with very effective patterns. By dry distillation the bark yields an empyreumatic oil, called *diogott* in Russia, used in the preparation of Russia leather; to this oil the peculiar pleasant odour of the leather is due. The bark itself is used in tanning; and by the Samoiedes and Kamchatkans it is ground up and eaten on account of the starchy matter it contains. A sugary sap is drawn from the trunk in the spring before the opening of the leaf-buds, and is fermented into a kind of beer and vinegar The whole tree, but especially the bark and leaves, has a very pleasant resinous odour, and from the young leaves and buds an essential oil is distilled with water The leaves are used as fodder in northern latitudes The species which belong peculiarly to America (*B. lenta, excelsa, nigra, papyracea*, &c.) are generally similar in appearance and properties to *B. alba*, and have the same range of applications. The largest and most valuable is the black birch (*B. lenta*), found abundantly over an extensive area in British North America, growing 60 to 70 feet high, and 2 to 3 feet in diameter. It is a wood most extensively used for furniture and for carriage building, being tough in texture and bearing shocks well, while much of it has a handsome grain, and it is susceptible of a fine polish. The bark, which is dark brown or reddish, and very durable, is used by Indians and backwoodsmen in the same way as the bark of *B. alba* is used in Northern Europe. Concerning the canoe or paper birch (*B. papyracea*), which some regard as a variety of the white birch, Mr Bernard R. Ross, of the Hudson's Bay Company, writes:—"The canoe or paper birch is found as far north as 70° N. on the American continent, but it becomes rare and stunted in the Arctic circle. It is a tree of the greatest value to the inhabitants of the Mackenzie River district in British North America. Its bark is used for the construction of canoes, and for drinking cups, dishes, and baskets. From the wood, platters, axe handles, snow-shoe frames, and dog sledges are made, and it is worked into articles of furniture which are susceptible of a good polish. The sap which flows in the spring is drawn off and boiled down to an agreeable spirit, or fermented with a birch-wine of considerable alcoholic strength. The bark is also used by the Christianized American Indians as a substitute for paper." A species (*B. Bhojputtra*) growing on the Himalayan Mountains, as high up as 9000 feet, yields large quantities of fine thin papery bark, extensively sent down to the plains as a substitute for wrapping-paper, for covering the "snakes" of hookahs, and for umbrellas. It is also said to be used as writing paper by the mountaineers; and in Kashmir it is in general use for roofing houses.

BIRCH, Thomas, historical and biographical writer, and one of the early trustees and benefactors of the British Museum, was born in London, November 23, 1705. He was the son of a coffee-mill maker, and was to have followed his father's business; but his active mind and ambition of higher pursuits led him into the paths of literature. His parents were members of the Society of Friends, and therefore he had not the advantages of a university training. But by persevering application to study and to teaching he qualified himself for the ministry of the Church of England. In 1728 he obtained a curacy, and in the same year he married. His wife died in the following year. He was ordained priest in December 1731, and was soon after recommended to the favour of Philip Yorke, then attorney-general, afterwards Lord Chancellor and earl of Hardwicke, to whom he owed his successive preferments in the church. His first benefice was the vicarage of Ulting in Essex. In 1734 he was appointed domestic chaplain to the earl of Kilmarnock, who was beheaded for his share in the rebellion of '45. He afterwards held successively benefices in Pembrokeshire, Gloucestershire, and the city of London. His last church preferment was to the rectory of Depden in Essex, to which he was presented in February 1761. In his latter years he was appointed chaplain to the princess Amelia. His literary attainments procured him election as a fellow of the Royal Society in February 1735, and in the following December he was chosen a member of the Society of Antiquaries. He held the office of Secretary to the Royal Society for thirteen years 1752–1765. From the university of Aberdeen he received the degrees first of M.A., and afterwards (1753) of D.D. The degree of D.D. was also conferred on him about the same time by the archbishop of Canterbury. Dr Birch was engaged in a large number of literary undertakings. His appetite and his capacity for hard work were extraordinary. Besides his diversified labours of compilation and editing, he transcribed many volumes in the library of Lambeth Palace, and carried on an extensive correspondence with literary men. He was an early riser; and amidst all his labours he found time to take part in social enjoyments. He was only in his sixty-first year when he was killed by a fall from his horse in Hampstead Road, January 9, 1766. He bequeathed his books and manuscripts, with part of his pictures and prints, to the British Museum. The rest of his property, in value about £500, he gave to be invested in Government securities, the interest to be applied in augmenting the salaries of the three assistant librarians.

His principal publications were: 1. *The General Dictionary, Historical and Critical*, including a new translation of Bayle, and interspersed with several thousand new lives, in 10 volumes fol., 1734–1741. 2. *Thurloe's State Papers*, 7 vols. folio, 1742. 3. *Dr Cudworth's Intellectual System, improved from the Latin edition of Mosheim; his Discourse on the true Notion of the Lord's Supper;* and two *Sermons*, with an *Account of his Life and Writings*, 2 vols. 4to, 1743. 4. *The Life of the Honourable Robert Boyle*, 1744, prefixed to an edition of that philosopher's works. 5. *The Lives of Illustrious Persons of Great Britain*, to accompany the engravings of Houbraken and Vertue, 1747–1752. 6. *An Inquiry into the Share which King Charles I. had in the Transactions of the Earl of Glamorgan*, 1747, 8vo. 7. An edition of *Spenser's Faery Queen*, 1751, 3 vols. 4to, with prints from designs by Kent. 8. *The Miscellaneous Works of Sir Walter Raleigh, with his Life*, 1751, 2 vols. 8vo. 9. *The Theological, Moral, Dramatic, and Poetical Works of Mrs Catherine Cockburn, with a Life*, 1751, 2 vols. 8vo. 10. *The Life of Dr Tillotson, Archbishop of Canterbury, compiled chiefly from his Original Papers and Letters*, 1752, 8vo. 11. *Milton's Prose Works*, 1753, 2 vols. 4to, *with a Life*. 12. *Memoirs of the Reign of Queen Elizabeth, from the year* 1581 *till her death*; illustrated from the original papers of Anthony Bacon, Esq., and from other MSS., 1754, 2 vols. 4to. 13. *The History of the Royal Society of London*, 1756 and 1757, 4 vols. 4to. 14. *The Life of Henry Prince of Wales, eldest son of James I., compiled chiefly from his own papers and other MSS.*, 1760, 8vo. 15. *The Letters, Speeches, &c., of Lord Chancellor Bacon.* His numerous communications to the Royal Society may be seen in the *Philosophical Transactions*.

BIRD, William, an English composer, and one of the best organists of his time, was born about 1540, and died at London, 4th July 1623. He was appointed organist of Lincoln cathedral in 1563; and in 1575 he and his master Tallis were gentlemen of the chapel royal, and organists to Queen Elizabeth. Bird was the earliest English composer of madrigals, and some of his numerous sacred compositions are still much esteemed. Most of them were published during his lifetime under a patent from Queen Elizabeth, which secured to him and Tallis the sole right to print and sell music. Between 1575 and 1611 there were issued under this patent eight different collections of his works, with such titles as *Cantiones Sacræ; Gradualia; Psalmes, Songs, and Sonets*, &c. The vocal canon *Non nobis Domine*, generally attributed to him, is well known, and often sung. He also wrote a number of pieces for Queen Elizabeth's Virginal Book, and other similar collections. In his compositions there is a freedom and elegance rarely found in the music of his period. A full account of Bird's life by E. F. Rimbault is prefixed to one of his Masses, published by the Musical Antiquarian Society.



# BIRDS

## ANATOMY OF BIRDS.

In the consideration of the Anatomy of Birds, classification will be quite a secondary matter, and merely employed for the elucidation of internal structure. Some sort of grouping, however, is indispensable; and that is accordingly adopted, as the most convenient for the morphologist, which was first proposed by Professor Huxley,[1] with the introduction of certain modifications rendered necessary by the present writer's own researches—researches, it may be added, which have been carried on in constant communication with that investigator.

A little examination will show that the groups made by consideration of any, even the most important, morphological modifications, cannot be *superimposed upon* groups made by reference to the whole sum of the characters of the Bird. This may be easily explained. About half the known Birds, 5000 or thereabouts, belong, according to G. R. Gray, to Professor Huxley's group, the *Coracomorphæ*. These birds undergo a peculiar metamorphosis of the naso-palatal structures, and are called by Professor Huxley the *Ægithognathæ* on that account. Now all the *Coracomorphæ* have the ægithognathous palate, but so also have the *Cypselidæ*, or Swifts, which are placed by this author with the Humming-birds and Goatsuckers, both of which groups are simply schizognathous. Moreover, below the Passerine types, and only next above the Semi-struthious Tinamous, we find the Hemipods, *Turnicidæ*, or *Turnicimorphæ*, and these have an ægithognathous palate. So also has another type, *Thinocorus*, which lies on the same low zoological level as the Hemipods. This latter bird is essentially a small Geranomorph, but it is below the true Cranes, and unites in its palate characters belonging to the Ostriches below it and the Passerines which ascend, zoologically, far above it.

The difficulty of applying this very valuable morphological grouping, and making it fit in with one that is more general and distinctively zoological (that is, having reference to every character, external and internal), does not take away anything of real value from it. To the anatomist such a mode of viewing the various types is perfectly natural, however hard it may be to satisfy the pure zoologist as to its great value. Certainly, the structures of the skull and face govern the whole body, as it were; every other part of the organism corresponds to what is observable there. Nor must it be forgotten that the true mode of studying any kind of creature is that of its *development*; and the head undergoes the most remarkable morphological changes.

In the following scheme we have added one new morphological group to Professor Huxley's classification. This group includes the Woodpeckers and Wrynecks, *Picidæ* and *Yungidæ*. Zoologically it forms the family *Celeomorphæ* (Huxley); its morphological term is *Saurognathæ* (Parker).

[1] "On the Classification of Birds; and of the taxonomic value of the modifications of certain of the cranial bones observable in that class," *Proceedings of the Zoological Society*, April 11, 1867, pp. 415–472. This classification is somewhat modified in a later paper by the same author, in which a very masterly description is given of the Gallinaceous group (*Alectoromorphæ*, Huxley), "On the Classification and Distribution of the *Alectoromorphæ* and *Heteromorphæ*," *ibid.*, May 14, 1868, pp. 293–319. The same author repeats, in essentially the same form, the original classification in his *Anatomy of the Vertebrated Animals* (1871, p. 272). The materials from which the modified views here given have been taken are in a series of contributions by Mr Parker to the *Transactions of the Linnean and Zoological Societies* now (1875) passing through the press. For figures of the skeleton see Mr Eyton's *Osteologia Avium*.

Every one who has laboured at the anatomy of this class must have been struck by its marvellous uniformity; almost countless numbers of species are found passing insensibly into one another, and differing in the slightest manner. The best modern zoologists are at times almost at their wits' end to know by what characters they may distinguish their genera and species. This has been well put by Professor Huxley (*Anat. of Vert. Anim.*) He says (p. 272)—"Though this class contains a great number of specific forms, the structural modifications which they present are of comparatively little importance; any two birds which can be selected differing from one another far less than the extreme types of the *Lacertilia*, and hardly more than the extreme forms of the *Chelonia*, do. Hence the characters by which the following groups" (see subjoined table) "are separated appear almost insignificant when compared with those by which the divisions of the *Reptilia* are indicated."

### Morphological Classification of Birds.

A. The metacarpals not ankylosed together: The tail longer than the body.

I. Saururæ.

1. *Archæopterygidæ*.

B. The metacarpals ankylosed together. The tail considerably shorter than the body.

A. The sternum devoid of a keel.

II. Ratitæ.

*a.* The wing with a rudimentary, or very short, humerus, and with not more than one ungual phalanx.

*α.* A hallux.

2. *Apterygidæ* (the Kiwis).

*β.* No hallux.

3. *Dinornithidæ* (the Moas).

4. *Casuaridæ* (the Cassowaries and Emeus).

*b.* The wing with a long humerus, and with two ungual phalanges.

*α.* The ischia uniting immediately beneath the sacrum, and the pubes free.

5. *Rheidæ* (the American Ostriches).

*β.* The ischia free, and the pubes uniting in a ventral symphysis.

6. *Struthionidæ* (the Ostriches).

The sternum provided with a keel.[2]

III. Carinatæ.

*a.* The vomer broad behind, and interposing between the pterygoids, the palatines, and the basi-sphenoidal rostrum (**Dromæognathæ**).

7. *Tinamomorphæ* (the Tinamous).

*b.* The vomer narrow behind; the pterygoids and palatines articulating largely with the basi-sphenoidal rostrum.

*α.* The maxillo-palatines free.[3]

i. The vomer pointed in front (**Schizognathæ**).

8. *Charadriomorphæ* (the Plovers).

9. *Cecomorphæ* (the Gulls).

10. *Sphenisomorphæ* (the Penguins).

11. *Geranomorphæ* (the Cranes).[4]

12. *Alectoromorphæ* (the Fowls).

13. *Pteroclomorphæ* (the Sand-Grouse).

14. *Peristeromorphæ* (the Pigeons).

15. *Heteromorphæ* (the Hoazins).

16. *Coccygomorphæ* (part), (the Goatsuckers).

[2] The keel is but little developed in *Strigops* (*Psittacidæ*), in *Didus* (*Dididæ*), and in *Aptornis* (*Rallidæ*).

[3] Professor Huxley here gives in a note two exceptions, namely, *Cvpx* and *Dicholophus*. The latter bird, the Cariama, is, however, as Mr Parker has shown, a low, gruiform, rapacious bird, having its maxillo-palatines united by suture, and being an example of a bird with *imperfect direct desmognathism*.

[4] With the exception of *Thinocorus*, see below.

17. *Trochilomorphæ* (the Humming-Birds).
    ii. The vomer truncated in front (**Ægithognathæ**).
18. *Geranomorphæ* (part), (the exceptional subfamily *Thinocorinæ*, Thinocorus).
19. *Turnicomorphæ* (the Hemipods).
20. *Cypselomorphæ* (the Swifts).
21. *Coracomorphæ* (the Passerines).
    iii. The vomerine halves permanently distinct, and the maxillo-palatines arrested (**Saurognathæ**).
22. *Celeomorphæ* (the Woodpeckers).
    *a*. The maxillo-palatines united, either by coalescence with the ossified septum nasi; or, 2*d*, by meeting at the mid-line and forming a suture; or, 3*d*, in the fullest degree, by complete ankylosis of the right and left plates.
23. *Actomorphæ* (the Birds of Prey).
24. *Psittacomorphæ* (the Parrots).
25. *Coccygomorphæ* (the Cuckoos. Kingfishers, and Trogons).
26. *Chenomorphæ* (the Anserine Birds).
27. *Amphimorphæ* (the Flamingoes).
28. *Pelargomorphæ* (the Storks).
29. *Dysporomorphæ* (the Cormorants).

The above scheme is a nail in a sure place; and on it, for the present, we may hang all that we know, or are learning, of the anatomical structure of this class of Vertebrates. That which relates to the *Carinatæ* must, however, be regarded merely as a *list* of Birds having a similar facial structure.

For the general ornithologist it is very suggestive and helpful, and will save him from looking merely on outward appearances; for the study of structure and development is looking into the heart of the matter.

## The Skull.

To both the zoologist and the palæontologist an explanation of the *skeleton* will be of the greatest value, for the framework must of necessity be correlated to the nervous system, and also govern the development of the muscles. It will here form the first and the largest part of our work. And as all things in the skeleton are conformed to the modifications of the skull, and, moreover, as the skull is the most knotty problem to the morphologist, it will receive the attention due to its superior importance.

Instead of describing the adult skull, and then showing how it develops, it would seem to be better to follow the stages of its growth, and thus see the meaning of the parts, and what metamorphic changes take place to give it its adult characters. Space will not permit any detail of the general embryology of the Bird, but the skull will be described from the time when the rudiments of the chondro-cranium are first fairly visible, that is, about the fifth day of incubation.[1]

As the *Schizognathous* type of skull, such as is seen in the Fowl, is the simplest variety found in the *Carinatæ*, it will be the most convenient for comparison with that of the *Ratitæ* and the Tinamous (the *Dromæognathous* variety) below, and the *Desmognathous*, and other kinds seen in Birds above the *Gallinaceæ* in the zoological scale.

*The Cranium of the Fowl—First Stage.*—The chondro-cranium may be seen at the end of the fourth and the beginning of the fifth day of incubation, although the cartilage has as yet but little consistence, its cells being imperfectly soldered together. The head of the skull at this stage still shows the "visceral clefts;" and it is bent upon itself by what is called the *mesocephalic flexure*. When the membranous roof of the skull and the brain are removed at this stage, the whole floor is not seen from above, the fore-part being bent under and looking backwards.

In the hinder half of the skull-floor, behind the eyeballs, we see a broad plate of tissue (fig. 1, *comp.* fig. 4, *i.v.*) which is passing rapidly from the condition of stellate cells into proper hyaline cartilage.

This plate is divided at the mid-line by a straight, somewhat beaded rod of soft indifferent tissue, which does not chondrify; it is rounded at its fore-end. This truly azygous part is the notochord (*n.c.*), or primary axis of the skeletal parts of the embryo; it lies directly beneath the neural axis, and is one of the parts earliest visible to the embryologist. The broad plate on each side is seen to be hollow, and to contain a pear-shaped diverticulum of the primordial ear-sac (*cl.*), which is planted, as it were, in the very substance of the basal plate, at its middle. The outer granular covering of the ear-sac becomes cartilage, and so does the basal plate—the "investing mass" of Rathke, the "parachordal cartilage" of Huxley.[2]

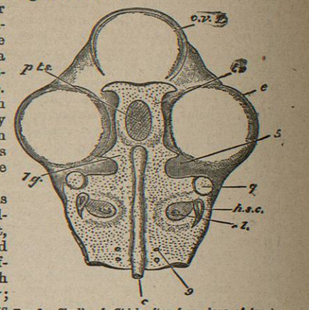


Fig. 1.—Skull of *Chick* after four days of incubation, with head three lines long, first stage, from above, × 9 diameters. Most of the brain has been removed. *c.v.1*, first cerebral vesicle; *pt.s.*, pituitary space; *tr.*, trabeculæ cranii; *lg.*, lingula formed by junction of trabeculæ with the parachordal cartilages on each side of notochord (*n.c.*); *e.*, eye; *cl.*, cochlea; *q.*, quadrate cartilage; *h.s.c.*, horizontal semicircular canal; 5, foramen ovale; 9, hypoglossal nerve.

But the process by which these two separate morphological territories become converted into solid cheese-like cartilage is carried on blindly, as it were, and no distinction of parts is at present traceable; evident differentiation of morphological territories is often *late* in the higher types of vertebrata. The tissue which surrounds the spinal chord where this part passes into the brain is still soft; it will chondrify soon to form the occipital arch. The bulbous end of the notochord ends a little behind an oval membranous space or fontanelle in the skull-floor—the *pituitary space* (*pt.s.*). Near the end of the notochord, on each side, the cartilage suddenly narrows, for here we are in front of the impacted ear-sacs; at this part a bending of the narrow anterior end of the parachordal rounded notch (5) is formed, over which the trigeminal nerve passes. The anterior margin of the notch (afterwards formed into the *foramen ovale*) is formed by the cartilage; its actual extremity looks forward and outward, towards the eyeball. At present the bands which are continued forward, surrounding the pituitary space, are superimposed upon, and indistinct from, the ends of the parachordal cartilages; in the next stage they will be seen more distinctly. These flat bands of dense granular tissue are the *trabeculæ cranii* of Rathke (*tr.*), and they were supposed by him to be mere continuations of the parachordal bands, an error corrected some years ago by Professor Huxley. These little rafters of the cranium bend gently round the oval pituitary space; they then com-

[1] The whole development of the *Chick* is explained in a masterly and lucid manner by Messrs Foster and Balfour in their excellent work, *The Elements of Embryology*, London: Macmillan and Co. Part I., 1874. The description of the fowl's skull here given is principally from Mr Parker's paper, *Phil. Trans.*, 1869, plates 81–87, pp. 755–807. For a detailed description of the anatomy of birds, see Dr H. G. Bronn's *Klassen und Ordnungen des Thierreichs*, 1869, 6te Band, IV. Abtheilung, "Vögel."

[2] See Huxley on "Menobranchus," *Proceedings of Zoological Society*, March 17, 1874, p. 197.



pletely unite into a broad inter-nasal plate, which is bent over upon itself so as to appear on the under surface of the face.

The inter-nasal plate is arched and winged—the rudimentary condition of the nasal sacs, the apertures of which are seen beneath the arched part below (fig. 2, *n.*)

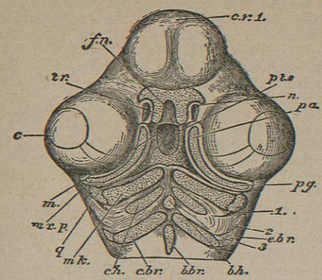


Fig. 2.—The same as fig. 1, seen from below. *f.n.*, fronto-nasal plate; *n.*, external nostril; *m.*, mouth; *m.v.p.*, maxillo-palatine, containing pterygo-palatine bar (*pg. p.t.*); *mk.*, Meckel's rod, or free mandibular bar; *c.h.*, cerato-hyal; *b.h.*, basi-hyal; *c.br.* cerato-branchial; *e.br.*, epi-branchial; *b.br.*, basi-branchial; 1, 2, 3, 1st, 2d, and 3d visceral clefts.

The trabeculæ, antero-inferiorly, become free again; these free extremities are the ventral ends of this the first *visceral arch*; they form the pith of the flat, emarginate rudimentary *neb.* This part is called the "fronto-nasal process" (fig. 2, *f.n.*)

On the sides of the face behind the mouth are seen slits (fig. 2, 1, 2, 3); these are the "visceral clefts," which are always developed in embryonic vertebrata. Between these clefts the tissue of the "mesoblast" is thickening into cartilaginous rods; these rods are the post-oral visceral arches, the rudiments of the lower jaw and hyoid bone. But beneath the eye is seen an arcuate bar of tissue more solid than its surroundings; this is the pterygo-palatine rod. It is developed in the maxillo-palatine process of the mandibular or first post-oral arch; it represents the bar of cartilage which, in the Frog, connects the mandibular suspensorium with the ethmoidal region.[1]

The *first* visceral arch, then, runs along in front of the parachordal cartilages; the trabeculæ cranii are its right and left *moieties*. The *second* arch can only be understood by reference to the development of the lower types of Vertebrata; for in the Shark, Skate, Newt, and Frog the pterygo-palatine portion is not a distinct cartilage, but runs forward as a *process* of the suspensory part of the lower jaw. But this early division of a visceral arch into an antero-superior and a postero-inferior bar is very constant in the next or *second* visceral arch from the *Skate* up to *Man*. Let it be remembered that the *cartilaginous* stage is the second; in the first stage the skeletal parts are membranous. They are formed of soft stellate cells in the mesoblast.[2]

At present the subocular pterygo-palatine bar is very little denser than the tissue in which it is imbedded, but the mandible itself is fast passing into cartilage. Already it is in two pieces, a suspensory piece (figs. 1 and 2, *q.*), and a free rod (*mk.*); the upper piece becomes the quadrate, and the lower, longer part the articulo-Meckelian bar. The processes of the tuberous upper piece are indistinct, but it is sinuous below where it articulates with the thick end of the free bar. These bars nearly, but not quite, meet in the rudimentary chin, the ventral end of the lower jaw. Properly speaking, the hyoid arch is composed of *two* visceral arches; but the term is now applied strictly to the first of these, namely, the second visceral, or the arch of the tongue. At present this arch has, with the one in front of it, its *antero-superior* piece quite soft; it, too, is *late* in its development. The two lower pieces (fig. 2, *c.h.*) form the skeleton of the tongue. They are the cerato-hyals, and between these is a small basi-hyal (*b.h.*) answering to the first basi-branchial of a Fish. The third post-oral arch is very similar, but it is larger, and its upper piece is already fast chondrifying. That corresponds to the first epi-branchial of a Fish, the lower piece to the first cerato-branchial, and the median wedge to the second basi-branchial.[3]

*Cranium of Fowl—Second Stage.*—In from twenty-four to thirty hours, or about the beginning of the sixth day of incubation, the chondro-cranium of the chick has undergone sundry and notable changes. A sectional view (fig. 3) shows that the hinder and front cartilages, parachordal and trabecular, are applied to each other unconformably, the parachordal tracts rising high between the second and third cerebral vesicles, and forming the posterior pituitary wall, a shelving structure in which the axial skeleton ends.

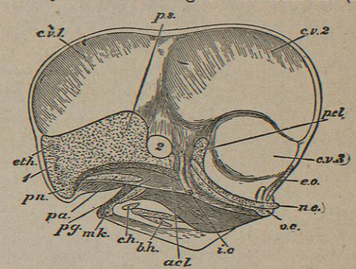


Fig. 3.—Head of *Chick*, second stage, after five days of incubation; length of head, 4 lines; × 6 diameters; a vertical section. *c.v.1*, *c.v.2*, *c.v.3*, 1st, 2d, and 3d cerebral vesicles; 1, 2, localities of first and second nerves (olfactory and optic); *pn.*, prenasal cartilage; *eth.*, ethmoid; *a.cl.*, anterior clinoid wall; *p.cl.*, posterior clinoid wall; *n.c.*, notochord; *o.c.*, occipital condyle (from this point to *p.cl.* the cartilage is parachordal); *e.o.*, exoccipital; *i.c.*, internal carotid artery; *pa.*, palatine; *pg.*, pterygoid region; *mk.*, Meckel's cartilage; *c.h.*, cerato-hyal; *b.h.*, basi-hyal; *p.s.*, presphenoidal region.

A bird's-eye view of the hinder skull-floor at this stage (fig. 4) shows that the dorsal or hinder ends of the trabeculæ have opened out, like a pair of callipers, and that the out-turned ends of the parachordal cartilages are fused with the inner margin of these apices. The bud-shaped process, which has almost freed itself from the rest, opposite the bulbous end of the notochord, is the true apex of the first visceral bar, or trabecula; in the next stage it is far more distinct and instructive. Turning again to the vertical section (fig. 3), we see that the commissure of the trabeculæ, or inter-nasal plate,[4] has now become a high wall of cartilage, separating not only the nasal sacs, but also the eyeballs.

That part of the septum which now looks, not only downwards, but is also turned somewhat backward (fig. 3, *eth.*), will ultimately lie in the upper part of the nasal and frontal regions. A new thing has appeared, namely, an

[1] See article Amphibia, vol. i. p. 755, fig. 9, between *pd.* and *d.O.*

[2] See Foster and Balfour's work, p. 223.

[3] See Parker "On the Salmon's Skull," *Phil. Trans.*, 1873, plate 6, fig. 3. See also plate 2 of the same paper for the subdivision, in a Teleostean Fish, of the hyoid arch.

[4] This corresponds to the flattened, narrow mesethmoid of Menobranchus. See Amphibia, vol. i. pp. 756 757 figs. 11, 12

azygous cartilaginous bud at the mid-line of the fronto-nasal process; it is about to become the axis of the beak, and will turn forwards and upwards. This is the prenasal or basi-trabecular cartilage, a notable morphological element *up* here, amongst the Birds, and *down* amongst the lower or cartilaginous types of Fishes. At the present it corresponds exactly to the state of the Green Turtle's skull (chondro-cranium) at the time of hatching, and in that type it stops at this stage, not raising itself into a forth-standing rostrum.

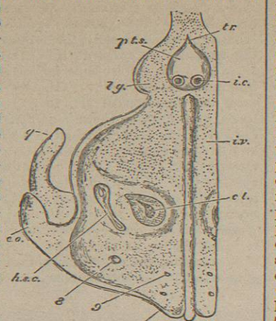


FIG. 4. Skull of *Chick* whose head was five lines long, more than half of bird's-eye view, × 12 diameters. Lettering as above, with addition of *i.v.*, investing mass, or parachordal cartilages; *i.c.*, internal carotid artery; 8, foramen for vagus nerve. Here the lingula (*lg.*) shows the apex of the trabeculæ externally.

The mouth, which in the first stage was a large four-sided cleft, with produced corners, and clean beneath the head, as in a Skate, is now a space, the axis of which points more forward than downward, a good step towards its eventual direction. The further development of the facial arches will be best studied in older specimens at the end of this, the second stage; but at its commencement there is wanted the condition of the *antero-superior* segment of the hyoid, or second post-oral arch. This has not been worked out in the Fowl's chick, but in an embryo of the House Martin (*Chelidon urbica*), corresponding to the stage given in our third figure as to development.

In this instance the quadrate and articular Meckelian cartilages have acquired very nearly their proper form (fig. 5, *q.*, *ar.*, *mk.*), the suspensorial part having a free for-

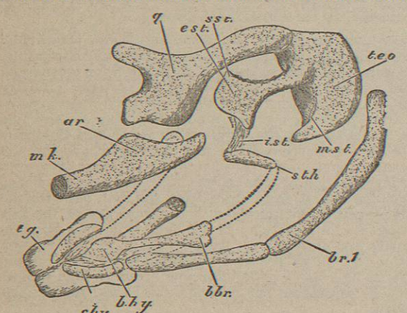


FIG. 5.—Facial arches of House Martin (*Chelidon urbica*), middle of incubation, × 20 diameters. *q.*, quadrate, with orbital process or "pedicle" in front, "otic process" behind, and articular facet below; *ar.*, articular part of mandible; *mk.*, Meckel's cartilage (cut through); *m.st.*, medio-stapedial (the line from the letters only reaches *half-way* to this bar); *s.st.*, supra-stapedial; *e.st.*, extra-stapedial; *i.st.*, infra-stapedial (soft); *st.h.*, stylo-hyal; *t.e.o.*, tympanic wing of exoccipital; *tg.*, tongue; *c.hy.* cerato-hyal; *b.hy.*, basi-hyal; *b.br.*, basi-branchial; *br.* 1, 1st branchial or thyro-hyal.

ward and inward looking process, the "pedicle," and backward turned process, the "otic process," articulating with the auditory sac (this is drawn as cut away in part, and only that which is conjoined to the occipital cartilage (*t.e.o.*) is given). Just below *and behind* the otic process of the quadrate, exactly where in riper embryos we find the *fenestra ovalis*, having fitted into it the elegant oval base of the "columella auris," there is in this instance a curious trowel of cartilage, continuous by the upturned end of its handle with the very substance of the ear-capsule. The solid sickle-shaped cartilage behind this is the "tympanic wing" of the exoccipital (*t.e.o.*) Here we have the wanting upper and anterior segment of the hyoid arch, corresponding to the separately developed pterygo-palatine bar, its "serial homologue." The blade or free end of the trowel is concave on the under side, and is thick above and at its margin on the outside; it is pointed above and below. A ligament connects the upper point with the ear-capsule behind the quadrate, and another tract of soft *indifferent tissue* reaches downwards to a small bar of cartilage, which looks backwards and a little downwards. This little cartilage (*st.h.*) is only connected with the distal piece (*c.hy.*) by fibrous tissue; it is the stylo-hyal, and corresponds to what is permanent in the Crocodile. The bar itself is the "medio-stapedial" (*m.st.*); it will soon segment itself off from the ear-capsule, bringing away with it an oval piece of the periotic wall; that oval part is the true stapes. The broad part of the "blade" is the extra-stapedial, and on it will be stretched the *membrani tympani*. It precisely corresponds now with that of that old Lacertian *Hatteria* or *Sphenodon*.[1]

The "stylo-hyal" will soon be conjoined to the extra-stapedial plate, and the (afterwards) chondrified band will be the "infra-stapedial."[2]

In a few hours the changes that have taken place in the chick's skull are very noticeable and important; these are recorded as the end of the second stage.

A side view of the chondro-cranium (fig. 6), the membrano-cranium above the brain being removed, shows how fast the life-processes are moulding the embryonic head into the fashion seen in the adult; no trace of bone has appeared, save in the sides of the mandible. The roof of the skull never chondrifies, but is covered in by secondary bones. Like the skull of an adult Shark or Skate, the whole chondro-cranium is one continuous structure—all save the post-oral arches. The auditory mass is now environed by cartilage stretching over the back of the head—the occipital, and by wing-like growths that wall-in the bulk of the brain behind the eyes—the alisphenoid (*a.s.*) The high

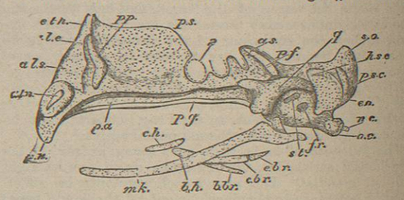


FIG. 6.—Skull of *Chick*, second stage, head 5 lines long, × 6 diameters. Outer view, with brain and roof removed to show chondro-cranium. Letters as in figs. 1–4, with the addition of *al.n.*, alinasal cartilage; *al.s.*, aliseptal; *al.e.*, alethmoidal; *p.p.*, pars plana; *a.s.*, alisphenoid; *p.f.*, post-frontal (sphenotic region); *s.o.*, super-occipital; *st.*, stapes; *f.r.*, foramen rotundum; *p.s.c.*, posterior semicircular canal.

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[1] See Huxley "On the Representatives of the Malleus and Incus of the Mammalia in the other Vertebrata," *Proc. Zool. Soc.*, May 27, 1869, pp. 394–397, figs. 1–4.

[2] For a comparison of these parts with the *ossicula auditus* of the Mammal, see also Parker "On the Structure and Development of the Skull in the Pig," *Phil. Trans.* 1874 p. 331.



orbito-nasal wall is one continuous plate of cartilage, seemingly only a crest upgrowing from the coalesced tract of the trabeculæ. The arched wings of this part, which we saw in the first stage, can be seen to be marked off into three regions—an alethmoid (*al.e.*), an aliseptal (*al.s.*), and an alinasal (*al.n.*); in the latter is the external nostril, and dividing the eye from the nose is a flat partition, the *pars plana* (*p.p.*) Between the nasal openings and their curtains and valves, the prenasal cartilage (*p.n*), still arcuate, is yet rising in front; whilst, behind and above, the great middle wall (*eth.*) terminates by a bud of cartilage, which marks the fore-end of the cranial cavity, and the groove on each side below this is for the nerve of smell (1). The oval pituitary space has become a neat round opening, through which the internal carotid arteries enter; it never chondrifies below, and has to be floored afterwards by secondary bone. The upper hyoid element (*st.*) has now freed itself from the periotic cartilage, bringing away so much as serves for the dilated dorsal end, and thus leaving an open window (*fenestra ovalis*), to which this forms the accurately fitted shutter. In front of this small cartilage, the quadrate (*q.*) shows almost its adult form, and the double lower condyle fits into a sinuous concavity on the end of Meckel's cartilage (*mk.*) This free bar—the mandible—sends backwards a posterior, and inwards an internal angular process. The later and feebler pterygo-palatine sickles are now formed internally of small thin-walled spheroidal, and externally of fusiform, cells of a larger size. They ossify before chondrification can take place.

Interposed between the skin of the palate and fauces below and the basis cranii above, is a thick mat of granular tissue, which does not, however, chondrify, but ossifies as the parasphenoid and basi-temporal bones.

*Cranium of Fowl—Third Stage.*—After about three or four days, that is, about the middle of the second week of incubation, the chondro-cranium has not only undergone great changes in size and form, it is also now beginning to become an *osteo-cranium*. All that is cartilaginous has acquired a neat finish (figs. 7, 8); the occipital condyle (*o.c.*) is perfect; the super-occipital arch is complete (fig. 8, *s.o.*); and bone is forming in three places in the occiput (*n.c., e.o.*), and the bone (*pa.s.*) which underlies the orbital septum has grafted itself upon the cartilage of the basi-sphenoidal region. That bone, the parasphenoid (*r.b.s.*), and the other investing bones, are now growing in the tissue between the skin and the cranio-facial elements; those that can be seen below are shown in figure 8, the remainder can be described in riper stages. The downward bend (not shown in the figure) of the prenasal rostrum (*p.n.*) is but gentle; this long spatulate continuation of the base of the orbito-nasal septum, the "basi-trabecular bar," or foremost keystone piece of the body, is now at its fullest height of growth, and ready to decline. It is now the accurate

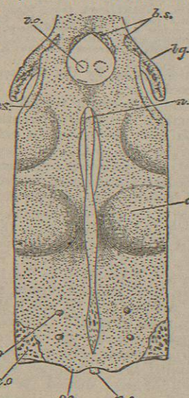


FIG. 7.—Skull of *Chick*, third stage, part of basal region, from above, × 13 diameters. *a.s.*, root of ali-sphenoid; *b.s.*, basi-sphenoid. The notochord (*n.c.*) is seen to lie in an open space in front—the posterior basi-cranial fontanelle—and to be bony behind; the bony matter is the rudiment of the basi-occipital.

counterpart of the axis of the cutwater of such Fishes as the Skate, Saw-fish, and Shark. Those who look for the under-

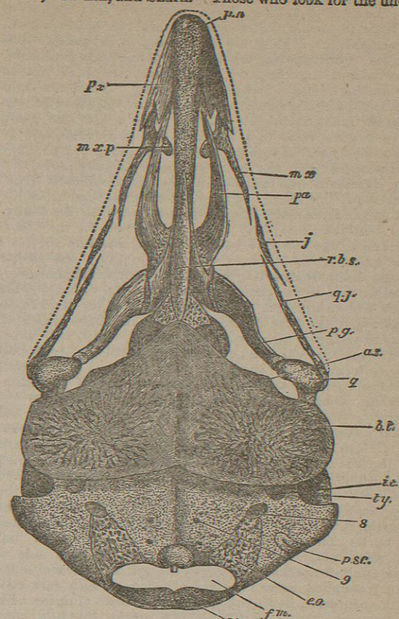


FIG. 8.—Skull of *Chick*, third stage, under view, × 10 diameters. Around the large prenasal cartilage *p.n.*, which, behind, runs into the septum nasi, are seen the premaxillaries (*px.*) These are the commencement of a chain of splints running to the quadrate (*q.*), viz., *mx.*, maxillary; *mx.p.*, its inner process; *j.*, jugal; *q.j.*, quadrato-jugal. Within these are—*pa.* palatine; *pg.*, pterygoid; *r.b.s.*, rostrum of basi-sphenoid (parasphenoid); this is spreading into the basi-sphenoidal region, flanked by the lingulæ, and above and behind are the ali-sphenoids (*a.s.*) In the broad part are the following, viz., *b.t.*, basi-temporals; *ty.*, tympanic cavity; *f.m.*, foramen magnum; *b.e.o.*, the bony exoccipitals; *s.o* super-occipital. Other letters as above.

lying *unity* of the various types may here see how fit this unpaired rod is to have modelled on it all kinds of beaks of Birds. On this bar a tri-radiate patch of bone is formed right and left, leaving it as yet uncovered below, above, and at the fore-end. These are the young premaxillaries, and are bones that in most Birds, as in Osseous Fishes, overshadow and starve the upper jaw-bones, or maxillaries proper, so large, relatively, in most other types. Already they have each a palatine, a nasal, and a dentary process. The machinery of the first post-oral is shown (fig. 8), all save the free mandible, which will be described in a more advanced stage. The quadrate (*q.*) is ossifying; the pterygoid and palatines (*pg., pa.*) are ossified; they are very simple bars. Between the premaxillary and the quadrate are bones that have been formed in the outer part of the "maxillo-palatine process" of the embryo; they are the feeble maxillary, with its ingrowing maxillo-palatine plate, and the still feebler jugal and quadrato-jugal (*mx., mx.v., j., q.j.*)

On the mid-line a grooved style of bone, the rostrum of the parasphenoid, carries the rounded lower edge of the