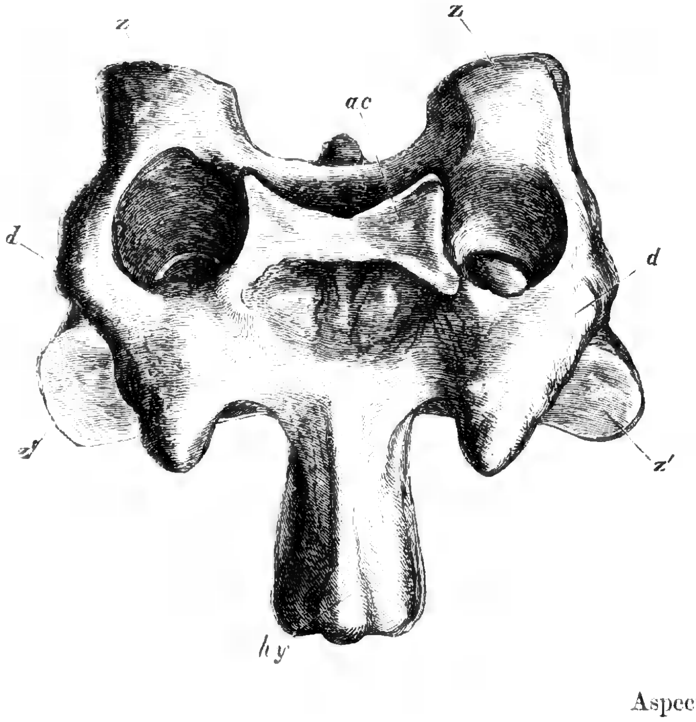
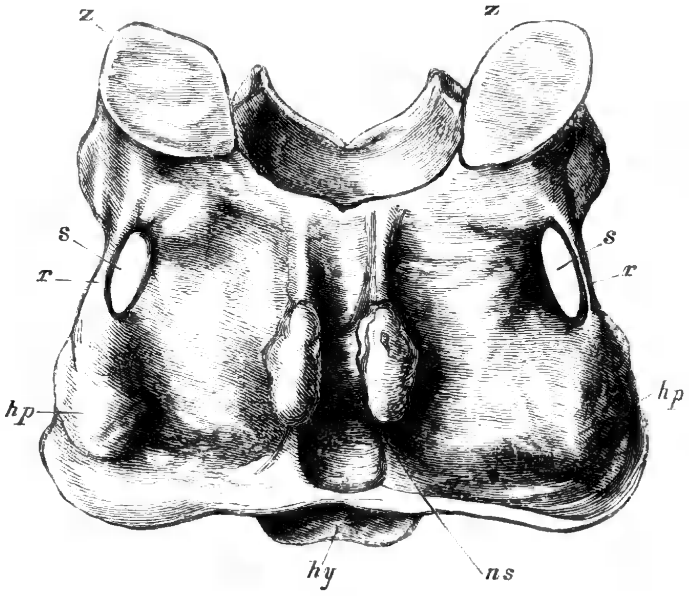


Fig. 11.



Aspects.
Fig. 8, lateral; 9, preaxial; 10, hæmal (ventral); 11, neural (dorsal).

The pleurapophysis (fig. 8, *pl*) is more prominently marked than in *Struthio*; a low tuberosity represents the diapophysis (fig. 10, *d*); the interzygapophysial bar (fig. 11, *r*) has gained breadth; the interzygapophysial foramen (fig. 11, *s*) is well defined.

On the under part of the centrum (fig. 10) the transverse preaxial articular concave tract is followed by a broad depression beyond. From this begins the medial ridge, which expands into the tuberous hypapophysis (*hy*). This is less produced than in the axis.

The chief differences from the Ostrich, besides the shorter or broader and deeper proportions of the entire vertebra, are seen in the more distinct hypapophysis, the better-developed hyperapophyses (fig. 8, *hp*), and the more distinctly bifid character of the neural spine (figs. 9 & 11, *ns*).

This spine rises a short way before it divides; a ridge extends from the fore and hind margins of each division, and defines the depression (for the insertion of elastic ligaments) in front and behind the undivided base: this, at its summit, is not more than one fifth of the antero-posterior extent of the neural platform. (The specimen figured is from a higher and larger individual than the articulated skeleton.)

FOURTH VERTEBRA (½ natural size).

Fig. 12.

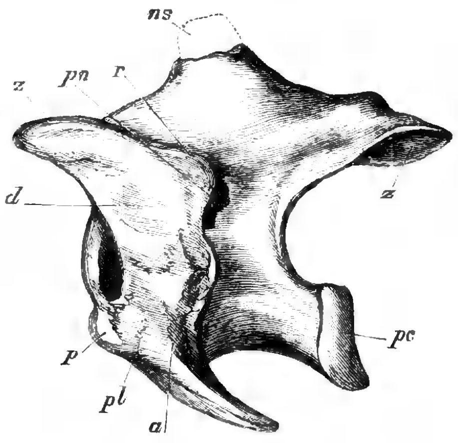
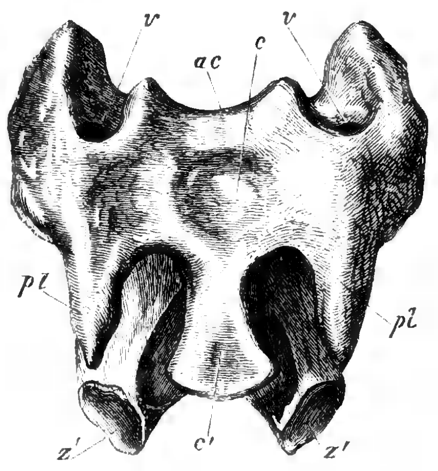


Fig. 13.



Aspects.

Fig. 12, lateral; 13, hæmal.

The fourth cervical vertebra of *Dinornis maximus* (figs. 12, 13), representing, with increase of size, the proportional characteristics of the third, resembles that of the Ostrich in the greater production of the pleurapophysis, *pl*, and in the absence of the hypapophysis.

The interzygapophysial plate, *r*, not extending to the postzygapophysis, *z*, does not circumscribe the space forming the foramen, *s*, in figs. 8 & 11; and the pneumatic foramen (fig. 12, *pn*) comes into view. The zygapophysial articulations, *z*, *z*, become elongated; the posterior outlets of the vertebrarterial canals expand.

There is little, if any, modification of the pre- or post-axial articular surfaces (*ac*, *pc*) of the centrum. The hæmal depression (fig. 13, *c*) behind the preaxial surface (*ac*) is deeper than in the third cervical; and the angle between this and the hind half of the centrum, *c′*, owing to the non-development of the hypapophysis, is more marked. The spine (fig. 12, *ns*) repeats its small basal extent and bifid character.

The diapophysial plate (fig. 12, *d*) extends its origin from the outer side of the prezygapophysis, *z*, halfway towards that of the postzygapophysis, before it bends down to coalesce with the pleurapophysis, *pl*; the broad outer wall of the vertebrarterial canal (fig. 13, *v*) thus formed is the 'pleurapophysial band' of Mivart[1]. It sends forward from its lower anterior angle a short obtuse parapophysis (fig. 12, *p*). The riblet, *pl*, extends backward from the opposite or hinder angle. The vertical hind border of the 'band' has two semilunar insertional impressions, the angle (fig. 12, *a*) between which is less produced than in *Struthio*.

The pleurapophysial band has a relatively greater vertical extent than in *Struthio*; and this relates to the corresponding excess of vertical over longitudinal dimensions in the entire vertebra of *Dinornis* as compared with *Struthio*.

In the direct under view (fig. 13) the pleurapophysis extends almost to the vertical level of the postzygapophysis, *z′* (compare with fig. 24, Mivart, *loc. cit.*); a more marked difference from *Struthio* is in the bifid neural spine of *Dinornis*. There is no medial hypapophysial ridge in *D. maximus*.

In *D. elephantopus* the fourth cervical has the hinder half of the lower surface of the centrum relatively wider than in fig. 13, *c′*; the prezygapophyses are less produced forward than in fig. 12, *z*.

Glancing along the cervical region, in the articulated skeleton of *Dinornis maximus*, one sees, as in that of *D. elephantopus*, that the two (parial) neural spines continue to be developed throughout that series of vertebræ, the uniting basal band subsiding somewhat in the fifth cervical, and each spine being then represented by a ridge continued forward from the hyperapophysis, converging toward its fellow as it rises; but it attains no great height in any vertebra. In the fourteenth cervical, where the parial neural spines are most marked in this respect, the uniting base gains in vertical extent.

The parial hypapophyses ('catapophyses,' Mivart) commence at the fifth cervical as low tubercular ridges. They come nearest to each other at the fourteenth, but do not, in *Dinornis*, circumscribe a hæmal canal in any vertebra[2]. In the fifteenth cervical the parials combine to form a single medial hypapophysis near the middle of the length of the under surface.

In one skeleton of *D. elephantopus* this coalescence takes place at a sixteenth cervical, the antecedent series having one more vertebra than in the skeleton of *D. maximus* here described.

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[1] *Loc. cit.* p. 398.

[2] Comp. with this modification the cervical vertebra in the Flamingo (Owen, 'Anat. of Vertebrates,' vol. i. p. 29, fig. 20, *h*).

The pleurapophysial plate is sculptured outwardly by longitudinal ridges and channels; the riblet loses relative length after the sixth or seventh cervical. The pre- and post-axial articular surfaces retain their essential character throughout, being concavo-convex in opposite directions; the fore surface is always superior in breadth, and this dimension, though less in the hind surface, is greater than the vertical diameter. A larger proportion of the neural surface of the fore end of the centrum is uncovered by the neural arch after the third and fourth cervicals.

From the neck series are selected vertebræ for views corresponding to some of those given by Mivart of the Ostrich, which best illustrate the modifications of such vertebræ in the larger flightless bird.

SIXTH VERTEBRA (½ nat. size).

Fig. 14.

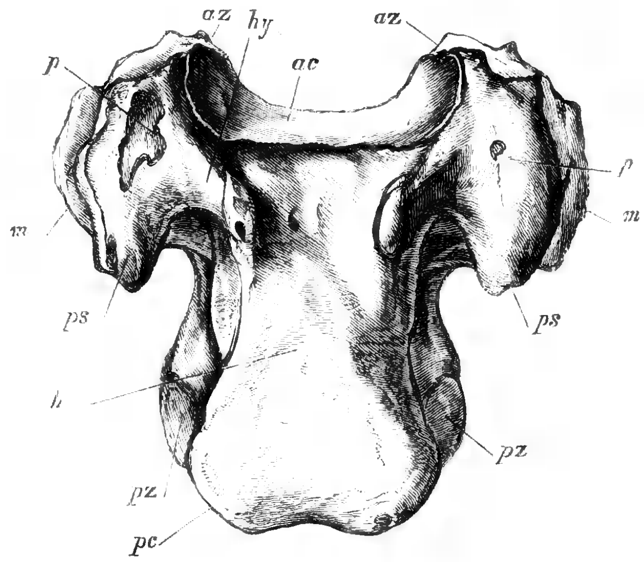

Fig. 14, hæmal (ventral) aspect.

The hypapophyses in the sixth cervical (fig. 14, *hy*) are oblong, smoothly obtuse tuberosities. The exterior of the parapophysial part (*p*) of the pleurapophysial plate (*p*, *ps*) is longitudinally channelled and ridged; the riblet is shortened, as in *Struthio* [1], but in a greater degree. The interzygapophysial bar, though short, leaves a foramen before it is lost in the base of the postzygapophysis. The metapophysis (fig. 14, *m*, *m*) is a mere slight outswelling of the diapophysial mass. The anterior depression at the hæmal surface of the centrum is no longer defined; it is the beginning of the longitudinal channel *h*, banked by the hypapophyses. Behind these the surface is smooth and flat; then again becomes slightly concave transversely at the expanded hind part of the centrum, *pc*.

[1] Mivart, *loc. cit.* p. 400, fig. 25.

The neural spine is represented by a pointed ligamentous surface above the fore border of the arch; behind this rises the pair of low obtuse processes subsiding into the hyperapophyses above the postzygapophyses.

As the neural roof subsides behind the part between the bases of the parial, *quasi*-neural spines, their connecting-bar is so indicated. The hind part of each spine extends, subsiding to the hyperapophyses.

TWELFTH VERTEBRA (½ natural size).

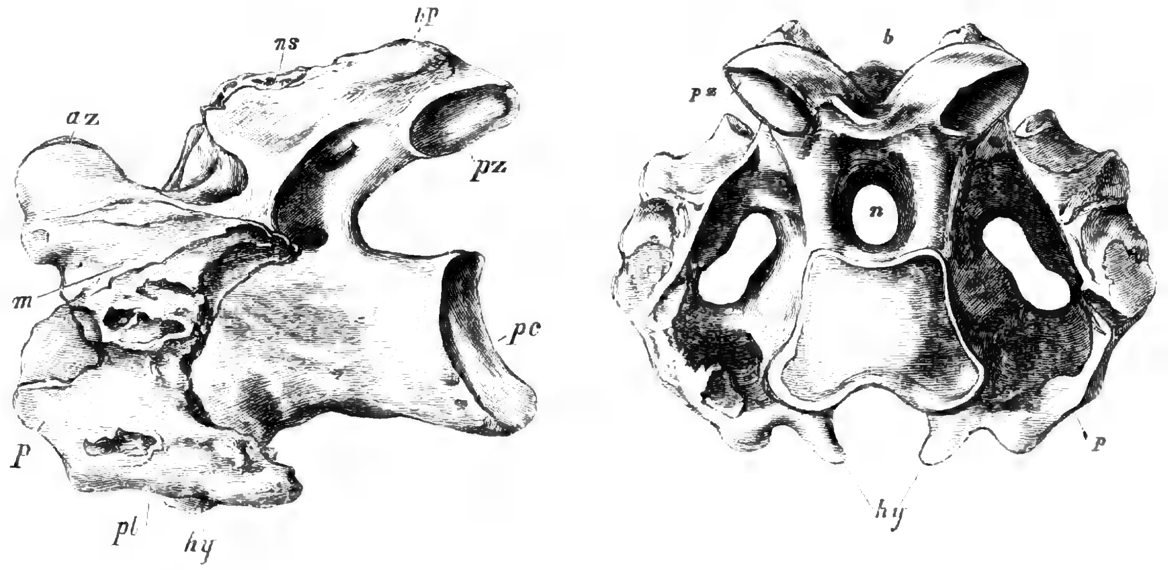
Fig. 15.

Fig. 16.

Aspects.

Fig. 15, lateral; 16, postaxial.

The twelfth cervical is chiefly distinguished by the nearer proximity to one another of the hypapophyses, the extremities of which, in a direct hind view (fig. 16, *hy*), appear below the divisions of the postaxial surface, *pc*, not at its sides, as in *Struthio*[1]. The transverse diameter of the postaxial part of the neural arch, taken outside the pedicles, is one fourth less than the same diameter of the preaxial part. The riblet (fig. 15, *pl*), though longer than in the six or seven preceding cervicals, is relatively shorter than in the fourth (fig. 12, *pl*). The neural arch attains its greatest length in the twelfth vertebra. The connecting bar (fig. 16, *b*) of the parial neural spines is slightly raised, and is better defined before and behind by the rough pits for the elastic ligaments than in some of the antecedent cervicals. The breadth of the neural platform across the postzygapophyses is relatively greater, in a small degree, than in the antecedent cervicals; yet their articular surfaces (fig. 15, *pz*) remain longer in proportion to their breadth. The perforation of the interzygapophysial bar continues.

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[1] Ib. *loc. cit.* p. 493, fig. 30, *c*.

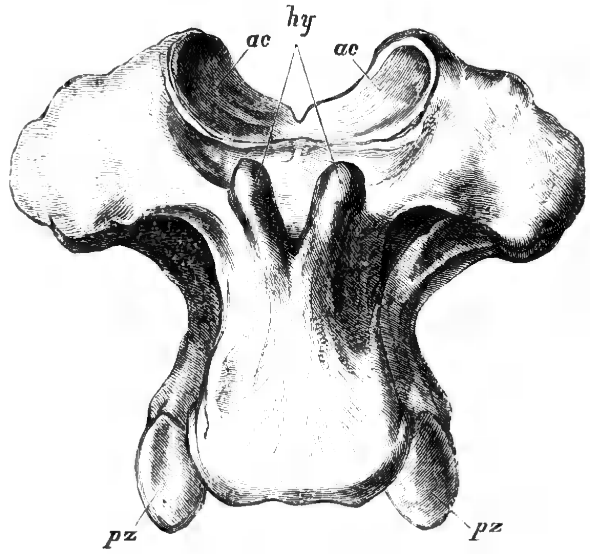
The longitudinal ridges of the pleurapophysial plate (fig. 15, *pl*) are more prominent; the upper one assumes more the character of a metapophysis (ib. *m*).

The cervical vertebra of *Dinornis giganteus*, figured of the natural size in plate 40, vol. iii. of the 'Zoological Transactions,' is the answerable one to the twelfth in the huger representative species of the South Island of New Zealand. It is less broad in proportion to its length, and thus conforms to the more slender metatarsals characteristic of *D. giganteus* of the North Island. The transverse connecting bar of the neural spines, marked *s* in fig. 5 of the plate 40, rises nearer to the summits of the parial divisions; the ridges continued from these, forward, converging to the fore margin of the neural arch, are longer and broader than in *Dinornis maximus*; the hollow behind the neural spines is also broader.

The thirteenth and fourteenth vertebræ in *Dinornis* are most nearly matched by the sixteenth and seventeenth in *Struthio camelus*, in which species the eighteenth vertebra

FOURTEENTH VERTEBRA ($\frac{1}{2}$ natural size).

Fig. 17.



Aspect.

Fig. 17, hæmal (ventral).

(fig. 41 of Mivart), like the fifteenth in *Dinornis* (fig. 19), first changes its parial or double for a single hypapophysis, *hy*. My figure 17 may therefore be contrasted with figures 34 and 39 of Mivart, which show the same aspect (hæmal or ventral) of the vertebræ compared. And here I may note that the processes seen in profile in Mivart's figures 33 and 34 are indicated by the symbol *c* in the sixteenth vertebra, and by the symbol *hy* in the seventeenth; similarly, they are described as '*catapophyses*' at p. 405, and '*hypapophyses*' at p. 406. I note them, under the latter denomination, in the thirteenth as in the fourteenth vertebra of *Dinornis maximus*, and the similarity is such between these vertebræ that I proceed to the description of the fourteenth.

In the fourteenth cervical (fig. 17) the more approximated hypapophyses, *hy*, arise from a low common prominence further back from the preaxial surface; and the longitudinal channel in the lower surface, in the twelfth and thirteenth vertebræ, is here somewhat interrupted by such prominence. The transition of these into a single medial hypapophysis is thus indicated. The present vertebra in *Dinornis maximus* approaches the character of the seventeenth vertebra in the Ostrich [1], especially in the above modification of the hæmal surface [2], to which view of the vertebra of *Dinornis maximus*, corresponding to the seventeenth of *Struthio*, I here restrict my illustrations of such vertebra.

The processes (*c* in Mivart's fig. 34, *hy* in his figure 39) are serial homotypes. The recognition of this fact led me to speak of Mivart's 'catapophyses' as "parial hypapophyses" in the Memoir on *Cnemiornis* (Trans. Zool. Soc. ix. p. 260), and again, under a sense of the convenience of a substantive term, as 'præhypapophyses' (ib. ib.), in contradistinction with the 'hypapophyses' at the hind part of the centrum in the axis and third cervical. The antero-posterior extent of the pleurapophysial plate is shortened in the fourteenth vertebra of *Dinornis*, as in the seventeenth of *Struthio*; but the pleurapophysis itself is less produced in *Dinornis*. The neural spines have not approximated and coalesced as in *Struthio*. The section of the supporting column of the parial neural spines is transversely quadrate; both fore and hind surfaces are impressed by a definite rough tract for the elastic ligaments. The preaxial surface retains a greater relative breadth to the postaxial than in *Struthio*; the vertebrarterial canals are relatively wider.

The next step in the transmutation of Mivart's 'catapophysis' into the normally situated single hypapophysis in birds is presented by the fifteenth cervical of *Dinornis maximus* (figs. 18–21), which is the last of that series in the present skeleton.

A single obtuse process descends from a low base coextensive nearly with the hæmal surface of the centrum (fig. 19, *hy*); but the base of this process in one example is connected by a ridge continued from each side to the hind border of the pleurapophysis (ib. *pl*), and there is a slight swelling (the final trace of the parial character) at the beginning of each ridge. A pair of low tuberosities, connected by a ridge, mark the hind border of the lower surface of the centrum.

With the vertical extension of bone, *hy*, from this surface for muscular attachments, a corresponding but greater one marks the opposite or neural surface, one process (*hy*, fig. 18) descending, the other (*ns*) ascending. The neural spine gives off a pair of low tuberosities, one on each side, near its summit: from each there is continued the usual ridge curving back to the hyperapophysis (fig. 18, *hp*), which still overtops the postzygapophysis, *pz*.

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[1] Mivart, *loc. cit.* p. 406, figs. 35–39.

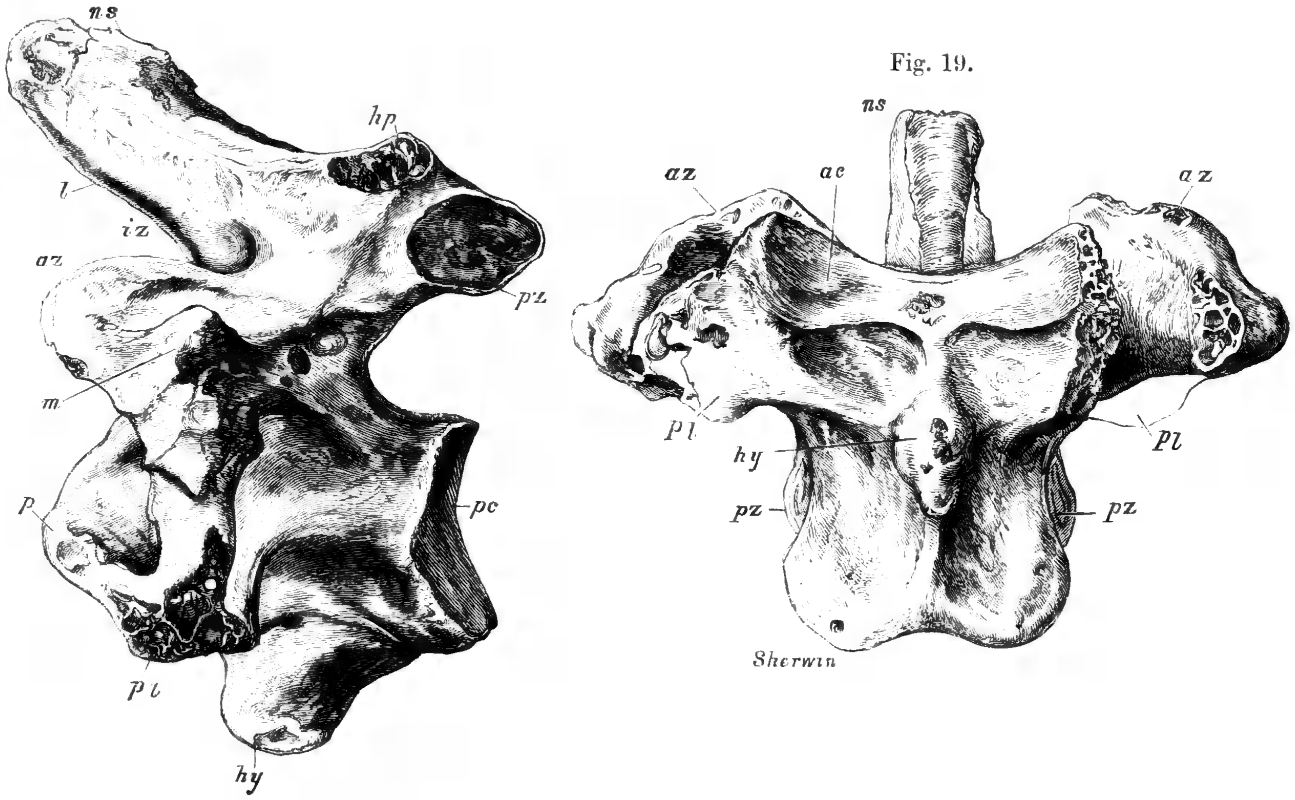
[2] Ib. ib. fig. 39.

A mere rudiment of the interzygapophysial band now remains, but behind it is a small foramen leading to the cancelli of the neurapophysis; a corresponding foramen is noticed in *Struthio*[1]. The pneumatic foramen is, as usual, beneath the base of the diapophysis, which process shows its tuberous outstanding metapophysis (fig. 18, *m*) well marked above the pleurapophysial band, *pl.* This, as in the seventeenth (last cervical) vertebra in *Struthio*, is short antero-posteriorly, and each margin is concave, with a blunt production of its hinder and lower angle still representing the cervical riblet. Each vertebrarterial canal (figs. 20, 21, *v*), as in *Struthio*, exceeds the neural canal in capacity.

FIFTEENTH VERTEBRA ($\frac{1}{2}$ nat. size).

Fig. 18.

Fig. 19.



Aspects.

Fig. 18, lateral; 19, hæmal (ventral).

If the transverse expansion of the fore part of the centrum be reckoned as due to the bases of 'parapophyses,' the fore or preaxial articular surface (*ac*, fig. 20) may be said to extend thereupon; but the parapophysis, *ps*, in *Dinornis maximus* may better be held to spring out external to the preaxial surface than in *Struthio*. The outer

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[1] Mivart, *loc. cit.* p. 409.

FIFTEENTH VERTEBRA ($\frac{1}{2}$ nat. size).

Fig. 20.

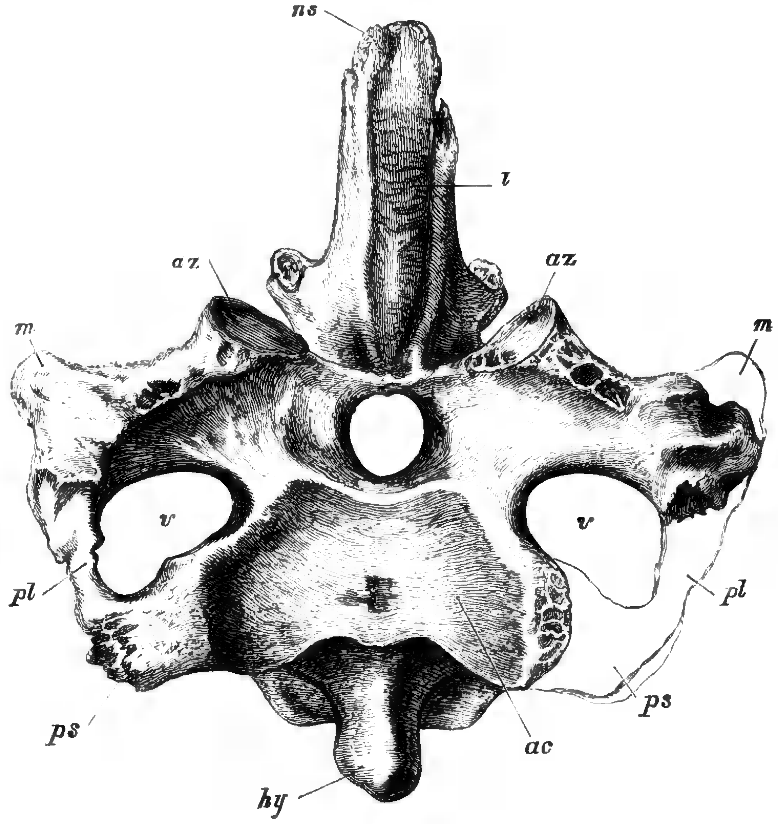
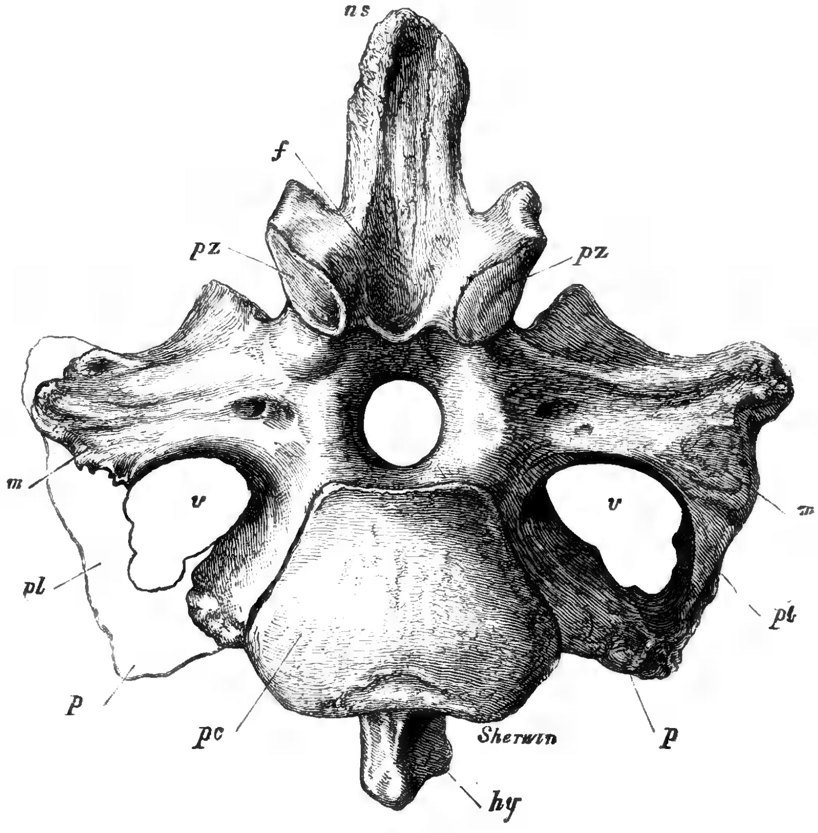


Fig. 21.



Aspects.
Fig. 20, preaxial; 21, postaxial.

border of the prezygapophysis (fig. 20, *az*) now begins to rise, and gives a more inward or medial aspect to the oblique articular surface. The postzygapophyses (fig. 21, *pz*, *pz*) show a corresponding change in the contrary sense, but they do not extend postaxially beyond the centrum in so great a degree as in *Struthio*[1]. A marked difference between the vertebræ here compared is in the greater height and greater breadth of the neural spine in *Dinornis*; but the chief distinction is shown by the coexistence in *Struthio* of an independent or movable pleurapophysis with the first appearance of the single and simple hypapophysis. In *Dinornis* such condition of the hypapophysis is associated with a continued confluence of the riblet, *pl*. In other words, the single hypapophysis marks the first dorsal vertebra in *Struthio*[2] and the last cervical in *Dinornis* (fig. 18, *hy*).

The character of the fifteenth cervical in the series of the skeleton of *D. maximus* is that of the sixteenth cervical in the neck-series of Hutton's skeleton of *D. elephantopus*; and this is followed by a seventeenth cervical, or one with anchylosed pleurapophyses, beyond which there are seven vertebræ for a dorsal series. But in both the sixteenth and seventeenth cervicals the neural spine is bifid; the ridges from the hyperapophyses converge to the base of a single neural spine only in the first of the series of vertebræ in which the pleurapophyses retain their independence and mobility. If my series of cervicals in *D. maximus* be, as it seems by characters of juxtaposition, the correct number, Hutton's specimen of the skeleton of *D. elephantopus* has two additional cervicals, in all seventeen, instead of fifteen as in *Apteryx*. These remarks are based on a photograph of the skeleton in the Otago Museum.

In a cervical vertebra (figures 22, 23, 24) of *D. giganteus*, which I regard as homologous with the fifteenth or last cervical of *D. maximus*, the neural spine (fig. 23, *ns*) retains, as in *D. elephantopus*, its bifid character; but the parial portions are relatively less developed, and their connecting bar (ib. *b*) has begun to rise, indicating, as it were, a rudiment of the single and longer neural spine in *D. maximus*. The hypapophysis (figs. 22, 24, *hy*) is single, and its base is supported by the ridges from the pleurapophyses representing the 'catapophyses' of Mivart. The posterior hypapophysial tubercles (ib. *hy'*) are better marked than in figure 19 (*D. maximus*).

The neck-vertebræ in every species of *Dinornis* in which I have been able to determine them correspond, with unimportant modifications, with those above described and figured, and in like degree differ from their homologues in *Struthio*.

In the well-marked class of Vertebrates characterized by the many cervical vertebræ, these, as a rule, are small; but in *Apteryx*, and especially in *Dinornis*, they are exceptionally large. Some of those in *Dinornis maximus* almost equal in size the neck-vertebræ of the horse.

The muscular system, as has been shown in *Apteryx* (p. 44), is correspondingly developed; and when, to the proportionably still more powerful neck-muscles in

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[1] Comp. fig. 18, *pz*, with Mivart, *loc. cit.* p. 406, fig. 35.

[2] Mivart, *loc. cit.* p. 408, fig. 40.

Dinornis, were added their thick integument and covering of feathers, the neck must have been a feature of strength very different from the slender character of that lengthy part in an Ostrich and the like living birds.

FIFTEENTH VERTEBRA, *Dinornis giganteus* ($\frac{1}{2}$ nat. size).

Fig. 22.

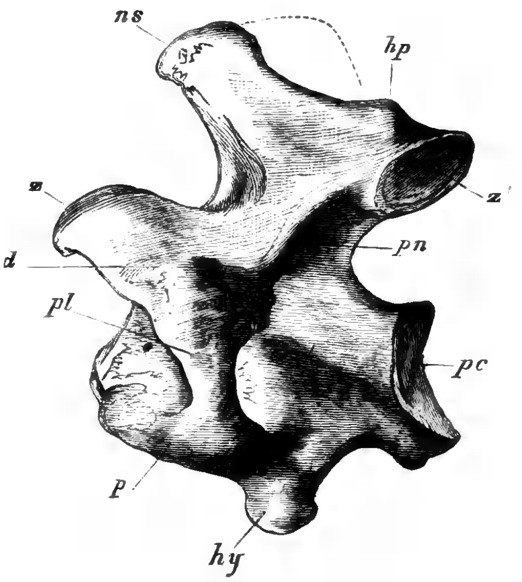


Fig. 23.

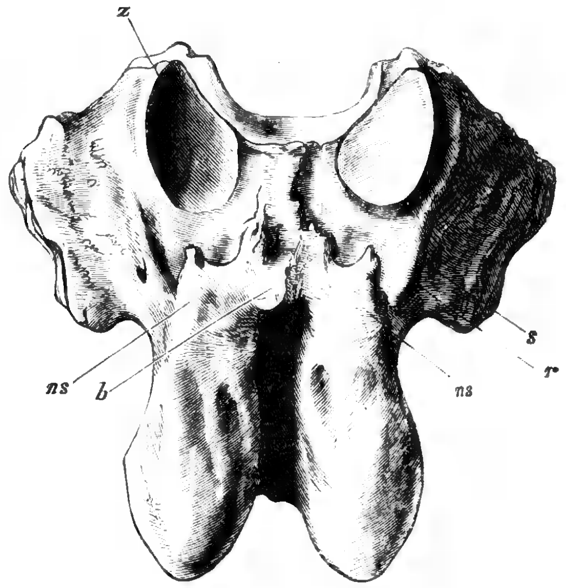
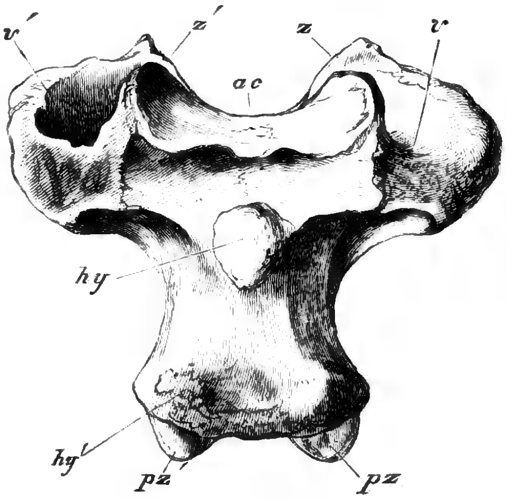


Fig. 24.



Aspects.
Fig. 22, lateral; 23, neural; 24, hæmal.

This consideration adds significance to the record of one of the oldest living Colonists in New Zealand, recently published.

"In 1844, at Wellington," writes Mr. Hamilton, "I was present, as Governor Fitzroy's private secretary, at a conversation held with a very old Maori, who asserted that he had seen Captain Cook. Major Richmond, then Superintendent of Wellington, was, I think, also present. I cannot recollect who was the Governor's interpreter. This Maori (Haumatangi), so far as my memory now serves me, I should guess was 70 years old; at all events he was brought forward as one of the oldest of his people then residing about Port Nicholson. Being asked 'Had he ever seen a Moa?' he replied, 'Yes, he had seen the last one that had been heard of.' When questioned as to what it was like, he described it as a very large tall bird, with a neck like a horse's neck. At the same time he made a long upward stroke in the air with his right hand, raising it far above his head, and so as to suggest a very fair idea of the shape of a Moa's neck and head, such as I have since seen them in the skeleton birds of the magnificent collection which Dr. Julius Haast has gathered together in the Canterbury Museum. There is no bird or animal of large size indigenous to New Zealand to which an old Maori could liken the Moa. The horse was probably the only creature imported by us in 1844 in which he could possibly find any kind of likeness calculated to give *us* a fair general idea of the shape and height of the bird's neck and head. If he had never himself seen a Moa, how—unless he had received its description, handed down from Maoris, who had seen one—could he possibly have hit upon such an idea as to refer us to the tall arched neck of the horse for a likeness? The gesture which he made with his hand remains impressed upon my memory as freshly as if seen only yesterday, as one that was singularly descriptive. It was like a sketch being made, as it were, in the air" [1].

Reckoning, by a convenient, though somewhat artificial character, as a first dorsal the vertebra which first retains its pleurapophyses as independent movable elements, such vertebra (the sixteenth), in *Dinornis maximus*, answers to the eighteenth in *Struthio*, of which Prof. Mivart gives two instructive views ($\frac{1}{2}$ natural size) [2].

I subjoin a corresponding figure (figs. 25, 26), similarly reduced, of the first dorsal in *Dinornis maximus*.

If the hypapophysis (fig. 26, *hy*) be taken as a guide, the present vertebra in *Dinornis* would answer to the nineteenth in *Struthio*, which is the second vertebra in that genus showing the single medial hypapophysis at this region of the spine, and associated with the articular facet, *p*, for the movable pleurapophysis.

In *Dinornis* the parapophysis, *p*, is less produced forward or outward; the neural spine, *ns*, is more elongated and inclines forward; it is also thicker, more quadrate in section. In another vertebra it is less elongate than in the figure and less inclined forward; the costal surface, also on *p*, is likewise deeper and is subcircular in shape.

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[1] "Notes on Maori Traditions of the Moa," by J. W. Hamilton, Esq., 'Transactions of the New-Zealand Institute,' vol. vii. 1875, p. 121.

[2] *Loc. cit.* p. 408, figs. 40, 41.

The preaxial surface has its vertical extent not so inferior to the transverse as in *Struthio.*

The pleurapophysis articulates with a small shallow pit on a very short parapophysis; the 'head' is supported on a neck 1½ inch long, and slender in proportion to the body and tubercular process, which is sent off at an angle of 45′ with the neck; it terminates by a smooth round tubercle, fitting a corresponding pit on the lower surface of the diapophysis, which it thus underprops. The body of the rib is flattened, 1 inch 3 lines broad at the divergence of the cervical and tubercular branches; it is slightly curved inward and forward, and gradually terminates in a point. No hæmapophysis (sternal rib) is developed in the sixteenth (1st dorsal) vertebra of *Dinornis maximus.*

SIXTEENTH VERTEBRA (' 1st dorsal,' ½ nat. size).

Fig. 25.

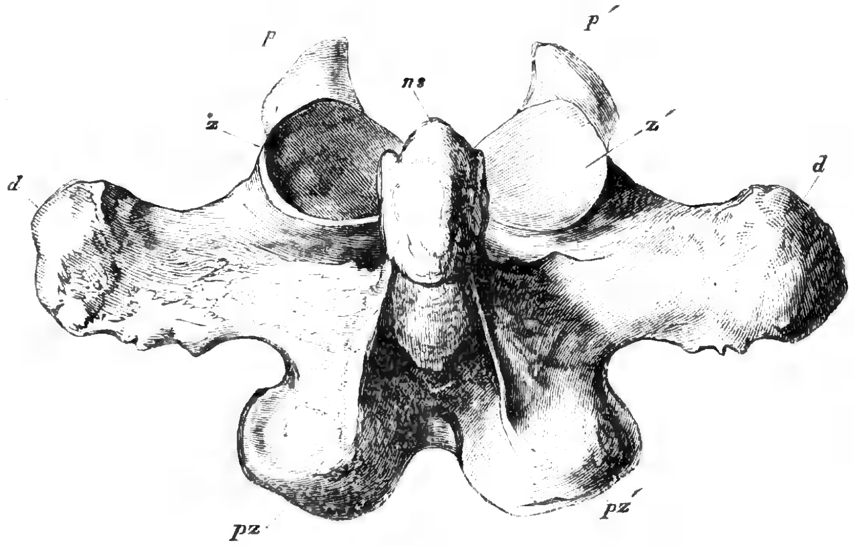


Fig. 25, neural aspect.

Fig. 26.

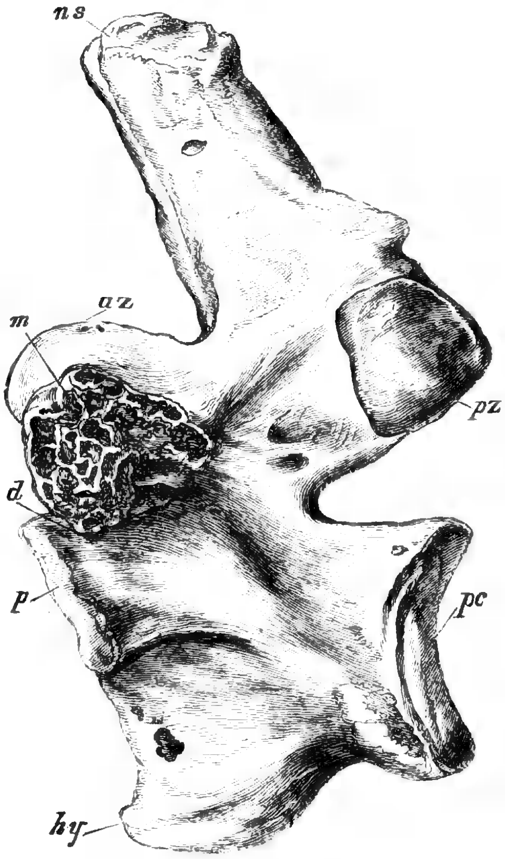


Fig. 26, lateral aspect.

In the first dorsal vertebra of *D. elephantopus* the hypapophysis is more central in position, more tuberous, less compressed, with a shorter base; in other words, retaining more of the character of that process in the last cervical.

The seventeenth vertebra, answering to the twentieth or third dorsal in the Ostrich, and repeating the character of the hypapophysis in the first dorsal, exemplifies also the difference of being the first of the vertebral series, traced from the skull, in which the segment, or osteocomma, is completed by a perfect hæmal arch.

The centrum and neural arch show no notable differences from those of the sixteenth vertebra. The pleurapophysis, with a similar double articulation, has increased in size and conspicuously in length; it also supports an 'epipleural appendage,' which is broad and slightly curved upward, where it overlaps the succeeding rib. The hæmapophysis is ossified and synovially articulated with the pleurapophysis above and with the hæmal spine ('sternum') below. Towards its hæmal end it expands and develops a tubercle.

The size of the dorsals in *D. maximus* increases slightly as they recede, and chiefly in breadth, by the outgrowth of the diapophyses, accompanied by a greater size of the rib and greater length and divergence of its capitular and tubercular processes. In the present vertebra (third dorsal) the base of the hypapophysis, though shorter than in the second dorsal, occupies a greater extent of the hæmal surface of the centrum than in the third dorsal of *Struthio*. Not more of the fore part of the neural surface of the centrum is exposed than in the antecedent dorsals and terminal cervical vertebra. The postaxial surface continues to be narrow in proportion to its height; but its transverse convexity increases, and is relatively greater than in *Struthio*. The transverse concavity of the preaxial surface has also increased; it is still convex vertically along its middle third. In a homologous vertebra of the present species of *Dinornis* I have noted a variety in the hypapophysis in the interruption of its basal extent producing a small *quasi* second hypapophysis near the postaxial surface.

The pleurapophysis, with a slight increase of length, and of that of its appendage, is as in the second dorsal. The hæmapophysis ('sternal rib') articulates by a transversely extended bitubereular end with the sternum.

The nineteenth vertebra (fourth dorsal, figs. 27–29), corresponding with the first of those having their pleurapophyses free and articulating with their hæmapophyses in *Struthio* (figures 47, 48, 'Mivart,' p. 413), has the centrum less cuneiform in transverse section, the sides converging, with a certain convexity, hæmad to a low and short ridge or keel, produced and thickened anteriorly, near the preaxial surface (fig. 27, *hy*).

Prof. Mivart reckons the dorsal series as commencing with the vertebra thus typically complete in regard to its hæmal arch. I prefer to retain the character of a free pleurapophysis as denoting the present class of axial segments.

Thus the nineteenth vertebra in *Dinornis*, or fourth of the dorsal series, answers to the twenty-first in *Struthio*, which is the fourth supporting a free pleurapophysis (vertebral rib), and the first in which this element articulates with its hæmapophysis (sternal rib). The hæmapophysis of the twentieth vertebra in *Struthio* is developed, but is articulated only with its spine (sternum) and does not join by its opposite end the pleurapophysis. Such condition I have not yet seen in any species of *Dinornis*.

With respect to the twenty-first vertebra in *Struthio*, Mivart remarks, that "it is so much like the twentieth that little need be said in its description" (p. 413). My figure 28 may therefore be contrasted with figure 46 in Mivart's monograph (p. 411, *loc. cit.*) for illustrations of the differential characters in question.

NINETEENTH VERTEBRA ('4th dorsal,' $\frac{1}{2}$ nat. size).

Fig. 27.

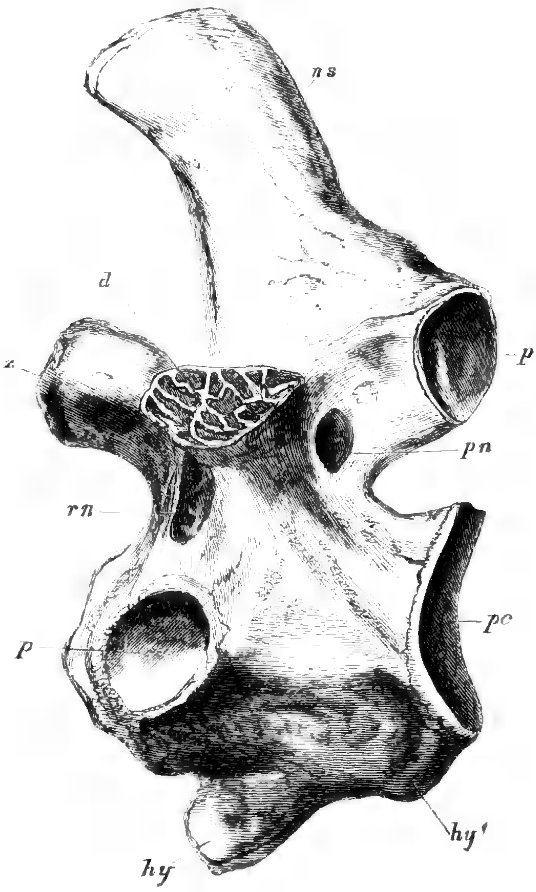


Fig. 28.

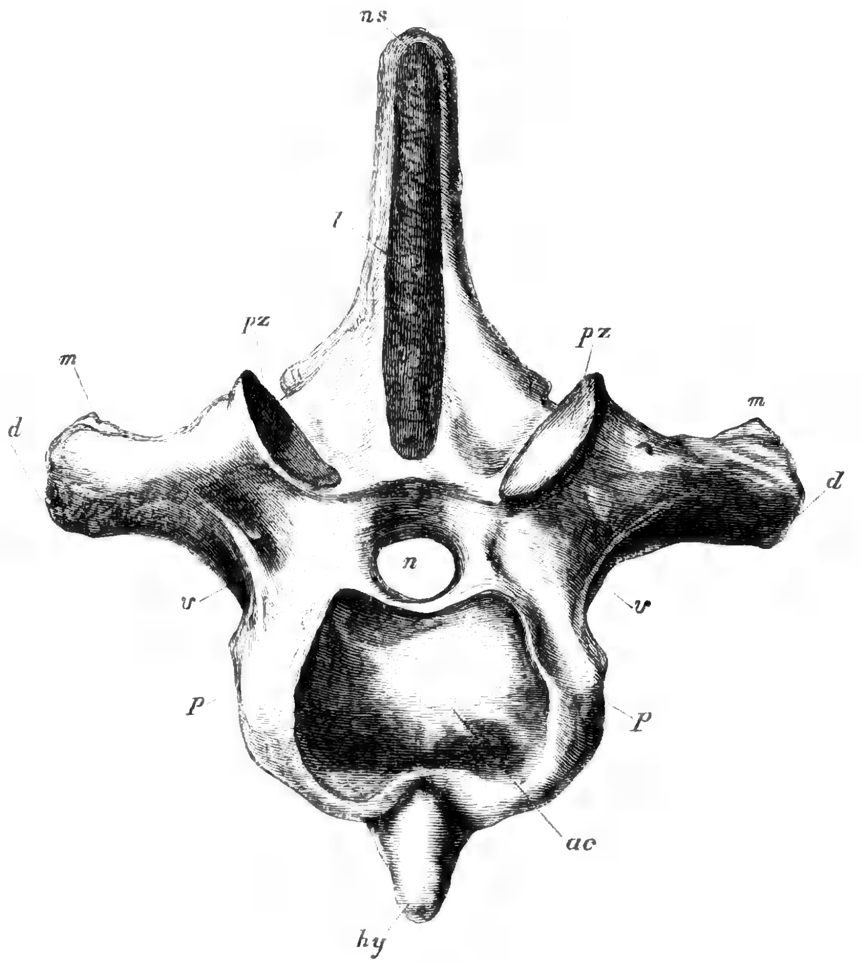
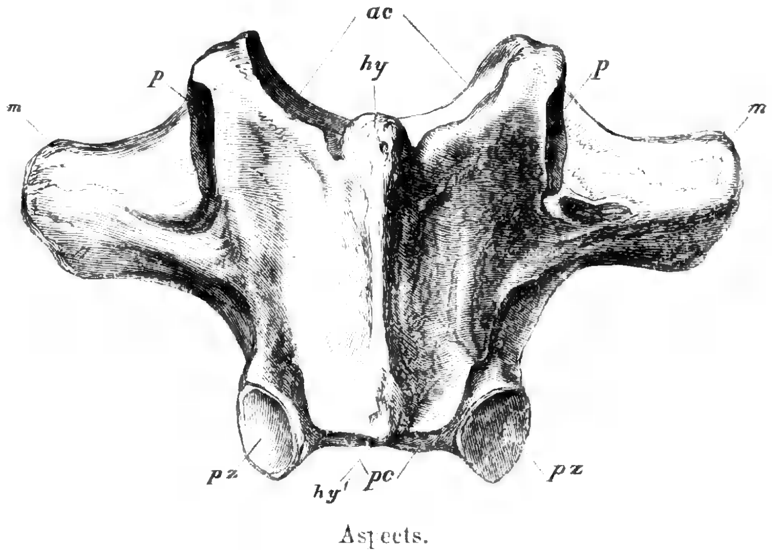


Fig. 29.



Aspects.

Fig. 27, lateral; 28, preaxial; 29, neural.

The three views (figs. 27, 28, 29) of the nineteenth, or fourth dorsal, vertebra of *Dinornis maximus* correspond with those views of the twenty-first vertebra of *Struthio* given by Mivart in figs. 47, 48 (*loc. cit.*). In this comparison, among the distinguishing characteristics of the Dinornithic vertebra, are, first, the greater relative height of the neural arch and spine, whereby the distance of the parapophysial, *p*, from the prezygapophysial, *z*, surfaces is relatively greater. The diapophysis, *d*, is less extended lengthwise, but more produced transversely and vertically; it also terminates with a tuberosity which might be reckoned as a low metapophysis, fig. 28, *m*, overtopping the small articulation, *d*, which now looks outwardly for the attachment of the rib's tubercle.

A reticulo-pneumatic fossa (*rn*, fig. 27) intervenes, as in *Struthio*, between the par- and diapophysis. A larger pneumatic foramen (ib. *pn*) opens behind the diapophysis (*d*). The neural spine (*ns*) retains its characteristically greater height and thickness, with minor relative antero-posterior extent than in *Struthio*. Its fore and hind surfaces are occupied by well-defined rough tracts for the elastic ligaments (fig. 28, *l*).

The preaxial surface (ib. *ac*), less transversely and more vertically extended than in the antecedent vertebra, retains something of its bilobed character by the emargination of its upper and lower articular borders. The parapophysis (*p*) projects with its rib-surface distinct from the articular facet (*ac*) of the centrum. The postaxial surface shows an unsymmetrical form in two examples of this vertebra, encroaching further upon the left side of the centrum in one, and upon the right side in the other. Both are individual varieties.

The hypapophysis (*hy*, fig. 29), reduced vertically, is coextensive with the under surface of the centrum, and slightly produced and expanded at both ends (fig. 27, *hy*, *hy'*). In the direct view from beneath (fig. 29) the more advanced position of the diapophyses (*m*) and the less produced hind part of the neural platform and its postzygapophysial surfaces (*pz*) are well shown, in contrast with Mivart's figure 48, in *Struthio* (*loc. cit.* p. 413).

The hæmapophysis of the fourth dorsal did not, in the specimen under description, articulate directly with the costal border of the sternum, but through the medium of the hæmapophysis of the third dorsal.

In the fifth dorsal (twentieth) vertebra the fore and hind productions of the hæmal keel of the centrum assume the character of distinct hypapophyses, of which the anterior (*hy*) is unciform, being produced forward with the end upcurved, so as to receive the tuberous hind part of the hypapophysial ridge of the fourth dorsal into its concavity; the posterior one (*hy'*) is low and simple. Figure 30 is a side view of the centrum of this vertebra, showing this singular and, as far as I have observed, unique development of pre- and post-hypapophyses.

The parapophysial rib-cup (*p*) is rather larger, and the neural spine has greater fore-and-aft breadth than in the preceding (fourth dorsal) vertebra. This spine greatly exceeds in both height and thickness that in *Struthio*. A pair of depressions, answering

TWENTIETH VERTEBRA ('5th dorsal,' ½ nat. size).

Fig. 30.

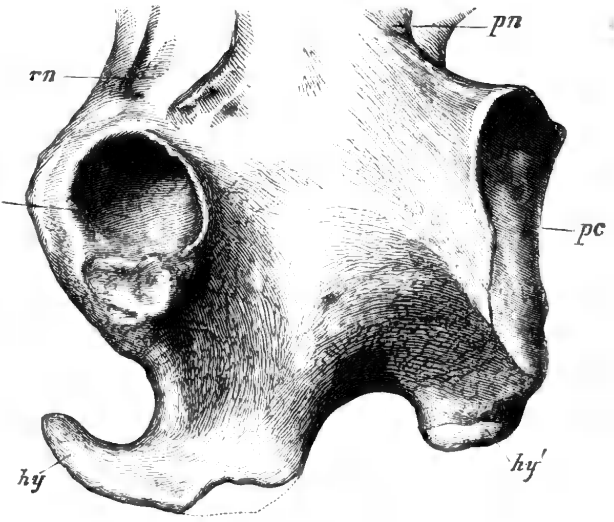


Fig. 30, lateral aspect.

TWENTY-FIRST VERTEBRA ('6th dorsal,' ½ nat. size).

Fig. 31. Fig. 32.

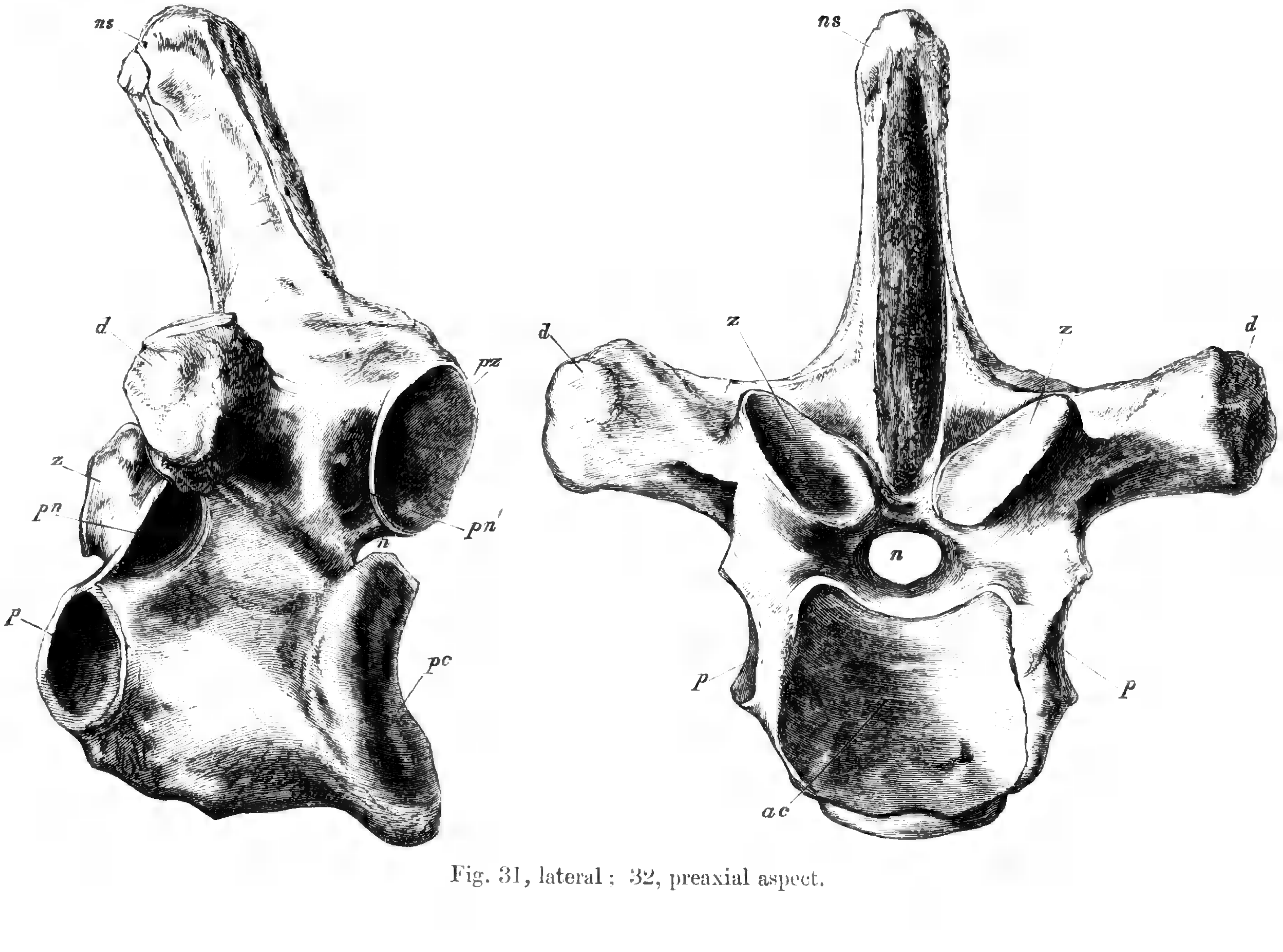


Fig. 31, lateral; 32, preaxial aspect.

to those marked f^1 in Mivart's figure 57 of the last dorsal vertebra, are here well marked.

In the sixth dorsal (twenty-first vertebra, figs. 31, 32) the hypapophysis is suppressed, as in the twenty-second (fifth dorsal) vertebra of *Struthio* ('Mivart,' figs. 49–51)[1], with which the present will be compared. The articular surface (fig. 32, *ac*) thus almost "entirely occupies the preaxial end of the centrum"[2]: only a few lines breadth on each side of the neural half of that surface is non-articular in *Dinornis*, and may be ascribed to the fore part of the parapophysis (ib. *p*). The vertical as compared with the transverse diameter of the preaxial surface is greater than in *Struthio*. The characteristic height of the neural spine in *Dinornis* (figs. 31, 32, *ns*) is still more marked in this comparison. The pneumatic orifice (fig. 31, *pn*) between the par- and di-apophyses is the chief one for admission of air into the vertebral substance; but a small homologue (ib. *pn′*) of the posterior pneumatic orifice remains.

The postaxial surface (fig. 31, *pc*) is absolutely and much more relatively approximated to the postzygapophysis (ib. *pz*) than in *Struthio*. The neural canal (fig. 32, *n*) is transversely, not vertically, elliptical (comp. Mivart's fig. 51). The sides of the preaxial surface are much produced, and the transverse concavity of that surface is proportionally deepened. The lower border of the postaxial surface is more produced than in *Struthio*, rendering the lower contour of the centrum in *Dinornis* more concave (comp. fig. 31 with fig. 49, Mivart, *loc. cit.*). The zygapophysial surfaces are relatively more extensive in *Dinornis*, the dorsal vertebræ being more securely interlocked in the larger terrestrial bird.

The characteristically broad and massive proportions of these vertebræ in *Dinornis* are well brought out in comparing figs. 27–32 with figs. 47–51 of Mivart, *loc. cit.* The minor length and greater thickness of the diapophyses, *d*, and the much greater development of the neural spine are exemplified in fig. 32 as contrasted with fig. 51 (Mivart, *loc. cit.*).

The vertebra in *Dinornis* which answers, in rib-character, to that in *Struthio* supporting the eighth pair of movable pleurapophyses is that which supports the seventh pair. In both genera it is the hindmost rib-vertebra not confluent with the sacrum. In the present skeleton of *Dinornis* it is the twenty-second vertebra, counting from the occiput; in *Struthio* it is the twenty-fifth. Of this Prof. Mivart gives four figures[3]. The chief differential characters of its homologue in *Dinornis maximus* will be exemplified in the two subjoined cuts from the lateral (fig. 33) and postaxial (fig. 34) aspects.

In the comparison of figure 33 with figure 54 ('Mivart'), the deep longitudinal concavity of the under surface (*c*) of the centrum may be first remarked, due in *Dinornis* to a downward production of the border of the preaxial articular surface (*ac*) and a still greater production in the same direction of the postaxial surface (*pc*), augmented by the development of a pair of hypapophyses (fig. 34, *hy*). These are not developed in

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[1] *Loc. cit.* p. 414.

[2] Ib. p. 414.

[3] *Loc. cit.* p. 419, figs. 54–57.

TWENTY-SECOND VERTEBRA ('7th dorsal,' ½ nat. size).

Fig. 33.

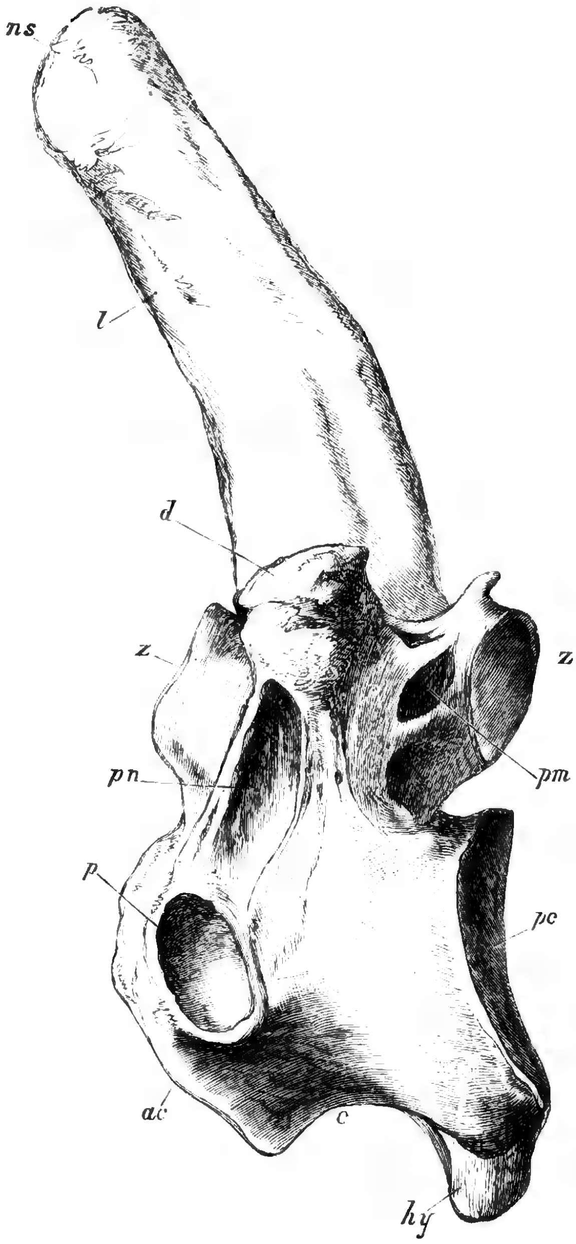
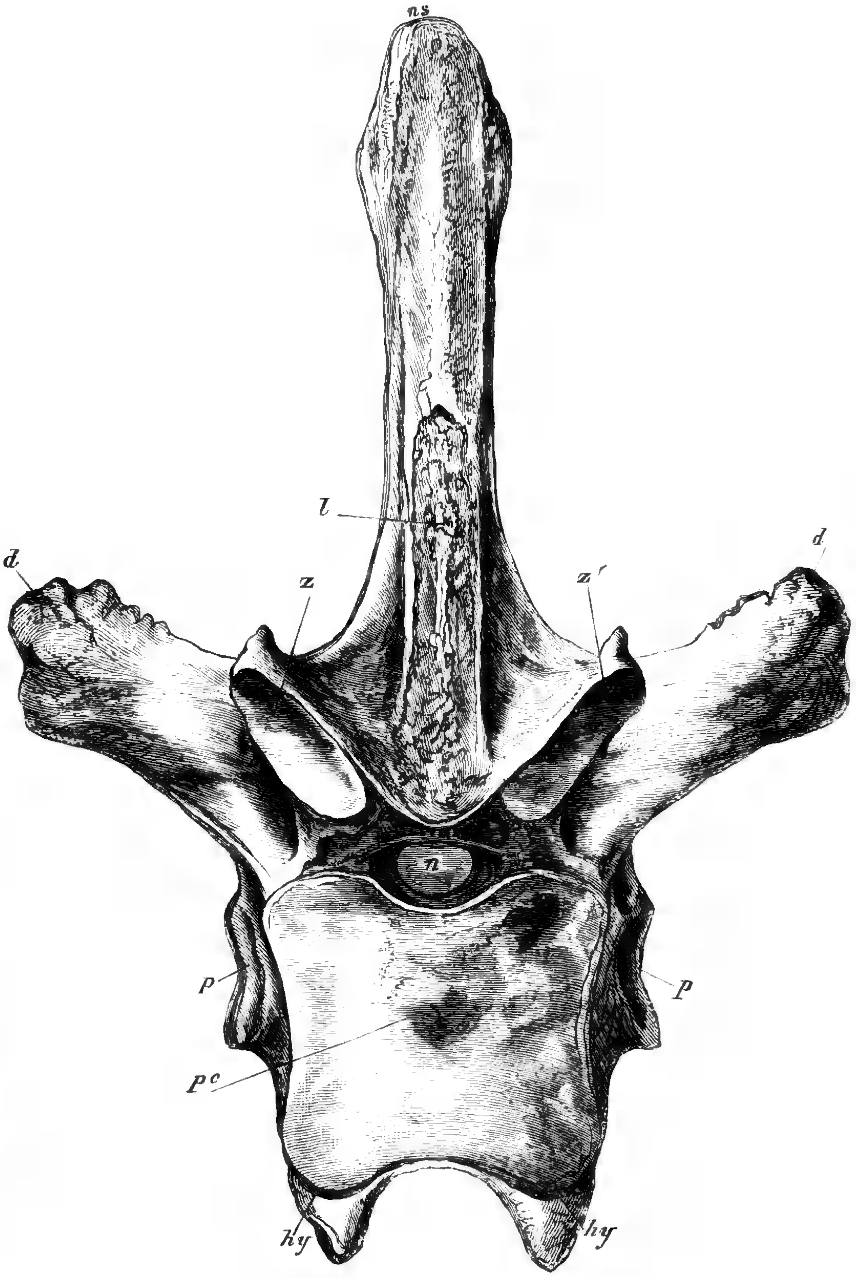


Fig. 34.



Aspects.

Fig. 33, lateral; 34, postaxial.

Struthio. Rudiments may be indicated by the letters *hy* in Mivart's fig. 54; but they are not noticed in the text. In the transverse direction the hæmal surface of the centrum is convex, as in *Struthio.*

The preaxial surface in *Dinornis* is subquadrate, through the production of its inferior angles, which, like the upper ones, are rounded off. Its transverse concavity is less than in the sixth dorsal: it is relatively larger in proportion to the centrum than in that vertebra. The postaxial surface is more definitely subquadrate, with the angles rounded off and the upper and lower borders emarginate (fig. 34, *pc*). The transverse convexity is not greater than the vertical concavity; both are feeble, so that the entire surface approaches to flatness; and in a duplicate homologue the flattening is greater than in the specimen figured. In both the surface has lost its synovial smoothness, through suppression of motion upon the first sacral vertebra. The transverse dimension does not exceed, as it does in *Struthio*, the vertical one.

The neural canal (fig. 34, *n*) is more depressed than in the twenty-first vertebra, and still more deviates from the form shown by the hinder outlet in Mivart's figure 56 of the Ostrich. The parapophysis in *Dinornis* (fig. 33, *p*) is represented merely by the raised margin of the capitular concavity. The diapophysis is less massive in proportion to the rest of the vertebra, and especially the neural spine, than in the antecedent dorsal. The neural spine is not carinate along either the fore or the hind border; both present a flat rough surface, about two thirds the breadth of each smooth lateral surface. A transverse section of the spine thus gives an oblong quadrate figure. A pair of depressions at the fore part of the base of the spine intervene between it and the prezygapophyses; they answer to the 'antero-lateral fossæ,' f^1, in Mivart's figures 55, 57. A narrower pair of fossæ hold a like relation to the postzygapophyses, answering to those marked f^3 in figs. 56 & 67 ('Mivart'). The fossæ, f^2, ib. ib., are feebly, if at all, represented in *Dinornis*.

The pleurapophysis retains its twofold articulation, but has lost in length; its hæmapophysis is attached to that of the preceding segment, and this element fails to reach its spine (sternum) in the fifth and subsequent dorsals.

The sternum may be considered, archetypally, as a coalescence of four or more such hæmal spines, the foremost retaining its connexions with its hæmapophyses, which are expanded in *Struthio* and in birds of flight as 'coracoids;' but in *Dinornis* the 'coracoids' retain the slender proportions of the true thoracic hæmapophyses. They are also here confluent with their pleurapophyses, which, detached as a 'scapula' from its proper centrum, has the proximal end free without articular head, and in *Dinornis* is reduced to the normal form of a rib with diminished proportions.

Retaining these views of the 'general homology' of the sternum, I find its proper place of description at the part of the axial skeleton here attained.

The sternum belonging to the skeleton of *Dinornis maximus* under description has suffered some mutilation; but a detached example of the bone, transmitted from New Zealand to Edinburgh (Plate XCVIII.), shows a unique condition of integrity.

Still regarding, after long practice in the interpretation of avian fossils, the sternum as one of the most characteristic and taxonomically instructive parts of the skeleton of the bird, I append figures of the natural size of this most perfectly preserved specimen of the bone, which is referable to the largest of the known species of *Dinornis*[1].

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[1] This statement is made on the faith of the sternum transmitted with the rest of the skeleton of *Dinornis*

This specimen of sternum is now in the Museum of Science and Art at Edinburgh, and has been kindly confided to me for the purpose of the present Work. It agrees in general characters with that of *Dinornis elephantopus* (Plate LXXII.), but with specific differences. It shows the articular cavities (Plate XCVIII. fig. 5, *b*, *b*) for the coracoids, the two costal borders (figs. 3 & 4), and the hind border entire. The latter, besides the two lateral deep and wide emarginations, *f*, *f*, has a small and shallow medial one (*g*, *g*). A similar, but smaller, yet relatively deeper, medial notch characterizes the corresponding part of the hind border of the sternum of *Dinornis rheïdes* (Plate LXXIII.).

This three-notched type of hind border is, so far as I know, unique, or peculiar to the sternum of *Dinornis*.

The specimen under description (Plate XCVIII.) is more convex externally, more concave internally, than in *Dinornis elephantopus*, as represented by the subject of Plate LXXII. The anterior border is bent inward[1], and mainly defines the deeper part of the concavity on that surface (fig. 2, *a*). The integrity of that border with its terminal costal processes (*d*, *d*) shows it to describe a feeble curve concave backward (fig. 5). It is smoothly rounded, and about half an inch in thickness; its extent in a straight line is 8¼ inches.

An accidental or individual loss of symmetry distinguishes the present specimen. The right cavity (fig. 5, *b*) for the coracoid is deeper and better defined than the left (ib. *b*′). It would seem that the chief work of depressing the sternum in inspiration had fallen to the right scapulo-coracoid bone, and that in this act the inspired air had been driven with more force into the left sternal air-cell or reservoir, an act which had been so long or so often repeated as to have pressed the corresponding part of the sternum more outward than on the right side, resulting in a deeper inner concavity (ib. fig. 2, *pn*) and more prominent outer convexity (ib. fig. 1, *s*) on the left half of the fore part of the bony plate. On its opposite surface the number of small pneumatic foramina is greater, and they are somewhat larger in the deeper left depression than in the shallower right one.

The lateral borders of the inner concavity are formed by the extension inward of that margin of the costal tract (*c*, *c*), especially at the second and third articular surfaces. The outer border near the first or anterior costal surface projects externally. About one inch and a half of the end of the left lateral process seems to have been, in the bird's lifetime, broken from that process, and subsequently reunited to it (at *h*′, figs. 1 & 2).

It is interesting to remark, in connexion with the abrogation of the wing-bones and

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maximus having been so discovered in relation therewith as to justify Dr. Haast's determination, and by the agreement of such mutilated sternum with the answerable parts of the entire specimen.

[1] See 'Note,' p. 255.

power of flight, that the sternum does not increase in size in the ratio of the increase of the legs and general stature of the species of *Dinornis*.

The length of the present sternum at its mid line, and the breadth from tip to tip of the lateral processes, are less than that of the subject of Plate LXXII. But the length of the body of the sternum anterior to the lateral hind notches is greater in the present bone, whilst that of the part prolonged between those notches is less; the costal border (Plate XCVIII. figs. 3 & 4) is nevertheless absolutely longer in the present sternum; and although in the angle of divergence of the lateral processes (*h, h*) it conforms to the type of the sternum of *Dinornis elephantopus*, and with it departs in a marked degree from that of *Dinornis rheïdes*, yet the differences noted are sufficient to indicate that the present perfect sternum accords more closely with that of the skeleton of *Dinornis robustus*, and has, at least, belonged to a distinct species of the group of Moas, which, on sternal characters, might be denoted by the generic term *Palapteryx*.

There is, however, a gradational approach to the less divergent type of sternum exemplified in *Dinornis rheïdes*. In (*Palapteryx*) *elephantopus*, e. g., the breadth of the fore border of the sternum being 8 inches, that of the bone at the ends of the divergent processes is 15 inches.

In *Dinornis robustus* the breadth of the fore border being 8 inches 3 lines, that of the bone at the ends of the divergent process is 13 inches.

In *Dinornis maximus* the breadth of the fore border of the sternum being 9 inches, that of the bone at the end of the divergent processes is but 12 inches; moreover, the length of the sternum anterior to the notches is relatively rather more than in *D. robustus*, and makes a corresponding approach to the more elongate type of sternum represented by *D. rheïdes*.

With these approaches, in sternal gradations, to that type the limb-bones coincide, showing longer and more slender proportions as compared with *Dinornis elephantopus* and *D. crassus*; so that, even accepting, or resuming for convenience' sake, my old subdivision of Moas into two subgenera, I cannot shut out the conviction of its essential artificiality.

It is hardly probable that a nominal generic distinction will be ultimately accepted on the differences here pointed out between the sternums of the species of *Dinornis* outlined in cut, fig. 35, especially as they are associated with corresponding gradational differences of proportion in the bones of the hind limbs.

Admitting such generic or subgeneric group for the species *crassus* and *elephantopus*, showing the extreme divergence of sternal processes with robustness of hind limbs, and if the term *Palapteryx* had not had priority, I must have adopted Reichenbach's *Emeus*[1], of which my *Dinornis* (*Palapteryx*) *crassus* is the type.

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[1] Das natürliche System der Vögel, 4to, 1849–50, p. xxx.

Dr. von Haast has followed his ornithological countryman's procedure in a further generic subdivision of the *Dinornithidæ*[1].

Dinornis didiformis—the type of Reichenbach's genus *Anomalopteryx* (1850)—is the type of Von Haast's genus *Meiornis* (1874). The *Eurapteryx* of Von Haast (1874) is the *Syornis* of Reichenbach (1850), both represented by *Dinornis casuarinus.*

My *Dinornis curtus* is the type of Reichenbach's genus *Cela*: his genus *Movia* has *Dinornis ingens* for the type. The old generic term *Dinornis* is restricted by Reichenbach to the species *D. struthioides*; and *D. giganteus* is referred to a genus *Moa* (1850).

These generifications of the accomplished author of the 'Handbuch der speciellen Ornithologie' have not met with acceptance or favour at the hands of subsequent systematists. Whether the parallel labours of Dr. von Haast will be more fortunate remains to be seen.

Returning to my more congenial task of Comparative Anatomy, if Plate XCVIII. or the reduced outlines of the sternum in species of *Dinornis* (cut, fig. 35) be compared with the figures of the sternum of *Struthio* in Mivart's figs. 77–79, the straightness of the anterior border and the smallness of the contiguous coracoid grooves (*b*, *b′* in Plate XCVIII.) contrast with the undulate contour of the same border and the length of those grooves (*c*, *c*) in *Struthio*, which almost meet at the mid line. The body of the breastbone is more convex and bulging in the Ostrich; the lateral processes (called 'xiphoid,' and marked *lx* by Mivart) are absolutely and relatively much shorter; the medial posterior processes, which seem to me more analogous to the mammalian 'xiphoid' (Plate XCVIII. *g*, *g*), are wanting in *Struthio*; and instead of the mid notch (ib. *n*) there is, in *Struthio*, an obtuse production.

The costal border shows differences, as in longitudinal extent, in accordance with the greater number of sternal ribs to which it gives attachment in *Struthio*; this border differs also in breadth and in the complexity of the articular surfaces, corresponding, in *Struthio*, to the more expanded and subbifid sternal ends of five of the six pairs of sternal ribs which articulate therewith in that existing form.

The sternum of *Apteryx* conforms much more closely to the type of that bone in *Dinornis* than does the sternum in any other known species of bird. Modification has reigned in the peripheral prehensile portion of the cephalic extremity of the vertebral column to the degree of generic distinction manifested by the kinds of Kivi.

To the side view[2] of "the sacral and caudal vertebræ of a young Ostrich"[3] Prof. Mivart[4] has added a hæmal ('ventral' or lower) view (fig. 60, *loc. cit.*) and a neural

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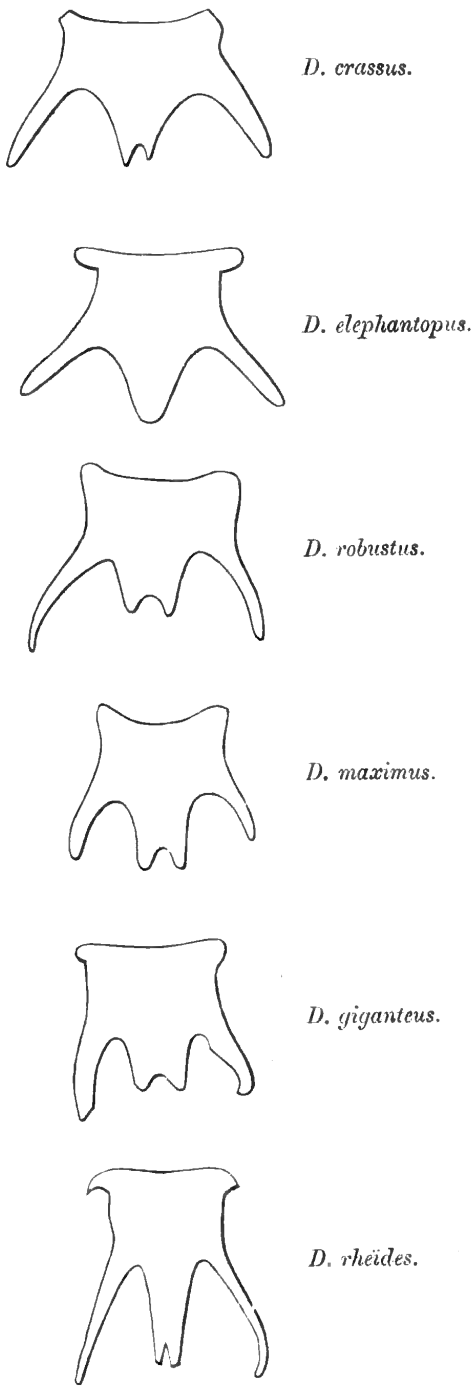
[1] "Address to the Philosophical Institute of Canterbury," in the 'Lyttelton Times' of Friday, March 6th, 1874; reprinted in the 'Transactions of the New-Zealand Institute,' vol. vi. June 1874, p. 419.

[2] 'Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27.

[3] 'Descriptive Catalogue of the Osteological Series contained in the Museum of the Royal College of Surgeons of England,' 4to, 1853, p. 266, no. 1885.

[4] "The Museum of the College of Surgeons fortunately possesses a preparation of the sacral vertebræ (figs. 58, 59, 60, and 61) of a young Ostrich in an unanchylosed condition, which enables the serial description of

Fig. 35.



Specific modifications of the sternum in the genus *Dinornis*.

('dorsal' or upper) view (fig. 61, *loc. cit.*). The modifications of sacral structure here exhibited, which have proved most instructive in their application to the vertebræ of extinct animals, are the alternate disposition of certain centrums and neural arches and of a few other centrums and pleurapophyses. In *Mammalia* such disposition of the heads of ribs across the articular intervals of the centrums is the rule in dorsal vertebræ, and a like disposition of the neural arches occurs in the dorsal vertebræ of *Chelonia*; but the concurrence of the alternating positions of centrums with both elements appears not to have been observed in the sacral region of any vertebrate until the task of determining the singular detached centrums in the *Iguanodon* and other large extinct *Reptilia* led me to a series of researches into the sacral structures and their development in existing Vertebrates. These researches led, among other results, to the detection, in the long sacrum of birds, of "a shifting of the neural arch from the middle of the body to the interspace of two adjoining centrums, each neural arch being there supported by two contiguous vertebræ, the interspace of which is opposite the middle of the base of the arch above, and the nervous foramen is opposite the middle of each centrum"[1]. By this modification, "that part of the spine subject to greatest pressure is more securely locked together;" and I further remarked that, "this structure is beautifully exemplified in the sacrum of the young Ostrich"[2].

The detached centrums of such vertebræ yielded the key to the characters of the

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individual vertebræ to be completed" (Zool. Trans. viii. p. 420). Probably my preparation, No. 1885, may be here alluded to.

[1] 'Reports of the British Association,' 8vo, 1841, "On British Fossil Reptiles," p. 106.

[2] Ib. ib.

Dinosaurian vertebræ figured in plates xii. *et seq.* of my 'History of British Fossil Reptiles'[1]. Every subsequent discovery of a true Dinosaur has confirmed the applicability and value of this character of the extinct order.

The 'sacrum' in *Dinornis* I continue to characterize, as in other birds, by the anchylosis of the vertebræ, through which that single mass of the 'spinal column' results. The concomitant anchylosis of the iliac, ischial, and pubic bones constitutes the 'pelvis.' In birds "anchylosis converts a large proportion of the vertebral column into a sacrum"[2]. When it is said, and legitimately in its taxonomic application, that "the *Cetacea* have no sacrum," it is to be understood that vertebræ homologous with the sacrals of the bird have not coalesced: when a mammal is said to have but two "sacral vertebræ," the homologues of two of the sacral vertebræ of the bird have coalesced. In *Dinornis maximus* seventeen vertebræ have so coalesced, and include the homologues of vertebræ which in mammals retain their primitive freedom, and may be characterized as 'dorsal,' 'lumbar,' and 'caudal.' When it is said that birds have no lumbar vertebræ, a similar remark applies to that which has been offered respecting the absence of sacral vertebræ in the *Cetacea.*

The first or foremost sacral vertebra in *Dinornis maximus* (twenty-third of the entire series) offers to its pleurapophysis, which retains its mobility, a parapophysial cup near the upper and fore part of the centrum, and a small rough facet on its diapophysis. The pleurapophyses of the second and third sacrals are anchylosed each to its parapophysis, and thence, by a bony plate, continued from the upper part of the 'cervix' to the lower part of the diapophysis. These two last ribs are progressively shortened, but still project beyond the iliac roof. Their more reduced serial homologues form the transverse osseous bars abutting against the outswelling antacetabular part of the ilium, with which the pubis has coalesced (Plate XX. fig. 2).

After the second sacral centrum that element, in succeeding vertebræ, quickly loses length. In the section of the sacrum of *Dinornis maximus* (Pl. CXIV. fig. 2, $\frac{1}{3}$ nat. size) the interval between the first (1) and second nerve-outlets, which is 2 inches 7 lines, is reduced to 6 lines between the sixth (6) and seventh outlets, and to a less extent in the four succeeding outlets. Between the twelfth (12) and thirteenth outlets the interval is 9 lines, and it increases to 1 inch 6 lines between the fifteenth and sixteenth (16) outlets. Of these nerve-outlets, the separation of the motory from the sensory division is well marked at their commencement from the neural canal in the fourth sacral, and so continues to the twelfth. In the thirteenth the size of the outlet is much reduced: from this part the myelon is restricted to the supply of the terminal contracted part of the spinal column called 'tail;' and here we have the sign of the beginning of the

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[1] Quarto, part vi. (1855).

[2] 'Anat. of Vertebrates,' 8vo, 1866, ii. p. 29. The homologies of certain of these with the vertebræ called 'dorsal,' 'lumbar,' and 'caudal,' in other vertebrate classes, are given in my 'Archetype,' &c., 8vo, 1848, p. 90 *et seq.*

caudal series of vertebræ, of which five have been enlisted or conscripted into the service of the sacrum.

The sacro-neural canal (Plate CXIV. fig. 2) retains a vertical diameter of 8 lines along the first three vertebræ; it then expands gradually to the sixth and rapidly to the ninth sacral, where the vertical diameter reaches to 1 inch 6 lines. The anterior or 'hæmal' myelonal columns would seem to have made a bulge between the eighth and tenth vertebræ; and the neural canal, again contracting, shows its diameter of 8 lines between the thirteenth and fourteenth outlets, and is reduced to 4 lines in the last or seventeenth sacral vertebra.

The motory and sensory divisions of the nerve-outlets continue distinct to the outer surface of the vertebra as far as the twelfth sacral, the neural (dorsal, upper) or sensory division being the smallest, and diminishing more rapidly than the hæmal (lower, motory) outlet after the ninth of these. The canal gains in transverse as in vertical expanse, but in a rather less degree.

Parapophysial abutments cease after the eighth sacral, and are resumed at the twelfth. The diapophysial ones increase in length from the fifth sacral, but with much diminished breadth, to the ninth sacral, when they increase in breadth as well as length, and curve upward, backward, and slightly outward to buttress up the expanded postacetabular part of the ilium.

Between the smooth compact inner layer of bone forming the neural canal and the somewhat thicker outer layer, the osseous substance of the sacrum is coarsely reticulate and pneumatic. Larger subserial vacuities mark, in vertical section (Plate CXIV. fig. 2), some of the anterior obliterated vertebral interspaces; and the longest or chief laminæ, rising from the roof of the neural canal, indicate the neural spines at distances corresponding to the nerve-outlets, answering to the fourth sacral vertebra. The spine-plate curves gently forward; while those of the sixth, seventh, and eighth sacrals rise vertically, and the succeeding ones curve gently backward.

In the comparison of the sacrum of *Dinornis*, as exemplified by the present species, with that of *Struthio*, as illustrated in Prof. Mivart's paper [1], I may premise that the first three (anchylosed) vertebræ are reckoned, by its author, as 'dorso-lumbar' (26th and 27th) and lumbar (28th) vertebræ. It will be understood, therefore, that in my description of the specimen "in the Museum of the College of Surgeons" [2], figured in Mivart's cut 59, "the neural arch of the fifth sacral vertebra has advanced, and rests over the interspace between its own and the preceding centrum; at the eleventh vertebra it has resumed its normal position and connexions" [2]. My 'fifth sacral' is Mivart's 'second' (*s* 2), and my 'eleventh' sacral is Mivart's eighth; the last five sacrals in the twenty anchylosed vertebræ of the mature Ostrich (Plate XIX. fig. 4) are reckoned by him as the first five caudals in that bird.

In *Dinornis* the twenty-fourth vertebra (3rd sacral), answering to the twenty-eighth

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[1] *Loc. cit.* pp. 420–427, figs. 58–62.

[2] 'Catalogue' *ut suprà*, 4to, 1853, p. 266.

vertebra of *Struthio* (Mivart's 'lumbar vertebra'), differs in presenting an unmistakably rib-like pleurapophysis, although unanchylosed. The fourth sacral in *Dinornis* is the first which may be said to "present no indication of a rib," and which would be entitled to the term "lumbar," according to such character. I view, however, the parapophysial element of this transverse process as more probably the serial homologue of the cervical part of the preceding pleurapophysis.

With this explanation the neural arch of the fifth sacral vertebra in *Dinornis*, as in *Struthio*, advances and crosses the interspace between its own and the preceding centrum; and the thirteenth vertebra is that in which the arch resumes its normal connexions. Thus the interlocked part of the sacrum in *Dinornis* is more extensive than in *Struthio*, and relates to the heavier mass which the pelvis had to transmit upon the femora.

The antacetabular part of the sacrum (1st to 6th vertebra in *Dinornis*) is relatively shorter and broader than in *Struthio*; the postacetabular part is still broader in proportion to its length; and this part is shorter than the antacetabular part, instead of being, as in *Struthio*, longer.

More striking differences are presented by the pelvis as a whole (Plates XIX., XX., XX.*a*, XCVI. fig 4). The antacetabular plate of the ischium is relatively longer; the postacetabular part is shorter, but much broader in *Dinornis* than in *Struthio* (Plate XIX. fig. 4): the greater relative breadth of the entire pelvis would seem to relate to the larger proportional size of the egg in *Dinornis*.

The ischium is shorter and deeper than in *Struthio*: it unites with the ilium anteriorly to bound there the ischiadic notch, which remains open posteriorly, as in *Struthio*, and is not circumscribed by a second terminal union of the ischium with the ilium, as in *Dromaius*. The obturator interspace, closed behind, as in *Struthio*, by ischial confluence with the pubis, and having its fore part defined by the descending process of the ischium, is much narrower in *Dinornis*, as in *Apteryx*. The pubis does not send off so long and well-defined a 'pectineal process'[1], as in *Struthio*; its body extends backward parallel with the ischium, slightly concave downward, and terminates in the vertical expansion joining the ischium without being continued downward and forward to meet its fellow at the symphysis, a structure which is peculiar, among birds, to the genus *Struthio*.

The type of the pelvis in *Dinornis* is that of the *Apteryx*, not of the Emu or Cassowary; it differs therefrom in less marked modifications than from the pelvis in *Struthio* and *Rhea*.

The number of terminal sacral vertebræ in *Dinornis maximus*, answering to those defined as 'sacro-caudals'[2], is four. The last of these in *Dinornis* is the thirty-ninth of the vertebral series; in *Struthio* it is the forty-sixth.

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[1] For this process in *Apteryx australis*, see p. 35, Pls. VIII. & IX. In the two skeletons of the smaller Kivi (*Apteryx Owenii*, Gd.) I have found ossification extending along the ligament attaching the pectineal process to the last sacral rib.

[2] Mivart, *ut suprà*, p. 426, fig. 62.

In *Apteryx australis* there are nine caudal vertebræ, the anterior ones of greater relative vertical extent than in *Struthionidæ*; but as they recede they gain in transverse and lose in vertical diameter. The last two coalesce to form the 'ploughshare' bone[1].

FORTY-FIRST, or SECOND CAUDAL, VERTEBRA ($\frac{1}{2}$ nat. size).

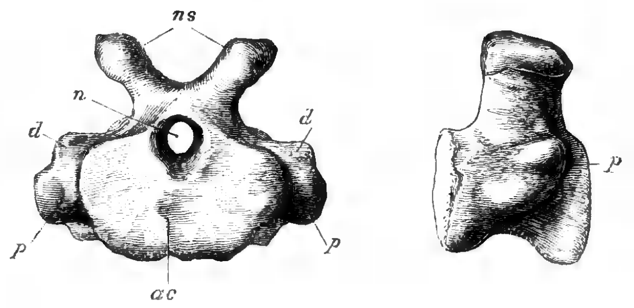
Fig. 36. Fig. 37.

Aspects.

Fig. 36, preaxial; 37, lateral.

I am not certain that I possess the fortieth vertebra or 'first free caudal' in *Dinornis*. The second, if it be not the first (figs. 36 & 37), has the centrum broader in proportion to its length and height than in *Struthio*. The contour of the preaxial surface (*ac*) is subhexagonal, with the upper line short and emarginate, forming the lower boundary of the neural canal (*n*).

The surface of *ac* is irregular, indicative of syndesmotic union with the sacrum (or first caudal), deviating on the whole from flatness by a slight convexity: the opposite articular surface is undulate, slightly concave at the middle third, convex to the periphery: the angles of the hexagon are rounded off. The under surface is longitudinally concave, a mid channel being bounded by a pair of longitudinal ridges. A thick, short, obtuse, subbifid parapophysial ridge (fig. 37, *p*) extends from the middle of the antero-lateral part of the centrum obliquely backward to near the upper and outer angle of the hinder articular surface. The neural canal (fig. 36, *n*) is small and subcircular; in *Struthio* its section gives a vertical ellipse. The diapophysis is represented by the upper division (fig. 36, *d*) of the tuberous diparapophysis. In *Struthio* the diapophysis is a distinct process from the parapophysis, and is the longer and larger of the two. The neural canal in *Struthio* is surmounted by a thick subquadrate mass with its enlarged tuberous extremity subbifid posteriorly.

In *Dinornis* the character of the double neural spine, which distinguishes, in the present comparison, several of the neck-vertebræ, is resumed in those of the tail. A pair of low, thick, short, tuberous processes (fig. 36, *ns*) diverge from the roof of the neural canal and simulate a '*spina bifida*.'

This character is continued through the caudal series to the foremost of the three

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[1] *Ante*, p. 32, Plate VIII.

vertebræ (figs. 38, 39) which coalesce to form the homologue of the terminal 'os en charrue,' or 'ploughshare bone,' in most other birds, and in all those that fly and possess the 'rectrices' or 'rudder-feathers,' as the tail-quills are termed.

In the description of the skeleton of *Dinornis elephantopus*, p. 223, nine caudal vertebræ are noted, as in the *Apteryx*, reckoning the terminal bone as one of the series, and its leading distinction of shape from that in birds of flight is pointed out. The character of the bifid neural spine is indicated as "a pair of tubercles supported by a low transversely extended neural arch" (p. 233).

FORTY-SIXTH, FORTY-SEVENTH, and FORTY-EIGHTH VERTEBRÆ, or Terminal Caudals ($\frac{1}{2}$ nat. size).

Fig. 38.

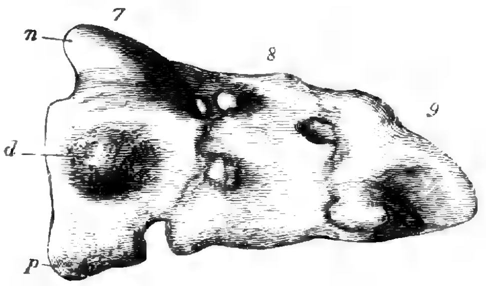
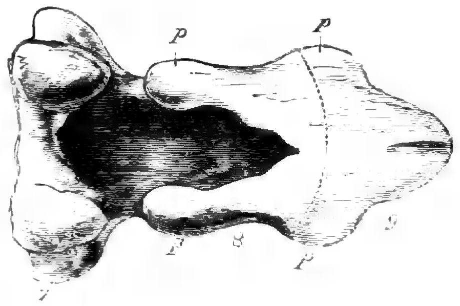


Fig. 39.



Aspects.

Fig. 38, lateral ; 39, hæmal.

In a species of *Dinornis*, which Capt. Hutton thinks may be *D. crassus*[1], the last three caudal vertebræ coalesce into the 'ploughshare bone' (figs. 38 & 39); but this, as in *D. elephantopus*, *D. maximus*, and doubtless in the rest of the genus, has no claim to the shape, common in birds, which suggested the vernacular name[2].

The neural spine is suppressed in the last two of these caudals (fig. 38, 8, 9), which are reduced to the central element with, perhaps, a neural ridge imperforate; and this ridge forms the uppermost of the three ridges which characterize the three-sided cone constituted by these two terminal vertebræ. Of the three sides the lower is the broadest (fig. 39, 9).

In the penultimate (8th caudal) vertebra the lower surface (ib. 8) presents a triangular excavation, the base being turned forward and the sides formed by the last rudiments of parapophyses (ib. 8, 9, *p*, *p*); the apex of the cavity extends to the anchylosis with the last vertebra. The sides of both vertebræ are subconcave, the centrum expanding at both ends. The *quasi*-parapophysial expansions of the fore end

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[1] "The box also contains a complete set of caudal vertebræ of *D. crassus* (?) from Shag Point: these are from one bird."—Letter dated "Dunedin, N.Z., 13th Dec. 1875." These vertebræ were six in number, reckoning the soldered three as one. I doubt their including the entire series.

[2] 'Os en charrue,' Fr.

of the last centrum (ib. 9, *p*) extend beyond the hinder expansions of the penultimate vertebra. The centrum of the last vertebra contracts to an obtuse point, grooved below.

The antepenultimate vertebra retains its neural arch, canal, and bifid spine (fig. 38, 7, *n*), differing only in size and the stunted character of the processes from the antecedent free caudals.

The lower and fore part of the sides of the centrum extend as short, broad, obtuse parapophyses. These render the under surface of the centrum transversely concave. A similar low obtuse diapophysis projects from the base of the neural arch and contiguous part of the centrum with which it has coalesced. The gradual diminution of the terminal vertebræ of the tail to an obtuse point indicates that such an appendage was as little indicated by the plumage in *Dinornis* as in *Apteryx*.

In *Struthio* the transverse processes of the caudal vertebræ have assumed, in the third of the series (fig. 65, p. 429 of 'Mivart'), much of the coalesced characters of the first in *Dinornis* (fig. 36). The antero-posteriorly compressed and transversely extended mass representing the neural spine begins to shoot out its upper angles in the third caudal of *Struthio*, and in the sixth (fig. 66, p. 430 of 'Mivart') they more nearly repeat the parial divergent spines in *Dinornis* (fig. 36, *ns*). In the eighth caudal of *Struthio* (fig. 67. p. 430 of 'Mivart') a third low spine rises between them. The ninth caudal in *Struthio* (fig. 68, ib.), which is commonly found anchylosed at the neural and hæmal borders of its postaxial surface with the terminal 'ploughshare,' is the homologue of the foremost of the three terminal coalesced caudals in *Dinornis* (fig. 38, 7); but it has lost its transverse processes, and a terminally trifid lofty neural arch and spine represent the low arch and pair of tuberous neural spines in *Dinornis*.

Prof. Mivart[1] rightly notices the indications of the two terminal vertebræ which have coalesced to form the vertically extended laterally compressed plate of bone, with its irregular more or less rounded margin, so markedly distinguishing the termination of the vertebral column in *Struthio* from that in *Dinornis*.

The retention of the ploughshare character in the Ostrich relates to the large size of the feathers which it supports, and which represent the 'rudder-quills' ('rectrices') of normal birds of flight. Such caudal plumes, with the similar alar plumes, the better developed bones of the unavailable pair of wings and concomitantly developed sternum and scapular arch, concur in showing that the great existing flightless bird of Africa has receded in a less degree from the volant type than have the extinct wingless birds of New Zealand.

The terminal segments of the 'axial skeleton' in *Dinornis* differ from those in *Apteryx* mainly in the minor modifications of the elements and apophyses constituting the palate and beak. As these segments are omitted in Prof. Mivart's analysis of the axial skeleton of the Ostrich, the comparison of the individual vertebræ in advance of the atlas will not be here entered upon.

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[1] *Loc. cit.* p. 431, fig. 69.

The skull of *Dinornis maximus* differs chiefly in size from that of *D. robustus* and *D. ingens*. It presents the same type of beak and mouth-bones, the same low broad form of cranium. In the smaller species of *Dinornis*, through the minor difference in the size of brain, its case is in them relatively more convex and raised, a character which is most marked in the comparatively diminutive *Apteryx*. As the parts furthest from the centre are most subject to modifying influences, the bony framework of the beak, of which the palate forms part, departs in *Apteryx* still further than the cranium from the character of the skull in *Dinornis*.

The palatal generic characters of *Apteryx* are detailed at p. 29, and illustrated in Plate VII. fig. 2. The repeated pressure to which the beak is subject in perforating the soil for food being transferred to the hind buttress-bones formed by the tympanics, all the beak-bones articulated therewith have coalesced—the maxillaries laterally with the malo-squamosal styles, and mesially with the palatines, these carrying on the coalescence with the vomer and pterygoids; so that the upper beak, as a single bone, articulates with the tympanics by the diverging columns of its quadrifid base, the two outer and more slender ones with the outer cups, the two inner and thicker ones with the inner cups, the latter being strongly wedged, moreover, before reaching those latter cups, between the orbital plates of the tympanic and the pterapophyses or 'transverse processes of the sphenoid.' The advantage of a certain yielding movement of the tympanics under extreme pressure cannot fail to be noticed.

As the dinornithic modifications of the palate are more perfectly demonstrated in the skull of a *Dinornis crassus*, recently transmitted to me, than in that of *D. maximus*, they will be described in the section on the Restoration of that Species.

The height of the skeleton of *Dinornis maximus*, as articulated in an easy standing position, in the British Museum, is 11 feet; the length of the trunk (dorsal and sacral series of vertebræ) is 4 feet 4 inches; the length of the hind limb, in the same position, following the angle of the segments, is 9 feet; the total length of the skeleton, from the point of the beak to the end of the tail, following the curves of the spine, is 11 feet 4 inches.

DESCRIPTION OF THE PLATE.

PLATE XCVII.

Front view of the above skeleton: the individual Professor figured stands 5 feet 11 inches in height: he holds in one hand the original fragment of bone, and points with the other to the corresponding part in the *Dinornis maximus*. From a photograph.

RANGE OF VARIATION

EXEMPLIFIED IN

SPECIES OF DINORNIS.

HAVING given in the preceding Section details of the characters of the vertebræ of *Dinornis* compared with those in *Struthio*, I have taken for the subject of the present Section the skeletons of those Moas which exemplify the extent of variation of the family or genus as it is shown in the gradation from slenderness to robustness of form.

The species so selected are:—*Dinornis gracilis* (Plate CXII. fig. 1, and Plate CXIII. fig. 1), *D. casuarinus* (Plate CXII. fig. 2), *D. didiformis* (Plate CXI.), *D. rheïdes* (Plate CIX.), and *D. crassus* (Plate CVIII. and Plate CXIII. fig. 2). The two extremes in this series are exemplified in the latter Plate.

Under all these modifications, the essential characteristics of the osseous framework of the genus are retained, and the differences are due to proportion of parts, affecting also, in a certain degree, the shape of the bone, as in the skull and sternum. The chief seat of the proportional modifications, with less change of form, is the hind limb.

The length of the trunk, as represented by the dorsal and sacral vertebræ, retains a nearly constant proportion to the general size of the bird; it consists in all the species of the same number of vertebræ, viz. twenty-four, of which seven are dorsal and seventeen sacral. The number of vertebræ in the neck appears to be fifteen. I give these numbers as the rule or sum of my personal observations; exceptions, characteristic of species, may be ultimately determined; but I suspect the difference of one or two in the cervical series of certain mounted skeletons at Christchurch may be due to accident. The length of the hind limb varies in its proportion to the trunk, and chiefly through modifications of the tibia and metatarsus.

Thus in *Dinornis gracilis* the length of these two bones exceeds that of the trunk by 10 inches; in *D. casuarinus* the excess is 3 inches; in *D. didiformis* and *D. rheïdes* the two admeasurements are equal; in *D. crassus* the length of the trunk exceeds that of the tibia and metatarsus.

The presence of a back toe, inferred from the structure of the metatarsus, in *Dinornis ingens* and *D. dromioides* (p. 135), was subsequently confirmed by the acquisition of the proximal phalanx of that toe in *D. robustus* (Plate XLIX. figs. 1, *i*, 4 & 5), in *D. crassus* (Plate CXIII. fig. 2), and in *D. rheïdes* (Plate CIX.).

The indication, it is true, on which the inference was hazarded is of the faintest character; and the diminutive size and functionless condition of the high-placed 'hallux' accord therewith. The attachment of this rudimental toe was merely ligamentous. The probability, however, I think, is, that, in the species of *Dinornis* in which the little bones have not been picked up with the larger parts of the skeleton, the absence of the hallux is due to that accident, rather than to non-development of the toe in such species. Its presence in the foot of species with the integument of that part preserved, as in *Dinornis ingens*[1], the metatarsus of which shows no conspicuous trace of such attachment, exposes the weakness of any conclusion from that character.

I therefore abandoned the generic character founded on the inference and subsequent discovery of the hallux shortly after the suggestion of such taxonomic value. One could not place *Dinornis giganteus* and its probably local variety, *Dinornis robustus*, in distinct genera, because no complete series of bones, including those of the hallux, had been found in the North Island, where *D. giganteus* seems to represent the *D. robustus* of the South Island; neither could the species *didiformis* be retained as a *Dinornis*, and the species *dromioides* be distinguished as a *Palapteryx*, on like grounds; nor *D. elephantopus* be similarly separated from *D. crassus*[2].

The scapular arch, like the hallux, was originally inferred (p. 124) from an articular fossa of the sternum (Plate XXXV. fig. 2, *c*, *c*); and the inference as to the small proportional size of such arch, in comparison with that of the Ostrich and other existing wingless birds, was confirmed by the determination of the confluent coracoid and scapula in the *Dinornis robustus* (p. 170, Plate LXIV. figs. 2, 3 & 4).

Small and shallow as were the depressions in the sternum of that species to which the coracoid had been ligamentously attached, these indications are less definite in the sternum of some other species; and with regard to the scapular arch, as to the hallux, it has been surmised that such arch was naturally absent in some kinds of *Dinornis*, as, for example, in the skeleton of *D. crassus* (Plate CVIII.), *D. rheïdes* (Plate CIX.), *D. gravis* (Plate CX.), *D. didiformis* (Plate CXI.), *D. gracilis* and *D. casuarinus* (Plate CXII.). I incline to the belief, however, that the skeletons in the Museum of Natural History, Christchurch, Canterbury Province, from which the photographs of those species were taken, are deficient in respect of the scapular arch, through the accident of the non-discovery of that small and slender rib-like bone, rather than that it was not originally present.

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[1] Trans. New-Zealand Institute, vol. vii. 1875, p. 266, pl. xix.

[2] In a letter from Capt. Hutton, dated "Otago Museum, May 6, 1876," he writes: "We have in the Museum legs, with the hind toe belonging to them, of *D. ingens*, *D. casuarinus*, and *D. gravis*."

Its rudimental condition in respect of size is exemplified in the figure of the skeleton of *Dinornis robustus* (Plate XCVI. fig. 1), where it is shown in its natural connexion with the outer angle of the fore border of the sternum.

The reduction of the side elements of the arch to their primitive type form, as 'pleurapophysis' (*scapula*) and 'hæmapophysis' (coracoid), is replete with interest to the student of the vertebrate archetype; and it still remains a question whether to the ridge indicative of the articular cavity in more modified and developed conditions of the arch there might be attached an appendage serially homologous with those (epipleural plates) of succeeding costal arches, and specially homologous with the humerus[1].

Supposing it to be ultimately determined that the scapular arch, as well as its appendage, the wing, be developed in certain kinds of Moa and not in others, the question might be mooted whether a generic distinction could be sustained on such grounds, and whether a non-development of the rudimental scapular arch was coincident with a non-development of the rudimental hallux. Should such coincidence be ultimately demonstrated, the taxonomist would have stronger grounds for a genus *Palapteryx*, as well as a genus *Dinornis*, than have hitherto been afforded.

But if the determination of acceptable genera of the *Dinornithidæ* has been opposed by the numerous specimens of bones discovered since the species were propounded, on characters yielded by a few bones, or by a single one, the addition of such specimens, by hundreds, to the Museums now established by the enlightened Colonists in the capitals of the several provinces of New Zealand have confirmed, in the main, such species. Such is the conclusion arrived at by Dr. v. Haast, of the province of Canterbury, to whom I am indebted for the photographs of the series of skeletons he has articulated for the Museum of Christchurch; and I may refer to the able article "On the Dimensions of *Dinornis* Bones"[2], by Captain F. W. Hutton, C.M.Z.S., for a similar encouraging result of the examination of the collection "of the remains of more than 200 birds" of the *Dinornithidæ*, now in the Museum of Otago, under his care.

Of *D. robustus* and *D. ingens* he remarks that the remains in this collection "were too few to warrant certain conclusions, but they appear to be distinct species." Dr. v. Haast's materials have enabled him to express a more decided opinion. I should, however, have felt less surprise if the suggestion that they may be but local varieties of the same species had been sustained.

Dinornis struthioïdes, of which evidences in the Otago Museum were "much more common than of the other two" (viz. *robustus* and *ingens*), is, in Capt. Hutton's opinion, a species "very distinct and easily recognized from any other."

"I refer five metatarsi to *D. rheïdes*, but I was unable to find in the whole collection

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[1] See the observations on this point at p. 170.

[2] Trans. of the New-Zealand Institute, vol. vii. 1875, p. 274.

a single femur small enough to answer to Professor Owen's dimensions." The femur in the skeleton of this species (Plate CIX. fig. 1) repeats, however, the length of 9 inches.

In the collection from the Glenmark Swamp, South Island, are bones that scarcely differ, save in size, from the dimensions of the type bones of *Dinornis didiformis* from the North Island. They are noted as of a large variety of that species[1]. Capt. Hutton remarks:—" The bones that I have arranged under the name *D. didiformis* belong probably to a new species. The tibia is well marked and quite distinct; but the femur and metatarsus that I have associated with it pass almost into *D. casuarinus*, but are rather smaller. *D. casuarinus* is undoubtedly a good species, easily distinguished by its tibia."

Possibly the *Dinornis* of the South Island, with the tibia characteristic of the *D. didiformis* of the North Island, may need to be noted, for the convenience of naming the bones, as *Dinornis Huttonii*. The acute observer to whom it would give me pleasure to dedicate such species, proceeds to state:—" *D. gravis* also appears to me to be a good species, although the tibia very closely approaches to that of *D. casuarinus*, but is more robust, the length being only about three and a half times the circumference of the middle of the shaft, while in *D. casuarinus* it is more than four times the circumference."

Capt. Hutton reports that "in a limestone cave at 'Doctor's Creek, Waritaki' (South Island), a nearly complete skeleton of a Moa was found, the bones lying in their proper position, wanting only the head, a few cervical and caudal vertebræ, and two small phalanges of the outer right toe;" and he concludes them to have belonged to the same individual.

He gives the following admeasurements of the leg-bones:—

	Femur. inches.	Tibia. inches.	Metatarse. inches.
" Length	11·80	21·1	9·1
Circumference at middle	6·83	5·6	6·0
Breadth proximal . . .	5·1	6·3	4·15
Breadth distal	6·1	3·75	5·3 "

If these dimensions be compared with those of the type femur of *Dinornis crassus* (*ante*, p. 133, Plate XL. fig. 4), it will be seen that, with the exception of the breadth of the distal end of the bone, the Waritaki specimen closely agrees with the dimensions of the specimen from Waikawaite, recorded in the general 'Table of Admeasurements,' p. 356. I have elsewhere remarked that limb-bones seem subject to variety as they recede in position from the trunk. The excess of breadth of the distal end, 6·1 as against 5·25, relates to a larger tibia, which agrees in size with that referred by Capt. Hutton to a " var. *major* of *D. crassus*" in his Table B, p. 278 (*tom. cit.*).

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[1] See *ante*, p. 357, addition to Note 8.

The metatarse, though shorter than the shortest variety of the compound bone which I have referred to *D. elephantopus* in my 'Table' (p. 356), nearly equals in some dimensions, and exceeds in proximal breadth, the metatarse of *D. elephantopus.*

The rich collection of limb-bones of Moas in the Otago Museum appears to exemplify a course of variation from my type of *Dinornis crassus* through the *D. crassus*, var. *major*, of Hutton to *D. elephantopus.*

It remains to be seen whether the femur follows *pari passu* the variations of the tibia, and especially of the metatarsus; above all, whether the dimensions of the trunk-bones, as exemplified in Plates LX. and CVIII., vary in the ratio of those of the metatarsi referred to *D. crassus*, *D. crassus*, var. *major*, and *D. elephantopus.*

The opinion of an observer who has "made 2000 measurements" in the rich series under his care ought to carry weight; and his conclusion on the species in question is thus given :—"Still, notwithstanding all that I have said, I am convinced that it will be necessary to retain the names both of *crassus* and *elephantopus* to mark both ends of the series as characterized by the proportions of the metatarsus, the length of which in *D. crassus* is more than four times the breadth of the middle shaft, while the length is less than four times the breadth in *D. elephantopus* and *D. gravis*"[1].

We have been accustomed to associate with the idea of a bird lightness, grace, swiftness of movement, exceptional command of aerial space; the converse of all these associations is shown in the framework of the thick-limbed, broad-bodied Moa represented in Plate CXIII. fig. 2. The bird stands as a colossus on a basis hard to be shaken, suggestive of herculean strength; it is 'of the earth earthy.' The exaggerated proportions of the limbs are heightened by contrast with the slender neck and diminutive head. Truly and emphatically has the deduction from the bone-fragment (Plate facing p. 72) been fulfilled—viz. that it bespoke the former existence in New Zealand of a bird "heavier and more sluggish than the Ostrich, and with shorter and thicker legs."

The figured skeleton of *Dinornis crassus* includes 15 cervical and 7 dorsal vertebræ; the two anterior sacrals support movable ribs, the number of these being 9 pairs. In the subject of Plate CVIII. the fore part of the iliac bone is mutilated, exposing the spine of the first sacral (8th dorsal by the character of the movable ribs). The second, third, and fourth ribs articulate by sternal portions with the sternum.

As the dinornithic modifications of the palate are more perfectly demonstrated in the skull of a *Dinornis crassus* recently transmitted to me than in those previously described (pp. 262–281), I subjoin a figure of the base of the skull in that species (Plate CXIV. fig. 1), and add the following remarks :—

In *Dinornis crassus* the palatal plates of the palatines (ib. 20) are anterior horizontal expansions of those bones which coalesce with the corresponding palatal plates of the maxillaries, not passing freely beneath them. The bony palate behind the premaxillary

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[1] *Tom. cit.* p. 277. Comp. Dr. Haast's remarks on *D. elephantopus*, quoted at p. 358 of the present work.

part of the mouth-roof may be truly termed the maxillo-palatine part of that roof, including parts of both bones. In the skull of *Dinornis ingens*, figured in Plate LXXXII. fig. 3, a portion of the palato-maxillary suture still remains, and a smaller portion is traceable in the present specimen of *D. crassus*.

Birds have the maxillary, 21, and palatine bones, 20, ossified, as in mammals, from separate centres, but have no maxillo-palatine bone, save by the accident of partial confluence. The specific palatal distinction from *D. ingens* appears in the course of the suture of the maxillo-palatine plate with the premaxillary. In *D. ingens* the suture runs across in an irregular wavy line; in *D. crassus* it presents an angular form, the maxillo-palatine plate being notched to receive the angular palatine process, 22′, of the premaxillary.

In *D. crassus*, as in *D. ingens* and *D. maximus*, the slender part of the palatine, continued backward from the palato-maxillary plate, is twisted so as to bring the inner edge of that plate downward, and to turn the horizontal under surface, 20, into a vertical outer surface of the bone, which rapidly gains in depth, and has its upper part bent inward, to complete with the vomer, 13, the hind wall of the palato-narial canal. At the outer and back part of the canal the palatine is thickened at its lower part to articulate with the pterygoid, 24.

The vomer is bifid, as in *D. ingens* and as in the first-described skull of *D. crassus* (p. 266, Plate LXXVI.). The parial plates of the vomer overlap the sides of the presphenoids, 9, of which the anterior apex, 9′, coalesced with the narial septum, projects beyond the vomer, and partially divides the prepalatine vacuity. The anterior ends of the halves are overlapped by the vomerine processes of the premaxillaries. Each half of the vomer consists of a deep vertical bony plate, almost meeting below the presphenoidal rostrum, expanding at both ends anteriorly to join the premaxillary and the palato-maxillary plates, and there bounding the palato-nares anteriorly; posteriorly expanding in a greater degree, and curving outward and forward to join the palatines, and form the posterior boundaries of the palato-nares. These apertures are each 1 inch 7 lines in length, 5½ lines in breadth; the breadth across both apertures is 1 inch 11½ lines, the additional half line giving the interval between the halves of the vomer.

The suture between the vomer and palatine, as one looks down upon the skull's base, runs along the bottom of the vomero-palatine or postnarial fossa, along a shallow channel there; it seems obliterated near the postero-external rather thickened border of that fossa. From this border the pterygoid process of the palatine is divided by a triangular shallow depression. The pterygoid bone, 24, is short, three-sided, with the sharp angle between the inner and outer facets of the under surface of the bone turned downward, and continuing backward a similar ridge on the under part of the palatine. The pterygoid has an extent of articulation with the tympanic of three lines in *D. crassus*, but one of more than half an inch in *D. maximus*. The pterapophyses are marked 5′.

The thickness of the leg-bones in proportion to the trunk, and of the metatarsi in proportion to their length, in *D. crassus*, *D. gravis*, and *D. elephantopus*, are unique in the class of Birds. They are associated with a greater breadth of the trunk, and especially with a greater breadth of the sternum, in proportion to its length.

The fragmentary condition of the sternum in the series of bones of *Dinornis elephantopus* first received led the articulator of the skeleton in the British Museum to restore that bone by a model on the type of the sternum of a less robust species at that time obtained (pp. 124, 196, Plate XLVIII.). Subsequently acquired specimens (p. 254, Plate LXXII.) have shown this bone to present in *D. elephantopus* the form and proportions of the sternum of *D. crassus* (Plate CXIII.), and afford a correction of the error[1] in the first attempt at a restoration of the skeleton of *D. elephantopus*, as regards the sternum (Plate LXI. fig. 1).

As in other forms of birds, which for some time may continue rare and scantily represented in collections, the few species there recognized usually offer well-marked differences, as in tints of plumage, proportions of bones, and even in general size; but as knowledge increases, forms or species showing intermediate characters are brought to light, and the previous differences are diminished by gradational modifications, which not only render the diagnosis of the genera difficult, but affect that of the species themselves. Under foresight of this course of knowledge, I have been led to refer to some kinds of *Dinornis* as being 'propagable varieties.'

Under present knowledge certain forms of Moa seem to be limited to the North Island, others to the South Island of New Zealand. The less robust and longer-legged forms appear to have prevailed in the North Island, the more robust and shorter-legged kinds in the South Island.

But already with the advance of knowledge of the extinct *Dinornithidæ* exceptions come to light.

If Moas with the character of *D. gravis* and *D. elephantopus* existed only in the South Island to the exclusion of other forms, and if Moas with the characters of *D. gracilis* and *D. casuarinus* held the same exclusive position in the North Island, the genetic relation of such species to food and other conditions of existence respectively peculiar to one or the other insular tract of land might be speculated on as a condition of their origin with some ground of acceptance. But, as in the case of the Geospizas of the Galapagos archipelago, the application of that supposed possible way of operation of nomogony, or secondary law of the origin of species, is unavailable, and the hypothesis in these, as in other cases, falls to the ground.

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[1] See cut, fig. 35, p. 419; but the more perfect sternum from which this cut was taken was mutilated at the postmedial border, which might originally have been bifid.

Admeasurements of the Skeletons of the subjoined species of *Dinornis*.

	robustus.		*elephantopus.*		*crassus.*		*rheïdes.*		*gracilis.*		*casuarinus.*		*didiformis.*	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Length of skeleton from point of beak to end of tail, following the curves of the spine, in the easy standing position	8	3	5	8	4	0	3	10	4	9	4	4	4	0
Height of skeleton, in the easy standing position, from sole to vertex, in a straight line	8	0[1]	5	5	3	6	3	4	5	8[2]	4	6[3]	3	8[4]
Length of trunk (dorsal and sacral series of vertebræ)	3	0	2	4	2	2	1	10	2	2	2	0	1	9
Length of hind limb, in the easy standing position, following the angles of the segments	6	2	4	9	3	10	3	4	4	8	3	3	3	0

On a review of the several species of *Dinornis* of which the osteological structure is known, the following generic characters may be deduced:—

1. Skull with a rather short, broad, moderately arched bill, not attaining the height of the cranium; occipital condyle not projecting so far back as the upper border of the occipital foramen.
2. Horizontal palatal plates of the palatines and maxillaries more or less confluent, not uniting solidly, but suturally, with the premaxillary and the vomer.
3. An Apterygian, not Dromæine, pelvis.
4. A short, broad sternum, with small, ill-defined coracoid pits, and with three posterior notches.
5. Scapula and coracoid small and feeble, forming no angle, or one of 170°, not developing a glenoid cavity at their bony confluence.
6. Four toes; the hallux small and high-placed.
7. Terminal confluent caudals of less vertical extent than the antecedent free caudals.

DESCRIPTION OF PLATES.

PLATE CVIII.

Side view of the skeleton of *Dinornis crassus.*

PLATE CIX.

Side view and front view of the skeleton of *Dinornis rheïdes.*

PLATE CX.

Side view and front view of the skeleton of *Dinornis gravis* (see *antè*, p. 385).

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[1] In the articulated skeleton figured the trunk is raised at too open an angle with the leg, and this is also outstretched as in walking.

[2] The trunk is raised at rather too open an angle. [3] Ib. [4] Ib.

PLATE CXI.

Side view and front view of the skeleton of *Dinornis didiformis.*

PLATE CXII.

Fig. 1. Side view of the skeleton of *Dinornis gracilis.*
Fig. 2. Side view of the skeleton of *Dinornis casuarinus.*

PLATE CXIII.

Fig. 1. Front view of the skeleton of *Dinornis gracilis.*
Fig. 2. Front view of the skeleton of *Dinornis crassus.*

RESTORATION

OF

NOTORNIS.

IN 1847 I detected in a series of bones, chiefly of *Dinornis*, collected by Walter Mantell, Esq., in a deposit of volcanic sand, at Waingongoro, North Island of New Zealand, a mutilated skull indicative of a large bird of the Ralline family, and representing, as it seemed to me, a generic form previously unknown in that family, for which the name NOTORNIS was accordingly proposed[1]. A sternum in the same collection of bones, which also presented 'ralline' characters, and might, from its size, have belonged to the same (as then supposed) extinct Coot, led me to define *Notornis* as "a struthious or brevipennate form of the *Rallidæ*, intermediate between *Porphyrio* and *Brachypteryx*"[2].

Two years later, viz. in 1849, a party of seamen hunting seals on the shores of Dusky Bay, in the south-west angle of the South Island of New Zealand, had their attention attracted by the trail of a bird on the snow, with which the ground happened at that time to be covered. The foot-prints were larger than those of a Kivi or any living bird of which they had then a knowledge in New Zealand, and they followed the track until they came in sight of a retreating bird about the size of a turkey. The dogs of the sealers were cheered on in pursuit, and, after a long chase, the bird was caught in the gully of a sound behind 'Resolution Island.' When chased it made no attempt to fly, but ran with great speed, and upon being captured, uttered loud cries and struggled violently. The bird was rescued from the dogs and kept alive a few days on board the sealers' schooner, when it was killed, and the body roasted and eaten by the crew.

The skin was fortunately preserved, and was obtained by Mr. W. Mantell, at that time visiting the south-west part of the South Island. He transmitted the rarity to his father, Dr. Gideon Mantell, F.R.S., who, in communicating the circumstance to the Zoological Society of London, wrote:—"To the natives of the pahs or villages on the homeward route, and at Wellington (North Island), the bird was a perfect novelty,

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[1] *Antè*, p. 173, and 'Proceedings of the Zoological Society of London,' January 11, 1848, p. 1.

[2] Ib. p. 9. The term *Ocydromus* had previously (1830) been proposed for the latter ralline genus by Wagler.

and excited much interest. I may add, that upon comparing the head of the bird with the fossil cranium and mandibles, and the figures and descriptions in the 'Zoological Transactions'[1], my son was at once convinced of their identity; and so delighted was he by the discovery of a living example of one of the supposed extinct contemporaries of the Moas, that he immediately wrote to me, and mentioned that the skull and beaks were alike in the recent and fossil specimens, and that the abbreviated and feeble development of the wings, both in their bones and plumage, were in perfect accordance with the indications afforded by the fossil humerus and sternum found by him at Waingongoro, and now in the British Museum, as pointed out by Professor Owen in the memoir above referred to."

This unique specimen was submitted to the eminent ornithologist, JOHN GOULD, Esq., F.R.S., for description and definition in his great work devoted to the recent avifauna of Australia. From that work I extract the following description of the living *Notornis* by my esteemed friend and fellow-labourer[2]:—

"The amount of interest which attaches to the present remarkable bird is perhaps greater than that which appertains to any other with which I am acquainted, inasmuch as it is one of the few remaining species of those singular forms which inhabited that supposed remnant of a former continent—New Zealand, and which have been so ably and learnedly described, from their semifossilized remains, by Professor Owen, who, as well as the scientific world in general, cannot fail to be highly gratified by the discovery of a recent example of a form previously known to us solely from a few osteogical fragments, and which, but for this fortunate discovery, would in all probability, like the Dodo, have shortly become all but traditional. While we congratulate ourselves upon the preservation of the skin, we must all deeply regret the loss of the bones, any one of which would have been in the highest degree valuable for the sake of comparison with the scanty remains which have been sent home from New Zealand.

"Upon a cursory view of this bird it might be mistaken for a gigantic kind of *Porphyrio*; but on examination of its structure it will be found to be generically distinct. It is allied to *Porphyrio* in the form of its bill and in its general colouring, and to *Tribonyx* in the structure of its feet, while in the feebleness of its wings and the structure of its tail it differs from both.

"From personal observation of the habits of *Tribonyx* and *Porphyrio*, I may venture to affirm that the habits and economy of the present bird more closely resemble those of the former than those of the latter; that it is doubtless of a recluse and extremely shy disposition; that being deprived, by the feeble structure of its wing, of the power of flight, it is compelled to depend upon its swiftness of foot for the means of evading its

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[1] Vol. iii. p. 377, pl. lvi. figs. 7–13 (1848), and p. 173, Pl. XLVII. of the present work.

[2] I have to express my obligations to Mr. Gould for permission to take, from the plate illustrative of his description, the requisite number of impressions for the copies of my present work.

natural enemies; and that, as is the case with *Tribonyx*, a person may be in its vicinity for weeks without ever catching a glimpse of it.

"From the thickness of its plumage and the great length of its back-feathers, we may infer that it affects low and humid situations, marshes, the banks of rivers, and the coverts of dripping ferns, so abundant in its native country. Like *Porphyrio* it doubtless enjoys the power of swimming, but would seem, from the structure of its legs, to be more terrestrial in its habits than the members of that genus.

"I have carefully compared the bill of this example with that figured by Professor Owen under the name of *Notornis mantelli*, and have little doubt that they are referable to one and the same species; and as we are now in possession of materials whence to obtain complete generic characters, I hasten to give the following details in addition to those supplied by Professor Owen.

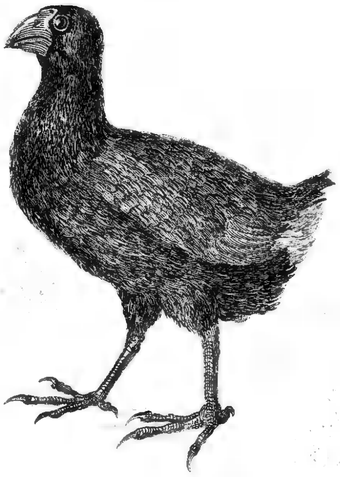
"Bill somewhat shorter than the head, greatly compressed on the sides, both mandibles being much deeper than broad; tomia sharp, curving downwards, inclining inwards, and slightly serrated; culmen elevated, much arched, and rising on the forehead to a line with the posterior angle of the eye; nostrils round, and placed in a depression near the base of the bill; wings very short, rounded, and slightly concave; primaries soft and yielding, the first short, third, fourth, fifth, sixth, and seventh equal and the longest; tail-feathers soft, yielding and loose in texture; tarsi powerful, longer than the toes, almost cylindrical, very broad anteriorly, defended in front and on either side posteriorly by broad and distinct scutellæ; the spaces between the scutellæ reticulated; anterior toes large and strong, armed with powerful hooked nails, and strongly scutellated on their upper surface; hind toe short, strong, placed somewhat high on the tarsus, and armed with a blunt hooked nail.

"Head, neck, breast, upper part of the abdomen, and flanks purplish blue; back, rump, upper tail-coverts, lesser wing-coverts, and tertiaries dark olive-green, tipped with verditer-green; at the nape of the neck a band of rich blue separating the purplish-blue of the neck from the green of the body; wings rich deep blue, the greater coverts tipped with verditer-green, forming crescentic bands when the wing is expanded; tail dark green; lower part of the abdomen, vent, and thighs dull bluish black; under tail-coverts white; bill and feet red.

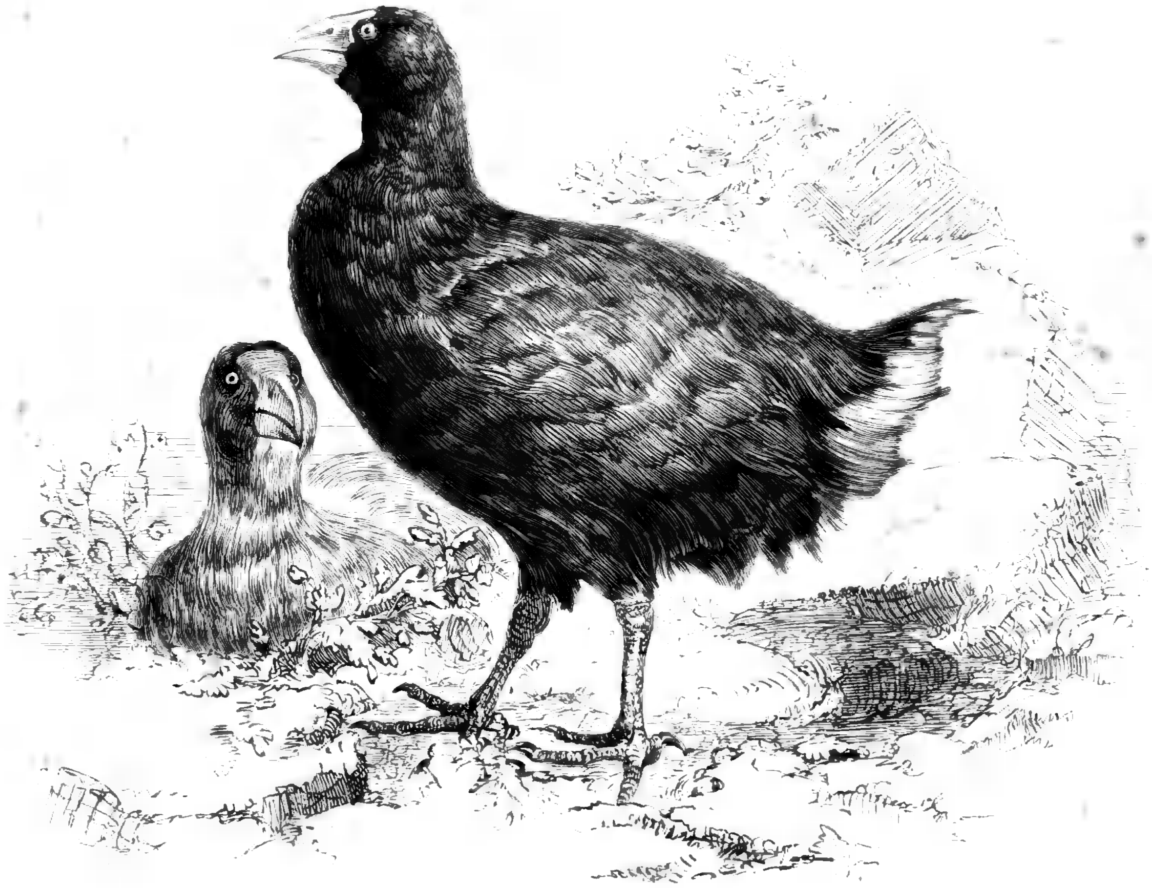
"Total length of the body 26 inches; bill, from the gape to the tip $2\frac{1}{8}$, from the tip to the posterior edge of the plate on the forehead 3; wing $8\frac{1}{2}$; tail $3\frac{1}{2}$; tarsi $3\frac{1}{2}$; middle toe 3, nail $\frac{7}{8}$; hind toe $\frac{7}{8}$, nail $\frac{3}{4}$."

Besides the skull and sternum, I had grounds for referring to *Notornis* a femur and a metatarsal bone in the series of fossils from Waingongoro.

The smaller Coot of New Zealand, called by the natives 'Pukeko' (*Porphyrio melanotis*, Gd.), comes nearest to *Notornis* in the form and proportions of the bill; but the *Tribonyx mortieri* of Tasmania and Australia offers a greater resemblance, in its feeble wings, thick legs, and short toes, than does any known existing Ralline of New Zealand, to the



great Coot of that country. I continue in hopeful expectation of the opportunity of working out more closely the affinities of *Notornis* by receiving, through some fortunate



great Coot of that country. I continue in hopeful expectation of the opportunity of working out more closely the affinities of *Notornis* by receiving, through some fortunate finder and friendly contributor, an entire skeleton of the bird. The ardent and accomplished students of the avifauna of New Zealand incline, however, to the opinion that the flightless Coot has become extinct.

It is true that a second skin of this bird was obtained by Mr. Walter Mantell, of whom it was obtained by purchase, together with the first skin, by the Trustees of the British Museum. I have not been able to ascertain the precise locality in which this second example of the living *Notornis* was taken or the circumstances of the capture.

Dr. Buller, in his excellent work on the living birds of New Zealand, writes:—

"Mr. Mantell was fortunate enough to secure a second specimen of *Notornis*; and these examples, the only two known, having been carefully mounted by Mr. Bartlett, now stand side by side in the National Collection of Great Britain, and, like the remains of the Dodo in the adjoining case, daily attract the attention of thousands of eager visitors!"[1]

Dr. Buller correctly states that the "second specimen, which is supposed to be a female, is somewhat smaller than the first in all its dimensions, has the colours generally duller, and the olive-green of the upper parts shaded brown"[2].

The first specimen he describes as that of an "adult male." No opportunity, however, was given in either instance for dissection by a person competent to determine the sex; and the supposed 'female' may have been an immature bird in an early phase of plumage. Dr. Buller gives as the native names of the *Notornis*, 'Moho,' 'Takahe,' and 'Tokohea.' But the remark quoted by Dr. Mantell from his son's letter, that the natives of the pahs and villages in his route homeward along the South Island, and at Wellington on the North Island, regarded the bird-skin as "a perfect novelty," must be borne in mind.

The date of the extinction of *Notornis* in the North Island may have been that of the *Dinornis*, *Apteryx*, and *Cnemiornis*. Even in the South Island, which was less peopled by the Maories, the *Notornis* would seem to have been driven to the south-west extremity, where I am still in hopes that, as Dr. Buller remarks, "Although no examples of the *Notornis* have, since 1848, been obtained, it does not necessarily follow that the species is absolutely extinct. The recluse habits of such a bird would account for its escaping notice in the only partially explored portions of the country"[3].

In Steward's Island and contiguous portions of dry land to the south-west of the South Island of New Zealand search might be made.

DESCRIPTION OF THE PLATE.

FRONTISPIECE TO VOL. I.

Side view of the larger specimen of the *Notornis* in the British Museum: nat. size.

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[1] 'A History of the Birds of New Zealand,' by Walter Lawry Buller, Sc.D., F.L.S., &c. 4to, 1872, p. 192.

[2] Ib. p. 189.

[3] *Op. cit.* p. 192.

MEMOIR

ON THE

INTEGUMENT AND PLUMAGE OF DINORNIS.

ALTHOUH reports, more or less sensational, of the view and even capture of a living gigantic Moa have obtained, from time to time, newspaper circulation, no specimen, dead or alive, has yet reached Europe, or come into the hands or purview of any competent scientific observer in New Zealand. No stuffed *Dinornis*, alongside the *Notornis*, enriches the ornithological gallery of the national collection of natural history. Yet, in 1848, such an acquisition would have been as unlooked for and as unlikely as that of the large and seemingly extinct Coot of New Zealand.

A faint gleam of hope of a possibility of such coming event passed across my mind when, in 1864, I received from the accomplished State Geologist of the Province of Wellington, JAMES HECTOR, M.D., F.R.S., &c., the announcement of the discovery of an almost entire skeleton of a large-sized Moa, in which "portions of the integument and feathers still remain attached to the sacrum "[1]. A portion of the skin was attached also to the sole of one foot of this specimen[2]. The skeleton in question, determined to belong to the species *Dinornis robustus*, was forwarded, as above stated, to the Museum of the Philosophical Society of York, and the experienced Keeper of that Museum communicated the results of his examination of the remains of the feathers to the Zoological Society of London[3].

The dried skin, with portions of feathers, was attached to the upper rhombic area of the pelvis (shown at *c*, *c*, fig. 3, Plate XX.), and extended, on the left side, beyond the ridge there bounding the area, down to a part where, beneath the skin, was attached the aponeurotic portion of a femoral muscle. The feather-bearing part of the skin forms a broad irregular transverse band, and, posteriorly, a little to the right of the centre, were many perforations in the rather thick and coarse skin, indicative of feathers that had disappeared. The remains of these, in places, were limited to the skin on the flat area, in which their insertions give rise to strongly marked papillæ.

" These remains consisted of the basal portions of the shaft and of the accessory

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[1] *Antè*, p. 154.

[2] The subject of the Memoir, p. 248, plate lxxi.

[3] " On the Feathers of *Dinornis robustus*, Owen." By W. S. Dallas, F.L.S., Proc. Zool. Soc., March 14, 1865, p. 265.

shaft, with here and there some traces of barbs. The longest portion of shaft so preserved did not exceed 2 inches; the quill was about $\frac{1}{24}$ of an inch in diameter. In the dried skin it was inserted $\frac{3}{16}$ of an inch, and the webs appear generally to have commenced about $\frac{1}{12}$ of an inch from the junction of the quill with the shaft.

" The longest accessory shaft measured 1½ inch in length, but, like the main shaft, was imperfect; it is more slender, and was doubtless shorter than the main shaft. This is slightly convex above, and shows the usual fine longitudinal furrow beneath. Here it is of a brown colour, but of a pale horn-colour above, probably," as Mr. Dallas remarks, " from exposure to external influences. The accessory shaft is of a pale horn-colour, and appears to be nearly cylindrical."

In Plate CXIV. fig. 8 shows the basal portion of one of the feathers detached from the skin, *a* being that of the main, and *b* of the accessory shaft; fig. 9 shows another basal portion with a smaller accessory shaft, *b*; fig. 10 shows part of a barb with the barbules, magnified 15 diameters. These figures are from Mr. Dallas's memoir.

" The barbs consist of slender flattened fibres, bearing long silky and very delicate barbules, without any trace of barbicels. When magnified, the barbule appears to be divided by faint transverse partitions into a series of cells, some of which, towards the apex, exhibit small tooth-like projections representing the rudiments of barbicels."

From his careful and patient examination of these relics of plumage, Mr. Dallas established the fact that the feathers of *Dinornis robustus* possessed a large accessory plume, like " the green-egged Emus and Cassowaries existing in the Australian region," and differed thereby " from the white-egged group of Struthiones represented in Africa and South America" (*op. cit.*).

Confirmation of this conclusion, in regard to probably another species of *Dinornis*, has since been obtained. In 1871 I was favoured by receiving from my valued correspondent, Capt. F. W. Hutton, F.L.S., the following letter:—

" Colonial Museum,
Wellington, N. Z., Sept. 1, 1871.

" SIR,

" Hearing that you have in preparation a work on the Moa, I think that an account of some feathers that I lately saw in the Otago Museum may be of interest to you.

" These feathers are stated to have been found by Mr. S. Thomson at the junction of the Manuhirikia with the Molyneux river, together with Moa-bones, under fifty feet of sand. Unfortunately none of the bones were preserved, so that it is not possible to say to what species they ought to be referred.

" The feathers are quite fresh in appearance, and have lost none of their colouring. They are four in number, and unfortunately all are broken.

" In one only is the tube preserved, showing the double plumes. The other three are all broken off above the tube, and differ from one another only in size. The largest is 7 inches in length, and gradually widens from $\frac{1}{4}$ inch at the base to rather more than $\frac{3}{4}$ inch at the tip, where it is broadly rounded off. The lower half is downy, the barbs having unconnected barbules, and is of a brownish grey colour. In the upper half the barbs are rather distant, unconnected, and without barbules. The brownish grey of the lower part passes here gradually into black, which colour it keeps as far as the rounded tip, which is pure white, forming a narrow segment of a circle. The shaft is not produced.

"In the double feather the tube is $\frac{1}{4}$ of an inch long, and narrow; the main shaft is broken off at $2\frac{3}{4}$ inches from the tube, before it has arrived at the black colour. The after-shaft is $4\frac{3}{4}$ inches in length, and nearly $\frac{1}{2}$ an inch broad at the tip. It is coloured exactly like the feather just described. I judge from this that the main shaft must have been about 6 inches in length, and therefore an inch longer than the after-shaft. The annexed sketch of one of the single feathers may assist you in understanding my description[1]. It is of the natural size.

"I remain,
"Yours truly,
(Signed) "F. W. Hutton."

"*Prof. Owen, F.R.S.*"

Feather of Moa.

This letter was speedily followed by confirmatory intelligence from Dr. Hector, F.R.S., of the finding of both skin and feathers of a Moa in another locality, the part of the bird retaining the tegumentary structures being the neck.

"Geological Survey,
Wellington, October 28, 1871.

"Dear Professor Owen,

"I have just received Dr. Thomson's account of his exploration of the cave where the Moa's neck was found. It is not very satisfactory; but there appears to have been many birds in such a position that their bodies must have slid down into a fissure. He appears to have secured a fine collection, among them being a complete skull with trachea attached, also fragments of skin and muscular tissue. He also sends me a few Moa-feathers, which were found by a digger, 18 feet from the surface, in alluvium. I enclose two of these feathers for you.

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[1] Capt. Hutton has since published a more careful figure of a better-preserved feather, which is copied in Plate CXIV. fig. 11.

"I will get all the information on the subject, and, if possible, examine the locality myself this summer. I have fowarded some publications to you by this mail, which I trust you will receive.

"Very sincerely yours,
(Signed) "JAMES HECTOR."

In the 'Transactions of the New-Zealand Institute,' vol. iv. 1872, my friendly correspondent states:—"I have now to describe another remarkable specimen from the same district, being the cervical vertebræ of a Moa, apparently of the largest size, upon the posterior aspect of which the skin, partly covered with feathers, is still attached by the shrivelled muscles and ligaments.

"The specimen in question belongs to Dr. Thomson, of Clyde, who obtained it from a gold-miner, and kindly forwarded it to me for description. It was discovered in a cave, or under an overhanging mass of mica-schist, the locality being thus described by Dr. Thomson, who has since visited it." After the account of the locality, Dr. T. proceeds to state:—"At our first visit, and on entering the first floor, our attention was attracted to the remains of a fire. We found numerous charred bones, both Moa-bones and sheep-bones, pieces of wood and spear-grass. No bones worthy of note were obtained here; but on entering the second floor, and by scraping away the loose dirt to a depth of two feet, we came upon numerous bones—femora, tibiæ, fibulæ, ribs, vertebræ, tracheal rings, and pieces of skin and muscle, also bones of the toes and tarsal bones and a portion of a pelvis. On one of the thigh-bones portions of muscular tissue are observed in pretty good preservation, and found on the same spot where the portion of neck was found."

The total length of this portion Dr. Hector gives as "16·5 inches." "It includes the first dorsal and last six cervical vertebræ, with the integument and shrivelled tissues enveloping them on the left side. The surfaces of the bones on the right side, where not covered by the integument, are quite free from all membrane and other tissues, but are quite perfect, without being in the least degree mineralized. The margin of the fragment of skin is sharply defined along the dorsal edge; but elsewhere it is soft, easily pulverized, and passing into adipocere.

"The circumference of the neck of the bird, at the upper part of the specimen, appears to have been about 18 inches, and the thickness of the skin about $\frac{3}{16}$ of an inch.

"The only indication of the matrix in which it had been imbedded was a fine micaceous sand that covered every part of the specimen like dust, there being no clay or other adherent matrix. On removing the sand with a soft brush from the skin, it was discovered to be of a dirty red-brown colour, and to form deep transverse folds, especially towards the upper part.

"The surface is roughened by elevated conical papillæ, from the apex of some of which springs a shorter transparent feather-barrel, never longer than half an inch. On the dorsal surface a few of the quills still carry fragments of the webs, some being two inches in length. From this it appears that the colour of the barbs was chestnut-red, like *Apteryx australis*, but that they had two equal plumes to each barrel, as in the Emu and Cassowary, and in that respect differed from the *Apteryx*, the feathers of which have no after-plume. On the other hand, the barbs of the webs of the feathers do not seem to have been soft and downy towards the base as in the Emu" [1]. As however, not any of the feathers had preserved their entire length, the equality of the after-plume in that dimension with the main plume is doubtful.

With regard to the preservation of the skin on the pelvic bones and cervical vertebræ of Moa-skeletons, it may, in part, be due to its unusual density and thickness in that bird, in which character the Kivi resembles its extinct allies.

I have already had occasion to remark:—"In the *Apteryx* the cutaneous system of muscles presents a more distinct and extensive development than has hitherto been met with in the class of Birds, a condition which is evidently connected with the peculiar thickness of the integument" [2]. So also Dr. Buller remarks:—"In preparing my specimens [of *Apteryx mantelli*] I was astonished at the toughness of the skin." And Mr. Dawson Rowley was led to observe:—"I have a portion of the skin of an adult male *Apteryx* before me; this is so thick that a pair of light shoes might easily be made of it. In setting up these birds, the toughness of the skin is such that it can hardly be relaxed: water has little effect upon it. It resembles leather" [3].

We need be the less surprised, therefore, to hear of cases of preservation of the thicker and harder skin covering the nude parts of the legs and feet. The Manuherikia instance (1864) has already been noticed (pp. 154 and 248). Ten years later the following parts were discovered in a crevice amongst the mica-schist rocks at Galloway station in the same (Manuherikia) district. They consisted of a right metatarsus with parts of the toes, a fragment of the left metatarsus, a right tibia, a left femur, and a fragment of a sternum. Capt. Hutton, in his memoir on these remains, states:—"Judging by the measurements, I believe them to belong to *Dinornis ingens*, Owen" [4].

In the right metatarsus "the whole of the skin and muscles of the posterior side are well preserved, while on nearly the whole of the anterior side they have gone. The bone thus exposed is bleached quite white, and the animal matter so much removed that the bone adheres to the tongue like ordinary Moa-bones found on the surface.

"The hind toe (hallux) is well preserved, being held in its position by the skin. Of the inner toe only the first joint remains, together with the flexor tendons. Of the middle toe the first two joints are left united with the skin of the sole of the foot. Of

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[1] *Tom. cit.* p. 114.

[2] *Antè*, p. 42.

[3] Buller, 'Birds of New Zealand,' 4to, 1873, p. 363. This is an exception to the character of the corium assigned to the class of birds in anatomical works.

[4] Trans. New-Zealand Institute, vol. vii. 1875, p. 266.

the outer toe all the joints are in their places, and the skin still covers the lower outer and part of the upper surfaces.

"The integument on the under surface of the toes is covered with small conical papillæ, about $\frac{1}{10}$ of an inch in diameter at the base, which increase in size towards the sole of the foot. There is a marked protuberance under the first and second joints of the outer toe. The papillæ here are larger and closely packed together, while on the outside of the toe they are small and rounded. On the back of the metatarsus the integument is covered by large irregular prominences nearly half an inch in diameter, divided by grooves from a tenth to a twentieth of an inch across, which are rough to the touch. These prominences are worn down quite flat, as proved by their striate surfaces, showing that the Moa, like the Emu, spent a considerable portion of its time with the lower surface of the metatarsus resting on the ground. On the sides of the leg the prominences are flat, slightly lengthened longitudinally, and with a divided wart-like surface; they are about the same size as those on the lower surface, but are set closer together, and are arranged in irregular longitudinal rows. On the sides of the tibio-metatarsal articulation the prominences are smaller, more rounded, and higher. Judging from the fragment of integument left on the anterior side of the metatarsus, its surface appears to have been covered with flat, more or less rounded, prominences in quincuncial arrangement, separated by flat smooth interspaces about a tenth of an inch wide. There is no appearance of its having been covered with horny scales as in *Apteryx*."

Such 'scutella' may, however, have been present in the missing integument. Those in front of the metatarsus in *Apteryx* are comparatively small, close-set, with overlapping margins, and vary somewhat in proportion according to the age of the bird as well as in the species: in the large grey Kivi (*A .haastii*), *e. g.*, the scutellæ are broader than in *A. oweni* and *A. australis*. "In colour the dried integument is yellowish brown, getting paler on the posterior surface." In conclusion, Capt. Hutton remarks, "that the extraordinary juxtaposition of decayed and lichen-covered bone with well-preserved skin and flesh, seems to me to point to some peculiarity in the atmosphere which enables flesh to resist decay when shaded from the rays of the sun, and by no means to prove that the bird to which the skin and flesh belonged lived at a later date than those whose bones we now find buried under the soil"[1].

The ecto- and endo-condylar fossæ and the intercondylar ridge were covered by their articular cartilage, brown and dry through exposure.

From the remnants of ligamentous and tendinous structures attached to the metatarsus, some repetitions of the muscular arrangements in the *Apteryx* (noted above, pp. 54–61) appear to have been detected by the able comparative anatomist, Dr. Coughtrey[2]. The specimen is in the Otago Museum.

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[1] *Tom. cit.* p. 268.

[2] See his excellent "Anatomical Notes on the Moa's Leg," &c. *tom. cit.* p. 269, pl. xix.

Subsequent to the reception of Moa-feathers from the deposits at the junction of the Manuherikia with the Molyneux river, Capt. Hutton was shown more feathers, which had been found between Alexandria and Roxburgh, 18 feet below the surface. "The feathers," he states, "from both these places are so much alike that there can be little doubt but that they belong to the same species of bird, their differences being simply due to their coming from different portions of the body. They are all quite fresh in appearance, and the colouring is as bright as if just plucked from the bird; but unfortunately all are more or less broken, and only one" (in the Otago Museum) "shows the tube that enters the skin. In this feather the length of the tube is $\frac{1}{25}$ of an inch, and it contains two plumes or feathers. The main plume is unbroken, and is 4·75 inches in length, and 0·5 of an inch broad at the tip; the other or accessory plume is 2·75 inches long and broken off, but in size it almost equals the main plume. The greater number of the feathers gradually enlarge from the tube to the tip, where they are rather bluntly rounded off; some, however, especially the more downy ones, have the sides more parallel. The largest was 7 inches long and 0·75 of an inch broad at the tip. The barbs are unconnected and rather distant, but not so much so as in most struthious birds. They are furnished with barbules up to the very tips of the feathers, except in a few cases where for a short distance the barbs are simple. No barbicels exist in any part of the feathers; the down portion is simply formed by the barbules being more elongated and set closer together. The shafts are slender and flexible, and do not project beyond the barbs. In colour the feathers are brown for about the basal two thirds, the more downy ones being of a redder brown than the others. This brown gradually shades off into black, which colour is kept as far as the rounded portion of the tip, which is pure white. The shaft is of the same colour as the feather"[1].

It thus appears that in other species of Moa besides the *Dinornis robustus* the feather has a well-developed accessory plume, and that the barbules are destitute of barbicels.

The presence of the accessory plume distinguishes such feather from that of any known species of *Apteryx*, and its relative size from the feather in *Dinornis* and *Casuarius*, in both which genera the 'accessory' equals or nearly so the 'main plume,' at least in the larger feathers of the trunk. In *Rhea* the accessory plume is represented by a tuft of down: in *Struthio* it is wanting.

In the type Kivi (*Apteryx australis*) each dorsal feather has the shaft and basal parts of the barbs rufous brown, the major (distal) parts of the barbs are black. The quill-tube is extremely small, narrow, and flexible. The downy part at the base of the feather is largely developed; the barbules are fine and long, giving to each barb the semblance of a miniature feather. In the North-Island variety (*A. mantelli*, Bart.) the tip is stiff and pointed, and on the upper and hinder parts of the body the shaft is produced to a sharp point, giving a rigid character to the plumage. In remote

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[1] "On some Moa Feathers." By Capt. F. W. Hutton, F.G.S., Trans. of the New-Zealand Institute, vol. iv. (1872), p. 172.

localities of the North Island, and more widely diffused in the South Island, there still exists a smaller species of *Apteryx* (*A. oweni*, Gld.), of which the plumage resembles that in (some species of) *Dinornis* in being softer and less rigid than in *A. mantelli*, in having a shorter basal downy portion, and in the tip of the feather being of a markedly lighter colour than the rest of the vane, which also presents portions or bars of fulvous brown and blackish brown. The analogous shades observable in the disinterred feathers of the Moa, and especially the lighter tip, perhaps blanched to whiteness, must have given, at least to the species of *Dinornis* to which the feather (Plate CXIV. fig. 11) belonged, a banded or mottled character.

A larger banded kind of *Apteryx* (*A. haastii*, Blr.), obtained on the high ridges above Okarita, on the west coast of the South Island, affords plumes approaching in size, nearer than in *A. oweni*, to those of the *Dinornis* above described; but the terminal tip is less marked. There is, however, as little appearance of an accessory plume in this as in other known kinds of Kivi.

In the "Notes on Moa-Caves in the Wakatipu District," communicated by Taylor White, Esq., to the Otago Institute, it is stated that at "thirty feet from the entrance, in the two-inch crust, a small quantity of double-shafted feathers, of a greyish brown colour and three inches long, were obtained." "Further on was a small collection of short sticks, fern and broom, which might be the remains of a nest. Here the feathers were scarcer, and a metatarsus was found in good preservation which measured 8 inches in length, 6$\frac{7}{8}$ girth at proximal end, 3$\frac{7}{8}$ at thinnest part, and 8$\frac{3}{4}$ girth at distal end; also portions of egg-shell of a green colour, which appeared to be parts of a large egg"[1].

The above dimensions of the metatarsal indicate its having formed part of a female of *Dinornis casuarinus*. Supposing the egg-fragments as well as the 'double-shafted' feathers to have been those of a Moa, they support Mr. Dallas's conclusion of the nearer affinity of *Dinornis* "to the green-egged Emus and Cassowaries" than to the Rhea and Ostrich. Capt. Hutton remarks:—"The green egg-shell from the cave at Mount Nicholas proves, on microscopical examination, to have the true *Dinornis* structure [see *antè*, p. 317]. It is of a rather pale sea-green colour, smooth, but not polished." "The feathers from this cave are not very well preserved. Most of them are pale yellow-brown, margined with darker, while a few were dark brown. The largest is 6$\frac{1}{2}$ inches. The feathers from the cave near Queenstown are in an excellent state of preservation, and many have both shafts quite complete. The 'after-shaft' is much more slender than the true shaft, but often nearly as long; the barbs gradually get more distant from one another towards the apex, and they are generally opposite on each side of the shaft. I saw no signs in any of the feathers of the barbs near the base being in groups of four or five, as described by Mr. Dallas in the 'Ann. & Mag. Natural History,' 3rd series, c. 16, p. 66, in the feathers of *D. robustus*. There are

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[1] Trans. of the New-Zealand Institute, 1876, vol. viii. p. 98.

no barbules on the barbs near the apex of the feather, and the shaft is not produced beyond the barbs. In colour these feathers are reddish brown, with a central longitudinal dash of dark brown towards the apex of the shaft. The down is brownish white." "These two caves, therefore, have furnished two new kinds of Moa-feathers, making three distinct kinds that are now known"[1].

As of the four existing species or established varieties of *Apteryx*, some have a barred, others a more uniformly coloured plumage, so the more numerous species, now extinct, of the *Dinornis* seem to have exhibited analogous differences of colour.

The sum of the discoveries of the remains of Moas in Maori cooking-gounds, and of eggs, skin, and feathers in caves, graves, &c., points to the recent period, scarcely, I think, to be carried back beyond one or two centuries, of the extirpation of the species of the *Dinornithidæ*[2].

Mr. W. J. Hamilton shrewdly remarks:—"In 1844 little was known among the European population of the existence of Moa-bones, and very few had been found; but the Maoris always knew them when they saw them. It is a curious fact to note that they should have a name for the extinct bird's bones if it had never been known to their ancestors as a living bird"[3].

In reference to the statement (p. 443), "We found numerous charred bones, both Moa-bones and sheep-bones," if clear and satisfactory evidence had been adduced that these were mingled in the ashes of one and the same fire, the conclusion would be sustained that some kind of Moa was in existence after the introduction by Europeans of the sheep, the correctness of the reference of the bones to that domestic ruminant being admitted.

Another testimony to a similar conclusion has appeared in a New-Zealand newspaper:—

"*Antiquity of the Moa.*—The 'Otago Daily Times' says that a valuable piece of evidence, which points to the probability of the Moa having lived in comparatively recent times, has just been brought to light. When in London, Dr. Hector ascertained that in the British Museum there were certain cases which had been brought from New Zealand by Capt. Cook, and which were still unopened. Dr. Hector was allowed to examine the boxes, which contained Maori curiosities, and in one of them was a spear ornamented with a tuft of Moa-feathers. With the permission of the Trustees of the Museum he detached one of the feathers, and he has brought it out to New Zealand. Strange that this evidence should have reposed in the cellars of the British Museum for a century."

I submitted this paragraph, reflecting on the "Department of Mediæval Antiquities,"

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[1] Trans. of the New-Zealand Institute, 1876, vol. viii. p. 101.

[2] See "On the Identity of the Moa-hunters with the present Maori Race." By Alex. M^cKay, of the Geological Survey Department. Trans. of New-Zealand Institute, vol. vii. p. 98.

[3] "Notes on Maori Traditions of the Moa," ib. p. 122.

to my esteemed colleague the Keeper of that department, and received from him the following note:—

"Department of Antiquities, Dec. 26, 1876.

"Dear Professor Owen,

"The paragraph which you have shown me from a New-Zealand paper is singularly inaccurate.

"First as to Capt. Cook's collection: that portion that was sent to the Museum (a very small one, I suspect) was exhibited in old Montagu House, and removed to the present Ethnographic Room before I came to the Museum in 1851. I have never found any cases containing specimens from the collection not unpacked; and, in fact, in a great rummage I made through our stores when I came, I did not discover any cases of ethnological specimens.

"The specimens from New Zealand to which the paragraph refers are not, as you are aware, at the British Museum at all, but form part of the 'Christy Collection,' deposited at 103 Victoria Street. I do not know where Mr. Christy obtained them, or whether they were brought back by Capt. Cook.

"Dr. Hector was looking over the collection of New-Zealand objects, and kindly giving me information about them, when he saw the iron fish-hook with the black feathers, and I then called his attention to the *hani* similarly ornamented.

"As to whether the feathers are Moa or not I will not venture to say, but leave it to those better qualified to give an opinion.

"Yours sincerely,

"Augustus W. Franks.

"Neither of the Christy specimens were packed away, but exhibited in the glass cases."

I have critically examined every feather in these dateless New-Zealand implements, and I subjoin a description of one of the feathers, which, by their size, had best claim to be deemed of a Moa. It is from the 'hani' examined by Dr. Hector.

This feather is 5 inches 2 lines in length, 2 inches in breadth at its broadest part midway between the quill and tip of the vane. An extent of quill of 4 lines is preserved, including rather more than 1 line of the transparent hollow inserted portion.

After two lines extent of the solid opake portion of the 'quill' or 'barrel,' where it assumes the structure of the 'shaft,' the 'vane' commences by lateral series of white 'down-barbs;' the first pair are half a line in length, increasing at the sixth pair to 3 lines in length, and at the tenth suddenly lengthening to 5 lines; the tip of this barb assumes the greyish-brown tint which prevails over more and more of the lengthening barbs, until the basal whitish downy character disappears at about an inch from the beginning of the series of barbs. These, at first rapidly, then gradually, gain in length to near the mid-length of the feather, where the barb attains 1 inch 3 lines in length. The breadth of the feather there is reduced by the oblique and wavy disposition of the barbs. They quit the shaft by curving outward with the convexity toward the tip; then continue with a more gentle bend concave toward the tip and inclining thereto.

As the barbs approach the mid-length of the feather the barbules cease to be developed at the tip of the barb, and the simple filamentary terminal part of the barb forms a greater proportion of its length as the barbs decrease in total length and approach the tip in position.

The grey-brown colour of the barbs preserves the same degree from the basal third to the tip of the feather. The dorsal part of the shaft approaches to blackness at its mid-length and continues to the tip.

The barbules connect the barbs together for the extent of a line and a half along the basal third of the feather, and for a gradually decreasing length to the apical third, where the barbs become free in their whole extent as far as the tip.

The differences which this feather presents as compared with that of the *Dinornis* described in the preceding pages, and figured in Plate CXIV., are as follows:—

1st. The entire absence of an accessory plume or 'after-shaft.'

2nd. The downy barbs at the base of the main shaft.

3rd. The greater breadth as compared with the length of the feather.

4th. The gradual diminution of breadth from the second third part of the length of the feather to the tip, which is pointed.

5th. The absence of the white colour which distinguishes the broad truncate tip of the Moa-feather, Plate CXIV. fig. 11.

6th. The absence of barbules at the terminal portions of the barbs along the apical half of the feather.

In each and all of these differences the feathers adorning the New-Zealand weapon accord with those of the *Apteryx*. If feathers of 5 inches 2 lines in length cannot be found in any individuals of existing kinds of Kivi, a species larger than these may have afforded the ornament in question. Those attached to the 'fish-hook,' which is of iron, are too mutilated and decayed to yield reliable characters.

MEMOIR

ON THE

ORNITHICHNITES,

OR

FOOT-PRINTS OF SPECIES OF DINORNIS.

THESE impressions were first noticed in or about the year 1866 by a ferryman on the right bank of the Taruhero river, just below high-water mark, at Turanganui, Poverty Bay, North Island of New Zealand[1].

The discovery being reported to the Rev. Archdeacon W. L. Williams, he communicated his observations to the Auckland Institute, and presented impressions of the foot-prints and casts of the same to the Museum of the Institute. The locality was subsequently inspected by the Hon. T. B. Gillies, who has added a record of his observations on the locality[2].

Examples of these ornithichnites have successively reached me through the kindness of my friend T. W. Cockburn Hood, Esq., and by a donation to the British Museum by the Rev. Henry Davies, M.A., who had received the specimens from his brother, now resident in Auckland, New Zealand.

The conditions of the preservation of these foot-prints are those which are not uncommon in connexion with the 'ichnites' of various extinct animals in Europe and America[3]. A stratum of uniform character, soft enough to receive and hard enough to retain the impression, is alternately exposed and submerged through its position on a tidal shore between high- and low-water mark.

During the period that elapses between one spring tide and the next, the highest part of the stratum or deposit is exposed long enough to receive many foot-prints. During the hours of hot sunshine the so trodden surface may become baked hard and dry; and before the return of the tidal wave, turbid with the comminuted materials of a second stratum, has power to break up the preceding one, the impressions may

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[1] 'Transactions of the New-Zealand Institute,' 1872, vol. iv. p. 124, pl. 8 (sketch-map).

[2] *Tom. cit.* p. 127.

[3] Owen, 'Palæontology,' 8vo (2nd ed. 1861), pp. 177–181.

have received a deposit of such comminuted materials, whereby a cast may be taken of the mould previously made, and such mould be preserved.

Or, the impressions made at low tide may receive before the turn sand drifted by the wind, and that in such quantity as to preserve the impression from being broken up by the eddyings of the returning tide. The comminuted materials of the sea-bed will then be deposited upon the drift-sand blown into the foot-prints during the ebb; and such layer of sand will be interposed between the strata forming the sea-bed, such strata varying in thickness according to the intervals between the atmospheric movements which have spread the sand over the bed. In due course of time this stratified sea-bed acquires the consistency of rock, as in the case of the New Red Sandstone of Cheshire and Connecticut.

The stratified deposits which have received and retained impressions of a *Dinornis* at Turanganui are described "as a portion of rock about 14 feet in length, and about 5 feet in width"[1]; but further on the Archdeacon describes "the rock" as being "very soft, containing a large proportion of fine pumiceous sand"[2]. "Soon after the impressions were made a quantity of sand, much coarser than that which enters into the composition of the rock, must have been drifted over it by the wind, filling up all the foot-prints, and covering the whole surface to a moderate depth; the general thickness of the layer, after having been compressed by subsequent deposits, is about five eighths of an inch. That this must have happened soon after the impressions were made, and before the mud had become quite dry, is indicated by the way in which this coarser sand is imbedded in the bottom of the impressions"[3].

The tract of impressed 'rock' is just below high-water mark. "Subsequent deposits of [fluviatile] silt have taken place, covering that in which the impressions are found to the depth of about 2 feet." "Overlying the whole is a layer of sand, gravel, shells, and soil to the depth of 4 feet"[4].

The account given by the Hon. Mr. Gillies is essentially in accordance with that by Archdeacon Williams. The height of the land above the (present) high-water mark is about 5 feet. This is composed of sandy alluvium containing shelly layers of recent species. Below this occur successive strata of imperfectly solidified pumiceous sandy mudstones, or muddy pumiceous sandstones, each from four to six inches thick, but separated from each other by a thin layer of from a quarter to half an inch thick of pure coarse sand. "These foot-marks are found on about the fourth or fifth layer below the alluvial [*qu.* æolian] deposit above referred to, and are protected from the superincumbent layer by this thin layer of pure sand. These layers have a dip of about six degrees to the southward, and the foot-marks were found about 2 feet 6 inches below the level of the alluvial deposit above, the rock, however, dipping eastward to about ten degrees"[5].

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[1] Williams, *loc. cit.* p. 124.

[2] Ib. ib. p. 125.

[3] Ib. ib.

[4] Ib. ib.

[5] *Tom. cit.* p. 127.

The matrix of a foot-print of the size of that figured in Plate CXVI. fig. 1 consisted of quartzose sand and finely comminuted clay; no tufaceous deposit was detected in it. The impressed slab was presented to the British Museum by the Rev. R. H. Davies, of Chelsea, who had received it from a brother resident at Auckland. It was accompanied by the following note:—"This specimen was found at the junction of the Waikanai Creek with the Turanganui River, at Gisborne, Poverty Bay, New Zealand."

The formation is of a recent character, geologically.

From the evidences of the foot-prints which have reached me, I refer them to three species of *Dinornis*. The largest series agree in size with the foot-bones of *Dinornis ingens*, and they exhibit indications of the tip of a hind toe having touched the sand after the sole of the foot had sunk about an inch therein. (See the three impressions, fig. 2, in Plate CXVI.)

From the tip of the middle toe (III.) to that of the back toe measures 1 foot 6 inches; the extreme breadth of the foot is 13 inches; the length of the middle toe, including the end of its metatarsal, would be about 15 inches; but the skin covering that end would probably not touch hard ground, nor would the back toe, on such ground, reach the surface. These impressions were probably made by a *Dinornis ingens*.

The second series of ornithichnites, fig. 3, I refer to *Dinornis struthioides*; the third series, fig. 4, to *Dinornis dromioides*. Of this series a cast of one of the foot-prints is lithographed of the natural size, fig. 1. It indicates a greater proportional extent of the interdigital connecting membrane than in the Emu or Cassowary, and a foot better adapted for progression over yielding or swampy ground. The presence of a back toe, as in fig. 2, I., would give, on the foot sinking to a certain depth, additional resistance in traversing boggy land.

DESCRIPTION OF THE PLATE.

PLATE CXVI.

Fig. 1. Cast of foot-print of *Dinornis dromioides*: nat. size.

Fig. 2. Reduced outlines of impressions of three of a consecutive series of foot-prints of *Dinornis ingens*.

Fig. 3. Reduced outlines of impressions of three of a consecutive series of foot-prints of *Dinornis struthioides*.

Fig. 4. Reduced outlines of impressions of a series of five consecutive foot-prints of *Dinornis dromioides*.

MEMOIR

ON THE

FOOD, NESTS, AND TRADITIONS

OF THE

MOAS (*DINORNIS*).

THE generation of the natives of New Zealand has passed away who received the traditions of ancestors to whom the living Moas were familiar; but such traditions have been fortunately collected by colonists who have mastered the Maori dialects, and from these I have selected notices of the living habits, the food, and nidification of the now extinct species of *Dinornis* which seemed most worthy of addition to a scientific record of that singular genus of huge wingless birds.

It is scarcely necessary to remark that no evidence of this genus has been met with in any other part of the world than the islands now called "New Zealand."

Sir George Grey, K.C.B., in a letter to the Zoological Society of London, read 24th February, 1870, communicated interesting results of his intercourse with the Maoris, while Governor of New Zealand, and since his return to that colony as a resident in the North Island.

Sir George writes:—"The natives all know the word 'Moa' as describing the extinct bird; and when I went to New Zealand twenty-five years ago, the natives invariably spoke to me of the Moa as a bird well known to their ancestors. They spoke of the Moa in exactly the same manner as they did of 'the Kakapo' (*Strigops*), 'the Kiwi' (*Apteryx*), 'the Weka' (*Ocydromus*), and an extinct kind of Rails (*Aptornis*?, *Notornis*?) in districts where all these birds had disappeared." Sir George, who is an accomplished scholar in the melodious Polynesian dialect of the Maoris, proceeds to state:—"Allusions to the Moa are to be found in their poems, sometimes together with allusions to birds still in existence in some parts of the islands. From these circumstances, and from former frequent conversations with old natives, I have never entertained the slightest doubt that the Moa was found by the ancestors of the present New-Zealand race when they first occupied the islands, and that, by degrees, the Moa was destroyed and disappeared, as have been several other wingless birds from different parts of New Zealand. For instance, in page 9 of 'Ko nga Moteata, me nga Hakirara o nga Maori' (one vol. 8vo, New Zealand, Wellington, 1853), you will find a man speaking of the death of his sons, who says, 'Ka ngaro, i te ngaro, a te moa' ('they have disappeared as completely as the Moa')"[1].

This testimony is confirmed and supplemented by the devoted missionary, the Rev. Richard Taylor, in a paper read before the Wellington Philosophical Society, 6th November, 1872:—"Early in 1843 I removed from the Bay of Islands to Wanganui, and my first journey was along the coast of Waimate. As we were resting on the shore near the Waingongoro stream, I noticed the fragment of a bone, which reminded me of the one I found at Waiapu. I took it up, and asked my natives what it was. They replied, 'A Moa's bone, what else? Look around, and you will see plenty of them.' I jumped up, and, to my amazement, I found the sandy plain covered with a number of little mounds entirely composed of Moa-bones; it appeared to me to be a regular necropolis of the race. I was struck with wonder at the sight, but lost no time in selecting some of the most perfect of the bones. I had a box in which my supplies for the journey were carried; this I emptied, and filled with the bones instead, to the amazement of my followers, who exclaimed, 'What is he doing? What can he possibly want with those old Moa-bones?' One suggested, '*hei rongoa pea*' (to make medicine, perhaps); to this the others consented, saying '*koia pea*' (most likely)"[2].

The specimens so collected, which reached me through the kindness of Capt. Sir Everard Home, Bart., R.N., are acknowledged in my third communication on *Dinornis* (June 23rd, 1846) to the Zoological Society of London (*antè*, p. 118). Most of the specimens yielded acceptable confirmation of the species, founded on the collection of bones previously transmitted by the Rev. William Williams, the present Bishop of Waiapu (*antè*, p. 75). "They told me," proceeds Mr. Taylor, "that these huge birds were formerly very abundant before the Europeans came, but they gradually diminished and finally disappeared. Their nests were made of the refuse of fern-root, on which they fed, and they used to conceal themselves in the koromiko (*Veronica*) thickets, from which they were driven and killed by setting the thickets on fire: hence originated the saying, 'Te koromiko te rakau i Tunu ai té Moa' (the *Veronica* was the tree which roasted the Moa)."

Sir George Grey adduces a similar testimony from another Maori source. In one of the native poems which he has collected in the valuable volume above cited, p. 324, are the following lines:—

"Kua rongo 'no au,
Na Hikuao te Korohiko
Ko te rakau i tunua ai te Moa."

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[1] Proceedings of the Zool. Soc. 1870, p. 116.

[2] Transactions of the New-Zealand Institute, vol. v. (1872), p. 98.

Which Sir George renders as follows:—

"'I have heard, indeed, that from Hikuao was the Korohiko, the tree or shrub with which the Moa was cooked.' Probably the meaning is, that the boughs, leaves, and flowers of that tree were used to cover up the flesh of the Moa in the oven where it was cooked. In the same poem the Weka is immediately afterwards alluded to"[1].

The small flightless Rail (*Ocydromus*) is still designated by the Maoris by the name above recorded.

Confirmation of the traditional allusions to the food of the Moas is supplied by observations on the excrement found, together with bones, nests, and feathers of a *Dinornis* in a cavern explored by Taylor White, Esq. This cave is situated on a hill on the south side of Lake Wakatipu, Otago, South Island.

"Floor of fine powdered rock or sand, 9 inches deep, encrusted with crystals of sulphate of soda to 2 inches deep. Thirty feet from the entrance in the crust were scattered several double-shafted feathers, of a greyish-brown colour, 3 inches long. Height of cave here 3 feet 6 inches, width 6 feet[2].

"Further in was a small collection of short sticks, fern broom, which might be the remains of a nest. Here the feathers were scarcer, and a metatarsus was found in good preservation, which measured 8 inches in length, $6\frac{7}{8}$ inches in girth at the proximal end, $3\frac{1}{2}$ inches at thinnest part, and $8\frac{3}{4}$ inches in girth at distal end[3]. Also portions of egg-shell, of a green colour, which appeared to be parts of a large egg.

"In both these places feathers of different birds were found, the greater number belonging to the Paroquet (*Platycercus*). These appeared to be generally nearer to the surface than those first mentioned.

"Close to the end of the cave were found a fibula, measuring $11\frac{1}{8}$ inches in length, and $4\frac{7}{8}$ girth at the proximal end, several vertebræ, and an upper mandible. All these belonged to the same bird.

"There were also bones of other kinds of birds, some of which were very delicate, together with a considerable number of pieces of egg-shell; these were white. Excrement of a large bird was also found, which extended to a greater depth than the feathers. Some of this consisted of undigested fragments of what looked like the stalk of the fern."

Additional evidences were obtained from another cave, in a range of hills south of the Gorge road, about a mile from Queenstown, Otago, difficult of access, the hill being almost perpendicular below the entry of the cave. This entry is 14 feet high by 5 feet wide.

"Floor of drift mica-sand, 2 feet deep, below which are blocks of schist; then comes a steep descent for about 60 feet, of the average height of 6 feet to 8 feet, and an average width of 6 feet. A thin white incrustation appeared here and there on the

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[1] Proceedings of the Zoological Society, 1870, p. 117.

[2] "Notes on Moa-Caves," Trans. of the New Zealand-Institute, vol. viii. p. 97.

[3] These dimensions indicate the *Dinornis casuarinus*.

roof, but no drip. On the floor of this cave was found a quantity of double-shafted feathers of a brown colour, with a light colour down the tube ('shaft'), most plentiful 1 foot below the surface (indicating the amount of drift-sand blown in since the deposition); they appeared to be chiefly in a layer of hard-trodden excrement. Perfect droppings were also found in the sand, and a few specimens of a similar outward appearance contained undigested vegetable fragments, some of which seemed to be branches and stalks of ferns, broken into short pieces of $\frac{3}{4}$ of an inch in length. To the left of the mouth of the cave, a little higher up the hill, was a crevice of an angular form, about 5′ wide and 15′ deep, made by a forward slip of a portion of the hill. In this were found bones of a *D. robustus*, and of some smaller species, and a portion of a large egg." Mr. White conjectures, "The birds must have fallen or slipped in while examining its capabilities as a nesting-place."

Resuming the traditional evidence, I shall again quote from the interesting notes by the Rev. Mr. Taylor:—

"The last visit which I paid to Waingongoro was in 1866, in company with Sir George Grey. On our arrival there he asked me to show him the place where I discovered the great deposit of Moa-bones in 1843. I took him at once to the place, and to my astonishment I found the hillocks almost as thickly covered with bones as when I first saw them; the wind had uncovered the lower stratum since my former visit. A great number of these old ovens were opened; all of us worked in good earnest, and no one more heartily than the Governor. A large cloth was spread on the ground, and the various articles found were piled upon it. These were of a very miscellaneous character, consisting not only of bones of the Moa and fragments of its eggs, but of almost every other bird indigenous to these islands, including those of the Kakapo and Kiwi, with chert flakes, fragments of highly polished axes, and other articles. These ovens seem to have been made in a double line, and to have been used for many years, as each layer of ashes was separated by a thin stratum of sand from the one immediately below, and the number of them was very great. The natives informed me that when the Moa-hunt was to take place, notice was given to the neighbouring places, inviting them all to the battue. The party then spread out to inclose as large a space as possible and drive the birds from their haunts, then gradually contracting the line as they approached some lake or swamp, they at last rushed forward with loud yells, and drove the frightened birds into the water, where they could be easily approached in canoes, and despatched without their being able to make any resistance.

"These Moa-hunts were doubtless very destructive, as, from the number of men employed and the long lines of ovens, the slaughter must have been very great; and, in addition to this, from the large quantity of egg-shells, a clear proof is given that they were eagerly sought for and feasted upon. Thus the poor birds had little chance of continuing their race."

Mr. Taylor adduces a plaintive Maori saying, in which the traditional knowledge of the extirpation of the *Dinornithidæ* is applied, as in the chaunt above quoted from Sir George Grey—"'Kuá ngaro a Moa te iwi nei' (the Maori, like the Moa, has passed away)," remarking that "the Moa has passed away, and its hunters as well; and the proverb is being fulfilled in the progressive diminution of their descendants."

Mr. John White [1], Interpreter in Government transactions with the Maoris, learnt from them that, according to the traditions of their fathers, the Moas subsisted on the young shoots of the fern (rarauhe), and on grasses growing on the margins of the swamps, on young sprouts of the Karokia shrub, also on a water-plant called Pukekakeka; for this the Moa visited the lakes and pools near its native forests. "When the Moa was hunted, the tracks made by it to visit the water were sought, and men waited on these tracks to capture the bird. It is also said to live on fern-roots; the good kind, called 'roi,' of which there are three sorts, are found near the edges of the swamps, one on deep black soil, and one on the edge of the forests, which is called 'ronga.' This was dug up by the beak of the Moa, and was the food most eaten by them."

The tracks observed by Dr. Hector on the mountains near Jackson's Bay are such as would be made by huge birds pushing through scrub. Along the sides of such tracks the hunters would lurk to attack the birds in the manner described by Mr. White.

"The Moa did not go in large flocks, but usually a male and female and their young; hence the proverb, 'He whawhai tautau a Moa' (a fight between two and two, like the Moa), indicative of the sexual combats which the Moa-hunters had seen between the males of *Dinornis*.

"The nest was made by the bird collecting a heap of toi-toi or other grass, and in the centre on the top lay the eggs.

"The last Moa-hunt remembered in the North Island was at or near Whatakene, in the Bay of Plenty. The feathers of the birds killed there were, till a late period, in the possession of a chief called Apanui, an uncle of the half-caste James Nulloon, who was murdered by the Hauhaus at that place.

"At or a little before that hunt a Moa was killed on the plains near the foot of the Ruahine mountains, N.E. of Waipukurau, at Napier.

"The Maoris admitted that their ancestors were afraid of the Moa, as a kick from the foot of one would break the bones of the most powerful Brave; hence the people made strong spears of 'maire' or 'manuka' wood, six or eight feet long, and the sharp end of which was cut so that it might break and leave about six or eight inches of the spear in the bird. With these the men would hide behind the scrub on the side of the track, and when the birds were escaping from the fear of the noise of those who had driven them from the lakes, those spears were thrown at them, thus sticking in the bird; the

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[1] Trans. of the New-Zealand Institute (1875), vol. viii. p. 78.

scrub on the sides of the track would catch the spears and break the jagged end off, leaving it in the bird. As it had to pass many men, the broken spear-points thus put into the bird had caused it to yield in power when it had gained the open fern country, where it was attacked in its feeble condition by the most daring of the tribe." To this rendering of the native tradition, Mr. W. T. L. Trowers, F.L.S., of Wellington, New Zealand, appends the following note :—" I may mention that a hill on the east coast, called ' Karanga na Hape,' is said to derive its name from the circumstance that Hape, a chief of the Arawa, pursued a wounded Moa up the hill side, and attacked it with a ' taiaha,' when the bird kicked him and broke his thigh, and he rolled down the hill "[1]. The ' taiaha ' is the axe or adze of green jade-stone. The obsidian flint afforded the trenchant knives for cutting up the bird. Of this mineral the Maoris noted four kinds :—the black, called ' tuhua ' ; the light-coloured, called ' waiapu ' ; the green, called ' panetao ' ; and the red, called ' kahurangi.' " The first only was used in cutting up the Moa."

From this act probably was derived the ancestral knowledge communicated to Mr. White, viz. that " the Moa swallowed stones, which the Maori says was only of a certain sort ; and hence when they see a Turkey hone, or oil-stone, they call it ' Moa.' The stone used for polishing the Ponnamu is called ' Hoanga Moa ' (the stones which the Moa swallows) ; also comes the saying, when a heap of stones are seen on a plain where no other stones are seen, ' He tutal Moa ' (there is the Moa excrement)."

This saying is strongly confirmatory of the basis of actual observation on which the details on the native natural history of the Moas, collected by Mr. White, have rested.

That stone-heaps should be pointed out by Maoris as the excrement of a bird, would have excited in most unscientific settlers a scornful incredulity. But Moa-hunters may have seen such actually discharged, and would certainly, in opening the gizzard of a bird eviscerated prior to cooking, find such smoothly worn rounded pebbles as are described p. 337, and figured Plate XCII. fig. 9.

" Again, as the Maori after his arrival here was the cause of the extinction of the Moa, hence, when a tribe has been cut off by war, and not an individual has been saved, the tribe is said to be ' Ngaro i te ngaro a te Moa ' (lost as the extinction of the Moa)."

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[1] *Tom. cit.* p. 80.

CONCLUSION.

IN bringing to a close the record of the scrutiny and comparison of the evidences of the extinct wingless birds of New Zealand, some relaxation may be condoned by way of indulgence of the faculty of conjecture.

The cause and conditions of the extinction of these birds, discussed in pp. 457–459, may be held to be determined, and, approximately, the date of their disappearance.

But what can be said as to their origin? The first ground which suggests itself as a basis of speculation is, literally as well as figuratively, New Zealand itself. Since no evidence of such birds as those ranging in size from *Notornis* to the maximized form of *Dinornis* have been found in any other part of the globe, the conclusion seems legitimate that the species of those genera, as of *Aptornis* and *Cnemiornis*, did not exist elsewhere, at least on any known existing tract of dry land.

The naturalist, on the discovery and exploration of New Zealand, recognized the rare circumstance that, save the Maori and his dog, no predatory land-animal existed in the islands which could have alarmed or endangered the existence of such birds as form the subject of the present work: nor has any evidence of such enemy been discovered in any stratum or locality of either the North or South Island. It is, indeed, accepted as a notable fact in the geographical relations of living things, that, with the exception of some Bats and shore-haunting Seals, the mammalian class was unrepresented in New Zealand prior to the comparatively recent advent of the Polynesian people. The earliest maritime discoverer may have left the rat. Cook introduced the pig. Colonists have since spread abroad their domesticated mammals. There is no native terrestrial reptile in New Zealand, nor any evidence of an extinct one, which could have alarmed and stimulated an *Aptornis* or a *Dinornis* to the strenuous act of flight, if the ancestors of these birds had ever possessed wings in full functional development. It is true that a raptorial bird of unusual size did coexist with the Moas (pp. 141–150); but the menacing approach of such an enemy would excite a rush into the bush, the cleft, or the cave, not a rise into the medium of which an eagle is master. A swift course on land, or sudden dash or dive in water, would better avail in escape than such inferior flight as a Coot, a Goose, or a Moa could have accomplished if they had possessed such wings as one associates with our idea of a 'normal' bird.

The fact of a range of variety in size has been determined in the individuals of many species. Such variety affecting a *Cereopsis* to the degree shown by *Cnemiornis* would, in a corresponding degree, render the act of flight more difficult and laborious. Consequently if that act were not needed for the acquisition of food it might seldom or never be exercised in the absence of any enemy from which it would offer a way of escape.

By long disuse of the wings, continued through successive generations, those organs would become enfeebled, and ultimately atrophied to a degree affecting their capability to raise the body of the bird in the air.

The legs then monopolizing all the functions of locomotion would attain, through the concomitant frequency of exercise, proportional increase of power and size.

Under these conditions may be comprehended the origin of the great flightless Anserine bird which is entered as a 'species' in ornithological catalogues under the name of *Cnemiornis calcitrans*.

The same course of cogitation leads to the same conclusion as to the origin of *Notornis*, of *Aptornis*, and of *Dinornis*. The tendency to variation in size and proportions, after the reduction of wings to rudiments, leads to the minor modifications, called species, of such flightless genera.

The alternative is to surrender thought upon the mode of origin of such genera and species, and to repose in the conclusion that by some inconceivable miraculous manifestation of organizing force a male and female of *Cnemiornis calcitrans*, of *Notornis mantelli*, and of each species of *Aptornis* and *Dinornis*, were, at some remote and unknown point in time, created, with the fruitful power of propagating their kind; and that it was the pleasure of such Creator to construct their wings, bone for bone, muscle for muscle, nerve for nerve, after the pattern of the organs of flight in the normal birds most nearly allied to them, but, at the same time, to make the wings too small for the purpose of flight in these exceptions to the volant and feathered class.

Moreover, in such hypothetical instances of special creation, the miraculous power has been exercised in the limited area of our planet's surface now represented by New Zealand, and under conditions which rendered the useless appendages of no detriment to the well-being of the created species, until a period when these would, through want of wings, be blotted out of creation.

In illustration of the alternative view of the coming-in of species by the operation of a secondary law, I append to the pages devoted to the wingless or flightless birds of New Zealand brief accounts of similarly crippled birds from other localities.

There was a time when a northern sea-bird, larger than those now breeding in the 'Summer Isles' of the north of Scotland, and elsewhere in northern latitudes, flourished through its powers of obtaining food by diving and swimming, but which had lost its power of flight. It nevertheless possessed wings differing in no respect save in proportional size from those of the type manifested by the smaller existing Awks (*Alca torda*), which still exercise them in flight, and retain them of the due proportions for that act.

The increase of size of *Alca impennis* may be supposed to have been the condition of the discontinuance of the laborious attempts to carry its weight through the air. But the wings continuing to be applied, as in the smaller kinds of Awk, to assist in swimming, were retained of the size and with the proportions and the stunted closely imbricate plumage best adapted to the natatory function.

Ultimately came the great destroyer on the scene of life; and all recorded evidence goes to gain the verdict that the extirpation of the species (*Alca impennis*) was the work of man.

Assuming a secondary law of the origin of species, the conditions of the characters of *Alca impennis* are explicable on the Lamarckian hypothesis of the 'modus operandi' of such law. Rejecting a secondary cause in favour of a primary one, the original pair of *Alca impennis* were miraculously made in close conformity with the type of *Alca torda*, but with wings too small for the body and too feeble for effecting flight, such disproportion being the condition, on a coming event, of the destruction of the species.

In the same view is added to the 'Appendix' of the present work a brief notice of two species of terrestrial birds which, like *Dinornis*, have become extinct within the historical period, viz., the Dodo of the Island of Mauritius, and the Solitaire of the Island of Rodriguez. It will be helpful in the present speculation to determine how far the conditions of existence and of extinction of these wingless birds resemble those of the analogous species in New Zealand.

Both *Didus* and *Pezophaps* surpassed in size the existing species of birds to which they bore the nearest affinity. Each genus was restricted, like *Dinornis*, to a limited tract of land. No evidences have been discovered in either Mauritius or Rodriguez of contemporary predatory animals, from the assaults of which a large bird would be impelled to escape by a rapid flight.

Each of these richly wooded tropical islands affords abundant subsistence to vegetarian and omnivorous birds, and each, prior to the advent of geographical discoverers, was destitute of creatures able or desirous to destroy such birds. If the food was wholly, or chiefly, on the surface, the power of traversing such surface would be of as much advantage to the bird as to the herbivorous quadruped. As flight calls for more effort than course, so cursorial progression would be more commonly practised in such happy islands for obtaining the daily food. The advent or proximity of a known element of danger might excite the quicker mode of motion; the bird would then betake itself by a hurried flight to a safer locality. If, however, these insular birds had never known a foe, the stimulus to the use of the wings would be wanting in species needing only to traverse the ground in quest of food. In the case of New Zealand, for example, the roots of wide-spread ferns, rich in farinaceous and amylaceous principles, tempting the birds to pluck, would stimulate such development of bone and muscle of the neck as is noted in pp. 407–420; or, if greater force was needed for the uprooting, the habit of scratching the food out of the ground would lead to excessive development of the muscles of the leg and foot. So such daily habitual exercise of legs and feet by unscared Rasorials would lead in successive generations to such developments of hind limbs as the Dodo and Solitaire present.

We recognize in the stunted wings of the Dodo, as in the skull and the rest of the skeleton, evidences of its affinity to the Dove family (*Columbacei* or *Gemitores*). The framework of the anterior limbs conforms, save in size and in the prominence of the processes for muscular attachments, to the scapula, coracoid, furculum, brachial and antibrachial bones, carpus, metacarpus, limited number of digits, and their extremely modified phalanges, of the perfect instrument of flight in truly winged birds.

The minor modifications of the volant mechanism characteristic of the *Columbacei* are as plainly demonstrable in *Didus* and *Pezophaps* as are those of the Coots in the minor modifications of the useless wings of *Notornis*, and those of the Geese in the like modifications of the useless wings of the *Cnemiornis*—'useless,' in such instance, referring to the act of flight.

These comparisons and considerations lead me to regard the Dodo as a degenerate dove. It exemplifies the origin of a species agreeably with the partially applied hypothesis of Buffon [1], and through the way of operation of the secondary law of the origin of species suggested and advocated by Lamarck [2].

The same course of argument which has been suggested by the impennate Awk of northern shores and the flightless Doves of the Mascarene Islands applies, as we have seen, to the Moas of New Zealand. But in these the degree of atrophy, which seems to have been carried to total loss, of the limb-appendages of the scapulo-coracoid arch implies the operation of the influence of disuse through a period of pre-Maori æons greatly exceeding the time during which the Lamarckian law has operated on the Cassowary, the Rhea, and the Ostrich.

In reference to the subject of the foregoing speculation, another hypothesis has, however, been propounded, viz. that birds are transmuted and advanced Dinosaurs, and that the feathered, hot-blooded, quick-breathing class made its first step in life-promotion from the naked, cold-blooded, slow-breathing reptiles, under the low form of *Struthiones* or *Cursores*, as yet incapable of flight [3].

According to this view the Dodo is a predecessor of the Crown Pigeon, the *Notornis* of the Coot, the *Cnemiornis* of the Goose, and the *Dinornis* of some, as yet, unknown winged form, unless the course of evolution, through the Moas, has come to an untimely end.

Alleged facts of embryology have been adduced in support of this idea, and the assertion has been hazarded that "if the whole hind quarters, from the ilium to the toes, of a half-hatched chicken could be suddenly enlarged, ossified, and fossilized as they are, they would furnish us with the last step of the transition between Birds and Reptiles; for there would be nothing in their characters to prevent *us* from referring them to the *Dinosaurs*."

I am barred, however, from joining the biologists indicated by the plural pronoun,

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[1] 'Histoire Naturelle,' tom. xiv. p. 311, 4to, 1876. Buffon does not enter into the conditions of degeneration of parts.

[2] 'Philosophie Zoologique,' 2 vols. tom. i. chaps. iii., vi., vii., 8vo, 1803. On the influence of exercise and of disuse in altering the proportions of parts and organs.

[3] Prof. Huxley, 'Quarterly Journal of the Geological Society,' vol. xxvi. p. 29.

by the following facts. The greater number of the sacro-vertebral attachments of the chick's ilium, in whatever degree enlarged and fossilized, would lead me to refer it to the avian, not the reptilian type. I should also note the presence in the ischium of an obturator process wanting in the Dinosaur, and the absence of a pectineal process in the chick's pubis, present in the bone of the Dinosaur, and, further, the parallelism and backward extension of both pelvic bones in the chick, contrasted with their downward extension and divergence in the Dinosaur.

In further testing the embryological ground evoked, I find the differences between the half-hatched chick and the full-grown Dinosaur grow and multiply as the comparison proceeds. The distal epiphysis of the chick's tibia is not only larger and more complex than that of the Dinosaur, but it articulates, not with one of four tarsal bones, but with the proximal epiphysis of a compound metatarsus. The fibula of the chick ends in a point at some distance above the ankle-joint, whilst in the Dinosaur its distal end expands, is parallel with that of the tibia, and has an epiphysis which articulates with a calcaneum [1]. I should further note the backward direction of the innermost or first toe (I.) in the chick, and contrast it with the parallel position of that toe with the forwardly directed second toe in the Dinosauria, before committing myself to a reference of an embryo bird to that order. If the entire skeleton of an immature bird of any order, whether volant or not, were enlarged to the dimensions of that of a Dinosaur, the characters of the few dorsal and caudal vertebræ, of the many cervical vertebræ, and of the skull, the absence of an anterior pair of limbs with fore paws organized to be applied to the soil and to take their share in the support and progression of a long and bulky trunk, with the massive head of a Dinosaur, would be decisive against the reference of such imaginary gigantic chick to any known representative of a terrestrial order of reptiles. In no birds are the sacral vertebræ so few as in Dinosauria; and in those birds which, from the embryonal proportions of the wings, their great size and terrestrial habits, are adduced to exemplify Dinosaurian origin and affinity, the number of the sacral vertebræ ranges from seventeen (*Dinornis*) to twenty (*Struthio*). I may refer to my 'Monograph' above cited for an analysis of the grounds of ascription of a bipedal mode of locomotion to the Dinosauria, in further support of the idea of their ancestral relationship to winged birds through the terrestrial gigantic forms of the feathered class.

In now submitting the grounds on which the view of the origin of the flightless or wingless birds by way of degeneration from antecedent winged forms is preferred, I fully appreciate the limited application of the Lamarckian hypothesis in the exposition of the secondary law of the origin of organic species.

But I would add that, without knowing or pretending to know the ways of operation of such secondary cause, the vast increase of knowledge-stores of biological phenomena

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[1] See 'Monograph on the Fossil Reptilia of the Kimmeridge Clay;' in the volume of the Palæontographical Society issued in 1875, p. 84, fig. 16, "*Dinornis* chick and *Scelidosaur*."

makes it as hard to comprehend them intelligibly in any degree, on the assumption of primary or direct creation of species, as it was difficult for Copernicus to understand and explain the vast accession of astronomical facts in his day, on the belief of the subservient relation of sun to earth, of the posteriority of the creation of the luminary to that of the light-receiver, and of their respective relations of motion, as then held. To the objection, how, on his assumption of the diurnal rotation of the earth, loose things remained on its surface, Copernicus could offer no explanation. Neither has the biologist been able, as yet, to explain how the *Ramphorhynchus* became transmuted into the *Archeopteryx*. It is open, of course, to deny such change, or that the feathered class has been, in any way, a development of an unfeathered one. But if speculation on the origin of Aves by secondary law be allowable, the extinct volant forms of the Reptilia offer a much more likely point of departure than the extinct heavy quadrupedal and terrestrial forms of the cold-blooded class. And if we restrict our survey to a narrower field, where conditions of life and of structure are surer and more abundant, and so speculate on the genesis of *Didus* or *Dinornis*, guiding or reining the roaming fancy by facts, the geographical limitation of such ornithicnitoid species, and their primitive association exclusively with creatures of which they could have no dread, suggest the more obvious and intelligible hypothesis of derivation from antecedent birds of flight, whose wings they still show more or less aborted, according to Buffon's principle of transmutation by degeneration––with a progressive predominance of the legs over the wings, ultimately resulting, agreeably with the Lamarckian view, in a maximization of the terrestrial and abortion of the aerial instruments of locomotion.

APPENDIX.

On a new Genus of large Wingless Bird (Dromornis[1] australis, *Owen*) *from a Post-tertiary Deposit in Queensland, Australia.*

IN 1836 Sir Thomas Mitchell, F.G.S., Surveyor-General of Australia, discovered in the breccia-cave of Wellington Valley a femur, wanting the lower end, mutilated and incrusted with the red stalagmite of the cave, which I determined to belong to a large bird, probably, from its size, struthious or brevipennate, but not presenting characters which, at that time, justified me in suggesting closer affinities. Three views of this fossil, of rather less than half the natural size, formed the subject of pl. 32. figs. 12, 13, of my "Palæontological Appendix" to Mitchell's work[2].

The length of this fossil was 13 inches, the breadth of the middle of the shaft was not quite 3 inches.

In 1869 the Rev. W. B. Clarke, F.G.S., Government Geologist of the Province of New South Wales, made known the interesting discovery of a femur, nearly 12 inches in length, during the digging of a well at Peak Downs, in Queensland[3].

The well was sunk through 30 feet of the black trappean alluvial soil common in that part of Australia, and then through 150 feet of drift pebbles and boulders, on one of which boulders ("at that depth," 150 feet?) rested a short, thick femur, so filled with mineral matter (calc spar and iron pyrites) as to give the internal structure more the appearance of a reptilian than an ornithic bone[4].

Mr. Clarke submitted this fossil to the able Curator of the Australian Museum, Sydney, and states that "Mr. Krefft has compared it with a collection sent over from New Zealand by Dr. Haast, and has been enabled to determine it to be a bone belonging to *Dinornis*." The communication is accordingly headed "*Dinornis*, an Australian genus."

So exceptional an extension of New-Zealand forms of life to the Australian continent greatly added to my desire of further and more intimate acquaintance with this second evidence of a large extinct Australian bird—more especially as the femora of *Dinornis* received from New Zealand subsequently to the publication of Mitchell's work led me to perceive, from the antero-posterior compression of the shaft and the sessile position of the head in the femur from the Wellington-Valley cavern, that it resembled that bone in the Emu rather than in the Dinornis.

My wishes on this point, as on others connected with the palæontology of Australia,

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[1] *δρόμος*, cursus, *ὄρνις*, avis. [2] Three Expeditions into the Interior of Eastern Australia, vol. ii. 8vo. 1838.

[3] "*Dinornis*, an Australian Genus," Geological Magazine, vol. vi. (1869) p. 383. [4] *Loc. cit.* p. 383.

met with a prompt and hearty response. The Trustees of the Australian Museum directed the unique bird's bone to be moulded, and they forwarded to me a plaster cast.

Mr. Krefft was so good as to have three photographs taken of the fossil:—one showing the back view of the bone, three fifths the natural size; the two others the front views of the proximal and distal halves of the bone, of very nearly the natural size.

With these evidences a satisfactory comparison can be made of the Australian fossil with the femora of other large wingless birds, both recent and extinct.

The bone is the right femur (Pl. C.). It measures 11 inches 6 lines; and there may be an inch more of this dimension lost by the abrasion to which both ends have been subject. The middle third of the shaft is entire, and shows its natural form and surface; the breadth of this part is 2 inches 6 lines; the antero-posterior thickness does not exceed 1 inch 7 lines (ib. fig. 2). The extreme breadth of the upper end is 5 inches 3 lines, that of the lower end is 5 inches; but these latter dimensions fall short, probably by half an inch, of those which the unabraded or entire femur would have yielded.

Of the femora of *Dinornis* I selected for comparison that of *Din. elephantopus*[1], as nearest to the present fossil in regard to length (13 inches); the breadth of the shaft is the same, or, in the largest examples of *D. elephantopus,* exceeds only by 2 lines that of the Australian femur.

But the shaft of the bone in *Dromornis* is compressed from before backward; its transverse section is a narrow oval (ib. fig. 2), while that of the *Dinornis* is a fuller and less regular oval (ib. fig. 3) from the greater proportion of fore-and-aft breadth of the shaft. The back part of the shaft of *Dromornis australis,* besides being less convex transversely, is devoid of the strong ridges and tuberosities which characterize that part in all the species of *Dinornis*; in this respect, as in the shape of the transverse section of the femoral shaft, *Dromornis* resembles more that bone in the Emu (*Dromaius ater*). The bifurcate anterior muscular ("intervastal") ridge which characterizes the fore part of the femoral shaft in *Dinornis elephantopus,* as in other species of that genus, is not defined on that part of the femur of *Dromornis.* The longitudinal ridge, descending from the pretrochanterian ridge to the ectocondylar expansion, is traceable in the cast, but is less strongly marked than in *Dinornis.* The mutilation of the prominent parts at the proximal end of the femur begets a reticence in drawing conclusions from apparent differences; but some were evidently inherent in the original when entire. The periphery of the head of the femur (*d*) is not constricted so as to give the appearance of a "neck," as it is in *Dinornis.*

The trochanterian part of the articular surface (*c*) is more horizontal, does not ascend as it recedes from the head, in *Dromornis.* So far as the trochanter (*f*) is preserved in the cast, and appears in the photographs, it does not rise above the level of the head (*a*) of the femur, and seems not to have risen, when entire, so much above it, as in *Dinornis*; he lay of the trochanterian articular tract agrees with these indications of the remain-

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[1] Pl. LVI. fig. 1.

ing epitrochanterian ridge (*f*). In the above differences *Dromornis* more resembles *Dromaius*.

The ectotrochanterian surface is slightly concave, bounded above by a low arched ridge, from which the rough convex epitrochanterian part of the surface ascended to the crowning ridge. In this character *Dromornis* resembles *Dromaius*, and differs from *Dinornis*.

It resembles *Dinornis*, and differs from *Dromaius*, in the absence of the pneumatic foramen at the hind part of the upper expansion of the femur. This expansion is also relatively greater than in *Dromaius*, and recalls rather that of *Dinornis*; but the breadth of the ectotrochanterian tract is relatively less than in *Dinornis gravis*, and still less than in the exceptionally thick and massive femur of *Dinornis elephantopus*. The fore part of the upper femoral expansion has had its outer wall crushed in; but, in both the cast and the photograph, there is an indication of a rough subcircular tract, answering to that which is conspicuous in *Dinornis* (Pl. LVI. fig. 1, *i*), but which is not present in *Dromaius*.

The outer crust of the femoral wall has been crushed inwards at the distal third of the fore part of the shaft; but the rotular surface seems to have been broad and shallow. In the prominence and thick convexity of the fore part of the expansion of the outer condyle *Dromornis* resembles *Dinornis* rather than *Dromaius*. The transverse extent of the distal end, in proportion to the size of the shaft of the femur, is less than in *Dinornis*, but is greater than in *Dromaius*.

The popliteal cavity (Pl. C. fig. 1, *z*) is oblique, and is deeper and better-defined, especially above, than in *Dinornis*; it is divided from the intercondylar cavity (*v*) by a ridge (*w*) similar to that in *Dinornis*, and which I do not find in *Dromaius*. The intercondylar cavity or pit (*v*) is deep, and smaller than in *Dinornis gravis*; it is deeper, but much smaller, than in *Dinornis elephantopus* (*loc. cit.* pl. 43. fig. 3). There is a rough "gluteal" depression (ib. fig. 1, *x*), less deep than in *Dinornis gravis*, and situated nearer the popliteal cavity, and with a more posterior aspect than in *Dinornis elephantopus*.

The mutilation of the prominent parts of both femoral condyles precludes further profitable comparisons of the fossil under consideration.

But from those for which it affords sufficient grounds, I infer that in its essential characters this femur resembles more that bone in the Emu than in the Moa, and that the characters in which it more resembles *Dinornis* are concomitant with, and related to, the more general strength and robustness of the bone—from which we may infer that the species manifested dinornithic strength and proportions of the hind limbs, combined with characters of closer affinity to the existing smaller, more slender-limbed, and swifter wingless bird peculiar to the Australian contine

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[1] I can now repeat with more confidence the remark in my Memoir on *Apteryx*:—"No remnant of a *Dinornis* has yet been found in any of the contiguous islands; and I have again searched for such in the collections of post-pliocene fossils from Australia."—*Ante*, p. 136.

From the proportions of the femur of *Dromornis* I infer also that those of the tibia and metatarse would be longer and more slender than in *Dinornis elephantopus*, and in a greater degree than is the case with the femur. Consequently the stature of *Dromornis* would be greater in proportion to the solitary bone by which we now know it than is that of the *Dinornis elephantopus*. We may therefore have a comfortable assurance that it indicates the former existence in Australia of a bird nearly of the stature of the Ostrich, but with relatively shorter and stronger hind limbs.

The period at which this large wingless bird trod that singular land was that at which the elephantine Marsupial (*Diprotodon*) flourished. I have received remains of both this genus and the somewhat smaller pachydermal Marsupial (*Nototherium*) from the mass of drift and boulder deposit when this had been reached, at depths equal to that yielding the bird's fossil at Peak Downs, in the sinking of wells in Queensland.

The mineralized condition of these herbivorous mammalian fossils has suggested a comparison of them with the fossil remains of Saurian Reptiles from Oolitic and even older Mesozoic beds in England. Yet the Mollusca which have left their shells with the petrified Australian bones are of the same species as those still living in the fresh waters of the Condamine and its tributary creeks, in the bed of which so many evidences of extinct Marsupial life have been discovered.

From the general analogy, not unfrequently pointed out, between the recent animal and vegetable forms of the Australian continent and the extinct ones of the European Oolitic beds, together with the massive mineralized condition of the ornithic and mammalian fossils found deep in the enormous superficial accumulations of drift and trappean alluvium, we are led to surmise that Australia, or parts of that continent, have not been subject to the frequent movements by which the earth's crust has been modified in the European continent, but that it may have been subject exclusively to the subaerial conditions of change from the period of the Oolitic deposits in our hemisphere. Thus the *Dromornis* of Queensland may have been contemporary with the impressors of the ornithicnites of Connecticut.

DESCRIPTION OF THE PLATE.

PLATE C.

Fig. 1. Back view of the femur of *Dromornis australis*.
Fig. 2. Form of transverse section of middle of the shaft.
Fig. 3. Form of transverse section of the same part of the femur of *Din. elephantopus*.

Dromornis australis from New South Wales and South Australia.

A second evidence of a large and, by the texture of the bone, wingless bird, has been transmitted to me from South Australia. It was found in a cavern in the 'Mount Gambier range' of hills in that province.

It is the lower portion, with the articular end a little mutilated, of a left tibia (Plate CXVIII.). It corresponds in size with the same part in *Dinornis elephantopus* (Plate LVI. fig. 4), and is rather larger than that of *Gastornis parisiensis*[1]. The modifications of the distal end of the tibia, being, as pointed out in the 'Paper' quoted below, more salient and characteristic than those of the femur, the present specimen is valuable as a test of the conclusions drawn from the subject of Plate C.

As to the first difference which I note in the Australian fossil tibia, the bone resembles that of *Gastornis* and differs from that of *Dinornis*, viz. in the medial position of the 'precondylar groove'[2] (Pl. CXVIII. fig. 1, *p*). In every species of *Dinornis* this groove is near the inner (tibial) margin of the fore part of the bone (see Plate LVI. fig. 4. and Pl. XLII. fig. 1, *p*, *Dinornis gravis*). In both *Dinornis* and *Gastornis* the groove is crossed by a bridge of bone. Of this bridge there is no trace in the present Australian fossil, and there is no evidence of fracture of the piers of such a bridge. The margins of the groove whence the bridge springs in *Dinornis* are, in *Dromornis*, broadly convex and entire. *Dromaius* and *Casuarius*[3] have the precondylar groove, but not the bridge. In both the groove is not medial, as in *Dromornis*, but is nearer the inner border of the tibia, less near, however, than in *Dinornis*. In *Struthio* there is neither groove nor bridge; but in place of the groove there is a transverse rising of the bone. *Apteryx* offers a miniature resemblance to *Dinornis* in the tibial character of the precondylar groove.

The distal expansion is relatively less, in comparison with the shaft of the tibia, in *Dromornis* than in *Dinornis elephantopus* (the species which *Dromornis* most resembles in the size of the shaft). The inner border of the distal end of the shaft (Pl. CXVIII. fig. 3, *a*) is broader than in *Dinornis*, in which it contracts almost to a ridge as it passes to the beginning of the posterior production of the inner (tibial) condyle. In *Dromornis* the corresponding part of the shaft, *a*, maintains a smooth transverse convexity to the condyle *s*. The anterior production of the inner boundary of the rotular part of the intercondylar space (ib. fig. 2, *b*) is more prominent in *Dromornis* than in *Dinornis*. The hind part of the inner condyle (ib. fig. 1, *s*) is less produced than in *Dinornis* and the corresponding part of the outer condyle, *t*, is less convex. There is no definite cavity below the precondylar groove for the antentocondylar prominence of the metatarse.

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[6] Quarterly Journal of the Geological Society of London, August 1856, pl. iii. p. 204.

[2] Anat. of Vertebrates, ii. p. 78.

[3] Osteol. Catal. Mus. Coll. Surg. 4to, 1853, vol. i. p. 250.

There are other minor differences; but the above-defined patent ones sufficiently establish the fact of a nearer resemblance in the tibia, as in the femur, of the gigantic wingless bird of Australia to the genera still there represented (*Dromaius* and *Casuarius*), than to *Dinornis, Apteryx*, or *Struthio*.

The following are comparative admeasurements:—

	Dromornis.		*Dinornis* (*elephantopus*).		*Struthio.*	
	in.	lines.	in.	lines.	in.	lines.
Transverse breadth of the shaft of the tibia at the commencement of the distal expansion .	2	2	2	3	1	5
Ditto ditto distal condyles .	3	5	4	0	2	9

The fossil above described is in a more mineralized condition, consequently of greater specific gravity, than any bone of *Dinornis* which I have hitherto received. It is supposed to have come from a cave in Mount Gambier, South Australia; but I can only speak with certainty as to the locality, not as to the circumstances of its discovery.

One cannot, of course, state confidently that it is a bone of the same species of bird as the mutilated femur from the Cave of Wellington Valley[1], or of that from the drift at Peak Downs, in Queensland[2].

But the relation of size to these bones, and the difference of proportion to the tibia of *Dinornis* exemplified in the above-given admeasurements, oppose no obstacle to the reference, rather support it, and bear out the inference deduced from the femur.

The third evidence of *Dromornis* is a portion of the pelvis, 5½ inches by 4½ inches in size, including the left acetabulum. It was disinterred from a depth of 200 feet at the 'Canadian Gold Lead,' in New South Wales, and was kindly transmitted to me by the Rev. W. B. Clarke, M.A., F.R.S. I have minutely compared this fragment with the answerable part of the pelvis in other birds. It differs least, save in size, from that part in *Dromaius*. From the species of *Dinornis* (*D. elephantopus* and *D. robustus*) the pelvis of which is about the size of that yielding the portion in question, I note the following differences:—The acetabular outlet has a more circular form in *Dromornis*; the acetabular origin, or base of the pubis, is longer, while that of the ischium is shorter. The following are admeasurements:—

	Dromornis australis.		*Dinornis robustus.*	
	in.	lines.	in.	lines.
Acetabulum, vertical diameter	2	10	2	9
Acetabulum, transverse diameter	2	11	2	6
Pubis, extent of preserved base	3	0	2	0
Ischium, from lower border of base to ridge . .	3	10	4	0

Dromornis had an extensive range in Australia. It has left remains in Wellington

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[1] Mitchell's 'Three Expeditions into the Interior of Eastern Australia,' 8vo, "Palæontological Appendix," pl. 32. figs. 12, 13 (1838).

[2] Trans. Zool. Soc. vol. viii. p. 384 (1872).

Valley and in Goree, near Mudgee, New South Wales, at Peak Downs, in Queensland, and in the Mount Gambier range in South Australia. From each of these localities the witnesses concur in testifying to an addition of another genus of gigantic birds to the unwinged group—a genus which existed and has become extinct in the Australian continent, and which had closer kinship with the still existing struthious genera of that continent than with the extinct Moas of New Zealand.

DESCRIPTION OF THE PLATE.

PLATE CXVIII.

Distal portion of tibia of *Dromornis australis*.

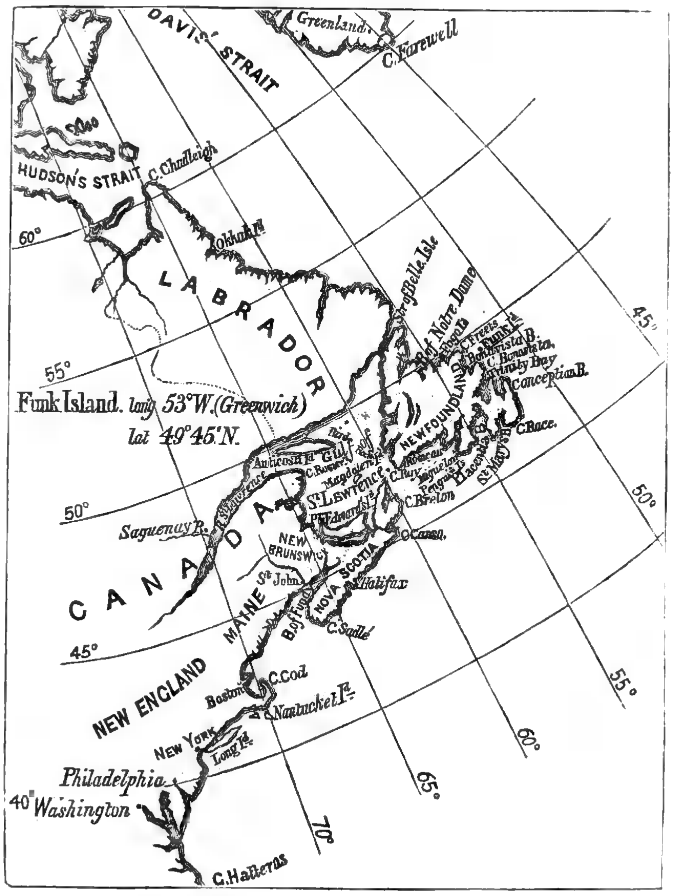
Fig. 1. Back view.
Fig. 2. Front view.
Fig. 3. Inner side view.
Fig. 4. Broken end of shaft, showing thickness of wall and size of medullary cavity.

SUPPLEMENT.

MEMOIR
ON THE
EXTINCT WINGLESS SEA-BIRD, OR GARFOWL,
INCLUDING A
DESCRIPTION OF THE SKELETON OF THE
ALCA IMPENNIS, *L.*

MR. ALFRED NEWTON, M.A., F.L.S., who, with his friend the late lamented and accomplished naturalist Mr. J. Wolley, has contributed valuable materials[1] for the history of the Garfowl (*Alca impennis*, L.), prosecuting his endeavours to obtain additional materials for that history, has received the body of a specimen, dried, flattened, featherless, and mummified, like the Penguins from the guano-masses of the Peruvian islands. This specimen was obtained from one of the old breeding-places of the extinct bird, Funk Island, long. 53° W., lat. 49° 45′ N., off the coast of Newfoundland, by the Bishop of that colonial diocese, and was transmitted by his Lordship to Mr. Newton, who has kindly confided it to me for description, with permission to treat the specimen as might best serve the interests of science.

A preliminary photograph of the mummy having been taken, it was



Old breeding-ground of *Alca impennis*.

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[1] See abstract of Mr. Wolley's "Researches in Iceland respecting the Garefowl, or Great Auk (*Alca impennis*, Linn.)," by Alfred Newton, Esq., M.A., F.Z.S., 'Ibis,' October 1861, p. 374.

accordingly macerated for the extraction of the skeleton, and has yielded the skull, bones of the trunk, scapular arch, and furculum, right humerus, right femur, tibia, and fibula.

Learning that Mr. John Hancock, the accomplished and artistic taxidermist of Newcastle-on-Tyne, had extracted the bones of the extremities from a rare skin of *Alca impennis,* I wrote for the loan of those of the left side, and was favoured by a prompt and kind acquiescence, the bones being stated to be from a mature female bird.

I have thus at command the materials for a description of the complete osteology of this most rare and now generally regarded as extinct bird.

In my 'Descriptive Catalogue of the Osteological Series contained in the Museum of the Royal College of Surgeons of England,'[1] I have briefly noticed characteristics of the cranium, dorsal vertebræ, scapula, coracoid, femur, and tibia of an *Alca impennis* which the founder of the collection, John Hunter, had succeeded in procuring; Mr. Blyth had previously made known the fact that the humerus "possessed a very small internal cavity, while the tibia was completely filled with marrow"[2]; and these are the only published notices of the osteology of the bird with which I am acquainted.

§ 1. *Vertebral column.*

In the present specimen there are twenty-two moveable vertebræ between the skull and sacrum, the last nine supporting moveable ribs, of which the first two pairs have free extremities; the succeeding pairs of free pleurapophyses articulate with hæmapophyses, and these with the sternum.

The sacrum appears to include fourteen vertebræ, of which the first supports a tenth moveable pair of ribs, the last of the ordinary thoracic costal series: its hæmapophysis does not reach the sternum.

The caudal vertebræ are fourteen in number, of which the last three are blended together, and the first, by its pelvic relations, might claim to belong to the sacral series.

The centrum of the atlas, anchylosed as an odontoid process to the axis vertebra, presents a pair of small facets for articulation with the posterior basal angles of its proper neurapophyses; but these are mainly supported by the hypapophysis, simulating the body of the atlas, and with which they are confluent. The back part of the hypapophysis offers a flat surface to the centrum of the axis, beneath which it is slightly produced at its lower part, being here wedged into the notch between the true bodies of the axis and atlas. The fore part of the hypapophysis combines with the neurapophyses to form the cup for the condyle of the occiput; the cup is emarginate above, and traversed by the ligamentous continuation of the "odontoid" in its way to adhere to the upper part of the occipital ball. The atlantal neurapophyses diverge as they rise, and are joined together above by a broad plate slightly arching across from one to the other

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[1] 4to, 1853, vol. i. p. 221, preps. nos. 1150–1160.

[2] Proc. Zool. Soc. November 14, 1837, p. 122.

neurapophysis. A process extends backward from each place of junction. There is no neural spine. The neural canal has a wide transversely elliptical area.

The body of the axis is elongate, compressed and carinate below, the keel being slightly produced and curved at the hind part. The expanded anterior end of the centrum has a small notch near or at the junction of the neurapophyses. These develope postzygapophyses, above which are produced strong trihedral anapophyses; there is a thick, obtusely ended, slightly recurved neural spine.

The third cervical developes a compressed hypapophysis, slightly thickened and flattened below, from the hinder half of the centrum. From the sides of the base of the hypapophysis ridges diverge to parapophyses at the expanded fore part of the centrum, which is flat and triangular below; above each ridge the centrum is concave. Below the præzygapophysis a diapophysis coalesces with the short pleurapophysis, which circumscribes a vertebrarterial canal, the foremost of the series; above the postzygapophysis there projects a trihedral anapophysis, less thick than that of the axis. A sharp horizontal ridge passes from the post- to the præ-zygapophysis, having a small vertical perforation behind; the neural spine is a little higher and less thick than that of the axis. The pleurapophysis projects as a slender, straight, obtuse process about 2½ lines backward; the intervening "vertebrarterial" canal is above a line in diameter.

The fourth cervical (Pl. II. figs. 4 & 5) resembles the third, but with shorter pleur- (*pl*), hyp- (*hy*), and an-apophyses (*a*), and with a rather shorter neural spine (*ns*). The vertical foramen in the interzygapophysial ridge (*iz*) is larger than in the third vertebra; and below this a shorter ridge (*r*) passes to the base of the præzygapophysis (*z*). The posterior part of the neural arch is broader than the interior.

In the fifth vertebra the interzygapophysial ridge is wanting; but the one beneath is more developed. The anapophyses are reduced to ridges diverging from a stumpy neural spine to the postzygapophyses (*z'*). The diapophysis makes a backward projection distinct from and above the pleurapophysis; there is an obtusely angular hypapophysial keel (Pl. II. fig. 6, *hy*).

In the sixth to the ninth cervicals the hypapophysis is obsolete, and the parapophysis (Pl. I. fig. 1, *p*) sends a stumpy projection downward, increasing to the ninth, where it forms the side of a quasi-hæmal canal; the backward extension of the rib is reduced to a mere angle. On the broad depressed upper surface of the neural arch, both neural spine and anapophyses are represented by low ridges: the posterior part of the neural arch is narrower than the anterior. The diapophysis (ib. *d*) continues to project outward, and becomes bifurcate by a groove.

In the tenth cervical the hypapophysis (ib. *hy*) suddenly reappears as a compressed quadrate plate from the whole under surface of the centrum, a little inclined forward, especially at the front angle.

In the eleventh cervical there is a similar but rather shorter hypapophysial plate, and the pleurapophyses begin again to project backward, and the neural spine (*ns*) to reappear.

In the twelfth cervical the hypapophysis is reduced to a short triangular process, and the neural spine forms a low thick knob; the pleurapophyses are still anchylosed as mere processes.

In the thirteenth cervical they elongate, but are fixed; the hypapophysis is a mere ridge; the parapophyses reappear as ridges; the diapophysis is widely cleft, and the hinder and lower portions afterwards alone represent this process; the neural spine is a higher tubercle than in the twelfth vertebra.

The fourteenth vertebra, retaining its pleurapophyses as free elements, may be reckoned as the first dorsal (Pl. I. fig. 1, D); its centrum is broader than it is long, with a medial and two marginal ridges below: the first ridge is hypapophysial; the latter are parapophysial, and are most produced, each bounding a concavity on the under surface of the vertebra. The pleurapophysis (ib. *pl*) is a simple, straight style, 6 lines in length, articulated to the under part of the base of the diapophysis, which is now a broad, triangular, depressed plate. The neural spine is a strong, compressed, quadrate plate in this and the succeeding dorsals.

In the second dorsal the parapophysial or lateral hypapophysial ridges are more produced, especially at the hinder angle. The pleurapophysis is a long, nearly straight style of about 3 inches in length, and supports at the beginning of its lower or distal third an epipleural plate curving upward. The head of the rib is expanded and articulates to much of the under part of the diapophysis. The quadrate neural spine gains in fore-and-aft extent.

In the third dorsal the lateral hypapophysial plates are longer and narrower, and begin to be supported as processes from the descending inferior part of the centrum. The pleurapophysis, 3 inches 7 lines in length, articulates above by a head and tubercle with the centrum and under part of the diapophysis, and below with a straight hæmapophysis, 1 inch 5 lines in length, and expanding at its sternal end to articulate with an oblong cavity, transverse to the broad costal margin of that bone. The epipleural is a plate 1 inch in length, and from 1 to 2 lines broad.

In the fourth dorsal (Pl. II. fig. 7), the parapophyses are converted into a hypapophysis in the form of a broad bifurcate process, the prongs diverging at a wide angle as they descend from the common produced base (*hy*). The pleurapophysis, with the head more distinct from the tubercle, and supported on a longer neck, is 4 inches in length, and articulates with a hæmapophysis 1 inch 10 lines in length. The diapophyses (ib. *d*) are long and broad; the zygapophyses (ib. *z*, *z'*) small and short. The neural spine (ib. *ns*) increases in antero-posterior but not in vertical diameter, and preserves the quadrate form.

In the fifth dorsal, the stem of the bifurcate hypapophysis lengthens. The pleurapophysis, 4 inches 10 lines in length, continues as slender as the preceding, and articulates with a hæmapophysis 3 inches 2 lines in length, and slightly bent.

The sixth dorsal has a longer and narrower stem of its bifurcate hypapophysis; but the fork is broken off. The pleurapophysis is as in the fifth, but with a longer and more curved hæmapophysis, 4 inches in length, and with a rather shorter epipleural lamina.

In the seventh dorsal the hypapophysis is a compressed subquadrate plate, a little expanded at its lower margin. The pleurapophysis, 6 inches in length, retains its slenderness; the hæmapophysis is 4 inches 8 lines in length.

In the eighth dorsal, the hypapophysis is suddenly reduced to a low triangular process. The pleurapophysis, 6 inches 3 lines in length, articulates with a hæmapophysis of more slender proportions, 5 inches 2 lines in length.

In the ninth dorsal, the hypapophysis is again represented by a low median ridge. The pleurapophysis, 6 inches 6 lines in length, articulates with a hæmapophysis (*h*) 5 inches 6 lines in length; and this is the last of those that directly articulate with the sternum.

The tenth dorsal becomes, by confluence of its centrum, the first sacral (ib. s), but retains its neural spine distinct from, though contiguous with, the long sacral ridge; its pleurapophysis (*pl*) is 6 inches 2 lines in length, and articulates with a hæmapophysis (*h*) 5 inches 2 lines in length, the distal end of which is applied to the preceding hæmapophysis about one inch from its articular end.

In the dorsal region, the articular facets of the centrum are simplified to a very slight convexity in front and a corresponding concavity behind (Pl. II. fig. 7, *c*).

The sacrum (Pl. I. fig. 1, s), 4 inches 2 lines in length, and including about thirteen vertebræ, presents at its beginning rather long and narrow centrums; but these expand laterally, and subside vertically to the sixth, whence they gradually again contract in breadth to the antepenultimate vertebra: the centrums are all confluent. The hinder half of the expanded rhomboid portion of the under surface of the sacrum is broadly and slightly grooved.

Transverse processes, from the second to the sixth sacral inclusive, abut against the ilia: in the next three vertebræ these processes are scarcely marked; they reappear in the following sacrals, with articular surfaces for the ilia, increasing in vertical extent. The first free caudal has also a short thick transverse process, which abuts against the ilio-ischial part of the os innominatum.

The length of the iliac element (Pl. I. fig. 1, 62) of this bone is 4 inches 6 lines; its extreme breadth, an inch from the fore margin, is 9 lines. That margin is rounded; the outer one is at first convex, then concave, contracting before expanding again, and thickening (at 62) to contribute to the acetabulum. The expanded fore part of the ilium is a very thin lamella. The acetabulum, widely open, is overtopped by an articular facet adapted to the upper part of the neck of the femur. The ilium quickly contracts in breadth behind the acetabulum, beyond which it extends nearly 2 inches, as far back as the third caudal; it coalesces with the ischium about an inch behind the acetabulum, circumscribing an elliptic ischiadic foramen (*i*) 9 lines in length and 4 lines in short diameter.

The ischium (63), after the iliac confluence, extends backward as a pointed styloid process an inch in length. The ischium forms the back part of the acetabulum, the pubis the under part; the obturator vacuity (*o*) between ischium and pubis is only 5 lines in length and 2 lines in short diameter. The ischio-pubic harmonia beyond this is 1½ inch in length; the slender pubis (64) then extends freely backward and slightly outward and downward for 2 inches 6 lines, of a rib-like shape; its total length is 4 inches.

The first free caudal has a depressed subquadrate centrum, broad and depressed diapophyses inclined backward, with terminal pelvic articulations as above stated. The second, third, and fourth caudals diminish in size, and more so in the breadth of the diapophyses, which end freely.

A small hæmapophysial tubercle is wedged between the second and third caudal centrums; a larger plate is between the third and fourth caudals; it begins to be compressed between the fourth and fifth caudals. The next hæmapophysis resembles a short compressed spine, inclined forward; the fifth and sixth hæmapophyses diminish in size; the seventh and eighth are elongate bones underlying the centrums, with which they are nearly coextensive. One sees that the under and fore part of the terminal anchylosed mass of caudals is a confluent hæmapophysis of like shape.

The diapophyses increase in length from the fourth to the seventh caudals; these decrease in the eighth and ninth, and disappear in the tenth. The neural spines are stumpy and thick on the anterior caudals, look longer, because thinner, on the succeeding ones to the ninth, are short on the tenth and eleventh, and are represented by a continuous ridge on the terminal coalesced vertebræ. The length of the caudal region is 3 inches 9 lines.

From the position of the acetabula, and prior to sacral confluence, there would be shown eighteen free caudal vertebræ in the young Garfowl: one sees that if these vertebræ had continued free and participated in the rate of growth of the antecedent centrums, how similar a caudal appendage to that of the *Archæopteryx*[1] would have resulted.

The sternum (Pl. I. *hs*, 60; Pl. II. figs. 1 & 2) is long, narrow, entire, with the keel (*hs*) equalling in depth the breadth of the mid part of the bone. The "episternum" (*e*) is short, compressed, wedge-shaped, with its thin obtuse apex curved a little down and back. The "coracoid" grooves (*b*) are separated from each other by the base of the episternum (*e*): each is divided into an inner and an outer articular facet; the inner one (Pl. II. fig. 2, *b*) is the largest, and is subtriangular, the broadest part being sustained by a kind of buttress-like prominence, each buttress (*f*, *f*) diverging from the fore part of the origin of the sternal keel (*hs*). The outer facet (ib. *b'*) is bounded by a short plate in front, and by the base of the costal process behind.

The "costal" process[2] (*d*) is subcompressed, triangular, with an obtuse apex directed

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[1] Phil. Trans. 1863, p. 44, pl. 1.

[2] See the definition of this and the other processes in art. *Aves*, 'Cyclopædia of Anatomy and Physiology,' vol. i. 8vo, 1836. The sternum of the bird is not the homologue of the plastron of the Tortoise; it is never

upward, the base intervening between the coracoid (*b*) and costal (*a*) surfaces. The latter, occupying 1 inch 9 lines of the sternal border behind the costal process, presents seven articulations (Pls. I. & II. fig. 1, *a*, *a*) for as many hæmapophyses (ib. *h*), progressively decreasing in size as these likewise diminish at their sternal ends. The sternum is continued 4 inches 5 lines behind the costal borders, slightly expanding before it is rounded off to the end, which is truncate, and reduced to a breadth of 9 lines.

The front border of the sternal keel, 1 inch 10 lines in depth, is concave and carinate (Pl. II. fig. 2), the obtuse anterior angle of the keel being produced toward the furculum (Pl. I. fig. 1, 58), but not reaching or coalescing with that bone. The keel extends, gradually losing depth, to within an inch of the hind end of the sternum, and at its subsidence a pair of curved lines (Pl. II. fig. 1, *l*), convex backward, diverge to near the lateral borders, and are reflected forward, three or four lines from the border, to the end of the costal surface (*a*). The total length of the sternum is 7 inches 8 lines; its greatest breadth is 2 inches 3 lines.

§ 2. *Skull.*

The skull is long and narrow, the rostral part forming nearly the two anterior thirds, compressed, and deep; the orbits are large, with only the upper half of their bony rim defined. The cranium is very small, and chiefly seen at the upper half of the posterior fifth part of the entire skull (Pl. I. fig. 2). The interorbital region slopes to the base of the upper mandible, which, rising at its compressed part, leaves a wide concavity in the contour line between the mandible and the cranium proper. Both the temporal (*t*) and the superorbital glandular (*so*) depressions are deep and sharply defined, meeting, but separated respectively, at the mid line by a low, sharp crest.

There is a large lower and a small upper vacuity in the interorbital septum, the former continuous posteriorly with the optic vacuity, the latter with the olfactory vacuity: in the anterior cranial wall there is a pair of vacuities, one on each side of the orbito-sphenoidal base of the ossification, dividing the upper from the lower vacuity in the bony interorbital septum.

The occipital tubercle is subhemispheroid, projecting below the level of the basi-occipital (ib. fig. 3, 1). This is transversely extended, subcarinate, divided by a pair of transverse curved ridges from the basisphenoid (ib. 5). The paroccipitals (ib. 4) are broad, obtuse, trihedral, the narrowest surface being mesiad; the fore surface is concave; the outer margin is continued as a ridge upon the occipital surface, defining the share

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developed from longitudinally consecutive series of lateral elements such as represent the hæmapophyses of certain dorsal segments in *Chelonia*. In most birds ossification of the sternum begins from a pair of centres, which, meeting and coalescing at the mid line, thence extend into the cartilaginous basis of the keel. The extra pair in the anomalous sternum of Gallinæ is special and exceptional in the Bird class. The application of the names of the elements of the Chelonian plastron to parts of the Avian sternum is to be deprecated, save in the case of the episternum, the bifurcate character of which is shown by bone in Passerines.

thereto contributed by the mastoid: the fore part of the base forms the posterior tympanic cup. The mastoid (Pl. I. fig. 3, 8) is short, obtuse, inclined downward and forward. The inner and back part of its base is excavated by a deep transverse oval fossa for the anterior condyle of the tympanic element (ib. 28).

The occipital surface of the cranium is vertical, subsemicircular; its upper and lateral border forms a deep and sharp ridge, dividing it from the temporal fossæ. Each fossa is divided into an anterior (ib. fig. 1, 11) and posterior (ib. *t*) compartment; the latter divisions meet above and define a short low "parietal" ridge (ib. fig. 2, 7).

The fore or postorbital part of the temporal fossa is divided from the deeper back part by a low ridge descending from the hind angle of the smooth convex frontal tract to the fore part of the mastoid. The interorbital supracranial space is occupied by the deep oblong fossæ (ib. *so*) of the superorbital glands, between which fossæ is a sharp median ridge. A lateral ridge defines each fossa from the superorbital ridge itself, which is very narrow. There is an oval vacuity for the duct of the gland at the outer and fore part of each superorbital fossa, 4 lines, by 2 lines in diameter; and there are two or three foramina at the back part of each fossa, leading to the orbit. The postorbital process (12) is depressed and triangular, impressed above by the fore part of the temporal fossa, which is there divided by a short longitudinal ridge from the superorbital glandular fossa.

The prefrontals (ib. fig. 1, 14) send outward a triangular antorbital plate, which inclines a little forward to join the lacrymal, but leaving an intermediate lacrymal vacuity about the same size as that for the duct of the superorbital gland.

The basisphenoid rapidly narrows as it advances forward, and does not send out processes (pterapophyses) for the tympanic or pterygoid bones; its presphenoid prolongation (ib. fig. 3, 9) diminishes in transverse but increases in vertical extent, developing upward the lower part of the interorbital ridge, which is continuous with the ossified anterior part of the interorbital septum, and, by means of its backward extension, with the orbitosphenoids (ib. 10). The lower border of the presphenoid is convex, and rests upon the groove formed by the approximated palatines (20) and intervening vomer (13).

The very thin fore part of the cranial wall shows four large vacuities, one medial and superior, triangular, and giving exit to the crura of the olfactory lobes, which slightly groove the under surface of the interorbital part of the frontals on their way to the prefrontals. On each side and a little below the olfactory aperture is an irregular oblong vacuity. An ossified tract of the interorbital septum extends from the confluent orbitosphenoids, between the above vacuities and below the olfactory one, forward to the anterior ossified part of the septum: a narrow unossified tract lies above, and a broader unossified oblong space is beneath this upper ossified part of the septum. The inferior vacuity gives exit to the optic and orbital nerves.

The palatines (ib. fig. 3, 20) are broadest behind, and present each towards the palate a long triangular surface sloping from within outward and downward, and defined mesially by a low vertical plate bounding an angular cavity thus formed on that surface. The narrower anterior prolongations of the palatines are confluent with the palatal processes of the maxillaries (Pl. I. fig. 3, 21), near to which they also develope from their inner border a low vertical ridge. The upper surface of each palatal, near its middle part, developes the curved outer wall of the posterior nostril, which is convex externally; the palatal terminations of these nostrils are longer and narrower, and are divided by the compressed elongate vomer (13).

The nasals, confluent behind with the frontals, prefrontals, and lacrymals, soon divide into their premaxillary (ib. fig. 2, 15) and maxillary (15′) branches ; the former, at first divided by a fissure from the nasal part of the premaxillary (22), coalesce therewith anteriorly ; the longer styliform maxillary processes coalesce by their lower end with the maxillary.

The broad part of the palatal plate of the maxillary (ib. fig. 3, 21), whence its palatine, malar, nasal, and premaxillary processes diverge, is perforated by the oblique foramen (*l*) conveying the lacrymal and superorbital secretions to the angle of the mouth. The premaxillary processes are divided by the back part of the long prepalatine fissure (*f*), about 2 lines in breadth. The malar process is depressed, about an inch in length, and underlaps the fore half of the malar. The nasal process rises to the inner side of, and is partly confluent with the maxillary process of the nasal bone; which process (ib. fig. 1, 15′) is subcylindrical, and extends downward and forward from the interspace between the lacrymal bone and the premaxillary part of the nasal, dividing the large external nostril (15′) from the antorbital (21′) vacuity.

The premaxillary chiefly forms the compressed, subarcuate, pointed upper mandible, which is grooved on the narrow palatal surface (ib. fig. 3, 22″) for an extent of 1 inch 6 lines from the apex, where the prepalatal vacuity commences. The fore end of the groove is divided by a short delicate median ridge. The nasal process of the premaxillary (22) assumes behind the rostral part of the bone a trihedral shape, gradually becoming flat and then concave below ; it is grooved above, the groove deepening to a fissure, and dividing the back part of the process where it joins the frontal. The nasals (15) are also partly divided by linear fissures from this part of the premaxillary, with which they are confluent at both ends.

The pterygoids (fig. 3, 24) are slender, slightly bent, trihedral bones, articulating anteriorly to short pterygoid processes at the inner and back part of the palatines, and posteriorly with an articular tubercle on the inner side of the base of the inner division of the lower articular end of the tympanic (28). The limits of the styliform malar (ib. fig. 3, 26) and squamosal (27) are indicated by grooves ; the latter articulates with the outstanding lower and outer angle of the tympanic.

The tympanic articulates by two convex condyles with the mastoid and paroccipital ; its body slightly contracts below these, and sends from its fore part a long compressed triangular process, with the apex obliquely truncate ; its lower end is much expanded, and supports two articular surfaces : the outer one (fig. 3, 28) is oblong and oblique, convex anteriorly, and concave posteriorly, where it is extended upon a short posterior process, forming the squamosal cup; the inner and smaller facet is convex, and above this is the pterygoid tubercle.

The lower tympanic condyles are adapted to two corresponding cavities on the articular part of the mandibular ramus, which developes behind them a vertical triangular surface, the outer and inner margins of which are produced into cristæ. There is a small coronoid process external and anterior to the outer articular surface. The surangular part of the ramus shows an oval vacuity, about 3 lines by 2 lines; the groove defining the surangular from the angular part widens as it advances, and leads to an oblong fissure between the surangular and dentary elements.

The splenial element retains its distinctness posteriorly, and a groove upon the lower margin of the ramus indicates the extent of its forward production: the posterior limits of the posteriorly bifurcate dentary element are clearly defined. The right and left of these elements coalesce to form a compressed, pointed symphysis, 1 inch long, half an inch deep at the back part, gradually contracting forwards to a point, with a grooved upper surface; the upper margin of the symphysis is slightly convex lengthwise, the under margin slightly concave lengthwise.

The outer surface of the symphysial part of the jaw is roughened by numerous small perforations and grooves, indicating the vascularity of the periosteum in connexion with the reproductive matrix of the horny sheath of the beak: the tip of the premaxillary has a similarly sculptured surface.

The basihyal, including the urohyal, is 10 lines in length; the fore end of the basihyal is slightly expanded, and occupied by a trochlear articular surface, convex transversely, concave vertically. The bone again expands to form the pair of concave oval articular facets for the thyrohyals, beyond which it is continued as a slender pointed style (urohyal) for about 4 lines; the part anterior to this is the true basihyal. The thyrohyals (hyobranchyals) are slender, slightly bent styles, 2 inches long, swelling into a small knob at both ends, the one articulated to the basihyal being rather the largest.

§ 3. *Scapular Arch and Appendage.*

The bladebone (Pl. I. fig. 1, 51), 3 inches 8 lines in length, extends backward to the ninth rib, gradually expanding vertically and more quickly flattening laterally to its free extremity, which is truncate obliquely from above downward and backward. The proximal end has opposite dimensions, being much expanded laterally or transversely to the axis of the trunk, and narrowest vertically; it presents a broad transverse condyle, which is a little expanded at each end, to the coracoid. The outer end is the broadest; the inner one the most produced. The shaft of the scapula quickly contracts to a transverse diameter of 3 lines, and then begins to grow thin and broad, but as if with a kind of twist, the inner or medial border near the head of the bone becoming the upper border about a fifth of the way from that end. The inner end of the condyle is connected by a strong ligament with the end of the furculum.

The coracoid (Pl. I. fig. 1, 52) has a breadth at its sternal end of 14 lines: the medial side of this end is thick, with the posterior angle produced; the outer side is thin, and sends off above the sternal articulation a lamelliform process. The inner side of the sternal expansion is slightly concave. The coracoid contracts to a diameter of 5 lines, continuing thick and convex along its medial border; it sends off from the inner and back part of its proximal end a strong compressed process, which is perforated, and which developes the articular cavity for the inner condyle of the scapula, and is attached by a short ligament to the end of the furculum: the main continuation of the body of the bone supplies the rest of the joint for the scapula, with the major part of that for the humerus, and then arches forward as a strong process to abut against the articular surface of the clavicle (furcular prong), situated upon the upper and outer part of that bone, about 6 lines from the extremity, which is ligamentously connected with the scapula and inner part of the clavicular process of the coracoid. The body of the coracoid is, as usual, straight and inclined from the sternum upward, forward, and slightly outward, losing breadth, gaining thickness, and assuming the trihedral form as it rises.

The clavicle (ib. 58), anterior to the coracoid articulation, becomes compressed, curves with a strong convexity forward, and then bends inward and backward, thickening and expanding to become confluent with its fellow, in the form of an inverted but somewhat narrow arch (Pl. II. fig. 3). The length of each half of the so-formed furculum, following the curve, is 4 inches 6 lines; a short convex ridge is developed from the point of confluence, which does not reach the anterior apex of the sternal keel.

The humerus (Pl. I. fig. 1, 53; Pl. II. figs. 8, 9, 10), 4 inches 2 lines in length, is much expanded at the proximal end (Pl. II. fig. 8), where it measures 1 inch across: the shaft is compressed, measuring 6 lines in long diameter, and only 2½ lines in short diameter, midway between the two ends (as in the outline above the fig. 9).

The articular head (*a*) is a semioval convexity, 8 lines by 4½ lines, overhanging the concavity (*d*) on the anconal side, with the long axis extending from the radial (*b*) to the ulnar (*c*) side, and with the ends continued upon the beginning of the radial and ulnar (*c′*) crests, of which the former is upper, the latter lower, in the natural position of the bone. The radial crest or tuber is directly continued, contracting, into the pectoral ridge. The ulnar crest is prominent, subtriangular, convex palmad, concave anconad, and sending off on this surface a thick ridge (*c′*) which divides the concavity into a proximal depression (*d*), and a deeper distal one (*e*), into which an air-cell has entered, but without pushing itself into the interior of the bone. From near the radial end of the articular convexity, a thick ridge or raised rough surface (*f*) extends about 8 lines down the bone; it gives insertion, by a well-marked narrow elliptical depression, to the second pectoral muscle, the raiser of the wing. Below this ridge the convexity of the shaft rapidly subsides into the almost flattened outer or radial surface. The opposite surface at the proximal end of the shaft is concave, but becomes slightly convex, transversely, down the rest of the shaft. The borders bounding the flattened shaft, of which the radial one is formed chiefly by the pectoral ridge, describe very slight sigmoid curves. The pectoral ridge is long and low, much less developed than in birds of flight. A short ridge (Pl. II. fig. 9, *g*), abruptly rising from the end of the radial border, extends to the middle of the distal anconal side of the radial condyle. This (fig. 10, *h*) is long and narrow, extending further proximad by half its length than the ulnar condyle (ib. *i*) does. The ulnar condyle is shorter and thicker: both project towards the palmar aspect, and do not terminate the bone distally. The broad articular surface of the ulna is adapted to both condyles, but covers only the distal half of the radial one, the radius gliding upon the upper half. The breadth of both condyles is 5 lines. The anconal surface (fig. 9) is divided into two grooves by three ridges, the ulnar one (*k*) being the longest, the radial one (*l*) the shortest; and the ulnar anconal groove is consequently larger than the radial one. All the three anconal ridges project distally beyond the condyles. There is a well-marked flat surface above the ulnar condyle for the attachment of a strong lateral ligament.

The shaft of the humerus contains a narrow medullary cavity (fig. 9′). The orifice of the medullary artery is close to the anconal border, about an inch below the ulnar edge.

The radius (Pl. I. 54) and ulna (55), connected only at their extremities, have opposite curves, leaving a wide interosseous space. The radius is but half the thickness of the ulna, and is more bent. A tuberosity projects on the radial side just below the thickened proximal articular end: below this the shaft is slightly contracted; it then expands and becomes compressed, with the radial border more convex than the ulnar one is concave. The anconal surface is longitudinally channelled near the radial edge, deepening towards the wrist, where there is a second but short groove ulnad of the longer one.

The olecranon is short, obtuse, with a longitudinal groove on each side of its base, narrowing the bone between the process and the articular surface of the ulna. A sesamoid in the biceps flexor tendon plays in the palmar groove; it is the homotype of the patella: two other sesamoids in the triceps extensor tendon play in the two grooves in the anconal part of the distal end of the humerus: these answer homotypally to the fibular extension which plays in the popliteal groove of the outer femoral condyle. The shaft of the ulna, though compressed, is at the proximal half three-sided, the narrowest side being toward the radius, and contracting to a sharp border at the distal half. There are no quill-pits. The distal articular surface is convex from the radial to the ulnar side, but slightly concave transversely, and is accordingly somewhat trochlear. A tuberosity projects above it on the outer side, near the radius. The length of the antibrachium is 2 inches 4 lines.

The radial carpal bone (Pl. I. 56) presents a trochlear surface, concave from the radial to the ulnar end, convex transversely to the magnum, here confluent with the base of the mid metacarpal (III). The ulnar carpal (55') is the smaller bone, and offers a deeper groove to the convex compressed process of the base of the fourth or "annulus" metacarpal (IV). The second or index metacarpal (II) is 6 lines long, compressed, and confluent by its whole length to that of the medius. It supports a phalanx (1), 10 lines long and pointed at the end, which does not quite reach that of the mid metacarpal. This (ib. fig. 1, III) is 1 inch 9 lines long, inclusive of the magnum, and is confluent with the fourth slender metacarpal (IV) at both ends, leaving an interosseous space 1 inch 1 line long and 2 lines wide.

The proximal phalanx of the medius (III. 1) is broader than the metacarpal, having its ulnar border extended into a ridge and slightly produced beyond the distal articular end. To this is joined a second phalanx (ib. 2), terminating, like that of the forefinger, in a point. The length of the hand is 3 inches 6 lines. The broad and flattened general character of the bones of the fore limb relate to the support of a surface in the shortened wing adequate, as a fin, to strike the water with effect.

§ 4. *Pelvic Arch and Appendage.*

The pelvic arch has been described. Its appendage departs less from the general ornithic type than does that of the scapular arch.

The femur (Pl. I. fig. 1, 65; Pl. II. fig. 11), 2 inches 10 lines in length, shows the usual extension of articular cartilage from the head to the upper part of the neck and great trochanter, expanding upon the latter. The ligamentum teres is implanted in the upper part of the head. The trochanter does not rise to a higher level; the ridge at its fore part descends about 6 lines upon the bone, gradually subsiding; the back or outer side of the trochanter is broad and nearly flat; the popliteal side of the shaft of the proximal part is flattened, the rotular side is concave. The shaft soon assumes a full elliptic transverse section, is very slightly bent, with the concavity backward; it slightly expands to the distal condyles. It has a large medullary cavity. The rotular groove is wide, and is partially defined from the intercondyloid or popliteal groove, in which are the depressions for the crucial ligaments. The outer condyle has the usual backward or popliteal production, vertically grooved for the compressed head of the fibula.

The tibia (Pl. I. fig. 1, 66; Pl. II. fig. 12) is 5 inches 2 lines in length. The proximal articular surface is but feebly defined; the tibial or inner division is the largest; the fibular division is convex. The rotular process, of a triangular form, with a base as broad as the tibia, rises half an inch above the articular surface, and sends off a procnemial (Pl. II. fig. 12, *p*) and an ectocnemial (*e*) ridge. The latter is short, thick, and angular; the former is long, thin, and also forms a low angle. The proximal part of the shaft of the tibia is trihedral: there is an oblong tuberosity on the inner or tibial side. Eight lines below the articular surface commences the fibular ridge, which has a similar extent; the fibula is anchylosed therewith in the skeleton from the mummified specimen, but not in the bones of the Great Auk sent to me by Mr. John Hancock. After an interval of separation of about 3 lines, the fibula (ib. 67) coalesces in both specimens with the tibia, and can be traced to within an inch of the distal end of the bone. The shaft of the tibia soon acquires a form giving an ellipse in transverse section, elongated from side to side; it very gradually diminishes to within an inch of the distal end, and then slightly expands to the condyles. The precondyloid groove (*f*) for the tendon of the extensor communis muscle is bridged over by ligament, not by bone; it subsides upon the shaft an inch below its summit; it is submedian in position; its lower outlet is transversely elliptical, and just above the intercondyloid space. Of the anterior prominent parts of the distal condyles, the outer (fibular) one (*b*) is rather broader than the inner (*a*), and is narrower than the intercondyloid space.

The canal leading to the bridge is wide and bounded by a ridge chiefly on the tibial side. The ectocondyloid surface is almost flat, slightly concave; the entocondyloid surface is made more concave by the prominence of the periphery of the condyle, and is divided by a ridge developing a tubercle towards the posterior part of the condyle. The posterior trochlear surface of the condyle is very slightly concave transversely, with a low median convexity. The transverse and antero-posterior diameters of the distal condyles are equal.

The metatarse (Pl. I. fig. 1, 69; Pl. II. fig. 13), 2 inches 2 lines long, has the outer condyloid concavity (*b*) lower than the inner one (*a*) anteriorly; the calcaneal ridge is low and vertically perforated. In the anterior concavity there is a smaller fore-and-aft canal. The inner (tibial) element (*a*, *ii*) is the shortest; the trochlea of the middle one extends 3 lines beyond it; the cleft between this and the outer trochlea extends anteriorly to the lower fore-and-aft canal (*c*), but not posteriorly. The outer condyle (*iv*) ends about a line above the middle one.

The inner toe (Pl. I. fig. 1, *ii*), of three phalanges, is 2 inches 5 lines long; the middle toe (*iii*), of four phalanges, is 3 inches 3 lines long; the outer toe (*iv*), of five phalanges, is 3 inches 2 lines in length, and the slenderest of the three, the middle one being the thickest.

Save in parts of the cranium, no bone in the skeleton of *Alca impennis* is pneumatic; but the humerus has a medullary cavity, as well as the femur and tibia.

§ 5. *Comparison of the Skeleton.*

In *Alca impennis* there are twenty-two free vertebræ between the skull and sacrum, in *Alca torda* twenty-one; but, in the specimen in the museum of the Royal College of Surgeons[1] yielding that number, the homologue of the twenty-second vertebra in *Alca impennis*, supporting the penultimate pair of free thoracic ribs, has coalesced with the

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[1] Catalogue of Osteology, 4to, 1853, vol. i. p. 221, no. 1146.

sacrum. The last pair of ribs, articulated in both species to a sacral vertebra, have hæmapophyses which do not reach the sternum. The chief numerical difference in the vertebral column is in the excess of caudal vertebræ in the Garfowl. The dorsal vertebræ have the same simple shallow ball-and-socket joint, the ball being anterior in *Alca torda*, as in *A. impennis*; and this structure I have also found more feebly developed in the dorsal of *Uria grylle*: in *Phaleris* both co-adapted surfaces are nearly flat. The main difference in the skull is the shortness, greater relative depth, and stronger convex curve of the upper contour of the solid prenarial part of the premaxillary: every other better character of affinity is very closely repeated.

The sternum of *Alca torda* repeats the characteristics of that of *Alca impennis*, with the exception of a notch on each side of the back part, 1 inch long by 3 lines wide. In *Alca (Phaleris*, Temm.) *psittacula*, Pallas, the sternum is more dilated posteriorly, and the notches are represented by oblong foramina of a wider form. The interorbital part of the cranial roof is narrower, and the upper end of the lacrymal projects upward and backward as a process. In *Uria grylle* (Pl. II. fig. 14), besides the posterior notches (*f*) answering to those of *Alca torda*, there is a small perforation, sometimes two (ib. f', f''), on the inner side of each.

The furcular and scapular arches of *Alca torda* closely correspond with those of *Alca impennis*. The coracoid is similarly perforated for a branch of the pectoral artery.

The humerus closely agrees in shape and proportion; the difference in the wing-bones, in adaptive relation to the power of flight, of *Alca torda*, begins to manifest itself in the antibrachial bones, which are longer and less compressed than in *Alca impennis*, the ulna also having a row of quill-pits or knobs: the bones of the head are shorter relatively to the ulna than in *Alca impennis*.

A closer resemblance is maintained between *Alca torda* and *A. impennis* in the bones of the pelvic limb, and is especially seen in the shape and proportions of the rotular process, with its pro- and ecto-cnemial ridges, and in the proportions and attachments of the fibula.

The sum of the comparisons of the skeleton of *Alca impennis* with that in other Auks, Phalerins, and Puffins, and also in Guillemots, goes to exemplify the close affinity of the Garfowl to those sea-birds, and to indicate that it is a modified apterous member of the *Alcadæ*.

The Penguin, similarly apterous or with wings reduced to the function of fins, shows its essential distinction from the Garfowl in all the flight-giving parts of the skeleton. The number of vertebræ between the skull and sacrum is, indeed, the same; but only eight support moveable ribs, the total number of which is nine pairs, the last pair being sacral. The atlantal hypapophysis is produced below into a compressed process; the anapophyses of the axis and two following vertebræ are mere tuberosities, not elongated into processes. The pleurapophyses are styliform and produced backward in the third to the tenth cervical, thence are shortened to the fourteenth, when the pleurapophysis reappears as a separate styliform rib. The first four cervical vertebræ have each a single posterior hypapophysis; the sixth to the tenth inclusive have a pair of parapophyses simulating anterior hypapophyses.

The parapophyses begin to project downward in the sixth cervical, increase in size and convergence to the ninth, and at the tenth have a common median base, like a bifurcate anterior hypapophysis; in the eleventh cervical they disappear, and are replaced by a true hypapophysis from the mid line of the under surface of the centrum: it is a compressed subquadrate plate, decreasing in length in the three succeeding cervicals, in the last of which the parapophyses reappear as short horizontally extended plates, the origins of which, approximating in the second dorsal, combine in the third to form the lamelliform stem of a pair of diverging plates, which decrease in size in the fourth with antero-posterior increase of the base of the stem, and in the fifth dorsal are reduced to an expansion of the end of the stem, which now has reassumed the character and position of a compressed lamelliform hypapophysis, which gradually diminishes to the last dorsal[1]. In the sacrum it is represented by a hypapophysial ridge, which subsides in the fourth of the coalesced series of vertebræ.

In *Alca impennis* the lamelliform hypapophysis first appears on the tenth vertebra, is reduced to a tubercle on the twelfth, and disappears on the thirteenth and fourteenth. The fore part of the sacrum is carinate below in the Penguin, but not in the Garfowl. The number of free caudal vertebræ is eight in the Penguin, eleven in the Garfowl.

The cranial part of the skull is proportionally larger and longer in the Penguin; it is smooth and more convex above; neither the temporal nor superorbital glandular depressions meet at the mid line, and the temporal depression is narrower above, and is not divided into an anterior and posterior facet as in the Garfowl. In *Eudyptes chrysolophus* the glandular depressions are large, deep, and meet for a short extent anteriorly: the temporal fossæ are more than an inch apart on the calvarium. The cerebellar prominence projects much further at the back of the skull in the Penguin than in the Garfowl. The paroccipital process is stronger than the mastoid, whilst in the Garfowl they are equally developed. The condyles of the tympanic are bent more back, the orbital process of this bone is relatively shorter, and the distal articular end is narrower, in the Penguin. The pterygoids are more expanded anteriorly; the palatines are broader, and are convex below, in the Penguin, instead of being concave.

The nasal bone retains its distinctness from the premaxillary and maxillary in the Penguin, and has coalesced only with the frontal and prefrontal posteriorly; its maxillary prong is inclined more forward, at an acuter angle with the premaxillary prong, than in the Garfowl, and it ends in a free point. The lacrymal is broader and longer, reaching the malar below in the Penguin. The premaxillary is comparatively short and rounded: the Penguins have a quite different type of beak from that in the *Alcadæ*. The malo-squamosal zygoma is sigmoidally bent, chiefly concave below, not straight as

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[1] Phil. Trans. 1851, pl. 52. figs. 48–51.

in the Garfowl. The mandible retains as instructive marks of its primitive composition in the Penguin as in the Garfowl, and enables one to see that in the former the surangular is relatively longer, the dentary shorter, but with its lower prong more produced posteriorly; the angular is more produced behind the articular; the rostral part of the dentary corresponds in shape with the same part of the premaxillary, and differs in the same degree from that of the Garfowl[1].

The sternum, perhaps the most characteristic of natural affinity of any single bone in the bird's skeleton, exemplifies the essential distinction of the two species, which are alike adaptively modified for marine existence, with abrogation of the power of flight.

In the Penguin the sternum is destitute of episternal process, and has two posterior notches, equalling in depth half the length of the entire bone. The front and lower borders of the keel are straight. The coracoid grooves meet at the mid line, and their posterior wall is developed into a broad triangular process, with an obtuse apex, the outer angle of the base of which answers to the costal process of the sternum in *Alca impennis*. The costal part of the lateral border is relatively shorter in the Penguin, and affords articulation to only six hæmapophyses. The lateral margins behind the costal portion converge to the posterior part of the sternum, the middle part of which between the lateral styles narrows to a point where the keel ends.

The coracoids in *Aptenodytes* are conspicuous for their great length and strength, for their columnar-like convexity transversely on the outer or fore surface, and their flattened hinder or inner surface, which is concave transversely at its lower third. In *Aptenodytes antarcticus* the length of the coracoid is four-fifths that of the sternum; in *Alca impennis* it is less than two-fifths. The inner lamelliform process from the scapular end is more produced in *Aptenodytes*, and is notched in *Eudyptes*, instead of being perforated; the outer lamelliform process from the sternal end is much less produced. The scapula in *Aptenodytes* is remarkable for its unusual breadth as compared with that of other birds; it is nearly twice as long as the humerus, whereas in *Alca impennis* it is shorter than the humerus.

The clavicles in the Penguin are also of unusual breadth towards their upper ends, and converge to their medial union at a more acute angle than in *Alca impennis*. The humerus, besides being relatively shorter in the Penguin, is broader and more compressed, less expanded at both ends, but especially proximally.

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[1] In *Sula* the basioccipital is impressed by a pair of large and deep circular pits for the insertion of strong *musculi recti capitis antici*: these pits are bounded externally by strong ridges descending and diverging from the sides of the occipital condyle to the hypapophysial tuberosities. From the outside of the base of each tuberosity a buttress flies upward and outward to the paroccipital, circumscribing the space in which lie the carotid and pneumogastric foramina. The pretympanic fossa between the alisphenoid and mastoid rises vertically for more than half an inch; its inferior subcircular opening or entry is 4 lines in diameter. There are no pterapophyses. The coalesced palatines present a narrow, oblong, flattened surface below; and from the mid line of the posterior part descends a triangular crest of bone, between the pterygoid articulations. The palatal nostril is single, medial, 2 lines wide by 8 lines long.

The pneumatic fossa is much deeper, but does not extend into the shaft; the two olecranial grooves are relatively narrower, and restricted to the posterior inferior angle of the lamelliform shaft; a sesamoid in the extensor tendon plays upon each. The articular surfaces for the radius and ulna are feeble convexities upon almost the same transverse line, and the joint scarcely allows of the movements of flexion and extension. In the *Alca impennis* it is adapted for much freer motions.

The radius and ulna are of equal size in the Penguin, are much compressed, straight, and leaving a mere linear interosseous space. The shaft is solid[1]. The ulnar carpal bone projects as a flattened triangular plate from that side of the wrist, and simulates by its distal extension a metacarpal bone. The radial (index) metacarpal is feebly indicated by a low ridge from the proximal half of that border of the mid metacarpal—this is broad and flat; the narrower but similarly shaped "fourth" metacarpal coalesces, as usual, by both ends with the third; each of these supports a proximal phalanx, which is pointed in the "fourth"; that of the mid digit supports a second phalanx, also compressed and pointed. The "hand" in the Penguin is longer than the humerus; in the Garfowl it is shorter.

The iliac bones in the Penguin are remarkable for their divergence as they advance from the acetabula, and for their convergence anteriorly; they describe a sigmoid curve, and are flattened horizontally: the sacrum is more expanded, and more abruptly so anterior to the acetabula. The crest of the sacrum is more developed throughout its whole length in the Penguin. The more extensive co-ossification of ilium and ischium reduces the ischiadic foramen to a much smaller relative size than in the Garfowl. The obturator foramen is continuous with the linear interval between the ischium and slender pubis, and this is much shorter relatively than in the Garfowl, extending scarcely as much beyond the ischium as this does beyond the ilium.

The femur of the Penguin is thicker in proportion to its length. The rotular process of the tibia is shorter; the hollow between the pro- and ecto-cnemial crests is deeper; the patella is relatively larger. The anterior distal tendinous groove is bridged over by bone. The ridge on the tibial side of the back part of the distal trochlea is more produced in the Penguin. But the most marked distinction in the bones of the leg of the Penguin is the shortness, breadth, and persistent amount of distinctness of the three confluent metatarsals. The toes are also relatively shorter and thicker; and there is a rudiment of a hallux or inner toe[2], which is entirely wanting in *Alca impennis.*

The result of this comparison is to show that the Urinatores of Blyth (Orr's Cuvier's 'Animal Kingdom,' 8vo, 1840, p. 267) is an artificial group, and that the wingless sea-bird of the southern region is of a family distinct from that to which the wingless sea-bird of the north belonged: but we have not yet found among the winged

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[1] Catalogue of Osteology, vol. i. p. 219, no. 1137.

[2] Descriptive Catalogue of the Osteology, Mus. Coll. Surg. vol. v. p. 216, no. 1117.

sea-fowl of the south any that manifest so close an affinity with the species of *Aptenodytes* as many of the northern winged sea-fowl show to *Alca impennis*. To speculate upon the derivative origin of either bird would be more agreeable than useful or really instructive.

Since the foregoing pages were in type, I have been favoured by SAMUEL LAING, Esq., of Keiss Castle, Wick, N. B., with an inspection of the remains of animals serving as food to an ancient race of men of the flint age, in Caithness-shire.

Amongst the bones of birds in this kitchen-midden, including those of the Gannet (*Sula bassana*), Shag (*Phalacrocorax graculus*), Cormorant (*Phalacrocorax carbo*), and Razor-bill (*Alca torda*), were the following bones of the Garfowl (*Alca impennis*, L.) :—

The anterior or free extremity of the premaxillary ; a right and left humerus ; a left tibia, and parts of three other tibiæ, left and right.

The premaxillary showed a little more vertical diameter than that of the specimen from Newfoundland, here described. In both, the extent from the tip to the fore margin of the bony external nostril is 2 inches ; the vertical diameter in front of the nostril in one is 9½ lines, in the other it is 11 lines.

The more recent testimonies of the Garfowl in the N.W. coasts of Scotland may be seen in MACAULAY, 'History of Kilda,' 1764, and in SIBBALD, 'Scotia Illustrata,' 1684.

DESCRIPTION OF THE PLATES.

PLATE I. (*Alca impennis*).

Fig. 1. Side view of the skeleton of the Garfowl (*Alca impennis*) : half nat. size.
Fig. 2. Upper view of the skull : nat. size.
Fig. 3. Under view of the skull : nat. size.
Fig. 4. Upper view of the skull of *Uria Grylle* : nat. size.

PLATE II. (*Alca impennis*).

Fig. 1. Under surface of the sternum of *Alca impennis*.
Fig. 2. Fore part of the same sternum.
Fig. 3. Furculum of *Alca impennis*.
Fig. 4. Under view of fourth cervical vertebra of *Alca impennis*.
Fig. 5. Upper view of fourth cervical vertebra of *Alca impennis*.
Fig. 6. Side view of fourth cervical vertebra of *Alca impennis*.
Fig. 7. Back view of fourth dorsal vertebra of *Alca impennis*.

Fig. 8. Proximal half of humerus, anconal or outer side, *Alca impennis.*
Fig. 9. Distal half of humerus, anconal side, *Alca impennis.*
Fig. 9'. Outline of section of shaft and medullary cavity of *Alca impennis.*
Fig. 10. Distal end of shaft and medullary cavity of *Alca impennis.*
Fig. 11. Front view of left femur, *Alca impennis.*
Fig. 12. Front view of left tibia and fibula, *Alca impennis.*
Fig. 13. Front view of right metatarsus, *Alca impennis.*
Fig. 14. Under surface of the sternum of *Uria Grylle.*

(All the figures of Plate II. are of the natural size.)

SUPPLEMENT II.

MEMOIR

ON THE

EXTINCT WINGLESS GROUND-DOVE, OR DODO,

WITH A

COMPARISON OF THE SKELETONS OF

DIDUS INEPTUS AND D. (PEZOPHAPS) SOLITARIUS.

A REMARKABLE and interesting relation of the birds with wings undeveloped as instruments of flight[1] is that of the restriction of particular genera and species to definite, and sometimes limited, geographical areas.

The Ostrich has the great continent of Africa for its range; but the genus *Struthio* is unrepresented in other quarters of the globe. *Rhea*, or the three-toed Ostrich, is, in like manner, limited to S. America. *Dromaius* is Australian; but the tract of land over which the Emus range is large enough to have led to its being regarded as a "Fifth Continent." The Casuaries are distributed about the remnants of the old Melanesian continent, of which the northern border of Australia and the contiguous island of New Guinea are the chief; specific modifications of the type-bird, such as that represented by *Casuarius bennettii* of New Britain, being found in smaller neighbouring outlying parts.

The subjects of the preceding Monographs have added frequent illustrations of the law of Geographical Distribution in the restriction of so many and so large species of an extinct genus, *Dinornis*, to the islands of New Zealand. The living species of *Apteryx* of the same islands there solely represent the extinct giants, as the almost extinct *Notornis* of the South Island may be said to represent the larger extinct New-Zealand Rallines, *Aptornis* and *Cnemiornis*.

An anticipation hazarded in the first "Memoir on *Dinornis*" (p. 105), viz. that other evidences of bulky birds unable to fly or swim await the researches of the naturalist[2], has been remarkably fulfilled.

Madagascar has revealed most interesting evidences of a gigantic tridactyle wingless genus, *Æpyornis*; but the equally peculiar form of ground-bird limited to the smaller

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[1] It is in this sense that birds are termed "wingless" in the present work.

[2] Transactions of the Zoological Society, vol. iii. p. 267 (1843).

island of the same geographical region—Mauritius—has occupied a greater share of the attention of ornithologists.

As the Dodo, together with the Great Awk, have perished, or passed away as living species, like *Dinornis*, within the historical period, I have deemed them suitable subjects for Supplements to the larger work devoted to the wingless birds of New Zealand.

With respect to *Didus ineptus* much information has been obtained since the date of the first Memoir, in which a passing analogical reference is made to it[1].

The osseous part of the organization of the Dodo has now been almost entirely recovered, and forms the chief subject of the present Supplement.

This bird appears to have been first seen by the Portuguese in 1497, during the famous voyage of Vasco de Gama, who, having doubled the Cape of Good Hope, discovered some sixty leagues beyond it an isle, which, from the number of birds found upon it "of the size and forms of Swans, but with wings like those of the Bat," he called "Ilha des Cisnes." About a century afterwards, the Dutch, following the track of the adventurous Portuguese, took possession of the "Island of Cerne," which they afterwards called "Mauritius:" and in the account of the voyage of Jacob van Neck and Wybrand van Warwijk, undertaken in 1598, the peculiar birds of that island are described, under the name of *Walgh-vogels*, as being "as large as Swans, with large heads, and a kind of hood thereon; no wings, but, in place of them, three or four black little pens, and their tails consisting of four or five curled plumelets." A similar description is given, with a figure of the Dodo, in De Bry's 'Descriptio Insulæ Do Cerne a nobis Mauritius dictæ' (1601). A second grotesque figure was published by Clusius in his 'Exotica' (1605), taken from a rough sketch of the Dodo by a Dutch seaman who had seen the bird in a voyage to the Moluccas in the year 1598: Clusius adds the following more valuable evidence of the Dodo, from actual inspection of part of the bird. "I happened," says Clusius, "to see in the house of Peter Pauwius, primary Professor of Physic in the University of Leyden, a leg thereof cut off at the knee, lately brought over out of Mauritius his island. It was not very long from the knee to the bending of the foot, being but little more than four inches [Dutch], but of a greater thickness, so that it was almost four inches in compass and covered with thick-set scales: on the upper side broader and of a yellowish colour; on the under or back part of the leg lesser and dusky. The upper side of the toes was also covered with broad scales; the under side wholly callous. The toes were short for so thick a leg, for the length of the greatest or middlemost toe to the nail did not much exceed two inches; that of the other toe next to it scarce came up to two inches; the back-toe fell something short of an inch and a half; but the claws of all were thick, hard, black, less than an inch long, but that of the back-toe longer than the rest, exceeding an inch"[2].

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[1] P. 1. See also Transactions of the Zoological Society, vol. ii. p. 257 (1838).

[2] From Willughby's Translation, quoted by W. J. Broderip, Esq., F.R.S., the learned contributor of the article Dodo in the 'Penny Cyclopædia.'

In the voyage of Jacob Heemskerk and Wolfert Harmanz to the East Indies in 1601–1603 (small 4to, Amsterdam, 1648), the heavy short-winged birds of Mauritius are called "Dod-aarsen:" "they could not fly, and were so fat that they could scarcely go." They fell therefore an easy prey to the Dutch voyagers, who seem to have visited the Mauritius, from the period of their conquest of the island in 1598 to about 1660, with the express object of provisioning their ships for the remainder of the voyage to India at the expense of the Dodos. Bontius (1658) says, "It is a slow-paced and stupid bird, and which easily becomes a prey to the fowlers. The flesh, especially of the breast, is fat, esculent, and so copious that three or four Dodos will sometimes suffice to fill an hundred seamen's bellies. If they be old, or not well-boiled, they are of difficult digestion, and are salted and stored up for provision of victual. There are found in their stomachs stones of an ash-colour, of divers figures and magnitudes, yet not bred there, as the common people and seamen fancy, but swallowed by the bird." The Dutch seem to have effected in the course of about two centuries the total extirpation of the Dodo.

Tradescant, the botanist, had obtained a stuffed specimen from Holland in the reign of Queen Elizabeth. In the 12mo catalogue of his museum, entitled 'Collection of Rarities, preserved at South Lambeth, near London,' 1656, we find among the "Whole Birds,"—"Dodar, from the island Mauritius; it is not able to flie, being so big."

Adam Olearius, in 'Die Gottorfische Kuntskammer,' 1666, gives a shaded figure of the head of the 'Walch Vogel' of Clusius, and an outline of the rest of the bird, whence it was surmised that the head of a Dodo had existed in the museum of the Duke of Gottorf or Gottorp, and the skull was found and is now preserved in the Royal Museum of Copenhagen.

The museum of the Tradescants, father and son, became the property of Dr. Elias Ashmole in 1664, who added much to the collection and afterwards presented it to the University of Oxford. The following evidence is there preserved of the unique specimen of the Dodo:—"In the Ashmolean Catalogue made by Ed. Llhwyd, Musæi Procustos, 1684, the entry of the bird is 'No. 29, Gallus gallinaceus peregrinus Clusii,' &c. In a catalogue made subsequently to 1755, it is stated 'that the numbers from 5 to 46 being decayed, were ordered to be removed at a meeting of a majority of the visitors, January 8th, 1755.' Among these of course was included the Dodo, its number being 29"[1]. The order of the Visitors is recorded as follows:—"Illa quibus nullus in margine assignatur numerus a Musæo subducta sunt cimelia annuentibus Vice-Cancellario aliisque Curatoribus ad ea lustranda convocatis, die Januarii 8vo, A.D. 1755."

This gives the date of destruction of the last stuffed specimen of the bird; but the dried head (pl. 16. fig. 5) and one foot (pls. 41 & 42) were preserved by the worthy Procustos, and soon rose to the rank of the chief rarities of the Ashmolean Museum. The help which science failed to receive from its then representatives was rendered by art.

Years passed away: the island of Mauritius received accessions of colonists; the

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[1] Duncan on the Dodo, Zoological Journal, vol. iii. p. 559.

ardour of naturalists led them to inquiry and careful search, but the Wald-vogel and Dod-aarse of the old Dutch voyagers had ceased to exist.

The general fidelity of the ancient Dutch paintings of the Dodo, and of their having been actually taken from a living bird, was, however, doubted; and even as late as 1830, some modern ornithologists deemed the association of the head and feet to be strange and improbable. I was induced, in view of this and some other zoological questions, to visit Holland in the summer of 1838.

Being struck with the minuteness and accuracy with which the exotic species of animals had been depicted by Savery and Breughel in their favourite subjects, which gave them scope for grouping together a great variety of animals, and knowing that the celebrated menagerie of the contemporary Stadtholder, Prince Maurice, had afforded the living models to these artists, I sat down before Savery's 'Orpheus and the Beasts,' in the Museum at the Hague, to make a list of the species which the picture sufficiently evinced that the artist had had the opportunity of studying alive. In one corner of this picture is a beautifully finished figure of the Dodo, which, though but three inches long, shows the auricular circle of feathers, the scutation of the tarsi, and the loose structure of the caudal plumes. In the general configuration and characters of the head and body, and in the number, position, and proportions of the toes, this beautiful miniature accords with the full-sized oil-painting of the Dodo in the Ashmolean Museum at Oxford, attributed to Savery, and also with the well-known oil-painting[1] in the British Museum; the disposition of the epidermal scutes, reticulate upon the metatarse, in a row of broad scutes on the upper surface of the toes, accords with that shown in the dried foot attributed to the Dodo in the British Museum. This removed all doubt in my mind of the fidelity of the paintings above cited, and I redoubled my endeavours to stimulate residents in the Mauritius to search for and obtain bones of the Dodo. Twenty-eight years elapsed before this desire was fulfilled. In the meanwhile the happy perception by Professor J. Reinhardt, in 1843, of the resemblance of the beak of the Dodo to that of certain tropical Doves, forming Cuvier's genus *Vinago*, characterized by their proportionally larger, more strongly arched and compressed beak than in other Pigeons, and the still closer resemblance in miniature of the beak of an allied Dove from the Samoan Islands (which resemblance led Mr. Peale, in 1848, to assign it to a genus *Didunculus*), directed the osteologist to the family in which the most instructive comparisons with the remnants of the Dodo then accessible could be made.

The results of these comparisons with the bones of the head and foot exposed in or extracted from the Ashmolean specimens were given in the beautiful work by Strickland and Melville, entitled 'Dodo and its Kindred,' 4to, 1848.

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[1] Edwards says of this painting: "The original picture was drawn in Holland from the living bird, brought from St. Maurice's Island, in the East Indies, in the early times of the discovery of the Indies by the way of the Cape of Good Hope. It was the property of the late Sir Hans Sloane to the time of his death; and afterwards becoming my property I deposited it in the British Museum as a great curiosity."

In 1863 I had the opportunity of making known to the Bishop of Mauritius the desirability of obtaining for the British Museum any remains of the Dodo which, through his Lordship's recommendation and influence, might be discovered in that part of his diocese; and in 1865 I received from Mr. George Clark, Master of the Diocesan School at Mahébourg, Mauritius, the series of bones which formed the subject of a paper on *Didus ineptus* published in the sixth volume of the 'Transactions of the Zoological Society of London.'[1]

Accessions of bony remains speedily followed, both from the Mauritius and the neighbouring island of Rodriguez, the latter throwing the same light upon the extinct "Solitaire" of the old French voyager Leguat as the Mauritian remains had done on the "Walgh-vogel," "Dronte," or "Dod-aers" of the contemporary Dutch seamen.

The osteology of the Solitaire, referred to a genus *Pezophaps* by Strickland, forms the subject of an instructive paper in the 'Philosophical Transactions'[2].

I propose in the present 'Supplement' to combine observations on the skeleton of *Didus ineptus*, L., with those on *Didus solitarius*, Gm. (*Pezophaps*, Str.).

Both extinct birds agree in the extent and kind of anchylosis in the dorsal region of the spine: it affects the three vertebræ preceding the last free, rib-bearing dorsal. In both species the neural spines have run together into a bony ridge, with a straight, thickened upper free border. In both the confluence of the neural arches is only interrupted by the conjugational foramina, which are similar in size and shape.

My series of these coalesced vertebræ included two varieties:—one showing a feeble beginning of the hypapophysis at the fore part of the last vertebra (pl. 17. fig. 5, O.); the other a better-developed, though small, hypapophysis, but so extended as to reach, and coalesce at its extremity with, that of the antecedent vertebra, leaving a vacuity corresponding with the wider one between the first and second of the coalesced hypapophyses. In *Pezophaps* the specimen (pl. 15. fig. 51, N.) resembles the variety (pl. 17. fig. 5, O.) of *Didus*, save in the absence of any indication of hypapophysis on the third vertebra. And in the instructive example of the three partially anchylosed vertebræ of a young *Pezophaps* (pl. 16. fig. 60, N.) the third vertebra shows no hypapophysis[3]. In this specimen anchylosis is seen to have begun at the neural arch and spine, chiefly between the first and second vertebræ, and co-ossification of the centrums is more advanced between the first and second than between the second and third of these vertebræ.

The inference that these anchylosed vertebræ included the penultimate, antepenultimate, and the next dorsal vertebra in advance, and that only one free dorsal vertebra

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[1] Communicated January 9th, 1866 (p. 49).

[2] By Professor A. and Mr. E. Newton, "On the Osteology of the Solitaire, &c.," Phil. Trans. 1869, pls. 17 & 18, figs. 66, 68–70. Future references to this interesting and instructive Memoir will be made under the letter N.; those to my own Memoir, of 1866, on *Didus* by the letter O.

[3] In other respects the last of the three anchylosed dorsal vertebræ in *Pezophaps* does "bear a great general resemblance to the same bone in *Didus*."

intervened between the coalesced mass and the sacrum, was confirmed by the specimens of *Pezophaps* (N., p. 332), as it has been by additional vertebræ of *Didus*; and the correspondence of both the extinct Mascarene species with the *Columbidæ* in this vertebral character must now be held to be well established.

One would be glad to receive the evidence of the vertebral formula which the entire skeleton of one and the same individual of *Didus* or *Pezophaps* would afford; but the discovery of such with the bones in requisite contiguity has yet to be made. The concurrence, therefore, of Messrs. A. & E. Newton, as to the number of movable thoracic or dorsal ribs[1], with the estimate similarly formed by myself from comparison of detached vertebræ of *Didus*[2], is welcome.

To both the Mauritian and Rodriguez extinct Ground-Doves may be referred eight pairs of dorsal ribs. For the similarity of size and proportions of some of these ribs, and of the confluent epipleural appendage, figures 5 & 7, pl. 16 (O.), may be compared with figures 63 & 64, pl. 16 (N.). The first and second are wanting in the subject of Pl. I.

The first material discrepancy between *Didus* and *Pezophaps*, or between the descriptions of their respective osteologies here quoted, is in the number of sternal ribs.

To Messrs. Newton there appear to be only four pairs in *Pezophaps*, the last articulating with the sixth dorsal rib[3]: four only are preserved in the articulated skeleton of the Dodo (Pl. I.). It is to be regretted that the mutilated lateral border of the best-preserved sternum of *Pezophaps*, one of six received by the Messrs. Newton, does not allow a certain conclusion to be arrived at as to the number of articular surfaces on the costal border.

Messrs. Newton do not entertain so much doubt on this point as I do; they write:—"A more remarkable difference is presented by the costal border in this" [their best-preserved] "specimen, which shows articular surfaces for four sternal ribs only, instead of five, which is the normal number in *Didus*; and, so far as can be determined from the broken state of the remaining specimens, there is nothing to induce the belief that they possessed more than four such surfaces"[4].

If any one will compare fig. 2, pl. 18, O., with fig. 74, pl. 18, N., he may be allowed to doubt whether the fracture following the fourth articular surface on the costal border of the least-mutilated sternum of *Pezophaps* may not have removed a fifth narrow ridge like that (fig. 2, pl. 18, O., *c* 5) to which the fifth sternal rib articulates in *Didus*. Admitting, however, that "too much importance must not be placed on this character"[5], and cognizant of instances, like that cited by Messrs. Newton, of *five* articular surfaces on one side, and *four* on the other, yet I am unwilling to suppose that the last (in *Didus*, "sixth") sternal rib, which terminates below in a point and joins the antecedent sternal rib before attaining the sternum, had not its homologue in *Pezophaps*. I quite concur, however, with the observant and conscientious authors of

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[1] N., p. 332.
[2] O., p. 53.
[3] N., p. 334.
[4] N., p. 338.
[5] N., p. 338.

the Monograph on the Solitaire that its affinity to the Dodo "is nowhere better shown than on a comparison of the sterna of the two forms"[1].

The deeper and more approximate coracoid grooves in the sternum of *Pezophaps* relate to the greater size, thickness, and breadth, especially of the sternal half and articular end of the coracoid in that extinct genus. In additional specimens of the sternum of *Didus*, the antero-median depression of the inner surface is more marked than in the subject of fig. 2, pl. 18 (O.); but in none has it perforated the bone as in fig. 74, pl. 18 (N.). Considering the peculiarity of the configuration of sternum in the Solitaire and Dodo—unlike that of any other bird known to me, as to Messrs. Newton—the degree of affinity of the two forms appears to be closer than would admit of real or intelligible generic distinction. The Solitaire is a longer-legged, more active, variety of Ground-Dove, in which the abortion of unused wings had not extended to the degree manifested by the larger, heavier, and more sluggish form.

In the articulated skeleton of the Dodo (Pls. I. and II.) I assign twelve vertebræ to the cervical series, as in the restoration in pl. 15 of my original Memoir; and this is the estimate of the number of the cervical vertebræ in *Pezophaps* to which Messrs. Newton are led after careful comparison and analysis of the "hundred and sixty-one vertebræ" of that extinct bird in their collection[2].

In the unlikely contingency of the disinterment of the bones of any individual Dodo or Solitaire which may have lain so undisturbed as to demonstrate the precise number of vertebræ intervening between the skull and pelvis, the accuracy of our respective inductions as to the vertebral formula may be put beyond question. But should it prove that there have been one or two cervicals more or less than have been assigned to *Didus* and to *Pezophaps*, the responsibility as to the former bird will rest with the author of the Memoir of 1866, and not with the artist, as to whose figure of the skeleton of *Didunculus*, in pl. 15 of that Memoir, I must observe that there are plainly twelve cervicals given, neither more nor less, succeeded by seven dorsals, of which the three confluent ones are the fourth, fifth, and sixth, as in *Didus* and *Pezophaps*.

In the pelvis of the Dodo the pubis extends freely backward, with a curve convex outward and downward, and for an extent corresponding with the characters of the same bone in *Pezophaps*. (Compare Pls. I. and II. of the present "Supplement" with fig. 70, pl. 18, N., and the restoration in dotted outlines in fig. 179, pl. 24, N.) Nevertheless a pelvis with the whole extent and entire lower border of the ischium seems still to be a desideratum in the collections of the bones of both *Didus* and *Pezophaps* which have as yet reached England. The better-preserved sacral elements of the pelvis permitted sixteen vertebræ to be counted in that extensive anchylosed mass of bone-segments. Messrs. Newton state that one specimen of pelvis of *Pezophaps*, complete in its posterior half, "has eighteen coalesced sacral vertebræ." It is to be regretted that this specimen is not figured; the subjects, at least, of figs. 66, 68, 69, & 70, in their paper, are plainly

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[1] N., p. 338.

[2] N., p. 332.

mutilated behind. The two "perfect examples" [of sacrum ?] "of *Didus ineptus* show only sixteen (vertebræ), which is probably the normal number in that species." *Op. cit.* N., p. 334.

The essential characters of the pelvis show a close correspondence in *Didus* and *Pezophaps*. "The articular surface of the centrum of the last dorsal" [first 'sacral' by the character of confluence] "is in *Pezophaps* almost exactly as in *Didus*"[1]. Other pelvic correspondences are seen in the general shape and disposition of the ilia, which, however, are not developed behind in *Pezophaps* so as to give the flatness and breadth to the posterior half of the pelvis which seem to specifically characterize the Dodo. The position of the skeleton in Pl. II. has been selected to exemplify this peculiarity. Other particulars, especially the more essential ones, such as the length, curvature, and movable articulation of the ribs of the first sacral vertebra[2]—the confluence, shortness, and straightness of the pleurapophyses of the next three sacrals—the suppression of the rib-elements in the three succeeding vertebræ, and their reappearance in the eighth and sometimes in the ninth sacral as strong abutments against the ilia above and behind the acetabula—and the indications of "prerenal," "midrenal," and "postrenal" depressions—are all correspondences with the pelvis in *Didunculus* and *Goura*, which *Pezophaps* shows in common with *Didus*.

The chief difference between *Didus* and *Pezophaps* in cranial structure is the degree in which the cancellous tissue is developed between the outer and inner "tables," the minor quantity of that tissue in *Pezophaps* leaving a flatness of the frontals above the orbits contrasting with the convexity of that part of the cranium in *Didus* (pl. 16. fig. 5, text) (Pl. I. Suppl.). I suspect that when the part of the skull of the Solitaire may be found, supplying what is wanting in the specimens figured in figs. 149, 150, pl. 22 (N.), there will be a depression or concavity in the profile contour between the fore part of the frontals and the naso-premaxillaries, which will suggest the presence of a "frontal protuberance" differing only in degree from that so called in *Didus*. Messrs. Newton recognize the fact that "the frontals rise abruptly as in *Didus*"[3], the precise extent of the "rise" being yet to be determined in *Pezophaps*. A section of the cranium of a Solitaire, like that of the Dodo, in fig. 1, pl. 23 (O.), would, if it had been made and figured in N., have afforded ready means of judging of the degree and value of the difference in cranial structure of the two extinct Columbaceans. The

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[1] N., p. 334.

[2] In this, as in my former paper, I adhere to the usual characters of the sacrum afforded by coalescence. Messrs. Newton are influenced by its extent—and where it leaves the ribs free, reckon such vertebræ as "dorsal." Accordingly my "first sacral" is their "last dorsal." Anchylosis, like most of the characters of the classes of vertebræ in anthropotomy, is an artificial one, and might justify the ascription to the *Columbacei* or "*Gemitores*" of four sacrums, viz. "caudal," "pelvic," "lumbar," and "dorsal;" for the vertebræ answering to the lumbar and anterior caudals in Mammals and Reptiles are massed with the interacetabular or proper pelvic vertebræ into one extensive and complex bone.

[3] N., p. 347.

orbital chambers are relatively, not absolutely, larger in the Solitaire. Taking the distance between the anterior and posterior orbital process in fig. 149, pl. 22 (N.), I find it three lines less than the same admeasurement in the skull of the Dodo in pl. 15 (O.).

In like manner I discern no essential or generic difference of character in upper or lower mandibles of *Pezophaps* and *Didus*, only such modifications of shape and proportion as may differentiate such closely allied species. With the longer proportional metatarsals of the Solitaire goes a more slender and lighter-constructed beak (fig. 179, pl. 24, N.). The authors, however, note a "remarkable variation in the size of the upper mandible in different individuals, to the extent of very nearly one half the linear dimensions between the largest and smallest specimens, of which the collection contains thirteen in all."[1] Is there an intermediate gradational series? May this difference of length of beak concur with that pointed out by Strickland in the length of leg?

Better specimens of the mandible of *Pezophaps* than had reached Messrs. Newton at the date of publication of their instructive memoir seem to be needed to solve these questions, and are indispensable for profitable comparison with that part in *Didus* (pl. 16. fig. 5 *n*, text). The portions of the mandibular rami described and figured in N., however, serve to show an agreement with the maxilla in the more slender and less powerful proportions. It is interesting to note that the differences in size and proportion are less in the proximal than the distal elements of the mandible.

No tympanic bone of *Didus* has yet reached me; so that I am unable to give figures of it separately, in order to compare with those of the Solitaire, figs. 163–168 in pl. 22 (N.).

The atrophy of wings had not proceeded so far in the extinct Ground-Dove of Rodriguez as in the larger species of the Mauritius. The constituents of the scapular arch—scapula (pl. 19. figs. 97–99, N.) and coracoid (ib. figs. 76–79)—are absolutely larger, or are relatively thicker or broader (pl. 19. figs. 132, 133) in *Pezophaps* than in *Didus*; and the same difference of proportion prevails in the humerus, radius, and ulna. The expansion of the distal end of the scapula in *Pezophaps* makes the general curve of the upper and anterior border slightly concave; in *Didus*, beyond the proximal concavity of the curve of that border, it runs straight to near the distal end, towards which it curves, convexly, as in *Pezophaps*. The absence of any example of confluence of scapula and coracoid in the rich series of specimens possessed by Messrs. Newton of these bones (thirty-six of scapula, twenty-seven of coracoid) in the bird of Rodriguez, indicates a more habitual and powerful use of the appendage of the arch than was exercised by *Didus*. The halves of the slender furculum, which long remain separate in the Dodo, coalesce below earlier in the Solitaire.

The bones of the manus of the Dodo are still unknown; the desire to obtain such is increased since the discovery that the metacarpus of *Pezophaps* has, on the radial border, a large subspherical knob resembling a tumour, and compared by its

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[1] N., p. 347.

describers to a callus-like mass of diseased bone. Its repetition, however, in all the perfect specimens, its association with a similar outgrowth from the radial border of the distal end of the radius in the larger examples of that bone, supposed by Messrs. Newton to be of the male Solitaire, and the notice of the same structure in the living bird by Leguat[1], show it to be normal in *Pezophaps*, though, when fully developed, perhaps sexual. Such tumefaction of the metacarpus has not been noticed in any of the accounts or figures of the living Dodo, and it may well be one of the marks of distinction between the Solitaire and Dodo. I should not be disposed, however, to assign to the metacarpal knob a higher than specific value.

In *Didus* and *Pezophaps* the metatarsal bone presents, besides difference of proportions illustrated in a paper by Strickland[2] and in the joint work of Strickland and Melville[3], differences of structure, which I fix at a like value. As the characters afforded by the articular extremities of the metatarsal of *Pezophaps* are obscured, more or less, by the stalagmitic incrustation of the bones figured in pl. 15 of 'Dodo and its Kindred,' I believe that the subjects of Pl. III. of the present Supplement may not be deemed superflous or be unacceptable.

The metatarsus of *Pezophaps* is represented by bones of different dimensions, but may be said to be, as Strickland recognized them to be, "large" and "small," the variations in these two categories ranging within narrow limits. The two nearly perfect specimens, a right and left, presented by Professor Newton to the British Museum, are of the large size, and would be referred by Strickland to his *Pezophaps solitaria*. I have also had under observation three metatarsi (of the right side) of the small size, by which Strickland characterized his *Pezophaps minor*[4]. The following description is

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[1] "The bone of their wing grows greater towards the extremity, and forms a little round mass under the feathers, as big as a musket ball." Quoted by Messrs. Newton at p. 350 of their memoir.

[2] Trans. Zool. Soc. vol. iv. p. 187, pl. 55.

[3] 'Dodo and its Kindred,' 4to, 1848, pls. 11 & 15.

[4] Trans. Zool. Soc. vol. iv. p. 191. One of these specimens is alluded to by the Messrs. Newton as follows:—"In addition to these *eighteen* specimens, we are informed that in 1860 or 1861 a tibia, the shaft of a tarso-metatarsal, and some fragments of the shaft of a femur, all of which belonged to the Solitaire, were sent to Professor Owen by M. Bouton of the Museum at Mauritius; but the fate of these specimens is unknown to us." They are referred to in the following letter:—

"8 Great Ormond Street, Queen Square, W.C.,
"18th December, 1860.

"Dear Sir,—By the last 'Overland' from Mauritius I received from the Curator of the Museum of Port Louis the two fragments of bones, which he suspects to be those of the Dodo, and he is anxious to have your opinion in the matter. Under these circumstances I have taken the liberty of sending them to you just as they came to me on Saturday last. The Curator writes me: 'Je les ai trouvés dans la Collection du Muséum déposés à côté d'ossements fossiles de Tortues recueillies dans un dépôt Calcaire aux Quatre Cocos, à Flacq, à une petite distance de la mer. No. 1 me paraît se rapprocher à la figure 1, planche xv. de Strickland, et dans ce cas serait un fragment du tibia droit du Solitaire; No. 2 se rapproche de la figure 2 *a* de la planche xv. de Strickland. Ce serait dans ce cas le métatarse droit auquel il manquerait une portion de l'articulation from the larger metatarsi (Pl. III. figs. 1–4, fig. 13). The entocondylar cavity (*a*) is deeper and wider from before backward than the ectocondylar one (*b*); it has the same transverse diameter. The intercondylar tuberosity (*c*) rises to the height of 4½ lines from a base 7 lines in breadth, and terminates obtusely; the fore-and-aft extent of the base occupies rather more than half that of the proximal articular surface, of which a flat triangular tract (fig. 13, *d*), 6 lines in breadth posteriorly, intervenes between the back parts of the ento- and ecto-condylar cavities; and from it is continued a tract, of a breadth of 1 or 2 lines, along the back part of the ectocondylar fossa. The obtuse low summit of the ectometatarsal ridge marks the outer termination of the rising between the anterior and posterior parts of the so divided ectocondylar surface (Pl. III. fig. 13, *b*). A difference of colour and of texture indicates that the articular cartilage was not continued upon the flat triangular intercondylar facet (ib. *d*). The extreme transverse extent of the proximal articular surface is 1 inch 6 lines; the extreme fore-and-aft extent of that surface is 9 lines. In *Pezophaps minor* (ib. fig. 12) these dimensions give 1 inch 3 lines and 7½ lines respectively.

The side of the entocondylar division of the proximal end is traversed by three longitudinal ridges. The anterior, beginning by a slight rise of the articular border, extends along the inner (tibial) side of the entometatarsal about one third of the way down; it is the "entometatarsal ridge" (fig. 4, *e*, *e*). The second ridge begins at the highest part of the entocondylar border, and subsides after a downward course of two thirds of an inch; it is the "entocondylar" ridge (*f*). The third ridge begins at the back part of the entocondylar border, makes a curve as it descends toward the inner side of the entometatarsal, but descends before attaining that side, and is continued downward two thirds of the length of that metatarsal as the "entogastrocnemial" ridge (fig. 4, *g*). The second

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inférieure et la totalité de l'articulation supérieure . . . . s'ils sont ce que je les crois être, je vous prie de me les renvoyer ensuite quand ils seront examinés.'

"As my friend mentions the district of Flacq, I know that several fossil remains have been found there; and some years ago when I was in the island, I and other friends made an examination of the locality in order to find some remains of the Dodo, at the request of Mr. Strickland, who was them preparing his excellent work on the Dodo, &c.

"If, therefore, you will do me the favour to give me your opinion on the fragments I now take the liberty of sending you, such an opinion from so high an authority will set the matter at rest.

"I remain, dear Sir,
"Very truly yours,
(Signed) "James Morris."

"*Professor Owen, &c. &c.*"

The fragment of the tibia marked No. 1, included the distal articular end and part of the shaft of that bone; No. 2 was rightly recognized by M. Bouton. Both portions belonged to the *Pezophaps minor*, Str. So named, they were returned to the Museum at Port Louis, Mauritius. The first and sole evidence of Messrs. Newton's interest in these fragments reached me with their memoir. Any previous inquiry would have, at once and most readily, received the reply given in the present note. No portion of femur, and no entire tibia, were sent to me.

short ridge (*f*), in some specimens, joins the third to form the entogastrocnemial ridge. The fore part of the entocondylar expansion shows two or three oblong tuberosities, in the same transverse line, the outermost of which (fig. 3, *h*) extends down as a short ridge and forms part of the inner boundary of the "anterior interosseous depression (*i*).

This, which is due to the retrogression of the head of the mesometatarsal (III), is bounded above by the part of the confluent epiphysis developing the intercondylar tuberosity (*c*); its sides are formed by the more advanced proximal ends of the ento- (II) and ecto- (IV) metatarsals, the latter bone defining that side of the fossa by a ridge or ridge-like angle continued into the "ectometatarsal ridge" (*k*), which descends inclining to the outer side of the lower part of the ectometatarsal (IV). Into the antinterosseal depression (*i*) open the two fore-and-aft canals between the upper ends of the metatarsals, that (*l*) between the ento- and meso-metatarsal being the largest; it is vertically elliptical, 3½ lines by 2½ lines in diameter. The canal between the meso- and ecto-metatarsals opens into the fossa by a vertical slit (fig. 3, *m*), two lines long and two thirds of a line wide. Below the larger foramen is a rough surface (*n*) for the insertion of the "tibialis anticus;" it does not project. The interosseous depression (*i*) gradually shallows and contracts as it descends, or as the middle metatarsal advances into line with the outer and inner ones, the boundaries being defined by low narrow antinterosseal ridges, which, midway down the shaft, diverge as they descend, the outer one (fig 3, *o*) terminating in the groove leading to the lower interosseal canal (*p*) between the meso- (III) and ecto- (IV) metatarsals. The anterior orifice of this canal (fig. 3, *p*) is vertically oblong, about 1⅓ of a line in width; the posterior orifice (fig. 2, *p'*) is minute and circular. The bar or bridge of bone (ib. *q*), from the neck of the ectotrochlea (IV) to that of the mesotrochlea (III), converts the remaining interspace behind into a vertical "adductor" canal, leading from the anterior orifice of the lower interosseal canal (*p*) to the interval between the ecto- and meso-trochleæ. The tendon of the "adductor digiti externi" traverses this canal, to be inserted into the inner side of the base of the proximal phalanx of the outer toe.

The calcaneal process (*r*, *s*) is developed from the back part of the head of the mesometatarsal (III) and the part of the proximal epiphysis confluent therewith; it is divided into ento- (*r*) and ecto- (*s*) calcaneal portions, by the tendinal canal (*t*) completed by peripheral ossification between those portions; this uniting plate of bone is impressed externally by an open shallow tendinal groove (*u*). The outer part of the ectocalcaneal process is impressed by a narrower and deeper tendinal groove. The posterior rough and flattened surface of the entocalcaneal process is elongate and contracted below; in *Pezophaps minor* (Pl. III. fig. 6, *r*), where alone I have seen it entire, it is 10 lines long by 3½ lines in extreme width. The ectocalcaneal process (ib. *s*) shows a similar surface, 7 lines in length and 2 lines in breadth, in *Pez. minor*. A deep and wide elongate channel (fig. 4, *v*) intervenes between the entogastrocnemial ridge (*g*) and the calcaneal process (*r*), with its sustaining buttress formed by the back part of the mesometatarsal; into the upper part of this concavity opens the canal (*l*) between the ento- and meso-metatarsals. The smaller interosseous canal (*m*), between the meso- and ecto-metatarsals, opens into the shallower depression (fig. 1, *w*) external to the calcaneal prominence. This depression is bounded externally by the ectogastrocnemial ridge (*x*), which describes a slight curve, convex backward, as it descends to terminate on the ectotrochlear ridge (fig. 2, *z*). From the back part of the mesometatarsal (fig. 2, r'), which projects in a subtriangular form, a narrow (postinterosseal) ridge (ib. *y*) is continued, which descends for some way outside of and parallel with the one continued down from r'; but at the beginning of the trochlear expanse it bends outward, and terminates in the tuberosity, or thicker ridge[1] (*z*), at the outer and hinder part of the ectotrochlea (IV). The entogastrocnemial ridge[2] (*g*) terminates at the upper border of the "hallucial surface" (I). The mid ridge or hind angle of the mesometatarsal (III) runs down along the outer side of the hallucial surface, almost subsiding, but seeming to be continued by a strong oblique ridge (fig. 2, α), lost upon the back part of the neck of the entotrochlea (II). A tendinal groove (fig. 2, B) extends from the upper and outer part of the oblique ridge to or near to the interspace between the ento- and meso-trochleæ.

The post-trochlear depression (fig. 2, γ), bounded by the oblique ridges (α & *z*), and by the backwardly produced ento- (II) and ecto- (IV) trochleæ, is shallow, but well defined.

The entotrochlea (II) is convex anteriorly, canaliculate behind, and chiefly through the production of its inner and hinder part. The ectotrochlea (IV) is less concave, almost flat, transversely, behind, its outer and hinder border being less produced and more rounded off. The depression (*i**) on the outer side of the ectotrochlea is rather deeper and better defined than that on the inner side of the entotrochlea (Pl. III. fig. 4, II). The outer trochlea does not extend so low down as the inner one; and the interspace between it and the mid trochlea reaches higher up, especially behind, so that the outer part of the neck of the mid trochlea (fig. 2, III) is the longest. The mid groove of that trochlea runs from the fore to the hind part, and is deepest anteriorly (fig. 3, III).

As compared with *Didus*, the entocondylar cavity (*a*) is deeper, and the margin better defined, in *Pezophaps* (figs. 12, 13). The intercondylar tubercle is higher and less obtuse in *Pezophaps*. The hind border of the entocondylar expansion extends further in *Pezophaps* than in *Didus* before passing to the inner side of the entocalcaneal process (ib. *r*). The upper border of the entocalcaneal process is thinner in *Pezo-*

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[1] This is mutilated in the specimen figured in Trans. Zool. Soc. vol. iv. pl. 55. fig. C.

[2] The insertions of "the strong ligamentous aponeurosis" formed by the confluence of the tendons of the *gastrocnemius internus* and *gastrocnemius externus* (p. 58, text) are represented in pl. 11. fig. 2, R, and in fig. 1; also in pl. 14. R***, in *Apteryx australis*. The ridges termed "gastrocnemial" mark the lines of insertion of this strong aponeurotic sheath for the tendons of the deeper-seated muscles, chiefly flexors of the toes.

phaps. The calcaneal canal (*t*) is smaller. The tendinal groove (fig. 1, *u*) is shallower. The ectocalcaneal process (*s*) is narrower: the groove on the outer side of that process is also narrower, and is defined by a ridge not developed in *Didus*. The short ridge or process below the posterior margin of the entocondylar cavity in *Didus* (fig. 10, *j*) is more developed; it is feebly indicated in *Pezophaps*, and is continued into the entogastrocnemial ridge (fig. 4, *g*), which is not the case in *Didus*. *Didus* has not the entometatarsal ridge (fig. 4, *e*) anterior to the entogastrocnemial ridge (ib. *g*), but only the latter, which is strongly marked and more internal in position (fig. 16, *g*).

The postinternal depression (fig. 2, *v*) receiving the larger of the two upper interosseal canals (*l*) is narrower, and in *Pezophaps minor* deeper, than in *Didus*, owing to the more posterior position, in *Pezophaps*, of the entogastrocnemial ridge (*g*) defining that depression internally. The antero-superior interosseal depression (*i*) is deeper in *Pezophaps* than in *Didus*; but the insertional surface for the *tibialis anticus* (fig. 14, *n*) is better-defined in *Didus*. The anterior ectometatarsal ridge (fig. 1, *k*) is more strongly marked in *Pezophaps* than in *Didus*.

The groove leading to the lower interosseal canal is more strongly marked in *Didus* (fig. 15, *p*) than in *Pezophaps* (fig. 3, *p*), and indicates a more powerful "adductor muscle," the tendon of which emerges at the interspace between the neck of the middle and outer trochleæ, in its course to be inserted into the outer toe.

The middle trochlea (III), as compared with the outer (IV) and inner (II) trochleæ, is larger in *Pezophaps* (fig. 3) than in *Didus* (fig. 15); its relative position to the outer and inner trochleæ, and the consequent curve which they describe transversely, I find, in the specimens before me, to be the same in both extinct genera.

In order to facilitate future comparisons and the following of the above descriptions, I subjoin the names of the parts and their symbols in Pl. III. which appeared to me to call for special notice in this part of the osteology of *Didus* and *Pezophaps*.

Parts of Metatarsus.

	marked		marked
Entocondylar cavity	*a*	Ectinterosseal canal	*m*
Ectocondylar cavity	*b*	Facet for "tibialis-anticus" tendon	*n*
Intercondylar process	*c*	Antinterosseal ridges	*o*
Intercondylar triangular tract	*d*	Lower interosseal or "adductor" canal, anterior orifice	*p*
Entometatarsal ridge	*e*	Lower interosseal or "adductor" canal, posterior orifice	*p'*
Entocondylar ridge	*f*	Adductor bridge	*q*
Entogastrocnemial ridge	*g*	Entocalcaneal process	*r*
Entocondylar tuberosity	*h*	Ectocalcaneal process	*s*
Antinterosseal depression	*i*	Calcaneal canal	*t*
Ectometatarsal ridge	*k*		
Entinterosseal canal	*l*		

	marked		marked
Calcaneal groove	*u*	Entotrochlear ridge	*α*
Postinternal depression	*v*	Intertrochlear groove	*β* or B
Postexternal depression	*w*	Posttrochlear depression	*γ*
Ectogastrocnemial ridge	*x*	Ectotrochlear depression	*i**
Postinterosseal ridge	*y*	Entotrochlea	II
Ectotrochlear ridge	*z*	Mesotrochlea	III
Hallucial surface	I	Ectotrochlea	IV

The "hallucial facet" is not higher above the entocondyle in *Pezophaps* than it is in *Didus*; the greater length of the metatarsus is due to elongation of the shaft between that surface and the subsidence of the calcaneal process.

The shorter and stronger metatarsus of *Didus* indicates more powerful actions of the foot, in reference to the greater weight of body to support—perhaps, also, to more habitual and powerful applications in scratching up the soil.

The longer and more slender metatarsus of *Pezophaps* relates, as Strickland justly observes[1], to the lighter weight and more active movements of that bird, which seems to have preserved its existence to a later period (1735) than the Dodo.

In a Memoir on the *Apteryx*, read August 14th, 1838, and printed in the second volume of the 'Zoological Transactions' (p. 257), the composition of the metatarsus is described as follows:—"The upper articular surface is formed by a single broad piece. The original separation of the bone below into three pieces is plainly indicated by two deep grooves on the anterior and posterior part of the proximal extremity; the intermediate portion of bone is very narrow anteriorly, but broad and prominent on the opposite side" (p. 293). This prominence was indicated in subsequent Memoirs as the "calcaneal process;" but it does not form the whole upper end or head of the middle piece or metatarsal element.

In the Memoir on the genus *Dinornis* I entered, with a view to determine the composition and processes of the metatarsal bone, into an analysis of its development, and showed, in an immature Ostrich (p. 81), that the head of the middle of the three normal metatarsals, which middle bone may be reckoned as that of the third digit, if the rudimental metatarsus of the back toe be viewed as the innermost or first metatarsal, projects posteriorly beyond those of the other two (second and fourth), and developes the chief and commonly sole "calcaneal process." I also showed that the mid metatarsal, in its descent toward the toes, changes its relative position to the others, coming gradually forward and developing its condyle in advance of, or in a plane somewhat anterior to, the condyles of the second (inner) and fourth (outermost) metatarsals.

Messrs. Newton, in reference to the "calcaneal process," or the "inner or longest"

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[1] Annals and Magazine of Nat. Hist. 2nd ser. vol. iii. 138.

one in *Pezophaps*, state, "This process is now regarded[1] as the head of the third (anchylosed) metatarsal," and quote Gegenbaur as their authority. I must, however, enter my dissent from that view. The process, as its name implies, is only a part of the head of the third or mid metatarsal. The portion of the head in advance of the origin of the process is wedged between the heads of the second and fourth metatarsals, and in a greater degree in *Dinornis* (*tom. cit.* pl. 28. figs. 4 & 7) than in *Struthio* (ib. fig. 2).

In a subsequent Memoir (July 14, 1846) the upper and hinder outstanding process of the middle element of the compound bone is termed "calcaneal"[2], in reference to its functional analogy to the calcaneal fulcrum in Mammals, not to indicate homology, as Professor Gegenbaur appears to have believed. The metatarsal element to which any tarsal homology might be applicable is expressly limited to the one affording articular cavities to the tibial trochleæ, and "which seems to represent a proximal epiphysis"[3].

To the three principal elements of the shaft the following names and symbols were applied[4]:—"'entometatarse' (II), 'mesometatarse' (III), 'ectometatarse' (IV)"—the numerals referring to the toes in the type or pentadactyle foot, which the three metatarsus elements respectively bore.

The "calcaneal process" is not the "head" of the mesometatarse (III), but, as the name rightly implies, is a process from the upper and back part of that element, conjoined with a corresponding projection from the part of the common epiphysis covering the mesometatarsal.

DESCRIPTION OF THE PLATES.

PLATE I.

Side view of the skeleton of the Dodo (*Didus ineptus*, Linn.), articulated and displayed in the Ornithological Gallery of the British Museum.

PLATE II.

Oblique back view of the same skeleton.

Both these Plates are taken from photographs, corrected, as to perspective and better indication of details, from the subject. The lithographs are reduced to $\frac{1}{3}$ the natural size.

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[1] "*Cf.* Gegenbaur, Arch. für Anat. und Physiol. 1863, pp. 450–472; Untersuchungen zur vergleichenden Anatomie der Wirbelthiere (4to, Leipzig, 1864), pp. 93–108, pl. 6."

[2] "The posterior surface of the calcaneal process is broad, triangular, vertically grooved, and perforated at its base" (Trans. Zool. Soc. iv. p. 52).

[3] Trans. Zool. Soc. vol. iii. p. 243 (1843); and, in the present work, see p. 229, pl. 58 (metatarsus of immature *Dinornis crassus* and *D. elephantopus*).

[4] Trans. Zool. Soc. vol. iv. p. 3 (1850).

PLATE III.

Metatarsals of Pezophaps *and* Didus.

Fig. 1. Outer side view (*Pezophaps solitaria*, Str.).
Fig. 2. Back view (*Pezophaps solitaria*, Str.).
Fig. 3. Front view (*Pezophaps solitaria*, Str.).
Fig. 4. Inner side view (*Pezophaps solitaria*, Str.).
Fig. 5. Outer side view (*Pezophaps minor*, Str.).
Fig. 6. Back view (*Pezophaps minor*, Str.).
Fig. 7. Front view (*Pezophaps minor*, Str.).
Fig. 8. Outer side view of proximal end (*Didus ineptus*, Linn.).
Fig. 9. Outer side view of distal end (*Didus ineptus*, Linn.).
Fig. 10. Back view of proximal end (*Didus ineptus*, Linn.).
Fig. 11. Back view of distal end (*Didus ineptus*, Linn.).
Fig. 12. Proximal articular surfaces (*Pezophaps minor*, Str.).
Fig. 13. Proximal articular surfaces (*Pezophaps solitaria*, Str.).
Fig. 14. Front view of proximal end (*Didus ineptus*, Linn.).
Fig. 15. Front view of distal end (*Didus ineptus*, Linn.).
Fig. 16. Inner side view of proximal end (*Didus ineptus*, Linn.).
Fig. 17. Inner side view of distal end (*Didus ineptus*, Linn.).

All the figures are of the natural size.

SUPPLEMENT III.

MEMOIR

ON THE

EXTINCT WINGLESS GROUND-DOVE, OR SOLITAIRE (*PEZOPHAPS SOLITARIA*, Strickland).

SINCE the preceding 'Supplement' was printed off, osseous remains collected in the Island of Rodriguez during the "Transit-of-Venus Expedition," and now in the British Museum, have supplied materials for the articulation of the skeletons of both the large and small examples of the Solitaire (Pl. IV.).

Both varieties being extinct, their relation to sex cannot be anatomically determined. The affinity of the Doves (*Columbaceæ*, *Gemitores*) to the *Rasores*, with the combative habit and carpal weapon of the larger variety (ib. fig. 1, ɪɪ), lead me to refer it to the male sex.

In the skeleton of both male (Pl. IV. fig. 1) and female (ib. fig. 2) *Pezophaps*, the number of cervical vertebræ is 12, that of the dorsal 6, a 7th free-rib-bearing vertebra being made "sacral" by ankylosis with the rest of that coalesced group of bones.

So much of the vertebral formula thus accords with that of *Didunculus*[1]. As in that dove, also, the three middle dorsal vertebræ (third, fourth, and fifth) have coalesced, and their square truncate spines form a strong bony crest. Four pairs of ribs are connected, by ossified hæmapophyses, with the sternum; and this bone deviates mainly from the columbaceous type by the minor development of the keel, in relation to the atrophy of the chief muscles of flight.

Sixteen coalesced vertebræ constitute the sacrum of *Pezophaps*, as of *Didus*; and seven free vertebræ beyond the pelvis support the tail-feathers. Thus the vertebral formula of *Pezophaps* is:—

$$C.\ 12,\ D.\ 6,\ S.\ 16,\ Cd.\ 7,\ = 41.$$

There is one free-rib-bearing vertebra less, and one sternal rib less, than in *Didus*; and this difference accords with the larger proportional trunk of the heavier Ground-Dove of the Mauritian island.

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[1] See the figure of the skeleton of the didiform species of the Samoan Isles in my 'Memoir on the Dodo,' 4to. 1866, pl. iii. fig. 2.

In the atlas and third vertebra the interzygapophysial bar, with the foramen it defines, is present [1]. The neural spine subsides to a pair of tuberosities in the fifth cervical; and this bifid condition is traceable to the ninth, where each division degenerates to the beginning of a ridge leading to the hyperapophysis. This process [2], conspicuous and large on the axis and third vertebra, subsides in the following, but rises from its rudimental state in the ninth and following cervicals.

The protuberance from the underpart of the par-pleurapophysis of the fifth and sixth cervicals shows as the "catapophysis" of Mivart in the seventh; and converging towards its fellow, the pair of inferior processes become distinct in the ninth, approximate in the eleventh, and blend into the single median hyapophysis in the twelfth cervical vertebra. This process increases in vertical and fore-and-aft extent to the middle of the three coalesced dorsals, and almost disappears in the hindmost (fifth dorsal); it is similarly represented as a low mesial ridge in the last free dorsal (sixth).

The sternum of *Pezophaps*, as of *Didus*, accords with the didunculine modification of the Dove's breast-bone, in the breadth, for example, of the ectolateral processes and the absence of entolateral ones. The median hinder end of the sternum is narrower, more "xiphoid" in character, than in *Didunculus*. The four articular ridges and depressions in each costal border are close-set up, especially the third and fourth.

The costal process is both broad and thick, presenting a trihedral subconcave facet towards the ribs. The thin ectolateral plate overlaps the two hinder hæmapophyses joining the sternum. The mesial pneumatic fossa at the anterior part of the sternal concavity communicates by a canal with the convex or outer surface. The convex contour of the sternal keel is due to the suppression of the anterior subangular extension which is present in the volant Dodlet.

The first and obvious character in which the great extinct Ground-Doves differ from the smaller existing volant kinds is in the small proportion of the brain-case to the rest of the skull. If the length of the cranium be taken from the back of the occiput to the front of the frontal bone, it is in *Pezophaps* rather more than half that of the skull; in *Didus* it is little more than one third.

The difference is not due to the small relative size of the orbits, but to the great relative length of the beak, especially of the narial part, in *Didus*. This part, which includes the lateral bony external nostrils, is relatively shorter in *Pezophaps* than in *Didus*.

The interorbital septum is entire in both genera.

In both *Didus* and *Pezophaps* the upper grooved border of the foramen magnum extends further back than the condyle. The occiput, in *Pezophaps* (Pl. V. fig. 3), is vertical, feebly convex vertically and transversely, divided by a pair of arched inser-

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[1] *Antè*, p. 396, fig. 11, *r*, *s*, third cervical of *D. maximus*.

[2] *Antè*, p. 394, fig. 4, *hp*.

tional depressions from the rugose, somewhat overhanging hind tract of the parietal region (ib. 7). The temporal fossa is larger, relatively and absolutely, in *Pezophaps* than in *Didus*; it resembles that of *Treron*. The elevation of the frontal region is due, in *Pezophaps*, as in *Didus* and *Treron*, to excess of bony cellular diploë, and takes place in advance of the orbits in all Columbidæ. The interorbital tract of the cranium (Pl. V. fig. 1, 11) rises from the premaxillo-nasal platform (ib. 15, 22′) more abruptly in *Pezophaps* than in *Didus*; but it sooner subsides, and the fronto-parietal tract, or vertex, is flatter. This tract is smooth, but surrounded by a broad rugose elevated border, continued from the superorbital ridge backward over the temporal fossa, then across the postparietal region (ib. 7) to meet the ridge on the opposite side. The superorbital tracts converge forward to form the frontal convexity. This, however, is mesially cleft, exposing a deeper-seated smooth tract, over which a bony fringe projects on each side. This structure exists in a minor degree in the female: the superorbital tract is more rugose in the male than in the female *Pezophaps*.

The chief difference between *Didus* and *Pezophaps* in cranial structure is the degree in which the cancellous tissue is developed between the outer and inner "tables," the minor quantity of that tissue in *Pezophaps* causing less elevation and convexity of the frontals above the orbits as compared with that part of the cranium in *Didus*.

The lacrymal, coalesced with the prefrontal part of the frontal, curves down and back in front of the orbit; it is impressed by a deep, wide, smooth, longitudinal channel externally, conducting the duct to the naso-lacrymal orifice anterior to the orbit.

To view the neurapophyses of the nasal vertebra, the nasals, premaxillary, and coalesced part of the frontals must be removed; and then the homologue of the "os en ceinture" of batrachotomy and of the "æthmoid" of anthropotomy is brought into view, with part of the confluent olfactory capsules.

The essential elements of the anterior terminal segment have undergone extreme modification, and travelled far from the almost typical condition which they present in most fishes[1].

In the bird strong processes answering to diapophyses are extended outwards from the neurapophysial or essential parts of the prefrontals; and to these the name "prefrontal" is restricted by some who retain the term "æthmoid" for the plates transmitting the olfactory nerves from the rhinencephalon. In *Macropus* and most other marsupials the corresponding extension is grooved longitudinally, as in *Didus* and *Pezophaps*; but the fissure transmitting to the nose the lacrymal duct, anterior to the grooved lacrymal bone, in the bird, is reduced to a fossa with one or two foramina in the implacental mammal.

The maxillary sends up a strong nasal process confluent with the outer branch (15′) of that bone, which articulates with the swollen fore part of the frontal, outside the base of the inner division (15) of the nasal bone. The common coalesced bases of the

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[1] See, *e. g.*, the prefrontals of *Xiphias* in my 'Archetype of the Vertebrate Skeleton,' pl. i. fig. 5, 14.

nasals and nasal process of the premaxillary rise as a transverse bar (Pl. V. fig. 2, *x'*), with a convex anterior border, above the rostral divisions of these bones: in this character *Pezophaps* resembles *Treron* and *Didunculus*; while in *Didus* the premaxillary and nasal portions of the elevated basal tract are indicated by grooves therein. In both genera, as in recent doves, 15 and 22' are confluent with 11. Beyond the confluence the divisions of the nasal pair are separated by the nasal process of the premaxillary (22'). The inner division or normal part of the nasal is 1 inch 8 lines in length; it extends forward for half that length along the outside of the premaxillary, then inclines mesiad beneath that bone, coming into contact with its fellow for six lines extent of their terminal pointed end; they underprop the nasal process of the premaxillary; and thus we have, in the extreme variation of an extreme segment of the vertebral axis, the hæmal spine closing the tubular series by overlapping the neural spine of its own segment. The under surface of the nasal process of the premaxillary is impressed by the shallow channel receiving the underpropping fore part of the midnasals.

The nasal process of the premaxillary retains its primitive or normal character as a pair of bones in a greater degree than in *Goura*, and much greater than in *Didus*. In the male *Pezophaps* an interspace of 4 millims. separates their basal portions; and the narrower fissure in the female skull extends halfway towards the tip of the bone. The anterior confluent portions of the premaxillaries terminate in the "core" of the beak, the shape of which, more columbaceous than in *Didus*, is shown in Pl. V., 22. The "maxilla," or upper mandible, formed, as in other birds, by the nasals, premaxillaries, maxillaries, and palatines, inclusive of the vomer, here magnified, with parts of the molars, and of the turbinals, constitutes, as in *Goura*, one half of the length of the skull.

The excavated under surface of the core (Pl. V. fig. 5) is divided by a mesial septum, which expands into a longitudinal channel prior to the separation of halves of the premaxillary (ib. 22). The wall of the excavation is reticulate, as in *Didus*. The inner surfaces of the "halves," 22, are at first channelled, and then become transversely convex. The line of their confluence with the similarly long and narrow palatines, 20, is defaced. The palatal plate, 21, of the maxillary overlies the premaxillo-palatine beam, 20–22. The lateral confluence of the maxillary and premaxillary is obliterated; the maxillary expands vertically as it recedes, and divides into its palatal, jugal, and nasal portions. The jugal part is continued by the confluent jugal and squamosal style to the articular pit at the outer and lower part of the tympanic (28); it is straight beneath the orbit (Pl. V. fig. 1, 27), and has no postorbital rising or process as in *Dinornis*.

The inner wall of the orbit is formed mainly by the orbito-sphenoids, which deliver the optic nerves to their organs near the back part of the cavity. Though much compressed, as in all birds, they form a complete interorbital septum.

The roof of the orbit is formed by the frontal exclusively; the septum rapidly expands as it rises to the frontal roof, the breadth of that roof, taken across the postfrontals, being 2 inches 10 lines.

The interorbital foramen for the exit of the ophthalmic branch of the 5th nerve and vessels is of equal vertical diameter with the optic foramen, but leads to a canal directed obliquely upward and forward, and so appears rather as a fissure.

The temporal fossa seems to have two boundaries above—the border of the ridge continued from the postfrontal to the parietal, 7, and the arched ridge upon the mastoid, 8, marking the extent of origin of the crotaphyte muscle; the latter may be regarded as the true boundary. The fossa is produced below into three processes: the middle and largest is the "tympanic process" of the mastoid; the hind and smallest process is the "postmastoid" one; the fore process may be a production of the parietal, or of this together with the postfrontal. The relative position of the three descending productions of the temporal fossa agrees with that in *Goura* and most Doves.

Viewing the coalesced mass of nasals, premaxillaries, and frontals forming the upper part of the base of the beak (Pl. V. figs. 2 & 4), it is hard to suppose that the right and left nasals were not only separated by the interposed premaxillaries (ib. 15, 22), but that the outer and inner divisions of each nasal have not contracted a separate union with the frontals: but no doubt the common base of each nasal is represented by part of the arched transverse bar, *x*, and its mesial hind production, which is overlapped by the frontal fringes.

The basi-presphenoid (Pl. V. fig. 5, 5, 9) is 2 inches long in the male; it has no pterapophyses.

There is, as is well known, no "maxillo-palatine" or "prevomerine bone" in the bird's skull distinct from the proper maxillary or proper palatine. The latter bone (ib. ib. 20) speedily coalesces with the premaxillary in front, and the maxillary (21′) above, as does this with the premaxillary in front and with the malar bone behind. Their respective limits are definable by their unconfluent condition in the immature bird.

In *Pezophaps* the persistent linear suture between the palatal part of the maxillary and the palatine commences 1 inch 10 lines from the tip of the beak; it defines a linear tract of the maxillary of 1 inch 3 lines extent. External to this suture is the palatine tract, coalesced with the maxillary, in breadth 2 lines, in length 10 lines; when the palatine becomes free, it is twisted on itself, forms a vertical plate of 3 to 4 lines depth, and sends off from the mesial side of the hinder part the horizontal plate, which bends mesiad. Between these right and left mesial plates of the palatines is an interval of 2½ lines. The interpalatine vacuity in advance of the horizontal plates is 4½ lines across. The upper parts of the hinder five lines of the palatines are applied to the convex sides of the presphenoids. The pterygoids (24) abut against the basisphenoid immediately behind the palatines, each pterygoid diverging and expanding to abut against the tympanic. The maxillo-palatal cleft is long and of moderate and uniform width; the interpalatal cleft is wider until the inner plates are developed.

The beak of the bird serves as both hand and mouth; the apex of the wedge, in these functions, is driven against resisting bodies sometimes of considerable hardness. In all birds the opening and closing of the bill are acts of prehension. In many birds these latter movements are not limited to the lower jaw, but a mechanism exists for raising the upper jaw as well. The joint between the base of the bill and the cranium is made flexible by diverse modifications. The tympanic is fashioned in relation therewith; it is connected by two beams or columns of bone, on each side of the skull, with the fore part of the upper jaw. The outer beam, commencing forward at the side of the maxillary, is continued by the malo-squamosal style to the outer side of the transversely expanded lower part of the tympanic. The inner beam, commencing by the palatal process of the premaxillary, is continued backward by the palatine and pterygoid bones to the inner side of the lower end of the tympanic. Any swinging to and fro of this bone upon its single or double upper ball-and-socket joint is transferred to the "core" by the four beams converging thereto. The action of the outer beam upon the maxillary is conjoined with that of the lower beam upon the premaxillary by the overlapping broad palatal plate of the maxillary, which is more or less confluent with the palatine and premaxillary bones beneath.

The movements of the mandibular part of the bill are transferred by the long bar-like rami of the lower jaw to the lower end of the tympanic, with which those rami are movably articulated by a combined double ball-and-socket and also trochlear articulation.

When the tympanics are swung forward they communicate that motion by their six converging bony bars to the upper and lower cores, raising the former, depressing the latter; in short, opening the mouth. When the tympanics swing backward, opposite movements are transferred forward by the connecting bars, and the beak is shut.

But when in this state it is used (as by the Woodpecker) as a pick or wedge, the strength of the blow transferred backwards by the three divergent pairs of bars is met. not by a rigid basis, which might have involved fracture of those bars or of some of them, but by a yielding one, as in the butts with elastic buffers terminating a railway line, for arresting and receiving the shock of a train.

The beak as a whole, and especially its outward and visible portions, have suggested to ornithologists characters of groups with good and accepted descriptive terms: the modifications of a part of the mechanism, a single beam, seem inadequate to sustain a new nomenclature.

The basisphenoid (Pl. V. fig. 5, 5) in advance of the ridge or process which underhangs the bony outlets of the Eustachian tubes loses breadth, and seems narrowest where impressed by the abutting ends of the pterygoids (24).

The postarticular end of the mandible of *Didus* differs from that in most Columbidæ in not being abruptly truncated, but produced in the form of a short right or rather open angle with the apex obtuse (Pl. I.). That of *Pezophaps* (Pl. IV. fig. 1) is more columbaceous: it is produced a short way behind the articulation, and is vertically truncate, without loss of depth. It agrees in this respect with *Didunculus*.

There is nothing extraordinary in the conformation of the pelvis of *Pezophaps*. The acetabulum is situated in the anterior half, as in *Didus* (Pl. I.). The ischium (Pl. IV. 63), coalesces with the ilium (62) at two points, circumscribing a moderate subelliptic "foramen ischiadicum," as in *Didus*. The pubis (64) does not send upwards a process to meet the downward one from the ischium, and so define the "tendinal" from the "obturator" interspace.

The pelvis in the male skeleton shows the whole extent of the entire lower border of the ischium; and its slender hinder termination is produced into contact with the pubis (64), from which bone a rough low tuberosity rises to form the syndesmosis with the ischium (63). On the left side the extremity of the ischium is broken off; but the syndesmotic process of the pubis testifies to an original union like that on the right side.

Here, therefore, we have an acceptable proof of an osteological correspondence with existing doves, which the imperfect examples of the pelvis previously acquired did not exhibit.

The scapula of *Pezophaps* repeats, in a minor degree, the angular beginning of the hinder thin border above the elongate neck of the bone, but projects less as a process than in *Didus*[1]; the distal or free end expands as in *Didus*. The straightness of the bone is more marked than in *Didus*.

The metacarpus of the male (Pl. IV. fig. 1, II.) repeats the tuberous process figured by Prof. Newton in pl. xix. figs. 87–90 of his richly illustrated memoir[2], and testifies, as he shows, to the value of Leguat's record, and to the accuracy of that original observer of the living bird.

If a single specimen of a metacarpal bone of some unknown animal, such as is figured in Pl. IV., II, had previously come to the hands of a palæontologist, he would have concluded the bony tumour to have been of morbid nature and origin, and set it down as an exceptional pathological phenomenon. Any other opinion (above all, one holding such tumour to be a constant structure, functional in the healthy individual, and of moment in guiding to a knowledge of the species or sex) would have hazarded the estimate of such palæontologist's standing in his science.

In the rich collection of bones of *Pezophaps*, the subject of Prof. Newton's instructive paper (*tom. cit.*), were not fewer than thirty-two specimens of the metacarpus. "That it would be very short was a safe inference from what we know of it in other flightless birds; but it could hardly have been expected to obtain from it such a singular confirmation of Leguat's statement regarding a remarkable peculiarity in the 'Solitaire' as observed by him, nor that it should furnish an explanation of the

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[1] 'Memoir on the Dodo,' pl. viii. figs. 6, 9, 51.

[2] Phil. Trans. 1869.

curious bony growth on the distal end of the ulna and radius already mentioned as presented by the specimens of supposed males. All the perfect specimens of the metacarpal have on the radial side a more or less spherical bony knob or callus-like mass developed immediately beyond the proximal end and the pollex. . . . The appearance of the knob is much that of diseased bone; it has probably been covered by a cartilaginous integument" (ib. p. 342). The author then repeats the quotation given by Strickland in his excellent work:—" L'os de l'aileron grossit à l'extrémité, & forme sous la plume une petite masse ronde comme une balle de mousquet: cela & le bec sont la principale défense de cet oiseau"[1].

The specimens of metacarpus of the larger, combative sex of *Pezophaps* in the British Museum show the same structure, which may be seen in the articulated skeleton of the, probably, male Solitaire now there exhibited (Pl. IV. fig. 1).

This hard, irregular, prominent mass, which holds the place of the spine in the Spur-winged Goose, may be compared to a "knuckle-duster;" with it the combative sex delivered his blows, in the hard and well-contested fights to which Leguat testifies: —" Ils ne volent point, leurs ailes sont trop petites pour soutenir le poids de leurs corps. Ils ne s'en servent que pour se battre, & pour faire le moulinet, quand ils veulent s'appeller l'un l'autre."

I here infer the writer to mean that one function of their stunted wing was to do battle with each other; and the peculiar development in question I take to have been the combative weapon. The entire wings were in action in executing the amorous pirouettes:—" Ils font avec vitesse vingt ou trente pirouëttes tout de suite, du même côté, pendant l'espace de quatre ou cinq minutes."

Of the bones of the hind limbs, the greater relative length of both femur, tibia, and metatarsus, as compared with the skull and sternum, is first notable in *Pezophaps* (Pl. IV.) in contrast with *Didus* (Pl. I.).

The columbine characters of the metatarsus are manifested in both species. These characters in *Pezophaps* are recorded in pp. 30–36, and are repeated in that bone of the subject of Plate IV.

The following are admeasurements of the skeleton of the two extinct species of Ground-Doves:—

		Pezophaps solitaria.			*Didus ineptus.*		
		ft.	in.	lin.	ft.	in.	lin.
Length of vertebral axis, from tip of beak to end of coccyx, following the curves	*Mas.*	2	11	0	3	2	0
	Fem.	2	7	0			
Height in easy standing position	*Mas.*	2	7	0	2	0	0
	Fem.	2	2	0			
Length of leg, from proximal end of tibia to sole	*Mas.*	1	4	6	1	2	0
	Fem.	1	1	0			

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[1] Strickland, 'The Dodo and its Kindred,' 4to, 1848, quoting the 'Voyage et Avantures de François Leguat,' 2 vols. 12mo, 2nd ed. 1720, vol. i. p. 98.

The Solitaires were found living in great numbers by the colony of Huguenots who settled in the island of Rodriguez, under their leader M. François Leguat, in 1691.

Pezophaps, according to the testimony of Leguat, lays but one egg at the breeding-season; and the same was probably the case with *Didus*, as it is with the existing species of fruit-eating doves (*Carpophaga*) and the passenger pigeons (*Ectopistes*).

The Moas appear to have been similarly restricted, as their living representatives, the Kivis, also are, in the number of the eggs of each brood.

The condition of the existence of *Pezophaps*, and probably that of its flightless structure, was the absence of any extirpating enemy in the island to which the species was restricted. Feeding on the date, the plantain, and other tropical products of a rich vegetation encumbering the soil when ripe and fallen, their flesh was sapid as well as nutritious; and the early Huguenot colonists commenced the work of extirpation, which their successors and the quadrupeds (cats and pigs) which they introduced completed.

In assigning the origin of the species *Pezophaps solitaria* to the operation of a primary law, by way of direct creation of a primitive pair, the osseous tumour on the wrist of the male, and the fore pair of limbs in both sexes, framed on a pattern fitting them to exercise the faculty of flight and for no other kind of locomotion on land, but of too small a size for that end, are among the incidents of this "thaumatogeny," or inconceivable mode of genesis.

The other alternative is a reference of the species to the operation of a secondary law, by no means implying disbelief in, or involving denial of, the Lawgiver. In speculating on the mode of operation of such law, the following facts present themselves:—

Pezophaps solitaria was the largest kind of land-bird observed by the first settlers in the island of Rodriguez.

It differed in no other respect from the class-characters of the other birds of that island save in the inability to fly by the action of its wings.

There were no enemies native to the island able to take advantage of that disablement.

"Il ne s'y trouve aucun animal à quatre pieds, que des rats, des lézards, & des tortues de terre, desquelles y a trois différentes espèces," writes Leguat in his interesting little book[1].

The Solitaires had no call for practising or endeavouring to effect that hardest and most strenuous mode of locomotion to obtain sustenance or fulfil any of the conditions of preservation of the individual or of the species; they were never scared into such violent exercise.

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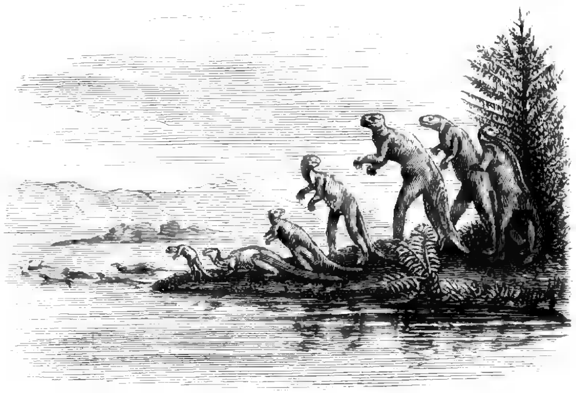
[1] Voyage et Avantures de François Leguat, & de ses Compagnons, en deux isles désertes des Indes Orientales. Avec la relation des choses les plus remarquables qu'ils ont observées dans l'Isle Maurice, à Batavia, au Cap de Bonne-Espérance, dans l'Isle St.-Hélène, & en d'autres endroits de leur Route. Le tout enriché de Cartes & de Figures. Tome Premier & Tome Second (12mo). A Londres, chez David Mortier, Marchand Libraire. 1708.

Upon these facts I found a conclusion as to how the specific character of wings, useless as such, came to be; and this conclusion as to *Pezophaps solitaria* is the same which I have set forth more at length in relation to *Didus ineptus*[1], and which I deem to be applicable to the still larger terrestrial birds discovered, as in the case of *Æpyornis*, *Dinornis*, *Aptornis*, *Notornis*, *Cnemiornis*, in similar geographical and associated zoological conditions—these birds, like the Dodo and Solitaire, having become extirpated through alterations of the latter conditions, *i. e.* by introduction of species new to their island homes, and with dispositions and powers destructive of such flightless birds. Thus is illustrated the origin of species by a condition of the way of work of a secondary law suggested by Lamarck.

Two alternative hypotheses have been propounded. One, by Mr. Darwin, is discussed and conjecturally exemplified by the authors of the paper "On the Osteology of the Solitaire" (Phil. Trans. 1869, pp. 356–358). The other hypothesis assumes that the *Iguanodon*, *Megalosaurus*, *Scelidosaurus*, and other Dinosaurian reptiles walked on the hind pair of legs, like birds, and initiated that class by becoming transmuted into the warm-blooded, feathered, but wingless species. No suggestion has been made by the authors or acceptors of this hypothesis as to the way of operation or conditions of the transmutation. But I have been favoured with a photograph from New York of the "Restorations according to Professors Huxley and Waterhouse Hawkins" of the reptilian ancestors of the Moas, now, or to be, placed in the Public Park of that City.



In most of the instances of wingless birds affinity to more favoured or normal members of the feathered class has been traced.

The Penguins (*Impennes*) cannot be dissociated from the smaller *Urinatores*, which retain the volant function of the wings.

Alca impennis is not generically separable, in judicious taxonomy, from the smaller swiftly flying *Alca torda*.

The genera *Aptornis* and *Notornis*, with keelless breast-bones, cannot be divorced from the family of Coots.

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[1] 'Memoir on the Dodo,' 4to, 1866, pp. 49–51.

Cnemiornis, although also with a "ratite" or uncarinate sternum, must stand beside *Cereopsis* in the Anserine group of Anatidæ.

The Didines are but generic modifications of a great natural division of Rasores, the existing members of which, of smaller size, retain their faculty of flight.

Dinornis shows the consequence of disuse of wings in a greater degree than does *Apteryx*. But, although the winged forms from which the Kiwi, the Cassowary, the Emu, the Rhea, the Ostrich, and the *Æpyornis* have severally degenerated remain to be determined, the wingless kinds each have structural characteristics encouraging the quest, and testifying against the artificial group (*Megistanes*, Vieillot; *Proceri*, Illiger; *Ratitæ*, Merrem; *Struthionidæ*, Vigors) based upon modifications of the breast-bone and scapular arch, the consequences of disuse and degeneration of the muscles of flight, and with which a loose character of plumage is more or less associated.

The results of the researches which have determined the real affinities of extinct birds with keelless breast-bones and long-angled scapulo-coracoids, devoid of acromial and clavicular processes, support a reasonable expectation that the existing wingless genera, which have been shown to differ from one another considerably in important anatomical structures, in correlation with their distinct and remote habitats, will be ultimately referred to as many distinct natural groups which are now, or which formerly have been, represented by volant and typical members of the feathered class.

EXPLANATION OF THE PLATES.

PLATE IV.

Fig. 1. Reduced side view of the skeleton of the male Solitaire.
Fig. 2. Reduced side view of the skeleton of the female Solitaire.
Fig. 3. Copy of a figure of the living Solitaire, from the frontispiece to Leguat's work, above cited.

PLATE V.

Fig. 1. Side view of the skull of the male Solitaire.
Fig. 2. Top view of the skull of the same.
Fig. 3. Occipital surface of the skull of the same.
Fig. 4. Top view of the skull of the female Solitaire.
Fig. 5. Under view of the skull of the same.

All the figures are of the natural size.

Notice of a fragment of the Femur of a Gigantic Bird of New Zealand. By Richard Owen Esqr. F.R.S. F.Z.S. &c (Zoological Transactions Vol. III. Part 1)
Read November 12th 1839.

The fragment of bone here described was placed in my hands for examination by Mr Rule, with the statement that it was found in the Island of New Zealand, where the natives have a tradition that it belonged to a bird of the Eagle kind, but which has become extinct, and to which they give the name of "Movie". Similar bones it is said are found buried in the banks of the rivers of New Zealand.

The fragment is the shaft of a femur with both extremities broken off. The length of the fragment is six inches, & its smallest circumference five inches & a half. The exterior surface of the bone is not quite smooth, but is sculptured with very shallow reticulate indentations: it also presents some well-marked intermuscular ridges. One of these ridges (Pl. III. fig 1.) extends down the middle of the anterior surface of the shaft to about one third from the lower end where it bifurcates: two other ridges or lineæ asperæ, traverse longitudinally the posterior or concave side of the shaft (Pl. III. fig 2.): that nearest the outer or fibular side of the bone is broad ~~rugged~~ & rugged, the other is a mere linear rising.

The first & most obvious idea of the nature of this bone would probably be that it belonged to the human species, or to some of the larger domestic animals introduced into New Zealand by the settlers for food or draught. It is, however, nearly double the circumference of the femur of an ordinary-sized man: it also differs in the greater expansion of the two extremities than would be presented by a section of the same length from any part of the shaft of a human femur, & by the

interspace between the two longitudinal ridges at the posterior part of the bone; there is a single linea aspera in the corresponding part of the shaft of the human femur, where likewise the orifice of the ascending canal of the medullary artery is conspicuous.

From the femur of the Ox or ~~Buffalo~~ Buffalo, the bone from New Zealand differs in its cylindrical form; in the Ox it is three sided, and in the corresponding part of the shaft of the femur the trochanter minor would be included, of which there is no trace in the fossil; whilst on the other hand, both the anterior & the two posterior longitudinal ridges are absent in the femur of the Ox: the difference between the bone from New Zealand, & the shaft of the humerus of an Ox is still more striking.

A portion of the shaft of the femur of a Horse or Ass corresponding in length with that of the bone here described would have exhibited a portion of the small trochanter, as well as nearly the whole of the external r third trochanter, & of the deep & rough depression below this trochanter. The orifice of the medullary rtery is as conspicuous in the femur of the horse s in that of the Ox, on the outer & posterior part of e middle of the shaft.

he shaft of the femur in the Hog approaches more early in form to that of the fossil than the bones ith which it has just been compared, but no pecies of Sus is now known which presents a femur f equal size. The exterior linea aspera is formed y a sharp angle which divides the outer from the osterior surface of the bone, both of which sur- aces are nearly flat in the Hog's femur; the orresponding ridge, besides being less sharply eveloped than in the fossil, is situated more on e posterior side of the bone: the anterior bi- ineating ridge is wanting in the femur of e Hog.

If the bone from New Zealand be compared with the femur of the Camel or the Llama, as great differences present themselves as in the human femur; the single linea aspera on the middle of the posterior surface of the bone, and the perforation of the medullary artery, upon or near that ridge, forbid an approximation of these large Ruminants, with the fossil.

The femur of the Kangaroo is at once distinguished by the longitudinal tuberosity developed on the middle of the posterior part of the shaft.

The femur of the Dog, independently of its inferiority in size in the largest specimens of this quadruped, differs from the fossil in the absence of the anterior ridge, & in the presence of the medullary canal near the middle of the posterior part of the shaft.

In order that no reasonable ground might remain for doubting the accuracy of the conclusion to which I have arrived in regard to the above described bone, I have compared it with the long bones of other Mammalia approaching it in size, notwithstanding the improbability of their ever having found their way to the Islands of New Zealand.

A section of the shaft of a femur of the Grisly Bear, and of other large species of Ursus corresponding in length & thickness with the fossil, does not give the expansion of both extremities, & is moreover flatter antero-posteriorly, the same difference is presented in the femur of the Lion, & other large species of Felis. The femora of both the two last cited genera of Mammalia were characterized by the aperture of the medullary artery at the middle of the posterior part of the shaft.

The femur of the Ourang outang differs as much as any of the preceding Mammalia from the fossil.

The difference between the fossil & the humeri

and other long bones of the Mammalia above cited are equally or more marked than in the femora. – The texture of the bone which affords the chief evidence of its ornithic character, presents an extremely dense exterior crust varying from one to two lines in thickness; this then rapidly degenerates into a lamello-cellular structure of from two to three lines in thickness. The lamellae arise vertically to the internal surface of the dense wall, are ~~directly~~ directed obliquely to the axis of the bone, decussate, & intercept spaces which are generally of a rhomboidal form, & from two to three lines in diameter. This coarse cancellated structure is continued through the whole longitudinal extent of the fragment, & immediately bounds the medullary cavity of the bone, which is about one inch in diameter in the middle and slightly expands towards the extremities. There is no bone of similar size which presents a cancellous texture so closely resembling that of the present bone as does ~~that~~ the femur of the Ostrich; but this structure is interrupted in the Ostrich at the middle of the shaft, where the parietes of the medullary, or rather air-cavity, are smooth & unbroken. From this difference I conclude our extinct bird to have been a heavier & more sluggish species than the Ostrich; its femur, & probably its whole leg, was shorter & thicker. In no other femur resembling or approaching in form and size that of which the shaft is here described have I found superficial reticulate impressions like those above described, except in that of the Ostrich. The Ostrich's femur is subcompressed while the present fragment is cylindrical approaching in this respect nearer to the femur of the Emeu; but its diameter is one

third greater than that of the largest Emeu's with which I have compared it. The bones of the extremities of the great Testudo Elephantopus are solid throughout; those of the Crocodile have no cancellous structure like the present bone. The cancellous texture of mammiferous bones, again, is of a much finer & more fibrous character than in the fossil.

Although I speak of the bone under this term, it must be observed that it does not present the character of a true fossil, being by no means completely mineralized; it has probably been on or in the ground for some time, but still retains much of its animal matter.

The discovery of the relic of a large struthious bird in New Zealand is one of peculiar interest on account of the remarkable character of the existing fauna of that Island, which still includes one of the most extraordinary and anomalous genera, of the Struthious order; & because of the close analogy which the event indicated by the present relic offers to the extinction of the Dodo of the islands of the Mauritius & Rodrigue. So far as a judgment can be formed from a single fragment, it seems probable that the bird to which the above described bone belonged, presented proportions more nearly resembling those of the Dodo than of any of the existing Struthionidae. In the partially explored state of the islands of New Zealand it would be premature to pronounce the large Struthious bird thus indicated to be extinct. The present notice it is hoped, may tend to accelerate its discovery, if it be still in being, or may stimulate to the collection of the remaining parts of the skeleton, if the species no longer exists."

Description of the Plate —

Plate III.

Fig 1. Anterior view of the fragment
2. Posterior ditto.
3. Internal view of its cancellous structure.

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Prof Owen's 2d Memoir on Dinornis, ~~[illegible]~~ (Proceedings Zoolog. Society)

·/· Note to Page 32. The following abstract ~~follows~~ of gives ~~[illegible]~~ the evidence from which the results were obtained

f3 1° The maturity of the different-sized bones indicating different species was demonstrated by reference to the long retention of immature characters in the same bone - the tarso-metatarsal - of existing Struthionidæ; & by the fact of a tarso metatarsal of a half grown Dinornis giganteus, manifesting the same incomplete coalescence of its primitively distinct elements; shewing that the Dinornis like the Ostrich had a tardy ossification of the skeleton, as compared with birds of flight.

[One mature tibia of a smaller size, established a species less than the Dinornis didiformis, & which from its similarity of stature to the great Bustard (Otis tarda), ~~Prof. O.~~ is named ~~called~~ D. otidiformis.

The largest tibia belonging to the D. giganteus, presented the extraordinary length of 2 feet 11 inches. The shaft of a smaller, about two feet long when entire, was referred to D. ~~struthioides~~ struthioides.

A femur indicated a species of the size of the Emeu & was named D. dromaioides.

No part of the skull, sternum, ribs, or wing-bones had been transmitted, but ~~Prof. O.~~ the author pointed out the physiological reasons for concluding that the development of the anterior extremities must have presented in the Dinornis an intermediate condition between that in the Emeu & ~~that~~ in the Apteryx.

The largest D. giganteus according to the proportions of the Ostrich must have stood 10 feet five inches; but according to those of the Cassowary nine feet five inches; its average stature might be taken at ten feet.

[The Dinornis struthioides was seven feet high, which is the average stature of the Struthio Camelus.

[D. dromaioides, from its femur corresponding in size with that of the Emeu whose average height is between five & six feet, was probably five feet high.

The height of D. didiformis four feet, exceeding therefore the extinct Dodo (Didus ineptus), but evidently resembling it in its stouter proportions, & shorter metatarsus, as compared with other species of Dinornis.