have the centrum very convex at one end and very concave at the other, and so give rise to a ball-and-socket joint at each junction between the successive centra. Such vertebræ may be procœlous *i.e.*, have the cup in front and the ball behind), as in existing Crocodiles, or opisthocœlous *(i.e.,* with the cup behind and the ball in front), as in the Bony Pike Fish *(Lepidosteus),* the Land Salamander, and the cervical vertebræ of Ruminants ; sometimes a vertebra may be biconvex (*i.e.*, have a ball at each end of its centrum), as in the first caudal vertebra of the Crocodile ; or, very rarely, there may be two prominences, or the cups may exist side by side on one surface of a centrum, as in some cervical vertebræ of Chelonians. Instead of intervertebral disks, with spheroidal remnants of the notochord, adjacent vertebræ are often (as in Snakes) united by what are called synovial sacs, or membranous closed bags containing an albuminous fluid called "synovia” and commonly known as “joint-oil.”

The various parts of a vertebra may be all united to form one single bone, as is generally the case in the higher animals, but such is by no means universally the case. In the Ichthyosaurus we find the neural arch permanently distinct from the centrum ; and in the Carp the transverse processes are separate. The neural arch itself may be made up of two separate pieces on each side, as in some Elasmobranch Fishes, *e.g., Raia* and *Spinax.*

Sometimes the neural arch, instead of reposing upon its own centrum only, appears, as it were, shifted so as to be connected with two adjacent centra, as is the case, *e.g.,* with the dorsal vertebræ of Tortoises.

Generally the nerves which pass outwards from the spinal marrow which lies in the neural canal pass out in the intervals between adjacent neural arches. Instead of this, however, they sometimes perforate the neural arch.

Neural spines, though generally single, may be double or altogether absent, and sometimes, as in Tortoises, they may intimately coalesce with superimposed dermal plates.

*Cervical Vertebræ.—*As has been already indicated, no vertebræ can be distinguished as cervical in the class of Fishes. Never­theless the first three or four vertebræ next the head may, in some of these animals, present a marked difference from the succeeding vertebræ, being much elongated and united to each other by suture, as in *Fistularia* and *Bagrus,* and they may, as in the latter Fish, develop a continuous inferior vascular canal. The second and third vertebræ may form a hollow bladder-like case of bone, as in *Cobitis,* or send outwards or downwards special processes, as

in the Carp.

In Amphibians only a single vertebra can be called cervical, but in Sauropsidans the number may be very large. Thus in the Swan it amounts to twenty-five, while in some of the Plesiosaurians it exceeded forty. Birds, being animals which have to perform with the beak functions which in most animals are performed by limbs, require to have a very movable neck ; and consequently a considerable number of joints (and therefore of vertebræ) are required in the neck, which is the only part of the spinal column that is very flexible. In Serpents, which have the whole spinal column very flexible, no really satisfactory line can be drawn between cervical and dorsal vertebræ. In Lizards there are usually from seven to nine, but in the whole class of Mammals (whether the neck be very long, as in the Giraffe, or, like that of the Porpoise, extremely short) there are constantly but seven cervical vertebræ, except in the Sloths, which may have from nine to six, the Manatee, which has but six, and the Manis, which may have eight. All the cervical vertebræ may become anchylosed together into a single mass, as usually in the true Whales. Ordinarily in Mammals the transverse process is said to be perforated, *i.e.*, there are two such on each side, which are short and connected at their distal ends by a bony bridge which represents what, in the thorax, is known as a rib, as is shown by their condition in other classes of Vertebrates. Indeed in the lowest Mammals *(Echidna* and *Or­nithorhynchus)* these osseous bridges have the form of distinct, more or less **Y**-shaped bones, as also in the Crocodile, where they are much prolonged. In many Lizards and Birds the posterior cervical vertebræ bear long ribs, and are only counted as cervical because such ribs do not reach the breast bone, while more pos­teriorly placed ribs do attain it. The two superimposed transverse processes, with the rib joining them attached to succeeding vertebræ, form on each side of the neck a sort of bony canal in which runs

the vertebral artery. Sometimes, however, as in the Camels and Llamas, this canal is replaced by one excavated in the neural arches. In some Cetaceans the external bar (or rudimentary rib) is wanting, so that there come to be two elongated transverse pro­cesses on each side.

Successive cervical vertebræ may differ strikingly one from another. Thus in the common European Terrapin we find the fourth cervical vertebra with its centrum convex in front and concave behind. The centrum of the fifth is biconvex. That of the sixth is concave in front with a double convexity behind. The seventh is doubly convex both in front and behind. The eighth is doubly concave at each end. The ninth is doubly convex in front and singly so behind.

The first cervical vertebra is known as the atlas, and joins the skull, which in Man it supports. It may be fused in one solid mass with the skull, as in the Sturgeon, or with a certain number of vertebræ, as in the Rays. It may be united by suture, as in *Bagrus.* The vertebral part of the atlas may be unossified, as in the Wombat, or remain a distinct bone, as in the Thylacine. The neural spine may be detached from the neural arch, as in the Crocodile and Tunny. Its ventral part may send out a pointed process towards the head, as in *Amphiuma.* It may develop two concave surfaces to articulate with the skull, as in Amphibians and Mammals, or only a single cup, as in Sauropsidans generally.

The second cervical vertebra is known as the axis, and is dis­tinguishable in all Vertebrates above the *Ichthyopsida.* Its centrum develops anteriorly a special peg-like or tooth-like pro­minence known as the odontoid process, round which the head and atlas vertebra turn as on a pivot. This process may (as in many Reptiles and in the *Ornithorhynchus* amongst Mammals) remain a distinct bone, and is regarded as the true centrum of the atlas, which thus generally coalesces into the axis vertebra instead of with the other portions of its own vertebra. The odontoid process may be absent in certain Mammals, as amongst Cetaceans.

*Dorso-Lumbar Vertebræ.—*The vertebræ which come between the cervical vertebræ and those (sacral) which support the pelvic limbs, or, when these latter are absent, the vertebræ between the cervical and the caudal vertebræ, form the vertebræ of the trunk. These are subdivisible into dorsal and lumbar when some of them (always the more anterior) bear ribs and others do not but have transverse processes only.

The number of trunk (or dorso-lumbar) vertebræ varies greatly, being very few in Frogs and Tortoises and very numerous in Serpents. In Mammals it ranges from about seventeen, in some Primates, to twenty-seven, in *Hyrax.* A definite number of trunk vertebræ is characteristic of certain groups of Mammals, though this number may be made up by different numbers of dorsal and lumbar vertebræ.

*Dorsal Vertebræ. —*Rib-bearing vertebræ are structures constantly found in all Vertebrate animals save certain Fishes and Amphibians. Dorsal vertebræ must be considered as including the whole number of trunk vertebræ in Serpents, since in those animals the whole series of the latter support ribs.

An ordinary Mammalian dorsal vertebra consists of a body and neural arch with articular processes or zygapophyses and with a more or less elongated neural spine, and a transverse process which juts out and bears an articular surface at its end. This process answers to the more dorsal of each pair of transverse pro­cesses on each side of a cervical vertebra. Another articular surface placed at about the junction of the neural arch and centrum answers to the more ventral of each pair of transverse processes on each side of a cervical vertebra.

The rib which on each side of the vertebra articulates with these two surfaces has generally itself such a surface at its prox­imal end (or head) and another on a more or less marked promi­nence called the tubercle of the rib. These are respectively designated the capitulum and tuberculum, and therefore the pro­cesses or articular surfaces of the vertebra to which the capitulum and tuberculum are respectively attached are called the capitular and tubercular processes or surfaces, as the case may be.

Sometimes each vertebra carries but one such articular surface (that for the capitulum of the ribs), as in the Dolphin. The two articular surfaces may co-exist at different levels on one single process, as in the dorsal vertebræ of the Crocodile, or they may be in close apposition, and, as it were, fused together, as in Serpents. They may, however, be supported by two quite distinct processes —one dorsal, the other ventral,—as in *Ichthyosaurus* and *Meno­branchus.*

Man has twelve dorsal vertebræ. This is a little below the average of his class, where there may be twenty-four, as in the Two-toed Sloth. There are more than twelve in most Reptiles, while in Birds there are mostly but seven to nine, or, very rarely, eleven, while there may, as in *Ciconia alba,* be but three reckoned as dorsal on account of' the great extent of ossification in the sacrum or part connected with the legs.

The most remarkable modification of dorsal vertebræ is that in Tortoises and Turtles, where the neural spines expand at their