Define the following:

Acromegaly, gigantism, rickets, scurvy, achondroplasia, osteomalacia, hyperstosis, osteomyelitis, osteoperosis, craniostenosis, deviated septum, sinusitis, spina bifida, whiplash
The Skeletal System: Bone Tissue

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
- Attachment site for muscles
- Storage of the minerals, calcium & phosphate
- Blood cell production occurs in red bone marrow (hemopoiesis)
- Energy storage in yellow bone marrow
Types of Bones

- **Long bones**: arms, legs
- **Short bones**: wrist, ankles
- **Flat bones**: ribs, sternum, shoulder blades, hip bones, and cranial bones
- **Irregular bones**: vertebrae and facial bones
Anatomy of a Long Bone

- **Diaphysis** = shaft of a long bone
- **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, innermost part of a compact bone
- **Endosteum** = lining of marrow cavity
- **Periosteum** = tough membrane covering bone but not the cartilage
Cell Types of Bone

- **Osteoprogenitor cells**: stem cells (undifferentiated)
- **Osteoblasts**: produce the matrix
- **Osteocytes**: mature bone cells
- **Osteoclasts**: large, multinucleated cells; dissolve matrix and release stored minerals
Development of Bone Tissue

Both types of bone formation begin with mesenchymal cells.

Mesenchymal cells transform into chondroblasts which form cartilage.

Or

Mesenchymal cells become osteoblasts which form bone.
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
The Trabeculae of Spongy Bone

Latticework of thin plates of bone called trabeculae

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.

Spongy bone reduces the weight of the skeleton and makes it easier for muscles to move the bones
Bone Formation, Growth, and Remodeling

The skeleton is bone and cartilage.

In embryos mostly hyaline cartilage which is replaced by bones in most areas.

Most bones develop using the hyaline cartilage as their “models”.
Bone Formation = Ossification

Hyaline cartilage model is completely covered with bone matrix by bone-forming cells called osteoblasts.

The enclosed hyaline cartilage model is digested which opens up a medullary cavity within the newly formed bone.
Bone Formation

1. Proliferation
2. Hypertrophy
3. Calcification
4. Cell death
5. Ossification
6. Remodeling
Two regions maintain their hyaline model cartilage:

1. **Articular cartilage**: reduce friction at joint surfaces

2. **Epiphyseal plates**: provide for longitudinal growth of the long bones during childhood.
Factors Necessary for proper bone formation:

- Vitamin A
- Vitamin C
- Vitamin D
- Hormone thyroxine
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.
  (epiphyseal line)
Factors Affecting Bone Growth

1. Nutrition
   - adequate levels of minerals and vitamins
     - calcium and phosphorus for bone growth

2. Sufficient levels of specific hormones during childhood need insulin-like growth factor
   - promotes cell division at epiphyseal plate
   - need hGH (growth), thyroid (T3 & T4) and insulin
2. Cont’d...sex steroids at puberty

- growth spurt and closure of the epiphyseal growth plate
- estrogens promote female changes -- wider pelvis
- When sex hormones increase, bone growth accelerates rapidly

3. Heredity: all people have a genetic potential for height

4. Exercise and “stress”: bones that don’t get, used lose calcium
Hormonal Abnormalities

- Oversecretion of hGH during childhood produces gigantism.
- Undersecretion of hGH or thyroid hormone during childhood produces short stature.
- Both men or women that lack estrogen receptors on cells grow taller than normal.
- Estrogen responsible for closure of growth plate.
Bone Remodeling

Bones are remodeled as the long bones grow which accounts for the prejections and thickening of bones which increase their strength in areas where bulky muscles are attached.

Here osteoblasts lay down new matrix and become trapped within it.

Once trapped they become osteocytes or mature bone cells.
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
Fractures

- Named for shape or position of fracture line
- Common types of fractures:
  1. Simple—no break in skin (closed fracture, completely internal)
  2. Compound—bones protrude through the skin (open fracture)
  3. Comminuted—broken ends of bones are fragmented (elderly)
  4. Greenstick—partial fracture (children)
5. **Impacted**—bones are forced into each other
6. **Compression**—crushed bone
7. **Spiral**—rugged break when excessive twisting forces are applied
Repair of a Fracture

1. Hematoma—blood filled swelling

2. Fibrocartilage callus—mass of repair tissue, cartilage matrix, bony matrix, collagen

3. Bony callus—as more osteoblasts and osteoclasts migrate into the area and multiply the fibrocartilage is replaced by a callus made of spongy bone

4. Over time the bony callus is remodeled...makes a permanent patch
Calcium Homeostasis & Bone Tissue

- Skeleton is reservoir of Calcium & Phosphate
- Vitamin D is necessary for absorption and transport of Ca & P ions
- Calcium ions involved with many body systems
- Small changes in blood levels of calcium ions can be deadly (plasma level maintained 9-11mg/100mL)
  - Cardiac arrest if too high
  - Respiratory arrest if too low
- Parathyroid hormone (PTH) is secreted if calcium ion levels falls
  - osteoclast activity increased, kidney retains calcium ion and produces calcitriol
- Calcitonin hormone is secreted from the thyroid if calcium ion blood levels get too high
  - increases osteoblast activity
  - increases bone formation by osteoblasts
Aging & Bone Tissue

• Demineralization = loss of minerals
  - very rapid in women 40-45 yrs. as estrogens levels decrease (estrogen therapy prescribed)
  - in males, begins after age 60
• Decrease in protein synthesis
  - decrease in growth hormone
  - decrease in collagen production which gives bone its tensile strength
  - bone becomes brittle & susceptible to fracture
Osteoporosis

• Decreased bone mass resulting in porous bones

• Prevention or decrease in severity
  • adequate diet, weight-bearing exercise, & estrogen replacement therapy (for menopausal women)
  • behavior when young may be most important factor
Disorders of Bone Ossification

Rickets
- calcium salts are not deposited properly
- bones of growing children are soft
- bowed legs, skull, rib cage, and pelvic deformities result

Osteomalacia
- new adult bone produced during remodeling fails to ossify
- hip fractures are common
**Bone markings:**

- **Tuberosity** - a large round bump used for muscle attachment

- **Condyle** - smooth, round bump of bone that helps form a joint

- **Foramen** - a hole in the bone for blood vessels and nerves to pass through

- **Hiatus** - a hole in a membrane for blood vessels and nerves to pass through

- **Trochanter** - large, round projection of a bone, found only on the femur
The Skeletal System

Axial Skeleton
Axial Skeleton

Skull, Vertebral column and the bony thorax
Skull

Two sets of bones

Cranium: encloses the brain tissue

Facial bones hold the eyes and allow the facial muscles to show feelings
All but one of the bones of the skull are joined by sutures...immovable locking joints.

The mandible (jaw bone) is attached by a freely movable joint.
4 Sutures found in the Skull

1. **Lambdoid**
   Between the occipital & parietal bones

2. **Coronal**
   Frontal & parietal bones articulate at the coronal suture

3. **Sagittal**
   Between the two parietal bones

4. **Squamous**
   Between the parietal & temporal
Sutures

(a) Posterior view

(b) Superior view
Cranium

- 8 large flat bones
- All single bones except for the parietal and temporal which are paired
- The external auditory meatus is found in the temporal bone
- The bony roof of the mouth is formed by the palatine and maxillae bones
- The temporal bone has the styloid process, zygomatic process, and auditory ossicles
Cranial Bones Side View

(c) Lateral view
Cranial Bones, bottom view
Facial

14 bones compose the face

The orbit is formed by the lacrimal, sphenoid, ethmoid and frontal bones

12 are paired

Only the mandible and the vomer are single

The zygomatic arch is formed by the union of processes from the temporal and zygomatic bones

Tear glands are in the lacrimal fossa
Fetal Skull
The fibrous membranes connecting the cranial bones are called Fontanels...a baby’s pulse can be felt in these soft spots
Vertebral Column Spine

- Supports the skull, extends to the pelvis and transmits the weight of the body to the lower limbs
- 26 irregular bones, before birth 33 separate bones called vertebrae
Cervical Vertebrae

- 7 cervical vertebrae (neck)
- The second cervical vertebra is also known as the axis.
Thoracic Vertebrae

12 thoracic vertebrae (back)

Costal processes are located on these vertebrae.
Lumbar Vertebrae

Sacrum

Coccyx

(a)
5 lumbar vertebrae (lower back)

Single vertebrae are separated by pads of flexible fibrocartilage = intervertebral disks

These cushion and act as shock absorbers
9 vertebrae eventually fuse, forming the two composite bones ... sacrum (5) and coccyx (3-5)
A young person has disks with a high water content...90%
As we age the water content decreases
This is why older people get herniated (slipped) disks
If these disks press on the spinal cord or spinal nerves it really hurts!
Primary Curvatures

- Spinal curvatures in the thoracic and sacral regions
- Present at birth
Abnormal Spinal Curvature

Causes—injury, congenital, aging

1. Kyphosis—exaggerated thoracic curvature (hump back)
2. Lordosis—exaggerated lumbar curvature
3. Scoliosis—an abnormal, exaggerated lateral curvature

Spine curves to one side or the other

Usually painless but can cause severe distortion of the body
Bony Thorax

sternum, ribs, and thoracic vertebrae
Sternum

- Flat bone
- Fusion of 3 bones: manubrium, body, xiphoid process
- Attached to the first 7 pair (ribs)
- Manubrium is the portion of the sternum that articulates with the clavicles
Ribs

- 12 pairs
- First 7 are true ribs
- Next 5 are false ribs
  - Last 2 of these are floating ribs
- Ribs that have no connection to the sternum are called floating or false ribs
- Intercostal space is filled with intercostal muscles
1. What are the three abnormal curvatures that can happen to the spine? (include what part of the spine curves)

2. What can cause this? (3 things)

3. What is the function of the epiphyseal plate?

4. List the divisions of the vertebral column from most superior to inferior...cervical,
Skeleton Terminology (18)

- Fissure
- Head
- Tuberosity
- Sinus
- Spine
- Tubercle
- Foramen
- Trochanter
- Neck
- Sulcus
- Ramus
- Condyle
- Fossa
- Process
- Facet
- Crest
- Line
- Trochlea
Skeletal System: Appendicular Skeleton

- Pectoral girdle
- Pelvic girdle
- Upper limbs
- Lower limbs
Appendicular Skeleton
Pectoral (Shoulder) Girdle

- Consists of scapula and clavicle
- Clavicle articulates with sternum (sternoclavicular joint)
- Clavicle articulates with scapula (acromioclavicular joint)
- Scapula held in place by muscle only
- Upper limb attached to pectoral girdle at shoulder (glenohumeral joint)
Scapula

(a) Anterior view  (b) Lateral view  (c) Posterior view
Upper Extremity

- Each upper limb = 30 bones
  - humerus within the arm
  - ulna & radius within the forearm
  - carpal bones within the wrist
  - metacarpal bones within the palm
  - phalanges in the fingers
Humerus

- Large bone connecting your elbow to your shoulder
- Proximal end forms the shoulder joint
- Distal end forms the elbow joint
- Greater tubercle is the landmark near the proximal end
- Deltoid tuberosity is process that extends along the lateral border of the shaft
Forearm Bones

- The forearm connects the elbow to the wrist
- **Ulna** (on little finger side)
  - olecranon process is found on the ulna
  - located medial to the radius
- **Radius** (on thumb side)
  - proximal end is ROUND
  - “radius rocks the thumb”
  - articulates with the ulna and the carpals
Wrist

- 8 Carpal bones
- Carpal tunnel--tunnel of bone & flexor retinaculum (large ligament) housing tendons and nerves
  - Inflammation of the connective tissues between the flexor retinaculum and the carpal bones can compress the tendons and sensory nerves = carpal tunnel syndrome
Metacarpals and Phalanges

**Metacarpals**
- 5 total
- form the palms of the hands
- - knuckles (metacarpophalangeal joints)

**Phalanges**
- 14 total: each is called phalanx
- form the fingers
Pelvic girdle = two hipbones united at pubic symphysis

Each hip bone = ilium, pubis, and ischium

Pelvic Girdle = 2 os coxae, sacrum and coccyx

Each os coxae of the pelvic girdle consists of 3 fused bones: ilium, ischium and pubis
**Os Coxae**
Pelvic Facts

- The largest coxal bone is the ilium.
- The superior border of the ilium is the iliac crest. It acts as a point of attachment for both ligaments and muscles.
- When seated, the weight of the body is borne by the ischial tuberosities.
- The coccyx moves forward when a person sits.
- The sacrum and the coccyx are considered part of the pelvis, but not the lumbar vertebrae.
- The femur articulates with the coxa at the acetabulum.
Male & Female Pelvic Girdles

**Male pelvis**
- Larger and heavier
- larger articular surfaces
- relatively deep iliac fossa
- “heart-shaped” pelvic inlet
- ilia extend farther above sacrum
- pubic arch angle < 90°

**Female pelvis**
- wider & shallower
- larger pelvic inlet & outlet
- more space in true pelvis
- pubic arch angle > 90°
Differences in the skeletons of males & females are best seen in the pelvis.
Lower Extremity

- Each lower limb = 30 bones
  - femur and patella within the thigh
  - tibia & fibula within the leg
  - tarsal bones in the foot
  - metatarsals within the forefoot
  - phalanges in the toes
Femur and Patella

Femur (thighbone)
- Longest, heaviest & strongest bone in body
- Neck is common fracture site

Patella
- Knee cap
**Tibia and Fibula**

**Tibia**
- medial & larger bone of leg
- weight-bearing bone
- distal end articulates with the talus

**Fibula**
- not part of knee joint
- muscle attachment only
- lateral malleolus on distal end
Tarsus

Contains 7 tarsal bones

Talus = ankle bone

Calcaneus - heel bone
Metatarsus and Phalanges

- **Metatarsus**
  - midregion of the foot
  - 5 metatarsals

- **Phalanges**
  - distal portion of the foot
  - big toe is **hallux**
Arches of the Foot

**Function**
- distribute body weight over foot
- yield & spring back when weight is lifted
Clinical Problems

- **Flatfoot**
  - weakened ligaments allow bones of medial arch to drop
- **Clawfoot**
  - medial arch is too elevated
Bellringer

1. What is the largest bone in your body?
2. Which has more bones...feet or hands?
3. What bone is your “heel” bone?
4. What bone is your “ankle” bone?
5. How many true ribs do you have?
6. What is the distal lateral process on the fibula called?
7. Which bone is held in place only by muscle?
8. The pelvic girdle forms a joint with this bone of the axial skeleton.
Joints
Joints/Articulations

All bones in the body, except the hyoid, articulate with at least one other bone

Functions:
- Hold the bones together securely
- Give the rigid skeleton mobility and flexibility
Classification of Joints

Functional: amount of movement of the joints

1. Synarthrosis—immovable joints, sutures
2. Amphiarthrosis—slightly movable, axial
3. Diarthrosis—freely movable joints, limbs
Structural: type of connective tissue at joint

- Fibrous
- Cartilaginous
- Synovial
Fibrous Joints

- United by fibrous tissue
- Sutures of the skull
- Irregular edges are bound tightly by connective tissue
- No movement
Cartilaginous Joints

Bone ends are connected by cartilage

Amphiarthrotic—pubic symphysis, intervertebral joints of the spinal column (fibrocartilage)

Synarthrotic—growing long bones (hyaline cartilage)
Synovial Joints

Joints containing synovial fluid

All have four basic features

1. Articular cartilage—hyaline cartilage covers the ends of the bones forming the joint

2. Fibrous articular capsule—joint surfaces are covered by a capsule of fibrous connective tissue and lined with synovial membranes
3. Joint cavity—articular cavity encloses a cavity containing fluid

4. Reinforcing ligaments—fibrous cavity usually reinforced with ligaments.
   --Bursae (fluid filled synovial membrane sacs) are often found cushioning tendons where they cross bones
6 Types of Synovial Joints

- **Gliding joint** (plane joint) — permits limited movement usually in a single plane (ex. - carpals)
- **Hinge joint** — permits only angular movement in one plane (ex. - ulna, humerus)
- **Pivot joint** — permits only rotation (ex. - radius)
Ball and socket joint — permits rotation as well as other movements (ex. - humerus, scapula)

Saddle joint — concave on one axis and convex on another
Ellipsoidal joint (condyloid) — oval articular face that nestles within a depression in the opposing surface (ex. - metacarpal, phalanx)
Inflammatory disorders

1. Bursitis—water on the knee, inflammation of bursae or synovial membrane

2. Strain, sprain—extensive stretching of ligaments and tendons
3. Arthritis
   --osteoarthritis: most common, joint is being worn away
   --rheumatoid arthritis: autoimmune disorder, swelling of the synovial membrane
   --Gout: uric acid accumulates depositing crystals in soft tissues
Types of Movements
(Know for Muscles!!!!)

1. **Gliding**: two opposing surfaces slide past one another
   **carpal and tarsal bones, between the clavicles and the sternum**
Angular Movements:

2. **Flexion**: movement that reduces the angle between the articulating elements

3. **Extension**: increases the angle between articulating elements

4. **Hyperextension**: extension past the anatomical position
Flexion, Extension, Hyperextension
5. **Abduction**: movement away from the longitudinal axis of the body

6. **Adduction**: moving the abducted body part back toward the body
7. **Circumduction** - the movement of a distal part of the body in a circle
8. **Rotation**: bone revolves around its own longitudinal axis

- **Medial rotation** is turning of anterior surface in towards the midline
- **Lateral rotation** is turning of anterior surface away from the midline
9. **Pronation**: rotation that moves the wrist and hand from palm-facing-forward to palm facing back

10. **Supination**: rotates the palm back forward
SPECIAL MOVEMENTS

11. **Inversion**: twisting movement of the foot that turns the sole inwards

12. **Eversion**: turns the sole back out
13. **Dorsiflexion**: flexion of the ankle and elevation of the sole (dig in your heel)

14. **Plantar flexion**: extend the ankle and elevates the heel (standing on tip toes)
Movements of the Mandible

- Elevation = upward
- Depression = downward
- Protraction = forward
- Retraction = backward
Helpful Memory Tricks

- You feel with your phalanges
- The styloid process is pointy, like a stylus (temporal bone)
- You walk on tar with your toes/tarsals
- Drive your car (carpool) with your carpals
- Max’s moustache..........maxillary bone
- The mandible is the only bone that moves.......manual mandible

Vertebrae: Cats Taste Like Spicy Chicken (cervical, thoracic, lumbar, sacrum, coccyx)

# of vertebrae: times of day you eat: 7, 12, 5 (but don’t forget 5 fused in sacrum, 3-5 fused in coccyx)