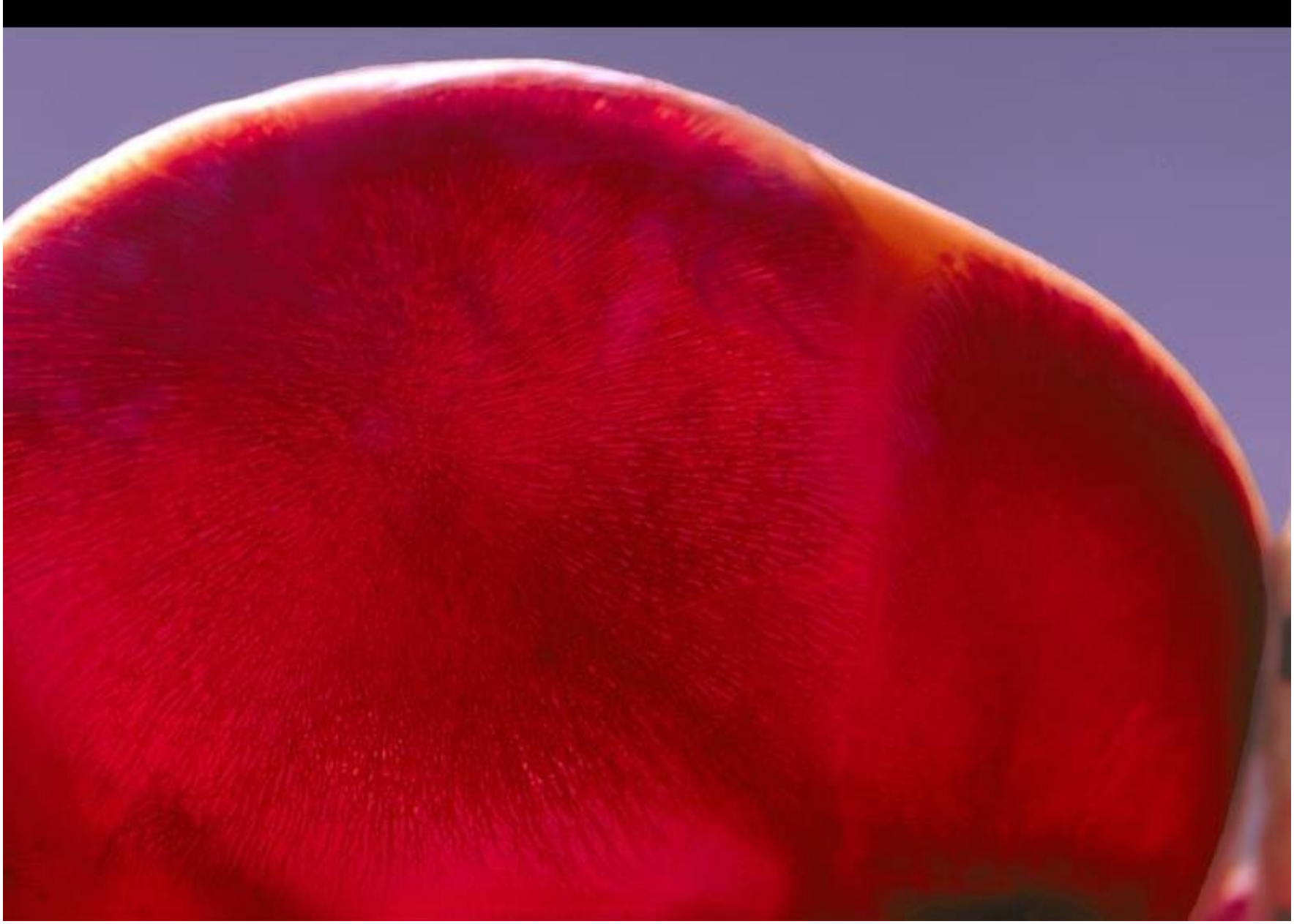
Ossification and Bone Remodeling



Pre-natal Ossification

Embryonic skeleton:

- fashioned from fibrous membranes or cartilage to accommodate mitosis.
- 2 types of pre-natal ossification (bone formation)

1. Intramembranous
   - Bone develops from fibrous membrane
   - Forms bones of skull and clavicle (most flat bones)
   - Contributes to the growth of short bones and thickening of long bones
   - Begins at 8 weeks of development

2. Endochondral
   - Bone develops from hyaline cartilage
   - Responsible for the formation of short and long bones
   - Begins 2nd month of dvlpmt

Intramembranous Ossification

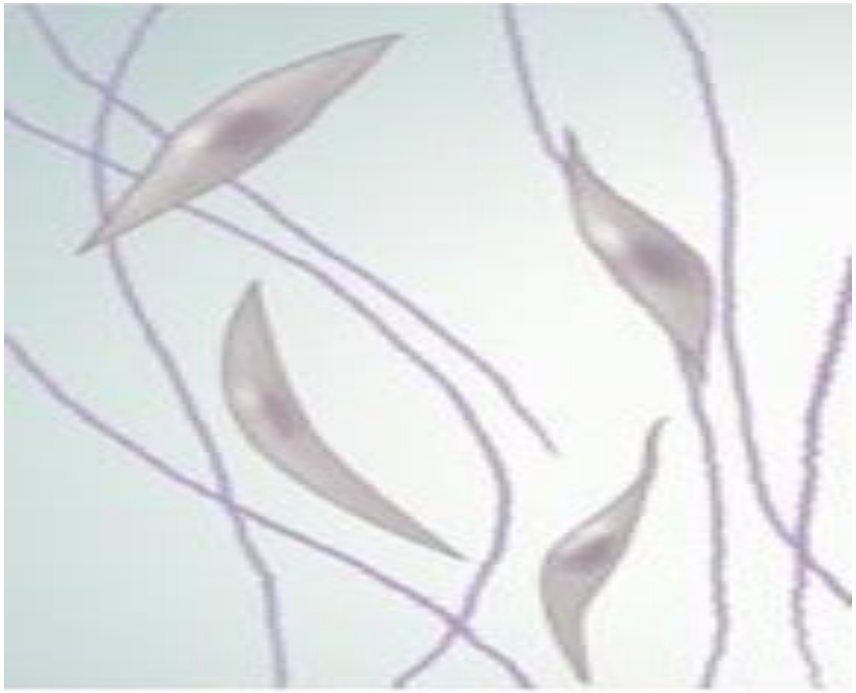
(prenatal)

Intramembranous ossification - location

- Fontanels and sutures are unique features that are found between skull bones.

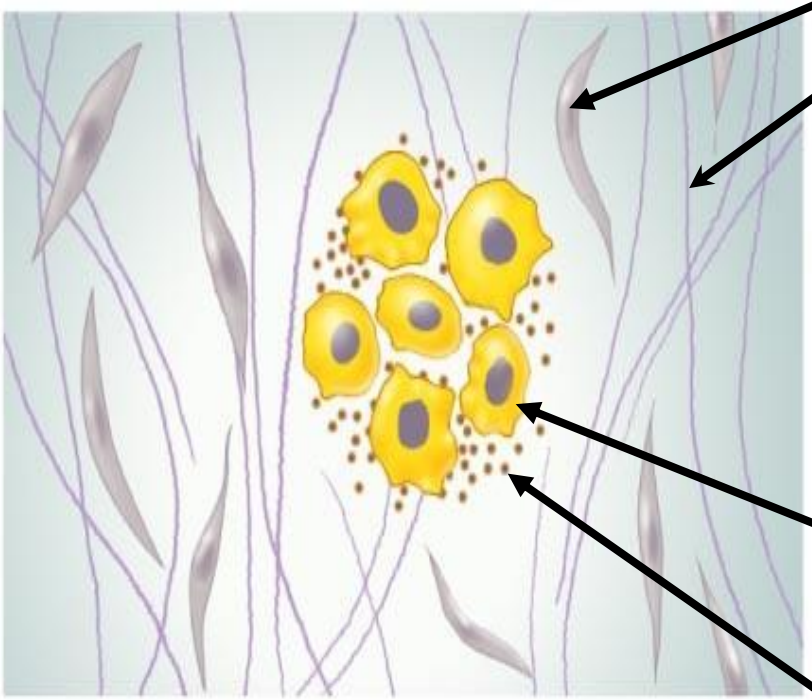
Intramembranous Ossification

(prenatal)



Intramembranous Ossification

(prenatal)



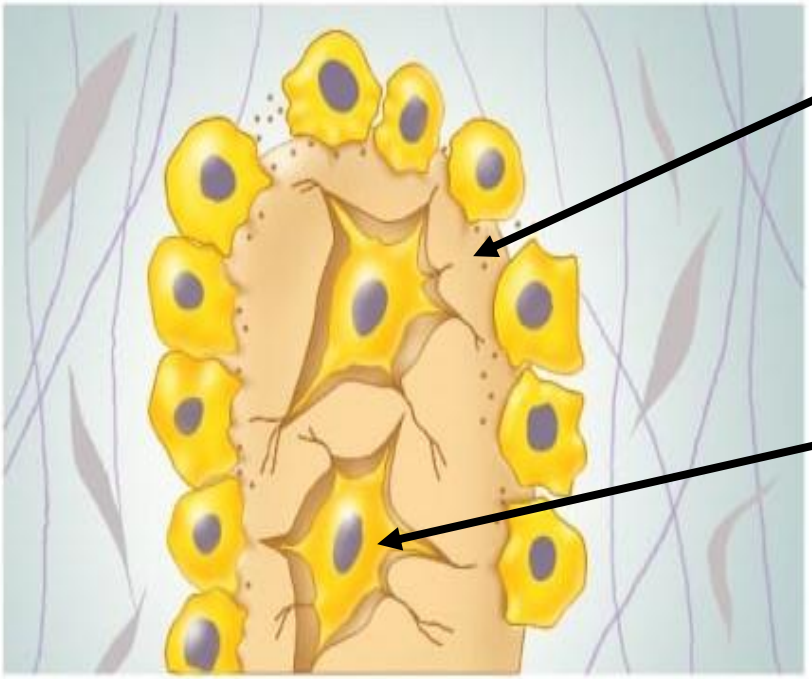
Mesenchymal cells create fibrous CT framework for ossification

Some mesenchymal cells differentiate into osteoblasts in an ossification center

Osteoblasts secrete bone matrix, osteoid

Intramembranous Ossification

(prenatal)

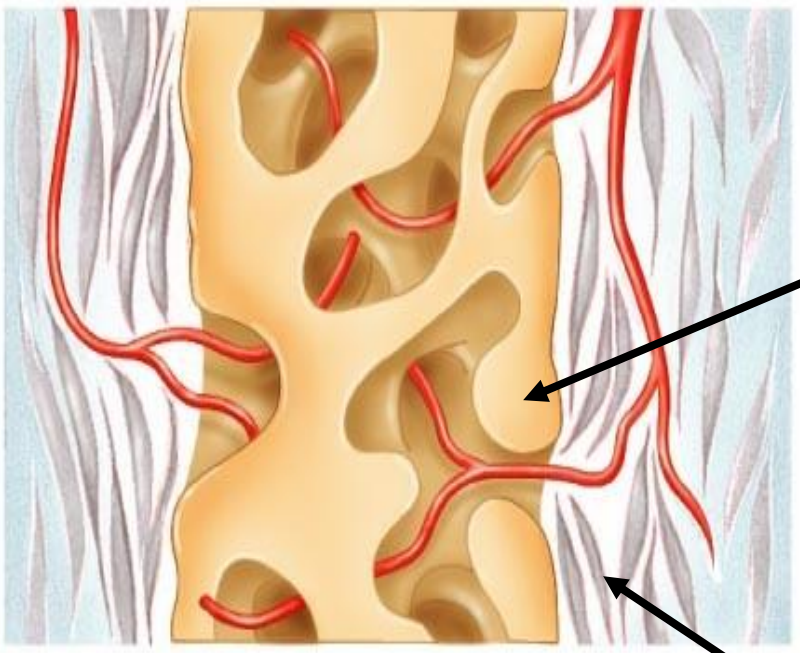


Mineralization and calcification of osteoid

Trapped osteoblasts become osteocytes

Intramembranous Ossification

(prenatal)

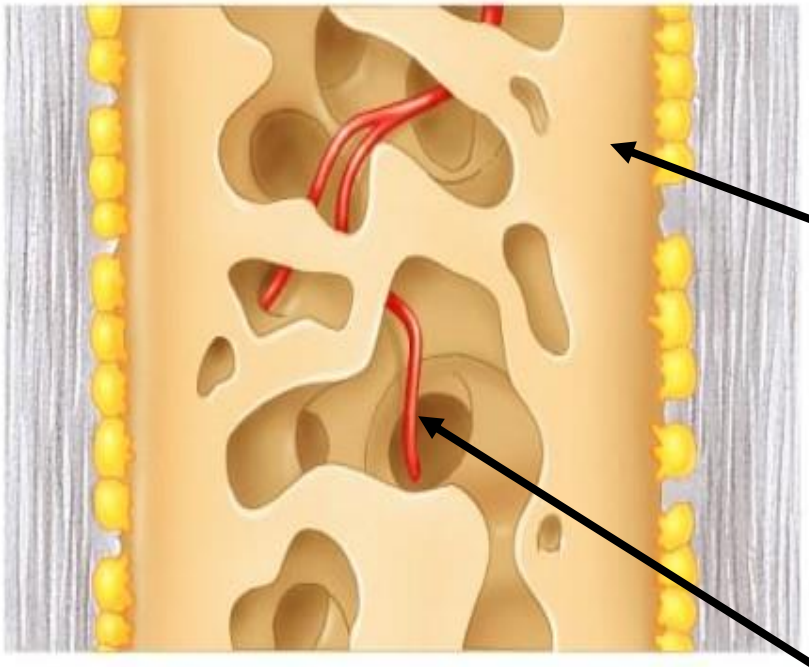


Several points of ossification occur and fuse forming spongy bone around embryonic blood vessels

Mesenchyme on bone face condense and differentiate into periosteum

Intramembranous Ossification

(prenatal)



The woven bone at the outer edge is remodeled and replaced by compact bone

Spongy bone (diploë) remains

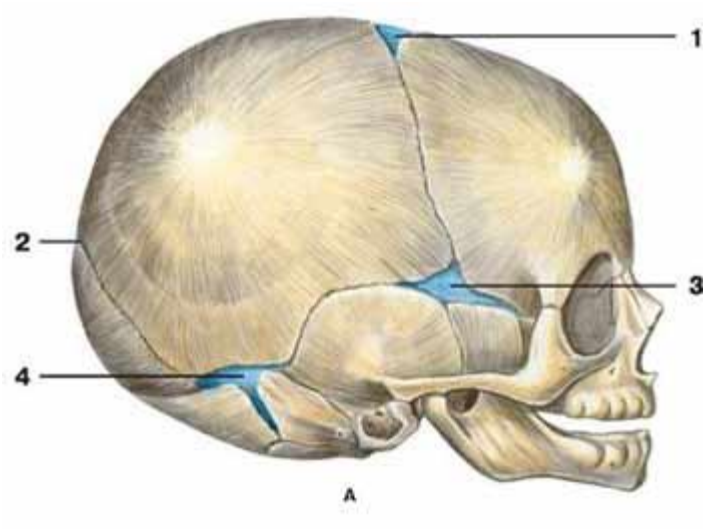
cavities made up of trabeculae fill with red marrow created from vessels (vascular tissue)

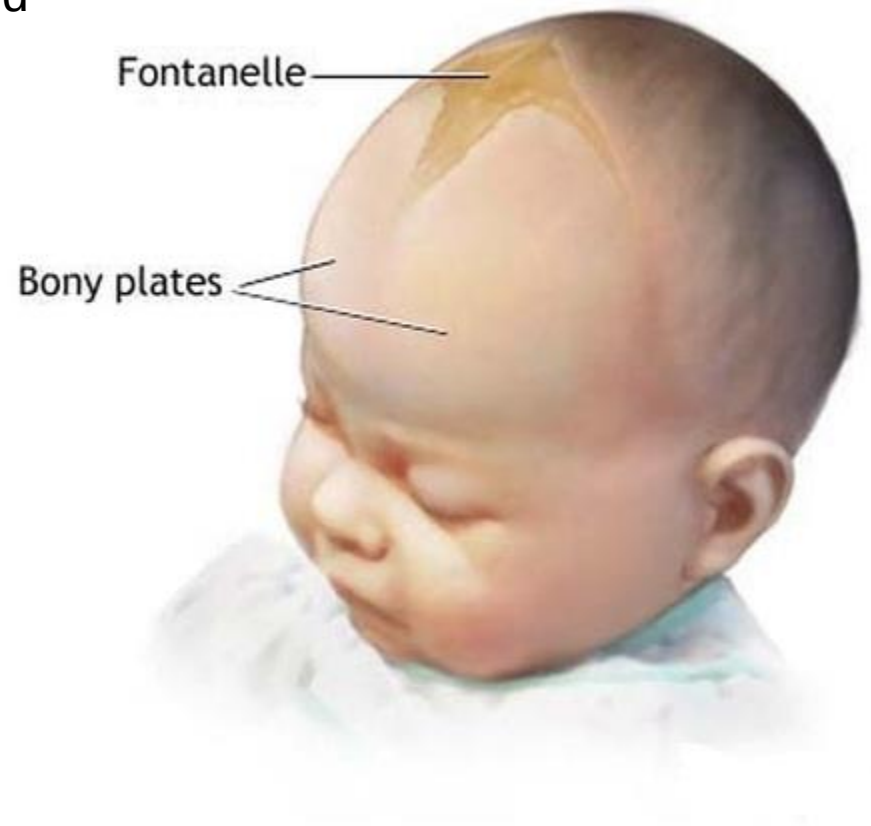
Note :Osteoblasts remain on bone surface to grow/remodel when needed

An anatomical feature of the infant human skull comprising any of the soft membranous gaps (sutures) between the cranial bones of a an infant

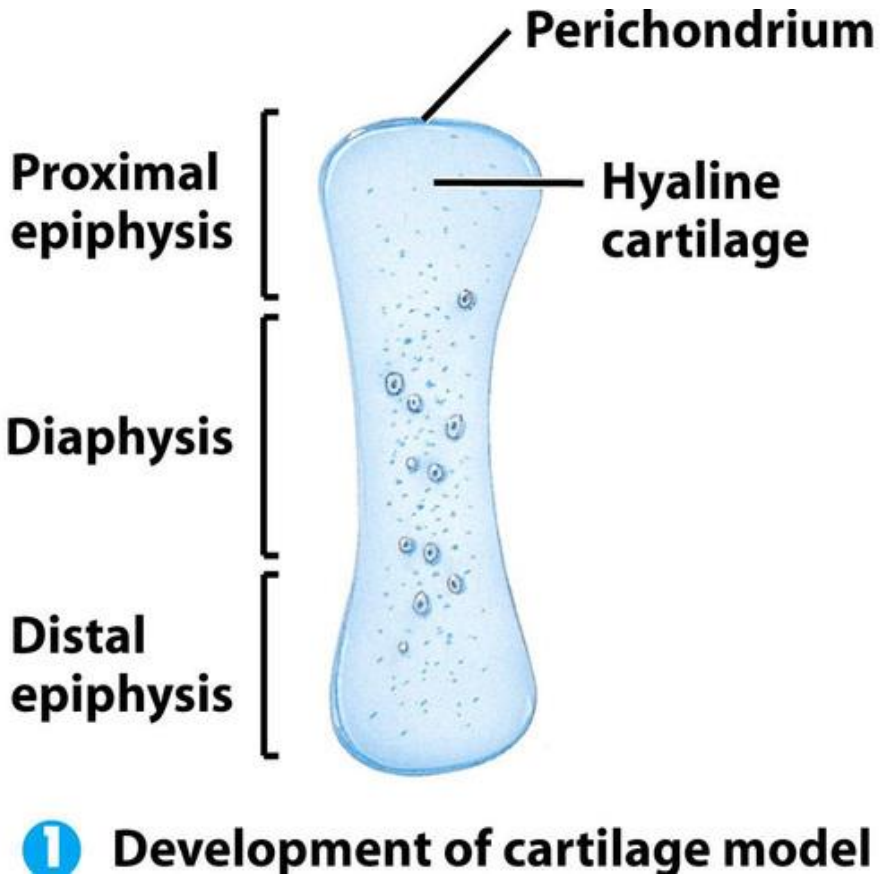
Fontanelles:

1. allow room for the baby's brain to grow
2. enable the head to be compressed during delivery.

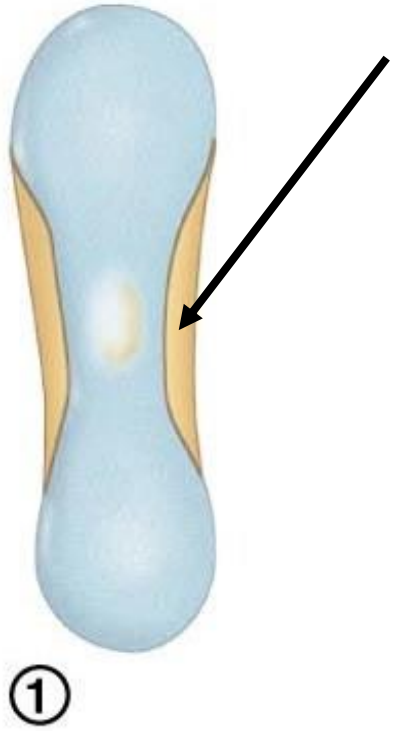




Endochondral Ossification



Endochondral Ossification



Bone collar formed around diaphysis by osteoblasts located on inner side of perichondrium

The collar impedes diffusion of oxygen and nutrients and the underlying cartilage, promoting degenerative changes there

Endochondral Ossification

primary ossification center

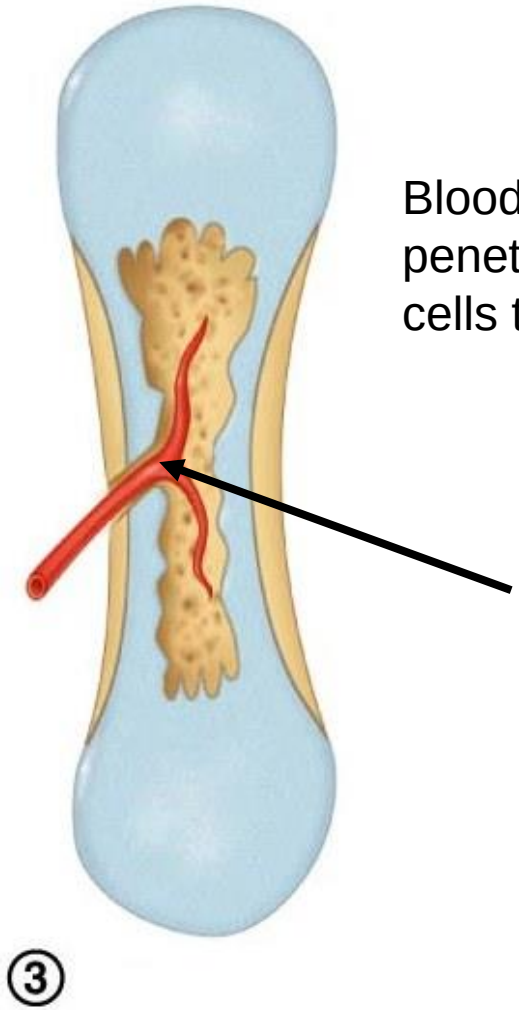
Cartilage calcifies, then the cells die and cavities form (cavitates)

Death of chondrocytes creates a porous structure consisting of Calcified cartilage remnants which become covered by a layer of osteoblast

Bone collar provides stability during cavitation

② Cartilage elsewhere continues to elongate

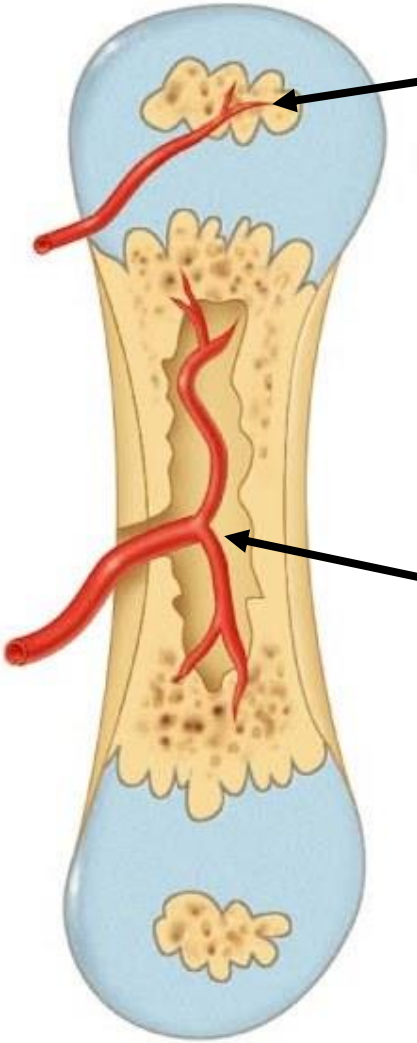
Endochondral Ossification



Blood vessels from perichondrium (now the periosteum) penetrate through the bone collar, bringing osteoproginator cells to the porous central region

Periosteal bud (lymph, blood vessels, nerves, red marrow, osteoblasts and osteoclasts) enters cavity and builds spongy bone

Endochondral Ossification

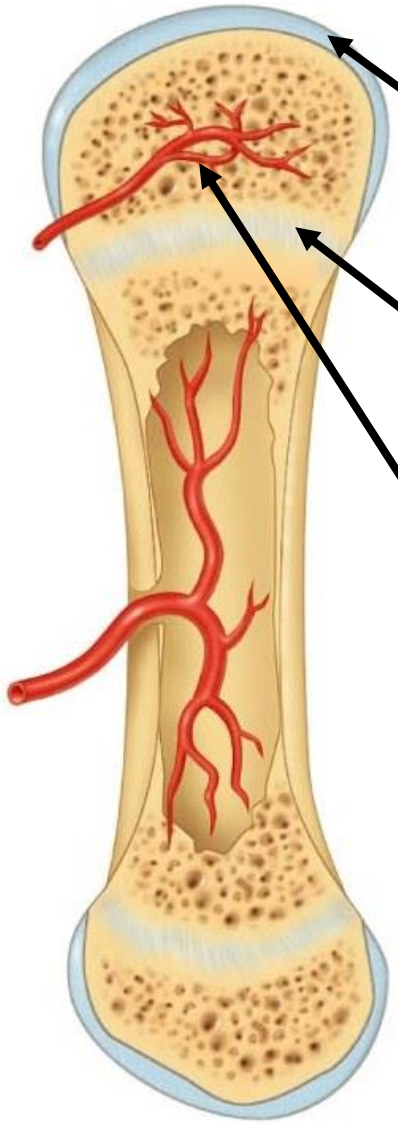


Secondary Ossification Center forms in epiphysis

Osteoclasts dissolve spongy bone to create medullary cavity

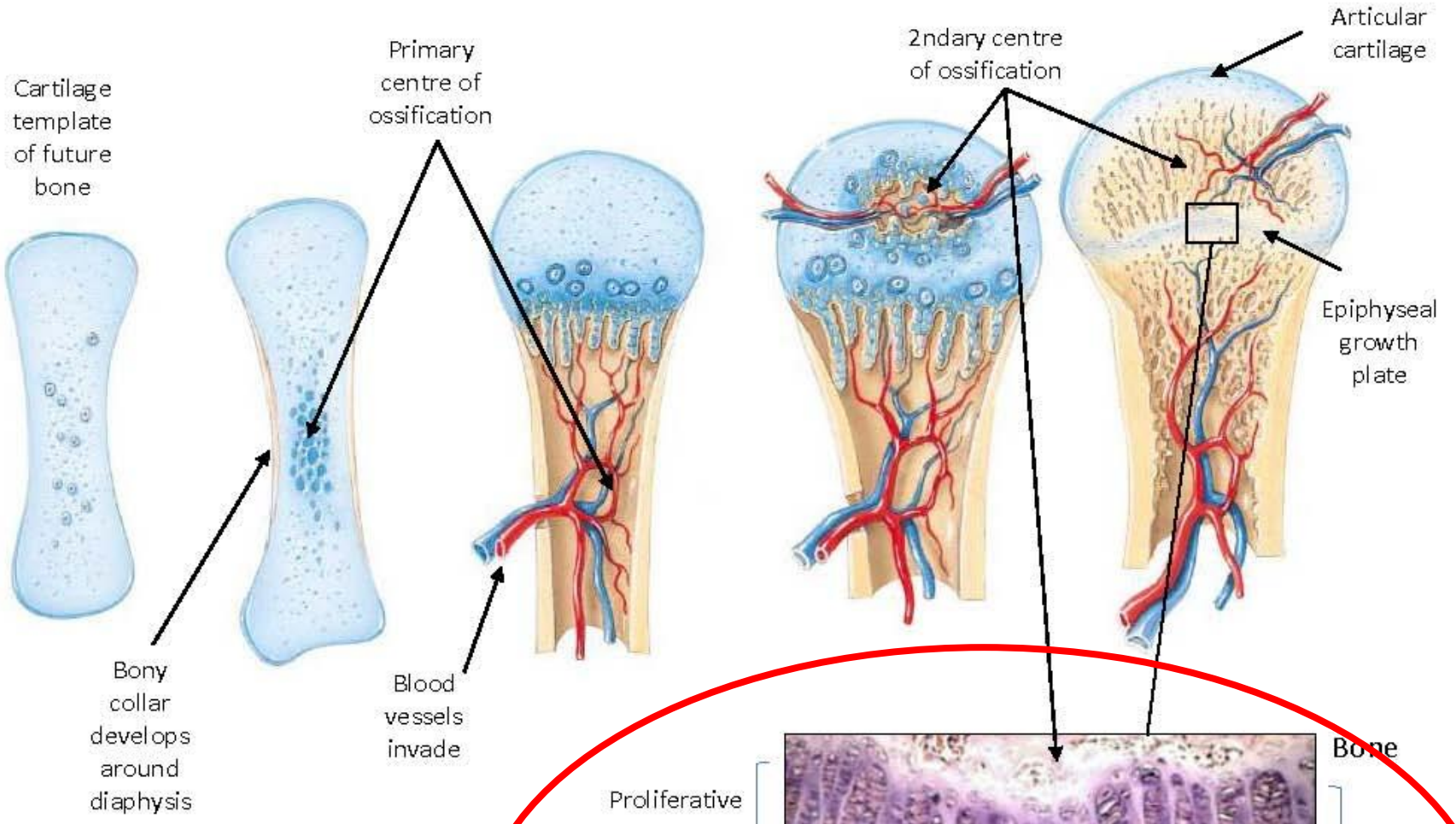
④

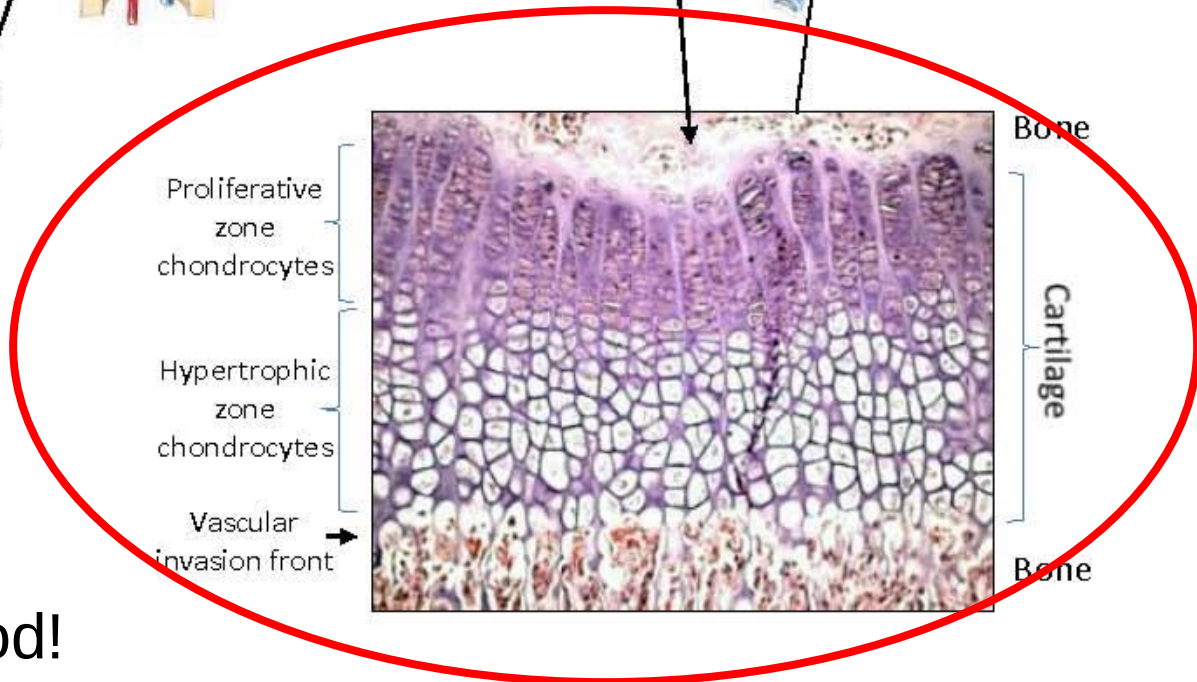
Endochondral Ossification



Hyaline only remains on epiphyseal surface (articular cartilage) and at diaphysis and epiphysis junction, to form the epiphyseal plates.

Secondary Ossification Center





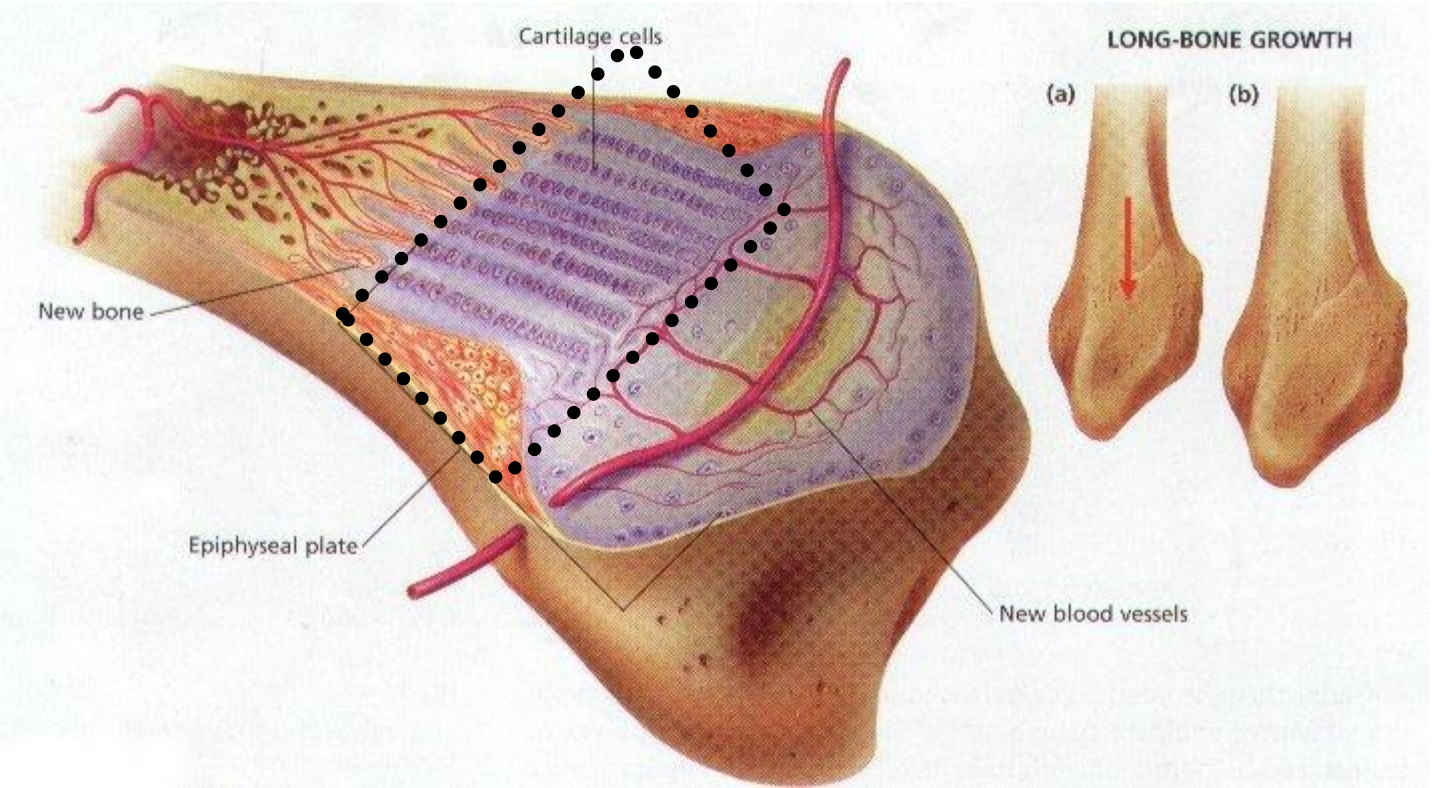
Endochondral Ossification:
the process by which most bones in the body grow

Growing taller throughout childhood!

Growing Taller!

(A closer look at the epiphyseal plate)

Lots of activity!



Growing Taller!

(A closer look at the epiphyseal plate)

• typical hyaline cartilage (resting)

1- Resting zone

• rapidly mitotic cartilage, lengthening bone; chondrocytes form columns

2- Growth zone

• enlarging size of chondrocytes (hypertrophy), this hypertrophy compresses the matrix into thin septa between chondrocytes

3- Hypertrophy zone

• matrix of cartilage calcifies and cells die forming small cavities

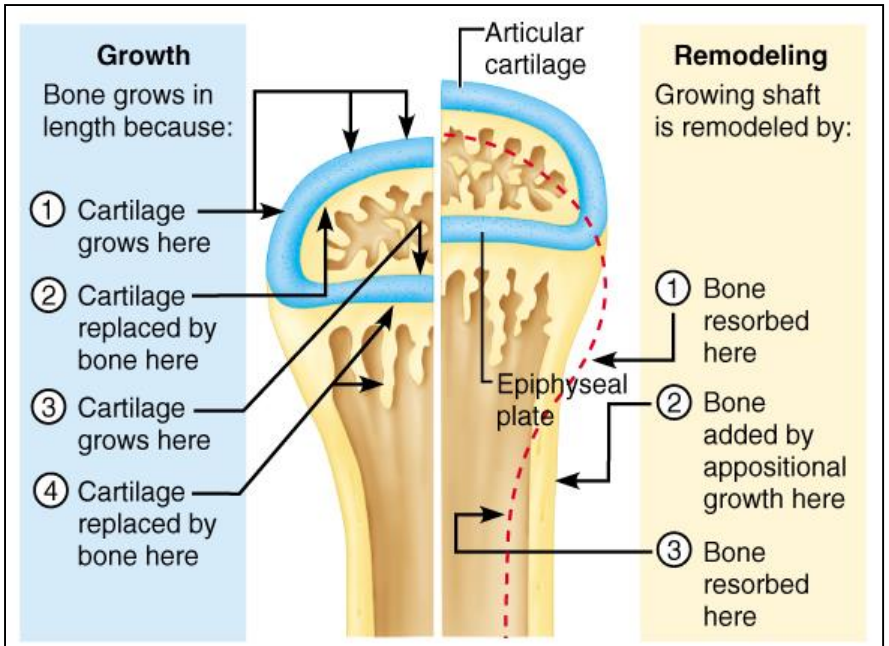
4- Calcification zone

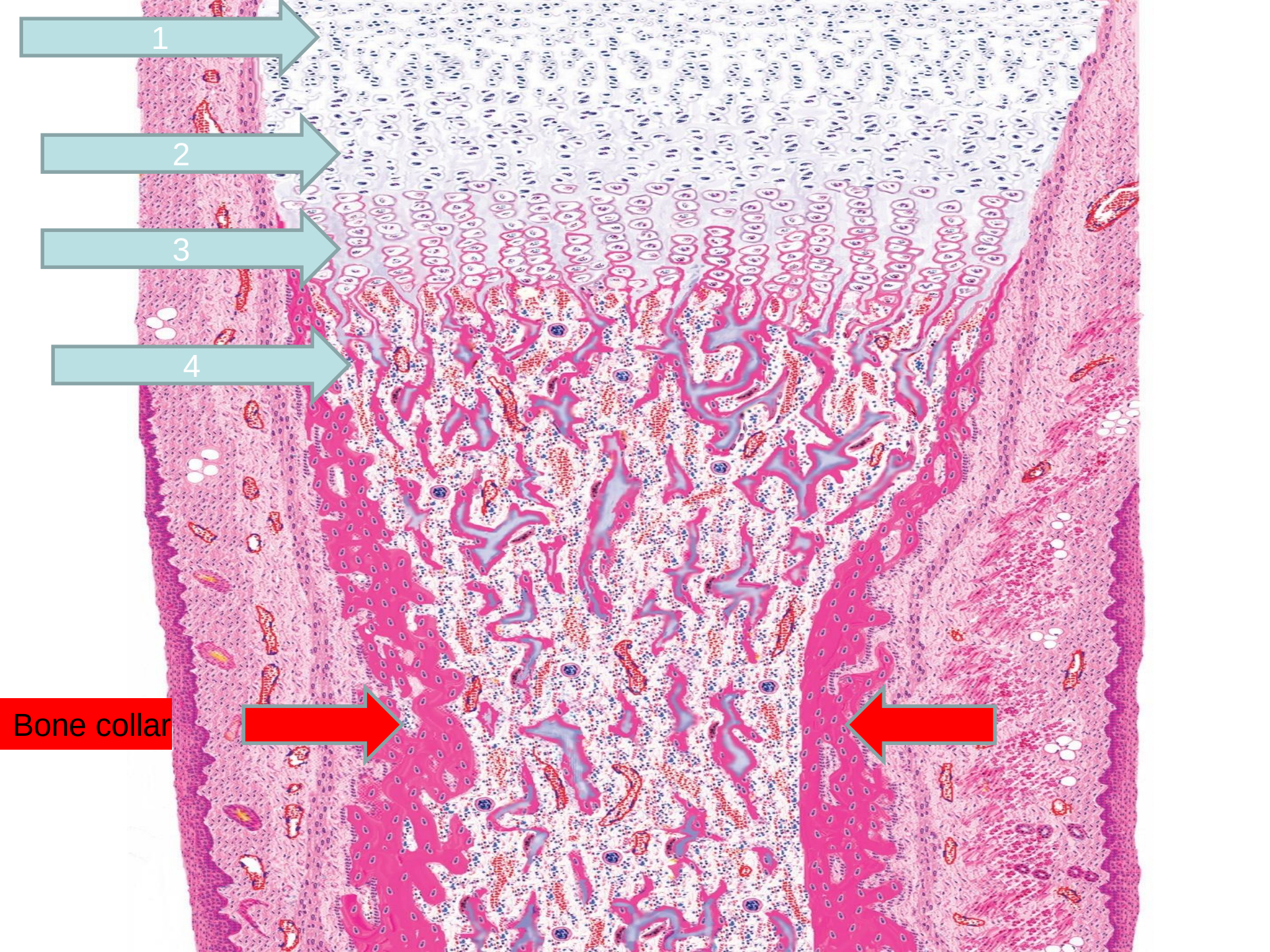
•Osteoblasts adhere to the remnants of calcified cartilage matrix and produce woven bone. Later this bone reshapes into spongy bone converted into medullary cavity or compact bone later as bone grows.

5- Ossification zone

Longitudinal Bone Growth

- Longitudinal Growth (interstitial) – cartilage continually grows and is replaced by bone
  - Bones lengthen entirely by growth of the **epiphyseal plates**
  - Cartilage is replaced with bone as quickly as it grows
  - *Epiphyseal plate maintains constant thickness*



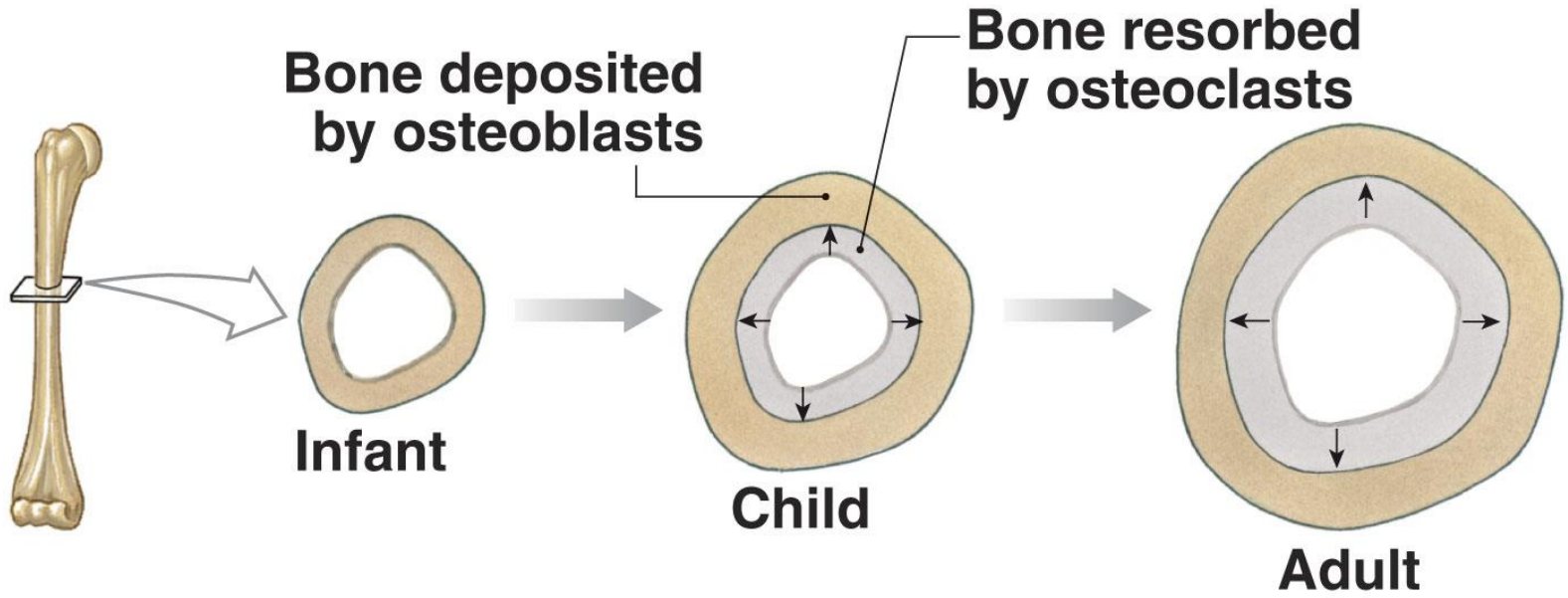

1
2
3
4
Bone collar

When does lengthening stop?

- End of adolescence - lengthening stops
  - Chondrocytes stop mitosis.
  - Plate thins out and replaced by bone
  - Diaphysis and epiphysis fuse to be one bone
    - Epiphyseal plate closure (18 yr old females, 21 yr old males)
- Thickening of bone continuous throughout life

Appositional Bone Growth

- Growing bones widen as they lengthen
- Appositional growth – growth of a bone by addition of bone tissue to its surface
- Bone is resorbed at endosteal surface and added at periosteal surface
  - Osteoblasts – add bone tissue to the external surface of the diaphysis
  - Osteoclasts – remove bone from the internal surface of the diaphysis



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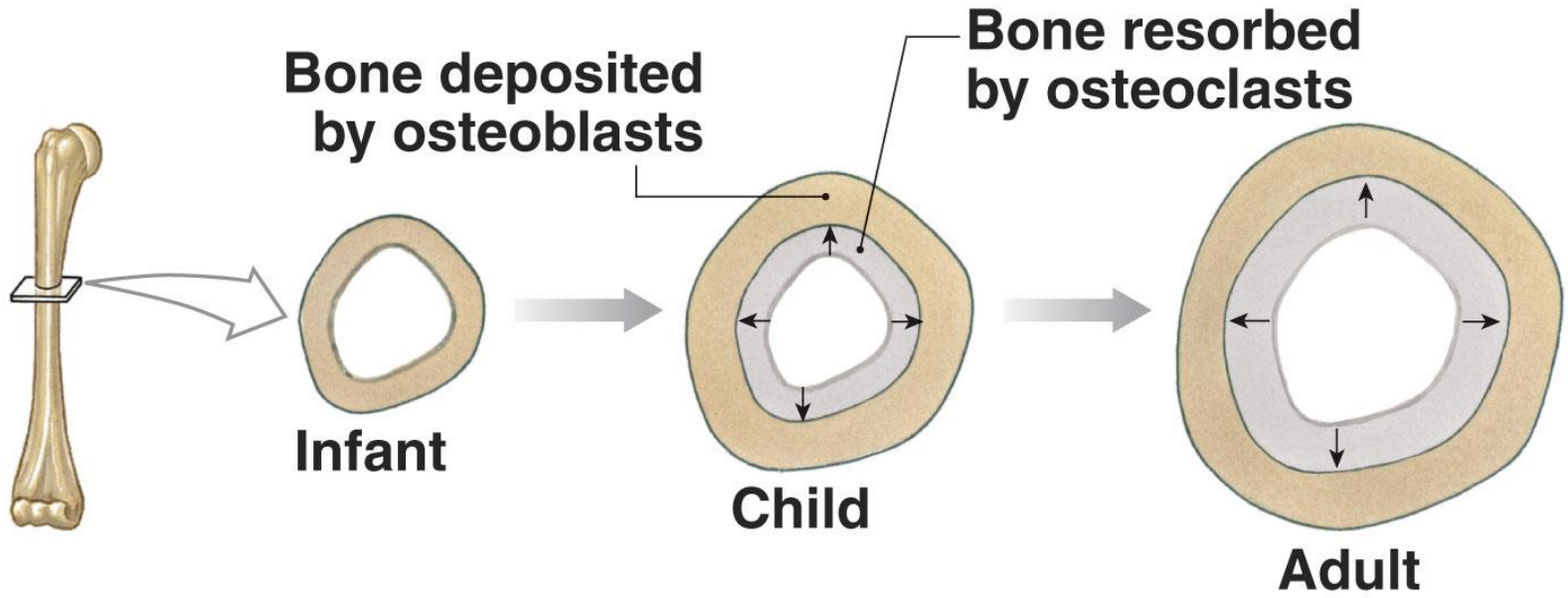
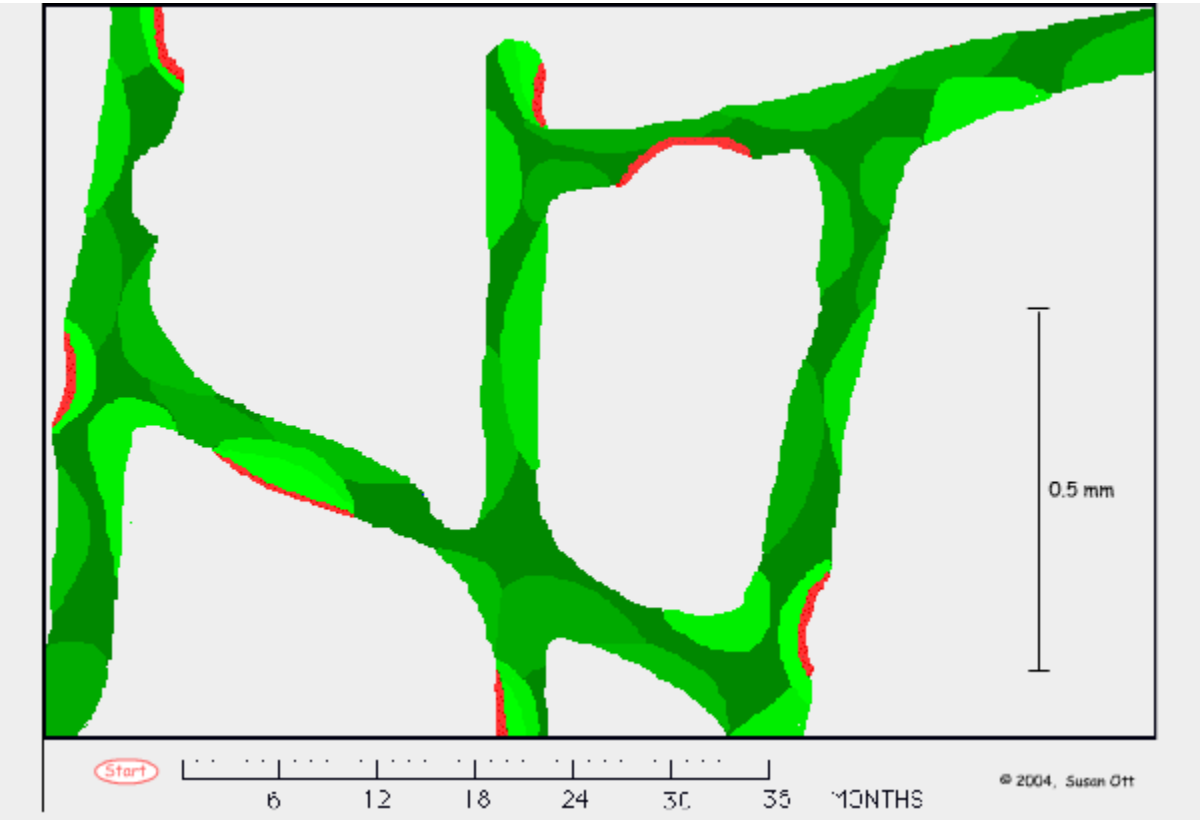


Bone Remodeling

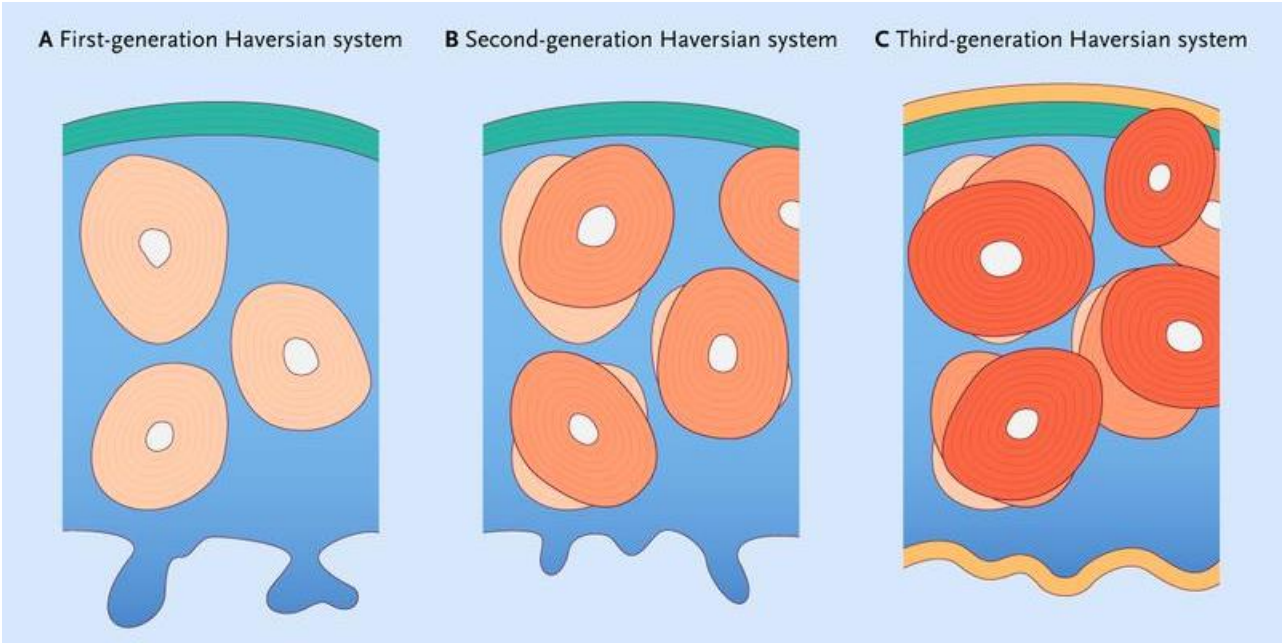
Involves:
- Dissolving/destroying bone
- New bone growth

- **Reshaping of the skeleton during growth**
- **Maintain calcium levels**
- **Repair of microfractures caused by everyday stresses**



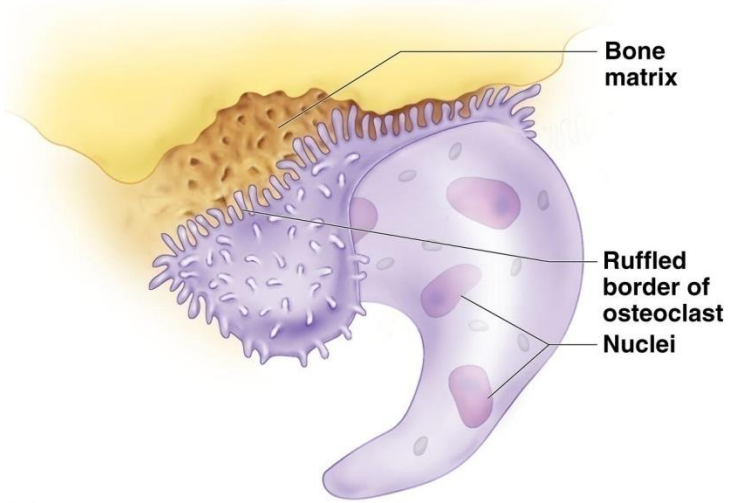
Dissolved material passed through osteoclasts and into bloodstream for reuse by the body (endocytosis and transcytosis)

compact bone remodelling



Bone Remodeling

- Bone Depostition
  - Occurs when bone is injured or extra strength is needed
  - Requires a healthy diet - protein, vitamins C, D, and A, and minerals (calcium, phosphorus, magnesium, manganese, etc.)
- Bone Resorption
  - Accomplished by Osteoclasts (multinucleate phagocytic cells)
  - Resorption involves osteoclast secretion of:
    - Lysosomal enzymes that digest organic matrix
    - HCl that converts calcium salts into soluble forms
  - Dissolved matrix is endocytosed and transcytosed into the interstitial fluid → the blood



Bone is Dynamic!

Bone is constantly remodeling and recycling

- Coupled process between:
  1. Bone deposition (by osteoblasts)
  2. Bone destruction/resorption (by osteoclasts)
- 5-7% of bone mass recycled weekly
- All spongy bone replaced every 3-4 years.
- All compact bone replaced every 10 years.

Prevents mineral salts from crystallizing; protecting against brittle bones and fractures

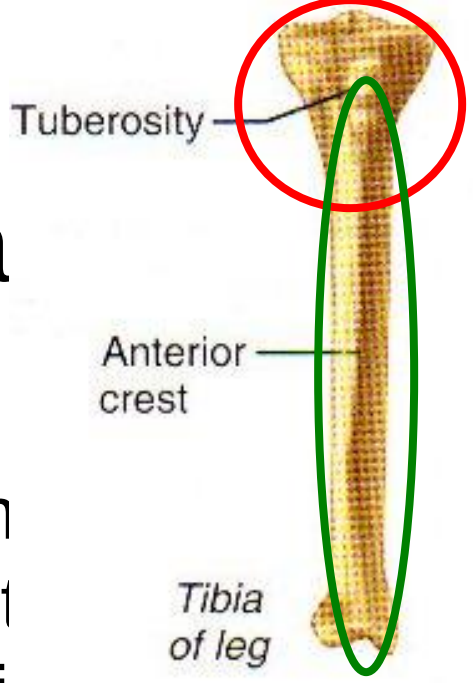
Bone growth regulated by hormones

- Human Growth Hormone (HGH): from pituitary gland in brain promotes epiphyseal plate activity
- Thyroid hormones: regulate HGH for proper bone proportions
- Puberty: Testosterone or Estrogen cause adolescent growth spurt and skeletal differences between the sexes:
  - Wider shoulders, larger bones, narrow pelvis in men
  - Wider hips, smaller upper body in women
- Excesses in any hormones can cause abnormal skeletal growth
  - Ex. gigantism or dwarfism

Robert Wadlow, world's tallest man 8 ft 11 inches

Yao Defen, gigantess currently in treatment for pituitary tumor in China. 7 ft 7 inches 396 lbs

Response to Mechanical/Gravitationa



– Bones respond to muscles pullin (mechanical stress) and to gravit bones strong where they are bei

- weight bearing activities → stronger projections where muscles/ligaments attach
- High rate of bone deposition in specific areas.

What you don't use, you lose. The stresses applied to bones during exercise are essential to maintaining bone strength and bone mass

Joints

- Diarthroses: permits free movement.
- Synarthroses: limited or no movement.
  - Synostosis: sutures
  - Chondrosis: growth plates
  - Syndesmosis: interosseous membrane
  - Symphysis: symphysis pubis

Synovial joint (diarthrosis)

- Fibrous joint capsule: continuous with the periosteum of the joined bones

- Synovial cavity: filled with synovial fluid.

- Synovial membrane: lines the inner surface of the capsule