Skeletal System: 206 bones- bones composed of osseous tissue (a type of connective tissue)

- joints - where 2 bones meet
- ligaments - connects bone to bone (strong, tough connective tissue)
- cartilage - strong, flexible connective tissue

locations
1. articulations- movable joints (provides smooth surface on joint)
2. need of flexibility: tip of nose, external ear, larynx (voice box), rib attachment

2 subdivisions: 
- Axial Skeleton: bones that form the longitudinal axis of the body
- Appendicular Skeleton: bones of the limbs and girdles

I. Bones: An Overview (pp. 130-139)

A. Functions of Bones

1. Supportive internal framework
   - bones form internal framework that supports and anchors all soft organs
   - bones of legs support body torso when standing erect
   - rib cage supports the thoracic wall

2. Protection of soft body organs
   - fused bones of skull protect brain
   - vertebrae protect the spinal cord
   - rib cage protects the thoracic organs (heart & lungs)

3. Movement using bones as levers
   - skeletal muscles attached to bones by tendons
   - bones used as levers to move body and its parts

4. Storage of calcium and phosphorus
   - fat is stored in the internal cavities of bones
   - minerals stored in bones
     - calcium - needed for
       1. neural transmission
       2. muscle contraction
       3. blood clot formation
     - hormones control movement of Ca to & from bones and blood

   - phosphorus - part of ATP, nucleic acids, and proteins

5. Hematopoiesis- blood cell formation in red marrow cavities of certain bones
   - location: usually spongy bone
B. Classification of Bones  (pp 131-132)  

2 types: **Compact Bone Tissue**- dense, smooth, and homogeneous 
very strong, can endure great stress & impacts

**Spongy Bone Tissue**- has small needle-like bone pieces within open spaces 
strong yet light-weight

Classification According to Shape: variety of shapes related to function

**Long Bones**- longer than width 
  shaft w/ heads at both ends 
  mostly compact bone (except epiphyses-ends) 
  location: limbs (except wrist & ankle)

**Short Bones**- cube shape 
  mostly spongy bone 
  location: wrist and ankle 
  sesameoid bones: special bones formed w/ in tendons 
  eg. patella

**Flat Bones**- thin and flattened 
  usually curved 
  2 thin layers of compact bone “sandwiching” layer of spongy bone 
  location: skull bones, ribs, sternum

**Irregular Bones**- neither long, short, or flat bones 
  location: vertebrae and hip bones
C. Structure of a Long Bone (pp. 132-133)

Gross Anatomy

**Diaphysis**- shaft

**Periosteum**- fibrous connective tissue that covers diaphysis (f'ns: 1. protection, 2. appositional growth, 3. contains collagen fibers that merge w/ those of tendons and ligaments that are attached to bone)

**Sharpey’s Fibers**- connective tissue fibers (also known as perforating fibers) connect periosteum to underlying bone

**Epiphyses**- ends of long bone

**Articular Cartilage**- covers epiphyses (instead of periosteum) decreases friction b/w bones of joints

**Epiphyseal Line**- remnant of epiphyseal plate

**Epiphyseal Plate**- flat plate of hyaline cartilage
location: in young, growing bones
causes lengthwise bone growth
end of puberty: hyaline cartilage replaced with bone

**Yellow Marrow**- also known as medullary cavity
location: cavity of shafts of adult bones
storage area for adipose (fat) tissue

**Red Marrow**- site of erythrocyte (RBC) production (hematopoiesis)
location: infant- shaft of long bone
adult- spongy layer flat bones epiphyses

**Bone Markings**- bone surface is not smooth (bumps, holes, and ridges)
projections (processes), depressions (cavities), holes indicate location of 1. muscle, tendon, or ligament attachment
2. holes for blood vessels & nerves to pass into bone
Microscopic Anatomy

osteocytes- mature bone cells

lacunae- cavities wh/ house osteocytes

lamellae- concentric circles of lacunae

central (haversian) canals- surrounds by lamellae
  run lengthwise through bony matrix
  carry blood vessels and nerves to all areas of bone

canaliculi- tiny canals radiating outward from central cans to all lacunae
  form transportation system that connects all bone cells to nutrient supply through
  hard boney matrix
  bone injuries heal quickly

perforating (Volkmann’s) canals- run into compact bone at right angles to shaft
  aids in communication from outside bone to its interior

Haversian system- (osteon) bone complex consisting of central canal & matrix rings
D. Bone Formation, Growth, and Remodeling  (pp. 134-138)

fetus - bones begin as cartilage
   cartilage- tough, flexible connective tissue (cartilage cells & collagen fibers)
   avascular- rely on diffusion of nutrients from nearby capillaries

ossification- process of bone formation
   process of replacing cartilage with bone tissue
   ossification begins ~ 3rd month of gestation (fetus)
   ends ~16-25 years old w/ closure of epiphyseal plate

fetus- 1. cartilage is covered with bone matrix produced by osteoblasts- bone-forming cells
       2. internal cartilage is broken down.....creating medullary cavity- yellow marrow

infant- a few bones remain as cartilage (skull...creating fontanels “soft spots”...allow brain growth)
       most bones replaced w/ bone matrix except: articular cartilage on epiphyses’ ends
       epiphyseal plate consisting of cartilage

childhood- long bone growth occurs and skull is ossified
            (loss of fontanels)

long bone growth:
controlled by growth hormone in childhood
   sex hormones during puberty

longitudinal growth: occurs at epiphyseal plates
   epiphysis end- more cartilage produced (lengthening bone)
   diaphysis end- cartilage replaced by bone matrix by osteoblasts

appositional growth: increases diameter of bone
   osteoblasts in periosteum add bone tissue to external diaphysis

periosteum- fibrous connective tissue membrane covering diaphysis
            connected to bone by Sharpey's fibers (perforating)
            contains osteoblasts (repair fractures too)
D. Bone Formation, Growth, and Remodeling  (pp. 134-138)

**osteoclasts**- giant bone-destroying cells activated by parathyroid hormone (PTH)

**osteoblasts**- produce bone matrix around itself creating an **osteocyte**

**osteocyte**- a mature bone cell

**bone remodeling**- necessary to maintain proportions & strength in bones as they grow
  - thickens bones increasing strength
  - creates large projections to increase strength in areas of large muscle attachment

occurs in response to

1. Δ’s in the pull of gravity and muscles on skeleton
   - det. where bone matrix is broken down or created

2. Δ’s in calcium levels in blood
   - **Ca level too low**: PTH stimulates osteoclasts to break down bone matrix, releasing Ca to blood
   - **Ca level too high**: Ca removed from flood & deposited into bone matrix as a calcium salt
E. Bone Fractures (pp. 138-139)

Types of Fractures
1. simple fracture (closed): bone does not penetrate skin
2. compound fracture (open): bone penetrates the skin

Comminuted: bone breaks into many fragments
common in elderly w/ brittle bones

Compression: bone is crushed
common in porous bones (osteoporosis)

Depressed: broken bone portion is pressed inward
skull fractures

Impacted: broken bone ends are forced into each other
common in “breaking fall w/ outstretched hands”

Spiral: ragged break occurs when excessive twisting forces are applied to a bone
common in sports fractures

Greenstick: bone breaks incompletely (like a green twig)
common in children (bones more flexible)

Reduction - realignment of broken bone ends
closed- achieved through moving bones back into alignment with hands
open- achieved through surgery with pins, plates, or wires to secure bones tog.

Immobilization- with a cast or traction (avg 6-8 weeks)

Repair of Fractures
1. Hematoma Formation- bcs vessels ruptured during break, osteocytes die (lack of nutrients)
2. Splinting of Break by Fibrocartilage Callus- consists of bony matrix, cartilage, collagen fibers
3. Bony Callus Formation- osteoblasts & osteoclasts move into area replacing callus w/ spongy bone
4. Bone Remodeling in Response to Mechanical Stress-
Skeleton: consists of **206 bones**

2 Parts:
1. **Axial** - skull, vertebral column, bony thorax  
   - **80 total**
2. **Appendicular** - limbs and girdles (pectoral & pelvic)  
   - **126 total**
   - **206 total**

**Axial: 80 total**

- **Skull:**
  - 8 cranial
  - 14 facial
- **Ears:** 6 total
- **Hyoid:** 1 total
- **Vertebral Column:**
  - 7 cervical vertebrae
  - 12 thoracic vertebrae
  - 5 lumbar vertebrae
  - 1 sacrum (5 fused vertebrae)
  - 1 coccyx (3-5 fused vertebrae)
- **Bony Thorax:**
  - 24 ribs (12 pairs)
  - 1 sternum
  - **25 total**
  - **80 total**

**Appendicular: 126 total**

- **Pectoral Girdle:**
  - 4 (2 scapula & 2 clavicles)
- **2 Upper Limbs:**
  - 2 upper arm (2 humerus)
  - 4 forearm (2 radius & 2 ulna)
  - 16 carpals (8 in each wrist)
  - 10 metacarpals
  - 28 phalanges (digits)
- **Pelvic Girdle:**
  - 2 coxal (ea. 3 fused: ilium, ischium, pubis)
- **2 Lower Limbs:**
  - 2 thigh (2 femur)
  - 2 patella
  - 4 lower leg (2 tibia & 2 fibula)
  - 14 tarsals (7 in each ankle)
  - 10 metatarsals
  - 28 phalanges (digits)
  - **126 total**
II. Axial Skeleton - forms longitudinal axis of the body
3 parts: skull, vertebral column, & bony thorax

Skull (pp. 139-145)
all but 1 skull bone (mandible) are joined together by suture- interlocking, immovable joints
skull formed by 2 sets of bones: 1. cranial (8)
2. facial (14)

Cranium- 8 large, flat bones encloses & protects the brain

(1) Frontal Bone- forms forehead
forms bony projections under eyebrows
forms superior aspect of eye orbit

(2) Parietal Bones- paired
form superior & lateral walls of cranium
sagittal suture- joins 2 parietal bones at midline of skull
coronal suture- joins 2 parietal bones to frontal bone

(2) Temporal Bones- paired
lie inferior to parietal bones middle ear located here
squamous suture- joins 2 temporal bones to parietal bones (above them)
significant bone markings

1. External Auditory Meatus- canal leading to eardrum & middle ear

2. Styloid Process- sharp, needle-like projection
inferior to auditory meatus
point of attachment for neck muscles

3. Zygomatic Process- bony bridge joining w/ zygomatic bone anteriorly

4. Mastoid Process- rough projection post. & inf. to auditory meatus
point of attachment for neck muscles

5. Jugular Foramen- b/w occipital & temporal bones
passageway for jugular vein

6. Carotid Canal- internal carotid artery passes through
ant. to jugular foramen on inferior aspect of skull

(1) Occipital Bone- most posterior bone of cranium
forms floor & back wall of skull condyles articulate w/ atlas
lambdoid suture- joins occipital bone to parietal bones
foramen magnum- lg. hole spinal cord connects to brain
occipital condyles- rest on axis (1st cervical vertebrae)

(1) Sphenoid Bone- butterfly shaped spans width of skull
forms part of floor of skull
sella turcica holds pituitary gland

(1) Ethmoid Bone- irregular shape lies anterior to sphenoid bone
forms roof of nasal cavity & part of medial walls of eye orbits
Skull

Cranial Bones  8 total bones  2 paired &  6 single

Ear Bones-  6 total bones  3 paired ossicles  malleus (hammer), incus (anvil), stapes (stirrup)
send vibration from tympanic membrane to inner ear

Hyoid Bone-  1 bone  only bone of body that does not articulate w/ any other bone
midneck region:  1 inch above larynx
f’ns:  movable base for tongue
attachment of muscles tht move larynx (up-down) when we speak or swallow

Facial Bones-  14 total bones:  12 paired &  2 single

(2) Maxillary Bones-  paired  fused to form upper jaw
keystone bone:  all face bones (except mandible) join maxillae
hold upper teeth in alveolar margin
palatine processes- form ant. part of hard palate
contain sinuses that drain into nasal passages (lighten skull bones)
mucosa lining continuation of nasal & throat mucosa- infections: sinusitis

(2) Palatine Bones-  paired  lie post. to palatine process of maxillary bones
form posterior part of hard palate

failure of palatine bones or palatine processes to fuse medially results in cleft palate

(2) Zygomatic Bones-  paired
form cheekbones & lateral walls of each orbit (eye socket)

(2) Lacrimal Bones-  paired  finger-nail size bones
form part of medial walls of each orbit  bears tear ducts
each bone has a groove- serves as a passageway for tears

(2) Nasal Bones-  paired  small rectangular bones
form bridge of nose

(1) Vomer Bone-  single bone  median line of nasal cavity
forms most of nasal septum

(2) Inferior Nasal Conchae-  paired  thin, curved  projecting from nasal cavity lateral walls

(1) Mandible-  single  lower jawbone
largest & strongest facial bone
parts:  body- horizontal part  forms chin
alveolar margin- holds lower teeth
located at superior ridge of mandible body
ramus- upright bar of bone extending from body of mandible
connects the mandible with the temporal bone
temporal-mandibular joint- only freely movable joint of skull

TMJ disorder
skull: superior view  (top of cranium removed)

skull: inferior view  (mandible removed)
Axial Skeleton: Skull, Vertebral Column, & Bony Thorax

Vertebral Column (Spine) (pp. 145-152) - “spine” extends from skull to pelvis

- transmits weight of body to lower limbs
- protects spinal cord
- consists of 26 irregular bones: 24 vertebrae & 1 sacrum & 1 coccyx
- vertebrae separated by intervertebral disks - fibrocartilage, cushion & absorb shock that decreases stress to brain during normal movement

- primary curvatures: thoracic region & sacral regions - present during birth
- secondary curvatures: cervical region - develops when baby begins to lift its head
- lumbar region - develops when baby begins to walk

- disks along with vertebral curvatures: 1. make spine (body trunk) flexible
- 2. enables spine to absorb shock & not pass shock to head

Vertebral Column Common Features:

- body (centrum) - disc-like, weight-bearing part of vertebra facing anteriorly in vertebral column
- vertebral arch - arch formed from the joining of all posterior extensions
- pedicle - posterior extension from body to transverse process
  - concavities above & below the pedicles are named vertebral notches & when vertebrae are articulated, the notches of ea. contiguous pr. form intervertebral foramina
- lamina - posterior extension from transverse process to spinous process
- vertebral foramen - canal through which the spinal cord passes
- transverse processes - two lateral projections from the vertebral arch
- spinous process - single projection arising from the posterior aspect of the vertebral arch
  - (vertebral arch = fused lamina)
- superior & inferior articular processes - paired projections lateral to the vertebral foramen
  - enables vertebra to form joints w/ adjacent vertebra

A typical vertebra consists of two essential parts - an anterior segment, the body, & a post. part: vertebral arch

The vertebral arch consists a pair of pedicles & laminae

- vertebral arch supports seven processes
  - 4 articular, 2 transverse, 1 spinous

When the vertebrae are articulated w/ ea. other the bodies form pillar of support for head & trunk

- vertebral foramina form a canal for spinal cord

- between every pair of vertebrae are 2 holes:
  - the intervertebral foramina, one on either side, for the transmission of the spinal nerves & blood vessels
Vertebral Column (Spine)

Cervical Vertebrae- C₁ - C₇
- 2° curvature

Thoracic Vertebrae- T₁ - T₁₂
- 1° curvature

Lumbar Vertebrae- L₁ - L₅
- 2° curvature

Sacrum- 5 fused vertebrae
- 1° curvature

Coccyx- 3 to 5 fused vertebrae

herniated (slipped) disk- protrusion or rupture of an intervertebral disk

Abnormal Spinal Curvatures
Scoliosis- exaggerated lateral bending of spinal column
Kyphosis- “hunchback” exaggerated thoracic curvature
Lordosis- “swayback” exaggerated lumbar curvature

spina bifida- congenital defect- incomplete closure of vertebral column
epidural anesthesia- used in obstetrics, injected into sacrum @ sacral hiatus
lumbar puncture- “spinal tap”, spinal fluid removed using a long needle b/w L₃-L₄ or L₄-L₅
Vertebral Column (Spine)
Cervical Vertebrae- C1 - C7
neck region of spine
1st two cervical vert. imp. f’n:

C1 (Atlas) - has no body
- receives & articulates with occipital condyles of skull
- enables head to nod “yes”

C2 (Axis) - has dens (odontoid process) on body & is the pivot point for atlas & skull
- odontoid process (dens) act as pivot pt. enabling head to not “no”

typical cervical vertebrae: (C3 - C7)

*smallest & lightest of all vertebrae

*spinous processes- short & divided into 2 branches
  stick straight back

*transverse processes contain foramina (unlike thoracic & lumbar)
  holes for vertebral arteries to pass up to brain

Superior view of articulated atlas & axis

(b)
Thoracic Vertebrae-  T1 - T12
12 unfused vertebrae
larger than cervical vertebrae

**body** - somewhat heart-shaped
- has 2 **costal facets** (articulating surfaces)
  receive the heads of the ribs

**spinous process**- longhooks sharply downward
- lever for muscle attachment

**transverse process**- no foramen

**vertebral foramen**- large circular

**intervertebral foramina**- larger than cervical
  decreases incidence of nerve compression

range of motion- limited because of rib articulations & long spinous processes

Lumbar Vertebrae-  L1 - L5
5 unfused larger vertebrae

support most of the weight of the body

**body**- blocklike, massive bean shape

**spinous process**- short, hatchet-shaped
  horizontal
  points straight back

**vertebral foramen**- smaller, triangular shaped
  not as many nerves passing thru

**pedicles**- longer & wider

**intervertebral foramina**- larger than cervical
  nerve compression is more common than thoracic region
Sacrum- 5 fused vertebrae
articulations: 1. superiorly with L5
2. inferiorly with coccyx
3. ala with coxal bone (ilium)
   (sacroiliac joint)
forms posterior wall of pelvis
median sacral crest- formed by fused spinous processes
sacral canal- canal continues inside vertebral canal terminates via a larger opening-
sacral hiatus- large opening vertebral canal
posterior sacral foramina- nerves pass thru

Coccyx
3-5 fused vertebrae
“tailbone”
vestigial- no longer functions

Bony Thorax (pp. 152-153)
protects thoracic cavity: heart & lungs
Sternum- breastbone
flat bone- contains red marrow
   Manubrium
   Body
   Xiphoid Process
Ribs- 12 pairs
“typical ribs” #3-9
   head- 2 facets sep. by a crest articulates with:
      - thoracic vertebrae
      - vertebra superior to it
   neck- connects head to shaft
   shaft- thin, flat, curved
      interior concave w/ groove for intercostal nerves & vessels
Bony Thorax

Ribs-

articulations- posteriorly w/ thoracic vertebrae
anterioy w/ sternum

True Ribs- superior seven rib pairs
- attach directly to sternum
  by costal cartilage
#1-7 ribs

False Ribs- inferior five rib pairs
- attach indirectly to sternum
  or not attached at all
# 8-12 ribs

Floating Ribs- inferior two rib pairs
- no sternal attachment
# 11, 12 ribs
**Appendicular Skeleton** (pp. 153-163)

**Shoulder Girdle- clavicle & scapula**

PRO:  very light & creates a flexible freely movable joint with arm because
1. pectoral girdle attaches in only 1 place w/ axial skeleton: **sternoclavicular jt**
2. scapula is loosely attached enabling it to slide back & forth against the thorax as muscles act
3. glenoid cavity is shallow, & shoulder joint is poorly reinforced by ligaments

CON: prone to dislocation

---

**Clavicles** (Collarbones)
articulations: 1. manubrium of sternum medially
2. acromion process of scapula laterally
clavicle braces arm away from top of thorax & prevents shoulder location

**Scapula** (Shoulder Blades)  triangular, flat bone with 2 large processes
not directly attached to axial skeleton- loosely held in place by trunk muscles
acromion process- enlarge end of the spone of the scapula
articulates with the lateral end of the clavicle: **acromioclavicular joint**
coracoid process- points over top shoulder & anchors some arm muscles
glenoid cavity- shallow socket tht receives the head of the humerus
Bones of the Upper Limbs (pp. 155-156)

Arm

Humerus
**Bones of the Upper Limbs** (pp. 155-156)

**Forearm**

*RADIUS* - lateral bone which follows thumb

*ULNA* - medial bone

**Hand**

*CARPALS* - two irregular rows of four bones each

*METACARPALS* - palm bones numbered 1 to 5 beginning w/ thumb

*PHALANGES*
Bones of the Upper Limb

Phalanges → Metacarpals → Carpals → Radius → Ulna → Humerus

Bones of the Pelvic Girdle (pp. 157-159)

Coxal (Hip) bones (2)
3 fused bones
Ilium

Ischium

Pubis

Sacroiliac (SI) Joint
Bones of the Pelvic Girdle (pp. 157-159)

Coxal (Hip) bones

Difference b/w male and female pelvic girdles
**Lower Limb Bones** (pp. 159 - 63)

**Thigh**

**Femur**

**Leg**

**Tibia** - weight-bearing shinbone
Foot

Tarsal Bones - consist of 7 bones

Metatarsals - 5 long bones

Phalanges - bones of toes
**Joints** (pp. 163 - 168)

**Functional Categories of Joints** (p. 163)

*Synarthroses*- immovable

*Amphiarthroses-* slightly movable

*Diarthroses-* freely movable

**Structural Categories of Joints** (pp. 163 - 165)

**Fibrous Joints**

*Sutures*- no movement

*Syndesmoses*- allow minimal “give”

**Cartilaginous Joints**

Hyaline cartilage connection at bone ends

**Synovial Joints**

*Articular Cartilage*- covers bone ends

*Fibrous Articular Capsule*- synovial membrane lining

*Joint Cavity*- lubricating synovial fluid

*Reinforcing Ligaments*
Types of Synovial Joints Based on Shape (pp. 165 - 167)
Plane Joint

Hinge Joint

Pivot Joint
Condyloid Joint

Saddle Joint

Ball-and-Socket Joint

Inflammatory Disorders of Joints (pp. 167 - 168)

Osteoarthritis (OA)- degenerative “wear and tear”

Rheumatoid Arthritis (RA)- autoimmune-related and most crippling

Gouty Arthritis- painful uric acid crystals in joints