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BALÆNICEPS REX.

XXII. *On the Osteology of* Balæniceps rex (*Gould*). *By* W. Kitchen Parker, *Mem. Micr. Soc.*

Read June 26, 1860.

[Plates LXIV., LXV., LXVI., & LXVII.]

Introduction.

No lover of nature can read Mr. Petherick's vivid and delightful description[1] of the native home and playground of those royal children of the Tropics, the Hippopotamus, the Crocodile, and the Balæniceps, without longing to see with his own eyes all this overflowing life.

'The miry places and the marishes' of these wild regions are appropriately tenanted by these portentous-looking representatives of the three great air-breathing Classes, the Mammals, Birds, and Reptiles.

Nor do such creatures harmonize less with each other than with their savage home; for one cannot even think of the great River-horse without the idea of his scaly neighbour at once suggesting itself; and the Balæniceps has certainly in its strange countenance an artistic, if not a family likeness to the Crocodile.

Like many of its large congeners, the Balæniceps is not merely a fish-eating bird,—carrion, especially intestines, being equally acceptable with fish. This is also the case with certain piscivorous birds belonging to other natural groups, *e. g.* the Sea-Eagles and Gulls; whilst the Pelicans, Cormorants, and Gannets feed more cleanlily, and abide by a purely fish-diet.

It is to the stilted, wading group of scavengers that the Balæniceps belongs, being one of the *Ardeæ affines*, and therefore intimately related to the White Stork, the Marabout, and the Adjutant. Its nearest relations, however, are the South American Boat-bill (*Cancroma cochlearia*) and the Little South African Umbre (*Scopus umbretta*).

The latter bird, before the discovery of its gigantic relation, seemed to be unique amongst the near relations of the Common Heron (*Ardea cinerea*), in having a strong hook to the upper beak; the Balæniceps, however, has this character in the highest degree, and it is not absent from the flat upper jaw of the Boat-bill. It is difficult for the systematist to choose his *type-form* amongst the Ardeine genera, including *Ciconia*, *Leptoptilus*, *Mycteria*, *Anastomus*, *Aramus*, *Ardea*, *Botaurus*, *Herodias*, *Nycticorax*, *Scopus*, *Cancroma*, and *Balæniceps*; but as the Heron is best known, and has the characters of the family moderately, but markedly developed, it is the most available.

Ardea is, moreover, one of the original genera of Linnæus; and the names and terms

[1] Proc. Zool. Soc. 1860, p. 195.

of that great man are classical and almost sacred: his genera and species are also exceedingly useful as starting-points. This bird, whose 'visage darts forth melancholy,' and whose head and jaws are not unlike (as the Arabs say) an upturned Arabian shoe, has necessarily many interesting points in its osteology. The purpose of this paper is to point out these peculiarities; and we shall take this opportunity of noting the analogies and homologies that occur to us in the osseous structure of the Vertebrata generally, and of Birds in particular. No anatomist can look at the skull of the Balæniceps without desiring very strongly to know the history of all that melting and coalescence of cranial 'elements' which he sees before him.

The rich literature for which we are indebted to the extraordinary labours of such men as Cuvier and Owen, who have principally used the gradational method, will not, however, satisfy the mind of him who would see Nature at her work, and behold the quiet formation of each part and member—'when as yet there are none of them.'

We are not without light on this subject: Baer, Vogt, Remak, Reichert, and other excellent Embryologists abroad, and Professors Goodsir and Huxley nearer home, have made us their deep and lasting debtors; and we are not without hope that more of our own countrymen will labour in this high field, incited thereto by such teachers of so pleasant and noble a science.

In describing the skeleton, and especially the skull of the Balæniceps, we shall use freely the published observations of the writers above-mentioned, depending, however, principally upon our own labours (as it regards the class of Birds especially), which have extended over some twenty years. And it seems to be a more natural and proper thing that each man should cautiously and honestly put down his own views, than that he should be content to become a stereotyped copy of any great master, multiplying his errors a thousand-fold, whilst he makes no addition to his truths.

It will be more convenient to begin the description of the skull of the Balæniceps at its more perfect part, the occipital region, than to take the *ethmo-vomerine sclerotome* as the starting-point; and a regional description will perhaps be better than one based on any theory of its essential segments. Those segments or sclerotomes must, however, be discussed; and it will be well to say at once that our own views on this subject approximate much more nearly to those of Professor Huxley than to the doctrine of the archetype of the vertebrate skeleton as taught by Professor Owen,—or to the views of Professor Goodsir, which are not less transcendental than those of his illustrious contemporary. Our references to the works of Professor Owen will be as follows:—

1. The article *Aves* in Todd's 'Cyclopædia of Anatomy and Physiology,' 1835.

2. Lectures on Comparative Anatomy, vol. ii. 1846.

3. Report on the Archetype and Homologies of the Vertebrate Skeleton, read at the Meeting of the British Association held at Southampton, 1846.

4. "On the Nature of Limbs:" a lecture delivered at the Royal Institution, Feb. 19, 1849.

5. Descriptive Catalogue of the Osteological Series contained in the Museum of the Royal College of Surgeons of England, 1853.

6. Principal forms of the Skeleton and the Teeth, in 'Orr's Circle of the Sciences,' 1856.

Professor Goodsir's profound views upon this most difficult and tangled subject will be found in the Edinburgh New Philosophical Journal for 1857, in an Abstract of Papers submitted by him to Section D. at the Cheltenham Meeting of the British Association, August 5—12, 1856.

Professor Huxley's opinions are published in his invaluable Croonian Lecture (in which are to be found several references to valuable works on the subject by Germans and others), published in the Proceedings of the Royal Society, Nov. 18, 1858; also in his paper on *Stagonolepis robertsoni*, Quart. Journ. Geol. Soc. vol. xv. 1859. Other important papers of Professor Huxley's are to be found in the same Journal, vol. xv. for 1860; namely, an account of some Amphibian and Reptilian remains from South Africa and Australia,—on *Rhamphorhynchus bucklandi*,—on a fossil bird and cetacean from New Zealand, and—on the dermal armour of *Crocodilus hastingsiæ*.

Dr. Humphry's beautiful work on the "Limbs of Vertebrate Animals," 1859, and Messrs. Strickland and Melville's description of the Anatomy of the Dodo and allied forms, in their noble work on the Dodo, 1848, will both be referred to.

The late Professor MacGillivray's works on the Birds of Great Britain; the excellent articles on Anatomy and Natural History in the 'Penny Cyclopædia'; Griffith's and Pigeon's translations of Cuvier's works; and the late Dr. Johann Müller's Book "on Generation," in his 'Elements of Physiology,' as translated by Dr. Baly, will all yield us some assistance. Those long-beaked mammals, the *Cetacea*, are profitable for reference when we consider the structure of birds; and an admirable article on these creatures will be found in Todd's 'Cyclopædia of Anatomy and Physiology,' by M. Frédéric Cuvier.

There is a very important and valuable paper by Dr. John Cleland in the Edinburgh New Philosophical Journal (vol. xii. No. 2. p. 242, October 1860), "on the Vomer in Man and the Mammalia, and on the Sphenoidal Spongy Bones." This is a model paper for unbiassed observation, and freedom from that pleasant mode of *supposing* instead of *ascertaining* what is the true nature of an anatomical element.

Occipital Region of the Skull of BALÆNICEPS. (Pl. LXV. fig. 3.)

The shape of the occipital sclerotome of the Balæniceps, as seen from behind, is sub-pentagonal; the upper margin is formed by two tubercular ridges, which meet at a very obtuse angle above, at the mid-line—the part from which the small crista occipitalis passes downwards. The lateral margins are vertical above, but turn inwards below, curving downwards, inwards, and forwards. The basal line is concave, being arched in such a manner as to slope downwards anteriorly; at its middle is placed the single hemispherical condyle, which is directed backwards, and slightly downwards, to form with the atlas a 'procœlian' articulation. Above this condyle is the 'foramen magnum' (fig. 3, *f m*), in shape slightly pentagonal, and nearly half an inch in diameter.

The supra-occipital region is one inch across, and besides its tiny mesial crest, has a pair of supero-lateral eminences (Pl. LXV. figs. 1, 3, 6, *ep*), the centre of the 'epiotic' pieces of the young bird: these elevations contain part of the superior and external semicircular canals. The epiotic eminences are separated from the upper mastoid eminences (Pl. LXV. figs. 1, 3, 6, *m*) by a depression of the marginal ridge, and by the vascular grooves which burrow in the occipital bone.

The outer half of each side of the upper margin is occupied by the upper mastoid eminences; they are therefore external to, and somewhat below, the epiotics, and are separated from the so-called par-occipital processes by a deep fossa. These upper mastoid projections help to wall-in the external semicircular canals and to bound the temporal fossa behind: they answer to the upper part of the mastoid of the Turtle (the 'par-occipital' of Owen, '*occipital externe*' of Cuvier).

The elegantly curved 'par-occipital' processes (Pl. LXV. figs. 1, 3, 7, *e o* & *p r o*) pass downwards, forwards, and inwards: passing insensibly into the basal region, they bound the ear-cavity behind and below, and contain part of the external and anterior semicircular canals. The upper margin of these processes laterally is the lower boundary of the temporal fossa, the two regions being separated by a ridge, below which ridge the 'par-occipital' forms a beautiful shell-like process, the anterior sigmoid margin of which very nearly reaches the huge 'os quadratum' (Pl. LXV. figs. 1, 3, 6, 7, *q*). Below and in front of this part the substance of the bone contracts, and passes on to join the delicate crescentic 'pterapophysis,' which forms the boundary of the basi-temporal, a bone to be described presently.

The basi-occipital and basi-temporal regions are, however, separated laterally by a notch, mesiad of which is a large reniform passage; the bridge over this passage being the connecting link between the basal part of the occipital and sphenoidal sclerotomes. This very pretty reniform opening is apparently the external outlet of the vagus nerve (Pl. LXV. figs. 3 & 7, *v g*). The basi-occipital region is of small antero-posterior extent, and lies directly between these foramina; it is slightly scooped and convex all round the condyle, and is perforated by a number of vascular openings. The condyle (fig. 3, *c*) is one-third of an inch in diameter, the entire breadth of the occipital bone is more than two inches, the height of the supra-occipital above the foramen magnum is two-thirds of an inch, and the wing-like par-occipitals are one inch deep.

Internal to the foramen magnum the bony labyrinth projects mesiad on each side, these projections being the line of anchylosis of the lateral occipitals (ex-occipitals of Professor Owen) with the largely developed petrosals. The external union of these elements is indicated by the *fenestra ovalis* (fig. 1, *f o*) and *rotunda* (the latter being of an oval shape in birds). The substance of the occipital bone is thick and richly cellular in the Balæniceps.

In the Chick, the occipital sclerotome is developed from five centres ; one basal, a pair of laterals, and a pair of upper or ' epiotic ' pieces. The basi-occipital of the Chick may be seen, on the eleventh day of incubation, as a short rod of bone in the upper stratum of the cartilage of the primordial basis cranii ; it encloses the tapering anterior extremity of the evanescent chorda dorsalis, but has not yet penetrated the thick cartilage beneath it, and is only just entering the substance of the, as yet, cartilaginous hemispherical condyle.

The basal centre lies on the same plane as the centre of ossification, which already occupies the posterior third of the basi-sphenoidal rostrum. The lateral or ex-occipitals may be seen at the same period as thin scales of bone of a somewhat crescentic shape, bounding the sides of the foramen magnum (hence their crescentic margin), sending upwards a process to join the epiotics, and another forwards and outwards to form the 'par-occipital' ala, and to ossify that part of the occipital sclerotome which in the Chelonia exists as a distinct ' mastoid.'

On the eleventh day of incubation most of the upper occipital region is still cartilaginous ; but on each side of the mesial line, a little above the foramen magnum, a pair of small oval osseous centres already exist ; they are about a line apart.

On the fourteenth day they are still nearly the same distance from each other ; but they are creeping up to the upper margin of the cartilaginous cranial wall, downwards nearly to the foramen magnum, and laterally they have begun to wall-in the superior semicircular canals.

On the sixteenth day these pieces (called ' epiotic bones ' by Prof. Huxley, Croon. Lect. p. 13) have reached each other, as well as the upper margin of the occipital cartilage and the superior boundary of the foramen magnum.

On the nineteenth day only the upper and lower fourths of the line of union of these ' epiotics ' are visible, and the external margin has reached the external as well as the superior semicircular canal.

In young Pigeons, a day after hatching, these ossifications have not commenced ; on the eighth day these rapidly-growing birds have a large single ' supra-occipital ' deeply notched in the middle, inferiorly, in the place of the oval membranous deficiency, or *fontanelle*, in the primordial occipital wall. In adult Pigeons, and also in the Dodo and Didunculus, traces of this structure still remain (see Strickland and Melville),—all the Columbinæ hitherto examined having a mesial ' supra-occipital ' foramen. These birds must be examined on about the third day for the separate epiotic pieces[1].

The broad smooth supra-occipital region of birds does not require a distinct interparietal, or central supra-occipital element ; but in the Chelonia, and probably in most

[1] As early as the third day after incubation, we find (from dissections made since the above was written) that in these *typical* birds there is only one osseous centre in the supra-occipital cartilage : it is shaped like a horse-shoe and is very rapid in growth.

reptiles, the central is the chief element. In *Coluber natrix* and in *Lacerta agilis*, Rathke has observed the epiotic centres before they had coalesced with the main part of the supra-occipital, and the mastoid element before it was fused to the ex-occipital (see Huxley, Croon. Lect. p. 61). In most osseous fishes the three supra-occipital elements continue distinct throughout life.

According to Professor Goodsir, the interparietal of the mammals is part of another sclerotome, being the homologue of the divided roof-bone of the temporal cincture, the so-called 'parietals' of oviparous vertebrata: Professor Goodsir calls these upper temporal elements temporo-parietals.

The mastoid would appear to be present in *Colymbus cristatus* (in very young birds), from some observations made by Dr. Hallman (Croon. Lect. p. 54); but examination of the development of Divers, Auks, Penguins, and allied birds is very desirable; and perhaps the Struthionidæ, taken early enough, might reveal a distinct osseous centre for this bone.

We consider Cuvier's 'rocher' in fishes and Professor Owen's 'petrosal' to be the mastoid; the large bone notched or perforated in front by the trigeminal nerve being, as Professor Huxley has unanswerably shown, the true petrosal (Croon. Lect. p. 24).

In the Common Mole, *Talpa europæa*, the mastoid is very large, and forms more of the cranial wall than its serial homologue, the squamosal; in this creature the petrosal forms nearly the whole of the labyrinth.

That the mastoid is not necessarily connected with the petrosal is shown in the skull of the Common Bat, *Vespertilio murinus*; for in this instance (and apparently in the Brazilian, *Molossus obscurus*), the mastoid is anchylosed to the ex- or lateral-occipital, and is only connected by membrane to the squamosal and petrous bone, the latter bone being totally distinct from all the surrounding elements.

We now return to the occipital bone of adult birds.

In the Hornbills (*Buceros*), where the mere size of the head (although extremely light) causes the expenditure of much muscular force, a tubercle exists above the foramen magnum, for the attachment of a very thick elastic ligament: this tubercle is wanting in the Balæniceps and the Adjutant.

In the Common Heron the occipital resembles that of the Balæniceps, but it is higher in proportion to its width; its upper boundary is almost straight, there being only a slight angle in the centre, where the transverse occipital crest is confluent with the sagittal; the par-occipital processes also are relatively much smaller. But the elegant basi-cranial pterapophyses, and the open Eustachian groove between the proper basi-sphenoid and the basi-temporal, are singularly like what we find in the Balæniceps. The Adjutant and the Albatros have this canal open in the dry skull, but in most birds it is more or less covered in, leaving only a central aperture.

In the Pelican the line of junction between the occiput and the upper part of the skull forms a very obtuse angle, these surfaces being at nearly a right angle in the

Balæniceps and Adjutant. There is only a general class-resemblance between this part of the Pelican's skull and that of the Balæniceps.

The occipital cincture in the Boat-bill (*Cancroma*) is intermediate between that of the Heron and the Balæniceps; the crests marking its boundary are thicker, but not more distinct than in the Heron; in Balæniceps these ridges are fainter, at least in the skull of this scarcely mature captive.

Upper Cranial Surface. (Pl. LXV. fig. 6.)

The upper surface of the skull in this strangely interesting bird is formed (as in the rest of its class) principally by the parietals (figs. 1 & 6, *p*) behind, and the principal frontals anteriorly. The lacrymals (figs. 1 & 6, *l*) generally assist the principal or sphenoido-frontals (figs. 1 & 6, *fr*) in front; but in the Balæniceps and a few other birds these bones are facial, being anchylosed to the nasals (figs. 1 & 6, *n*), or ethmoido-frontals of Goodsir, and intermaxillaries. The parietal region is eked out laterally in all birds by the squamosals (Pl. LXV. figs. 1, 3, 6, & 7, *sq*)—the temporals of Cuvier, and the mastoids of Owen, but incontestably shown to be the homologues of the mammalian squamosals in the masterly Croonian Lecture of Professor Huxley, p. 13.

The only birds having a broad, flat, smooth cranial surface at all comparable to that of the Balæniceps are the Maccaws (*Ara*); although some of the Totipalmatæ make some approach to it, *e. g.* the Pelican and the Gannet.

In *Cancroma* the distance between the orbits is proportionally much less, and the general surface, although smooth, is more irregular, whilst in the Adjutant it is convex and rough. In the Heron, the upper part of the skull is as polished and smooth as that of the Balæniceps; but its shape is very different, its length being very great in proportion to its breadth. The relative proportions of the upper part of the Balæniceps will be best shown by a few comparative measurements, the width and length being taken at the following points.

Measurements of Crania.

First measurement,—across the cranio-facial hinge.
Second measurement,—across the middle of the orbital margins.
Third measurement,—across the post-frontal processes.
Fourth measurement,—entire sagittal line of the skull proper.

	First measurement. in.	Second measurement. in.	Third measurement. in.	Fourth measurement. in.
1. Adjutant, *Leptoptilus*	2	$2\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{4}$
2. Whale-bird, *Balæniceps rex*	$1\frac{7}{8}$	$1\frac{1}{12}$	$3\frac{1}{10}$	$2\frac{1}{2}$
3. Boat-bill, *Cancroma cochlearia*	$\frac{6}{7}$	$\frac{2}{3}$	$1\frac{2}{5}$	$1\frac{5}{8}$
4. Goatsucker, *Podargus humeralis*	$\frac{5}{8}$	$\frac{6}{11}$	$1\frac{7}{8}$	$1\frac{1}{2}$
5. Grey Heron, *Ardea cinerea*	$\frac{6}{9}$	$\frac{7}{8}$	$1\frac{5}{13}$	$2\frac{1}{3}$
6. Hornbill, *Buceros bicornis*	$2\frac{1}{4}$	$2\frac{3}{7}$	$2\frac{1}{5}$	$2\frac{1}{3}$
7. Maccaw, *Ara ararauna*	$1\frac{2}{5}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$
8. Pelican, *Pelecanus onocrotalus*	$1\frac{2}{5}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$

In Balæniceps, as in the great Maccaws, the orbital margin of the frontal is higher (in the former $\frac{1}{8}$th of an inch) than the mesial part of the bone; and this marginal elevation in both kinds subsides gently into the slightly concave upper interorbital surface of the frontals. In the Maccaws and in the Balæniceps, the highest part of the cranium is between the post-frontal processes; and in the latter the shape of the cranial cavity is in some degree marked out on the external table of the frontal and parietal bones. The orbital margin of the frontal (or, as Professor Goodsir calls it, the sphenoido-frontal) in Balæniceps is, as is usual in this class, more or less notched or perforated by vessels. In the Boat-bill and in the Heron, the large eye-ball has elevated the orbital margin of the sphenoido-frontal; but this takes place most in the latter, in which bird the concavity between these margins is unusually deep.

In the rough, unevenly convex cranium of the Adjutant, the orbital margin is nearly half an inch below the mid-line of the frontal.

In Balæniceps, a gentle ridge of bone, arising from the posterior edge of the post-frontal process (figs. 1, 3, 6, *pf*) passes upwards and backwards to the distance of about two-fifths of an inch from the mesial line of the skull in the parietal region, and to one-third of an inch in front of the epiotic eminence. This gently curved ridge is the anterior boundary of the temporal fossa (Pl. LXV. figs. 1 & 3, *tf*), which is subtriangular in shape, and has for its posterior margin a line, nearly at right angles to its anterior boundary, which line runs outwards, downwards, and backwards, losing itself in the ridged crest of the upper mastoid eminence. The inferior margin of the temporal fossa is incomplete in front, there being a large semi-oval space between the post-frontal process and the articular surface of the base of the squamosal for the external condyle of the head of the os quadratum. Behind this external quadrato-squamosal facet a rough ridge of bone runs horizontally across, losing itself in the fossa between the upper mastoid eminence and the 'par-occipital' ala; this ridge defines the temporal fossa below and behind.

These fossæ are ten lines apart in Balæniceps; in the highly arched head of the Adjutant they do not meet by two inches; the distance of these fossæ in *Buceros bicornis* is one inch and four lines, in the Maccaw one inch and six lines; and in the Pelican they do not approximate more than in the Maccaws.

But in many birds, *e. g.* the Heron, Boat-bill, Podargus, Diver (*Colymbus*), and the larger Grebes (*Podiceps*), the temporal fossæ are only separated by a sharp interparietal crest, whilst their anterior and posterior boundaries are almost parallel. This is like what obtains in many other vertebrata, the extreme conditions of this sagittal ridge being found in such fishes as the *Ephippus*, *Pagellus*, and *Platax arthriticus*; in the Chameleon amongst the reptiles; and, in the mammals, in such skulls as those of the Tiger, Hyena, and certain Bats, *e. g. Molossus obscurus*.

The post-frontal process of the Balæniceps is strong, and descends downwards, and also slightly outwards and forwards, its length being eight lines. The end of this process is, according to Owen, formed in the Emeu by a distinct ossific centre[1]. We possess a sketch of it, from a dissection made by us many years ago of an Emeu only six weeks old.

This exceptional ossific centre appears to be the actual representative of the post-frontal of the cold-blooded vertebrates, and to be the upper neurapophysis of the pre-sphenoidal sclerotome. Professor Goodsir places it to the account of the post-sphenoid, the roof-bones of which, he says, are deficient in all the Ovipara[2]. In many birds, *e. g.* Parrots, Gallinæ, and the Adjutant, &c., the lower part of the temporal fossa is bridged over in front by the union of the post-frontal with a sort of zygomatic process of the squamosal.

In Balæniceps, the Heron, and the Boat-bill, the spur of the squamosal is quite rudimentary.

Professor Goodsir (*loc. cit.*) considers that the so-called 'frontals' of the Ovipara are not the homologues of the Mammalian frontals; these latter bones, besides roofing-in the ethmoidal region of the Mammal (which in that class is included in the cranium), contribute largely to the formation of the great cranial dome. The homologues of these latter bones are, according to him, to be found in the so-called 'nasals' of the Bird and prefrontals of the Reptile; but this requires much renewed investigation. The upper surface, therefore, of the Bird's skull is formed in front by sphenoido-frontals, and behind by the parietals. In Mammalia, the temporo- or inter-parietal, as a rule, is single[3]; but in the Muridæ, and in the Common Mole, this piece is relatively as large as both the parietals in many of the Ovipara. In the latter animal the proper frontals, called ethmoido-frontals by Goodsir, are very little extended beyond the ethmoidal region.

Squamosal (Pl. LXV. figs. 1, 3, 6, & 7, *sq*).—The element to which the 'quadratum' is suspended Cuvier calls 'temporal' in birds, and 'mastoid' in reptiles and fishes; Agassiz calls it '*écaille du temporal*'; and Professor Owen considers it to be the 'mastoid' in all the Ovipara. Dr. Hallman calls it 'squama temporis'; and we quite agree with Professor Huxley when he says (speaking of it in the bird), "there is not a single relation (save the connexion with the jugal) in which this bone does not resemble the squamosal of the *Mammalia*; there is not one in which it does not differ from the mastoid" (Croon. Lect. p. 14).

In the Chick, on the eleventh day of incubation, the sphenoido-frontals exist as a thin osseous scale along each orbital margin; the bony piece at its widest part extending about a line both above and below the upper orbital boundary. At the same time the parietals are small ovoid patches just above the squamosals, which are already ossified, and fully twice the size of their meta-neurapophyses, the parietals. In the Pigeon, one

[1] Owen, Osteol. Catal. vol. i. p. 260.
[2] Edinb. New Phil. Journ. 1857, p. 170.
[3] The inter- or temporo-parietals have two centres in the young Dugong, and probably in the 'Lissencephala' at an early age.

day after hatching, these three pairs of osseous centres are about equal to what may be seen in the Chick on the eleventh day (nine days before hatching).

Looking at the side of the Balæniceps' skull between the post-frontal and squamosal, there may be seen, eight lines mesiad of the anterior spur of the latter, a large oval foramen, which has a conjugational relation between the petrosal, ali-sphenoid, and basi-sphenoid. This passage (the foramen ovale) transmits the chief part of the trigeminal nerve, and is one of the best landmarks in the study of the anatomy of the cranium in all the Vertebrata. This aperture is wide below and narrow above; it is four lines in extent in its long diameter, the direction of which is backwards and outwards. A bristle passed across the floor of the cranium through both the foramina ovalia lies one line behind the posterior clinoid processes.

Ali-sphenoids. (Pl. LXV. fig. 1, *a s.*)

The ali-sphenoid of Balæniceps is crossed at its upper third by an ascending crescentic ridge which joins the post-frontal process and forms the antero-inferior boundary of the temporal fossa. At one-eighth of an inch in front of the foramen ovale there is a triangular eminence in a line with the middle of that passage; and at the same distance in front of this eminence, but higher up, a twin passage exists. This divided passage is a little below and behind the great optic foramen, which opens freely into its fellow of the opposite side, and which notches the posterior border of the connate orbito-sphenoid. The optic foramen of Balæniceps is half an inch in front of the foramen ovale and one-third of an inch higher up. A bristle passed through both the optic foramina lies in front of the anterior margin of the very deep sella turcica, and passes across the middle of the anterior or, rather, internal margin of the ali-sphenoids. The optic foramen is four lines in diameter; its shape is ovoid, the narrow end pointing outwards and a little downwards. Half an inch above this foramen another exists, half its size; this is the remains of that membranous tract in the primordial cranium between the cartilaginous interorbital septum and the cartilage in which the ali-sphenoid was developed: through a passage in the lowest part of this tract the optic nerve passed. By means of the extension of ossific matter from the growing ali-sphenoid, and the diverging alæ of the orbito-sphenoid, this membranous tract becomes bony for more than its middle half, its upper part continuing membranous, and its lower third becoming the large well-margined optic foramen.

There is a considerable eminence on the ali-sphenoid, two lines above the foramen ovale, which breaks into two elegant crescentic ridges, the anterior ridge passing at the distance of a line behind the one already described to the base of the post-frontal, whilst the posterior ridge passes outwards and backwards to the quadrato-squamosal joint. The bone across this middle part is very thick and cellular.

The ali-sphenoids wall-in a great part of the up-turned base of the brain; the diverging alæ of the connate orbito-sphenoids contributing but little to the cranial cavity, whilst the ethmoidal sclerotome is wholly facial and catacentric.

In the Chick, on the eleventh day of incubation, the cartilaginous ali-sphenoids have coalesced with the cartilage of the base of the cranium (although, from Rathke's observations on the Snake, they are perhaps separately formed at first in the membranous wall), but no osseous deposit has taken place. In the Pigeon, one day after hatching, the centre of this cartilaginous patch is still membranous, and this is the last part to ossify, but it is filled up at the end of the first week. In the Chick, on the fourteenth day, there is a wide ring of bone round the ali-sphenoid, the centre being still cartilaginous. This bone is bounded above by the sphenoido-frontal, in front by the orbito-sphenoid, supero-laterally by the squamosals, below by the basi-sphenoid, and behind by the petrosal.

Petrosal. (Pl. LXV. figs. 1 & 7, *pt.*)

This latter bone, the petrosal, has a very cellular character externally; its anterior margin is the foramen ovale, and its posterior termination is indicated by the fenestra ovalis, in which the base of the columella is fixed. Seen through the foramen magnum the petrous bones project considerably into the cranial cavity, passing as thick beams of bone upwards and backwards to lose themselves in the diploë of the combined parietals and epiotics, and downwards and forwards to coalesce with the basi-sphenoids just outside the posterior clinoid processes.

Speaking of the petrosal in the young Ostrich, Professor Huxley says (Croon. Lect. p. 12), "The par vagum passes out between the bony mass under description and the ex-occipital: the third division of the trigeminal leaves the skull between it and the ali-sphenoid. The portio dura and portio mollis enter it by foramina very similarly disposed to those in the Sheep: superiorly there is a fossa on the inner face of the bone, which corresponds with a more shallow depression in the Sheep, and like it supports a lobe of the cerebellum. Finally, the anterior inferior edge of the bone traverses the middle of the fossa which receives the mesencephalon. In every relation of importance, therefore, this bony mass corresponds with the petro-mastoid of the Sheep, while it differs from it only in its union with the ex-occipitals and the supra-occipital posteriorly, and its contact with the cranio-facial axis below."

In the Chick, on the eleventh day of incubation, and in the Pigeon, one day after that period, the petrosals are still entirely cartilaginous, the semicircular canals shining through the cartilage, which will be differentiated into these elements, the epiotics, and the mastoid margin of the ex-occipitals. In the Chick, on the fourteenth day, much ossific matter has been deposited, and two days later the relation of these parts can be well seen; but the most projecting parts of the semicircular canals still shine through the connecting cartilage. The mass of the petrosal lies internal to, or mesiad of, the ali-sphenoids in front, and the ex-occipitals behind, whilst externally they are hidden by the large ossa quadrata—the proximal hæmal elements of their own sclerotome, of which they are, if Professor Goodsir be right, the inferior neurapophyses: Professor Huxley prefers calling them, as well as the contiguous mastoids and epiotics, 'periotic bones.' The determination of the petrosal in the different classes of Vertebrata seems to Professor Huxley and to the writer to be a very straightforward and simple piece of work; but its bibliography is frightful; and although the form, functions, and relations of this element speak one language, its very existence has often been ignored when well developed, as it is almost invariably, whilst the somewhat inconstant 'mastoid' has been often mistaken for it.

That the exit of the main nerves can be depended upon for the determination of special homologies there can be but little doubt (see Huxley, Croon. Lect. p. 36): to us, the denial of this is the weakest point in one of the most masterly disquisitions on the subject of homologies we have ever had the pleasure and the advantage to read (see Professor Goodsir, *op. cit.* p. 171).

Bàsi-temporal (Parker). (Pl. LXV. figs. 3 & 7, *b t.*)

Above the petrous bone is the squamosal, and below it we have what might be the broad centrum of the 'temporal sclerotome' of Goodsir. In describing the basi-occipital, elegant crescentic laminæ, the pterapophyses (confluent in front) of the basi-temporal, were spoken of. This thin, free, horizontal margin of the base of the skull in the temporal region surrounds a semicircular mass of bone, the round border of which is in front, its mesial part is concave, and its sides thick, mammillate, and somewhat ridged transversely. These elevated tubercular masses are each one-third the width of the thick part of this bony base, the middle third being elegantly concave. This concave part alone lies in the same plane as the basi-occipital; the two original halves of this, the basi-temporal, being cortical ossifications of the original cartilaginous basis cranii. We have already said that the alar margins of this basi-temporal are confluent with the par-occipital alæ by the bridge of bone which forms the large lateral reniform foramen. These alar productions form the floor of the tympanic cavity, and are evidently the actual homologues of a pair of 'pterapophyses,' which are very largely developed in certain *lissencephalous* mammals, *e.g.* the Mole and the Hedgehog. In the latter animal the tympanics are mere osseous rings (these bones becoming fainter as we approach the Ovipara); but the internal and inferior part of the tympanic cavity is all formed by supplementary 'pterygoid plates,' which encroach upon the basi-occipital region, and have between them, in front of the basi-occipital, a large dome-shaped recess. Professor Owen's elegant term 'pterapophysis' is very convenient for these productions of the cranial centra—the analogues of the vertebral parapophyses and hypapophyses (processes that run insensibly into one another).

Now it is evident that these temporal pterapophyses of the Hedgehog are something supplementary, for they are a line and a half behind the pterygoid bones and the post-sphenoidal ento- and ecto-pterapophyses; whilst the basi-sphenoid itself is double its usual size, and looks very much like two coalesced pieces. Observations on the crania of young Insectivora are a great desideratum; for we shall see that the Ovipara have what might be taken for the centrum of a temporal sclerotome!

From our early days we have been in the habit of looking at the lower part of the sphenoido-temporal region in birds as something structurally distinct from the upper—that part which forms the 'sella,' and runs forward as the strong basal beam of the interorbital septum.

Looking at this region of the skull of the Chick on the eleventh day (a little past the middle of the incubating period), we find three centres to the 'basi-sphenoid,' one mesial and anterior, on the same high plane as the basi-occipital, and two symmetrical pieces below and between these higher osseous centres; the latter two are developed in the lowest stratum of that basi-cranial cartilage which fills-in the hypophysial space. These cortical ossifications lie exactly between the ossa quadrata, the fenestra ovalis being on a line with the posterior end, the foramen ovale lying over the anterior; their shape inclines to a right-angled triangle, the bases being opposed to each other. Each of these ossifications is a very thin shell, convex below and somewhat cupped above; and they never encroach much upon the primordial cartilage, forming (as they do in the adult bird) the thin lower table of the basis cranii, and connected to the single mesial element above by delicate threads of bone and by the osseous canal of the internal carotid. These pieces curve upwards both before and behind; the basi-occipital is horizontal; and the basi-sphenoid points steadily upwards, being ultimately anchylosed to the descending plate of the pre-sphenoid in front, and of the connate orbito-sphenoids in the middle, whilst its posterior extremity becomes fused to the basi-occipital, thus excluding the basi-temporals altogether from the cranial cavity. Professor Goodsir (*op. cit.* p. 154) says, "The passage of the anterior acuminated extremity of the centrum behind, beneath the lower margin of the pre-sphenoidal centrum, so as to support it, is merely an example of that longitudinal obliquity in the setting on of the cranial centrums against one another, which may be considered as the rule rather than an exception." These basi-temporals appear to be another pertinent instance; yet, after all, they do not necessarily belong to an additional segment of the cranium.

The anterior margin of these ossific centres continues free throughout life in many birds, the Eustachian canal being completed by membrane; this is especially the case in *Balæniceps*, *Ardea*, and *Diomedea*.

In young Rooks of the fourth week the basi-temporal is separate from the basi-sphenoid, and in the adult Merlin (*Falco æsalon*) and in the Lapwing (*Vanellus cristatus*) much of the suture still remains. The external margin of each basi-temporal forms the floor of the tympanic cavity, like the temporal pterapophyses of the Hedgehog and Mole. In the Chick, the ossification of these parts proceeds *pari passu* with that of the premaxillaries; they have coalesced with each other on the fourteenth day, at which time the pre-maxillaries are fused together, and the evanescent frontal process on which they were modelled has begun to shrink.

That the 'rostrum' of the Chelonians and Crocodiles is an unsymmetrical mesial ossification we have no doubt; not so the lower part of the so-called basi-sphenoid. Rathke says (Croon. Lect. p. 60) that "the body of the basi-sphenoid is (in the Snake) formed between the posterior fontanelle of the basis cranii and the pituitary space, therefore far from the cephalic part of the chorda! It ossifies by two lateral centres, each of which forms a ring round the carotid canal." This is exactly what occurs in the Chick; and we find that in the Chameleon (where the rostrum is feebly developed) these basi-temporal centres retain the posterior half of their connecting suture, whilst a trace of it still remains in the adult Blind-worm[1] (*Anguis fragilis*).

In young specimens of the *Crocodilus acutus* from San Domingo (for which we are indebted to Henry Power, Esq.), we find that the rostrum had coalesced with the basi-temporals, and these with each other, leaving a large open space between the tables of bone; and yet these specimens were only recently hatched when taken, the abdomen being nearly full of unused yolk-substance.

In the Pigeon, one day after hatching, the two halves of this lower piece, which Professor Goodsir would call the temporal centrum, had coalesced; but in large 'squabs' a week old, this *underlapping* piece was easily separable from the upper piece or true basi-sphenoid.

Nothing that we have ever seen in anatomical structure is more elegant than the condition of these parts in the Balæniceps and the Heron; in the latter they are essentially a miniature of those of the former: this is certainly not a faint and superficial mark of affinity.

That cranial centra may be developed from a pair of lateral centres is seen in the morphology of the human sphenoid bone (Meckel, as quoted by Professor Owen, Report on Archetype, p. 318), in the double ethmoid and vomer of the great Sudis (*Arapaima gigas*), and in the condition of the vomer and turbinals of the Lacertian and Ophidian,—the former (the vomer) being evidently a pair of latero-basal ossifications of the ethmoid, and the turbinals the corresponding pterapophyses or outgrowths of the ethmoidal sclerotome.

Basi-sphenoid. (Pl. LXV. figs. 1 & 7, *b s.*)

Many birds have, like the Mammalia, two pairs of basi-sphenoidal pterapophyses, an inner pair abutting against a process from the pterygoid (its proper cranial attachment),

[1] Since the above was written, we have dissected a young specimen of *Emys europæa*, and find that the basi-sphenoid is developed from a pair of lateral inferior centres, which soon coalesce in front, and then send forwards a triangular wedge of bone to fit-in between the pterygoids. In this specimen the 'rostrum,' which is the homologue of the basi-sphenoid of the Bird, is a knife-like plate of cartilage, which never ossifies in this and other small Chelonia. In the Crocodiles, in the Green Turtle, and in the 'Loggerhead' it does ossify.

and a posterior expanded pair that form the anterior wall of the tympanic cavity and the superior and anterior boundary of the Eustachian tubes. The anterior or inner pair are represented in Balæniceps by two bevelled articular surfaces on the sides of the great rostrum near its middle. We shall give some tables showing the modifications of these parts in various birds relatively to the pterygo-palatine apparatus. In front of these facets the basi-sphenoid of Balæniceps becomes gradually thinner, ending in a quadrate wedge-like process two lines anterior to its proper preceding homologue, the descending plate of the pre-sphenoid; to this plate the rostrum of the basi-sphenoid is anchylosed. Behind the articular facets the rostrum expands, at first gradually, forming a thick beam of bone three lines across, and then it suddenly expands on each side into the elegant, conchoidal, anteriorly incurved ecto-pterapophyses, the counterparts of the marginal wings of the basi-temporal. This element has most substance at the part where its tables and diploë pass into the descending plate of the orbito-sphenoids, just below the optic foramina.

That this is a most important basi-cranial element in birds is seen from its connexion, which must be studied in immature specimens. In the Chick, on the eleventh day of incubation, more than the posterior third of the rostrum is ossified, and this ossific centre, convex below and scooped above to receive the cartilaginous plate of the pre-sphenoid, bifurcates behind, each posterior wing-like moiety lying just in front of, and above, the basi-temporals. This single mesial osseous centre appears to be identical with the distinct so-called *pre-sphenoidal* ossification spoken of by Dr. Kölliker (Berichte von der Königlichen Zool. Anstalt zu Würzburg, 1849, p. 40) and Huxley (Croon. Lect. p. 11).

In the Chick, on the fourteenth day, this ossification of the true basi-sphenoid has already occupied all but the tip of the rostrum, and posteriorly has grown upwards in the direction of the ali-sphenoids and petrosals, and backwards towards the basi-occipital.

On the sixteenth day, however, these parts and their relations can be still more advantageously seen; for by this time the anterior cartilaginous tip is very small, whilst the posterior end of this large and most elegant osseous centre has reached the basi-occipital on the mid-line of the cranial floor, about a line behind the sella turcica, thus entirely excluding the basi-temporals. The groove on the upper surface of the gradually widening rostrum is bounded behind by the anterior wall of the sella turcica with its middle and lateral 'clinoid processes,' whilst opposite these processes the basi-sphenoid expands into the large ecto-pterapophyses, on the upper part of which the ali-sphenoids are attached; nearly the anterior half mesially being occupied by the deep 'sella,' the posterior margin of which is even and smooth, whilst its fundus is perforated by a large foramen (in adult birds) which communicates with the internal carotids. Behind the ecto-pterapophyses the basi-sphenoid contracts, its sigmoid converging margins articulating with the base of the petrosals, and its narrow terminal portion being exactly adapted to the basi-occipital.

We now return to the structure of the basi-sphenoid in the adult bird.

The structure of the basi-sphenoid of the Adjutant is less elegant indeed, but much resembles that of the Balæniceps; but its rostral portion is more like that of the latter than is the same part in the Heron. In this latter bird, at the point where the wing-like ecto-pterapophyses meet, in front of the aperture of the Eustachian tubes, the base of the skull becomes rather sharply carinate, and just in front of these coalesced ridges about one-fifth of an inch of the rostrum becomes synovial, the articular cartilage rising on each side of the mesial line about the twentieth of an inch. In the Boat-bill the rostrum is less carinate than in the Heron, and for four lines in extent the rostrum is coated with articular cartilage. We shall now show how the palato-maxillary fittings are attached to the rostrum in different birds; and these modifications may be conveniently thrown into groups, the characters of which will sometimes have considerable *family* or *relational* value; whilst we shall often find that the same teleological modifications will occur in the most dissociated tribes.

Modifications of the Basi-sphenoid in Relation to the Pterygo-palatine Apparatus.

Group 1.—The ethmoido-frontals (the so-called 'nasals[1]') and nasal processes of the pre-maxillaries being confluent with the principal or sphenoido-frontal, and the palatines having coalesced with each other and with the vomer, the carinate basi-sphenoid has no synovial cartilage. Motion is here limited to the pterygo-palatal and pterygo-quadrate articulations. The vomer is arrested.

Example:—*Buceros*, various species (the Hornbills).

Group 2.—In this group there is a strong transverse synovial hinge, formed by the contiguous margins of the coalesced lacrymals and sphenoido-frontals posteriorly, and of the 'nasals or ethmoido-frontals' and nasal processes of the pre-maxillaries anteriorly, which hinge is further strengthened by the *procœlian* articulation of the ethmoid with the pre-sphenoid. The motion of this cranio-facial hinge is very free, the pterygo-palatal joints gliding along a considerable tract of the rostrum; this process is adapted to them by being round, polished, and well covered with synovial cartilage. Answering to this structure, the pterygoids are long and slender, the quadrate bones and palatines high, or deep, and the vomer arrested.

Example:—*Psittacidæ* (the Parrot-tribe).

N.B. The *Ramphastidæ* or Toucan-tribe seem to connect this group with the next.

[1] We have not the least doubt of the homology of these bones: they are evidently the representatives of the 'nasals' of the Mammalia; the 'sphenoido-frontals' of Professor Goodsir being simply the counterparts of the mammalian 'frontals.'

Group 3.—The great fronto-maxillary hinge is here composed of splint-like laminæ of the nasal processes of the pre-maxillaries and nasals, which overlap the sphenoido-frontals; or the lacrymals and sphenoido-frontals are adapted to the contiguous bones of the facial sclerotome by a dentate suture, the margin of the hinge being more or less synovial. The rostrum of the basi-sphenoid in this group is either patched on each side or completely covered with synovial cartilage for a definite extent, on which lubricated space the pterygo-palatals glide. Vomer variable.

Examples:—

Aquilinæ (Eagles).
Accipitrinæ (Hawks, Falcons, Harriers, Kites, Buzzards).
Vulturinæ (Vultures).
Serpentarius (Secretary-bird).
Podargus humeralis (Giant Goatsucker).
Alcedo ispida (Common Kingfisher).
Dacelo giganteus (Giant Kingfisher).
Cuculus canorus (Common Cuckoo).
Phœnicophaus (a Cuculine genus).
Picus viridis (Green Woodpecker).
Trochilus colubris (Humming-bird).
Sylviinæ (Soft-billed Songsters).
Passerinæ (Hard-billed Songsters).
Corvinæ (Crow-tribe).
Lophyrus cristatus (Crowned Pigeon).
Didus ineptus (Dodo).
Didunculus strigirostris (Owl-billed Pigeon).
Hæmatopus ostralegus (Oyster-catcher).
Œdicnemus crepitans (Stone Curlew).
Platalea leucorodia (Spoonbill).
Otis tarda (Great Bustard).
Grus americana (American Crane).
Grus pavonina (Crowned Crane).
Ciconia alba (White Stork).
Balæniceps rex (Shoe-bill).
Cancroma cochlearia (Boat-bill).
Ardea cinerea (Heron).
Botaurus stellaris (Bittern).
Phœnicopterus ruber (Flamingo).
Rallus (Rail).
Gallinula chloropus (Water-hen).
Fulica atra (Coot).
Tribonyx mortieri (Native Hen).
Brachypteryx australis (Short-winged Rail).
Podiceps (Grebe).
Colymbus (Diver).
Uria (Guillemot).
Alca (Auk).
Eudyptes demersa (Penguin).
Sula bassana (Gannet).
Phalacrocorax carbo (Cormorant).
Pelecanus onocrotalus (Pelican).
Sterna (Tern).
Larus (Gull).
Procellaria (Petrel).
Diomedea exulans (Albatros).

Group 4.—Fronto-maxillary hinge more or less splint-like and elastic, palatines loosely connected with basi-sphenoid. Near the anterior end of the pterygoid there is, on its inner surface, an oval, flat-faced, elevated process, which looks upwards and inwards, and which is articulated to an exactly similar process on the basi-sphenoidal rostrum; this latter process being the well-known ento-pterapophysis of the post-sphenoidal centrum—the homologue of the internal pterygoid plate of the Mammalia and Man. Vomer variable.

Examples:—The typical Gallinaceous genera, *e. g.*, *Pavo cristatus*, *Meleagris gallopavo*, *Talegalla*, *Gallus*, *Perdix*, &c.

The Lamellirostres, *e. g.*, *Anas*, *Querquedula*, *Rhynchaspis*, *Mergus*, *Anser*, *Cygnus*; certain Fissirostres, *e. g.*, *Caprimulgus europæus*, *Cypselus apus*, and the one of the *Pro-*

cellaridæ, e. g. the Short-tailed Petrel (*Puffinus brevicauda*), from Green Island, Bass's Straits (1224, Osteol. Cat. Mus. Coll. Chir. vol. i. p. 230).

Group 5.—Fronto-maxillary hinge more or less moveable and splint-like; palato-pterygoid joints freely gliding on a more or less synovial 'rostrum'; ento-pterapophysis longer and more delicate, as is its answering apophysis on the pterygoid; the facets of this little apophysis are rather round than oval, and their position more backward, being midway between the palatine and os quadratum: in this group the vomer is often well developed and cellular.

Examples:—

- *Strix, Ulula, Asio, Bubo* (Owls).
- *Columba, Palumbus, Treron chlorogaster, Goura victoriæ, Geophaps smithii* (the typical Pigeons).
- *Vanellus cristatus* (Lapwing).
- *Charadrius hiaticula* (Ring Dotterel).
- *Scolopax* (Snipes and Woodcocks).
- *Limosa melanura* (Godwit).
- *Numenius arquata* (Curlew).
- *Tringa variabilis* (Sandpiper).

Group 6.—No movement of the facial on the cranial sclerotomes, the differentiation of the ethmoid and pre-sphenoid in the cranio-facial axis being soon obliterated by the fusion from below upwards of these vertical centrums. The rostrum is large, and the ento-pterapophyses unusually well developed; but they are not connected with the anterior part of their own hæmal bones, the pterygoids, as in Fowls and Geese, nor with the middle, as in Owls, Pigeons, and Snipes, but articulate with a facet on the distal end of these bones, which are wedged in between the ento-pterapophyses and the quadrate bones.

In these *non-typical* birds the pre-maxillaries are relatively small and feeble (as the rule), the maxillaries unusually large, and lying in the same plane as the pre-maxillaries; the palatals small, and pushed aside (so as to resemble the 'transverse bones' or 'ecto-pterygoids' of the Crocodile) by the unusual development of the vomer, which, thin, broad, and split at both ends, passes backwards to articulate with the pterygoids. These latter bones are not at all *bird-like,* but have taken on much of the laminar character of their homologues in the Reptilia, and are adapted to the vomer by a squamous suture, whereas in typical birds they articulate with the palatines by a synovial joint.

Example:—*Struthionidæ* (the Ostrich family).

Orbito-sphenoid. (Pl. LXV. fig. 1, *o s.*)

Looking at the middle part of the well-formed orbital roof of Balæniceps towards the axis, we see a small foramen two lines above the oval membranous space already mentioned as a landmark between the ali- and orbito-sphenoids. This small foramen pierces the sphenoido-frontal just above its union with the diverging plate of the orbito-sphenoid. Five lines in front of and a little above this passage is another, scarcely larger, which is continued as an open groove forwards and a little upwards into the nasal fossa. This groove is on the side of the upper thick part of the pre-sphenoid: the foramen itself, although single, answers to the many foramina of the cribriform plate of the ethmoid in mammals in function (for it carries the olfactory nerve), but not actually, seeing that the ethmoid of birds is facial and not cranial. The recess in which the 'rhinencephala' lie is formed by the diverging plates of the connate orbito-sphenoids below and by the frontals above; and although these lobes are the most anterior part of the brain, they are pitched up, as it were, against the roof-bones. The optic foramina mark the point where the orbito-sphenoid has become single and passes downwards and forwards, losing itself in front in the pre-sphenoid, and becoming confluent below with the 'rostrum' of the basi-sphenoid.

A fossa above the optic foramen is the upper landmark of the connate orbito- and pre-sphenoids—the neurapophyses and centrum of this semi-catacentric sclerotome, so curiously modified in relation to the large eye-balls. The centre of the originally membranous wall between the orbits is unusually well developed in Balæniceps, being generally arrested more or less in the Bird-class; it is, however, in this bird all converted into bone, the diploë of which is scarcely absent from even the central part. Although, for convenience-sake, we have separated the orbito-sphenoid from the pre-sphenoid in description, they are nevertheless only parts of one large inter-orbital ossification in the class of Birds.

The thick anterior part of the pre-sphenoid is the first to ossify; this process commencing in the Chicken about the twelfth day of incubation, and in the Pigeon near the time of hatching. The latter bird is able to fly before any of the orbito-sphenoidal region is ossified; and both the Chicken and the Emeu have attained a considerable size before the ossific matter reaches the ali-sphenoids.

In such birds as the Rail and Water-hen, the Grebe and the Cormorant, the interorbital septum is very incomplete. The leg of the inverted Y-shaped process bounding the common optic passage in *Gallinula chloropus* is an exogenous spur growing backwards and downwards from the pre-sphenoid; but nearly at right angles with this, another spur projects forwards and downwards. This latter spur, with the diverging alæ that coalesce with the ali-sphenoids just above each optic foramen, might easily be mistaken for the actual representative of the little Y-shaped interorbital bone of such fish as the Perch and the Sea-bream (*Pagellus centrodontus*). This latter ossicle has indeed been a 'bone of contention:' it is the 'sphénoïde antérieur' of Cuvier, the 'entosphénal' of Geoffroy, the 'os innominatum' of Hallman, and the 'ethmoïde cranien' of Agassiz; whilst Professor Owen, calling it the 'ento-sphenoid,' considers it to be the internal part of the centrum of the pre-sphenoidal vertebra; but its real nature was well seen by Professor Goodsir, who considers it to be a feebly developed centrum of the post-sphenoid, or perhaps even of the temporal sclerotome. We do not agree with Cuvier that it is part of the anterior sphenoid, nor with Professor Owen that it represents the "conjoined bases of the orbito-sphenoids in mammals:" we quite coincide with Dr. Hallman and Professor Huxley that its supposed representative in the Carp is the orbito-sphenoid; but not with Agassiz (with whom Professor Owen once agreed in this matter) that it is a cranial ethmoid. It does not agree with that hinder part of the connate orbito-sphenoids in the Carp which props up, and therefore lies *below* as well as in front of the ali-sphenoids (see Professor Huxley's figure of the section of the Carp's skull, Croon. Lect. p. 24)[1]. This is not really a digression (for the crania of the Vertebrata mutually explain each other); we will therefore give one word more about this elegant little bone. In the Sea-bream (*Pagellus centrodontus*) the structure of a typical fish can be well seen. Looking at the floor of this creature's skull, three remarkable bridges of bone are seen along the medial line: the hindermost of these is formed by the meeting of the ex-occipitals above their centrum; the middle bridge is formed in the same way by the petrosals, the basi-sphenoid lying at a great distance below the cranial floor; whilst the first bridge is formed by a single bone (this 'ento-sphenoid'), as though it were the serial homologue of these two pairs of bones behind. If this most anterior bridge belong to the same category as the petrosals and lateral occipitals, it should not directly precede the former were it the orbito-sphenoid; and it is not a lateral element; for perched up above and between it and the petrosals are the ali-sphenoids—pretty constant in fishes, but always high up, being feeble ossifications of the antero-lateral parts of the primordial skull, and lying in the midst of the still unossified cartilage that projects forwards on each side from the boundary of the great fontanelle. In the Reptilia proper the orbito-sphenoid is seldom present as a distinct bone; for, although the roof-bones of the pre-sphenoidal sclerotome are largely developed as the 'principal frontals,' the neurapophyses and centrum are arrested. In the Batrachia they break out again, the neurapophyses forming the ring, and the centrum (pre-sphenoid) the septum, of the 'os en ceinture' (see Goodsir, *op. cit.* p. 157).

Pre-sphenoid. (Pl. LXV. fig. 1, *psp* & *eth.*)

The pre-sphenoid of the Balæniceps is large and well-developed: no part of it can be seen from above, the roof-bones being very perfect; but it projects a line or so in front of them, just touching its serial homologue the ethmoid. All trace of the union of the orbital processes of the sphenoido-frontals with the pre-sphenoid is lost; but the groove for the olfactory nerve, and a descending process on each side marking the limits of the nasal fossæ (which are continued backwards for four lines on each side of the pre-sphenoid at its upper part) show where we are. This descending process is just behind the 'hinge,' half an inch mesiad of the orbital margin. A strong fascia connects it with another smaller projection on the side of the thick carinate anterior part of the pre-sphenoid, half an inch below the widely-dilated part which props up the

[1] The so-called 'ento-sphenoid' is properly an 'orbito-pre-sphenoid' in such fishes as the Carp and Salmon; but we class the little Y-shaped bone of the Percoids with the 'rostrum' of birds and the higher reptiles.

'principal frontals.' In the Heron these processes are bridged over by bone, thus walling-in the olfactory nerve. The anterior keeled margin of the pre-sphenoid of Balæniceps is sinuous, but vertical above, whilst its lower half retires a little before coalescing with the projecting 'rostrum.' In the Heron this centrum retires very much more, and the inferior antorbital process, after bridging over the olfactory nerve, sends an elegant curled lamina downwards, outwards, and forwards. This process, so large in the Albatros and many other birds (*e. g.* Snipes, Woodcocks, Pigeons, Goatsuckers, Owls, Parrots, &c.), but almost obsolete in the Balæniceps, Boat-bill, and Adjutant, in Gallinæ, Anatinæ, and in those wading, swimming, and diving birds in which the orbital margin is very incomplete, is a 'pterapophysis',[1] and its special homologue may be well seen in such mammals as the Rabbit. Serially, it is homologous with those 'pterygoid plates' spoken of as pertaining to the post-sphenoidal and occipital centrums.

The pre-sphenoid of Balæniceps is thick and cellular above, in front, and below; its middle part behind helps the orbito-sphenoid to finish the flat inter-orbital septum. In our description of the orbito-sphenoids, we spoke of the deficient ossification of this septum; we will add, that its extreme development, as to thickness and cellularity, is in Owls, especially the Screech Owl (*Strix flammea)*, and in Goatsuckers (*Caprimulgus*). In the diurnal Raptores it is more or less imperfect, as also in the Pigeons and Gallinaceæ; in Parrots, Toucans, Woodpeckers, and most of the Scansores, it is very perfect, but not in the Hornbills. It is very imperfect in the Corvine, Passerine, and Sylviine groups, so nearly related to each other, and so potent in genera and species. In the smaller Ardeine birds (*e. g. Ardea, Botaurus*, and *Cancroma*), in Cranes, Spoonbills, Curlews, Plovers, Godwits, Rails, Coots, Jacanas, Grebes, Divers, Auks, Gulls (the smaller species), Gannets, Cormorants, Penguins, Petrels, and even in the Albatroses, the inter-orbital septum is more or less incomplete. In the larger relations of Balæniceps this septum is perfect (*e. g. Ciconia alba*, and in *Leptoptilus*), and the same may be said of the *Struthionidæ*. For an account of the manner in which the olfactory chambers encroach upon the sides of the pre-sphenoid in such birds as the Ostrich, Dinornis, Apteryx, Cassowary, and Dodo, &c., see Professor Goodsir's paper (*op. cit.* p. 156). We may remark, however, that the Common Duck and the Albatros are familiar but very beautiful instances of birds in which these pre-sphenoidal nasal cavities are large and well-developed.

Lacrymal. (Pl. LXV. figs. 1 & 6, *l.*)

The next bone to be spoken of (the lacrymal) belongs properly to the face, but its important relations with the sphenoido-frontals and antorbital processes (pterapophyses) of the pre-sphenoid make it convenient for it to be dealt with at once.

[1] Where there is a distinct centre for this process, it is something more than a 'pterapophysis,' as may be seen in young Pigeons; in these birds it evidently is, what Professor Owen calls it, the homologue of the human 'os planum.'

The lacrymal (prefrontal of Dr. Melville) becomes confluent with the sphenoido-frontal in many genera of birds,—*e. g. Trochilus, Picus, Ramphastos, Buceros, Psittacus, Columba, Hemipodius, Ciconia, Recurvirostra, Limosa, Numenius, Vanellus, Parra, Apteryx, Anas, Anser, Pelecanus, Sula, Phalacrocorax, Gavia, Sterna, Larus*, &c.

In a large number of genera it articulates with both the sphenoido-frontals and nasals or ethmoido-frontals; the latter receiving about one-third of the internal margin of the lacrymal, the former two-thirds.

In many birds the lacrymal *coalesces* with the antorbital 'pterapophyses,' but *articulates* with the sphenoido-frontal,—*e. g.* in the Thrush and Lark; whilst in others it articulates with the antorbital process, but becomes confluent with the sphenoido-frontal,—*e. g.* in the Lapwing (*Vanellus cristatus*).

In those birds which have the upper part of the nasals well developed, *e. g.* the Pigeons, Gallinaceous Birds, and Ostriches (*Struthio, Rhea, Dromaius, Casuarius*), the lacrymal articulates entirely, or nearly so, with the nasal or ethmoido-frontal; also in the Divers (*Colymbus septentrionalis* and *glacialis*) the small lacrymal is in the same way entirely facial in position. The rarest condition of this bone is seen in certain large Australian Goat-suckers, *e. g. Podargus humeralis*, and in *Balæniceps*, in which birds it is not only altogether in front of the sphenoido-frontal, but also coalesces with the nasal above, and with the maxillary below. In these instances its upper and posterior portion forms the outer and anterior part of the great fronto-maxillary hinge, instead of being behind that hinge, and assisting the coalesced sphenoido- or principal frontals in forming it, as in Parrots, and indeed in most birds.

In *Cancroma* the lacrymal is small, much smaller in proportion than in its congeners, *Ciconia, Leptoptilus, Ardea, Botaurus*, and *Balæniceps*, and three-fourths of its articulation is cranial, or rather supra-orbital. In *Podargus* the lacrymal does not appear to extend down far, but bounds the orbit above and in front; in *Balæniceps*, however, it passes down to be articulated with the zygoma, and forms the whole of the anterior crescentic margin of the orbit. The most concave part of this margin is at the upper third: above that part the lacrymal is thick and rugous; below it becomes sharp, forming a very perfect anterior boundary to the enormously expanded orbits. Inside and a little in front of this clear sharp posterior margin of the deep lacrymal of *Balæniceps*, a thin plate of bone extends inwards to the extent of nearly four lines: in the upper part of this lamina (which is convex in front and concave behind) there is a large oval foramen, the upper border of which is three lines from the roof, and the lower below the middle of the bone; its shape is oval; its length six lines, and its width three. This is the proper opening of the lacrymal canal; it is quite external to the nasal fossæ, which in the dry skull open widely into the orbit in *Balæniceps*. The width of the lacrymal of *Balæniceps* above cannot be clearly seen; but for the lower two-thirds it appears (by a series of vascular passages along a more or less imperfect vertical tract of bone) to be about two lines. These marginal holes and grooves are on a plane with the pre-maxillary, but the orbital margin of the lacrymal is turned outwards at a considerable angle. This facial development of the lacrymal is like what we see in the Crocodile, and still more fully in certain mammals, *e. g. Bos, Ovis, Sus.* In the Albatros, a thin bone, broad above and pointed below, articulates with the lacrymal near its base in front, and passes downwards to be attached by a ligament to the palatine. In Eagles, Falcons, and Hawks, a small supra-orbital is articulated to the long outstanding process of the lacrymal, and helps to give them their peculiar frowning aspect. This supra-orbital is seen again in certain Crocodiles, and also in some fishes, *e. g.* the Carp. That the lacrymal is not a dermal bone (as Professor Owen says), but 'an actinapophysis of the ethmoidal neural arch,' see Professor Goodsir's arguments in the work already referred to (p. 152). This far-seeing anatomist's writings will not admit of condensation. If the lacrymal of the bird should turn out to be a 'prefronto-lacrymal[1],' then Professor Goodsir's views concerning the next bone, the 'nasal' of authors, will be seen to be mistaken.

Nasal or "Ethmoido-frontal." (Pl. LXV. figs. 1 & 6, *n.*)

As a rule, those cold-blooded oviparous vertebrata with horny toothless jaws (the Chelonia) have no distinct nasals. Professor Owen, who stands unrivalled in osteological experience, has, we believe, seen only three exceptions,—*e. g.* in the recent *Hydromedusa*, and in the fossil *Chelone planiceps* and *pulchriceps* (see 'Rep. on Archet.' p. 224).

The views of Professor Goodsir upon this very difficult subject deserve the most attentive consideration; and it is possible that even in the whole class of Birds there may be no distinct 'nasals;' in that case, that down-turned broad surface of the ethmoid, in such birds as the Vulture, the Hawk, and the Parrot, which, becoming ossified, converts the nostril into a small round anterior opening, would be an exogenous nasal. The nasal of the bird, however, has no descending antorbital process bounding the olfactory nerve externally, for the antorbitals of the bird belong to, or coalesce with, the sclerotome next behind. Perhaps the 'pre-frontals' continue membrano-cartilaginous in birds, or the so-called 'nasals' represent their upper and outer surface; or the lacrymals may be compound in their nature, although this is very unlikely; for it seems to us that the only ossified part of the prefrontal of the bird is the autogenous antorbital.

In those birds which have a broad nasal with its bifurcations widely apart, *e. g.* the Rook and the Fowl, the nasal fossa is oval, the anterior bifurcating margin of this bone being its posterior boundary; where the bone splits itself sharply, *e. g.* the Crane and Plover, the nasal fossa is of necessity angular behind.

In Fowls and Ostriches, the pre-sphenoid appears on the roof between the nasals and sphenoido-frontals; but in most birds these bones form a very perfect covering to this

[1] This is evidently the case when it coalesces with an autogenous antorbital process.

region. In the latter non-typical birds, *e. g. Dromaius* and *Rhea*, the process is obsolete which in ordinary birds descends from the nasal to the maxillary; and in *Rhea* the broad single nasal process of the coalesced pre-maxillaries is unusually short, being succeeded by the nasals, which here meet at the mid-line for some distance, divaricating again as they pass, narrow and splint-like, between the large lacrymals. This meeting of these bones along the mid-line is very exceptional in birds; yet they really do approach each other more nearly than would appear from a casual view of the matter. In such birds as the Pigeon, the thin splint-like mesial and lateral processes form but a small part of the bone, which, higher up, becomes cellular, meets its fellow, and forms a large mesial oval part of the forehead, pushing the narrow anterior portions of the great sphenoido-frontals aside. In birds with very cellular foreheads,—*e. g.* the Owls (*Strix*, *Ulula*, *Asio*, &c.), the Balearic Crane (*Grus pavonina*), the Woodcock (*Scolopax*),—the thin tips of the pre-maxillaries pierce the bone of this frontal region, wedging themselves in between the roof-bones and upturned centrum of the anterior sphenoidal cincture. But the nasals do more than this—they lose their lath-like character, and help to form the rich diploë of this region, most of which is contributed by the sphenoido-frontals. Generally in birds these ethmoidal roof-bones may be distinguished more easily than most of the elements of the upper surface of the head, if we except the lacrymals; and in several Struthious birds, Galline birds, and Rails, they continue pretty distinct throughout life, whilst in a great proportion of species traces of the sutural lines are persistent. This character, combined with their thin, fibrous, elastic condition, makes them very traceable. But this is not always the case; for in birds with a dense, close skull-wall, *e. g.* Parrots, Hornbills, Toucans, and Balæniceps, —and even with a cellular skull, as in the Podargus,—the traces of composite structure in these regions are most of them entirely obliterated. In most typical birds, the nasal either overlaps, pushes aside, or passes under the great frontal (its successor), becoming more or less anchylosed with it: anteriorly it splits or bifurcates, the upper process passing along the inferior and outer margin of the nasal process of the pre-maxillary, whilst the lower process passes downwards and forwards to join the palatal process of the maxillary and the maxillary itself. The extreme degree of coalescence which has taken place in this somewhat immature skull of the Balæniceps makes it impossible to point out the boundaries of the nasals; but some large skulls of the Common Duck scarcely half a year old, in which the sutures are still very evident, and the skull of the Heron will give a good idea of the relations and extent of this bone. The Adjutant (*Leptoptilus*), moreover, even in old age shows the sutural lines in this region, in rows of canals and passages, just as the facial extent of the lacrymal of Balæniceps is shown. In the latter bird, the width of the bone in front of the great cranio-facial hinge is barely two inches; in the former it is slightly above that measurement, and yet the width is not eked out by the lacrymals as in Balæniceps. The nasal processes of the pre-maxillaries in the Adjutant are each half an inch wide at the hinge, the nasals being of the same extent; but in birds which are flat in this region, as the Heron and the Duck, each nasal is nearly four times as wide as the delicate splint-like process of the pre-maxillary, instead of being merely the same width as in the Adjutant. Besides this, the extreme height and convexity of the posterior part of the ridge of the broad face of the Balæniceps must be considered, and also the distance between its nasal fossæ, as measured from the posterior boundary of each. In the Adjutant this distance is ten lines, in the Balæniceps fourteen, which makes it very probable that each nasal process of the pre-maxillary was, in the young bird, even wider than the nasal. Most birds in which the sutures can be seen show that the upper margin of the nasal passage is almost entirely bounded by the nasal, the posterior margin entirely, and a great part of the inferior margin. In Balæniceps this latter line separates the posterior part of the large pre-maxillary internally, as it passes towards its posterior angle, from the horizontal inferior turbinal, which, with its fellow, forms a nearly perfect palatal floor to the nasal fossæ. An arcuate line, its convexity upwards, passing from the middle of the inferior margin of the nasal passage to the point where the maxillary meets the lowest part of the lacrymal and the posterior angle of the pre-maxillary, will indicate, as near as may be, the anterior boundary of the lateral portion of the nasal.

Fronto-maxillary hinge. (Pl. LXV. figs. 1 & 6.)

Adhering to our plan of working *regionally*, we shall leave the ethmoid and ethmoidal hæmapophyses until the præ-maxillæ, nostrils, and cranio-facial hinge have been described.

In the great transverse hinge of the upper jaw on the head, the most external tooth-like process, which passes backwards outside a similar tooth of the frontal going forwards, belongs to the lacrymal, that bone having escaped from its usual connexion with the principal frontal. A third tooth inside these, and which, like the first, looks backwards, belongs to the 'nasal,' and is the outer part of its posterior boundary. This frontal margin is then continued nearly straight towards the mesial line, where about two-thirds of an inch of the hinge belongs to the pre-maxillary. The most projecting part of the hinge is mesial, the pre-maxillary encroaching upon the principal frontal; and, curious enough, this is the place for the great ball-like process of the Maccaws and Parrots, the cup being made in the pre-sphenoid. The lacrymal and 'nasal' tooth-like projections, as well as the corresponding parts in the frontal, are evidently coated in the recent state with articular cartilage, whilst the rest of the hinge seems to be something intermediate between 'harmony' and 'dentate suture.'

To return to the 'nasal.' Anterior to the hinge this bone is smooth, and gently inclines downwards, the smooth and bevelled surface being about half an inch square; it then rises, becoming very rough and punctate, and at five-sixths of an inch from the hinge forms the posterior boundary of the nasal fossa. The nostrils are at this part $1\frac{1}{8}$ inch apart, but further forwards only an inch of bone separates them. The upper margin of these passages, formed by the nasal, is rough, and their bony roof about a line thick ; the lower, formed partly by the same bone, is smoother, but strongly grooved by vessels ; whilst the posterior boundary of the fossa is curiously scooped, the upper scooped concavity being small, and the lower large, and reaching to within one-third of an inch of the orbit. The actual nasal passage is less than half an inch long, and one-sixth of an inch broad ; but the grooved and scooped parts of the osseous boundary beneath project both behind and in front of it, so as to make its vestibular part full an inch long. The nasal fossæ and passages in *Cancroma* are very similar to these structures in the Balæniceps, save that they are relatively larger, and the surrounding parts composed of thinner and smoother bone. In the Heron, the nasal passages, which freely open into each other, are actually longer than in the Balæniceps ; and in the Adjutant they are not so wide, but are twice as long.

The large, well-made nostrils in Balæniceps have no affinity with those of the Pelecaninæ, which are extremely small, and actually become obsolete in the adult of some species, *e. g.* the Cormorant.

Præ-maxilla. (Pl. LXV. figs. 1, 6, & 7, *p m x.*)

Fishes are curiously like birds in the condition of their proper maxillary bones, the 'ossa mystacea,' which were not for some time recognized as the true homologues of the mammalian and reptilian maxillaries. In most typical fishes they are above and behind the dentary margin of the inter-maxillaries, and are themselves edentulous,— the exceptions being in the Salmonidæ, *Sudis*, &c. Passing from the study of any ordinary mammal, or from the Chelonia or Crocodilia to *Balæniceps*, it would seem at first blush difficult to put down nine-tenths of the huge face of the latter to the pre-maxillary elements ; yet such is apparently the fact. Nor is this bird exceptional, for in all the Gallinæ the maxillary bones are, as in most typical fishes, above and behind the dentary margin ; and they are relatively small in all *typical* birds. We have, however, as in the class of Fishes, some instructive exceptions. In the Rhea, a bird whose nasals meet at the mid-line, and in which the sacrum is, much of it, as abortively developed as in the Frog, the maxillaries form half the region of the 'hard palate' and one-third of the dentary margin. In the Emeu (*Dromaius ater*) a similar state of things exists, save that the premaxillary sends a long posterior, angular process, which hides the large maxillary laterally. The rest of the Struthionidæ are more or less like the Rhea and the Emeu in this respect. We have also a similar state of things in the smaller genera of the Fissirostres, as may be seen in the Common Goatsucker (*Caprimulgus europæus*) if examined when quite young. In this bird two-thirds of the palatal region and one-third of the dentary margin are formed by the superior maxillary bone. In the Duck, about half of the margin is *maxillary*.

It was thought necessary to premise these remarks before passing on to describe the rest of the Balæniceps' face. Certainly a large amount of territory has this same pre-maxillary: the whole sweep of the broad and massive ridge, from the wide but anteriorly scanted sphenoido-frontals to the end of the great hooked beak, belongs to it, and much of the dentary margin; the extreme posterior angle is, however, evidently maxillary in its origin. Nor can it be said that the lacrymals and nasals have come

. . . . "cranking in,
And cut it from the best of all its land,
A huge half moon, a monstrous cantle out;"

for the lacrymals, although actually of good size, form but a narrow crescentic strip down the orbital margin; while the so-called 'nasals' have relatively but a small 'lot,' and that all shot into strips and angles. We shall see, moreover, that the pre-maxillary has the hard palate almost entirely to itself, the broad palatines overlapping a little behind; whilst the spongy ethmoidal pterapophyses run forward between and in front of the palatines, nearly filling up that postero-mesial space which, in many birds, is principally composed of membrane. Seen in profile, the dorsal ridge of the *Cancroma* is convex in its whole extent: but in Balæniceps the rise into the rough boss in front of the hinge is rather sudden, the dorsal line in front of the boss descending very gently to the middle; then rising again as gently as it descended, it gradually becomes the upper outline of the great terminal beak. The 'dip' of the dorsal outline is rather more than four lines.

The length of the upper jaw of Balæniceps (not measured along the curve, but in a straight line) is rather more than 7 inches, its broadest part, a little behind the middle, being nearly 3 inches. The same measurements in *Cancroma* are 3 inches, and 1 inch 8 lines. In the Adjutant the widest part is at the zygoma, which is 2 inches 2 lines, its length being 13 inches; and in the Pelican the length is 15 inches and 6 lines, and the broadest part (near the anterior fourth) is rather more than 1 inch 6 lines. Thus we see that in the elegant, broad pre-maxilla of the Boat-bill the breadth is more than half the length (its shape being like that of the distal two-thirds of the leaf of *Magnolia grandiflora*); that of the 'Whale-head' is more than twice as long as it is broad. If, however, the latter were less arched, its width would be relatively as great as that of its small relation. Drawing a basal line from margin to margin of the præ-maxilla, we find its palatine concavity to be 1 inch 2 lines high; this most hollowed part being one-fourth from its hinder margin, from which part the bony plate descends rather rapidly to join the palatines. The greatest concavity of the hard palate is more anterior in the Boat-bill, and it is two-fifths of an inch high; whilst the greatest height in the Adjutant is two-thirds of an inch, at one-fifth of the whole length from the posterior angle.

The 'hard palate' in the præ-maxilla of the Pelican is very flat between the great internal ridges, and, in some respects, the upper jaw of this bird has more resemblance to that of the Flamingo, save for the strange bend in the latter, than to the same part in the Balæniceps.

In most birds the highest part of the upper jaw is between the nasal fossæ, but in Balæniceps it rises just behind them into a sort of rough boss, the bone then becoming smoother for a quarter of an inch as it gently descends to the middle of the great transverse hinge. This character, with the backward extension of the jaw, the shortness of the principal frontals, and the very forward position of the enormous, well-margined orbits, helps to give a solemn, wise, but somewhat sinister aspect to the bird. Looking at the bird in his paddock, the first impression is that we have before us some strangely ancient form with " the breath of life " in it, and " standing upon its feet," concerning which Geology had taught us that " its bones were dried up, and its hope lost."

Passing from the rough boss forwards, we find the bone again becoming smoother, but it continues gently convex along the whole ridge until it expands in the large, terminal, hooked beak. On each side of this convex ridge the bone is scooped by vessels, is concave, and then suddenly rises into a sharp ridge, which overhangs a deep groove, forked at its commencement, as it rises above and below the nasal fossa, and becomes deep and narrow towards the middle, and wider and shallower as it turns off on either side to give boundary to the great terminal hook.

These sharp boundaries to the great sub-mesial grooves are at first seven-eighths of an inch apart, at the anterior third they are scarcely more than a quarter of an inch apart, and are three-quarters of an inch asunder at their termination on the lower margin.

In the dry skull of birds there is generally near the zygoma a large triangular space, its base being the anterior third of the zygoma, its front side the descending plate of the nasal, and the hinder side generally imperfectly bounded by the lacrymal. In the Balæniceps no such space exists, or only in rudiment, there being, on the anterior margin of the lacrymal, at its upper third, a groove terminating in a small oval passage passing inwards, which passage is then followed by a series of small vascular punctæ, indicating the place where the lacrymal, nasal, and angle of pre-maxillary have so completely coalesced. The outer broad surface of the præ-maxilla is not nearly so smooth as the crown of the head ; its substance is lighter, more marked by vessels, and its weight diminished by open areolar spaces,—an approach to the structure of the Pelican's upper jaw. The terminal beak is stronger than, but not so long and sharp as that of the Albatros ; it is thrice the size and strength of that of the Pelican ; and the curved tip of the Boat-bill's jaw and that of the Umbre are its feeble representatives. The tip of this strong beak is not sharp, but is slightly emarginate, being one-eighth of an inch broad, the emargination being still greater in the mandible. The outline of the lower margin of the præ-maxilla is very elegant, more so than in the Boat-bill. Looking at its anterior commencement, we find it rising gently up to the middle of the side of the great hook ; it then as gently descends, swelling outwards into the arc of a very large circle to within ten lines of the angle,—the rest of the marginal line being nearly straight.

The thinnest part of the bone is at the middle of the sides, as it is thick at the grooves, and again thickens so much towards the rather sharp margin as to give it the appearance of curving in.

In the Boat-bill all these characters are softened and feeble: the mesial portion is, as it were, pinched into a keel, convex along the mid-line and concave at its sides; whilst the grooves are wider and more open, and the sides of the jaw smooth and evenly convex as they turn slightly inwards to form the sharp margin. The great upper grooves are nearly obsolete in the Adjutant; in the Heron they are well marked in front of the nasal fossæ, but only pass halfway to the straight tip. In the Pelican they are distinct for two inches from the nasal fossæ, when they lose themselves in the large cellular scoopings that occupy so much of the interspace between the moderately convex ridge and the margin; yet the upper margins are indicated all the way by a row, on each side, of large oval vascular apertures, and again become distinct as they form the boundaries of the beaked tip of the bill. In the Spoonbill these upper pre-maxillary grooves are very distinct: diverging as they pass out from each nasal fossa, they run within one-tenth of an inch of the margin in the narrow part, and one-eighth in the broad spatulate end, round which they pass to become confluent above, a little posterior to the broad and gently curved tip. The large concave 'hard palate' of the Balæniceps is not a whit less elegant than the upper and lateral aspects of the jaw—indeed more so, if possible; the vascular grooves being here very perfect, as they pass out at right angles to the great mesial sinus, forking and inosculating laterally like the veins of a beautiful leaf.

To the distance of $1\frac{1}{8}$ inch from the tip, the mesial line below is keeled, at first rather sharply, but the ridge soon becomes convex, and widening as it passes backwards, is in reality continued along the greater part of the palate; but at the distance above-mentioned it is laid open—no longer a ridge, but a large vascular sinus.

For more than the anterior half this groove is sharply margined, and, besides the vascular openings into the lateral dendritic grooves, exhibits large open spaces which communicate with the rich diploë occupying the thick mesial ridge of the jaw. The margins then become smoother and more rounded, and the groove widens as it passes backwards to descend rather suddenly to the posterior boundary of the hard palate.

Turbinals or Ethmoidal Pterapophyses[1]. (Pl. LXV. fig. 7, *t b*.)

From the inner part of the articulation of the palatine with the pre-maxillary there is, on each side, a smooth convex ridge, which runs forwards for above an inch, slightly converging towards its fellow. A little behind where these ridges lose themselves in the surrounding bone there is an irregular opening about two lines in length, which opens from the mesial groove obliquely into the space above. Behind this there are several smaller passages scarcely true to the mid-line. These openings are all of them the remains of a membranous space, which is large in many birds, and lies in front of and

[1] We have adopted this term provisionally; Professor Goodsir would have us believe that these elements are neurapophyses (see *op. cit.* p. 144).

between the coalesced ethmoidal pterapophyses—elements which seldom combine with each other on the mid-line of the palate. The anterior largest passage just spoken of and the smooth convex ridges are the anterior and lateral landmarks of these bones; whilst their posterior margin terminates on each side in a small, elegant spur of bone, the point of each spur curving outwards, and each tip lying two lines from the deeply-grooved posterior line of union of the two bones. The palatals at their inner margin articulate with these palatal elements of the ethmoidal sclerotome[1].

This descending portion of the hard palate is easily understood by means of these landmarks, and by a careful comparison of their unusually developed condition in the Balæniceps with the skulls of birds in which ossification has not proceeded so far. The Adjutant, the Heron, the Duck, and the Common Rook, all help to explain these homologues of the cornua attached to the lower parts of the 'vomer' of certain Chelonia, and of the turbinals of the Lacertian and Ophidian.

The pterapophyses of the ethmoid have united along the mesial line of the palate in the Adjutant (*Leptoptilus*), in the Cancroma, in the Great Goatsucker (*Podargus humeralis*), in the Merlin (*Falco æsalon*), but not in *Aquila chrysaëtos* nor in *Accipiter nisus*, or in the Vulture. This floor of the ethmoidal neural space is complete beneath in the Kingfishers (*Dacelo* and *Alcedo*) and in the Spoonbill and other birds with large mandibles. In most birds, however, they do not meet mesially, and in the Ostrich group they are feebly represented. The condition of these parts is very exquisite in the smaller Fissirostres, *e. g. Caprimulgus europæus*—a good subject for the examination of an ossified true 'ethmoid,' and of these pterapophyses of the ethmoidal sclerotome.

At one-eighth of an inch external to the outer margin of the palatines of Balæniceps, a strong groove is scooped in the upper jaw, shallow at first, where it divides the angle of that bone into an outer larger and an inner smaller portion; it passes forwards, gradually rising within the sides of the hard palate, until at the anterior fourth it is midway between the margin and the mesial sinus. It then passes forwards to the base of the great beaked tip, where it meets the grooves already spoken of on the upper surface.

Seen from beneath, the upper jaw of the Balæniceps, from its elegantly curved outline, suddenly narrowing towards the tip, its submarginal grooves, at first parallel, and then taking a sigmoid curve inwards, to become nearly parallel again as they blend with the margin, and lastly, the mesial sinus with its transverse dendritic branches,—is certainly an object of great beauty. Before leaving this part, we may notice that the bifurcating vascular grooves passing from the mesial sinus open into a smaller lateral sinus which burrows the interior sharp edge of the great submarginal sigmoid groove. This great groove at its posterior end cuts away, as it were, part of the angle of the maxilla, to allow the mandible to fit tighter and to lock itself into the upper jaw; and the interior portion of the angle is thus always on a lower plane than the exterior.

[1] We have not been able to detect any separate osseous centre for these elements; they are evidently mere outgrowths from the maxillaries, and are the homologues of the inferior turbinals of Mammals.

This is almost the whole function of this groove in the Adjutant and many other birds, the dental margin at its posterior part being, in a manner, pushed up high by the action of the mandibular ramus; whilst in the anterior part of the upper jaw the groove is obsolete, and the mandible lies wholly under the maxilla.

This may be seen in the curious jaws of the Spoonbill: but in the Boat-bill the mandible passes within the zygoma, at the junction of the dentary with the surangular, and then soon liberates itself, adapting its margin very accurately to that of the maxilla; and this latter bird has no trace of this submarginal groove with its internal ridge, its hard palate being as simple as that of the Giant Goatsucker (*Podargus humeralis*).

In the Heron, which has a subterminal notch to the horny sheath of the maxilla, and very elegant lozenge-shape recurved horny teeth along the sheaths of both maxilla and mandible, the jaws fit together as in the Adjutant. But in the former bird submarginal ridges may be seen, faintly in the bone, clearly in its horny sheath, running along the posterior three-fifths of the hard palate, nearer the dentated margin than the mesial sharp ridge, but rather parallel with the mid-line than with the margin. In the anterior half of the hard palate of the Spoonbill, and in that part of the mandible adapted to it, a similar, rather faint ridge may be seen, running somewhat concentrically to the outline of these spatulate jaws.

In the Pelican (*P. onocrotalus*) the hard palate is subdivided into a broad mesial and two narrower marginal portions by two strong ridges, the mid-line being gently and evenly concave, and marked with large oblong passages.

These marginal portions, narrow behind, but becoming gradually broader towards the somewhat spatulate anterior part of the jaw, are strongly scooped, or concave; and in these concavities the mandibular rami lie, in the closed condition of the mouth. This scooping of the hard palate reaches nearly to the mid-line in the Flamingo, the mesial part of the hard palate in this bird being merely a rounded keel. Into these nearly semicylindrical spaces the round, thick, upper and inner parts of the mandibular rami are accurately fitted.

If space would permit, all these manifold but, anatomically, gentle modifications of structure might be explained and their final purpose illustrated; but every intelligent naturalist will at once see their meaning in the habits of each bird. Undoubtedly the Balæniceps comes nearest to the Turtle in this part of its structure, notwithstanding the difference of function of the homologous parts. These secondary ridges give perfection to the beautiful dentated shears of Turtles, so well constructed to "graze the sea-weed, their pasture"; whilst the additional maxillary ridges of this large-headed Heron, the Balæniceps, serve to break the spine of its finny prey.

Ethmoid. (Pl. LXV. fig. 1, *n p g*.)

The anterior portion of that mass of bone in the Ostrich which Professor Owen calls the connate 'prefrontals' (Rep. on Archet. p. 190. fig. 8. no. 14) is in the Balæniceps, the Adjutant, the Heron, the Rook, the Goatsucker (*Caprimulgus*), the Swift (*Cypselus*), and in various other birds, developed as a distinct centre of bone in the cranio-facial axis. The posterior osseous centre has already been described as the pre-sphenoid; the anterior element (which in a large number of birds consists principally of persistent cartilage, with a membranous space between it and its successor, the pre-sphenoid) is the true ethmoid, the catacentric centrum of the ethmoidal sclerotome (Goodsir, *op. cit.* p. 143). Cuvier called the posterior piece the 'ethmoïde.' It is evident that the axial parts of two cinctures, one of the *cranium* and the other of the *face* of the Struthionidæ, have been considered to belong merely to one segment of the skull. But evidence is not wanting to show that the large axial mass of bone figured 14 by Professor Owen (Rep. on Archet. fig. 8. p. 190) is developed even in the aberrant Brevipennes from an anterior and a posterior osseous centre. Many years ago we dissected and figured the cranio-facial axis of an Emeu (*Dromaius ater*) only six weeks old, in which the orbito-sphenoidal region, the antorbitals, and the anterior part of the so-called 'pre-frontal mass' were still cartilaginous. The flat-topped pieces, however (the anterior of which props up the 'nasals,' the posterior forming the buttress of the sphenoido-frontals), formed one V-shaped piece of bone, the upper portions being quite distinct, whilst the flat descending plates had evidently *coalesced*; for ossification commences, not at the point where these pieces had become confluent, but just below the horizontal outspread upper part, where, in this young Emeu, they were still widely distinct.

Looking at the lower part of the great fronto-maxillary hinge in the Balæniceps, we see, between the incurved plates of the lacrymals, a large mass of thinly-coated spongy bone, which forms the posterior part of the axis of the greatly-developed face. This broad-topped mass of bone acts as a buttress to the nasal processes of the pre-maxillaries and to the nasals, besides forming a large and important part of the 'great hinge,' and articulating with its immediate successor the pre-sphenoid below the hinge, thus adding strength to the junction of the roof-bones. This is the true 'ethmoid'; at least, it is the homologue of the mesial part of the human ethmoid, the out-standing process of which is called the 'crista-galli.' This centrum of the *face* of Balæniceps is as well developed as its *cranial* successor the pre-sphenoid; and the posterior aspect of the former is so much like the anterior aspect of the latter, that it seems like an illusion, and as though a mirror had given us a backward reflexion of the front of the pre-sphenoid.

The posterior face of the ethmoid of Balæniceps is sharply carinate for about two-thirds of its depth, the keel ceasing and a groove commencing opposite the projecting end of the basi-sphenoid. This groove, very shallow at first, runs downwards until it loses itself between the spur-shaped posterior processes of the ethmoidal pterapophyses in the mesial palatal groove. Where the keel ends, there the ethmoid, the centrum of this sclerotome, has coalesced with its low-lying pterapophyses. The mass of the ethmoid a few lines in front of the keel is much thicker than that of the pre-sphenoid; but the external bony table begins soon to be deficient on each side, and all trace of boundary between it and the surrounding bones is lost in a profusion of diploë, delicate as the veins of a leaf, and light as a downy feather. On each side of the shallow groove between the posterior edge of the coalesced pterapophyses there is a considerable pneumatic foramen, and from each spur-like point outside these passages there is a delicate ridge, which converges towards its fellow at the base of the vertical keel of the ethmoid, and then expanding forms on each side a wing-like crest of bone, which lies behind and strengthens the diploë of the pterapophyses as they pass upwards and a little outwards to coalesce with their roof-bone just within and behind the nostril. The lacrymals contribute of their substance to strengthen the bone at the same point; but in front of the incurved lacrymal plates, inside the pre-maxillary wall, outside the ethmoid, and above the up-tilted zygomatic plates of the maxillaries, there is on each side, in the dry skull, a large triangular space which opens freely into the orbits behind, and into the proper nasal fossæ above. Below these maxillary zygomatic plates there is another open space about half the size of the former; it is open behind; its floor is the extreme end of the palatal plate of the maxillary outside, and the broad origin of the palatine mesiad; whilst it is bounded internally by diploë common to the maxillary and the ethmoidal pterapophyses, and externally by the posterior angle of the maxillary.

We shall speak of the development of the facial sclerotome in birds, and of its general relations, after the maxillary and the 'zygoma' have been described.

Maxillary. (Pl. LXV. figs. 6 & 7, *m x.*)

At its origin the maxillary is broad, and its inner portion is principally composed of diploë, which passes insensibly into that of the ethmoidal pterapophyses mesiad, whilst, above and below, it arises in the fine diploë already mentioned as lying in front of the two large open posterior facial spaces; externally it is more compact, and is continuous with the posterior part of the wall of the pre-maxillary in front of the maxillary angle. The broad cellular origin of the maxillary soon contracts, the bone becoming compressed into a thin obliquely descending plate of bone, which lessens rapidly in width from the inner side. Whilst lessening in width it acquires a thick inner margin, and at about two lines behind the anterior zygomatic joint, the external part of which is evidently formed by the 'malar' or 'jugal,' it suddenly thickens as it is lost on the inner side of the zygomatic arch: just in this swelling region of the maxillary there are some pneumatic holes. The width of the up-tilted slanting portion of the maxillary is nine or ten lines at first; at an inch further backward, where it becomes lost in the malar, its width is four lines.

Zygomatic arch. (Pl. LXV. figs. 1, 6, & 7, *m x*, *m r*, *q j.*)

Where we can see the elements of the 'zygoma' in birds, we find that the zygomatic process of the maxillary forms about a third of the arch, lying within and below its successor. This next piece forms about another third, and lies in a supero-external position anteriorly; posteriorly it lies below and within the third moiety, the ' quadrato-jugal'—this latter element articulating with the external part of the base of the os quadratum. This zygomatic arch is nearly two inches long, its vertical breadth six lines or thereabouts (its middle being rather less), whilst its average thickness is three lines.

The upper and lower margins of this compound zygoma are rounded, but slightly thinned off and keeled, the former most so. The internal surface is smooth and convex, the external convexo-concave, the thickest and most convex part being near the lower margin, at the posterior third. The anterior end of the external part is articulated with the lacrymal and the posterior angle of the maxillary, which lies outside the base of the lacrymal above; it then sends a process into the substance of the maxillary, whilst below it is overlapped by it. There is evidently some articular cartilage here in the fresh state, as this hinge is rather freely moveable, notwithstanding the complete coalescence of the interior part of the zygoma with the upper jaw or maxilla. The extreme elasticity of the zygomatic plate of the maxillary allows of this movement; and we may remark that this anterior zygomatic joint has the compound character of arthrodia, gomphosis, dentate suture, and anchylosis. The upper margin of the bone is at first convex, and then concave, and convex again behind; and here, at the posterior fifth, there is a rough notched tubercle. The margin then suddenly falls, is crescentic in shape, and at the hinder tip of the crescent sends inwards a strong subconical process a quarter of an inch long, and at right angles to the main bone. The lower margin of the bone is nearly parallel with the upper, but is more internal, and is very convex as it lowers itself to become nearly parallel with the large crescentic notch above. The posterior internal process of the zygoma, best developed in Herons of any group, fits into a deep concavity of the os quadratum. The compound zygomatic bone is one of the rich and unique parts of the structure of Balæniceps. No other bird has anything comparable with it. The strongest of all birds' skulls is that of the Helmet Hornbill (*Buceros galeatus*), where the surface of the cranium is as deeply pitted as in the Crocodile; but here the zygoma is only one-third the size of that in *Balæniceps rex*. The zygoma in the Boat-bill and the Herons is more like an ossified tendon than anything else; and in the Adjutant it is relatively no stronger.

Development of Præ-maxilla.

In the Balæniceps all trace of suture between even the nasal processes of the pre-maxillaries is entirely lost, as much as in the Parrots and Hornbills; faint traces of this mesial suture may be seen in old Adjutants and Herons; whilst in a great number of birds it is distinct throughout life nearly down to the main body of the bone. In both the Chick and the young Pigeon, coalescence takes place rapidly between the lateral pieces up to the anterior end of the nasal passages. On the eleventh day of incubation the pre-maxillaries of the Chick are quite distinct, and a considerable oval space exists at the anterior end above, showing the long spatulate process of the primordial cranium *on* which the inter-maxillaries are moulded. The pre- or inter-maxillaries have, however, at this early period, much of their adult form, except that the nasal processes are short, and the sub-mesial palatine processes for articulation with the palatals are not yet developed; they may be seen three or four days later. The nasals are already ossified and have nearly their permanent form, overlapping the still cartilaginous pre-sphenoid behind, lying upon the ethmoid, and articulating below with the already ossified maxillaries. The spatulate 'rostrum' of the ethmo-vomerine cartilage is very elegant in birds: in the Chick it has attained its full size by the eleventh day; at this time it may be seen quite uncovered *beneath* the two pre-maxillary centres, like a small model of the Spoonbill's jaw.

This cartilage is very transitory; on the fourteenth day it has greatly shrunk, and by the nineteenth day of incubation it has become a mere thread of cartilage, being absorbed *pari passu* with the distal part of Meckel's cartilage. In the Snake the ossific centre for the pre-maxillary is azygous, like the cartilage *in* or *upon* which it is developed (Huxley, Croon. Lect. p. 60). In the Stickleback there are two cartilages *in* which the pre-maxillaries are developed (Croon. Lect. p. 29). The malars are ossified before the eleventh day in the Chick. The anterior part of the ethmo-vomerine axis of birds is always feebly developed; and in some birds the fibro-cartilage of which it is composed is deficient between the nostrils, *e. g.* in the Swan. The nostrils in Crocodiles and Mammals are pierced *in front* of the pre-maxillaries (just where the bones ossify latest in the Bird), "whereas in the typical Lacertians, and in the extinct Plesiosaurs, Ichthyosaurs, and Pterodactyles, in the Ophidians, Amphibians, and Birds, they open behind these bones" (Goodsir, *op. cit.* p. 139). There is, therefore, as Professor Goodsir shows, no *rhinal sclerotome* in these latter vertebrata. In the Bird, according to Professor Goodsir, the vomerine sclerotome is composed of the anterior fibro-cartilaginous portion of the primordial cranium (its catacentric centrum), and of the pre-maxillaries (its hæmal arch), whilst the neurapophyses are absent. The "marginal processes of the cartilaginous vomerine centrum extend down in front, so as to line the under- and fore-part of the nasal fossæ, projecting somewhat behind the inter-maxillary margin of the external nostril. The broad projecting upper portion of the cartilaginous septum occupies the position of the nasal bones, while the inferior portions project from behind the inter-maxillaries, like opercular actinapophyses" (Goodsir, *op. cit.* pp. 139, 140)[1].

The ossification of the posterior hyaline ethmoidal portion of the nasal septum is very varied, and takes place later than that of the pre-sphenoid. The ossified ethmo-vomerine axis of Balæniceps is nearly four lines thick between the nostrils, and consists of one mass of bone, as is the case indeed in most birds when these parts are ossified. In the Heron and Adjutant, only the flat upper surface of the ethmo-vomerine cartilage is ossified; in the Rook the ethmoid is knife-like, but small in longitudinal extent, whilst there are

[1] We think, with Professor Huxley, that the whole of this subject requires to be tested by the patient study of development, and that the existence of this vomerine sclerotome is very doubtful.

traces of ossification of the nasal septum below the nasal passages in front. In the Woodpecker (*Picus viridis*) there is more or less ossification of the septum both in the anterior and posterior ethmoidal regions.

We quite agree with Professor Goodsir in his determination of the maxillaries as bones having a hæmal relation to the facial sclerotome, but not that the 'quadrato-jugal' of the Bird is the representative of the 'squamosal' of the Mammal. The views of this excellent anatomist "on the actinapophyses of the ethmoidal sclerotome" are too long to be transcribed here, but are likewise too concentrated to be given in abstract (see *op. cit.* p. 151). We may, however, mention that Professor Goodsir classes the upper and middle turbinals in the same category; but they are, according to him, the internal or posterior actinapophyses of this cincture: the posterior of these processes becomes ossified in Parrots and in *Picus viridis*, and is anchylosed to the anterior and inner face of the antorbital: the same author considers the palatine or inferior turbinals to be 'neurapophyses.' In the Vulture there are an upper and a lower pair of ethmoidal pterapophyses; the former having an ethmoidal, and the latter a maxillary origin.

Palatines and Vomer in Vertebrata.

The imperative necessity for a thorough re-examination of the subject of the development of the bones of the palatine region in the Vertebrata must be felt by every one who has endeavoured to make Professor Goodsir's views on this subject clear to himself, whilst for the time all "old experience" is forcibly set aside (see *op. cit.* pp. 142–154, & pp. 159–162).

What the 'squamosal' and 'tympanic' have been to Professor Owen, that the 'palatine' and 'vomer' have been to Professor Goodsir; and, once wrong, we all know that the noblest minds go farthest astray.

There is evidently every reason to suppose that the ossified anterior and inferior part of the ethmo-vomerine cartilage of the osseous Fish is the true homologue of the divided 'vomer' of the Batrachian, Lacertian, and Ophidian, of the vomerine splints of the Crocodile, of the 'vomer' of the Chelonian, the Bird, and the Mammal. Even in Fishes it is sometimes double, as in *Sudis gigas*. What the 'transverse bones' or 'ectopterygoids' of the Crocodile, Lacertian, and Ophidian agree with in other vertebrata, it is impossible to say at present; it is not certain, at any rate, that Cuvier's 'transverse' and Owen's 'pterygoids' are their representatives in the Fish; they may be; and then it might turn out that Professor Owen's 'pre-tympanics' (Professor Huxley's 'metapterygoids') were the actual homologues of the ornithic and mammalian 'pterygoids': even then the ento-pterygoids would have to be accounted for. Evidently there are no ecto-pterygoids or transverse bones in these two latter classes, the Birds and Mammals, nor in the Chelonians and Batrachians[1]. The palatines of the Crocodilian are very peculiar,

[1] Query:—How can the ento-pterygoids of the Fish represent the 'bones of Bertin' in Man and their representatives in other mammalia? They seem to have a very slight connexion with the vomer, whilst the mammalian ossicles are evidently dismemberments of it.

and their meaning not at first sight evident; we have been only lately enlightened upon this subject by Professor Huxley himself, who has kindly demonstrated their structure to us in the Gavial.

In these reptiles (the Crocodilia), both the external, or *anterior*, and the posterior nares have a mammalian character; for the latter openings are not simply bounded externally and posteriorly by the palatines, as in birds, but those openings which agree with the posterior nares of the Bird are entirely shut from view in the palatine aspect of the skull. This is caused by the development of a very perfect *palatine* inferior plate to these elongated bones, the long palatine groove beneath the basis cranii being thus converted into a canal which is more or less divided into two parallel passages by the vomerine slips of bone, whilst the passages or tubes open on the posterior half of each pterygoid on its inner margin, where it joins its fellow of the opposite side and sends forwards a sharp process to join the vomer, just as the palatine does in the Bird.

The palatines of the Fowl are ossified before the eleventh day of incubation. The vomer of the Fowl is ossified by the end of the fourteenth day of incubation in the blastema that connects the rudimentary upper maxillary apparatus of each side; not apparently in pre-existent cartilage, but evidently in the membrane coating the ethmo-vomerine cartilage behind, and the sphenoidal rostrum in front. In the air-breathing Ovipara generally, the vomer seems to belong to the palato-maxillary apparatus quite as much as to the cranio-facial axis, and to be a sort of morphological bond between the skull and facial arches. In the Fish, however, it is an inferior ossification of the ethmo-vomerine cartilage, and bears upon it the ethmoid in the mid-line and the pre-frontals on each side. The relation of the vomer to the lateral masses of the ethmoid is exceedingly important, these masses being evidently the mammalian condition of the pre-frontals; Dr. Cleland has shown this with great clearness in his valuable paper; and one cannot help comparing the thin cortical mammalian vomer, becoming on each side one with the ethmoidal masses, to the thin basi-temporals of the Bird, which are so intimately connected with the structures of the ear, and which bear a similar relation to the basi-sphenoid that the vomer of the Mammal does to the central plate of the ethmoid.

Professor Owen (quoted by Professor Goodsir, *op. cit.* p. 146) describes (in the Osteological Catalogue, p. 166, No. 764) the skull of the Black Alligator (*A. niger*), in which "the vomer is divided at the median line, and the anterior expanded part of each moiety appears upon the bony palate, between the pre-maxillary and the maxillary; the palatine suture between the same bones bending down to the hinder border of the palatal anterior aperture of the nostrils."

Now, there are conditions of the vomer in other vertebrates curiously illustrative of this exceptional structure in the Crocodilian. Perhaps the Chelonian that comes nearest to the Crocodile in structure is the Logger-head Turtle (*Caretta caouana*); in this creature the maxillary palatal plates meet and articulate, but are separated posteriorly by the lower plate of the vomer and by the palatines. The latter bones are kept apart by the palatal plate of the vomer, but they have begun to form that tube-like prolongation of the posterior nares which attains its fullness in the Crocodile. In the Green Turtle (*Chelone mydas*) the inferior vomerine plate reaches the pre-maxillaries anteriorly, thus keeping the maxillary palatal processes widely apart ; in this species the palatine plate of the palate bone is not so well developed as in the Logger-head. In the smaller Tortoises the descending portion of the vomer is less decidedly *palatal*, and we have now before us the skull of a small *Emys* which has articulated to the sides of its vomer a pair of ' turbinals,' which are evidently the proper homologues of the ethmoidal palatal plates of Birds and of the turbinals of Lizards and Snakes. Professor Goodsir thinks that the palatine plate of the vomer of Tortoises and Turtles always consists essentially of these turbinal elements, which he names 'ethmoidal neurapophyses' (*op. cit.* p. 145). The study of its development would prove or disprove this opinion.

These small Chelonians with their feebly-developed and widely-separated ' palatines ' lead us to the Lacertians and Ophidians, creatures that expose their double vomer on the anterior palatine aspect of the skull, and have articulated to each moiety a very perfect osseous ' turbinal,' which bone Professor Goodsir now (in these orders) considers to be a mere exogenous outgrowth or cortical ossification of the ethmoid (p. 155). We agree with him here, but not with his finding ' ethmoidal neurapophyses in the divided vomer,' nor with his non-recognition of the actual homology of these Lacertian and Ophidian ' turbinals ' with those of the little Chelonian and of Birds generally.

We now come to the structure of these parts in birds and mammals. The vomer of the Goatsucker (*Caprimulgus europæus*), slightly grooved above and carinate below, appears in the palate, between the inferior or palatine turbinals. In the Merlin (*Falco æsalon*) these latter processes are anchylosed together, and form a large oblong mass behind the palatine plate of the pre-maxillary, and between the laminar origins of the palatine bones. The vomer, thin above and round below, articulates behind with the palatines, being wedged between their ascending plates ; in front it descends and forms a lozenge-shaped little block, notched in front and flat below, the inferior surface being quite palatal. This descending anterior part wedges itself in between and behind the palatine turbinals exactly as in the little Tortoise, supposing these bones not to have coalesced, which they seldom do, the Merlin itself being somewhat exceptional in this respect even among the Raptores. In the Rook, and in Corvine and Passerine birds generally, the broad emarginate anterior end of the vomer descends, and appears in front of and between the palatine turbinals. One more instance from the class of birds :—in the Albatros (*Diomedea exulans*) we have an exception to the rule mentioned by Mr. Goodsir (*op. cit.* p. 159), that the vomer is feeble when the palatines are large, and *vice versâ*. In this large palmiped the vomer is two inches and a half long, the palatines being relatively large. Thin and laminar below, at its junction with the palatines, the vomer of the Albatros diverges above into two very considerable laminæ, whilst it is smoothly carinate below.

The whole bone ascends gently until its lower margin is half an inch above the horizontal palatine plane; it then descends more rapidly anteriorly, and appears on the palatal floor a little between, but more in front of, the palatine turbinals; this part is more than half an inch long and rather more than a line in thickness, and is notched in front. The upper part of the descending portion loses its groove, becomes filled with pneumatic foramina, and is rounded and smooth anteriorly. In the Common Hare (*Lepus timidus*), with its almost obsolete palatine processes of the maxillary and palate bones, its one large palatine foramen, and large, deep, widely-open posterior nares, the vomer descends to the mesial palatine region, becoming thick and broad below, to articulate with the long narrow palatine processes of the pre-maxillaries. This is the most favourable of all creatures in which to see the complete fusion of the posterior lateral laminæ of the vomer with the lateral masses of the ethmoid, and to judge how easy it must be for the too rapid extension of the cranio-facial axis to break up the thin vomer during its ossification into distinct pieces (as the cranial roof-bones are often dismembered in Man), such as the 'bones of Bertin' in Man, and their representatives in the Pig, Fox, Chimpanzee, and the Cetaceans. In the Rodentia generally (*e. g. Arctomys*, *Mus*, *Arvicola*, &c.) the vomer does not reach the palatine plane.

Palatines, Posterior Nares, and Vomer. (Pl. LXV. figs. 1 & 7, *pal*, *p n*, *v*.)

The posterior nasal passages in the Balæniceps (and it does not differ essentially from other typical birds) are bounded in front by the palatine turbinals, on each side by the internal margin of each 'palatal,' whilst they are partially separated from each other by the 'vomer,' the partition being completed by membrane. The palatals in Balæniceps being obliquely placed and meeting behind, the posterior nares are defined by them posteriorly. The entire transverse extent of the palatals in front is two inches and a third, their antero-posterior extent being nearly two inches.

The coalesced palatines seen from beneath form a large, triangular, deeply and strongly concavo-convex mass of bone; the posterior nares being, as it were, cut out of the broad anterior base of the triangle, in front of which space there are the palatine turbinals, and along its middle the thin arrested vomer, whilst the apex is notched, truncate, and toothed to receive the pterygoids. Thin and laminar at their origin, the palatines are connected by suture with the pre-maxillaries and maxillaries (with the former internally, and with the latter externally); but the middle portion of this suture soon becomes converted into anchylosis. From the internal part of the suture a strong convex ridge, $\frac{3}{4}$ of an inch long, passes outwards, downwards, and backwards; the bone above the middle part of this ridge becoming thick and spongy, whilst it thins off behind. Internal and posterior to this broad convex ridge the bone becomes less broad, as it first passes upwards and backwards, and then curves suddenly downwards to meet its fellow and form a strong mesial keel. The hinder carinate part of the palatines, at their line of coalescence, is half an inch in extent. At its front part the mesial keel bifurcates, the bifurcation at each side becoming a crescentic portion of the inner margin of each ramus. The inner margin of each half is then notched once or twice, and then becomes again crescentic in outline, just behind the articulation with the palatine turbinals. The vertical middle portion of the palatines, at their coalescence, is full of large vacuities, the mesial line becoming more consistent where these bones coalesce with the triangular knife-like vomer. This bone (the vomer) is one-third of an inch long, the same at its base, convex in outline above, and concave below; the latter part having a round margin, whilst the former is sharp. The large coalesced palatines of this bird—each half of which, from its broad anterior origin, may be said to be plano-convexo-concave (the concavity on each side the mesial keel, and for an equal distance anterior to it, being very large)—form a very noble structure. No other bird seen by the writer has similar palatines. Those of the Boat-bill are distinct, broad, and flattened out, like the same bones in the Podargus, although in the latter bird they are coalesced. The vomer also is larger in the Boat-bill, and unites with the palatines on each side. In the large Adjutant the palatines are considerably less than in the Balæniceps, and are partly coalesced, but retain the type of structure common to the Storks and Herons, viz. a strong external and a sub-mesial keel to each bone, whilst the mesial line itself is concave below. In the Heron the palatines are very long and delicate, and are totally distinct from each other, except that at their middle they are tied together, as it were, by each of them sending an internal process forwards to be anchylosed to the vomer, which is here rather more developed.

In other fish-eating birds, where the motions of the upper jaw on the cranium are strong, we find that the coalesced palatines have the same essential structure as in the Balæniceps. In the Pelican, for nearly an inch, the palatines are flat, elastic, and quite separate; they then unite together, become stronger, have at first a thick, and then a thin margin, as in their hinder third they contract in width to articulate with the pterygoids. Between these thick margins a very strong keel is developed both above and below at the mesial line; and these keels run backwards, the upper to the articular surface on the basi-sphenoid, and the lower to the part where the pterygoids are attached. Behind the upper keel the palatines are scooped neatly to receive the basi-sphenoid, and behind the lower they are slightly notched. The end of each moiety of the bone, besides contributing to form the sphenoid groove, has two articular facets for each pterygoid, and there is a notch between the upper and lower facets. The palatines are nearly three inches and a half long in the Pelican. In the Cormorant and Gannet the structure is essentially the same; but they are long and parallel in outline, like those of the Heron. In these smaller Totipalmatæ the whole concave line of coalescence glides along the base of the orbital septum, just as in Balæniceps. In this great Heron (*Balæniceps*) we have a modification of the palatines not entirely unlike what is found in the Pelican, for the sake of strength and mobility in the upper jaw. In the Hornbill, as well as in the great Goatsucker, the palatines are coalesced; but this is an exceptional condition in birds. These bones are relatively small in Struthious birds, and they coalesce both with the maxillaries and the pterygoids in the Apteryx. In the Gallinæ they are mere flattened styles, just expanding at their distal extremities to send upwards and inwards a thin orbital plate; so that in these birds there is nothing startling in the idea of their being the ribs (pleurapophyses) of the nasal vertebra; nor would it be difficult, were we looking for cranial vertebræ, to suppose that the small simple bones (the pterygoids) attached to them behind were their appendages.

Pterygoid. (Pl. LXV. figs. 1 & 7 *p g*.)

The pterygoid of the Balæniceps is nearly an inch long, flat in the middle, clubbed at both ends, carinate above, and thicker and more rounded below, especially at the distal end; whilst the proximal end is marked with three ridges, one outside, one inside, and one beneath. The inside of the pterygoid, which is altogether the most concave, is scooped with three cavities, one in the middle, and one at each end; they communicate with pneumatic passages. The outer part of the proximal end has a slightly convex oblong condyle; the inner has three large and some smaller teeth, which fit into the end of the palatines. The distal end is obliquely scooped on its outside to form a shallow cup to articulate with the convexity of the os quadratum. Above this cup are some pneumatic holes, and above them a small spur, looking forwards. Synovial cartilage covers the oblong condyle at the proximal end, and lines the concavity at the distal, creeping on to the end of the bone. This small, oblong, thinnish, but really strong bone communicates the motion of the quadratum to the palatines, as the zygoma does to the premaxillaries. Were the same bone in the Heron magnified twice its size, it would be scarcely distinguishable from that of the Balæniceps. The pterygoids are almost ossified by the eleventh day of incubation in the Chick.

Os quadratum. (Pl. LXV. figs. 1, 3, 6 & 7 *q*.)

The os quadratum of the Balæniceps is a large, strong, quadrate bone, its upper side being $1\frac{1}{2}$ inch in extent, its posterior the same, its anterior $\frac{3}{4}$ inch, and the inferior side, measured in a straight line across the condyles that fit into the lower jaw, $1\frac{1}{4}$ inch. The large upper condyloid processes are 1 inch across; the outer appears externally, articulating with the squamosal, whilst the inner passes inwards and somewhat backwards, and partly encroaches on the par- and ex-occipitals. These upper condyloid processes are not, like the lower, completely covered with articular cartilage; for the cellular nature of the squamosal, petrosal, and occipital at this part allows them to touch the bone only at certain points, these more projecting parts being alone covered with articular cartilage: hence the discontinuity of that tissue on the head of the quadratum. The upper margin of the quadratum is sharp-edged and gently concave in outline; it expands a little at the anterior end to form the crescentic tip of the orbital process, which is a quarter of an inch across at its enlarged end. This orbital process is smooth and flat, gently convex externally and slightly concave within; it is at least two-thirds of an inch across at its junction with the body of the quadratum. The descending anterior margin of this part of the bone is considerably thicker than the upper, and it passes downwards and backwards for two-thirds of an inch. The bone then suddenly swells out internally, forms first the convex condyle for the distal end of the pterygoid, and then sends upwards and backwards a smooth crescentic ridge, with its concavity upwards, to the inner side of the posterior division of the great upper condyle. Above this ridge, at the centre of the inner face of the quadratum, there is a large sulcus, bounded above by a sharp ridge, and containing two or three large oval pneumatic foramina.

The external part of the quadratum is thick, smooth, and convex; but the outline from the anterior upper condyle to the deep round concavity for the nail-like process of the quadrato-jugal is concave. The distance between these parts is one inch, and the width at the surface of the cavity for the quadrato-jugal is nearly a quarter of an inch. Below this cup the bone expands to form the large posterior condyle for articulation with the mandible. This condyle passes backwards, inwards, and slightly downwards, being convexo-concavo-convex in its long diameter, and convex across. Nearly at right angles to the inner part of the posterior condyle, a double articular process passes equally forwards and inwards: its condyloid portions are nearly equal and parallel; but the outer lies on the lowest plane, whilst the inner, which is the smallest, terminates where the bone is elevated to articulate with the pterygoid. Between these large double condyles the base of the tympanic bone is smooth, concave, and pierced with several small pneumatic foramina.

Perhaps no English bird has a deeper 'gomphosis' for the posterior zygomatic articulation than the Common Heron; but a similar structure exists in the Storks and in many fish-eating birds, *e. g.* the Albatros, whilst this articulation is very shallow in the Pelican. In the Parrots it is moderately deep, and in these birds the orbital process is small; whilst the condyloid structures for articulation with the mandible are reduced to one large rounded crescentic internal ridge, with a small rudiment of an external articular process, just below the deep pit for the quadrato-jugal. Answering to this state of the quadratum, the mandible in these birds is deeply scooped to form an articular sulcus, which passes forwards, and slightly downwards, and inwards. The modifications of this bone in Birds, although gentle, as we pass from family to family, are nevertheless almost innumerable; yet it may be remarked here, that in Struthious birds they have none of that elegance which is so conspicuous in typical birds. Professor Huxley in his Croonian Lecture (1858) proves, from the labours of the great embryologists, Reichert, Rathke, and Goodsir, and also from his own researches, that this 'os quadratum' of Birds is the homologue of the 'incus' of Mammals, and of that lower articular portion of the great hyo-mandibular series of bones in the Fish, which has been named 'jugal' by Cuvier and 'hypo-tympanic' by Professor Owen.

Mandible. (Pl. LXV. figs. 1, 4 & 5.)

If the lower jaw of the Balæniceps were the only part of the osteology of this bird in our possession, the same element of the Boat-bill's skeleton would have sufficed for its interpretation. Yet the differences between the larger and the smaller bone are great, exactly answering to the modifications of the pre-maxilla in these two birds. The likeness and dissimilarity of these birds is something similar to that which exists between one of the smaller Antelopes, such as the Gazelle, and one of the massive species, *e. g.* the Eland. The necessary modifications in the structure of the skeleton required by *delicacy* on the one hand, and by *strength* on the other, are well seen in these two very congeneric species. The mandible of the Cancroma is just one degree stronger than that of the Giant Goatsucker (Podargus)—a bird whose relations, Caprimulgus and Cypselus, have the feeblest mandibles in the whole class, whilst the same bone in Balæniceps almost rivals the lower jaw of the Hornbills—birds in which this arch has its most massive growth. The *præ-maxilla* of Balæniceps is less outspread than that of Cancroma: but there is a reason in the structure of the bill in the former bird why the *mandible* should be still more narrowed; this is caused by the edge of this bone having to fit exactly in between the marginal and submarginal ridges of the upper jaw. Having been adapted in its anterior portion between these ridges, the rami diverge gently, so as to lie (in a vertical plane) outside the posterior half of the pre-maxilla, and also outside the zygoma to its end. Hence the lower jaw of the Balæniceps is in outline much less like the Magnolia leaf; it is more triangular, and keeps gradually widening for the anterior three-fourths of its length, when it takes a gentle turn inwards for the rest of its extent. In Cancroma the mandible is almost exactly adapted to the pre-maxilla at its edges, just passing within the margin as it approaches the zygoma; its lower thick part only lying a little outside that arch. This is very much like what takes place in the Goatsuckers, large and small. Moreover the tips of the pre-maxilla and mandible are not notched or emarginate in Cancroma, whilst they are very decidedly so in Balæniceps, especially in the latter organ. The extent of the confluent symphysis mandibulæ is much greater in proportion in the large bird than in the smaller one, as will be seen below, in a tabular comparison of this part in several species of birds. In Cancroma the dentary elements of the mandible (which form more than two-thirds of the rami) are quite distinct from the articular and angular portions, and the angular elements are scarcely confluent with the articular. None of these sutures exist in Balæniceps; although, from the analogy of its congeners, it must have had all the twelve centres of ossification, in its young state, that are found throughout life in the Crocodile. This *mammalian* solidity of the lower jaw is found in but few birds, *e. g.* the Parrots, Hornbills, and Toucans. The sharpest part of the edge of the mandible in Balæniceps is the first inch and a half; it then becomes more and more blunt and rounded, until we arive at that thick, rough, elevated posterior end of the dentary which seems to have worn away the margin of the maxilla at its zygomatic end. The mandible at this part rises to an obtuse angle, and is here $1\frac{1}{3}$ inch high, or deep, whilst its thickness here is more than one-third of an inch, lessening to one-eighth towards the smooth rounded inferior margin. A row of vascular holes lies a little below the upper margin all along the dentary element; and the whole of the part which is covered with strong horn is grooved and rough, especially towards the upper part. A rough thick margin also passes within the ramus below; whilst the inner surface, although richly dendritic with vascular grooves, is smoother than the outer. Three-fifths of the lower margin of the jaw is rough and covered with horn; the thickened tubercular structure then passes upwards, almost parallel with the upper margin of the jaw, but converging slowly to meet and blend into that margin at the most elevated part of the mandible. There is, towards the end of the symphysial line above, a triangular fossa, passing on each side into an inner submarginal groove, which groove slowly becomes obsolete in the posterior inner part of the dentary[1]. All that posterior part of the mandible which is not covered with horn is very smooth and polished, both without and within. The thickness of the dentary part of the mandible is pretty uniform, averaging about five lines—the thickest or widest part being at the symphysis. The height is very uniform for the first three inches, being about half an inch; it then gradually increases, until at the zygoma it is one inch and a third. The upper edge of the mandible at first rises for one-third of an inch; it then forms one gentle concave sweep to nearly the highest point; the ideal basal line to this arc being $5\frac{2}{3}$ inches in extent, and the mid-portion of the arc three-fifths of an inch from this basal line. From the gradual rise of the upper margin, and the increasing depth of the jaw behind, the outline of the lower margin is not so convex as the upper is concave.

The extent of the symphysis is $1\frac{1}{6}$ inch; it is grooved below, and above has at first a convexity, then a slight keel, whilst the latter third is occupied with the triangular fossa above mentioned. Behind the highest part on the upper margin the bone descends, at first slowly, then rapidly, to the external articular facet, which, more than three-fourths of an inch in extent, passes backwards and inwards. The widest part of this facet is the middle, which is also the most convex; the narrowest and most concave part is the inner. Anterior and interior to this is the deep double articular sulcus for the anterior condyles of the quadratum; the deepest and longest of these twin sulci is the external. They are together nearly half an inch across, and their anterior margin $1\frac{1}{3}$ inch from the posterior edge of the outer articular surfaces. These exquisitely-cut and adapted surfaces answer, as will be seen at once, to the lower condyles of the os quadratum.

The internal angular process projects inwards and backwards half an inch from the innermost articular groove; a ridge passes across and connects it with the posterior end of that groove, and behind this ridge there is a large oval pneumatic foramen

[1] This fossa, and these diverging grooves are imprints of a very important embryological structure; they show where the cartilages of Meckel ran and met each other (*infra*, p. 315).

leading to the rich diploë of the light, expanded, articular portions of the jaw. Several other pneumatic holes lie in the deep smooth concavity between the articular facets; and there is here and there a larger passage of the same nature on the internal face of the broad part of the ramus. The posterior angle of the jaw is half an inch below and a little behind the external articular facet; this angle is tubercular, and soon loses itself in the strong convex inferior margin of that flat, crescentic, smooth end of the mandible, the inner extremity of which has been described above. This broad end of the mandible, which passes a little forwards as well as inwards, is $1\frac{1}{3}$ inch in extent; and here the two inner angular processes of the opposite rami are only two-thirds of an inch apart. The large vascular foramen (inferior dental) is within, and half an inch behind the highest coronoid part of the jaw; it has a tubercle for muscular attachment close above it, another behind, and another still larger on the external margin, one-third of an inch external to it. The smooth, rounded, narrow inferior edge of the hinder part of the mandible, at $1\frac{1}{2}$ inch from the end, swells out and rises gently, becoming again slightly carinate as it nears the external angular process.

Subjoined is a Table of comparative measurements showing the length of the mandible measured along the curve, and the extent of the coalesced symphysis, in different birds, in inches and lines (or twelfths of an inch); also their proportion to each other.

	Length of Mandible.		Length of Symphysis.		Proportion.
	in.	lines.	in.	lines.	
Caprimulgus europæus . .	1	6	0	$\frac{1}{2}$	$\frac{1}{36}$
Podargus humeralis . . .	2	8	0	$1\frac{1}{2}$	$\frac{1}{21}$
Cancroma cochlearia . . .	4	8	0	$3\frac{1}{2}$	$\frac{1}{16}$
Balæniceps rex	8	6	1	2	$\frac{1}{7}$ nearly.
Ardea cinerea	6	3	1	3	$\frac{1}{5}$
Ciconia argala	15	4	4	8	$\frac{1}{3}$ nearly.
Buceros bicornis	11	8	7	8	$\frac{2}{3}$
Macrocercus ararauna . .	2	6	1	1	$\frac{2}{5}$
Calyptorhynchus naso . .	2	4	1	0	$\frac{1}{2}$ nearly.
Diomedea exulans . . .	9	6	0	10	$\frac{1}{11}$ nearly.
Platalea leucorodia . . .	8	0	2	8	$\frac{1}{3}$
Pelecanus onocrotalus . .	17	9	0	3	$\frac{1}{71}$

We see by the above table that the symphysis, in the Common Goatsucker, is twice as long, in proportion to the length of the jaw, as in the Pelican, and that the Boat-bill is four and a half times as strong at that part of the jaw, whilst the Balæniceps has just ten times as much symphysis as the Pelican. *Buceros bicornis* is quite without a peer in this part of its anatomy, although the Parrots come very near it. The relative length of the dentary portion of the mandible to the entire ramus is another very important point in the anatomy of the Bird's head; for, as a rule, the strong horny sheath reaches to the posterior end of this element of the mandible.

In the next table the length of the mandible is put into parallelism with the extreme length of the dentary, which overlaps the articular moiety of the ramus at its posterior end.

	Entire Ramus.		Dentary.	
	in.	lines.	in.	lines.
Caprimulgus europæus	1	6	0	10½
Podargus humeralis.	2	8	1	10
Cancroma cochlearia	4	8	3	6
Balæniceps rex	8	6	7	0
Ardea cinerea	6	3	4	6
Ciconia argala	15	4	13	0
Buceros bicornis.	11	8	10	0
Macrocercus ararauna	2	6	1	2
Calyptorhynchus naso	2	4	1	2
Diomedea exulans	9	6	7	0
Platalea leucorodia.	8	0	7	3
Pelecanus onocrotalus	17	9	6	9

Here it will be seen that the relative length of the dentary is, as a rule in birds with long bills, in direct proportion to the strength of the jaw, and that the Little Goat-sucker has in this respect the advantage of the Pelican; for both the dentary bone and the symphysis are larger in relation to the rest of the jaw in the little bird than in the great one. In *Caprimulgus* the dentary reaches more than halfway towards the end of the ramus, whilst in the Pelican it reaches very little above one-third. In *Buceros bicornis* five-sixths of the jaw is dentary, and in *Balæniceps* it bears the proportion of seven to eight and a half. In the Parrot tribe, the unique state of curvature of the upper jaw, which passes down in front of the mandible, causes that organ, especially the dentary part, to be short; but here what is lost in length is gained in depth, and the jaws of these birds are amongst the strongest in the class. The number of ossific centres in the mandible of birds can be seen only in young specimens, although a great proportion of the class retain parts of the sutural lines—the bones at these places being thin and elastic. But we have seen that whilst complete coalescence of these parts is the rule in such families as the Parrots, the Hornbills, and the Toucans, yet the Balæniceps is very peculiar, in its own group, in possessing this structure.

Professor Owen does not mention the existence of the 'coronoid' bone in the mandible of the young Ostrich; nor have we seen it in that bird, nor in the young Emeu. The same may be said of Owls, Pigeons, Gallinaceous birds, and the Crow tribe. In a very beautiful skeleton, however, of the Australian Jabiru, *Mycteria australis*, at the British Museum[1], this piece has a very similar size and form to that of the Crocodile, and is quite distinct, although coalescence has taken place to a very considerable extent in the other elements of the mandible.

In the Boat-bill it appears to have been large, but coalescence has defaced all but its anterior boundary, although probably it was distinct in the young bird; and as that part of the jaw is extremely well developed in the Balæniceps,—most likely in it too.

In the Heron it is large, and can still be traced even at the posterior part of its upper

[1] Prepared by Mr. E. Gerrard.

and lower margin, where it has contracted adhesion with the sur-angular and angular pieces: here it is lozenge-shaped, whilst in the Jabiru it is reniform.

The development and condition of the coronoid in the Adjutant is very much like what obtains in the Heron; the Albatros also has the same element large, and although bony union has taken place between it and the sur-angular above, as also with the articular and angular behind and below, yet its outline is easily traced. In Cranes and Geese the thin splint-like oblique 'coronoid' is either connate, or has coalesced with the 'articular' behind. In *Grus americana* there is an oblong membranous space anterior to the inferior dental foramen; in the Rook this space is oval, and is behind that passage; Passerine birds and Owls have a similar structure, but the Diurnal rapacious birds have a stronger and more completely ossified mandible. In the Little Goatsucker, *Caprimulgus europæus*, the articular moiety of the lower jaw is thick and cellular, compared with the dentary; it has no membranous part, and being curiously bowed outwards, the dental foramen enters it on the lower margin. Such modifications (which are endless, and in each case beautifully adapted to the life of the bird) are here mentioned only to show that the massive development of the mandible of the Balæniceps is to a great extent teleological. The embryological researches of Reichert and Rathke have proved that the articular element of the Bird's mandible is the ossified proximal end of Meckel's cartilage, and is the homologue of the 'malleus' of Mammals: see Professor Huxley's Croonian Lect. p. 16.

Development of the Mandible.

We must refer the reader to the excellent writings of Professors Goodsir and Huxley for an account of the morphological meaning of the mandible in birds and in vertebrates generally; the views of the former author will be found in the papers so often referred to (p. 173), and those of the latter in the Croonian Lecture (p. 16).

It must, however, be borne in mind that the mandible belongs to the same sclerotome as the squamosal and petrosal. Meckel's cartilage has attained its largest development in the Chick by the eleventh day of incubation, but it has become separate from its fellow of the opposite side at the distal end. The proximal cartilage (the 'quadrate') of this, the first proper facial arch, has begun to ossify in its thickest part at this time, but the 'articular' (or 'malleal') portion is entirely cartilaginous. The dentary elements are not only ossified, but, getting the start of the pre-maxillaries, they have become fused together at the symphysis. The angular and sur-angular pieces are also ossified; but the 'splenial' is still membranous; and there is no 'coronoid' in the Fowl. All the mandibular elements except the articular are formed (like the pre-maxillaries) in perichondrial membrane. From the fourteenth to the nineteenth day the cartilages of Meckel are seen to be wasting fast, just as the ethmo-vomerine process for the pre-maxillaries does. At the end of the second week of incubation the 'splenial' element is ossified, and there is a small square osseous centre in the thick 'articular' portion of

Meckel's cartilage. The external angular process is principally ossified from the 'angular' element (but it derives its cartilaginous base from Meckel's cartilage); the internal angular process is ossified directly from the 'articular.' All these processes may be seen equally well in the Pigeon or any common bird. Meckel's cartilage lasts a long while in the Chelonia and Batrachia. In osseous Fishes it becomes large, and is often persistent. In the Chondropterygii there are no distinct osseous elements formed upon the simple mandibular cartilage.

Tympanic Bone.

Before entering upon the description of the spinal column of Balæniceps, it is necessary for us to say a word or two about the tympanic bone.

The writer quite agrees with Köstlin, Goodsir, and Huxley, that the quadratum of birds is the homologue of the mammalian incus; if this is the case, where do we find the counterpart of the mammalian tympanic? Professor Huxley says[1], very truly, "that the tympanic of the Mammal does *not* articulate with the lower jaw, nor with the pterygoid, nor with the jugal or quadrato-jugal." Seventeen years ago we came upon a bony piece in the skull of a Pea-hen, which was carefully drawn at the time, and although examined and thought on again and again, it still continued to be an enigma,—the quadratum (as we were taught) standing for the homologue of the tympanic. Renewed study, however, of the development of the skull in Birds and other Vertebrata, by various labourers, having restored the quadratum to its proper category, we are now at liberty to reconsider and to classify our nameless bone.

This osseous piece of the skull of *Pavo cristatus* is of a spatulate shape, and is attached to that part of the auditory opening which is formed by the descending (paroccipital) ala of the occipital bone, just where it is confluent with the posterior angle of the squamosal. The narrow posterior end of the bone being thus articulated, the broad anterior part, which is somewhat notched and bifid, passes forwards and outwards, protecting the membrana tympani, and partly serving to give origin to that membrane at its posterior superior margin. The length of the bone is three lines, and its greatest breadth two lines, so that it is sufficiently large to protect the membrana tympani for two-thirds of its extent at its upper margin. The attachment and relations of this ossicle exactly agree with those of the tympanic bone of Mammalia, and its notched broad anterior margin appears to us to foreshadow the condition of the tympanic in the Human fœtus and in the adult Shrew and Echidna. We have searched in vain for this bony piece in any other bird, although the skulls of a great number have been examined. Hoping to find this bone again, at least in the Gallinæ, we have made fruitless search for it in the skulls of the undermentioned Gallinaceous genera; yet it may have been lost in those skulls that were prepared by maceration, and even in natural skeletons such a piece of bone would easily be dissected away, so that future

[1] Croonian Lecture, p. 15.

research may perhaps be rewarded by the discovery of this interesting element in other genera besides *Pavo*. The genera in which no tympanic has been found are—*Gallus*, *Phasianus*, *Meleagris*, *Oreophasis*, *Numida*, *Tetrao*, *Lagopus*, *Talegalla*, *Perdix*, *Coturnix*, *Hemipodius*, and *Pterocles*[1]. In the Common Green Woodpecker, *Picus viridis* (a solitary, shy, suspicious bird), we find very beautiful tympanic bullæ, as large in proportion to the skull as in ordinary Mammalia. These ear-drums are exceedingly like a pair of small cowrie-shells (*Trivia*), the oblong hourglass-shaped opening looking downwards and a little outwards. The posterior end of the opening, which is the narrowest, does not reach to the extremity of the bulla, but the wider anterior end is open and receives the posterior condyloid process of the os quadratum. The inferior part of the bulla is the most dilated, and its edge is the most incurved. This incurving of the edges, as well as the smooth surface and oval shape, give the bone its peculiar cowrie-like appearance. The upper part of the bulla of the Woodpecker appears to be formed by an ossification downwards and forwards from the squamosal and ex-occipital at their point of coalescence; the lower part would appear to be formed by an ossification forwards of the ex-occipital, the inner margin of which becomes anchylosed to the side of the basi-sphenoid. If, however, an opportunity occurs for us to examine this part in an embryo of the Woodpecker, we shall very probably find a separate tympanic ossicle of a V-shape; which would come still nearer to the U-shaped tympanic ring of Mammalia than the emarginate tympanic of the Pea-hen. The Common Duck has its tympanic cavity nearly as well developed as it is in the Woodpecker.

Os hyoides. (Pl. LXVI. fig. 2.)

The Balæniceps has a very small tongue, as is also the case in the Pelecanine birds, so that all that exists of the second facial arch is a small triangular basi-hyal (Pl. LXVI. fig. 2 *b h*) (not one-third of an inch long, and less in width), and a small subcylindrical uro-hyal, about one-sixth of an inch in length. The two pieces of the thyro-hyals (Pl. LXVI. fig. 2 *t h*) belong to the third facial or *branchial* arch (the first post-cranial arch), and are moderately developed; they measure together rather more than three inches and a half. The proximal piece is thin and scooped on its upper surface; the distal, smaller portion is round, and gradually decreases towards the end, which is tipped with cartilage.

Professor Goodsir (*op. cit.* p. 176) says that "in the second visceral lamina of the Bird the auditory columella is developed superiorly, and the feeble anterior horn of the hyoid below, while the elements of the suspensory or posterior horn of the hyoid are formed in the third visceral lamina."

At the end of the second week of incubation, the large proximal piece of the thyro-

[1] Since the above was written we have carefully prepared several skulls of each of the following species of *Gallinæ*, viz. *Gallus domesticus*, *Phasianus colchicus*, *Meleagris gallo-pavo*, *Tetrao tetrix* and *T. cupido*, *Perdix rubra* and *cinerea*, *Lagopus scoticus* and *Coturnix dactylisonans*; only in the Turkey and Grey Partridge do we find a rudiment of the tympanic, and that not constantly. It does not exist in *Crax globicera*.

hyal is nearly ossified in the Chick; but the small triangular glosso-hyal, the short terete divaricating cerato-hyals, the basi- and uro-hyals, as well as the distal thyro-hyal, are all entirely cartilaginous. In the Pigeon, at the time of hatching, we have the same state of things. In many birds the glosso-hyal, and the tips of the uro-hyals and thyro-hyals (distal pieces) remain cartilaginous.

Sclerotic Bones and Columella.

The sclerotals form a ring $1\frac{1}{8}$ inch across; their largest pieces are about a quarter of an inch wide: they are well-ossified. The 'columella' has not been preserved in this specimen; and the complex structures of the internal ear are formed principally by the petrosal, yet impinge upon and are partly formed by the surrounding bones, *e. g.* the epiotic and the mastoid portion of the ex-occipital. The basi-occipital and basi-sphenoid also contribute some part of their substance to the formation of the hard parts of this sense-organ.

Recapitulation of the Cranial 'Elements.'

We will retrace our steps a little, and look again at the constituent parts of the skull and face.

It is very convenient to consider the skull as a 'sys-sclerotome,' divided into a certain number of 'sclerotomes.' This method is more convenient than safe; but we will, as much as possible, avoid theorizing; yet we cannot, we think, go very far wrong if we consider what amount of segmentation is to be seen along the base of the most perfect skulls, *e. g.* those of the Mammalia.

In these creatures we have, from behind forwards, four basal parts or 'centra,' viz. the basi-occipital, the basi-sphenoid, the pre-sphenoid, and the mesial portion of the ethmoid; this latter bony mass having appended to it in front a large vertical cartilaginous apophysis, the ethmo-vomerine cartilage, whilst the thin cortical 'vomer' is related to it (indirectly) below. That great modern anatomist whose mind is most opulent in knowledge of these structures, Professor Owen, has only been able to make out four 'vertebræ' in the skull of the Vertebrata. Whilst we use Professor Owen's 'homological' terms for the cranial 'elements,' we still consider them only the 'analogues,' and not the true 'homologues,' of the pieces that go to make up a corporal vertebra. Moreover we shall find that the lateral and upper pieces do not correspond in number to the basal, and that the same bone may be a 'neurapophysis,' a 'diapophysis,' or a 'sense-capsule.' Whatever we may call this confusing abundance of upper and lateral pieces, whether segmentation, 'vegetative or irrelative repetition,' or 'intercalation of splanchnic bones' or 'sense-capsules,' we are still under the necessity of referring back to the unsegmented primary skull of the embryo; and any attempt to explain the nature of the skull which shall not be based upon a very extended 'embryology' will turn out to be mere waste of time.

Occipital Sclerotome in the Vertebrata.

1. The centrum or basal part—the 'basi-occipital.'
2. Infero-lateral elements—the 'ex-occipitals.'
3. Supero-lateral elements—the 'mastoids.'

N.B. These elements coalesce very early with the petrosal in Mammalia generally; but in the smaller Cheiroptera, *e. g. Vespertilio, Plecotus,* and *Molossus,* they coalesce with the ex-occipitals, and remain quite distinct from the petrosals. In many, if not most Birds, the mastoids are not distinct from the ex-occipitals, the outer margins of these bones having a 'periotic function.' In Chelonia the mastoids are large and permanently distinct; but in the Crocodilia and Ophidia they coalesce very early with the ex-occipitals; in the Lacertilia they are often distinct, but small; whilst in the Batrachia they are not distinct from the ex-occipitals. In Fishes the mastoids are often distinct, and are very large in the Gadidæ.

4 *a.* Supero-mesial elements—the inter-parietals.

N.B. These are evidently often formed from a pair of lateral elements in the Mammalia. The single piece in the adult is largest in the 'lissencephalous' mammals, *e. g. Mus, Talpa.* In Birds they do not exist. In the Abranchiate Reptilia the inter-parietal is single, and coalesces very early with the supero-sub-mesial elements. They have no separate existence in ordinary Batrachia. In Fishes the inter-parietal is single and generally remains distinct.

4 *b.* Supero-sub-mesial elements—the 'squama occipitalis,' or the 'epiotics.'

N.B. These elements form the principal parts of the supra-occipital region in the Mammals, and may be developed from a pair of lateral centres. In Birds their inner margin is thin and squamous—the outer margin taking on the 'epiotic' function; they coalesce very early, or are originally single in this class. In the Abranchiate Reptilia they are small as compared with the inter-parietal, and very early coalesce with it. In Fishes they are generally distinct, and are filled with the upper part of the semicircular canals.

Post-sphenoidal Sclerotome.

1 *a.* The centrum or basal part—the 'basi-sphenoid.'

N.B. This developes a very long exogenous 'rostrum' in typical Birds, and a short upper rostrum in Crocodilia and Chelonia.

1 *b.* Cortical inferior elements—the 'basi-temporals' (nobis).

N.B. These coalesce very early with each other and with the basi-sphenoid in Birds. They probably exist in the embryos of the higher Reptilia; for to us it is evident that in struthious Birds, and in all the cold-blooded Ovipara, the great 'rostrum' is a cortical ossification.

2. The posterior infero-lateral elements—the 'petrosals.'

N.B. These are amongst the most constant cranial elements in all the Vertebrata, and are the most important of the 'periotics.'

3. The anterior infero-lateral elements—the 'ali-sphenoids.'

N.B. These elements are very constant in Mammals and Birds. They are large in the Crocodilia, but feeble and inconstant in the rest of the Abranchiate Reptilia. They are not ossified in the Batrachia, and are generally very small in osseous Fishes.

4. The supero-lateral elements—the 'squamosals.'

N.B. These elements are large and well-developed in Mammalia, Birds, and Abranchiate Reptiles; they are scarcely differentiated in the Batrachia, and they are large and constant in the osseous Fishes.

5. Upper elements—the 'parietals.'

N.B. These are very constant throughout the Vertebrata, but are separated from each other in certain Carnivora, and in some osseous Fishes, by the inter-parietal.

The Pre-sphenoidal Sclerotome.

1. The centrum or basal part—the 'pre-sphenoid[1].'

N.B. This element, distinct and normal in the Mammalia, is high and compressed in Birds. It is not ossified, as a rule, in the Reptilia, but, according to Goodsir, forms part of the bony septum of the 'os en ceinture' in Snakes and Frogs: it has no distinct osseous representative in Fishes; the interorbital septum in this latter class being an orbito-pre-sphenoid.

2. The infero-lateral elements—the 'orbito-sphenoids.'

N.B. These elements—usually well-developed in the Mammalia, but extremely feeble in the Mole—are short and connate in Birds even when they have a distinct osseous centre[2], which is not always the case. In the Chelonia, Crocodilia, and Lacertilia they are fibro-cartilaginous, and appear to have no centre of their own in the Ophidia and Batrachia. They are generally unossified in Fishes.

3. The supero-lateral elements—the 'post-frontals.'

N.B. These elements are exogenous in Mammals, and, with one or two rare exceptions, they are not distinct in Birds. They are well developed in Crocodiles,

[1] In our description of the pre-sphenoid we have followed Professor Goodsir (*op. cit.* p. 154); if, however, Cuvier, Hallman and Huxley be right, not only the detached ossifications anterior to the 'hinge,' but also the upper and anterior portion of the great inter-orbital ossification, is essentially ethmoidal in its nature.

[2] Dr. Hallman (Die Vergleichende Osteologie des Schläfenbeins, Pl. I. fig. 2) represents the Goose as having a distinct V-shaped osseous centre for the orbito-sphenoids. In the African Ostrich there is one large osseous centre, an 'orbito-pre-sphenoid' exactly as in the Carp; whilst in the young Emeu of the sixth week after hatching, the posterior margin of the orbito-pre-sphenoidal cartilage is already ossified,—a condition precisely like what is seen in the half-grown Pike. Recent observations on Birds scarcely mature have yielded us a distinct osseus pre-sphenoid, with exogenous orbital alæ, in very many species: its absence is quite exceptional.

Chelonians, Lacertians, Ophidians, but not in the common Batrachia, *e. g.* *Rana*, *Bufo*. In osseous Fishes they are large and well-developed.

4. The superior elements—the ' frontals.'

N.B. These constant bones are often the largest of the cranial elements in the oviparous Vertebrata.

The Ethmo-vomerine Sclerotome.

1 *a*. The basal part or centrum—the ' ethmoid.'

N.B. The mesial part of the ethmoid in Mammals, including the ' crista galli,' is the central element of their most anterior sclerotome. In Birds this central piece is very variably developed, and soon coalesces with the pre-sphenoid in the Struthionidæ. In Crocodiles, Chelonians, Lacertians, and indeed in most Reptiles (except in some extinct forms, *e. g. Dicynodon*) (Huxley, Quart. Journ. Geol. Soc. vol. xv. pl. 22. p. 655), it is cartilaginous or membranous ; and the same might be said of the Ophidians and Batrachians, if Professor Goodsir's views were correct[1]. In osseous Fishes it is usually ossified,—from one centre in most species, but from two in the giant Sudis, and in the little Smelt (*Salmo eperlanus*).

1 *b*. Cortical element or elements—the single or double ' vomer.'

2. The internal-lateral elements—the ' pre-frontals.'

N.B. These form the lateral masses of the ' ethmoid ' in Mammals, are often cartilaginous in Birds, and are distinct and large in the Crocodiles and Batrachians ; but in the Chelonians, Lacertians, and Ophidians they coalesce, or are connate with the ' lacrymals.' They are large and distinct in osseous Fishes.

3. The external lateral elements—the ' lacrymals.'

N.B. These bones are generally distinct in Mammals : there is scarcely an exception to this rule in Birds : they are large and distinct in Crocodiles ; in the rest of the class of Reptiles they are not, as a rule, distinct from the pre-frontals. In Fishes they form the sub-orbital chain of bones.

4. The superior elements—the ' nasals.'

N.B. These pieces generally meet each other at the mid-line, and are sometimes single, in Mammalia ; in the Manatee they do not meet ; nor do they, as the rule, in Birds,—the Rhea and the Pigeons being exceptional. In Crocodiles they are distinct and meet as in Mammals, but are seldom distinct from the pre-fronto-lacrymal in Chelonia. In Lacertians they may be single or double ; in Ophidians they are large and meet on the mid-line ; in Batrachians and in osseous Fishes they are small and widely apart.

We have already spoken largely of the elements of the lower parts of the face : for

[1] A careful investigation of the development of the ethmo-vomerine axis in Birds will, we have no doubt, fully explain the meaning of this part of the skull in the Ophidians and Batrachians ; to us it appears that it is the pre-sphenoid which is abortively developed in all the lower Vertebrata.

the signification of these parts we refer the reader to the translation of Müller by Baly (1843, vol. ii. p. 1616), and to Professor Huxley's Croonian Lecture.

Vertebral Column. (Pl. LXVI. fig. 1, 3, 4, 5, 6 & 7.)

In studying the corporal vertebræ of the Balæniceps, we shall follow Professor Owen's plan, and consider all those vertebræ "'cervical' in the Bird that extend from the skull to the first vertebra with the hæmal arch complete, and those 'dorsal' that extend from that vertebra inclusive to the first vertebra embraced by, and anchylosed to, the iliac bones[1]." And again, "All those vertebræ may be called for convenience 'sacral,' in the Bird, which are confluent both by centrums and neural arches with each other and with the iliac bones." The remaining vertebræ are 'caudal,' and the last of these is formed of several embryonic vertebræ which are very imperfect in their development, become coalesced together, and are modified for their special function[2].

We here subjoin a Table of the number of vertebræ in the spinal column of different birds—some nearly related to the Balæniceps, and others from very distantly-related families.

	Total number of cervicals.	Number of cervicals with distinct pleurapophyses —floating ribs.	Number of true dorsals.	Number of vertebræ with ribs that articulate with hæmapophyses, most of which reach the sternum	Number of sacral vertebræ.	Number of free sacral ribs on each side.	Number of distinct caudal vertebræ.	Total from occiput to the end of the coccyx.
Balæniceps rex	17	2	4	5	17	1	6	44
Canceroma cochlearia	15	4	4	5	14	1	8	41
Ardea cinerea	19	3	4	5	14	1	7	44
Ciconia argala	17	2	4	5	15	1	7	43
Ciconia alba	17	2	3	5	15	2	7	42
Grus americana	19	2	6	8	17	2	7	49
Phœnicopterus ruber	18	2	5	6	13 or 14	1	9	?45
Grus pavonina	20	2	6	7		1	6	
Psophia crepitans	18	2	6	7	17	1	6	47
Parra jacana	16	3	4	5		1	7	
Fulica atra	15	1	7	8		1	9	
Cygnus olor	25	2	5	9		4	8	
Anser palustris	18	1	5	7	18	3	7	48
Anas boschas	16	1	5	8	17	3	8	46
Pelecanus onocrotalus	17	1	4	5		1	7	
Dromaius ater	21	3	5	5	22	1	9	57
Caprimulgus europæus	13	2	4	6	12	2	7	34
Alcedo ispida	15	2	4	5	13	1	7	39
Cypselus apus	13	2	4	6	11	2	8	36
Accipiter nisus	15	3	5	7	15	2	8	43
Falco æsalon	15	3	5	6	14 or 15	1	8	?43
Trochilus colibris	14	1	5	7	9	2	6	34
Passer domesticus	14	1	5	6	12	1	7	38

[1] Nature of Limbs, p. 103.

[2] The absolute number of vertebræ in any bird can only be ascertained by examining the spinal column at a very early stage: in some cases the last caudal is a compound bone formed of at least ten embryonic vertebræ.

This table of the numerical relations of the vertebral columns of certain birds, several of which birds are related to *Balæniceps*, will be referred to more than once in the description of this part of the skeleton. The great difficulty has been in enumerating the sacral vertebræ; but much care has been taken to examine sections and immature specimens; and where these have not been obtainable, the twin nerve-outlets on each side have been carefully counted. In some cases a doubt has been expressed; and in others, rather than err, we have left out the number in that column. The most important birds for comparison with the Balæniceps are those Grallæ which have short but compressed bodies, or short, stout, robust bodies, with only five pairs of thoracic hæmapophyses, the last pair of which may reach the sternum, as in the *Ciconiæ*, the Balæniceps having the same structure, or may be floating and imperfect, as in *Ardea* and *Cancroma*. The latter birds, as well as those of the genera *Aramus*, *Scopus*, *Botaurus*, *Nycterodius*, *Erodius*, and *Balæniceps*, have the chest flat, or compressed, whilst the *Ciconiæ* and *Mycteriæ* have a round full-shaped body. In the more distantly-related Cranes, and in the still more unrelated Gallinules, Rails, and Coots, the thorax is long as well as compressed, the compression being greatest in the latter group.

Flat compressed bodies are the rule amongst the Grallæ, the Rallidæ carrying that character to its extreme condition, whilst most of the Palmipeds have broad depressed bodies. The extreme of this opposite character occurs in the genera *Podiceps* and *Colymbus*.

We see by the above table that the Balæniceps has the same number of vertebræ in the entire spine as the Heron, three more than the Boat-bill, one more than the Adjutant, and two more than the White Stork. The diminution of the number of vertebræ in the Boat-bill is explained by its being a small and comparatively feeble form of the same type; for, other things being equal, a large bird has a greater number of vertebræ than its smaller congeners; and small birds, generally, have relatively shorter spines than large ones—the neck and sacrum being the parts in which this diminution most takes place. A glance at the table makes this clear, although the instances are but few; yet they could have been multiplied indefinitely. However, it is worth while to remember that the little Humming-bird has only thirty-four vertebræ in all; the Swift (best of fliers) only thirty-six; whilst the Emeu has fifty-seven. It is not intended to say here that the three last-mentioned birds are in the least congeneric; yet the rule will be found to hold good, as a general principle, in families as well as in the broad class.

Looking at the skeleton of this great Wader, we see one of the most striking instances of an aberrant form, conformable in all essentials to its type, and yet having structural affinities with all the families that lie in the region round about that central type.

When the skeleton has been described, and the curious affinities of the bird, whether patent, or more secret, have been shown, then perhaps some attempt will be made to prove that the Balæniceps is only one amongst many wanderers from typical restraint, and that all these *aberrants* are still 'under law.'

The cervical vertebræ of the Balæniceps are relatively stronger and shorter than those of the great Adjutant, whilst they form a remarkable contrast to those of the Heron—a bird which not only has more of these joints than its relations, but in which the individual vertebræ are exceedingly long and narrow. The difference between the structure of the neck in the typical Heron and in the Balæniceps is remarkably like what we see in the Mammalia, when we contrast the cervical vertebræ of the Vicugna with those of some large Stag, such as the Wapiti, or the Sambur Deer. The large, broad, spoon-shaped jaws and the flat head of the Boat-bill require a shorter neck and individually shorter vertebræ than those of the Heron with its long narrow cranium, and its narrow, straight, tapering, pointed mandibles.

Yet in nothing but in the decrease of number and the shortening of each joint do the cervical vertebræ of *Cancroma* differ from those of *Ardea*; whilst all the change that has taken place between those of *Balæniceps* and *Cancroma* is that in the former two vertebræ have been added, and the relative as well as real strength of each bone greatly increased.

Atlas. (Pl. LXVI. figs. 1, 3, 4 *at.*)

The atlas is small, as in all birds, and its 'procœlian' cup for the articular condyle of the occipital bone is large in proportion. This cup is imperfect, a large crescentic piece being cut away, as it were, from the top, to make room for the 'odontoid' process, which process, although ossified to the axis, in reality belongs to the atlas, being the internal or 'diaphysial' part of its centrum. Behind where the upper edge of the cup is cut away, there are two small articular facets of a semi-elliptical shape for articulation with the sides of the tip of the odontoid process. In *Balæniceps* and its allies there are no foramina for the vertebral arteries on the sides of the atlas. The post-zygapophyses of the atlas send backwards a rather broad triangular process for muscular attachment: these are obsolete in *Cancroma* and the Small-headed Heron; but they are largest in the Adjutant, in which bird they divaricate outwards. The posterior articular surface of the centrum of the atlas is of the usual U-shape, and the inferior surface is marked in its latter half by one mesial and a pair of lateral tubercles. The upper concave aspect of the centrum is full of small pneumatic holes.

Note.—In the Woodpecker and other arboreal birds, the cup of the atlas has a very perfect rim, but it is perforated below for the passage of the odontoid ligament; here also the vertebral arteries are bridged over. In the young Emeu the lower or 'hypophysial' part of the atlas is distinct from the neural arch as well as from its odontoid element. *Query*, does not this part of the Bird's centrum answer to the marginal parapophyses of the abdominal vertebræ of the Fish, as well as to the mesial hypapophyses of the Vertebrata generally?

It is not easy to draw a line between these processes or elements (which are so seldom autogenous), and to say where one begins and the other ends; at any rate the lateral processes of the base of the atlas are the homotypes of the parapophyses of the succeeding vertebræ, whilst the mesial tubercle is a rudimentary 'hypapophysis.'

Axis. (Pl. LXVI. fig. 1 *a x.*)

The 'axis' of *Balæniceps* is a short, high, swollen bone,—the low neural spine, the small hypapophysis, and the large post-zygapophyses being very cellular. The short odontoid process is flat above and convex below, having at each side near the tip an inferior facet to articulate with the atlas behind the rim of the cup. There is a distinct neck to this process, which is very cellular, as is also the front of the centrum between the branches of the U-shaped articular surface, corresponding with the posterior aspect of the atlas. The pre-zygapophyses are small, and lie on the margin of the neurapophysis; the post-zygapophyses are subtriangular, large, and concave. The posterior articular facet of the centrum is perfectly ornithic, being convex from side to side, and concave vertically. There is a rough oval facet in front, and another behind the low spine for the elastic ligament. The upper and lower transverse processes together form a vertical mass of thickened bone, perforated behind for air, but having extremely small openings in front for the vertebral arteries. This is similar to what occurs in its nearest congeners, *Cancroma* and *Ardea*, whilst the Storks, *e.g. Ciconia argala* and *alba*, have these vessels bridged over by a well-defined convex arch of bone. *Grus americana* possesses not only this bridge, but also a small 'rib,' which does not appear ever to have existed in the Stork and Heron groups, nor does it exist in the young Emeu. In the Common Fowl there is a pair of lateral bridges on the atlas, but none on the axis.

In the immature skeleton of the Emeu the anterior end of the centrum of the axis, including the odontoid process, all belongs to the atlas, and is quite distinct from the axis for the first few months; so that, if the atlas had all its rights, it would be much nearer in size to the axis. In the Goose one-third of the centrum of the axis belongs to the atlas, and the former bone has in this bird a small 'rib.' The neural canal of the axis of Balæniceps is narrower than that of the atlas; in the latter it is one-third of an inch wide, in the former one-quarter of an inch in front, but full one-third behind, the bone being bevelled away here between the post-zygapophyses. In the axis, and the two next vertebræ in this bird, the posterior tubercle for the elastic ligament lies in a recess formed by the projection backwards of the upper part of the bone. The margin of this projecting portion is rounded and smooth, and forms a very elegant arch over the inter-spinous tubercle, the piers of which arch lose themselves behind the thick tubercular mass of bone which forms the upper part of the post-zygapophyses. The articular facets of these latter processes lie directly under these tubercular masses.

Cervical Vertebræ. (Pl. LXVI. fig. 1 *cv*, and figs. 5 & 6.)

The facets of the post-zygapophyses of all the remaining cervical vertebræ are less concave and look a little more outwards (as well as downwards) than those of the axis; they are sub-oval, and, measured in the antero-posterior direction, are more than a quarter of an inch long in the upper part of the neck, and nearly half in the lower, diminishing again in the dorsal region. The pre-zygapophyses are exactly adapted to them, and necessarily look upwards and inwards. The articular surfaces of the centrums maintain their true ornithic character from the axis to the pelvis. The posterior surface of the axis already described has its counterpart in the rest of the post-central facets; whilst answering to these, those at the anterior end of each centrum are concave from side to side, and convex vertically. This beautifully strong mode of articulation allows of pretty free movement backwards and forwards between any two vertebræ; but it also permits some motion from side to side. From the third to the fifteenth cervical vertebra (inclusive), there are anchylosed rudimentary ribs or ‘pleurapophyses,’ and the first pair of these send down the strongest process; this inferior process of the short rib becomes more pointed and smaller until we reach the eleventh cervical vertebra, where it is obsolete. In this and in the succeeding vertebræ to the fifteenth the pleurapophysis scarcely projects downwards beyond the upper and lower transverse processes between which it lies, and to which it is anchylosed. The sixteenth cervical has a short two-headed rib, and that of the seventeenth is only half an inch shorter than the first dorsal rib, but it is narrower, very narrow in the middle, and has no appendage. This short condition of the cervical pleurapophyses is very much like what we find in the Boat-bill, the Herons and the Storks, as also in the Pelican; but in other Totipalmatæ—*e. g.* the Gannet and Cormorant—these ‘ribs’ are very long and styloid, especially in the latter bird, where they nearly reach the lower end of their own vertebra. The Colymbi are like the Cormorant in this respect, and so are the Flamingos, although these latter birds have very elongated cervical vertebræ, such as are only found again in the (typical) Herons and the Pelicans. But in the Cranes we have not only the long styliform pleurapophyses, but the tendons of the lateral muscles are ossified and continuous with the base of the small rib and with the diapophyses. These osseous splints are all parallel with each other and give a peculiar character to the skeleton of the neck in these birds. The ninth cervical of the Balæniceps (Pl. LXVI. figs. 5 & 6) may be taken as of a medium size, and its measurements are as follows:—Length $1\frac{1}{4}$ inch, breadth across the diapophyses $1\frac{1}{8}$ inch, and thickness at the middle two-fifths of an inch, and depth or height at the same part three-fifths of an inch. The third and fourth cervical are here not so quadrate in shape, seen from above, as in most birds. There is along the upper lateral margin in these two bones a large crescentic notch between the massive pre- and post-zygapophyses; but in the Adjutant this notch is bounded before and behind by a sharp spur of bone in the third, whilst in the fourth vertebra it is converted into a large oval foramen. This foramen is relatively smaller in the Fowl, but it exists in both the third and fourth joints. In the extremely compressed and elongated cervicals of the Heron, this foramen exists even on the fifth, whilst it is sometimes obliterated in the fourth. The third and fourth cervicals of the Balæniceps have low thick neural spines, marked before and behind by the large tubercle for the elastic ligament. The centrum of the fourth is compressed and has two oblong parallel tubercles beneath, the meaning of which will soon be explained. The compression of the centrum of the third cervical in Balæniceps is very great, and towards its hinder part there is a blunt rudimentary hypapophysis, marked below by three parallel lines. The fifth cervical of the Balæniceps begins to take on the normal shape of the vertebræ of the cervical region in birds: the spine without being higher is more compressed than in the fourth; the anterior inter-spinous tubercle is vertical, whilst that behind the neural spine is, as in most of the cervicals, very oblique. The centrum in this vertebra is thicker, having attained the normal proportions; but it is still convex beneath, and its anterior half is marked by two nearly parallel ridges about two lines apart from each other.

In this fifth vertebra, as well as in the fourth and the third, there is a pair of strong bridges for the vertebral arteries. These bridges are completely closed by an undivided bony ring to the fifteenth (inclusive), and they increase in size gradually; those of the third cervical being only a line and a half in diameter, whilst those of the fifteenth are nearly four lines across. The spine of the sixth cervical in Balæniceps is smaller than that of the fifth, and these processes decrease regularly to the thirteenth; but in the fourteenth the neural spine is more evident, whilst in the fifteenth to the seventeenth we have an approach to the condition of the process in the true dorsals. The inferior surface of the sixth cervical is concave, and at its anterior end the parapophyses send inwards a blunt process on each side, which processes, in the fresh state, are connected together by inter-osseous membrane, thus forming a canal for the carotid arteries. But in the seventh to the thirteenth (inclusive), these processes of the parapophyses meet at the mid-line (Pl. LXVI. fig. 5 *cc*), at which part they are somewhat carinate externally, whilst the passage itself is circular. The inferior margins of the centrums of these vertebræ, with four perfect canals, are marked by a sharp and rather scabrous ridge; between these marginal ridges the inferior surface of the centrum is rather flat, whilst it is more concave at each end. The concavity of the posterior third is formed by the swelling of the bone both outwards and downwards, on each side, to form the posterior articular facet. This lateral expansion leaves the bone scooped and concave at the mid-line, thus exactly adapting it to the anterior end of the next succeeding vertebra.

The principal pneumatic foramina enter the axis behind the upper transverse process, or diapophysis, but in the rest of the spine to the last caudal, the largest pneumatic openings are on the front face of these processes. The last carotid arch—that on the thirteenth cervical—is marked beneath by two small sub-mesial keels. The last four cervicals have no carotid arch or canal, but in their place there is, at the anterior end, a rather thick, subquadrate azygous process (Pl. LXVI. fig. 1 *hp*); that on the seventeenth, or last cervical, being the smallest, whilst that on the fifteenth is the largest, being about five lines broad and four lines deep. These are, according to Professor Owen, 'hypapophyses,' and the carotid canals, although formed by a pair of laminæ, he considers to be of the same nature.

From the thirteenth to the seventeenth cervical (inclusive) there is a much greater cellularity of the bone, and these lower vertebræ gradually increase in width; so that the seventeenth is more than $1\frac{1}{2}$ inch across the diapophyses, the ninth being only $1\frac{1}{8}$ wide at the same part. In the two last cervicals the upper articular surface for the 'tubercle' of the rib is flat, that for the round smooth 'head' is rather deeply concave, as in the dorsal vertebræ.

The formation of the carotid 'hæmal' canal in the neck of birds is exceedingly interesting, but its anatomy is not a little obscure. In 1844 Professor Owen[1] taught that these were typical vertebræ; but this mistake was soon corrected by him, and the true nature of these canals as productions of the centrum (in a part of the body of the bird where there are only very small rudiments of ribs and no hæmapophyses or hæmal spines) was shown. To the writer's mind, the distinction between parapophyses and hypapophyses is faulty, dividing as it does parts that are essentially one in signification. In his masterly memoir the 'Croonian Lecture[2],' Professor Huxley has shown the great uniformity and simplicity of the structure of the vertebral column in all the Vertebrata, and to his views our own have for a long time been approximating. But many a passage from Professor Owen's most invaluable works might be brought to show that these structures are far more simple and uniform than would appear from their nomenclature.

In Professor Owen's Report 'On the Archetype and Homologies,' read at the Meeting of the British Association held at Southampton in 1846, we have the following remarks (page 254 of the General Report):—

"In the Sturgeons (*Sturio*, *Polyodon*) the inner layer of the fibrous capsule of the gelatinous notochord has increased in thickness, and assumed the texture of tough hyaline cartilage. In the outer layer are developed distinct, firm, and opake cartilages, the neurapophyses, which consist of two superimposed pieces on each side, the basal portion bounding the neural canal, the apical portion, the parallel canal filled by fibrous elastic ligament and adipose tissue; above this is the single cartilaginous neural spine. The parapophyses are now distinctly developed, and joined together by a continuous expanded base, forming an inverted arch beneath the notochord for the vascular trunks, even in the abdomen. Pleurapophyses are articulated by ligament to the ends of the laterally projecting parapophyses in the first twelve or twenty abdominal vertebræ; in the anterior ones those 'vertebral ribs' are composed of two or three distinct cartilages. The posterior pleurapophyses are short and simple. The parapophyses gradually bend down to form hæmal arches in the tail, at the end of which we find hæmal cartilaginous spines corresponding to the neural spines above." And again in page 255:—"In the osseous fishes I find that the centrum is usually ossified from six points, four of which commence, as Rathke describes, in the bases of the two neurapophyses and the two parapophyses; but the terminal concave plates of the centrum are separately ossified[3]. They coalesce with the intermediate part of the centrum, which is sometimes completely

[1] See his Lectures on Comp. Anat., vol. ii. p. 44. [2] Delivered at the Royal Society, June 17, 1858.

[3] Vogt, Williamson, and Huxley speak of this annular 'diapophysis' as being ossified from only one centre.

ossified, but commonly a communicating aperture is left between the two terminal cones, and in many cases the plates by which calcification attains the periphery of the body leave interspaces permanently occupied by cartilage, forming cavities in the dried vertebræ, especially at their under part, or giving a reticulate surface to the sides of the centrum. The expanded bases of the neur- and par-apophyses usually soon become confluent with the bony centrum—sometimes first expanding so as wholly to enclose it; as, for example, in the Tunny, where the line of demarcation may always be seen at the border of the articular concavity, though it is quite obliterated at the centre, as a section through that part demonstrates." Again, page 256:—"In saurians, birds, and mammals, the notochord is enclosed by cartilage before ossification begins, which cartilage is continuous with the cartilaginous neurapophyses. In birds, the two histological processes, chondrification and ossification, do not precisely follow the same route. In the centrums of the dorsal and cervical vertebræ of the Chick chondrification is centripetal: it begins from two points at the sides, and proceeds inwards, the middle line of the under surface of the primitive notochord resisting the change longest. But, when the lateral cartilages have here coalesced, ossification begins at the middle line and diverges laterally; the primitive nuclei of the bony centres appearing as bilobed ossicles, and its direction is centrifugal. The lobes ascend to embrace the shrivelled remnant of the chorda, like the hollow vertebral centres in fishes. Only in the sacral vertebræ has ossification been seen to begin from two distinct points at the middle line. The bases of the separately ossifying neurapophyses extend over much of the centrum, and soon coalesce with it." Remark here, that the carotid canals are formed by exogenous marginal processes from the lower centre of ossification. We must be allowed to make another quotation. Speaking, in page 260, of the development of the anterior vertebræ of 'a large South American siluroid fish,' which has 'the first five centrums rigidly fixed together by continuous ossification below,' although 'the concave articular cavities, with the elastic capsules and contained fluid,' were seen in a vertical section, Professor Owen says, "The continuous bony plate supporting those centrums was perforated lengthwise by the aorta, offering another mode of the formation of a hæmal canal—viz. by exogenous ossification in and from the lower part of the outer layer of the capsule of the notochord; the carotid hæmal canal in the necks of birds seems to be similarly formed; and the neck of the Ichthyosaurus derives additional strength and fixation from apparently detached developments of bone in the lower part of the capsule of the notochord, at the inferior interspace between the occiput and atlas, and at those of two or three succeeding cervical vertebræ."

Note.—The odontoid process of the mammalian axis is considered by our author to belong to the same category[1]; but in that delightful little work of his on 'The Nature of Limbs' (1849), this ossific centre is described as the main or internal part of the centrum of the atlas, whilst the basal part of the atlas is considered to be the cortical or hypapophysial portion of that bone. See pages 94, 107, and 112.

[1] See page 261 of the same Report.

If we compare together the hæmal canals arising from vertebral centrums, without the help and intervention of hæmapophyses and hæmal spines, we must come to the conclusion that they are essentially formed in one manner. The posterior abdominal and caudal arches of the Sturgeon, Herring, Dory, Sea-bream (*Pagellus centrodontus*), the open caudal passages in the Ophidia, the closed arches in the Slow-worm, and lastly, the carotid canals in the neck of birds, thus have a homological unity.

Nor does the structure of the anterior vertebræ of the siluroid fishes (*Silurus*, *Bagrus*) present anything essentially new; for, as Professor Owen himself has shown, the passage for the aorta along the base of the coalesced centrums of these fish, is formed "by exogenous ossification in and from the lower part of the outer layer of the capsule of the notochord."

In distinguishing between diapophyses and parapophyses in the vertebræ of birds, we have to bear in mind the embryological fact, that during ossification "the bases of the separately ossifying neurapophyses extend over much of the centrum, and soon coalesce with it." But this fact is quite in harmony with what we find in the adult bird, for the bases of the upper transverse processes or 'diapophyses,' exogenous growths in the corporal vertebra from the neural arch, expand over the upper half of the sides of the centrum. The distinct ossification of the cortical part of the centrum in the atlas of birds is a pretty good guide as to what processes may be called 'parapophyses,' viz. just above the lower margin of the centrum, as well as at and beneath that margin.

The 'centrum' in oviparous vertebrata is almost as rich in processes having a teleological meaning as the 'neurapophyses;' yet parts arising from the neural arch are as a rule more definite in shape and function, and are consequently more easily classified than those spurs and processes which arise from the body of a vertebra.

So that the single median processes called 'hypapophyses' may be seen by tracing them in successive vertebræ in birds, to be formed by the gradual coalescence of parapophyses that have become in each succeeding bone nearer and nearer each other. Or the opposite method may be used in tracing them, and then we shall see a hypapophysis gradually bifurcating, the bifurcations becoming sessile, and forming distinct and true parapophyses. The Penguin is one of the best birds in which to see the 'specific unity' of these exogenous processes of the lower part of the centrum. In this bird (*Eudyptes demersa*) the two last cervicals have distinct floating ribs, and these vertebræ are followed by seven distinct dorsals, having the 'opisthocœlian' mode of articulation of their centrums.

In the penultimate cervical, which is very broad beneath, there is a pair of anterior cupped parapophyses for the heads of the small ribs, and a small mesial process between and a little behind these. In the last cervical, in addition to these three processes, there is a pair of broad thin widely divaricating processes passing backwards and outwards from the mesial one. In the first dorsal the anterior articulating processes are higher up on the side of the centrum, and the mesial process has vanished from between the two posterior pieces. In the second dorsal the two hinder processes are rather nearer the anterior end of the centrum, and are now evidently only one bifurcating piece. In the third dorsal this piece is losing its lateral processes; in the next three vertebræ they have become simple and further backwards in position, whilst in the last joint, that which articulates with the sacrum, this mesial process has vanished.

Retaining the familiar and valuable term 'parapophysis' for all these processes, we would distinguish the most marked varieties by a prefix, which should indicate their place and function. Thus *Pre-parapophysis* will indicate in birds that process which is anchylosed above to the rudimentary rib, and which sends down a spur of bone below to form half the carotid canal; in *Ophidia* it may be seen as a short and blunt spur beneath the articular diapophysis.

The posterior outstanding processes below the lower cervical centrums in the Penguin, Cormorant, and Fowl, and the pair of processes which form an open hæmal canal in the true Ophidians, and a closed canal in the Blind-worm, may be called *Post-parapophyses.*

The single inferior median process, so common in the centrums of the Vertebrata, can take on the prefix *hypo*; then, instead of hypapophysis, we shall have *hypo-parapophysis.* The caudal hæmal spine in the little *Anguis fragilis*, and in those fishes where there is no sign of its being anything but an exogenous growth from the down-bent parapophyses, may be termed a *meta-parapophysis.* Lastly, where this lower transverse process arises from near the middle of the side of the centrum, as in many osseous fishes, no prefix need be used: it is simply a *parapophysis.*

Professor Huxley shows that the ribs themselves, and the 'chevron bones' of the caudal vertebræ of many of the higher Vertebrata, are all developments of the 'centrum,' but having a distinct ossific centre[1].

Several of the middle cervical vertebræ have perfectly bony carotid canals in the following genera—viz. *Balæniceps, Cancroma, Ardea, Botaurus, Mycteria* (*M. australis*), *Pelecanus, Sula*, and *Picus*; the number is variable in skeletons of the same species, being greatest in old birds. However, as a rule in the class of birds, the mesial part of this canal is completed by interosseous membrane.

Dorsal Vertebræ and Ribs. (Pl. LXVI. figs. 1 & 7.)

The four true dorsal vertebræ of the Balæniceps are quite distinct from each other and from the sacrum. In the Pelican, and in one of the Humming-birds, the Mango Colibris (*Trochilus colibris*), the last two dorsals have entirely coalesced with the sacrum; that they are dorsal and not sacral vertebræ is proved by their anterior position with regard to the iliac bones, the true sacrals being over-canopied by these large 'pleurapophyses.'

The neural spine of the first dorsal is the longest, being seven-eighths of an inch in

[1] Croon. Lect., pp. 48 and 71.

extent, the rest are rather shorter, and are about the same length as the spine of the last cervical. These spines gradually increase in height, the first being one-fourth, and the last half an inch high. The upper ridge of the spine is the longest part; it is bifurcate behind and sometimes in front. The spines are thickest below, and thicker at their posterior than at their anterior margin. Their shape is oblong, the last being nearly square, but pitched, as it were, obliquely forwards. The anterior and posterior edges are rough for the attachment of the elastic ligament. The dorsal vertebræ are $1\frac{1}{2}$ inch wide across the strong thick diapophyses (Pl. LXVI. fig. 7), the last being the widest by a line or two; the diapophyses are widest in the first and narrowest in the last dorsal. These latter processes rise a little as they pass out from the neural arch; they are concave in outline in front and very arcuate behind, the terminal third being extended in the antero-posterior direction, and is on an average more than half an inch broad at this part.

The terminal part of the diapophysis is bevelled downwards, becomes narrow again, and just beneath its tip forms the flat oblique articular surface for the 'tubercle' of the rib. The diapophyses are very broad where they are one with the neural arch, and at this part in front each diapophysis has two or three large pneumatic foramina, and there is another large one on each side higher up at the junction of the diapophysis with the neural spine. The large oblique zygapophyses are much like those in the lower cervicals, but they gradually become smaller and nearer together as we pass backwards. Beneath each pre- and post-zygapophysis there is a large rounded, smooth, crescentic notch, which is formed into a foramen by the corresponding notch in the contiguous vertebra; this foramen is for the exit of the spinal nerves. These round notches have much the same character from the axis to the pelvis; they are formed at the expense of the strong vertical neurapophyses, which elements dilate above into the zygapophyses, and below into the expanded part which becomes confluent with the centrum. A large space, between the zygapophyses, of the spinal canal is left unprotected by bone. The arch formed by the confluent neurapophyses has a large crescentic notch both before and behind in the upper cervical vertebræ and in the dorsals, being smallest in the dorsal region. But in many of the middle cervicals the emargination between the post-zygapophyses is very large and triangular. These upper inter-laminar spaces are filled up in the fresh state by strong interosseous membrane. The spinal canal, very wide in the lower cervical region, becomes narrower in the dorsal, expands very much in the middle part of the sacrum, to narrow more and more down to the last caudal. The ribs are relatively inferior in strength to those of the more robust, thick-bodied Adjutant; the second dorsal rib is strongest and has a medium width of a quarter of an inch. Only the four true dorsal ribs have appendages (Pl. LXVI. fig. 1 *ap*), the longest of which on the second rib is less than an inch in length. The cupped short parapophyses that receive the rounded head of each rib rise higher, as we pass backwards; those of the last two dorsals being at the upper margin of the centrums.

The bodies (centrums) of the dorsals are more like those of the Storks than those of the Herons, being comparatively shorter and thicker than those of the more elongated and feebler typical bird—viz., the Heron. There is a very thick but small hypo-parapophysis at the anterior part of the first dorsal in Balæniceps, but none in the others. There are some rather large pneumatic foramina on the middle of the sides of the centrums of the dorsals rather high up. The dorsal and pelvic ribs dilating below, form at their tip a flattish articular surface for the hæmapophysis. The first of these ossified 'sternal ribs' is but little more than half an inch in length; the fifth, which joins the pelvic rib, is $2\frac{3}{8}$ inches long. These bones are broad above, narrow in the middle, and then expand considerably from side to side to form the transverse synovial surface for articulation with the sternum.

In certain birds, several of the dorsal vertebræ become anchylosed together; this is seen in one group of the Raptores—the Falcons, but not in the other families. In *Falco peregrinus, subbuteo, æsalon*, and *tinnunculus*; and (according to Professor Owen) in the Australian Hawk (*Ieracidea berigora*), five of these joints are thus anchylosed, one free vertebra intervening between these and the sacrum. The first of the five coalesced bones has a floating rib, and belongs to the cervical region. The same thing occurs in the Gallinæ and Columbinæ, but they have only four bones thus joined, the first of which has floating (cervical) ribs.

The Flamingo has the same structure as these latter birds, save that the ribs of the first in the anchylosed piece reach the sternum by hæmapophyses. Of the six true dorsals in the Agami (*Psophia crepitans*), the three first are anchylosed into one piece as perfectly as in the fowls. *Grus pavonina* has distinct dorsals, but *G. americana* has the second and third true dorsals combined into one bone. In the Grebes (*Podiceps*) and in the Dab-chick (*Sylbeocyclus europæus*) there are five true dorsals, the first four of which are quite confluent; this confluence in the latter bird affecting the hypo-parapophyses as in the *Gallinæ*. These inferior median processes are in some birds widely bifurcate. This may be best seen in the three first true dorsals of *Colymbus septentrionalis*, and in the three last cervicals and first true dorsal of *Alcedo ispida*. It is not, however, so common a character even as the confluence of the dorsal vertebræ; this latter state of the dorsal region being, after all, exceptional as to the entire class. Another modification of the dorsal vertebræ has to be noticed;—in birds with very compressed dorsal centrums, as the Lapwing, or with compressed and carinate centrums, as Parrots, Gannets, Cormorants, Puffins, and also in the Penguin, where the centrums are not so flat, the articulation of these elements is '*opisthocœlian*.' This character of an anterior ball and a posterior cup to the dorsal centrums is not found in the Pelican, which, added to the strange modification of its jaws, and the highly pneumatic state of its bones, make it very aberrant from the other Totipalmatæ. There is no floating abdominal hæmapophysis in the *Balæniceps*—although this is very common in birds (especially raptorial and insessorial species), it occurs however in the Adjutant. In the skeleton of a Red-necked Grebe (*Podiceps rubricollis*) prepared by the writer, there was one of these free hæmapophyses on the right side with the rudiment of a second near its tip; whilst on the left side there were two such bones, the anterior piece being very long, passing downwards more than an inch behind its homotype of the pelvic rib, and upwards of an inch behind the rib itself. A structure this well worth noticing, bringing us, as it does, so near to the condition of these parts in the Crocodile. In the Puffin (*Fratercula arctica*), and in the genera *Alca* and *Uria* the posterior ribs and hæmapophyses are prolonged so far backwards that the very angular articulation of the last or pelvic nearly reaches as far back as the tip of the very long and slender os pubis.

Sacral and Caudal Vertebræ. (Pl. LXVI. fig. 1 *sc*, *cd*; & Pl. LXVII. figs. 2 & 3 *sc*, & *cd*.)

The first two sacral vertebræ are almost as large as the dorsals, and their boundaries are very distinct; they then rapidly decrease in size and in distinctness; yet the next four are indicated by their short blunt pleurapophyses, the last two of which scarcely reach the ilium. The stunted pleurapophysis of the right side of the second sacral is not anchylosed to its parapophysis. After the first six, the next five sacrals have their extremely small pleurapophyses confluent with the sides of the centrums, without any out-standing part. The remaining six sacrals have out-standing coalesced pleurapophyses, the second and third of which are extremely thin, and are principally composed of threads of diploe. The neurapophyses of all the sacrals except the last have in this bird completely coalesced. Between the first and second sacral there is a large oval foramen for the exit of nerves, but it is much less than the passage formed in the dorsals between the neurapophyses of contiguous vertebræ. The posterior and anterior roots of the spinal nerves have separate outlets in the rest of the sacrum; and from these passages to the roof of the pelvis there is a large quantity of very rich diploe involving the substance of the neurapophyses, neural spines, diapophyses, and pleurapophyses. The neural spines of the sacrum are at first equal to those of the dorsals, but between the acetabula they spread, become rounded, and then obsolete. There is in this, as in most birds, a large triangular space for the insertion of the dorsal muscles on each side the sacral spines; the roof of this space is oblique and is formed by the ilium; the floor is horizontal, and consists of the diapophyses.

Looking at the pelvis from above (Pl. LXVII. fig. 2), there may be seen two pairs of small passages between the spine and the iliac bones, just as these large bones begin to divaricate before they turn outward on each side towards the acetabula. Behind these, as the spine gains breadth but loses height, there is a deep fissure divided by oblique septa on each side of the spine; these septa are the diapophyses of the middle part of the sacrum. The iliac bones become further and further apart; and where they join the coalesced dia- and neur-apophyses, four pairs more of oval passages, most of them quite small, indicate from above the boundaries of four more of the sacral vertebræ. Two additional pairs of large transversely oval openings or interspaces, the anterior pair of which is bridged over by a thread of bone near its outer end, bring us to the last sacral vertebra. This bone is united by its centrum to the centrum of the one before it, and by the tips of its coalesced ribs (which turn forwards near their ends) to the iliac bones, now $1\frac{1}{4}$ inch apart. The pleurapophyses of this last sacral are one third of an inch longer than its diapophyses ; these latter processes are bevelled at their ends, so that the transverse process is suddenly smaller where it is only composed of a rudimentary 'rib.' The neural canal can be seen between the two last sacrals. The counterpart of this last sacral vertebra of the Balæniceps forms the first of the caudal series in the Heron and the Adjutant ; and perhaps this would be the case in the next Balæniceps that should be dissected. The structure of the caudals is extremely like that of the last sacral, but they gradually acquire short neural spines, the last compound 'ploughshare bone' (which is composed of nine or ten embryonic vertebræ) being sharply carinate along nearly the whole of its upper margin. The ends of the coalesced caudal pleurapophyses project three lines below and external to the ends of the diapophyses, and are blunt, smooth, and clubbed. In the last three these transverse parts are gradually lost, whilst they gain on their inferior surface small forward-projecting coalesced 'hæmapophyses' (hypophyses of Huxley). A small distinct 'sesamoid bone' of this nature lies between the second and third centrum, and belongs to the latter. The last caudal is one inch and two lines long, measured along its base. These caudals of the Balæniceps have a very beautiful structure. They are not oily as in the Heron, but pneumatic as in the Adjutant ; and the air enters them principally by a large oval opening, which in the two first joints occupies the entire front of the broad basal part of the compound transverse process ; this large recess communicating by apertures with the whole of the interior of the bone. The external table of bone is extremely thin, the threads and areolar plates of diploe are delicate in the extreme, and the short diverging 'ribs' are mere hollow tubes, having extremely thin walls.

Pelvis. (Pl. LXVI. fig. 1 *il*, *ism*, *pb* ; and Pl. LXVII. figs. 2 & 3.)

The pelvis of this bird is very pleasing both to the anatomist and to the systematist. It has little in it even of a *generic* nature to distinguish it from that of our native grey Heron, and indeed, of all the true *Ardeæ* and *Botauri* : it might belong to a gigantic form of *Ardea* proper.

If this 'stranger in a strange land' (too early lost to the zoologist to gladden prematurely the anatomist with its rich spoils) had lived as long as the four Grey Herons did, whose bones now lie before the writer, the difference between their pelves would have been chiefly a difference of size. The comparative smoothness of the bone and its softer and more rounded outline would, with the lapse of years, have given it that sharpness and angularity which is seen in these Herons' pelves, arising from the strong crests on the margins of the iliac bones. The upper margin especially of each iliac bone as it diverges to overhang the acetabulum, and then form the upper and outer margin of the pelvic roof in the Heron, is feebly developed in the skeleton of this Balæniceps. The narrowness of the entire pelvis, and especially the contracted waist-like part, before the bone expands to articulate with the os femoris, is precisely what we find in all the true Ardeine birds, including *Cancroma*. But in the Storks the first thing that strikes the eye is the broad, expanded, foliaceous condition of this part of the skeleton. The narrow little pelvis of *Botaurus minutus* (so much like that of the Crake and Water Rail) is at once seen to be the diminutive counterpart of the same structure in the Balæniceps. We shall see, when we come to the bones of the feet, that Ralline affinities are not absent from this aberrant 'giant,' whilst such relationship appears in the structure of that more normal 'dwarf'—the little Bittern.

The pelvis of the Balæniceps at its narrow pre-femoral 'waist' is 1 inch and 3 lines wide; but it is $2\frac{1}{2}$ inches across the iliac crests where they rest upon and overhang the sacral ribs. The breadth across the pelvis behind its articular surfaces for the great trochanters is 3 inches and a line, being exactly the width of the widest part behind, which is one-third of an inch in front of the blunt in-turned terminal tips of the iliac bones. The margin of the pre-femoral part of the ilium is rather wide, (Pl. LXVII. fig. 2 *il*) and the bone itself here is not very concave, but passes rather steeply down for two-thirds of its width, to become more horizontal near the lower and outer margin. There is a large crescentic emargination on the front of the ilium, and the inferior and outer sharp boundary of this wide notch does not pass so far forwards as the upper and inner.

Half an inch behind the sacral rib there arises a sub-marginal muscular ridge which is crescentic, and runs backwards nearly to the acetabulum. This latter cup-like articular cavity is not perfected by bone, there being in the skeleton an internal oval passage as wide as the head of the thigh-bone. The anterior and upper two-thirds of this scooped articular ring is formed by the ilium; the rest belongs to the pubis below and to the ischium behind. Above and behind the 'acetabulum' is the slightly concave oval articular surface for the great trochanter; it passes obliquely upwards, outwards, and backwards. Exactly behind this part is the large sacro-ischiadic notch, or rather *foramen*—it is irregularly oval (Pl. LXVI. fig. 1 *in.*), its inferior margin being rather angular; it is one inch long—and behind it is the concave line of junction of the ilium and ischium, which is one inch and a line in extent.

The outer margin of the post-femoral part of the ilium is rounded and smooth; the bone then passes inwards and downwards to unite with the ischium below. There is a notch between these (coalesced) bones at the posterior end. The posterior inner margin of each iliac bone receives the rib of the last sacral vertebra and then passes, with a very elegant concave outline, bevelled, rounded, and smooth, to its extreme outer tip. This terminal end of the ilium lies on a lower plane than the upper and outer margin; so that, on a side view, the end of the ilium is very oblique, as is also the sinuous sharp posterior margin of the ischium (Pl. LXVI. fig. 1 *ism*). The inferior margin also of this bone (the ischium) is sharp, but it becomes thicker beneath the ischiadic foramen, the sharp inferior ridge first passing obliquely upwards to form the anterior margin of that foramen; and then the rest of the anterior part of the ischium is round below, convex within, and concave externally. The posterior end of the ischium is thin, incurved, and nearly touches the pubis, which reaches half an inch further backwards. That part of the ischium which, having coalesced with the ilium, passes downwards and a little outwards, is moderately thick, and is half an inch deep. The ischium passes obliquely backwards eight or nine lines further than the ilium; in this it resembles the Heron; in the White Stork it terminates in the same vertical line, but in the Adjutant and Boat-bill the ilium projects behind the ischium. In certain birds—*e. g.* the Fowl—a short but strong process projects forwards where the ilium joins the pubis beneath and rather in front of the acetabulum. In the Balæniceps and its congeners, the Herons and Boat-bills, as well as in the Storks, this spur is absent; yet the os pubis is very thick, rounded, and smooth at this part (Pl. LXVII, fig. 3 *il, ach*), but soon becomes thin and flat more posteriorly, where it is distinct from the mass of bone forming the lower part of the acetabulum. Its width is at first two lines, gradually expanding to more than three, two inches further on; it then contracts a little for half an inch, widens again, and then rapidly runs to a point as it curves inward to form its tip. This bone is of unusual width (Pl. LXVI. fig. 1 *pb*) twice as wide as in the large Indian Adjutant; but it has all the essential characters of the same bone in its congeners. This os pubis is flat externally, at first convex and ridged within, and then at its widest part slightly concave. The distance between the pubic bones is at first two inches, then at their widest part, which is in the same vertical line as the tips of the ilia, they have divaricated seven lines more. They now make an elegant curve inwards, below and a little external to the ischia, and their tips are but one inch and two lines apart. Seen from above, the curving inwards of the ilia, ischia, and ossa pubis is a very beautiful structure. Opposite the widest part of the ischiatic foramen, the pubis is four lines apart from the ischium; it gradually nears that bone, and they almost touch behind. An interosseous membrane perfects the great obturator foramen, here two inches and three-quarters in length.

Sternal Apparatus. (Pl. LXVI. fig. 1, and Pl. LXVII. fig. 1.)

The scapula, coracoid, and sternum, in this bird, are relatively stronger than in the Herons, being quite equal, in proportion to the size of the bird, to what they are in the Adjutant. A few comparisons will make this evident; the measurements are in inches and lines.

The scapula (Pl. LXVI. fig. 1 *sc*) is a very exact counterpart of that of the Adjutant, and so is the coracoid except at its head, which is more than an inch and a half broad in the great Indian bird, whilst in the Balæniceps this part has only half that breadth. There is also in the latter bird a flat oval articular surface in front of the head of the coracoid for the thick part of the furculum, which does not exist in the Adjutant. The coracoid of the Balæniceps (Pl. LXVI. fig. 1, and Pl. LXVII. fig. 1 *cor*) is half an inch

	Balæniceps.		Adjutant.		Grey Heron.	
	inches.	lines.	inches.	lines.	inches.	lines.
Length of scapula	4	3	5	6	3	2
Greatest breadth of scapula (*flat part*)		5½		8		2
Greatest length of coracoid	3	10	5	9	2	7
Breadth of lower articular surface of coracoid	1	5	2	1		9½
Length of sternal keel from apex to end	5	0	5	7	3	6
Breadth of sternum across costal processes	3	0	4	2	1	10½
Breadth of sternum across hyposternals	2	6½	2	10½	1	6
Length of hyposternal processes	1	4		8		8
Thickness of keel at the margin near the furculum		4		5½		1
Greatest depth of keel	1	3	2	0	1	0

broad at the middle part, and five lines thick; it then expands, is deeply grooved in front, has its internal edge sharp, which sharp edge at the top forms that incurved flat process which articulates by ligament with the tip of the ramus of the furculum, and with a similar but thicker process at the upper part of the proximal end of the scapula. The shallow glenoid cavity belongs equally to the scapula and the coracoid.

The sternum of Balæniceps (Pl. LXVI. fig. 1 *st*, and Pl. LXVII. fig. 1) differs from that of the Heron and agrees with that of the Adjutant in being very thick and cellular, except at its hinder part. Notwithstanding the thinness and delicacy of the sternums in the genera *Ardea*, *Botaurus*, *Nycticorax* (*Nycterodius*, Macg.) and *Cancroma*, they agree in all essentials with those of the true Storks. In Balæniceps, however, we encounter a host of difficulties both in the sternum and also in the furculum (Pl. LXVI. fig. 1 *fc*, and Pl. LXVII. fig. 1 *sy*), although its general shape and proportions agree well with that of the gigantic Storks. The hyo-sternals, or costal processes, are exactly like those of the Adjutant, but the epi-sternal process, which is distinct in the Adjutant, and long in the typical Herons, is not differentiated in Balæniceps. In Parrots, Woodpeckers, and Horn-bills, that emargination is absent which separates the epi-sternum in most birds from the tip of the sternal keel. The same thing occurs in the Balæniceps; so that in this Wader, as well as in those arboreal birds, the keel of the sternum projects some distance in front of the coracoid grooves. In all the more delicately formed Ardeine birds that we have examined, there is an ascending process within the angle and between the rami of the furculum; this is absent in Balæniceps, although it is present in Cancroma. In the latter bird, in the Bittern (*Botaurus stellaris*), and the Purple Heron (*Ardea purpurea*), the furculum is connected by ligament to the tip of the sternal keel; a state of things which occurs in the great majority of birds.

In *Ardea cinerea* (and most of the larger Herons), in *Nycticorax griseus*, *Botaurus minutus*, and in the genera *Ciconia* and *Mycteria*, the end of the furculum has a gliding synovial joint with the tip of the keel of the sternum; and this appears to be persistent even in very old birds. The same thing occurs in Gannets and in Cormorants. In the Secretary Vulture and in the White Pelican there is this claviculo-sternal articulation; but it becomes anchylosed in old age. In young Cranes—*e. g. Grus antigone*—this joint may be seen; but in full age, when the trachea has gone some distance into the sternum, it is entirely obliterated. We have not seen this structure in the somewhat aberrant Balearic Crane, nor in the Agami (*Psophia crepitans*), in which bird unmistakeable Gallinaceous characters are present. But in this young Balæniceps not only is all trace of a joint gone, but the amount of ossification and the actual strength of this part are very great indeed; it is a seven-times strengthened anchylosis. The upper surface of the sternum is deeply and evenly concave, its depth in the mid-part being one inch and a quarter, whilst the same part is only a line deeper in the Adjutant. These two birds agree also in the number of large pneumatic holes, especially at the anterior and middle region, and between the five hinges for the hæmapophyses on the upper margin of the sternum. In some of the Storks there are very small rudiments of a pair of sub-mesial emarginations besides the large lateral ones, which are constant.

In Balæniceps, however, these notches are nearly half an inch broad, leaving between them a xiphoid mesial process three lines wide at its extreme end. The outer notch is nine lines across, its external outline being the inner margin of the long narrow hyposternal process; the upper and external margin of this process running forwards to the joint for the 'sacral' hæmapophysis, is elegantly sigmoid. The great length of the hyposternal process (twice as long as that of the Adjutant) reminds us very strongly of the Rails and Coots, and still stronger Ralline features will show themselves towards the end of our task. The sub-mesial emarginations (very common in birds, but not present in the typical Ardeinæ) tell us of another Wader with strangely modified jaws—viz. the Spoon-bill, a bird which seems to stand, in Nature, between the Storks and the Ibises. The very thick strong keel of the sternum passes on to the end of the bone; in the Totipalmatæ—*e. g.* Pelican, Gannet, &c.—it only reaches half-way. In many birds—*e. g.* the Boat-bill, Herons, Storks, Cranes, Geese, &c.—the rami of the furculum are flat at the upper end, and passing within the head of each coracoid are there articulated. But in many other groups of birds—*e. g.* the Balæniceps, Diurnal and Nocturnal Raptores, Swifts, Goat-suckers, and different genera of the Totipalmatæ, as the Cormorants, Gannets, and Pelicans—the rami of this bone expand and become very thick before passing between the coracoids. In these latter cases the outer thickened part of the furculum forms an oval flat synovial surface which articulates with a similar surface on the front of the head of the coracoid, whilst the inner part of the ramus passes on, flat and triangular, to articulate with the inner side of the head of the coracoid. Measured in a straight line the symphysis of the furculum of the Balæniceps is $3\frac{3}{4}$ inches from its inner tip. These upper ends are 3 inches apart and the width across the thick anterior articular processes is $3\frac{3}{4}$ inches. It is therefore U-shaped as in the wide-bodied Storks, and not V-shaped as in the flat-bodied Herons. In the Pelican the enlargement formed by the furculum in front of the head of the coracoid, begins at the middle of the furcular ramus—in the Balæniceps at the upper third. In these two birds the enlargement is sudden (being thick and oval in Balæniceps, and flat and wide in the Pelican); but in Cormorants, Gannets, Eagles, Hawks, Swifts, &c., the enlargement is very gradual. The sudden turn backwards which the ramus takes at the thick part is very peculiar in the Balæniceps, a more perfect angle being formed there than in the Pelican and Gannet; but it is still a very obtuse angle; whilst in the Cormorant the thick articular third of each ramus is at a right angle with the lower contracted two-thirds. The middle contracted part of each furcular ramus is oval in section; the enlarged inferior part is convex without and concave within, whilst above their junction there is a transverse fossa full of pneumatic holes. The furculum is a peculiarly ornithic bone, but its feeble development in the struthious birds explains its nature as the homologue of the human clavicle; whilst Professor Owen considers it is also homologous with the large hæmapophyses of the atlas of Fishes[1].

The scapula in typical fish is composed of two pieces, and in them the coracoid attains its greatest dimensions. The former element (although composed of two pieces) is, in Professor Owen's opinion, the pleurapophysis of the occipital vertebræ; whilst the latter, the coracoid, is its hæmapophysis. This scapulo-coracoid hæmal arch, according to Professor Owen, always follows the heart and respiratory organs in the Vertebrata; so that the protection of these parts being in birds confined to such posterior vertebræ, gives rise to this enormous displacement of these inferior elements of the occipital vertebra. In Fishes the pelvis often swings beneath the occipital hæmal arch, and is as much displaced as the scapula, coracoid, and clavicle are in birds. In the latter class the pelvis is not displaced, the ilium being (in Owenian nomenclature) the extremely enlarged distal piece of a sacral pleurapophysis, whilst the ischium and pubis are hæmapophysial in their nature; one of the pairs of bones belonging to the ilium, whilst the other has its single-centred pleurapophysis[2] stunted and unconnected with its hæmapophysis. The terms epi-, hyo-, ento-, hypo- and xiphi-sternal processes are very convenient; but in his little work 'The Skeleton and the Teeth,' p. 215, Professor Owen says that Geoffroy St. Hilaire was wrong in supposing that these parts (with the exception of the ento-sternal) are homologous with the epi-, hyo-, hypo- and xiphi-sternal bones of the Chelonia. The circle of bones which in this latter class articulate with the expanded pleurapophyses above, and with the epi-, hyo-, hypo and xiphi- sternals below, are mere dermal plates; whilst the lateral pairs of the bones of the plastron are the

[1] There are, however, very grave reasons for doubting whether the clavicle of birds belongs to the same vertebra;—our opinion is that it does not.

[2] Professor Owen's views of the nature of limbs have not been corroborated by the researches of embryologists; Mr. Huxley says that 'the pectoral arch is originally totally distinct from the skull'; and Dr. Falconer has drawn my attention to Professor Goodsir's view that the pectoral members belong to, and are developments from, several somatomes and meta-somatomes. (Goodsir, *op. cit.*, p. 178; Huxley, *op. cit.*, p. 53.)

true hæmophyses. In typical birds the sternum is ossified from five centres ; and this extreme expansion of hæmal spines, by pairs of lateral, with an intercalated central carinated piece, is the exact counterpart of the so-called neural spines of the skulls in certain mammals—*e. g.*: the Hyæna, Badger, &c.

Upper Extremities. (Pl. LXVI. fig. 1.)

Before proceeding to describe the bones of the extremities, we insert a table showing the comparative lengths of the arm, fore-arm, hand, thigh, leg, shank, and toes (in inches and lines) in various birds.

	Length of humerus.		Length of ulna.		Length of metacarpus and mid-digit.		Length of femur.		Length of tibia.		Length of tarso-metatarse.		Length of hallux.		Length of inner-toe.		Length of mid-toe.		Length of outer-toe.	
	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.	in.	l.
Balæniceps rex	9	3	10	10	7	3	5	0	11	0	8	10	3	3	4	7	6	3½	5	9½
Cancroma cochlearia	3	6	4	2	3	2	2	4	4	5	2	11	1	3	1	8½	2	3	1	11½
Ardea cinerea..........	6	4	7	7	5	7	3	3	7	2	5	5	1	9½	2	8	3	5	2	11
Leptoptilus argala......	12	6	17	5	11	3	5	10	16	10	12	8	2	4	4	2	5	8	4	8
Phœnicopterus ruber	7	2	7	7	5	8	3	4	11	8	10	3		9	2	5	3	0	2	9
Fulica atra	3	1	2	7	2	10	2	2	4	0	2	3	1	2	2	5	3	4	3	0
Parra jacana	1	5	1	8	1	6	1	1	3	3	2	6	1	5½	2	1½	2	7	2	4
Podiceps rubricollis	4	1½	3	9	3	0	1	9	4	7	2	5		8	1	11	2	4	2	8
Pelecanus onocrotalus ..	12	0	13	8	8	9	4	3	7	4	4	2	2	2	3	1	4	3	4	3
Phalacrocorax carbo	6	3	6	9½	5	8	2	7	5	1	2	8	1	6	2	1	3	3	4	0
Diomedea exulans	15	8	15	7	10	9	4	4	9	8	4	6	......		5	8	6	10	6	6
Apteryx australis	1	10		9		6	4	3	6	7	3	0		9½	1	10	2	8	2	0
Dromanis ater	3	9	2	2	3	0	9	0	17	0	14	8	......		3	6	5	6	3	6
Cypselus apus		6½		9½	1	9		9	1	1		5		3½		5		5½		4
Trochilus colibris		3½		3½		9½		4		7		3		2		3		4		4½
Himantopus melanopterus	2	6	2	9	2	7	1	3	5	1	4	6	......		1	4	1	8	1	6

For a description of the structure of the bones of the upper and lower extremities in birds, the reader is referred to that invaluable little book in 'Orr's Circle of the Sciences,' viz. 'The Skeleton and the Teeth,' by Professor Owen, page 222. Notwithstanding the variety there is in the relative proportions and comparative strength of these parts, there is a truly wonderful uniformity of structure in the bones of the limbs ; so that Professor Owen considers them to be merely "teleologically divided appendages of the occipital and pelvic vertebræ." As compared with the size of the head, the strength of the cervical vertebræ, and the great development of the sternal apparatus, the bones of the limbs in this young Balæniceps have a somewhat delicate and feeble appearance. To say nothing of the very strong wing and leg-bones of the larger Storks, the Balæniceps has these parts relatively weaker than those of the Grey Heron. The Boat-bill (*Cancroma*) and the Umbre (*Scopus*) appear to be about equal in this respect (considering their size) to the Balæniceps. The anterior articular head of the humerus (Pl LXVI. fig. 1 *h*), the upper and lower crests (the latter with its internal pneumatic foramen), and the posterior condyles for articulation with the radius and ulna, are the exact counterparts of the same structures in the humerus of the Heron. The ulna in this captive[1] (Pl. LXVI. fig. 1 *u*) scarcely shows the knobs on its outer side for the secondary quills. The radius (Pl. LXVI. fig. 1 *r*) is very long and slender. The two carpals that continue free (Pl. LXVI. fig. 1 *cp* 1, *cp* 2), and the one, the "os magnum," which has coalesced with the middle metacarpal, answering to the third of a pentadactyle member; the outer and inner metacarpals, each with one phalangeal bone; and the middle metacarpal with its two phalanges (Pl. LXVI. fig. 1 *mc*), have all the same structure in Balæniceps as in the Heron. The humerus alone receives air; the rest are filled, in the living bird, with medulla.

Both in length and thickness, the bones of the wing are one-third larger in the Balæniceps than in the Grey Heron, but this is certainly not in proportion to the size of the two birds. If the head, neck, and feet had been in the Balæniceps relatively no greater encumbrance than the same parts are in our common Heron, yet the greatly increased magnitude of the bird would have demanded much larger wings for it to have been as capable as its smaller relative of high, buoyant, sailing, long-sustained flight. Our more solitary and wandering native bird flies at great heights, with little apparent labour,—his breeding-place being often at a great distance from his favourite fishing-stations. According to Mr. Petherick, the Balæniceps is much more social; and the habit, which he notices, of the bird taking itself off to high neighbouring trees when disturbed, is very unlike what our Heron does under like circumstances,—this bird being evidently aware of the fact that "its best defence is absence, and that all its safety is in remotion[2]." Judging from the large volume (for the weight is not considerable) of the neck and head, and from the large size of the feet, we are inclined to place the Balæniceps, as a flier, between the Water-hen and the Heron. The wing-bones of the Adjutant are nearly twice the diameter of those of the Balæniceps; the humerus of the latter is three-fourths the length of that of its great Indian relative; whilst the latter, the Adjutant, has its fore-arm and hand one-third longer than those of the Balæniceps.

The comparatively short and exceedingly strong humerus of the Adjutant, coupled with a line of insertion for the 'secondary' quills nearly eighteen inches long, and room for a series of 'primaries' almost a foot in extent, are most liberal allowances of skeletal basis for the Phœnix-like wing-quills of this huge bird.

Note.—The temptation to expatiate on the structure of the wing in this most fasci-

[1] That ardent and accomplished ornithologist Dr. Anton Fritsch, of Prague, informs me that he has examined a large and well-developed skeleton of *Balæniceps rex* in the possession of M. Schimper, of Stuttgart. This bird was several inches higher than the subject of this paper; and Dr. Fritsch's recollections of it are, that it was an old bird when taken, and, never having endured captivity, had much stronger and larger wing-bones.

[2] Familiar with the Heron from his childhood, the writer has only once seen it take to a tree near by when alarmed; on this sole occasion a fine old male bird had ventured too near the nest of a pair of Kestrils, and being hawked by them into a large tree and from that into some bushes, was easily taken alive. As a rule, when alarmed, a few minutes suffice for it to fly so far out of reach as to appear a mere speck in the sky.

nating class of Vertebrates, is very great, but must be resisted ; yet the foregoing table, although purposely exceedingly limited, might serve as prologue for a discourse of any length[1].

The main bones of the leg in Balæniceps are nearly exactly one-third longer than those of the Grey Heron, and one-third thicker. They have also very much the same structure. There is nothing particular to remark in the very straight cylindrical os femoris (Pl. LXVI. fig. 1 *fm*), with its roundish head, short neck, and its broad and externally rugose great trochanter—the upper facet of which is coated with articular cartilage, to glide upon the supra-acetabular facet of the ilium. The articular ends of the 'tibia' (Pl. LXVI. figs. 1, 8 & 9 *tb*) are well developed—the two upper facets for the condyles of the femur being very flat as in most birds ; and the ecto-, ento-, and epicnemial ridges are as well developed as in the Heron. This part of the tibia has a separate epiphysis in the young Emeu. There is a fibular ridge outside for the fibula, which bone is thick at the top where it glides under the fibular condyloid process outside the lower external condyle of the femur. The lower part of the fibula (Pl. LXVI. fig. 1 *fb*) is styloid, and this bone is short in the Balæniceps, being less than three inches long, whereas it is nearly an inch longer in the Heron, and nine inches in the Adjutant. The sigmoid curve at the lower part of the tibia is very slight, as in the Heron—this bone being straighter in the *Ardeæ* than in the *Ciconiæ*. The large inferior trochlea of the tibia (Pl. LXVI. figs. 8 & 9 *tb*) is well developed, as is the osseous bridge in front and above it, and the internal and external tubercles on its sides. These parts are larger in proportion in the Balæniceps than in the Heron. This inferior or distal end of the tibia is developed from a distinct osseous centre in young birds, which piece forms all the articular part, and sends upwards a wedge-shaped process in front—the seat of the ossification which makes the large, wide, oblique tendon-bridge. Below this bridge the bone is deeply scooped, and the concavity between the condyloid margins of the trochlea is very considerable. Query—Is this lower articular portion of the tibia an epiphysis of the tibia itself, or is it the homologue of the mammalian astragalus ? There is no 'sesamoid' os calcis in the Balæniceps, in which it agrees with the Herons and Storks.

The tarso-metatarse of Balæniceps (Pl. LXVI. figs. 1, 8, 9, 10 & 11 *tmt*) has its articular extremities more strongly developed than in the Heron,—its length and thickness still retaining the same relative size as the tibia, femur, and the bones of the wing. This bone is one-third longer than the same bone in the Heron, and one-third thicker in its shaft ; but the ecto- and ento-condyloid cavities and their margins are more strongly developed. The concavity also below and in front of the head of this bone is unusually deep ; but the intercondyloid tuberosity is not better developed than in the Boat-bill and the Herons, being very inferior to the same part in the Adjutant. In the

[1] In the works of Sir C. Bell, Dr. R. Grant, and Professors Owen and Rymer Jones, the reader will find this subject treated of as it should be.

latter bird there are only two calcaneal processes behind the head of the tarso-metatarsus ; the external of these being the most extended parallel to the metatarsus, whilst the internal projects furthest at right angles to the shaft. These processes in the Adjutant do not form a tendon-bridge, but there is a deep fossa between them. The structure of these parts in the Heron and in the Balæniceps is very different from that of the Adjutant, these birds having ecto-, meso-, and ento-calcaneal processes behind the head of each tarso-metatarsus. The ento-calcaneal process is by far the largest in these two birds, the meso-calcaneal being of intermediate size. These projections are very thick, and enclose two bridges or canals for tendons, besides forming two deep external grooves or sulci. The ento- and meso-calcaneal processes are principally formed by the middle metatarsal (Pl. LXVI. figs. 8 & 9 *tmt*), the head of which lies between and behind the external and internal pieces, whilst its distal end passes between and in front of the outer and inner coalesced portions. This distal end of the middle metatarsal (Pl. LXVI. figs. 10 & 11 *tmt*) has a grooved articular surface for the middle toe, whilst the articular surfaces of the inner and outer metatarsals are simple. The small suspended innermost metatarsal bone is 1 inch and 2 lines long, and has a large simple convex articular surface for the long hallux (Pl. LXVI. fig. 1 *tmt* 2). In young birds the proximal end of the tarso-metatarsus is separate from the three long bones that afterwards coalesce with each other and with it ; this broad thick piece of bone belongs to the tarsal series.

The hallux of the Balæniceps (Pl. LXVI. fig. 1 *d* 2) is nearly one-third longer than that of the Adjutant ; and the other toes (Pl. LXVI. fig. 1 *d* 3, 4 & 5) are much longer really, and therefore are relatively very disproportionate in size in the Balæniceps. The toes of the Heron are but little more than half the length of those of the Balæniceps, and are only half as thick ; the actual weight of the feet of the latter bird must therefore be eight times as much as those of the former. This disproportionate size of the feet in the Balæniceps as compared with those of the Heron—the bones of the wing and the main leg-bones being relatively weaker in the large bird—must be considered when the power of flight in the two birds is compared. There is nothing particular to remark upon in these large, well-formed phalanges of the Balæniceps : the arching of the hallux and of the claw-bones and the relative length of the latter are precisely like what are seen in the Heron.

The hallux of the Balæniceps, like that of the Heron, lies in nearly as low a plane as the other toes ; and in the former the hinder and outer toe are very mobile ; so that in walking the Balæniceps can turn the hallux very far inwards, and the outer toe very far outwards.

In its own circle, the Balæniceps represents the Macrodactylous Rails—*e. g. Fulica, Porphyrio, Gallinula, Parra*, and perhaps *Palamedea* ; but a knowledge of the structure of this last bird is still a desideratum.

From the feebleness of the wings and legs as compared with those of many of its congeners, from the length and thickness and great mobility of the toes, and from the unusual size (for an Ardeine bird) of the hyposternal processes, it seems fair to conclude that the Balæniceps is an oblique link between the Herons and the Rails; nevertheless the Ralline characters are feeble compared with those that are truly Ardeine. The Balæniceps is not more mysterious in its relationships than the Flamingo, the Secretary-bird, the Hemipodius, the Sand Grouse (*Pterocles*), or even than those beautiful little creatures, half *Warbler* and half *Swift*, the Swallows and Martins. It will be seen by the table (*supra*) that the outer toe of Balæniceps is only half an inch shorter than the middle toe; this is a disproportionate length of the outer toe as compared with what is seen in the Heron, and is equal to what is found in the Jacana (*Parra*), and the Coot (*Fulica*). In the Zygodactyles (*e.g.* the Parrot) the outer toes are long, for turning backwards; and this elongation of the outer toe is also the rule in the Palmipeds.

In the Duck the middle toe is only a line longer than the outer; in the Pelican they are equal; but in the Cormorant the outer is nine lines longer than the inner toe. This disproportion also occurs in the beautifully lobed feet of the Grebes (*e. g. Podiceps rubricollis*) and in the Divers (*Colymbus*). The middle toes are disproportionately long in the Diurnal Raptores and in the typical Goat-suckers (*Caprimulgus*) It will be seen from the table that the little arrested toes of the Swift somewhat reverse the order of things, the inner toe being longer than the outer. This little child of the sky has not more than three phalanges in any of its toes; but the forward-turned hallux has two joints like other birds.

We have only space here to refer to Dr. Humphrey's invaluable work on the 'Limbs of Vertebrate Animals,' and to say that he is quite opposed to Professor Owen's theory, which makes the scapulæ and iliac bones to be 'pleurapophyses:' they are not, in his (Dr. H.'s) opinion, '*pleural*,' but '*hæmal*.' Like most other anatomists, Dr. Humphrey is entirely opposed to the idea of the scapular arch being the hæmal part of the occipital sclerotome; he very truly says that the hyoid arch belongs to the occipital segment. (See Dr. Humphrey on 'The Human Skeleton,' p. 597; Report of the British Association, 1858, part 2, p. 126; and his work on the 'Limbs,' p. 32.)

Professor Goodsir classes the segments of the limbs of the Vertebrata in the same category as the 'appendages' or 'epi-pleural spines'—his 'actinapophysis' (*op. cit.*, p. 178).

In recapitulating the structural characters of the Balæniceps, only general remarks will be necessary. Truly, if the Boat-bill had been as yet undiscovered, with its beautiful, leaf-like, broadly arched upper jaw, and the little Umbre (*Scopus umbretta*) with its grooved and hooked beak, we might then have found our task difficult. Yet even then the highly modified conditions of the bill in other groups would have plentifully supplied us with helpful analogies. Even the families very nearly related to the Herons, as, for instance, the Ibis group, which contains the Spoonbill; the frailer forms of Waders, yielding us the Avocet; the Plovers with their knife-billed Oyster-catchers—all teach us what licence may be taken with the shape of the jaws for special reasons in the life of the bird, whilst the general structure is quite normal. In the Scansorial and Insessorial Orders (so potent in families, genera, and species), we are scarcely surprised at anything we meet with as to the form of the jaws and consequent modification of the structure of the outworks of the cranium. Seeing how many genera and species there are with such modifications of the jaws and cranium as we meet with in the Parrot group, the Woodpeckers, the Toucans and Araçaris, the King-fishers, the Hornbills, and the Humming-birds, we can scarcely forbear supposing that numberless links have been lost amongst the *Grallæ* and *Palmipeds*[1]. Looking at the *Totipalmate* family of the latter order, what great gulfs intervene between the Pelicans and the Cormorants, and respectively between the Gannet, Frigate-bird, and Tropic-bird (*Phaëton*)! With regard to Pelicans, Cormorants, and Gannets, their structure is certainly essentially the same, and can be confounded with no other group whatever; yet what a number of species, generic groups of species, ought to intervene between *Pelecanus* and *Phalacrocorax*, and between the latter and *Sula*! Nature is still more silent as to how she connected the Flamingos with the Geese: one of the links indeed has been found at the Goose end of this great gap, the *Cereopsis Novæ Hollandiæ*; but where are the others? Then, if these were found, we have to run up a long chain of forms between the Heron and the Flamingo; and we scarcely possess a link. Again, the great embryo-shaped reptilian Ostriches are only like a few widely distinct species belonging to family after family lost and gone for ever from the earth.

Compared with the paucity of species of the Ostrich group, the numbers without number of Corvine, Passerine, and Sylviine birds are truly wonderful; and all these families, with many more, have the same essential structure. It would require many a genus, each with its suite of species, to connect together, in the way the Passerine birds are connected together, the different members of the Ardeine group, especially if we include *Ciconia*, *Mycteria*, and *Anastomus*. Nevertheless the typical Herons (*e. g. Ardea*, *Botaurus*, *Nycterodius*, and *Egretta*) are rather numerous; and the modifications that have taken place in the Boat-bill and the Balæniceps do not at all affect the essential structure of these birds; these modifications may all be put down to the score of teleology.

A certain similarity has been mentioned between the structure of the Balæniceps, and that of the Pelican; but these are not relational modifications; and no arguments can be brought to prove the Balæniceps to be a Pelican but would almost equally serve to prove it to be a Parrot, a Serpentarius, or a Podargus.

If all the birds that have been, could be seen side by side with those that now are, it would be a goodly sight; no gaps *to leap* over, no missing links. Our knowledge of these things is in ' shreds and patches'; but still we can imagine that He who provided

[1] Whether this net-work of affinities owes its present incompleteness to losses of the past, or is to be filled up by future creations, it is after all impossible for us to determine. On the question of the potency of genera and species, see an admirable paper by the late Hugh E. Strickland, Ann. and Mag. Nat. Hist., Nov. 1840, p. 184.

the feast and invited the guests, did not set unrelated strangers side by side. George Herbert saw this long ago: he says,—

"Thy creatures leap not, but express a feast
"Where all the guests sit close, and nothing wants.
"Frogs marry fish and flesh; bats, bird and beast;
"Sponges, non-sense and sense; mines, the earth and plants *."

* Since this paper was written, the very interesting and important researches of Mr. A. D. Bartlett (see Proc. Zool. Soc. 1861, p. 131) have proved, beyond all dispute, that the *Balæniceps*, like the Boat-bill, is essentially a Heron. The structure of its dermal system is, in all important respects, the same as that of *Ardea*, *Cancroma*, *Eurypyga*, and *Botaurus*.

Our very first impression was that it would turn out to be much nearer akin to our native *Ardea cinerea* than to the Storks (*Ciconia*, *Leptoptilus*, and *Mycteria*).

The genus *Cancroma* might be placed sub-generically to *Balæniceps*; yet although the former has the most out-spread bill, it is less aberrant from the true Herons than the latter. Indeed the Balæniceps seems, as it were, to have borrowed characters from the Umbre (*Scopus*)—a bird not so nearly related to the Herons as itself,—and also from the Ibises on one hand, and from the Macrodactylous Rails on the other.

Not only does the Umbre differ from the true Herons, the Boat-bill, and the Balæniceps in the absence of the curious and characteristic powder-down patches, but its whole style of colouring is different; moreover the grey tint and the mealiness of the feathers of Balæniceps are truly ardeine, whilst the sad yet sinister aspect of its eyes leaves no doubt upon the mind as to its real affinities.

The skull of *Cancroma* would have been a perplexing study without the rest of its skeleton, which is remarkably normal, being that of a true Heron shortened in joint and limb. Now add to that shortening of the joints and members of a truly ardeine skeleton which we see in *Cancroma* the necessary robustness, and we have the osseous structure of Balæniceps at once.

But even in the enormous face and skull of this latter bird we have still nothing but teleological modifications; and the character of the Heron's skull is impressed upon every part.

The only real difference between the vertebræ of *Cancroma* and those of *Ardea* is the comparative shortness of those of the former; the vertebræ of *Balæniceps* are simply those of a gigantic Boat-bill.

The sternal apparatus of *Balæniceps* is the most extraordinary part of its structure; for although the scapulæ and coracoids are normal, yet the furculum and the sternum have undergone very unlooked-for changes. The furculum has very much the structure of that of the Totipalmatæ, and its angle is still more completely fused with the anterior end of the sternal keel than in birds of that family. In many respects the sternum is intermediate between that of the Heron and the Adjutant; but its anterior part is modified like that of the Scansores,

EXPLANATION OF PLATES.

PLATE LXIV.

Figures of male BALÆNICEPS REX from the living bird in the Zoological Gardens.

PLATE LXV.

Skull of BALÆNICEPS REX (Nat. size).

Fig. 1. Side view of skull.
- *pro.* Par-occipital process.
- *fo.* Passage leading to the fenestra ovalis.
- *m.* Upper mastoid eminence.
- *ep.* Epiotic eminence.
- *p.* Parietal.
- *fr.* Frontal.
- *tf.* Temporal fossæ.
- *sq.* Squamosal.
- *pf.* Post-frontal.
- *tr.* Passage for trigeminal nerve—foramen ovale.
- *op.* Optic foramen.
- *as.* Ali-sphenoid.
- *pt.* Petrosal.
- *bs.* Basi-sphenoid.
- *os.* Orbito-sphenoid.
- *psp.* Pre-sphenoid[1].
- *of.* Groove for the olfactory nerve.
- *l.* Lacrymal.
- *n.* Nasal.
- *npg.* Nasal passage. (The dotted line is on the septum.)
- *pmx.* Pre-maxillary.
- *eth.* Ethmoidal or anterior margin of pre-sphenoid of Goodsir; ethmoid of authors.
- *mr.* Malar; an oblique tract in front of the malar is the maxillary.
- *qj.* Quadrato-jugal.
- *q.* Os quadratum.
- *pal.* Palatine.
- *pg.* Pterygoid.

Fig. 2. Side view of mandible.
- *d.* Dentary.
- *sy.* Symphysis menti.
- *sag.* Surangular.
- *ag.* Angular.
- *art.* Articular.

Fig. 3. End view of skull.
- *c.* Hemispherical occipital condyle (end of basi-occipital).
- *fm.* Foramen magnum.
- *vg.* Passage for the vagus nerve.
- *eo.* Ex-occipital, spreading into the par-occipital process.
- *m.* Upper mastoid eminence.
- *ep.* Epiotic eminence.
- *so.* Supra-occipital crest.

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whilst the posterior part has marked Ralline and even Ibidine characters. The long toes, moreover, are like those of the Macrodactyli; but the leg-bones and the bones of the upper extremities are, save in point of size, exactly the counterpart of those of the common Grey Heron.

[1] The letters *psp* are on that part of the intero-orbital septum where the 'ethmoid' of authors has coalesced with the true pre- or rather orbito-pre-sphenoid: in the text we have followed Professor Goodsir (whom we now believe to be wrong) in attributing most of the septum to the pre-sphenoid.

Fig. 6

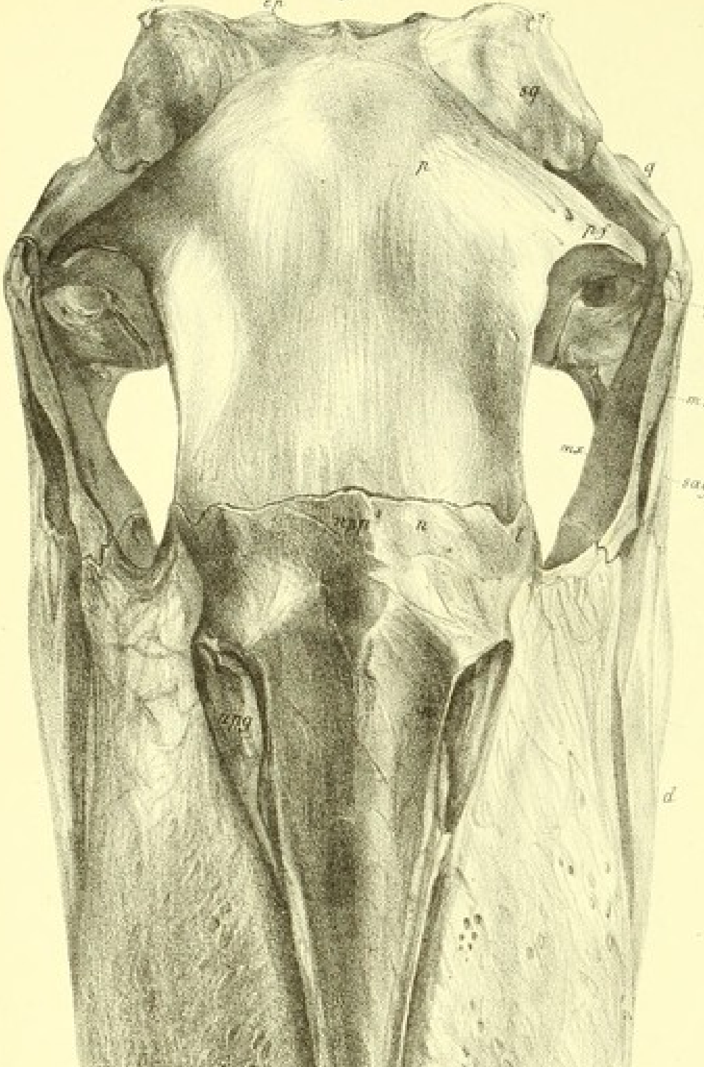
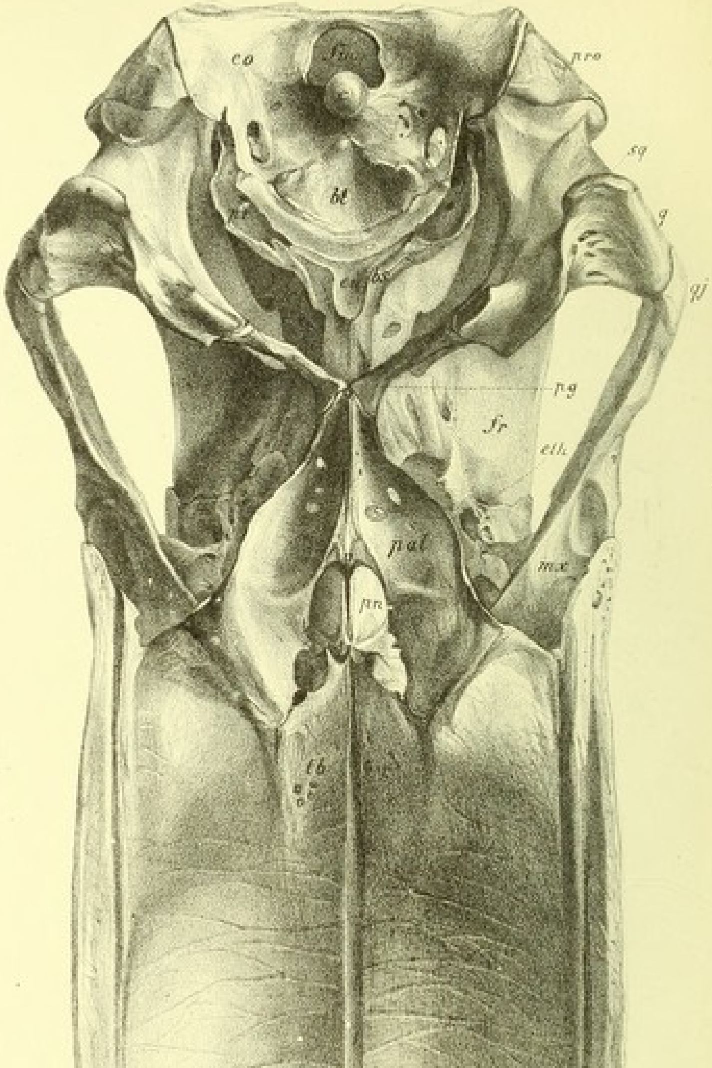


Fig. 7



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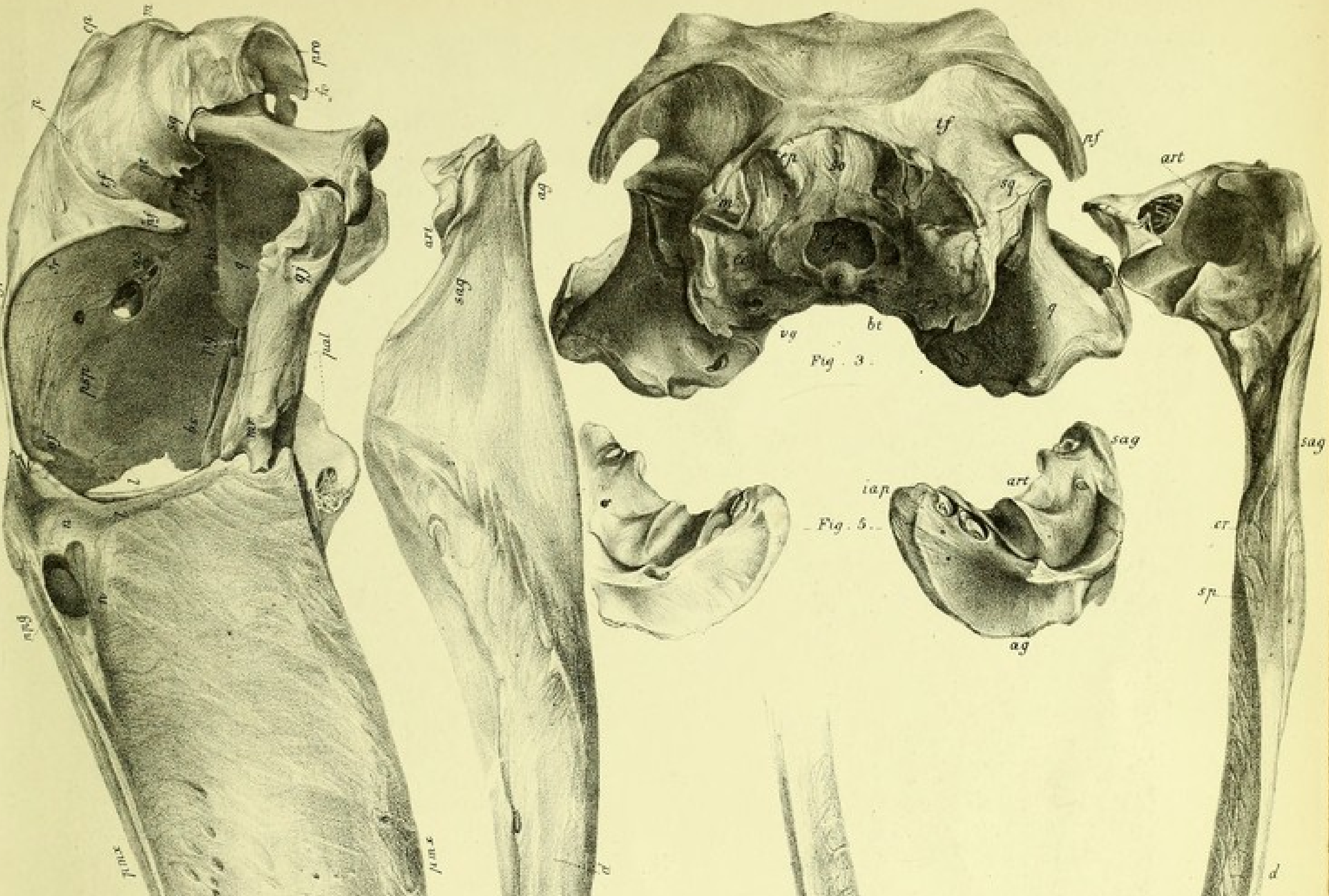
Balæniceps rex, Gould

Nat. Size.



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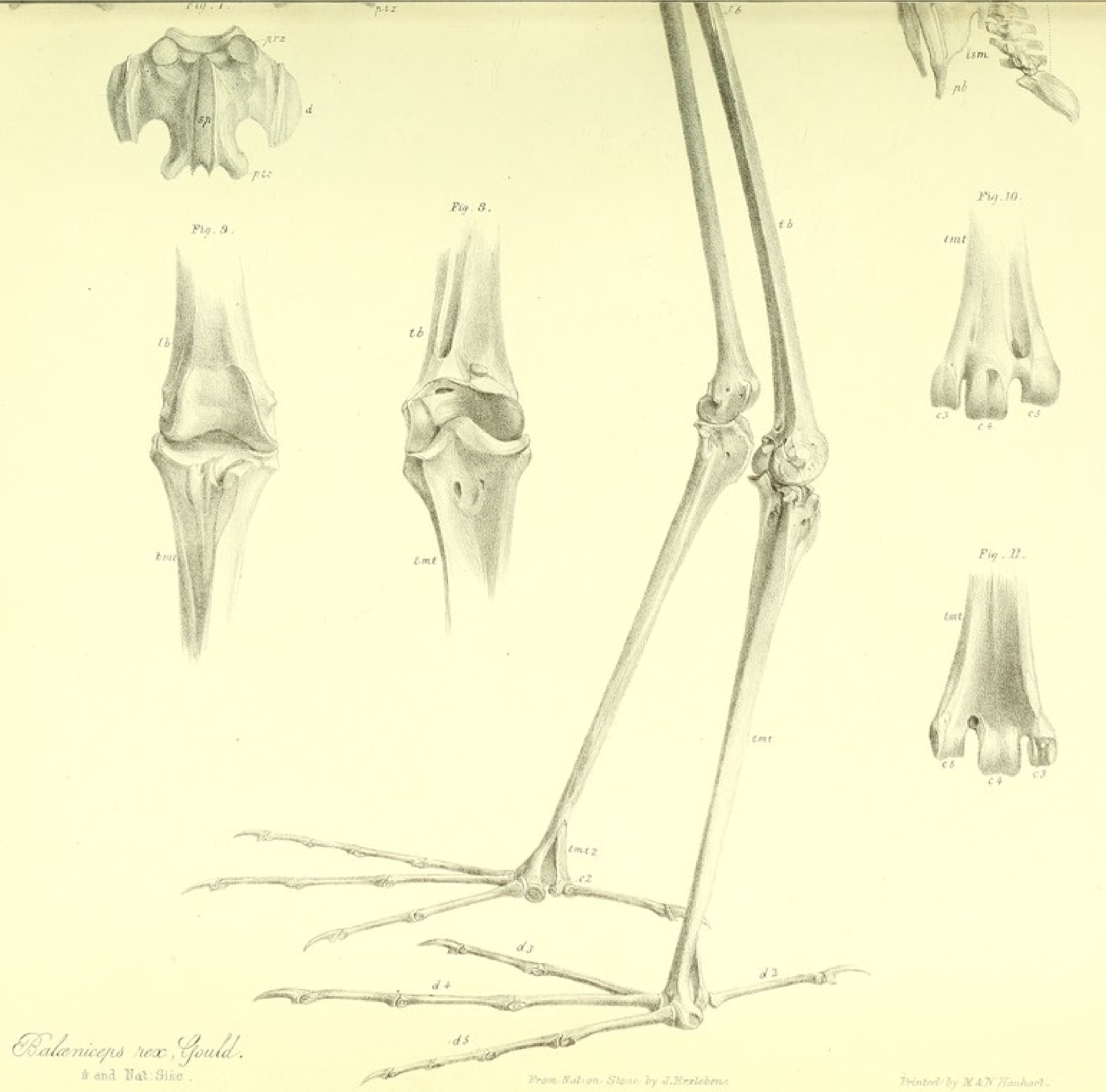
Balæniceps rex, Gould.

Nat. Size.



Balæniceps rex, Gould.

⅜ and Nat: Size.

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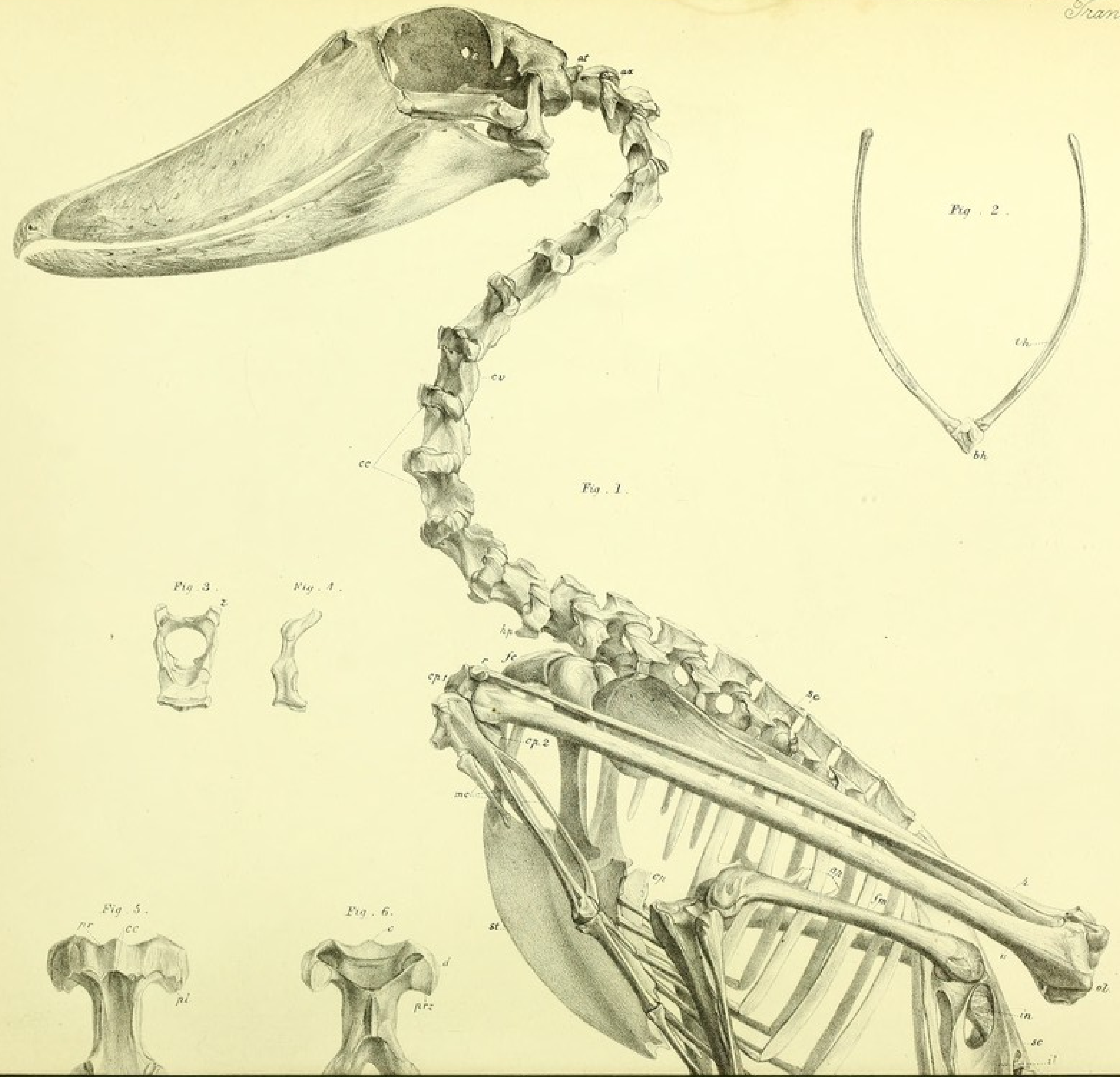
Trans. Zool. Soc. Vol. 4. Pl. 68



tf. Temporal fossa.
sq. Squamosal.
pf. Post-frontal.
bt. Basi-temporal.
q. Os quadratum.

Fig. 4. Upper view of mandible.
d. Dentary.
sy. Symphysis menti.
sag. Surangular.
art. Articular.
cr. Coronoid.
sp. Splenial.

Fig. 5. End view of mandible.
sag. Surangular.
ag. Angular.
art. Articular.
iap. Internal angular process.

Fig. 6. Upper view of skull and mandible.
m. Upper mastoid eminence.
ep. Epiotic eminence.
sq. Squamosal.
p. Parietal.
pf. Post-frontal (mesial of this process —the bone belongs to the frontal).
n. Nasal.
l. Lacrymal.
npp. Nasal processes of pre-maxillaries (these letters are in front of the hinge).
npg. Nasal passages.
g. Great sub-mesial groove.
pmx. Pre-maxillaries.
mx. Zygomatic process of maxillary.
mr. Malar.
qj. Quadrato-jugal.
q. Os quadratum.
d. Dentary.
sag. Surangular.

Fig. 7. Basal view of skull.
c. Condyle of basi-occipital.
fm. Foramen magnum.
eo. Ex-occipital.
pro. Par-occipital process.
bt. Basi-temporals.
pt. Fissure between basi-temporal and basi-sphenoid leading to petrosal.
bs. Basi-sphenoid.
eu. Groove for eustachian tubes.
sq. Part of quadratum articulating with squamosal.
fr. Frontal.
eth. Lateral ethmoidal region beneath the hinge.
pmx. Pre-maxillaries.
mg. Mesial groove.
lg. Lateral groove.
tb. Inferior turbinals (pterapophyses).
pn. Posterior nares.
v. Vomer.
pal. Palatines.
pg. Pterygoids.
mx. Maxillary.
qj. Quadrato-jugal.
q. Os quadratum.

PLATE LXVI.

Skeleton and Hyoid Bones.

Fig. 1. Side view of skeleton of *Balæniceps rex*, half nat. size.
at. Atlas.
ax. Axis.
cv. Cervical vertebræ.
cc. Carotid canals.

hp. Hypo-parapophysis.
sc. 1st dorsal vertebra (the dotted line leads to the scapula).
sc. Lower part of sacrum.
cd. Caudal vertebræ.
ap. Appendages of ribs.
il. Ilium.
in. Ischiadic notch or *foramen.*
ism. Ischium.
pb. Pubis.
st. Sternum.
cp. Costal process.
fc. Furculum (behind this bone is the coracoid).
sc. Scapula (upper letters).
h. Humerus.
r. Radius.
u. Ulna.
ol. Olecranon.
*cp*1. Upper carpal.
*cp*2. Lower carpal.
mc. Metacarpus (the bones below these are the phalanges).
fm. Os femoris.
tb. Tibia.
fb. Fibula.
tmt. Tarso-metatarsus.
*tmt*2. Metatarsal of second toe or hallux.
*c*2. Condyle of hallux.
*d*2. Hallux or true second toe.
*d*3. Third or inner toe.
*d*4. Fourth or middle toe.
*d*5. Fifth or outer toe.

Fig. 2. Hyoid bones, half nat. size.
bh. Basi-hyal, with rudiment of uro-hyal.
th. Thyro-hyal (the joint between the proximal and distal pieces is not shown in this figure).

Fig. 3. Posterior aspect of atlas, nat. size.
z. Post-zygapophysis.

Fig. 4. Lateral aspect of atlas, nat. size.

Fig. 5. Inferior aspect of 9th cervical vertebra, nat. size.
pl. Pleurapophysis.
pr. Parapophysis.
cc. Carotid canal.
c. Centrum.

Fig. 6. Superior aspect of 9th cervical vertebra, nat. size.
c. Centrum.
d. Diapophysis.
prz. Pre-zygapophysis.
ptg. Post-zygapophysis.

Fig. 7. Superior aspect of a dorsal vertebra (middle dorsal region), nat size.
sp. Spine (metaneurapophysis).
d. Diapophysis.
prz. Pre-zygapophysis.
ptz. Post-zygapophysis.

Fig. 8. Anterior aspect of tibio-tarsal joint, nat. size.
tb. Tibia, distal end.
tmt. Tarso-metatarsus, proximal end.

Fig. 9. Posterior aspect of tibio-tarsal joint, nat. size.
tb. Tibia, distal end.
tmt. Tarso-metatarsus, proximal end.

Fig. 10. Anterior aspect of distal end of tarso-metatarsus, nat. size.
tmt. Tarso-metatarsus, proximal end.
c 3, *c* 4 & *c* 5. Condyles for 3rd, 4th & 5th toes.

Fig. 11. Posterior aspect of distal end of tarso-metatarsus, nat. size.
tmt. Tarso-metatarsus.
c 3, *c* 4 & *c* 5. Condyles for 3rd, 4th & 5th toes.

Fig 3

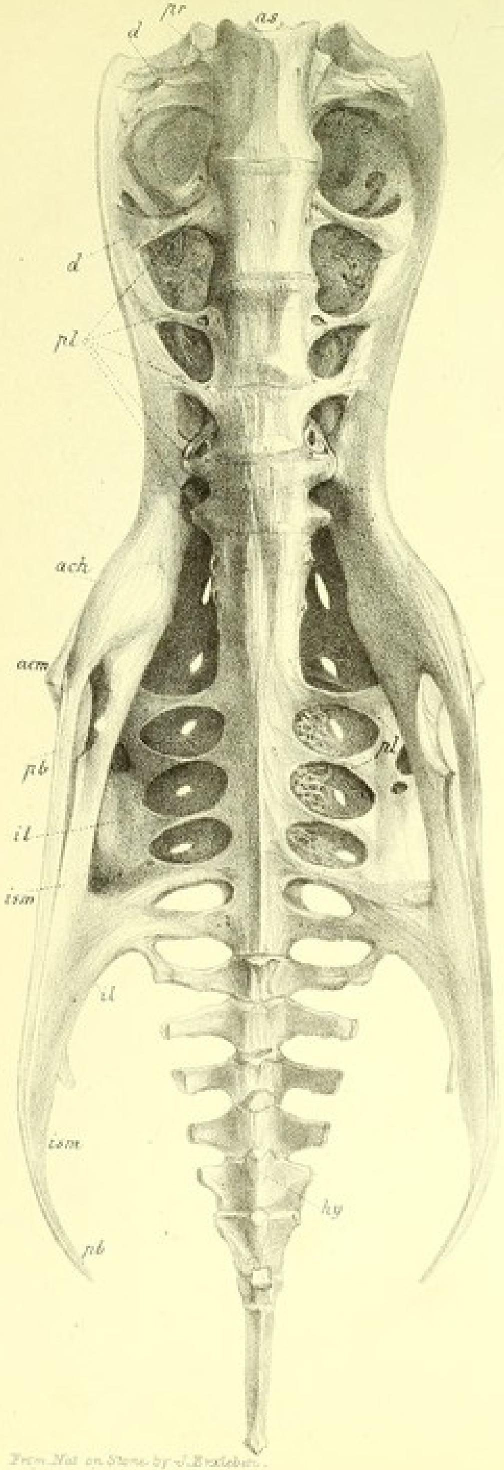


Fig. 2.

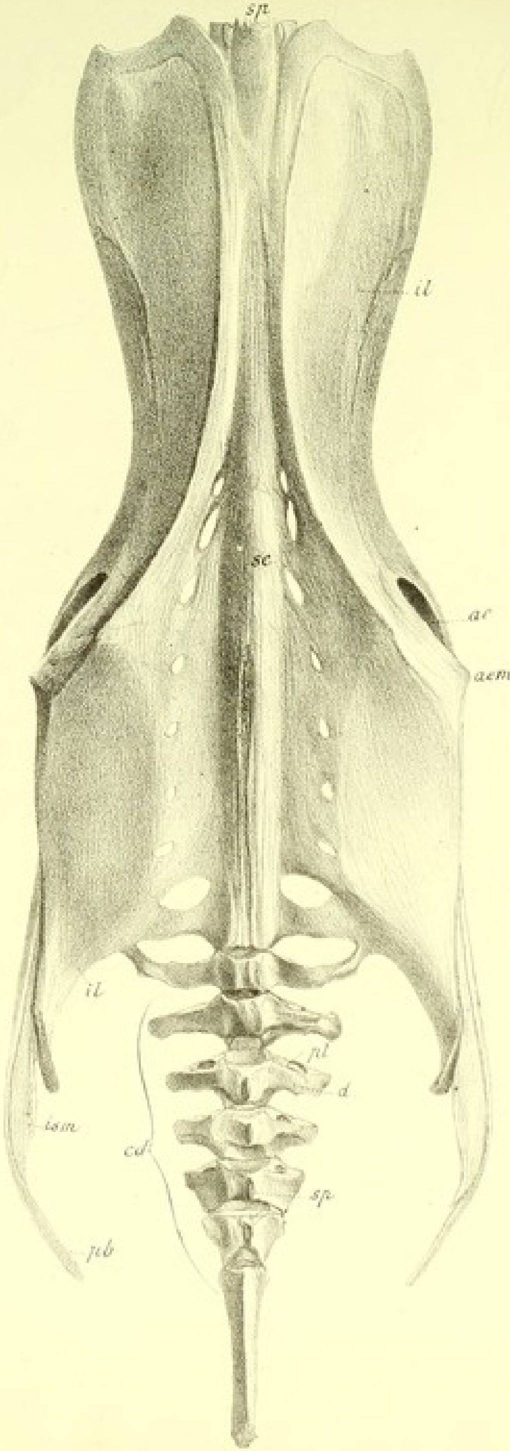


Fig. 1

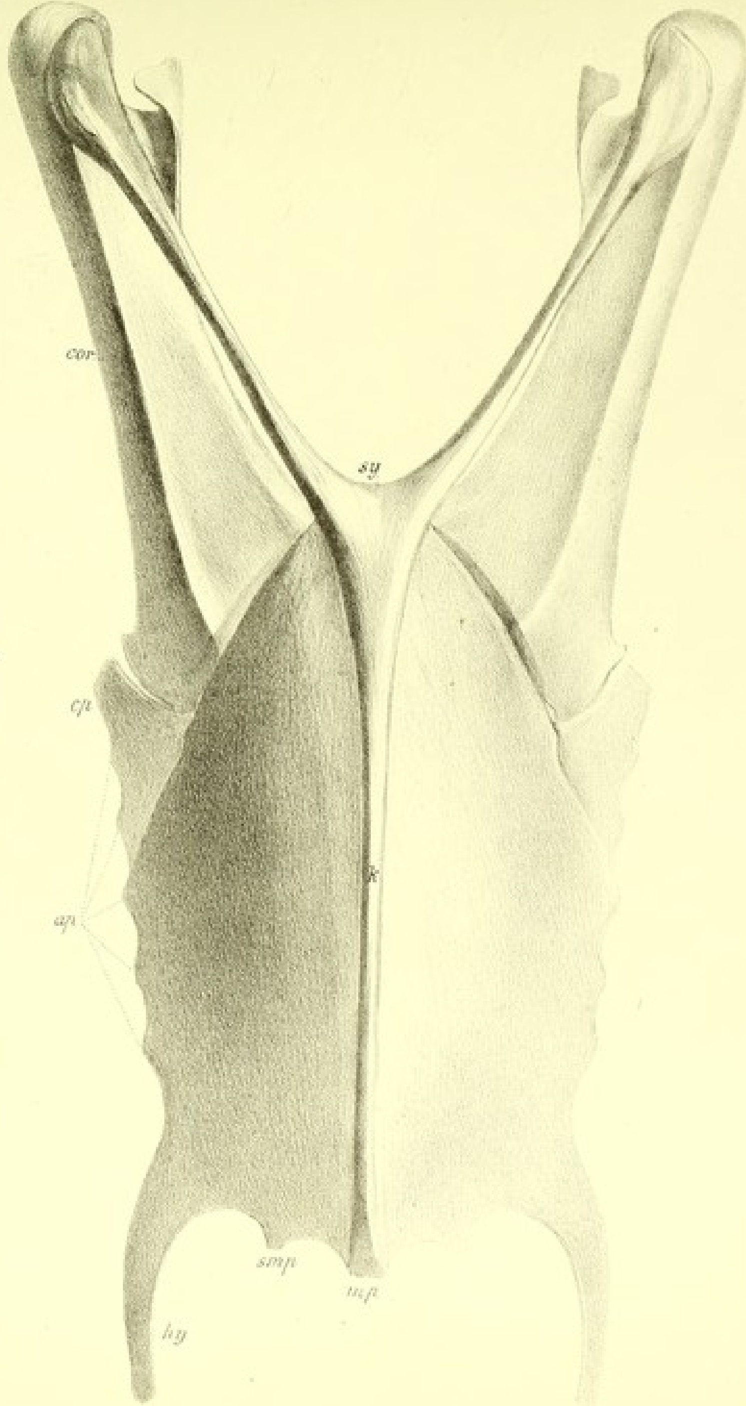


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PLATE LXVII.

Sternum and Pelvis of Balæniceps rex.

Fig. 1. Inferior aspect of sternal apparatus, nat. size.

sy. Symphysis of furculum.
cor. Coracoid.
k. Keel of sternum.
cp. Costal process of sternum.
ap. Articular processes for hæmapophyses.
mp. Median or xiphoid process.
smp. Sub-median process.
hy. Hypo-sternal process.

Fig. 2. Superior aspect of pelvis, nat. size.

sp. Spine of 1st sacral vertebra.
sc. Middle sacral region.
cd. Caudal vertebræ.
pl. Pleurapophysis of 2nd caudal.
d. Diapophysis.
sp. Spine of 4th caudal.
il. Ilium.
ism. Ischium.
pb. Pubis.
ac. Acetabulum.
aem. Articular eminence for great trochanter.

Fig. 3. Inferior aspect of pelvis, nat. size.

as. Anterior articulating surface of centrum of 1st sacral.
pr. Parapophysis of 1st sacral.
dd. Diapophyses of 1st and 2nd sacral.
pl. Pleurapophyses.
hy. Hypophysis of 4th caudal.
il. Ilium.
ism. Ischium.
pb. Pubis.
ach. Region of anchylosis of pelvic elements.
aem. Articular eminence for great trochanter.