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 one², 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:—

<table>
<thead>
<tr>
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<th>Dinornis ingens</th>
<th>D. robustus</th>
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<tbody>
<tr>
<td>Breadth of cranium across the mastoids</td>
<td>3 8</td>
<td>4 0</td>
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<tr>
<td>Length of cranium from superoccipital crest to premaxillary fossa</td>
<td>2 9</td>
<td>3 7</td>
</tr>
<tr>
<td>Breadth, greatest, of premaxillary</td>
<td>2 4</td>
<td>2 10</td>
</tr>
<tr>
<td>Breadth of cranium across the temporal fossae</td>
<td>2 8</td>
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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 fossae being the same in both. This difference arises from the greater relative depth of the fossae 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

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. LIII. 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 ½ 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+) 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. s, 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 basis- 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 vertebrae.

The mastoid (8) is large, thick, and obtuse, excavated below by a single oblong, oblique articular cavity (Pl. LXIII. fig. 1, w) 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 con-

tex 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 cribiform 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 con-
tracts transversely, expands in the opposite direction, assuming a trihedral shape,
widely excavated on the inner facet by the fossa (g), terminating in the large pneu-
matic 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 ptery-
goid (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. i) 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, ii) 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
develops 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

x 2
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 section¹, 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.

¹ See figure 1, next page.
"Section of the contour and formation of Manuherikia Valley." — J. H.

"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 metatarsus 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 inches¹, might indicate a sexual difference of stature, and that the skeleton from the Manuherikia Valley was probably that of a female which had perished with her chicks².

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, 1864³, 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

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.
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 ankylosed 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 5 1/2 lines, its height 3 1/2 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 basisphenoid 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 mamillary tuberosities (ib. 1'), which it conjointly forms with the basisphenoid, 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 (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 $1\frac{1}{2}$ 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 Aptornis¹ and Didus. The pretympanic process is very long in Notornis and Porphyrio².

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 eardrum 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 $5\frac{1}{2}$ 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, v) leading to a vertical fossa in the cranial wall, homologous with that wider and more conspicuous ‘pretympanic’

ⁱ Pl. XLIII. figs. 1–6. ² Pl. XLVII. figs. 1 & 7, s'.
fossa which characterizes the cranium in *Sula* and other *Pelecanidae*. From the back part of this extends the groove for the tympanic vein leading to the postlacerate fissure\(^1\) (Pl. LXV. fig. 1, e). Mesiad of the inner pneumatic foramen is the fossa terminated by the orifices of the vestibular fenestrae (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 preytympanic plate of the alisphenoid (ib. s) 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 ‘spenoideal 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 vertebrae 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 laminae (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, nn). 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, develops 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 overarchling 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 13, 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 homology², 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 eyeballs, 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

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 pages¹ 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 inclined². 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 Raptorens 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

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 Crocodilidae; 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 pretymppanic 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 fossae, 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 develops 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 lacrimal foramen, indicating the process to be a lacrimal (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 lacrimal 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 (28), 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 processes2. 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 Struthionidae"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’ 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 vertebrae"4. 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

1 "Dodo and its Kindred," ‘Osteology of the Dodo,’ 4to, 1848, p. 87.
2 Ibid.
3 Ibid.
4 ‘Anatomy, Descriptive and Surgical,’ by II. Gray, 8vo, p. 33, fig. 30.
exposed the alleged 'vertebral body' gives off a process "arching over the foramen, for the transmission of the olfactory and ophthalmic nerves". 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," — 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? Considering the varying number of points at which ossification commences in the body of a vertebra in the

1 "Dodo and its Kindred," &c., 4to, p. 87.
2 Zool. Trans. vol. v. p. 149.
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 osteogony 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 unmistakably, 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 'mastoide' 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 'mastoide' 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.


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, e). 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, \( e, c \)); 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

\[^{1}\text{Ante, p. 34, pl. ix. fig. 4, e, f, g.}\]
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.