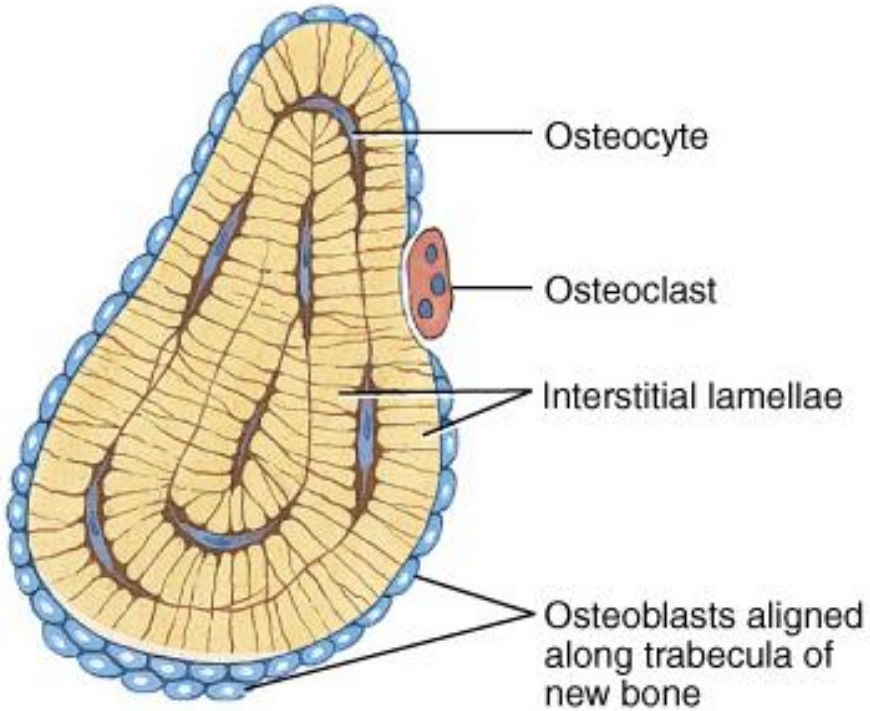
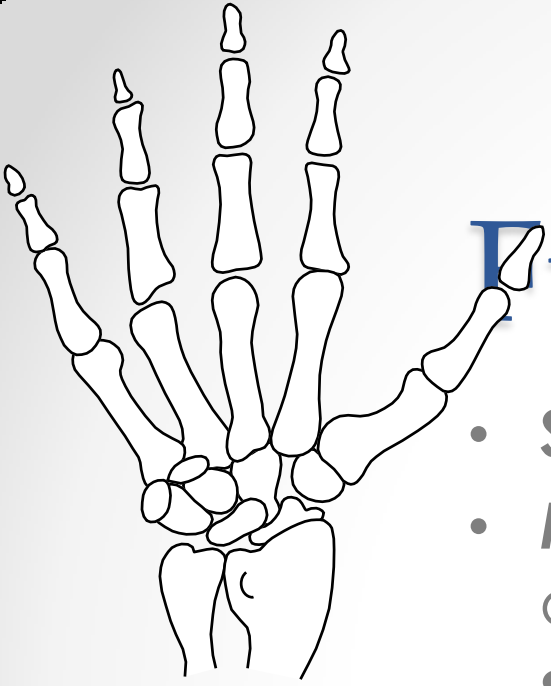
The Skeletal System: Bone Tissue

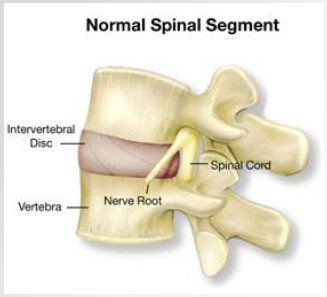


- Dynamic and ever-changing throughout life
- Skeleton composed of many different tissues
  - cartilage, bone tissue, epithelium, nerve, blood forming tissue, adipose, and dense connective tissue

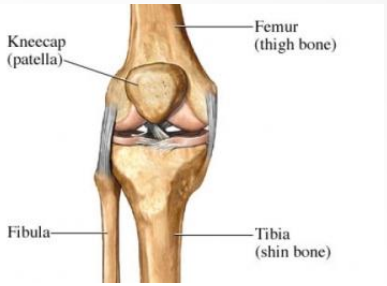


Functions of Bone

- **Supporting & protecting** soft tissues
- **Movement** is made possible being an attachment site for bone to muscle
- **Storage** of the minerals, calcium & phosphate -- mineral homeostasis
- **Blood cell production** occurs in red bone marrow (hemopoiesis)
- Energy storage in yellow bone marrow



Cartilage



- Is composed of chondrocytes(cartilage cells) located in lacunae(sm spaces) within an extensive matrix.
  - Collagen for flexibility & strength
  - Proteoglycans to trap water for rigidity & ability to spring back after compression
- Hyaline cartilage is the beginning of most bone in the body.
- Growth of length of bone and repairs start with hyaline cartilage that becomes bone.
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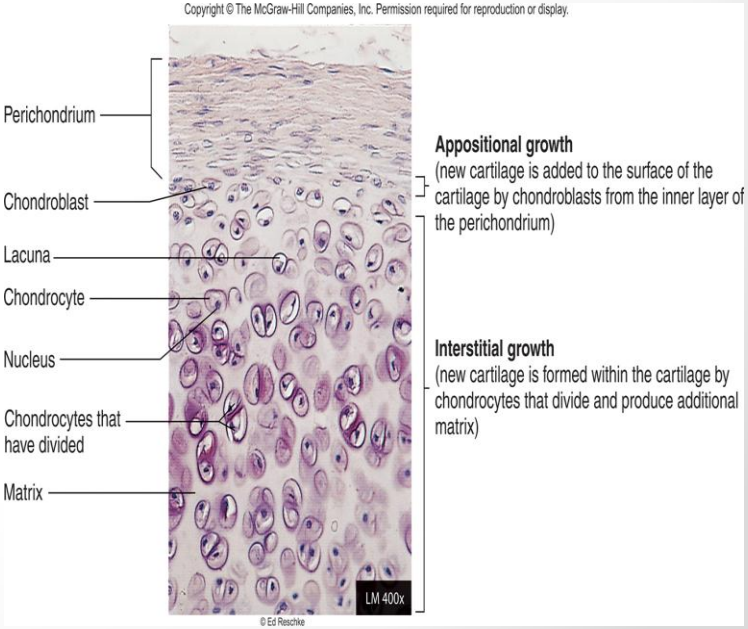
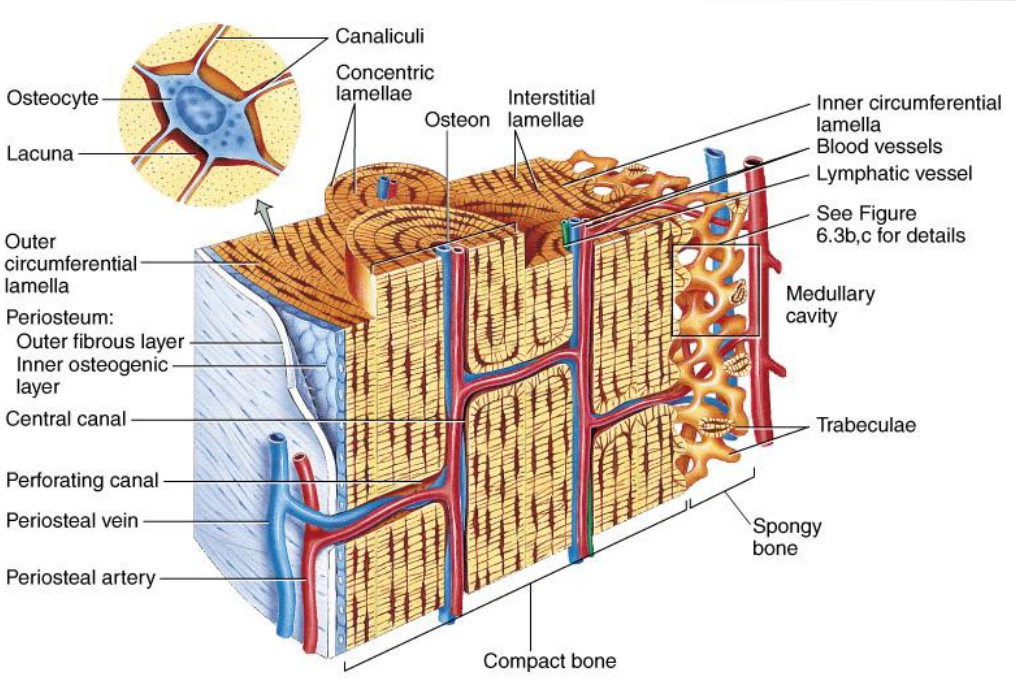


Histology of Bone

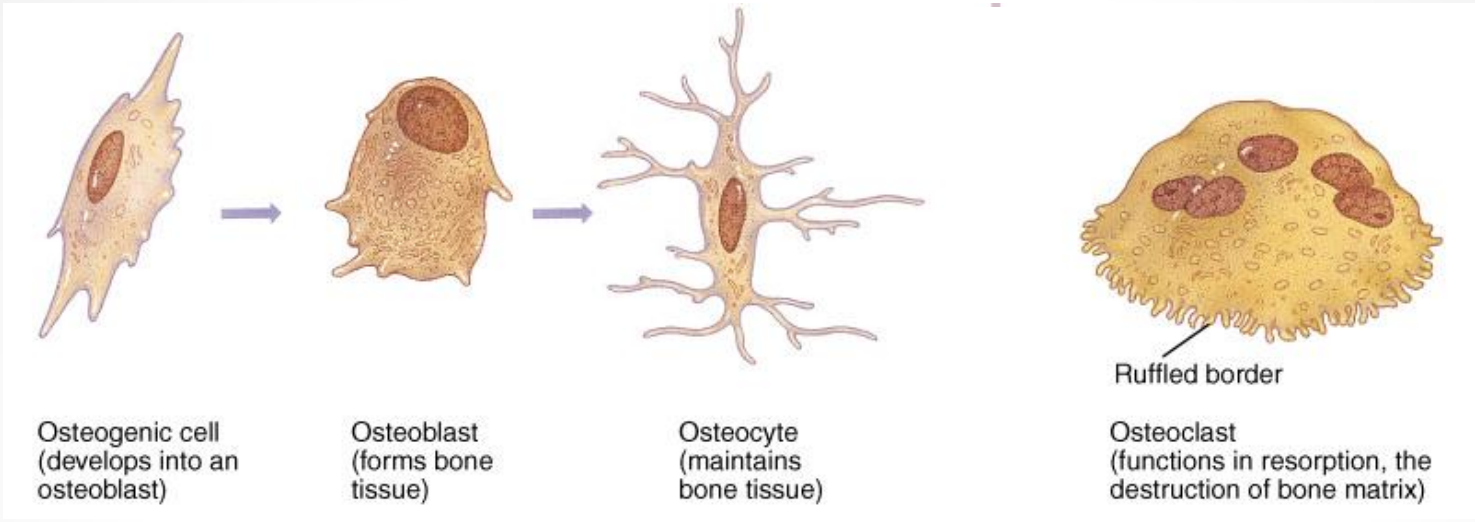
- A type of connective tissue as seen by widely spaced cells separated by matrix
- Matrix of 20% water, 35% collagen fibers & 45% crystalized minera salts
- 4 types of cells in bone tissue



Matrix of Bone

- Inorganic mineral salts provide bone's hardness
- Organic collagen fibers provide bone's flexibility
  - their tensile strength resists being stretched or torn
  - remove minerals with acid & rubbery structure results
- Mineralization (calcification) is hardening of tissue when mineral crystals deposit around collagen fibers
  - Remove collagen and bones become brittle
- Bone is not completely solid since it has small spaces for vessels and red bone marrow
  - Cancellous (spongy bone) has many such spaces
  - compact bone has very few

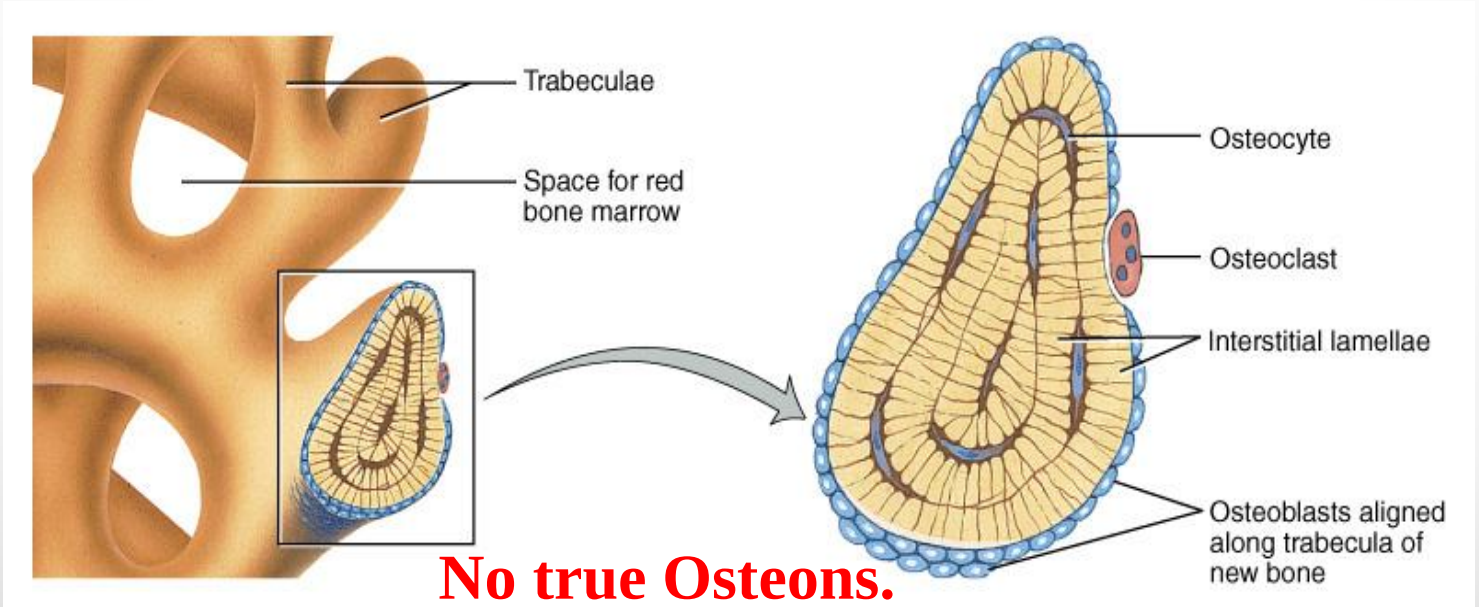
Cell Types of Bone



- **Osteoprogenitor cells** ---- undifferentiated cells
  - can divide to replace themselves & can become osteoblasts
  - found in inner layer of periosteum and endosteum
- **Osteoblasts**--form matrix & collagen fibers but can't divide
- **Osteocytes** ---mature cells that no longer secrete matrix
- **Osteoclasts**---- huge cells from fused monocytes (WBC)
  - function in bone resorption at surfaces such as endosteum

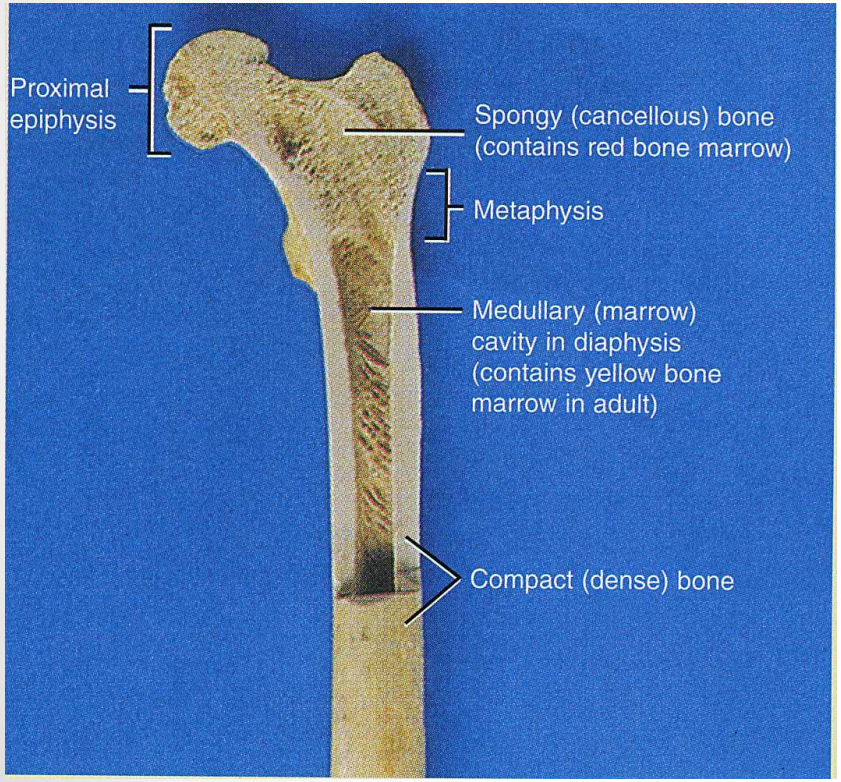
Cancellous or Spongy Bone

- **Trabiculae** are a latticework of thin plates of bone oriented along lines of stress
- Spaces in between these struts are filled with red marrow where blood cells develop
- Found in ends of long bones and inside flat bones such as the hipbones, sternum, sides of skull, and ribs.



No true Osteons.

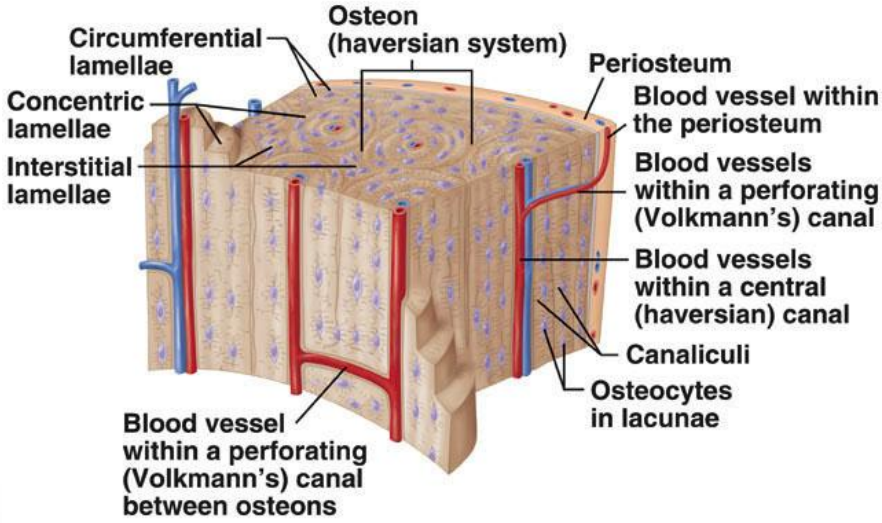
Compact or Dense Bone



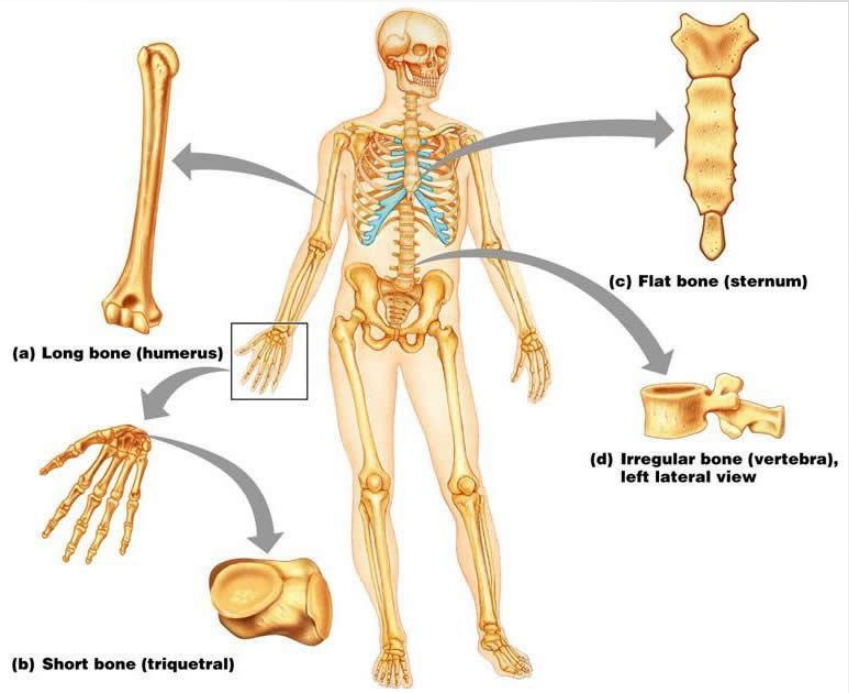
- Looks like solid hard layer of bone
- Makes up the shaft of long bones and the external layer of all bones
- Resists stresses produced by weight and movement

Histology of Compact Bone

- **Osteon(haversion canal)** is concentric rings (lamellae) of calcified matrix surrounding a vertically oriented blood vessel
- Osteocytes found in spaces called lacunae
- Osteocytes communicate through canaliculi filled with extracellular fluid that connect one cell to the next cell
- Interstitial lamellae represent older osteons that have been partially removed during tissue remodeling

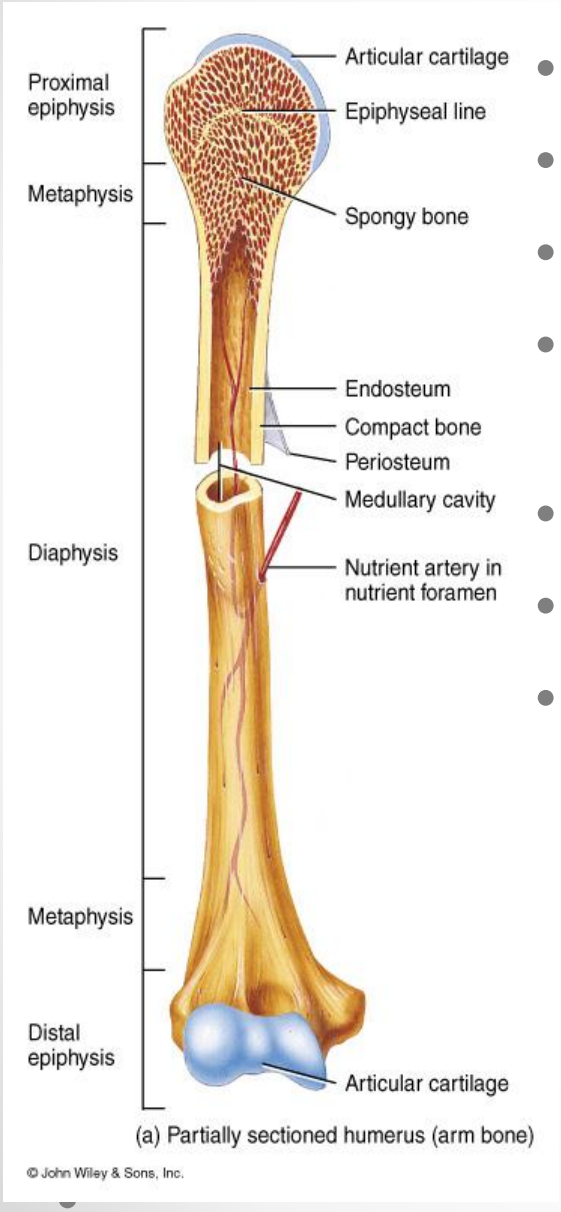


Bone Shapes



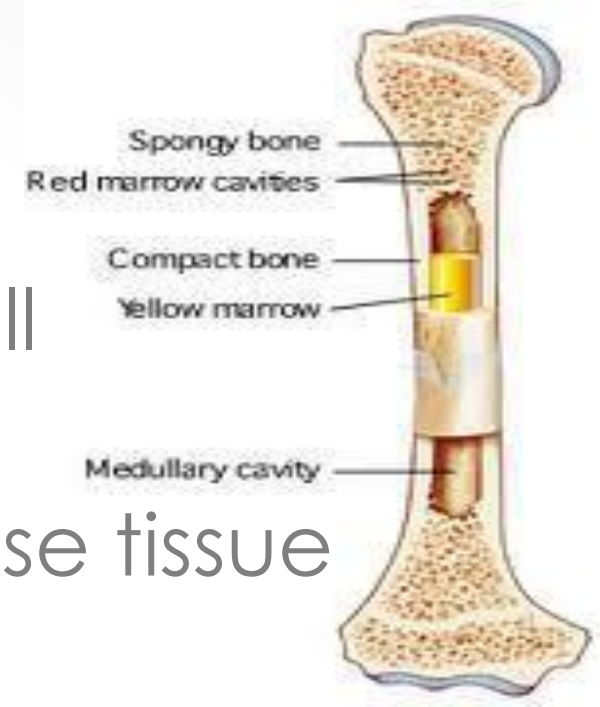
- **Long Bone-** longer then they are wide
  - Ex. Femur & humerus
- **Short Bone-** about as wide as long
  - Ex. Carpals & tarsals
- **Flat Bone-** very thin, flattened shape and are usually curved.
  - Ex. Ribs, sternum, scapulae
- **Irregular Bone-** shapes that do not fit into the other 3 categories
  - Ex. Vertebrae & facial

Anatomy of a Long Bone



- Diaphysis = shaft
- Epiphysis = one end of a long bone
- Metaphysis = growth plate region
- Articular cartilage over joint surfaces acts as friction & shock absorber
- Medullary cavity = marrow cavity
- Endosteum = lining of marrow cavity
- Periosteum = tough membrane covering bone but not the cartilage
  - fibrous layer = dense irregular CT
  - osteogenic layer = bone cells & blood vessels that nourish or help with repairs

Types of Marrow

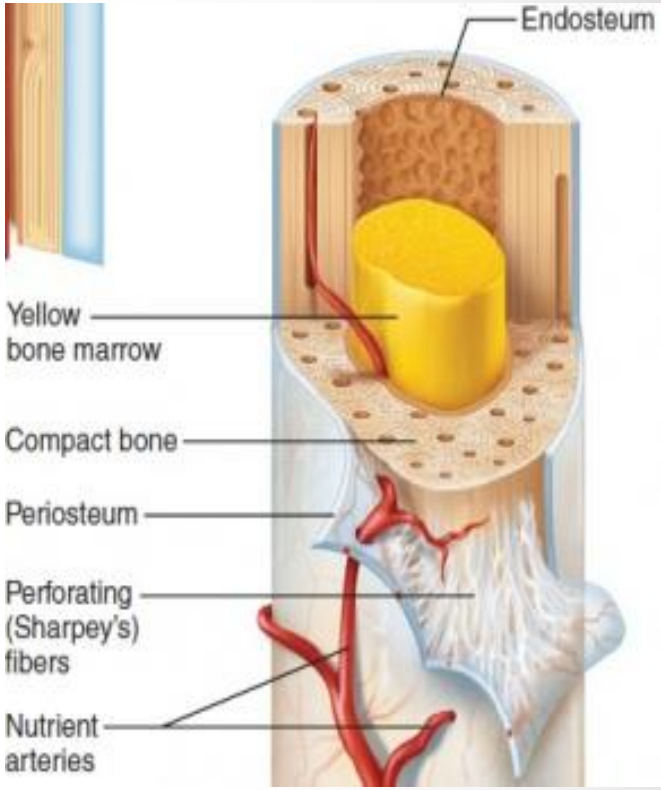


- **Red Marrow-** site of blood cell formation
- **Yellow Marrow-** mostly adipose tissue

- At birth- mostly red marrow
- Adulthood- yellow marrow replaces, except in the proximal ends of the long bone

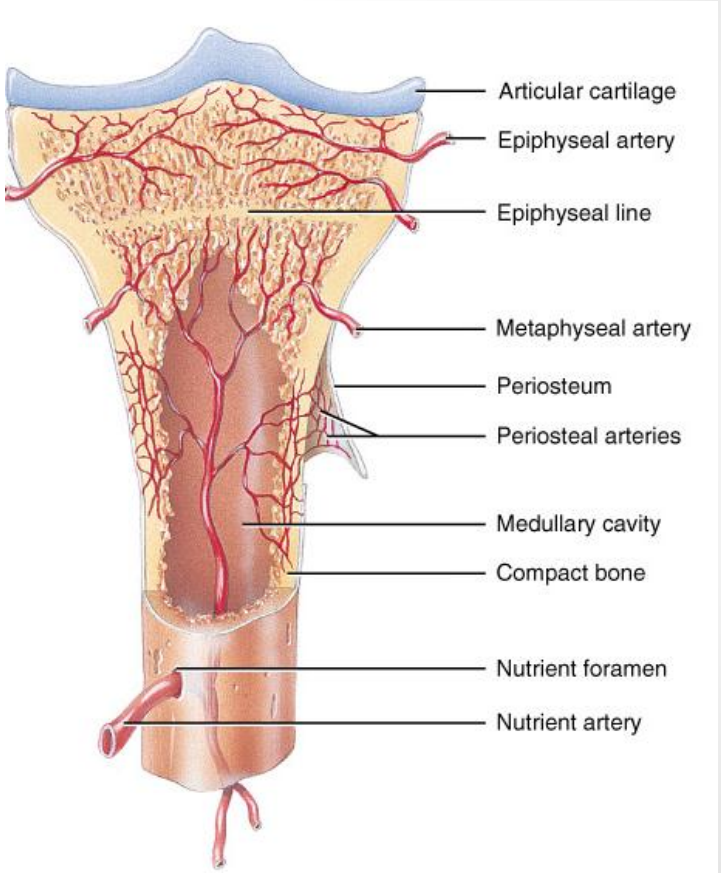
Bone Membranes & Linings

- **Periosteum**- connective tissue membrane the covers the outer surface of bone
  - Vascular and has nerves
- **Endosteum**- single layer of cells lining the internal surfaces of all cavities within bone



Blood and Nerve Supply of Bone

- **Periosteal arteries**
  - supply periosteum
- **Nutrient arteries**
  - enter through nutrient foramen
  - supplies compact bone of diaphysis & red marrow
- **Metaphyseal & epiphyseal aa.**
  - supply red marrow & bone tissue of epiphyses

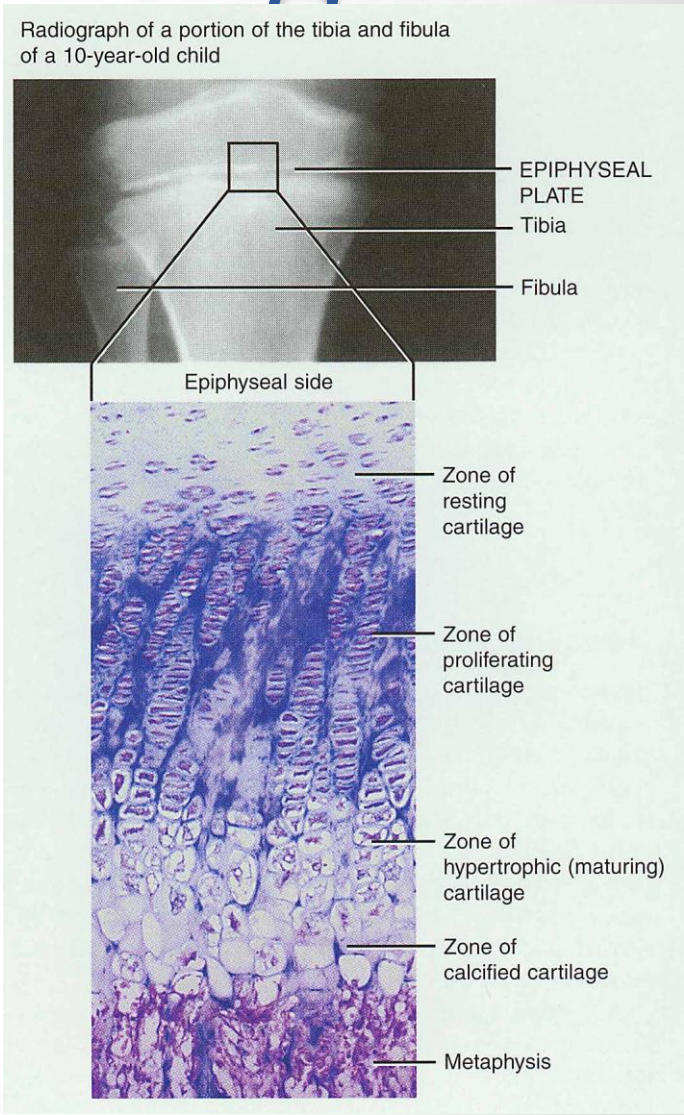


Bone Formation or Ossification

- Intramembranous bone formation = formation of bone directly from mesenchymal cells (embryo).
  - They become stem cells which can replicate to make specialized cells & more stem cells
    - Specialized stem bone cells – osteochondral progenitor cells
- Endochondral ossification = formation of bone within hyaline cartilage.
  - Chondrocytes release matrix vesicles, which initiate the formation of hydroxyapatie crystals
  - (minerals)

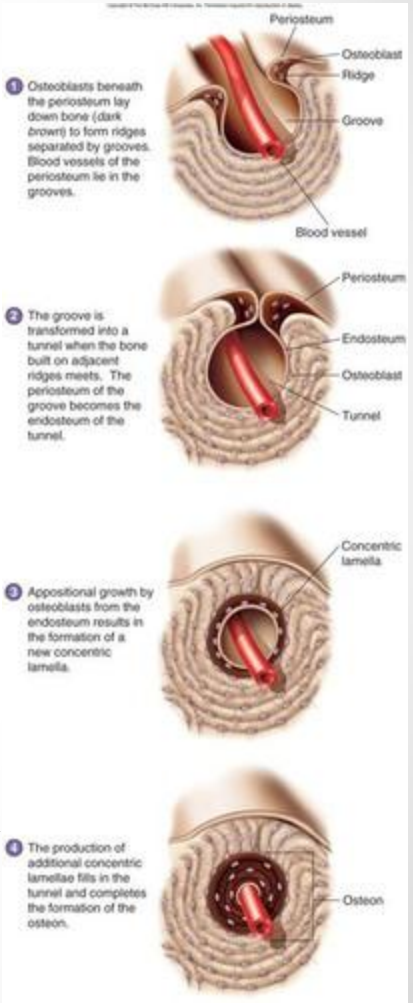
Bone Growth in Length

- Epiphyseal plate or cartilage growth plate
  - cartilage cells are produced by mitosis on epiphyseal side of plate
  - cartilage cells are destroyed and replaced by bone on diaphyseal side of plate
- Between ages 18 to 25, epiphyseal plates close.
  - cartilage cells stop dividing and bone replaces the cartilage (epiphyseal line)
- Growth in length stops at age 25



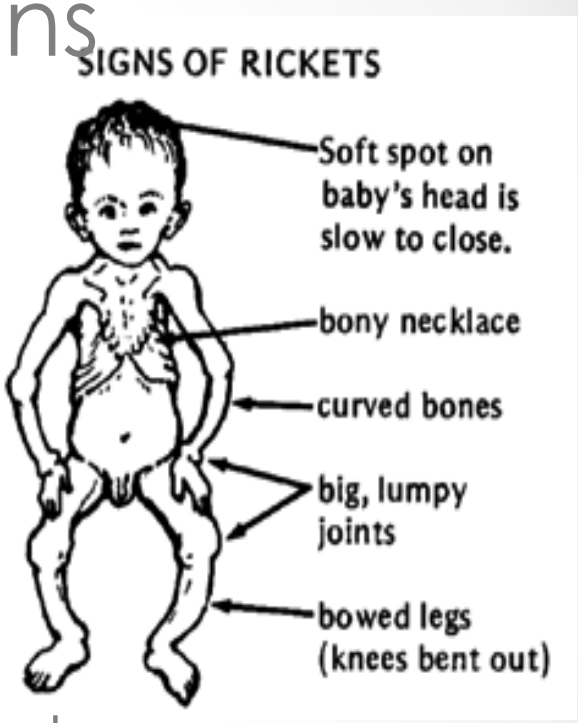
Long Bone Width Growth

- Growth in Bone Width is most rapid in young bone or at puberty.
  - Osteoblasts from periosteum lay down bone in ridges with grooves.
  - Blood vessels lie within each groove
  - More bone production causes grooves to become tunnels and the inner lining becomes endosteum
    - Osteoblasts in endosteum lay down mor bone in concentric lamella = onsteons



Factors Affecting Bone Growth

- **Nutrition**- intake of vitamins & minerals that support cartilage and bone growth
  - **Vitamin D**: normal absorption of calcium from intestines.
    - Taken in through diet
    - Synthesized due to skin exposure to sunlight
  - Lack of = **rickets** in children: bowed bones with enflamed joints &
- **osteomalacia** in adults: soft bones



Factors Affecting Bone Growth

- **Hormones-** GH (growth hormone) from the pituitary gland cause tissue growth
  - **Excess GH =** giantism is an abnormal increase in height
  - **Genetic factors =** Acromegaly is the increase in diameter or thickness of bone after 18-25
  - **Genetic factors** = Acondroplasia (dwarism) is abnormally short limbs with normal trunk and head
  - **Low GH** = P. Dwarfism is a totally smaller person in porportion
  - **Sex Hormones**
    - **Males = testosterone at puberty: slow ossifier**
    - **Females = estrogen at puberty: quick ossifier**

Bone Remodeling

- Ongoing through out life
  - osteoclasts remove old bone through enzyme release and osteoblast deposit new bone
    - In compact bone removal is from the inside (endosteum & medullary cavity) and renewal is on the outside (periosteum)
- Continual redistribution of bone matrix along lines of mechanical stress
  - distal femur is fully remodeled every 4 months
  - Use it or loose it!!!

Exercise & Bone Tissue

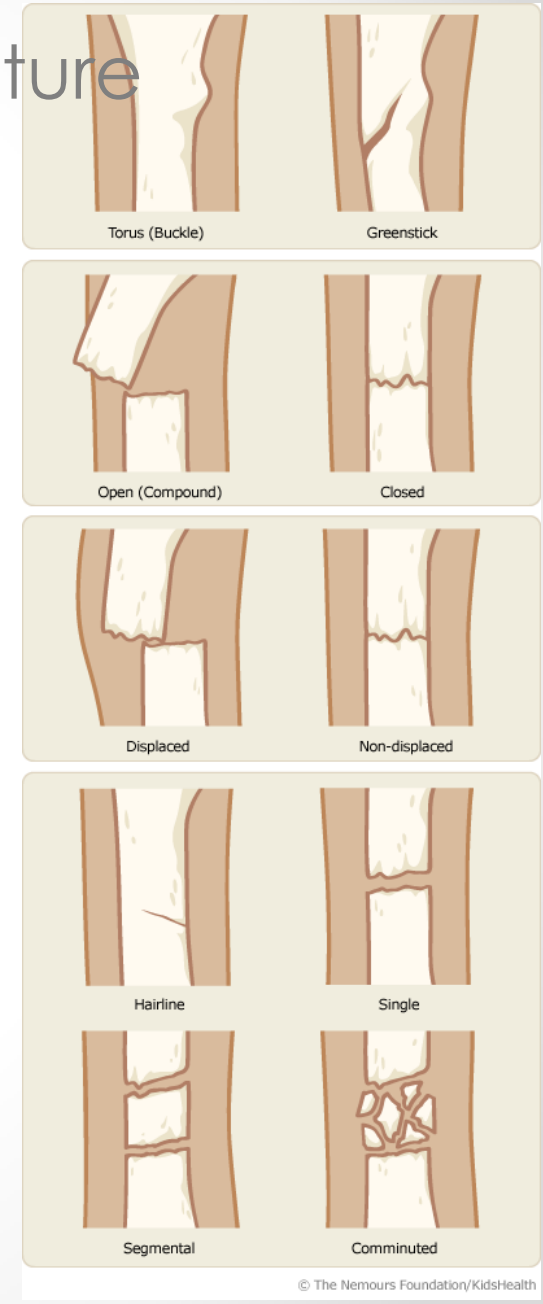
- Pull on bone by skeletal muscle and gravity is mechanical stress .
- Stress increases deposition of mineral salts & production of collagen (calcitonin prevents bone loss)
- Lack of mechanical stress results in bone loss
  - reduced activity while in a cast
  - astronauts in weightlessness
  - bedridden person
- Weight-bearing exercises build bone mass (walking or weight-lifting)

Fracture & Repair of Bone

- Fracture is break in a bone
- Healing is faster in bone than in cartilage due to lack of blood vessels in cartilage
- Healing of bone is still slow process due to vessel damage
  - Increased mechanical stress on bone –increased healing speed
- Clinical treatment
  - closed reduction = restore pieces to normal position by manipulation
  - open reduction = surgery

Fractures

- Named for shape or position of fracture line
- Common types of fracture
  - Closed (simple) -- no break in skin
  - Open (compound)--skin broken
  - comminuted -- broken ends of bones are fragmented
  - greenstick -- partial fracture
  - impacted -- one side of fracture driven into the interior of other side
  - Spiral – helical course around bone
  - oblique – runs obliquely in relation to the long axis of the bone
  - stress fracture -- microscopic fissures
    - from repeated strenuous activities



4 Steps of Bone Repair

- Hematoma Formation- localized mass of blood forms around fracture to form a clot
- Callus Formation- mass of tissue forms at site and clot is dissolved by macrophages. It consists of dense fibrous networks
- Callus Ossification- cancellous bone replaces the calluses. Immobilization is critical at this point (4-6 wks)
- Bone Remodeling- compact bone replaces cancellous bone and internal callus is removed restoring the medullary cavity (may take up to 1 yr)
  - TIDBIT: This process takes lots of calories!

Calcium Homeostasis & Bone Tissue

- Skeleton is reservoir of Calcium & Phosphate
- Calcium ions involved with many body systems
  - nerve & muscle cell function
  - blood clotting
  - enzyme function in many biochemical reactions
- Osteoblast activity = osteoclast activity = balance
- 2 Hormones regulation Ca^{+2} Levels
  - **Parathyroid hormone** (PTH): increases & decreases Ca^{+2} levels in blood
  - **Calcitonin**: decrease blood Ca^{+2} and osteoclast production

Aging & Bone Tissue

- Bone is being built through adolescence, holds its own in young adults, but is gradually lost in aged.
- Decrease in collagen & osteoblast production
- Peak of bone mass = 30
- Demineralization = loss of minerals
  - very rapid in women 40-45 as estrogens levels decrease
  - in males, begins after age 60

- Again: if you don't use it, you loose it

Osteoporosis

- Decreased bone mass resulting in porous bones
- Those at risk
  - white, thin, menopausal, smoking, drinking female with family history
  - athletes who are not menstruating due to decreased body fat & decreased estrogen levels
  - people allergic to milk or with eating disorders whose intake of calcium is too low
- Prevention or decrease in severity
  - adequate diet, weight-bearing exercise, & estrogen replacement therapy (for menopausal women)
  - behavior when young may be most important factor