bone on its outer side, which corresponds to the distal end of the ulna, but there is no trace of a third bone preserved, and there is only one central bone preserved. There are three phalanges in a digit. The femur is $1\frac{9}{20}$ inches long; its articular head appears to be small and hemispherical. There is a large internal trochanter extending down the shaft, which corresponds with the similarly placed ridge in the femur of Megalosaurs and other Saurischia.

The slender character of the ribs, which are different from those in known Theriodonts, suggests the possibility that these remains belong to a group distinct from both the Cynodontia and Gomphodontia.

A small badly preserved fragment of a skull found near to this fossil is described, but there appears to be no sufficient evidence for associating it with the other remains.

XVIII. "On the Evolution of the Vertebral Column of Fishes." By H. Gadow, Ph.D., F.R.S., and Miss E. C. Abbott.

Received June 20, 1894.

(Abstract.)

Concerning the segmental mesodermal products the following subdivision is adhered to:—

The term *myotome* is to be restricted to the whole rest of the protovertebra after the skeletogenous cells have been given off for the production of the *sklerotomes.*

The sum total of the sklerotomes makes up the skeletogenous layer.

The ending *tome* to indicate the primary, or earlier, less differentiated; the ending *mere* to signify the final condition or product.

Consequently, the protovertebræ divide into—I, Myotomes, each of which produces (1) one myomere or segment of the general mass of trunk-muscles, (2) cutis; II, Sklerotomes which produce skleromeres or skeletal trunk segments.

Each protovertebra produces a dorsal and a ventral sklerotome; strictly speaking, one sklerotome which consists of a separate dorsal and ventral half.

The protovertebral segments are not transverse "plates," but are curved into S-shape, the top end curving tail- and inwards, the middle and ventral thirds bulging headwards, the amount of curvature being (in 7 mm. embryos of Acanthias) so great that a transverse plane will cut through the dorsal and ventral third of one, and through the middle portion of the next following segment.

This S-shaped curving and consequent overlapping of the protovertebral "plates" SS is of fundamental importance for our under-

standing of the formation of the vertebral column, because it explains (1) the so-called new segmentation of the axial column, (2) the almost universal occurrence of more than one dorsal and one ventral pair of arcualia (namely, arches and intercalary pieces) in each of the later vertebral segments or skleromeres.

The explanation is as follows:—

1. The dorsal half of sklerotome 2 grows downwards and comes to lie behind the ventral half of sklerotome 1.

2. The ventral half of sklerotome 2 grows upwards and comes to lie in front of and below the dorsal half of sklerotome 3.

3. The formation of a physiological unit is effected by the combination or fusion of the unequally numbered sklerotomic halves, in such way that the dorsal half lies behind and above the ventral half.

The new skleromere I (= dorsal sklerotome 2+ventral sklerotome 1) stands now in the following relation to the myomeres; the dorsal end of the skleromere I coincides with myomere I; the septum between this myomere and the next previous one passes between dorsal sklerotome 2 and ventral sklerotome 1; this means to say right across the new skleromere I. This skleromere lies within the influence or range of action of two successive myomeres. Taken as a whole, the skleromere is "interprotovertebral," more correctly bi-protovertebral, because it is composed of two successive sklerotomes, namely, the ventral half of one and the dorsal half of a second.

Consequently, the "resegmentation" or "neugliederung" is brought about in a manner fundamentally different to that hitherto supposed to have taken place. If A and B mean two successive sklerotomes, a and b their dorsal, α and β their respective ventral halves, then the new skleromere is composed of $b+\alpha$ and not of $\frac{A+B}{2}$, because $b+\alpha$ is the same as $\frac{B \text{ dorsal}}{2}+\frac{A \text{ ventral}}{2}$.

The formation of a skleromere by the combination of alternating dorsal and ventral halves of sklerotomes explains also the presence of eight (four pairs) cartilaginous pieces, namely, basalia (so-called dorsal and ventral arches) and interbasalia (so-called intercalary pieces) for each complete segment.

The dorsal and ventral halves of the sklerotomes are pyramidal in shape, with their apices pointing respectively downwards and upwards. Each ventral pyramid extends with its apex above the chorda, and founds there (separated from the ventral mass by the subsequent rapid growth of the chorda and its sheath) a cluster of cells which remains henceforth behind (tailwards from) the basal mass of the dorsal pyramid. The latter founds, with its down-growing apex, a colony of cells below the chorda, and in front of the basal ventral mass. Thus are produced the basalia and interbasalia,

each colony or cluster of cells developing into a separate piece of cartilage. The basidorsal does not fuse with its interdorsal, because both are the offspring of two different sklerotomes, nor can the basidorsal fuse with its own offspring, namely, with the interventral, because both became, and remain, separated by the chorda and its sheath; they are connected only by the indifferent connective tissue of the membrana reuniens, but not by cartilage-forming cells.

Concerning the formation of centra or bodies of the vertebræ, we distinguish :—

I. *Chorda-centra, i.e.*, centra cut out of the full of the chordal sheath, which itself has been strengthened by invasion of cartilaginous cells from the skeletogenous layer. This migration of cartilage into the chordal sheath had already been hinted at by Kœlliker more than thirty years ago; it has recently been proved by Klaatsch, and has been corroborated by us. Chorda-centra are possessed by all Elasmobranchs, potentially by Dipnoi and Holocephali.

II. *Arch-centra, i.e.*, centra formed by the skeletogenous mass which remains entirely on the outside of the chordal sheath, which latter takes no share in their formation: osseous Ganoids and Teleostei.

Chorda-centra and arch-centra represent two different modes of development, each starting from an acentrous condition. This can be expressed as follows :—

Chordal sheath remaining entirely chordagenous.	Chordal sheath strengthened by invasion of skeletogenous cells, therefore with possibility of chorda-centra.
Cyclostomata, Cartilaginous Ganoids.	Dipnoi and Holocephali.

Formation of Centra.

Osseous Ganoids, Teleostei.	Elasmobranchs.
ARCH-CENTRA.	CHORDA-CENTRA.

The formation of chorda-centra being independent of the arcualia explains how and why the number of "centra" does not necessarily agree either with that of the arcualia or with that of the trunk-segments, *e.g.*, Hexanchus and tail of most other Elasmobranchs.

These leading differences and their modifications have been traced in Petromyzon, Acipenser, Amia, Lepidosteus, Protopterus, Chimæra, and in numerous Elasmobranchs.

In *Amia calva*, of which the adult and a young specimen of 57 mm. were examined, the *postcentrum, i.e.*, the posterior, archless disk of a complete tail-vertebra, was found to be formed by the interdorsalia and interventralia of the same sklerotome, while the *precentrum, i.e.* the arch-bearing disk or anterior half is formed by the basidorsals of

the same sklerotome and the basiventrals of the next previous sklerotome. Thus skleromere 50 is composed of a postcentrum = interdorsal 50 + interventral 50, and of a precentrum = basidorsal 50 + basiventral 49. The intermuscular septum runs obliquely across the precentrum, or, in other words, the precentra are bi-protovertebral or bi-myomeric, but not the postcentra. The precentra of the tail of Amia are homologous with the "pleurocentra" in the tail of the Jurassic Eurycormus, while Amia's postcentra are the same as the "hypocentra" of Eurycormus.

In *Lepidosteus osseus*, of which adult specimens and larvæ of various stages were examined, the combination of parts into one vertebral complex is superior to that of Amia, because each vertebra belongs, with its entire anterior half (interdorsal 50 + basiventral 50), to myomere 50, and with its posterior half (basidorsal 51 + interventral 51), to myomere 51. In other words, the vertebral mass is equally divided between two successive myomeres, or the myomeres have an equal share of the skleromeres. The vertebræ are now truly bi-protovertebral or bi-myomeric, each vertebra being composed of $a + b$.

XIX. "On the Structure and Affinities of *Heliopora cœrulea*, Pall., with some Observations on the Structure of *Xenia* and *Heteroxenia*." By GILBERT C. BOURNE, M.A., F.L.S., Fellow of New College, Oxford. Communicated by Professor LANKESTER, F.R.S. Received May 30, 1894.

(Abstract.)

I have had the opportunity of making a renewed examination of the structure of Heliopora, partly through the kindness of Professor Ray Lankester, who gave me a very well preserved fragment of a colony brought by Dr. S. J. Hickson from Talisse, Celebes. I have also used some specimens which I collected and preserved in spirit in Diego Garcia, and, in studying the dried corallum, I have had the advantage of a large collection, originally the property of the late Mr. George Brook, which Mrs. Brook has very kindly handed over to me.

All the specimens in my possession are referable to the only recent species known, *Heliopora cœrulea*, but one of them belongs to the variety *tuberosa*, Dana.

The Soft Tissues.—These form an even sheet, investing the surface of the colony, interrupted here and there by the mouths of the polyps, which are the only apertures opening on the surface. The structures described below are entirely superficial, and there is no direct com-