solid investment, as in *Ostracion* and the Seahorses (*Lοphobranchii),* or develop strong projecting spines, as in *Diodon.*

Fishes have two other very important exoskeletal structures, which may be bony or cartilaginous. One set of these structures consists of filamentary processes, which may be either horny or calcareous, and which support the skin of the fins, whether those of the back, belly, and tail, or those of the limbs ; such structures are termed “ fin-rays.” The other set consists of bony or cartilagin­ous hard parts, which serve to support the fin-rays, which therefore lie more deeply, or at least are less projecting, and are commonly termed “interspinous bones or cartilages,” but which may be con­veniently distinguished as *radiais* ; they are very important elements of the fins of Elasmobranchs.

Certain Siluroid fishes exhibit in the adjustment of portions of their dermal exoskeleton an altogether peculiar mode of articula­tion, called a shackle joint. This is in the form of a dermal scute articulated with a superposed spine. The scute has an osseous ring on its dorsal surface, and through this passes another osseous ring which forms part of the base of the superimposed spine.

In connexion with dermal scutes and spines may be mentioned those familiar yet exceptional structures, the bony horns of Ungu­lates. In the Oxen, Goats, and their allies horns exist on the head as bony cores, persisting throughout life, and supporting those “ hollow horns ” before noticed amongst the epidermal or epiblastic parts of the exoskeleton. As is the case with the scutes of Chelo- nians, these bony parts are intimately united with subjacent parts of the true endoskeleton. In the Giraffe there are three such bony prominences, which arise as distinct ossifications, and only later anchylose with the skull. These are the Giraffe’s pair of short horns, together with the median prominence in front of them. In the Deer we find bony antlers, which are shed annually and are destitute of any horny covering. Antlers may exist in both sexes, as in the Reindeer, but generally they are present in the males only. They arise as soft highly vascular prominences, and when fully grown become hardened by calcareous deposit. In some months the investing skin dries up and is got rid of ; and the horn itself falls off after the breeding season, leaving a stump whence a new antler shoots forth again in the following year. Antlers, as a rule, are branched—more so as the individual becomes older, till maturity is attained. Some Deer have enormous antlers, weighing as much as 70 lb, and formed at the rate of 1 lb a day.

*Teeth.—*The differences in structure, number, form, and develop­ment of the dental organs are so great that they cannot here be treated of. See vol. vii. pp. 232 *sg.* ; also vol. xv. pp. 349 *sg.*

Internal Skeleton of Vertebrata.

The most essential part of the Vertebrate internal skeleton is the spinal column, the foundation of which is laid by a temporary or permanent structure called the notochord or *chorda dorsalis.* At the anterior end of the spinal column there is almost always a solid structure known as the cranium or skull, to which mandibular, hyoidean, and branchial arches may or may not be attached. The spinal column may be divisible into cervical, thoracic, lumbar, sacral, and caudal portions, and may have pro­cesses projecting from it upwards, downwards, or laterally, with arches of varying extent, as neural arches, chevron bones, and ribs, together with a median ventral portion— the sternum. The whole of these parts taken together constitute the axial skeleton. This may exist alone if the body is limbless, but otherwise additional hard struc­tures are found which together constitute the appendicular skeleton.

Vertebrate animals never have more than two pairs of limbs, and each pair is attached to the body by the help of certain skeleton elements termed a limb-girdle, diverg­ing from which are the hard parts which constitute the skeleton of either “appendage” or “limb.” In addition to these we find in Fishes certain azygous structures—the unpaired fins,—the osseous or cartilaginous supports of which must be reckoned as a part of the appendicular skeleton. With the occasional (or possibly constant) exception of the notochord, the whole Vertebrate internal skeleton is a mesoblastic structure. In the great majority of the *Vertebrata* the skeleton is more or less bony, but it always in part consists of cartilaginous and fibrous structures.

The number and nature of the solid parts vary with

age in the same species. When, in the earlier stages of existence, the process of ossification has once begun, it goes on more or less rapidly till maturity is attained, and is continued, to a certain extent, throughout the whole of life.

The points at which bone formation begins and whence it radiates are termed “ centres of ossification,” and there may be one, two, or several of these in what is ultimately to become a single bone. Sometimes these “ centres ” have an important morphological significance, and in other instances they would seem to be determined by the size of the future structure.@@1 Bones are classed as “cartilage bones” or “membrane bones” according as they are formed either through the previous formation of a cartilage which subsequently ossifies or directly from membrane without the intervention of cartilage. These two classes can generally be easily distinguished, but there are instances in which it would seem that what is really the same corresponding bone differs as to its mode of origin in different animals. Moreover, a compound bone, formed of a membrane bone and a cartilage bone intimately united, may come to lose either its cartilaginous or its membranous elements, and thus further difficulties of interpretation may arise. There are also cases (as in the carapace of Chelonians) in which exoskeletal dermal bones coalesce with subjacent bones of the endoskeleton. Such bones may become deeper in position as development advances, and there is reason to think that not a few bones ordinarily reckoned as parts of the endoskeleton are of dermal origin, and first appeared in ancestral forms as placoid scutes or dermal spines.

As the development of the skeleton proceeds, ossification tends to fuse together more and more bones which at their first appearance were separate and distinct. This is notably the case in warm-blooded animals, and is most noteworthy in the warmest-blooded class—that of Birds.

Besides the coalescence of distinct bones, another fusion of bony structures occurs. This is due to the fact that the ends, or projecting portions, of what are essentially and ultimately one bone may for a time persist as distinct bony parts, termed “ epiphyses.” Thus, in the case of Man, the ends of the long bones of the limbs are at first separate from the main part (or shaft) of each long bone, and do not become continuous with the latter till the human frame has nearly attained maturity.

The hard parts of the internal skeleton, being those which as a framework support the body, form points of attachment for the muscles which move the body,—such hard parts being used as either levers or fulcra, as the case may be. The great majority of the bones are thus in­tended to move one upon another. The contiguous surfaces of bones form “joints,” which may be immovable, mixed, or movable. The bones of the skull are united by immovable joints, called “ sutures.” Joints are said to be mixed when the motion allowed is exceedingly slight, as when two bones are allowed to be slightly separated from each other by the intervention of a softer substance which is attached to both. We have examples of movable joints in the human neck, the two uppermost bones of which are articulated on the principle of a pivot ; in the elbow, which forms a hinge ; and in the shoulder, where the upper arm joins the shoulder-blade in a ball and socket joint.

If one convex articulating surface be globular, it is termed a head ; if it be elongated, it is called a condyle. If either of these is borne upon a narrow portion of bone, this latter is called a neck ; if a pulley-like surface is formed by such a juxtaposition of two condyles as to leave a depression between them, such an articular surface is named a trochlea.

The curious and exceptional arrangement termed a

@@@1 Balfour’s *Comparative Embryology,* vol. ii. p. 448.