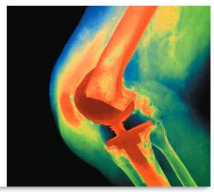
8

Articulations



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MODULE 8.1 CLASSIFICATION OF JOINTS

FUNCTIONAL CLASSIFICATION

Joints can be classified by how much *motion* they allow:

- **Synarthrosis** – does not allow any *movement* between articulating bones
- **Amphiarthrosis** – allows only a small amount of *movement* between articulating bones
- **Diarthrosis** – freely *moveable*, allowing a wide variety of specific movements

STRUCTURAL CLASSIFICATION

Joints can be classified based on their *structural features*.

- **Fibrous joints** – fastened together by *dense regular collagenous connective tissue* without a joint space between articulating bones; can be synarthroses or amphiarthroses
- **Cartilaginous joints** – fastened together with *cartilage* without a joint space; can be synarthroses or amphiarthroses
- **Synovial joints** – diarthrosis joints have a layer of *hyaline cartilage* on articulating surface of each bone; joint space is a *fluid-filled cavity* found between articulating bones

MODULE 8.2 STRUCTURAL CLASSIFICATION: FIBROUS JOINTS

SUTURES

- **Suture** – *immoveable* joint between edges of bones that make up cranium; fully fused sutures are very *stable*, well suited for *protecting* brain

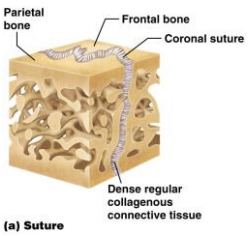


Figure 8.1a The three types of fibrous joints.

GOMPHOSES

- **Gomphosis** – *immoveable* joint between each tooth and its bony socket in jaw; **periodontal ligament** is a strong *fibrous membrane* that links tooth firmly to jaw bone

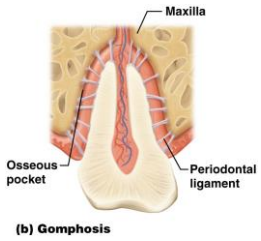


Figure 8.1b The three types of fibrous joints.

SYNDESMOSES

- **Syndesmosis** – joint between tibia, fibula, ulna, and radius; bones are joined by an interosseous membrane or ligament composed of *dense regular collagenous connective tissue*, which allows for small amount of movement

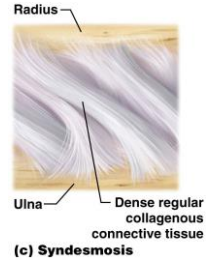


Figure 8.1c The three types of fibrous joints.

MODULE 8.3 STRUCTURAL CLASSIFICATION: CARTILAGINOUS JOINTS

SYNCHONDROSES

- **Synchondrosis** consists of bones linked together by *hyaline cartilage*; examples are synarthroses (**Figure 8.2a**):
  - **Epiphyseal plates** – composed of hyaline cartilage that connects diaphyses and epiphyses of *developing* long bones; *replaced with bone* during maturation (**Figure 8.2a**)
  - First **sternocostal** and **costochondral** joints are synchondroses that persist into adulthood (**Figure 8.2b**)

SYNCHONDROSES

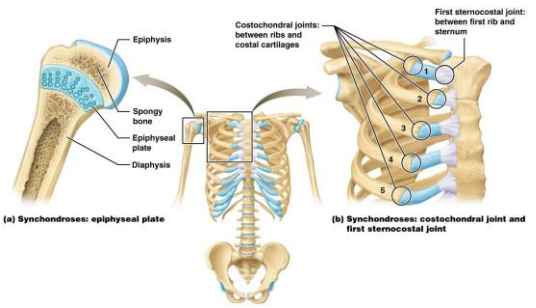


Figure 8.2a, b The two types of cartilaginous joints.

EPIPHYSEAL PLATE FRACTURES

- **Epiphyseal plate** in a child's long bone is one of the *weakest parts* of a developing skeleton; even a minor injury can fracture this delicate structure, possibly with lifelong consequences [differences in limb length, limb deformities, and early-onset arthritis (joint inflammation)]
- Most common causes include recreational activities, accidents, and competitive athletics; injuries may affect any joint but occur most often at epiphyseal plates of *forearm*

Epiphyseal Plate Fractures

- **Symptoms** include swelling, pain, and redness over injured joint
- **Treatment** depends on *severity* of fracture, which must be determined by careful diagnosis; minor epiphyseal plate fractures can generally be managed by immobilizing joint with a *cast*, but severe fractures usually require *surgery*
- Many patients benefit from *rehabilitation exercises* to strengthen bones and muscles surrounding joint and regain full function; fortunately, most fractures do not impair bone development if managed properly

Symphyses

- **Symphysis** – joint where bones are united by a *fibrocartilaginous pad* or *plug*; functionally an *amphiarthrosis* (**Figure 8.2b**, **c**, **d**)
  - Example of **Structure-Function Core Principle**; best suited for regions of skeleton that must resist *compression*
  - **Intervertebral joints** – between adjacent vertebral bodies of spinal column (**Figure 8.2c**)
  - **Pubic symphysis** – between pubic bones of pelvic girdle (**Figure 8.2d**)

Symphyses

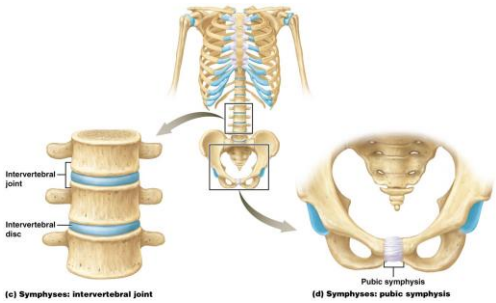


Figure 8.2c, d The two types of cartilaginous joints.

Module 8.4 Structural Classification: Synovial Joints

Structural Elements

- **Structural Elements** (**Figure 8.3**):
  - **Joint cavity** (**synovial cavity**) – space found between articulating bones
  - **Articular capsule** – double-layered structure

Structural Elements

- **Articular capsule** (continued):
  - *Outer* fibrous layer keeps articulating bones from being pulled apart and isolates joint from rest of body
  - *Inner* layer (**synovial membrane**) lines entire inner surface except where hyaline cartilage is present; cells in this membrane *secrete* **synovial fluid**
  - Example of **Structure-Function Core Principle**: inner layer provides joint with means for *obtaining* life-sustaining substances and *eliminating* waste products

Structural Elements

- **Synovial fluid** – *thick liquid* with the following 3 main functions:
  - Provides **lubrication** – reduces *friction* between articulating surfaces of a joint
  - Serves a metabolic function; provides a means for transportation of *nutrients* and *waste products* in absence of blood vessels within joint
  - Provides for **shock absorption**; helps to evenly distribute *stress* and *force* placed on articular surfaces during movement

Structural Elements

- **Articular cartilage** – composed of a thin layer of hyaline cartilage; *covers* all exposed articulating bones within a joint
- Provides a *smooth surface* for articulating bones to interact; reduces wear and tear created by *friction*, illustration of **Structure-Function Core Principle**
- **Avascular** because isolated within capsule; relies on synovial fluid for *oxygen*, *nutrients*, and *waste* removal
- **Other components of a synovial joint** include adipose tissue, nerves, and blood vessels

Structural Elements

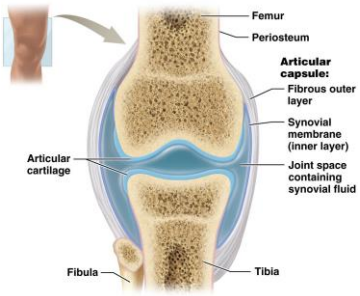


Figure 8.3 Structure of a typical synovial joint.

Stabilizing and Supporting Factors

- Synovial joints allow more *mobility* but are less *stable* than other joint types; the following structures provide additional stabilization (**Figure 8.4**):
  - **Ligament** – strand of dense, regular, collagenous connective tissue; links *one bone to another*; provides additional strength and reinforcement to a joint

Stabilizing and Supporting Factors

- **Tendon** – structural component of skeletal muscle; composed of dense regular collagenous connective tissue and connects *muscle* to *bone*
  - Tendons *cross* associated joints; provide stabilization when muscles are *contracted*
  - **Muscle tone** – continuous level of *muscle contraction*; provides a stabilizing force

Stabilizing and Supporting Factors

- **Bursae and tendon sheaths** also provide stabilization forces in high stress regions
  - **Bursa** – synovial fluid-filled fibrous structure helps to minimize *friction* between all moving parts associated with joints
  - **Tendon sheath** – long bursa that *surrounds tendons*; protects tendons as they slide across joint during movement

Stabilizing and Supporting Factors

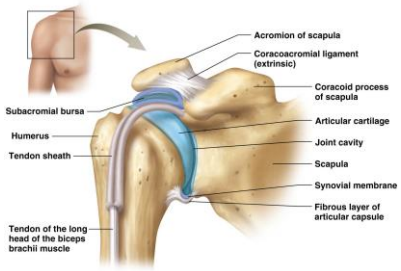


Figure 8.4 Supportive structures of a synovial joint.

Bursitis

- **Bursitis** refers to *inflammation of a bursa*; can result from a *single traumatic event* such as a fall, *repetitive movements* like pitching a baseball, or an *inflammatory disease* such as rheumatoid arthritis
- Most *common sites* of bursitis are shoulder, elbow, hip, and knee
- Clinical features of bursitis include *pain* both at rest and with motion of affected joint; joint may feel *tender*, *swollen*, and *warm*

Bursitis

- **Treatment** – aimed primarily at *reducing pain* and *swelling*; rest, ice, compression of injured area, and medications are beneficial in early stages of injury
- *Anti-inflammatory steroid medications* may be injected directly into bursa itself; fluid can also be *removed* from bursa to relieve swelling
- Left untreated, bursitis can become *chronically painful* and increasingly *difficult to cure*

Arthritis

- **Arthritis** – defined as *inflammation* of one or more joints which results in pain and limitations of joint movement; three common types of arthritis include:
  - **Osteoarthritis** – most common form; generally associated with *wear and tear*, *injuries*, and advanced *age*; is characterized by pain, joint stiffness, and lost mobility
  - **Rheumatoid arthritis** – associated with joint destruction mediated by individual's own *immune system*
  - **Gouty arthritis** – causes joint damage by generating an inflammatory reaction to *uric acid crystal* deposits

Module 8.5 Function of Synovial Joints

Functional Classes of Synovial Joints

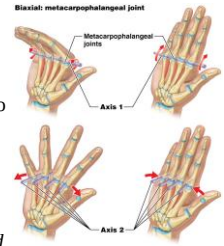
- Bones in a synovial joint move in different **planes** around an **axis** or **axes**; different possible joint configurations include:
  - **Nonaxial joints** – allow motion to occur in one or more planes <u>without</u> moving *around an axis*
  - **Uniaxial joints** – allow motion around only <u>one</u> *axis*
  - **Biaxial joints** – allow motion around <u>two</u> *axes*
  - **Multiaxial** (**triaxial**) **joints** – allow motion around <u>three</u> *axes*

Concept Boost: Understanding Axes of Motion

- **Elbow joint** has only one axis (axis 1 in figure) and acts like a *hinge*; allows motion in one plane perpendicular to axis
- Allows forearm and hand to move upward *toward* shoulder or to make opposite movement *away* from shoulder

Concept Boost: Understanding Axes of Motion

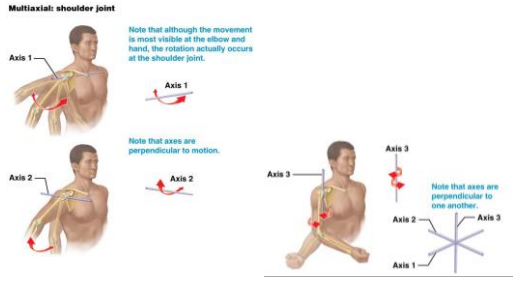
- **Metacarpophalangeal joints** – *biaxial*, between proximal phalanges and metacarpals
  - Can move around axis 1, allowing proximal phalanges to move *toward* and *away* from palm of hand (same as elbow joint)
  - Can also move around axis 2, allowing fingers to be *squeezed together* or *fanned out*



Concept Boost: Understanding Axes of Motion

- Third axis allows an *additional motion* that uniaxial and biaxial joints are not able to perform; **shoulder** is an example of a *multiaxial* joint
  - Humerus can move *forward* and *backward* around axis 1 (as when you swing arms back and forth while walking)
  - Humerus can also move *away* from and *toward* your body around axis 2 (as when you do jumping jacks)
  - Humerus can *rotate* (move in a circular fashion) around axis 3 (as when you throw a Frisbee)

Concept Boost: Understanding Axes of Motion



Movements at Synovial Joints

- Four general types of movement can take place at a synovial joint (**Figures 8.5**–**8.10**):
- **Gliding movements** – **gliding** is a *sliding motion* between articulating surfaces that is *nonaxial* (**Figure 8.5**)
- **Angular movements** – *increase* or *decrease angle* between articulating bones

Movements at Synovial Joints

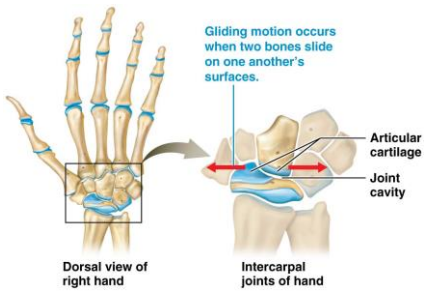


Figure 8.5 Gliding movements of synovial joints.

MOVEMENTS AT SYNOVIAL JOINTS

- Specific types of angular motion:
  - **Flexion** – decreases *angle* between articulating bones by bringing bones closer to one another (**Figure 8.6**)
  - **Extension** – increases *angle* between articulating bones, is opposite of flexion; articulating bones move away from one another
  - **Hyperextension** – extension beyond *anatomical position* of joint

MOVEMENTS AT SYNOVIAL JOINTS

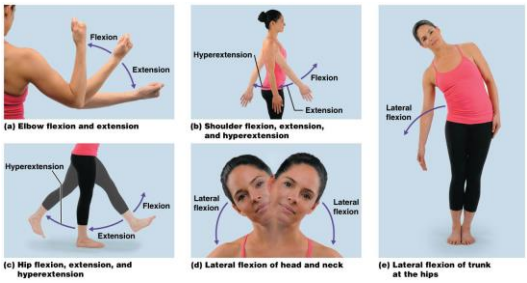


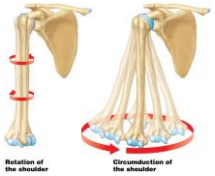
Figure 8.6 Angular movements: flexion and extension of synovial joints.

MOVEMENTS AT SYNOVIAL JOINTS

- Specific types of angular motion (continued):
  - **Abduction** – motion of a body part away from midline of body or another reference point (**Figure 8.7**)
  - **Adduction** – motion of a body part towards midline of body or another reference point; opposite of abduction

MOVEMENTS AT SYNOVIAL JOINTS

- Specific types of angular motion (continued):
  - **Circumduction** (**Figure 8.7e**) – only unpaired angular movement where a freely moveable distal bone moves on a fixed proximal bone in a *cone-shaped motion*; combination of flexion-extension and abduction-adduction



MOVEMENTS AT SYNOVIAL JOINTS

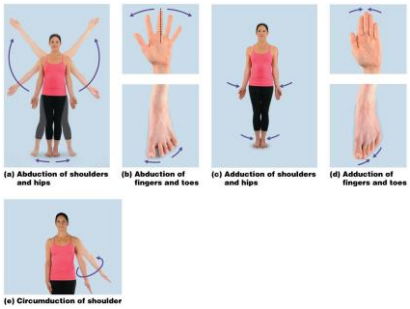


Figure 8.7 Angular movements: abduction, adduction, and circumduction of synovial joints.

MOVEMENTS AT SYNOVIAL JOINTS

- **Rotation** – *nonangular* motion in which one bone *rotates* on an imaginary line running down its middle longitudinal axis

Figure 8.8 Rotational movements: internal and external rotation of synovial joints.

Movements at Synovial Joints

- **Special Movements** include those types not otherwise defined by previous categories (**Figure 8.9**):
  - **Opposition and reposition**: opposition of thumb at first carpometacarpal joint allows thumb to move *across palmar surface of hand*; reposition is *opposite movement* that returns thumb to its anatomical position (**Figure 8.9a**, **b**)
  - **Depression and elevation**: depression is movement of a body part in an inferior direction while elevation moves a body part in a superior direction (**Figure 8.9c**, **d**)

Movements at Synovial Joints

Figure 8.9a-d Special movements of synovial joints.

Movements at Synovial Joints

- **Special Movements** (continued):
  - **Protraction and retraction**: protraction moves a body part in an *anterior* direction; retraction moves a body part in a *posterior* direction (**Figure 8.9e**, **f**)
  - **Inversion and eversion**: inversion is a rotational motion in which plantar surface of foot *rotates medially* toward midline of body; eversion *rotates foot laterally* away from midline (**Figure 8.9g**, **h**)

Movements at Synovial Joints

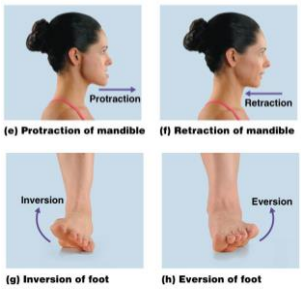


Figure 8.9e-h Special movements of synovial joints.

Movements at Synovial Joints

- **Special Movements** (continued):
  - **Dorsiflexion and plantarflexion**: dorsiflexion is a movement where angle between foot and leg decreases; angle between foot and leg increases during plantarflexion

Figure 8.9i-j Special movements of synovial joints.

Movements at Synovial Joints

- **Special Movements** (continued):
  - **Supination and pronation**: rotational movements of wrist and ankle regions

Figure 8.10 Special movements: supination and pronation.

Study Boost: Keeping Supination and Pronation Straight

- **Supination** vs. **pronation**: you *hold a cup of soup* when your hand is supinated, and you *pour it out* when your hand pronates
- **Abduction** vs. **adduction**: with abduction, you *abduct* (take away) part from body; with adduction, you *add part back* to body

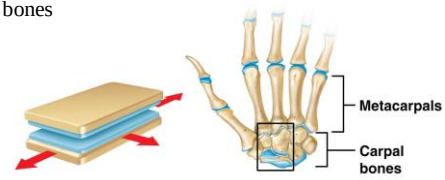
Range of Motion

- **Range of Motion**: amount of movement joint is capable of under *normal circumstances*
  - When you move your knee joint from a relaxed state to full flexion, and then return joint to its fully extended state, that is range of motion of knee
  - Uniaxial joints (such as knee) tend to have *smallest* range of motion; multiaxial joints (such as shoulder) tend to have *greatest*

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

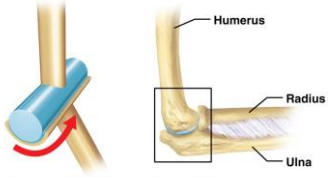


(a) Plane joint, nonaxial: intercarpal joint

Figure 8.11a The six types of synovial joints and the motion allowed at each.

Types of Synovial Joints

- **Hinge joint** – *convex* articular surface of one bone interacts with *concave* depression of a second bone; allows for *uniaxial movement*



(b) Hinge joint, uniaxial: elbow joint

Figure 8.11b The six types of synovial joints and the motion allowed at each.

Types of Synovial Joints

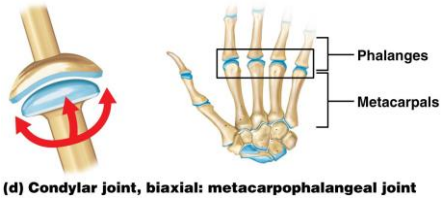
- **Pivot joint** – *rounded* end surface of one bone fits into a *groove* on surface of a second bone, allowing for *uniaxial movement* in which one bone pivots or rotates around other

(c) Pivot joint, uniaxial: atlantoaxial joint

Figure 8.11c The six types of synovial joints and the motion allowed at each.

TYPES OF SYNOVIAL JOINTS

- **Condylar or ellipsoid joint** – biaxial joint where oval, *convex* surface of one bone fits into a shallow, *concave* articular surface of a second bone

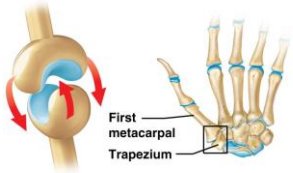


(d) Condylar joint, biaxial: metacarpophalangeal joint

Figure 8.11d The six types of synovial joints and the motion allowed at each.

TYPES OF SYNOVIAL JOINTS

- **Saddle joint** – each bone's articulating surface has both a *concave* and *convex* region; allows a great deal of motion for a *biaxial* joint



(e) Saddle joint, biaxial: carpometacarpal joint of thumb

Figure 8.11e The six types of synovial joints and the motion allowed at each.

TYPES OF SYNOVIAL JOINTS

- **Ball-and-socket joint** – *multiaxial* articulation in which articulating surface of one bone is *spherical* and fits into a *cup-shaped depression* in second bone; allows for a wide range of motion in around all three available axes

(f) Ball-and-socket joint, multiaxial: shoulder joint

Figure 8.11f The six types of synovial joints and the motion allowed at each.

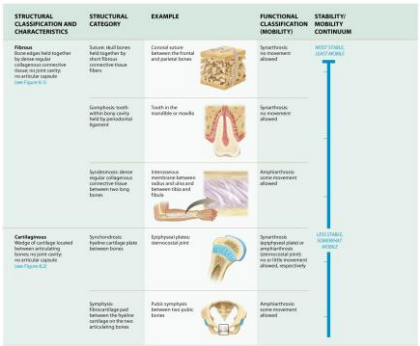


Figure 8.12 The Big Picture of Joint Classifications and Stability versus Mobility.

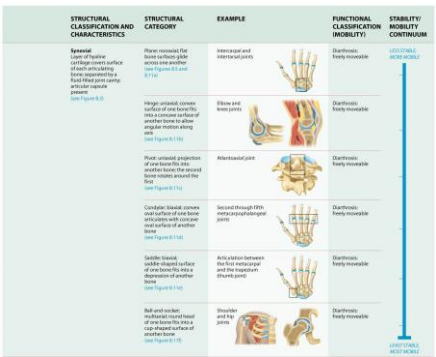


Figure 8.12 The Big Picture of Joint Classifications and Stability versus Mobility.

SPECIFIC HINGE JOINTS

Elbow – very stable hinge joint; composed of *two articulations* and *three strong ligaments* that support articular capsule (**Figure 8.13**):

- **Humeroulnar joint** – larger of two joints; articulation between *trochlea* of humerus and *trochlear notch* of ulna
- **Humeroradial joint** – articulation between *capitulum* of humerus and *head* of radius

Specific Hinge Joints

Elbow (continued):

- **Radial collateral ligament** (lateral collateral ligament) supports *lateral* side of joint
- **Ulnar collateral ligament** (medial collateral ligament) supports *medial* side of joint
- **Anular ligament** binds head of radius to neck of ulna; *stabilizes radial head*

Specific Hinge Joints

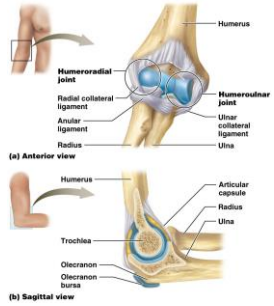
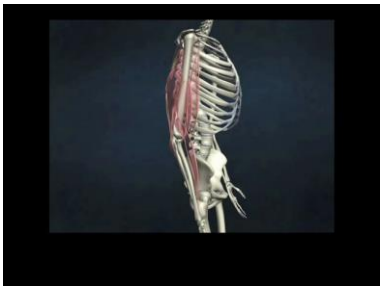


Figure 8.13 Anatomical structure of the elbow joint.

A&P Flix: Movement at the Elbow Joint



Specific Hinge Joints

- **Knee**:
  - **Patellar ligament** – distal continuation of quadriceps tendon; connects *distal patella* to *anterior tibia*
  - **Tibiofemoral joint** – articulation between *femoral and tibial condyles*
  - **Patellofemoral joint** – articulation between posterior surface of *patella* and anterior patellar surface of *femur*

Specific Hinge Joints

- **Knee** (continued):
  - **Medial** and **lateral meniscus** – C-shaped *fibrocartilaginous pads* found between femoral and tibial condyles; provide *shock absorption* and *stability* to knee joint
  - **Tibial collateral ligament** (medial collateral) – connects femur, medial meniscus, and tibia to one another to provide *medial joint stabilization*; prevents tibia from shifting too far laterally on femur

Specific Hinge Joints

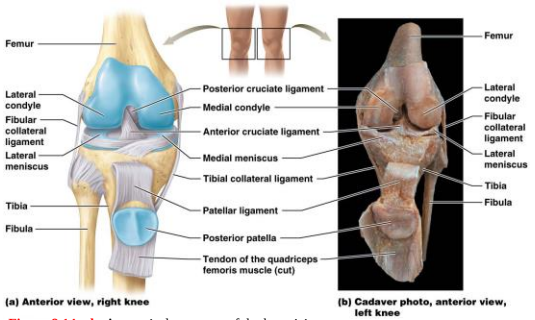


Figure 8.14a, b Anatomical structure of the knee joint.

Specific Hinge Joints

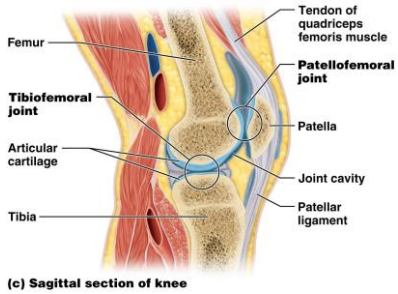


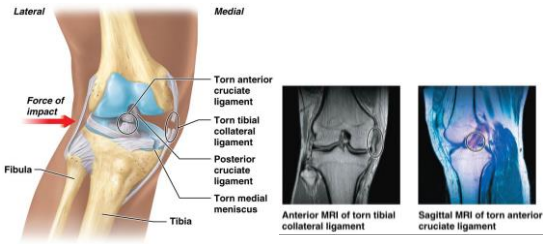
Figure 8.14c Anatomical structure of the knee joint.

A&P Flix: Movement at the Knee Joint

Knee Injuries and the Unhappy Triad

- Despite supportive structures, knee joint is still susceptible to injury; any activity that involves *quick changes in direction* can injure knee
- Athletes who participate in contact sports (football or soccer) are also at risk, especially if knee is *struck from side or from behind*
- A lateral blow (like an illegal block below knees) often ruptures *tibial collateral ligament*; *medial meniscus and anterior cruciate ligament* may tear as well, creating the "**unhappy triad**"
- **Fibular collateral** and **posterior collateral ligaments** can also be damaged, but this is less common

Knee Injuries and the Unhappy Triad



Knee Injuries and the Unhappy Triad

- **Treatment** depends on their *severity*:
  - Initial interventions include *rest*, *ice*, *compression*, and *anti-inflammatory medications* to reduce swelling and minimize pain
  - More severe injuries may require *surgical repair* of damaged ligaments
  - *Physical therapy* and *rehabilitation* to strengthen surrounding muscles are also helpful

Specific Hinge Joints

- **Shoulder** (**glenohumeral joint**) – one of the articulations of pectoral girdle, connects upper extremity with axial skeleton; composed of ball-shaped head of *humerus* and *glenoid cavity* on lateral scapula (**Figure 8.15**):
  - **Glenoid labrum** – *fibrocartilaginous ring*; increases depth of glenoid cavity to provide more *stability* to this multiaxial joint

Specific Hinge Joints

- **Shoulder** (continued):
  - **Biceps brachii tendon** – provides a stabilizing force as it passes over joint; helps keep head of humerus within glenoid cavity
  - Tendons of following muscles form **rotator cuff**, providing most of joint's structural stabilization and strength: **supraspinatus**, **infraspinatus**, **subscapularis**, and **teres minor**

Specific Hinge Joints

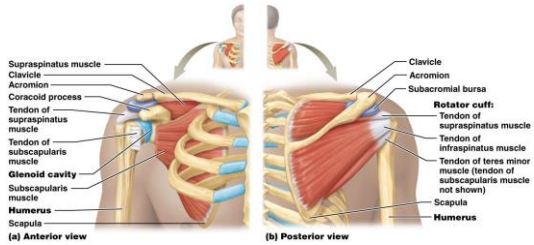


Figure 8.15a, b Anatomical structure of the shoulder joint.

Specific Hinge Joints

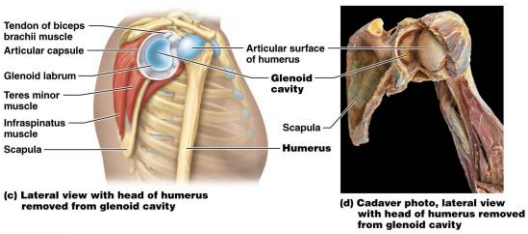
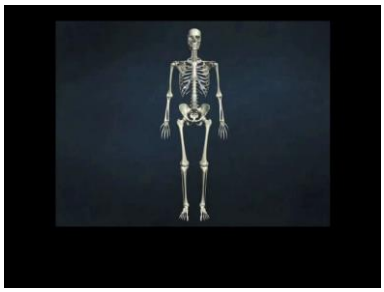
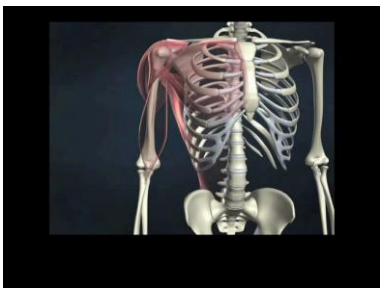


Figure 8.15c, d Anatomical structure of the shoulder joint.

A&P Flix: Movement at the Glenohumeral Joint: An Overview



A&P Flix: Movement at the Glenohumeral Joint



Shoulder Dislocations

- *Mobility* of shoulder joint comes at *expense* of stability; shoulder injuries are very common, accounting for *more than half* of all joint dislocations
- **Dislocated shoulder** – specific to *glenohumeral* joint; head of humerus is traumatically displaced from glenoid cavity
- **Separated shoulder** – another common injury, specific to *acromioclavicular joint*; not actually a component of shoulder

Shoulder Dislocations

- Contact sport athletes are especially susceptible to shoulder injuries, but anyone can suffer them under the right circumstances
- Any fall in which hand and forearm are outstretched can result in a dislocation injury; impact may force head of humerus *through inferior wall* of articular capsule (weakest relative to rest of capsule)

Shoulder Dislocations

- Chest wall muscles pull dislocated humeral head *superiorly* and *medially*; head comes to rest inferior to coracoid process of scapula
- Makes shoulder look *flattened* or "*squared off*"; injured person often holds wrist of affected shoulder against abdomen, the least painful position
- Some minor shoulder dislocations can "*pop*" *back into place* with limited effort; more severe injuries may need to be *surgically repaired*

Specific Hinge Joints

- **Hip** (**coxal joint**) – very stable, multiaxial articulation between *acetabulum* and ball-shaped *head of femur*; anatomical features make it stable enough for its weight-bearing responsibilities (**example of Structure-Function Core Principle**) (**Figure 8.16**):
  - **Acetabular labrum** – *fibrocartilaginous ring* that helps to stabilize head of femur within acetabulum
  - **Retinacular fibers** – *intracapsular ligaments* that surround neck of femur; reinforce joint capsule

Specific Hinge Joints

- **Hip** (continued):
  - **Iliofemoral ligament** – Y-shaped structure that reinforces *anterior* aspect of external joint capsule
  - **Ischiofemoral ligament** – spiral-shaped structure that supports *posterior* joint capsule
  - **Pubofemoral ligament** – triangular-shaped structure that supports *inferior* aspect of joint capsule
  - **Ligament of head of femur** – small ligament that connects head of femur with acetabulum; provides a pathway for small blood vessels servicing femoral head

Specific Hinge Joints

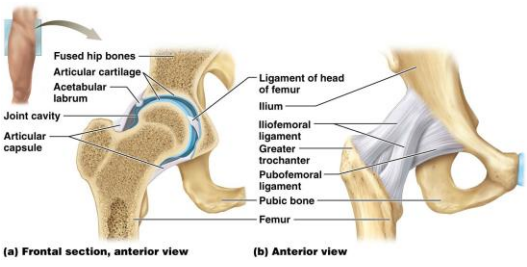


Figure 8.16a, b Anatomical structure of the hip joint.

Specific Hinge Joints

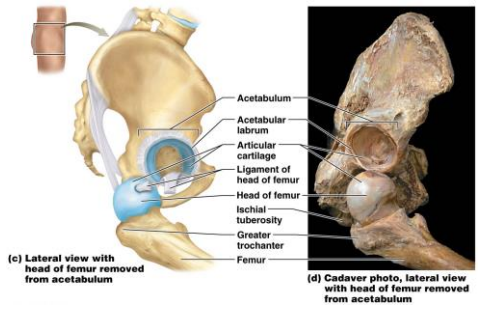


Figure 8.16c, d Anatomical structure of the hip joint.

Hip Joint Replacement Surgery

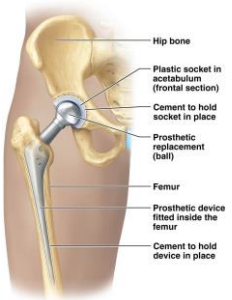
- **Hip replacement** – surgical procedure that replaces a painful damaged joint with an *artificial prosthetic device*; individual may elect to have a hip replaced due to debilitating pain and subsequent loss of joint function
- Severe *arthritis*, *trauma*, *fractures*, and *bone tumors* can all progress to point where hip joint replacement is an option

A&P Flix: Movement at the Hip Joint: An Overview

A&P Flix: Movement at the Hip Joint

Hip Joint Replacement Surgery

- **Total replacement** removes and replaces *head* of femur and reconstructs *acetabulum*
- **Partial replacement** removes only *head* of femur; replaces it with a prosthetic device, leaving acetabulum intact
- Choice of replacement depends on many factors, including *type of injury, patient's age,* and general *health*



Hip Joint Replacement Surgery

- Surgical complications are rare, further minimized with good postprocedure follow-up care
- Rigorous *rehabilitation program* usually follows surgery to restore normal function as soon as possible; may take 3–6 weeks for patient to completely return to normal daily activities