here as a rule. Consequently five centres are found; those for the two higher segments being single while the lower ones are often double. Later on in life a centre for the χiphisternum appears.

For further details see C. S. McMurrich, *The Development of the Human Body* (London, 1906). This includes bibliography, but G. Ruge’s paper on the development of the sternum (*Morph. Jahrb.* vi. 1880) is of special importance.

*Comparative Anatomy.—*Just as in development the [notochord forms the earliest structure for stiffening the embryo, so in the animal kingdom it appears before the true backbone or vertebral column is evolved. This is so important that the older phylum of Vertebrata has now been expanded into that of Chordata to include all animals which either permanently or temporarily possess a noto­chord. In the subphylum Adelochorda, which includes the worm­like Balanoglossus, as well as the colonial forms Rhabdopleura and Cephalodiscus, an entodermal structure, apparently corresponding to the notochord of higher forms, is found in the dorsal wall of the pharynx. In the subphylum Urochorda or Tunicata, to which the ascidians or sea-squirts belong, the notochord is present in the tail region only and as a rule disappears after the metamorphosis from the larval to the adult form. In the Acrania, which are represented by Amphioxus (the lancelet), and are sometimes classed as the lowest division of the subphylum Vertebrata, the notochord is permanent and extends the whole length of the animal. Both this and the nerve cord dorsal to it are enclosed in tubes of mesodermal connective tissue which are continuous with the fibrous myocom- mata between the myotomes. Here then is a notochord and a membranous vertebral column resembling a stage in man’s develop­ment. In the Cyclostomata (hags and lampreys) the notochord and its sheath persist through life, but in the adult lamprey (Petromyzon) cartilaginous neural arches are developed. In cartilaginous ganoid fishes like the sturgeon, the notochord is persistent and has a strong fibrous sheath into which the cartilage from the neural arches encroaches while in the elasmobranch fishes (sharks and rays) the cartilaginous centra are formed and grow into the notochord, thus causing its partial absorption. The growth is more marked peri­pherally than centrally, and so each centrum when removed is seen to be deeply concave toward both the head and tail ; such a vertebra is spoken of as *amphicoelous* and with one exception is always found in fishes which have centra. In the body fish (Teleostei) and mud­fish (Dipnoi) the vertebrae are ossified.

If a vertebra from the tail of a bony fish like the herring be ex­amined, it will be seen to have a ventral (haemal) arch surrounding the caudal blood-vessels and corresponding to the dorsal or neural arch which is also present. In the anterior or visceral part of the body the haemal arch is split and its two sides spread out deep to the muscles and lying between them and the coelom to form the ribs. In the elasmobranchs on the other hand the ribs lie among the muscles as they do in higher vertebrates, and the fact that both kinds of ribs are coexistent in the same segments in the interesting and archaic Nilotic fish *Polypterus bichir* shows that they are de­veloped independently of one another. The sternum is never found in fishes with the possible exception of the comb-toothed shark (Notidanus). Among the Amphibia the tailed forms (Urodela) have amphicoelous vertebrae in embryonic life and so have some of the adult salamanders, but usually the intercentral remnants of the notochord are pressed out of existence by the forward growth of the centrum behind it, so that in the adult each vertebra is only concave behind (opisthocoelous). In the Anura (frogs and toads), on the other hand, the centra are usually concave forward (procoelous) and some of the posterior ones become fused into a long delicate bone, the *urostyle.* The ribs of urodeles have forked vertebral ends and are thus attached to the centrum as well as to the neural arch of a vertebra; this forking is supposed to be homologous with the double ribs of Polypterus already referred to. The sternum as a constant structure first appears in amphibians and is more closely connected with the shoulder girdle than with the ribs, the ventral ends of which, except in the salamander Necturus, are rudimentary. It is not certain whether it is the homologue of the sternum of the fish Notidanus, but the subject is discussed by T. J. Parker and A. Μ. Paterson *{The Human Sternum,* London, 1904, ρ. 50), and still requires further research. If the sternum be regarded as a segmental structure or series of segmental structures corresponding to the centra of the vertebrae there is no reason why it should not develop independently of the intersegmental ribs and, when the ribs are suppressed, gain a secondary connexion with the shoulder girdle In Reptilia the centra of the vertebrae are usually procoelous, though there are a few examples, such as the archaic Tuatera lizard (Sphenodon), in which the amphicoelous arrangement persists. There are several cervical vertebrae instead of one, which is all the amphibians have. The odontoid bone is usually separate both from the atlas and axis while, between the atlas and the skull, there are rudiments of an extra intervertebral dorsal structure or *pro-atlas* in some forms such as the crocodile and Sphenodon lizard. Two sacral vertebrae (*i.e.* vertebrae articulating with the ilium) are generally present instead of the one of the Amphibia, but they are not fused together as in mammals. In the tail region haemal arches are often found enclosing the caudal artery and vein as they arc also in urodele amphibians; in some species these are separate and are then spoken of as *chevron bones.* In the Crocodilia intervertebral disks first appear. Ribs are present in the cervical, thoracic and lumbar regions, and in the Chelonia (tortoises) the cervical ones blend with the vertebrae as they do in higher forms. In crocodiles a definite vertebrarterial canal is established in the cervical region which henceforward becomes permanent. The shafts of the ribs arc sometimes all in one piece as in snakes or they may be developed by three separate centres as in Sphenodon with intervening joints. In these cases dorsal, intermediate and ventral elements to each shaft are present. In Crocodilia and Sphenodon there are spurs from each thoracic rib which overlap the next rib behind and arc known as *uncinate processes’,* they are developed in connexion with the origin of the external oblique muscle of the abdomen and are very constant in birds. The ventral elements of some of the hinder ribs are found in the Crocodilia lying loose in the myocommata of the rectus and obliquus internus (inscriptiones tendineae) and are known as abdominal ribs, while the sacral vertebrae articulate with the ilium through the intervention of short rods of bone, sometimes called p*leurapophyses,* which are no doubt sacral ribs. The sternum of reptiles is a broad plate of cartilage which may be calcified but is seldom converted into true bone; it always articulates with the coracoids (see section *Appendicular)* anteriorly and with a variable number of ribs laterally and posteriorly. It should not be confounded with the dagger-shaped interclavicle which, like the clavicles, is a membrane bone and overlaps the sternum vent rally. It is also probable that the interclavicle is morphologically quite distinct from the episternum, of which vestiges are present in man and are referred to above in the section on embryology (see fig. 27). In birds the characteristics are largely reptilian with some specialized adaptations to their bipedal locomotion and power of flight. One effect of this is that the two true sacral vertebrae become secondarily fused with the adjacent lumbar, caudal and even thoracic, and these again fuse with the ilium so that the posterior part of a bird’s trunk is very rigid. The neck, on the other hand, is very movable and the centra articulate by means of saddle-shaped joints which give the maximum of movement combined with strength (see Joints). The caudal vertebrae are fused into a flattened bone, the *pygostyle,* to support the tail feathers. In the fossil bird Archaeopteryx the centra are amphicoelous and the long tail has separate caudal vertebrae. The ribs are few and consist of dorsal (vertebral) and ventral (sternal) parts; the former almost always have uncinate processes. Free cervical ribs are often present and Archaeopteryx possessed abdominal ribs. The sternum is very large and in flying birds (Carinatae) has a median keel (carina) projecting from it, while the non-flying, ostrich-like birds (Ratitae) have no such structure.

In Mammalia the centra articulate by means of the intervertebral disks and it is only in this class that the epiphysial plates appear though these are absent in the Monotremata (duck-mole, &c.) and Sirenia (sea-cows). The cervical vertebrae are with a few exceptions (two-toed and three-toed sloths and the manatee or sea-cow) always seven in number, and some, usually all, of them have a vertebrar­terial canal in the transverse process. In some of the Cetacea they are fused together. In the Ornithorhynchus the odontoid is a separate bone, as it is in many reptiles, but this part includes the facets by means of which the axis and atlas articulate. The thoracic