A. Function of Bones
1. Support - form the framework that supports the body and cradles soft organs
2. _______________ - provide a protective case for the brain, spinal cord, and vital organs
3. Movement - provide levers for muscles
4. Mineral storage - reservoir for minerals, especially calcium and phosphorus
5. Blood cell formation - hematopoiesis occurs within the marrow cavities of bones

B. Classification of Bones: by Functional Group
Axial skeleton - bones of the skull, vertebral column, and rib cage
Appendicular skeleton - bones of the upper and lower limbs, shoulder, and hip

C. Classification of Bones: By Shape
1. Long bones - longer than they are wide (e.g., humerus)
2. ________ bones
   Cube-shaped bones of the wrist and ankle
   Bones that form within tendons (e.g., patella)
3. Flat bones - thin, flattened, and a bit curved (e.g., sternum, and most skull bones)
4. Irregular bones - bones with complicated shapes (e.g., vertebrae and hip bones)
   Sesamoid (Irregular bones) -"shaped like a sesame seed; form in a tendon; e.g. Direction of pull

D. Structure of Long Bone
1. LONG BONE
   a. Diaphysis
      i. Tubular shaft that forms the axis of long bones
      ii. Composed of compact bone that surrounds the medullary cavity
      iii. ________ bone marrow (fat) is contained in the medullary cavity
   b. Epiphyses
      i. Expanded ends of long bones
      ii. Exterior is compact bone, and the interior is spongy bone
      iii. Joint surface is covered with articular (hyaline) cartilage
      iv. Epiphyseal line separates the diaphysis from the epiphyses
2. BONE TEXTURES (Picture on previous slide)
   - Compact bone - dense outer layer
   - ___________ bone - honeycomb of trabeculae filled with yellow bone marrow

3. Membranes
   a. Periosteum - double-layered protective membrane
      i. Outer fibrous layer is dense regular connective tissue
      ii. Inner osteogenic layer is composed of osteoblasts and osteoclasts
      iii. Richly supplied with nerve fibers, blood, and lymphatic vessels, which enter the bone via nutrient foramina
      iv. Secured to underlying bone by Sharpey's fibers
   b. Endosteum - delicate membrane covering internal surfaces of bone

4. Compact Bone: Microscopic
   a. Haversian system, or osteon - the structural unit of compact bone
      i. ___________ - weight-bearing, column-like matrix tubes composed mainly of collagen
      ii. Haversian, or central canal - central channel containing blood vessels and nerves
      iii. Volkmann's canals - channels lying at right angles to the central canal, connecting blood and nerve supply of the periosteum to that of the Haversian canal
   b. Osteocytes - mature bone cells
   c. Lacunae - small cavities in bone that contain osteocytes
   d. Canaliculi - hairlike canals that connect lacunae to each other and the central canal

5. Compact Bone: Cells & Cell Products
   a. Organic
      i. Osteoblasts - bone-forming cells
      ii. ___________s - mature bone cells
      iii. Osteoclasts - large cells that resorb or break down bone matrix
      iv. Osteoid - unmineralized bone matrix composed of proteoglycans, glycoproteins, collagen
   b. Inorganic: Hydroxyapatites or mineral salts
      i. Sixty-five percent of bone by mass
      ii. Mainly calcium phosphates
      iii. Responsible for bone ___________ and its resistance to compression

E. Formation of Skeleton
   - Intramembranous ossification - bone develops from a fibrous membrane
   - Endochondral ossification - bone forms by replacing hyaline cartilage

1. Intramembranous Ossification
   - Begins in fetus; Formation of most of the flat bones of the skull and the clavicles
a. Stages
   i. An ossification center appears in the fibrous connective tissue membrane
   ii. Bone matrix is secreted within the _______________ membrane
   iii. Woven bone and periosteum form
   iv. Bone collar of compact bone forms, and red marrow appears
2. Endochondral Ossification
   - Begins in fetus using hyaline cartilage "bones" as models for bone construction
   - Requires breakdown of hyaline cartilage prior to ossification
   a. Stages
      i. Formation of bone collar
      ii. Cavitation of the hyaline cartilage
      iii. Invasion of internal cavities by the periosteal bud, and spongy bone formation
      iv. Formation of the medullary cavity; secondary ossification centers appear in epiphyses
      v. Ossification of the epiphyses, w/hyaline cartilage remaining only in the epiphyseal plates
3. Long Bone Growth and Remodeling
   - Growth in Length - cartilage continually grows and is replaced by bone as shown
   - Remodeling - bone is resorbed and added by Appositional Growth as shown ("width")
4. Hormones
   a. Homeostasis
      i. Rising blood ______ levels trigger the thyroid to release calcitonin
      ii. Calcitonin stimulates calcium salt deposit in bone
      iii. Falling blood Ca2+ levels signal parathyroid glands to release Parathyroid Hormone
      iv. PTH signals osteoclasts to degrade bone matrix and release Ca2+ into the blood
5. Bone Remodeling
   - Remodeling units - adjacent osteoblasts and osteoclasts deposit and resorb bone at periosteal
     and endosteal surfaces
   - Accomplished by osteoclasts
6. Bone Resorption
   a. Resorption involves osteoclast secretion of:
      - Lysosomal enzymes that digest organic matrix
      - _____ that convert calcium salts into soluble forms
   b. Dissolved matrix is transcytosed across the osteoclast's cell where it is secreted into the
      interstitial fluid and then into the blood

F. Bone Features
1. Purpose
   a. Projections, depressions, and holes that serve as:

   **GOOD TO KNOW! HELPFUL in LAB! Flash Cards!**
   i. Sites of attachment for muscles, ligaments, and tendons
   ii. ___________ surfaces
   iii. Conduits for blood vessels and nerves

   b. **PROJECTIONS: Attachment for Muscles & Ligaments**
   i. Tuberosity - rounded projection
   ii. Crest - narrow, prominent ridge of bone
   iii. Trochanter - large, blunt, irregular surface
   iv. Line - narrow ridge of bone
   v. Tubercle - small rounded projection
   vi. Epicondyle - raised area above a condyle
   vii. Spine - sharp, slender projection
   viii Process - any bony prominence

   c. **PROJECTIONS: Help in Formation of Joints**
   i. Head - bony expansion carried on a narrow neck
   ii. Facet - smooth, nearly flat articular surface
   iii. Condyle - rounded articular projection
   iv. Ramus - armlike bar of bone

   d. **DEPRESSONS: Opening & Other Bone Features**
   i. Meatus - canal-like passageway
   ii. Sinus - cavity within a bone
   iii. Fossa - shallow, basinlike depression
   iv. Groove - furrow
   v. Fissure - narrow, slitlike opening
   vi. Foramen - round or oval opening through a bone

G. **Common Types of Fractures**
1. Comminuted - bone fragments into three or more pieces; common in the elderly
2. Spiral - ragged break when bone is excessively twisted; common sports injury
3. Compression - bone is _____________; common in porous bones
4. Greenstick - incomplete fracture where one side of the bone breaks and the other side bends; common in children
H. Stages in the Healing of a Bone Fracture

1. Hematoma formation: Torn blood vessels hemorrhage & Clot forms (swollen, painful, inflamed)
2. Fibrocartilaginous callus forms:
   - Granulation tissue (soft callus) forms a few days after the fracture
   - Capillaries grow into the tissue and phagocytic cells begin cleaning debris
   a. Osteoblasts and fibroblasts migrate to the fracture and begin reconstructing the bone
   b. Fibroblasts secrete collagen fibers that connect broken bone ends
   c. Osteoblasts begin forming spongy bone
   d. Cartilaginous matrix that later calcifies
3. Bony callus formation
   a. New bone trabeculae appear in the fibrocartilaginous callus
   b. Fibrocartilaginous callus converts into a bony (hard) callus
   c. Bone callus begins 3-4 weeks after injury, continues until firm union forms 2-3 months later
4. Bone Remodeling
   a. Excess material (bone shaft exterior/ medullary canal) removed
   b. Shaft Walls Reconstructed (Compact bone is laid down)

I. Homeostatic Imbalances

1. Osteomalacia
   a. Bones are inadequately mineralized causing softened, weakened bones
   b. Main symptom is pain when weight is put on the affected bone
   c. Caused by insufficient calcium in the diet, or by vitamin D deficiency
2. Rickets
   a. Bones of children are inadequately mineralized causing softened, weakened bones
   b. Bowed legs and deformities of the pelvis, skull, and rib cage are common
   c. Caused by insufficient ______________ in the diet, or by vitamin D deficiency
3. Osteoporosis
   a. Group of diseases in which bone reabsorption outpaces bone deposit
   b. Spongy bone of the spine is most vulnerable
   c. Occurs most often in postmenopausal women
   d. Bones become so fragile that sneezing or stepping off a curb can cause fractures

J. Disease

1. Paget's Disease
   a. Characterized by excessive bone formation and breakdown (spotty weakening of bone)
   b. Pagetic bone with an excessively high ratio of woven to compact bone is formed
   c. Usually localized in the spine, pelvis, femur, and skull