

XII. *On the Axial Skeleton of the Ostrich (Struthio camelus).*

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Received June 18th, 1872.

RECENT investigations having made it probable that the line of affinity between Birds and Reptiles passes through the Struthious members of the first of these classes, I have deemed it advisable to commence a study of the axial skeleton of the *Sauropsida* by a detailed examination of that of the Ostrich, as of the most generalized type.

By kind permission of the authorities of the Royal College of Surgeons, I have been enabled to make use of the rich resources of that institution, not only for examination, but for the purposes of illustration, all the figures being from specimens in that Museum.

Bearing in mind the varying posture which the axial skeleton assumes in different Sauropsidans, I think it better, generally, to employ the term *preaxial* to denote that relation which in a vertical spinal column would be called "superior," and in a horizontal one "anterior." Similarly I use the word *postaxial* for what under the circumstances mentioned would be either "inferior" or "posterior." In the same way the terms *dorsal* and *ventral* stand for "posterior" or "superior," and for "anterior" or "inferior" respectively.

After describing the various vertebræ throughout the spine one after another, I propose to describe the pelvis as a whole, then the vertebral and sternal ribs, and the sternum, concluding with a recapitulation of the serial modifications the several parts and processes undergo as we proceed postaxially from the atlas to the coccyx.

There are seventeen *cervical vertebræ*, which, in the adult, have either no rib-like processes or only styloform and anchylosed ones (fig. 1, c).

The next three vertebræ bear longer ribs, generally articulated movably with their vertebræ and not directly connected with sternal ribs. They may be called *cervico-dorsal vertebræ* (fig. 1, c D).

The next five vertebræ (twenty-first to twenty-fifth inclusive) support long ribs, which unite distally with sternal ribs articulated to the sternum, and are therefore true *dorsal vertebræ*; these vertebræ do not anchylose together or with the sacrum (fig. 1, D). There are two vertebræ after these (twenty-sixth and twenty-seventh) which bear freely-ending ribs or rib-like processes, and which normally anchylose with the sacrum in the adult; these can be distinguished as *dorso-lumbar vertebræ*. Sometimes¹ there may be an extra

¹ As in the mounted skeleton in the Bird Gallery of the British Museum.

Fig. 1.

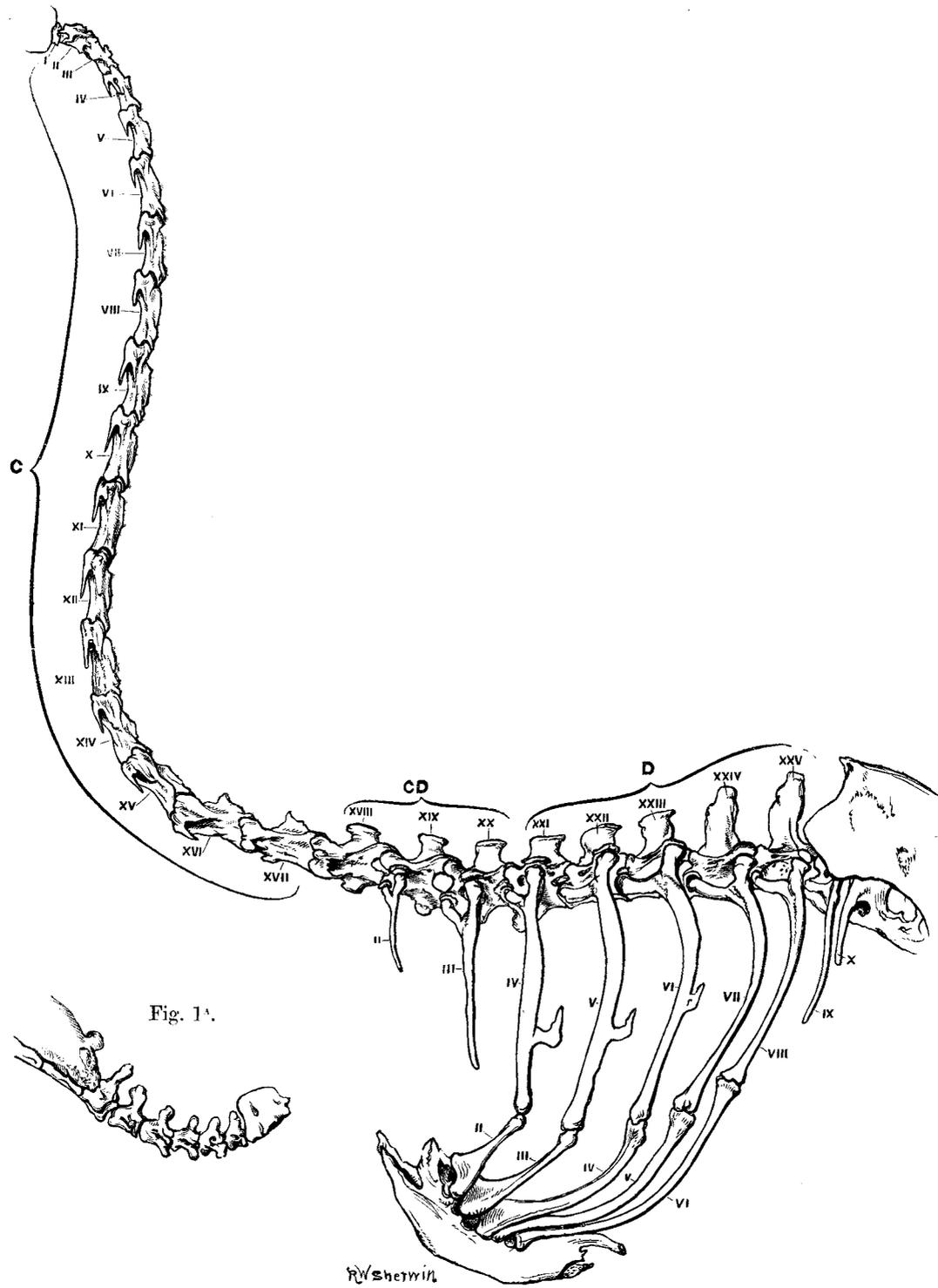


Fig. 1. Presacral part of axial skeleton; C, cervical vertebrae; CD, cervico-dorsal vertebrae; D, dorsal vertebrae.
 Fig. 1^a. Coccygeal vertebrae.

dorso-lumbar vertebra, there being three such with ribs, the first of which is connected by a styliform bone with the side of the sternal rib of the last true dorsal vertebra.

The next eight vertebræ (twenty-eighth to thirty-fifth) do not support long rib-like processes and are constantly anchylosed into one mass in adults; they may be called *lumbar vertebræ*.

Next follow three vertebræ with long distally expanded rib-like processes abutting against the ilia. It will be at least convenient to call these *sacral vertebræ*.

At the distal end of the sacral mass we have in the adult eight vertebræ (thirty-ninth to forty-sixth), which may be termed *sacro-caudal vertebræ*.

Finally there are ten postsacral vertebræ normally free in the adult, except the last two; these ten are the true *caudal vertebræ* (fig. 1^A). The number of these vertebræ may sometimes, however, be reduced to eight¹.

There are thus normally fifty-six vertebræ from the atlas to the coccyx inclusively. In some skeletons, however, there may be one or two vertebræ short or a vertebra in excess; and when such divergences exist, the differential characters of all the various vertebræ are correspondingly modified; and this should be borne in mind when the description here given is compared with such skeletons.

THE PRESACRAL VERTEBRÆ.

THE CERVICAL VERTEBRÆ.

THE ATLAS.—The atlas of the Ostrich presents an extreme contrast to the same bone in all mammals, even the lowest, in that it is so small a bone, being little more than an osseous ring, ventrally thickened with three short postaxial projections, and not being more than a quarter the bulk of the axis.

Nevertheless, though this vertebra as a whole is relatively so small compared with the atlas of mammals, yet that part of it which is median and ventral (*i. e.* that hypapophysial ossification which holds the place of a “centrum”) is relatively much larger than in any mammal. This might perhaps be anticipated from the articulation of the vertebral column with the skull being median in birds, through a single condyle, instead of lateral as in mammals through a pair of condyles.

The atlas of the Ostrich consists of this *quasi* body and two neural laminae, which meet together dorsally, but do not develop a neural spine.

The whole vertebra in the adult consists of one bone, no trace remaining of the primitive separation between the neural laminae and the median ventral portion.

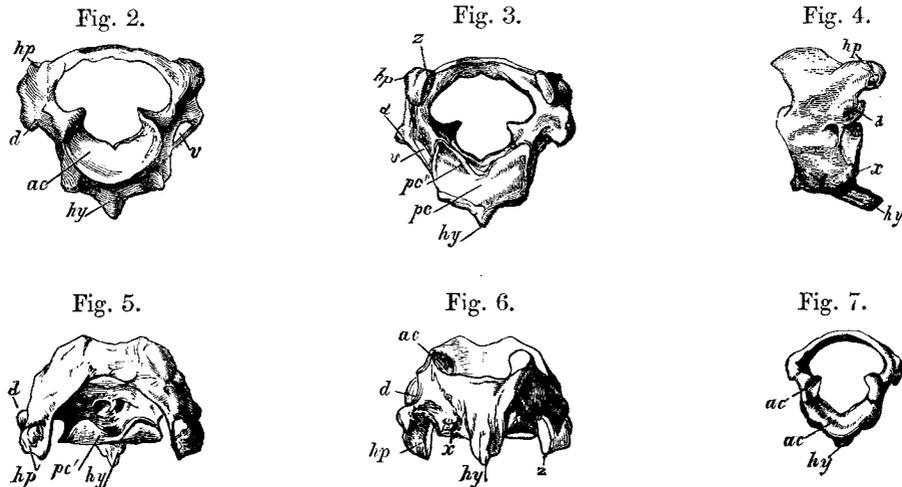
This latter (the *quasi-body*) apart from its junctions with the neural arch, may be said to have four surfaces—one ventral, one dorsal (or neural), one preaxial, and one postaxial; and these four surfaces are divided by four corresponding margins.

The *preaxial surface of the centrum*, which articulates with the occipital condyle.

¹ As in the mounted specimen, No. 1362, in the Museum of the College of Surgeons.

presents a crescentic, transversely extended concavity, as it were a cup, with a considerable median dorsal portion cut away for the reception of the odontoid process of the axis vertebra (fig. 2, *ac*).

ATLAS VERTEBRA (natural size).



Aspects.

Fig. 2, preaxial; 3, postaxial; 4, lateral; 5, dorsal; 6, ventral; 7, preaxial of immature bone.

ac, Preaxial articular surface of centrum; *ac'*, portion of such surface formed by neural lamina; *d*, diapophysis or tubercular process; *hp*, hyperapophysis; *hy*, hypapophysis; *pc*, postaxial articular surface of centrum; *pc'* lateral prolongation of the same surface; *v*, canal for vertebral artery (the spiculum of bone which encloses this is seen to be wanting on one side); *x*, a rounded tubercle representing a lateral hypapophysial process; *z*, postzygapophysis.

The dorsal margin of this preaxial surface forms thus a strongly concave line; and its ventral margin is bounded by a longer line of generally similar curvature (the horns of the crescentic articular surface being as broad as its middle); but the median portion of the ventral margin may occasionally be slightly produced (as in the specimen 1362 B), so as to cause that margin to present a rounded prominence.

The *postaxial surface*, which is applied to the centrum of the axis ventrad of the odontoid process, presents a crescentic transversely extended articular surface (fig. 3, *pc*, *pc'*). This surface is gently convex dorso-ventrally, but straight and flat transversely. Its upper margin is strongly concave, and is produced preaxially on each side, the postaxial articular surface of the quasi-body thus extending on each side somewhat on to the dorsal (neural) surface of the same part, and there articulating with the sides of the ventral surface of the root of the odontoid process.

The ventral margin of the postaxial surface of the atlas is more or less convex, with its median portion drawn out into a postaxially projecting hypapophysial process (figs. 3, 4, & 6, *hy*).

The *neural surface* of the quasi-body is gently concave transversely, with a marked pit (fig. 5) in its midst, no doubt for a ligament proceeding dorsad to the pit at the root of the odontoid process on its ventral aspect.

Its pre- and postaxial margins would be nearly parallel, but that the latter is encroached on by the lateral extensions preaxial of the postaxial articular surface, as before mentioned.

Its preaxial margin is similarly, though to a less extent, encroached on, on each side, by the postaxial lateral extensions of the preaxial articular surface. The little lateral facets thus formed on each side of each end of the dorsal (or neural) surface articulate with the sides of the odontoid process of the axis (fig. 5, *p c'*).

The *ventral surface* of the quasi-body is gently convex from side to side, and slightly concave antero-posteriorly in its middle.

Its preaxial margin is generally slightly concave, though it may be (as in specimen 1362 B) slightly convex; its postaxial margin is nearly straight, except for the sudden production postaxial of the median hypapophysial process before referred to (fig. 6, *hy*).

This process has a width equal to about a third of that of the postaxial surface of the quasi-centrum; and the length of its free projection may nearly equal or may slightly exceed its breadth.

A small rounded tubercle or lateral hypapophysial process (figs. 4, 6, *x*) may be developed on each side of the root of the median hypapophysial process, close to the postaxial margin of the ventral surface of the quasi-body; and a slight ridge may run obliquely outwards and preaxially from each of these tubercles nearly to the preaxial margin of such ventral surface.

The hypapophysial process is directed postaxial, and but slightly ventrad; indeed its free extremity (as in specimen 1362 B) may have a slightly dorsal curvature.

The dorsal surface of this process articulates with the middle of the front part of the ventral surface of the centrum of the axis vertebra.

The *neural arch* may be considered as consisting of two lateral halves dorsally united in the middle line.

Each lateral half springs from the side of the quasi-centrum by a narrow portion or *pedicle*, expanding dorsally into a neural lamina.

A narrow band or a mere spiculum of bone (figs. 2 & 3) may spring from the more postaxial part of the side of the quasi-centrum, and may fuse above with the posterior part of the pedicle, forming a foramen or short bony canal for the vertebral artery. The preaxial margin of the pedicle is strongly concave, but develops no process of any kind.

Its postaxial margin is also strongly concave, and ends above in a decided postzygapophysis; but before reaching that postzygapophysis it develops a more or less marked rounded prominence, which is a rudimentary tubercular process or *diapophysis*¹ (figs. 2, 3, & 5, *d*).

The little band or spiculum of bone before noticed, wherever it is developed, fuses

¹ I use the word diapophysis to denote all parts which are homotypes of the process articulating with the tubercle of the rib when this exists. Similarly I employ the term parapophysis to denote the part with which the head of the rib articulates.

dorsally with this diapophysial tubercle. It is thus essentially the "neck" of an undeveloped rib; and its ventral junction with the quasi-centrum is essentially a *parapophysis* or capitular process.

Sometimes the postaxial margin of this diapophysial tubercle is slightly produced postaxially, thus affording a faint indication of a prominence much more developed in succeeding vertebræ.

The *postzygapophysis* projects strongly postaxiad, and has on its inner side a small rounded articular surface, which looks inwards and also slightly ventrad (figs. 3, 6, *z*). This surface is slightly concave dorso-ventrally, and nearly straight antero-posteriorly.

On its dorsal surface each postzygapophysis bears a more or less marked rounded tubercle, which is a *hyperapophysis*¹ (figs. 3, 4, & 5, *hp*).

From each postzygapophysis the neural lamina extends preaxially and somewhat dorsad, meeting its fellow of the opposite side without (as before said) developing any neural spine. The conjoined neural laminæ thus form a low flat arch of bone, the preaxial margin (fig. 5) of which is slightly convex, but the postaxial margin very strongly concave, on account of the strong postaxiad projection of the two postzygapophyses (fig. 3, 6, *z*).

No foramina are developed, other than those for the vertebral arteries before described.

The immature condition of the atlas vertebra (as seen in the specimen 1397 A of the College-of-Surgeons Museum) shows that the neural arches meet together dorsally, so as to form a straight, though short, antero-posteriorly directed line of junction.

Similarly each pedicle joins the quasi-centrum by a line of junction which is nearly straight or slightly concave dorsally.

The ventral ends of the neural laminæ furnish the dorsal ends of the crescentic articular surface for the occipital condyle, also the articular facets for the side of the odontoid process and for the ventral surface of its root (fig. 7, *ac'*).

THE AXIS.

The axis of the Ostrich exceeds the atlas in size far more than is the case in the axial skeleton of any mammal. It also differs from a mammalian axis in that it is, for all its predominance over the atlas, insignificant in size when compared with the more posterior cervical vertebræ.

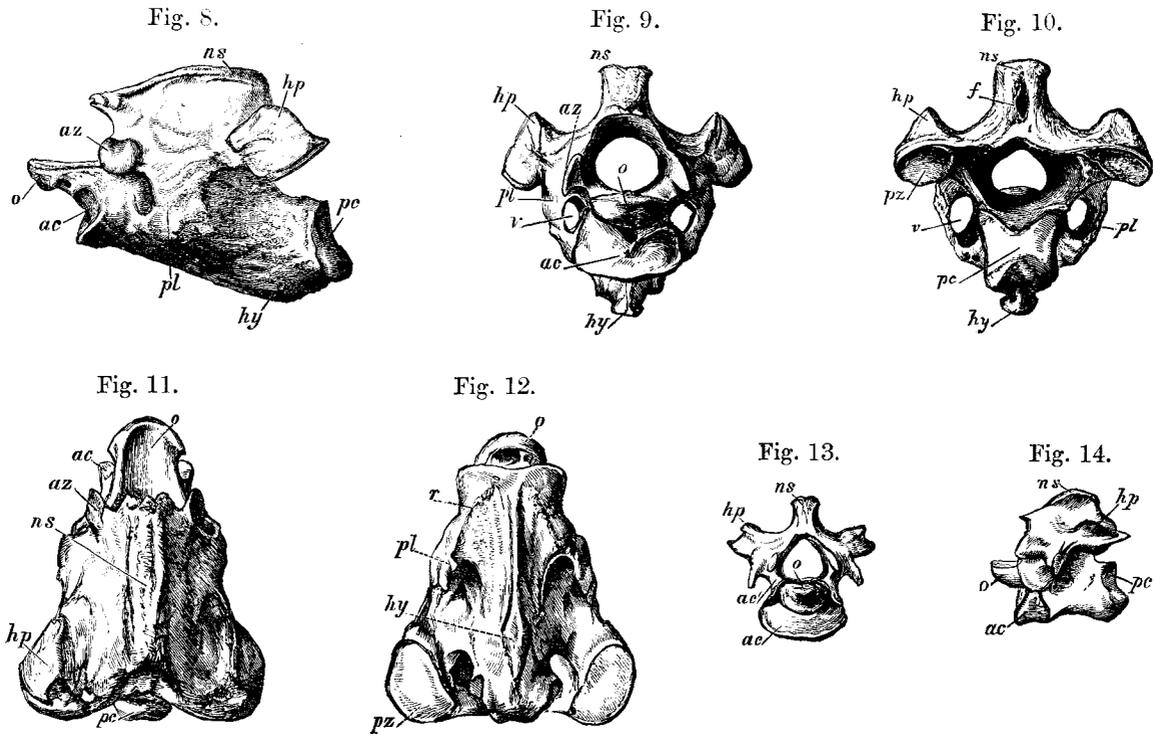
In the small size of the odontoid process when compared with the centrum, the Ostrich's axis vertebra also differs from that of the highest vertebrate class.

As compared with the atlas of the Ostrich, the axis differs most markedly in the great excess of its antero-posterior development over that in other directions.

The axis consists of a centrum, odontoid process, and neural arch, with zygapophyses and other outgrowths or annexations.

¹ This process is well seen in the cervical vertebræ of the Dingo, where it was first described. See Proc. Zool Soc. 1865, pp. 574 & 579, figs. 5, 7, & 9, *h*.

AXIS VERTEBRA (natural size).



Aspects.

Fig. 8, lateral; 9, preaxial; 10, postaxial; 11, dorsal; 12, ventral; 13, preaxial; 14, lateral of immature bone.

Letters as before, except *az*, prezygapophysis; *ns*, neural spine; *o*, odontoid process; *pl*, rib-like or pleurapophysial lamella; *pz*, postzygapophysis; *r*, running backwards and outwards to parapophysis; *f*, fossa (for ligament) on postaxial aspect of neural spine.

The whole vertebra in the adult consists of one bone.

The *centrum* may be considered as regards its four surfaces:—

The *preaxial surface*, which joins the postaxial surface of the quasi-body of the atlas, presents a crescentic, transversely extended articular surface, more or less strongly concave dorso-ventrally, but nearly straight transversely.

Its ventral margin is slightly convex, generally flattened, and never produced medianly.

Its dorsal margin is not easily defined, as the preaxial articular surface of the centrum is prolonged dorsally on to each side of the ventral aspect of the root of the odontoid process. Its dorsal margin, however, if we count such prolongations as belonging to the preaxial surface of the centrum, must be described as strongly concave (figs. 8, 9, *ac*).

The *postaxial surface* differs greatly in shape from the preaxial surface. Its ventral part is prolonged ventrad into a hypapophysial process; but apart from this it exhibits an articular surface the outline of which approximates slightly to that of an hour-glass (fig. 10, *pc*). This articular surface is strongly concave dorso-ventrally and strongly convex transversely. Its dorsal and ventral margins are both very decidedly concave,

and its two outer margins very slightly so; the transverse extent of the dorsal margin of this surface considerably exceeds that of its ventral margin. The ventral margin of the whole centrum is of course not only convex, but much produced ventrad by reason of the hypapophysial process. The extreme width of the articular surface of the postaxial side of the centrum exceeds its dorso-ventral extent only slightly. The ventral lip of the articular surface extends much further postaxially than does its dorsal margin (fig. 8, *pc*); but this extension is actually less, and relatively very far less, than the postaxial extension of the hypapophysial process of the atlas.

The *neural surface*, even apart from the dorsal surface of the odontoid process, which continues it on preaxiad, is exceedingly prolonged compared with that of the atlas. Nearly straight antero-posteriorly, it is slightly concave transversely.

Certain small irregular foramina may lead into the substance of the centrum from nearly the postaxial extremity of this neural surface, the postaxial margin of which is slightly convex.

The *ventral surface* of the centrum is nowhere concave, but is greatly produced ventrad medianly, except at and towards its preaxial end. Its preaxial margin is nearly straight, but may be very slightly convex or very slightly concave; its postaxial margin is narrower, but is very strongly convex (fig. 12).

The median production before referred to is a strong hypapophysial (figs. 8, 12, *hy*) ridge, which, beginning a little preaxiad of the antero-posterior middle of the ventral surface of the centrum, rapidly increases in prominence postaxially till near the postaxial margin, when it yet more suddenly subsides. Its ventral margin is nowhere pointed, but presents a curve, the preaxial slope of which is more gradual than the postaxial one.

As the hypapophysial ridge increases and decreases in dorso-ventral extent, it also, but more gradually, increases and decreases in its transverse dimension. Its ventral surface, however, is not flattened out.

Two ridges (fig. 12, *r*) traverse obliquely the preaxial part of the ventral surface of the centrum, diverging postaxially from a little behind its preaxial margin to the parapophysial part hereafter to be noticed. These ridges seem to be the homotypes of those which run preaxiad from the lateral hypapophysial tubercles on the ventral surface of the atlas vertebra.

The *odontoid process* is between three and four times the size of the hypapophysial process of the atlas vertebra. Its preaxial margin is rounded; its upper surface is flat or slightly concave, continuing on preaxially the dorsal (or neural) surface of the centrum. Its ventral aspect presents three surfaces. The most postaxial of these three is the continuation preaxiad of the preaxial articular surface of the centrum; and it is this part which articulates with the little articular surfaces prolonged preaxiad on to the postaxial part of the dorsal surface of the quasi-centrum of the atlas.

The median surface of the three is irregularly excavated and probably gives attach-

ment to a ligament going ventrad to the pit on the middle of the dorsal surface of the quasi-centrum of the atlas.

The most preaxial of the three surfaces is smooth and articular, and in part joins with the preaxial articular facets of the dorsal surface of the quasi-centrum of the atlas; in part it joins the occipital condyle (fig. 9, *o*). It completes, as it were, the cup mainly formed by the preaxial concavity of that quasi-centrum, the dorsal excavation of which it fills up, occupying as it does the space between the horns of the preaxial articular surface of the atlas.

The *neural arch* is very much more extended antero-posteriorly, more solid, and furnished with more annexed processes than is the neural arch of the axis.

The pedicle, or part ventral to the zygapophyses, is so little extended dorsally as to be insignificant. The postaxial margin of the pedicle is very concave (fig. 8).

A flat band of bone ascends obliquely on each side (figs. 8, 9, *pl*) from the antero-lateral side of the centrum (where the transverse oblique ridge runs into the parapophysis) to between the prezygapophysis and the postzygapophysis, the band expanding dorsally and forming a sort of antero-posterior ridge or plate, connecting these zygapophyses.

This band shelters beneath it the vertebral artery.

On the side of the centrum and neural arch, within the band, are irregular foramina leading into the substance of the vertebra.

The oblique band of bone is essentially the neck of a rib, and corresponds with the spiculum before noticed as sometimes existing beside the atlas.

The dorsal expansion of the band is the diapophysis; its inferior origin is the parapophysis.

The preaxial margin of the oblique band of bone is more or less concave. A slight angular process projects postaxially from its postaxial margin (fig. 8, *pl*).

Each *prezygapophysis* is small and rounded, looks outwards and slightly dorsad, is a little convex dorso-ventrally, and nearly straight antero-posteriorly (figs. 8, 9 & 11, *az*).

The *postzygapophysis* is between two and four times the size of the prezygapophysis; its antero-posterior decidedly exceeds its transverse diameter. It looks mainly ventrad, but slightly postaxial also (figs. 10 & 12, *pz*).

On its dorsal surface each postzygapophysis bears a very prominent and conspicuous hyperapophysis (figs. 8, 10, & 12, *hp*).

The neural laminae at their point of union dorsally, develop a low but strong and stout *neural spine* or, rather, ridge (figs. 8, 9, 10, & 11, *ns*).

This neural spine gradually rises as we proceed from the preaxial margin of the neural arch postaxially. It attains its greatest elevation at the postaxial end of the middle third of the neural arch. From that point it descends rather sharply to the postaxial border of the neural arch, presenting a margin which is slightly concave postaxially.

The neural spine is excavated by a fossa (for a ligament) on its postaxial surface (fig. 10, *f*); but preaxially it dips gradually to the preaxial border of the neural arch, without either excavation or process of any kind.

The neural arch encloses a space which is smaller than that enclosed by the neural arch of the atlas; and the transverse diameter of this space is especially diminished, the arch thus appearing less low relatively.

When viewed in its dorsal aspect (fig. 11), the neural arch is seen to expand greatly postaxiad, its transverse diameter between the postzygapophyses being double that between the prezygapophyses. Its preaxial margin is concave, with a median preaxial projection; its postaxial margin is generally more or less slightly concave.

No foramina are developed other than those already noted.

The immature condition of the axis vertebra (as seen in the specimen 1397 A of the College-of-Surgeons Museum) shows that the neural laminae become perfectly ankylosed together and to the centrum at a time when the neural laminae of the atlas remain altogether distinct, as also the odontoid process (or rather "bone") itself.

The odontoid bone forms a very large part of the so-called centrum of the axis, as well as the whole of the odontoid process itself (fig. 14, *ac*). All the articular surfaces of the axis for the quasi-body of the atlas are formed by this odontoid bone, except the little surfaces at the sides of the ventral surface of the root of the apparent odontoid process of the adult. These are seen to be formed by the preaxial ventral ends of the neural laminae themselves (fig. 13, *ac'*).

At this early stage, the lateral perforations of the vertebra (one just postaxial to the diapophysis, and one at the side of the centrum and placed more ventrally) are relatively larger and much more conspicuous.

THE THIRD VERTEBRA.

The third vertebra exceeds the axis in size very much less indeed than the axis exceeds the atlas.

Its most striking difference in appearance from the axis depends on the absence of the odontoid process and the larger development of the prezygapophyses, which give the bone a quadrate appearance when viewed dorsally, instead of that preaxial tapering which marks the axis (fig. 15).

The vertebra consists of the same parts as the axis, except the odontoid process; and these are similarly fused into one solid and complex bone.

As to the *centrum*, its *preaxial surface*, which joins the postaxial surface of the centrum of the axis, presents a transversely extended articular surface, very concave from side to side and convex dorso-ventrally; both the dorsal and ventral margins of this surface are strongly concave, while its lateral margins are slightly convex. The whole articular surface looks more ventrad than preaxiad (figs. 16, 17, *ac*).

The *postaxial surface* does not differ from its preaxial surface in shape nearly so

THIRD VERTEBRA (natural size).

Fig. 15.

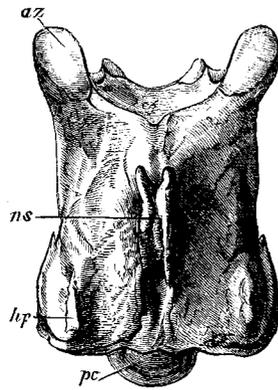


Fig. 16.

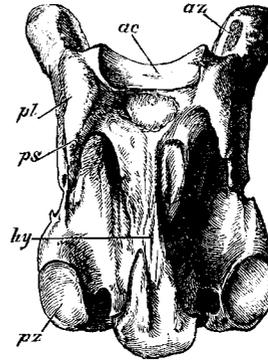


Fig. 17.

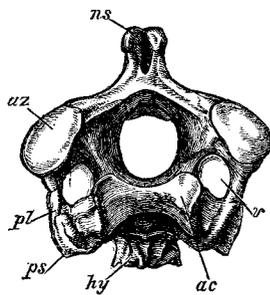


Fig. 18.

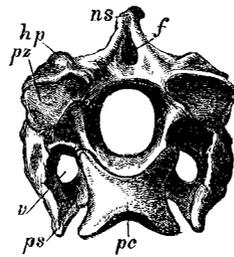
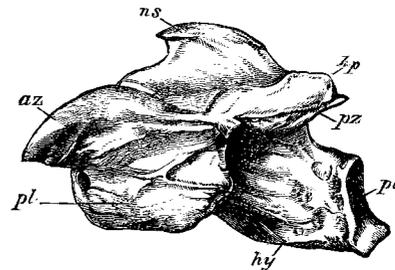


Fig. 19.



Aspects.

Fig. 15, dorsal; 16, ventral; 17, preaxial; 18, postaxial; 19, lateral.

Letters as before; and besides:—*n*, metapophysis; and *ps*, parapophysial root of pleurapophysial lamella.

much, nor in the same way, as the postaxial surface of the centrum of the axis differs from that vertebra's preaxial surface (fig. 18, *pc*).

The postaxial surface of the body of the third vertebra closely resembles the corresponding surface of the axis, while it presents a corresponding but inverted relation to its own preaxial central surface, being strongly convex transversely and concave dorso-ventrally, the whole surface looking dorsad as well as postaxiad (figs. 15 & 19, *pc*).

This surface differs from the corresponding surface of the axis in that its ventral part is not prolonged ventrad into a hypapophysial process, in that its extreme dorso-ventral diameter is less in proportion to its extreme transverse dimension, and in that the transverse extent of the dorsal margin exceeds that of the ventral margin to a less degree. Still its ventral margin is sometimes convex (not coinciding with the ventral margin of the central articular surface); but its dorsal and lateral margins seem always concave.

The *neural surface* of the centrum, but for its greater length, is very like that of the axis, abstraction being made of the (here absent) odontoid process.

The preaxial margin of the neural surface is strongly concave; its postaxial margin is slightly convex (fig. 15).

The *ventral surface* of the centrum is strongly concave from side to side at its most preaxial fourth; and its preaxial margin is concave. A little preaxial of the middle of the ventral surface a median hypapophysial process (figs. 16 & 19, *hy*) arises, which, for a little, gradually increases in depth postaxial, and then proceeds directly postaxial, coinciding with the ventral surface of the centrum—the postaxial part of the hypapophysial process being flattened on its ventral surface, so that this may be said to have two lateral margins which diverge postaxially. The hinder margin of the hypapophysis is at the same time the hinder margin of the centrum and is strongly convex.

The hypapophysis does not extend nearly so suddenly and prominently ventrad as does the hypapophysis of the axis.

No oblique ridges diverge postaxially from near the preaxial margin of the third vertebra, as they do in that of the axis; but there is a great prominence on each side near the preaxial margin, and it is their projection ventrad which makes the preaxial part of the ventral surface concave.

The *neural arch* is much like that of the axis, except that its prezygapophysial and pleurapophysial parts (fig. 19, *az* & *pl*) are much more developed, while its neural spine is less so.

The pedicle is similarly low, with a concave postaxial margin. Its preaxial margin is more extended dorso-ventrally and more concave than is that of the pedicle of the axis vertebra.

The flat pleurapophysial band of bone (for the vertebral artery) has greatly increased in antero-posterior extent, compared with that of the axis vertebra, being about equal to half the extent of the centrum in this dimension. It extends oblique dorsad from the parapophysis and expands till it merges into, or, rather, comes to constitute an interzygapophysial ridge, the anterior end of which may appear as a slight prominence (*metapophysial*) outside and beneath the prezygapophysis (as in specimen 1362 B on the left side).

The preaxial margin of the pleurapophysial lamella is concave. Its postaxial margin is irregular from defective ossification; but it may (as in 1362 A, right side) develop a slight median, postaxial, bluntly pointed prominence (fig. 19).

At the middle of the side of the neural arch, near the dorsal postaxial end of the plurapophysial lamella, is a depression with irregular foramina, leading into the substance of the bone.

Each *prezygapophysis* presents an oblong articular surface, which looks preaxially and dorsally, and is nearly, if not quite, twice as long antero-posteriorly as it is broad. It is slightly convex in both directions, but more so antero-posteriorly (figs. 15, 17, & 19, *az*).

Each *postzygapophysis* (figs. 16, 18, & 19, *pz*) is about the same size as the prezygapophysis, but is slightly less developed in the antero-posterior direction. Its antero-posterior diameter very much exceeds its transverse diameter, as much as, or more so, than in the axis vertebra. The articular surface is slightly concave transversely and nearly flat antero-posteriorly.

It looks mainly ventrad, but slightly postaxiad also.

On its dorsal surface each postzygapophysis bears a prominent *hyperapophysis*, which, however, is considerably smaller than in the axis vertebra (figs. 15 & 19 *hp*).

The neural laminae develop a low neural spine, which, however, extends less both dorsally and antero-posteriorly than does the neurapophysis of the axis. Instead of rising gradually from the preaxial margin of the neural arch, it springs up suddenly, at some distance postaxiad from that preaxial margin (figs. 15 & 19, *ns*). It subsides less suddenly, at about the same distance from the postaxial margin of the neural arch as its origin is distant from the preaxial margin of that arch. It occupies rather less than the middle three fifths of the dorsal surface of the neural arch.

The neural spine is excavated medianly on its postaxial surface (a fossa for a ligament thus being formed) in the same way that the same part of the axis is excavated (fig. 18, *f*).

The preaxial surface of the neural spine of this third vertebra, however, is also excavated, and in such a way as to cause that spine to bifurcate preaxially (figs. 15, 17, & 19, *ns*), the two preaxial margins of the depression projecting preaxiad at their dorsal ends, and making the short preaxial margin of the neural spine concave.

The neural arch encloses a space of very little different width from that enclosed by the neural arch of the axis (fig. 17).

When viewed above, the neural arch is subquadrate, the transverse diameter of the prezygapophyses about equalling that of the postzygapophyses. Its preaxial margin is much more strongly concave than is the corresponding margin of the axis; its posterior margin may be slightly concave or nearly straight (fig. 15).

THE FOURTH VERTEBRA.

The fourth vertebra exceeds the third about as much as the third exceeds the second (counting the odontoid process); but in general appearance and arrangement and development of parts, the fourth vertebra very much more nearly agrees with the third than does the third with the second.

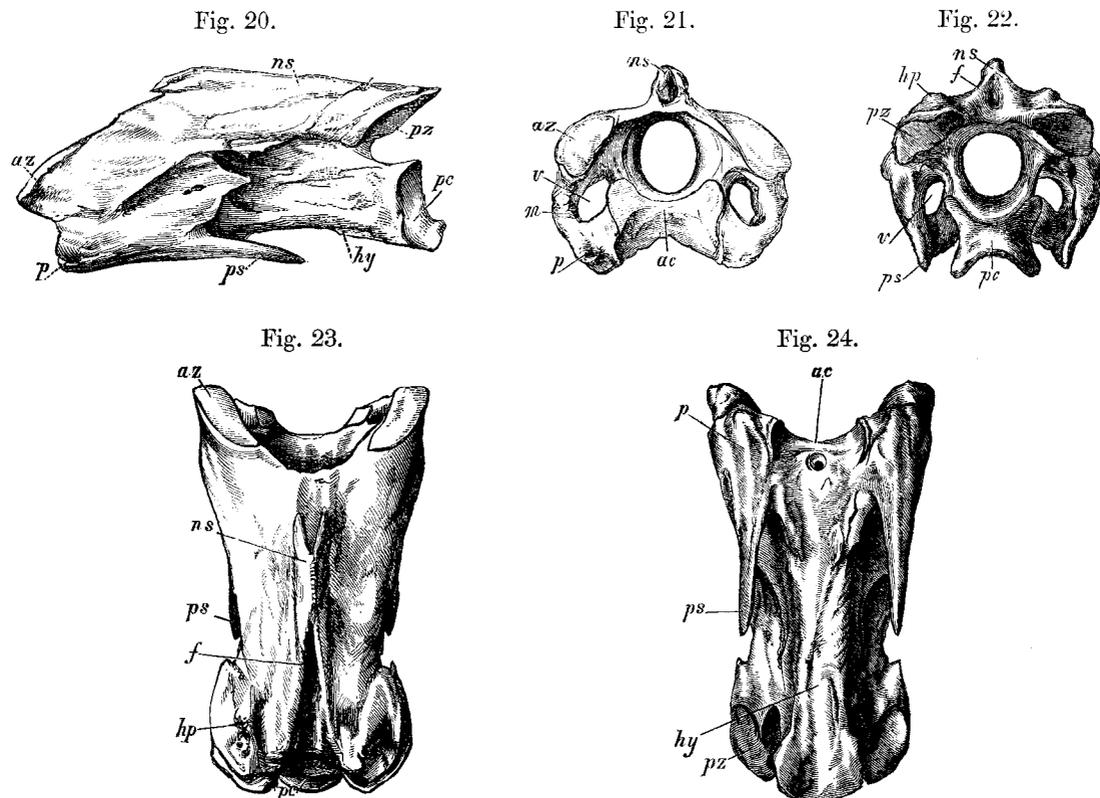
As to the *centrum*, its *preaxial surface* is quite like that of the third vertebra, except that it is rather more extended transversely and looks slightly less ventrad (figs. 21 & 24, *ac*).

The *postaxial surface* only differs from the preaxial surface in the same antithetical way that the two corresponding surfaces of the third vertebra differ from each other (figs. 20 & 22, *pc*). It differs from the postaxial surface of the third in that its ventral margin is more strongly concave and nearly coincides with the concave ventral margin of the articular surface, and in that the transverse extent of the dorsal part of that surface is nearly equalled by the transverse extent of its ventral part.

The *neural surface* of the centrum closely resembles that of the third vertebra, except that, of course, its absolute length is greater.

The *ventral surface* of the centrum agrees with that of the third vertebra, except that the median hypapophysis is much less developed (fig. 20, *hy*), being only in the form of a slight ridge extending antero-posteriorly along the middle third of the centrum.

FOURTH VERTEBRA (natural size).



Aspects.

Fig. 20, lateral; 21, preaxial; 22, postaxial; 23, dorsal; 24, ventral.

Letters as before, except that *p* denotes parapophysis, and *ps* the rib-like, freely projecting, pleurapophysial process.

It also differs from the third vertebra in that its most postaxial part is decidedly, though slightly, concave transversely, and in that the parapophyses, project a little more sharply and strongly ventrad.

The *neural arch* is very like that of the third vertebra, except that its pleurapophysial part is more developed, while its neurapophysis, being actually about the same size, is relatively less.

The pleurapophysial band is rather more extended antero-posteriorly, though it does not quite attain the postzygapophysis as it does in the third vertebra; while from the ventral end of its postaxial margin (*i. e.* from the parapophysis) a long, tapering, styliform, rib-like process projects in nearly a straight line postaxially (fig. 20, *ps*).

The length of the free part of this process is less than half the antero-posterior extent of the centrum, though its extremity may project beyond the antero-posterior median point of the centrum.

The postaxial margin of the pleurapophysial band is irregular, often more or less slightly concave, and proceeds obliquely dorsad and postaxiad.

At the anterior part of this band a slight metapophysial prominence may appear between the preaxial end of the parapophysis and the prezygapophysis.

The *zygapophyses* closely resemble those of the third vertebra.

The *hyperapophyses* on the postzygapophyses are absolutely, and still more relatively, smaller than in the third vertebra, though they are still noticeable prominences (figs. 20, & 23, *hp*).

The neural spine and the neural arch generally agree with those of the third vertebra, except that the latter is less quadrate when viewed from above. This is owing to the transverse diameter of the preaxial part of the vertebra (measured across the prezygapophyses) considerably exceeding that of its postaxial part (measured across the postzygapophyses), instead of these two dimensions being equal as in the third vertebra. The postaxial margin of the neural arch is also always decidedly concave (fig. 23), instead of being nearly straight as sometimes is the case in the third vertebra.

THE FIFTH VERTEBRA.

The fifth vertebra, though again a large bone antero-posteriorly, more closely resembles in shape the fourth vertebra than does the fourth the third (fig. 1, C, *v*).

The *preaxial surface* of its *centrum* quite agrees with that of the fourth vertebra, while its *postaxial surface* differs only in having its articular surface relatively broader and narrower dorso-ventrally in its middle (the two sides of the hour-glass coming there nearer together), and in having the ventral margin of that surface very considerably more extended than its dorsal margin, and, concomitantly, its lateral margins rather more concave.

The *neural surface* is similar to that of the centrum of the fourth vertebra, except that it is perhaps rather more exposed at its preaxial end, through the slightly greater cutting away, as it were, of the more preaxial part of the neural arch.

The *ventral surface* of the centrum agrees with that of the fourth vertebra, except that its postaxial part is more decidedly and extensively concave transversely, and that the median hypapophysial ridge is still less developed.

The *neural arch* is, of course, longer than that of the fourth vertebra, but is otherwise very like it. The pleurapophysial band more decidedly fails to attain the postzygapophysis; while at the dorsal end of its slightly concave, oblique, postaxial margin a slight pointed process projects postaxiad, which process is the homotype of the slight projection noticed as extending from the postaxial margin of the band in the axis

vertebra. It has here mounted more dorsally. The styliform rib-like process is rather longer in this fifth vertebra, but otherwise like that of the fourth.

The *metapophysis* is rather more swollen and prominent; but the *hyperapophysis* is still more reduced.

The *prezygapophysis* projects preaxially beyond the *parapophysis* to a less degree than is the case in the fourth vertebra.

The *neural spine* is relatively less than that of the fourth vertebra, but otherwise resembles it, except that the two margins of the preaxial excavation do not stand out preaxially on processes with near so much distinctness.

The *neural arch* when viewed from above is still less quadrate than in the fourth vertebra, because the transverse extent of the preaxial end of the fifth vertebra exceeds that of the postaxial part of the same vertebra more than the one exceeds the other in the fourth vertebra.

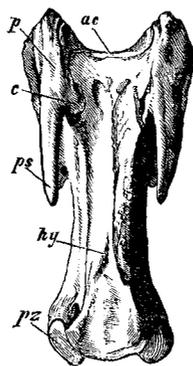
The postaxial margin of the neural arch is also much more decidedly and sharply concave.

THE SIXTH VERTEBRA.

The sixth vertebra, though a larger bone than the fifth, resembles the latter in form and proportions, even more than the fifth vertebra resembles the fourth. Both the

VENTRAL ASPECT OF SIXTH VERTEBRA (natural size).

Fig. 25.



Letters as in last figures, and in addition *c*, catapophysis.

pre- and postaxial surfaces of the *centrum* agree with those of the fifth vertebra respectively; and the neural surface only differs from that of its serial predecessor in being slightly more exposed preaxially.

The ventral surface exhibits no noticeable differences, except that the hypapophysial ridge is still more obsolete, and that the postero-inner part of each *parapophysis* begins

to exhibit a special though slight prominence (directed medianly inwards and ventrad), which is the beginning of the differentiation of the *catapophysis*¹ (fig. 25, c).

The *metapophysis* may be again slightly more prominent; while the *hyperapophysis* is so reduced that it would perhaps escape notice were it not traced from the more preaxial vertebræ.

The *prezygapophysis* projects beyond the parapophysis still less than in the fifth vertebra, sometimes scarcely or not at all so. Its articular surface is even also relatively longer and narrower than in the bone last described.

The neural spine is excavated, both pre- and postaxially, more obliquely and extensively than in the fifth vertebra; so that its median unexcavated part is relatively, and may be absolutely, shorter. The lateral margins of the preaxial excavation do not at all develop preaxial processes.

Both the pre- and postaxial margins of the neural arch are rather more concave than in the fifth vertebra.

THE SEVENTH VERTEBRA.

The seventh vertebra is rather larger than the sixth vertebra, but in other respects is so complete a repetition of the latter as hardly to need distinct notice except in the following few points.

The *catapophyses* and *metapophyses* are rather more prominent; and the neural spine has (at least sometimes) a greater development dorsad.

The *prezygapophyses* do not project forwards quite so much as do the *parapophyses*, instead of projecting, in a greater or less degree, more preaxially, as has always been the case in the vertebræ hitherto described; their articular surfaces are directed rather more inwards than are those of the sixth vertebra.

THE EIGHTH, NINTH, AND TENTH VERTEBRÆ.

These vertebræ slightly increase in length antero-posteriorly, though the rate of increase diminishes as we proceed postaxially. In these three vertebræ the *catapophysial projection* gradually becomes more marked; and thereby the preaxial part of the ventral surface of the centrum becomes more concave, as also the ventral margin of its preaxial surface.

The *metapophyses* remain as marked (fig. 28, m) or become rather more so, while the *hyperapophyses* disappear.

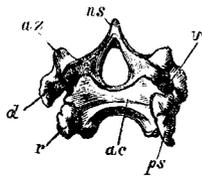
¹ From *κατά*, down. These processes are, as it were, merely transitional processes, sometimes merging with the parapophysis dorsally, and sometimes with the hypapophysis ventrally. By giving them therefore a distinct name I by no means wish to ignore their transition; but as these parts are often so distinct and conspicuous as to require description and distinct reference, it is convenient to be able to speak of them substantively and adjectively by a distinct term. By *catapophyses* I mean parts which are distinguishable from, but intermediate between, parapophyses and hypapophyses, and which are placed on the ventral side of the former.

The interval between the pre- and postaxial excavations of the neural spine progressively increases.

In the tenth vertebra the transverse dimension of the postaxial part of the neural arch (measured from outer margin to outer margin of the two postzygapophyses) begins to be slightly less in defect compared with the same dimension of the preaxial part of that arch.

PREAXIAL ASPECT OF EIGHTH VERTEBRA.
Immature condition (natural size).

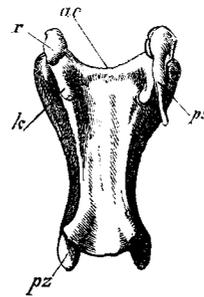
Fig. 26.



The rib-like part, *ps*, is removed on the left side ;
d, diapophysis.

VENTRAL ASPECT OF EIGHTH VERTEBRA.
Immature condition (natural size).

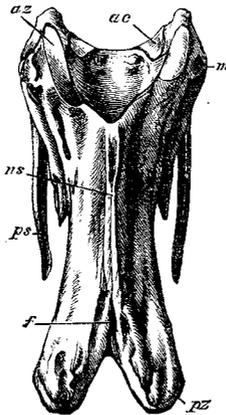
Fig. 27.



Letters as before, except *k*, catapophysis, and
r, parapophysis.

NINTH VERTEBRA (size $\frac{2}{3}$ of nature).

Fig. 28.



Dorsal aspect. Letters as before.

In the tenth vertebra also the prezygapophysis projects about as far preaxially as does the parapophysis.

THE ELEVENTH VERTEBRA.

The eleventh vertebra is of very nearly the same length as the tenth, especially as estimated by the antero-posterior extent between the preaxial end of the prezygapophysis and the postaxial end of the postzygapophysis. This vertebra, however, is very slightly more massive than the preceding one.

The postaxial articular surface of the centrum has the transverse extent of its ventral margin very little in excess of that of its dorsal margin. The articular surfaces of the *prezygapophyses* look more directly dorsad and less inwardly; those of the *postzygapophyses* are broader.

The median unexcavated part of the neural spine is again more or less longer antero-posteriorly. The postaxial part of the neural arch still more nearly approaches in width the preaxial part of that arch than in the tenth vertebra; and its postaxial margin is less concave.

THE TWELFTH VERTEBRA.

The twelfth vertebra carries on the progressive modifications indicated in the eleventh vertebra, and it is slightly longer and more massive than that vertebra.

The *catapophyses* may here first project ventrally as sharply marked processes (figs. 30 & 32, *c*).

TWELFTH VERTEBRA ($\frac{2}{3}$ natural size).

Fig. 29.

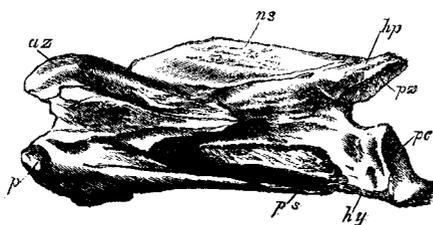


Fig. 30.

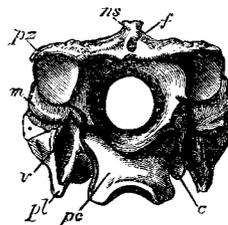


Fig. 31.

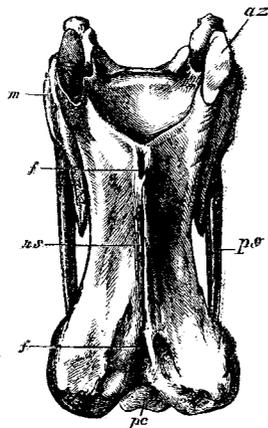
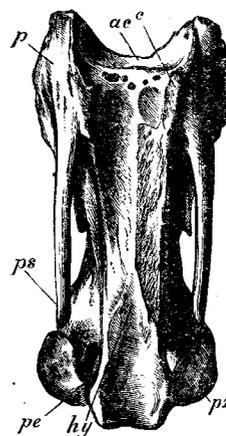


Fig. 32.



Aspects.

Fig. 29, lateral; 30, postaxial; 31, dorsal; and 32, ventral.

Letters as before; *c*, catapophysis.

The transverse extent of the postaxial part of the neural arch nearly equals that of its preaxial part.

The styliform rib here generally attains its maximum of length.

THE THIRTEENTH VERTEBRA.

This vertebra slightly exceeds the twelfth in length, but still more in breadth and stoutness. Here, once more, the dorso-ventral extent of the lateral margin of the postaxial surface of the centrum equals the transverse extent of the dorsal margin of that surface.

The neural arch here attains about its maximum of antero-posterior extent, measured pre- and postaxially in the middle line.

The median unexcavated part of the neural spine is slightly shorter antero-posteriorly than in the twelfth vertebra.

The free projection of the styliform rib may be for the first time less in extent than in the vertebra next (preaxially) to it; but it is at the same time thicker.

The transverse extent of the postaxial part of the neural arch nearly equals that of its preaxial part; and concomitantly with this greater projection outwards of the postzygapophyses, the lateral margins of the neural laminae (viewed dorsally) become more concave.

The articular surfaces of both zygapophyses, but especially of the postzygapophyses, are broader in proportion to their length.

THE FOURTEENTH VERTEBRA.

The fourteenth vertebra scarcely exceeds the thirteenth in length, though it does so very decidedly in breadth. Indeed the antero-posterior length of the neural arch in the dorsal middle line is absolutely, though very slightly, less than in the thirteenth vertebra.

The styliform ribs are thicker, the catapophyses more projecting, the zygapophysial articular surfaces broader, while the four margins of the postaxial articular surface of the centrum have become about equal.

The canal for the vertebral artery has also become rather more capacious.

THE FIFTEENTH VERTEBRA.

With this vertebra the absolute antero-posterior dimension has begun slightly to decrease; but the transverse development continues to progress. The styliform ribs are still stouter, the zygapophysial surfaces still broader, the neural spine thicker and shorter, and the lateral margins of the neural arch more concave. The postaxial excavation of the neural spine is enlarged into a considerable fossa.

The metapophysis is rather prominent beneath a prezygapophysis, which may here once again begin to decidedly project, preaxially, beyond the parapophyses.

THE SIXTEENTH VERTEBRA.

The sixteenth vertebra is, again, like the fifteenth, shorter than its preaxial predecessor; and even the transverse dimension, measured across the postzygapophyses, is scarcely if at all greater, though the preaxial part of the vertebra is enlarged transversely, and therefore relatively to the more postaxial part as well as absolutely. The posterior end

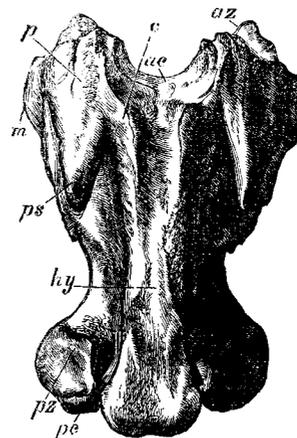
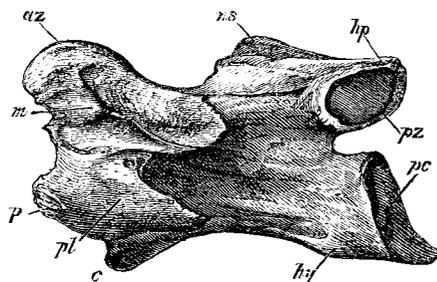
of the ventral surface of the centrum has notably increased in width. The styliform ribs are no longer styliform, but stout obtusely pointed processes, projecting, however, postaxiad and slightly ventrad as usual (fig. 34, *ps*).

The *catapophyses* (figs. 33 & 34, *c*) are very largely developed, projecting not only ventrad but somewhat proximad also; they are so extended inwards that the interval between their ventral ends is decidedly less than the breadth of the middle of the ventral surface of the centrum behind them, a condition which we have not yet met with. The middle of the ventral surface of the centrum may still show a trace of the antero-posteriorly extended hypapophysial ridge (fig. 34, *hy*).

SIXTEENTH VERTEBRA ($\frac{2}{3}$ natural size).

Fig. 33.

Fig. 34.



Aspects.

Fig. 33, lateral; 34, ventral. Letters as before.

The pleurapophysial lamella is beginning decidedly to diminish in antero-posterior extent; but the metapophysis is largely prominent beneath a prezygapophysis, which may project very considerably preaxiad beyond the parapophysis (figs. 33 & 34, *m*).

The low neural spine is as thick as in the fifteenth vertebra and also shorter antero-posteriorly; its posterior excavation is enlarged into a deep conical fossa, the dorso-lateral margins of which diverge to the postzygapophyses—without, however, sheltering it or covering it in, except to a minute extent on each side.

The articular surfaces of the postzygapophyses are nearly as wide transversely as long pre- and postaxially.

THE SEVENTEENTH VERTEBRA.

The seventeenth vertebra differs very considerably from the sixteenth, and more than the latter differs from the fifteenth. It is shorter and at the same time broader, while the breadth of its preaxial part is still more in excess of that of its postaxial part (fig. 38) than was the case in the sixteenth vertebra. Thus we have a return to a predominance which existed in more preaxially situated cervical vertebræ (fig. 25).

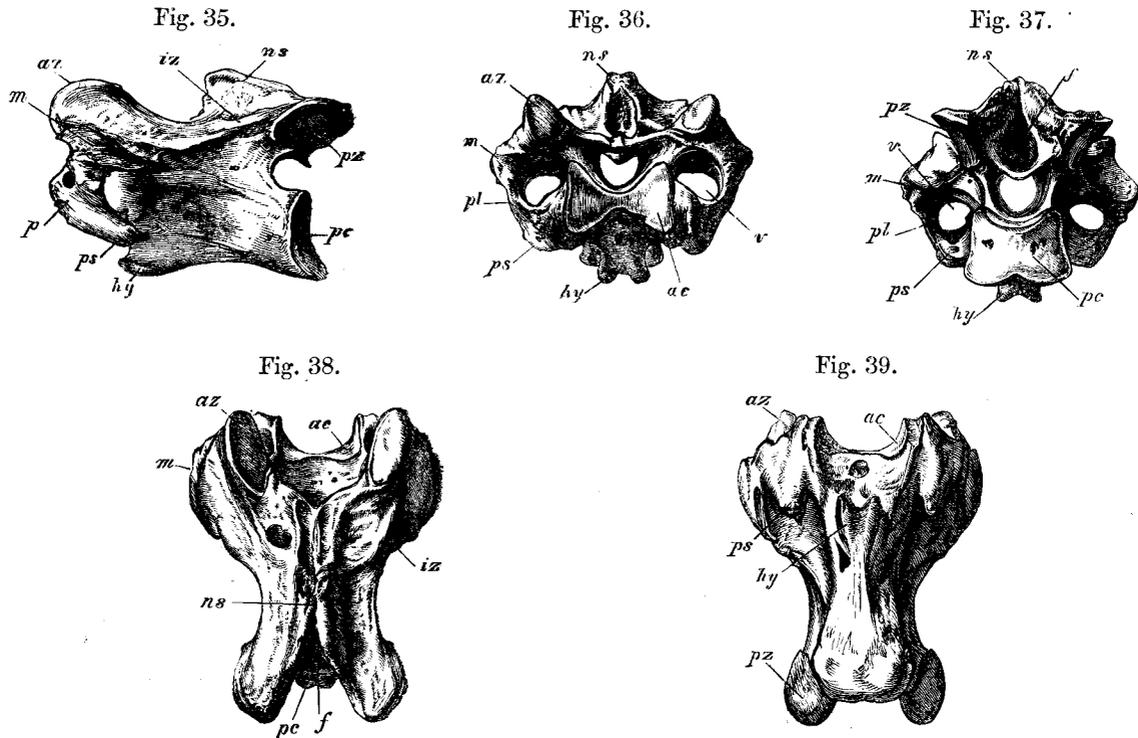
As regards the *centrum*, its *preaxial surface* has the shape of its ventral margin changed by the appearance of two small hypapophysial processes (fig. 36, *hy*).

Its *postaxial surface* is larger both actually and relatively; while its ventral margin has once more become more extended transversely than its dorsal margin, and at the same time is less concave than in the vertebra last described (fig. 37, *pc*).

The *neural surface* of the centrum may be more exposed by the further cutting away, as it were, of the preaxial part of the neural arch.

The *ventral surface* of the centrum presents somewhat of a return to the proportions of the third vertebra, if abstraction is made of the *hypapophyses* (fig. 39).

SEVENTEENTH VERTEBRA ($\frac{1}{2}$ natural size).



Aspects.

Fig. 35, lateral; 36, preaxial; 37, postaxial; 38, dorsal; and 39, ventral. Letters as before.

These latter processes (which may conveniently be said to represent and take the place of absent *catapophyses*) project as a pair of short processes, springing from beneath about the middle (both antero-posteriorly and transversely) of the centrum. They extend ventrally and preaxially, and diverge from each other towards their apices, instead of converging like the *catapophyses* of the sixteenth vertebra.

The *hypapophyses* may be separated by a notch which extends dorsad to the general level of the ventral surface of the centrum, or may be only imperfectly divided from one another as in the specimen figured.

In front of these hypapophyses the ventral surface of the centrum presents a wide and rather shallow transverse concavity, bounded by two diverging ridges, which proceed respectively from the root of each hypapophysis to the adjacent parapophysis. Behind the hypapophyses there is no trace whatever of a median hypapophysial ridge, but the centrum widens rapidly backwards into a nearly flat slightly concave surface with a rounded postaxial margin.

In the place of styliform ribs there are conical prominences so short and stumpy that their nature would hardly be suspected but for the conditions presented by more preaxial vertebræ; their direction, however, is the same as heretofore (figs. 35 & 36, *ps*).

The pleurapophysial bands of bone are still less extended antero-posteriorly, though they enclose a canal for the vertebral artery, which has now become so large as nearly to equal the neural canal in diameter (fig. 37, *v*).

The *metapophysis* (figs. 35, 36 & 38 *m*) is very largely developed; but the prezygapophysis extends less decidedly preaxial of the parapophysis than in the sixteenth vertebra.

The *postzygapophysis* also projects postaxially a little beyond the centrum.

The prezygapophysial articular surfaces look slightly more inwards, and the postzygapophysial ones decidedly more outwards, than in the sixteenth or preceding vertebræ.

The *neural spine* has become so wide as (it may be for the first time) to exceed in transverse extent the dorsal surface of the neural laminæ on either side of it.

The anterior excavation of the neural spine (fig. 36, *ns*) has become a considerable and open fossa, while its posterior excavation (fig. 37, *f*) has assumed very large proportions, with a vertical preaxial wall, and laterally more or less sheltered and overshadowed by the projecting margins of the ridges, which diverge postaxially from the neural spine to the postzygapophyses. The neural spine itself is very little extended antero-posteriorly, less than in any of the nine preceding vertebræ; but it has a greater extension dorsad.

One or two conspicuous foramina lead from the side of the centrum or neural arch into the substance of the bone.

CERVICO-DORSAL VERTEBRÆ.

THE EIGHTEENTH VERTEBRA.

The eighteenth vertebra differs as much from the seventeenth as does the latter from the sixteenth.

It is a larger bone than the seventeenth vertebra, inasmuch as, though the centrum is shorter, the extreme antero-posterior extent of the whole vertebra is not less, while its transverse and its dorso-ventral dimensions are augmented.

The excess of the transverse diameter of its preaxial part over that of its postaxial part is greater than even in the seventeenth vertebra (fig. 41).

This vertebra bears the first rib.

The *centrum* has its *preaxial* articular surface with its dorsal margin more concave and its ventral margin less concave than in the seventeenth vertebra. The outline of the inferior margin of the whole centrum is modified by the hypapophysial process.

The *postaxial* surface of the centrum is relatively more extended transversely, with its ventral margin wider and more in excess of its dorsal margin than in the seventeenth vertebra, while at the same time the ventral margin is still less concave.

EIGHTEENTH VERTEBRA ($\frac{1}{2}$ natural size).

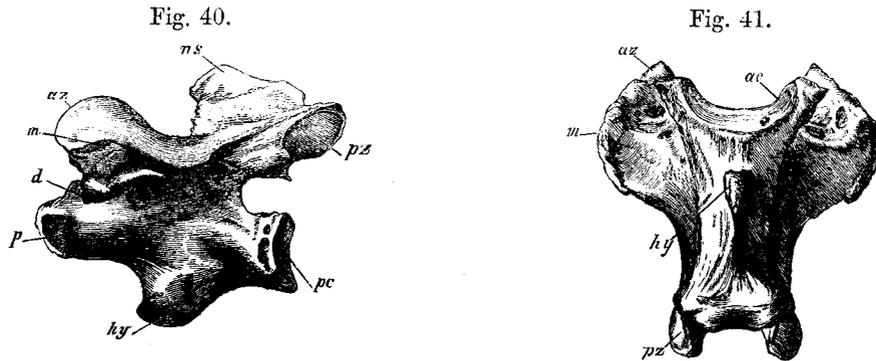


Fig. 40, lateral aspect; 41, ventral aspect. Letters the same, except that *d* denotes the diapophysis.

The *ventral surface* of the centrum is wide and but very slightly concave at either its preaxial or its postaxial part. There is a very thick median hypapophysis extending from the middle of the ventral surface, and more or less bifurcating ventrally into two short, rounded, diverging processes (fig. 41, *hy*).

No diverging or other ridges connect the *hypapophysis* with the parapophyses; but a ridge may run postaxially from each parapophysis to the postaxial margin of the ventral surface of the centrum, the two ridges bounding that surface laterally.

The postaxial margin of the ventral surface is less convex than in the seventeenth vertebra.

If there is no free rib, the pleurapophysial band of bone representing it is extremely short antero-posteriorly. Each margin of it is concave, while from the ventral end of its postaxial margin a triangular blunt prominence (the last rudiment of the styloform rib of more preaxial vertebræ) projects postaxially, but at the same time in a more ventral direction than that taken by any of the styloform ribs before described. Such is its condition in a highly ossified skeleton; but very often the pleurapophysial band appears as a separate rib, and in this free condition it is described below as the first rib (fig. 75, 1).

This osseous band, when it is ankylosed to the vertebra, bounds externally a bony canal for the vertebral artery, which is so large that it exceeds in diameter the neural canal itself.

This arterial canal is bounded internally by the neural lamina and inferiorly by the

great lateral projection of the parapophysis, on to which here, as in the more preaxial vertebræ, the preaxial articular surface of the centrum extends itself.

Superiorly the canal for the artery is bounded by a process of bone, which extends outwards from beside and beneath the prezygapophysis (being in fact a *diapophysis*, or tubercular process)¹, on the outer side of which is to be seen a prominence still representing the *metapophysis* (figs. 40 & 41, *m*).

These parts exist in the same way in preceding vertebræ; but they are most conveniently noticed here on account of the large size they attain on the dorsal and ventral sides respectively of the great canal for the vertebral artery.

The articular surfaces of the prezygapophyses look more inwardly, and those of the postzygapophyses more outwardly, than do the corresponding surfaces of the seventeenth vertebra; and the postzygapophyses also extend postaxially beyond the centrum to a greater degree (fig. 40, *pz*).

The *neural spine* may be longer antero-posteriorly, and is wider transversely as well as more extended dorsad than is the neural spine of the preceding vertebra.

Its anterior excavation is larger and has a nearly vertical postaxial wall, with two prominent ridges, which bound it laterally and proceed preaxially and nearly parallel to near the preaxial margin of the neural arch.

The posterior excavation of the neural spine is at about its maximum of development in this vertebra, and is overshadowed and protected by the postaxial extent of its dorsal lateral margins, which diverge from the neural spine to the postzygapophyses.

The pre- and postaxial margins of the neural arch are strongly concave, though the former is not so much so as is the corresponding part in the seventeenth vertebra.

Sometimes two conspicuous foramina lead into the substance of the bone on either side. One of these is placed a little on the ventral side of the interzygapophysial ridge, rather nearer to the postaxial margin of the pedicle of the neural arch than to its preaxial border; the other may be sometimes found at the side of the middle of the centrum, directly ventrad to the first foramen.

THE NINETEENTH VERTEBRA.

The nineteenth vertebra is very like the eighteenth in size and general shape, although it has never any pleurapophysial osseous band, but always an articulated rib (the second rib) instead.

This absence of course produces a striking difference in the general appearance of the vertebra when it is viewed preaxially.

The *centrum* presents a *preaxial surface* which ends in an obtusely pointed process on each side; and both the dorsal and ventral margins of its articular surface are less concave than are the corresponding margins of the eighteenth vertebra (fig. 43, *ac*).

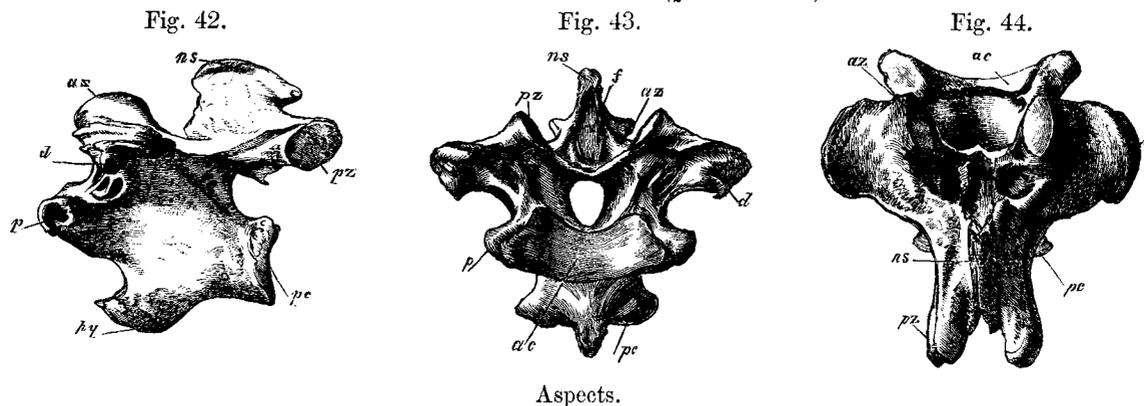
¹ The *diapophysis* is that part to which the tubercle of the rib is attached, while its head joins the *parapophysis*.

The *postaxial aspect* of the centrum shows an articular surface which may be more quadrate, its ventral margin often less preponderating over its dorsal margin than in the preceding vertebra. The latter is also less concave, while the former is nearly straight and may even be very slightly convex.

The ventral surface has its preaxial margin more expanded and less sharply concave, and its postaxial margin often less convex than is the case with the eighteenth vertebra.

The *hypapophysis* is a single rounded, obtuse tubercle. It extends rather more ventrad and sometimes less preaxial than does that of the preceding vertebra. The under surface of the centrum may be concave antero-posteriorly in the middle line behind the hypapophysis.

NINETEENTH VERTEBRA ($\frac{1}{2}$ natural size).



Aspects.

Fig. 42, lateral; 43, preaxial; 44, dorsal. Letters as before.

The ventral aspect of the hypapophysis exhibits, as it were, a slight lingering tendency to bifurcate.

Behind the hypapophysis the surface of the centrum begins to be slightly convex transversely instead of being concave.

Not only is there, as has been said, no pleurapophysial band of bone, but no ridge runs postaxially from the parapophysis, the side of the centrum being continued uninterruptedly dorsad into the side of the neural arch, the whole forming one concavo-convex expanse.

The *parapophysis* extends preaxially and slightly outwards, and has at the outside of it a small, rather deep, concavity for the head of the rib, and on its inner side the lateral continuation of the preaxial central articular surface (fig. 42, *p*).

The *diapophysis* projects slightly more outwards from the prezygapophysis, is more antero-posteriorly extended; and the dorso-ventral distance between it and the parapophysis is greater than heretofore, extending to the preaxial margin of the neural lamina. From its ventral outer side, near its preaxial end, the diapophysis develops a rounded prominence (fig. 42, *d*) to receive the tubercle of the rib. Beneath it the preaxial surface of the neural lamina is deeply and irregularly excavated, and another

smaller excavation (either several small openings or one large foramen) is placed a little preaxially of the postaxial margin of the neural lamina, on the ventral side of the interzygapophysial ridge.

The *neural spine* has its dorsal margin more antero-posteriorly extended than in the eighteenth vertebra; and consequently the margins of the ridges running from it to the postzygapophyses, instead of sloping gradually, run at first a little preaxially, thus forming a slightly acute angle.

The postaxial excavation of the neural spine is much as in the eighteenth vertebra, though somewhat less deep. The preaxial surface of the neural spine is vertical, but cannot always be said to be medianly excavated; rather there is sometimes a slight depression on each side of it on the neural lamina.

The *prezygapophyses* are broader than in the eighteenth vertebra, and look rather more inwards. The *postzygapophyses* are smaller and look even more outwardly. For the first time their transverse (here actually dorso-ventral) diameter may exceed their antero-posterior development; and they are so produced that their articular surfaces may be altogether postaxial to the postaxial margin of the centrum. The preaxial margin of the neural arch begins to show a little median preaxially directed process (fig. 44).

THE TWENTIETH VERTEBRA.

The twentieth vertebra closely resembles the nineteenth, with the centrum, diapophyses, and neural spines slightly enlarged.

The *centrum* has its *preaxial* articular surface relatively deeper dorso-ventrally; and its lateral parapophysial terminations are not so much laterally produced.

TWENTIETH VERTEBRA ($\frac{1}{2}$ natural size).

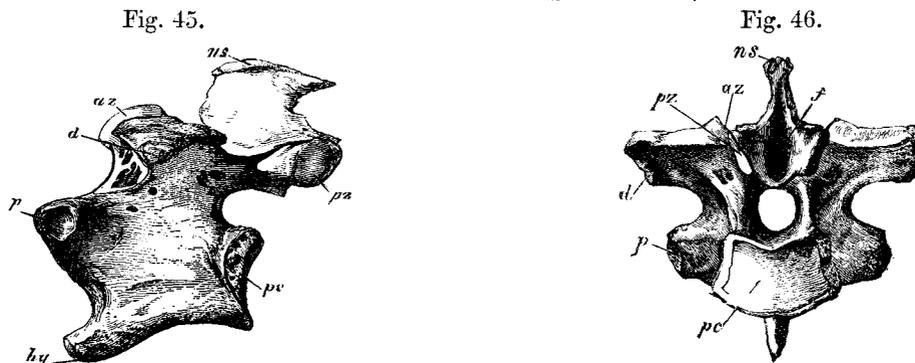


Fig. 45, lateral aspect; 46, postaxial aspect. Letters as before.

The pre- and postaxial diapophysial excavations of the neural lamina are the same as in the nineteenth vertebra; only the postaxial excavation is relatively the more extensive.

The *postaxial* surface has its ventral margin more convex, but relatively shorter compared with its dorsal margin, than in the nineteenth vertebra; the whole articular surface begins also to be less convex transversely and less concave dorso-ventrally.

The *neural* surface of the centrum is still more exposed than heretofore by the cutting away, as it were, of the preaxial part of the neural arch, which has a more marked median process.

The *ventral* surface is nowhere concave transversely, though somewhat so antero-posteriorly; not, however, to the same degree as in the nineteenth vertebra. The preaxial margin is also somewhat less concave, and the postaxial margin less convex.

There is a median *hypapophysis* which may or may not be somewhat expanded laterally towards its tip, and which may or may not project more strongly preaxial than in the nineteenth vertebra, and may have its dorsal surface concave transversely. The ventral surface of its apex may be marked with a short, faint, antero-posterior groove, the last trace of the bifurcation of the process in more preaxial vertebræ.

The side of the centrum is continuous with that of the neural arch, exhibiting an undulating expanse (concavo-convex dorso-ventrally), which is smooth, save that there may be a scarcely perceptible indication of a ridge running obliquely ventrad from the capitular process to the postaxial margin of the centrum.

The *parapophysis* extends less both preaxially and outwards than in the nineteenth vertebra; but the articular fossa for the head of the rib is larger, though nearly, if not quite, as deep (fig. 45, *p*).

The *diapophysis* again projects more outwards, is more extended antero-posteriorly, and more remote from the parapophysis than in the preceding vertebra. It bears on its ventral side, more close to its external margin, a convex articular surface (fig. 45, *d*) for the tubercle of the rib, which surface is rather more elongated and less rounded than it is in the nineteenth vertebra. It is placed about as near to the preaxial margin of the diapophysis as to its postaxial margin, or rather nearer; and therefore more postaxially with relation to the whole, more extended, diapophysis than in the more preaxial vertebra.

Ventral and preaxial to this surface the preaxial aspect of the neural lamina (pedicle) is deeply, widely, and irregularly excavated; and another excavation is placed near the postaxial margin of the pedicle, in the same position as in the nineteenth vertebra, but larger in size.

The *neural spine* is more extended both dorsally and antero-posteriorly, having a straight dorsal margin, which about equals in length its preaxial margin and also the transverse diameter of the postaxial articular surface of the centrum.

The postaxial excavation of the spine extends less dorsally, the dorsal part of the neural spine presenting postaxially a single margin, instead of a flat surface bounded by two ridges as in the nineteenth vertebra.

From the side of the neural spine two laminae of bone proceed postaxially to the postzygapophyses, bounding externally that fossa behind the neural spine which represents the postaxial excavation of that spine, which we have seen to exist in vertebræ nearer the skull.

The dorsal margins of these laminae form nearly a right angle with the postaxial margin of the neural spine.

The articular surfaces of the zygapophyses are still smaller; and the postaxial ones project still more postaxially beyond the centrum than in the nineteenth vertebra (fig. 45, *pz*).

The twentieth vertebra supports a long rib, which ends freely and does not come into contact with any sternal rib, though it is related to the first of these (fig. 75, III).

THE DORSAL VERTEBRÆ.

THE TWENTY-FIRST VERTEBRA.

The twenty-first vertebra is so much like the twentieth that little need be said in its description.

The preaxial articular surface of the centrum is deeper dorso-ventrally.

The *hypapophysis* is generally smaller, especially narrower from side to side, and its preaxial margin is more concave; it may show a rather more marked tendency to distal bifurcation (fig. 48, *hy*).

No oblique ridge traverses the side of the centrum; but there may be some defects of ossification dorsally, just ventrad of the diapophysis.

The *parapophysis* extends less; but its articular fossa (*p*) is larger.

TWENTY-FIRST VERTEBRA ($\frac{1}{2}$ natural size.)

Fig. 47.

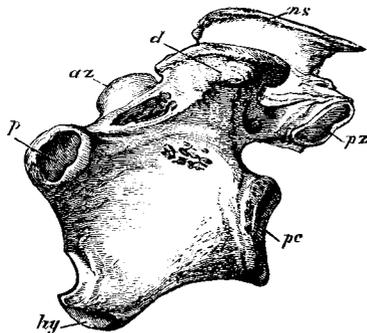


Fig. 48.

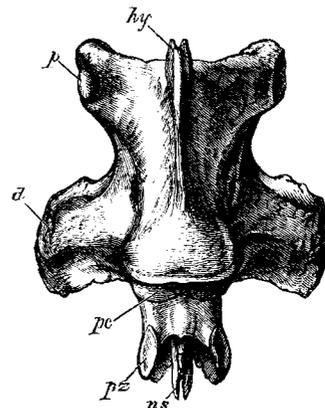


Fig. 47, lateral aspect; 48, ventral surface. Letters as before.

The diapophysial excavations are plainly to be seen; the postaxial one has the form of a single foramen or fossa.

Besides these, there is a defect of ossification in the side of the centrum, just below the middle of the diapophysis.

The *diapophysis* projects obliquely postaxiad and slightly dorsad, as well as outwards, and is much more remote from the parapophysis than in the twentieth vertebra.

The tubercular convexity (*d*) is less marked, and is situated almost as near the post-axial border of the diapophysis as it is near its preaxial margin.

Excavations occur preaxially, as in the preceding vertebra; but postaxially they may exist close to the postaxial margin of the diapophysis, extending inwards to the base of the neural spine.

The *neural spine* is more extended dorsally and slightly so antero-posteriorly; its dorsal margin is rather convex, and bifurcates slightly at each end. That concavity which in the preceding vertebra exists on each side of the preaxial root of the neural spine is here deeper.

The postaxial fossa is smaller; and the margins of the laminae which laterally bound it form rather less than a right angle with the postaxial margin of the neural spine.

The zygapophysial articular surfaces are again slightly diminished. The twenty-first vertebra supports a long rib, which articulates by its distal end with the second sternal rib.

THE TWENTY-SECOND VERTEBRA.

This vertebra is of about the same size as the twenty-first, in some respects less developed, in others more so.

Its *centrum* has its *preaxial* surface entirely occupied by the articular surface, and the ventral margins of both coincide, as there is no hypapophysial production. The surface is deeper dorso-ventrally, is less laterally produced, and may have its dorsal and ventral margins more concave and convex respectively.

TWENTY-SECOND VERTEBRA ($\frac{1}{2}$ natural size).

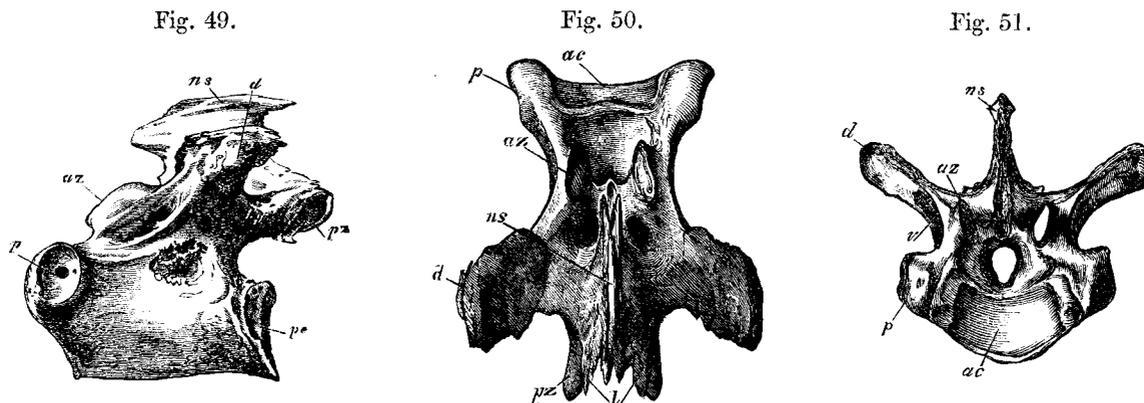


Fig. 49, lateral aspect; 50, dorsal aspect; 51, preaxial aspect. Letters as before, except *v*, excavation on preaxial side of diapophysis.

Excavations are to be seen on the preaxial, postaxial, and ventral aspects of the diapophysis, the preaxial one being very much the larger.

The *postaxial* surface of the centrum is rather larger and flatter, but very similar in figure to that of the twentieth vertebra; its dorsal margin, however, is rather wide and less concave.

The *neural* surface of the centrum is more concave transversely at its preaxial part than in the vertebra last described.

The *ventral* surface is destitute of any hypapophysis; but its nearly straight median portion is in the form of a slightly marked antero-posterior ridge. On each side of this the centrum rounds off, so that its ventral surface is convex transversely throughout; its lateral margins are, when viewed dorsally (fig. 50), strongly concave, owing to the expansion of the pre- and postaxial ends of the centrum. The concavity of the preaxial margin is much as in the twenty-first vertebra; but the postaxial margin is less convex.

The sides of the centrum and neural arch are continuous, without any trace even of a ridge; but there may be defects of ossification beneath the diapophysis.

The *parapophysis* extends out less even than in the twenty-first vertebra; and its articular fossa is larger (especially dorso-ventrally), but shallower.

The *diapophysis* is much longer and very much produced obliquely, postaxial and slightly dorsad; its remoteness from the parapophysis is again augmented in passing to this vertebra from the twentieth.

The convexity for the tubercle of this rib is, like that of the twenty-first vertebra, smaller and less marked than in the twentieth vertebra, and may be nearer to the postaxial margin of the diapophysis than it is to its preaxial margin.

The distal part of the diapophysis is more antero-posteriorly extended than the more proximal part.

Numerous irregular preaxial diapophysial excavations are placed beneath the ridge running from the prezygapophysis to the diapophysis; and other large excavations appear behind the diapophysis and on each side of the postzygapophysis, extending close to the ventral side of the postaxial margin of the diapophysis, which margin runs inwards to the base of the neural spine.

The *neural spine* is more extended dorsally, but not antero-posteriorly; it has a slightly convex dorsal margin, and bifurcates again at each end (fig. 50, *ns*).

That concavity which in the two preceding vertebræ exists on each side of the preaxial root of the neural spine is here yet further deepened.

The postaxial fossa of the neural spine is smaller; and the margins of the laminae which laterally bound it form an obtuse angle with the postaxial margin of that spine.

The articular surfaces of the zygapophyses are again still smaller, and look almost entirely inwards and outwards respectively. Almost the whole surface of the postzygapophysis projects postaxially beyond the postaxial surface of the centrum.

The twenty-second vertebra supports a long rib, which articulates by its distal end with the third sternal rib.

THE TWENTY-THIRD VERTEBRA.

This vertebra is so like its preaxial predecessor that little need be said in its description.

The postaxial surface of the *centrum* is relatively deeper dorso-ventrally, and its ventral margin is slightly concave.

The parapophysial surface for the head of the rib is much as in the twenty-second vertebra (fig. 52, *p*). The *diapophysis* extends somewhat less postaxially, and is less antero-posteriorly extended at its distal end; and the surface for the tubercle is somewhat less remote from the parapophysis.

The *neural spine* is more extended dorsally, being longer in this direction than antero-posteriorly.

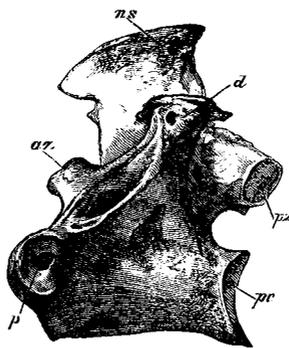
The prezygapophysial articular surfaces are smaller than those of the twenty-second vertebra; but the same cannot be said of the postzygapophysial ones.

Great excavations appear on each side of the vertebra, in front of, ventrad to, and behind the diapophysis.

Thus we have a side fossa, partially filled up with little lamellæ and spicula of bone,

TWENTY-THIRD VERTEBRA ($\frac{1}{2}$ natural size).

Fig. 52.



Lateral aspect. Letters as before.

on the preaxial aspect of the root of the diapophysis. The fossa is bounded dorsally by the ridge running from the dorsal side of the diapophysis to the prezygapophysis, on the ventral side by the ridge running from the ventral side of the diapophysis to the parapophysis. Again, there is a great depression at the side of the neural lamina, just ventrad to the diapophysis; and the same may exist in the two preceding vertebræ.

On the dorsum of the neural arch we see that the lateral depressions on each side of the preaxial part of the neural spine have much extended. The postaxial median excavation of the neural spine is more open, while the margins of the laminae which laterally bound it form a very obtuse angle with the postaxial margin of that spine.

Those postaxial excavations which in the two preceding vertebræ were mentioned as existing on each side immediately ventrad to the postaxial margin of the diapophysis may be here more conspicuous; they may be so, in part, on account of the less development postaxially of the dorsum of the diapophysis, so that these lateral postaxial excavations may appear on the dorsum of the vertebra and as but slightly separated from the preaxial lateral depressions on each side.

The postzygapophyses either do not project at all postaxially beyond the centrum, or but very slightly so (fig. 52, *pz*).

The twenty-third vertebra supports a long rib (the sixth), which articulates at its ventral end with the fourth sternal rib.

THE TWENTY-FOURTH VERTEBRA.

The twenty-fourth vertebra differs from the twenty-third principally in the much greater length (dorsally) of the neural spine.

The *centrum* has its postaxial surface more concave dorso-ventrally, as also is its ventral margin, which at the same time is more everted postaxially.

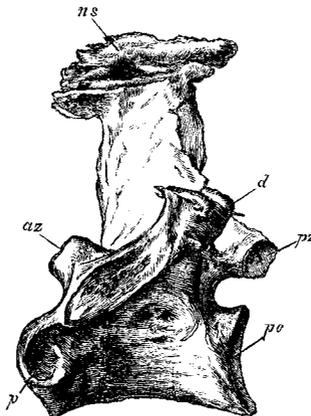
The *ventral* surface is slightly flatter. The neural canal, which has been diminishing in the last few vertebræ, is here decidedly smaller.

The *parapophysis* is much as in the twenty-third vertebra.

The *diapophysis* is somewhat less produced preaxially; and its distal end is more

THE TWENTY-FOURTH VERTEBRA ($\frac{1}{2}$ natural size).

Fig. 53.



Lateral aspect. Letters as before.

rounded. The surface for the tubercle is again less remote from that for the head of the rib (fig. 53, *d*).

The lateral excavation on each preaxial side of the root of the *neural spine* is still larger, and separated only by a vertical lamella of bone from the postaxial lateral excavation, which is here greatly augmented in size.

Thus, when the neural arch is viewed dorsally, five radiating lamellæ are seen to separate five subequal fossæ.

The two preaxial lateral excavations are separated by the preaxial part of the root of the neural spine. The two postaxial lateral excavations are each separated from the adjacent preaxial lateral excavation by a vertical lamella of bone running from the middle of the side of the neural spine outwards and postaxially to the postaxial part of the diapophysis. The two postaxial lateral excavations are separated from the remaining median postaxial excavation by the two lamellæ which laterally bound the median

postaxial excavation, and which diverge from the hinder part of the neural spine to the postzygapophysies.

This fifth fossa (the median postaxial fossa) shows signs of subdivision at its fundus through a slight postaxial projection of the postaxial margin of the root of the neural spine.

The apex of the neural spine is somewhat swollen, and may be much extended antero-posteriorly.

The postzygapophysial surfaces are here, again, somewhat larger, and look much more ventrally and less outwards.

The twenty-fourth vertebra supports a long rib (the seventh), which articulates by its ventral end with the fifth sternal rib.

THE TWENTY-FIFTH VERTEBRA.

This last of the free vertebræ differs greatly from any yet described, and considerably even from the twenty-fourth vertebra, principally in the diminution of the centrum and great augmentation of the neural spine.

The *centrum* has its *preaxial* surface less extended dorso-ventrally, while its ventral margin is concave as well as its dorsal one (fig. 55, *ac*).

The *postaxial* surface of the centrum may be different from any thing we have hitherto seen; its transverse extent may be nearly three times its dorso-ventral dimension. There may be scarcely a trace of dorso-ventral concavity, while the whole surface may be but very feebly convex from side to side¹; on the other hand, there may be little difference between it and the postaxial surface of the twenty-fourth vertebra².

The neural canal is even more contracted, especially in its dorso-ventral extent at its postaxial end, than in the twenty-fourth vertebra.

The *ventral* surface of the centrum presents a quadrangular, subequilateral, much flattened surface, such as we have not yet met with; its lateral margins, however, are still concave, while its pre- and postaxial margins are respectively rather more concave and convex than in the twenty-fourth vertebra.

The *parapophysis* is much as in the twenty-fourth vertebra, but extends less outwards.

The *diapophysis* is more slender, and projects directly outwards and somewhat dorsally; its distal half, at the least, is rather pre- and postaxially compressed than dorso-ventrally depressed. The surface for the tubercle is again less remote from that of the head of the rib.

The prezygapophysies are larger than in the twenty-fourth vertebra, and look more dorsad; the postzygapophysial articular surfaces are still smaller than in the preceding vertebra, and look still more ventrad.

The lateral excavations on the ventral and preaxial sides of the diapophysis have more

¹ As in the specimen 1362_A in the College-of-Surgeons Museum.

² As in the specimen 1317 in the College-of-Surgeons Museum.

or less coalesced by the abortion of the lamella running from the root of the diapophysis to the parapophysis.

The *neural spine* is swollen at its distal end, and is in length about twice the antero-posterior extent of the whole vertebra.

When the neural arch is viewed from above, there may be sometimes seen six fossæ (fig. 57, f^1 , f^2 , f^3), owing, when this is the case, to the complete subdivision of the median postaxial fossa into two by the greater postaxial development of the postaxial margin of the neural spine, which may extend to the postaxial margin of the neural arch.

TWENTY-FIFTH VERTEBRA ($\frac{1}{2}$ natural size).

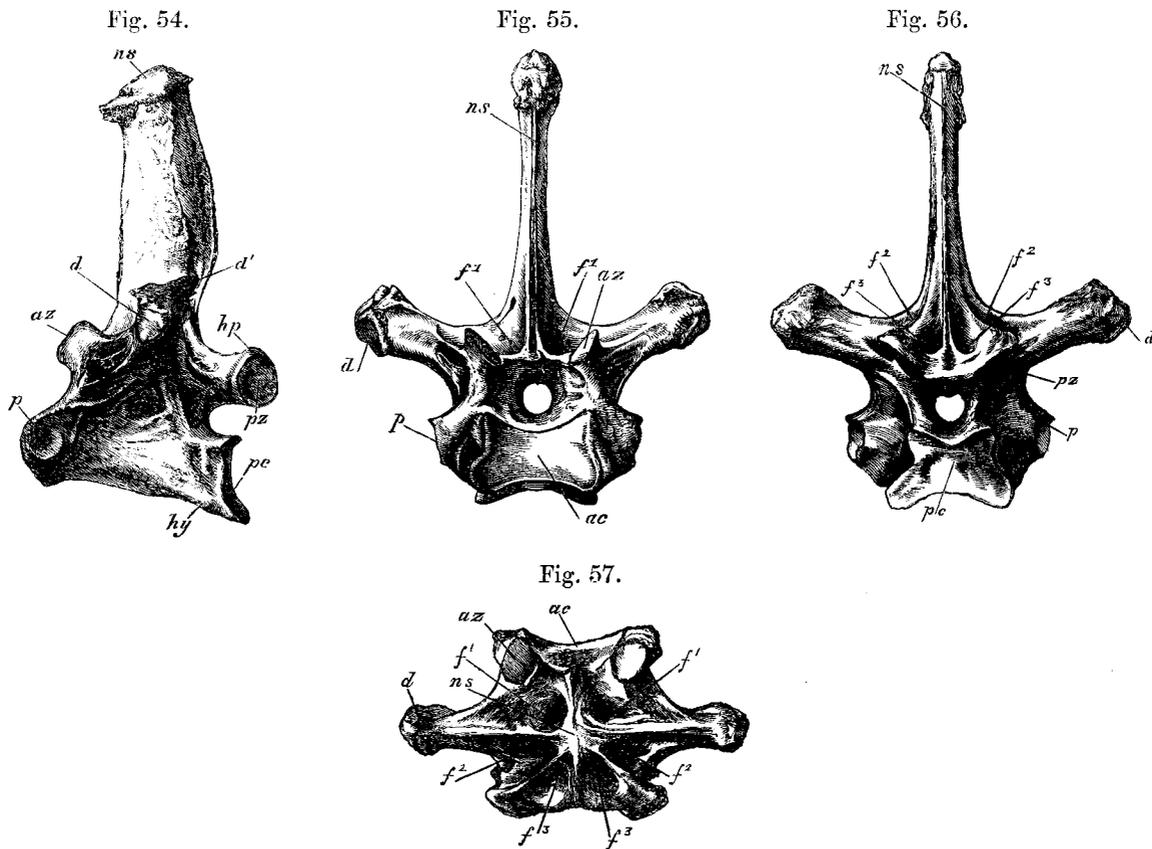


Fig. 57.

Aspects.

Fig. 54, lateral; 55, preaxial; 56, postaxial; 57, dorsal (the neural spine being cut short off).
Letters as before, except f^1 , antero-lateral fossa; f^2 , lateral fossa; f^3 , posterior fossa of neural arch.

The degree of special development of this vertebra varies, however, with the more or less preaxial extension of the ilia, also with the total number of vertebræ of which the spinal column consists; for there may be one less than the number herein given.

The twenty-fifth vertebra supports a long rib (the eighth), which articulates with the sixth sternal rib.

THE LUMBO-SACRO-CAUDAL VERTEBRÆ.

These vertebræ are normally twenty in number, and are, in the adult, ankylosed together and also with the innominate bones into one great osseous mass (figs. 70-73).

The various individual vertebræ cannot, therefore, be described from the adult; but the Museum of the College of Surgeons fortunately possesses a preparation of the sacral vertebræ (figs. 58, 59, 60, 61, & 62) of a young Ostrich in an unankylosed condition, which enables the serial description of individual vertebræ to be completed.

THE DORSO-LUMBAR VERTEBRÆ.

THE TWENTY-SIXTH VERTEBRA.

This vertebra has, of course, its preaxial surface formed to correspond with the postaxial surface of the twenty-fifth vertebra. It may be greatly or not quite completely overlapped by the iliac bones.

Its *parapophysis* is smaller than that of the preceding vertebra, with a smaller articular surface for the capitulum.

Its *diapophysis* is shorter, more compressed in an oblique pre- and postaxial direction, so as to have its dorso-ventral diameter widest ventrad and preaxiad; its articular surface is also elongated in the same direction.

Its spinous process is yet higher than in the twenty-fifth vertebra.

This vertebra is mostly, but not always, confluent with the sacrum in the adult. It supports a distinct rib (the ninth), which, however, generally ends freely at its ventral extremity without joining any sternal rib; indeed there is no true sternal rib corresponding to it, though it may be connected by a styliform bone with the sternal rib of the preceding vertebra.

THE TWENTY-SEVENTH VERTEBRA.

This vertebra is always, in the adult, confluent with the sacrum; and its rib (the tenth) is almost always an ankylosed process (but not always so, as *e. g.* in the specimen 1362B).

Its spine is again higher.

Its *diapophysis* is still more compressed, appearing as a lamella, the greatest breadth of which is inclined still more preaxiad and ventrad than in the twenty-sixth vertebra.

The *parapophysis* is much smaller, and is directed as much dorsad as ventrad, if not more so.

The ankylosis of the transverse processes and rib results in the formation of a perforated transverse process, with its greatly produced extremity (the shaft of the rib) extending ventrally, slightly arched convex preaxially, greatly flattened from within outwards, and with sharp, pre- and postaxial margins (figs. 70, 71, 72, & 73, *pl.*).

THE LUMBAR VERTEBRÆ.

THE TWENTY-EIGHTH VERTEBRA.

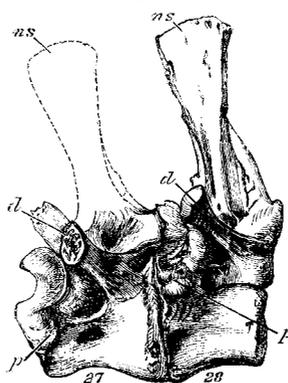
This is hardly to be distinguished in the adult, save by its transverse processes, which are strongly inclined postaxiad and dorsad, and are the first, since the axis, which present no indication of a rib.

The under surface of its centrum is transversely concave (fig. 73).

From the immature condition it may be seen that the spinous process is again higher, that the diapophysis inclines outwards and dorsad and is ventrally continuous with the parapophysis, that there are no postzygapophyses, but that its neural arch joins that of the twenty-ninth vertebra by suture (fig. 58, 28).

LATERAL ASPECT OF TWENTY-SEVENTH AND TWENTY-EIGHTH VERTEBRÆ.

Fig. 58.



Letters as before.

THE TWENTY-NINTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 1) like the preceding, but with a slightly higher spine, more vertically extended transverse process, and no zygapophyses.

THE THIRTIETH VERTEBRA.

This vertebra (figs. 59, 60, and 61, 2), as indicated by the young condition, has its spinous process yet higher; its diapophysis is also more dorsally produced, so that with the conjoined parapophysis there is presented an elongated vertical surface for the ilium. Without zygapophyses its neural arch is united to its centrum only by suture, and does not extend postaxially so far as the latter, thus leaving a large intervertebral opening between it and the ventral part of the neural arch of the next vertebra (fig. 59).

THE THIRTY-FIRST VERTEBRA.

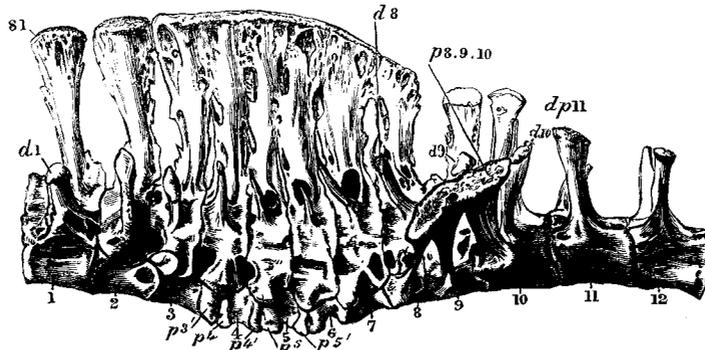
This vertebra (figs. 59, 60, & 61, 3) has a spinous process slightly more elevated, and even in the immature condition (fig. 59, 3) has this process ankylosed with that of the next postaxial vertebra.

Its *neural arch* is united by suture to its fellows and to the centrum, and is antero-posteriorly contracted below, so as to have a large intervertebral opening both pre- and postaxial of it.

The most preaxial part slightly rests on the postaxial extremity of the thirtieth vertebra.

LATERAL ASPECT OF LUMBAR AND SACRAL VERTEBRÆ OF AN IMMATURE SPECIMEN
($\frac{2}{3}$ natural size).

Fig. 59.



1. Twenty-ninth (or second lumbar) vertebra; d^1 , its diapophysis; s^1 , its neural spine. 2. Thirtieth vertebra.
3. Thirty-first vertebra; p^3 , its posterior parapophysial projection, which concurs with the anterior (and smaller) parapophysial projection (p^4) of the next vertebra to form an articular surface for the ilium. 4. Thirty-second vertebra; p^4 and p^4 , anterior (preaxial) and posterior (postaxial) parapophysial projections; the latter concurs with the anterior parapophysial projection (p^5) of the succeeding vertebra to form an articular surface. 5. Thirty-third vertebra; p^5 and p^5 , its parapophysial projections. 6. Thirty-fourth vertebra. 7. Thirty-fifth vertebra. 8. Thirty-sixth (or first sacral) vertebra; d^8 , its diapophysis; $p^{8,9,10}$, its rib or capitulum, which has coalesced distally with the same parts of the two succeeding vertebrae. 9. Thirty-seventh vertebra. 10. Thirty-eighth vertebra. 11. Thirty-ninth (or first sacro-caudal) vertebra; dp^{11} , its conjoined dia- and parapophysis. 12. Fortieth (or second sacro-caudal) vertebra.

The *diapophysis* is inclined like that of the last vertebra, but has a flattened surface at its extremity; it is quite separate from the parapophysis, which is formed by the ventral part of the neural arch, and offers a rounded, flat, articular surface (fig. 59) to the ilium. This surface is very slightly reinforced by minute adjacent portions of the centra of this and the preceding vertebra.

The side of the *centrum* at its postaxial part exhibits a small neural foramen near its dorsal border and in front of a large parapophysial surface (fig. 59, p^3), which this part of the centrum contributes towards the proper parapophysial surface of the next vertebra.

THE THIRTY-SECOND VERTEBRA.

This vertebra (figs. 59, 60, & 61, 4) has a spinous process at its maximum of development and ankylosed to the adjacent spines.

Its *centrum* is shorter pre- and postaxially, and its ventral surface is concave transversely and very strongly so at each lateral margin.

Its *neural arch* rests half on the postaxial part of the preceding centrum, half on the preaxial part of its own centrum; it has a large intervertebral opening both pre- and postaxial of its ventral portion.

The *diapophysis* is elongated and slender, ascends dorsal and slightly preaxial and outwards, with a small external flattened facet at its extremity (fig. 59, 4).

The *parapophysis* is formed in a minute degree by the most ventral point of the neural arch, but mainly and subequally by the adjacent portions of the centra which support the arch (fig. 59, p^3 & p^4).

The neural foramen of the centrum is larger.

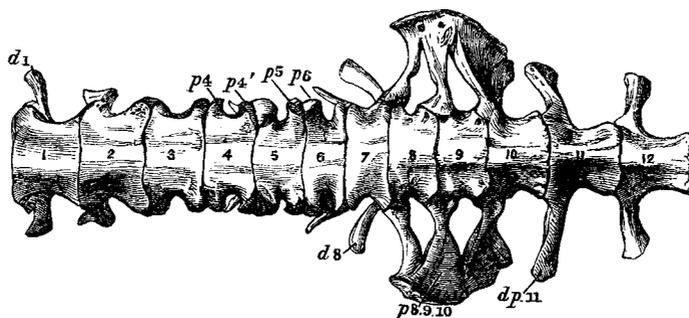
THE THIRTY-THIRD VERTEBRA.

This vertebra (figs. 59, 60, & 61, 5) is similar to that last described; but the diapophysis is shorter, the neural arch more antero-posteriorly extended at its ventral part, the intervertebral opening postaxial to it being much smaller.

VENTRAL ASPECT OF LUMBAR AND SACRAL VERTEBRÆ OF AN IMMATURE SPECIMEN.

($\frac{2}{3}$ natural size).

Fig. 60.



1-12. Centra of vertebrae from twenty-ninth to fortieth inclusive; d^1 , diapophysis of twenty-ninth vertebra; d^8 , diapophysis of thirty-sixth vertebra; dp^{11} , diapophysis of thirty-ninth vertebra conjoined with its parapophysis; p^4 , anterior parapophysial projection of thirty-second vertebra; $p^{4'}$ posterior parapophysial projection of the same vertebra; p^5 , posterior parapophysial projection of thirty-third vertebra; p^6 , anterior parapophysial projection of thirty-fourth vertebra; $p^{8,9,10}$, conjoined parapophyses of thirty-sixth, thirty-seventh, and thirty-eighth vertebrae. The last of these three is ankylosed to its supporting centrum (10); but each of the two preceding capitula is united by suture, with a pair of slight parapophysial projections contributed by contiguous vertebrae.

There is a considerable defect of ossification in the neural arch (fig. 61, 5) on each side of the spine, oval in shape and extending nearly from the spinous process to the *diapophysis*.

The ventral surface of its *centrum* (fig. 60, 5) is slightly narrower antero-posteriorly,

with each lateral margin extremely concave, through the two parapophysial processes which the centrum throws out. The preaxial one of these is the more considerable.

The neural foramen of the centrum is again rather larger.

THE THIRTY-FOURTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 6) has again its neural arch supported on two centra; but it rests rather more on its own. It has a larger dorsal defect of ossification (fig. 61, 6) than in the thirty-third vertebra, extending quite from the diapophysis to the neural spine.

The *neural spine* is slightly less extended, though still ankylosed both pre- and post-axially, even in the young.

Its *diapophysis* is rather longer (fig. 61, *d*⁶) than in the last vertebra, and inclined more preaxial. Both the pre- and postaxial intervertebral openings are smaller.

Its *centrum*, the ventral surface of which is exceedingly short antero-posteriorly, forms half of a large parapophysial surface (fig. 60, *p*⁶) at its preaxial part, and the greater part of a very much smaller parapophysial surface at its postaxial part.

The neural foramen of the centrum is again large; it is here almost at its maximum (fig. 61, 6).

THE THIRTY-FIFTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 7) rests mainly on its own centrum. The postaxial intervertebral opening is bounded below by its neural arch. The defect of ossification of this neural arch is at its maximum (fig. 61, 7), and more dorso-ventrally extended than in the thirty-fourth vertebra.

The *diapophysis* is longer, almost as slender as in the last vertebra, and inclined more preaxially (fig. 61, 7).

The *parapophysial* surface is much smaller, and is formed less by its own centrum than by that of the more preaxial vertebra.

The postvertebral interspace is again rather smaller.

The neural foramen of the centrum is smaller.

THE SACRAL VERTEBRÆ.

THE THIRTY-SIXTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 8) is distinguishable in the adult as that which furnishes (from the preaxial end of its centrum) the first of those three parapophysial roots which ascend and meet together to form the large bony plate which abuts against the ilium just behind the acetabulum.

In the young it is easily distinguishable as the most preaxial one which develops from the preaxial end of its centrum a suture-united parapophysial process or capitulum of a rib (fig. 60, *p*⁸).

Compared with the thirty-fifth vertebra, its neural arch is more antero-posteriorly extended, and shows a less defect of ossification dorsally (fig. 61, 8). Ventrally the neural lamina extends postaxially over the preaxial half of the root of the capitulum of the next vertebra, and thence ascends so as completely to enclose the postvertebral perforation, so that the neural arch may be said to be rather perforated than postaxially notched. The postvertebral interspace or perforation is considerably larger than in the three preceding instances.

The *diapophysis* (figs. 59, 60, & 61, d^8) is remote from the parapophysis, is stouter than that of the preceding vertebra, and extends more outwards and less preaxially.

The *parapophysis* is a scarcely noticeable prominence from the side of the preaxial part of the ventral side of the centrum; and this concurs with a process from the postaxial part of the thirty-fifth vertebra (fig. 60, 7 & 8) to form a surface for the capitulum. This capitulum arises thence by an expanded base with a somewhat hexagonal outline, rapidly contracts, then rapidly expands, ascending dorsally and postaxially to ankylose with the similar expansion of the capitulum next behind, and contributing to form the dorsally and postaxially extended surface (fig. 59, p^{8-9-10}) which abuts against the postacetabular part of the ilium.

THE THIRTY-SEVENTH VERTEBRA.

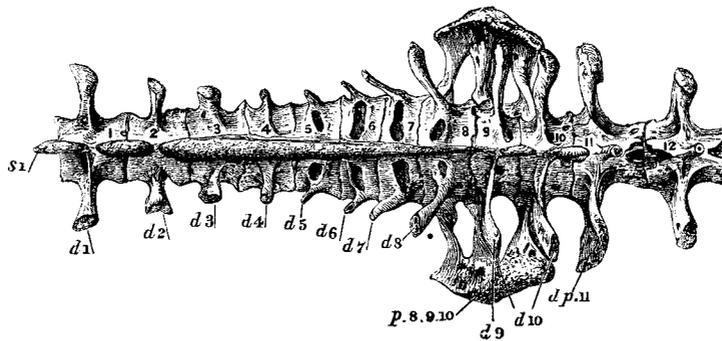
This vertebra (figs. 59, 60, & 61, 9) has a lower neural spine, which, in the young, is free both pre- and postaxially.

Its centrum, but not its neural arch, is more extended antero-posteriorly than in the last vertebra.

DORSAL ASPECT OF LUMBAR AND SACRAL VERTEBRÆ OF AN IMMATURE SPECIMEN

($\frac{2}{3}$ natural size).

Fig. 61.



1-12. Neural arches of vertebrae from the twenty-ninth to the fortieth inclusive; d^1-d^{10} , diapophyses of these vertebrae to the thirty-eighth inclusive; dp^{11} , conjoined di- and parapophysis of the thirty-ninth vertebra; p^{8-9-10} , conjoined capitula of sacral vertebrae; s^1 , neural spine of twenty-ninth vertebra. In the neural arches of the vertebrae from the thirty-third to the thirty-sixth, considerable defects of ossification are to be seen.

The defect of ossification in the neural arch is very small and behind the diapophysis (fig. 61, 9).

The *diapophysis* (figs. 59 & 61, d^9) is much larger, more expanded dorso-ventrally, and is connected with the root of the spinous process by a ridge; it projects outwards and dorsad and very slightly postaxiad.

The neural lamina is scarcely notched behind for the spinal nerves; and the post-vertebral interspace is less than in the two preceding vertebræ.

The *capitulum* is again united by suture, but is supported more by the preaxial parapophysial surface of its own centrum than by the postaxial central projection of the thirty-sixth vertebra (fig. 60). The capitulum, though it arises from a similarly expanded base, does not contract so much as in the preceding vertebra; it extends and expands to join its serial predecessor and successor; but it projects slightly preaxially instead of projecting postaxially as does that of the thirty-sixth vertebra.

THE THIRTY-EIGHTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 10) has its centrum a little more antero-posteriorly extended (fig. 60, 10) and considerably more convex transversely than the centrum of the preceding vertebra.

Its neural spine is quite free, less high, and more slender.

Its *diapophysis* (figs. 59 & 61, d^{10}) closely resembles that of the thirty-seventh vertebra; but its *capitulum* is ankylosed (fig. 60, p^{10}) at a time when the two preceding capitula are still united by suture to the centra. It is almost entirely supported by its own centrum, is still less contracted above its origin, and, projecting decidedly preaxiad as well as dorsad, comes into contact with its own diapophysis, as well as ankyloses with the two capitula preceding.

There is no lateral defect of ossification in the neural arch; but it is slightly excavated in the middle line postaxially to the neural spine.

There is no postvertebral interspace or perforation, except what is quite minute.

THE SACRO-CAUDAL VERTEBRÆ.

THE THIRTY-NINTH VERTEBRA.

This vertebra (figs. 59, 60, & 61, 11) is slightly more antero-posteriorly extended than is the preceding vertebra; its neural spine is lower and more slender; and its neural arch is medianly notched at its postaxial border, very decidedly (fig. 61, 11) and slightly so at the middle of its opposite margin.

Diapophysis, *parapophysis*, and *capitulum* all combine in one ankylosed transverse process, which projects much, as does the diapophysis of the thirty-eighth vertebra, but is never dorso-ventrally extended. Its most ventral point of origin does not extend so far ventrad as does that of the capitulum of the preceding vertebra.

THE FORTIETH VERTEBRA.

This has the transverse and spinous processes less developed, and the former have a rather more dorsal origin (figs. 59, 60, & 61, 12).

The median notch of the neural arch is more marked (fig. 61, 12).

The centrum is more excavated, causing each lateral margin of its ventral surface to be more concave.

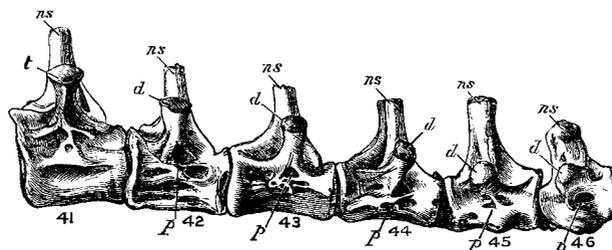
THE FORTY-FIRST VERTEBRA.

The differences just noted are here intensified (fig. 62, 41).

The under surface of the centrum begins to exhibit antero-posteriorly directed excavations of its substance.

LATERAL ASPECT OF THE VERTEBRÆ FROM THE FORTIETH TO THE FORTY-SIXTH INCLUSIVE IN AN IMMATURE CONDITION (natural size).

Fig. 62.



d, diapophyses; *ns*, neural spines; *p*, parapophyses; *t*, transverse processes, including the undifferentiated parapophyses and diapophyses.

THE FORTY-SECOND VERTEBRA.

Again we find an intensification of the same characters; but, in addition, the root of each transverse process sends out a minute process on its ventral origin, *i. e.* a *parapophysis* (fig. 62, 42, *p*).

THE FORTY-THIRD AND FORTY FOURTH VERTEBRÆ.

With progressive diminution of the other process, the *parapophysis* is here rather more prominent (fig. 62, 43 & 44).

The ventral surface of the centrum is more excavated.

THE FORTY-FIFTH AND FORTY-SIXTH VERTEBRÆ.

These vertebrae are like the two last noticed, but are smaller, and have the diapophysis projecting preaxially and more decidedly separated from the more marked parapophyses, which latter project outwards, one from each lateral margin of each centrum, while the ventral surface of each centrum is deeply excavated antero-posteriorly on each side of a median antero-posterior lamella (fig. 62, 45 & 46).

THE CAUDAL VERTEBRÆ.

THE FORTY-SEVENTH VERTEBRA.

This vertebra remains normally unanchylosed with the preceding bone in the adult bird.

It has a massive centrum and a neural arch small in circuit and very little developed antero-posteriorly, with a wide and massive neural spine and a moderate transverse process.

The *centrum* has its *postaxial surface* nearly flat or slightly concave or convex.

Its dorsal margin is slightly concave, its ventral margin very slightly convex.

The *preaxial surface* of its centrum is slightly concave, and its ventral margin nearly straight.

THE FORTY-SEVENTH, or FIRST CAUDAL VERTEBRA (natural size).

Fig. 63.

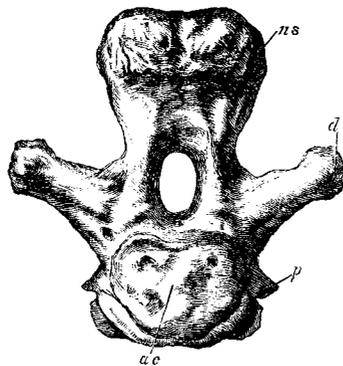


Fig. 64.



Fig. 63, preaxial aspect; 64, lateral aspect (left side). Letters as before.

The *ventral surface* of the centrum shows the subparallel antero-posterior excavations separated by a considerable interval. The excavations, however, are less extensive than are those in more preaxial vertebræ.

The *diapophysis* (figs. 63 & 64, *d*) projects dorsad, outwards and very slightly postaxiad; it is subconical, rather flattened pre- and postaxially, and with a somewhat rounded extremity. A very small *parapophysial* process projects from or ventrad of the ventral side of its root, extending slightly outwards from the lateral margin of the ventral surface of the centrum at or postaxiad of the antero-posterior middle point of that margin (figs. 63 & 64, *p*).

The neural lamina of each side has its postaxial margin nearly vertical; but its preaxial margin is inclined preaxiad and dorsad.

The *neural spine* is much more developed transversely than antero-posteriorly, and shows a tendency to bifurcate, its lateral extremities extending more or less outwards and preaxially.

There are no zygapophyses.

THE FORTY-EIGHTH VERTEBRA.

This vertebra is like the last, except that there are no subcentral excavations. The *diapophyses* extend less dorsad; and the *parapophysial* projection is smaller on each side.

THE FORTY-NINTH VERTEBRA.

This vertebra differs from the preceding chiefly in the sudden reappearance of a parapophysis of considerable size. It is, however, continuous with the diapophyses, the two appearing as a transverse process, which projects outwards and slightly post-axial from the postaxial part of the side of the centrum, and expands dorso-ventrally towards its distal end (fig. 65, *d*, *p*).

THE FORTY-NINTH, OR THIRD CAUDAL VERTEBRA (natural size).

Fig. 65.

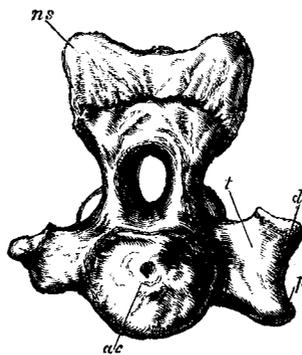


Fig. 65, preaxial aspect. Letters as before, except that *t* denotes the "transverse process," which probably contains both a diapophysial (*d*), and a parapophysial (*p*) element.

Its free outer margin is dorso-ventrally concave, the prominence at the dorsal side of the concavity representing the rounded end of the diapophysis, while the sometimes less marked prominence on the ventral side of the concavity represents the rounded end of the parapophysis. The preaxial surface of the transverse process is excavated and dorso-ventrally concave.

THE FIFTIETH VERTEBRA.

The fiftieth vertebra is slightly smaller than the forty-ninth, which it greatly resembles, except that the parapophysial (ventral) extremity of the transverse process is decidedly more produced than the diapophysial one.

The neural canal is also smaller, and the lateral summits of the laterally bifurcating neural spine more divergent.

THE FIFTY-FIRST VERTEBRA.

Here we find an intensification of the differences noticed in describing the fiftieth vertebra; and the outer margin of the centrum also more nearly approaches a circle.

The preaxial surface of the centrum is decidedly concave.

THE FIFTY-SECOND VERTEBRA.

This vertebra closely resembles its serial predecessor, but is smaller in size (fig. 66).

THE FIFTY-SECOND, OR SIXTH CAUDAL VERTEBRA (natural size).

Fig. 66.

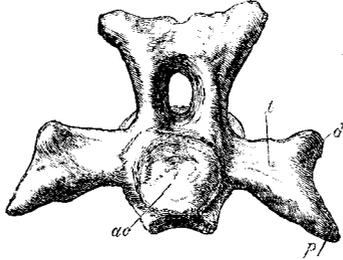


Fig. 66, preaxial aspect. Letters as before.

THE FIFTY-THIRD VERTEBRA.

Here the transverse processes project more postaxiad and ventrad, and the diapophysial part has greatly decreased relatively to the parapophysis. The spinous process shows a more or less marked tendency to become trifold transversely at its apex.

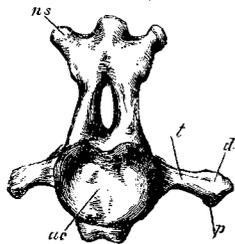
THE FIFTY-FOURTH VERTEBRA.

This vertebra (fig. 67) is much smaller than its predecessor. The transverse processes are very much smaller, but the apex of the neural spine is very distinctly trifold transversely.

The preaxial surface of the centrum is decidedly concave, as in all the vertebræ since the fiftieth.

THE FIFTY-FOURTH, OR
EIGHTH CAUDAL VERTEBRA
(natural size).

Fig. 67.



THE FIFTY-FIFTH AND FIFTY-SIXTH, OR
NINTH AND TENTH CAUDAL VERTEBRÆ
(natural size).

Fig. 68.

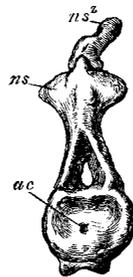


Fig. 69.

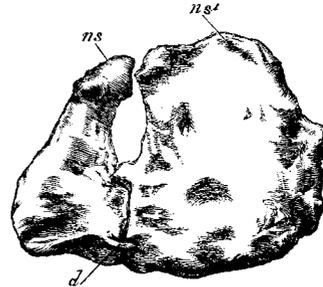


Fig. 67, preaxial aspect (letters as before); 68, preaxial aspect of ninth caudal vertebra; ns^2 , neural spine of tenth caudal vertebra; 69, lateral aspect; d , osseous bridge connecting the portions.

THE FIFTY-FIFTH VERTEBRA.

This vertebra is devoid of transverse processes; or there are at most but minute faint

traces of diapophysial and parapophysial prominences. The neural spine is more or less trifold at its distal end (fig. 68, *ns*).

The postaxial surface of the centrum is decidedly concave.

The vertebra often becomes ankylosed with the next and last, both by its centrum and the distal portion of its spine.

THE FIFTY-SIXTH VERTEBRA.

This vertebra has no neural arch and no transverse process (fig. 69).

It is a dorso-ventrally extended lamina of bone, extremely compressed laterally, with a very irregular, generally more or less rounded, margin dorsally, ventrally, and post-axially. It often anchyloses with the preceding vertebra at the dorsal and ventral parts of its preaxial surface, or rather margin, thus producing a foramen which looks from side to side.

The existence of another (but minute) foramen placed postaxially to that just described may indicate that this bone really consists of two or more vertebræ fused and anchylosed into one osseous mass.

Sometimes a little bridge of bone (fig. 69, *d*) connects its centrum, laterally, with the centrum of the fifty-fifth, or ninth caudal, vertebra.

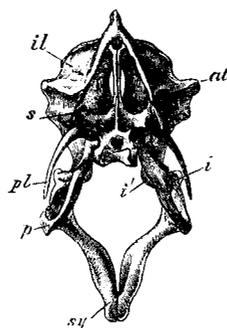
THE PELVIS.

This enormous bone consists of no less than twenty-two vertebræ, more or less completely anchylosed together (in the adult), and with the two ossa innominata, which latter thus cannot conveniently be excluded from the description of the axial skeleton.

Preaxially the sacrum exhibits the preaxial surface of the first sacral vertebra (with characters corresponding with the vertebra naturally preaxial to it) roofed over by the

PREAXIAL ASPECT OF PELVIS ($\frac{1}{3}$ natural size).

Fig. 70.



at, antitrochanteric process; *i* and *i'*, ischium; *il*, ilium; *p*, pubis; *pl*, rib; *s*, spinous process of postanterior vertebræ; *sy*, pubic symphysis.

two iliac bones (*il*), which meet together over the dorsal end of its spine and diverge ventrad at an angle of about 63° —the two diverging lines being carried on by the two anchylosed ribs (*pl*) of the first sacral vertebra.

Within the line of these ribs is to be seen a very large ventral arch, each side or lateral half of which is bent at an angle into a dorsal and ventral division or limb, which, when viewed preaxially, appears as follows:—

The dorsal division, or limb, consists mainly of the pubic bone (*p*), which diverges from its fellow of the opposite side at an angle of about 66° . The external margin of this limb is, in the main, concave externally; but the outline is interrupted by the more distant jutting out of the posterior part (*i*) of the ischium. The internal margin of the dorsal limb is convex, but with its outline interrupted, and the convexity exaggerated by the projecting inwards (*i*) of the more anterior part of the ischium.

The ventral division or limb is bent inwards on the dorsal limb (of the same half of the great ventral arch) at an angle of about 115° , and consists of the pubis, which terminates ventrally by meeting its fellow in (*sy*) a ventral symphysis.

The external margin of this ventral division is concave; its internal margin is convex.

When the pelvis is viewed *postaxially* the same great ventral arch is seen to be connected dorsally with a pentagonal mass, one angle of which is dorsad, and which has in its midst the postaxial surface of the small twenty-second sacral vertebra, *i. e.* the forty-seventh vertebra of the whole spinal column.

The two dorsal sides of the pentagon meet at an angle of about 118° ; and the margin of each, from the point of junction outwards, is slightly concave, then more strongly convex, then still more sharply concave, the sharp concavity being produced by the prominence of the antitrochanteric process. Each of these dorsal sides is formed by an ilium.

From the tip of this last-mentioned process each lateral margin of the pentagon proceeds ventrad, forming with the adjacent dorsal side an angle of about 90° ; its margin is, for its greater part, gently concave, and is formed by the ischium; it forms with the ventral side of the pentagon an angle of about 120° .

This ventral side of the pentagon is formed by the pubes, and is more or less horizontal.

When the pelvis is viewed *laterally* (fig. 71), the sacrum being horizontal, we have a dorsal elongated mass (made up of the ilium and sacrum) something like the skull of a bird, with the tip of the beak turned postaxially, from which two long bars of bone (*i* & *p*) diverge ventrally and proceed postaxiad to join and end in a great recurved process (*sy*).

These bars proceed from beneath the acetabulum.

The acetabulum is placed on the ventral side of the ilio-sacral mass, so that its postaxial margin is on the preaxial side of the middle point of that elongated mass.

Within the acetabulum are to be seen the four slender, dorsally and preaxially extended diapophyses of the thirty-second, thirty-third, thirty-fourth, and thirty-fifth vertebræ.

The dorsal margin of the preacetabular part of the ilium forms the roof of the cranial

part of what may be fancifully compared to a bird's skull, while the same margin of the postacetabular part of the ilium forms the apparent upper margin of the beak of such a skull, the whole (straight) inferior margin being formed by the ventral surface of the sacrum.

The ventrally proceeding osseous bars (the pubis and ischium) join in an expansion (*i*) situated ventrally to and opposite the postaxial end of the sacrum.

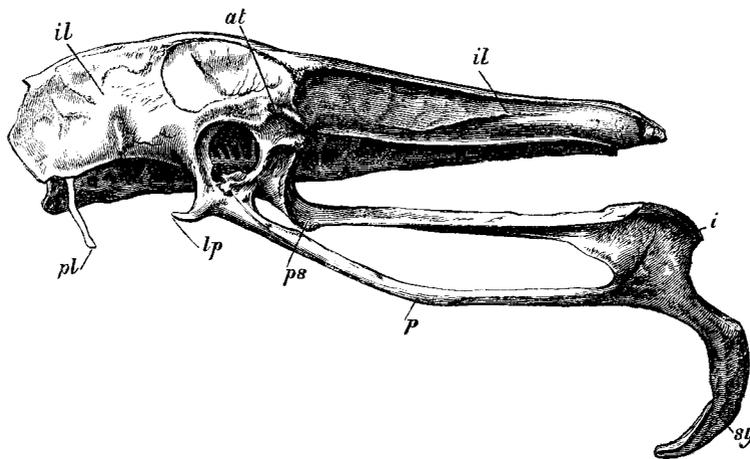
Beyond this point the pubis curves backwards, and then sharply first downwards (*sy*) and then forwards, its preaxial extremity advancing a little preaxial of the extreme point to which the whole sacrum extends postaxial.

The obturator foramen is very elongated, and is divided into a very small anterior and a very larger posterior portion by a process (*ps*) of the ischium which joins the pubis a little behind the acetabulum.

The pubis, at its junction with the ilium, develops a strongly projecting, curved and pointed ilio-pectineal process (*lp*). Sometimes a small process projects from the middle of the ventral margin of the pubis.

LATERAL ASPECT OF PELVIS ($\frac{1}{6}$ natural size).

Fig. 71.



Letters as last, except *lp*, ilio-pectineal process, and *ps*, process of ischium dividing off the small anterior part of the elongated obturator foramen.

The extreme pre- and postaxial extent of the pelvis is almost double its greatest dorsoventral dimension.

When the pelvis is viewed *dorsally* (fig. 72) we see in the middle of its preaxial third the dorsal iliac median ridge, and on each side the concave external margins of the ilia, with the two sacral ribs (*pl*) protruding, one on each side, from the more preaxial part of those margins. At about the middle third of the total pre- and postaxial diameter of the pelvis the antitrochanteric processes (*at*) stand sharply outwards. Behind a transverse line joining these processes we have five elongated pieces of bone, the middle

one of which proceeds directly postaxiad, while on each side of it two pieces proceed postaxiad and obliquely outwards till they reach a transverse line nearly coinciding with the postaxial end of the median piece, after which they bend inwards, at an angle of about 90° , to meet in the middle line.

The median piece consists of the postacetabular parts of the two ilia with the postacetabular sacral vertebræ; its lateral margins are gently concave; and it terminates postaxially in two diverging horns, which consist of the two postaxial ends of the two ilia projecting postaxiad beyond the last sacral vertebra. Between the antitrochanteric processes each ilium presents a rather wide convex surface; but this very rapidly narrows postaxially till at about the last sacral vertebra but two, whence it again slightly expands laterally to about the postaxial margin of the last sacral vertebra, after which it gently contracts to a bluntly pointed termination directed postaxiad, ventrad, and slightly outward.

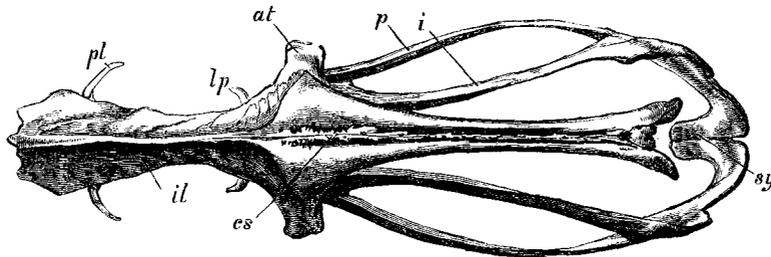
The two postacetabular dorsal expansions of the ilia are separated from the conjoined expansions of the spines of the sacral vertebræ (*cs*) by two very elongated narrow fissures, which run pre- and postaxiad nearly parallel to each other. The primitive distinctness of those conjoined sacral spines is indicated by successive foramina or defects of ossification.

The two lateral diverging pieces (*i* & *p*) on each side of the median postacetabular ilio-sacral piece are, of course, the ischium and pubis on each side.

The two ischia (*i*) seem to diverge at an angle of about 20° , the two pubes (*p*) at an angle of about nearly 30° ; but the latter curve inwards and join the ischia at the lateral expansion before mentioned. Preaxiad of this junction the outer margin of the pubis is convex, and its inner margin concave, while the outer margin of the ischium is concave and its inner margin convex.

DORSAL ASPECT OF PELVIS ($\frac{1}{8}$ natural size).

Fig. 72.



Letters as last, except *cs*, median crest formed by the coalesced spinous processes of the sacral vertebræ.

Postaxiad of the lateral expansions the two pubes converge and meet in the symphysis (*sy*), and then project sharply preaxiad. Each pubis, therefore, postaxially to the lateral expansion, has a postaxial margin which is convex, and a preaxial margin which is concave.

The greatest transverse diameter of the entire pelvis is across the pubes, at about the middle of their antero-posterior extent.

The greatest transverse diameter of the ilio-sacral mass is between the antitrochanteric processes.

The pelvis when viewed *ventrally* (fig. 73) presents, of course, relations corresponding with those already noticed as shown by the dorsal view. Here, however, the two iliopectineal eminences (*lp*) are very conspicuous, diverging, as they do, preaxial from the preaxial end of each pubis.

The rough surface for the attachment of a small bone, or else a bony process, is also noticeable at about the middle (pre- and postaxially) of the ventral surface of each pubis.

The ventral surface of the sacrum is visible throughout, forming one elongated bone in the middle line (in the adult), except that sometimes the last (twenty-second) sacral vertebra shows the line of junction of its centrum with that of the twenty-first sacral vertebra.

This median bone, then (formed of the coalesced centra), is widest in front of the acetabula, where it is concave transversely, and finally (between the two postaxial halves of the postacetabular parts of the ilia) it is flat, with successive pairs of antero-posteriorly directed excavations with a bony median ridge between each such pair of excavations.

The sacrum tapers backwards very gradually indeed.

The lateral processes of the adult sacrum are shown by immature specimens to have various natures.

Thus we have on each side at first (at the twenty-sixth vertebra) a truly articulated rib,

Next an anchylosed rib,

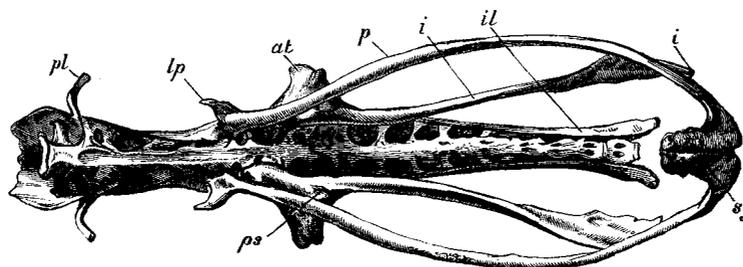
Next a transverse process arising entirely from the neural arch, and much inclined postaxiad (fig. 58, 28, *d*),

Next one similar, but smaller (fig. 59, *d*¹),

Then a shorter, formed by a preaxial process of the centrum and by the parapophysis of the thirtieth vertebra,

VENTRAL ASPECT OF PELVIS ($\frac{1}{6}$ natural size).

Fig. 73.



Letters as before.

Next a still smaller process formed by the adjacent parapophysial processes of the centra (thirtieth and thirty-first), together with the neural parapophysis of the thirty-first vertebra (fig. 59 & 60).

After this follows a larger process on a lower (more ventral) level, abutting directly against the proximal end of the ischium, and formed almost exclusively by the adjacent parapophysial (central) processes of the thirty-first and thirty-second vertebræ (fig. 59, *p* 3 & *p* 4).

Next follows a smaller and even shorter process, formed by the adjacent parapophysial (central) processes of the thirty-second and thirty-third vertebræ (fig. 59, *p*⁴ & *p*⁵).

Then we have a closely approximated smaller process, similarly formed by the thirty-third and thirty-fourth vertebræ, and, after, a scarcely noticeable prominence formed in the same way by the thirty-fourth and thirty-fifth vertebræ (fig. 60, 6, 7).

Next follow three conspicuous capitula, uniting distally to form an expanded plate, and belonging respectively to the thirty-sixth, thirty-seventh, and thirty-eighth vertebræ (figs. 59, 60, & 61, *p*^{8 9 10}).

Eight transverse processes then serially succeed, belonging to the eight next vertebræ; and the prominent lateral margins of the centra of the five most posterior sacral vertebræ may be regarded as rudimentary parapophyses.

THE ILIUM (figs. 70-74).

This bone extends preaxial to roof the twenty-sixth or even the twenty-fifth vertebra; its dorsal margin is gently convex; its preaxial margin is irregular, more or less produced at its ventral part. The ventral margin of the preacetabular part of the ilium is concave, being bent more or less strongly ventrad preaxially to the acetabulum. At its ventral end it here gives rise to a sharp-pointed ilio-pectineal process (*lp*) or spine, which projects strongly preaxially outwards and somewhat ventrad.

The ilium forms the preaxial and dorsal border of the acetabulum and the dorsal half of the much-projecting antitrochanteric process (fig. 74).

The postacetabular part of the ilium is longer than the preacetabular part; but the excess is less in the young than in the adult. Unlike the preacetabular part, it is separated, even in the adult, from the spines (fig. 72, *cs*) of the caudo-sacral vertebræ; and, in the young, even from those of the true sacral vertebræ. It tapers gradually backwards, the two borders (dorsal and ventral) being nearly straight and approaching each other postaxial at an angle of about 13°.

The free postaxial extremity curves somewhat outwards in the adult (fig. 72).

The dorsum of the ilium is marked by a gluteal line or ridge, which curves outwards and postaxially (fig. 72) to above the antitrochanteric process; thence it continues on postaxial, at first curving inwards, but ultimately (at about the middle of the postacetabular part of the ilium) curving outwards to the posterior extremity of the bone.

THE PUBIS.

The pubis is an exceedingly long and narrow bone, extending postaxiad and ventrad from the acetabulum to considerably beyond the postaxial extremity of the ilium, yet not so much so relatively in the young as in the adult.

The pubis first curves slightly downwards, as well as strongly postaxiad, then somewhat dorsally and outwards, then inwards and ventrad, and curves sharply round directly ventrad, and afterwards and finally preaxiad, at the same time meeting its fellow of the opposite side in a postaxial and ventral pubic symphyse.

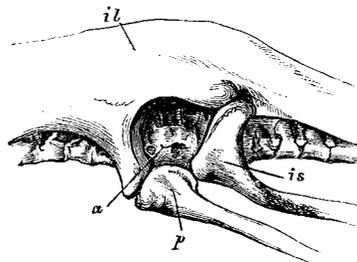
In the adult the pubis anchyloses with the ischium (fig. 71, *i*).

The pubis forms a small ventral portion of the margin of the acetabulum (fig. 74, *p*).

LATERAL ASPECT OF THE ACETABULAR REGION OF AN IMMATURE PELVIS

($\frac{1}{2}$ natural size).

Fig. 74.



a, acetabulum; *il*, ilium; *is*, ischium; *p*, pubis.

It develops a ridge on its dorsal aspect a little behind the acetabulum, which ridge makes a projection dorsad in the ventral margin of the obturator foramen.

The pubis does not seem to take any share in forming the ilio-pectineal spine.

At its ventral convexity the ventral margin of the pubis may, at about its middle, develop a bony process. This process is generally, however, only represented by a slight thickening of the margin. To this point a small distinct bone¹ is sometimes attached, which, when it becomes anchylosed, constitutes the process referred to as occasionally present.

THE ISCHIUM.

The ischium is the shortest of the three pelvic bones. Narrow for the greater part of its length, it expands at each end.

Preaxially it anchyloses with the ilium dorsally, and with the pubis ventrally.

Postaxially it anchyloses with the pubis (fig. 71, *i*), but not at all with the ilium.

It forms about a third (the postaxial ventral third) of the margin of the acetabulum, and the ventral half of the antitrochanteric process (fig. 74, *is*).

From the outer postaxial margin of this process a sharp ridge continues ventrad upon

¹ This bone has been described and figured by Mr. A. H. Garrod (in the Proc. Zool. Soc. for March 1872, p. 359), who has suggested the possibility of its representing the marsupial bone.

a ventrally extending prominence (figs. 71 & 73, *ps*), which approaches the pubis very closely, and nearly divides a small oval preaxial part of the obturator foramen from a very elongated and large postaxial portion.

The shaft of the ischium is divided by three longitudinal ridges:—one well marked and dorsal in position; another ventral, and only marked at the more postaxial part of the shaft; a third external and very marked, extending from the process approaching the pubis to the postaxial extremity of the bone.

At its postaxial end the ischium in the adult expands into a subquadrate dorso-ventrally expanded plate of bone (fig. 71, *i*) more or less convex externally for the greater part of its extent.

The ischium extends postaxially beyond the ilium, relatively more in the young condition than in the adult bird.

THE RIBS.

The ribs consist of two series, the *vertebral* and the *sternal* ribs, the former series being the more developed both in number and size.

THE VERTEBRAL RIBS.

Of these there may be said to be normally ten on each side, though the first and last of these very generally appear in the form of ankylosed transverse processes of their respective vertebræ.

Five of the vertebral ribs articulate with sternal ribs, which themselves join the sternum directly by distinct articular surfaces (fig. 1, IV, V, VI, VII, & VIII).

Behind these there are normally two ribs, which end freely at their ventral extremities; but there may be three such ribs. In the latter case the first of these may be continued on ventrally by a distinct, curved, rod-like bone, which bone does not reach the sternum, but is applied to the ventral side of the sternal rib next in advance.

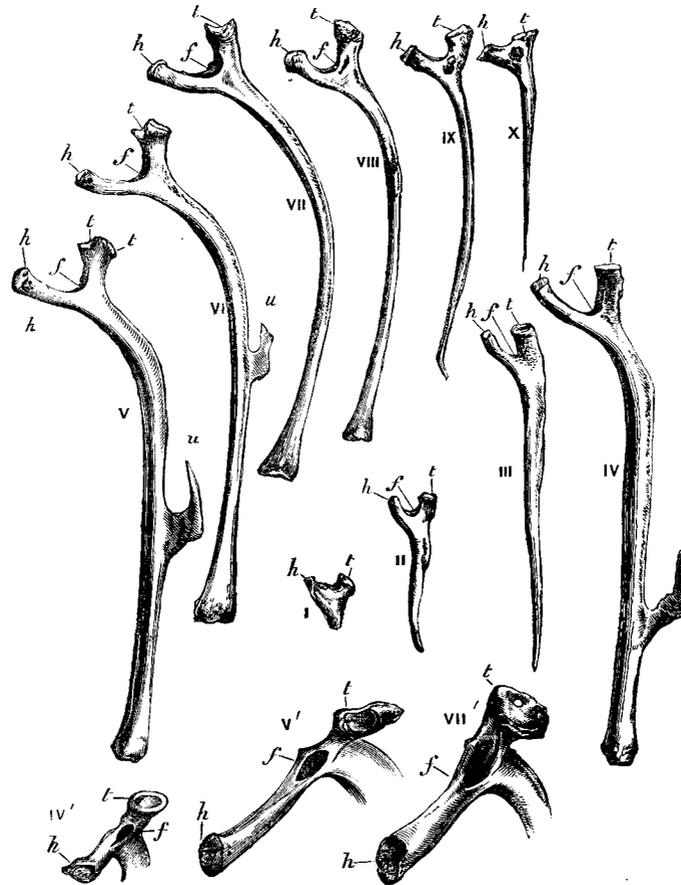
The First Rib.

This little rib (fig. 75, 1) is attached to the eighteenth vertebra, and very often ankyloses with it. It is a flat bone, subtriangular in shape, with its three margins concave, but especially the preaxial margin. Its length only exceeds its breadth by one quarter, if so much, of the latter, and is less than half that of the centrum of the vertebra to which it is attached. It projects freely postaxially at its distal end; and preaxially it presents a head and neck, or *capitulum* (*h*), and a tubercle or *tuberculum* (*t*), subsequently developed to articulate respectively with the para- and diapophysis. Both capitulum and tuberculum are broad and rather flattened pre- and postaxially, being less slender and less rounded than the distal end of the rib.

The capitulum exhibits scarcely any distinct rounded articular surface; but the tuberculum shows a flattened, slightly excavated facet at its extremity.

There is a small pneumatic foramen in the vertebral margin near the head of the rib. The dorsal (or more postaxial) margin of the rib is rather shorter than the ventral one, owing to the head and neck being slightly longer than the tubercle.

THE VERTEBRAL RIBS OF RIGHT SIDE (size of figures I-X, $\frac{1}{4}$ natural size; figures IV', V', VII', $\frac{1}{2}$ natural size).
Fig. 75.



I. first rib: its preaxial margin is between *h* and *t*; its vertebral margin extends downwards from *t* to the apex of its ventral margin. II. second rib. III. third rib. IV. fourth rib; IV'. proximal end of fourth rib, showing the pneumatic foramen (*f*), the cup-like surface for the diapophysis (*t*), and the convex tubercle (*h*) for the parapophysis. V. fifth rib; V'. its proximal end (the small but sharp prominence near the letter *f* is produced by the ridge which passes outside the root of the capitulum). VI. sixth rib. VII. seventh rib; VII'. its proximal end, showing the great articular surface for the diapophysis and the very large pneumatic foramen. VIII. eighth rib, showing the small opening or defect of ossification on the tuberculum, near its junction with the capitulum. IX. ninth rib, showing a defect of ossification larger than that in the eighth rib. X. tenth rib, with a defect of ossification relatively yet larger. In all the figures, *h* denotes the capitulum, and *t* the tuberculum; *u*, the uncinat process.

The Second Rib.

This still absolutely small rib (fig. 75, II) is relatively much elongated compared with the first rib, its length being about three times its greatest breadth, and three times the

length of the first rib, or even more. Nevertheless its length is to the extreme length of the nineteenth vertebra (to which it is attached) only as about seven to six.

It projects freely ventrad (fig. 1, II), and is in the form of a **Y** with very short arms and with a curved stem. The stem is, on the whole, rather concave outwards, but with a slightly sigmoid flexure. The head and neck of the rib (*h*) may be more slender than any part except the distal end of the rib; more slender absolutely, and very much more so relatively than in the first rib. The head itself has a subcircular circumference.

The tuberculum (*t*) is slightly shorter than the neck, but considerably broader, much flattened pre- and postaxially, but with a rounded articular concavity at its tip. It is very little larger absolutely, and very much less so relatively, than in the first rib.

The vertebral margin (between the head and tubercle) is strongly concave, very much more so than in the first rib. It presents an exceedingly large pneumatic foramen (*f*).

The ventral or preaxial margin of the rib is more rounded than the dorsal or postaxial one. Proceeding distad from the capitulum, this margin is at first gently concave and then gently convex.

The postaxial margin may develop a low, long prominence, with a rounded outline, a little distad of the tuberculum. On this account this margin, proceeding distad from the tuberculum, is at first concave, then convex, and then again gently concave.

The Third Rib.

The third rib (fig. 75, III) is a little more than twice the length of the second rib; but neither the capitulum nor the tuberculum is quite twice the length of the capitulum and tuberculum of the latter.

This third rib bears a proportion in length to the twentieth vertebra (to which it is attached) about as $3\frac{1}{2}$ to $7\frac{1}{2}$.

It projects freely ventrad and slightly postaxiad; and the tail of its **Y** has a similar, though less marked, curvature to that of the second rib (fig. 1, III).

The capitulum is relatively rather longer and more slender in proportion to the tuberculum than in the second rib; it is the slenderest part, except close to the actual extremity of the free distal end.

The head itself presents a rounded, convex, articular surface for the parapophysis; that on the tubercle (for the diapophysis) is nearly twice the size of the corresponding surface on the second rib. Its dorso-ventral diameter slightly but decidedly exceeds its pre- and postaxial extent.

The vertebral margin (between the capitulum and tuberculum) is much more sharply concave than in the second rib, forming an acute angle of about 60° ; but its pneumatic foramen is little, if any, larger.

The tuberculum seems to continue on in the main and general direction of the rib, and the capitulum to diverge obliquely inwards from this.

The preaxial or ventral margin of the rib is generally rounded, the dorsal margin sharp.

There is no sudden inflection in the rib which can be called an "angle;" nor does its dorsal margin develop a rounded prominence as was the case in the second rib.

The entire preaxial margin is at first (*i. e.* proximally) concave, and afterwards very gently convex.

The entire dorsal margin is at first very slightly convex, and then concave in a little more marked degree.

The Fourth Rib.

Though the increase in length of the fourth rib (fig. 75, IV & IV') is much less than we meet with in proceeding from the second to the third, yet it exceeds the last-mentioned very considerably in bulk and massiveness, though it is less, if not much less, than half as long again (fig. 1, IV).

The fourth does not end freely, but articulates distally by an expanded concave surface, with the second sternal rib; it is attached dorsally to the twenty-first vertebra.

The increase in length of the capitulum of the rib (as compared with that of the third rib) is considerably greater than that of the tuberculum. Concomitantly with this, it seems rather to be the capitulum which continues on the general curve of the rib, from which the tuberculum diverges obliquely dorsad.

The stem or tail of the **Y**, *i. e.* the shaft or body of the rib, presents no sigmoid flexure, but bends rather suddenly a little distad of the junction of the capitulum and tuberculum. Through this bending, the rib may be said to have a sort of "angle."

The capitulum is actually longer than that of the third rib, and relatively longer as compared with the tuberculum, though not as compared with the whole rib. It is actually the slenderest part.

The head itself (fig. 75, IV', *h*) presents a convex articular surface, which is preponderatingly developed dorso-ventrally, being nearly twice as long in this direction as transversely.

The vertebral margin (between the capitulum and tuberculum) is less sharply concave, its margins forming an angle of about 70°. The pneumatic foramen (*f*) is actually larger, but relatively smaller.

The tuberculum and its articular surface for the diapophysis (*t*) are much more extended antero-posteriorly, the latter being thus twice as long as broad.

The preaxial margin of the body of the rib is sharper than in the third rib; in fact a rounded ridge near the preaxial margin (on the visceral surface of the rib) seems to answer to the actual ventral margin of the third rib, as, like the latter, it continues on the prominence of the capitulum. If so, then the actual preaxial margin of the fourth rib, at its proximal part, would seem to be formed from a lamella of bone being developed on the ventral side of what was, in the third rib, the actual preaxial margin.

The whole preaxial margin is nearly on one level vertically.

The postaxial margin is sharp, and becomes more prominent at the angle, causing this part of the margin to be convex.

At about the dorsal end of the distal third of the postaxial margin of the rib a large lamelliform uncinatè process is thrown out. It stands out at its origin nearly at right angles to the course of the rib, and then turns sharply dorsad and tapers to a point, running nearly parallel to the course of the rib; the uncinatè process is thus bent at right angles.

The Fifth Rib.

This rib (fig. 75, v & v') which is attached dorsally to the twenty-second vertebra, closely resembles the fourth: it is, however, larger; and its distal part is more slender, expanding, nevertheless, at the distal end to form a concave surface for junction with the third sternal rib (fig. 1, v).

Both the capitulum and tuberculum are longer and diverge at an angle of about 75° , having a large pneumatic foramen (fig. 75, v', f) at the vertebral margin, where they bifurcate.

The length of the capitulum, as compared with that of the tuberculum, has also somewhat increased.

The shaft of the rib is more bent on the head and tubercle, and has a rather more decided "angle;" but its margins are in the main similar to those of the third rib.

The uncinatè process (*u*) is placed more proximally, springing from nearer the middle of the length of the shaft of the rib; it extends out rather less, and its recurved portion is more slender.

The preaxial margin of the shaft is continued into that of the tuberculum by a ridge (fig. 75, v', near f) passing outside the root of the capitulum, *i.e.* preaxially to that root.

The Sixth Rib.

This rib (fig. 75, vi) is attached to the twenty-third vertebra, and very closely resembles the fifth, which it about equals in length; its distal half, however, is more slender and more rounded, though its distal end may, on the contrary be more expanded. It articulates distally with the fourth sternal rib (fig. 1, vi).

The pneumatic foramen is larger; and the capitulum and tuberculum diverge at an angle of about 80° .

The proximal part of the shaft of the rib is rather more bent.

The uncinatè process (*u*) springs from the dorsal margin, at about the middle point between the distal end of the rib and the root of the tuberculum. It is very much smaller, and, though rather broader at its root, much blunter, and may be not half the length of the recurved part of that of the fifth rib.

The articular surface for the diapophysis is rather larger and more concave.

The ridge passing outside the root of the capitulum is more marked than in the fifth rib.

The Seventh Rib.

The seventh rib (fig. 75, VII & VII') is attached to the twenty-fourth vertebra. In spite of its being much more bent, it is decidedly shorter (by nearly the length of its tuberculum) than the sixth rib, though it is longer than the fourth rib when measured along its convexity (fig. 1, VII).

The capitulum and tuberculum diverge at an angle of about 80°. The pneumatic foramen (VII', *f*') is still larger, forming quite a chasm. The articular surface for the diapophysis is also rather larger (VII', *t*').

The shaft of the rib is more rounded and slender generally, especially towards its distal part, which, however, expands towards its extremity so largely as to about equal in size the distal end of the sixth rib. It articulates at its distal end with the fifth sternal rib.

The shaft is also bent, with a decided or slight sigmoid flexure, convex postaxially at its more proximal part, and convex preaxially at its more distal part; but it may only show a preaxial concavity and a postaxial convexity.

The ridge traversing the outside of the root of the capitulum is still more marked.

There appears to be generally no rudiment even of an uncinat process, but it may be developed, though always to a less extent than in the seventh rib.

The Eighth Rib.

This rib (attached to the twenty-fifth vertebra) is smaller in all dimensions (fig. 75, VIII) than the seventh rib, and in length is intermediate between the third and the fourth ribs.

It closely resembles in shape the seventh rib; but the capitulum is rather less long compared with the tuberculum; the pneumatic foramen is smaller; but there are small openings on the postaxial or inner surface of the tuberculum. The articular surface for the diapophysis is smaller and nearly flat.

The shaft of the bone is more or less bent; it may exhibit a rudiment of an uncinat process. It articulates at its ventral end with the sixth sternal rib (fig. 1, VIII).

The Ninth Rib.

The ninth rib (attached to the twenty-sixth vertebra) is much shorter, about the same length as the third, and, like the latter, ends freely at its distal end (fig. 75, IX). It is much more slender than any other rib. Compared with the eighth rib, the capitulum is again shorter relatively, exceeding the tuberculum less in proportion. The pneumatic foramen on the margin of the neck is minute; but there is a large aperture on the postaxial aspect of the tuberculum, where the capitulum joins it. The shaft of the bone is again straighter (fig. 1, IX).

The ninth rib may have at its ventral end an extremely long, slender, curved bone applied by its other extremity to the outer or ventral side of the sixth sternal rib.

The Tenth Rib.

This rib (normally ankylosed in the adult with the sacrum and pelvis) generally appears as an elongated ventrally produced process (figs. 70, 71, 72, & 73, *pl*) of the twenty-seventh vertebra, as therein noticed. The rib is compressed from within outwards (fig. 1, *x*).

The tenth is only about from $\frac{2}{3}$ to $\frac{3}{4}$ as long as the ninth rib, and may be somewhat shorter than the second rib when this latter is measured from the root of the tuberculum distad. Its inner (here actually postaxial) surface between the tuberculum and capitulum is but very slightly concave; its preaxial margin is convex, and its postaxial one concave.

On the postaxial side of the expanded proximal part of the rib is a large pneumatic opening.

The ridge, which in more preaxial ribs ascended the outer surface of the shaft to the interval of the head and tubercle and went on ultimately to the tubercle, is here produced into a sharp crest, which is the actual outer and preaxial margin of the shaft of the rib, and which lies close to that margin all the way to the dorsal extremity of the tuberculum.

An Eleventh Rib

may be developed, which then closely corresponds with the conditions here attributed to the tenth rib. When this development occurs, the tenth rib approximates in its form very nearly to what has here been described as the ninth rib.

THE STERNAL RIBS.

These six ribs increase gradually in length postaxially from the first to the sixth; so that the fourth is rather more than twice the length of the second, and the sixth is from two and a half to three times the length of the second; the third is more than half the length of the sixth (fig. 1, II, III, IV, V, VI).

The sternal ribs are greatly expanded dorso-ventrally at their distal (sternal) ends, but do not bifurcate and divide into two processes like the tuberculum and the capitulum of the vertebral ribs.

All these ribs, except the first, unite with one or other of the vertebral ribs by a distinct joint.

The angle formed by the second sternal rib with its vertebral rib is only slightly obtuse, viz. about 129° ; the angle formed by the third sternal rib with its vertebral rib is more obtuse, viz. about 140° .

The fourth sternal rib continues on the curve of its vertebral rib, while the fifth sternal rib cannot be said to form any angle other than 180° with its vertebral rib.

The First Sternal Rib.

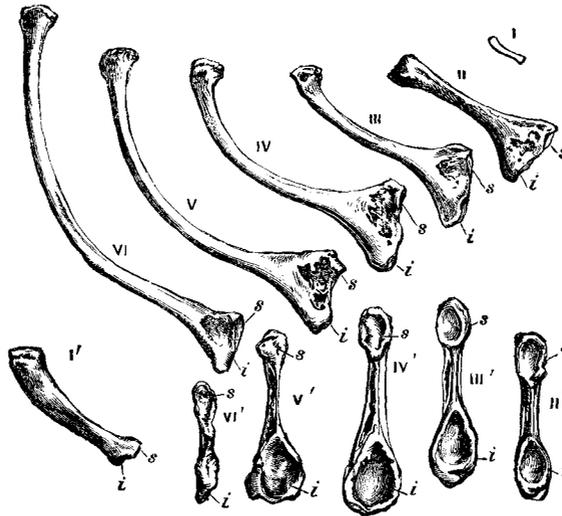
This rib (fig. 76, I & I'), of which I have not been able to see an adult specimen, seems (from the immature skeleton) to be a subcylindrical bone but little expanded at

its sternal end, and only a little more than half the length of the second sternal rib. It is articulated distally in front of the fossa, which is preaxial to the first vertical septum of the pleurosteon.

It only seems to be connected with the third vertebral rib by soft tissues intervening between them.

STERNAL RIBS OF RIGHT SIDE (I-VI, $\frac{1}{4}$ natural size; I', the first rib of an immature specimen, natural size; II', III', IV', V', and VI', $\frac{1}{2}$ natural size).

Fig. 76.



I-VI. Lateral aspect of the six sternal ribs; II'-VI'. The articular surfaces of the second, third, fourth, fifth, and sixth sternal ribs.

In all the figures *s* represents the concavity which articulates with the dorsal convexity of each pleurosteal septum, and *i* represents the concave articular surface for the ventral articular convexity of each such septum.

The Second Sternal Rib.

The second sternal rib (fig. 76, II & II') is of about the same length as the second vertebral rib, though it articulates with the fourth vertebral rib. It is irregularly rounded at its proximal end; but its distal end is very greatly expanded dorso-ventrally, and compressed pre- and postaxially, with a pneumatic foramen on its postaxial surface at its expanded part.

The ventral end of the rib presents two superimposed elongated concavities (*s* & *i*) to fit on to the two superimposed articular convexities of the first septum of the pleurosteon of the sternum (fig. 79, *i*, *s*). The bone is slightly curved, with the convexity dorsad.

The Third Sternal Rib.

This rib (fig. 76, III & III') is rather less than half as long again as the second sternal rib, and is more curved.

Its proximal end is rounded, but more antero-posteriorly compressed than in the second sternal rib.

Its distal end is absolutely more but relatively less expanded; and the two concave articular surfaces are no longer subequal in size, but the ventral one (*i*) much exceeds the dorsal one.

The postaxial surface of the distal expansion of the bone exhibits large irregular excavations.

The postaxial surface of the shaft of this rib is flattened; but its preaxial surface exhibits a prominent ascending ridge.

The Fourth Sternal Rib.

The fourth sternal rib (fig. 76, iv & iv') is slightly more than twice the length of the second, and is more curved, the concavity, of course, being also dorsal.

The preaxial end presents a wider articular surface for the vertebral rib.

Its distal end is only very slightly more expanded dorso-ventrally, and is therefore relatively less so expanded.

The disproportion between its two concave distal articular surfaces is still greater, the dorsal surface (*s*) being relatively still smaller.

The postaxial surface of the distal expansion is still more excavated.

The postaxial surface of the shaft is again flattened; but the ridge on its preaxial surface is much less marked.

The Fifth Sternal Rib.

The fifth sternal rib (fig. 76, v & v') is longer and slightly more curved than the fourth, being about once and a half the length of the third sternal rib.

Its proximal surface (for articulation with the seventh vertebral rib) is broader and flatter than the corresponding surface of the fourth sternal rib, is absolutely rather less dorso-ventrally expanded, and therefore very decidedly so relatively.

Its articular surfaces (*s* & *i*) are still more unequal. Its shaft is more rounded post-axially as well as preaxially, and there is no ascending ridge on either surface.

The Sixth Sternal Rib.

This rib (fig. 76, vi & vi') is longer again than the fifth one, but slightly less curved; its length is decidedly more than two and a half times the length of the second sternal rib.

Its proximal end is still flatter, and the antero-posterior dimension of its articular surface is less inferior to its transverse extent.

The sternal end of the rib is less extended dorso-ventrally than in any other sternal rib, except the first, and its articular surfaces have again approached each other. The inner, or rather preaxial, margin of the shaft is sharper than in the other sternal ribs.

Occasionally a long delicate ossicle, a *seventh sternal rib* (though it does not join the sternum), may be developed, extending ventrad and preaxiad from the ventral end of that rib which is postaxial to the one which distally unites with the sixth sternal rib.

It is applied externally and ventrad to the side of the sixth sternal rib. It is, in fact, the ossified cartilage of a "false" rib.

THE STERNUM.

This is a wide sheet of bone with four margins and two surfaces (figs. 77 & 78).

Its external (inferior or ventral) surface is convex, but irregularly undulating. Though there is no true keel, yet there is an oval elevated and flattened tract placed in the middle line at the postaxial half of the bone (fig. 77, *f*). The extreme antero-posterior length of the sternum is to its transverse dimension as about 5 to 3. Medianly and preaxially from the flattened tract a very low ridge may be developed forwards and dorsad. The internal (superior or visceral) surface of the sternum is strongly concave in both directions. At the bottom of the concavity there may be small openings into the substance of the bone.

THE STERNUM (figs. 77 & 78, $\frac{1}{6}$ natural size ; fig. 79, $\frac{1}{3}$ natural size).

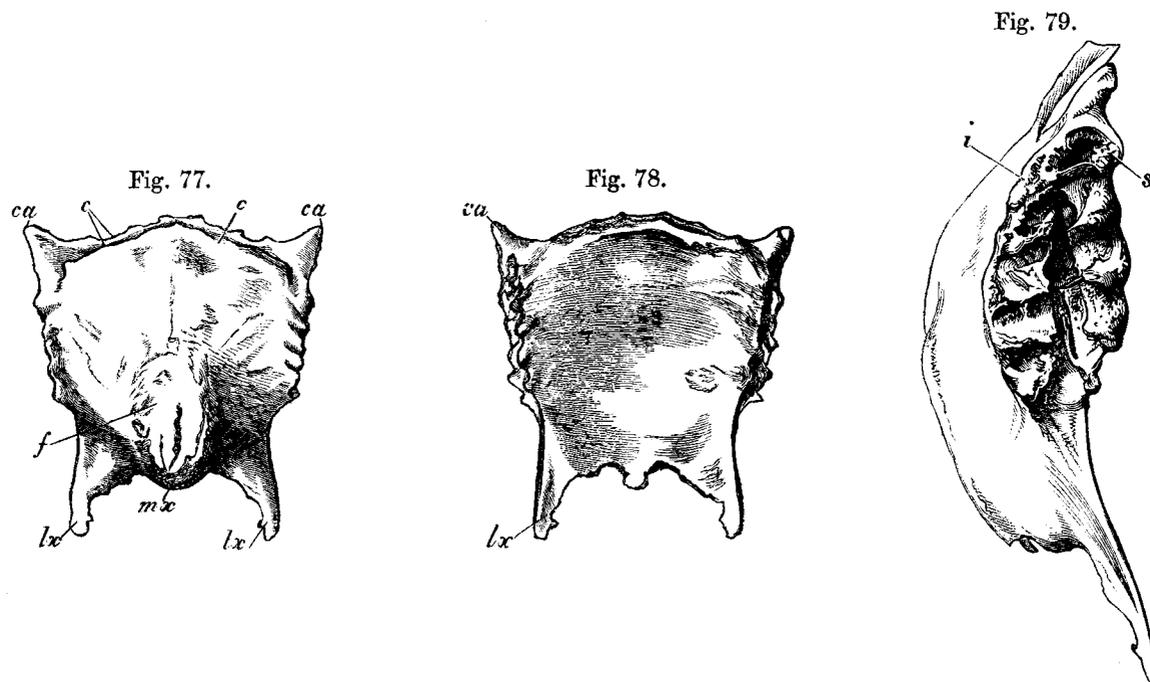


Fig. 77, outer aspect; fig. 78, inner aspect; *cc*, coracoid grooves; *f*, flattened tract; *ca ca*, costal angles; *lx lx*, lateral xiphoid processes; *mx*, median xiphoid process.

Fig. 79, lateral aspect, showing the five excavations of the pleurosteon separated by five septa, each septum with two articular convexities for one of the sternal ribs; *i*, one of the ventral articular convexities; *s*, one of the dorsal articular convexities.

The preaxial margin shows two elongated coracoid grooves, which form with each other an angle of about 120° . These two grooves nearly meet together in the middle line (fig. 77, *cc*).

The ventral (inferior) margin of the grooves does not extend so far preaxially as does the dorsal (superior) margin, especially towards the outer ends of the grooves.

At the middle of the dorsal margin there may be a wide notch or a slight median prominence. Between this notch or prominence and the outer ends of the dorsal lip of the preaxial margin that lip is concave, owing to the production preaxially and outwards of the costal angles (fig. 77, *ca*).

The postaxial margin of the sternum is deeply excavated, owing to the prominence of two external xiphoid processes (fig. 77, *lx*). In the middle of the postaxial margin there is a prominence, the median xiphoid, which, however, does not extend far (fig. 77, *mx*). Between this and each lateral xiphoid there is another rather irregular and less marked prominence.

Each lateral margin of the sternum is slightly concave, owing to the angle (about 155°) formed by the external margin of the lateral xiphoid with that of the pleurosteon.

The pleurosteon has a very wide and excavated external margin to receive the dorso-ventrally expanded ends of the sternal ribs: it is divided by five more or less complete bony septa, between which are, in the dry skeleton, five deep excavations (fig. 79). The edges of these septa proceed obliquely ventrad and postaxiad; and each develops two convex articular surfaces (one at the dorsal and one at the ventral part of each septum) for the corresponding articular concavities of the sternal ribs. The first septum has these articular convexities most prominent and most approximated (fig. 79, *is*). The fifth septum has them but very slightly marked.

VERTEBRAL PARTS AND PROCESSES.

It remains now, in conclusion, to consider the several parts and processes of the vertebræ, as regards the varying condition of the same parts in different regions of the spinal column.

Centra.

With the exception of that of the atlas, each centrum is connected by suture or ankylosis with the rest of the vertebra to which it belongs.

In absolute size the centra of the true dorsal vertebræ excel.

Except the preaxial surface of the axis (and apart from the atlas) all the cervical and true dorsal vertebræ have their centra concavo-convex at each axial end.

The centra may, however, be slightly biconcave, as in some of the caudal vertebræ.

Adjacent centra may be ankylosed together from the twenty-sixth to the forty-sixth vertebra inclusive.

The centra may or may not develop parapophysial, catapophysial, or hypapophysial processes.

The pre- and postaxial diameter of centra may greatly exceed their transverse dimension, as in the cervical vertebræ.

The reverse condition may obtain, as in the thirty-first to thirty-seventh vertebræ.

The ventral surface of the centrum may be much excavated antero-posteriorly, as in the caudal vertebræ.

Neural Laminae.

The neural laminae are attached to their own centra only, except in the thirty-second to the thirty-sixth vertebræ.

In the thirty-second, thirty-third, and thirty-fourth vertebræ the neural arch rests on part of the centrum of the adjacent preaxial vertebra; but the arch may, as in the thirty-first vertebra, partly rest on the centrum postaxial to its own.

The neural arches are highest relatively to their transverse extent in the lumbar vertebræ; they are most pre- and postaxially developed in the cervical vertebræ, and least so in the caudal vertebræ.

Adjacent neural arches may join each other by suture, as in the lumbar and sacral vertebræ in the young condition—by ankylosis, as in the sacral region of the adult—by articular processes, as in most parts of the axial skeleton—or in none of these ways, as in the caudal region.

The neural laminae almost always develop diapophyses.

Neural Spines.

These parts attain their maximum height in the lumbar region, where (in the adult) they unite together by ankylosis.

They are most pre- and postaxially extended in the cervical region, and most transversely extended, relatively, in the caudal region.

A neural spine may be trifold, as in the eighth caudal.

Prezygapophyses.

These surfaces may be wanting when the postzygapophyses exist in the same vertebra, as in the atlas; they may be wanting as well as the postzygapophyses, as in the post-dorsal vertebræ.

Very much longer (pre- and postaxially) than broad, they may broaden considerably, as in the dorsal vertebræ.

Having become larger they may again diminish in size, as in the posterior dorsals.

Strongly convex pre- and postaxially, as in the cervical region, they may become nearly flat, as in the dorsal region.

Looking mainly dorsad in the cervical region, they come to look mainly inwards in the dorsal region.

Postzygapophyses.

These may exist without prezygapophyses, as in the atlas.

They undergo changes of form and direction corresponding with those of the prezygapophyses, but they never become quite so small as do the latter in the dorsal region.

Metapophyses.

These processes would escape notice were it not for their recognition through their more developed homologues in other animals.

They are more or less to be distinguished outside and ventrad of the prezygapophyses from the fourth vertebra to about the eighteenth, after which they seem to merge in the wider diapophysial expansion.

Hyperapophyses.

These are only conspicuous in the axis and the third and fourth cervical vertebræ, where they are situated above the postzygapophyses. Rudiments of them are to be found on the atlas, and on vertebræ postaxial to the fourth, till perhaps the tenth vertebra.

Paraxial Parts.

By *paraxial parts*¹ I mean those portions of the skeleton which diverge from the centra and neural arches laterally, and tend to surround the visceral cavity.

They include:—1, upper transverse processes or diapophyses; 2, lower transverse processes or parapophyses; 3, pleurapophysial parts, *i. e.* the ribs, with their capitular and tubercular portions, sternal ribs, and sternum, or parts representing the whole or portions of each pair of capitula and tubercula, with only a rudiment, or without any rudiment, of more distal pleurapophysial elements.

These parts considered as one whole are, of course, as to size, most developed and most differentiated in the true dorsal vertebræ.

They are least differentiated in the true caudal region, where they stand out laterally as simple imperforate “transverse processes.”

Diapophyses.

These are, with the neural spines, the most constant of all the processes, appearing even in the lumbar, dorsal, and caudal regions, where there are no zygapophyses.

More or less antero-posteriorly extended in the cervical region, they are much so in the dorsal one. In the lumbar region they are long and slender, singularly remote from their respective parapophyses, and widely diverging from the latter.

In the first four postsacral vertebræ the diapophyses quite coincide with the para-

¹ See P. Z. S. 1870, p. 260, note; and see also Trans. of Linnean Society for April 21, 1870.

pophyses, as also in the posterior caudal vertebræ, though in the latter a tendency to diverge is shown by the projecting extremities of each transverse process.

Parapophyses.

These are very constant structures, existing either as lower transverse processes or as articular surfaces for the capitula of the ribs.

In the lumbar region their place of development singularly descends, being there placed quite at the ventral edge of the sides of the centra.

They ascend through the three true sacral vertebræ, till in the most anterior caudal (or anterior sacro-caudal) vertebræ they reassume the same position they occupied in the posterior dorsal region. In the more postaxial vertebræ their place of origin again descends, and occupies the side of quite the ventral surface of each centrum.

The parapophysis of the thirty-first vertebra is almost entirely formed by the neural arch; but in the three succeeding vertebræ each parapophysial prominence is produced by the concurrence of processes from the centra of adjoining vertebræ, the thirty-second, thirty-third, and thirty-fourth vertebræ having each such a projection from each end of each side of each centrum.

These low complex parapophysial projections abut against the ischium and ventral margin of the acetabulum.

Pleurapophyses.

By *pleurapophyses* I mean ribs and all elements of the paraxial system which are serially homologous with ribs, including their capitula and tubercula.

Consequently when the diapophyses and parapophyses are respectively connected by an osseous bridge, such bridge is pleurapophysial.

To the thirty-sixth, thirty-seventh, and thirty-eighth vertebræ three capitula of large size are attached; they expand as they extend postaxiad and dorsad to abut against the ilium.

Hypapophyses.

These are developed as twofold or azygos processes from beneath certain vertebræ, generally from the seventeenth to the twenty-first inclusive, as already described.

Catapophyses.

These have been already noticed as developed from the more postaxial of the true cervical vertebræ, generally anterior to the seventeenth vertebra.

