of the vomers with the alinasal wall and turbinal, and the possession, by the embryo bird at least, of a pair of "upper labials," corresponding to the *inner* upper pair in Snakes, Sharks, and Skate; the vomers are either partial or entire ossification of these cartilages. Besides these, there re-appear in most of the *Ægithognathæ* the so-called "inferior turbinals," or nostril-bones of the Snake and Lizard, and these are attached to the shoulders of the double, and generally, ox-face-shaped vomer.[1] The nasal labyrinth is very large in the Rook, but does not differ in essentials from that of the Fowl, above described.

The septum nasi (*s.n.*) retains much of its original flatness below, and is thus *alate;* the vomer (*v.*) of the young bird is broad and grooved above; in the old bird, ossification running some distance along the alinasal wall and alinasal turbinal (*n.tb.*), the bone becomes not only emarginate, but also very massive in front. In the Lark (*Alauda arvensis*) this bony matter in the macerated skull leaves huge goat-horn processes to the fore-angles of the vomer. Ægithognathism occurs in different degrees; thus, we may have its morphological conditions—

a. Incomplete: as in *Turnix*.
b. Complete var. 1: *Pachyrhamphus*, *Pipra*.
c. Complete var. 2: *Corvus*, *Alauda*.
d. Compound: *Gymnorhina*, *Artamus*.

a. Incomplete. Here the large "labials" are imperfectly ossified by the two vomers, and these bones are only strongly attached to the nasal labyrinth by fibrous tissue.

b. Complete var. 1. In these cases the labials are often only imperfectly ossified by the vomerine centres; these centres also are distinct from those ossifying the alinasal cartilages; but the union of these parts is perfect.

c. Complete var. 2. In these cases the labials are often small and completely ossified by the vomers; but the bony deposit runs riot into the alinasal wall and turbinal, so that in the adult all distinction of the parts may be lost.

d. Compound. Here the flat arcuate end of the maxillo-palatine is free, but the mass of that plate meets its fellow of the opposite side and coalesces with it, and with a highly ossified nasal septum. In these *Southern types* the "transpalatine" is a long spike, as in the *Alcedidæ*. In all these varieties the septo-maxillaries may, and do mostly, occur. They cannot always be found.[2]

Concluding our remarks upon this morphological type, its value is shown by this—that it is exactly superimposable upon the *Coracomorphæ*, if we reject the bird that shows its initial or imperfect condition, as the Hemipod, and stubbornly hold to the popular view that Swifts are a kind of Swallow—for as to their nobler part, their head, they are merely a variety of that type. Thus the zoologist and the morphologist may here join hands.

The SAUROGNATHOUS *Type — Cranium of the* Picus Minor.—This group, Professor Huxley's *Celeomorphæ* (*op. cit.* 448 and 467), is so remarkable and difficult of determination, that although our author saw clearly many most important characters (quite sufficient for the elimination of this group from the *Coccygomorphæ*), yet the materials at hand were not sufficient for a perfect account of this type of skull. A fellow-worker has had fuller opportunities.[3] Like the Parrots, these birds form a relatively small and neat group; the most outlying forms are *Picumnus* and *Yunx*, but these form no obstruction to their classification. Mr Parker's proposed morphological term for these birds is *Saurognathæ*, and the two terms can be superimposed, *Celeomorphæ* being their zoological name. Professor Huxley saw that these birds were not desmognathous; that their vomerine moieties remained distinct; that their maxillo-palatines are but little developed; and that supernumerary bones on the inner edge of the palatines in *Picus minor* corresponded to the curious bars that are seen in the larger kinds. He also, with quick insight, says that their palate exhibits a "degradation and simplification of the Ægithognathous structure." This is strictly true; the elementary parts are the same, but in the Woodpeckers they retain a very *Reptilian* distinctness, and even arrest of growth. Yet with that arrest there is combined a modification and metamorphosis of certain parts, such as is undergone by no other type. They are in some respects the most simple and embryonic, and in others the most highly specialized birds in the whole class. Their basi-pterygoids are arrested; their basi-temporal region large and wide. Two or three tympanics on each side help to form their remarkable *cowrie-shaped* ear-drum, which is mainly built up by the basi-temporals and exoccipitals. The lower end of the quadrate has the usual form; the bone itself is short; the pterygoids are long, slender, angular, and forked; the lower and foremost fork is the meso-pterygoid element, which does not become segmented off, and thus their pterygoids answer to that of a Snake or Lizard, and reach to the vomer.[4]

The palatines (fig. 27, *pa.*) have their postero-external

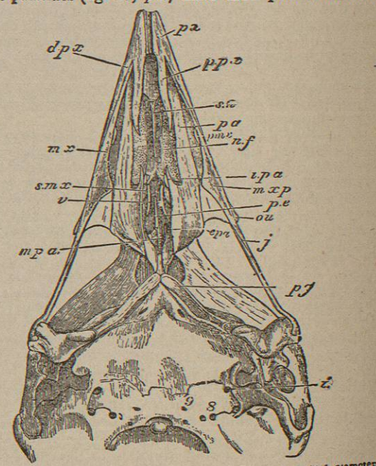

FIG. 27.—Palatal view of skull of a nestling of *Picus minor*. × 4 diameters. *i.pa.*, inter-palatine spur; *s.mx.*, septo-maxillary; *m.pa.*, medio-palatine.

[1] There is not space here to give illustration of all these details; but papers by Mr Parker are now (1875) appearing in the *Transactions of the Linnean and Zoological Societies*, in which these structures are copiously illustrated.

[2] Professor Huxley (*op. cit.*, p. 472) was as unfortunate in his specimen of *Menura* as in that of *Trochilus* (see p. 468, where these birds are said to have their vomer truncated, whereas it is *spiked*); for in Mr Garrod's specimens of the Lyre-bird's skulls the maxillo palatines are large bony plates, like those of ordinary *Coracomorphæ*. The vomer of *Menura* is exactly like that of the Chough (*Fregilus graculus*), and also of many *young Coracomorphæ*, for the two moieties do not necessarily form a re-entering angle or notch in front; that is often largely due to the osseous growth creeping into the alinasal cartilages. *Menura* has one character of great importance, viz., it retains the super-orbital chain of ossicles, like *Peophia* and the *Tinamidæ*.

[3] See Mr Parker's paper "On the *Picidæ*," in the *Linnean Transactions*, 1875, series 2, vol. i. plates 1–5.

[4] See Günther "On *Hatteria*," *Phil. Trans.*, 1867, plate 1, fig 2, p. 5.

angle either rounded or obtuse-angled. The post-palatine region is bevelled off remarkably; but in *Picumnus minutus*, the lips of this part are greatly developed, as in the lower Passerines of South America;[1] but in them this marked region appears to be always ossified directly from the main bone, whilst in *Picumnus* it is a separate ossification—a perfectly unique thing, as far as the writer's knowledge goes. The broad main part of the palatine suddenly narrows at its first third, the remaining two-thirds being the long splintery prepalatine, opposite the beginning of which the inner lip runs into an "inter-palatine" spike (*i.pa.*) The ethmo-palatine processes are extremely long in the nestling of *Yunx*, and very short in that of *Picus minor* (*e.pa.*) They are the free anterior ends of that ascending plate which lies under the parasphenoidal rostrum. These plates are united by a cartilaginous commissure, dagger-shaped, which ossifies as the most marked medio-palatine (*m.pa.*) seen in the class. The prepalatine band passes between the dentary and palatine spurs of the premaxillary (*px.*), as in the adult fowl. Oddly enough, they run on the inner side of the palatal process of the premaxillary in most of the *Ægithognathæ*. This is an after-modification, for in the young of *Struthio camelus* and *Gallus domesticus* the fore-end of the one and the hinder end of the other process are broad, and the two unite by suture. In the higher birds the processes overlap on either side, but orderly as to natural groups. The free end of the pre-maxillary palatine process looks backward to the free inter-palatine spur in the young (fig. 27); but in old birds, as may well be seen in *Gecinus viridis*, *Picus analis*, and *P. major*, these parts are formed into delicate bridges of bone, which also are thrown along to the ethmo-palatines. This is done by the vomerine series. The "septo-maxillaries" are not single conchoidal plates of bone, as in the Snake and Lizard; but are broken up into grains, which melt into each other again. Even the vomer itself is double on each side in *Gecinus viridis*, whilst in *Hemilophus fulvus* there are three septo-maxillaries on the left side and five on the right. These ossicles lie on the inner side of the palatines, and are normally connected behind by means of the vomer to the ethmo-palatine; where *normal ornithic ankylosis* takes place in adult birds, there these curious length-wise bridges are formed. Yet this is only part of their complexity, for median septo-maxillaries appear, two of them in *Gecinus*, and these are found in the substance of long, right and left, *labial cartilages*. These do not ossify in *Hemilophus*, but unite at the mid-line; in *Gecinus* they overlap largely to gain the mid-line. In the same species, to add to the complexity, a large shell of bone, from the *inturned alinasal wall*, becomes more or less free of its own origin, and unites to the vomerine series. All this has been seen and explained by writing and by figures.[2]

The maxillo-palatine processes scarcely grow inwards at all in *Picumnus;* in *Yunx* they are rather larger; larger still in *Picus minor* (fig. 27, *mx.p.*) Where they are largest, as in *Gecinus*, they just rest upon the outer edge of the palatines, covering nearly half their width. In all, the under face of the maxillary has an open pneumatic space at this part. But, as if to fill up that which was wanting, a separate palatine plate appears on the inner edge of the maxillary further forward, *only on the left side*, however (fig. 27, *p.mx.*) This is a semi-oval wedge of bone, and has its symmetrical counterparts in several families of the *Coracomorphæ*, viz., *Emberiza*, *Cardinalis*, &c.

These birds are saurognathous in other respects, *e.g.*, their nasal labyrinth is unusually simple. The "inferior turbinal," which has *three* coils in *Rhea* and *Tinamus*, and *two* in most birds, is in *Gecinus* merely bi-alate; in *Yunx* it makes less than a single turn, whilst the alinasal turbinal of that bird has two turns, and that of *Gecinus* one. *Gecinus* is in all respects the most specialized, *Picumnus* the most embryonic, and *Yunx* the most passerine of the *Celeomorphæ*. Also, in *Gecinus* the nasal labyrinth is most ossified, and in *Yunx* least. In *Gecinus* the "columella auris" has two supra-stapedial spurs and two infra-stapedial bands, which have united with the tongue-shaped stylo-hyal: this has in it a bony centre. The small cerato-hyals early coalesce into one arrowhead-shaped bone, and then comes a very long, highly ossified, and elastic basi-hyal, with no uro-hyal behind it. Joined to this are a pair of lower thyro-hyals, half its length; but the upper pieces are four times the length of the lower, and they, passing first down the sides of the upper part of the neck, again turn gently upwards and forwards, ploughing themselves a furrow on the skull top, and deflecting gently to the right nasal roof, where they end.

[1] See Parker "On *Ægithognathæ*," part i., *Zool. Trans.*, 1875, plates 54–62.

[2] *Ibid.*, "On the *Picidæ*," *op. cit.*

All these things being considered, it will seem contradictory now to assert the great uniformity of the skulls of Birds, and indeed of the Birds themselves. Yet so it is; and the countless modifications that offer themselves for observation are gentle in the extreme. One form often is seen to pass into another by almost insensible gradations. One thing is certain, namely, that an anatomist not familiar with this class, and coming to its study fresh from the Reptiles, would find himself at fault at every turn; for he would see changes altogether as great as if he had passed from the Helminthoid types, and from mere *larvæ* and *pupæ* of the Insects to the (to him supposably) unthought-of *imagines* that spring from those low and worm-like stages.

In the rest of the Birds' organization abundant evidence of the same specialization will be seen. The mind fails to desire more beauty or to contemplate more exquisite adaptations. An almost infinite variety of Vertebrate life is to be found in this class. Of its members some dig and bury their germs, which rise again in full plumage, whilst others watch and incessantly feed their tender brood in the shady covert or "on the crags of the rock and the strong place." In locomotion some walk, others run, or they may wade, swim, plunge, or dive, whilst most of them "fly in the open firmament of heaven."

THE VERTEBRAL COLUMN, RIBS, AND STERNUM.[3]

The spinal column of birds contains numerous and well-ossified vertebræ, a considerable number of which (more than six) are ankylosed together to form a sacrum. Of the vertebræ which enter into the composition of this complex bone, however, not more than from three to five can be regarded as the homologues of the sacral vertebræ of a Crocodilian or Lacertilian Reptile. The rest are borrowed, in front, from the lumbar and dorsal regions; behind,

[3] See Parker "On the Osteology of Gallinaceous Birds and Tinamous," *Trans. Zool. Soc.*, vol. v., 1863; "On the Systematic Position of the Crested Screamer (*Chauna chavaria*)," *Proc. Zool. Soc.*, Dec. 8, 1863; "On the Osteology of *Microglossa alecto*," *ibid.*, Feb. 23, 1865; "On the Osteology of the Kagu (*Rhinochetus jubatus*)," *Trans. Zool. Soc.*, vol. vi. Huxley "On the Classification of Birds," *Proc. Zool. Soc.*, April 11, 1867; "On the Alectoromorphæ," *ibid.*, May 14, 1868; "The Anatomy of Vertebrate Animals," 1871, p. 272. M. Edmond Alix, *Essai sur l'Appareil Locomoteur des Oiseaux*, Paris, 1874,—a most important work. The writer will often use the "very words" of Professor Huxley, despairing, as he does, of coming near that excellent writer, either in *condensation* or *order*. The working student will find the axial skeleton of the Ostrich most profusely and beautifully illustrated in Professor Mivart's paper (*Trans. Zool. Soc.*, vol. viii. part 7). Every ornithologist will be grateful for that piece of work.

from the tail. The cervical region of the spine is always long; and its vertebræ, which are never fewer than eight, and may be as many as twenty-three, are, for the most part, large in proportion to those of the rest of the body.

The atlas is a relatively small, ring-like bone; and the transverse ligament may become ossified and divide its aperture into two—an upper for the spinal cord, and a lower for the odontoid process of the axis vertebra. The *os odontoideum* is always ankylosed with the second vertebra, and constitutes a peg-like odontoid process.

The spines of the succeeding cervical vertebræ are often obsolete, and are never very prominent in the middle region of the neck. The anterior faces of their elongated vertebral centra are *convex from above downwards*, and *concave from side to side;* whilst the posterior faces are cylindrical, slightly excavated *from above downwards*, and *convex from side to side.* (The contrary of this is stated in Professor Huxley's *Verteb. Anim.*, p. 276, where the author, by a *lapsus memoriæ*, puts it *vice versa*.) Hence, in vertical section the centra appear *opisthocœlous;* in horizontal section, *procœlous*, and not the contrary, as is stated by our author; and the structure is exceedingly characteristic of birds. The under surfaces of the centra frequently give off median inferior processes. In the *Ratitæ* it is obvious that the cervical vertebræ have short transverse

FIG. 28.—A cervical vertebra from the middle of the neck of a *Fowl*; natural size. *a*, side view; *b*, upper view; *c*, lower view; *pr.z.*, pre-zygapophyses; *pt.z.*, post-zygapophyses.

processes and ribs, disposed very much as in the *Crocodilia*. For, in young birds, the anterior end of the lateral face of each vertebra bears two small processes, an upper and a lower; and this expanded head of a styliform rib is articulated with these by two facets, which represent the capitulum and the tuberculum (Huxley, *op. cit.*, p. 276). In the chicken of the Emeu (*Dromæus novæ-hollandiæ*) the writer, in 1843, carefully worked out and figured these parts. Of the twenty cervical vertebræ only the atlas and axis were devoid of distinct ribs; this individual was six weeks old. These riblets were bony wedges, with a sharp point; but that was free, and the thick upper end was jammed in between upper and lower transverse processes (*diapophysis* and *parapophysis*). The last but one of the ribs became suddenly larger, and the last was two-thirds the size of its successor—the first dorsal. Then followed six large ribs on each side, the last two floating. The vertebra bearing the last of these, and twenty more, are closely embraced by the fore-and-aft growth of the ilium, and form the so-called sacrum. Of the twenty vertebræ between the first overlapped bone with a floating rib and the nine *ribless* caudals, there are five with free ribs, small, and hatchet-shaped, quite like those in the neck of the Crocodile. These, from being attached to a parapophysial cup near the fore-end of the centrum, get more forward, and wedge in between their own vertebra and the one in front. The next four vertebræ, which give exit to the sacral plexus (or at least to most of it), have no ribs, and are very broad and short. They develop lamellar upper transverse processes, but their spines are aborted. Then come eleven vertebræ, in front of the free caudal, that have short ribs; the first two pairs are ankylosed already, then *four pairs* are distinct, and the remaining five have their ribs ankylosed, and then becoming shorter and more pedate externally, get further backwards on the centrum. Thus, in a Bird as old as six weeks after hatching, there are eighteen pairs of cervical, and nine pairs of so-called sacral ribs still distinct. Moreover, the ribs are quite aborted on the first and second cervical, on the four *true* sacral,—perchance, the next after this is also sacral,—and on all the caudal vertebræ which have only papilliform transverse processes. There are fifty-five vertebræ in all in the Emeu, thus:—cervical, twenty; dorsal, five; dorso-lumbar (the first with a large rib and really the sixth dorsal), six; sacral (proper), four; uro-sacral, eleven; caudal, nine. We shall return to these data in describing the sacrum of the Fowl.

With age the cervical ribs (of the *Ratitæ*) may become completely ankylosed. In *Apteryx australis* one, below, remains free; in *Struthio camelus*, two; and in *Dromæus novæ-hollandiæ*, three; and then they appear like transverse processes, perforated at the base by a canal, which, as in the *Crocodilia*, contains the vertebral artery and vein, and the main trunk of the sympathetic nerve. The cervical ribs and transverse processes are similarly disposed in very young *Carinatæ;* but in these birds their form frequently becomes much modified in the adult, and they develop prolongations which extend downwards and inwards, and protect the carotid artery or arteries. The neural arches have well-developed pre- and post-zygapophyses. The ribs of one or two of the posterior cervical vertebræ become elongated and freely movable in the *Carinatæ*, as in the *Ratitæ*.

The first dorsal vertebra is defined as such by the union of the ribs with the sternum by means of a sternal rib, which not only, as in the *Crocodilia*, becomes articulated with the vertebral rib, but is converted into complete bone, and is connected by a true articulation with the margin of the sternum. The number of the dorsal vertebræ (reckoning under that head all the vertebræ, after the first dorsal, which possess distinct ribs, whether they be fixed or free) varies. The centra of the dorsal vertebræ either possess cylindroidal articular faces, like those of the neck, as is usually the case; or more or fewer of them may have their faces spheroidal, as in the Penguins [Plovers (and their kin *Vanellus cristatus*, *Totanus fuscus*, &c.), Gulls, Cormorants, and Parrots]. In this case the convex face is anterior, the concave, posterior. They may, or may not, develop inferior median processes [which may be simple, as in the Cormorant, where they exist on several lower cervical, on all the dorsal, and in five sacro-lumbar; or they may bifurcate into two broad, bony leaves, as in *Colymbus*]. They usually possess well-marked spinous processes [which begin in the two or three lower cervicals]. Sometimes they are slightly movable upon one another [bound strongly, in many cases, by ossified tendons of great strength and elasticity]; sometimes they become ankylosed together into a solid mass. [When this takes place the last cervical is ankylosed to the three first dorsal, as in the fowl, the fourth remaining free, and the fifth coalescing with the lumbar; or, as many as *five* may ankylose together, leaving one free, and the last ankylosed to the lumbar, as in *Falco œsalon*. But this number often differs with age, as may be seen in different individuals of *Psophia crepitans*. and other, more typical, Cranes.]

It is characteristic of the dorsal vertebræ of Birds that the posterior, no less than the anterior, vertebræ present a facet or small process on the body, or lower part of the arch, of the vertebra for the capitulum of the rib, while the upper part of the neural arch gives off a more elongated process for the tuberculum. Thus, the transverse processes of all the dorsal vertebræ of a Bird resemble those of the two anterior dorsals of a Crocodile, and no part of the vertebral column of a Bird presents transverse processes with a step for the head of the rib, like those of the

great majority of the vertebræ of *Crocodilia*, *Dinosauria*, *Dicynodontia*, and *Pterosauria*. [The triangular facets for the tubercular processes are scarcely scooped; those for the capitular are neat, round, shallow cups.] The discrimination of the proper lumbar, sacral, and anterior caudal vertebræ, in the ankylosed mass which constitutes the so-called "sacrum" of the Bird, is a matter of considerable difficulty. The general arrangement is as follows:—The most anterior lumbar vertebra has a broad transverse process, which corresponds in form and position with the tubercular transverse process of the last dorsal. In the succeeding lumbar vertebræ the process extends downwards; and in the hindermost [the *third*] it is continued from the centrum, as well as from the arch of the vertebra, and forms a broad mass which abuts against the ilium.[1] This process might well be taken for a sacral rib, and its vertebra for a proper sacral vertebra. But, in the first place, I find no distinct ossification in it [there are *five* of these lumbar vertebra in the Emeu, two more than in the Fowl, and they all have distinct ribs; and the *ribless* vertebræ are five in the Fowl and four in the Emeu]; and, secondly, the nerves which issue from the intervertebral foramina in front of and behind the vertebra enter into the lumbar plexus, which gives origin to the crural and obturator nerves, and not into the sacral plexus, which is the product of the nerves which issue from the intervertebral foramina of the proper sacral vertebræ in other *Vertebrata*. Behind the last lumbar vertebra follow, at most, five vertebræ which have no ribs; but their arches give off horizontal, lamellar processes, which unite with the ilia. [In the Emeu these *four* vertebræ show not the least trace of ribs, and are flat bricks of bone, below, jammed together like the cervical centra of a *Cetacean*.] The nerves which issue from the intervertebral foramina of these vertebræ unite to form the sacral plexus, whence the great sciatic nerve is given off; and I [Professor Huxley] take them to be the homologues of the sacral vertebræ of the *Reptilia*. The deep fossæ between the centra of these vertebræ, their transverse processes, and the ilia, are occupied by the middle lobes of the kidneys. If these be the true sacral vertebræ, it follows that their successors are anterior caudal. They have expanded upper transverse processes, like the proper sacral vertebræ; but, in addition, three or four of the most anterior of these vertebræ possess ribs, which, like the proper sacral ribs of Reptiles, are suturally united, or ankylosed proximally, with both the neural arches and the centra of these vertebræ; while, distally, they expand and abut against the ilium. The ankylosed caudal vertebræ may be distinguished as *uro-sacral*.

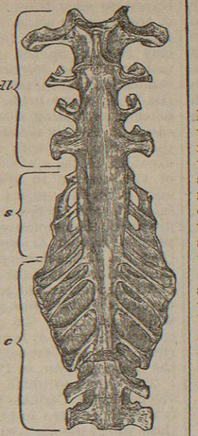

FIG. 29.—The "sacrum" of a young *Fowl*; natural size, seen from below. *d.l.*, dorso-lumbar, *s*, sacral, *c*, caudal vertebræ.

We now give a table showing the number of bones in the so-called sacrum of Birds—so many vertebræ as are covered by the ilia and ankylosed together. Here the distinction between *dorsal* and *lumbar* is, that the former possess elongated ribs; and the table will show forms of extreme *length* and of extreme *shortness*, for a Bird; and also, as in the Fowl, of a medium type. Most of the instances are derived from the sacral bones of young Birds.

	d.	..	s.	u.s.		Total.
Dromæus novæ-hollandiæ ...	1	5	4	11	=	21
Cygnus olor	2	5	4	10	=	21
Colymbus glacialis and *C. septentrionalis*	2	3	5	7	=	17
Gallus domesticus.....	1	3	5	6	=	15[2]
Alcedo ispida.....	1	2	4	6	=	13
Upupa epops.....	1	2	3	5	=	11
Cypselus apus.....	2	1	3	5	=	11

In both the Hoopoe and the Swift the first of these sacrals has an outstanding rib-process. In the Swift the rib on the second of the enclosed dorsals is very long, and its flanking rib nearly reaches the sternum. The next or third vertebra, the lumbar, has *below* it, neither reaching to it above, nor by its sternal piece to the sternum below, another rib; it is two-thirds the size of its predecessor, and only occurs on the *right* side. This will show how, by gradations the most gentle, the vertebræ and their ribs are specialized in each particular type, and also how very arbitrary is our nomenclature.

The Swan has eight free vertebræ behind the *uro-sacral*, and as the last of these is in these types composed of ten vertebræ originally, there are primarily twenty-seven vertebræ in the Swan's tail. The caudal vertebræ which succeed the *uro-sacral* may be numerous and all distinct from one another, as in *Archæopteryx*, or few and distinct, as in *Rhea;* but more generally, only the anterior caudal vertebræ are distinct and movable, the rest being ankylosed into a ploughshare-shaped bone or *pygostyle*, which supports the tail feathers and the uropygial gland, and sometimes, as in the Woodpecker and some other Birds expands below into a broad polygonal disk.

The centra of the movable presacral vertebræ of Birds are connected together by fibro-cartilaginous rings, which extend from the circumference of one to that of the next. Each ring is continued inwards into a disk, with free anterior and posterior faces—the *meniscus*. The meniscus thins towards its centre, which is always perforated. The synovial space between any two centra is, therefore, divided by the meniscus into two very narrow chambers, which communicate by the aperture of the meniscus. Sometimes the meniscus is reduced to a rudiment; while, in other cases, it may be united, more or less extensively, with the faces of the centra of the vertebræ. In the caudal region the union is complete, and the meniscus altogether resembles an ordinary intervertebral cartilage.

A ligament traverses the centre of the aperture of the meniscus, and in the Duck contains the intervertebral portion of the notochord. As Jäger[3] has shown, it is the homologue of the odontoid ligament in the cranio-spinal articulation, and of the pulpy central part of the intervertebral fibro-cartilages in *Mammalia*. All the vertebral ribs in the dorsal region, except, perhaps, the very last free ribs, have widely separated capitula and tubercula. More or fewer have well-ossified uncinate processes attached to their posterior margins, as in the *Crocodilia* [and *Hatteria*. These are separate, both as cartilage and as bone, at first; we have only failed to find them in the Crested Screamer (*Chauna chavaria*). Among the *Ratitæ* they are very small and few in number; in the Emeu and in the Apteryx they are large; they evidently correspond with the unsevered rib-flaps of the little Ant-eater (Parker's *Shoulder-*

[1] It would be more proper to say that ossification extends into and from the centrum as well as from the neural arch. The process, like other processes, exists before the centrum is differentiated from the arch by ossification (Huxley).

[2] Professor Huxley's figure (80, p. 278) only shows *five* uro-sacral, there are *six* in the Fowl.

[3] "Das Wirbelkörpergelenk der Vögel," *Sitzungsberichte der Wiener Akademie*, 1858.

girdle and Sternum, plate 22, figs. 19, 20).] The vertebral ribs are completely ossified up to their junction with the sternal ribs.

The Sternum, Limb-girdles, and Limbs.[1]

The sternum in Birds is a broad plate of cartilage which is always more or less completely replaced in the adult by membrane bone.[2] It begins to ossify by, at fewest, two centres, one on each side, as in the *Ratitæ*. In the *Carinatæ* it usually begins to ossify by five centres, of which one is median for the keel, and two are in pairs for the lateral parts of the sternum. Thus the sternum of a Chicken is at one time separable into five distinct bones, of which the central keel-bearing ossification (fig. 30) is termed the

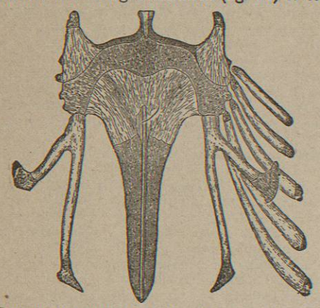

Fig. 30.—Sternum of a Chick (*Gallus domesticus*) three days old, lower view. × three diameters. The cartilage is shaded and dotted, and the bony centres are light and striated. The front external processes are the "costals," and are ossified each by a *pleurosteon*; the median front process is the rostrum, and on each side of it are seen the coracoid grooves. The fore-part of the middle, most of which is carinate, is ossified already by the *lophosteon*; the forked xiphoids on each side are each largely occupied by a *metosteon*; on the right side the sternal ribs are shown.

lophosteon, the antero-lateral piece which articulates with the ribs, *pleurosteon*, and the postero-lateral bifurcated piece, *metosteon*.

[In *Turnix* there are two more centres, mesiad of the pleurostea, these are the *coracostea*; in *Dicholophus* the median part suddenly dilates, behind, into a heart-shaped flap of cartilage, which has an endosteal patch, the *urosteon*.]

Though the sternum, in most Birds, seems to differ very much in form from that of the *Reptilia*, it is rhomboidal in the *Casuariidæ*, where it differs from the Reptilian sternum chiefly in the greater proportional length of its posterior sides, the absence of median backward prolongations, and the convexity of its ventral surface. But in other Birds, and notably in many *Carinatæ*, the antero-lateral edges, which are grooved to receive the coracoids, form a much more open angle than in the *Reptilia*, while the postero-lateral edges become parallel or diverge: and a wide, straight, or convex transverse edge takes the place of the posterior angle. Two, or four, membranous fontanelles may remain in the posterior moiety of the sternum when ossification takes place, and give rise to as many holes, or deep notches, separating slender processes in the dry skeleton. All these correspond with so many divisions of the xiphoid process of the sternum in *Mammalia*, and hence are called *middle*, *internal*, and *external xiphoid processes*. Sometimes a median process, *rostrum* or *manubrium* (figs. 30, 31), is developed from the anterior angle of the sternum, and its antero-lateral angles are developed into *costal processes*, which may bear the articular surfaces for more or fewer of the ribs. The two last-named structures are very distinct in the *Coracomorphæ*, or Passerine Birds.

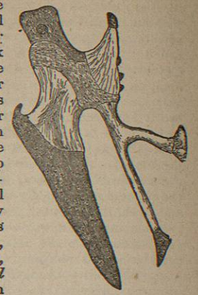

Fig. 31.—A side view of the Chick's sternum, showing the perforation through the rostrum, and the depth and apiculation of the keel. The external and internal (posterior) "xiphoid processes" are seen to end in pedate expansions. In this, as in the lower view, the great size of the "notches" is shown.

The extent to which the keel of the lophosteon is developed in the Carinate birds varies very much. In *Strigops* it is rudimentary; in birds of powerful flight, as well as in those which use their wings for swimming, it is exceedingly large.

The *pectoral arch* presents a long, narrow, and recurved scapula (fig. 32), without any supra-scapula, and a coracoid

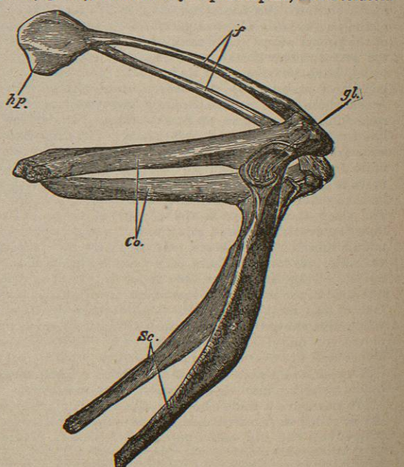

Fig. 32.—Shoulder-girdle of adult *Fowl*, nat. size; oblique side view inverted. *sc.* scapula; *co.* coracoids; *fc.* clavicles; *hp.* hypocleidium, or inter-clavicle; *gl.* glenoidal cavity

[1] See Harting, *L'Appareil Episternal des Oiseaux*, Utrecht, 1864. Parker, "On *Balæniceps rex*," *Trans. Zool. Soc.*, vol. iv. plates 66, 67; "On Gallinaceous Birds and Tinamous," *T. Z. S.*, vol. v. plates 35–41; "On the Kagu," *T. Z. S.*, vol. vi. plates 91, 92; *Shoulder-girdle and Sternum*, plates 13–18; Huxley, "On the *Alectoromorphæ*," *P. Z. S.*, May 14, 1868; *Anatomy of Vert. Anim.*, p. 280; Owen, "On *Alca impennis*, L.," *T. Z. S.*, vol. v. p. 317, plates 51, 52; "On the Osteology of the Dodo," *T. Z. S.*, vol. vi. plates 15–24, and *T. Z. S.*, vol. vii. plates 64, 65; "On Dinornis," *T. Z. S.*, vol. vii. plates 7–9; "On *Aptornis defossor*," *T. Z. S.*, vol. vii. plates 42, 43, and *T. Z. S.*, vol. viii. plates 14–16; Murie, "On *Geocichla varia*," *Proc. Zool. Soc.*, Feb. 27, 1868, p. 163; [4] Ou *Scotopelia peli*," *Jour. Anat. and Phys.*, vol. vi. p. 170, plate 11; "On Todus," *Proc. Zool. Soc.*, May 21, 1872, pp. 664–680, plate 55; "On Colius," *The Ibis*, July 1872, pp. 263–280, plate 10; "On the Motmots," *Ibis*, Oct. 1872, pp. 383–412, plates 13–15; "On the Upupidæ," *Ibis*, April 1873, pp. 181–211, plates 5–7; "On Fregilupus," *Proc. Zool. Soc.*, June 16, 1874, pp. 474–488, plates 61, 62; M. Edmond Alix., *Essai sur l'appareil locomoteur des Oiseaux*, Paris, 1874.

[2] These statements do not apply to *Archæopteryx*; its structure is very imperfectly known (Huxley).

(*co.*), fitted by its proximal end in the groove in the antero-lateral edge of the sternum. The inner ends of the coracoids often overlap, as in *Lacertilia*; otherwise the shoulder-girdle is unlike that of any of the *Reptilia*, except the *Pterosauria*. The coracoid is usually completely ossified, and presents no fontanelle. There is no distinct epicoracoid. The two bones take nearly equal shares in the formation of the glenoidal cavity, and usually remain unankylosed and distinct in this region.

In the *Ratitæ* the long axis of that part of the scapula which lies near the glenoidal cavity is parallel or coincident with that of the coracoid, and the two bones become completely ankylosed. But in all the *Carinatæ* the long axis of the scapula forms an acute, or only slightly obtuse angle (*Ocydromus*, *Didus*) with that of the coracoid. A small bone, the *scapula accessoria*, is developed on the outer side of the shoulder-joint in most *Coracomorphæ* and *Celeomorphæ*.

In the *Carinatæ* the glenoidal end of the scapula is divided into two portions: a *glenoidal* process, which expands to form the upper part of the glenoidal cavity, and to unite with the coracoid; and an *acromial* process, which gives attachment to the outer end of the clavicle. The glenoidal end of the coracoid is in like manner divided into two portions: a *glenoidal* process, which unites with the scapula, and a *clavicular* process, which articulates with the outer surface of the clavicle near its outer end. The clavicular process of the coracoid does not represent the procoracoid of *Lacertilia*; rudiments of that bone unite with the clavicle. In the *Ratitæ* there is no distinct clavicular process; but the anterior part of the coracoid, near the glenoid cavity, may be produced and separated by a notch or fontanelle from the rest, or developed down to the sternum (in *Struthio*) as a lacertilian procoracoid. There is no trace of clavicles in *Apteryx*, *Rhea*, *Struthio*, and some Parrots; but in the latter there is generally an ossified, distinct, short procoracoid. In the Emeu and in some *Carinatæ* (*Didus*, *Rhamphastos toco*, *Corythaix buffoni*, *Buceros albirostris*), the clavicles remain distinct from one another, or connected only by fibrous tissue; but in the majority of Birds they are very early ankylosed together, and with the representative of the inter-clavicle, in the middle line, into a single bone, the *furculum*, the strength of which bears a pretty close relation to the exertion required of the wings in flight or in natation. In the Passerine Birds the scapular end of the clavicle is enlarged by a procoracoid rudiment of cartilage, which ossifies separately, producing the expansion above and in front called *epicleidium*.

A median process (*hypocleidium*) is frequently developed from the inter-clavicular part of the furculum, and this may be united with the carina of the sternum by strong fibrous tissue, or even by continuous ossification. In *Opisthocomus*[1] the furculum is ankylosed with the manubrial part of the sternum on the one hand, and with the coracoids on the other. Ankylosis of the furculum with the coracoids has also been observed in *Didus*,[2] and with both keel and coracoid in *Fregata aquila* (*Shoulder-girdle and Sternum*, p 15, 1; see also the actual specimen in the museum of Coll. Surg. Eng.).

The fore-limb of a Bird, when in a state of rest (fig. 33), exhibits a great change of position, if it be compared with that of an ordinary Reptile; and the change is of a character similar to, but in some respects greater, than that which the arm of a man presents when compared with the fore-limb of a quadrupedal Mammal. The humerus lies parallel with the axis of the body, its proper ventral surface looking outwards. The fore-arm is in a position midway between pronation and supination, and the

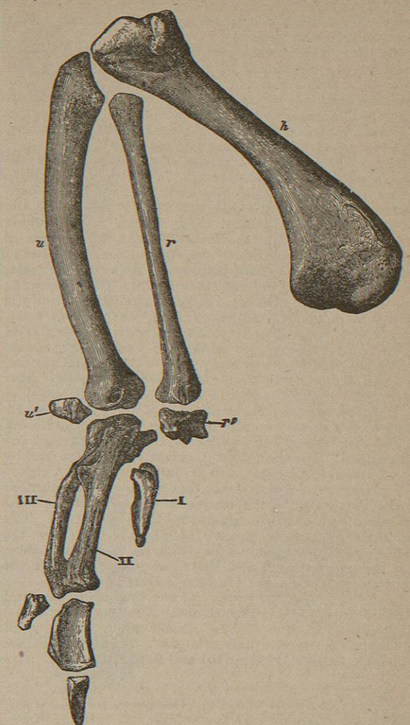

Fig. 33.—Bones of Fowl's right wing, adult, nat. size. *h.*, humerus; *r.*, radius; *u.*, ulnar; *r'.*, *u'.*, radial and ulnar carpal bones; with the three digits I., II., III.

manus is bent back upon the ulnar side of the fore-arm in a position not of flexion but of abduction.

In ordinary Birds the proximal end of the humerus is expanded, and its articular head transversely elongated. Its ventral face is convex, and provided with a strong preaxial ridge, which gives attachment to the pectoral muscle. The proper dorsal face is concave from side to side, especially towards the postaxial margin, where the pneumatic aperture occurs in those birds which have the humerus hollow. The distal end is expanded, and the articular surface for the radius is a convex facet, directed obliquely inwards on its ventral face. In this respect the Bird's humerus exaggerates a feature of that of the Lizard's.

In the *Ratitæ* these peculiarities are very feebly, or not at all, marked, the humerus being a slender, cylindrical, slightly-curved bone. In the *Casuariidæ*, *Dinornithidæ*, and *Apterygidæ*, the fore-limb is extraordinarily reduced, and may become rudimentary. In the Penguins and, to

[1] Huxley "On the *Alectoromorphæ*," p. 306, figs. 8 and 9.

[2] Owen "On the Dodo," *Trans. Zool. Soc.*, vol. vi. part 2, p. 63, plate 20, fig. 4.