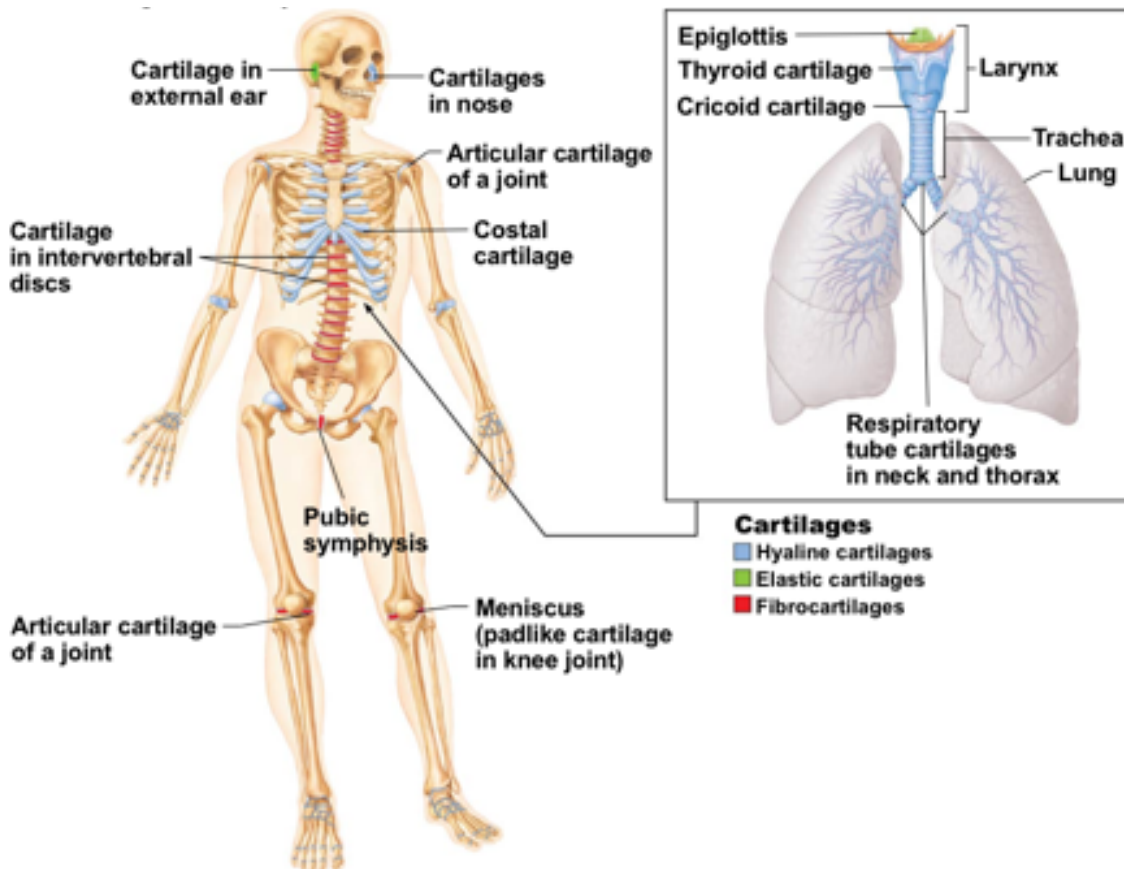


Bones and Skeletal Tissues

Dr. Gary Mumaugh – Campbellsville University

Cartilage

- Location and basic structure of cartilages
 - Found throughout adult body
 - *Cartilage in the external ear*
 - *Cartilage of the nose*
 - *Articular cartilages and costal cartilage*
 - *Cartilages in the larynx and trachea*
 - *Intervertebral discs, pubic symphysis, and articular discs*
- Perichondrium
 - Surrounds cartilages
 - Resists outward pressure
 - Functions in growth and repair of cartilage
- Consists primarily of water
- Is a resilient tissue
 - Springs back to original shape



Types of Cartilage

- All cartilages share some similarities
 - Cell type is the chondrocyte
 - Chondrocytes are located within lacunae
 - Matrix contains
 - *Fibers*
 - Jellylike ground substance

Hyaline cartilage

- Most abundant cartilage
- Chondrocytes appear spherical
- Collagen unit fibril is the only type of fiber in the matrix
- Ground substance holds a large amount of water
- Provides support through flexibility

Elastic cartilage

- Contains many elastic fibers
- Able to tolerate repeated bending
- Locations—epiglottis and cartilage of external ear

Fibrocartilage

- Resists strong compression and strong tension
- An intermediate between hyaline and elastic cartilage
- Locations—pubic symphysis, menisci of knee, anulus fibrosus

Tissues in Bone

- Bones contain several types of tissues
 - Dominated by bone connective tissue
 - Contain nervous tissue and blood connective tissue
 - Contain cartilage in articular cartilages
 - Contain epithelial tissue lining blood vessels

Function of Bones

- Support – form the framework that supports the body and cradles soft organs
- Protection – provide a protective case for the brain, spinal cord, and vital organs
- Movement – provide levers for muscles
- Mineral storage – reservoir for minerals, especially calcium and phosphorus
- Blood cell formation – hematopoiesis occurs within the marrow cavities of bones

Bone Tissue

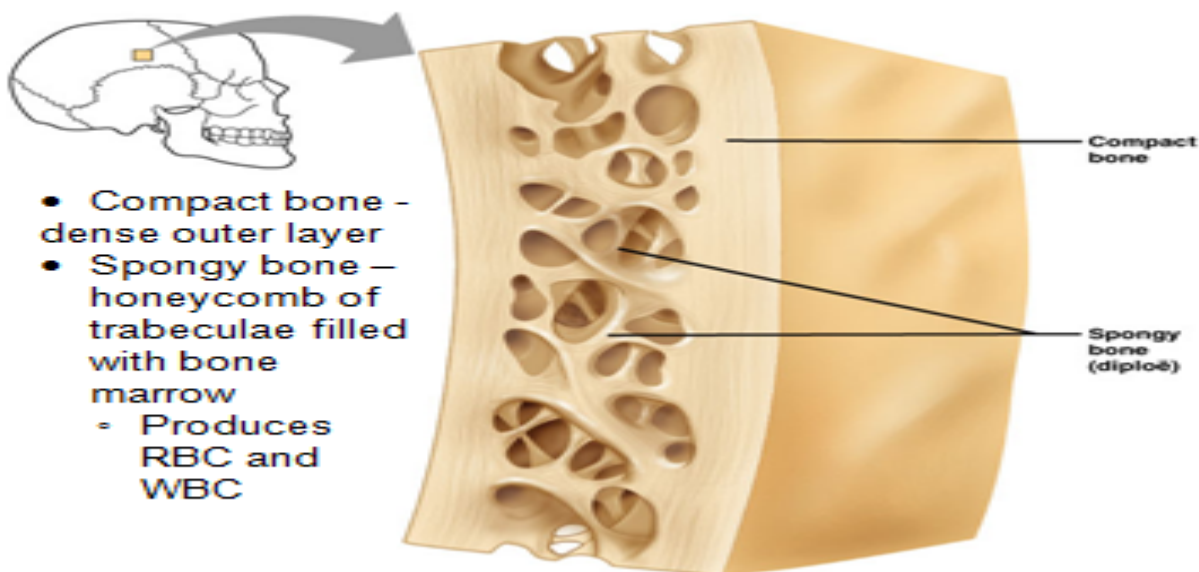
- Bone tissue
 - Organic components
- *Cells, fibers, and ground substance*
 - Inorganic components
- *Mineral salts that invade bony matrix*

Extracellular Matrix

- Unique composition of matrix
 - Gives bone exceptional properties
 - 35%—organic components
- *Contribute to flexibility and tensile strength*
 - 65%—inorganic components
- *Provide exceptional hardness, resist compression*

Cells

- Three types of cells in bone produce or maintain bone
 - Osteogenic cells—stem cells that differentiate into osteoblasts
 - Osteoblasts—actively produce and secrete bone matrix
- *Bone matrix is osteoid*
 - Osteocytes—keep bone matrix healthy
 - Osteoclasts
 - Found within bone tissue
 - Responsible for resorption of bone
 - Are derived from a line of white blood cells
 - Secrete hydrochloric acid and lysosomal enzymes

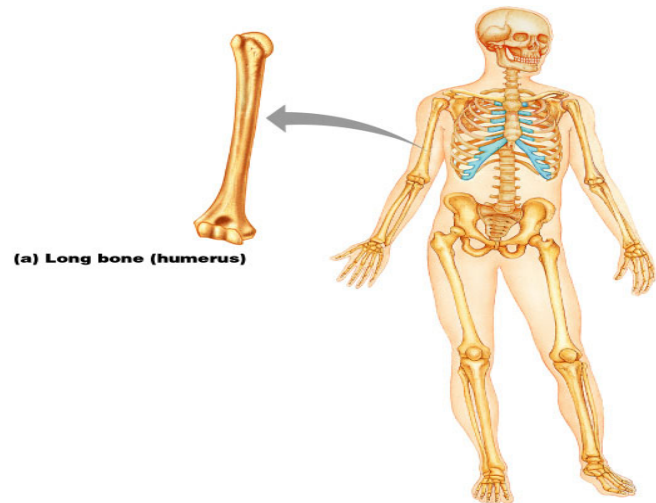


Shape of Bones

- Long bones
- Short bones
- Flat bones
- Irregular bones

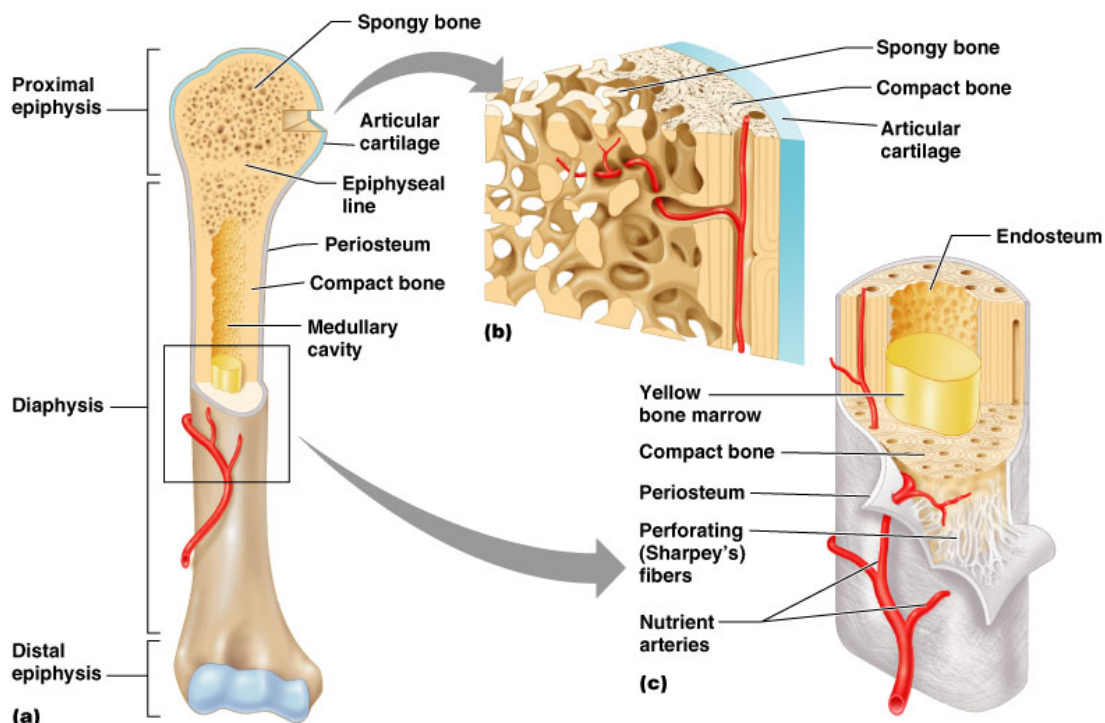
Long Bones

- Long bones – longer than they are wide
- Humerus, radius, ulna
- Femur, tibia, fibula



Structure of Long Bones

- Diaphysis
 - Tubular shaft that forms the axis of long bones
- Epiphyses
 - Expanded ends of long bones
 - Joint surface is covered with articular (hyaline) cartilage
 - Epiphyseal line separates the diaphysis from the epiphyses
- Blood vessels—well vascularized
- Medullary cavity—hollow cavity filled with yellow marrow
- Membranes
 - Periosteum, perforating collagen fiber bundles (Sharpey's fibers), and endosteum

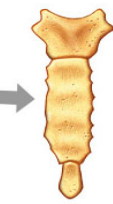
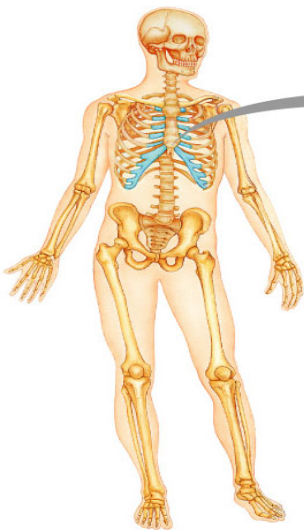


Short Bones

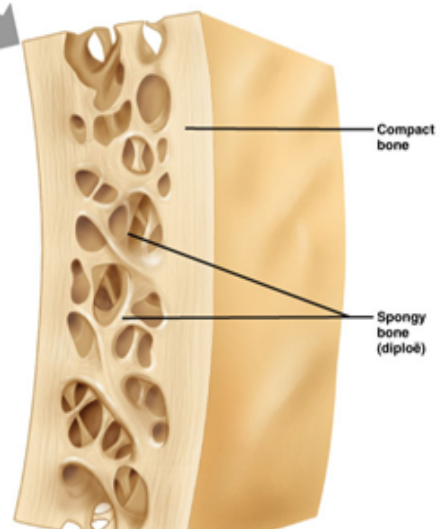
- Short bones
 - Bones of the wrist and ankle
 - Bones that form within tendons (e.g., patella)

Flat Bones

- Flat bones – thin, flattened, and a bit curved (e.g., sternum, and most skull bones)

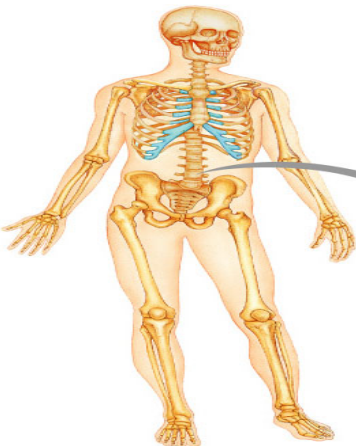


(c) Flat bone (sternum)

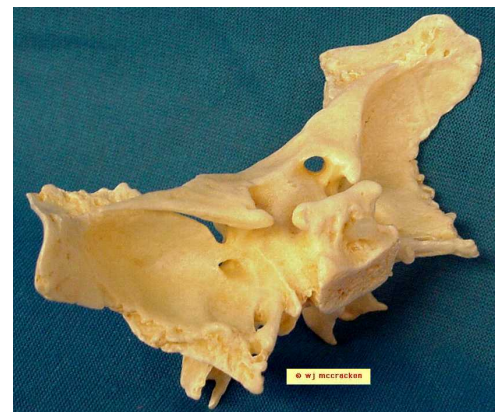


Irregular Bones

- Irregular bones – bones with complicated shapes (e.g., vertebrae and hip bones)

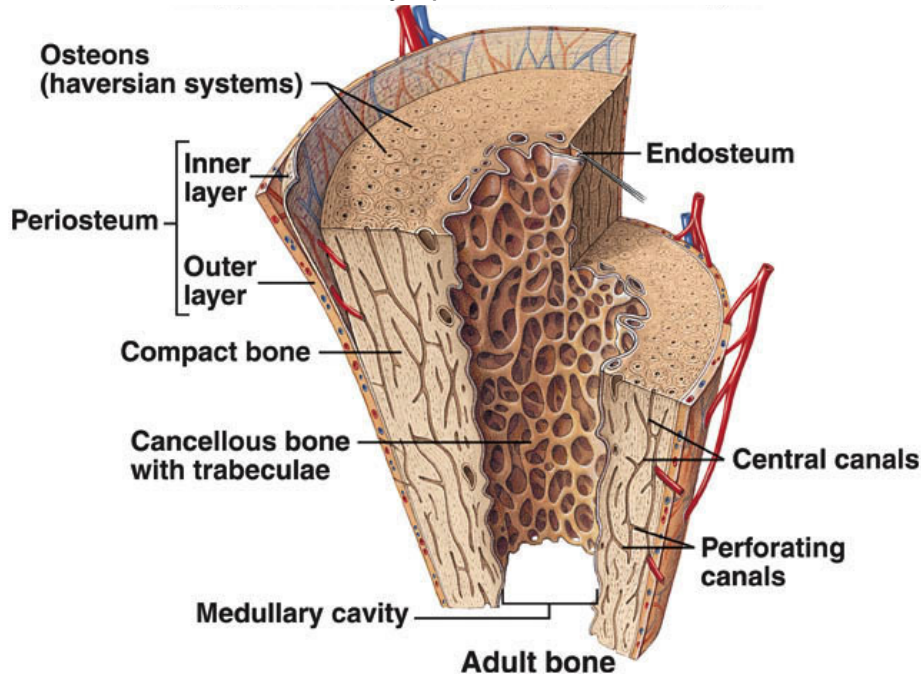


(d) Irregular bone (vertebra),
left lateral view



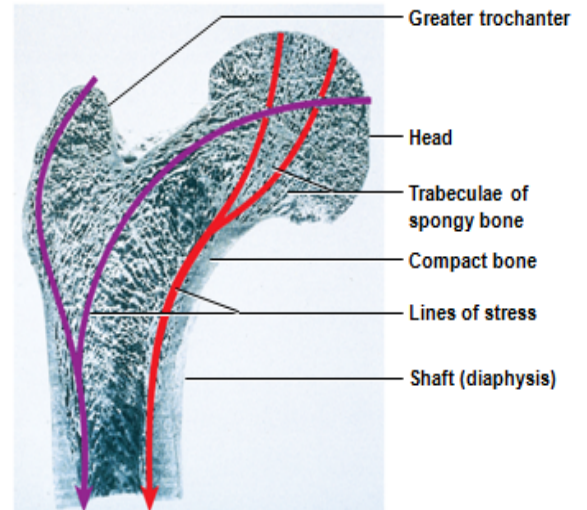
Bone Membranes

- Periosteum – double-layered protective membrane
 - Outer fibrous layer is dense regular connective tissue
 - Richly supplied with nerve fibers, blood, and lymphatic vessels, which enter the



surfaces of bone

Design of Spongy Bone

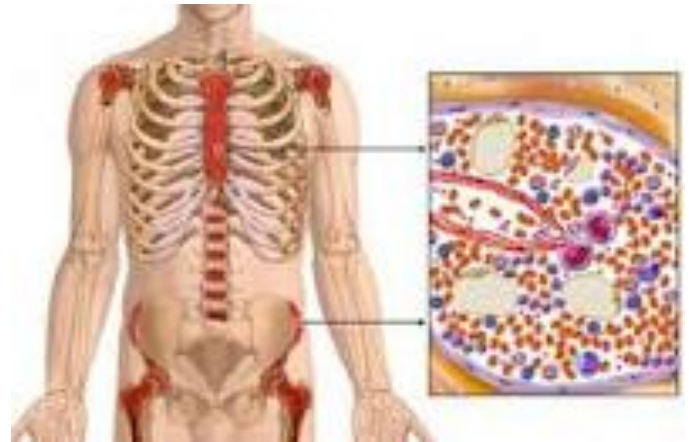


bone via nutrient foramina

- Endosteum – delicate membrane covering internal

Bone Marrow

- Bone marrow – general term for soft tissue that occupies the marrow cavity of a long bone and small spaces amid the trabeculae of spongy bone
- Red marrow
 - in nearly every bone in a child
 - hemopoietic tissue - produces blood cells
 - in adults, found in skull, vertebrae, ribs, sternum, part of pelvic girdle, and proximal heads of humerus and femur
- Yellow marrow found in adults
 - most red marrow turns into fatty yellow marrow
 - no longer produces blood

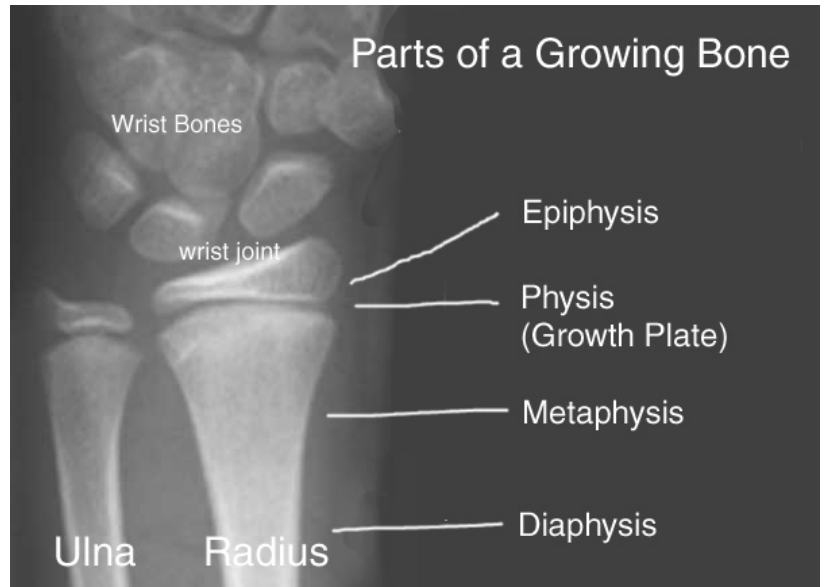


Bone Development

- ossification or osteogenesis – the formation of bone
- in the human fetus and infant, bone develops by two methods:
 - intramembranous ossification
 - endochondral ossification

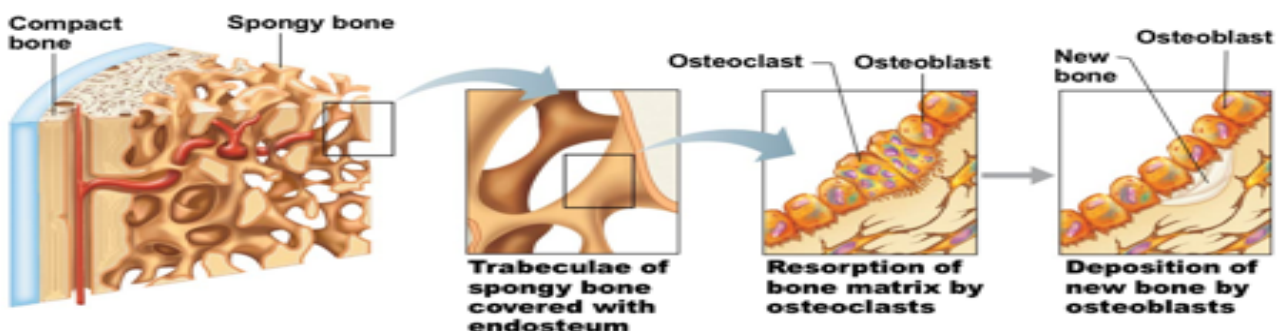
Bone Growth

- ossification continues throughout life with the growth and remodeling of bones
- bones grow in two directions: length and width
- bone elongation
 - Epiphyseal plate – a region of transition from cartilage to bone
 - functions as growth zone where the bones elongate
 - consists of typical hyaline cartilage in the middle
 - with a transition zone on each side where cartilage is being replaced by bone



Bone Remodeling

- Bone is a dynamic living tissue
 - 500 mg of calcium may enter or leave the adult skeleton each day
 - Bone matrix and osteocytes are continually removed and replaced
 - Cancellous bone of the skeleton is replaced every 3–4 years
 - Compact bone is replaced every 10 years
- Bone deposit and removal
 - Occurs at periosteal and endosteal surfaces
- Bone remodeling
 - Bone deposition—accomplished by osteoblasts
 - Bone reabsorption—accomplished by osteoclasts



Postnatal Growth of Endochondral Bones

- During childhood and adolescence:
 - Bones lengthen entirely by growth of the epiphyseal plates
 - Cartilage is replaced with bone connective tissue as quickly as it grows
 - Epiphyseal plate maintains constant thickness
 - Whole bone lengthens

Postnatal Growth of Endochondral Bones

- As adolescence draws to an end:
 - Chondroblasts divide less often
 - Epiphyseal plates become thinner
 - *Cartilage stops growing*
 - *Replaced by bone tissue*
- Long bones stop lengthening when diaphysis and epiphysis fuse

Postnatal Growth of Endochondral Bones

- Growing bones widen as they lengthen
 - Osteoblasts—add bone tissue to the external surface of the diaphysis
 - Osteoclasts—remove bone from the internal surface of the diaphysis
- Appositional growth—growth of a bone by addition of bone tissue to its surface

Factors Affecting Bone Growth

- Heredity
- Nutrition
 - Calcium, phosphorus, protein, Vitamin D, A, C
- Hormones
- Exercise or “stress”
 - Without bones becoming weight bearing, they lose calcium

Hormonal Regulation of Bone Growth During Youth

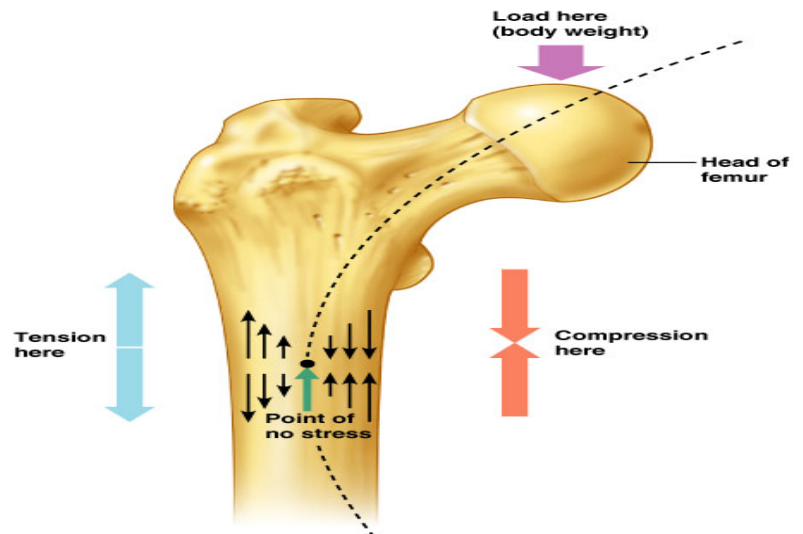
- During infancy and childhood, epiphyseal plate activity is stimulated by growth hormone
- During puberty, testosterone and estrogens:
 - Initially promote adolescent growth spurts
 - Cause masculinization and feminization of specific parts of the skeleton
 - Later induce epiphyseal plate closure, ending longitudinal bone growth

Importance of Ionic Calcium in the Body

- Calcium is necessary for:
 - Transmission of nerve impulses
 - Muscle contraction
 - Blood coagulation
 - Secretion by glands and nerve cells
 - Cell division

Response to Mechanical Stress

- Wolff's law – a bone grows or remodels in response to the forces or demands placed upon it
- Observations supporting Wolff's law include
 - Long bones are thickest midway along the shaft (where bending stress is greatest)
 - Curved bones are thickest where they are most likely to buckle



Bone Markings

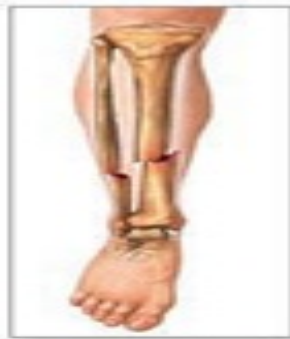
- Superficial surfaces of bones reflect stresses on them
- There are three broad categories of bone markings:
 - Projections for muscle attachment
 - Surfaces that form joints
 - Depressions and openings

Bone Fractures (Breaks)

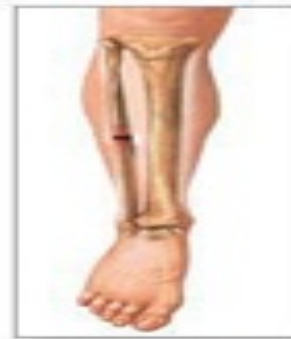
- Bone fractures are classified by:
 - The position of the bone ends after fracture
 - The completeness of the break
 - The orientation of the bone to the long axis
 - Whether or not the bones ends penetrate the skin
- Types of Bone Fractures
 - Compound (open) – bone ends penetrate the skin
 - Simple (closed) – bone ends do not penetrate the skin
 - Greenstick – incomplete fracture where one side of the bone breaks and the other side bends; common in children
 - Comminuted – bone fragments into three or more pieces; common in the elderly
 - Compression – bone is crushed; common in porous bones



Greenstick (incomplete)



Transverse



Simple

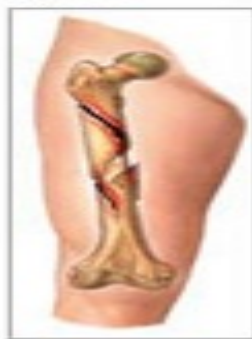
Fracture types



Oblique



Comminuted



Spiral



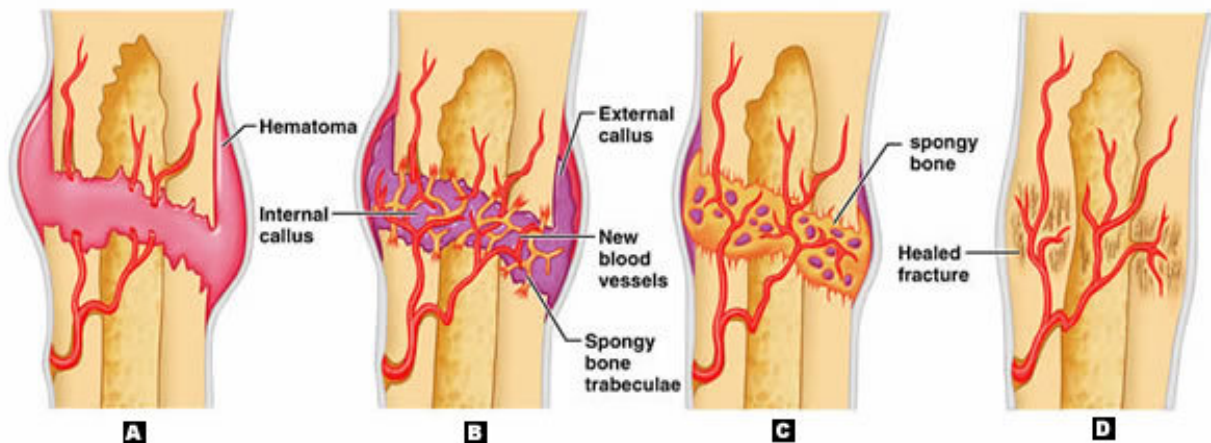
Compound



Stages in the Healing of a Bone Fracture

- Hematoma formation A
 - Torn blood vessels hemorrhage
 - A mass of clotted blood (hematoma) forms at the fracture site
 - Site becomes swollen, painful, and inflamed
- Fibrocartilaginous callus forms B
- Bony callus formation C

- Bone callus begins 3-4 weeks after injury, and continues until firm union is formed 2-3 months later
- **Bone remodeling**
 - Excess material on the bone shaft exterior and in the medullary canal is removed
 - Compact bone is laid down to reconstruct shaft walls



The Skeleton Throughout Life

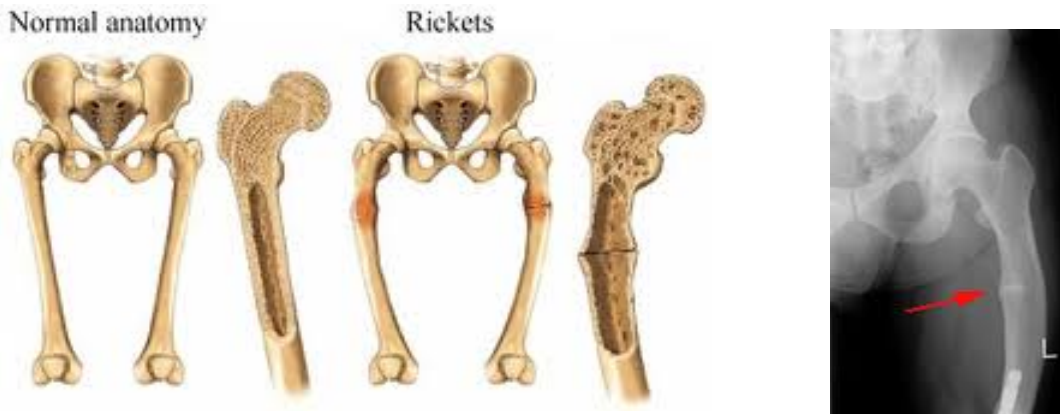
- Cartilage grows quickly in youth
- Skeleton shows fewer chondrocytes in the elderly
- Bones are a timetable
 - Mesoderm - Gives rise to embryonic mesenchyme cells
 - Mesenchyme - Produces membranes and cartilage
 - Membranes and cartilage ossify

The Skeleton Throughout Life

- Skeleton grows until the age of 18–21 years
- In children and adolescents, bone formation exceeds rate of bone reabsorption
- In young adults, bone formation and bone reabsorption are in balance
- In old age, reabsorption predominates
- Bone mass declines with age

Homeostatic Imbalances

- **Osteomalacia**
 - Bones are inadequately mineralized causing softened, weakened bones
 - Main symptom is pain when weight is put on the affected bone
 - Caused by insufficient calcium in the diet, or by vitamin D deficiency
- **Rickets**
 - Bones of children are inadequately mineralized causing softened, weakened bones
 - Bowed legs and deformities of the pelvis, skull, and rib cage are common
 - Caused by insufficient calcium in the diet, or by vitamin D deficiency



- **Osteopenia**
 - Normal bone demineralization seen after 35-40 years old
- **Osteoporosis**
 - Spongy bone of the spine is most vulnerable
 - Occurs most often in postmenopausal women
 - Bones become so fragile that sneezing or stepping off a curb can cause fractures
 - **Osteoporosis Treatment**
 - **Calcium and vitamin D supplements**
 - 1200 mg. of calcium per day
 - Increased weight-bearing exercise
 - Hormone (estrogen) replacement therapy (HRT) slows bone loss
 - Natural progesterone cream prompts new bone growth

