I. Bones an overview
   *Axial skeleton* – longitudinal axis
   *Appendicular skeleton* – limbs and girdles
   *Skeletal system* – bones, joints, cartilages, ligaments

A. Functions of the bones
   1. Support – support, anchor all soft organs, bones of legs act as pillars, rib cage supports the thoracic wall.
   2. Protection – protect soft body organs.
   3. Movement – skeletal muscles attached to bones by tendons, use bones as levers to move the body and its parts.
   4. Storage
      a. Fat – stored in internal cavities of bones
      b. Minerals – calcium and phosphorus
   5. Blood cell formation – *hematopoiesis* in marrow cavities

B. Classification of bones – adult skeleton has 206 bones, there are two types of bone tissue, 1.) **compact bone** – dense, looks smooth and homogenous and 2.) **spongy bone** – small needle like pieces and lots of empty spaces, there are four classes of bones based on shape

1. **Long bones**
   a. Longer than wider
   b. Shaft with heads at both ends
   c. Mostly compact bone
   d. Includes bones of limbs except wrists and ankles

2. **Short bones**
   a. Cube shaped
   b. Mostly spongy bone
   c. Includes wrist and ankle bones
   d. **Sesamoid bones** – form within tendons, special type of short bone, example - patella or kneecap

3. **Flat bones**
   a. Thin, flattened, and usually curved
   b. Two thin layers of compact bone sandwiching a layer of spongy bone
   c. Skull, ribs, and sternum

4. **Irregular bones**
   a. Do not fit the other categories
   b. Vertebrae and hip bones

II. Structure of a long bone

A. Gross anatomy (Figure 5.2 on pg. 137)
   1. **Diaphysis** – shaft, most of the bone’s length, compact bone
   2. **Periosteum** – fibrous connective tissue membrane covers and protects diaphysis
   3. **Sharpey’s (perforating) fibers** – hundreds of connective tissue fibers that secure the periosteum to the underlying bone
   4. **Epiphyses** – ends of the long bones, thin layer of compact bone enclosing spongy bone
      *Articular cartilage* covers the surface, it is glassy hyaline cartilage, provides a smooth and slippery surface
      *Epiphyseal line* – thin line of bony tissue spanning the epiphysis, remnant of epiphyseal plate (found in kids when bones are growing, causes lengthwise growth, turn into solid bone by the end of puberty)
II. Structure of a long bone (cont.)
   A. Gross anatomy (cont.)
      5. **Yellow marrow/medullary cavity** – the cavity of the shaft in adults filled with adipose or fat tissue
      6. **Red marrow** – forms blood cells, found in cavities of spongy bone of flat bones and the epiphyses of some long bones (*infants all marrow is red marrow*)
      7. Bone Markings – reveal where muscles, tendons, ligaments attach, or blood vessels and nerves may pass. (Table 5.1 pg. 138)
         *Projections/processes – grow out from the bone
         *Depressions/cavities – indentations
         *All the terms that begin with T are projections, with F are depressions (except for facet)
   B. Microscopic anatomy (Figure 5.3 pg. 139)
      1. **Osteocytes** – mature bone cells
      2. **Lacunae** – tiny cavities within matrix that house the osteocytes
      3. **Lamellae** – concentric circles of lacunae around a central (Haversian) canal which run lengthwise and carry blood vessels and nerves
      4. **Haversian system/osteon** – each complex consisting of the central canal and rings
      5. **Canaliculi** – tiny canals that radiate out from the central canal, transport system, bones are well nourished even though they are so hard, and so they heal fast
      6. **Volkmann’s (perforating) canals** – run at right angles to the shaft, from outside to in

III. Bone formation, growth, and remodeling
   A. Skeleton is formed of cartilage and bone
   B. Embryo – made up of hyaline cartilage
   C. **Ossification** – bone formation, hyaline cartilage model is completely covered with bone matrix by bone forming cells called osteoblasts, articular cartilages persist for life (on the ends of bones), and epiphyseal plates provide longitudinal growth during childhood
   D. **Appositional Growth** – bones increase in diameter, controlled by growth hormone, and sex hormones during puberty until epiphyseal plates are converted to bone
   E. Bones are continually remodeled (WHERE) in response to calcium levels in the blood and the pull of gravity and muscles on the skeleton
   F. When blood Ca\(^+\) levels drop → parathyroid gland releases parathyroid hormone (PTH) → PTH activates osteoclasts, which are bone destroying cells, they break down the matrix of the bone and release Ca\(^+\).
   G. When blood Ca\(^+\) level too high (hypercalcemia) – calcium is deposited in bone
   H. **Homeostatic Imbalance**
      *Rickets* – disease of children in which bone fails to calcify, bowing of leg bones, due to lack of calcium or vitamin D

IV. Bone fractures
   A. **Closed (simple) fracture** – bone breaks cleanly and does not penetrate the skin
   B. **Open (compound) fracture** – broken bone ends penetrate through the skin, high risk of infection
   C. **Greenstick fractures** – common only in children because the bones are not fully formed (flexible)
   D. Reduction of fractures
      1. **Closed reduction** – put back together by the physician’s hand
      2. **Open reduction** – surgery is performed and the open ends are secured together by pins or wires
      3. Cast is put on for 6-8 weeks
   E. Repair of bone fractures (figure 5.5 pg. 143)
      1. A hematoma is formed
      2. The break is splinted by a fibrocartilage callus
      3. Bony callus is formed
      4. Bone remodeling occurs
AXIAL SKELETON – skull, vertebral column, bony thorax

I. Skull – formed by the cranium (protects brain) and facial bones (eyes, face muscles), all joined by sutures (interlocking and immovable joints), exception is mandible (jawbone)

A. Cranium – 8 large flat bones

1. Frontal bone – forehead, bony projections under eyebrows, superior part of each eye’s orbit
2. Parietal bones (2) – superior and lateral walls of cranium, sagittal suture in the middle between them, coronal suture where they meet frontal bone
3. Temporal bones (2) – inferior to parietal bones and join them at the squamous sutures
   a. External acoustic (auditory) meatus – canal that leads to the eardrum and the middle ear
   b. Styloid process – sharp needlelike projection, inferior to the external acoustic meatus, provides attachment for neck muscles
   c. Zygomatic process – thin bridge of bone that joins with the cheek bone (zygomatic) anteriorly
   d. Mastoid process – full of air cavities, rough projection posterior and inferior to the external acoustic meatus, provides attachment for neck muscles, because it is so close to the middle ear, infections can spread here and cause mastoiditis, which is dangerous because it is so close to the brain and it can spread
   e. Jugular foramen – at the junction of the occipital and temporal bones, passage for jugular vein, the largest vein in head for drainage
   f. Internal acoustic meatus – anterior to the jugular foramen and in the cranial cavity, cranial nerves VII & VIII pass through here (facial and vestibulocochlear nerves)
   g. Carotid canal – anterior to the jugular foramen, internal carotid artery runs through here, supplies blood to most of the brain
4. Occipital bone – most posterior, joins parietal bones at the lambdoid suture, foramen magnum is a large opening in the base, it is the place where the spinal cord attaches to the brain, on each side there are occipital condyles which rest on the first vertebra
5. Sphenoid bone – butterfly-shaped, spans the width of the skull, forms the floor of the cranial cavity
   a. Sella tursica (turk’s saddle) – in the midline of sphenoid bone, small depression, holds the pituitary gland in place
   b. Foramen ovale – in line with the posterior end of the sella tursica, cranial nerve V (trigeminal nerve), nerve that control chewing muscles of lower jaw
   c. Optic canal – seen exteriorly forming part of the eye orbit, optic nerve to eye
   d. Superior orbital fissure – seen exteriorly forming part of the eye orbit, cranial nerves III, IV, VI, nerves that control eye movement
   e. Sphenoid sinuses – located in the central part
6. Ethmoid bone – very irregular, roof of nasal cavity
   a. Crista galli – outermost covering of the brain attaches here
   b. Cribriform plates – allow nerve fibers from the olfactory (smell) receptors of the nose to reach the brain
   c. Superior & middle nasal conchae – form lateral walls of the nasal cavity

B. Facial bones – 14 bones form the face, 12 paired, mandible and vomer are single

1. Maxillae – form upper jaw, “keystone” bone of the face
   a. Alveolar margin – upper teeth here
   b. Palatine processes – anterior part of the hard palate of the mouth
   c. Paranasal sinuses – surround the nasal cavity, lighten the skull, amplify sound
   *Sinusitis – inflammation of the sinuses, headaches, jaw pain
2. Palatine bones – posterior part of the hard palate, cleft palate when don’t fuse
3. Zygomatic bones – “cheek bones” and part of lateral orbits
4. Lacrimal bones – “cheek bones” and part of lateral orbits
5. Nasal bones – bridge of nose
I. Skull (cont.)

B. Facial Bones (cont.)
6. *Vomer bone* – single bone in the median line of the nasal cavity, forms nasal septum
7. *Inferior nasal conchae* – thin curved bones projecting from lateral walls of the nasal cavity
8. *Mandible* – lower jaw, largest & strongest bone of the face, alveolar ridge for lower teeth, makes the only freely movable joint in the skull with temporal bones
9. *Hyoid bone* – closely related to the mandible and temporal bones. *It is a unique bone because it does not articulate with any other bone in the body. Suspended above the larynx. Serves as a movable base for the tongue and attachment for muscles that raise and lower the larynx when we swallow and speak.
10. *Fetal skull* – contains fontanels which are fibrous membranes connecting the cranial bones, “soft spots” can feel the baby’s pulse. Anterior fontanel is large and diamond shaped, the posterior fontanel is smaller and triangular. These allow the fetal skull to be compressed slightly during birth. They are converted to bone gradually and are gone by age 22-24 months.

II. *Vertebral column* (spine) – axial support of the body, extends from the bottom of the skull down to the coccyx, formed by 26 irregular bones

A. Each one is called a vertebrae, as well as sacrum and coccyx at the bottom
1. *Cervical vertebrae* – 7, neck
2. *Thoracic vertebrae* – 12, by ribs
3. *Lumbar vertebrae* - 5, in the low back
B. *Intervertebral disc* – pad of flexible fibrocartilage that separates the vertebrae, serves as a cushion, shock absorber, and still allows flexibility, in the young it has a high water contents and then starts drying out with age
  *Homeostatic Imbalance – *Herniated (slipped) discs*: older people are predisposed to herniations because their discs start to dry out, also can occur with exceptional twisting forces almost at any age. If the protruded disc presses on the spinal cord or a spinal nerve, numbness, excruciating pain, leg pain, leg weakness, muscle atrophy, or gait alterations can result.
C. The discs and the S-shaped structure of the vertebral column work together to prevent shock to the head when we walk or run.
1. *Primary curvatures* – thoracic and sacral region, present at birth
2. *Secondary curvatures* – cervical and lumbar regions, cervical develops when a baby begins to raise its head, and lumbar when it begins to walk
  *Homeostatic Imbalance –* Abnormal spinal curvatures: congenital (present at birth), idiopathic (no known cause), from disease, from bad posture, or unequal muscle pull on the spine
  a. *Kyphosis* – increased thoracic curve
  b. *Lordosis* – increased lumbar curve
  c. *Scoliosis* – a curvature to the side in any region
D. Structure of vertebrae
1. *Body/centrum* – disc like, weight bearing, faces anteriorly
2. *Vertebral arch* – arch formed from joining of laminae and pedicles
3. *Vertebral foramen* – canal for spinal cord
4. *Transverse processes* (tp’s) – 2 lateral projections from the vertebral arches
5. *Spinous process* (sp’s) – single projection from vertebral arch
6. *Superior and inferior articular processes* – paired projections lateral to the vertebral foramen, allowing the vertebrae to form joints with the vertebrae above and below (referred to as facet joints)
E. *Cervical vertebrae*: C1 to C7
1. C1 – *Atlas*, no vertebral body, occipital condyles of the skull rest here, “nod”
2. C2 – *Axis*, acts as a pivot for the rotation of the atlas and skull, has dens (odontoid process), allows you to rotate your head from side to side, “no”
II. Vertebral column (cont.)

E. Cervical vertebrae (cont.)

3. **C3 – C7** – typical cervical vertebrae, light and small, sp’s are short and divided, tp’s have foramina for vertebral artery

F. **Thoracic vertebrae** – T1 to T12, all are typical, larger then cervical, heart shaped body with 2 costal facets for rib heads, sp’s are long and hook sharply down

G. **Lumbar vertebrae** – L1 to L5, massive, block like bodies, short hatchet shaped sp’s, receive most of the stress of the vertebral column therefore they are the sturdiest

H. **Sacro** – 5 fused vertebrae, forms posterior wall of pelvis

1. **Alae** – wing like, articulate laterally with hip bones and form the sacroiliac joints (si joints)
2. **Median sacral crest** – fused sp’s, laterally are sacral foramina
3. **Sacral canal** – vertebral canal inside, terminates in a large inferior opening called the sacral hiatus

I. **Coccyx** – formed from the fusion of 3 to 5 tiny, irregularly shaped vertebrae, “tailbone”

III. Bony thorax – sternum, ribs, thoracic vertebrae, “thoracic cage” protects heart, lungs, and major blood vessels

A. **Sternum** (breastbone) – flat bone, fused **manubrium, body, & xiphoid process**, attaches to the first 7 ribs

1. **Jugular notch** – concave upper border of manubrium, level with T3
2. **Sternal angle** – manubrium and body meet at slight angle, form transverse ridge at the level of 2nd ribs, good landmark
3. **Xiphisternal joint** – sternal body and xiphoid process fuse here, T9 level *sternal puncture* – obtain samples of hematopoietic tissue to diagnose blood diseases

B. **Ribs** – 12 pairs of ribs for the walls of the bony thorax, all articulate with vertebral column posteriorly, intercostal muscles in intercostals spaces for aid in breathing

1. **True ribs** – first 7 pairs, attach to sternum by costal cartilage
2. **False ribs** – next 5 pairs, either attach to the sternum indirectly or not at all, the last 2 pairs of false ribs lack the sternal attachments and are called “floating ribs”

APPENDICULAR SKELETON – 126 bones of the limbs (appendages) and the pectoral and pelvic girdles, which attach the limbs to the axial skeleton.

I. Bones of the shoulder girdle (pectoral girdle)

A. **Clavicle** (collarbone)

1. Slender, double curved bone
2. Medially attached to manubrium, laterally to scapula
3. Acts as a brace to hold the arm away from the top of the thorax and helps prevent shoulder dislocation

B. **Scapula** (shoulder blade)

1. Triangular shaped and called “wings”
2. **Acromion** – enlarged end of the spine of the scapula
3. **Coracoid process** – beaklike, next to acromion, anchors muscles of arm
4. **Acromioclavicular joint** (ac joint) – where acromion and clavicle meet
5. **Suprascapular notch** – medial to coracoid, nerve passageway
6. **Glenoid cavity** – socket that receives the head of the humerus

C. Overall function of shoulder girdle

1. Very light and allows the upper limb to have exceptionally free movement
2. Shoulder girdle attaches to the axial skeleton at the sternoclavicular joint
3. Loose attachment of the scapula allows it to slide easily against the thorax
4. Glenoid cavity is shallow and the shoulder joint is poorly reinforced by ligaments
5. Biggest drawback – shoulder girdle is very easily dislocated
II. Bones of the upper limbs

A. Arm (shoulder to elbow) – made up of only the Humerus
   1. Head at proximal end, fits into the glenoid cavity of the scapula
   2. Greater and lesser tubercles – opposite to the head, sites of muscle attachments
   3. Deltoid tuberosity – midpoint of shaft, roughened area, deltoid muscle attachment
   4. Radial groove – runs obliquely down posterior shaft, course of radial nerve
   5. Trochlea – at distal end, on medial side, articulates with bones of forearm
   6. Capitulum – at distal end, on lateral side, articulates with bones of forearm
   7. Coronoid fossa – depression above the trochlea anteriorly
   8. Olecranon fossa - on the posterior surface
   9. Medial and lateral epicondyles – distal, one located on each side

B. Forearm (elbow to wrist)
   1. Radius - lateral bone, thumb side of forearm
      a. Head and neck – proximal end, head is disc shaped
      b. Radioulnar joints – both proximal and distal, connect radius and ulna
      c. Interosseous membrane – flexible membrane that connects radius and ulna the entire length, located in between them
      d. Styloid process – at distal end
      e. Radial tuberosity – below the disc shaped head, tendon of biceps attaches here
   2. Ulna – medial bone, on pinky side of forearm
      a. Coronoid process – on anterior proximal end
      b. Olecranon process – on posterior proximal end
      c. Trochlear notch – in between the two processes
      d. Styloid process – at distal end

C. Hand – carpals, metacarpals, phalanges
   1. Carpal Bones – 2 irregular rows of four bones each, form the carpus (wrist), bound together by ligaments that restrict movement, Scaphoid, Lunate, Triquetral, Pisiform, Trapezium, Trapezoid, Capitate, Hamate, just remember Stuffing Little Toys Past The Throat Can Hurt
   2. Metacarpals – make up the palm of the hand, numbered 1 to 5 starting at thumb, heads of the metacarpals make your knuckles
   3. Phalanges – bones of the fingers, 14 total, each finger has a proximal, middle, and distal except the thumb which has only proximal and distal

III. Bones of the pelvic girdle – 2 coxal bones (ossa coxae), large and heavy, function is weight bearing
*Bony pelvis – sacrum, coccyx, hip bones

A. Hip bone – fused ilium, ischium, and pubis.
   1. Ilium – is a large flaring bone, connects posteriorly with sacrum at the sacroiliac joints (si joints)
      a. Iliac crest – upper edge of alae (put your hands over your hips)
      b. Anterior superior iliac spine and a posterior superior iliac spine
   2. Ischium – “sit-down bone” that forms the inferior and medial portion of hip bone
      a. Ischial tuberosity – roughened area that receives body weight when you are sitting
      b. Ischial spine – superior to tuberosity
      c. Greater sciatic notch – allows blood vessels and the large sciatic nerve to pass from the pelvis posteriorly into the thigh
   3. Pubis (pubic bone) – most anterior portion
      a. Obturator foramen – opening that allows blood vessels and nerves to pass into the anterior part of the thigh
      b. Public symphysis – anterior joint where pubic bones meet
   4. Acetabulum – deep socket formed by the fusion of all three bones, receives head of femur
   5. False pelvis – superior to true pelvis
III. Bones of the pelvic girdle
   A. Hip bone (cont.)
      6. **True pelvis** – important in women because it must be big enough for the infant’s head to pass
         a. **Outlet** – inferior opening of the pelvis
         b. **Inlet** – superior opening
            *The female inlet is larger and more circular
            *Female pelvis is shallower and the bones are lighter and thinner
            *Female ilia flare more laterally
            *Female sacrum is shorter and less curved
            *Female ischial spines are shorter and farther apart; thus the outlet is larger
            *Female pubic arch is more rounded

IV. Bones of the Lower Limbs (thigh, leg, foot)
   A. **Femur** – thigh bone, heaviest and strongest bone in the body
      1. Ball like head proximally with neck below it, articulates with acetabulum
      2. **Greater and lesser trochanters** separated anteriorly by intertrochanteric line and posteriorly by intertrochanteric crest
      3. **Gluteal tuberosity** – located on the shaft, serves as muscle attachment
      4. **Lateral and medial condyles** – distal, articulate with the tibia below
      5. **Intercondylar fossa** – separates condyles posteriorly
      6. **Patellar surface** – smooth, anteriorly on distal femur, forms joint with **patella** (kneecap)
   B. **Leg** – tibia and fibula connected along their length by interosseous membrane
      1. **Tibia** – shin bone, larger and medial
         a. **Medial and later condyles** – at proximal end, separated by intercondylar eminence, articulate with femur to form knee joint
         b. **Tibial tuberosity** – a roughened area on the anterior tibia where patellar tendon attaches
         c. **Medial malleolus** – forms the inner bulge of the ankle
         d. **Anterior border** – anterior surface area of tibia, sharp and unprotected by muscle, easily felt
      2. **Fibula** – thin and stick like
         a. Forms joints with tibia both proximally and distally
         b. Has NO part in forming the knee joint
         c. **Lateral malleolus** – form the outer part of the ankle
   C. **Foot** – tarsals, metatarsals, & phalanges
      1. Functions to support our body weight and serves as a body lever that allows us to propel our bodies forward when we walk and run
      2. **Tarsus** – posterior half of the foot composed of 7 tarsal bones
         a. **Calcaneus** – heel-bone
         b. **Talus** – between the tibia and the calcaneus
         c. **Navicular**
         d. **Cuboid**
         e. **Medial cuneiform**
         f. **Intermediate cuneiform**
         g. **Lateral cuneiform**
      3. **Metatarsals** – 5 bones, form the sole of the foot
      4. **Phalanges** – 14 bones that form the toes, (similar to the hand) the big toe only has 2 bones proximal and distal, all others have 3 bones proximal, middle, and distal
Joints (articulations) – function to hold bones together and give mobility
*Synarthroses = immovable joints, sutures, connected by collagen fibers
*Amphiarthroses = slightly movable joints, intervertebral joints, have a disc of cartilage
*Diarthroses = freely movable joints, have a joint cavity, found in the appendicular skeleton

I. Types of joints
   A. **Fibrous Joints** – united by fibrous tissue, sutures in skull
      *Syndesmosis – connecting fibers are longer than those of sutures, have more of a “give”, ie. distal joint of tibia and fibula
   B. **Cartilaginous joints** – bone ends are connected by cartilage, ie. pubic symphysis, discs in spine
   C. **Synovial Joints** – bone ends are separated by a joint cavity (articular cavity) containing synovial fluid, cavity also has articular cartilage (hyaline cartilage) on the ends of the bones and the entire joint is enclosed by a joint capsule (articular capsule)
      1. Plane joint
      2. Hinge joint
      3. Pivot joint
      4. Condyloid joint
      5. Saddle joint
      6. Ball-and-socket joint

II. Homeostatic Imbalances
   A. **Osteoarthritis** – chronic degeneration in the aged, “wear-and-tear arthritis” cartilage breaks down and develops extra bone, bone spurs
   B. **Rheumatoid Arthritis** – chronic inflammatory disorder, starts 40-50 yrs. old, 3X more common in women, usually multiple and symmetrical joints involved, autoimmune disorder, deforms bones and can be crippling
   C. **Gouty Arthritis (Gout)** – uric acid accumulates in the blood and is deposited as needle-shaped crystals in the soft tissues of joints, leads to painful attacks usually in a single joint especially the big toe, most common in men

III. Developmental aspects of the skeleton
   *Fetal skeleton comes from hyaline cartilage
   ***Osteoporosis** – bone thinning disease, afflicts half of women over 65 and 20% of men over the age of 70, makes bones so fragile that a hug or sneeze can cause a fracture