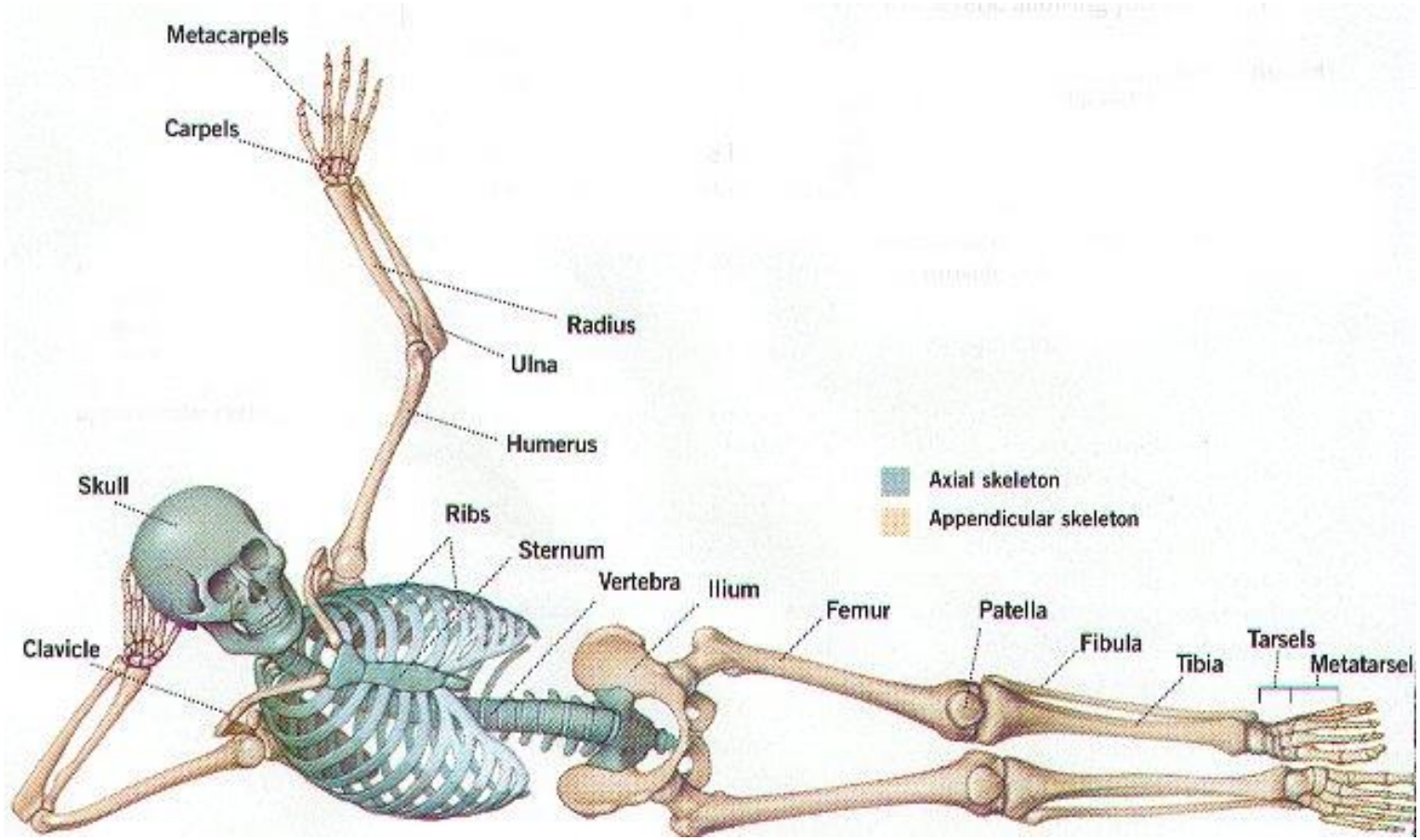
Skeletal System



Functions

1) Support – internal framework that supports and anchors all soft organs
2) Protection – skull protects brain
3) Movement – skeletal muscles attach to bones
4) Storage – store minerals (Ca, P, and electrolytes) and fats
5) Blood cell formation – (hematopoiesis) occurs within marrow cavities

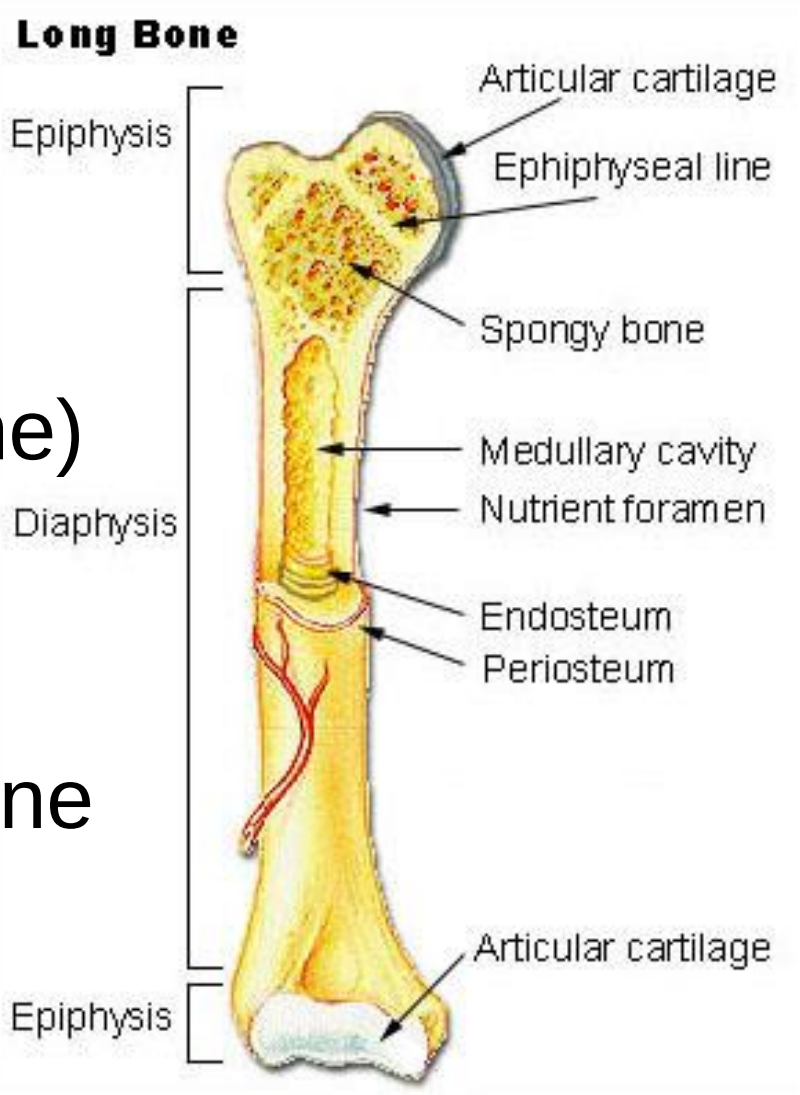
2 Divisions of Skeletal System

- Axial skeleton – skull, vertebral column, and bony thorax

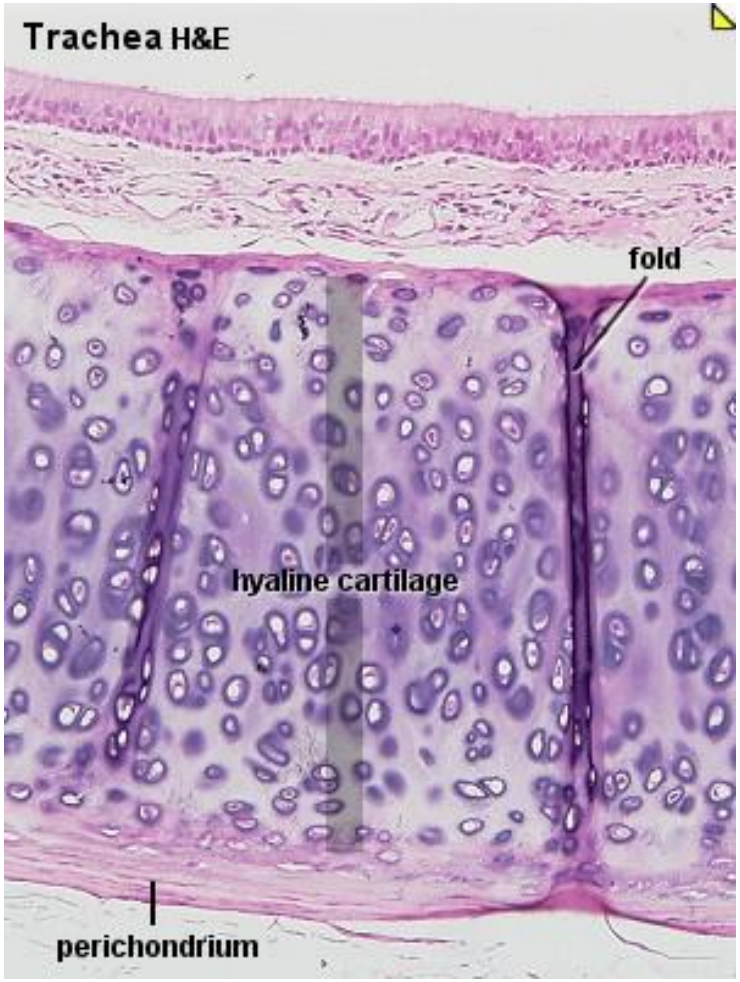
- Appendicular skeleton – arms, legs, shoulder, and pelvis

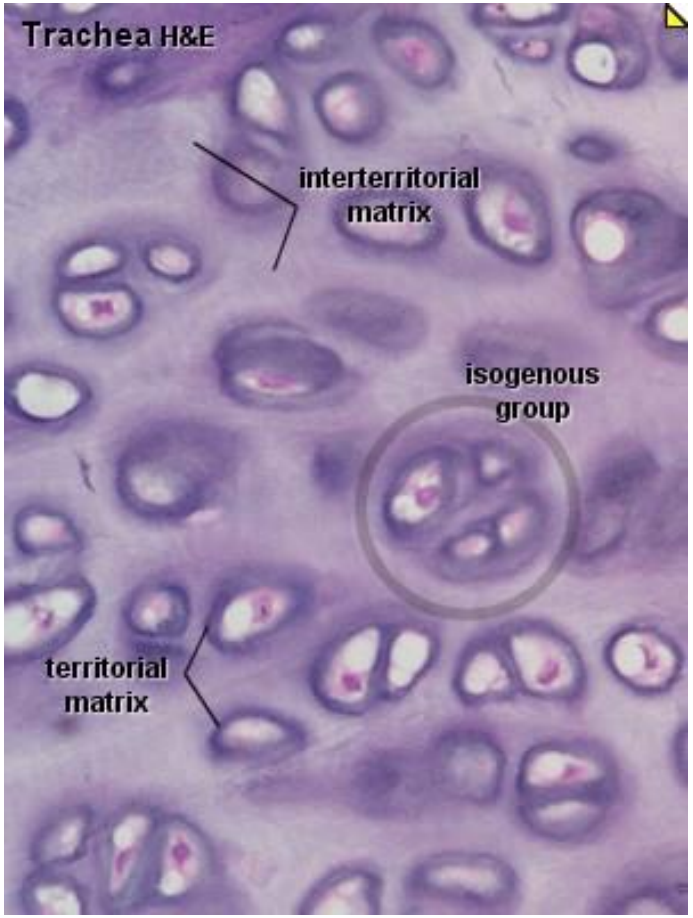
Structure of Long Bone

- Periosteum
- Diaphysis
- Epiphysis
- Articular cartilage (hyaline)
- Epiphyseal plate or line
- Yellow and red marrow
- Compact and spongy bone

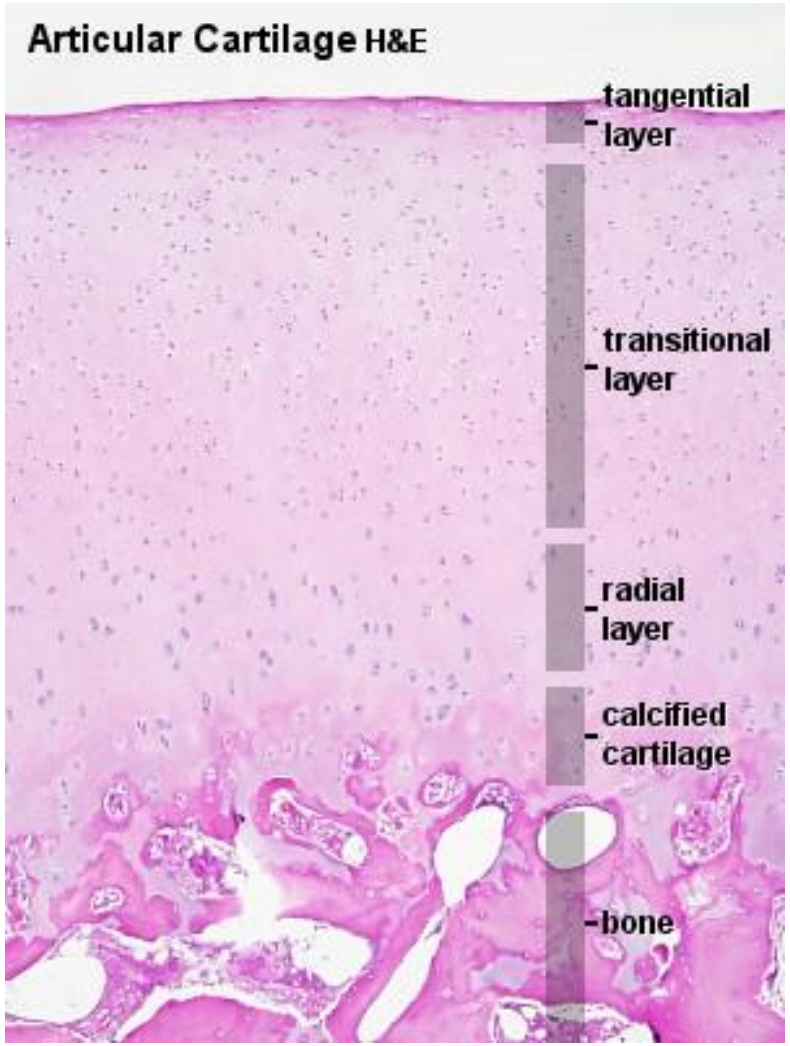


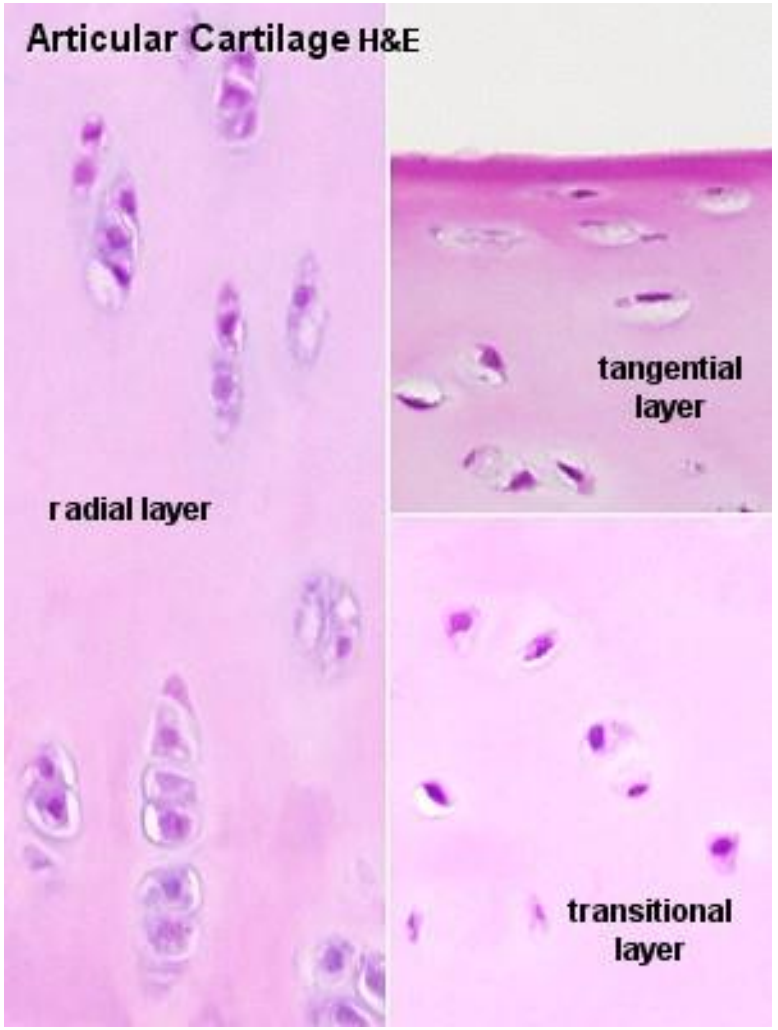
Hyaline Cartilage





Articular Cartilage (Hyaline)





Compact vs. Spongy Bone

- Compact = dense and smooth

- Spongy = small needle-like pieces of bone and contains mostly open space

Bone Shapes

- Long bone – femur, humerus, ulna, tibia
- Short bone – carpals, tarsals
- Flat bone – skull, ribs, sternum
- Irregular bone – vertebrae, pelvic bones
- Sesmoid bone – patella

Bony Markings

- Projections and processes – sites of soft tissue attachment
  - Ex: tuberosity, malleoli, epicondyle, trochanter
- Depressions, cavities, and holes – places were nerves and blood vessels can pass
  - Ex: foramen, fossa

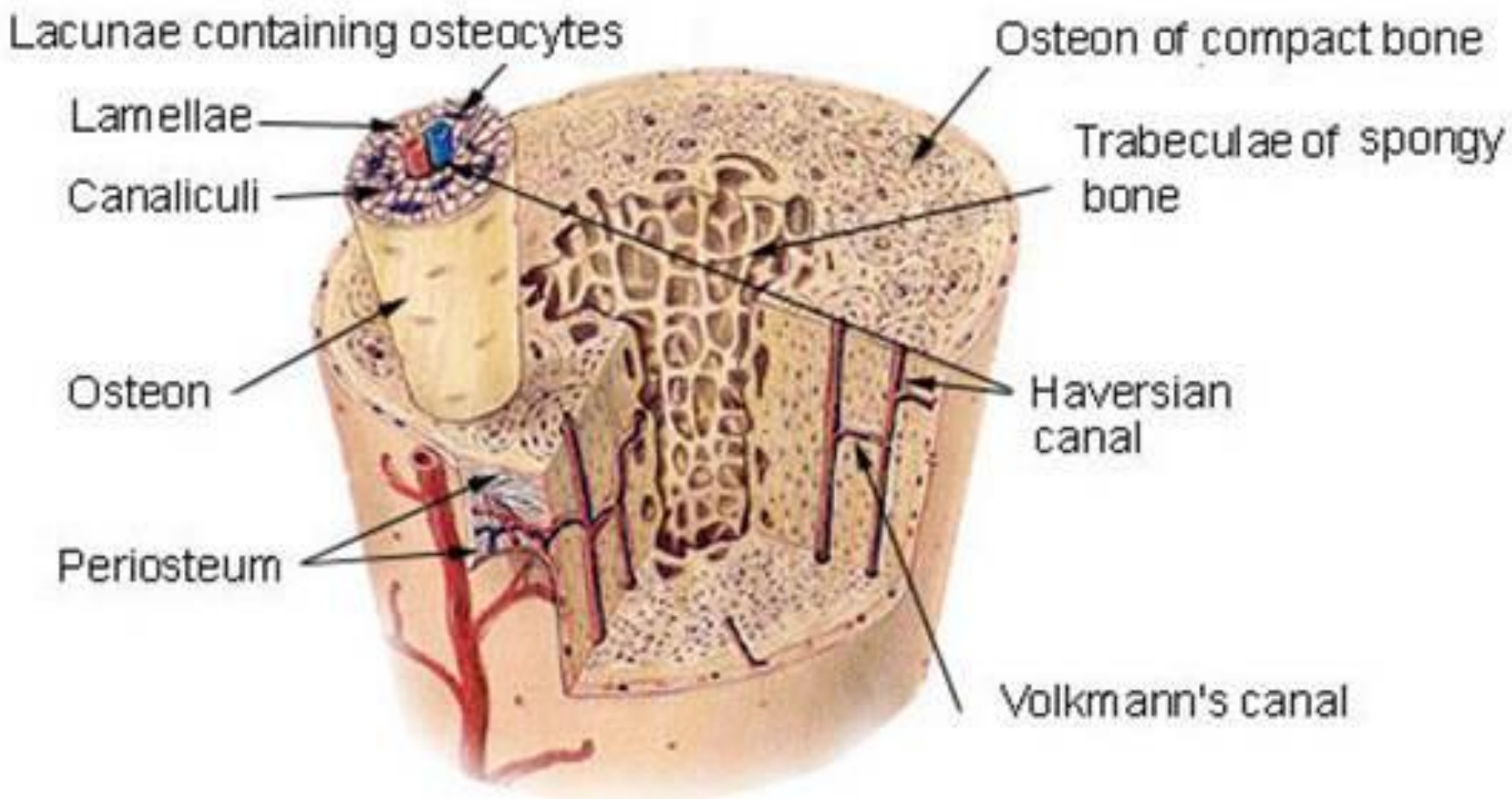
Types of Cells

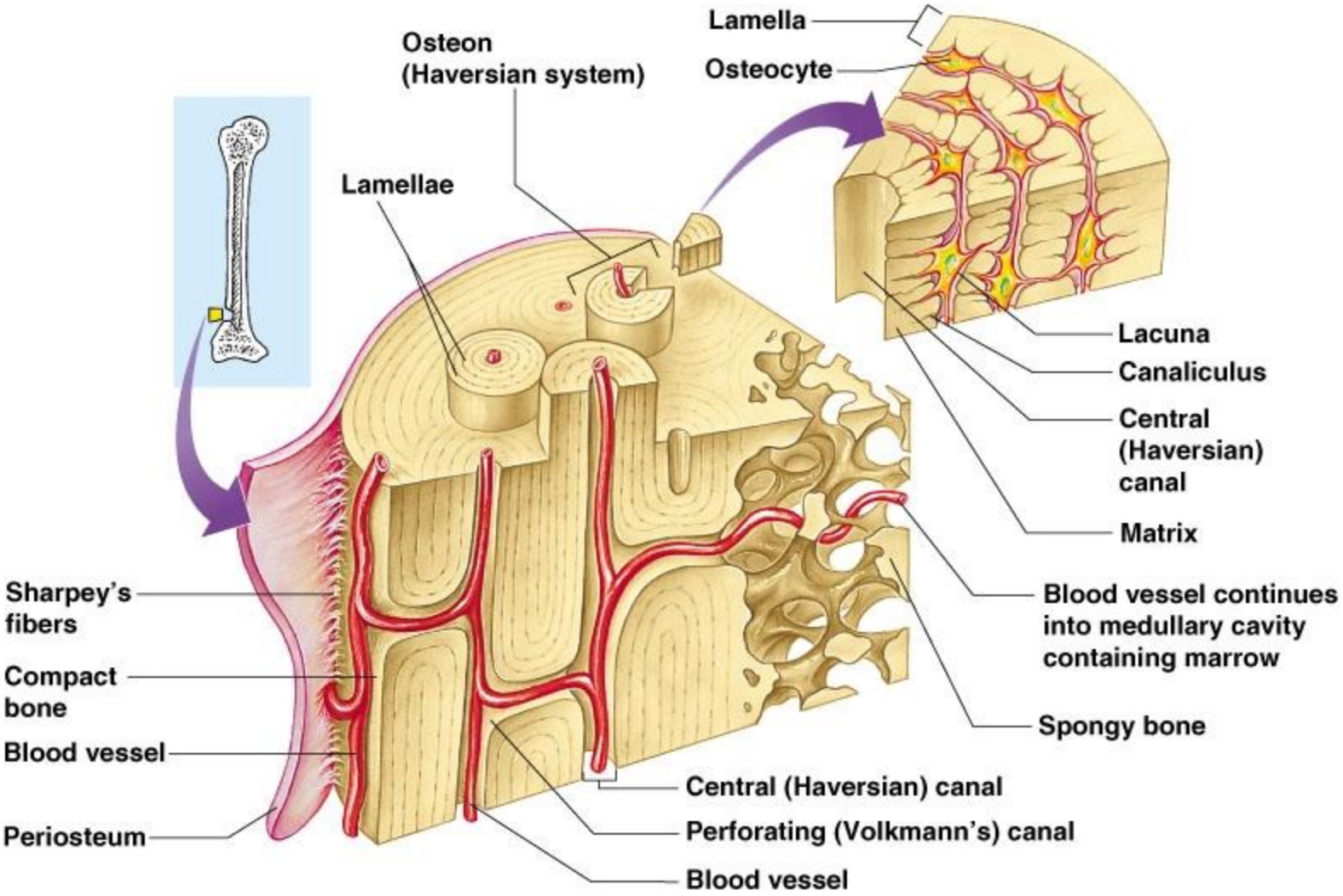
- Osteocytes – inactive osteoblasts that become trapped in the matrix
  - Mature bone cells
- Osteoblasts – bone forming cells
- Osteoclasts – destroys and reabsorbed worn bone tissue

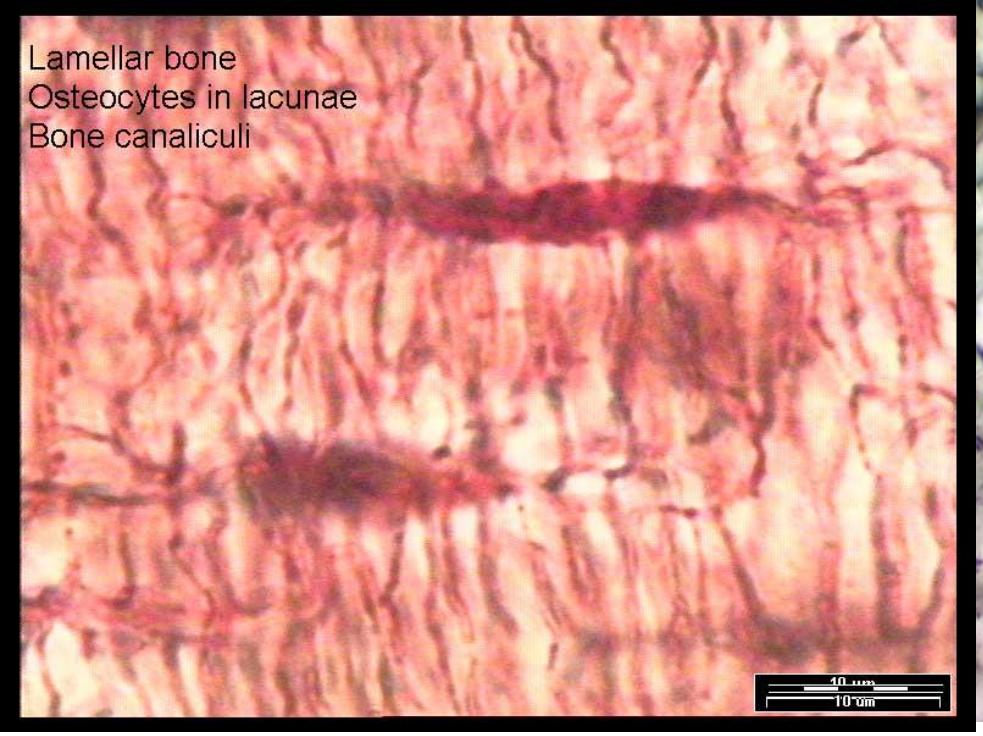
Microscopic Anatomy

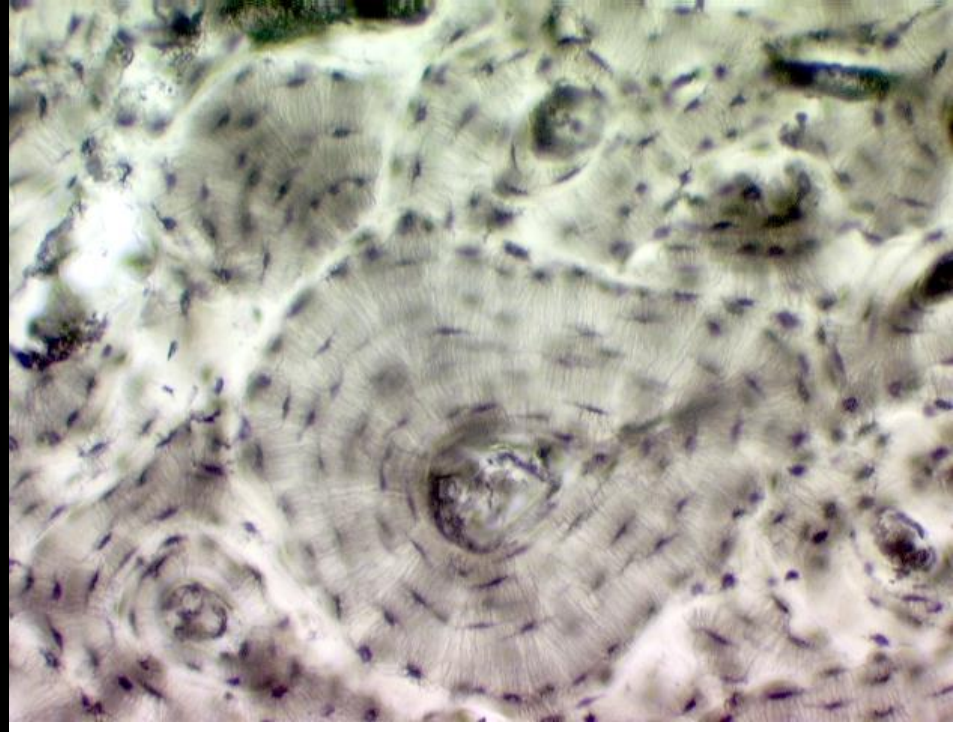
- Osteon → Haversian canal + Lamellae
- Lamellae → Lacunae → Osteocytes
- Canaliculi – tiny canals that connect bone cells to nutrient supply
- Perforating (Volkmann's) canal – canals that connect outside of bone to the inside

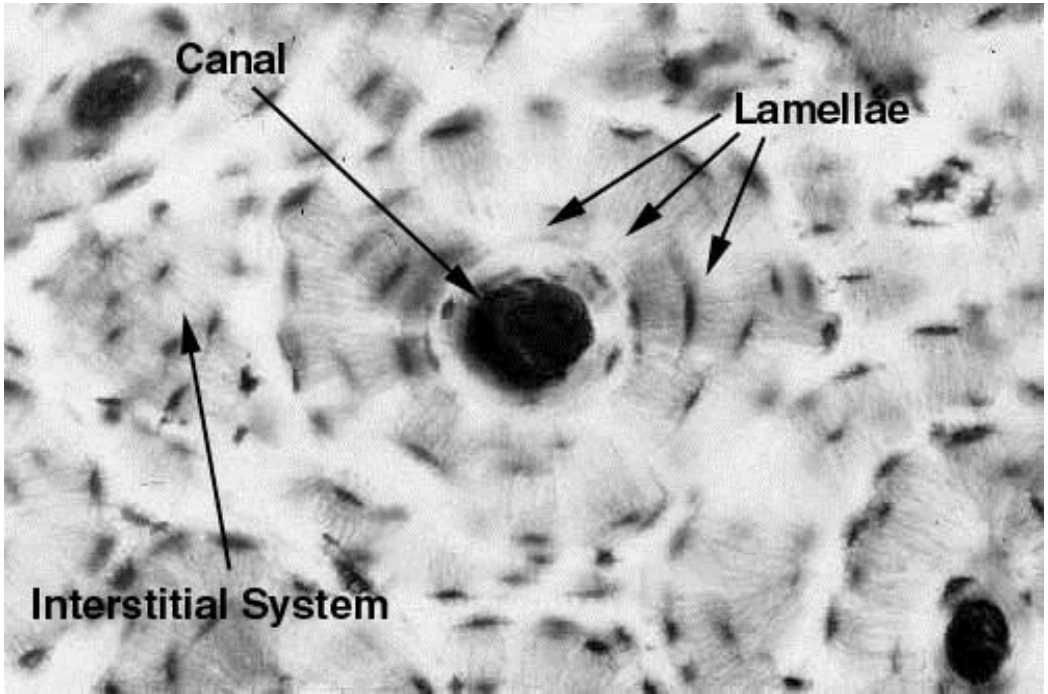
Compact Bone & Spongy (Cancellous Bone)

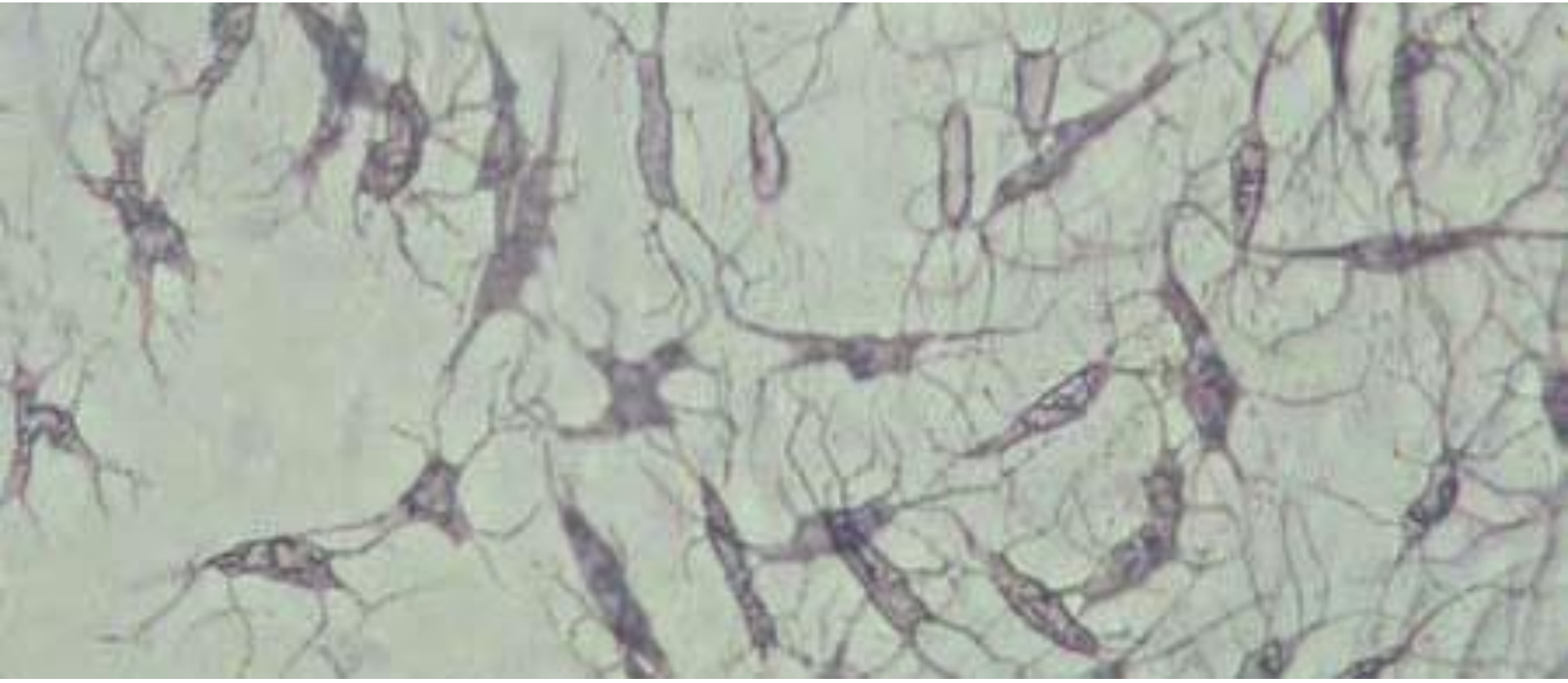





Lamellar bone
Osteocytes in lacunae
Bone canaliculi
40 um
10 um




Canal
Lamellae
Interstitial System



Development

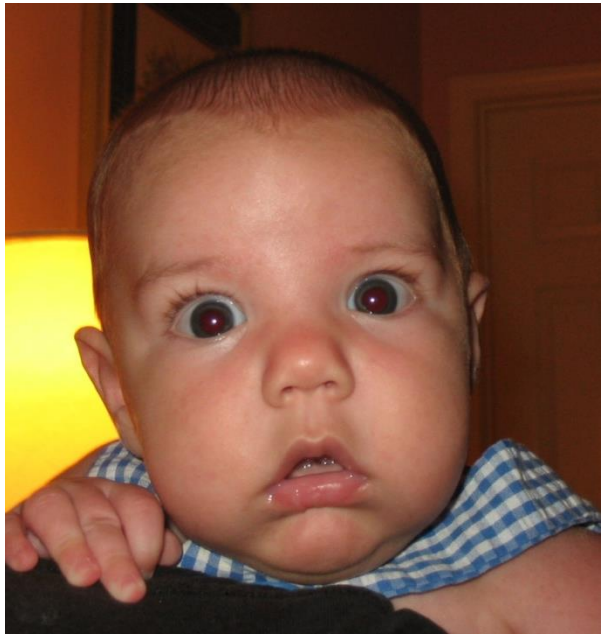
- Embryo
  - Skeleton made of cartilage
  - Cartilage turned into bone along the sides and inside the bones
- Fetus
  - Bone continues to develop from cartilage
  - Bone in the middle of the bone gets destroyed and medullary cavity is formed
  - Blood vessels continue to grow within the bone


visuals:unlimited

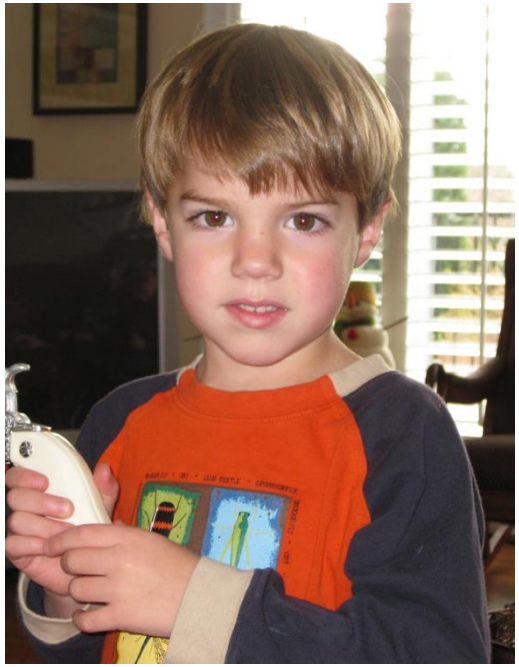
Development

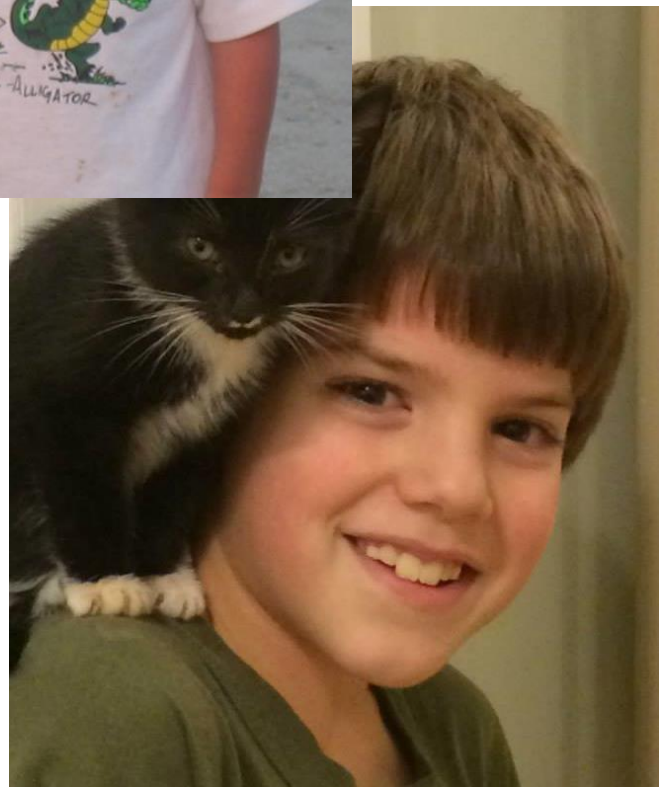
- Birth
  - Fontanels allow for brain growth
    - Fontanel = soft, flexible fibrous region between 2 flat bones in developing skull
  - Spine curves convex posteriorly

- 2 Years
  - Cranium fully developed
  - Skull ¾ of adult size
  - Spine curves convex anteriorly (S-shaped spine) to help prevent shock during walking from traveling to skull




Hilton Head
Island
LATER ALLIGATOR





Development

- 6-11 Years
  - Skull almost adult size
  - Head enlarges and features emerge
  - Cheekbones and nose become prominent
  - Jaw increases in size

- End of Adolescence
  - Epiphyseal plates close
  - Female pelvis widens
  - Male skeleton becomes thicker

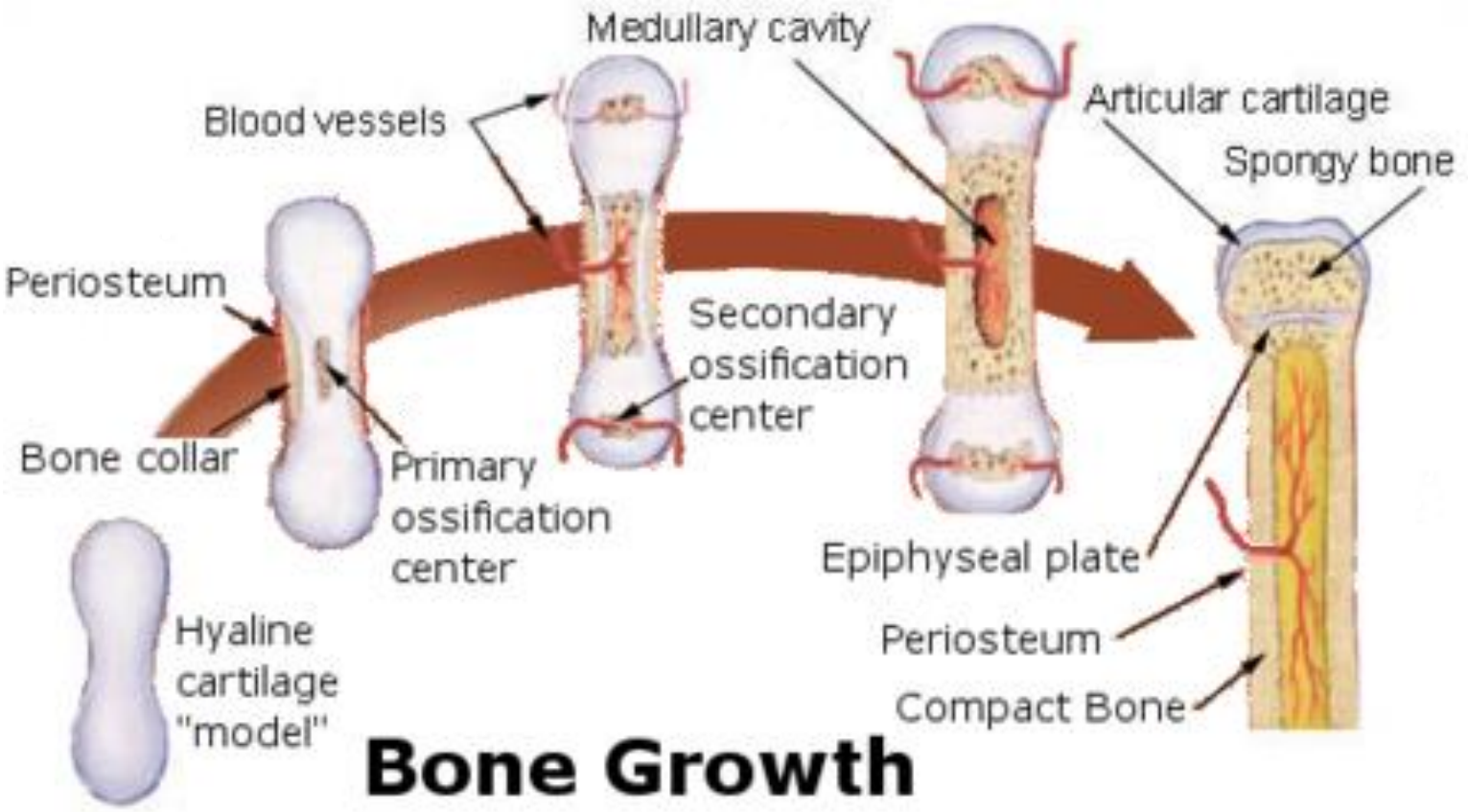

THE SALTY
DOG CAFE

Development

- Late Middle Age
  - Relatively little change up to this age
- Old Age
  - Bone mass decreases
  - Joints can deteriorate

Bone Formation

- Ossification – bone formation
- Growth controlled by hormones – human growth hormone and sex hormones
- Fetal skeleton is mostly cartilage


Medullary cavity
Blood vessels
Articular cartilage
Spongy bone
Periosteum
Secondary ossification center
Bone collar
Primary ossification center
Epiphyseal plate
Hyaline cartilage "model"
Periosteum
Compact Bone

Bone Growth

Steps of Bone Formation

- Periosteum develops around the hyaline cartilage

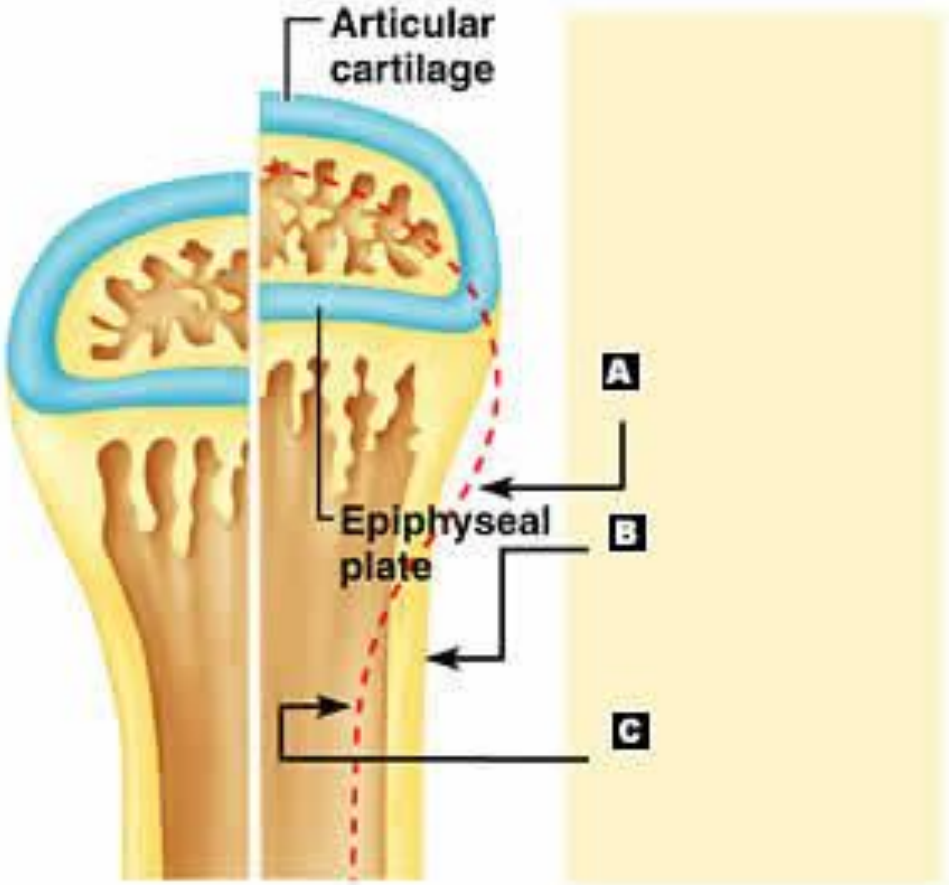
- Cartilage begins to calcify in the center of the bone through the action of the osteoblasts

- Blood vessels and osteoblasts move into the disintegrating cartilage and form compact and spongy bone – compact continues to thicken on the outside

- The medullary cavity then develops in the center of the bone

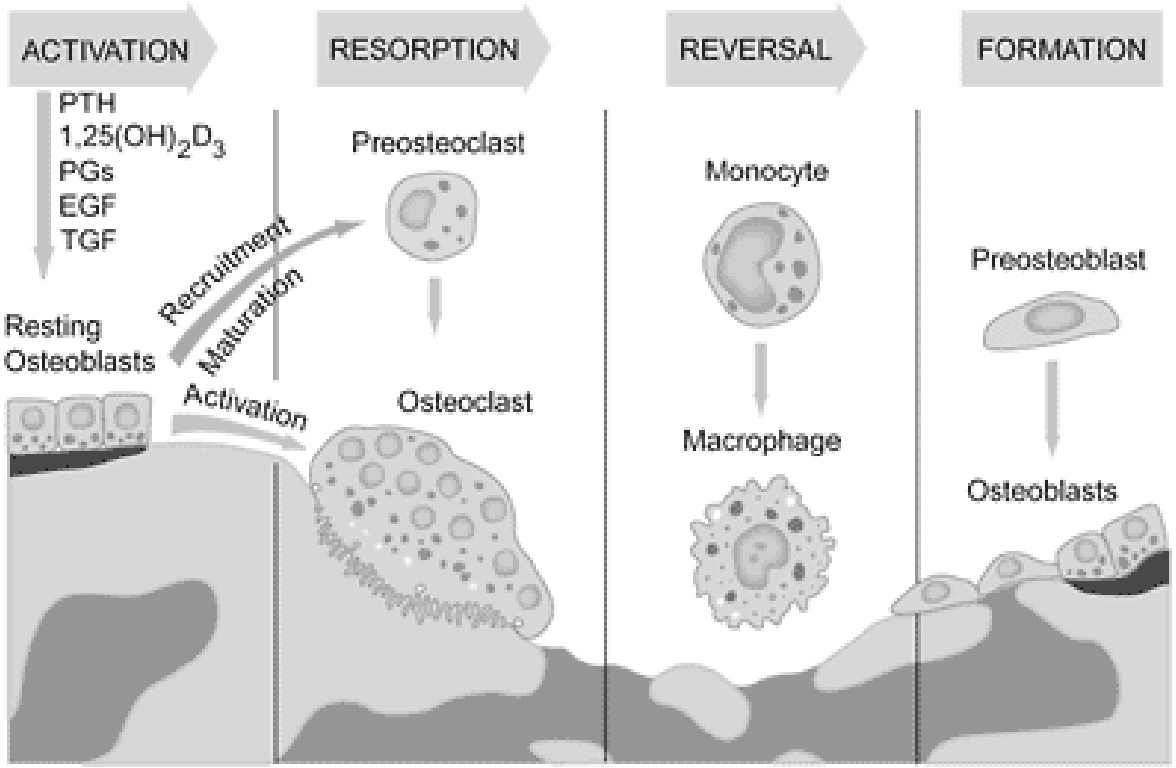
- Epiphysis remain partly cartilage with the epiphyseal plate forming the boundary between the two ossification sites (the ends of the bone and the middle)

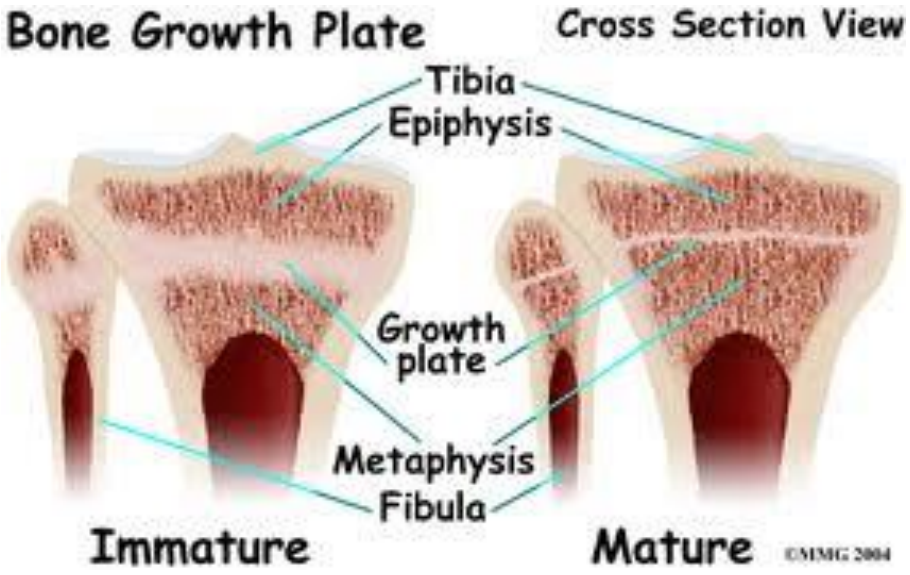
- As the bone grows longer, the plate moves



Bone Formation: The Details

- Cartilage at the ends of the bones will enlarge and extracellular matrix forms around them
- Calcium salts accumulate in the matrix and cause some of the old cartilage cells to die
- Osteoclasts break down the calcified matrix and osteoblasts form new bone tissue
- Once the cartilage in the epiphyseal plate gets broken down, the plate will close and no more grow will occur


ACTIVATION
RESORPTION
REVERSAL
FORMATION
PTH
1,25(OH)2D3
PGs
EGF
TGF
Preosteoclast
Monocyte
Preosteoblast
Recruitment
Maturation
Resting
Osteoblasts
Activation
Osteoclast
Macrophage
Osteoblasts


Bone Growth Plate
Cross Section View
Tibia
Epiphysis
Growth plate
Metaphysis
Fibula
Immature
Mature
©MMG 2004

Bone Remodeling

- Needed to maintain normal proportions and strength
- Bones thicken and form larger projections
- Osteoblasts lay down new matrix and get trapped
  - Becomes osteocytes

- Calcium salts within the bone matrix makes bones hard and collagen fibers makes bone flexible
  - Bones are extremely hard, yet light weight
  - Bones can resist tension and other forces acting on it because of its composition

Bone – Dynamic and Active Tissue

- Factors affecting bone remodeling

  1) Pull of gravity and muscles on skeleton

  * Stress of muscular attachments and gravity – determines **where** bone matrix gets broken down or formed

  * Bones will thicken and strengthen with physical exercise

2) Ca+ levels in blood

A. If Ca+ levels decrease – parathyroid gland (PTH) is stimulated

- PTH activates osteoclasts (bone destroying cells) to break down bone matrix to release Ca+
- PTH determines **when** bone gets broken down

B. If Ca+ levels increase – (hypercalcemia)

- Ca+ gets deposited in bone matrix by Calcitonin

Disorders

As humans get older, the skeleton changes and get develop various disorders or injuries

Spinal Disorders

- Curves in the spine and the intervertebral discs are used as shock absorbers when we walk
  - Prevents the brain from receiving shock waves from the ground when we walk

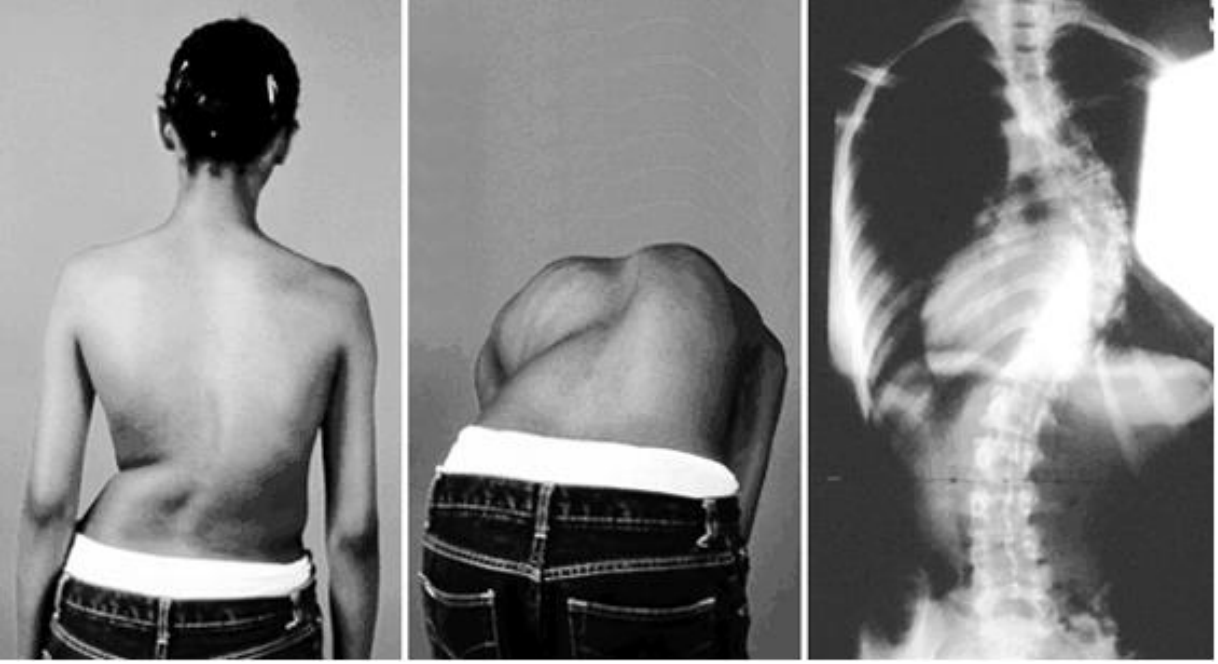
Abnormalities in the curvature of the spine:

- Scoliosis – lateral bend in the vertebral column

- Kyphosis – greater than normal posterior curve of the thoracic vertebrae

- Lordosis – greater than normal anterior curve in the lumbar vertebrae

Guess the spinal disorder…

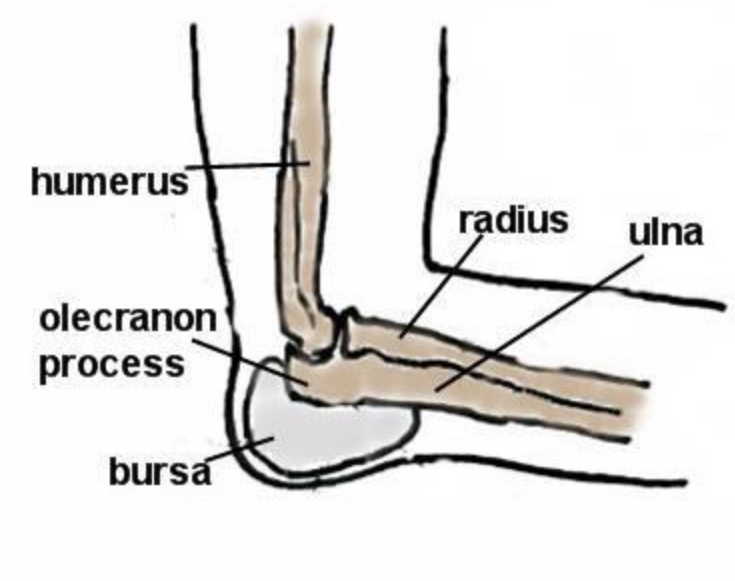


Disorders

- Rickets – poor nutrition – bone fail to calcify
  - Due to lack of Calcium in diet or lack of vitamin D

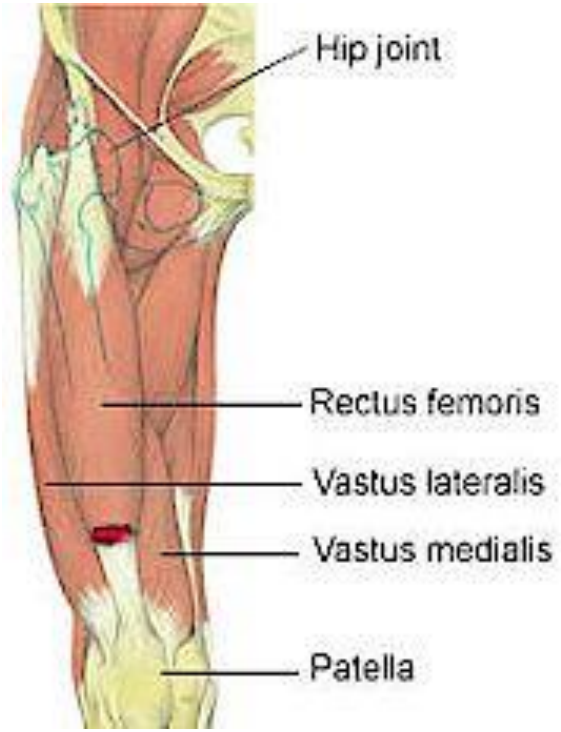
Disorders

- Bursitis – inflammation of the bursa sac



Disorders

- Sprain – tear in a ligament
- Strain – tear in a muscle



Disorders

- Arthritis – describes over 100 different inflammatory or degenerative diseases that damages joints

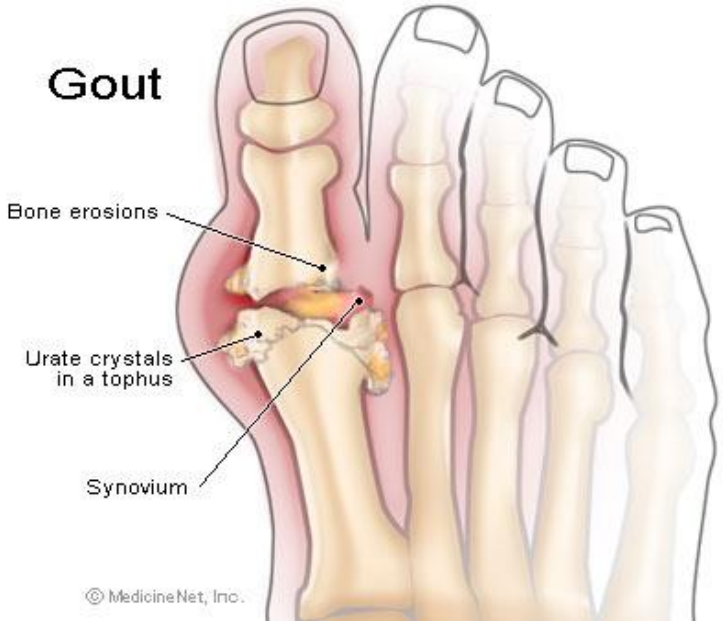
- Osteoarthritis (OA) – most common wear and tear chronic degeneration
  - Mainly affects the aged

Disorders

- Rheumatoid arthritis (RA) – autoimmune disease – body's immune system attempts to destroy its own tissues

Disorders

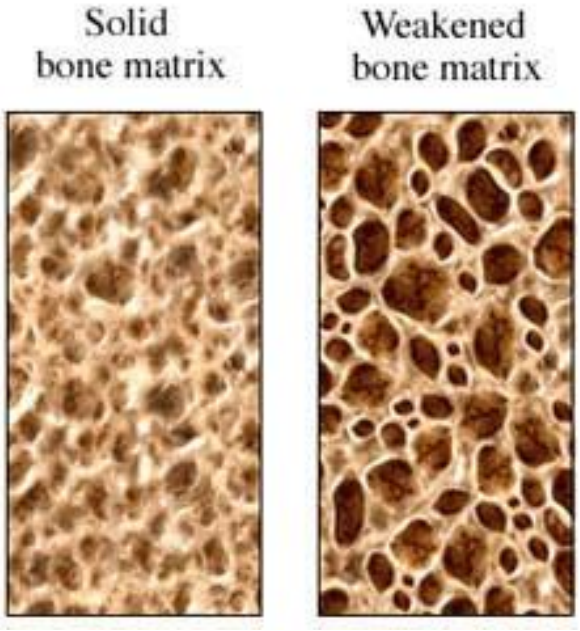
- Gouty arthritis – gout – when uric acid gets built up in blood and deposited sharp crystals in soft tissues of joints

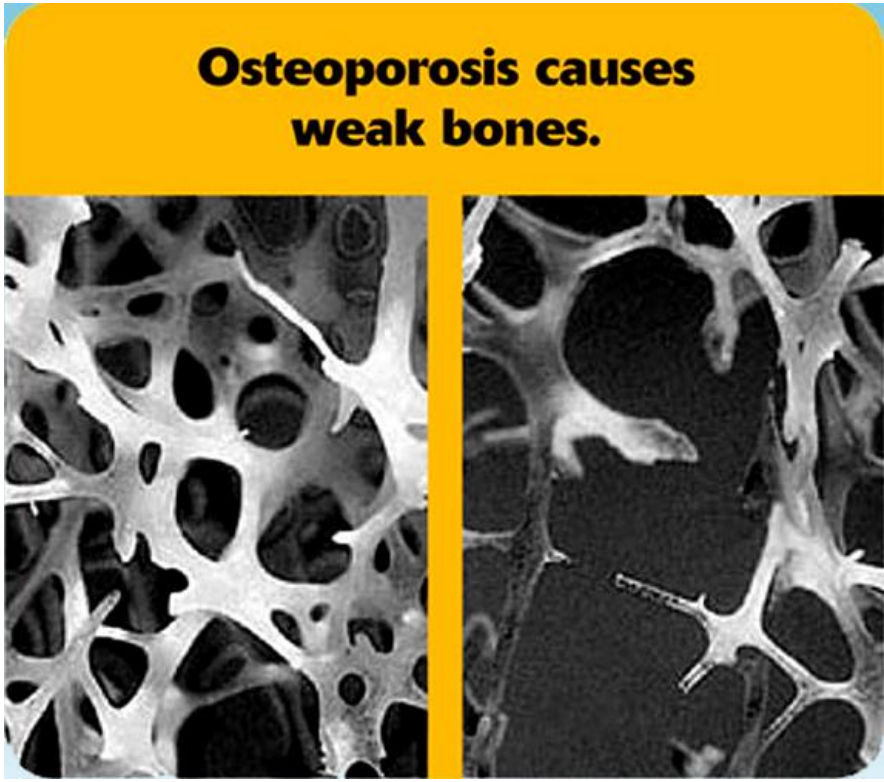


Disorders

Osteoporosis – loss of bone mass leading to thin, fragile bones

Bone section through hip



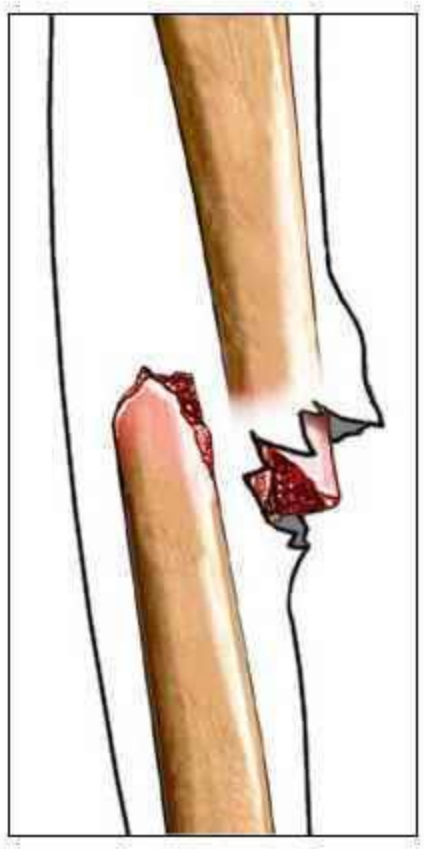


Fractures

- Simple – Bone breaks cleanly but does not break skin

Fractures

- Compound – Broken ends of bone protrude through skin
  - Open fractures are more susceptible to infection

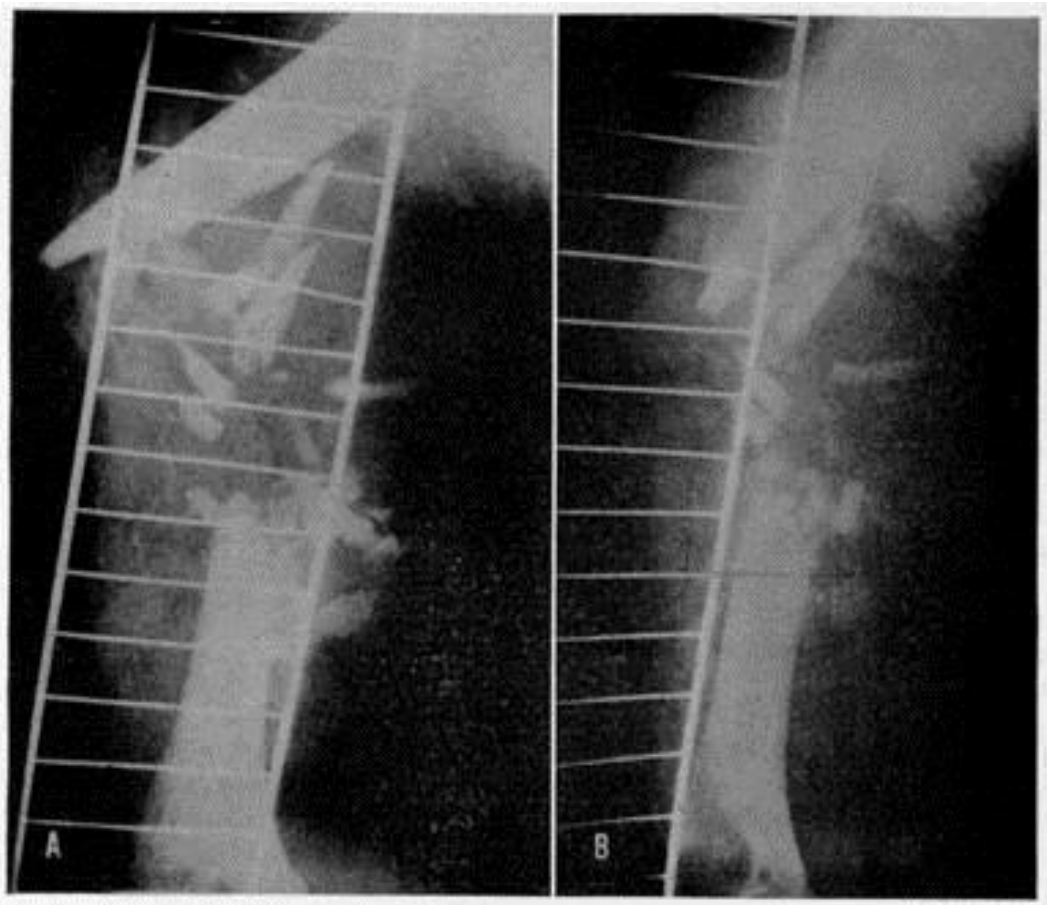



A
B
C
D


M 35 01 1
21 Au
:34

Fractures

- Comminuted – bone breaks into many fragments

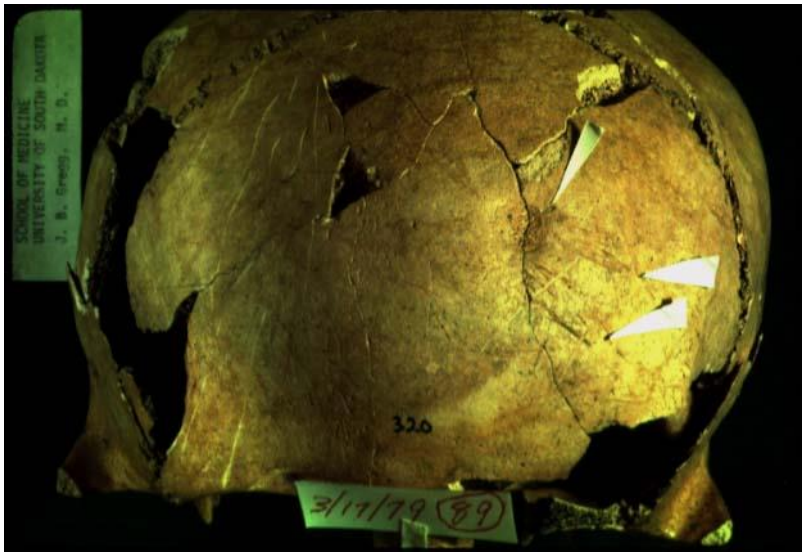


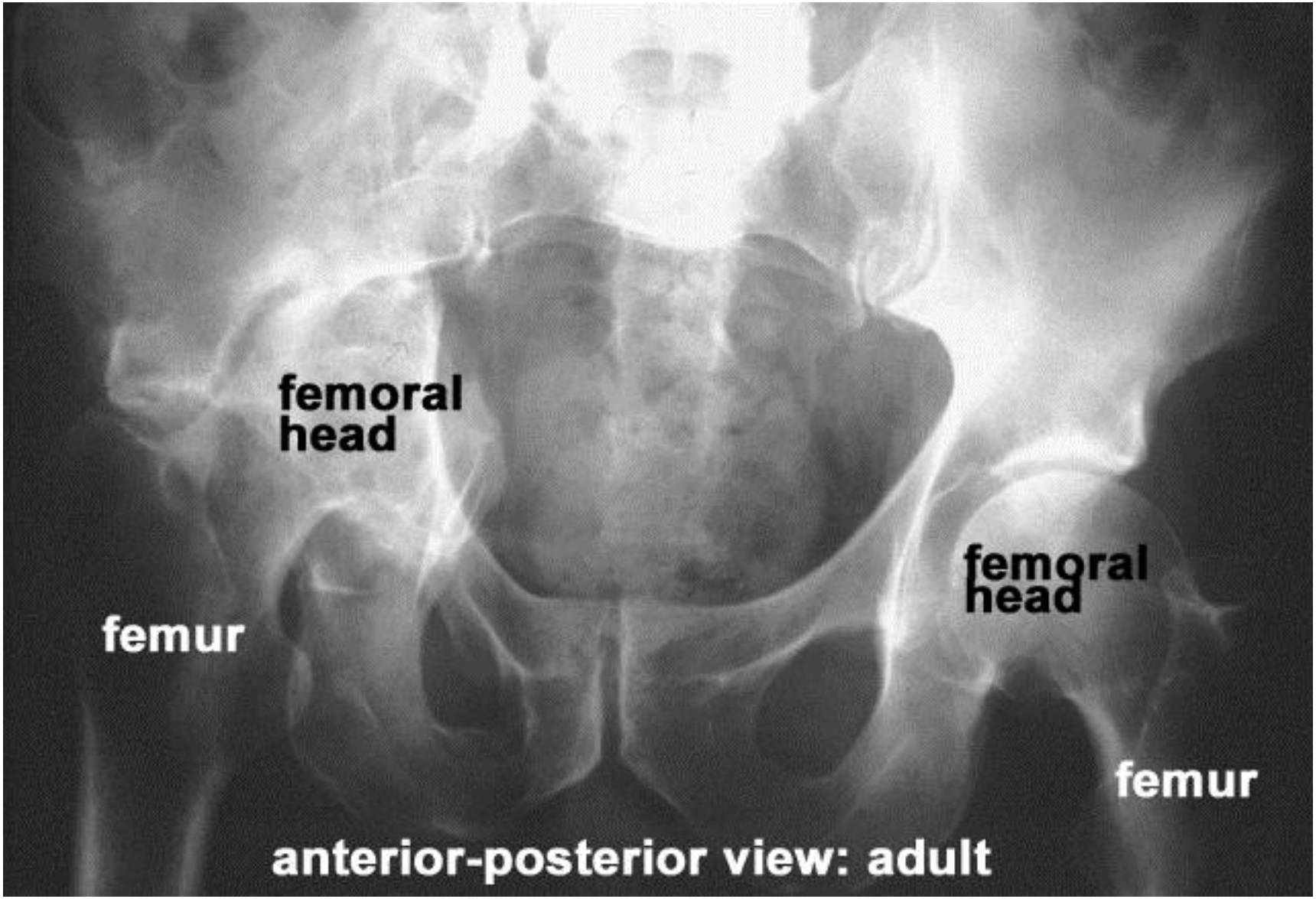
AFIP Fd-44-19

FIGURE 38.—Severe compound comminuted fracture of middle third of shaft of right humerus with loss of more than 4 cm. of bone. Management by approximation of major fragments with single wire suture and wound closure. A and B. Anteroposterior and lateral roentgenograms made on patient's admission to evacuation hospital before initial wound surgery. At this operation, the brachial artery and the median and ulnar nerves were found intact, but the radial nerve was severed.

Fractures

- Compression – bone is crushed and collapses on itself
- Depression – broken bone portion is pressed inward in the direction of the force




femoral
head
femoral
head
femur
femur
anterior-posterior view: adult

Fractures

- Impacted – broken bone ends are forced into each other

- Spiral – ragged break when twisting forces are applied


R

Fractures

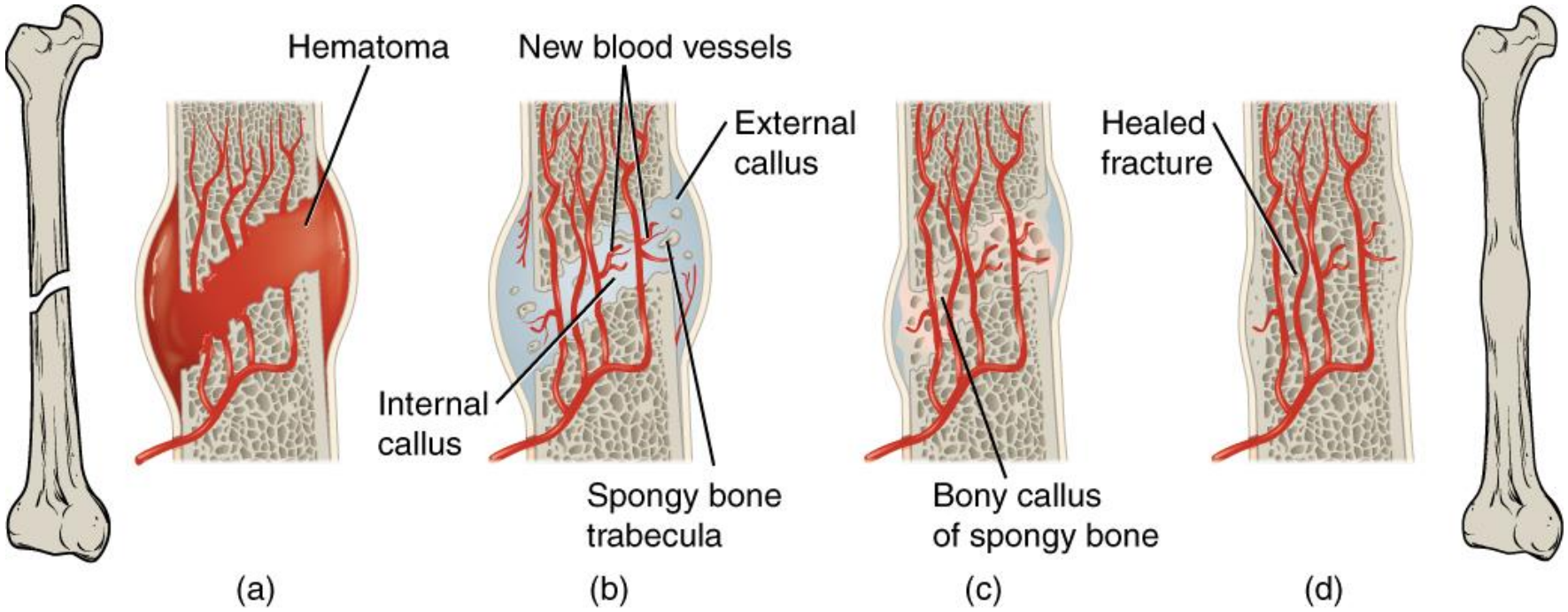
- Greenstick – bone breaks incompletely

Extra Fact

- Smoking decreases bone mineral density and interferes with healing
- Marijuana can also affect bone density and impede O_2 from going to the bone tissue
  - Can lead to more bone fractures

Healing a Bone Fracture

- Hematoma forms – blood escaped from vessels
- Fibrocartilage callus and spongy bone forms
- Bony callus forms – replaces fibrocartilage
- Bone remodeling occurs – osteoclasts remove excess bony tissue restoring the bone


Hematoma
New blood vessels
External callus
Internal callus
Spongy bone trabecula
Bony callus of spongy bone
Healed fracture
(a)
(b)
(c)
(d)

Axial Skeleton

- Curvatures
  - Purpose = Shock absorber when walking
  - Adults = lumbar spine has an anterior curve
  - Infants = lumbar spine has a posterior curve
    - This changes when the baby starts sitting on their own
- Intervertebral discs
  - Cartilage between the vertebrae that also acts as shock absorbers

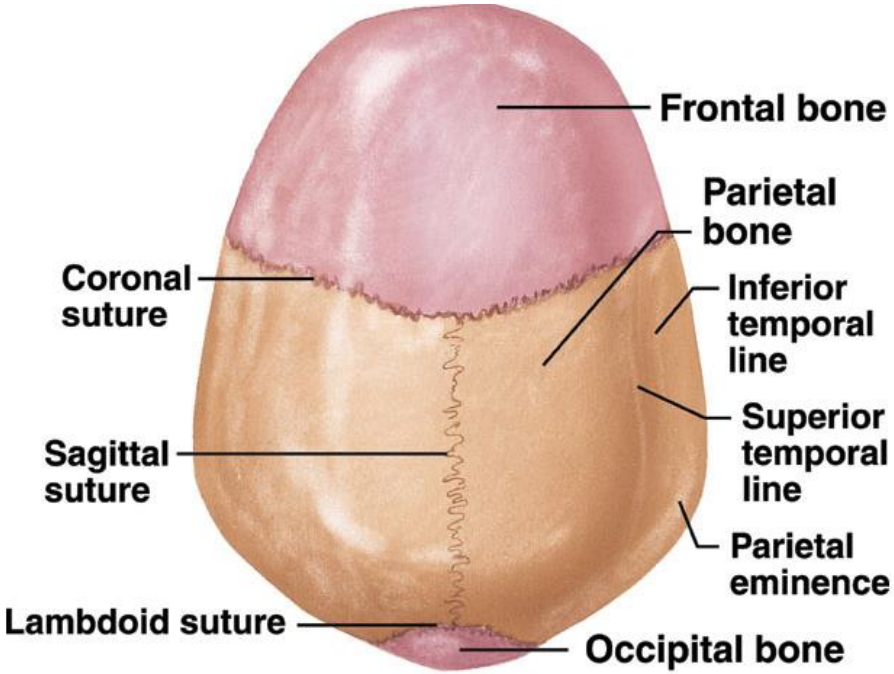
Bones of the Skull

- Frontal
- Parietal
- Occipital
- Temporal
- Sphenoid
- Ethmoid
- Mandible
- Maxillae
- Palatine
- Zygomatic
- Lacrimal
- Nasal
- Vomer

Suture Joints and Holes

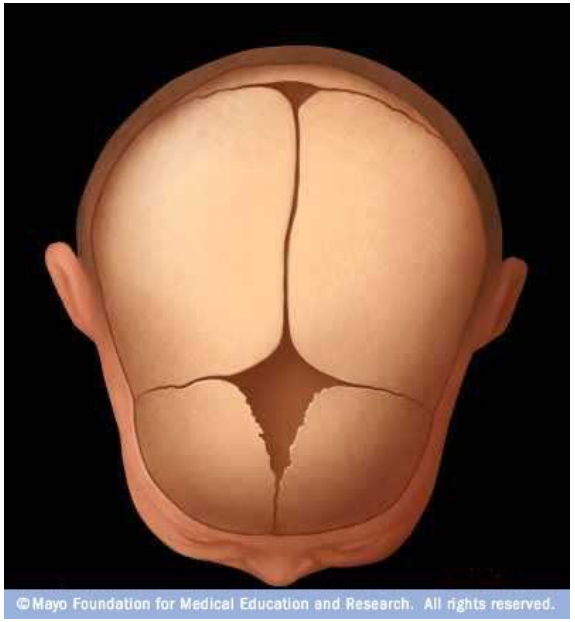
- Coronal – between frontal and parietal
- Lambdoid – between parietal and occipital
- Sagittal – between two parietals

- Foramen magnum – opening that spinal cord travels through

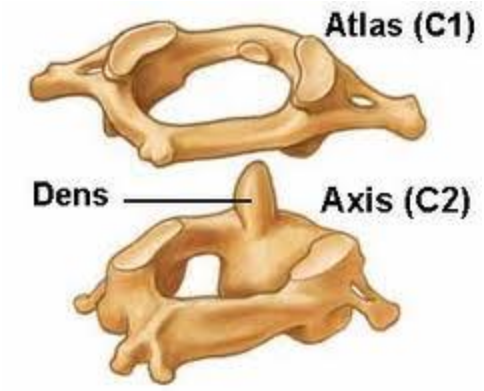


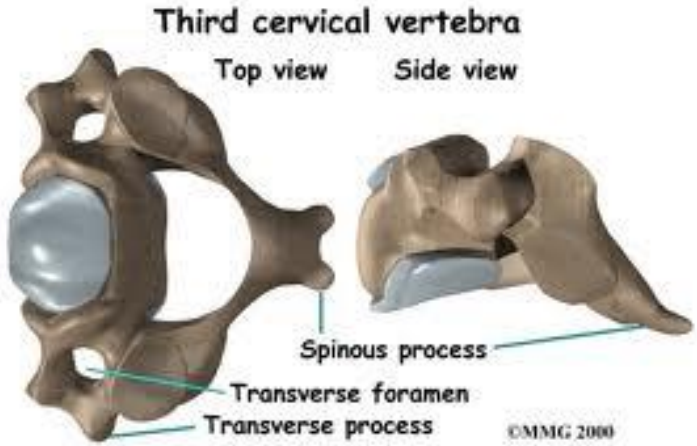
Infant Skull

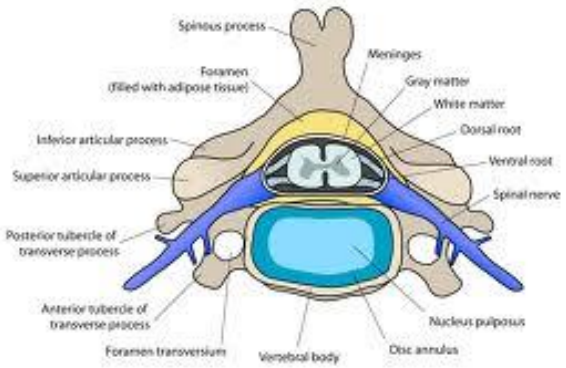
- Fontanels = soft, flexible membranes between the bones of the skull (soft spot)
  - Allows for movement between bones during birth and brain growth

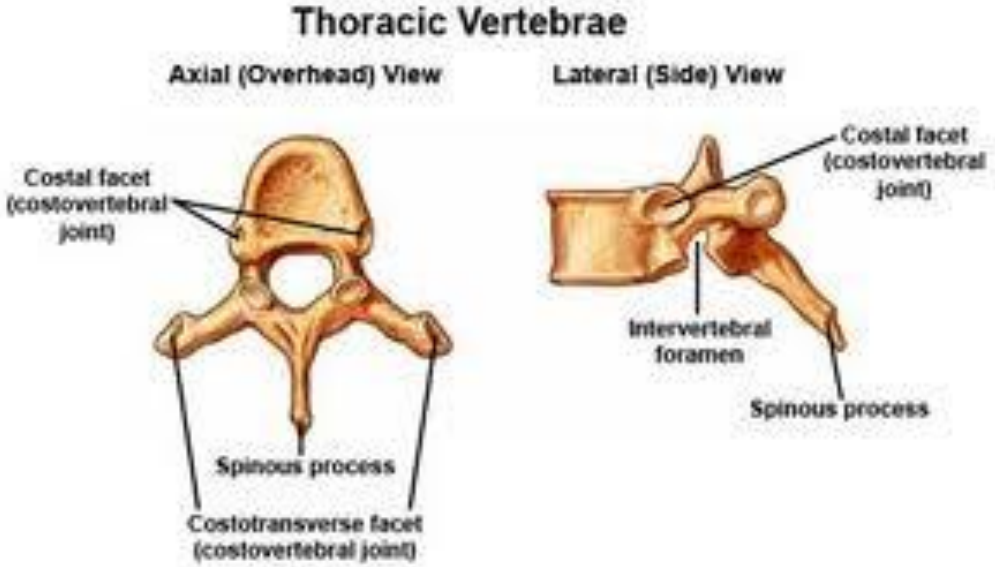


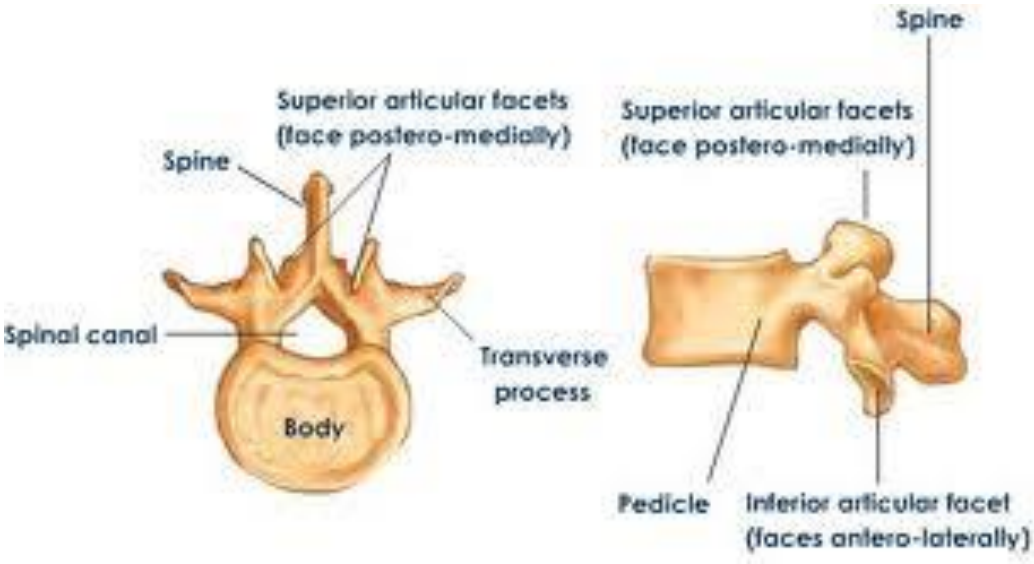
Types of Vertebrae









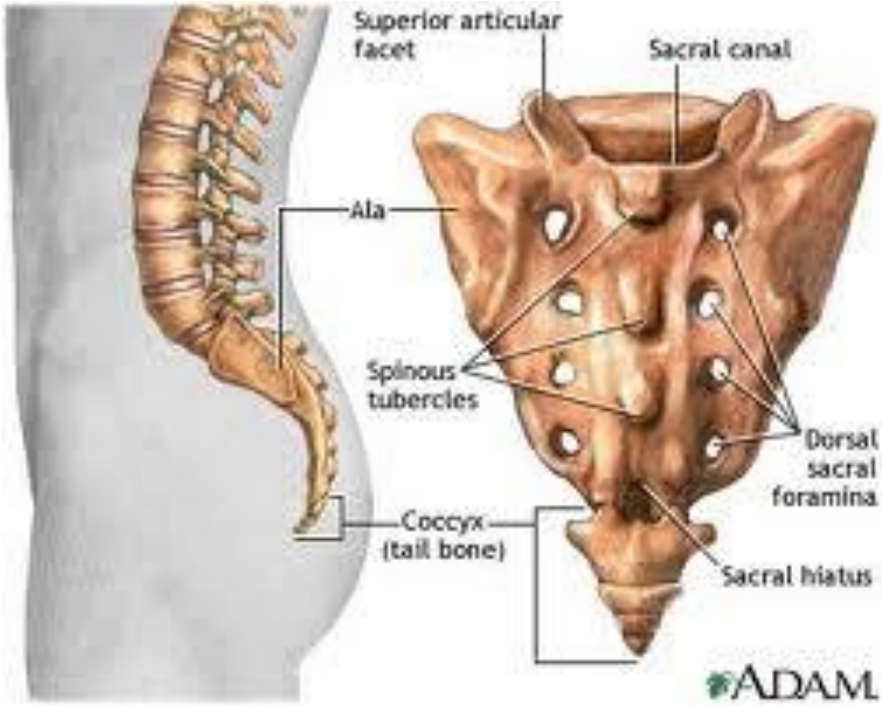


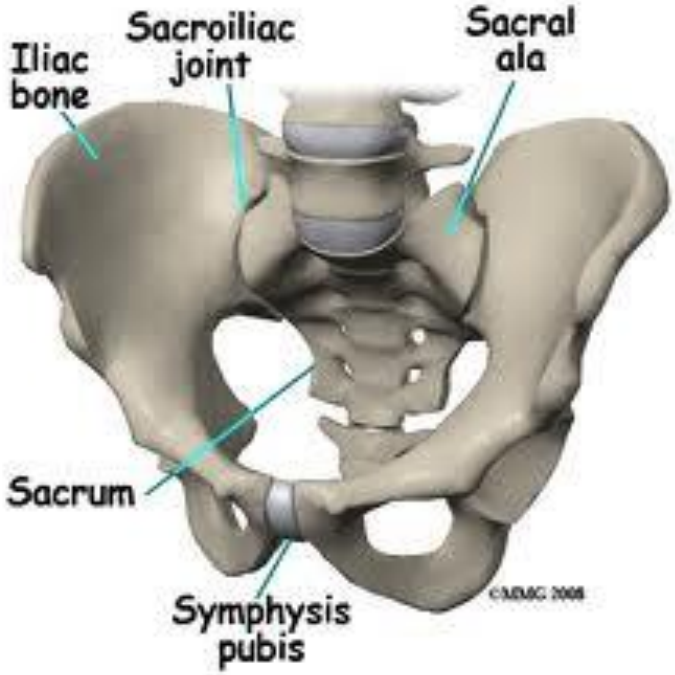
Types of Vertebrae

- Cervical – 7 bones, has transverse foramen
- Thoracic – 12 bones, has lateral facets that attach the ribs to the vertebrae
- Lumbar – 5 bones, largest of the 3 types

Sacrum and Coccyx

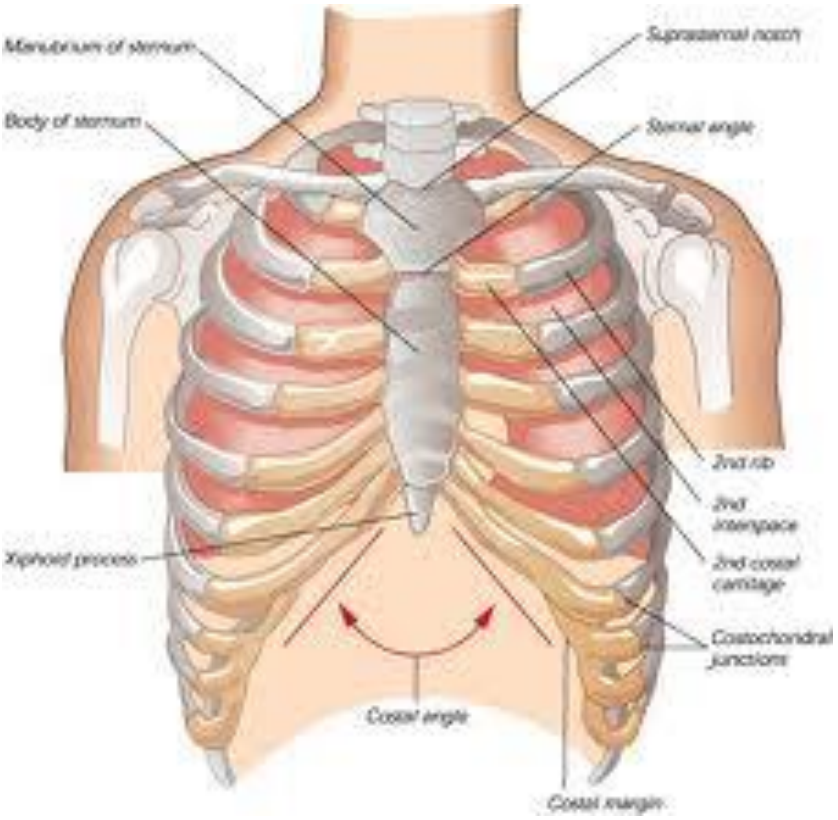
- Ligaments hold the bottom part of the spinal column to the pelvic bones
- Foramen in the sacrum allow blood vessels to travel to the legs





Sternum and Rib Cage

- True Ribs = anterior attachment to sternum
- False Ribs = indirect anterior attachment to sternum
- Floating Ribs = no anterior attachment to sternum



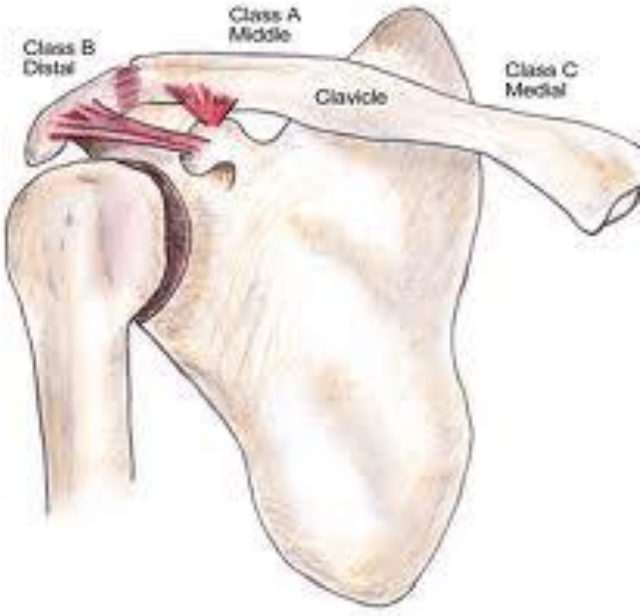
- Intercoastal muscles lie between the ribs to help with breathing

Appendicular Skeleton

- Contains the shoulder and pelvic girdles as well as the bones of the arms and legs

- Shoulder girdle = scapula, humerus, and clavicle
- Pelvic girdle = pelvic bones and femur

Clavicle and Scapula



- AC joint = acromial-clavicular joint
- SC joint = sternal-clavicular joint

- Scapula provides sites for muscle attachment (rotator cuff muscles)
- Scapula lies on the posterior aspect of the body

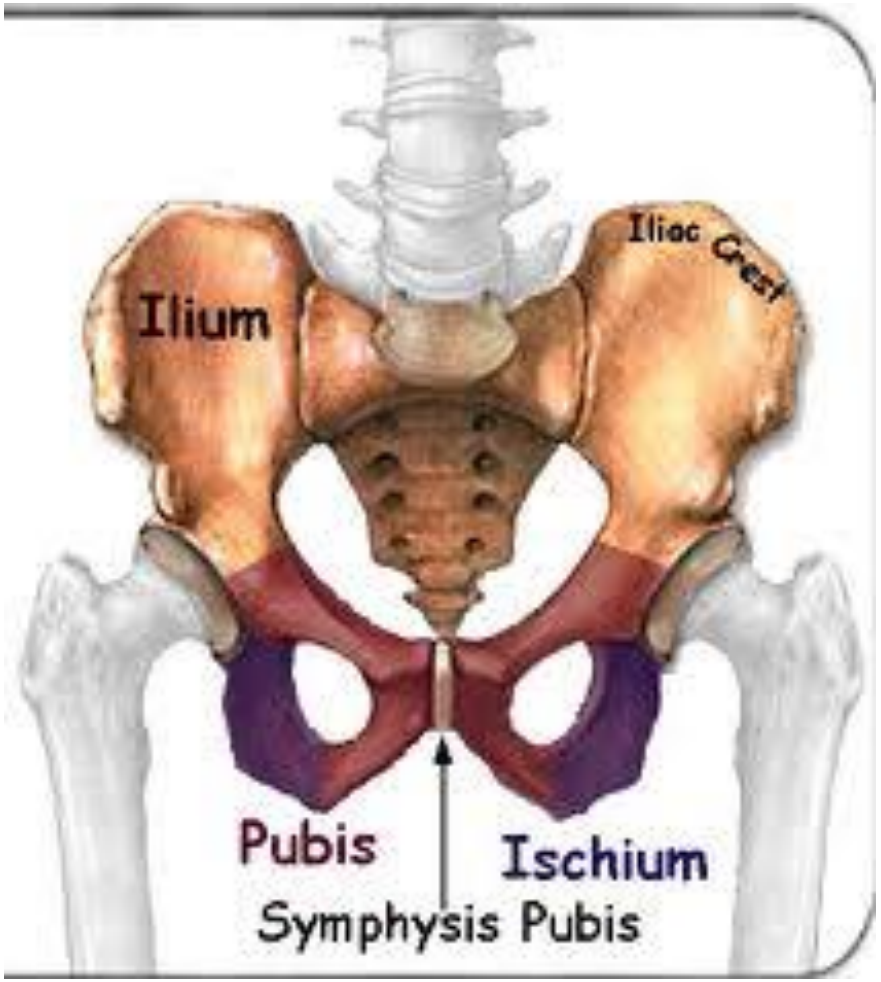
Arm and Hand

- Humerus – head fits into the cavity on the scapula
- Radius – moves with the ulna to allow for lower arm rotation
- Ulna – forms the main part of the elbow joint
  - Olecranon process = point of elbow

Pelvis

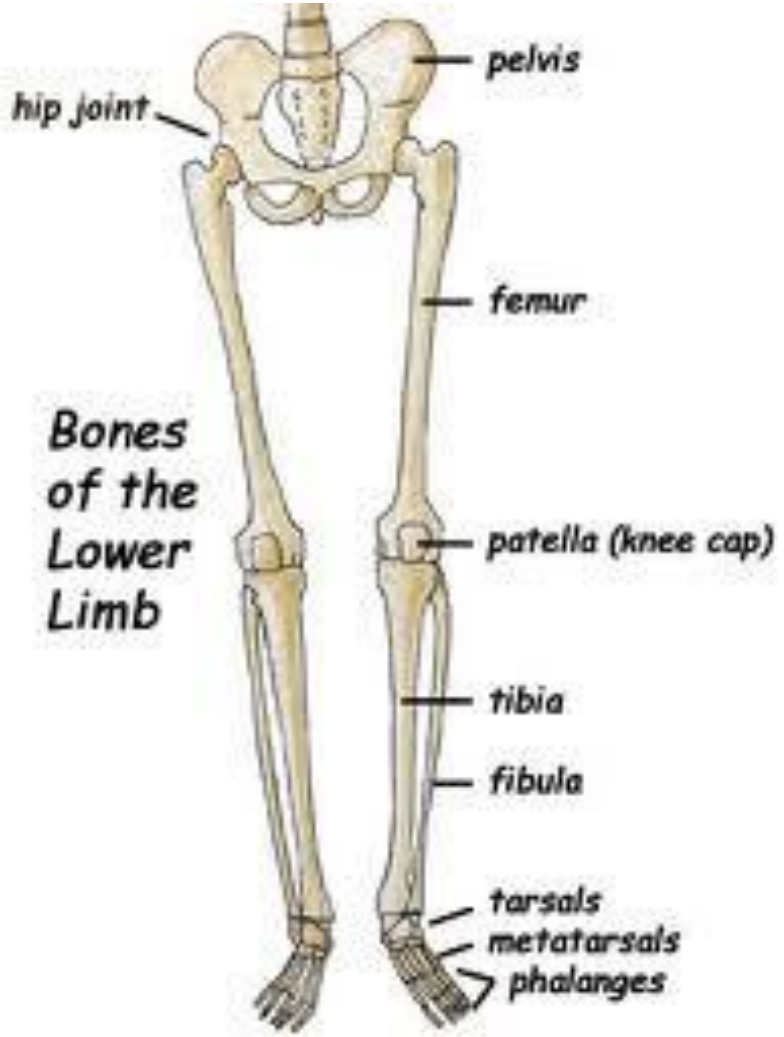
- 3 bones = ilium, ishium, and pubic bones vused together

- Female pelvis is wider than a male pelvis



Leg and Foot

- Head of the femur – attaches to the cavity in the pelvic bone (acetabulum)
- Ankle bones = malleoli from the tibia and fibula
- Tibia is the main weight bearing bone of the lower leg
- Patella – sesmoid bone that glides in the groove of the femur to bend the knee
- Calcaneus = heel bone
- Talus – tibia and fibula sit on this bone to form the ankle joint



Joints / Articulations

Join bones together securely but give rigid skeleton stability

Classification: Structurally and Functionally

Functional

- Synarthroses – immovable joint
  - Sutures in skull
- Amphiarthroses – slightly movable joint
  - Joints between intervertebral discs
- Diarthroses – freely movable joint
  - Any joint in arms and legs

Structural

- Fibrous – sutures and syndesmoses
- Cartilaginous – pubic symphysis (synarthroses) and intervertebral joints
  - hyaline cartilage at ends of bones and at ends of ribs (amphiarthroses)
- Synovial – articulating with bone ends and contain synovial fluid

Synovial Joints

- Plane/Gliding – sliding and twisting movement (between carpals)
- Hinge – movement in one plane (elbow or knee)
- Pivot – rotation around a central axis (radius and ulna or atlas and axis)
- Saddle – movement around a convex and concave joint (carpal and metacarpal)
- Ball and Socket – all planes of movement (shoulder or hip)

- Skeleton