The Skeletal System

- Parts of the skeletal system
  - Bones (skeleton)
  - Joints
  - Cartilages
  - Ligaments
- Divided into two divisions
  - Axial skeleton
  - Appendicular skeleton

Functions of Bones

- **Support** - holds up soft tissues & maintains body shape
- **Protection** of internal organs critical to survival such as brain, heart & lungs
- **Lever system** – muscles act on bones to produce movement
- **Mineral storage** – matrix composed of minerals
- **Blood cell formation** - produced by marrow of many bones

Functions of Cartilage

- Model for bone growth - abundant in embryo & fetus – model from which most adult bones develop
- Provides a smooth cushion between adjacent bones
- Provides firm flexible support (nose, ears, ribs & trachea)
- Relatively rigid, but springs back to original shape if bent or slightly compressed; excellent shock absorber

Functions of Ligaments and Tendons

- **Ligaments**
  - Attach bones to bones
  - Provide stability
- **Tendons**
  - Attach muscles to bones
  - Anchors muscle to bone for movement
  - Example: Achilles tendon

Bones of the Human Body

- The adult skeleton has 206 bones - makes up 18 - 20% of your body weight
- Two basic types of bone tissue
- Compact/Dense bone (solid)
  - Homogeneous
  - Forms diaphysis of long bones & thinner surfaces of all other bones
- Cancellous/Spongy bone (porous)
  - Small needle-like pieces of bone
  - Many open spaces
  - Forms epiphyses of long bones & center of all other bones

**Classification of Bones on the Basis of Shape**

(a) Long bone
   (e.g., humerus of arm)

(b) Short bones
   (e.g., carpals of wrist)

(c) Flat bone
   (e.g., parietal bone of skull)

(d) Irregular bone
   (e.g., vertebra)

**Classification of Bones**

- Long bones
  - Typically longer than wide
  - Have a shaft (diaphysis) with heads at both ends (epiphyses)
  - Contain mostly compact bone
    - Examples: Femur, humerus
  - If still growing, has an epiphyseal or growth plate composed of cartilage between each epiphysis & diaphysis
- Short bones
  - Generally cube-shape
  - Contain mostly spongy bone
- Examples: Carpals, tarsals

(b) Short bones
(e.g., carpals of wrist)

- Flat bones
  - Thin and flattened
  - Usually curved
  - Thin layers of compact bone around a layer of spongy bone
    - Examples: Skull, ribs, sternum, scapula

(c) Flat bone
(e.g., parietal bone of skull)

- Irregular bones
  - Irregular shape
  - Do not fit into other bone classification categories
    - Example: Vertebrae and facial bones

(d) Irregular bone
(e.g., vertebra)

Gross Anatomy of a Long Bone
- Diaphysis
  - Shaft
  - Composed of compact bone
- Epiphysis
  - Ends of the bone
  - Composed mostly of spongy bone
Structures of a Long Bone

- Periosteum
  o Outside covering of the diaphysis
  o Fibrous connective tissue membrane
- Sharpey's fibers
  o Secure periosteum to underlying bone
- Arteries
  o Supply bone cells with nutrients
- Articular cartilage
  o Covers the external surface of the epiphyses
  o Made of hyaline cartilage
  o Decreases friction at joint surfaces
- Medullary cavity
  o Cavity of the shaft
  o Contains yellow marrow (mostly fat) in adults
  o Contains red marrow (for blood cell formation) in infants

Bone Markings

- Surface features of bones
- Sites of attachments for muscles, tendons, and ligaments
- Passages for nerves and blood vessels
- Categories of bone markings
  o Projections and processes – grow out from the bone surface
  o Depressions or cavities – indentations
- Projections or processes that form joints:
  o **Condyle** = a large rounded prominence that forms a joint.
    - Ex: medial condyle of the femur
  o **Head** = rounded projection that forms a joint and is supported on the constricted portion (**neck**) of a bone.
    - Ex: head of the femur
  o **Facet** = smooth, flat articular surface.
    - Ex: facet on a vertebra
  o **Ramus** = armlike bar of bone
    - Ex: ramus of the mandible
- Processes to which tendons, ligaments & other connective tissues attach:
  o **Tuberosity** = large rounded projection, usually w/ a rough surface.
    - Ex: deltid tuberosity of the humerus
Spine = sharp, slender often pointed projection.
  - Ex: spine of the scapula

Trochanter = large blunt projection found only on the femur.
  - Ex: greater trochanter of femur

Crest = Prominent narrow border or ridge.
  - Ex: iliac crest of the pelvic girdle

Line = narrow ridge of bone; less prominent than a crest
  - Ex: intertrochanteric line of femur

Tubercle = small rounded projection or process.
  - Ex: adductor tubercle of femur

Epicondyle = raised area on or above a condyle
  - Ex: lateral and medial epicondyle of the femur

Process = any bony prominence
  - Ex: spinous process of vertebra

Depressions and openings allowing blood vessels and nerves to pass:
  - Foramen (pl. – foramina) = rounded or oval opening through a bone.
    - Ex: foramen magnum of the occipital bone
  - Meatus = tubelike channel extending within a bone.
    - Ex: external auditory meatus of the temporal bone
  - Fossa = shallow depression in or on a bone, often serving as an articular surface.
    - Ex: mandibular fossa of the temporal bone
  - Sinus = cavity within a bone, filled with air and lined w/ mucus membrane.
    - Ex: sinus of the frontal bone
  - Groove = furrow
    - Ex: mandibular groove
  - Fissure = narrow, slitlike opening.
    - Ex: inferior orbital fissure

Microscopic Anatomy of Bone
  - Osteon (Haversian System)
    - A unit of bone
  - Central (Haversian) canal
    - Opening in the center of an osteon
    - Carries blood vessels and nerves
  - Perforating (Volkman’s) canal
    - Canal perpendicular to the central canal
    - Carries blood vessels and nerves
• Lacunae
  o Cavities containing bone cells (osteocytes)
  o Arranged in concentric rings
• Lamellae
  o Rings around the central canal
  o Sites of lacunae
• Canaliculi
  o Tiny canals
  o Radiate from the central canal to lacunae
  o Form a transport system

Changes in the Human Skeleton
• In embryos, the skeleton is primarily hyaline cartilage
• During development, much of this cartilage is replaced by bone = ossification (os = means bone)
  o Minerals involved in ossification include:
    • Calcium Ca++
    • Vitamin D
    • Potassium K+
    • Phosphorus P
    • Magnesium Mg++
    • Iron Fe++
    • Sodium Na+
    • Chlorine Cl⁻
- Cartilage remains in isolated areas
  - Bridge of the nose
  - Parts of ribs
  - Joints

**Spongy Bone Formation**

- In the beginning...at 8 weeks of fetal development...your skeleton was in place. It was cartilage.
- **Hyaline Cartilage Cell / Chondrocyte**
  1. The cells secrete a matrix (jelly-like junk)
  2. Minerals are absorbed by the matrix.
- The matrix hardens: **endochondral ossification**.
- The entombed cartilage cells die.

- Meanwhile back at the periosteum & endosteum our hero is born: **osteoblast!**
- The osteoblasts travel to the epiphysis via the blood vessels (BV) where they set up house.
- They secrete a matrix and absorb minerals, this also hardens = **ossifies**!
- The processes disappear from the osteoblasts and a canal forms = **canalculi** (small channels)
• **Trabecula** (plate-like) – where cartilage cells died and got replaced by bone cells (follow the lines of stress = strength!)
• **Spaces** – where cartilage cells died but were not replaced

**Compact Bone Formation**

• It is not replacement of cartilage by bone.
• It is a direct formation of bone.
• Osteoblasts from the periosteum and endosteum stay and form compact bone
• Compact bone is made fast and thick and the center cannot get enough service…
• A new bone cell is made = **osteoclast** (Bone destroyer)

![Image of osteoclast]

• The osteoclasts (like a termite!) tunnel out the compact bone to open up the **medullary canal** and a BV and nerve grow into the tunnel.
  (red marrow = produce RBC, yellow = adipose tissue)
• A new bone cell appears = **osteocyte** (maintains bone)

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**Bone Growth**

- Later, usually after birth, secondary ossification centers form in the epiphyses. Ossification in the epiphyses is similar to that in the diaphysis except that the spongy bone is retained instead of being broken down to form a medullary cavity. When secondary ossification is complete, the hyaline cartilage is totally replaced by bone except in two areas. A region of hyaline cartilage remains over the surface of the epiphysis as the articular cartilage and another area of cartilage remains between the epiphysis and diaphysis. This is the **epiphyseal plate** or growth region.
- Bones grow in length at the epiphyseal plate by a process that is similar to endochondral ossification. The cartilage in the region of the epiphyseal plate next to the epiphysis continues to grow by mitosis. The chondrocytes, in the region next to the diaphysis, age and degenerate. Osteoblasts move in and ossify the matrix to form bone. This process continues throughout childhood and the adolescent years until the cartilage growth slows and finally stops. When cartilage growth ceases, usually in the early twenties, the epiphyseal plate completely ossifies so that only a thin epiphyseal line remains and the bones can no longer grow in length. **Bone growth is under the influence of growth hormone from the anterior pituitary gland and sex hormones from the ovaries and testes.**

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**Bone Growth**

- Epiphyseal plates allow for growth of long bone during childhood
  - New cartilage is continuously formed
  - Older cartilage becomes ossified
    - Cartilage is broken down
- Bone replaces cartilage
- Bones are remodeled and lengthened until growth stops
  - Bones change shape somewhat
  - Bones grow in width

Long Bone Formation and Growth
Types of Bone Cells
- Osteocytes
  - Mature bone cells
- Osteoblasts
  - Bone-forming cells
- Osteoclasts
  - Bone-destroying cells
  - Break down bone matrix for remodeling and release of calcium
- Bone remodeling is a process by both osteoblasts and osteoclasts

Bone Fractures
- A break in a bone
- Types of bone fractures
  - Closed (simple) fracture – break that does not penetrate the skin
  - Open (compound) fracture – broken bone penetrates through the skin
- Bone fractures are treated by reduction and immobilization
  - Realignment of the bone

Common Types of Fractures

<table>
<thead>
<tr>
<th>Fracture type</th>
<th>Illustration</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comminuted</td>
<td><img src="image" alt="Comminuted Fracture" /></td>
<td>Bone breaks into many fragments.</td>
<td>Particularly common in the aged, whose bones are more brittle.</td>
</tr>
<tr>
<td>Compression</td>
<td><img src="image" alt="Compression Fracture" /></td>
<td>Bone is crushed.</td>
<td>Common in porous bones (i.e., osteoporotic bones).</td>
</tr>
<tr>
<td>Depressed</td>
<td><img src="image" alt="Depressed Fracture" /></td>
<td>Broken bone portion is pressed inward.</td>
<td>Typical of skull fracture.</td>
</tr>
<tr>
<td>Impacted</td>
<td><img src="image" alt="Impacted Fracture" /></td>
<td>Broken bone ends are forced into each other.</td>
<td>Commonly occurs when one attempts to break a fall with outstretched arms.</td>
</tr>
<tr>
<td>Spiral</td>
<td><img src="image" alt="Spiral Fracture" /></td>
<td>Ragged break occurs when excessive twisting forces are applied to a bone.</td>
<td>Common sports fracture.</td>
</tr>
<tr>
<td>Greenstick</td>
<td><img src="image" alt="Greenstick Fracture" /></td>
<td>Bone breaks incompletely, much in the way a green twig breaks.</td>
<td>Common in children, whose bones are more flexible than those of adults.</td>
</tr>
</tbody>
</table>

Repair of Bone Fractures
- Hematoma (blood-filled swelling) is formed
- Break is splinted by fibrocartilage to form a callus
- Fibrocartilage callus is replaced by a bony callus
- Bony callus is remodeled to form a permanent patch
Stages in the Healing of a Bone Fracture

1. Hematoma formation
2. Fibrocartilage callus formation
3. Bony callus formation
4. Bone remodeling