VIII. *On the Structure and Development of the Skull in the Ostrich Tribe.* *By* WILLIAM KITCHEN PARKER, *F.Z.S.* *Communicated by Professor* T. H. HUXLEY, *F.R.S.*

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Introduction.

THE present paper is intended to be the first of a series on the Anatomy of the Vertebrate Skull; and I have chosen the cranium and face of the Ostriches as a starting-point, principally because of the mid position of these birds in the vertebrate sub-kingdom, and, in some degree also, because of their *generalized* character. Indeed, to any one familiar, on the one hand, with the structure of the skull in the higher mammalian types, and on the other with that of the osseous fishes, the skull of an Ostrich is interesting and important in a very high degree; serving, at it does, as a *key* to open up the meaning of parts so extremely unlike as the true *homologues* in the Fish and in the Mammal often are. And further, whilst aiding the anatomist in revealing the true morphological counterparts in the highest, as compared with the lowest types, the skull of an ostrich does also form a *link* of the utmost value for connecting together that of a cold-blooded and that of a warm-blooded creature.

I hope to follow up this first paper by one on the development of the skull and face in the Common Fowl, and this for two reasons; first, because this bird is the most available, in all its stages, to the morphologist, and also because it takes us further up amongst the branches of the great *ornithic tree*; leading us by gentle gradations towards those higher types in which the feathered tribes culminate.

Afterwards the "Sauropsida," as a whole, being one of the three great primary divisions of the Vertebrata, may be investigated still more completely; then the Mammalia, and ultimately the "Ichthyopsida." I may mention that the material for these papers is not altogether wanting; but much more research is needed to make it available for the purposes of science.

Having laboured much at the Fishes, I naturally look at the skull of the Bird with the eye of an ichthyotomist: this will explain why certain terms, either new to anatomical science, or only existing in my own published papers in the Transactions of the Zoological Society, have been used. For although the true counterpart of some bone, distinct and well known as to its mere form in the lower classes, may exist in the Mammalia, yet if it be not *autogenous* in them, but existing as a mere outgrowth of some other, then the distinct bony piece of the lower type of vertebrate must have its own proper name, and cannot be described as a *process* or outgrowth.

In the present paper I shall have to speak of a bone which, although distinct in

Amphibians, Snakes, Lizards, and Birds, is a mere *palatine* outgrowth of the maxillary in Crocodiles and Mammals; working ascendingly, I call this bone (mistaken by CUVIER and most others for a "turbinal") simply the "prevomer."

A similar instance is not far to seek; for the palatine plate of the palate-bone of the Crocodile and Mammal is in certain Birds (*e. g.* the "Lamellirostres") a small but distinct ossicle; this I have called "interpalatine." On the whole, however, I have endeavoured to keep very close to the old familiar human-anatomy terms, eschewing meanwhile all those synonyms which appear to me to mislead the student who is in search of true morphological unity.

For opportunities of studying very many valuable specimens that I could not have otherwise seen, I have to thank the Council and Officers of the Royal College of Surgeons—especially Mr. W. H. FLOWER; and also Dr. SCLATER and the other Officers of the Zoological Society.

Nor must I forget to state that throughout my work I have constantly had the great advantage of the advice and cooperation of my friend Professor HUXLEY.

The Skull of the Great Ostrich (Struthio camelus, "A.").

For a description of the earliest stages of growth in the Bird's skull I must refer the reader to Professor HUXLEY'S new work on the 'Elements of Comparative Anatomy,' pp. 130–142, fig. 57, A–F'.

My youngest struthious embryos are those of the African Ostrich (*Struthio camelus*); two of these were scarcely larger than a sparrow; but the head of each was $1\frac{1}{2}$ inch long, whilst the shanks measured only 9 lines.

At this stage ("*Struthio*, A.") the cartilaginous skull is perfectly formed (Plate VII.), and a few of the bones which develope in it have appeared; there is no trace, however, of some very important of these bone-patches. On the other hand, the calcareous substance has begun to harden those dense webs of fibrous tissue which are destined to form the secondary bones, viz. those which have no preexisting hyaline cartilage. A considerable part of the primordial skull is a long time before it ossifies; some of it does not ossify at all; and some very important parts—the anterior third of the coalesced "trabeculæ cranii" and the anterior or lower two-thirds of "MECKEL'S cartilages"—are absorbed soon after hatching.

As a rule, the secondary bones (opercular bones, splint bones) appear first; they are not formed at random, but the fibrous matrix which becomes osseous tissue is in some degree separated into bone-territories by the intervention of somewhat looser tracts of connective tissue. It seems to be quite certain that the *diaphysial* osseous deposit, even in cartilage-bones, is at first quite external to the cartilage-cells and their progeny, and even to the intercellular substance which binds them into one clear, cheese-like mass.

But the connective tissue which enwraps hyaline cartilage (perichondrium) is at one time internal, and at another time external to the first laying in of phosphate of lime. This gives us a most important fundamental distinction between primary and secondary bones; for although the bone-layer of a cartilaginous plate or rod may never affect the cartilage-cells at all, yet it is always *inside* the perichondrium. The splint bones may enfold persistent cartilage, or this *pith* may be absorbed; whilst in other cases we find the secondary bone rambling away far from the cartilage which served at first as its model, and running up and down any aponeurotic tract that may be available for it. Splint bones are not called *secondary* because of any lateness in their appearance—they are the first to appear; but cartilage is the first, or embryonic skeleton, and in certain low Vertebrata never takes on a calcareous condition.

One important difficulty turns up in this part of our research, and that arises from the fact that certain parts of the face, viz. the pterygo-palatine arcade, ossify as early as the earliest splint bones, whilst the tissues of the embryo are still simply cellular. Careful attention to this matter has led me to see that the difficulty is not at all insuperable, and that it does not in the least affect the distinction between the two classes of ossifications. I shall explain this more perfectly in subsequent papers; yet it seemed necessary to me to premise my description of the struthious skull with some remarks on the histology of the ossifying structures.

I must remark, further, that in studying RATHKE'S beautiful researches (by the help of Professor HUXLEY'S translations), I have been often confused by the use of the term "cartilage," both for condensed tracts of fibrous tissue, and for the true, or hyaline cartilage. The loose use of this term in RATHKE'S most invaluable works makes it necessary that those who follow him should repeat his observations in every possible instance. Holding this one point of weakness in memory, no better guide can be had.

I have also been led to differ very considerably from this truly great anatomist in the determination of the homologous bones in the various classes. Professor HUXLEY'S researches have shed much light upon this matter, but I find still further correction needed.

Returning to the earliest of the struthious skulls, we find that the hyaline cartilage which has been formed in the primordial membranous brain-case is perfectly continuous (Plate VII.). And this is not only the case with the proper cranial chamber, but parts truly *facial* are in nowise differentiated from those which belong to the cranium proper. Thus the auditory capsules are continuous with the occipital cartilage behind and below, and with the posterior sphenoidal region in front and below. The anterior sphenoidal cartilage passes (in front) continuously into the upper parts of the lateral ethmoids above, and into the great middle ethmoidal plate below (Plate VII. figs. 1 & 2, *eth.*, *o.s.*, *p.e.*, *p.s.*).

These two pairs of sense-capsules, the olfactory and the auditory, are not the only parts which are continuous, as cartilage, with the cranium; but the primordial, or fundamental part of the intermaxillary apparatus (Plate VII. figs. 1 & 2, *p.n.*) has not shown the least disposition to segment itself from the vertical ethmoid, and indeed it is one with the continuous orbito-nasal septum. On the other hand, the palatine has been long differentiated from the lateral ethmoid, and the quadrate cartilage from the front, and the stapes from the hinder part of the auditory capsule (Plate VII. fig. 4, *pa.–q.*).

The cartilaginous skull of the Ostrich is at this stage perfectly formed; yet the intercellular substance is scanty, and the whole structure is very friable: its shape will undergo but little change.

Beginning at the basioccipital region, we find a large conical mass of notochord (Plate VII. figs. 1, 2 & 6, *n.c.*) reaching only halfway to the deep cavity of the "sella turcica;" this mass is enclosed in the thick investing cartilage, which is deficient at the top and thick below, and has its posterior half enveloped in the large, transversely oval, occipital condyle. In front of this condyle, both above and below, there is a thin layer of bone (Plate VII. figs. 1 & 2, *b.o.*); the upper layer is encroaching upon the cartilage downwards, and the lower lamina upwards, but there is a thick mass of untouched cells between them. The upper lamina of bone is oval, the lower lozenge-shaped; the latter reaches in front to a trifoliate mass of cartilage, which has almost filled in the original space between each half of the investing mass, just up to the point where each cranial "trabecula" is given off. There is in front of this secondary growth of cartilage a true pituitary "fontanelle" (Plate VII. fig. 4, *p.t.s.*) still remaining; it is oval, and about half a line in fore-and-aft extent. In the cranial floor, however, the cartilage is still more deficient; and the anterior half of the "investing mass," viz. that which belongs to the posterior sphenoid, is separated by a fissure (Plate VII. fig. 1, *b.o.*).

It will be seen in my subsequent papers how all these minute particulars bear upon the structure of the skull in other classes, and how they look back upon the earlier stages of even the ornithic skull. The exoccipital (Plate VII. figs. 1, 2, 4 & 6, *e.o.*) does not begin at two points, but takes advantage of the cartilaginous selvedge formed by the "foramen magnum;" it spreads equally inwards and outwards, embracing the thick ascending plate; the laminæ eventually meet each other in the substance of the cartilage. At this stage the exoccipital is a very small patch, notched in front, where it half encloses the anterior condyloid foramen (Plate VII. figs. 1 & 2, 9.); it does not reach the chink for the vagus nerve. The whole of the broad, flat superoccipital cartilage, and the whole of the periotic capsule (Plate VII. figs. 1, 2 & 6, *s.o.*, *a.s.c.*, *p.s.c.*, *h.s.c.*) is still free from ossific deposit; the former part is already very thick, but the cartilage covering the large semicircular canals is thin, and reveals their form very perfectly on the wide vertical occipital plane (Plate VII. fig. 6). These are the posterior and horizontal canals, but the largest of the three is the anterior, and this is entirely seen within the cranial cavity (Plate VII. fig. 2); the obliquity of the whole capsule is so great that this canal is tilted backwards into the superoccipital region, and receives, ultimately, much of its bony investment from the superoccipital piece.

The sinus canal (Plate VII. figs. 2 & 5, *s.c.*), near the junction of the posterior semicircular canal with the upper edge of the superoccipital cartilage, is very wide but short; it is well seen within, at its commencement; and without, at its termination.

The fourth and last ossific centre to be described, as at present occupying the cranial cartilage, is the basisphenoid (Plate VII. fig. 2, *b.s.* & *r.b.s.*): this bone begins, at first, as an upper and a lower lamina. But unlike the basioccipital, the laminæ are not originally in the same vertical line; for the upper deposit takes place in the fundus of the deep "sella turcica," and the lower appears below the middle of the anterior sphenoidal cartilage (Plate VII. fig. 2).

This anomaly arises out of a disposition of the cranial structure in the embryo of the Bird, which has, from vicious interpretation, been the cause of much perplexity and error. In fig. 57, F′, p. 139 of Professor HUXLEY's "Elements," a most instructive condition of the early skull of the chick is given; at this stage the occipital region of the skull, with the enclosed "chorda," is more than half the whole length of the basis-cranii; in my earliest ostrich-embryo the cephalic part of the chorda is only one-twentieth part of the length of the skull-base. This change has arisen from the great extension of the investing mass, and of its forthstanding outgrowths, the "trabeculæ." In this young ostrich the chorda is separated from the pituitary body by a mass of cartilage equal to that which invests it (Plate VII. figs. 1 & 2); whilst the large, oval pituitary space of the earlier stage has been nearly obliterated, not only by the formation of a cartilaginous floor, but also by the convergence, during growth, of the trabeculæ themselves. In an intermediate stage between Professor HUXLEY's fig. 57, F′ and this which I describe, the pituitary space became a mere slit anteriorly; and this fissure was filled in below by a dagger-shaped band of dense cellular tissue. Whilst the edges of the trabeculæ behind were being connected together by a floor of cartilage, the same growth of cells was taking place in the interior of the dagger-shaped band, thus enlarging it, and giving to it a pith of true cartilage. The extension forward of the true pituitary floor reaches in this young ostrich to the middle of the alæ nasi (Plate VII. fig. 2, *al.n.–r.b.s.*); and that is the part which answers to the diverging point of the trabecular cornua in Professor HUXLEY's figure 57, F′: these cornua were wholly enclosed in the fronto-nasal process (*op. cit.* fig. 57, F, K). Beneath the "sella" (Plate VII. fig. 1, *p.t.s*, fig. 2, *b.s.*) the bony layer is thin; but the long style or rostrum is already wholly ossified in "*Struthio*, A;" this is of great importance to notice, for the style does not chondrify in the cold-blooded ovipara, and in typical birds greater time is allowed for the maturation of the cartilage-cells than in the Struthionidæ. The early appearance of the basisphenoid in birds has something to do with its inordinate size; for the late-appearing presphenoid in them never reaches the trabecular region below, the thick presellar part of the basisphenoid uniting with the perpendicular ethmoid; thus both of these latter bones encroach upon the presphenoidal territory. The median layer of the pituitary floor, and the thick, high, almost perpendicular walls of the "sella" (Plate VII. fig. 1, *a.cl.–p.cl.*) are as yet unossified, as is nearly the whole remainder of the cartilaginous skull at this stage.

The alisphenoid (Plate VII. figs. 1, 2 & 3, *a.s.*) is completely preformed in cartilage; and this cartilage has no membranous fontanelle, or remnant of the original membranous brain-sac; it is subpentagonal, is notched at its postero-inferior angle for the large trigeminal nerve (Plate VII. figs. 1, 2 & 3, 5), and is continuous with the periotic capsule behind, and with the sellar region of the basisphenoid below. It is convex outside, and concave within, and is of considerable thickness.

In the Ostrich-tribe and in all embryo-birds, the posterior sphenoid is further complicated by two thick outgrowths of cartilage, the anterior pterygoid processes (Plate VII. figs. 2 & 4, *a.p.*); they arise in the Struthionidæ on each side, and somewhat in front of the sella turcica, and project outwards and forwards to abut against the true, or *internal* pterygoid bones. In this stage (*Struthio*, A.) they are only slightly ossified at their base by the long inferior bony piece, which is already spreading out posteriorly.

The internal carotid arteries (Plate VII. figs. 2 & 4, *i.c.*) pierce the thick, wide investing mass opposite the anterior end of the basioccipital; close below each carotid canal, near the edge of the chondrified mass, there is already a small irregular patch of bone; this is the "basitemporal" (Plate VII. fig. 4, *b.t.*), or "lingula sphenoidalis." Between the coalesced rafters of the skull and the secondary skull-balk (Plate VII. fig. 2, *p.s.–pe.–r.b.s.*) (rostrum of basisphenoid) there is much fibrous tissue, except as we approach the anterior clinoid wall: this fissure is only slowly obliterated.

The coalesced trabeculæ maintain a pretty equal thickness to their termination in front; near the end, however, they lose their height, become broader, curve slightly downwards, and end in a rounded subspatulate manner (Plate VII. figs. 1–5, *p.n.*). After the basis cranii had recovered from its mesocephalic flexure, both the optic and the olfactory sacs approximated; and the simple, indifferent tissue between them became converted into one continuous vertical plate of cartilage with its investing perichondrium. Thus the presphenoid, the vertical, or middle ethmoid, and the nasal septum, form one continuous plate (Plate VII. fig. 2), somewhat thinner between the eyes and the turbinal coils than at the other parts, but altogether thinner than the base of the plate which was formed by the coalescence and chondrification of the trabeculæ.

The highest part of this orbito-nasal septum is the homologue of the "crista galli" (Plate VII. figs. 1, 2 & 3, *cr.g.*) of the human skull, on each side of which the olfactory lobes (1) pass to terminate inside the simple rudiments of the cribriform plate (*eth.*, *al.e.*). The hemispheres of the cerebrum only reach this point, and they lie obliquely on a pair of laminæ which grow out of the posterior half of the orbital septum. These oblong plates have their free angles rounded; each posterior angle lying a short distance from the alisphenoid, and each plate being less than half the size of the posterior sphenoidal ala—these are the orbito-sphenoids (Plate VII. figs. 1 & 2, *o.s.*).

In front of these orbital alæ the septum is notched above, and this notch passes on each side into the groove for the olfactory lobe; above these grooves the septum gives out its ethmoidal alæ (Plate VII. figs. 1 & 2): the delicate cartilages of the nasal sacs being continuous with the septum of the orbits and the nose, and also with each other.

They may, however, be described regionally; and then we have the aliethmoid (*al.e.*, *eth.*), which grows outwards and downwards to form the feeble upper and middle turbinals, the aliseptal plates (*al.s.*), which form the inferior turbinals, and the alinasal laminæ (*al.n.*), the homologues of our alæ nasi. I shall describe these parts more fully in embryos further advanced. The prenasal cartilaginous rostrum (*p.n.*) belongs to the visceral laminæ of the front, or terminal part of the head; in this stage it is at its fullest growth, and soon begin to shrink, but not before it has served as a model to the splint bones which are vicarious of it. The great general fontanelle (Plate VII. fig. 1, *o.s.–s.o.*), or space left unfinished by cartilage—the orbito-sphenoids, alisphenoids, periotic crest, and superoccipital cartilage together failing to form even half of the brain-case—has to be roofed in by the frontals, or orbito-sphenoidal splints, and by the parietals, or alisphenoidal splints (Plate VII. figs. 3 & 5, *f.p.*). These two pairs of bones are formed, as usual, in the outer layer of the embryonic "dura mater;" at this stage they are mere patches, not half the required size; they are moreover mere aggregations of minute, irregular bony points, only partially hiding the mat of fibrous tissue in which they are being deposited. The superoccipital cartilage (*s.o.*) has here no splint or interparietal piece as in the mammal, where two such ossific centres appear above the superoccipital and between the parietals. The mesencephalic region (Plate VII. figs. 3, 5 & 6, *fo.*) is still very prominent, although the optic lobes are beginning to be inferior to the hemispheres in size.

Further forward there are two other pairs of feeble bony patches, the splints belonging to the olfactory laminæ; they are the external and the upper ethmoid splints, the nasals and the lacrymals (Plate VII. figs. 3 & 5, *n.l.*).

Their present form is a small rough model of their persistent condition; they have been well differentiated in mere connective or fibrous tissue; and at this stage the lime is merely diffused through the web in small granules: such a condition, the fibrous web being rendered denser by so much lime, might easily cause these tracts to be mistaken for true cartilage, if only low powers were used in their examination. The nasals and lacrymals certainly belong to the facial category, for they are *opercular* additions to the olfactory cartilages, the *upper* surface of which would be a continuation of the cranial *floor*, if the brain were continued so far forward into the nasal region.

Before leaving the skull- and sense-capsules, I would remark that in the formation of true hyaline cartilage the cells of the orbitonasal septum do not bear a *filial* relation to those of the "trabeculæ." Each structure is preformed in simple or indifferent tissue, and the differentiation of tracts of such cellular substance into a fibrous web, or into cheese-like cartilage, is one of the first great formative processes of which we can give no account. Afterwards the growth of each region takes place by the proliferation of such metamorphosed cells, the progeny formed within the parent cells being of the same nature as their parents.

When, however, a sufficient mass of these has been formed in each region, then, whether the tract be of fibrous tissue or of hyaline cartilage, the bony metamorphosis takes place indifferently, and the distinction is lost again; the two temporary tissues, notwithstanding their very different attributes, giving place to a uniform bony structure, which, when completely formed, tells no tale of its former history.

The next parts to be described are the facial arches—visceral arches of the head; and here it will be well to attend with the utmost care to what may be really seen, rather than to what has been written upon the subject. The first poststomal arch is the most highly developed in the Ostrich, in typical birds, and in the Vertebrata generally, it may therefore be our starting-point; still it will be necessary, more or less, to study all the four arches in connexion.

In *Struthio*, A., the proximal part—quadrate cartilage, incus—(Plate VII. figs. 3–6, *q.*) is already completely segmented from that part of the investing mass which is in front of the periotic capsule, and which is indeed the basal part of its investment; for the cartilage which covers in the simple auditory sac, and that which grows round the "medulla oblongata," are both continuous with that which invests the cephalic part of the "chorda." The mandibular pedicel has its true origin along the outside of the base of the auditory sac; the pedicel of the hyoid ramus arises from the posterior part of its base, somewhat behind and below the quadrate cartilage; the second *pre*stomal arch (palatine) arises from the base of the posterior wall of the nasal sac, and the first prestomal (intermaxillary) never becomes perfectly segmented from the base of the internasal septum; the latter part, being the extreme of the series, thus keeps to a low type of growth like, but still more simple than, the mandibular arch of the Chimæroid fishes; the Lepidosiren also, and the Batrachia generally. The mandible of the Ostrich (Plate VII. fig. 3, *q.–d.*) does not show the typical form of a visceral arch so well as many of the higher birds, especially the Gallinæ; the truest form being a descending proximal part, to which is swung a long bar projecting both backwards and forwards, and which lies nearly in the same plane as the cranio-facial axis. The high development of this arch is shown in its complete separation by a synovial joint from the end of the bar in front of it—the pterygo-palatine arcade; and also in as perfect a division between the suspending portion from the long, almost horizontal bar. The long anterior part (MECKEL's cartilage) has grown, as it were, at the expense of the posterior more incurved rod (the internal angular process, manubrium mallei of Mammals); and the very free joint between the quadrate and the articular portion allows this arch to form a large angle with the palatine (the rudimentary second prestomal arch) when the mouth is opened. The quadrate cartilage is large, and rather clumsily formed; its head or suspending part shows no trace of subdivision into an anterior and a posterior incudal crus; and its orbital or metapterygoid portion is large and thick. A film of bone (Plate VII. figs. 3 & 4, *q.*) has appeared under the perichondrium at the postero-external part of the shaft: on the outside this lamella is seen to be creeping on to the metapterygoid process, which is ossified continuously with the main part of the bone.

At the base of the cartilage there is a thick crescentic convexity (Plate VII. fig. 4, *q.*), the horns of the crescent looking forwards, and being very large and swollen. The head of the detached mandibular cartilage (Plate VII. fig. 3, *ar.*)—wholly unossified at this stage—is scooped to receive the convexity of the base of the quadrate; the anterior bar is very long (partly seen in Plate VII. fig. 3, above *s.a.*) and terete, gently tapering towards its blunt anterior extremity; this is MECKEL'S cartilage. The posterior bar, or internal angular process, is short, thick, and incurved. The mandibular splints are as far advanced as those of the skull; and that which overlaps the detached proximal piece (Plate VII. figs. 3–6, *sq.*) is larger than the parietal; it is lozenge-shaped, the obliquely-placed inferior angle being the largest, and running down the side of the quadrate cartilage. This splint is the true homologue of the squamosal of the Mammal, of the temporo-mastoid of the frog, and of the preopercular of the osseous fish. Outside the detached bar there are three splints, the dentary being distal, the surangular and angular being proximal (Plate VII. fig. 3, *d.s.a.a.*): on the inside there are two, the splenial, or distal piece, and the coronoid, or proximal.

The pterygo-palatine or second prestomal arch is developed after a lower type, and in a more hurried manner, and there is no free descending ray. It has been completely ossified during the embryonic *simplicity* of the cellular tissue in which it was roughly premodelled. It is not in the Ostrich composed of more than two pieces, the pterygoid behind, and the palatine in front (Plate VII. fig. 4, *p.g.–pa.*); and the proximal part, or pedicel, is not segmented from the posterior end of the palatine; it is its *orbital* process. The two bones articulate by an oblique suture, which is not persistent, being lost again in the adult bird. The ends of this horizontal divided bar differ very much; that which is formed by the palatine becoming a sharp style which interdigitates with the inter-maxillary splints, whilst the connexion of the pterygoid with the quadrate cartilage is by a cup-and-ball synovial joint: the cup belongs to the pterygoid, and the ball (a very important part in a descending survey of the vertebrate skull) to the quadrate cartilage. Another synovial joint; of an oval form, and with a flattish sinuous face, appears on the inner side of the pterygoid; it articulates with a similar facet on the end of the anterior pterygoid process of the basisphenoid (Plate VII. figs. 2 & 4, *a.p.*). The splints of the pterygo-palatine rod are in a very feeble condition, the zygoma being a mere tendon, and only the jugal and quadrato-jugal (Plate VII. *j.q.j.*) being developed. Moreover, the position of these splints is very peculiar; for although in an early state of the "maxillary rudiment" the tissue in which they have been formed lay close outside the pterygo-palatine streak, yet the rapid widening of the mouth has caused the removal of the zygoma far external to the palatine (primordial) rod.

The facial flaps which grow down from the frontal wall of the early embryo are connate, but are generally notched, the notch indicating where a slit should be. In the lobes of this essentially double lamina the trabeculæ terminate, and they form its pith—just as the pterygo-palatine streak of tissue forms the pith of the maxillary rudiment, *miscalled* "the maxillary process of the first visceral arch," and just as MECKEL'S cartilage is the pith of the mandibular arch.

We saw that the second prestomal rod had become inferior, morphologically, to the first poststomal: a still further degradation takes place in the intermaxillary, that is, in its primordial parts; for in the bird the rods coalesce throughout their whole length, whilst the plane of the rods is coincident with that of the cranio-facial axis, of which they, from lack of segmentation, are a mere forward continuation. At this stage (*Struthio*, "A.") these confluent rods (Plate VII. figs. 1–5, *p.n.*) are at their fullest development; afterwards, all that part which is free of the nasal passages anteriorly, gradually shrinks, is very small at the time of hatching, and eventually disappears. The foremost two-thirds of MECKEL'S cartilages undergo the same wasting; but this decadence is not seen in any part of the palatine rod, at least in the Ostrich: in some birds, *e. g.*, the Psittacinæ, the palatines become premorse anteriorly. But this is in the osseous stage, which the prenasal and Meckelian cartilages never attain to, being merely temporary structures.

That part of the premaxillary pith which does continue in the Ostrich, is ossified continuously with the perpendicular ethmoid: this is extremely unlike what obtains in the higher birds, where the vestibular or *sifting* portion of the nasal structures, and the axis of the intermaxillary structures, become wholly segmented from the skull and from that part of the nasal capsule which is supplied with the olfactory filaments, and which gives origin to the palatine pedicel. An exorbitant development of the anterior intermaxillary splints is characteristic of birds, but in *Struthio*, and most of its congeners, it is the vomer which attains to the greatest relative size. There may be four pairs of intermaxillary splints; but in the Ostrich the essentially double vomer (Plate VII. fig. 4, *v.*) is only split at each end—it is an azygous piece; this is the inferior and posterior splint, and is apt to run far backwards into the palatine region, sheathing the coalesced trabecular beam anteriorly, and the rostrum of the basisphenoid behind.

In the Ostrich, as in all birds, the intermaxillaries (Plate VII. *p.x.*) themselves are always symmetrical; but their separateness is extremely transitory; they commence upon the sides of the upper surface of the depressed end of the prenasal rostrum—their proper pith of cartilage. Each piece is composed of a body, from which proceed the nasal (Plate VII. fig. 5, *p.x.*), angular (Plate VII. fig. 3, *p.x.*), and palatine (Plate VII. fig. 4, *p.x.*) processes.

The dentary margin of the body of these bones meets the palatine processes at an acute angle; in the Mammal this space is the anterior half of the "anterior palatine foramen;" it is filled up in the bird on each side by the anterior pointed end of the middle intermaxillary splint. These bones, the "prevomers" (Plate VII. figs. 3 & 4, *p.v.*) have been much misunderstood, being mistaken in the bird for the true maxillaries, and in the Ophidians, Lacertians, and Amphibians for the inferior turbinals.

Already in *Struthio*, "A.," they have almost attained their proper form, and each bone may be described as possessing a body, a nasal, an internal or palatine, an external or zygomatic process, and a pedate proximal process, in relation to the sides of the trabecular rod. In *Struthio camelus* the nasal process is a mere thin and not very broad bridge of bone passing from the proximal to the zygomatic process, on a somewhat higher plane than the body of the bone; thus making the isthmus between the proximal (internal) part and body of the bone to be double.

This bone supplies a good instance of the manner in which a splint bone may be formed by the ossification of an aponeurotic tract quite at right angles to and a great distance from the primary rod to which it belongs. All these splints appear to belong to the *external* category; if so, only the mandible in the Ostrich-tribe has *internal* splints. The coalescence of the axial rods makes this apparent difference.

In *Struthio* the vomer (Plate VII. fig. 4, *v.*) has three prongs anteriorly, and is deeply bilobed behind, passing backwards as an under beam, beyond the middle of the basisphenoidal rostrum in the adult; in *Struthio*, A., one-third of the rostrum is thus underlaid. Certainly the formation of the vomer is at first in the *outer* layer of the perichondrium which invests all that part of the cranio-facial axis lying in front of the antorbital lamina ("pars plana," "middle turbinal"). The "turbinals" have overshadowed intellectually, as they do literally, this matter of the great extent of the primordial part of the intermaxillary apparatus, and the real bearing of its splint-system. Afterwards I will show the fruitfulness of this idea, and how it throws a trail of light along the whole series of "vomers" from their first birth in the Sturgeon to their latest incoming in our own species. The true nature of this splint, the unravelling of the much misunderstood "prevomers," the exact nature of the intermaxillaries proper, and the finding for all these a true embryonic preskeletal basis, is no mean object of ambition.

The rest of the face is the hyoid arch, with its attached thyrohyals (1st branchial arch (Plate VII. fig. 7). The proximal part of the hyoid arch is the "columella" (stapes); it is a mere cylinder of cartilage, which flattens out into an oval disk above, where it serves as an *operculum* to the fenestra ovalis (fenestra of the vestibule), and is branched below, the thin branches not ossifying. Far removed from this part we find the hyoid cornua on a plane with the base of the skull, and altogether small, and coalesced with each other and with a truly basal piece. The cerato-, basi-, and uro-hyals (Plate VII. fig. 7, *c.h.–b.h.–u.h.*) are thus already one piece, which is at present totally unossified. These primordial hyoid horns are an exact imitation of an early state of their serial homologues in the first prestomal (intermaxillary) arch (see HUXLEY's Elem., p, 138, fig. 57, F′, *rr.*). There is much mystery at present hanging over the relation of the cornua of the hyoid to the proximal pieces. Articulating distally with the basal portion of this hyoid cartilage is a rod of cartilage which has another smaller rod articulated to it above, which latter ends in a point. These are the thyro-hyals (*t.h.* 1 & 2), or rudiments of the first branchial arch; proximally they are free, and curl round behind the occipital cartilage; none of the lingual cartilages possess any splints, as they do in fishes: the lower thyro-hyal is rapidly ossifying in *Struthio*, "A."

Struthio, "B."

The head of the next embryo of *Struthio camelus* measured 2½ inches in length, but although the body of the chick was about the size of that of a pigeon, yet there was nearly a pound weight of unused yolk in the egg.

At this stage the skull has increased to nearly twice the length of that which I have been describing, and with this greatly augmented bulk we also have the incoming of new osseous parts, as well as a great maturation of those already existing, and a commenced deterioration of those *quasi-larval* structures which disappear during the slow, gentle, but real metamorphosis which the parts of the ornithic skull and face undergo.

The angle of the occiput with the basicranial axis (Plate VIII. fig. 1) has greatly lessened, and is not many degrees above a right angle, to which degree of acuteness it never attains even in the adult bird. The base of each hemisphere, anteriorly, is in *Struthio*, A. five lines, or nearly, above the true base of the skull, *i. e.* the lower edge of the basisphenoidal rostrum; in *Struthio*, B. it is seven lines, and in the adult twenty-one, or an inch and three-quarters, the rostrum at that part being seven lines in depth. But the brain at this part lies on the gently *convex* surface of the orbitosphenoids; the anterior sphenoid is thus altogether lifted up above the actual basal line of the skull, the whole depth of the basisphenoid below and just in front of the optic foramina being in the adult a full inch. To the student of the mammalian skull all these details will appear strange enough; but the bird's skull is a curious problem, and he who shall explain it will have done much towards producing a harmony of all vertebrate crania.

The cartilaginous investing mass in *Struthio*, B., has on each side grown nearer to the mid line; the notochord has thus thus become pinched into a thin vertical plate; the basioccipital and the exoccipital (Plate VIII. fig. 2, *b.o.e.o.*) also, have increased both relatively and really, the cartilage within their laminæ being much metamorphosed. In the superoccipital region a large, irregularly hexagonal plate of bone has appeared, reaching above to the converged parietals, and below already bounding the "foramen magnum" (Plates VIII. fig. 4, *s.o.*). I have not been able to see this superoccipital element on its first appearance in the "Struthionidæ," but the only genus in which I have found it as an originally azygous piece is *Turdus* (the Thrushes); even in *Passer*, *Erythacus*, and *Corvus*—good representatives of three great, and eminently typical families—there are two superoccipitals at first. And it may be also noted that this element is, relatively, exorbitantly large in the Ostrich-tribe.

The cartilage investing the auditory capsule has greatly increased in thickness, and the prootic and opisthotic (Plate VIII. fig. 4, *op.*) bones have just appeared; the latter may be seen externally (its outer lamina) outside the base of the "posterior vertical canal."

The basitemporals have coalesced (Plate VIII. fig. 2, *b.t.*) and form a narrow band reaching across beneath the skull from one internal carotid opening (*i.c.*) to the other; but they have also entirely coalesced with the terminal end of the true basisphenoid, so that already their exact limits cannot be seen; yet it is evident from other members of this group of birds that this temporal belt is partly formed by the basisphenoid in the mid line. Not only has the bony matter spread far along the great anterior pterygoid processes, but has also sent out two more (posterior) wings, the ossific matter of which is creeping into the anterior part of the broad investing mass (Plate VIII. fig. 2, *p.r.p.*).

The "rostrum" (Plate VIII. figs. 1 & 2, *r.b.s.*) has greatly increased in size and has become relatively longer, reaching to the extreme limits of the alæ nasi and external nasal passages. There is still a thick spheno-occipital synchondrosis, and an oval remnant of the pituitary fontanelle (Plate VIII. fig. 2, *p.t.s.*). Two oblong jagged centres have appeared in the alisphenoidal cartilage, one above and the other below (Plate VIII. fig. 1, *a.s.*); they are nearly equal in size, the upper being the longest; there are two nearly equal bones formed in the front in *Passer domesticus*; and in *Nisus vulgaris* there is a small ossicle in front of the main piece. The anterior sphenoid (Plate VIII. fig. 1, *o.s.p.s.*) is still wholly unossified; it is, as it were, altogether hindered in its growth and development by the excessive size of the territories bounding it before and behind: lateness of ossification is a very constant concomitant of cramped development, just as an overshadowed tree is slow in its leafing.

The ethmoid has commenced to ossify both in its upper and perpendicular portions (Plate VIII. figs. 1 & 3, *eth. p.e.*); but I will defer a description of these until I come to describe a somewhat later stage (*Struthio*, C.).

The cranial and nasal splint bones (*f.p.n.*) have increased relatively, as well as really, and the fronto-parietal fontanelle (Plate VIII. fig. 3, *fo.*) is very small; the frontals and parietals are coming extensively into contact, and are forming the coronal and sagittal sutures; the middle third of the lambdoidal suture (Plate VIII. fig. 4) is also complete.

The nasals and lacrymals (*n.l.*) are becoming dense through the more perfect ossification of the fibrous lamina in which they are developed. The same may be said of all the splint bones seen in the facial parts of the skull and in the mandible. The pterygoid (*p.g.*) has become more nearly like that of the adult bird, and the palatine (*pa.*) has lost the sharp point at its anterior end. The broad proximal, the distal, and metapterygoid portions of the "os quadratum" (*q.*) (incus) are still unossified, like the ends of the anterior pterygoid processes; and the base and shaft of the "columella" (*st.*) have become bony. But the *malleal* part of the mandible is still soft, even its articular persistent end (Plate VIII. figs. 1 & 5, *ar.*). The whole of the lingual cartilages have merely grown, but have not altered their condition, as to ossification, from what we saw in *Struthio*, "A." (Plate VIII. fig. 6).

Struthio, "C."

In *Struthio*, C. all these processes have advanced a step or two further, although no new bony centre has appeared. The upper fontanelle has almost disappeared. The superoccipital is spreading laterally, the exoccipitals (Plate VIII. fig. 8, *e.o.*) have acquired an elegant fan-shaped form behind; the notochord (Plate VIII. fig. 10, *n.c.*) has its anterior two-thirds enclosed in bone (basioccipital), from the fusion of the two laminæ. The two laminæ of the basisphenoid (Plate VIII. fig. 10, *b.s.*) have coalesced, and the clinoid regions are becoming bony; the alisphenoid (*a.s.*) is entirely ossified. The posterior part of the anterior vertical canal (Plate VIII. fig. 10, *a.s.c.*) is enclosed in the superoccipital, and the ampulla is now embodied in the "prootic" (*pro.*), which is bilobate, and which commenced on the supero-anterior thick edge of the auditory capsule: beginning at a selvedge, it was most probably single from the first. The opisthotic (Plate VIII. figs. 8 & 10, *op.*) is five or six times the size we saw it in *Struthio*, B.; its outer lamina (fig. 8) is an inverted crescent; its inner (fig. 10) is semicircular; they are quite distinct. A very large mass of occipital and auditory cartilage (Plate VIII. figs. 8, 9, 10) is still in a soft state, as is all the rest of the cranio-facial axis, except the ethmoid. The middle or perpendicular ethmoid (Plate VIII. fig. 10, *p.e.*) has an ossification which is roundish, and is nearly 4 lines in diameter; its two laminæ (right and left) have coalesced by a small internal isthmus (Plate X. fig. 1, *p.e.*); and the edges are creeping in all directions *on* and *into* the cartilaginous mass.

It may be remarked here that this mode of *diaphysial* ossification,—viz. by two external laminæ, where there are two free surfaces to the cartilage, by one where there is only one, by a bilobate ossicle when the bone begins on a selvedge, and by a ring in cylindrical rods—is never departed from (as far as I have seen) in the oviparous vertebrata.

In by far the greater number of instances the process is the same amongst the Mammalia; but in the Fish (*Teleostei*) the retention of a pith of unchanged and constantly proliferating cartilage is the rule. This is not a gathering together into definite bone-plots of the tiny ossicles which are scattered broadcast over the cartilage in the Plagiostomes, for their bone-grains are intercellular. The thin bony sheath (but for sectional views) might easily be mistaken either in the adult fish, or in the embryos of the higher group, for a splint bone, especially as it often appears in cylindrical bones on one side at first, that side being the freest and most exposed. It must also be held in mind that there is a stage in which the new bony matter has not as yet touched the cartilage-cells, and that this is a persistent condition in certain delicate minute fish, e. g. *Gobius minutus.* Returning to the ethmoid of *Struthio*, C., we find a condition which is apparently unique; for the ethnoidal alæ which turn over to form the feeble cribriform plate are not ossified separately as in most of the typical birds, the middle plate in them being entirely completed by the vertical piece, but a bone begins at the top of the broad surface, oval in form, and having only this upper lamina (Plate VIII. figs. 3 & 10, *eth.*). The upper part of the prefrontals, at least, are thus *connate*; but the "pars plana" generally has its own centre, or centres, even in the Struthionidæ.

The cartilage between these two ethmoidal bones in *Struthio*, "C." is only a line deep, and coalescence soon takes place. No other bone appears in the cranio-facial axis; for these two azygous bones, after they anchylose, spread forwards through the whole of the septum nasi, which in this abnormal group is not differentiated from the middle ethmoid. The alæ of the septum, or roots of the great inferior turbinal cartilages, are ossified continuously in the same way, and as a roof to the continuous vertical plate; but the mass of these cartilaginous folds continues soft in the adult. Seen from within, the "upper," "middle," "inferior," and alinasal turbinals form one connected, continuous series of swelling masses (Plate VIII. fig. 7); but the representative of the upper turbinal and its cribriform plate in the Mammal is here a mere descending wing (Plate X. fig. 1, *al.e.*), only folding upon itself where it passes insensibly into the roots of the inferior turbinal; and the olfactory lobe lies *between* it and the middle plate (Plate X. fig. 1, I), in that chink which is so copiously bridged over, and thus converted into a vertical row of holes in the Mammal. The spaces seen on the side of the upper turbinal fold behind (Plate VIII. fig. 1, *p.e.*), where it passes into the "pars plana," are not for olfactory filaments, but depend upon a certain unfinished condition of the cartilaginous lamella, and are quite inside, and even behind that part of the olfactory crus which gives off the filaments. A fissure lower down (Plate VIII. fig. 1, *al.e.pp.*) partly divides the upper turbinal lamella from the large but very *simple* "pars plana," but above that there is a broad continuous connecting plate. Below, at its external angle, the pars plana is connected with the outstanding, foot-shaped, lower end of the inferior turbinal (Plate X. fig. 1, *a.i.t.*) by a narrow isthmus; so that there are three antorbital plates, or rather regions—an upper or inner, a middle or lower, and an outer and somewhat anterior lobe; these belong respectively to the upper, middle, and lower turbinals.

The only fold or outgrowth which can safely be said to belong to the middle turbinal is near the base of the pars plana (Plate VIII. fig. 11, *m.t.b.*); it is triangular, horizontal, and runs outwards and forwards, lying between the largest posterior part of the inferior turbinal and the proximal plate of the prevomer. The most complex part of the inferior turbinal (Plate X. fig. 3, *i.t.*) is the fullest or hinder part; and although much less complex than that of the Cassowary, or even than that of the Emu, it is yet greatly in advance of the same part in the *Rhea*, the Tinamou, or the typical bird. The septal ala (Plate X. fig. 3, *al.s.*) passes outwards, downwards, and then inwards, walling in the whole nasal labyrinth, save for the chink between the free edge of the alæ and the base of the septum (Plate X. fig. 3). Where the aliseptal cartilage begins to turn downwards it sends off an outgrowth, which is directly vertical behind, and afterwards turns inwards; at this anterior part it splits into two lamellæ, which curl upwards, each being about a semicircle (Plate X. fig. 3, *i.t.*). But posteriorly these secondary lamellæ are divided again; and of these tertiary folds, the nearest but one to the septum forms more than a complete coil (Plate X. fig. 3, *i.t.*). Below these lamellæ another has been given off from the outer (primary) wall (Plate X. figs. 3, 4, 5, *n.t.*), and when this reaches the alinasal region it becomes as complex as the front part of the inferior turbinal; this is the "alinasal turbinal." The septum, as soon as we pass in front of the olfactory bulbs, is very thick at top; it then becomes thin, and thickens into a strong (trabecular) beam; this beam being underlaid by the "rostrum," and this again by the vomer (Plate X.

figs. 3, 4, 5, *s.n. r.b.s. v.*). Further forwards, the septum gently narrows to the middle, and then thickens again towards the base, the sectional view of which is always bulbous (Plate X. fig. 5). The alæ nasi grow forwards beyond their *axial* attachment; between them runs the evanescent premaxillary axis, which is flattened from above downwards (Plate X. fig. 6). There is no such outgrowing of the base of the septum as is to be seen in the embryo Ox, in the Crocodile, and in the Frog; yet such an inferior expansion is to be seen in many birds, especially the Raptores. In the Turtle (*Chelone mydas*) the alæ nasi and the base of the septum become confluent at one point.

Rhea.

My illustrations of the development of the skull of the *Rhea* will be from a comparison of the adult skull with that of the ripe *pullus*. I have already given figures of the adult *Rhea americana*, Zool. Trans. vol. v. pl. 42; and there are several notices of its structure in that paper, more especially as compared with that of the Syrrhaptes and the Tinamou. The ripe chicks of the Rhea from the Gardens of the Zoological Society were of a *mixed* kind; the *sire* being the subspecies (?) called *R. macrorhyncha* by Dr. SCLATER (Zool. Trans. vol. iv. pt. 8. pl. 69, & fig. 2. p. 356; & P.Z.S. 1860, p. 207), whilst the *dam* was the ordinary *R. americana*. In some respects the *Rhea* comes much nearer the ordinary land birds, e. g. *Otis*, *Gallus*, than the African Ostrich; in others it is much more aberrant from the ornithic type. It is also the best bird in the Class for illustrating the structure of the Fish, and the lower kinds of Reptilia—the Amphibians, Ophidians, and Lacertians. Notwithstanding the large size of these *pulli*, the cartilage-bones have not all appeared, but the membrane-bones have attained to a degree of development almost equal to that which is found in an ordinary adult Lacertian. The condition, moreover, of the primordial (*larval*) skull is such as will have to undergo great changes of relative proportion, and of subsequent resorption in certain tracts, before it reaches its adult condition.

A chink in the upper aspect of the oval basioccipital shows a feeble remnant of the notochord in its axis (Plate IX. fig. 1, *b.o.*.); the bone itself is insulated by cartilage. The exoccipitals are large, hourglass-shaped within (Plate IX. fig. 1, *e.o.*), and trilobate at the external and outer margin (Plate IX. fig. 6, *e.o.*); a notch above, near the crescentic venous groove, shows that a large peninsula of this bone (above) belongs to the opisthotic (*op.*), which is still distinct within (Plate X. fig. 7, *op.*): this is exactly like what we see in the ripe embryo of the Crocodile. The occipital condyle is bilobate transversely (Plate IX. fig. 1), as is very common in birds having a smack of the reptile in them; it is still cartilaginous, but the ex- and basi-occipitals are creeping into it at its sides and in front. The superoccipital (Plate IX. fig. 6, *s.o.*) shows no trace of suture down its middle (although assuredly it did once exist, if *analogy* is of any value); it is a large, elegant, six-sided, winged bone, angular above, crescentic below, grooved and perforated for veins submarginally, and has the upper part of its sides convex, the lower concave. This bone has a large margin of cartilage on each side of it; it has, however, reached the foramen magnum below, and the sagittal suture between the parietals above. It has embraced three-fourths of the anterior semicircular canal within (Plate X. fig. 7, *a.s.c.*); thus anticipating the epiotic in its function, and, as it were, causing it to be both late and small: this is extremely common, and in by far the larger proportion of birds the epiotic is prevented from appearing by this vicarious overgrowth of the superoccipital; this is well seen also in the Chelonians.

The "occipito-sphenoidal synchondrosis" (Plate X. fig. 7) is nearly a line in fore-and-aft extent, and a notable margin of cartilage divides the whole body of the basisphenoid from its neighbour-bones laterally, *e. g.* the alisphenoid and the prootic (Plate X. fig. 7). The two lamellæ of the basisphenoid are completely welded together, and the two lateral lamellæ (the basitemporals) have also coalesced *with the sides* of the basisphenoid below (Plate X. fig. 7, *bt.*). Two small passages, connected by a groove, feebly remind us of the once large pituitary space; behind these the basisphenoid can be seen growing towards the basioccipital, the basitemporals being *lateral*, as in the Mammalia (Plate IX. fig. 4). That mass of cartilage which takes the place of RATHKE's "middle trabecula" (the posterior clinoid bridge) (Plate IX. fig. 1, *p.cl.*) runs continuously across the floor of the skull into the tract which at present separates the alisphenoid from the prootic. This clinoid bridge is filially related to the tissue which formed the most projecting angle of the skull-base in the "cranial flexure" of the early embryo. In front of the "infundibulum" the ossific matter has reached the common optic foramen (Plate IX. fig. 2, & Plate X. fig. 7, *bs.*); so that there is a large compressed prepituitary portion already developed to the basisphenoid; afterwards it will have grown forward enough to meet and coalesce with the vertical ethmoid (*p.e.*), although they are at present 4 lines apart. The acquisition of the basitemporals gives the basisphenoid a bilobate form behind and below (Plate IX. fig. 4); above, the bone is split beneath the clinoid bridge (Plate IX. fig. 1), and the fissure is the remnant of the space in which the extreme point of the notochord neared the infundibulum: it is much larger in Reptiles, and being in them deficient of cartilage, forms the "posterior basicranial fontanelle" of RATHKE. The, at present, rather slender "rostrum" runs forwards to the middle of the alæ nasi (Plate IX. fig. 2, & Plate X. fig. 7, *r.bs.*); it is relatively somewhat shorter in the adult; it is entirely ossified. The alisphenoids (Plates IX. & X. *a.s.*) are at this stage composed only of one piece; but the ossific matter has scarcely reached the great trigeminal nerve (5), and overarches only the ophthalmic (5, *a*); the anterior margin is also soft, and so is part of the supero-external angle. Only part, however; for here is developed the true (*ichthyic*) "postfrontal" (Plate X. fig. 8, *pf.*); it is somewhat like the blade of a hatchet, and is a line and a half across. It is best seen in the Rhea of any bird I am acquainted with, although it turns up in the Emu and the Tinamou (as we shall see), in the typical "Raptores," e. g. *Nisus vulgaris*, and in the nocturnal species also, *e. g.* the Barn-Owl (*Strix flammea*). This bone is not the homologue of the so-called postfrontal of the Reptile, which is a mere postorbital scale, and a reappearance (in a feebler form) of that postero-lateral roof-scale of the Sturgeon which Professor HUXLEY, by a curious twin-mistake, has at once compared to the "pterotic" of the Fish and to the squamosal of the air-breathing Vertebrata (see 'Principles of Comp. Anat.' p. 205. fig. 82, F.).

The outer anchylosed part of the opisthotic is oblong; the inner free lamina is wedge-shaped; only a fissure separates it from the exoccipital, but a clear margin of cartilage insulates it from the prootic (Plate X. fig. 7, *op. pro. e.o.*). This latter piece is at present entirely *within* the skull (see fig. 2 of Plate IX., showing its absence on the outside), its commencement being close to the internal meatus, as in birds generally, and not over the ampulla of the anterior canal, as in *Struthio* (Plate VIII. fig. 10, *pro.*). In the Sheep, when the fœtal head is 2 inches 9 lines in length, the relatively small prootic has commenced by two ossific patches at the same part, as in the African Ostrich. I mention this to show how *ornithically* aberrant the Great Ostrich is in this respect. In the osseous Fish the prootic, of necessity, is developed from an *outer* lamella, although the bony matter creeps round into the skull behind the trigeminal nerve, and finds all the good solid cartilage there is, especially towards the base; it thus may be seen skinning over the periotic basicranial bridge (see HUXLEY, *op. cit.* p. 167, fig. 68, *p.r.o.*).

Laterally the whole of the periotic cartilage is still soft in the ripe pullus of the Rhea (*supra*), as is also the thick edge of the paroccipital wing (Plate IX. fig. 2, *e.o.*), which is continuous with it, but within (Plate X. fig. 7, *pro.*) the prootic walls in much of the cranium; it is roughly hourglass-shaped, and has the multiperforate fossa for the seventh nerve exactly in its centre.

The epiotic (mastoid) has not yet made its appearance; there is some room left for it, however, in the cartilage which hides the junction of the anterior and posterior canals, in that which lines the "lateral cerebellar fossa," and outside the crown of the great "anterior semicircular canal" (Plate IX. fig. 2, & Plate X. fig. 7).

The anterior sphenoid (*o.s. p.s.*) is as yet unossified; its region is small, as in most birds, and its alæ (orbitosphenoids) are the mere outturned edges of its thickened top (Plate IX. fig. 1, *o.s.*). The vertical part is rather thin below, and is bounded in front by the interorbital fenestra, and behind by the common optic passage. A large fissure, filled up by a remnant of the early membranous skull, separates the anterior sphenoid from the great ala on each side; it is a temporary orbito-alisphenoidal fontanelle (Plate X. fig. 8.), the merest trace of which can be seen just above the optic passage in the adult.

A large pear-shaped fenestra has been formed in front of the presphenoid (Plate IX. fig. 2, *i.o.s.*) as large as that cartilage; the deficiency of cartilage here depends upon the room required by the large eyes, which nearly touch each other, and by a growth of the septum too rapid for the proliferation of the cartilage-cells. The band of cartilage above this fenestra is about a line deep, most of it being ossified by the vertical ethmoid; in the adult it is nearly—in old age, perhaps, quite—filled in by periosteal layers of bone. The vertical ethmoid (Plate X. fig. 7, *p.e.*) is already a large plate of bone; it does not quite reach the fenestra behind; has not reached the trabecular region below, but above it has become anchylosed to a great extent to the broad upper bony piece—the connate upper prefrontals (Plate IX. fig. 1, *eth.*). This latter bone is pear-shaped on its upper, partly exposed aspect (Plate IX. fig. 5, *eth.*), the crista galli being nearly hardened by it at its narrow hinder end; its broad front portion has extended nearly as far as it will extend, into the root of each upper turbinal (Plate IX. fig. 1). Relatively, in the adult, it reaches one-third further forwards; then the septal region is cartilaginous for a slight extent (3 lines), and then an equal-sized tract of bone ends it in front. The coalesced ethmoid bones terminate in a nearly straight line in front; this truncate end leaning backwards below, at which part the rest of the septum is a styliform cartilage an inch in length. Between this lower and the partly ossified upper bar, there is a large notch (Zoological Transactions, vol. v. plate 42, fig. 4, *eth. s.n.*). We here catch the first glimpse of the important septum nasi of the typical bird. The whole septal region is relatively much smaller in the adult than in the young Rhea. In the young, the vertical ethmoid is a hatchet-shaped ossicle, thickest where the "pars plana" approaches it; in the old bird an oval fenestra, 6 lines by 4, has been caused by the absorption of the bone above the relatively lessened pars plana, and between the termination of the olfactory crura (see *op. cit.* plate 42, fig. 4, *m.s.*).

I see no turbinal outgrowths on the down- and in-turned upper lamella (Plate X. fig. 9, *al.e*), but external to the confluence of the huge inferior turbinal with the pars plana there is, inside its elegantly plicate external part (Plate X. fig. 11, *p.p*), an obliquely vertical oblong outgrowth, which in a sinuous manner turns first inwards and then outwards (Plate X. fig. 10, *m.t.b*). Both margins of the pars plana are free, but above it runs insensibly into the rudiment of the cribriform plate (aliethmoid), and in front and below it is to some degree confluent with the funnel-shaped end of the large inferior turbinal (Plate X. fig. 11, *i.t.b.*). This latter cartilage has its root in the septal region, all along from the upper turbinal to the commencement of the alæ nasi (Plates IX. & X. *al.s.*). The simple aliethmoidal lamella turns inwards, where it receives the olfactory filaments and protects the bulb (Plate IX. fig. 2, & Plate X. fig. 9, *al.e.*); as soon as this cartilage expands again it has become the root of the inferior (anterior) turbinal. This ala of the septum stretches out some distance, then curls round a little, then splits into two lamellæ (Plate X. figs. 14, 15), the outer of which forms the semi-cylindrical wall of this part of the nasal labyrinth; the inner lamella (*i.t.b.*) turns abruptly inwards, coiling itself into a most beautiful scroll, with three complete turns of the spire. This inferior turbinal scroll is half an inch in length in the ripe pullus; the scroll is, at its middle, 2 lines in diameter; a shallow fossa passing from above, rather suddenly backwards, shows from the outside where the egg-shaped alinasal fold begins (Plate IX. figs. 1–3, *al.n.*). This lamina, continuous with the last, is not simple, but the secondary plait which arises within it, and which turns inwards, bifurcates, one plait half the width of the other, turning upwards and outwards, the other downwards and outwards (Plate X. fig. 16). Inside this double lamella (the alinasal turbinal) there is a thick cushion of dense fibrous tissue. The only part of these cartilaginous folds which ossifies is the pars plana; there is one centre for the inner part which walls in the end of the inferior turbinal scroll, and which runs upwards towards the olfactory crus; and another for the plaited part which sends inwards the middle turbinal outgrowth (Zoological Transactions, vol. v. plate 42, fig. 4, *ao.* 1, *ao.* 2). Already the prenasal rostrum is diminishing in size, afterwards it will vanish, and with it a goodly territory of the septum between the alæ nasi; thus two cartilaginous, and one actually ossified tract, disappear by the time the bird is full-grown. Mere connective fibre is left in these absorbed regions. Three tracts of unossified cartilage are seen in a section of the ethmoid in the ripe young; the upper is the core of the upper bone, the middle is above the junction of the two vertical lamellæ, and below the coalescence of the upper and lower bone; the lowest tract is between the vertical lamellæ, and is continuous with the unchanged trabecular region (Plate X. fig. 13). I have already shown that the prenasal rod (*pn.*), formed by the coalescence of the anterior horns of the trabeculæ, is really the proper axis of the intermaxillary apparatus; the primordial part of the palatine arch behaves differently. As in *Struthio*, the palatines and pterygoids (Plate IX. figs. 1, 2 & 4, *pa.pg.*) ossify whilst the tissue is in a simply cellular condition; the pterygoids are like those of the Ostrich-tribe, but the palatines show scarcely any of the anterior bar, and thus differ very much not only from ordinary birds, but also from the Great Ostrich. Indeed the whole bar is almost divided obliquely from end to end to form the pterygoid and palatine, the former being broad behind and sharp in front, and the latter narrow and broad in the contrary direction; the inner edge of the broad deeply-toothed anterior end of the palatine is the suspensory part of this arcade, the axis of the pterygo-palatine apparatus*. The triradiate, massive, quadrate cartilage (Plate IX. *q.*) is still unossified at the end of its metapterygoid process, and at the upper and lower articular surfaces; the former is a continuous oblong condyle, as in all the congeners of this genus. The "articulare" (Plate IX. figs 2 & 3, *ar.*) has begun to form in the thick *malleal* head of MECKEL'S cartilage; its first lamella appears in the flat posterior face, which ends inwards in the clubbed internal angular (manubrial) process; all the rest of the primordial part of the mandible is still cartilaginous (Plate IX. fig. 2, *mk.*), anteriorly it has begun to shrink. The main part of the auditory columella (Plate IX. fig. 3, *st.*) (stapes) has ossified, the cartilaginous part is triple; one flat bar in a line with the bony rod, a long terete branch, running forwards at right angles to the stem, and a smaller similar rod going directly backwards. This is the detached suspensory part of the hyoid arch; the disjoined rami and base are, together, elegantly arrow-shaped (Plate IX. fig. 7, *c.h.b.h.*), for each flat cerato-hyal cartilage has joined its fellow at the mid line, forming a point anteriorly, whilst each ramus passes backwards free and pointed. The basihyal is very pointed in front where it fits into the acute angle formed by the meeting of the flat cornua; it has no uro-hyal prolongation, the thyro-

* Only the *pier* of the palato-pterygoid arch is ever developed in the Vertebrata generally; there is no segmented descending rod.

hyals (*th.* 1, *th.* 2) (1st branchials) articulating on each side of its somewhat broadened end. The third poststomal is, as usual, composed of two rods on each side; ossification has far advanced in the larger proximal rod. The upper thyro-hyals, the basi-, and the cerato-hyals are not at present in the least ossified.

Having despatched the primordial parts of the Rhea's skull and face, I turn to the *opercular* or splint-bone series. Most of these have already assumed very much of their persistent form, but they are entirely unanchylosed; so they thus present us with an extremely valuable series of objects for comparison with other vertebrates.

The upper, marginal, and orbital regions of the frontals (Plate IX. figs. 3–6, *f.*) are well formed, and the bone is acquiring a considerable thickness; the same may be said of the parietals (*p.*); only a trace of the two sagittal fontanelles can be seen (Plate IX. fig. 5). The lacrymals and nasals (lateral and upper ethmoidal splints) are completely formed (*l.n.*), the latter having no descending process (Plate IX. fig. 5, *n.*), thus differing from *Struthio*, and the former having a large fenestra in its antorbital plate (Plate IX. fig. 3, *l.*). Ostrich-like, the nasal processes of the intermaxillaries are completely fused (Plate IX. fig. 5, *px.*); they end in front of the broad upper ethmoidal bone, which condition is not lost in the adult. Round that bone, the blunt styles formed by the posterior part of the nasals creep for some distance on to the narrow, wedge-like ends of the frontals (Plate IX. fig. 5). The large, extremely thin and splintery palatine processes of the intermaxillaries (Plate IX. fig. 4, *px.*) are very remarkable, and they are separated by a very clearly cut fissure from the marginal part; into this fissure, behind, where it widens, the pointed wedge-like end of the prevomer (Plate IX. fig. 4, *pv.*) fits, thus obliterating the "anterior palatine foramen."

The prevomers have their largest relative development in the Rhea, and their smallest in the "Gallinæ," "Tetraoninæ," "Pteroclinæ," and "Hemipodiinæ" (compare the figures in plates 34–36 with *pv.* in plate 42 of Zoological Transactions, vol. v.).

The very perfect development of the ascending process (Plate IX. figs. 3 & 5, and Plate X. fig. 14) makes this bone in the Rhea very valuable for comparison with that of the Ophidian; and although the nasal gland is not enclosed between the vomer and prevomer as in the snake, yet its duct so passes down outside the great inferior turbinal as to pour the secretion out at the identical place in which it is discharged in that reptile (Plate IX. fig. 3, *d.n.g.*). Moreover, the root of the ascending process of the Rhea's prevomer is to be seen ascending *over* the edge of the deeply bifurcate vomer (Plate X. fig. 14, *v.*), which is almost a double bone. This submesial portion of the prevomer is in reality the *proximal* portion, which has its immediate relation to the intermaxillary axis, as the middle splint; all the rest of the bone, which has spread out to such an exorbitant size, receives its explanation in the fact that in the Bird this splint takes up the place which should for the most part be filled by the maxillary. Serially, the prevomer is the homologue of the "interpalatine." A large irregular fenestra is formed in this bone in the adult bird; it is curiously scooped below (Zoological Transactions, vol. v. plate 42, *pv.*), and a notch has appeared separating the palatine from the proximal process; the palatine and zygomatic processes of the prevomer are not far from parallel, and are nearly of the same length (Plate IX. fig. 4). The proximal (submesial) part of the prevomer of the Rhea is much wider than that of the Ostrich, and is less distinctly marked off from the body of the bone. To sum up the regions of this huge bone—a bone so strongly limited as to its occurrence in a separate condition in the classes and orders of the Vertebrata, but constant and attaining its highest autogenous condition in birds—we have a body, a premaxillary, an ascending, a proximal, a palatine, and a zygomatic process.

The vomer of the Rhea (Plate IX. fig. 4, *v*) is exceedingly instructive, being very large, and having its two symmetrical halves united merely by an isthmus at its middle, only one-fourth the length of the bone, so that it has but narrowly escaped being double —a condition not really wanting in the bird-class, *e. g.* in *Numida meleagris* and *Musicapa grisola.*

The vomer of the Rhea is a very close counterpart of that of the Chelonians, a group peculiar amongst reptiles in having this bone azygous; for the middle part or septum of the "middle nares" is high, compressed, and keeled below, whilst the hinder part is on a higher plane than the front portion. The front part is divided by a deep, clean, oblong notch, and the rami, grooved below, lie on the enormous palatine plates of the intermaxillaries; in the Chelonian the front part is unsplit, and is affixed by a transverse suture to the short palatine portion of the intermaxillaries. The higher placed, outspread, posterior portion of the vomer in both the Tortoise and the Rhea, articulates with both the palatines and the pterygoids; the inner part of the maxillary of the Chelonian, in relation to the vomer, just takes the place of the prevomer of the bird.

Again, in this genus there is no maxillary splint-bone; this part of the face is subject to extreme reverses of development even when present, but its absence in perhaps more than *ninety-five per cent.* of the ornithic genera, appears to have been hitherto unexpected and unlooked for.

Both to Professor HUXLEY and myself the prevomer of the bird seemed to be a very awkwardly fitting representative of the maxilla of the other classes, but it was not until a rudiment of the true maxilla turned up to me in an unripe Emu-chick that the real state of the case was understood.

The anterior and posterior external splints of the pterygo-palatine arcade, viz. the jugal and quadrato-jugal (Plate IX. figs. 3–5, *j.qj.*) are very feeble, as usual, in the Rhea; the latter is extremely short and passes within the jugal, only appearing outside, close to its articulation with the quadrate bone. These outwardly-drawn splints are persistently distinct (see Zool. Trans. vol. v. plate 42, figs. 1, 2, & 4, *j.qj.*).

The proximal or suspensorial splint of the mandibular arch is not long a free bone, but soon coalesces with the sides of the skull proper and auditory capsule; it is the squamosal (Plate IX. figs. 3–6, *sq.*), and is very large and *batrachoid* in this bird, as in the other Ostriches; and, as in the rest of this group, although not in other birds, it is excluded from the cranial cavity, of which it only forms at any time a vicarious part.

It is well ossified in the mature chick of the Rhea, and clamps the quadrate cartilage very strongly; it also helps the prootic capsule to carry the single condyle of the os quadratum, whilst the hinder part of its lower margin forms a strong eave to the tympanic chamber, but does not carry the fibro-cartilaginous tympanic ring; this part is untouched when the squamosal is slipped off in the macerated skull (Plate IX. fig. 2).

The free or Meckelian part of the mandible has its usual splints; viz., three external, the dentary, surangular, and angular (Plate IX. fig. 3, *d.a.sa.*); and two internal, the splenial and the coronoid; they are well developed at the time of hatching, but are free. In the old bird the dentary keeps its distinctness, and the splenial does not make haste to coalesce with its neighbours.

There are no splints to the enfeebled hyoid arch, and it is instructive to see how suddenly the development of the second and third poststomal arches is stopped, whilst the succeeding ones exist only for a few days, even as simple cellular tissue. The descending plate, which grows from the investing mass to form the piers of both the mandibular and hyoid arches, is in all fishes subdivided so as to form an immense proximal piece for the attachment of the segmented hyoid crus. But directly we come to the air-breathing groups, with open nostrils and a tympanic cavity, then we see this mass giving most of its proliferating tissue to the formation of the mandibular pier, the proximal part of the hyoid arch being converted into the auditory columella or stapes. In mammals, where the hyoid arch is not unfrequently attached to the skull, this is attained, not by a resumption of the proper suspensorium, but by a direct downgrowth from the epiotic region of the auditory cartilage.

Dromæus, "A."

My youngest specimen of the Emu is an embryo one week short of the full period of incubation; it is of the species *Dromæus irroratus* of SCLATER and BARTLETT.

I have been very fortunate in obtaining five different stages of development of the skull in the genus *Dromæus*; some belonging to *D. irroratus*, and others to *D. novæ-hollandiæ*. Moreover the study of this genus is very important, as, like the Dinornis, it belongs to the Casuarine group, in which the mammalian characters become most unmistakeable. Already in *Dromæus*, A., the ossific process is far advanced, and in some respects further than in the young pulli of the Rhea, which had been incubated eight weeks, or one longer than in this instance. The basioccipital (Plate XI. fig. 2, *b.o.*) is much larger than in the Rhea, and is less evenly oblong, swelling out between the entrance of the internal carotids (Plate XI. fig. 2, *i.c.*), and then wedging itself in between the ovoidal basitemporals (*bt.*), and applying itself by a narrow but transverse surface to the end of the basisphenoid, this synchondrosis being well seen below. A narrow band of cartilage separates the last bone from its arches, the exoccipitals (*e.o.*), and they have already reached their huge key-stone, the superoccipital (*s.o.*). Behind, the opisthotic forms an upper lobe of the exoccipital (Plate XI. fig. 4, *op.*) united by a broad isthmus; within it is free (Plate XI. fig. 7, *op*), as in the Crocodile and the Rhea. The condyloid foramina, and those for the vagus (8, 9), are quite surrounded by the bony matter of the exoccipitals; the paroccipital ala is still soft (*e.o.*) at its thick margin. The large lozenge-shaped superoccipital (*s.o.*) forms nearly a right angle by the meeting anteriorly of its parietal margins; these edges are not straight, but convex at the ends and concave at the middle. More than a fourth of the occipital foramen is formed above by this bone (Plate XI. fig. 4, *s.o.*). The great sinus-passage opens out 4 lines from its fellow in a deep groove, beyond which the bone is fast extending (Plate XI. fig. 2, *s.c.*); the whole breadth of this (once double) bone is $6\frac{1}{2}$ lines, its height 6 lines. The basisphenoid is largely ossified, and the small basitemporals, pushed from each other by the azygous piece, having coalesced with its sides behind (Plate XI. figs. 2 & 7, *b.s.b.t.*), they form the hindermost of three pairs of wings, now growing out of the thick part of the great basisphenoid. These *lingular* elements are 2 lines long by $1\frac{1}{2}$ line in breadth; they are grooved on their upper surface by the internal carotid (*i.c.*). The middle pair of wings grow directly out of the body of the basisphenoid; they are the thick, broad "posterior pterygoid processes" (*pr.p.*); they are deeply scooped from behind forwards to give capacity to the ear-drum. Between these two pairs of wings there is a shallow groove, the badly defined "Eustachian tube" (Plate XI. fig. 7, *Eu.*); and between the posterior and anterior pterygoid processes (*a.p.*) there is a notch, a groove, and a foramen. The latter processes (anterior pterygoid) have their usual large size, and are turned forwards as well as outwards; between these spurs there are a few vascular passages where the membranous pituitary space once existed. The rostrum (*r.b.s.*) fails of its gigantic size in this genus, but at this early stage it is $\frac{3}{4}$ inch long and a line in thickness at its root; it reaches nearly to the alæ nasi. The deep prepituitary portion of the basisphenoid is already far advanced; and the alisphenoids are almost completely ossified (Plate XI. fig. 1, *b.s.a.s.*); within, a nearly horizontal ridge divides the upper third from the lower two-thirds, both of these spaces being concave; the high postero-superior angle entirely shuts out the squamosal from the cranial cavity; the postfrontal process is still soft (Plate XI. fig. 1, *pf.*). We saw that the outer lamina of the opisthotic had coalesced below with the upper edge of the exoccipital; within, the fan-shaped inner plate has all but coalesced with the exoccipital, whilst a clear band of cartilage divides it from the prootic. This *reptilian* disposal of the "otic" centres prevails throughout the Bird-class, and is in perfect harmony with numberless other erpetic characters. A large space of cartilage separates the prootic above from the epiotic process of the superoccipital (Plate XI. fig. 4); in this the small epiotic would have appeared, as we shall see in our next example. The "pterotic" region is small and unossified; it will be divided equally between the already large prootic and the alisphenoid, but the bony centre itself has not yet shown itself to me in the Bird-class. The prootic (Plate XI. fig. 7, *pro.*) is a very *internal* bone, as in the Rhea; although large it is completely insulated by unchanged cartilage; half the arch of the anterior, and the posterior half of the horizontal canal are still imbedded in cartilage only. The orbito-sphenoidal laminæ are narrow (Plate XI. fig. 1, *o.s.*), intermediate in size between those of the Rhea and the Ostrich; but the presphenoid is not so *ornithic* as in the former, being deeper and broader; moreover it has, in accordance with that almost constant correlation of size and precocity, already appeared in the form of two oblong bony points on the right side, in the somewhat obtuse angle formed by the giving off of the orbito-sphenoid. This appearance of the presphenoid as two linearly arranged ossicles is a *lacertian* character, and breaks out here and there in the bird-class, e. g. *Pavo*, *Nisus*; but in the "Lacertilia" the anterior sphenoid is relatively very large —large, as it were, at the expense both of the alisphenoids and vertical ethmoid, and its development is by many centres of ossification. The interorbital "fenestra" is not half so large as in the Rhea (if it exists at all in *Struthio* it is but small and transitory); it is ovoidal in shape, and only bordered by bone at top. This bone is the upper and posterior part of the vertical ethmoid (Plate XI. fig. 1, *p.e.*), which is already large, and by the absorption (or non-development) of cartilage, deeply and broadly notched above; this notch (Plate XI. fig. 1, *i.e.s.*) is converted into a fenestra by the upper (connate) ethmoidal piece of bone, which is already closely adherent to the lower centre. The large hinder half of the lower bone is thickened by a nearly vertical ridge in its upper two-thirds, where the pars plana (*p.p.*) applies itself; above this is the descending plate of the upper bone, and this is very thin, for it lies between the olfactory crura. The nasal process of the intermaxillaries reaches the front of the upper bone, and the lower bone has only reached this (vertical) line; all in front of this is still cartilaginous, one flat vertical plate reaching to the body of the coalesced intermaxillaries. In the groove below, where these bones have completely fused, there is the merest trace of the intermaxillary axis, or prenasal cartilage (Plate XI. fig. 2, *px.*), which is thus seen to disappear much earlier in the Emu than in its congeners. But the fate of the axis of each palatine arch is very different, its ossification being so early, and its importance as a persistent bony part being so great. The anterior bone, the palatine (Plate XI. fig. 2, *pa.*), is at an unusual distance from its fellow, because of the very out-turned forks of the vomer (*v.*) behind; this is the case quite as much as in the Ouaran Lizard (*Psammosaurus scincus*), but the long styliform ends of the pterygoids (*p.g.*) creep on to the vomerine forks, and thus approach the mid line more closely. Each palatine is a low triangle, the apex of which is the proximal (orbital) part, the anterior basal angle being prolonged into a small style, fitting inside the inner retral process of the prevomer; the posterior basal angle is blunt, and lies outside the pterygoid (Plate XI. fig. 2). The basal part of this triangle is thick; the rest, or inner part of the bone, is thin and delicately reticulate; it will be absorbed considerably in the centre. The pterygoids (*p.g.*) are thick and terete behind, flat and splintery for four-fifths of their extent; an oval sinuous condyle at the extreme end of each fits (by a synovial joint) on to the pterygoid facet of the os quadratum (Plate XI. fig. 2, *q.*); but the facet on the pterygoid is continued round the inner edge, because the lower half of the condyle is jammed in between the os quadratum and the anterior pterygoid process (Plate XI. fig. 2). The structure of these parts is a sort of morphological halting between the ornithic and the reptilian types; but the spur of the basitemporal which stands out against the pterygoid of the Lizard never articulates with that bone in birds, and in them is seldom developed to any extent; it is very large on each side, however, in the King Vulture, and in the so-called *Dinornis casuarinus*, Owen, a gigantic pickaxe-headed Rail (see Zool. Trans. vol. iii. pl. 52 for beautiful figures of this (?) extinct bird). On the other hand, the true azygous basisphenoid is aborted in all the Lacertilia, and therefore those spurs of it which culminate in the Struthionidæ, exist persistently in nearly half the ornithic genera, appear in the embryo of all, and reappear in the Cavies amongst the Mammalia, have no existence in the Lizard-tribe. A misapprehension of the nature of these spurs, and of their relations, has vitiated much that has been written upon this subject, and quite prevented anatomists from educing a true harmony of the parts.

The os quadratum (Plate XI. figs. 1, 2, *q.*) of this young Emu is wedged between and packed amongst its surroundings much more like its counterpart in the Tortoise than the same bone in the typical bird, so delicately hinged, and so free in motion.

The close adhesion to it, in an embryonic manner, of its own splint, the squamosal, (*sq.*), contributes much to this fixedness; in the typical bird the squamosal becomes much more mammalian, and after helping the prootic to form a glenoid cavity for the anterior or outer head of the bone, then stands off from it to allow of great freedom of motion. In all birds, as in Lizards, the large head of the quadrate bone reaches the exoccipital, passing over the lateral (tympanic) part of the opisthotic; in the Chelonian this latter part is so large that it receives the most backwardly projecting part of the condyle, and excludes the exoccipital from the hinge; still by far the greater part of the descending plate of the investing mass, in the auditory region, goes to form the mandibular suspensorium, whilst only a little of its *hinder* and *inner* part is devoted to the stapes, so contrary to what obtains in the ichthyic type.

The proper positive explanation of the bearings of these parts is not to be given by a reference to the uses and fitnesses of them in their last or osseous stage, but by reference to their primordial condition at a time when the thickening mass of cells around the cephalic part of the notochord was growing equally over the simple (cutaneous) auditory sac, and over the medulla oblongata, as the incipient occipital arch. At that time this continuous tissue sent down, amongst others, the mandibular ray, the thick upper part of which, as soon as chondrification commenced, appeared as a mass of cells, distinct both from the side of the skull above and from the top of MECKEL'S cartilage below. This great proximal expansion of the mandibular arch is a correlate of the arrested, starved condition of its serial homologue next behind. In the cartilaginous stage of the skull there was no definite boundary-line between the auditory capsule and the occipital arch; afterwards the bony pieces that result from the calcareous metamorphosis of the cartilage in certain territories intercalate remarkably, and interchange not only function but existence as we pass from group to group of the Vertebrata. Thus from one common morphological stem there springs an endless variety of detail,—detail, unimportant as to essential nature, but exquisitely fitted to the needs of each of the many myriads of species possessing the vertebrate type of structure*.

The extreme occipital end of the condyle of the os quadratum in this Emu-chick, most of the metapterygoid process, and a thin stratum of the base of the bone, are still unossified; the clubbed metapterygoid is characteristically struthious (Plate XI. fig. 1). In some points the ossific process is more precocious in the Emu than in the Rhea; in others it is slower. The "articulare" (Plate XI. fig. 6, *ar.*) is equal already to what we see in the Rhea a week further in advance; it is developed by an upper (articular) and a posterior lamina (Plate XI. fig. 4, *ar.*); these have already coalesced through the thickness of the cartilage; MECKEL'S cartilage is much more wasted than in the full-timed Rhea (Plate XI. fig. 5, *mk.*). The external splints (dentary, surangular, and angular) and the internal (splenial and coronoid) (Plate XI. figs. 1, 4, 5, & 6, *d.*, *sa. a.*, *cr.*, *sp.*) are in an excellent stage for comparison with those of the Reptile, being exactly in that stage of completeness and yet distinctness which is persistent in the cold-blooded "Sauropsida." The anterior part of each dentary forms with its fellow (Plate XI. fig. 5, *d.*) a beautiful outspread structure, a close counterpart of the next arch but one in front (the intermaxillary) (Plate XI. fig. 3, *px.*), and well illustrating the extreme licence taken by a secondary or splint bone, after having once originated in its simple primordial model. The state of things here, before MECKEL'S cartilage is removed by absorption, is very similar to the relation existing between the wide-spread growth of the fish's clavicle (coracoid of OWEN), and the feeble coraco-scapular cartilage within it (ulna and radius of the same author). The proximal splint of the mandible (the squamosal) (Plate XI. fig. 1, *sq.*) is still separate (above) from the great posterior sphenoidal operculum (the parietal) (*p.*), and there is no mistaking its homology with the so-called temporo-mastoid of the frog, and the preoperculum of the fish.

Above it the parietals have grown upwards to their junction at the sagittal line (Plate XI. fig. 3); they are already thick bones; the frontals (*f.*) have also met, but the anterior fontanelle (*fo.*) is a lozenge, with sides a line in extent; the posterior fontanelle is filled up by the apex of the superoccipital (*s o.*). Altogether this opercular roof is more convex than in the Rhea and the Ostrich; it remains so, though in a less degree, throughout life, thus bringing the Emu near to the Apteryx and the Tinamou in this respect. The original membranous skull is still to seen in the orbito-sphenoidal region; but the true relation of the frontal splint to the orbito-sphenoidal cartilage (Plate XI. fig. 1, *f.*, *o.s.*) is well shown at this stage by the manner in which the bony fibres of the orbital plate of the frontal are creeping over the outer surface of their cartilaginous model. Narrowing in front, the frontals run close upon the upper ethmoidal plate, and also passing by it become grooved to receive the pointed ends of the nasals (Plate XI. fig. 3). These latter bones (*n.*) are more ornithic than in the Rhea, having a slight

* All this is self-evident enough to those who have grown weary of working backwards, but which must be repeated again, "line upon line and precept upon precept," to those whose intellects have not been severely trained by patient labour in the science of development.

descending process (Plate XI. fig. 1, *n.*): in this young bird the intermaxillaries separate them, the still ununited tips of these bones lying a little over the ethmoid (Plate XI. fig. 3, *n.*, *eth.*). Afterwards, in the adult, the nasals for some distance nearly approach; for the lengthening of the cranio-facial axis has by this time given a very lacertian shortness to the nasal processes of the intermaxillaries. Essentially, the lacrymals (Plate XI. fig. 1, *l.*), with their long superorbital process and their fenestrate antorbital plate, differ little from those of the Rhea; they are already well grown. The intermaxillaries (*px.*) have been partly described; the nasal portion is vastly different from the same process in the Rhea and Ostrich, being almost as feeble as in the Cassowary (Plate XI. fig. 3, *px.*). The extremely coarse vascularity of this part, as of the corresponding part of the dentaries, makes the bone like a Madrepore (Plate XI. figs. 1, 2, & 3); it is an excellent struthious character. The height of this part, in this young one especially, brings *Dromæus irroratus* very close to Professor OWEN's *Palapteryx geranöides* (see Zool. Trans. vol. iii. part 5, pl. 54. fig. 1. p. 361). In this embryo the dentary margin of the intermaxillary is 1 inch 3 lines in extent, thus reaching to within 4 lines of the posterior end of the zygoma (Plate XI. fig. 1, *px.*), and well illustrating the potency of this most anterior arch, even in so simple and, as it were, elementary a bird as the Emu; and this is the bird in which I have found the best rudiment of the true maxillary bone (Plate XI. fig. 1, & Plate XIII. figs. 12 & 13, *mx.*). As in the Meckelian, so in the prenasal cartilage, there has been a much quicker absorption of substance: speaking of class characters, none could be more assuredly set down to the *mammalian* category; and the Emu, as one of the Casuarine group, is in many other respects the most outlandish of its class, and one of the nearest feathered relations of the hairy tribes. This early loss of the model has not, however, resulted in an earlier coalescence of the symmetrical splints; behind the coalesced part of the intermaxillaries the palatine plates (Plate XI. fig. 2, *px.*) are seen—much smaller, however, than in the Rhea, where the dentary margin is so short. The intense interweaving of the members of the struthious group is well seen here; for the African Ostrich rather sides with the Emu than with the Rhea in the structure of its intermaxillaries, and we shall see that in many points the Dinornis ties the Ostrich to the Emu. As to the prevomer of the Emu (Plate XI. fig. 2, & Plate XIII. figs. 12 & 13, *pv.*), its anterior process is smaller, and its body longer than in the Rhea, in which the widest part, viz. that bounding the middle nares, is short; next to it comes *Struthio*, then Dromæus, and then the Cassowary, in which the length and narrowness of the body of the prevomer rivals that of the Apteryx and the Tinamou. In the Rhea the two retral processes are of the same length; in the Emu the zygomatic style is very long, the inner style very short; the Ostrich agrees with the Rhea in this point. A few large foramina are seen on the palatal surface of this bone, which is gently concave; the upper surface is much more complex, and the bone unexpectedly takes on characters which have their fulness in the various tribes of typical birds. The ascending process (Plate XI. fig. 1, *n.p.v.*) is a mere bud, but more distinct than in the African Ostrich; the little bony bridge a little in front of this is similar; but whilst the posterior margin of that lamina is, in the Ostrich, not extended backwards, in the Emu it does grow both backwards and upwards, and swells into a thick-lipped shell of bone (Plate XI. fig. 2, & Plate XIII. fig. 13, *pv.*). This curious spongy shell is beautifully seen in the Eagle, and in many other birds: in some groups, for instance, all the "Lamellirostres," including the Palamedeas, the bones meet and coalesce along the mid line—a curious anticipation of the precisely similar junction of the maxillaries in all the Mammalia, and in the Crocodiles. This prevomerine bridge is well shown in Mr. ERXLEBEN'S figure of the Balæniceps' skull (Zool. Trans. vol. iv. pl. 65, figs. 7 & 8, p. 297, there described by me under the name of Turbinals, or "Ethmoidal pterapophyses").

The vomer (Plate XI. fig. 2, *v.*) in this embryo of the Emu is more than an inch in length, nearly half the length of the whole skull and face; as before mentioned, it is extremely divergent behind, and like the Ostrich's vomer it is trifurcate in front; the middle prong is very long and slender.

In this bone the Emu agrees with the Great Ostrich and not with the Rhea and Cassowary, which have it bifurcate at both ends. The two ends of the Emu's vomer are more nearly on the same plane than in the Rhea, where it comes nearer that of the Chelonian; in the next stage (six weeks old), at any rate in *D. Novæ Hollandiæ*, the vomer is straighter still. The long middle prong of the vomer in this early specimen reaches to the very extremity of the septum; but only the premaxillaries wrap themselves round the prevomerine rod—the approximated and coalesced "trabecular horns." But typical birds teach that the whole base of the septum proper belongs to the intermaxillary apparatus.

The bones that form the zygoma are very feeble, but they are all present in this and in a few other birds. The first or true maxillary (Plate XI. fig. 1, & Plate XIII. figs. 12 & 13, *mx.*) is 5 lines long by $\frac{1}{2}$ a line in thickness; it is pointed at both ends, and lying close above, scarcely reaches as far backwards as the very prolonged angular process of the intermaxillary. This last process, the zygomatic process of the prevomer, the maxillary, and the zygomatic bone (jugal) (*j.*), are all tied together at one point external to the junction of the palatine with the inner retral process of the vomer. The jugal is twice the length of the quadrato-jugal (*q.j.*), which lies principally on the inside of the zygoma, and they are each of them twice as thick as the maxillary. At this stage the broadening of the whole palate has removed the maxillary and jugal one line from the outer edge of the palatine even at its nearest part (Plate XI. fig. 2).

The lingual cartilages (Plate XI. fig. 8) and the auditory columella (Plate XI. fig. 7) are in much the same condition as in the Rhea at the full period; only the columella and the lower thyro-hyal are ossified, and that not perfectly. The basihyal has sent backwards a uro-hyal (*b.h.*, *u.h.*) process which is a step in advance of the Rhea, whilst both these birds have the cerato-hyals alike in form and much more perfect than in *Struthio* (Plate XI. fig. 8, *c.h.*).

Dromæus, "B."

In this specimen I have not only to describe a difference of age, but also a distinct species. Drawings made by me twenty years since show in a very strong light the difference between the Emu with a somewhat pointed beak, and with a straight culmen, *D. Novæ Hollandiæ*, and the *Roman-nosed* kind, which has been termed (*op. cit.*) *D. irroratus*. My early observations on the latter kind were made on the skeleton of an adult individual in the Museum of King's College, London; those upon *D. Novæ Hollandiæ* were from a young bird (six weeks old) which I obtained early in the year 1844 from the Aviary of the late Sir ROBERT HERON *. This young individual I will now describe; and this description and my figures can be compared with the subject of them in the Museum of the College of Surgeons. Although in full age the bill of *D. irroratus* acquires a slightly decurved condition, yet that which I have described is very straight, and the contrast between it and this young *D. Novæ Hollandiæ* is very marked. Here the more delicate bill reminds one much more of the Tinamou, and even of the Apteryx, than the Roman-nosed kind, where the face is much more like that of the Goatsucker, and the bill very convex at its setting on, not gently arcuate altogether, as in this species.

This is a very valuable morphological stage, for there has been but little coalescence, and yet the bones have become closely contiguous; there are also some new bony pieces; the diplöe also has begun to form freely in the interspace between the outer and inner laminæ. The part taken by the basioccipital (Plate XII. fig. 2, *b.o.*) in the formation of the condyle is well seen, the sides only being formed by the lateral elements: on the whole, this transverse and somewhat dimpled condyle is very reptilian, and so is the whole of the basal bony piece. In the Rhea the oblong basioccipital is very *mammalian*; but here it is elegantly lozenge-shaped, its sides jutting out so as to form not much more than a right angle, the anterior part of the bone being wedged in between the basitemporals (*b.t.*). Altogether this bone and the basal parts of the sphenoid form a mysterious combination of the characters of the Lizard and the Guineapig (*Cavia aperea*), and it is most instructive to see this in a bird which seems like the first rude sketch of the feathered type of Vertebrata.

The large exoccipitals (Plate XII. figs. 1 & 4, *e.o.*) are now well formed, and appear larger than they really are, because of the addition in their upper edge (outside) of the large opisthotics (Plate XI. fig. 9, *op.*); the ends of the sutures between these bones are not as yet obliterated. The condyloid foramina, and that for the "vagus" (Plate XII. fig. 2), have a large margin of bone inside them, and are thus removed away from the basioccipital; the tympanic ala of the exoccipital (Plate XII. fig. 4, *e.o.*) is thick and clumsy, and is only very gently concave anteriorly, whilst in many typical birds, *e. g.* "Turdinæ," "Emberizinæ," "Picinæ," "Anatinæ," it forms a large part of their very elegant "bulla tympani." The large pentagonal superoccipital bone (Plate XI. fig. 4, *so.*)

* These came originally from the late Earl of DERBY's Collection.

is completely ossified, and the sinus canal is well walled in; the whole region is very similar to what is seen in the Apteryx.

Inside the skull the opisthotic is seen as a distinct wedge of bone, with its sharp end downwards, but the superoccipital has taken up most of the epiotic region—not all, for this bone, although small, is now to be well seen, roofing in the little lateral lobe of the cerebellum behind. The external lamina of the epiotic (Plate XI. fig. 10, *ep.*) is only to be seen by paring away the large outer angle of the superoccipital; the bone is subquadrate, gently concave within, whilst on the outside it is as gently convex. The external surface of the bone is absorbed towards the mid line of the skull to form a large pneumatic foramen, which connects the hollow interior of the bone with the diplöe of the superoccipital. Inside the skull, both below and above the small epiotic, a small synchondrosis exists between the prootic (Plate XI. fig. 10, *pro.*) and the superoccipital; the upper is the largest, and is at the anterior third of the great anterior semicircular canal (*a.s.c.*); the rest of the large prootic is well ossified, both within and without. The nature of the bar of bone formed by the opisthotic (Plate XI. fig. 10, & Plate XII. fig. 5, *op.*), which separates the auditory fenestræ (f. ovalis and f. rotunda), can be well seen at this stage; above the head of the "stapes" (Plate XI. fig. 10, *st.*), which lies in the fenestra ovalis, the suture separating the epiotic from the opisthotic (Plate XII. fig. 5, *ep. op.*), externally, is well shown. Returning to the base of the skull, we find the combined basitemporals and basisphenoid (Plate XII. fig. 2, *b.t.*, *b.s.*) forming a very elegant structure; the former are oval masses 2 lines across, the latter is seen as a large four-winged mass, sending forwards a long, gradually attenuating style (*r.b.s.*). One very small passage still exists in the front of the pituitary space, which has become convex by a triangular mass of bone with the apex forwards; laterally the Eustachian grooves (Plate XII. fig. 2, *Eu.*) have become much better defined; behind them we see the internal carotids (*i.c.*) grooving the basitemporals. The "posterior pterygoid processes" (*p.r.p.*) are extremely large, and cellular anteriorly, the scooping of each plate passing into one common vacuity in the very body of the basisphenoid; all this is truly ornithic. The bone is very wide between the "anterior pterygoid processes," which project outwards, downwards, and a little forwards. Where the basisphenoid meets the basioccipital below, it is somewhat split (Plate XII. fig. 2), and here the suture between the lateral and median basisphenoidal elements can be still seen; the basitemporals are dentate, as they underlap the occipito-sphenoidal synchondrosis; a little cartilage separates them from the basioccipital behind these teeth. The delicate pointed end of the rostrum (*r.b.s.*) reaches to the same vertical line as the front of the upper ethmoidal plate; it lies in the well-marked vomerine groove.

The prepituitary portion of the basisphenoid (Plate XII. fig. 1, *b.s.*) is still 4 lines from the ethmoid; the well-ossified alisphenoids have, at their supero-external angle, a small epiphysis, the "postfrontal" (Plate XII. fig. 1, *a.s.*, *p.f.*). The bony centre at the junction of the orbito-sphenoids with the descending presphenoidal plate is now enlarged (Plate XII. fig. 1, *o.s.*); the two pieces have become one, and this is spreading into the alæ; it commenced in this case in the floor of the skull; in the young *D. irroratus* the two bony points began in the angle on the right side. The interorbital fenestra (Plate XII. fig. 1, *i.o.s.*) is small and very high up, and the interethmoidal fenestra (*i.e.s.*) is increasing; it is twice the size of the other. The large, irregularly V-shaped vertical ethmoid (*p.e.*) bounds most of this fenestra; its sutures (in front and behind) with the upper oval bone (Plate XII. fig. 3, *eth.*) are not yet obliterated; that behind is best seen. The descending part of the upper bone is thick both before and behind; above the fenestra it is extremely thin. All the rest of the cranio-facial axis is still unossified, and the septum nasi (*s.n.*), which is deeply emarginate in front, has (relatively) retreated far back; the prenasal cartilage has become a mere thread of tissue; the whole of the rest of the olfactory cartilages are still soft.

The axis of the palatine apparatus is different from what we saw in the almost ripe embryo; for the pterygoid is more outspread (reptilian), whilst the anterior part of the palatine has become elongated (Plate XII. fig. 2, *p.g.*, *pa.*), and the broad part thinner in the middle, the absorption of its substance having increased. The metapterygoid process of the quadrate bone (*q.*) is still unossified to a great degree; if an epiphysis were to develope in this cartilage, we should have the metapterygoid of the Fish, the Lizard, and the Python*.

The "articulare" (Plate XII. fig. 1, *ar.*) is now a curious, thick, three-faced wedge of bone, and the Meckelian rod is gradually wasting.

The os hyoides has acquired a basi-hyal bone; the uro-hyal, although continuous, is still cartilaginous, as are the cerato-hyals, the upper thyro-hyals, and the ends of the lower thyro-hyals.

The squamosal (Plate XII. figs. 1–4, *sq.*) is already very thick, and the "zygomatic process," instead of joining the malar, as in Mammals, grows down the quadratum to the very edge of the articular cartilage. It may not be easy for the mere anthropotomist to see the relation of the squamous part of the temporal to the little "incus," but the problem is soluble enough in this young Emu; a splint could not be put on better than this is. The five pairs of *secondary* pieces (Plate XII. fig. 1) in the lower jaw are all distinct, but are well grown; the coronoid is the shortest, does not rise to the edge of the jaw, and has nothing whatever to do with the coronoid "process" of the dentary in the Mammal. As for the true maxillary, it has either not been ever separate, or it has already coalesced with either the malar or the prevomer; the jugal and quadrato-jugal (Plate XII. figs. 1, 2, & 3, *j.*, *q.j.*) together form a round style.

I have already spoken of the decreased width and lessened elevation of the premaxillary; its prenasal groove is almost extinct (Plate XII. fig. 2, *p.x.*); there is a large

* In my paper on the "Gallinæ," p. 221, I have spoken of the absence of the metapterygoid in certain groups of the Vertebrata, amongst them the Ophidia; since then I have found it very distinct on the *front* of the os quadratum in a half-grown *Python Sebæ*, the gift of Mr. WATERHOUSE HAWKINS, and in other non-venomous snakes.

slit in the palate behind the solid part of the intermaxillaries. The prevomers are very thin, and studded with small irregular fenestræ (Plate XII. fig. 2, *p.v.*). The middle fork of the vomer has become less than the lateral ones in front (*v.*), the middle of the bone has become higher, and the hinder forks still more divaricate. The descending process of the nasal is nearly obsolete (Plate XII. fig. 1, *n.*); the broad upper part has spread further over the upper ethmoid (Plate XII. fig. 3, *eth.*). No important change has taken place in the lacrymals (*l.*), but the frontals and parietals (*f.*, *p.*) have become much more developed than in the nearly ripe chick. Even the upper fontanelle (Plate XII. fig. 3) is nearly filled up; but there are still two orbital fontanelles, the orbital plate of the frontal being very narrow at present, but closely adherent to its own cartilage—the orbito-sphenoid.

Dromæus, "C."

The third stage of the Emu's skull is that of a young of the freckled species (*D. irroratus*), evidently about two months, or perhaps ten weeks old *. There is in this a considerable advance on the last; and as this skull was partly disarticulated by maceration, I shall speak chiefly of the axial bones; and it must be remembered that although the two Emus are closely related species, yet some qualification must be made in the comparison of stages of birds only *generically* the same.

The triple nature of the transversely oval condyle of the occiput (Plate XII. fig. 6, *o.c.*) is well seen, the lateral elements almost meeting on the upper surface of the mesial piece. The basioccipital (Plate XIII. fig. 1, *b.o.*) ends much more bluntly forwards than in the last, and is very thick as well as very broad; it reaches out on each side in a sharp angle; the broad anterior margin makes the basitemporals diverge more than in the last. The exoccipitals (*e.o.*) are very massive; together they only form half the foramen magnum (Plate XII. fig. 6.), more than a fourth of which is completed by the superoccipital (*s.o.*) above. The opisthotic has still only half its suture (in the middle) obliterated (Plate XII. fig. 6, *op.*); it has to be deducted from the exoccipital. The superoccipital forms a very elegant crown to the occipital arch (Plate XII. fig. 6, *s.o.*); a blunt keel has appeared on the mid line; within, half the anterior and most of the posterior vertical canals (Plate XIII. fig. 4, *a.s.c.*, *p.s.c.*) can be seen in its substance.

The inner part of the opisthotic has not hastened to coalesce with the exoccipital (Plate XIII. fig. 4, *op.*), and the small squarish epiotic (Plate XIII. fig. 4, *ep.*) is still quite distinct. The exorbitantly large prootic (Plate XIII. figs. 1, 2, 3, & 4, *pro.*) has six irregular sides, and convexities and sinuosities without number. Below, it articulates by a dentate suture with the basioccipital (*b.o.*), in front, by a similar suture with the alisphenoid (*a.s.*). On the thick rounded upper surface the equally thick parietal rests, whilst the outer scooped surface is shielded by the incudal splint (squamosal), just hiding from view the extensive suture connecting it with the opisthotic and the exoccipital (Plate XIII. fig. 2 shows these removed); above the opisthotic it

* Lent me by Mr. Flower, the eminent articulator.

articulates with the superoccipital, this suture being short without and of great extent within; the lower angle of the parietal hides this suture on the outside. But one of the most important relations of the prootic is that with the basisphenoid, viz. at its antero-inferior edge (Plate XIII. fig. 2). The suture of the prootic with the basioccipital lies at an obtuse angle to that with the basisphenoid; above this line of suture, and in front of the groove in which the trigeminal nerve lies (Plate XIII. figs. 2 & 3), a knob-like mass of the prootic is jammed into a rough cup in the basisphenoid, between the thick divided posterior clinoid bridge (*p.cl.*) and the outspread "posterior wings" (*p.r.p.*). The antero-inferior part of the prootic within (Plate XIII. fig. 4) is smooth, convexo-concave, the scooping being at the mid line and below, for the bone thickens round the "internal meatus" (Plate XIII. fig. 4); external to this thickening the prootic is hollowed, in continuity with the concave surface of the alisphenoid. Between the meatus, with its thickened margin and its drilled fundus, is the deep well-like recess for the lateral lobe of the cerebellum (Plate XIII. fig. 4); and in the back of this mass, towards the top, is the epiotic (*ep.*). Here is seen the suture between the prootic and superoccipital, this suture being interrupted by the intrusion of the inner face of the epiotic. Down in the depths of this pit can be seen a right-angled smooth facet of the exoccipital; below the lower junction of the prootic with the superoccipital comes the head of the opisthotic (inner) wedge (Plate XIII. fig. 4, *op.*); and the lower margin of the superoccipital is viewed resting upon the prootic in front, the opisthotic in the middle, and the exoccipital behind.

This may be complex enough, but the heaviest part is to come; and those who have merely studied anatomy in the pleasing works of the transcendentalists, and who have learned that both the basisphenoid and the presphenoid are found in the chondrified sheath of the notochord, and that to be well seen in the bird they must be separated by *a saw*, seeing that they are unhappily *connate*, will be rather staggered by the actual bones figured in these Plates, and to be now described *.

Undoubtedly the basisphenoid of the bird is the most remarkable of all known bones, and a knowledge of its development is fundamental to the study, not only of the ornithic skull, but, indeed, of all other skulls. For the skull alone, to say nothing of the corporal part of each vertebrate *microcosm*, has on it the impression and obsignation of the great universe itself; and "the edifice of this universe is, in its structure, to the human intellect contemplating it, like a labyrinth; where from all sides there present themselves so many ambiguous pathways, such fallacious similitudes of things and their

* "But this enslaved condition of the sciences is nought else than a thing bred from the audacity of the few, and the sloth and pusillanimity of the rest of mankind. For as soon as any particular science has in parts been somewhat diligently tilled and laboured, some one has usually arisen, confident in his talent, and accepted and celebrated on account of the compendiousness of his method, who, in so far as regards appearances, has established the art, but in reality has corrupted the labours of his predecessors. Yet what he has done is wont to be well-pleasing to succeeding generations on account of the easy utility of his work, and their wearisomeness and impatience of renewed inquiry."—BACON, Prolegomena to the 'Instauratio Magna.'

signs, such oblique and interwoven knots of nature; and the journey over it is to be constantly made under the uncertain light of the senses, sometimes shining out, sometimes hiding itself, through the forests of experience and particular facts"*.

The prodigal development of the bird's basisphenoid (Plate XIII. figs. 1, 2, & 3) is seen, not merely in its breadth but also in its length, reaching, as it does, sometimes to the furthest end of the base of the nasal septum; in its vertical growth also, seeing that it shoots upwards to form a very considerable moiety of the interorbital septum, and in thus joining the great vertical ethmoid, leaves but little territory to the presphenoid. In these generalized birds (the Ostriches), so near to the Reptiles and to the Mammals, it might have been expected that the basisphenoid would have derived a feebleness on both hands, from its relation to that of these outlying congeners. In one respect it does so, viz. in the symmetrical *autogenous* basitemporal portion; not so the azygous piece, or true basisphenoid; for here in these very birds its transverse growth attains its fulness: every one will see that a free growth of the "investing mass" lies at the root of this matter.

Compared with the last specimen, the basitemporals (*b.t.*) are nearer together at the mid line, and do not underlie the basioccipital; in front of the fossa which separates them the pituitary floor is convex and somewhat perforate. The Eustachian canal Plate XIII. fig. 1, *eu.*), membranous below, and the deep fissure between the anterior and posterior pterygoid processes, are well seen (Plate XIII. fig. 1, *a.p.*, *pr.p.*); as also the curve of the great subcylindrical anterior wing, with the somewhat sudden narrowing of the prepituitary, high, vertical portion, as below it passes into the rather slender rostrum (*r.b.s.*), which shows its shallow groove, in the upper view, to receive the trabecular structure; for the rostrum itself is altogether a subtrabecular structure. It would not have been altogether *below*, but *between* as well, if the trabeculæ had not coalesced together. The oval crown of the high prepituitary mass is the *connate* anterior clinoid process (Plate XIII. fig. 3, *a.cl.*), behind which is the transversely oval, deep, backwardly curved "sella turcica" (*s.l.t.*), into the fundus of which the carotid canals open.

Behind this pituitary "well," and between the thick crests of the posterior pterygoid processes, is the posterior clinoid bridge (*p.cl.*) in the "middle trabecular region:" a slit divides it at the middle, and this slit passes down the oblique, gradually narrowing, postpituitary mass (Plate XIII. fig. 3). The embryonic skull explains this; for after the investing mass has increased around and in front of the pointed end of the notochord, it gradually, whilst separating that structure from the pituitary body, grows round this body, the cartilage into which the mass is being metamorphosed meeting behind to form the posterior clinoid wall, and growing up from the edges of the trabecula in front of the pituitary body to form the anterior clinoid mass. The broad band of tissue behind the "infundibulum" must coalesce more slowly than that in front of it, even in the process of chondrification; this is repeated when that cartilage is metamorphosed into bone. Whilst the lower lamina of the new basisphenoid is growing

* Bacon.

backwards, forwards, and a little upwards, the upper lamina of bone in the fundus of the "sella" is growing upwards right and left into the clinoid bridge and posterior pterygoid processes, and backwards along the floor of the skull. The two wings of this upper bony lamina only slowly meet behind the "sella," both above in the great transverse bridge, and below in the postpituitary skull-floor; hence the *slit* which for a long while is seen at the mid line in this and other birds. In the side view, the slit which separates the high prepituitary mass from the root of the rostrum below (Plate XIII. fig. 2, *b.s.*, *r.b.s.*), shows how that this rostrum is an extension of the secondary growth of cartilage below the "infundibulum," and altogether distinct from the trabeculæ; the late-formed cartilage of this floor and its rostral prolongation, however, is soon formed into a continuous mass with the cartilaginous trabeculæ. A front view (Plate XIII. fig. 7), supposing the rostrum to be severed at its free part, shows the structure of this bone well, and also that the posterior pterygoid processes lie on a *higher* plane than the spurs in front of them. This extension outwards of the great basisphenoid is a correlate of the *transverse* position of the alisphenoids, which are best seen, not at the sides, as in most vertebrata, but in *front* (Plate XIII. fig. 7, *a.s.*), as they form the large posterior walls of the orbit. These irregularly pentagonal bones are only gently convex at or near the outward (posterior) margin; much of their orbital surface is smoothly flat as they approach, thin and splintery towards the small anterior sphenoid. Although subpentagonal, each side of the alisphenoid is rounded or convex; the external and lower margins are thick; the outer (upper) angle has a feebly expressed epiphysis, the postfrontal (*p.f.*); whilst the lower margin is deeply scooped near the inner and the outer cornu; with the help of the basal bones, these notches are converted into the foramina ovalia (5), and rotunda (5, *a*). Between these bones and below and behind the presphenoid is the large semicircular "common optic foramen" (2); the anterior sphenoid is connected with the alisphenoid by mere fibre (Plate XIII. fig. 7, *p.s.*), a remnant of the original membranous skull, and now forming part of the "postorbital fontanelle" of each side; a remnant of this exists in the adult; periosteal layers of bone have filled up the rest. The presphenoid and ethmoid (Plate XIII. fig. 5, *eth.*) are still separate; the two moieties of the latter have quite coalesced; it is a large bone; its alæ are ossified almost as far as in the adult; and the fenestra is somewhat more circumscribed by periosteal layers. The bone has still territory, fore and aft, in a cartilaginous condition, but it has reached the rostrum below; seen from behind (Plate XIII. fig. 6) the olfactory notches show themselves above that upper bar, which ultimately joins the presphenoid. The lower part of the turbinals (antorbital, "pars plana vel papyracea") is still wholly soft, and wholly separate, except by a fibrous connexion from the perpendicular plate.

The fenestra in the antorbital plate of the lacrymal is well shown (Plate XIII. fig. 8); as also the splints of the lower jaw (Plate XIII. figs. 9–11). Whilst much of the outer and anterior part of the articular cartilage is still unossified, yet at the apex of the internal angular process (Plate XIII. fig. 9, *p.fo.*) the pneumatic foramen is well formed, and the interior of the bone is being absorbed on one side, whilst it is only forming on the other. The articular cartilage is carefully wrapped in its splints before ossification commences; when their *model* is fully ossified, then they coalesce to a great extent.

Dromœus, "D."

My fourth specimen of the Emu was put into my hands in an unmacerated condition by Mr. BARTLETT; it had died on its voyage from Australia, and was of the freckled kind (*Dromœus irroratus*, Scl. and B.). This individual was but little older than the last, yet some important changes have taken place; there are also some individual differences; and besides this, as it was in a fresh state, I am able to give drawings and descriptions of the complex nasal cartilages. The cranial part is very high, and smoothly ovoidal; indeed its form is such as is found in the young of the Great Ostrich when the entire chick is no larger than a sparrow, *Struthio*, "A;" the frontal convexities over the hemispheres have a peculiar fœtal character, although the bird was fully half the size of the adult. In respect of its roundness this skull comes near that of the Apteryx; but that which distinguishes the latter bird is the great size and breadth of the occipital region as compared with the rest of the skull, a character which it shares with the lowest monotrematous and placental Mammals, e.g. *Echidna*, *Ornithorhynchus*, *Sorex*, and *Talpa*. In this specimen of *D. irroratus* the basisphenoidal rostrum is deeper and more cultrate than in the last, and there is a more marked remnant of the pituitary space; the basitemporals do not converge so much, and consequently the occipito-sphenoidal synchondrosis is better seen below.

The postfrontal is scarcely more developed, being almost entirely cartilaginous, and the descending plate of the presphenoid is still soft. The orbito-presphenoidal bone began at the top, in the skull-floor; the high part of the basisphenoid and the vertical ethmoid are still far apart. The ethmoidal "fenestra" is divided into two by a broad periosteal bar of bone, leaving only a small space membranous above and below.

The delicate maxillary style has partly coalesced with the styloid angular process of the intermaxillary; but for the early specimen its existence could not have been proved. The palatine fenestra has become definite; it is oval, and about $\frac{1}{9}$th of an inch in diameter.

The pterygoid is very flat, splintery, and unlike the elegant terete bone of the typical birds. The height of the intermaxillary in front, and the strength and form of the whole bone, reminds one strongly of the same part in *Dinornis robustus*, and especially of the subgeneric form, *Palapteryx* (Zool. Trans. vol. iii. pl. 54, where in fig. 1 the intermaxillary fragment is placed considerably too far from the skull). The os quadratum is a marvellously swollen clumsy bone, totally unlike its homologue in the most gigantic of the Rails—the mis-called *Dinornis casuarinus* (*op. cit.* pl. 52). As in the Blackbird (*Turdus merula*), the base of the stapes is perforate like that of the Mammal; this is caused by its having a large pneumatic hole on one side and a lesser passage on the other; the apex has a triradiate piece of cartilage growing from it.

The edges of the upper ethmoidal bone have not descended far into the aliethmoidal cartilaginous plates (Plate XII. fig. 7, *al.e.*, *eth.*); in the adult the bone grows downwards and inwards, and then stops, leaving the rest soft. To one fresh from the study of the nasal labyrinth in the Mammals, the extreme simplicity of the *olfactory region* in the Emu would be very perplexing; to one fresh from the study of this part in the lower Vertebrata, the complexity of that part of the nose of the Emu which is supplied by the fifth nerve would be just as strange. There is no discontinuity of the nasal cartilages in the Emu (Plate XII. fig. 7), such as we see in the higher birds, and yet the *regions* are not ill-defined. The three turbinals of Man and his alæ nasi supply us with familiar conceptions, and the ordinary works on human anatomy with familiar terms, yet these may be modified a little to suit wider groups, and the necessities of a fuller morphology.

The terms which I have been in the habit of using (see Zool. Trans. vol. v. pp. 149–242) are for the homologue of the upper turbinal "aliethmoid," for the middle "antorbital," or sometimes the old term "pars plana," for the root of the inferior turbinal "aliseptal," and "alinasal" for the alæ nasi.

When the turbinals of the Emu are seen from within (Plate XII. fig. 7, *u.tb*), the upper one looks to have a very large development; it is all hollow, and simple, however (Plate XII. fig. 8); for the aliethmoid, after growing outwards, turns round, and grows towards the axis of the skull; in doing so it grows upwards also, in a rounded manner. It then keeps (for some distance downwards, and much more in front than behind) near the perpendicular ethmoid, then makes a semicylindrical curve outwards; the lower edge of this outward part being continuous with the top of the pars plana (antorbital). In a vertically transverse section this simple cartilage presents the form of the letter S (Plate XII. fig. 8), there being a deep concavity on the inside, at the top; then a large convexity; then a deep, almost cylindrical groove separating the upper from the lower turbinal. On the outside the upper part is a semicylinder, then a flask-shaped cavity, with the neck behind, and then below it is the swelling top of the middle ethmoid. Seen from within, the upper turbinal looks like a miniature bagpipe with the broad end forwards (Plate XII. fig. 7). This is really the homologue of the cribriform plate (as well as of its turbinal outgrowths) of the Mammal; but here there is no sieve-like structure, and there are no lamellar outgrowths.

Close as we now stand to the Mammal, it is yet very hard to see the exact bearings of this subject: the present Hunterian Professor of Anatomy did once, with his keener insight, give the writer a clue to trace its mazes by; it has, however, required much persistent work to make it clear. The hole through which the olfactory crus of the bird passes out of the cranium into the orbit, is not a *single* representative of the *many* pores through which the olfactory filaments of the Mammal pass; the membrane which encloses that crus is really part of the skull-floor; and the chink through which the olfactory crus passes anteriorly, between the aliethmoid and the perpendicular plate, is the homologue of that vertical series of passages which lies nearest the crista galli of the Mammal. In the bird this chink is not subdivided, and the crus passes *in* to give off its filaments from its dilated end. In the bird the cranial cavity is aborted anteriorly by the upgrowth of the great interorbital septum; the crista galli underprops the frontals directly, and the posterior end of the middle ethmoid (above) goes far back to join the presphenoid. On the latter the olfactory crura rest; the sides of the former (the supero-posterior part of the middle ethmoid) are grooved to lodge them as they pass mesiad of, and over the large eyeballs to reach their destination. The posterior margin of the pars plana is thick and turned inwards, and stands upwards and a little backwards; nearly all its inner surface is occupied with an ovoidal tent-like outgrowth (Plate XII. fig. 7, *m.t.b.*, a bristle is passed into the opening), which is bifurcate a little below, and which, for the lower half of its anterior margin, is not confluent with the primary cartilage; this slit therefore opens into the deep crescentic groove which separates the upper from the middle turbinal. These two swellings lie near together, and the posterior end of the lower turbinal passes equally downwards and backwards beneath them (Plate XII. fig. 7, *i.t.b.*). This lower turbinal is not at all simple; it is complex beyond expectation.

As soon as the primary septal ala (continuous with the ethmoidal) begins to turn inwards, it becomes double (Plate XII. fig. 9, *al.s.*, *i.t.b.*), one lamina keeping the sigmoid curve of the upper turbinal, the other growing downwards, and then first outwards and afterwards inwards, to form the outer nasal wall; when it is nearly halfway down it gives off, from its outside, a small lamella which is connected by a fascia with the edge of the upper jaw. This fascia halfway down gives off a horizontal lamella (Plate XII. fig. 9), which joins the cartilaginous wall within; the cartilaginous plate nearly reaches the base of the septum nasi (*s.n.*), it becomes the ala nasi anteriorly. The inner sigmoid lamella (Plate XII. fig. 9, *i.t.b.*), which towards the septum is first convex, then concave, and then convex again, gives off truly cartilaginous secondary lamellæ, four of which bifurcate again, whilst five continue simple; so that in all there are no less than thirteen free plates. Behind, this great inferior turbinal becomes simpler (Plate XII. figs. 7 & 8, *i.t.b.*), and this part is seen from below roofing the middle nasal passage (Plate XI. fig. 2, *i.t.b.*); in front it does the same, and ends at the middle of the true ala nasi; this latter cartilage (Plate XI. fig. 3, *al.n.*) has no independent outgrowths of its own; it is very large and simple, and ends in a crescentic manner over the oblique anterior nasal opening. The somewhat thin nasal septum (Plate XII. fig. 9, *s.n.*) is one continuous sheet of smooth cartilage, and at first almost entirely fills up the space below the nasal processes of the intermaxillaries, to their solid part in front; afterwards, when ossified, it will be relatively much smaller. The manner in which the lacrymal embraces the lateral ethmoidal structures at every available point of contact (Plate XII. fig. 8, *l.*), shows its true nature as the protective "operculum" of this region; a band of cartilage, which becomes thicker-edged below, lines the front of the antorbital plate of the lacrymal almost to its edge; it is the lower and posterior part of the inferior turbinal (*a.i.t.*), and is often in higher birds an autogenous cartilage, to be afterwards separately ossified; and there is nothing in the bird's skull more curious than this lower "antorbital," which in certain species so closely imitates the "transpalatine" of the Reptile.

I have already spoken of the skull of the adult Emu, and shall here merely recapitulate some points, and add a few more. The drawings which were made by me many years ago from the specimen of *D. irroratus* in the King's College Museum, need not be given.

The sutures both above and below are nearly obliterated from the skull proper; a little of the sagittal suture is seen close behind the *exposed* upper ethmoid; the nasal processes of the intermaxillaries (thoroughly confluent) do not reach to this broad plate. The characteristic lateral groove in the side of each intermaxillary and dentary is intensified in size and depth. The terminal diverging rami of the vomer have become more divergent, and the palatine fenestra has become so large as to make the bone a mere irregular ring. All the bones of the maxillary and intermaxillary regions keep their distinctness. The aliethmoid has become bony further down, and has joined the ossified pars plana; the interorbital septum has lost its fenestra, being filled up with periosteal layers, and the nasal septum, now relatively less, has become ossified continuously with the ethmoid.

Casuarius Bennettii (The Mooruk).

I have been very fortunate in obtaining from the Gardens of the Zoological Society two young Mooruks at the time of hatching, both imperfect, but the one more than supplementing the other. It is not for nothing that the Cassowary has a sort of porcupine's quills growing out of its wings, as though it were contemplating the shearing of all its (very simple) plumes, ready to become one of the hairy class—the Mammals. I was not aware, and I had it from the mouth of my friend Professor HUXLEY that he was not aware, how much of the essential mammal there is hidden under the plumy cloak of the Cassowary; and yet, compared with other birds, the Cassowary is *low* and *reptilian*; what the Chimæra is to the more elegant typical fishes, that the Cassowary is to ordinary birds; not, indeed, to the same extent is this difference, yet it is the same in kind.

These strong-bodied *borderers*, having certainly laws of their own, are yet only partially amenable to the law (morphological law) of the more inland tribes of the regions between which they lie. Here then the morphologist has presented to him one of those "oblique and interwoven windings and knots of nature" of which BACON speaks; and no little pleasure and profit will accrue to him who shall even partially untie a knot like this.

The ornithic discrepancies of this bird must be detailed now; and if the present paper should throw any real light upon the bearings of this bird's skull, and show how its morphology looks backwards to the cold-blooded classes, forwards to the Mammals, and upwards to the innumerable members of its own (feathered) group, my labour will not have been in vain.

The transversely oval occipital condyle (Plate XIV. fig. 2, *o.c.*) has on its upper surface a cleft, in which lie the compressed remains of the notochord; this condyle is not yet ossified. This embryonic remnant, a little further forwards, is enclosed in the cartilage nearer the top than the bottom; it is gradually lost in the basioccipital bony centre.

This centre (*b.o.*) would be elegantly lozenge-shaped, were it not that the front and the hinder angles are premorse; it is *reptilian* in its lateral angular extension, as in the Emu. The growth of the exoccipitals (*e.o.*) in all directions has caused the vagus and condyloid foramina (8, 9) to be enclosed in bone, the condyle to be protected by bone laterally, and the opisthotics (outer laminæ) to be no longer distinct from the outer part of these occipital arches (Plate XIV. fig. 4, *op.*); they are at present, however, mere islands of bone, being completely surrounded by cartilage, save at the opisthotic or upper margin, externally. A distinct tract of cartilage separates the lateral from the upper occipital (Plate XIV. fig. 2, *s.o.*); and the epiotic, the upper part of the opisthotic, and the outer part of the exoccipital regions are still unossified. The large superoccipital comes nearer to the pentagon in shape than in the other "Struthionidæ," the basal margin is much broader, and the sinus-passages (*s.c.*) are further apart. At the mid line this bone is feebly keeled; on the inside (Plate XIV. fig. 5, *s.o.*) its vicariously epiotic part is embracing the hinder half of the "anterior" semicircular canal (*a.s.c.*); whilst for a line in extent this canal is unossified, the rest is covered in by the prootic (*pro.*), but a large, vertically oblong tract of cartilage runs down from the top of the great canal arch to the top of the inner face of the exoccipital. The opisthotic lies close to this face in the inside (Plate XIV. fig. 5, *op.*), but is still separate, and a narrow strip of cartilage intervenes between it and the prootic; the epiotic has not made its appearance, and the fossa, under the great arch, where it should come is much shallower than in the other Ostriches (Plate XIV. fig. 5). The prootic is already large, its inner lamina being the largest (*pro.*); the two bony plates are fused together over the ampulla of the great anterior canal (Plate XIV. fig. 6, *a.s.c.*) (and indeed through the substance of the cartilage), save at their margins. A considerable mass of cartilage still separates the prootic from the basioccipital and basisphenoid below (Plate XIV. fig. 6); this is continuous with the remnant which intervenes between the two basal bones (*b.o.*, *b.s.*). A small patch of cartilage comes between the prootic and the alisphenoid, and there is no trace of the great "pterotic" crest of the fish (Plate XIV. figs. 5 & 6). A half-ossified band of cartilage runs across the "foramen ovale" (5), making it double, as in the Carp. If the semicircular canals were only walled in by a thin layer of bone, they would be seen to be marvellously like those of the Lizard; in both the Lizard and the bird these tubes and their bulbs are a very beautiful structure. The angularity of the basioccipital, and the two pairs of lateral outgrowths to the basisphenoid (Plate XIV. fig. 2, *a.p.*, *pr.p.*), mark the very mixed character of the skull-base of the young Cassowary, for the synchondrosis is nearly as fully seen below as above; more so than in any other bird, as far as I know. Yet at this very place we see an important embryological and, as it were, reptilian character; for the broadish terminal end of the basisphenoid is not only bifid, but the split is really an oval space (Plate XIV. fig. 2, *b.s.*), the remnant of the "posterior basicranial fontanelle" of RATHKE. My earliest specimens of *Struthio camelus* do not show this; they only, like other birds, show the split above; so also neither the Emu nor the Rhea have this space below; and I have described an Emu a week younger than this Cassowary.

Not less unmistakeable is the *mammalian* nature of the small, *late*, long distinct basitemporals (Plate XIV. fig. 2, *b.t.*) or "lingulæ;" in *Struthio camelus* (B.), a stage of the embryo three weeks earlier at least, these bones had not only coalesced with each other, but also with the basisphenoid. In young ripe Crocodiles, the same stage as this Cassowary, a mere trace of the distinctness of these bones is seen. In *Chelone mydas*, at the same age, the sutures can be traced, and often for a long while in that group the basitemporals do not coalesce as I have seen in *Emys Europæa*, and as is well shown in Dr. GRAY's figure of *Cyclanosteus senegalensis* (Zool. Proc. 1864, pt. 1. p. 96); but in that order, as in most Reptiles, these bones meet at the mid line, and extend through the entire substance of the basis cranii. But in the Mammalia, where for the most part these bones are quite lateral and very small, they continue distinct in some cases, e. g., in the Walrus (*Trichechus*), until the creature is well nigh full grown. Still in the Cassowary they retain the ornithic and reptilian function of forming a floor to, and helping to enring the internal carotid artery (*i.c.*), a vessel which takes shelter in the prootic, or the tympanic, or in both, in the Mammalia. The anterior and posterior pterygoid processes (*a.p.*, *p.r.p.*) are perfectly struthious, and there is not much to remark upon in them, save that they come very close to the same parts in the Emu, as in that bird the Eustachian tubes are merely overshadowed by bone, and open into one common palatine slit between and behind the (struthiously distinct) middle nares.

The "rostrum" of the basisphenoid (*r.b.s.*) is somewhat stronger than in the Emu, and is intermediate between that of the latter bird and the Rhea; it passes under the septum for a shorter distance than is usual in the Struthionidæ. The broad part of the basisphenoid is such as would be seen in the young Fowl if four-fifths of the basitemporals were cut away, leaving only a remnant at each hinder angle; thus exposing the synchondrosis of the two mesial bones, and laying bare the Eustachian trumpets. A layer of fibrous tissue separates the "rostrum" from the coalesced trabeculæ (Plate XIV. fig. 8) up to the high prepituitary part of the basisphenoid. The alisphenoids (Plate XIV. figs. 1, 5, & 6, *a.s.*) are relatively higher than in the other Ostriches, and they are not so ornithically transverse; there is a great approach to the lateralness seen in the Crocodile and the Mammal. They are ossified, save at the postfrontal spur (*p.f.*), in front of the divided "foramen ovale," and below; but the upper basisphenoidal lamella has nearly reached them on each side (Plate XIV. figs. 5 & 6); the "foramen rotundum" (5, *a*) is principally bounded by the cartilage which underlies the alisphenoid anteriorly. A broad right-angled space lies between the upper arched margin of the prootic and the sinuous posterior margin of the alisphenoid (Plate XIV. figs. 5 & 6); in the Fish this space is filled up by the great "pterotic" cartilage-bone, which has in front of it, and interlocked into it, an almost equally developed external alisphenoidal epiphysis—the postfrontal. The alisphenoid, in this as in the other "Struthionidæ," is a convexo-concave thick bone, its scooped part being within; it has no central "fontanelle" as in many birds; but, as is the rule in the whole class, an oblong fontanelle intervenes between it and the margin of the orbito-sphenoid (Plate XIV. fig. 1, *o.s.*).

This is a remnant of that extensive space in the Lacertian skull which extends from the Y-shaped orbito-sphenoid to the margin of the prootic, and which is somewhat defended by an upgrowing rod ("columella" of CUVIER) of the pterygo-palatine arcade. The whole of the anterior sphenoid (Plate XIV. fig. 1, *o.s. p.s.*) is still mere cartilage, and the wings, about 3 lines in extent, are only a line broad (Plate X. fig. 20, *o.s.*); *lateness* in ossification and stunted growth are, as usual, here associated. The interorbital "fenestra" (Plate XIV. fig. 1) is oval; the long diameter vertical, and it is $3\frac{1}{2}$ lines by 2 in size; a full "line" of cartilage intervenes between it and the perpendicular ethmoid (*p.e.*). The continuous interorbital septum is very large, the orbit being 9 lines in diameter; thus the ethmoidal region is very large indeed, reaching behind over and below the whole fenestra, and in front taking in, without a notch or a change of tissue, all the way between the turbinals and the alæ nasi. Then it is not merely the height of the perpendicular ethmoid which gives it its great size, but the upper piece in this group of "Struthionidæ" takes on a monstrous growth. In all the members of the Struthious family the mode of ossification (by an upper and a lower centre) is peculiar; and so is the persistent exposure of the crown of the cranio-facial axis: this is normal in osseous Fishes; but in them, as in typical birds, the perpendicular bone reaches through to the top, and is not capped by a second piece.

It is the overgrowth of this upper piece (Plates X. & XIV. *eth.*) which gives the Cassowaries their great peculiarity; for in them it not merely *appears* at the surface, but it emerges, like the intrusion of a hypogene rock through the secondary strata of the earth's crust, leaving the frontals and lacrymals merely flanking its sides (Plate X. figs. 18 & 20, & Plate XIV. figs. 1, 3, 4, & 8). This is not like the account which is given of the Cassowary's crest in the Osteological Catalogue of the Museum of the College of Surgeons (vol. i. p. 259, No. 1356); but the distinguished author of that Catalogue had evidently not been so fortunate as to obtain the head of a Cassowary chick. I had compared the Ostriches to the Sharks and Rays long before I saw the meaning of the Cassowary's crest, but this huge swelling upgrowth of the anterior part of the primordial skull carries the mind back to the same part of the organization of the lower plagiostomes, e. g. *Chimæra* and *Callorhynchus*.

The crest of the adult Mooruk (*C. Bennettii*) has three thick convex ridges meeting at the top—one in a line with the axis of the skull, and the two others out-turned like the horns of the coalesced parietal bone in Lizards (see the excellent figure given in Dr. SCLATER'S paper on the "Struthionidæ," Trans. Zool. Soc. vol. iv. pl. 72). This curious ethmoidal horn-core, with its leaden-black horny sheath, is a pretty exact miniature of that strange old three-wayed bridge which may be seen in the small but extremely ancient town of Crowland, in the Fens of Lincolnshire.

At this early period there is no mark of the high three-rayed ridge; for the whole upper surface (Plate XIV. fig. 3, *eth.*), which has a lanceolate outline, is smoothly convex; but it is already a full "line" higher than the bones that flank it (Plate XIV. fig. 1.). If we turn to the figure of *Casuarius bicarunculatus* (*op. cit.* pl. 73), we shall see that the crest is arrested at this low simple condition; *C. uniappendiculatus* (*op. cit.* pl. 74) is intermediate between *C. bicarunculatus* and *C. galeatus* (*op. cit.* pl. 71), in which it attains its greatest actual height, although it retains the lanceolate outline. A section of the broad upper ethmoid of the Mooruk-chick (Plate XIV. figs. 7 & 8) shows that it is already one of the thickest bones in the skull; anteriorly (fig. 7) its arch is about one-third of a circle, further back (fig. 8) the arch is like that of a low-crowned bridge, and all this wide, less elevated hinder part is a mere hollow dome, being behind the supporting perpendicular plate, which, as a broad-topped wall, underprops the foremost part of this ethmoidal crest (Plate XIV. fig. 7, *p.e.*). Here one important difference presents itself: in the other already described "Struthionidæ," the upper plate sends down a keel between the olfactory lobes, and it is this part which is primarily thin, and always grooved for the lodgement of those organs; in the Cassowary, however, the vertical plate is completely formed by the middle or perpendicular ethmoid, which is as much expanded at the top as the upper ethmoid in the other Ostriches. The greatest fore-and-aft extent of the middle ethmoid (Plate XIV. fig. 1, *p.e.*) at present is 4 lines; but it has reached the upper ethmoid above, and has reached within a line of the basisphenoidal "rostrum" below. Between the lateral ethmoid (upper and middle turbinals) the bone is thin (Plate XIV. fig. 7, *p.e.*); but it is not fenestrate as in the Emu: this internasal "window" is very variable in the bird-class generally, existing oftener amongst water-birds than amongst the arboreal tribes. The rest of the cranio-facial axis is one continued, smooth, thickish, cartilaginous plate; there being no change as we pass from the vertical ethmoid to the septum nasi proper: this plate (Plate X. fig. 19, *s.n.*) fills up the whole of the large intermaxillary angle (*i. e.* between the body and its processes), as in the embryo of typical birds.

As in the other "Struthionidæ" and the Mammalia, there is a perfect continuity of all the nasal cartilages; the alæ that grow from the upper edges of the great general orbito-nasal septum being converted into cartilage by the metamorphosis of the whole of its simple cells, without any of that breaking up into distinct territories which we see in the purer bird-types. These upper olfactory wings extend on each side for a distance of 1 inch 8 lines, the whole length of the skull and face being 2 inches and 8 lines; for the hinder end of the upper ethmoid lies in the same vertical line as the common optic foramen, and the alæ nasi fill up the angle of the intermaxillaries on each side (Plate X. figs. 1 & 3). Posteriorly these long wings (connate in their bony stage) perform the rare function of largely helping, dome-like, to roof in the hemispheres of the brain (Plate X. fig. 20, & Plate XIV. figs. 1, 3, 4, & 8, *eth.*); in front they project somewhat beyond the most jutting point of the nasal septum to form the breath-valves. All these large birds, which "walk through dry places," have that part of the nose which is merely supplied by the nasal portion of the fifth nerve, very large (largest of all in the Cassowary), whilst the true olfactory region is small, and simple enough. The simple fold of cartilage (Plate X. fig. 17, *al.e.*, *u.t.b.*), which, turning abruptly inward, forms a triangular, somewhat swollen elevation outside the end of the olfactory bulb, is all we have here of that exquisitely perforate and highly complex mass which in the Mammal receives the name of cribriform plate and upper turbinal. Close on its outside, and towards the top, the nasal branch of the ophthalmic nerve (Plate XIV. fig. 7, *n.n.*) is seen creeping downwards to supply the rich outgrowths of the wings of the nasal septum. Below, the ethmoidal ala passes down into the pars plana (Plate X. fig. 17, & Plate XIV. fig. 7, *pp.*) behind, and into the nasal wall, which grows down from the root of the inferior turbinal. The pars plana is a high triangle, its base below, and it is somewhat convex; its free margin lies close to the perpendicular ethmoid, and on its inner face is the middle turbinal. This outgrowth (Plate X. fig. 17, & Plate XIV. figs. 9–11, *m.t.b.*) is a somewhat hourglass-shaped tent, with a small opening in front; it is gently convex above, then slightly concave, and then thickens into two converging roots below; it is 3 lines long by 1 in breadth. The position of this tent is oblique, for it passes downwards and forwards; a valley of the same breadth as this turbinal separates it from the infolded upper turbinal; below this *true* olfactory region lies the hinder part of the inferior turbinal (Plate X. fig. 17, *i.t.b.*, *a.i.t.*), the last folds of which can be seen in the middle nares, when the skull is looked at from below. Both the upper and lower turbinals lie in the orbit (Plate XIV. fig. 1), which is bounded in front by the descending portion of the large lacrymal (*l.*); inside this bone, and further forwards, inside the ascending plate of the prevomer (Plate XIV. fig. 1, *p.v.*), we have the inferior turbinal, which has its largest volume below the broadest part of the nasals, where the ossification of the upper ethmoid at present ends. A section at this part (Plate X. fig. 19) shows a very unexpected richness of cartilaginous outgrowth, such as is seen in no other known bird, the Emu making the nearest approach to it. The septum nasi (*s.n.*) is rather thick at this part, very swollen below, where the trabeculæ lay, and somewhat thickened also in the middle; above it gives off its alæ (*al.s.*), which rise in a rounded manner, and then curve downwards and outwards. At a line from the mid line the alar lamella splits, the outer plate being moderately convex in section, and forming the cartilaginous nasal wall, whilst the inner plate curves abruptly inwards, forms nearly a semicircle, and then begins to give off secondary and tertiary lamellæ (*i.t.b.*). There are twenty of these folds on each side, nearly a third more than in the Emu, but formed after the same fashion, some of them being single (secondary), and some double and even treble (tertiary lamellæ). The outer nasal wall passes below the inferior turbinal folds, and ends behind in a curious thick blunt hook (Plate X. figs. 18 & 19, & Plate XIV. figs. 1 & 7, *a.i.t.*), on the convexity of which the base of the antorbital plate of the lacrymal rests, and which ends externally inside the zygomatic process of the prevomer (*p.v.*). Both behind and in front (Plate X. fig. 18) the turbinal folds become simpler; but they reach nearly to the anterior nasal passage in front, and form a roof to the middle nares behind. There is therefore no special turbinal to the alinasal cartilage, as there is no actual boundary line between these two regions. This makes the alæ nasi look larger than they are (Plate XIV. fig. 1, *al.n.*) actually, and this is one of those most interesting instances of the very *general* nature of the Cassowary. The study of the structures of these vertebrates, in which differentiation or segmentation is imperfectly performed, will be found to be fraught with the richest results to morphology. The anterior nares (*a.na.*) are mere low-lying slits, gradually widening in front; the middle nares (Plate XIV. fig. 2, *m.na.*) are large, suboval, and perfectly struthious, being greatly severed by the intrusion of the over-large vomer (*v.*). The curious inferior turbinal hook is the continuous homologue of the distinct lower antorbital piece of certain birds, *e. g.* "Musophaginæ," "Larinæ," "Procellarinæ," &c.

The visceral rays are very variously developed as usual, the first prestomal being never other than continuous with the skull base; and already at this stage the anterior (prenasal) half has waned into a mere thread.

The posterior half of the *larval* intermaxillary is the thick swollen base of the internasal cartilaginous plate (Plate X. fig. 19, *s.n.*); and there is never any line of distinction between this wall, which, as a continuation of the ethmo-presphenoidal cartilage divides one nasal labyrinth from the other, and the double (trabecular) foundation on which it rests. The primordial part of the palatine apparatus—the second pair of prestomal bars—is as simple as usual, there being only the palatine and pterygoid (Plate XIV. fig. 2, *pa.*, *pg.*) bones, answering to the pier of the arch only. The former is almost horizontal; the inner proximal edge, the anterior point of which is attached to its true basis (the lateral ethmoid), lying a little higher than the thick outer edge of the bone. The oblique sutural line between the palatine and pterygoid is of great extent, the former bone passing nearly to the end of the latter, this bone (the pterygoid) also running along the whole inner margin of the palatine. Anteriorly the external margin of the palatine fits, by harmony, with the inner edge of the prevomer (*p.v.*), this almost confused interlocking of primary with secondary bones being a constant thing in the structure of the facial arches. The front edge of the broad part of the palatine, bounding the middle nasal opening, is sharp and toothed; the external margin of the bone is sinuous, the front spur turning inwards, whilst that which clamps the pterygoid curves a little outwards; below, the broad part of the bone is scooped, making the middle nostril deeper. The pterygoids have their usual struthious form, being thick behind, where the quadrate and sphenoidal facets are placed, and thin and splintery in front, where the "mesopterygoid" becomes segmented off in other birds. The great visceral arch, the first poststomal or mandibular, has nothing very remarkable about its primordial structures; this is to be said, however, that the quadrate (Plate XIV. figs. 1–3, *q.*) is not so cumbrous a bone as in the Emu, the metapterygoid process (not quite ossified) being rounder and smaller; the oblong upper condyle stands on a longer neck than is usual, and the body of the bone is more compressed from before backwards; there is already a wind-passage in the flat hinder face of this bone (Plate XIV. fig. 2, *q.*). Ossification has commenced in the articular head of MECKEL'S cartilage (Plate XIV. fig. 4, *ar.*), which has scarcely begun to shrink anteriorly, although nearly buried in the splints.

The broadly triangular, deeply lancinate (or rather *runcinate*) tongue has in its substance the lower part of the second pair of poststomal rays; these are coalesced at the mid line, and together are like a thick heart-shaped leaf (Plate XIV. fig. 12, *c.h.*). The basal cartilage (*b.h.*), thick in the middle and bluntly pointed at both ends, fits in front into the notch made by the posterior divergence of the flat "cornua minora." The lower thyro-hyal (*th.* 1) is considerably ossified, the upper piece (*th.* 2), the cerato-hyals, and the combined basi- and uro-hyals (*bh.*, *uh.*) not at all; the whole structure agrees closely with the like parts in the Emu.

There is nothing especial in the auditory "columella" (Plate XIV. fig. 2, *st.*), which agrees with that of the Emu.

There is very much that is of interest in the splint-system of bones in the Mooruk's skull. There is very little trace of the posterior fontanelle (Plate XIV. fig. 4), for the superoccipital has already fitted into the very obtuse angle formed, by the meeting of the parietals behind; the anterior fontanelle (*fo.*) is lozenge-shaped, and is 2 lines across. The squarish parietals (*p.*) are becoming thick, and are already considerably scooped to form the temporal fossæ; they are very curved, for the skull is *high*, as in the Emu. The frontals are still higher, are becoming thick, but are very squamous behind; at the mid line (Plate XIV. figs. 1–8, *f.*) they are cut off from much of their territory by the uprising of the overgrown ethmoid; so they are mere styles in front and lie under the edge of the broad ethmoid, and wedge themselves in between and below the lacrymals and nasals (Plate XIV. fig. 7). The orbital plate of the frontal is for the most part only 2 lines in breadth, but it is sending a long pointed lamella to be strapped to the side of its proper primordial pattern—the orbito-sphenoid (Plate XIV. figs. 1 & 14, *f.*, *os.*). The lacrymals (*l.*)—the splints that apply themselves with exceeding closeness to the lateral ethmoidal region (Plate X. fig. 19, & Plate XIV. fig. 7)—are very large, as in most of the Ostrich-group; they send a long process to supply the place of the absent superorbitals; and apply themselves by a very long harmony-suture to the still larger nasals; the antorbital plate of the lacrymal is thicker than usual, has no fenestra, and is somewhat pedate below (Plate X. fig. 18, & Plate XIV. fig. 7). The nasals are very peculiar, if compared with those of the purer types of birds; they come nearest those of the Rhea as to their mutual approach at the mid line, and to those of the Great Ostrich in the size of the very ornithic descending process (Plate XIV. figs. 1 & 3, *n.*). Yet this process is very feeble; and on the whole the nasals of the Cassowary are an exaggeration of what is seen in the other "Struthionidæ," even in those very characters which are especially struthious. Behind, they reach to the very middle of the superorbital region, are there mere thick styles widely thrust apart, like the half-open blades of a pair of scissors; but they become very broad and massive between the body of the lacrymals, and where they have met in front of the narrow end of the exposed upper ethmoid. Even in this young specimen the nasals lie together for one-third of an inch, and then, for the same distance, gently diverge to let in the feeble, coalesced nasal part of the intermaxillaries (Plate XIV. fig. 3). The descending crus of the nasal is a small style, which lies obliquely in front of the exposed upper part of the lacrymal; it does not reach the gooseberry-prickle-shaped ascending process of the prevomer (Plate XIV. fig. 1, *p.v.*). The posterior nasal blades are scooped; the thick part has large pores; the anterior narrower part is strongly convex, each bone fitting itself on to its own primordial mould or pattern, *e. g.* the arched wings that give off the rich inferior turbinal outgrowth. Although the nasal be a mere splint—an "aliseptal operculum"—yet its development and modification are of great interest to the morphologist. I shall therefore, in this case, anticipate my future papers, and compare this part of the Cassowary's head with that of another of the "Grallæ," indeed, but with one which ranks above most of that heterogeneous "Order," viz. with the "Aves Altrices." The common Heron (*Ardea cinerea*) shows to what *typical* height a wading bird may attain, and I am fortunate in possessing the skull of a fledgling*.

The whole length of this skull is 5 inches 9 lines, and yet the intermaxillaries, measured along the nasal processes, are 4 inches 2 lines in length; the solid part is $9\frac{1}{2}$ lines in extent, and the dentary margin, to the end of the angle, 2 inches 10 lines. The entire length of the nasals is $3\frac{1}{2}$ inches; their hinder part is broad, flat, splintery, and pointed at the extreme end; at the broadest part they meet within half a line; but the very delicate styloid ends of the intermaxillaries can be seen between them, lying on an acutely-angular space between the frontals, and showing a trace of the ethmoid.

The nasals in front of the lacrymals divide, the upper crus, wholly separated from its fellow, becoming gradually an extremely delicate style, which runs up to the solid part of the intermaxillary. The lower crus of the nasal is thick, descends obliquely forwards, lies on the prevomer, and has the flat fibrous angle of the intermaxillary clamping its outside. The suture between the nasal processes of the intermaxillaries can be traced nearly forwards to the solid part of the bone, viz. for 3 inches 3 lines. The prevomers reach within an inch of the end of the beak in front, and within 4 lines of the quadrate bone behind; they are 3 inches 8 lines in fore-and-aft extent; the whole extent of the intermaxillary apparatus being 4 inches 9 lines, one inch less than the length of the whole skull and face. This disproportion of the intermaxillary apparatus becomes still more inordinate in the adult bird, and much more extraordinary measurements could be given from the skulls of the "Ibidinæ" and "Tringinæ."

The nasal processes of the intermaxillaries (Plate XIV. figs. 1 & 3, *px.*) in this young Mooruk are less than half an inch long, one-seventh the length of those of the young Heron, a bird not much more advanced in development, and of a smaller size. In the Ouaran Lizard (*Psammosaurus scincus*), a species of Monitor, the single process of the azygous intermaxillary cleaves the azygous nasal; this styliform compressed process is longer than its counterpart in the young Mooruk. Amongst the mammals the "Leporidæ" have the largest intermaxillaries (if we except the Cetacea, Monotremata, &c.); but the long process which each bone gives off, to pass upwards and be

* This bird, although ready to fly, had not left its *elevated* cradle; it was from the heronry in Milton Park, Northamptonshire, on the estate of Earl FITZWILLIAM.

let into the frontal, is *outside* the broad turbinated nasal. Altogether the Cassowaries have the smallest intermaxillaries, not excepting even the "Fissirostral" birds, *e. g. Caprimulgus*, *Cypselus*, &c. The marginal grooves are well shown on the body of the intermaxillary of the young Mooruk. They have their counterparts in the dentary rami (Plate XIV. fig. 1, *p.x.*, *d.*). Beneath, the canal which contains the remnant of the prenasal cartilage is well marked (Plate XIV. fig. 3, *p.x.*); behind that canal the bone is double on each side; the thick styloid dentary process running outside to the base of the lacrymal, and the flat palatine process (mesiad) running back to the broadest part of the vomer, and becoming notched towards the end.

The prevomer (Plate XIV. *p.v.*) is well developed; anteriorly it reaches further forwards than the long vomer, and within 5 lines of the end of the upper bill; it is 1 inch 4 lines long, a line longer than the vomer. This middle intermaxillary splint appears on the zygomatic margin of the cheek for 5 lines; there is no maxillary to hide it, but the jugal overlaps it for some distance. Externally, in front, a long styloid process fits into that notch in the intermaxillary which should be the "anterior palatine foramen;" behind this it widens inwards to join the broad part of the vomer (one of its most essential and primary connexions), then for half an inch it is scarcely $1\frac{1}{2}$ line wide, and, notched behind, it gives off a short spur to join the palatine, and a longer one to fit to the jugal (Plate XIV. figs. 1 & 3, *p.v.*).

The ascending process—that which gives the bone its thoroughly ophidian character—is much like that of the Rhea (Plate XIV. fig. 1, *p.v.*); it is triangular, and curved backwards at its blunt point: the point needed to be but a little sharper to have made this process, with its broad basis, a very near counterpart, in form, of the prickle (*aculeus*) of the gooseberry-bush. It is worthy of notice how the over-development of the three almost equal intermaxillary splints has in these birds sufficed to wall-in the soft nose-labyrinth in the absence of the great, usual, maxillary splint. This latter bone is badly developed (above) in Snakes and Monitor-Lizards, and is a frail sieve of bony openwork, strengthened above by a strong oblique beam from the intermaxillary, in Hares and Rabbits (*Lepus*), creatures rich in *oviparous* characters.

The vomer of the Mooruk (Plate X. figs. 18 & 19, & Plate XIV. fig. 3, *v.*) is of great length, and is also very broad at the anterior part—that part which answers to the lower portion of the bone in the Chelonian; it is very much split at both ends, especially behind, and, as may be seen also in the adult common Cassowary, the bone is like two pieces conjoined by a long isthmus in the middle.

Anteriorly the vomer underlies the septum nasi, then two-thirds of the rostrum of the basisphenoid (Plate XIV. fig. 7, *r.b.s.*, *v.*); and its hinder lobes are strongly fitted beneath each "mesopterygoid" spur of the pterygoids (Plate XIV. fig. 3, *v. pg.*). So that Nature has very carefully builded the bird's skull, laying balk upon balk; first the rafters (trabeculæ) grew together, and made the strong beam-like basis of the orbito-nasal partition-wall; then the pituitary floor grew forwards, first as cartilage and then as a bony rostrum beneath this beam, fitting in a groove-and-tongue manner most accurately, the groove being in the "rostrum" and the tongue on the "septum;" and then these became strongly undergirt by the bony semicylindrical vomer. Moreover, behind the vomer, the middle (sphenoidal) balk grows out on each side in the form of strong spurs, which stretch across to the pterygoid like a roof-collar or wind-beam. This very safe kind of building is best seen in these "Struthionidæ," for in other birds the cross-bars, or the lower beam, or both, may be deficient; the vomer being very variable, and the anterior pterygoid processes soon becoming arrested in many genera and families.

In this Cassowary we see but a poor remnant of the second prestomal splints, the inner pair being absent, the first outer pair mere flattened styles—the jugals (Plate XIV. figs. 1, 2, 3, *j.*); whilst the second, the quadrato-jugals (*q.j.*), are very small addenda to the jugals, just serving to connect the zygomata to the quadrate bones. Moreover, as we have seen, these splints are thrust away from their early-ossifying primordial bars by the intrusion of the huge middle splints (prevomers) of the first prestomal arcade.

The squamosals of the Struthionidæ all speak one language, but in none are the utterances so distinct as in the case of the Cassowary. If the reader will refer to Professor HUXLEY's new work on Anatomy, and compare fig. 65, *Pr.Op.* p. 162, fig. 84, *F.* p. 208, and fig. 86, *C.z.* p. 214, with the squamosal of the young Mooruk, he will see at one glance a complete harmony of the "preoperculum" of the Fish, the temporal "operculum" of the Lepidosiren, the "temporo-mastoid" of the Frog, and the squamosal of the air-breathing Vertebrata. As to the Frog and the Mooruk, the shape of the bone has merely to vary from that of a hammer to that of a hatchet, and the oneness is absolute. But it is not on the accident of shape that I would rely to prove this identification, but on the history of the development of the bone, viz., as a splint upon the quadrate pedicel of the mandibular ray, whether that pedicel be segmented from the periotic capsule and "investing mass," or whether it be continuous with it*.

The mandibular splints have their usual development, the dentary (Plate XIV. fig. 1, *d.*) being the longest, and the splenial the next in size, then the surangular (*s.a.*), whilst the angular (*a.*) and the coronoid are nearly of the same size. The pinched face of the Cassowary makes the mandibles to be much like those of the Tinamou, the rami meeting at a very acute angle, and the dentaries being narrow feeble bones. If these mandibular splints were during growth to become as free of the primary ray as those of the palato-maxillary region, we should have essentially what occurs in the inner and outer splints of the huge hyoid arches of the osseous fish.

I have studied the structure of the skull in the adult condition both of the common species (*H. galeatus*) and also of the Mooruk (*C. Bennettii*), but my space will not serve to trace the changes, which are similar to those that take place in the other "Struthionidæ;" the description above given of the chick will serve the student as a guide in his interpretation of the fully developed skull.

* The supposed "squamosal" of the Fish does not stand in the way now (see HUXLEY, *op. cit.* p. 188). CUVIER and OWEN made the nearest guess as to its nature.

Dinornis robustus.

No specimens of the skulls of young individuals of the Dinornis have come under my notice, only sternal and pelvic bones; I have, however, some remarks to make upon the adult skull of the subextinct form. I have studied the skull of *Dinornis robustus* both in the specimens contained in the British Museum, and also in Professor HYRTL's fine skeleton *.

But the freshest and most perfect skeleton and skull of this bird has been recently added to the York Museum; and some of the bones, both young and old, were exhibited and described by THOMAS ALLIS, Esq., F.L.S., at a Meeting of the Linnean Society, June 16th, 1864. Tendon, cartilage, skin, and even feathers still adhered to these precious bones, the dried articular cartilage having the amber-coloured tint seen in the bones of creatures not long dead. The skull was not exhibited at that Meeting, but my friend H. B. BRADY, Esq. (well known as a Rhizopodist) has kindly supplied me with the three very beautiful photographs of these *fresh* bones of the Moa, published by MONKHOUSE and Co. 4to. Lendal, York.

One of these gives an obliquely lateral view of the skull and mandible, and on another sheet there is a basal view of the skull, and an upper view of the coalesced mandibles. All the York specimens were taken out of the same sand-dune in New Zealand, both young and old, the young ones having the sternum in two distinct halves, and the pelvis in distinct pieces; the ilium quite detached, the ischium and pubis undergoing anchylosis. These *chickens* must have been nearly twice the bulk of a large Turkey. The skull of the adult is beautifully displayed in these photographs, is nearly perfect, and the relations of this bird to the other "Struthionidæ" can be clearly read off in the light of what has been given above, in my account of the early skulls of the well-known living types. It may be well to remark, in passing, that the pelvis of *Dinornis robustus* answers to the simple type of that of the Apteryx, Cassowary, Emu, and Tinamou; whilst the sternum reminds the observer both of that of *Struthio* and of *Apteryx*. Besides characters of its own, the skull has those of the African Ostrich and of the Emu; we have seen that the Ostrich comes between the Emu and the Rhea: the relations of the whole group are very interwoven.

The robustness of the skeleton generally is not wanting in the skull, every part showing a solidity, a breadth, and a depth very unlike what is seen in the largest and strongest of the well-known living forms; and ossification has gone on to a higher degree than is usual in this family of birds, and more like what occurs in the Rails. It would be difficult to find two skulls in more perfect contrast with each other than that of *Dinornis robustus* and of the so-called *Dinornis casuarinus* (Trans. Zool. Soc. vol. iii. pls. 52 & 53, p. 348), the latter being in reality a Notornis†. It will save trouble in the comparison

* In the International Exhibition of 1862.

† Being anxious to know whether the eminent author of the paper above referred to had changed his view as to the nature of the pickaxe-headed bird since 1848, I referred to the well-known recent work of his (OWEN, Palæontology, 2nd edit. 1861, pp. 330–31). In that work the species of his genus *Palapteryx* are, with

of these forms if the latter bird is put at once into its own group; its specific name may stand, but I shall take the liberty, for the present at least, to speak of this huge Rail as *Notornis casuarinus*. In the Dinornis (see the photographs mentioned above) the occipital condyle is sessile, transversely oval, and deeply dimpled; in the great Notornis this condyle is elegantly hemispherical, strongly pedunculated, and has the dimple obsolete. In the Dinornis, as in the other Ostriches, the basioccipital is deeply scooped in front of the condyle below, and then becomes very tumid; in the Notornis there is one continuous concavity along the mid line, from the condyle to the front of the basitemporals; whilst each side of the bone gives off a strong keel where it joins with the down-turned edges of the exoccipitals; thus we get the most perfect counterpart of the basioccipital region of the "Delphinidæ." In the Dinornis the foramen magnum is subcircular; in the large Notornis it is oblong, being very high, and having almost straight sides. The exoccipitals of the Dinornis are very shallow, and help to form the tympanic cavity to a small extent only; the reverse of this is the case in the Notornis. In the Dinornis the basitemporals are small and entirely lateral; and in this photograph, in which the skull is given in a figure only 16 lines in length, a remnant of the posterior basicranial fontanelle can be seen, and this presupposes the absence of the secondary floor at that part. In the gigantic Notornis the basitemporals have their highest development. I had already noticed the extreme thickness of the combined basitemporal mass in the little native Corn-crake (*Crex pratensis*), and then in that connecting link between the Rails and Cranes, the Trumpeter (*Psophia crepitans*), and was therefore prepared to see a large outgrowing mass in this region in a gigantic form of the Rail-type. The outgrowing wings (pterygoid processes) of the basioccipital are repeated again in the basitemporals; and here, in this Giant Rail, they attain the largest size ever seen in the bird-class; next to this bird, in this respect comes the King Vulture (*Sarcorhamphus papa*), and next to that the Palamedea (*Chauna chavaria*); but in the latter the basitemporal mass, which is extremely thick, is developed most from side to side.

Now we saw that, in respect of the basitemporals, the Cassowary came nearest to the ordinary Mammalia; and the Dinornis is a casuarine Ostrich. This Great Rail, on the other hand, like the King Vulture and the Palamedea, has retained the basitemporal pterygoid processes of the Lizard. Now in the Lacertilia there is the merest shadow of the basisphenoidal "rostrum"; and in *Notornis casuarinus* it has about the smallest relative development of any bird that I am acquainted with—far smaller than in the other members of the Rail-tribe.

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great judgment, all merged in the genus *Dinornis*; the species are thus very numerous, viz., *D. elephantopus, giganteus, ingens, struthioïdes, rheïdes, dromioïdes, casuarinus, robustus, crassus, geranöides*, and *curtus*. Here is *D. casuarinus* in the very midst of ten struthious species, and yet as long ago as 1848 Professor OWEN well knew that the skull which he described under that name did not belong to a struthious bird.

It is but just to remark that the author had some doubts on his mind (see Zool. Trans. vol. iii. pt. 5, pp. 350 & 376) as to this matter; and one would be glad to know whether the term *casuarinus* has been applied by him to some really struthious fossil, the adze-headed bird being left out of the question.

We have shown that this rostrum attains its extremest size in the "Struthionidæ;" and amongst them it is largest in the African Ostrich. *Dinornis robustus* agrees entirely with the African bird in this respect, as the photograph beautifully shows, for the lower table of the bone is broken towards the base, and the coarse diploë can be seen within; in front of this abrasion the rostrum is seen swelling out into an enormous basiseptal beam, exactly as in *Struthio camelus*. At the base of the rostrum, in front of the basitemporals, the great anterior pterygoid processes are given off in the Dinornis; they extend further outwards than the basitemporals, as in all the Struthionidæ, and in no other birds. These processes are aborted in all the Rails, a mere trace being visible in some of them, as in the Crake; they are quite aborted in the Notornis, and they exist in no known Reptile; but they reappear in some Mammals, e. g., *Cavia*. In all the "Struthionidæ" the body of the basisphenoid intervenes (below) between the openings of the Eustachian tubes; in all other birds the basitemporals meet below these tubes so as to protect them with a lip-like floor, the tubes opening together close to the mid line; all this is well seen in the Notornis.

When in old birds the Eustachian tubes are at all enclosed in bone, in members of the Ostrich family the sheath is quite lateral, and is formed by the meeting of one lip from the basitemporal, and another from the "posterior pterygoid process;" they evidently have not even this protection in the Dinornis, but, as in the Emu, are only roofed by bone, and are at the widest distance apart. We spoke of both basitemporal and of anterior basisphenoidal outgrowths (wings); they coexist in the Palamedea and the King Vulture, but not in the Great Rail, which thus diverges furthest from the birds towards the Lizards; it had them all, however, in its infancy, for they exist in all embryo-birds.

In *Dinornis* the thick "rostrum" passes forwards to within a short distance of the body of the intermaxillary; in *Notornis* the feeble rostrum is broken off anteriorly; but even if it passed on in front of the vertical ethmoid as far as it does in *Crex*, *Ocydromus*, *Porphyrio*, and *Psophia*, yet it would still be an inch from the body of the intermaxillary. In *Dinornis*, as in the other Ostriches, the perpendicular ethmoid ossifies the whole septum, filling up the space between the large nasal fossæ; in *Notornis* this bone stops abruptly beneath the cranio-facial hinge, in the manner of a typical bird. The posterior wall of the lateral ethmoid is well ossified in *Dinornis*, and has coalesced with the middle bone; these osseous plates extend much further outwards than in *Notornis*.

The os quadratum of *Dinornis* is quite struthious, the upper head not being divided into two heads, the foreshadowings of the incudal crura of the Mammal; and the metapterygoid process is bluntly conical, as in the Emu. In the Giant Notornis this bone is thoroughly ralline, and at the same time perfectly typical. Professor OWEN has described it under the term tympanic (*op. cit.* p. 256), and has well shown its peculiarities. It comes very near that of its ralline congeners, especially *Crex*; and the form of its double upper head, convexo-concave, broad metapterygoid process, and pimple-shaped pterygoid process, are all diagnostic characteristics showing its true relationships.

The Ostriches have their pterygoid at its hinder end curled round the front margin of the os quadratum; there is a feebly-marked synovial facet on each bone, concave on the pterygoid, and convex on the quadratum; not so in typical birds, nor in the Notornis. If we look at the bone from below (*op. cit.* pl. 52, figs. 3, 28), we see a small, very high, bluntly cone-shaped process; on this the glenoid cavity at the end of the pterygoid rolls; it is one of the sharpest points of distinction between Ostriches and other birds. Let the observer take the oldest Green Turtle's head (*Chelone mydas*), and although he will not be able to find a distinct metapterygoid process, yet he will find this *pterygoid* process as a blunt style of cartilage; in the dry skull it loses this soft part, and a deep fossa is left.

The point of this cartilaginous projection articulates with the down-turned top of the now sickled-shaped, but once cylindrical "epi-pterygoid" (PARKER; "columella," CUV.); this latter bone, so large and erect in Lizards generally, is a mere transitory epiphysis in the highest types of birds, *e. g.* the Thrushes (*Turdus*), but the cup on its posterior end (= upper in the Lizard) rolls on the knob-like pterygoid process of the os quadratum. My apology for this digression is, that this knob-like process on the os quadratum of the Great Notornis is to the morphologist "a nail fastened in a sure place;" and on it, supposing a mere fragment of this os quadratum had been all we possessed of this bird, might have been hung the full weight of my assertion, viz. that the bird in question is not a congener of the Dinornis*.

The form of the pterygoids is determined by their relations, and can be deduced in both *Dinornis* and *Notornis*; totally different they must have been: in the latter they were slender, and yet short bones, with a deep concavity at the posterior end, and with no facet for the basisphenoid, such as existed in the Dinornis.

The palatines are not shown in the photograph of the Dinornis's skull, but the condition of the surrounding bones show that they were like those of the Emu, and projected but little in front of the suspensorial part. In the Great Notornis each palatine runs $2\frac{1}{2}$ inches in front of the proximal orbital process, and, totally unlike the feeble simple struthious palatine, has the typically ornithic deep groove below, bounded by the two well-marked keels. These palatines, instead of being wide apart, and having a huge vomer separating the two very distinct middle nostrils, are only separated by a space 3 lines wide; in this space (above) lies the tiny vomer, only 8 lines in length, scarcely

* Professor OWEN was perfectly aware of the non-struthious nature of this pickaxe-headed bird; he says (*op. cit.* p. 375), "The Dinornis, if it have no near ally in any known existing bird of New Zealand, appears to have but little immediate affinity to any of the struthious or other known birds in the rest of the world." Now I have compared this skull with those of the genera *Crex, Ocydromus, Tribonyx, Brachypteryx, Rallus, Gallinula, Notornis* (*Mantelli*), *Porphyrio*, and *Fulica*—all true Rails, and with those of the birds that lie in the region round about the Rails, such as *Psophia, Rhinochetus*, &c., and I am perfectly satisfied of its ralline nature. Moreover, now that there are many true struthious heads of the *Dinornis* in the British Museum, how is it that this skull, nearly as precious, and quite as unique as the skeleton of the *Archeopteryx*, is still shown to the public as that of a Dinornis?

as large as that of *Porphyrio poliocephalus.* In this vomer the hinder forks are larger than the body, which is slightly split at its apex: in its congeners this end is somewhat clubbed; the vomer is lost from this very fresh *Dinornis robustus* (York specimen). But the prevomer is well seen on one side; and its suture with the intermaxillary and its palatine zygomatic and ascending process are well shown: in the latter (ophidian) process it agrees rather with the Rhea and the Cassowary than with the Emu, or the African Ostrich. The prevomer of the Great Notornis is much broken; but it agrees with the Rails and many other typical birds in the manner in which it projects mesiad of the palatine, as it overlaps it in front of the middle nares. The largest part of the prevomer (the oblique lobe) is broken off in this fossil.

But the intermaxillaries of these two types diverge fully as much as any part; the madrepore-like perforateness of the body of the bone shows the place of *Dinornis robustus*; the oblique sparsely-scattered holes in the bone of the Notornis are exactly such as are seen in the smaller *Notornis Mantelli*, in *Porphyrio*, and *Ocydromus*, *Crex*, &c. The lateral grooves, known to every tyro, are well marked in the photographs. They are not present in the Notornis. In one thing these two gigantic forms agree, *e. g.* in the size of the body of the bone; but whilst in the Dinornis it is broadly-outspread, in the *Notornis* it is pinched, decurved, and apiculate. But the nasal process in *Dinornis* only reaches to the lacrymals, stopping in front of the broad ethmoid, and lying loosely over the rest of the face, as in its congeners; in the Notornis it reaches to the same transverse line as the postfrontal spurs, and is sunken into the substance of the skull above, and completely buries the ethmoid. Moreover, this process is thin and lath-like in *Dinornis*; it is a thick slab of bone in the Notornis. The nasals, as far as they are free, are quite struthious; in that family they end in a blunt style; in the Notornis their sutures can be well seen, and they are nearly half an inch wide, where they fit in between the frontals; they are crescentic in this their largest moiety, and curve round behind the nasal process of the intermaxillary, which lies low down between them; for the nasals are more than flush with the top of the frontals. The Dinornis, like the Rhea and Emu (*Dromæus Novæ Hollandiæ*), had scarcely any descending process to the nasal; in the Notornis the fragment of the root of this process shows it to have had precisely the same obliquity as in the ordinary Rails. The frontal region is of extraordinary breadth in *Dinornis robustus*; and the brows are so completely shielded by the outgrowing of the frontals, that the long superorbital process of the lacrymal has melted into the edge of the frontal, a space only being left for the upper part of the small nasal gland. The bony lowering of the brows is seen in other large massive forms, *e. g.* the Dodo (*Didus*), the Adjutant (*Leptoptilus*), and the King Vulture (*Sarcorhamphus*). The edge of the post-frontal is so much produced that the semicircularity of the superorbital rim is lost, and a sinuous and somewhat notched outline results. The whole upper head is one broad, gently convex shield-like mass, shelving down into the extremely wide and rather low occipital region. The temporal fossæ are not so well marked as in *Struthio camelus*, and that notwithstanding the far greater strength of the jaws. The thick, backwardly turned postfrontal is an inch in front of the descending splint-plate of the squamosal, which does not reach so far down the side of the os quadratum as in the ordinary Ostriches. This process is, however, nearly an inch long; in *Struthio camelus* 8 lines, and about 6 lines in the Great Notornis; but in the latter bird there is another osseous tongue an inch in length, and which runs over in front of the os quadratum to within 3 lines of the postfrontal, to which it is connected by an osseous bridge. This supernumerary bar of bone is double in *Porphyrio poliocephalus*, and the front one has connected with it a large ossified mass of the tendon of the temporal muscle.

The large anterior process in the Great Notornis lies so tightly upon the os quadratum, that a synovial gliding joint is formed at that part—a very curious structure. In *Porphyrio* the postfrontal is very short, and does not reach the squamosal spur; old individuals of the Psophia have this long process, which is of tendinous origin. This temporal bridge, which could not have existed if the postfrontal of the Great Notornis had not been of an inordinate size, is the rule in the Gallinaceæ, but is imperfect in *Talegalla*. But this overgrowth of the postfrontal in the Notornis is, as may be seen by the large oblique passages above it, merely a shooting of bone into the dense fibrous tissue of the superciliary region, and extends nearly an inch from the cartilaginous knob on the alisphenoid, which is the true postfrontal. This thick, notched, slit-up mass is ossified separately as distinct bones in the Psophia (half a Rail and half a Crane) and the Tinamous. The temporal fossæ of the Giant Notornis are equally developed with those of *N. Mantelli* and the Porphyrio, almost more so; and very different indeed to their indefiniteness in the strong-headed *Dinornis robustus*, notwithstanding that its jaws are relatively twice as strong as those of the Emu. Undoubtedly the lower jaw of this large Rail, with its pickaxe-shaped upper jaw, monstrously large ossa quadrata, and wide, deep, and well-margined temporal fossæ, must have been very strong; only a little inferior in this respect to that of *Notornis Mantelli*. In Pl. 53, figs. 1, 2, 3, *op. cit.* are given figures of the end of one of the mandibular rami of a large bird; on comparing these with the mandibles of struthious birds and Rails, I find that they agree with the latter; and with none better than the jaw of the little Corn-Crake, *Crex pratensis*. The whole shape of the "articulare," and the manner in which the "coronoid" turns obliquely upwards on the inside of the large open space, thus dividing it into two, these are perfectly ralline, and make it very probable that these are figures of part of the mandible of the Great Rail (*Notornis casuarinus*, Owen, sp.). With regard to the curve of the Great Notornis's bill, I think a few comparisons will make the matter clear. Let the reader put beside this large skull that of *Porphyrio poliocephalus*, and of the semiralline *Psophia*; if one straight line be drawn from the tip of the bill to the end of the zygoma, and another from the commencement of the zygoma to this ideal basal line, he will have the following results, viz. that the vertical line is one-ninth the length of the basal in the Porphyrio, and one-seventh in the other two. The curve downwards in the Great Notornis and in the Psophia is equal, is similar, and in the latter only wants the robustness of the former to make the likeness striking. This accords with the fact that the

Psophia agrees with this huge bird in another point in which the latter diverges from the ordinary Rails, viz. in the perfectness of the interorbital septum.

Professor OWEN (*op. cit.* p. 351) was somewhat staggered at finding the sulcus where the coronal suture had been in the Great Rail's skull, "behind the relative position of the persistent coronal suture in the skull of the Palapteryx." A very early stage of the Gallinule's skull explains this; for this and many other water-birds have the parietals very narrow, and the frontals extending far back; whereas the "Struthionidæ," one and all, including the Apteryx, have large broad parietals. The author of the paper quoted above seems to have despaired of finding any near relative for his supposed *Dinornis casuarinus* (see p. 375). I think that its relationships are evident enough, but its "spot is not the spot of the" daughters of the Ostrich.

Yet the predicament in which this huge bird seemed to be placed is really that of the Psophia; for at present we know of no near relative to this bird, which having a truly ralline head set upon the body of a Crane, yet possesses also the superorbital chain of ossicles in common with the struthious Tinamou; this character being borrowed from the Skink-lizards, who borrowed it from the ganoid Fish. Then, curious enough, the Psophia, as we have seen, differs from the Tinamous, the Cranes, and the Rails in having a strongly decurved beak and a perfectly ossified interorbital septum—in this agreeing with the most extraordinary development of the ralline type. Does all this bear upon the morphology of the struthious skull? Certainly; for I have to eliminate the false *Dinornis*, and to put the true typical bird beside the aberrant Ostrich, for comparison's sake: the gigantic Notornis served well for such a comparison. The author of the oft-quoted paper (p. 373) speaks of its "crocodilian cranium;" this may lead to some misconception. This is merely in the thickness of the basal part of the skull; and that is basilateral, and not mesial, as in the Crocodile.

But in the presence of the large basitemporal pterygoid processes, it agrees with the rest of the Rails and the Psophia, and only differs from them in their relative size; and the basal region is relatively quite as thick in *Fulica* and *Crex*. Then the extraordinary development of the tympanic cavities and of the Eustachian tubes in the Crocodile is not in anywise repeated in the Great Notornis, which only differs from the Ostriches, and not from typical birds. There are birds certainly which come near the Crocodile in the upward extension of the tympanic cavities, *e. g.* the Albatros and the "Rapaces," especially the Owls; in these the large diverticula, which pass upwards and inwards, do virtually meet at the mid line through the openness of the diploë which intervenes (at top) between the actual cavities. These extensions upward of the tympanic cavities can be seen distinctly in the "Rallinæ," and a trace can be detected in the Ostrich; but in no known bird is there anything like the Eustachian meatuses of the Crocodile; we might as well look for such pterygoids and such a palatine region as this creature possesses.

There is nothing more characteristic of the struthious bird than the structure of its intermaxillaries and nasals; and the only birds which approach the Ostriches in the loose manner in which the nasal processes of the intermaxillaries fit upon the top of the ethmoid anteriorly, are the Gallinaceæ; the Rails are very different in this respect. The skull of the Gallinule's chick is very instructive, as showing the *typical* condition of these parts; and with this little bird the extinct gigantic form agrees in all essentials. In the young Gallinule (about five weeks old) the nasal processes of the intermaxillaries are already quite confluent; and both together form a relatively large bar of bone, the exact counterpart of that of the gigantic form. But the whole of this bar is not to be seen from above, for it enters, almost undiminished in size, beneath the broad posterior part of the nasals, which form the front half of the superorbital region, from side to side. These broad plates still further hide the nasal part of the intermaxillary by each sending forwards a rounded lobe, the two lobes thus increasing the roof over this bar. The upper view of the skull of the Great Notornis shows this hiding of the posterior part of the intermaxillary, but not to the same degree; indeed this structure may be seen in many water-birds, *e. g.* the "Lamellirostres," especially the Palamedea and the Mute Swan; but in these the nasal part of the intermaxillaries is very slender, and the mesial suture is persistent.

Palapteryx.

The same valuable paper (plates 54 & 55, p. 360) contains figures and descriptions of the remains of some true struthious birds, under the generic term *Palapteryx*. I must refer the reader to the paper itself for the descriptions, reminding him that the nomenclature of the bony parts is very different from that which I am in the habit of using; *e. g.* Professor OWEN'S "mastoid" is my squamosal; his squamosal is here called "quadrato-jugal," and his "tympanic" "os quadratum," besides several others. I have carefully examined the original specimens, as well as the drawings in Professor OWEN'S paper, and I am quite of opinion that the somewhat unfortunate generic term *Palapteryx*—which would seem to indicate that this is the more generalized and ancient form of *Apteryx*—has been very properly dropped, as the birds were evidently, to all intents and purposes, only specifically distinct from the largest forms of *Dinornis.*

The beautiful photographs of *D. robustus* show that the solid part of the intermaxillary was unusually long and large, and that it was more decurved than is usual in the group; yet the differences between these extinct congeners of the Emu were not much greater than may be seen between *Dromæus irroratus* and *D. Novæ Hollandiæ.* The profile figure of *Palapteryx geranöides*? shows the intermaxillary too far removed from the skull, and thus giving the appearance of a longer head than that bird really possessed (see plate 54, fig. 1, *op. cit.*). The height and strength of the upper and lower jaws of this bird are somewhat remarkable for one of the "Struthionidæ," but *Dromæus irroratus* connects it with the feebler-faced *D. Novæ Hollandiæ.* The basal figure (fig. 3) beautifully displays the characters of the true Dinornis; and there is a remnant of the pituitary space, showing that the basitemporals were lateral, as in all the group. Like *Dinornis robustus*, the basisphenoidal "rostrum" swells out as it passes forwards; thus showing the relationship to the African type, which, as I have already related, is also strengthened by the condition of the sternum in *D. robustus*. It is extremely probable that at no far distant period New Zealand was inhabited by a large number of species of *Dinornis*, some of which may have had differences such as would, if we knew them, enable us to make some subgenera out of this group. Perhaps, at present, *Palapteryx* had better hold the smaller kinds, in a subgeneric way, and the largest kinds be called *Dinornis*; as for the so-called *D. casuarinus*, let it wheel off to its own phalanx, and take rank as the chief of the Rails.

Apteryx australis.

Not possessing any materials for working out the development of the young *Apteryx*, I must refer the reader to M. BLANCHARD'S very valuable work, 'L'Organisation du Règne Animal,' 20e Livraison, Oiseaux, Livraison 1re.

The two plates given in this first Number, on the Birds, are from drawings made by M. BLANCHARD himself, of the osteology of a young individual of *Apteryx australis*; they are exquisitely drawn and engraved, and are of the highest interest and value.

As I am able to compare these plates with the large series of young struthious skulls already described, and also with an almost indefinite number of growing skulls of the more typical species of land- and water-birds (in some cases of very many stages of the same species), I think that such a comparison will not be devoid of value. I must also refer the reader to Professor OWEN'S invaluable contributions on this subject (see Zool. Trans. vol. ii., and Osteol. Catalogue Mus. Coll. Surg. vol. i. p. 250. No. 1355*). M. BLANCHARD'S figure of the basal view of the skull (plate 2, fig. 2) does not give us anything that is new, for in this region coalescence of the parts in this young individual had already obliterated most of the sutures. The perfect struthiousness of the bird is, however, well shown; and the articulation of the large, distinct, flat posterior crura of the vomer can be seen articulating with the splint-like anterior part of the pterygoid, to the outer side of which bone the palatines have become anchylosed. The converging ridges that meet at the root of the basisphenoidal "rostrum," one from each basitemporal, join a keel which runs forwards under the rostrum, and backwards halfway to the basioccipital. The "rostrum" is subcarinate in the round-headed *Dromæus irroratus*, so different from *Struthio*, *Dinornis*, and *Rhea* in this respect. On each side, where the vomer becomes solid, the palatine can be seen articulating with the palatine process of the long intermaxillary. The transverse occipital condyle, the continuous head of the "os quadratum," and the very shallow drum-cavity, with its perforate roof and thick obtuse exoccipital back-wall, are well shown in fig. 2.

* There are some remarkable errors in this otherwise valuable abstract of Professor OWEN'S larger paper on the Apteryx; *e. g.* the "Ibis" referred to is not an Ibis at all, but one of the long-billed "Tringinæ" (see also p. 242. No. 1293); then the pterygoid processes in the Lacertine *Sauria* grow out of the basitemporals, and not out of the basisphenoid, which is aborted in them; lastly, the counterparts of the anterior pterygoid processes of the "Struthionidæ" exist in the embryo of all birds, and are developed in about two-fifths of the genera.

The lateral view (fig. 3) shows that the frontal had not coalesced with the parietal above, nor with the alisphenoid below; and also its distinctness from the nasal and antorbito-lacrymal mass anteriorly.

The gentle manner in which the occipital region graduates into the parietal is well shown in this figure (3), reminding the observer of the skulls of the Echidna, Mole, and Shrew; we also see the similar graduation of the skull into the face. The squamosal has united with the lower edge of the parietal; it binds the os quadratum strongly, with its large descending process, as in the other "Struthionidæ." The anterior sphenoid is of small extent, the "rostrum" is distinct from its base, but both base and alæ are completely confluent with the largely developed lateral ethmoids. These plates are very large and swollen; the upper, answering to the cribriform plate and back of the upper turbinal, the lower part to the pars plana, or back of the middle turbinal. There is a large notch in the lower edge of the orbital plate of the frontal; but this is made into a large irregular foramen by the immediate contiguity of the upper edge of the simple cribriform plate; this is the "upper orbital fontanelle;" and at this part the olfactory crus is only protected externally by membrane. There is no such open space in the skull of the adult African Ostrich, and in the Rhea it is only large enough to allow the olfactory crus to escape into the orbit, along which it passes to gain the *non*-cribriform chink between the vertical ethmoid and its ala. In the Tinamou (*Tinamus robustus* and *variegatus*) the broad end of this fontanelle and the olfactory chink are half an inch apart at the top of the large orbit. The postfrontal part of the alisphenoid is not developed, and the feeble postorbital process of the frontal does not come near that part of the skull; this is similar to what is seen in the Mole. The tumid "pars plana" projects outwards to anchylose with the inner edge of the lacrymal, which has the usual fenestra, but is very small, and is shorn of its superorbital part; moreover the large lateral development of the ethmoid has pushed up against the descending crus of the nasal, another unique character for a bird.

The middle plate of the ethmoid is not differentiated from the septum nasi, which has a fenestra behind, between the fullest part of the inferior turbinals. The metapterygoid process of the os quadratum is seen to be obtusely conical, as in the Emu, the quadrato-jugal to be much longer than is usual in the "Struthionidæ," the malar to be of the ordinary size, and the zygomatic process of the prevomer to reach nearly halfway along the zygoma.

With the skulls of two species of Tinamou before me, I am able to decipher the structure of the nasal of the Apteryx; for, as in those birds, it has a descending bar to this bone, which, as in them, thickens as it descends obliquely forwards, and is pedate below; behind, and within it, there is evidently a slight upgrowth of the prevomer (the ophidian process), such as I shall soon describe in the Tinamou.

The end view of the Apteryx's skull (pl. 2. fig. 3) shows the roundness of the crown, the great width of the occiput (unique in being the widest part of the skull), the transverse character (not hemispherical) of the occipital condyle, the projection, so smooth and round (as in the Mole) of the superoccipital plate, and the persistence of the middle part of the lambdoidal suture.

Perhaps the most interesting part of these illustrations is the upper view (pl. 2. fig. 1), for here are to be seen the greatest number of sutures.

Only the middle third of the lambdoidal is to be seen; but the sagittal and the coronoid are completely open, and show their teeth well. The parietals are aberrantly large, as in the other "Struthionidæ;" but the frontals, defrauded behind, are projected further forwards than in typical birds, on account of the diminished size of the posterior part of the nasals. An oval space, more than a line in length, appears in the parietal part of the sagittal suture, nearer the coronal than the lambdoidal suture. This is the famous *lacertian* "parietal fontanelle," which in the Apteryx appears for a little time and then vanishes away. Even in the dense skull of the Blind-worm (*Anguis fragilis*) this space will not fill up, but is a notable oval neat hole, and its constancy in the Lacertilia is not a little remarkable. In examining the skull of an extremely young Gecko*, I find that the great anterior fontanelle is lozenge-shaped, and that the posterior angle is rounded (and the same condition is to be seen in *Hæmatopus* during the first summer); this becomes the remnant of the originally large space which does not fill up. Now there are certain groups of birds which approach the Reptiles evidently, but not the Mammalia as well, as we see in the Ostrich-tribe; amongst these are the "Lamellirostres," from the hen-faced, free-toed Palamedeass, to the most perfectly-toothed of living feathered types—the Goosanders (*Merganser*). The semi-terrestrial species scarcely hide the fore paw in the wing; these are the Geese and the Screamers (*Palamedea*, *Chauna*). Now in the Geese and Swans the "parietal fontanelle" of the Lizard reappears, and is often persistent; for in very old individuals the anterior fontanelle is badly filled up. In the oldest and densest common Goose's skull in my possession three of the angles of the original lozenge are still open, the posterior of these being the counterpart of that in the adult Lizard. In the Common Duck (*Anas boschas*) this structure may be seen during the first summer; it then fills up. The upper view (fig. 1) of the Apteryx's skull shows well the extension forwards of the parietals, and consequent shortening of the frontals, which, however, are themselves developed much more anteriorly than in other birds; for, as in the other Ostriches, the nasals of the Apteryx are but narrow behind, and the exposed portion of the ethmoid is only moderate, as in the Rhea. The long nasal part of the intermaxillaries, as is usual in the tribe, ends in front of the lacrymal; but this is not unlike what is seen in those simpler types of the "Grallæ" which have, like the Apteryx, long bills, e. g. *Tringa*, *Limosa*, *Numenius*, *Hæmatopus*. In most of these, these processes are very delicate, and pointed towards the end; but in the *Hæmatopus ostralegus* each moiety (in the young bird) ends separately in a flat lath-like flap; this divergence of these intermaxillary rami, with a rather persistent separateness, and their flat condition, is exactly like what is shown in this figure of the Apteryx. This leaning, as it were, to

* A *Hemidactylus*, from Barbadoes.

the simple, but thoroughly differentiated and typical "Grallæ" is extremely interesting, because in the next subgroup (the Tinamous) the characters of special types begin to break out and to become unmistakeable; so that these birds seem to have something mixed and monstrous in them, a very patchwork of ornithic qualities. The nasal processes of the intermaxillaries of the Apteryx continue distinct (at this stage) for an inch; combined, they form a strong bar more than 3 lines thick; then the solid part is extremely short, and being deeply grooved, looks as though the nostrils were subterminal; the nasals flank the nasal processes of the intermaxillaries for nearly half their length posteriorly. The angle of the dentary plate of each intermaxillary reaches two lines further backwards than the nasal process.

Plate 2, figs. 3 & 5, show the five usual splints and the "articulare;" the symphysis is three-fifths the length of the mandibles; and the splenial pieces, which are 3 inches long, have nearly half their length in front of the divergence of the rami.

The os hyoides (pl. 2. fig. 8) agrees with what I have described in the Emu and Cassowary, viz. a basi-uro-hyal piece pointed at both ends, and a two-jointed pair of first branchials; but the flattened cerato-hyals are not shown in this figure.

In the descriptions that follow I shall make use of these observations upon the skull of the young Apteryx; and a comparison of the Tinamous with the other "Struthionidæ," without the Apteryx, would have been very imperfect. Of all known birds, the Apteryx and the Cassowary appear to me to be least ornithic and most generalized; the leaning of the latter is evidently most to the Gallinaceæ, that of the former to the long-billed "Pluvialinæ;" but the Cassowary and the Apteryx seem to approach equally near to the Mammal on one hand, and to the Reptile on the other.

Tinamus variegatus and *robustus*.

I have in another place (Zool. Trans. vol. v.) described the skull of *Tinamus robustus*, but there are points of its structure which must be described here, in comparison with that of *T. variegatus*. In the paper just referred to I have given at length my reasons for placing these birds with the "Struthionidæ;" we shall find as we proceed that whatever tendencies to affinity with other groups may be discerned in the larger Ostriches, yet these declarations for special types are but feebly uttered, when compared with what is manifested in the "Tinaminæ." The Fowl and the Plover strive for mastery here, but the nature of the bird has to be drained through several generic "limbecks" before it becomes pure and simple enough to be truly gallinaceous or truly pluvialine; the Sandgrouse and the Hemipods, and even the Megapods, all intervene between the evidently heterogeneous Tinamou and the true Fowl and Plover*.

The first point to be noticed in the Tinamou, the occipital condyle (Plate XV. fig. 2, *oc.*), is a departure from what we have seen in the "Struthionidæ;" and although this

* Now the hand of DARWIN is not with me in all this; nor need the patient positive observer be anxious as to what these things will grow; the truth of the matter being ascertained, let come of it what will, we are not careful to answer in this matter.

bird comes so near the "Gallinæ," which have this knob bifid, yet in the Tinamous it is oval longitudinally, being an exaggeration of what exists in the Rails and even in Plovers. The thick basal region of the skull (*b.o.*, *b.s.*) is gently convex, and in *T. robustus* is also slightly carinate anteriorly; there are indeed four carinæ, as in the Apteryx, the longitudinal ridge being broken at the base of the rostrum, by a remnant of the pituitary space (see Zool. Trans. vol. v. pl. 40, fig. 1, in which figure the converging lateral ridges might be mistaken for the edges of the basitemporals, which in typical birds do meet at that point). The eustachian canals are floored by bone for a very small space, and lie very far apart at their exit—further apart than in some of the large Ostriches. The rostrum of the basisphenoid (*r.b.s.*) is keeled in both species—most so in *T. robustus*, in which it extends further forwards than in *T. variegatus.* The anterior pterygoid processes (*a.p.*) are wider in the former than in the latter, but there is no evident difference in the posterior outgrowths; in both the spurs that often grow from the basitemporals are entirely aborted. The extreme shallowness of the ear-drum, arising from the shortness of the exoccipital wings (Plate XV. fig. 1, *e.o.*), is well shown in both; the occipital plane agrees, on the whole, with that of the Apteryx, but the edge of the parietals overhangs the superoccipital instead of graduating insensibly into it (Plate XV. fig. 1). There is more bone in the septum of *T. variegatus* than in that of *T. robustus*, but in the latter the presphenoid reaches the conjunction of the basisphenoid with the perpendicular ethmoid; it does not in *T. variegatus* (Plate XV. figs. 1 & 4, *p.s.*). In the latter the anterior sphenoid stands in front of the orbital plates of the frontal; in *T. robustus* it passes behind those plates. In both there is a most unique display of sutures at this part, these being most clearly seen in *T. variegatus* (Plate XV. figs. 1 & 3), although the bird (as Mr. BARTLETT informs me) was in its fourth year. In this bird the alisphenoid (*a.s.*) is distinct from the frontal (*f.*) above, from the basisphenoid (*b.s.*) below, and from the orbito-sphenoid (*o.s.*) in front; also from the postfrontal epiphysis at its supero-external angle (*p.f.*). The extremely small presphenoid and orbito-sphenoids are still separated from their surroundings by distinct sutures, the upper bar of the ethmoid (fig. 1, *p.e.*) nearly reaching the alisphenoids, and nearly insulating the interorbital fenestra behind—a most unusual abortion of the anterior sphenoid, as compared with the Mammal, the Reptile, or even with some of the Struthionidæ, but perfectly ornithic. The sagittal and lambdoidal sutures (Plate XV. fig. 3) are thoroughly obliterated; but the coronal suture (Plate XV. fig. 3) is as completely open as in the Lizard, and joins that between the alisphenoid and frontal on each side. In *T. robustus* the alisphenoid has joined itself to the basisphenoid below; the other sutures are the same, and the important coronal suture was not drawn in my other paper because the skull was diseased at top; afterwards I found the suture thoroughly open at the sides, as in *T. variegatus*. This is only part of what is reptilian in these birds; and it is curiously in contrast with the very solidified condition of the rest of the skull. In *T. variegatus* the suture between the high prepituitary portion of the basisphenoid and the lower bar of the ethmoid is quite visible; and in both the junction of the rostrum with the ethmo-presphenoidal plate can be seen, although anchylosis has taken place in some degree. In both the perpendicular ethmoid is continued on into the septum nasi, the whole being one bone, reaching from the exit of the optic nerves to no great distance from the solid part of the intermaxillary. No distinction between the upper and vertical ethmoid can be seen, and in *T. robustus* the aliethmoid, pars plana, and basal part of the inferior turbinal have coalesced with each other, and with the antorbital plate of the lacrymal, thus agreeing with the Apteryx. In *T. variegatus*, however, the boundaries of all these parts can be clearly seen as fine sutures (Plate XV. fig. 13), the upper and perpendicular part (*eth.*, *p.e.*) only having lost their distinctness. In one important point the stouter kind (*T. robustus*) differs from the other, and approaches the typical birds, viz., in the commencement of the great ethmo-septal cleft (Plate XV. fig. 8, *c.f.c.*), by which the upper jaw is allowed to be hinged in to the head. All birds go through the struthious stage in their embryonic condition, and at a further stage agree with this Tinamou. In *T. variegatus*, so nearly allied, this cleft does not appear; this shows the importance of not drawing our conclusions too hastily, and of the necessity for suspecting mere negative evidence—the "instance contradictory" may turn up in the hundredth species*. There is a very regular posterior nasal zone, in which ossification takes place freely (Plate XV. fig. 13, *eth.*, *a.i.t.*); on a sudden it stops, and then all the rest, save the axis and a little of the roof, or roots of the inferior turbinals, is cartilaginous; yet in *T. robustus* some dendritic bony threads creep forwards into these cartilages; there are no true upper and middle turbinal outgrowths; and the ossified part of the inferior turbinal is closely conjoined to the front of the outstanding part of the "pars plana" (Plate XV. fig. 13, *p.p.*, *al.s.*); its upper part is vertical, and nearly parallel with the perpendicular ethmoid (*p.e.*), thus moving upwards to join the slanting overhanging aliethmoidal lamella (Plate XV. fig. 13, *al.e.*), the only rudiment of the upper turbinal mass and cribriform plate of the mammal. Anteriorly, this lamella, where it grows out of the septum nasi, becomes the outer nasal wall and root of the inferior turbinal (Plate XV. figs. 9, 13, *al.s.*); it passes nearly halfway down in a convex manner, and then becomes double, the outer plate forming a new convexity, and the inner turning upwards and inwards to coil rather more than twice (Plate XV. fig. 9, *it.b.*). Further forwards its coil is only one and a third (fig. 10), and then in the alinasal region, when the alæ are free of the septum, it simply passes inwards and a little downwards, but like the alinasal of the Rhea, its outgrowth is a little more labyrinthic than the inferior turbinal, for it gives off the rudiments of three other plates (Plate XV. fig. 11). The complication of these turbinal growths in the alinasal region is an interesting character. I must refer to my other paper for a description of the facial structures of the Tinamou, merely remarking that the anterior part of the palatine (Plate XV. fig. 2, *pa.*) is much shorter in *T. variegatus*, and that the metapterygoid process of the os quadratum (*q.*) is much broader (*ralline*) than in

* As far as I have seen there is no "mesopterygoid" in the typical "Struthionidæ," nor in *Tinamus variegatus* and *robustus*; an "instance contradictory" turns up, however, in *T. brasiliensis* sive *major*, where it is very large, and permanently distinct.

T. robustus. The nasal processes of the intermaxillaries (*px.*) are entirely soldered together in both kinds, but they are very pluvialine, as may be seen by comparing them with those of the Lapwing; they also agree, in the main, with those of the Apteryx, save that the tips come close together and are very narrow, as in most of the "Pluvialinæ" (Plate XV. fig. 3, *px.*). The lateral grooves, the beautiful vascular punctæ, the short angular processes, and the large, long, flat palatine processes of the intermaxillaries (Plate XV. fig. 3) are all strictly struthious, as may be seen by a comparison of the numerous figures showing these parts. In *T. variegatus* the ascending process of the prevomer is small, and the pedate proximal process is not marked out from the body of the bone (Plate XV. fig. 2, *p.v.*); in *T. robustus*, however, we come nearer the "Gallinaceæ" proper, the Megapods, the Sandgrouse, the Hemipods, and the innumerable Corvine, Sylviine, Fringilline, and other related groups in the differentiation of this remarkable process, long supposed to be the inferior turbinal. In *T. robustus*, this narrow, flat, curled, gradually widening process is turned somewhat backward; and as it passes also inwards comes down upon the anterior process of the palatine, and coalesces with its upper and inner edge (Plate XV. figs. 6, 7, *p.v.*). The delicate angular process of the intermaxillary is $1\frac{1}{2}$ line long in *T. variegatus*, and 6 lines long in *T. robustus*, in which it is continued to the foot of the descending process of the nasal (Plate XV. figs. 6, 7); feeble, indeed, and clubbed at its end. The very large "vomer" (Plate XV. fig. 2, *v.*), deeply cleft behind, and having two long forks in front, is struthious enough; in the Hemipods it is extremely short and broad; in the Sandgrouse and Pigeons seldom present at all; in the "Phasianinæ" and "Tetraoninæ" it is very feeble, and not much stronger in the Megapods; in the Plovers and Rails it attains a medium size; but the Tinamous hold with the large Ostriches in this most important and very reliable character. The nasals (*n.*) of the Tinamous come still nearer to those of the Plovers than do those of the Apteryx; but the posterior portion is so completely amalgamated with the frontal, ethmoid, and lacrymal, that it cannot be told how much nearer they came to the Plover's nasals. To all appearance there is but little difference; and so also as to the frontals (*f.*), especially if we compare the Tinamous skull with such species as have but little of the frontal developed below and beyond the nasal gland. So also the lacrymals (*l.*); these have lost their superorbital process, and like the Cassowary, have no antorbital fenestra. The narrowest part of the combined frontals is only 3 lines in *T. robustus*, scarcely more than 2 lines in *T. variegatus*; the outer margin being also bevelled deeply for the nasal gland, and that also almost to the postorbital region. But in *Vanellus*, *Charadrius*, and others, the frontals run below and beyond the gland, and are very wide; I have already shown (Trans. Zool. Soc. vol. v.) how this is supplemented in *Tinamus robustus*. In that bird the superorbital chain of bones is single, with one intercalary bone on each side; but *T. variegatus* has two rows (Plate XV. fig. 3, *s.o.b.*) all along, about 14 or 15 on each side. I have already compared these to the superorbitals of the Skink-lizards, Blind-worms, and Trigonal Cayman, and have noticed their presence in another bird, viz., the Trumpeter (*Psophia crepitans*), only in an enfeebled form. I would now add to this category the marginal plates of the cranial bucklers of the recent and extinct ganoid Fish, viz., *Sturio*, *Dipterus*, *Osteolepis*. The bone in the Sturgeon, which Professor HUXLEY has compared to the so-called squamosal (pterotic) of the osseous fish, is merely one of this category; so also are those in front of it, one of these being the homologue of the postorbital bone of the Reptilia, and a mere splint-bone, and not the homologue of the postfrontal of the Fish and the Bird. I am aware that in the Skinks and Blind-worms the process of ossification has affected much more of the derm-fibres than in the bird, only a thin layer being left as a *quick* for the epidermic cells, which form the investing scales; this, however, does not alter the homology of the parts; nor would it if the whole skin were converted into hard, naked, enamelled bone. Any one familiar with the histological development of these parts will make no difficulty here.

The mandibles of the Tinamou (Zool. Trans. vol. v. pl. 40, figs. 3, 6, 7) are as truly struthious; the thoroughly cemented symphysis is $5\frac{1}{2}$ lines in extent in *T. variegatus*, and the lateral lines and the large punctæ are the precise counterpart of those in the upper jaw. The distinctness of the mandibular splints is feebly shown, and there is no open space; the angles of the jaws (external and internal) are but little produced; the latter, the most important, being the homologue of the "manubrium mallei," is in a low developmental condition, this part being relatively largest in the little "hammer" of the Mammal, and completely wanting in the large "articulare" of the osseous Fish. They are both large in the Gallo-anserine series of birds; and the internal angular process is large in Finches and Crows.

The os hyoides (Plate XV. fig. 12) is much like that of the Gallinaceæ in outward form, but is in reality much less developed; the narrow cerato-hyal cartilages (*c.h.*) have almost coalesced; they are distinct at the middle, and they diverge behind. The basi-hyal (*b.h.*) is not distinct from the uro-hyal (*u.h.*); but a short bone is developed in the proximal part of the latter; it is rounded, and blunt at the end. The lowest thyro-hyal (*th.* 1) is almost entirely ossified, and the upper (*th.* 2) has only the tip cartilaginous; these parts come very near to those of the Fowls, but they have a bony basi-hyal also; and in them the posterior two-thirds of the partly coalesced cerato-hyals has become bony.

Description of the Plates*.

PLATE VII.

Struthio camelus, "A." One-third of incubating period.

Fig. 1. Primordial skull, seen from above; 3 diameters: *b.o.* basioccipital; *n.c.* notochord; *e.o.* exoccipital; *f.m.* foramen magnum; *s.o.* superoccipital; 9. 9th nerve; *a.s.c.* anterior semicircular canal; 5. trigeminal nerve; *a.s.* alisphenoid; *i.c.* internal carotid; *pt.s.* pituitary space; *p.cl.* posterior clinoid; *a.cl.* anterior clinoid; 2. optic nerve; *o.s.* orbito-sphenoid; *cr.g.* crista galli; *eth.* ethmoid; *p.p.* pars plana; *al.e.* aliethmoid; *al.s.* aliseptal; *al.n.* alinasal; *p.n.* prenasal.

Fig. 2. Vertical section of the same skull; 3 diameters: *o.c.* occipital condyle; 8. 8th nerve; 7. 7th nerve; *b.s.* basisphenoid; *s.c.* sinus canal; *a.p.* anterior pterygoid process; *p.s.* presphenoid; *r.b.s.* rostrum of basisphenoid; *p.e.* perpendicular ethmoid; *s.n.* septum nasi; 1. olfactory nerve.

Fig. 3. Side view of entire skull; 3 diameters: *m.t.* membrana tympani; *n.g.* nasal gland; *d.* dentary; *s.a.* surangular; *a.* angular; *ar.* articular.

Fig. 4. Lower view of ditto; 3 diameters: *b.t.* basitemporal; *p.g.* pterygoid; *pa.* palatine; *p.v.* prevomer; *v.* vomer.

Fig. 5. Upper view of the same skull; 3 diameters: *q.* quadrato-jugal; *j.* jugal; *n.* nasal; *l.* lacrymal; *p.x.* premaxillary.

Fig. 6. End view of the entire of skull of the same; 3 diameters: *fo.* fontanelle; *f.* frontal; *p.* parietal; *sq.* squamosal; *q.* os quadratum; *p.s.c.* posterior semicircular canal; *h.s.c.* horizontal semicircular canal.

Fig. 7. Os hyoides of the same; 3 diameters: *c.h.* cerato-hyals; *b.h.* basi-hyal; *u.h.* urohyal; *th.* 1. lower thyro-hyal; *th.* 2. upper ditto.

PLATE VIII.

Fig. 1. Side view of skull of *Struthio camelus*, "B.;" 2 diameters.

Fig. 2. Lower view of the same; 2 diameters: *st.* stapes; *p.r.p.* posterior pterygoid process.

Fig. 3. Upper view of skull of *Struthio*, "B.;" 2 diameters.

Fig. 4. End view of skull of *Struthio camelus*, "B.;" 2 diameters: *p.c.f.* posterior condyloid foramen; *op.* opisthotic.

Fig. 5. End of mandible, seen from above, of *Struthio*, "C.:" *pn.* pneumatic foramen.

* The *cartilage-bones* are distinguished from the *splint-bones* in the Plates by being sparsely dotted; the cartilage itself is finely and closely dotted, and the membranous spaces are cross-barred.

Fig. 6. Os hyoides of *Struthio*, "C.;" 2 diameters.

Fig. 7. Vertical section of anterior part of skull of *Struthio*, "C.;" 2 diameters. The oblique lines 1–1 to 6–6 show where the sections in Plate X. were taken, viz. 1, 1 to fig. 1, 2, 2 to fig. 2, &c. on to 6, 6, which answers to fig. 6.

Fig. 8. End view of skull of *Struthio*, "C.;" 2 diameters.

Fig. 9. Part of primordial skull of *Struthio*, "C.;" 2 diameters: *eu.* Eustachian groove; *a.r.q.* articular facet on the exoccipital wing for os quadratum; *f.s.r.* fenestra rotunda vel cochleæ.

Fig. 10. Vertical section of the skull of *Struthio*, "C.;" 2 diameters: 5. foramen ovale, with f. rotundum in front of it; *m.k.* MECKEL'S cartilage; *sp.* splenial; *cr.* coronoid.

Fig. 11. Section taken transversely through pars plana, and end of inferior turbinal of *Struthio*, "C.;" 4 diameters: *m.t.b.* middle turbinal fold; *i.t.b.* base of inferior turbinal; *ext.* external aspect of pars plana; *int.* internal ditto.

PLATE IX.

Fig. 1. *Rhea americana*, var. Primordial skull, seen from above: *p.f.* postfrontal; 2 diameters.

Fig. 2. Side view; 2 diameters.

Fig. 3. Entire skull, side view: *d.n.g.* duct of nasal gland; 2 diameters.

Fig. 4. Entire skull, lower view; 2 diameters.

Fig. 5. Entire skull, upper view; 2 diameters.

Fig. 6. Entire skull, end view; 2 diameters.

Fig. 7. Os hyoides; 2 diameters.

PLATE X.

Fig. 1. Transversely vertical section of skull of *Struthio*, "C." in front of the eye-ball, seen from behind; 4 diameters: *a.i.t.* angle of inferior turbinal.

Fig. 2. A similar section further forwards; 4 diameters: *n.px.* nasal process of premaxillary; *i.t.* inferior turbinal; *s.n.* septum nasi.

Fig. 3. Another section a line or two in advance of the last; 4 diameters: *n.t.* nasal turbinal.

Fig. 4. Another section in front of the last; 4 diameters: *a.px.* angle of premaxillary.

Fig. 5. Another through the alæ nasi; 4 diameters.

Fig. 6. Another in front of the alæ nasi; 4 diameters.

Fig. 7. Vertical longitudinal section of primordial skull of *Rhea*; 2 diameters: *i.o.s.* interorbital space; 5 *a.* foramen rotundum.

Fig. 8. *Rhea Americana*, var. Part of skull, side view; 4 diameters. The outer part is pared away to show the semicircular canals.

Fig. 9. Section of upper ethmoid, showing its alæ, in the Rhea.

Fig. 10. Horizontal section through pars plana of *Rhea*; 4 diameters.

Fig. 11. Front view of pars plana and middle turbinal of *Rhea*, showing a section of the lower turbinal; 4 diameters.

Fig. 12. Part of fig. 13; 8 diameters.

Fig. 13. Section of combined upper and perpendicular ethmoids of *Rhea*, showing their junction and the coalescence of the right and left lamellæ of the perpendicular part; 4 diameters.

Fig. 14. Ditto, section through the widest part of the inferior turbinals of *Rhea*; 4 diameters.

Fig. 15. Transversely vertical section through the septum nasi and lower turbinal of *Rhea* further forwards; 4 diameters.

Fig. 16. Similar section through the alæ nasi of the same, showing the fibrous pads attached to the nasal turbinals; 4 diameters.

Fig. 17. View from within of pars plana of the Mooruk, with its middle turbinal, simple upper turbinal semi-scroll, and posterior part of inferior turbinal; 4 diameters.

Fig. 18. Ditto, section through anterior part of ethmoid of the same, and posterior part of inferior turbinal; 4 diameters.

Fig. 19. Ditto, section through widest part of nasals, and fullest part of inferior turbinals; 4 diameters.

Fig. 20. Ditto, section through the hinder part of ethmoid of the Mooruk, and through frontals and anterior sphenoid; 4 diameters.

PLATE XI.

Fig. 1. *Dromæus irroratus*, "A." Side view of skull; 2 diameters: *i.e.s.* interethmoidal space.

Fig. 2. Ditto, basal view; 2 diameters.

Fig. 3. Ditto, upper view; 2 diameters.

Fig. 4. Ditto, ditto, end view; 2 diameters.

Fig. 5. Upper view of part of lower jaw of the same Emu; 4 diameters: *sp.* splenial.

Fig. 6. Ditto, ditto, proximal end seen from above; 4 diameters: *c.r.* coronoid.

Fig. 7. Ditto, obliquely basal view of hinder part of skull; 4 diameters: *m.p.g.* metapterygoid; *eu.* Eustachian groove; *sy.* symplectic, with its anterior and posterior rays given off near the shaft of the "stapes."

Fig. 8. Ditto, os hyoides; 2 diameters.

Fig. 9. End view of skull of "*Dromæus* B.;" $1\frac{1}{2}$ diameter.

Fig. 10. *Dromæus Novæ-Hollandiæ* ("B."). Part of skull and face, side view; 3 diameters: *ep.* epiotic; *m.p.q.* metapterygoid process of os quadratum.

PLATE XII.

Fig. 1. Side view of skull of "*Dromæus*, B."; $1\frac{1}{2}$ diameter.
Fig. 2. Basal view of skull; $1\frac{1}{2}$ diameter.
Fig. 3. Upper view of ditto; $1\frac{1}{2}$ diameter.
Fig. 4. Side view of part of the same skull; 3 diameters.
Fig. 5. Part of the same preparation, shown in Plate XI. fig. 10; 6 diameters: *sy.* symplectic; *an.* anterior process; *p.r.* posterior process.
Fig. 6. End view of primordial skull of *Dromæus irroratus* ("C."), two months old; 2 diameters.
Fig. 7. Upper, middle, and hinder part of inferior turbinal, seen from within, of *Dromæus*, "D." (2 diameters).
Fig. 8. Ditto, the same preparation seen from the front.
Fig. 9. *Dromæus irroratus* ("D."), half-grown. Section through fullest part of inferior turbinal; 2 diameters.

PLATE XIII.

Fig. 1. Basal view of skull of "*Dromæus*, C.;" $1\frac{1}{2}$ diameter.
Fig. 2. Side view (external) of the same; $1\frac{1}{2}$ diameter.
Fig. 3. The same, seen from above; $1\frac{1}{2}$ diameter.
Fig. 4. Internal view of hinder part of ditto; $1\frac{1}{2}$ diameter.
Fig. 5. Side view of ethmoid, showing part of interorbital, and part of internasal septum; $1\frac{1}{2}$ diameter.
Fig. 6. Hinder view of same; $1\frac{1}{2}$ diameter.
Fig. 7. The skull, front view, as seen from the back of the orbits; $1\frac{1}{2}$ diameter.
Fig. 8. Front view of lacrymal; $1\frac{1}{2}$ diameter.
Fig. 9. Proximal upper view of mandible; $1\frac{1}{2}$ diameter.
Fig. 10. Proximal end view of mandible; $1\frac{1}{2}$ diameter.
Fig. 11. Proximal part of mandible, seen from below; $1\frac{1}{2}$ diameter.
Fig. 12. Facial bones of *Dromæus irroratus* ("A."), seen from above: *m.x.* maxillary; 4 diameters.
Fig. 13. Side view of the same, showing both the maxillary and the oblique (proximal) process of the prevomer.

PLATE XIV.

Casuarinus Bennettii (full period).

Fig. 1. Side view of skull; 2 diameters.
Fig. 2. Lower view of skull; 2 diameters.
Fig. 3. Upper view of skull; 2 diameters.

Fig. 4. End view of skull; 2 diameters.

Fig. 5. Side view of skull from within; 2 diameters.

Fig. 6. Side view of skull of do. with the outer part pared away to show the structures of the internal sac; 4 diameters: *c.h.l.* cochlea; *c.f.* cerebellar fossa.

Fig. 7. Transversely vertical section of skull of *C. Bennettii*, seen close behind the lateral ethmoids; 2 diameters.

Fig. 8. A similar section through the interorbital space; 4 diameters.

Fig. 9. Horizontal section through the left pars plana with its middle turbinal tent; 8 diameters.

Fig. 10. Another section at the lower part of the turbinal, showing a bifurcation of the turbinal outgrowth; 8 diameters.

Fig. 11. A similar section a line lower down than fig. 9, showing the anterior opening into the tent; 8 diameters.

Fig. 12. Os hyoides of *C. Bennettii*; 2 diameters.

PLATE XV.

Fig. 1. Side view of skull of *Tinamus variegatus*, adult (4th year): *s.o.b.* superorbitals; 2 diameters.

Fig. 2. Basal view of skull; 2 diameters.

Fig. 3. Upper view of skull; 2 diameters.

Fig. 4. Part of fig. 2; 4 diameters; showing the anterior sphenoid and its surroundings: *f.* orbital plate of frontal.

Fig. 5. *Tinamus robustus*, adult. Inside of anterior part of skull; 4 diameters.

Fig. 6. *Tinamus robustus*, part of the face seen from above; 4 diameters: *p.p.v.* proximal process of prevomer.

Fig. 7. *Tinamus robustus*, side view: *p.x.* angle of premaxillary.

Fig. 8. *Tinamus robustus*, part of ethmoid and nasal septum, side view; 4 diameters: *c.f.c.* rudiment of cranio-facial cleft.

Fig. 9. Section through fullest part of the inferior turbinals of *Tinamus variegatus*; 6 diameters.

Fig. 10. Another section further forwards; 6 diameters.

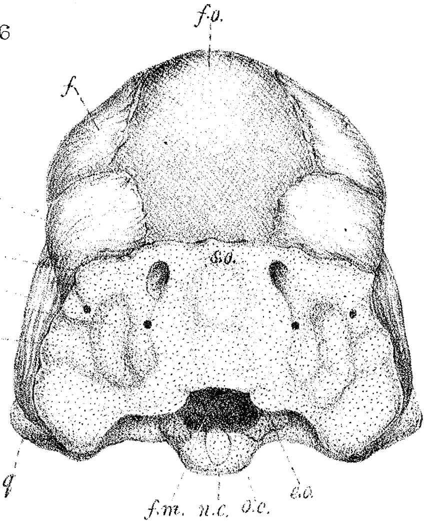
Fig. 11. Another through the alæ nasi, and in front of the septum nasi; 6 diameters.

Fig. 12. Os hyoides of *Tinamus variegatus*; 2 diameters.

Fig. 13. *Tinamus variegatus*, adult. Side view of nasal structures, with the lateral bones removed; 4 diameters.

Fig. 14. Inferior turbinals of *Psophia crepitans* without the prepalatine splints; 4 diameters.

Fig. 6



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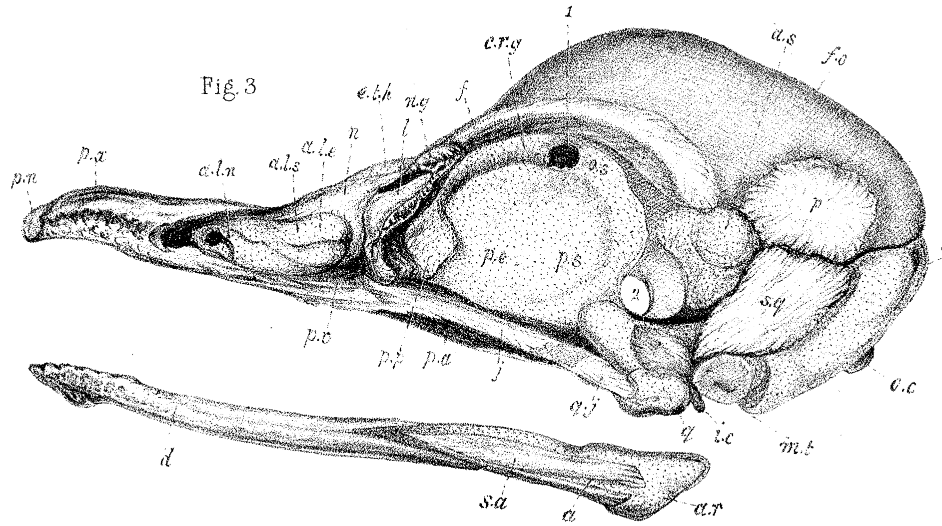
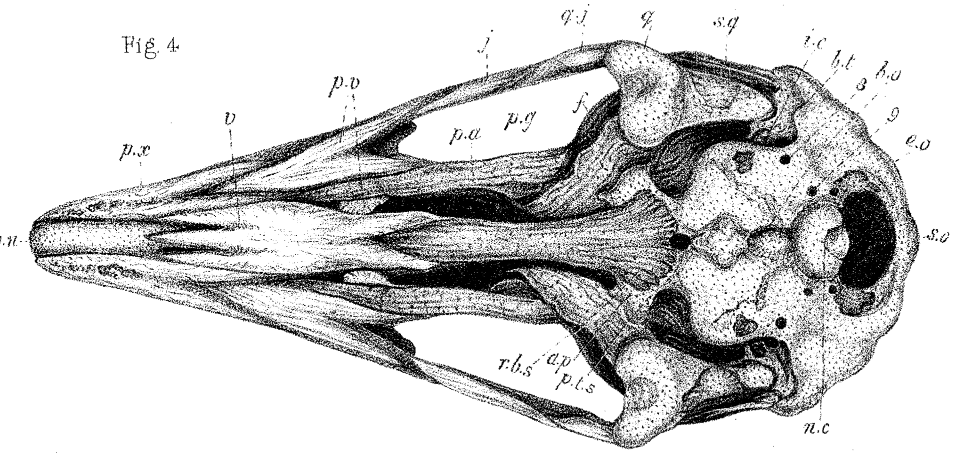


Fig. 4



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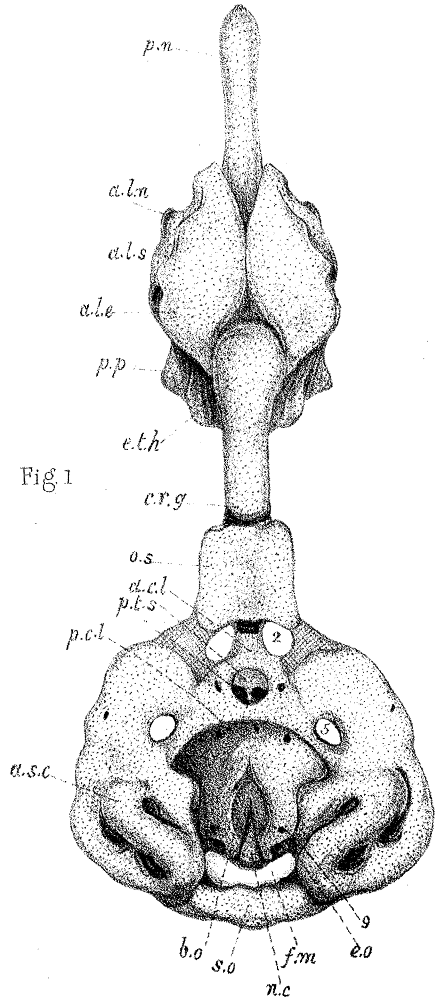

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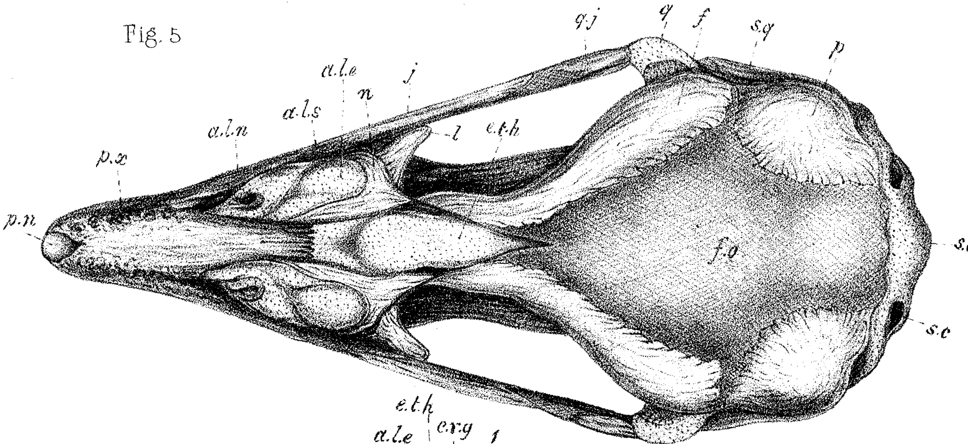

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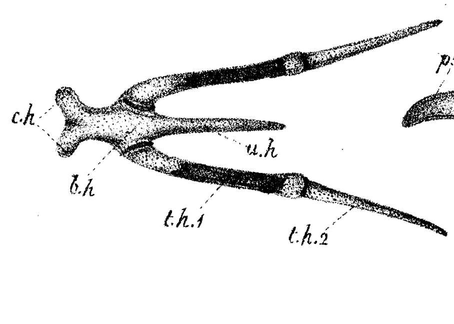

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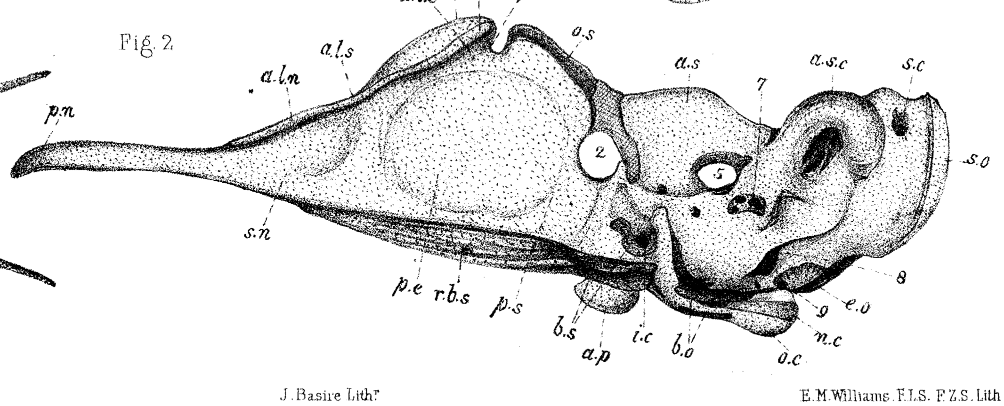
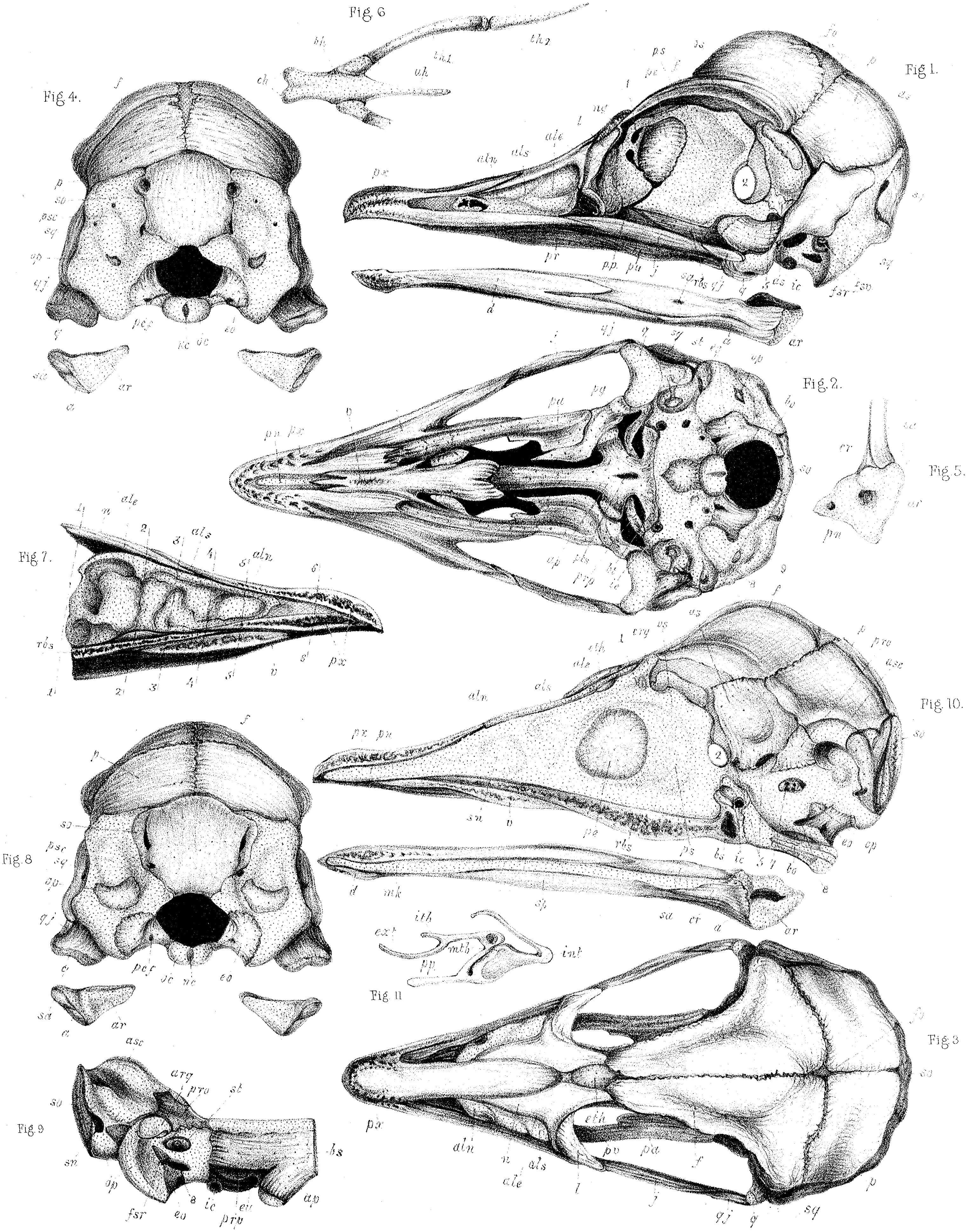


W. K. Parker ad. Nat. del. J. Basire Lith. E. M. Williams. F.L.S. F.Z.S. Lith.

Struthio "A". 3. Diam.

Pl. 7. Page 114. 123.



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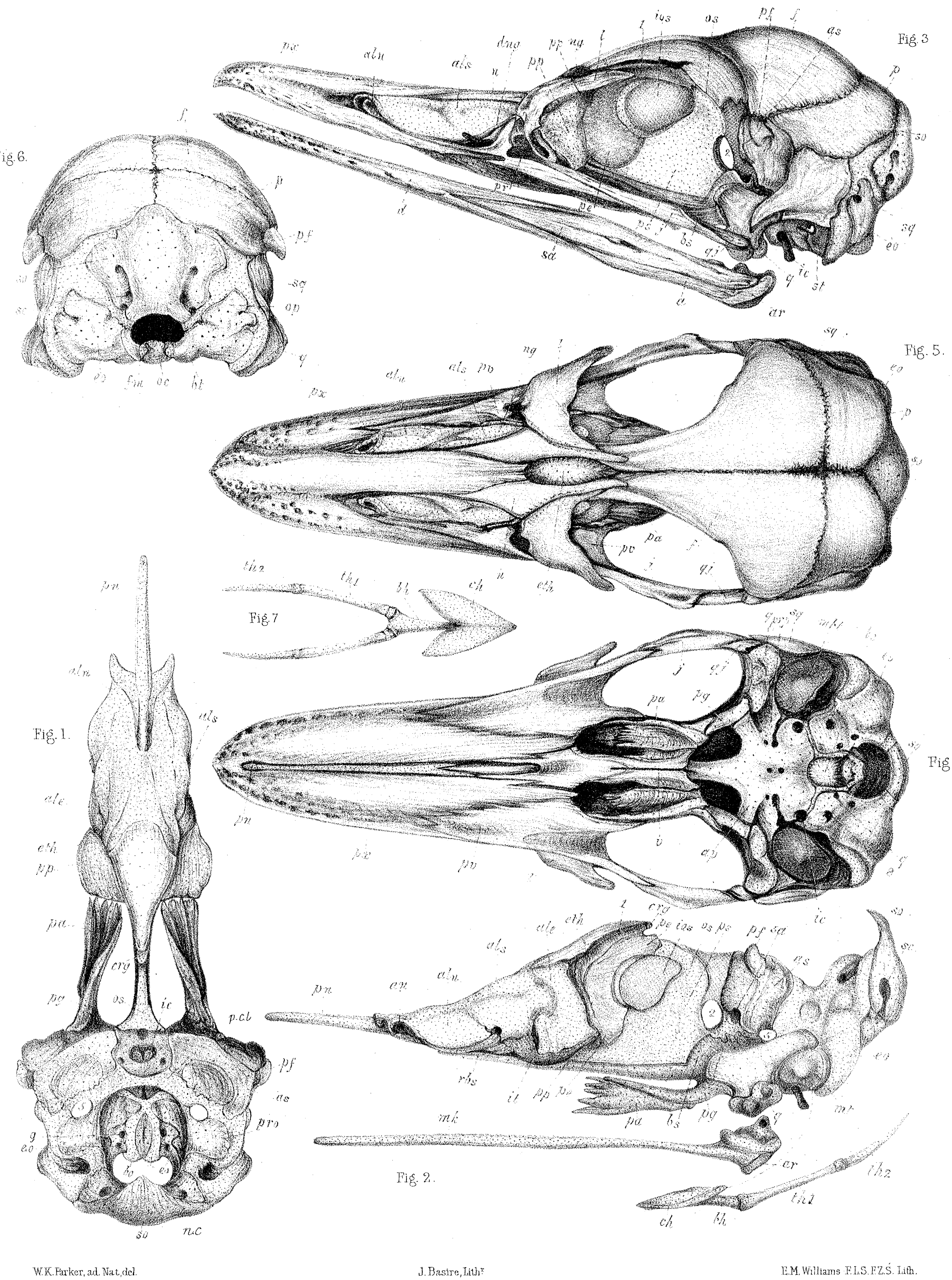
Struthio "B" 2 Diam.



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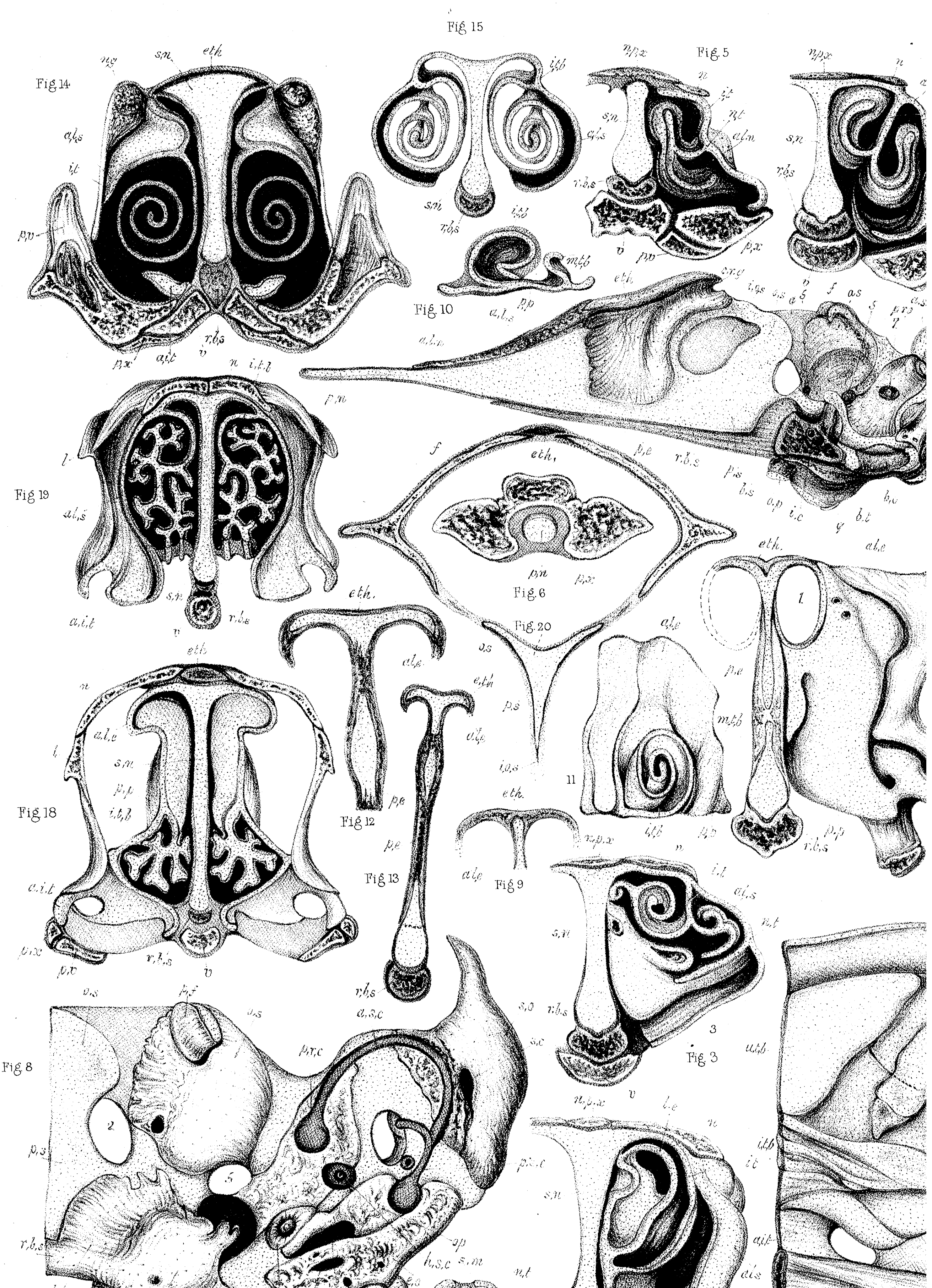
Rhea americana var. 2 Diam.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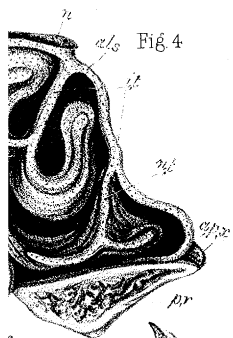

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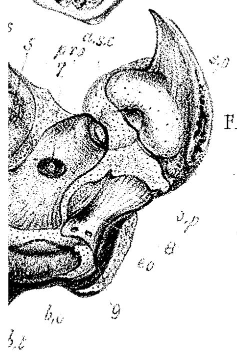

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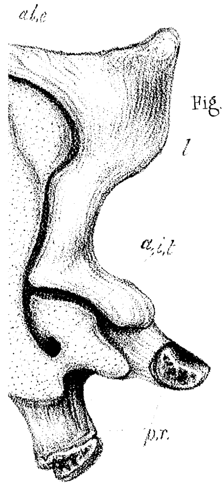

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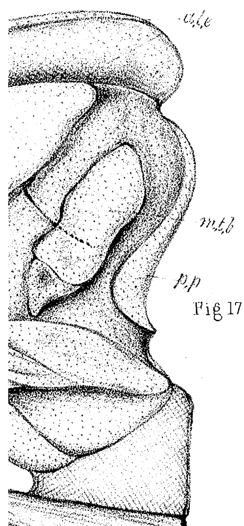

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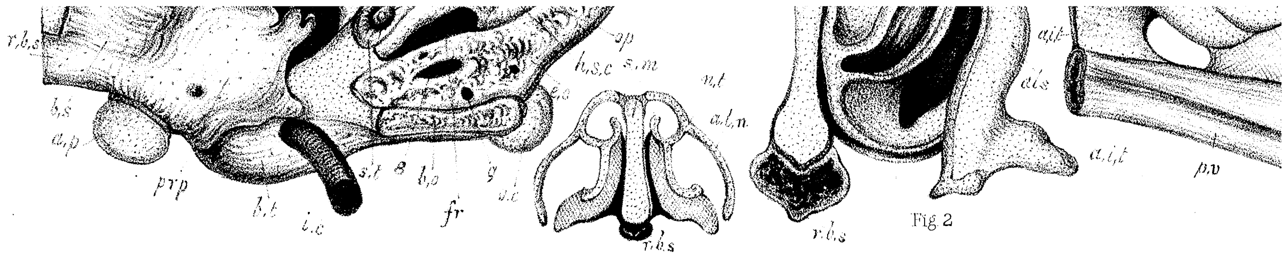
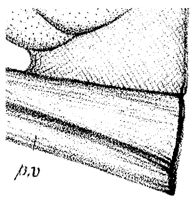


Fig. 16

W.K. Parker, ad Nat. del

J. Basire Lith.

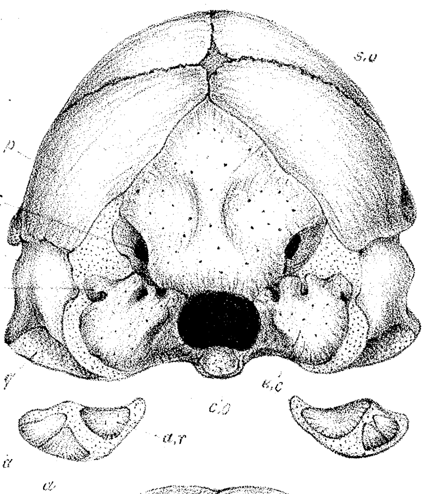
1 _6_ Struthio "C." 4 Diam_7 16_ Rhea americana var 4 & 8 Diam 17 20_ Casuarius Bennettii

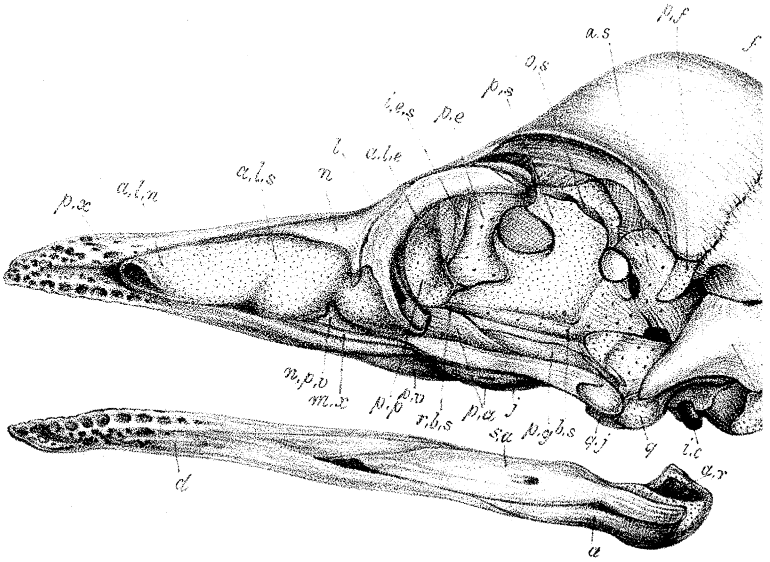


E. M. Williams. F.L.S. F.Z.S. Lith.

nnettii _4. Diam

Fig 4





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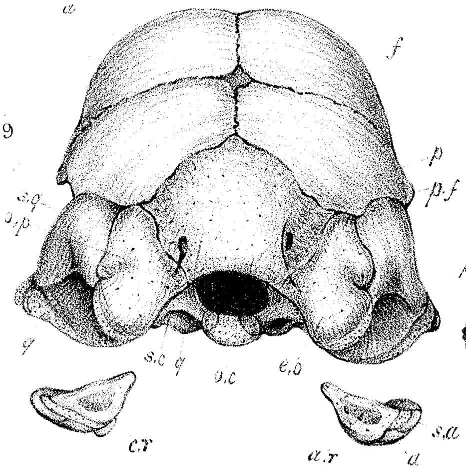

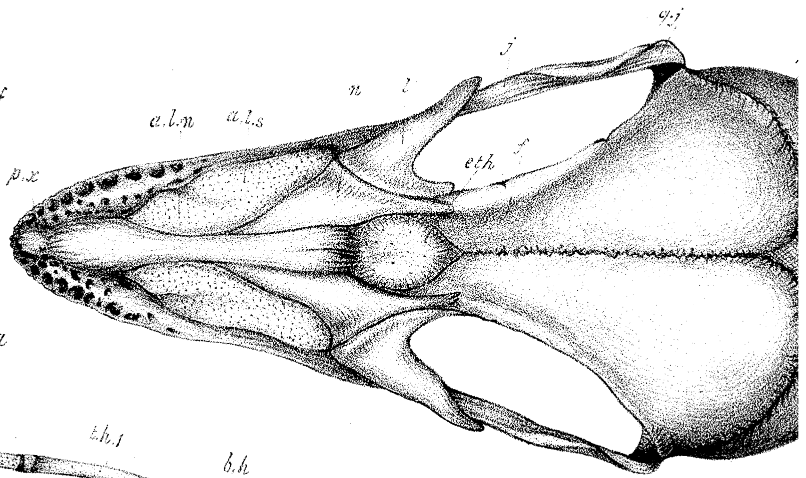

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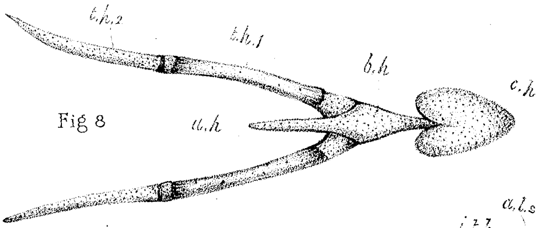

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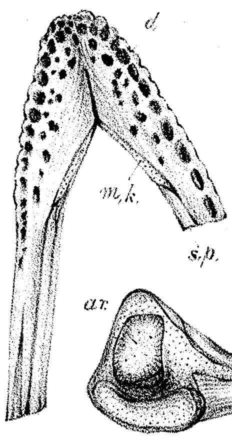

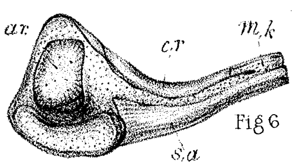

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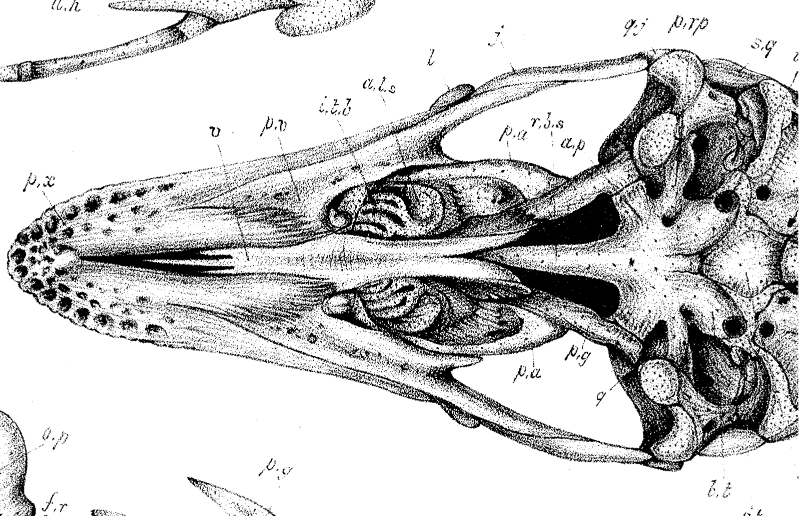


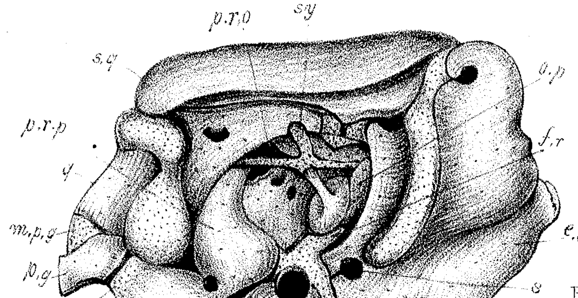
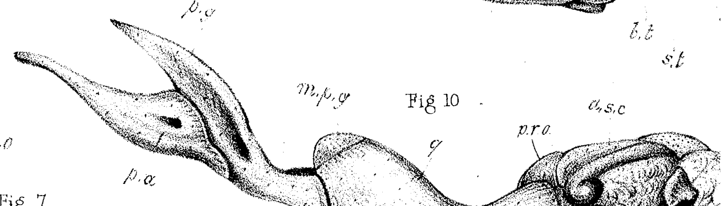
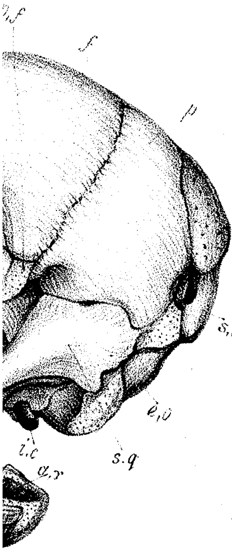


Fig 7

Fig 10





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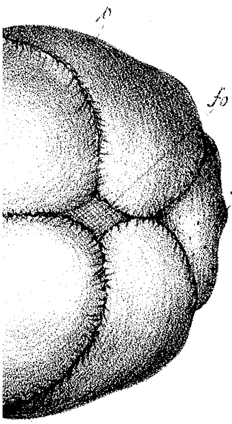

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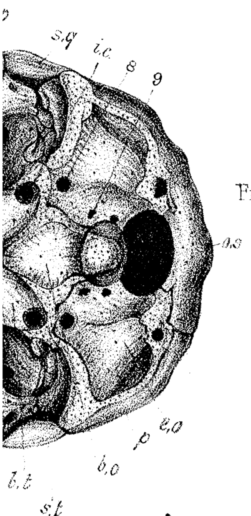

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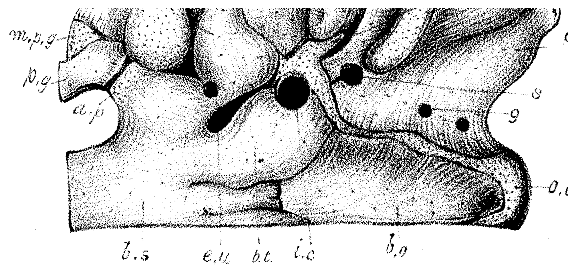

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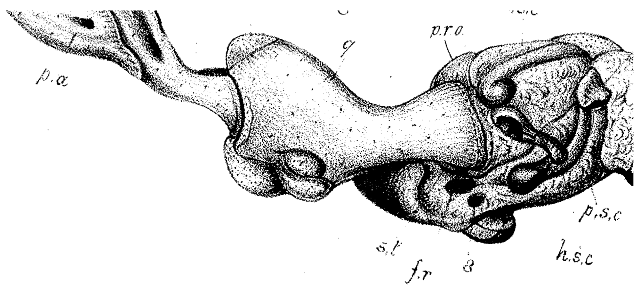

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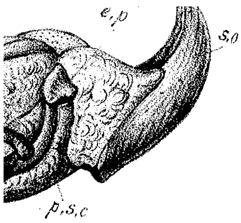
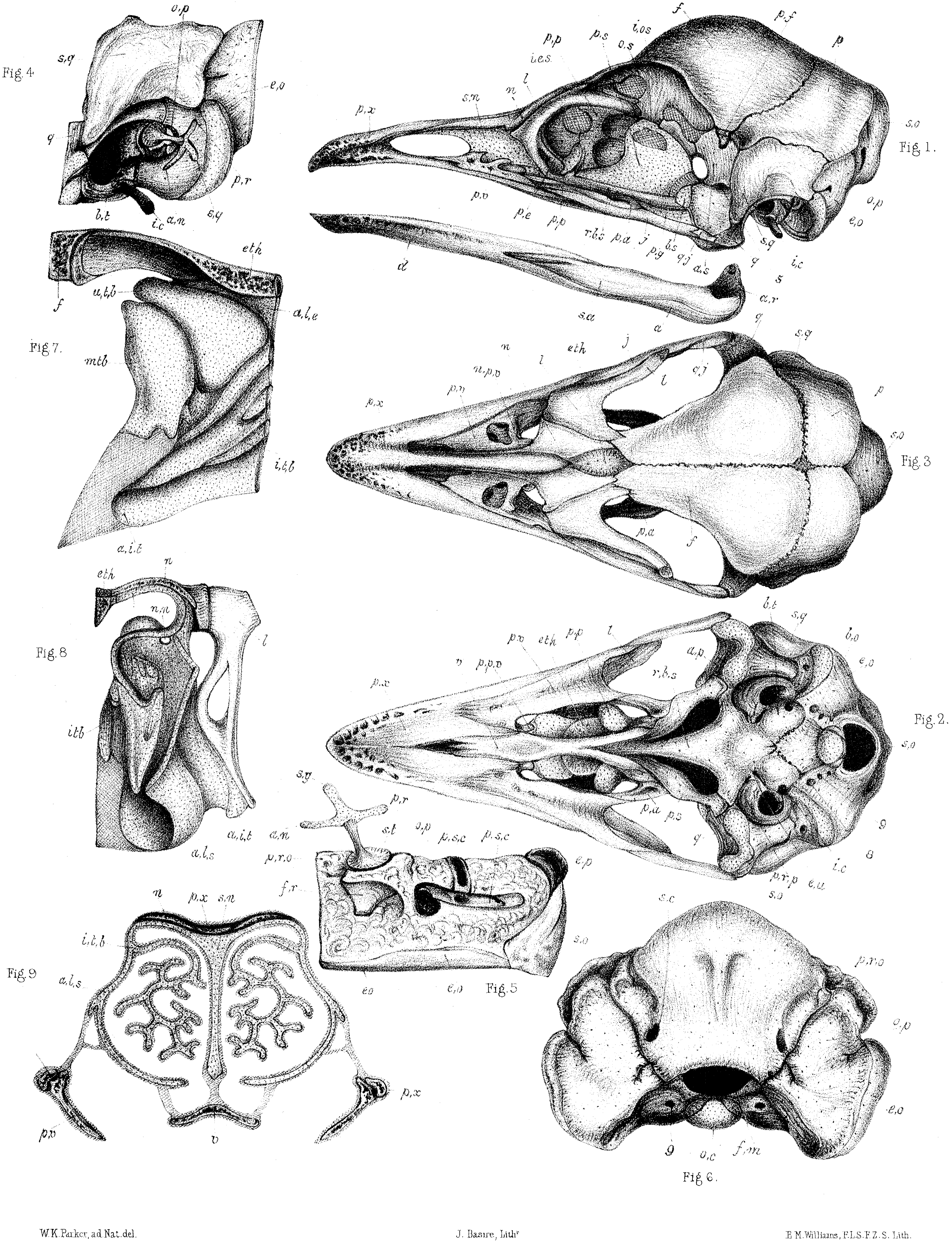


E M. Williams, F.L.S. F.Z.S. Lith.

LIII.



W.K. Parker, ad Nat. del. J. Basire, Lith. E.M. Williams, F.L.S. F.Z.S. Lith.

1.5. Dromous novæ hollandiæ "B" 1½ 3 & 6 Diam. 6. D. irroratus "C" 1½ Diam. 7. 8. 9. D. irr. "D" 2 Diam.

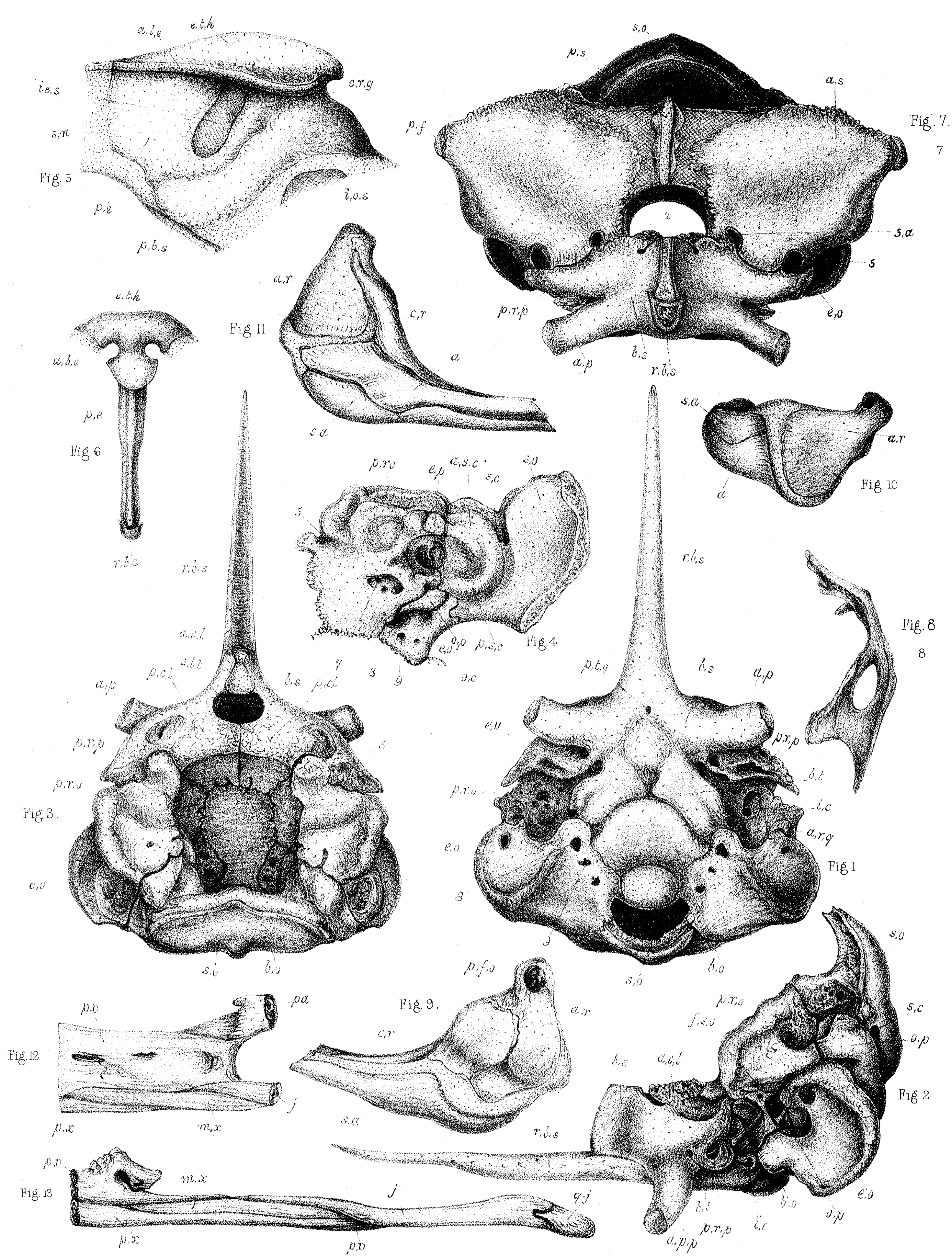

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Fig 11
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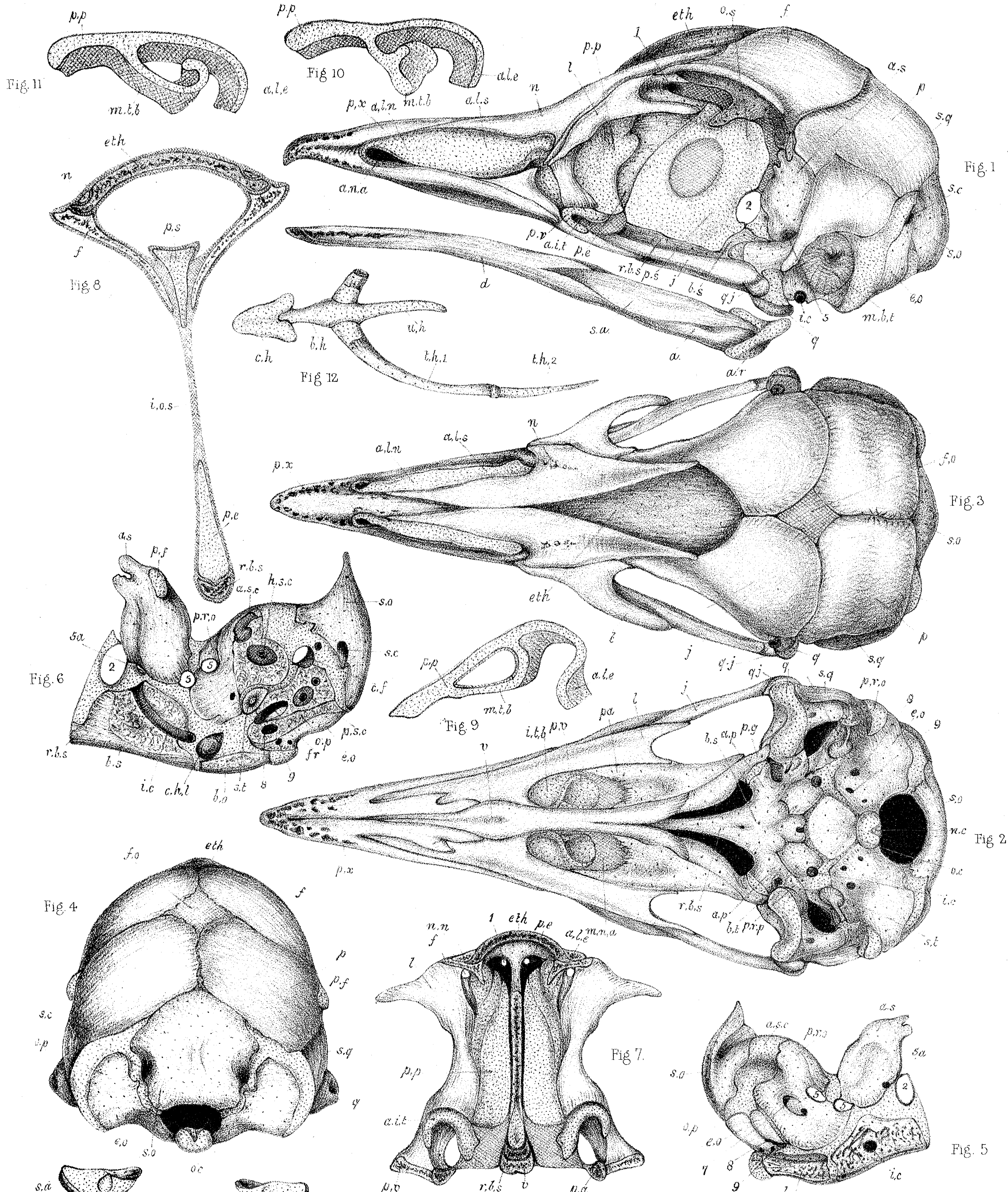
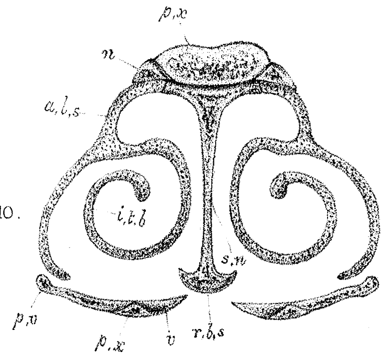


W. K. Parker, ad. Nat. del.   J. Basire Lith^r E. M. Williams, F.L.S. F.Z.S. Lith.

Casuarius Bennetii. 2.4. & 8. Diam.



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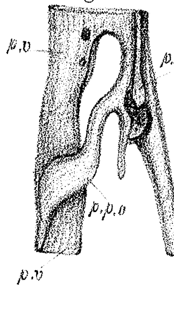

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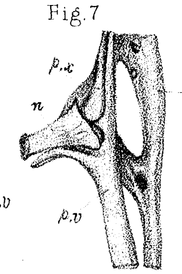

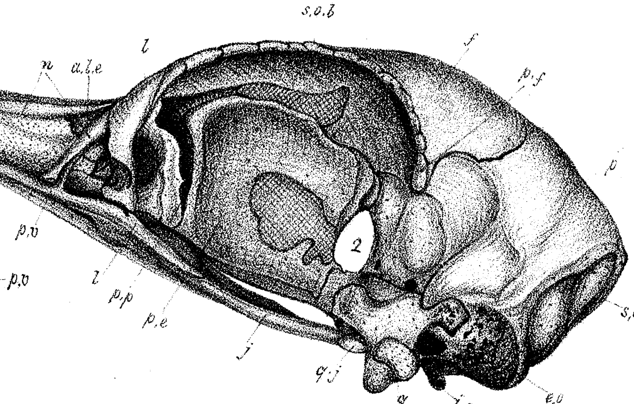

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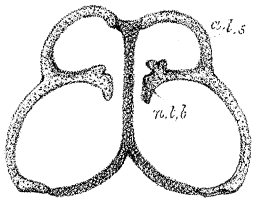

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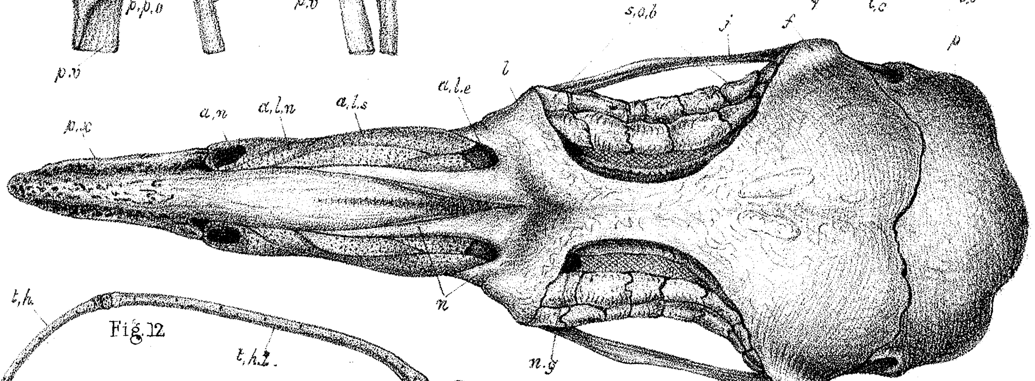

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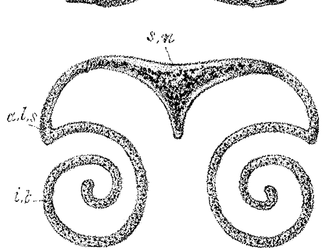
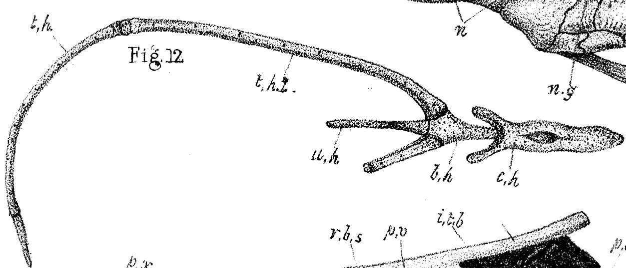
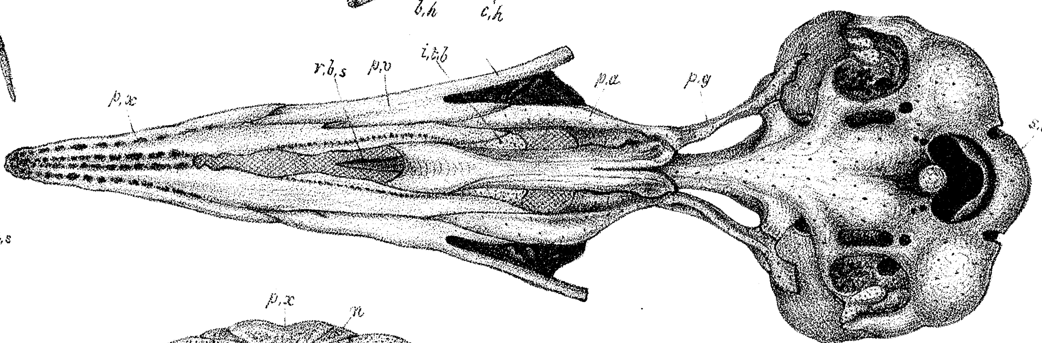


Fig. 14

Fig. 12





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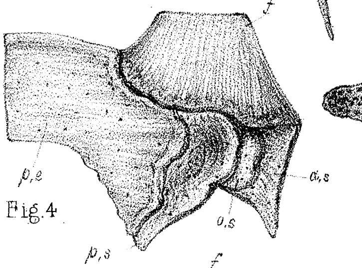

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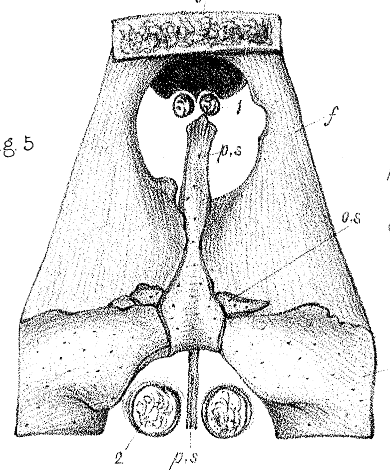

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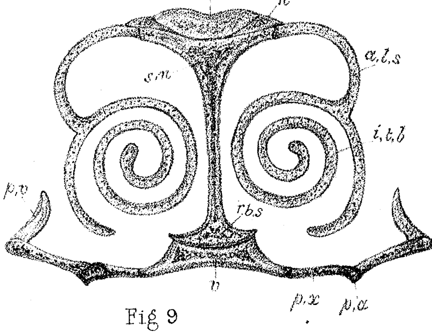

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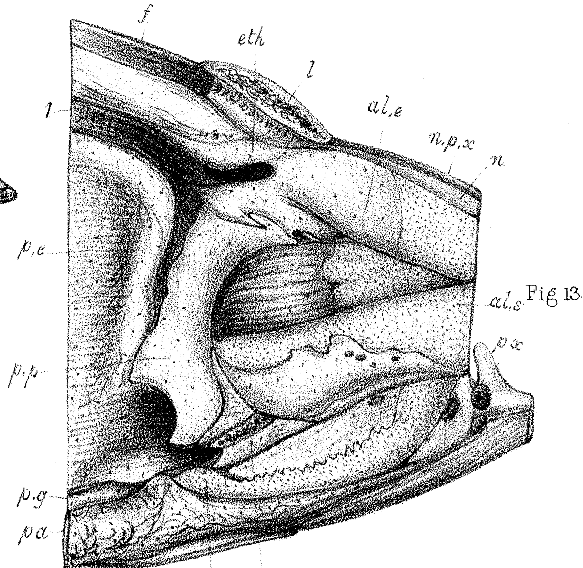

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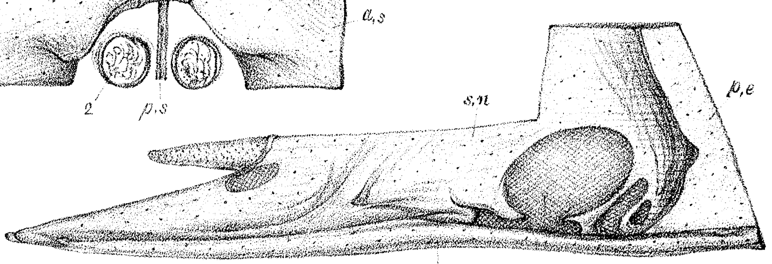

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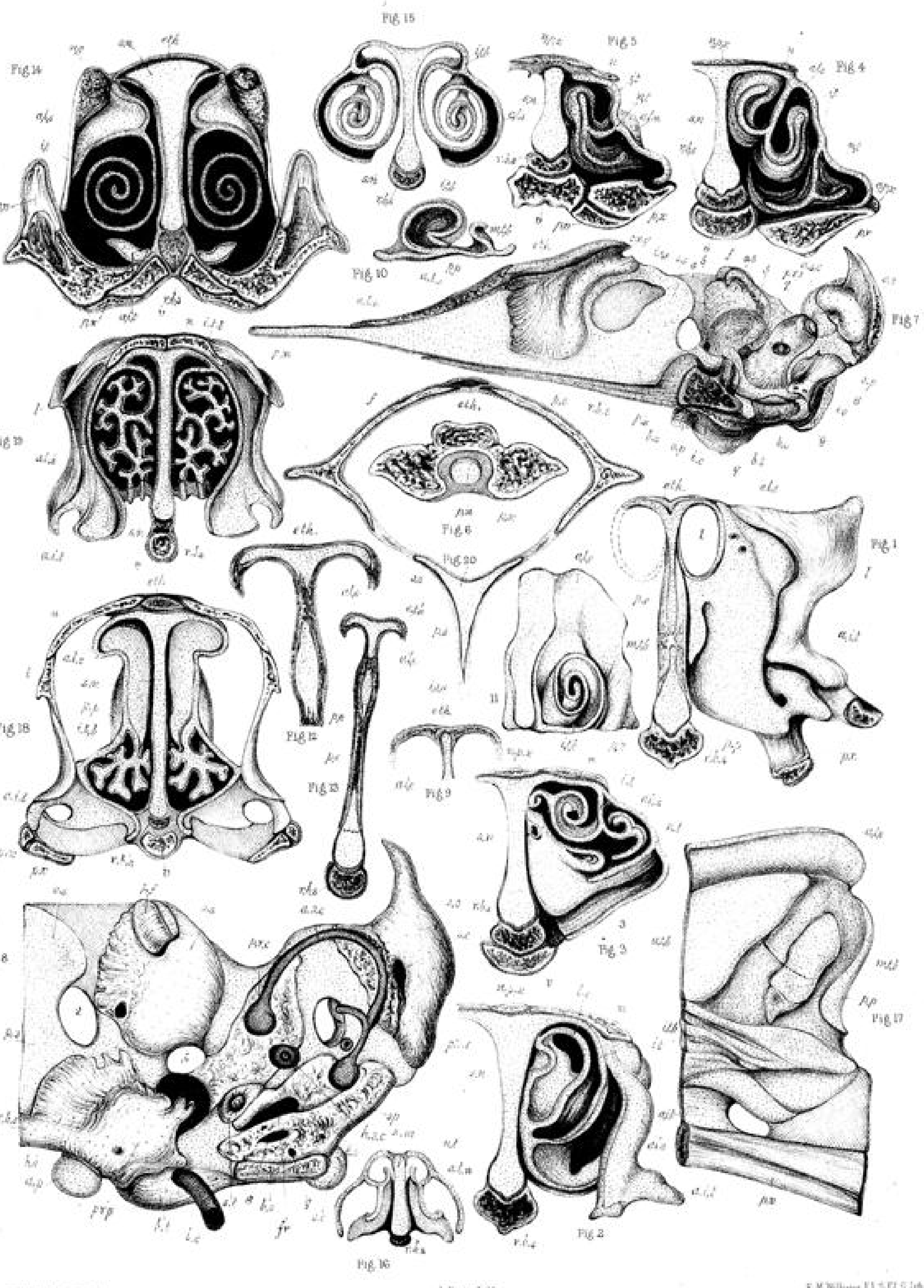
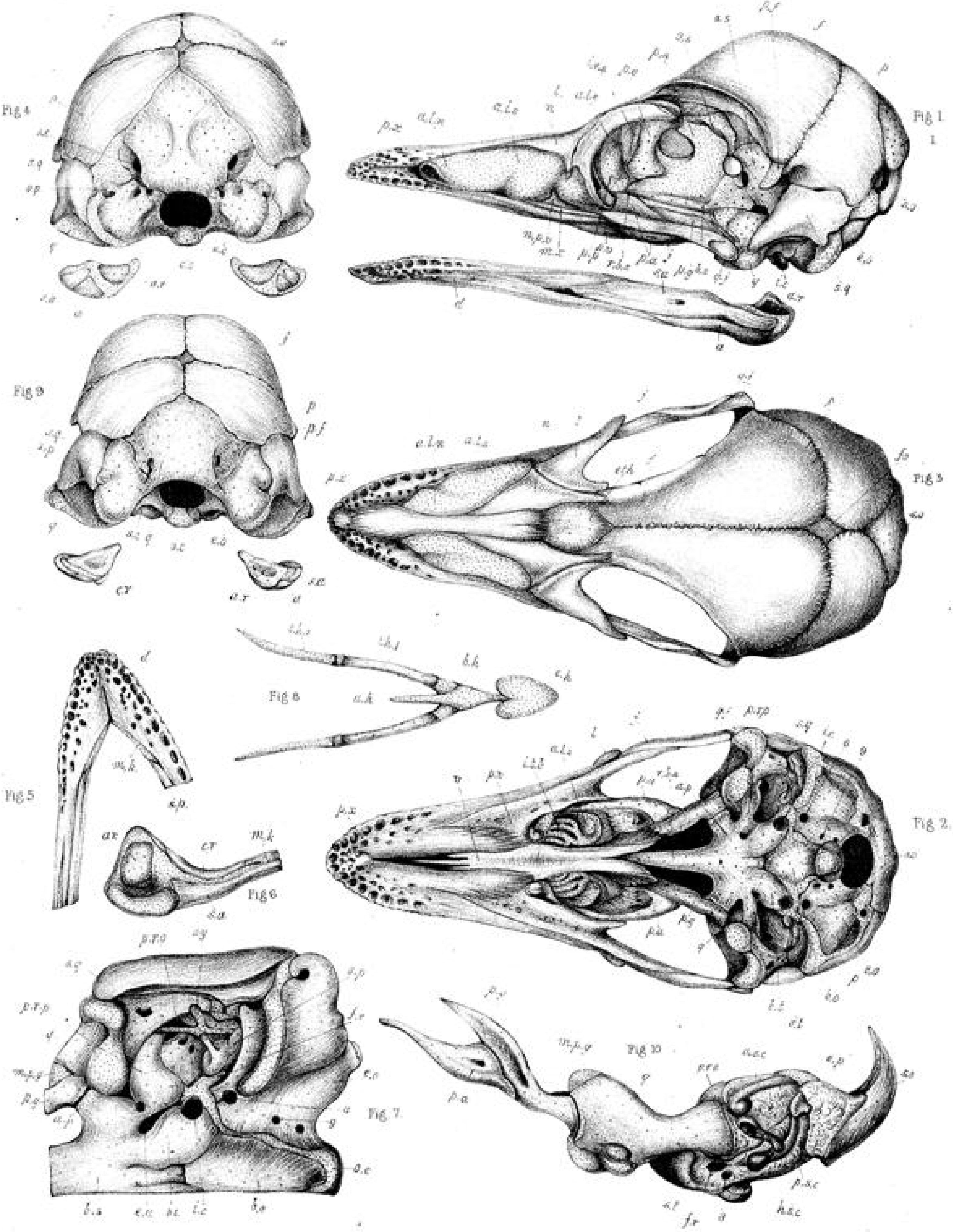


W.K. Parker, ad Nat. del. J. Basire Lith. E. M. Williams F.L.S. F.G.S. Lith.

1_6. Struthio "C." 4 Diam._7_16. Rhea americana, var. 4 & 8 Diam. 17_20. Casuarius Bennetti, 4 Diam.



W. K. Parker, ad Nat. del. J. Basire Lith. E. M. Williams, F.L.S. F.Z.S. Lith.

1.8. Dromeus irroratus "A" 2 & 4 Diam. 9.10. D. N. hollandiae "B" 1½ & 3 Diam.