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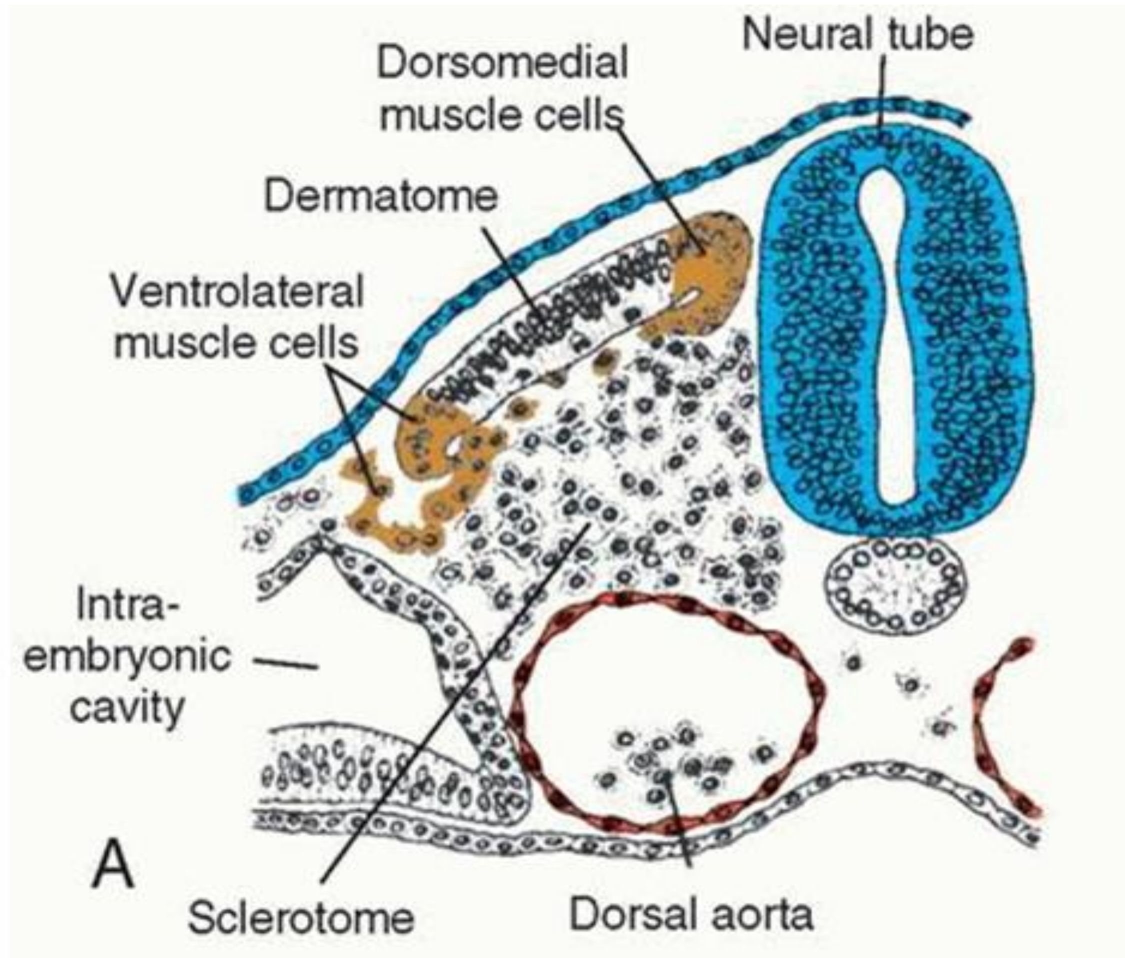
Skeletal System

The skeletal system develops from

1.Paraxial and

2. Lateral plate

3. Neural crest.



SOMITES

Sclerotome

Dermomyotome.

Mesoderm germ form skeleton

1. Chondrification (chondrogenesis) is the process by which cartilage is formed from condensed mesenchyme tissue,
2. which differentiates into chondroblasts and begins secrete:
3. The molecules (aggrecan and collagen type II) that form the extracellular matrix.

- Mesodermal cells give rise to mesenchyme
- Bones first appear as condensations of mesenchymal cells that form bone models.
- Most flat bones develop in mesenchyme within preexisting membranous sheaths;
- this type of osteogenesis is called intramembranous bone formation.
- Mesenchymal models of most limb bones are transformed into cartilage bone models, which later become ossified by endochondral bone formation.

Histogenesis of Cartilage

1. Cartilage develops from mesenchyme and first appears in embryos during the fifth week.

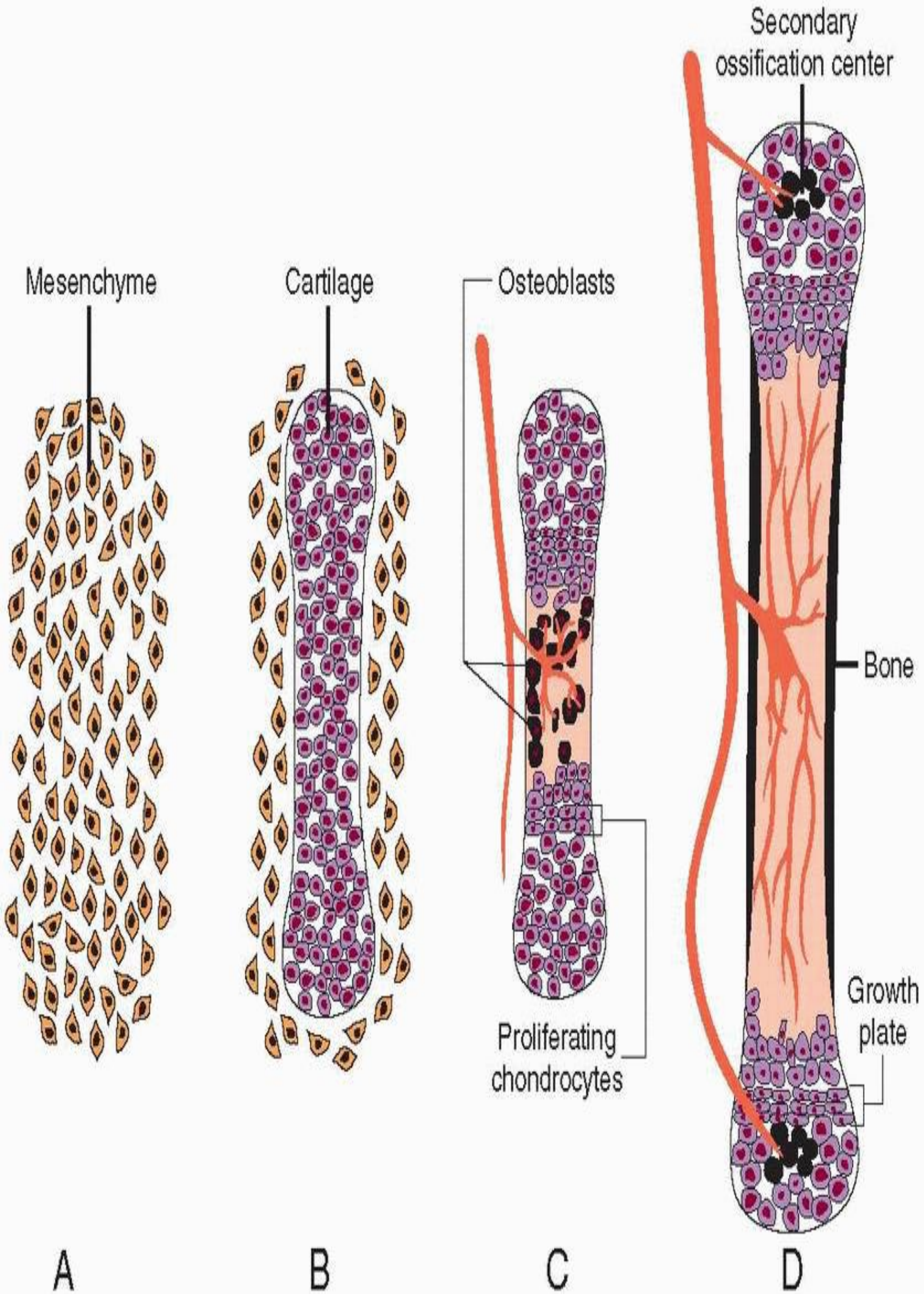
In areas where cartilage is to develop, the mesenchyme condenses to form chondrification centers.

2. The mesenchymal cells differentiate into chondroblasts that secrete collagenous fibrils and the ground substance (extracellular matrix).

3. Subsequently, collagenous and/or elastic fibers are deposited in the intercellular substance or matrix.

Histogenesis of Bone

Bone primarily develops in two types of connective tissue, mesenchyme and cartilage, but can also develop in other connective tissues. Like cartilage, bone consists of cells and an organic intercellular substance-the bone matrix-that comprises collagen fibrils embedded in an amorphous component.

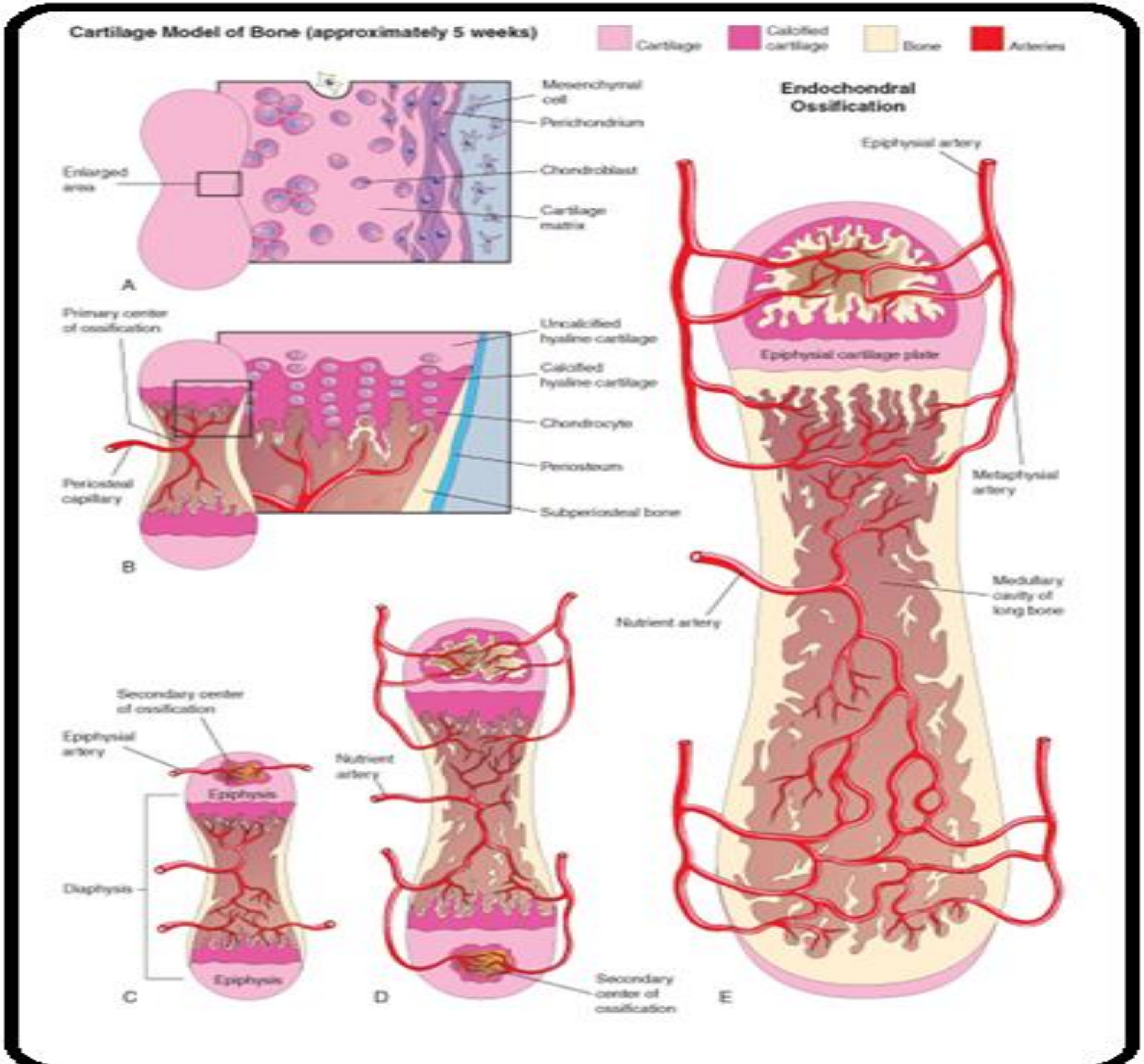


Endochondral bone formation.

A. Mesenchyme cells begin to condense and differentiate into chondrocytes.

B. B. Chondrocytes form a cartilaginous model of the prospective bone.

C,D. Blood vessels invade the center of the cartilaginous model, bringing osteoblasts (black cells) and restricting proliferating chondrocytic cells to the ends (epiphyses) of the bones. Chondrocytes toward the shaft side (diaphysis) undergo hypertrophy and apoptosis as they mineralize the surrounding matrix. Osteoblasts bind to the mineralized matrix and deposit bone matrices. Later, as blood vessels invade the epiphyses, secondary ossification centers form. Growth of the bones is maintained by proliferation of chondrocytes in the growth plates .


Cartilage Model of Bone (approximately 5 weeks)
Cartilage
Calcified cartilage
Bone
Arteries
Mesenchymal cell
Perichondrium
Enlarged area
Chondroblast
Cartilage matrix
A
Endochondral Ossification
Epiphysial artery
Primary center of ossification
Uncalcified hyaline cartilage
Calcified hyaline cartilage
Chondrocyte
Periosteal capillary
Periosteum
Subperiosteal bone
B
Epiphysial cartilage plate
Metaphysial artery
Modullary cavity of long bone
Nutrient artery
Secondary center of ossification
Epiphysial artery
Epiphysis
Nutrient artery
Diaphysis
Epiphysis
C
D
Secondary center of ossification
E

Intramembranous Ossification

The mesenchyme form membranous sheath.

The mesenchyme condenses and becomes highly vascular; some cells differentiate into osteoblasts (bone-forming cells) and begin to deposit unmineralized matrix-osteoid.

Calcium phosphate is then deposited in the osteoid tissue as it is organized into bone.

Bone osteoblasts are trapped in the matrix and become osteocytes.

Then the bone lamellae (layers) are formed.

During fetal and postnatal life, there is continuous remodeling of bone by the coordinated action of osteoclasts and osteoblasts.

Endochondral Ossification

Endochondral ossification (cartilaginous bone formation) is a type of bone formation that occurs in preexisting cartilaginous models. In a long bone, for example, the primary center of ossification appears in the diaphysis-the part of a long bone between its ends-that forms the shaft of the bone. At this center of ossification, chondrocytes (cartilage cells) increase in size (hypertrophy), the matrix becomes calcified, and the cells die.

Concurrently, a thin layer of bone is deposited under the perichondrium surrounding the diaphysis; thus, the perichondrium becomes the periosteum.

Some invading cells differentiate into hemopoietic cells, blood cells, of the bone marrow. The spicules of bone are remodeled by the action of osteoclasts and osteoblasts.

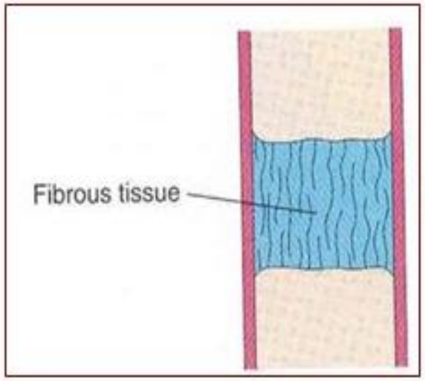
DEVELOPMENT OF JOINTS

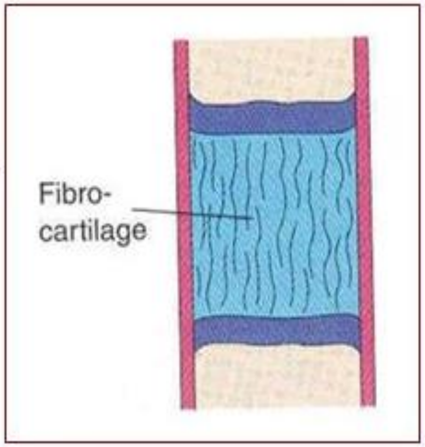
Joints begin to develop with the appearance of the interzonal mesenchyme during the sixth week, and by the end of the eighth week, they resemble adult joints.

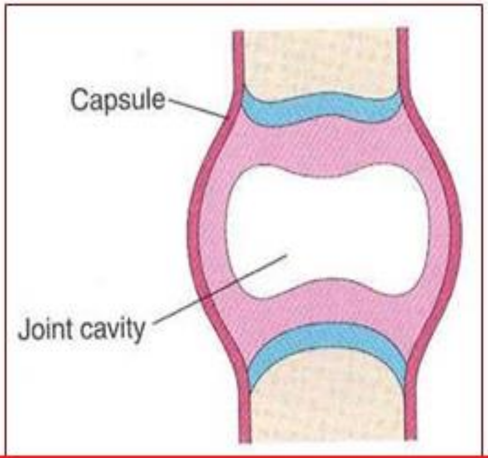
Development of Joints

Joints develop from mesoderm lying between bones:

- **In fibrous joints:** mesoderm differentiates into dense fibrous connective tissue.
- **In cartilaginous joints:** mesoderm differentiates into cartilage.
- **In synovial joints:** a synovial cavity is formed inside mesoderm; mesoderm differentiates into synovial membrane, capsule & ligaments.







Fibrous Joints

During the development of fibrous joints, the interzonal mesenchyme between the developing bones differentiates into dense fibrous tissue (see Fig. 14-6D), for example, the sutures of the cranium are fibrous joints.

Cartilaginous Joints

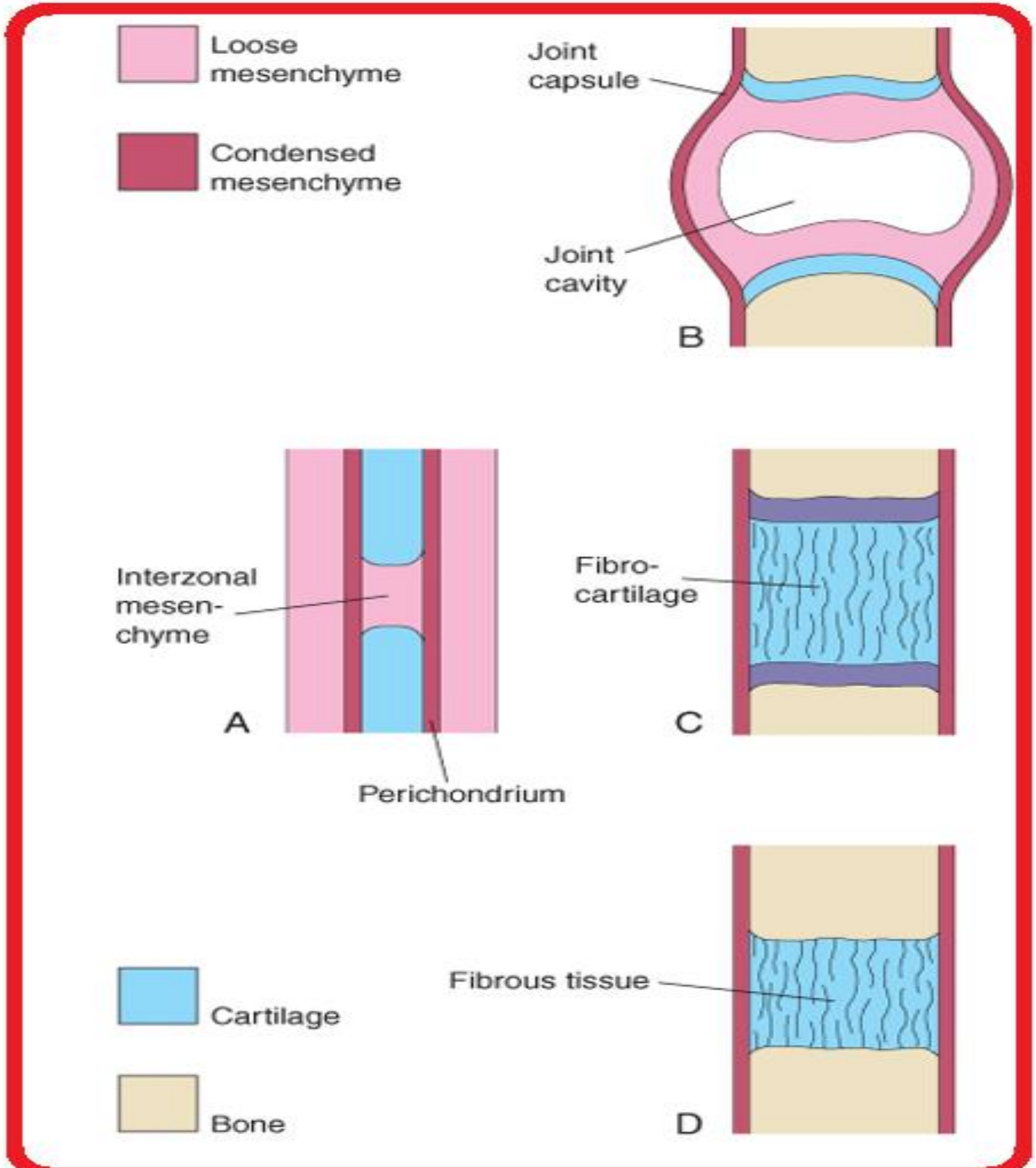
During the development of cartilaginous joints, the interzonal mesenchyme between the developing bones differentiates into hyaline cartilage (e.g., the costochondral joints) or fibrocartilage (e.g., the pubic symphysis) (see Fig. 14-6C).

Synovial Joints

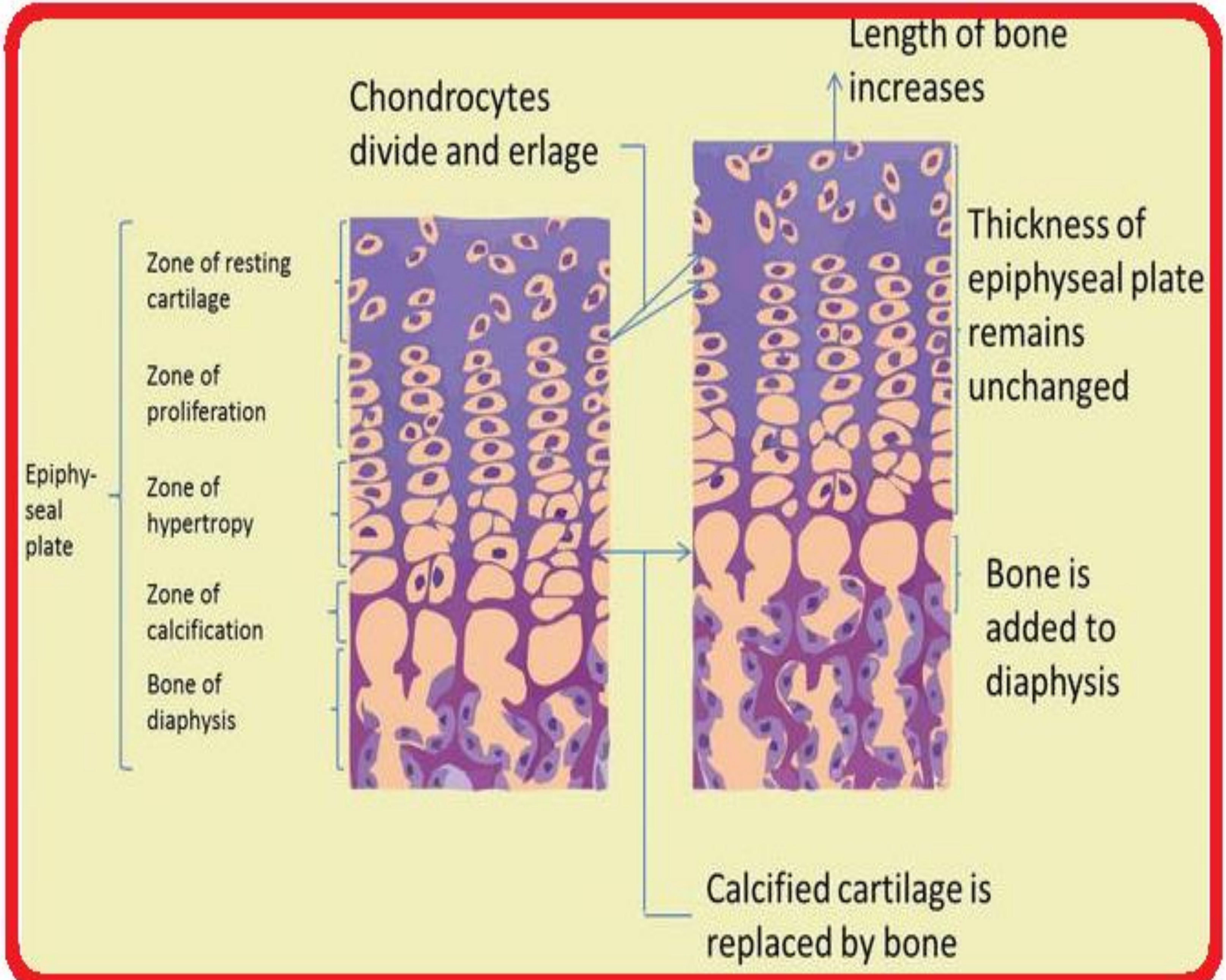
During the development of synovial joints (e.g., the knee joint), the interzonal mesenchyme between the developing bones differentiates as follows :

1. Peripherally it forms the capsular and other ligaments.
2. Centrally it disappears, and the resulting space becomes the joint cavity or synovial cavity.
3. Where it lines the joint capsule and articular surfaces, it forms the synovial membrane (which secretes synovial fluid),

1. Probably as a result of joint movements, the mesenchymal cells subsequently disappear from the surfaces of the articular cartilages.
2. An abnormal intrauterine environment restricting embryonic and fetal movements may interfere with limb development and cause joint fixation.



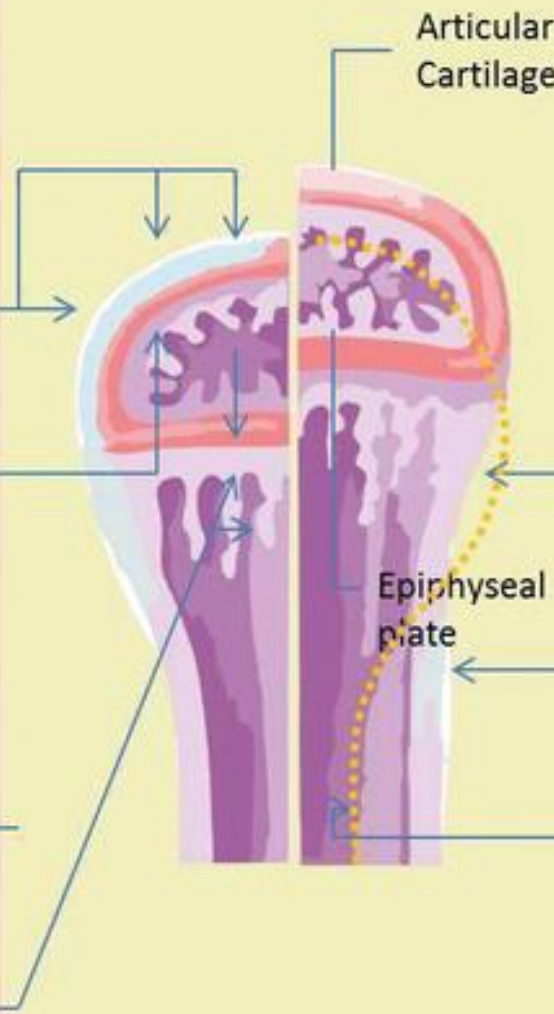
Loose mesenchyme
Condensed mesenchyme
Joint capsule
Joint cavity
B
Interzonal mesen- chyme
A
Perichondrium
Fibro- cartilage
C
Cartilage
Bone
Fibrous tissue
D


Length of bone increases
Chondrocytes divide and erlage
Thickness of epiphyseal plate remains unchanged
Epiphy-seal plate
Zone of resting cartilage
Zone of proliferation
Zone of hypertropy
Zone of calcification
Bone of diaphysis
Bone is added to diaphysis
Calcified cartilage is replaced by bone

Growth

Bone grows in length because :

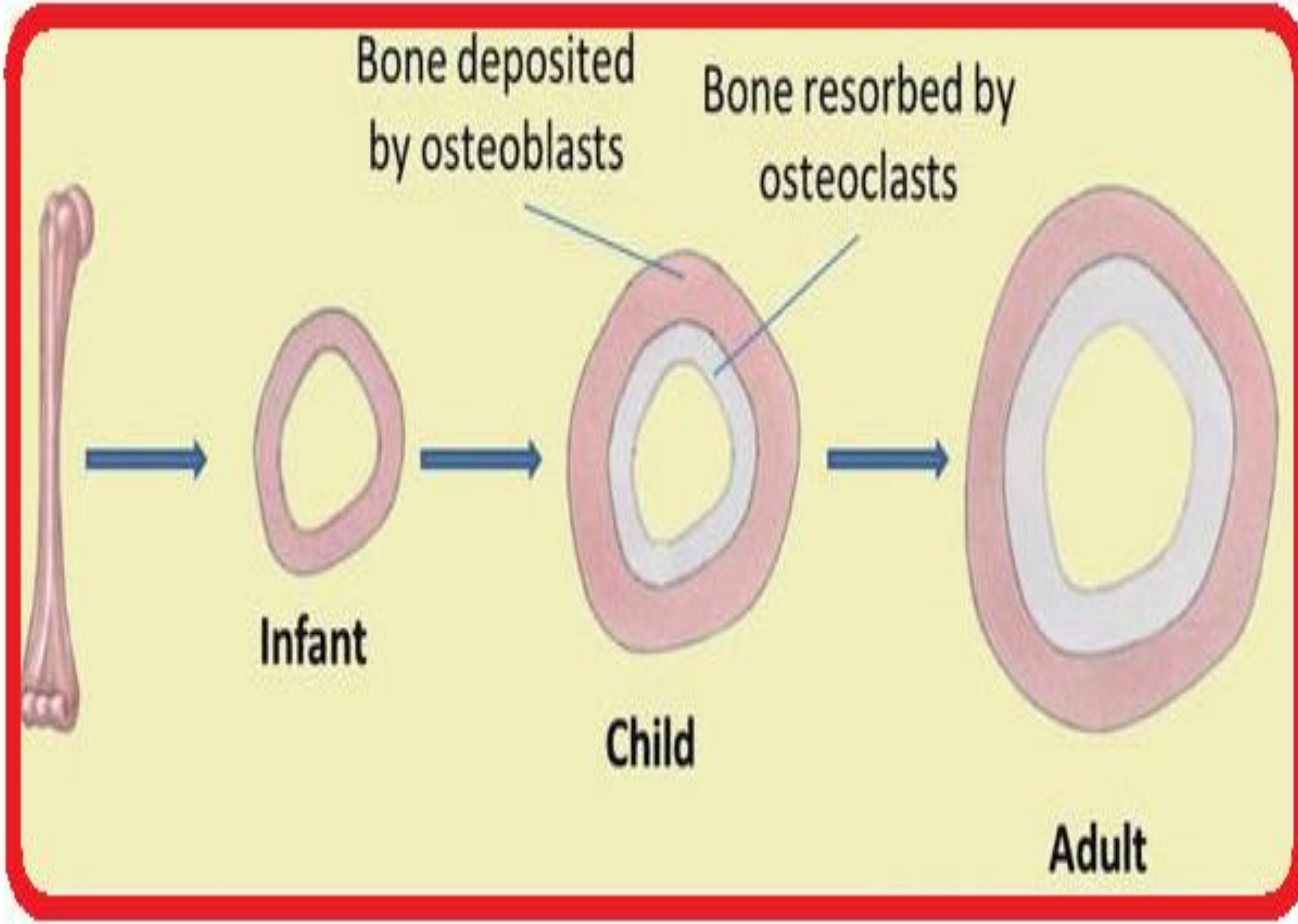
1. Cartilage Grows here
2. Cartilage replaced by bone here
3. Cartilage grows here
4. Cartilage replaced by bone here



Remodelling

Growing shaft is remodeled by :

1. Bone resorbed here
2. Bone added by appositional growth here
3. Bone resorbed here


Bone deposited by osteoblasts
Bone resorbed by osteoclasts
Infant
Child
Adult

THANKS

LIMBS (4w end)

An **OUTPOCKETINGS FROM THE VENTROLATERAL BODY WALL called limb bud.**

Forelimb first and hindlimb 1 to 2 days later

Initially, the limb buds consist of a mesenchymal core derived from the parietal (somatic) layer of lateral plate mesoderm that will form the bones and connective tissues of the limb.

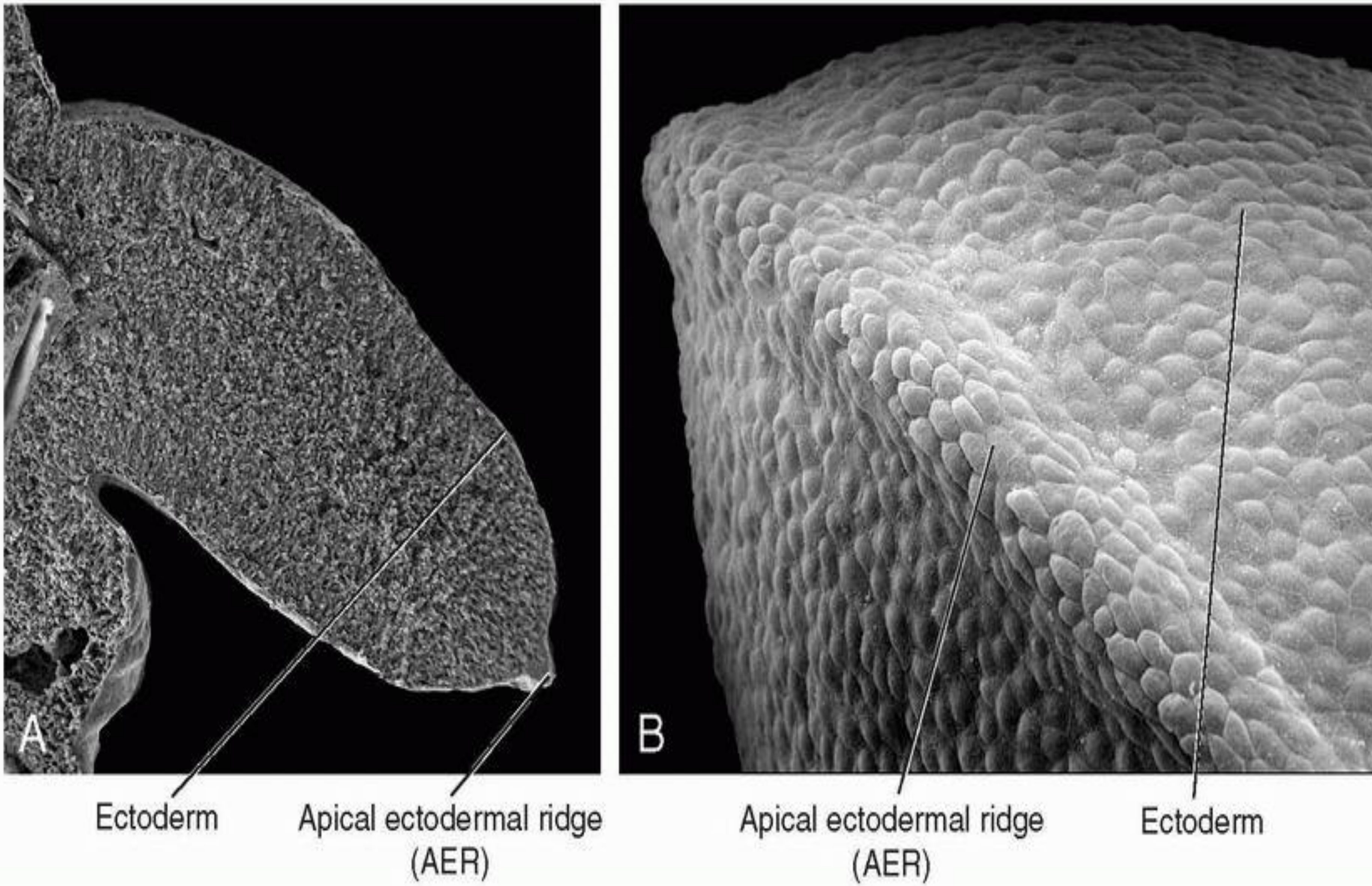
This is covered by a layer of ectoderm.

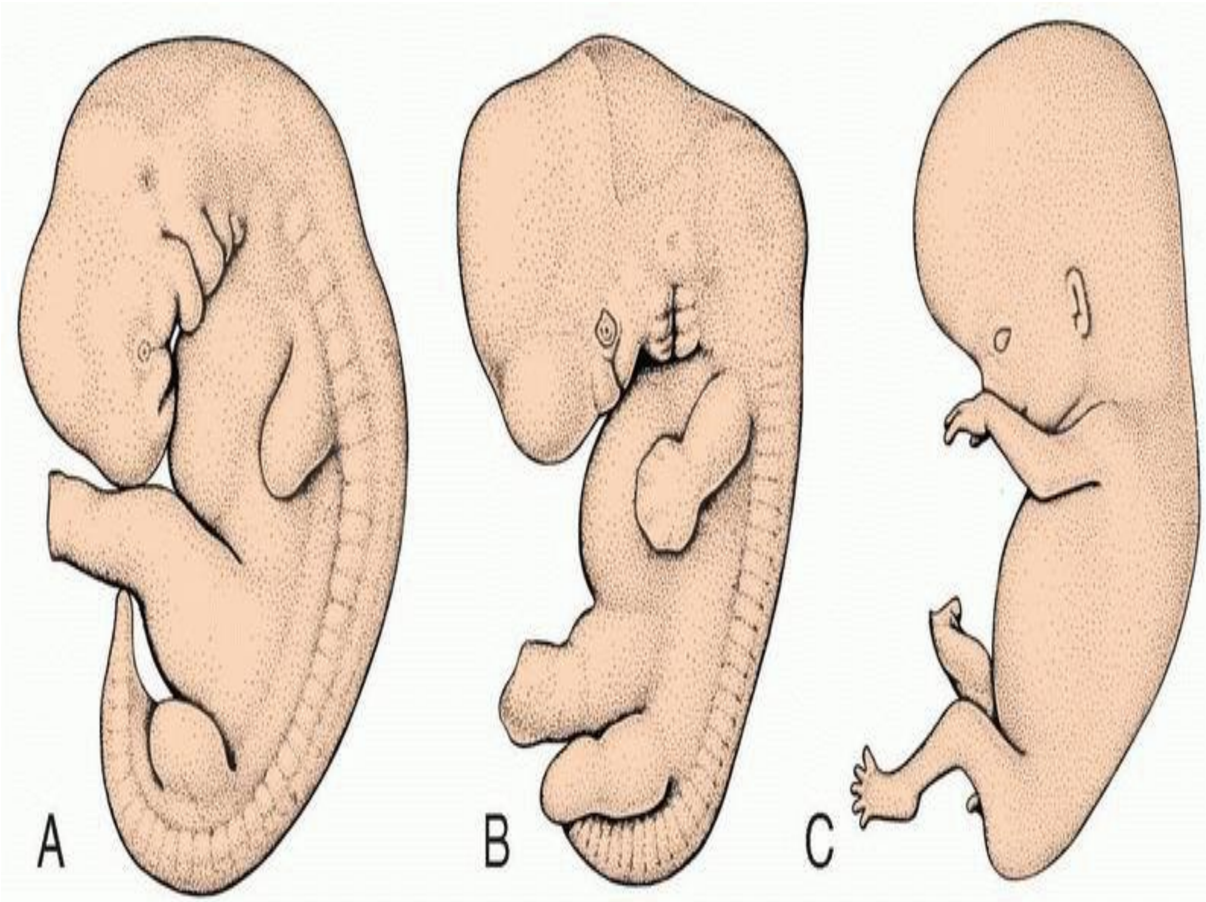
Ectoderm at the distal border of the limb

Which THICKENS

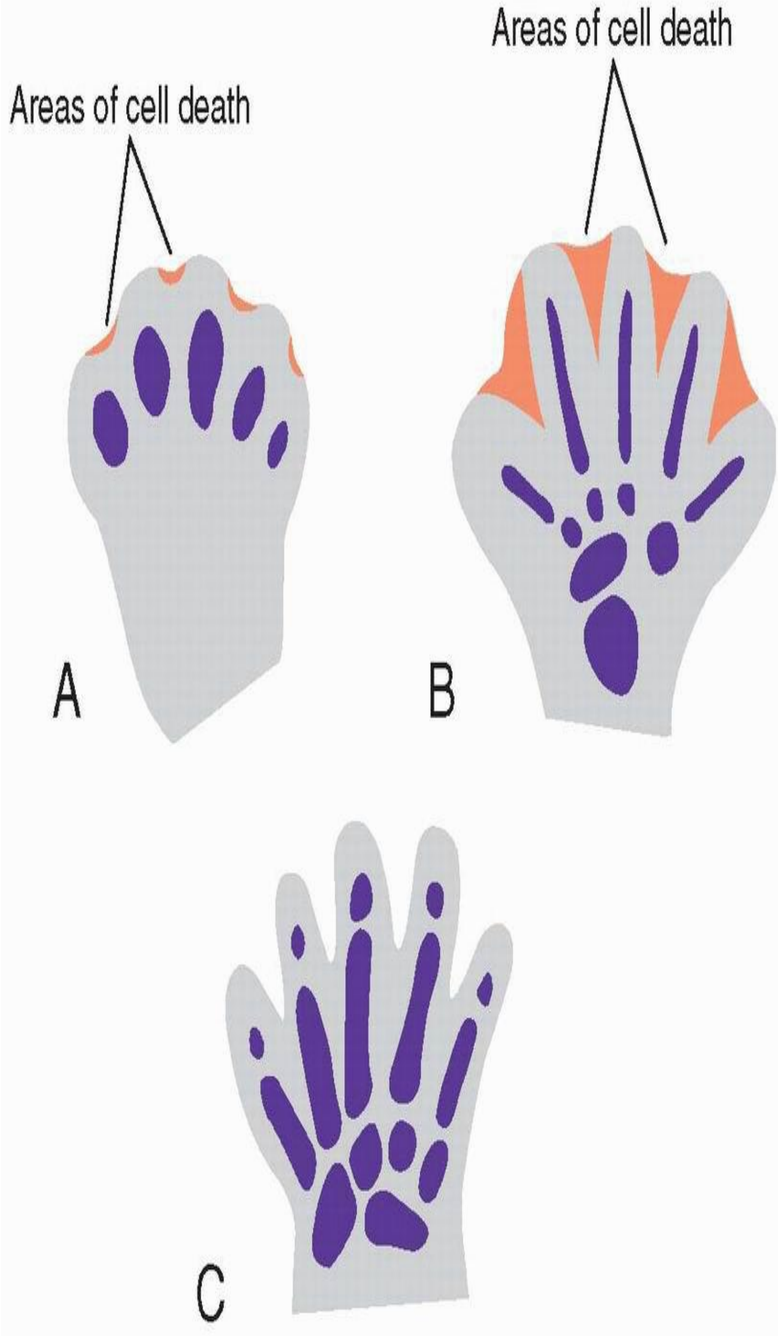
To forms the >>>>>> **APICAL ECTODERMAL RIDGE**

APICAL ECTODERMAL RIDGE (AER).

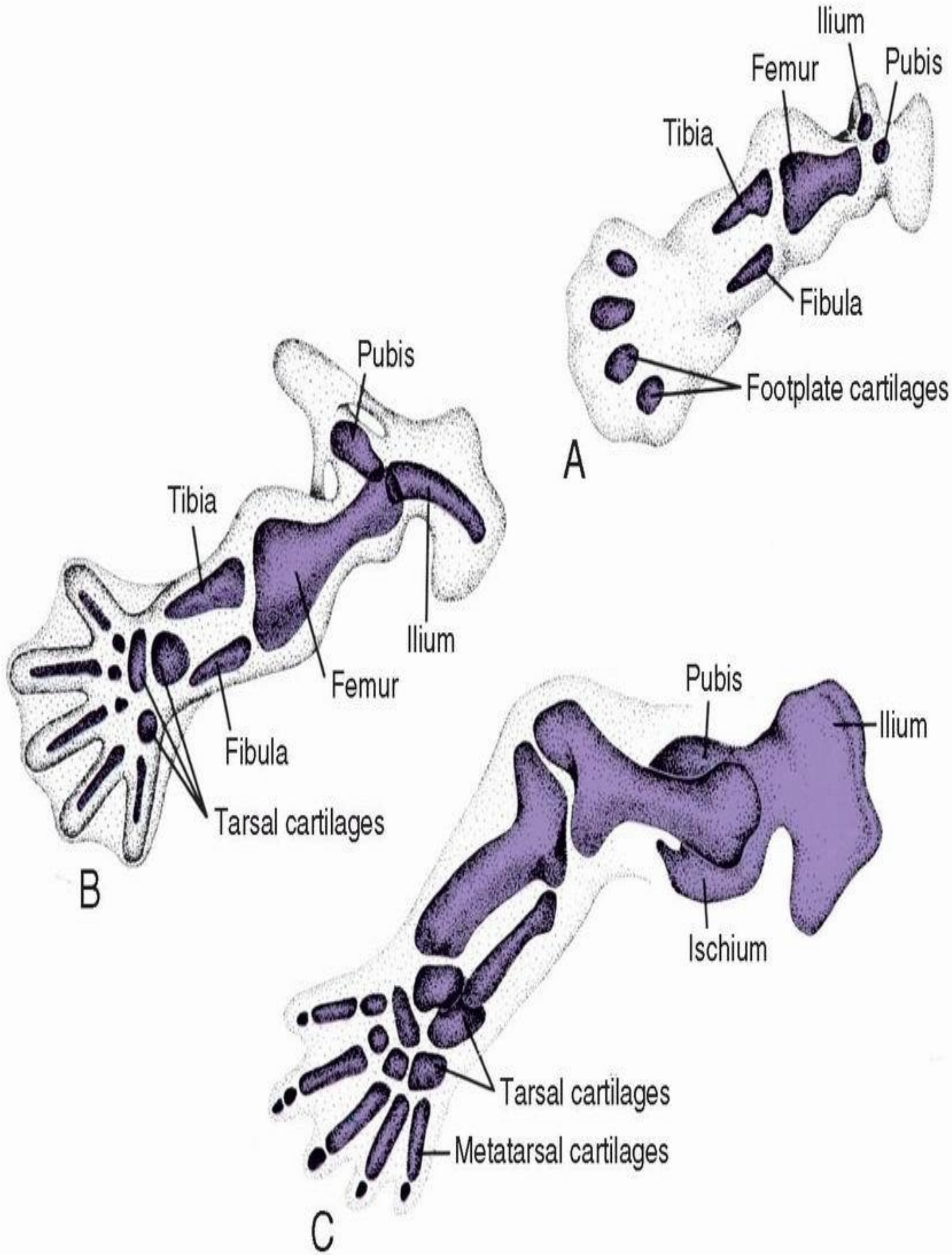




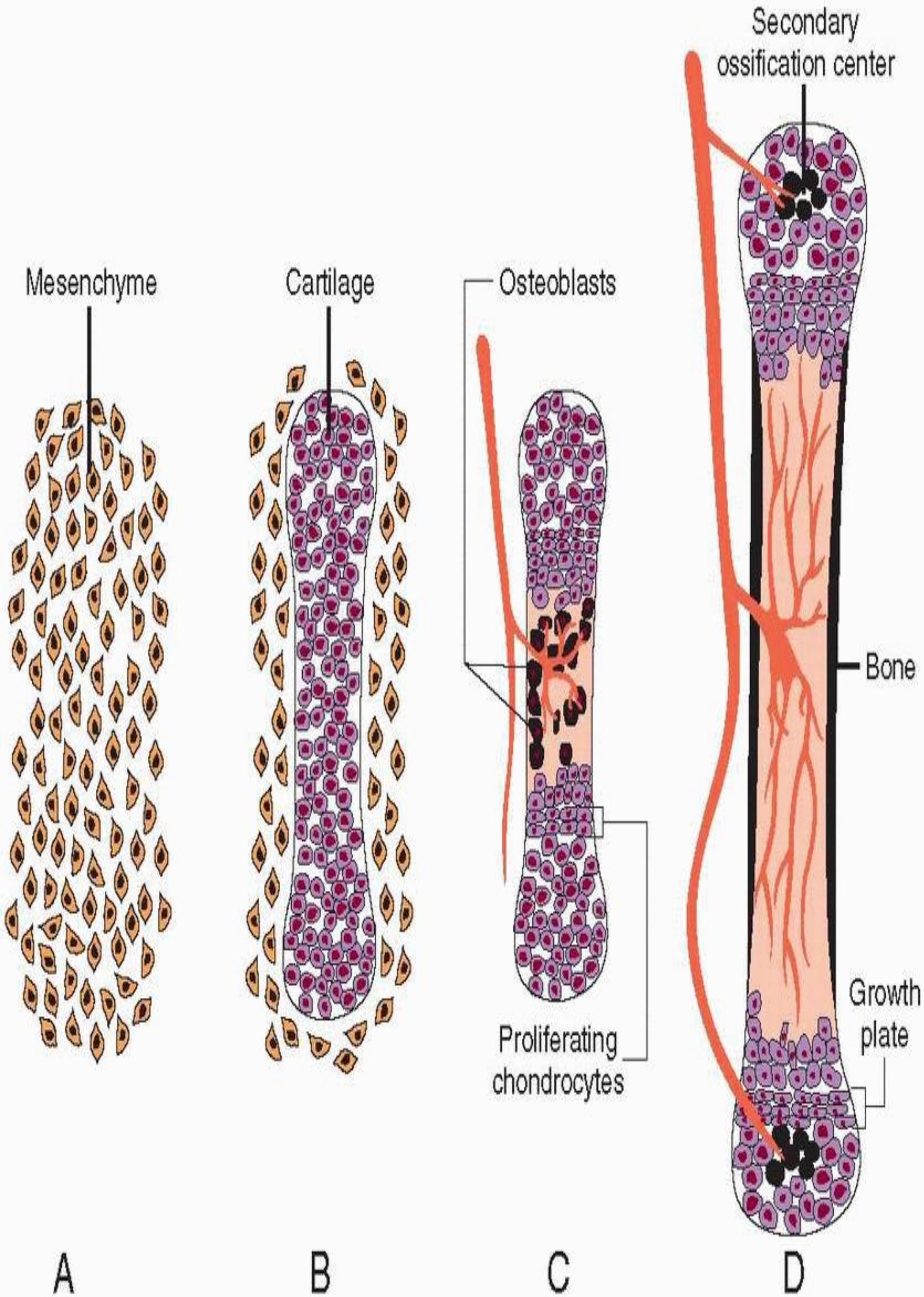
- Development of the limb buds in human embryos. A. At 5 weeks. B. At 6 weeks. C. At 8 weeks. Hindlimb development lags behind forelimb development by 1 to 2 days.



Schematic of human hands. A. At 48 days. Cell death in the apical ectodermal ridge creates a separate ridge for each digit. B. At 51 days. Cell death in the interdigital spaces produces separation of the digits. C. At 56 days. Digit separation is complete.



A. Lower extremity of an early 6-week embryo, illustrating the first hyaline cartilage models. B,C. Complete set of cartilage models at the end of the sixth week and the beginning of the eighth week, respectively.



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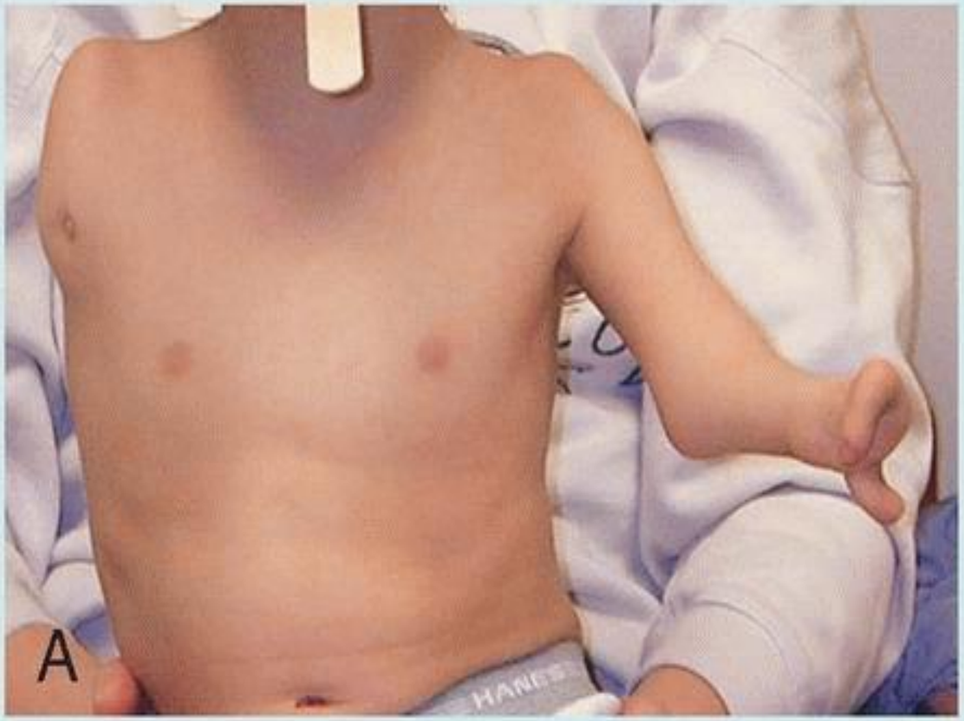

Figure 9.19 **A.** Child with unilateral amelia and multiple defects of the left upper limb. **B.** Patient with a form of meromelia called *phocomelia*. The hands are attached to the trunk by irregularly shaped bones.

Digital defects. A. Brachydactyly, short digits. B. Syndactyly, fused digits. C. Polydactyly, extra digits. D. Cleft foot, lobster claw deformity. Any of these defects may involve either the hands or feet or both.

Digit amputations resulting from amniotic bands.

Clubfoot

Amniotic bands

Congenital hip dislocation

underdevelopment of the acetabulum and head of the femur. It is rather common and occurs mostly in female newborns. Although dislocation usually occurs after birth, the abnormality of the bones develops prenatally. Because many babies with congenital hip dislocation

Breech deliveries,

Laxity of the joint capsule.

RIBS AND STERNUM

Sclerotome cells that remain in the paraxial mesoderm.

Costal cartilages are formed by sclerotome cells that migrate into the adjacent lateral plate mesoderm

STERNUM

Two sternal bands are formed in the parietal (somatic) layer of lateral plate mesoderm on either side of the midline, and these later fuse to form cartilaginous models of the manubrium, sternebrae, and xiphoid process.

Clinical Correlates

Cervical ribs >>>> brachial plexus or the subclavian artery.

Cleft sternum

Pectus excavatum

is the term for a depressed sternum

Pectus carinatum

anteriorly projecting sternum.

THANKS