Chapter 6: Bone and Bone Tissue

Skeletal system

= __________, ___________, ___________

Bones are main organs:
- osseous tissue
- dense regular and irregular CT, plus bone marrow

Module 6.1: Introduction to Bones as Organs

FUNCTIONS OF THE SKELETAL SYSTEM

• Functions:
  1. Protection
  2. Mineral storage and ______________________
  3. Blood cell formation: _________________ involved in formation of blood cells
     (hematopoiesis or hemopoiesis)
  4. Fat storage: in yellow bone marrow of ______________
  5. Movement: bones are sites for skeletal muscle attachment
  6. Support: supports weight and provides ______________

BONE STRUCTURE CLASSIFICATION

(based on shape)

1. Long bones
   - longer than they are wide;
   - include most bones in arms and legs

2. Short bones
   – roughly cube-shaped
   - include carpals and __________
3. Flat bones
   – thin and broad bones
   - ribs, pelvis, sternum and __________________

4. Irregular bones
   – include ____________ and certain skull bones

5. Sesamoid bones
   – located within ____________

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Structure of long bone:

- **Periosteum**
  - membrane surrounds outer surface
- **Perforating fibers** (Sharpey’s fibers)
  - anchors periosteum firmly to bone surface
- **Diaphysis** – ________________
- **Epiphysis** - _________ of long bone (proximal & distal)
- **Articular cartilage** – hyaline cartilage
- **Marrow cavity** – contains bone marrow (red or yellow)
- **Endosteum** – thin membrane lining marrow cavity

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**Compact bone**
- hard, dense outer region
- allows bone to resist stresses (compression & twisting)

**Spongy bone** (___________ bone)
- found inside cortical bone
  - *honeycomb-like framework* of bony struts;
  - resist forces from many directions

**Epiphyseal lines**
- separates epiphyses from diaphysis
  - remnants of epiphyseal plates
• **Epiphyseal plates (___________ plates)**
  - hyaline cartilage found in developing bones of children

Structure of short, flat, irregular, and sesamoid bones
  - covered by periosteum
  - diploë = two outer layers of thin compact bone with middle layer of spongy bone
  - sinuses = air-filled spaces ________________

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**Bone Marrow Transplantation**

• Diseases of blood
  
• Needle is inserted into pelvic bone
  
• Recipient’s marrow is destroyed
  
• Complications –
    - Many recipients can return to a healthy life if transplant “takes”

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→ **Module 6.2: Microscopic Structure**

**Extracellular matrix of bone:**
  
• **Inorganic matrix** (65%)
    – consisting of ___________ (hydroxyapatite salts of Ca & P)
  
• **Organic matrix** (35%)
    - osteoid
    - consists of collagen fibers and usual ECM

**Bone cells:**
  
• **Osteogenic** – differentiate into osteoblasts
  
• **Osteoblasts** – ______________
  
• **Osteocytes** – mature bone cells in lacunae
  
• **Osteoclasts**
    - bone ____________
    - secrete acid and enzymes
Structure of compact bone:

**Osteon** (Haversian system)
- **Lamellae** = concentric rings of *thin layers of bone*
- **Central canal** = contains blood vessels & nerves
- **Lacunae** = ________ for osteocyte
- **Canaliculi** = ________
- **Perforating canals (Volkmann’s canals)** perpendicular to central canals

→ *Module 6.3: Bone Formation and Ossification*

**OSSIFICATION**

- **Ossification (osteogenesis)**
  - Process of bone formation
  - Begins in embryonic period and continues throughout adulthood

[fetal “skeleton”]

[14 weeks]

cartilage template fibrous CT

**endochondral**

fibrous CT

**intramembranous**

**BONE**

**INTRAMEMBRANOUS OSSIFICATION**

- **Intramembranous ossification**
  - forms many ____________(bones of skull and clavicles)
  - formed within a *mesenchymal* ____________
  - spongy bone ossifies before outer compact bone layers
  - forms **primary ossification center**
– _________ = areas of incomplete intramembranous ossification

ENDOCHONDRAL OSSIFICATION

• Endochondral ossification (Figure 6.12):
  – Bone development for all bones below head except _________
  – Many bones complete ossification by age 7

• Endochondral ossification
  - bones begin within hyaline _________
  – Hyaline cartilage model made of chondrocytes, collagen, and ECM surrounded by CT perichondrium
  – Cartilage breaks down
  – Collar formation (periosteum)
  – _________ ossification center mid-diaphysis
  - secondary ossification centers at _________
Most bones of skeleton formed this way.

Osteoporosis and Healthy Bones
• Most common bone disease in U.S

• Diagnosed by bone density measurement

• Causes – dietary (calcium and/or vitamin D deficiency)

• Prevention

• Treatment

→ Module 6.4: Bone Growth in Length

GROWTH IN LENGTH

Growth in Length
• Long bones lengthen via longitudinal growth; involves division of _________ (not osteocytes or osteoblasts) in epiphyseal plate
• Bone growth takes place at epiphysis on side closest to diaphysis
• Epiphyseal plate
1. **Zone of reserve cartilage** – (found closest to epiphysis) contains cells that are not directly involved in bone growth but can be recruited for cell division if need arises.

2. **Zone of proliferation** - consists of actively dividing chondrocytes by endochondral ossification.

3. **Zone of hypertrophy and maturation** (next region closer to diaphysis) contains mature chondrocytes.

4. **Zone of calcification** (second to last region) contains dead chondrocytes, some of which have been calcified. 
   *Calcified cartilage is replaced with bone.*

5. **Zone of ossification** (last region) consists of calcified chondrocytes and osteoblasts.

   - Longitudinal growth continues at epiphyseal plate as long as mitosis continues in zone of proliferation:
     - Mitotic rate slows around ages of 12-15 years old
     - Between ages of 18-21 epiphyseal plate is **closed**
     - _____________ is a calcified remnant of epiphyseal plate

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**GROWTH IN WIDTH**

**Appositional growth** = ______________

- Osteoblasts, *lay down new bone*
  - Appositional growth does not result in immediate formation of osteons; instead, *new circumferential lamellae* are formed
  - Bones may *continue to increase in width* even after epiphyseal plates have closed and bone is no longer *lengthening*

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**Achondroplasia**

- Most common cause of **dwarfism**; gene defect

- Defective gene produces an *abnormal growth factor receptor*

- Bones form and grow abnormally

- Long-term problems
ROLE OF HORMONES IN BONE GROWTH

• GH – secreted by anterior pituitary gland; enhances protein synthesis and cell division in most all tissues, including bone.

• __________ - pronounced effect on bone growth:
  – Increases appositional growth in males
  – Increases *rate of mitosis in epiphyseal plate*; leads to “growth spurts” in teenage years

• *Estrogen* also plays a role in bone growth:
  – Increases *rate of longitudinal growth* and inhibits osteoclasts
  – Accelerates closure of epiphyseal plate at much faster rate than testosterone

→ average height differences between genders

Gigantism and Acromegaly

• Excess GH can produce two conditions, depending on when in life it develops; both generally caused by a ________ that secretes hormone

• **Childhood** – condition is __________

• **Adulthood** – condition is __________

→ Module 6.5: Bone Remodeling and Repair

BONE REMODELING

• **Bone remodeling** = new bone is formed by bone ________ and old bone is removed by bone ________
  – Maintenance of *calcium ion homeostasis*
  – *Replacement* of old brittle bone with newer bone
  – *Adaptation* to tension and stress

• **PTH** (parathyroid hormone from parathyroid gland) stimulates effects that __________
  – Increases osteoclast activity
  – Increases *absorption* of calcium from gut
  – Inhibits calcium *loss* in urine

• **Calcitonin** (from thyroid gland)
  – Increases ________ blood Ca+2 levels
  – Inhibits osteoclasts
  – Increases calcium loss in urine
Thyroid Gland Secretes __________

Parathyroid Glands Secretes __________

• Factors influencing bone remodeling are summarized:

Fractures:

– Simple fractures vs _______________ fractures

– Spiral

– Compression

– Comminuted

– Avulsion

– Greenstick

– Epiphyseal plate
Chapter 7: The Skeletal System

Skeletal System = ______ bones plus cartilages
- Axial (80 bones)
- Appendicular (126 bones)

→ Module 7.1: Overview of the Skeletal System

Axial skeleton
  – Skull, vertebral column, thoracic cage (ribs, sternum), ________________

• Appendicular skeleton
  – Bones of pectoral girdle, upper limb, pelvic girdle, and lower limb

Pectoral girdle – _______________; anchors upper limb to trunk
Pelvic girdle – _______________ bones; anchors lower limb to trunk

→ Module 7.2: The Skull

OVERVIEW OF SKULL STRUCTURE

• Skull = 22 bones organized in two groups:
  – Cranial bones – collectively known as cranium, composed of _____ bones
    (STEP OFF my skull)

  • Frontal -1
  • Occipital -1
  • Ethmoid -1
  • Sphenoid – 1
  • Parietal – 2
  • Temporal – 2
– **Facial bones** = _______ bones
  • Maxillary – 2
  • Zygomatic -2
  • Nasal -2
  • Lacrimal -2
  • Palatine -2
  • Inferior nasal concha -2
  • Mandible -1
  • Vomer -1

• Sinuses = __________, membrane-lined spaces;
  **paranasal sinuses** = frontal, ethmoid, sphenoid, maxillary

**CAVITIES OF THE SKULL**

• **Orbit** – FLEZMS 7 fused bones; form walls that encase eyeball, lacrimal gland, and their associated blood vessels, muscles, and nerves
  – Frontal bone
  – Lacrimal
  – Ethmoid
  – Zygomatic
  – Maxilla
  – Sphenoid bone
  - and __________ bones

**THE FETAL SKULL**

**Fontanel** (soft spot) = area of incomplete ______________________
  Anterior
  Posterior
  Sphenoid
  Mastoid

**HYOID BONE**

• **Hyoid**
  – doesn’t **articulate** with any other bones
  – C-shaped bone
  – Provides numerous muscle attachment points involved in __________________________
Forensic Skull Anatomy

- Forensic investigators often must identify human remains with little to go on except bones; can provide many clues (particularly skull); one of most basic traits that can be identified from a skull is gender
- Four obvious differences:

Module 7.3: Vertebral Column & Thoracic Cage

**OVERVIEW OF THE VERTEBRAL COLUMN**

**Vertebral column (spine)** – composed of about ______ bones (vertebrae)

- 7 **cervical** – located in ______
- 12 **thoracic** – articulate with ______
- 5 **lumbar** – in ______

- 5 fused **sacral** (collectively called sacrum)
- 3-5 fused **coccygeal** (collectively called coccyx)

- **Spinal curvatures** – C-shaped vertebral column of newborn → S-shaped secondary curvatures as infant grows
  - Primary curvatures (_______ and sacral) present during fetal dev.
  - Secondary curvatures (_______ and lumbar) dev. after fetal period

- **Abnormal spinal curvatures:**
  - **Scoliosis** – abnormal ______ curvatures
  - **Lordosis** (swayback) – exaggerated **cervical** and ______ curvatures
  - **Kyphosis** (hunchback)
    - exaggeration of ______ curvature

**STRUCTURE OF THE VERTEBRAE**

- **Cervical** (7) – smallest vertebrae
  - ______ foramina allows passage of vertebral arteries and veins
  - C1 (_______)
    - Lacks vertebral body
    - Articulates with occipital condyles and C2
  - C2 (_______)
    - **Dens** (odontoid process) protrudes from body
  - Allows for rotational movement of head at neck; (shaking your head “no”)
• Thoracic vertebrae (12)
  - long spinous processes
  - **Superior** and **inferior costal facets** (articulate with **head of rib**)
  - **Transverse costal facets** on transverse processes (articulate with __________ on rib)
  Posterior view: Shaped like __________

• Lumbar vertebrae (5)
  – **largest and heaviest** of all vertebrae (______________)
  Posterior view- shaped like __________

• Sacrum – 5 **fused** sacral vertebrae
  – **Sacral promontory** – bony *projection* at anterior margin of base (superior aspect)
  - **Sacral foramina** – 4 pairs of holes allows for ______ ______

• Coccyx = 4 fused (3-5) vertebrae

**STUDY BOOST: REMEMBERING SKULL BONES AND VERTEBRAE**

• **PEST OF 6** (*six cranial bones*): Parietal, Ethmoid, Sphenoid, Temporal, Occipital, Frontal
• **Virgil Is Now Making My Pet Zebra Laugh** (*facial bones*): Vomer, Inferior nasal conchae, Nasal, Mandible, Maxillae, Palatine, Zygomatic, Lacrimal
• **For Easier Sinus Memorization** (*paranasal sinuses*):
  Frontal, Ethmoidal, Sphenoidal, Maxillary
• **Breakfast at 7, lunch at 12, dinner at 5** (*number of vertebrae*): 7 cervical, 12 thoracic, and 5 lumbar

**Sphenoid = Bat bone**  **Ethmoid = iceberg in skull**
**INTERVERTEBRAL DISC**

- **Intervertebral disc**
  = fibrocartilage pad found between bodies vertebrae
- **Nucleus pulposus** – jelly-like substance; shock absorber
- **Anulus fibrosus** – outer ring of __________
  Herniated disc or “slipped disc”

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**Herniated Disc**

- A tear in anulus fibrosus can allow nucleus pulposus to protrude, a condition known as a herniated disc (commonly called a slipped disc)
- Bulging nucleus pulposus compresses nerve
- Treatments

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**THE THORACIC CAGE**

- **Thoracic cage**
  =
  - sternum
    - **Manubrium** – superiormost
    - **Body** - middle
    - **Xiphoid process** – inferior

**Rib cage**= 12 pairs of ribs and their costal cartilages
- Ribs 1–7 (______ribs or **vertebrosternal** ribs) attach to sternum via their **costal** cartilages
- Ribs 8–12 (______ribs) not directly attached to sternum
  - **Vertebrochondral** ribs 8–10 – attached to cartilage of 7th rib
  - _________ or **vertebral** ribs 11 & 12
  - are not attached to sternum

Structure of a typical rib.

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**The Sternum and CPR**

- **Cardiopulmonary resuscitation (CPR)**
  
  - Correct placement of hands on sternum is critical
Module 7.4: Bones of the Pectoral Girdle and Upper Limb

PECTORAL GIRDLE

- Pectoral girdle – clavicle and scapula
  - Clavicle
    - Sternal end
    - Acromial end
  - Scapula
    - Acromion
    - Coracoid process
    - Subscapular fossa (anterior aspect)
    - Glenoid cavity (articulates with head of humerus)
    - Spine (_________ ridge)
    - Supraspinous fossa
    - Infraspinous fossa

THE HUMERUS

- Humerus
  - head articulates with glenoid cavity at shoulder joint
  - __________ neck is a groove surrounding head
  - __________ neck proximal diaphysis
  - greater & lesser tubercle lateral and anterior to head
  - olecranon fossa
  - coronoid fossa
  - capitulum
  - trochlea

BONES OF THE FOREARM

Bones of forearm (antebrachium)
- Radius (_______ bone)
  - head, neck, radial tuberosity, styloid process
- Ulna (_______)
  - trochlear notch, olecranon, coronoid process, radial notch, styloid process
Wrist (carpus) – _________________ (carpals) (lateral to medial)
– Scaphoid, Lunate, Triquetrum, Pisiform (proximal)
– Trapezium, Trapezoid, Capitate, Hamate (distal)

Metacarpals – 5 each hand
Phalanges – 14 each hand
- proximal, middle, and distal __________
- Thumb proximal & distal phalanx

Wrist Fractures
• Wrist is the most frequently injured region of upper limb;
• Fractures
  Colles fracture

Module 7.5: Bones of the Pelvic Girdle and Lower Limb

Pelvic girdle =
• coxal bones (also known as os coxae)
• Articulates with sacrum (axial skeleton)

Pelvis – bowl-shaped sacrum and two coxal bones; creates boundary for pelvic cavity
  Pelvic inlet – oval opening formed by sacrum and pelvic girdle
  Pelvic brim – bony ridge surrounding inlet that defines boundaries between greater and lesser pelvis

• Each __________ is composed of 3 fused bones:
  ilium, ischium, and pubis

Female and male pelvis differ between genders:
  female pelvis (adapted for childbirth) is wider and shallower than male
• **Shape of greater pelvis:**
  - pelvis is *wider* in females with *flared* iliac crests
  - increases distance between ASIS

• **Coccyx and sacrum:**
  - female sacrum is *wider* and *shorter* than male sacrum
  - while female coccyx is *more moveable* and *more posterior* than male

• **Pelvic inlet and outlet:** female inlet is usually *wider* and *oval-shaped* whereas male inlet is *narrow* and *heart shaped*; female outlet is generally *wider* than male

• **Acetabula:** generally *farther apart* in females and pointed more *anteriorly* than in males

• **Pubic arch:**
  – angle measured in females = __________
  – male arch measures between __________

FEMUR AND PATELLA

• **Femur** – *largest* and *strongest* bone
  – **head** articulates with ___________ at hip joint
  – **Neck**
  – **Greater and Lesser trochanter**
  – **Linea aspera**
  – **Medial** and a **lateral condyles**
  – **Patellar surface**

• **Patella**

BONES OF THE LEG: TIBIA AND FIBULA

• **Tibia** (**bone**) larger bone, wt. bearing
  – Tibial tuberosity
  – Medial malleolus

• **Fibula** (**bone**)
  – Lateral malleolus
• **Tarsals** – 7 short bones
  – *Proximal* tarsals: ________, *calcaneus*, and *navicular*
  – *Distal* tarsals medial to lateral: 3 *cuneiforms* (medial, intermediate, lateral) and *cuboid*

• **Metatarsals** – 5 in each foot

• **Phalanges** – 14 in each foot

**STUDY BOOST: REMEMBERING BONES OF THE ARM AND LEG**

**Carpals: Stop Letting The People Touch The Cadaver’s Hand**
  = Scaphoid, Lunate, Triquetrum, Pisiform, Trapezium, Trapezoid, Capitate, Hamate
(Mentions “hand”, so remember that it describes carpals, not tarsals; trapeziUM is by thUMb)

**Tarsals: College Needs Me In Lab Classes**
  = Talus, Calcaneus, Navicular; Medial, Intermediate, & Lateral cuneiform, Cuboid
Chapter 8: Articulations

Articulations (joints) = where bones meet
- allow __________
- provide __________
- allow long bones to _________ (epiphyseal plate)

Module 8.1: Classification of Joints

FUNCTIONAL CLASSIFICATION

Based on __________:
• Synarthrosis – no movement between articulating bones
• Amphiarthrosis – small amount of movement between articulating bones
• Diarthrosis – freely moveable, allowing a wide variety of specific movements

STRUCTURAL CLASSIFICATION

Based on their __________ features:
• Fibrous joints – dense regular collagenous CT; (synarthroses or amphiarthroses)
• Cartilaginous joints – cartilage; (synarthroses or amphiarthroses)
• Synovial joints – fluid-filled joint capsule with hyaline cartilage at articular ends; (diarthrosis)

Module 8.2: Structural Classification: Fibrous Joints

FIBROUS JOINTS

3 types:
• Suture
• Gomphosis
• Syndesmosis

• Suture - fibrous CT
          _______________ of cranium; immoveable joint

• Gomphosis – tooth in bony socket (periodontal ligament);
          ____________ joint

• Syndesmosis – joint between tibia & fibula, ulna & radius (interosseous membrane);
          ______________
Module 8.3: Structural Classification: Cartilaginous Joints

2 types:
• Synchondrosis
• Symphysis

Synchondrosis - hyaline cartilage;
Synarthroses (epiphyseal plate, 1st sternocostal and costochondral joints);

Epiphyseal Plate Fractures
• Epiphyseal plate in a child’s long bone is one of the weakest parts of a developing skeleton

• Treatment

Module 8.4: Structural Classification: Synovial Joints

Synovial Joints:
– Joint cavity (synovial cavity) – space found between articulating bones

– Articular capsule – double-layered structure
  • Outer fibrous layer
  • Inner synovial membrane → synovial fluid (lubricates, metabolic fcn., shock absorber)

- _______ cartilage – hyaline cartilage; covers all exposed articulating bones within a joint

– Diarthrosis
STABILIZING AND SUPPORTING FACTORS

• Synovial joints allow more *mobility*
  – less *stable* than other joint types
  - structures that provide additional stabilization:
    Ligament – dense regular CT connects ____________
    Tendon - dense regular CT connects ____________

Bursae and tendon sheaths provide stabilization forces

Bursitis

• *Most common sites* of bursitis
  • Clinical features

ARTHRITEIS

• Arthritis – defined as *inflammation* of one or more joints which results in pain and limitations of joint movement:
  – Osteoarthritis (OA) – most common; associated with ____________, *injuries*, and advanced *age*; characterized by pain, joint stiffness, and lost mobility
  – Rheumatoid arthritis (RA) – associated with joint destruction; ______________
  – Gouty arthritis – joint damage due to inflammatory reaction to ____________ deposits

→ Module 8.5: Functions of Synovial Joints

MOVEMENTS AT SYNOVIAL JOINTS

• Gliding movements – *sliding motion* between articulating surfaces
• Flexion, Extension, Hyperextension
• Abduction, Adduction
• Circumduction, Rotation
• Inversion, Eversion
• Supination, Pronation
• Dorsiflexion, Plantar flexion
Module 8.6: Types of Synovial Joints

Types of Synovial Joints

- **Plane joint** (gliding joint) – most simple and least mobile articulation between flat surfaces of two bones

- **Hinge joint** – convex articular surface of one bone interacts with concave depression of second bone

- **Pivot joint** – one bone pivots or rotates around other

- **Condylar (ellipsoid) joint** – convex surface of one bone fits into concave articular surface of a second bone

- **Saddle joint** – each bone’s articulating surface has both a concave and convex region

- **Ball-and-socket joint** – spherical surface of one bone fits into cup-shaped depression in second bone

Specific Hinge Joints

**Elbow** – very stable hinge joint:
- **Humeroulnar joint** – articulation between *trochlea* of humerus and *trochlear notch* of ulna
- **Humeroradial joint** – articulation between *capitulum* of humerus and *head* of radius

**Knee**:
- ____________ joint – articulation between *femoral* and *tibial condyles*
- **Patellofemoral joint** – articulation between posterior surface of *patella* and anterior patellar surface of *femur*
- **Medial** and **lateral meniscus** – fibrocartilage pads between femoral and tibial condyles
- **Tibial collateral ligament** (medial collateral) – connects femur, medial meniscus, and tibia to one another to provide *medial joint stabilization*
Knee Injuries and the Unhappy Triad

- **Shoulder** (______________) – ball-shaped head of humerus and glenoid cavity:
  - Glenoid labrum – fibrocartilaginous ring; increases depth of glenoid cavity to provide more stability
  - Biceps brachii tendon - helps keep head of humerus within glenoid cavity
  - Rotator cuff, providing most of joint's structural stabilization: ______________, infraspinatus, subscapularis, and __________

A & P FLIX: MOVEMENT AT THE GLENOHUMERAL JOINT

- **Hip** (__________) – acetabulum and ball-shaped head of femur:
  - Acetabular labrum – fibrocartilaginous ring that helps to stabilize head of femur within acetabulum

A & P FLIX: MOVEMENT AT THE HIP JOINT

Hip Joint Replacement Surgery

- **Hip replacement** – surgical procedure that replaces a painful damaged joint with an artificial prosthetic device

- Severe arthritis, trauma, fractures, and bone tumors can all progress to point where hip joint replacement is an option

- **Total replacement**

- **Partial replacement**