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 __________

**BONE STRUCTURE**

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

**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*

Structure of spongy bone
- usually not wt. bearing
- not organized into osteons
  ________________ = bony struts

→ Module 6.3: Bone Formation and Ossification

OSSIFICATION

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

[fetal “skeleton”]
**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

- 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

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
**Achondroplasia**

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

- Defective gene produces an **abnormal growth factor receptor**

- Bones form and grow abnormally

- Long-term problems

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**ROLE OF HORMONES IN BONE GROWTH**

- **Somatotropin** (GH) – secreted by **anterior pituitary gland**; enhances protein synthesis and cell division in most all tissues, including bone

- **Somatotropin** - 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

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**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 __________

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**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 ___________
  *blood Ca+2 levels*
  - Increases osteoclast activity
  - Increases *absorption* of calcium from gut
  - Inhibits calcium *loss* in urine

**• Calcitonin** (from thyroid gland)
  - Causes __________ 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

• 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:
  o Scoliosis – abnormal ________ curvatures
  o Lordosis (swayback) – exaggerated cervical and ________ curvatures
  o 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 __________

• **Sacro** – 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

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

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

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.

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
BONES OF THE WRIST: CARPALS

Wrist (carpus) – _________________ (carpals)
(lateral to medial)
  – Scaphoid, Lunate, Triquetrum, Pisiform (proximal)
  – Trapezium, Trapezoid, Capitate, Hamate (distal)

BONES OF THE HAND AND FINGERS: METACARPALS AND PHALANGES

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

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
BONES OF THE ANKLE AND FOOT:
TARSALS, METATARSALS, AND PHALANGES

- **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

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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
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

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

Fibrous Joints

- Symphysis – *fibrocartilaginous pad; amphiarthrosis*
  - ______________
  - Pubic symphysis

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 $\rightarrow$ synovial fluid (lubricates, metabolic fcn.,
    shock absorber)
  - __________ cartilage – *hyaline cartilage*; covers all exposed articulating bones
    within a joint

- Diarthrosis
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

**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*

A & P FLIX: MOVEMENT AT THE ELBOW

A & P FLIX: MOVEMENT AT THE KNEE JOINT
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**