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”]

[14 weeks]

cartilage template fibrous CT

**endochondral**

fibrous CT

**intramembranous**
**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

ROLE OF HORMONES IN BONE GROWTH

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

• Prolonged 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

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:

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**Bone Repair**

**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

STRUCTURE OF THE SKELETAL SYSTEM
& SKELETAL CARTILAGES

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

Bone Markings

Fossa –
Canal (meatus)-
Condyle -
Head -
Foramen –

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

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**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

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**THE FETAL SKULL**

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

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**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 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

Thoracic giraffe  Lumbering moose
• **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](image)

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](image)

**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](image)

**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** (_________
  - trochelear 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

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

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**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**

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**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

**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

**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
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](image)

- **Bursitis**

  - Most common sites of bursitis
    
    - Clinical features

ARTHHRITIS

- **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*

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**