place in the core of mesenchyme in the centre of each limb.@@1 This substance first becomes changed into cartilage, except perhaps in the case of the clavicle, though there is at present some doubt as to how much of this bone is chondrified before ossification reaches it.

The present belief is that, although a deposit of lime salts constitut­ing the process of calcification may and frequently does occur in cartilage, true ossification or the orderly disposal of that deposit into bony tissue can only take place through the intervention of osteo­blasts and osteoclasts, and as these cells are not formed in cartilage they must make their way in from the surrounding fibrous tissue which constitutes the periohondrium.

The factors which determine the general shape and proportionate size of each limb bone are at work while the cartilage is being formed, because each future bone has a good cartilaginous model laid down before ossification begins. Calcification usually begins at one point in each bone, unless that bone be a compound one formed by the fusion of two or more elements which were distinct in lower verte­brate types, as is the case with the os innominatum.

It is interesting to notice that this centre of calcification, which will later on be the centre of ossification, is usually in the middle of the shaft of a long bone, or, when a cuboidal block of. cartilage is dealt with, as in the case of the carpal and tarsal bones, in that place which is farthest away from the periphery, and which is likely to be least well nourished. There seems, too, to be a general tendency for larger masses of cartilage to begin calcifying before smaller ones. Contrasting these facts with the behaviour of tumours, which contain cartilage and which are liable to undergo a process of calcareous degeneration, the present writer is led to suspect that the calcification which precedes ossification in cartilage may be a degenerative change brought about by ill-nutrition. However this may be, there is little doubt that the calcification, once established, acts as an attraction for blood-vessels, which probably bring with them osteoblasts, and the subsequent ossification is a process which needs and receives a plenteous supply of nourishment. After a long bone has reached a certain size it very often has extra centres of ossification developed at its ends as well as at places where important muscles have raised lever-like knobs of cartilage on the model. These extra centres are called *epiphyses,* and it is convenient to distinguish three varieties of these: (a) *pressure epiphyses* at the joint ends of long bones; (b) *traction epiphyses,* where muscles pull; and (c) *atavistic epiphyses,* the mechanical causes of which are more remote, but which represent structures of greater import in the lowlier vertebrates. With regard to the pressure epiphyses, they form a cap which protects the *epiphysial line,* or plate of cartilage, by means of which the bone in­creases in length, but they are certainly not essential to the growth of a bone, because they often do not appear until the bone has been growing for a long time, while in birds they are not found at all. The traction epiphyses are, in the opinion of the writer, originally pieces of cartilage which have the same nature as sesamoid cartilages developed in the play of a tendon, where it presses against a neigh­bouring cartilaginous model of a bone, and which, instead of remain­ing separate structures throughout life, as is the case with the patella, fuse early with the model against which they are pulled, and so form a knob. For practical purposes the coracoid process of man may be regarded as an example of an atavistic epiphysis or perhaps of two atavistic epiphyses. (For further details on this subject see the writer’s papers on epiphyses, *Jour. Anat. and Phys.* vol. xxxvii. P. 315; vol. xxxviii. p. 248; vol. xxxix. p. 402.)

Turning now to the development of the individual bones of the axial skeleton, the clavicle, as has been mentioned, is partly fibrous, and partly cartilaginous, but the exact proportions are still imperfectly known; its primary centre is the earliest of all in the body to appear, while its sternal epiphysis does not come till the bone is fully grown, and so can have no effect on the growth of the bone. It is probably one of the atavistic class, and is often regarded as the vestige of the precoracoid (see subsection on comparative anatomy), though it may represent the inter-clavicle, which, as has been pointed out in the article on the axial skeleton, is quite distinct from the episternum. It sometimes fails to appear at all.

The centres for the scapula arc shown in the accompanying figures (fig. 19). G. B. Hówes regarded the subcoracoid centre as the atavistic epiphysis representing the coracoid bone of lower verte­

brates, while the human coracoid he looked upon as the equivalent of the epicoracoid. The epiphyses in the vertebral border are ata­vistic and represent the supra-scapular element (see section below on *Comparative Anatomy).*

In the humerus the centre for the shaft appears about the eighth week of foetal life, which is the usual time for primary centres. The head, trochlea and capitellum have pressure epiphyses, while those for the tuberosities and condyles are of the traction variety.

The ulna is a very interesting bone because there is no pressure epiphysis for its upper end. The upper epiphysis shown in fig. 21 does not encroach upon the articular surface, but is a pure traction epiphysis developed in the triceps tendon and serially homologous with the patella (a sesamoid bone) in the lower limb.

In the radius there are two terminal pressure epiphyses and one traction for the insertion of the biceps.

The carpus ossifies after birth, one centre for each bone occurring in the following order: os magnum, 11 to 12 months; unciform, 12 to 14 months; cuneiform, 3 years; semilunar, 5 to 6 years; trap­ezium, 6 years; scaphoid, 6 years; trapezoid, 6 to 7 years; pisiform, 10 to 12 years.

Up to the third month of foetal life a separate cartilage for the os centrale (see subsection on comparative anatomy) is found, but this later on fuses with the scaphoid. It will be noticed that, broadly speaking, the larger cartilaginous masses ossify before the smaller.

The metacarpal bones have one centre each for the shaft and one epiphysis for the head, except that for the thumb which has one centre for the shaft and one epiphysis for the proximal end.

The phalanges develop in the same way that the metacarpal bone of the thumb does.

The os innominatum has three primary centres for the ilium, ischium and pubis.

The special centres for the crest of the ilium are probably a serial repetition of those for the vertebral border of the scapula (see fig. 19) ; that for the anterior inferior spine is a purely human traction epiphysis connected with the use of the straight head of the rectus femoris in the upright position. The centre for the pubic symphysis probably represents the epipubis of amphibians, while that for the tuberosity of the ischium is the hypoischium of reptiles (see sub­section on comparative anatomy). The most anterior of the epi­physes in the acetabulum is the os acetabuli of lower mammals, while the occasional one for the spine of the pubis is often looked on as the vestige of the marsupial bone of monotremes and marsupials. It will thus be seen that many of the secondary centres of the os innominatum are of the nature of atavistic epiphyses.

The femur has two pressure epiphyses, one for the head and another for the lower end, and two traction for the great and small trochanters.

The cartilaginous patella does not appear until the third month of foetal life, that is well after the quadriceps extensor cruris, in the tendon of which it is formed, is defined. Its ossification begins in the third year. The patella is usually looked upon as the largest and most typical example of a sesamoid bone in the body.

The tibia has a pressure epiphysis at cither end, but that for the upper comes down in front so as to include a good deal of the tubercle. In almost any other mammal, and often in man himself, it may be

@@@1 By mesenchyme is meant that part of the mesoderm, or middle layer of the embryo, in which the cells are irregularly scattered in a matrix, and are not arranged in definite rows or sheets as in the ■coelomic membrane.