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 

- **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”]

[14 weeks]

cartilage template fibrous CT

**endochondral**

fibrous CT

**intramembranous**

BONE
INTRAMEMBRANOUS

• **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

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

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 ________
  blood Ca+2 levels
  o Increases osteoclast activity
  o Increases absorption of calcium from gut
  o Inhibits calcium loss in urine

• Calcitonin (from thyroid gland)
  causes ________ blood Ca+2 levels
  o Inhibits osteoclasts
  o 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:
  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 ____________

• **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**

• **PEST OF** 6 (six cranial bones): Parietal, Ethmoid, Sphenoid, Temporal, Occipital, Frontal
• **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”

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
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

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

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

**ARTHRITIS**

- **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

**A & P FLIX: MOVEMENT AT THE ELBOW**

- **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 ____________

• Hip (______) – acetabulum and ball-shaped head of femur:
  – Acetabular labrum – fibrocartilageous ring that helps to stabilize head of femur within acetabulum

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