Introduction

- **Joints**, or articulations, are connections between bones that may or may not permit movement.
  - Cartilage, fluid, or dense connective tissues are usually involved in holding joints together.
- Joints are classified functionally by the amount of movement they allow.
  - Immovable or slightly movable joints tend to be in the axial skeleton.
  - Freely movable joints are more common in the appendicular skeleton.
## Classification of Joints

<table>
<thead>
<tr>
<th>Functional Category</th>
<th>Structural Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNAHRTROSIS (no movement)</td>
<td>Fibrous Suture Gomphosis Cartilaginous Synchondrosis Bony fusion Synostosis</td>
<td>Fibrous connections plus extensive interlocking Fibrous connections plus insertion in alveolar process Interposition of cartilage plate Conversion of other articular form to a solid mass of bone</td>
<td>Between the bones of the skull Periodontal ligaments between the teeth and jaws Epiphyseal cartilages Portions of the skull, such as along the frontal suture; epiphyseal lines</td>
</tr>
<tr>
<td>AMPHIARTHROSIS (little movement)</td>
<td>Fibrous Syndesmosis Cartilaginous Symphysis</td>
<td>Ligamentous connection Connection by a pad of fibrous cartilage</td>
<td>Between the tibia and fibula Between right and left hip bones of pelvis; between adjacent vertebral bodies</td>
</tr>
<tr>
<td>DIARTHROSIS (free movement)</td>
<td>Synovial Monaxial Biaxial Triaxial</td>
<td>Complex joint bounded by joint capsule and containing synovial fluid Permits movement in one plane Permits movement in two planes Permits movement in all three planes</td>
<td>Numerous; subdivided by range of movement (see Figures 8.3 to 8.6) Elbow, ankle Ribs, wrist Shoulder, hip</td>
</tr>
</tbody>
</table>
# Classification of Joints

## Table 8.2 A Structural Classification of Articulations

<table>
<thead>
<tr>
<th>Structure</th>
<th>Type</th>
<th>Functional Category</th>
<th>Example*</th>
</tr>
</thead>
<tbody>
<tr>
<td>BONY FUSION</td>
<td>Synostosis</td>
<td>Synarthrosis</td>
<td>Frontal bone (fusion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Frontal suture</td>
</tr>
<tr>
<td>FIBROUS JOINT</td>
<td>Suture</td>
<td>Synarthrosis</td>
<td>Lambdoid suture</td>
</tr>
<tr>
<td></td>
<td>Gomphosis</td>
<td>Synarthrosis Synarthrosis Amphiarthrosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Syndesmosis</td>
<td></td>
<td>Skull</td>
</tr>
<tr>
<td>CARTILAGINOUS JOINT</td>
<td>Synchondrosis Symphysys</td>
<td>Synarthrosis Synarthrosis Amphiarthrosis</td>
<td></td>
</tr>
<tr>
<td>SYNOVIAL JOINT</td>
<td>Monaxial Biaxial Triaxial</td>
<td>All diarthoses</td>
<td>Symphysys</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pubic symphysys</td>
</tr>
</tbody>
</table>

*For other examples, see

---

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Classification of Joints

- **Synarthroses (Immovable Joints)**
  - *Sutures* are joints found only in the skull.
    - Bony edges interlock and short dense connective tissue fiber holds the bones together.
  - A *gomphosis* is the joint between a tooth and the alveolar fossa of the maxillae or mandible.
    - Periodontal ligaments hold the tooth to the bone in the gomphosis.
  - A *synchondrosis* is a joint in which hyaline cartilage separates the ends of the bones involved in the joint.
  - A *synostosis* occurs if bones fuse together to form one bone.
Classification of Joints

- **Amphiarthroses** (Slightly Movable Joints)
  - A *syndesmosis* occurs when bones are connected by relatively long connective tissue ligaments.
  - Connecting bones using a fibrocartilage pad forms a *symphysis*. 
Classification of Joints

- **Diarthroses (Freely Movable Joints)**
  - *Synovial joints* are typically found at the ends of long bones in the upper and lower limbs.
  - All synovial joints have 6 basic characteristics:
    - A joint capsule
    - Articular cartilages
    - A joint cavity filled with *synovial fluid*
    - A *synovial membrane* lining the joint capsule
    - Accessory structures
    - Sensory nerves and blood vessels
Figure 8.1a  Structure of a Synovial Joint

(a) Synovial joint, sagittal section
Classification of Joints

Figure 8.1b Structure of a Synovial Joint
Synovial fluid has three functions:

- Lubricates the surfaces of the articular cartilages on the ends of the bones
- Nourishes the chondrocytes by entering and exiting the articular cartilages due to the forces acting on the joint
- Acts as a shock absorber
Articular Form and Function

- **Types of Movement**
  - *Linear movements*
  - *Angular movements*
  - *Rotation*
  - *Special movements*
<table>
<thead>
<tr>
<th>(a) Initial position</th>
<th>(b) Linear motion (Gliding)</th>
<th>(c) Angular motion</th>
<th>(d) Circumduction</th>
<th>(e) Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencil at right angles to surface.</td>
<td>Pencil remains vertical, but tip moves away from point of origin.</td>
<td>Tip remains stationary, but shaft changes angle relative to the surface.</td>
<td>Circumduction is a type of angular motion. Tip remains stationary while the shaft, held at an angle less than 90°, describes a complete circle.</td>
<td>With tip at same point, the angle of the shaft remains unchanged as the shaft spins around its longitudinal axis.</td>
</tr>
</tbody>
</table>

Figure 8.2  A Simple Model of Articular Motion
Articular Form and Function

- Special Movements
  - Movements at the ankle include
    - Eversion/inversion
    - Dorsiflexion/plantar flexion
  - Movement of the vertebral column includes
    - Lateral flexion
  - Movement of the pollex (thumb)
    - Opposition/reposition
Special movements that occur at many joints include:

- Protraction is movement anteriorly in the horizontal plane.
- Retraction is movement posteriorly in the horizontal plane.
- Elevation is movement cranially in the vertical axis.
- Depression is movement caudally in the vertical axis.
Figure 8.3a,c  Angular Movements
Figure 8.3b,d  Angular Movements
Figure 8.4  Rotational Movements
Figure 8.5a-c  Special Movements
Figure 8.5d-f  Special Movements
A Structural Classification of Joints

- **Plane joints**
  - Nonaxial joints
  - Multiaxial joints

- **Hinge joints**
  - Flexion and extension

- **Pivot joints**
  - Rotational movements
Articular Form and Function

- A Structural Classification of Joints (cont.)
  - Condylar joints
    - Flexion/extension and abduction/adduction
  - Saddle joints
    - Biaxial joints that also allow circumduction
  - Ball and socket joints
    - Triaxial joints
Figure 8.6a  A Structural Classification of Synovial Joints

(a) Gliding joint
Articular Form and Function

Figure 8.6b  A Structural Classification of Synovial Joints
Articular Form and Function

Figure 8.6c  A Structural Classification of Synovial Joints

(c) Pivot joint
Figure 8.6d  A Structural Classification of Synovial Joints
Figure 8.6e  A Structural Classification of Synovial Joints
Articular Form and Function

Figure 8.6f  A Structural Classification of Synovial Joints

(f) Ball-and-socket joint
Figure 8.7  The Temporomandibular Joint (Lateral View)

(a) Lateral view
Figure 8.7 The Temporomandibular Joint (Sectional View)
Figure 8.8  Intervertebral Articulations

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.9a  Damage to the Intervertebral Discs

(a) Lateral view of distorted intervertebral disc
Representative Articulations

Figure 8.9b Damage to the Intervertebral Discs

(b) Herniated disc, superior view
Vertebral Movements

- There are four possible movements of the vertebral column:
  - Anterior flexion, or bending forward
  - Extension, or bending backward
  - Lateral flexion, or bending to the side
  - Rotation, or twisting
# Representative Articulations

## TABLE 8.3 Articulations of the Axial Skeleton

<table>
<thead>
<tr>
<th>Element</th>
<th>Joint</th>
<th>Type of Articulation</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SKULL</strong></td>
<td>Various</td>
<td>Synarthroses (suture or synostosis)</td>
<td>None</td>
</tr>
<tr>
<td>Cranial and facial bones of skull</td>
<td>Alveolar</td>
<td>Synarthrosis (gomphosis)</td>
<td>None</td>
</tr>
<tr>
<td>Maxillae/teeth</td>
<td>Alveolar</td>
<td>As above</td>
<td>None</td>
</tr>
<tr>
<td>Mandible/teeth</td>
<td>Temporomandibular</td>
<td>Combined plane joint and hinge</td>
<td>Elevation/depression, lateral gliding, limited protraction/retraction</td>
</tr>
<tr>
<td>Temporal bone/mandible</td>
<td></td>
<td>diarthrosis</td>
<td></td>
</tr>
<tr>
<td><strong>VERTEBRAL COLUMN</strong></td>
<td>Atlanto-occipital</td>
<td>Condylar diarthrosis</td>
<td>Flexion/extension</td>
</tr>
<tr>
<td>Occipital bone/atlas</td>
<td>Atlanto-axial</td>
<td>Pivot diarthrosis</td>
<td>Rotation</td>
</tr>
<tr>
<td>Atlas/axis</td>
<td>Intervertebral (between vertebral bodies)</td>
<td>Amphiarthrosis (symphysis)</td>
<td>Slight movement</td>
</tr>
<tr>
<td>Other vertebral elements</td>
<td>Intervertebral (between articular processes)</td>
<td>Planar diarthrosis</td>
<td>Slight rotation and flexion/extension</td>
</tr>
<tr>
<td><strong>Thoracic vertebrae/ribs</strong></td>
<td>Vertebrocostal</td>
<td>Planar diarthrosis</td>
<td>Elevation/depression</td>
</tr>
<tr>
<td>Rib/costal cartilage</td>
<td>Sternocostal</td>
<td>Synchronidrosis</td>
<td>None</td>
</tr>
<tr>
<td>Costal cartilage/sternum</td>
<td></td>
<td>Synchronidrosis (rib 1)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planar diarthrosis (ribs 2–7)</td>
<td>Slight gliding movement</td>
</tr>
<tr>
<td><strong>L₃/sacrum</strong></td>
<td>Between body of L₃ and sacral body</td>
<td>Amphiarthrosis (symphysis)</td>
<td>Slight movement</td>
</tr>
<tr>
<td></td>
<td>Between inferior articular processes of L₃ and articular processes of sacrum</td>
<td>Planar diarthrosis</td>
<td>Slight flexion/extension</td>
</tr>
<tr>
<td><strong>Sacrum/os coxae</strong></td>
<td>Sacro-iliac</td>
<td>Planar diarthrosis</td>
<td>Slight gliding movement</td>
</tr>
<tr>
<td>Sacrum/coccyx</td>
<td>Sacrococcygeal</td>
<td>Planar diarthrosis (may become fused)</td>
<td>Slight movement</td>
</tr>
<tr>
<td>Coccygeal bones</td>
<td></td>
<td>Synarthrosis (synostosis)</td>
<td>None</td>
</tr>
</tbody>
</table>
Figure 8.10  The Sterno-clavicular Joint

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.11a  The Glenohumeral Joint (Anterior View)
Figure 8.11b  The Glenohumeral Joint (Lateral View of Pectoral Girdle)
Figure 8.11c  The Glenohumeral Joint (Anterior View, Frontal Section)
Figure 8.11d  The Glenohumeral Joint (Superior View, Horizontal Section)
Figure 8.12a  The Elbow Joint (Lateral View)
Figure 8.12b  The Elbow Joint (Medial View)
Figure 8.12  The Elbow Joint (X-ray, Sagittal View, and Articular Surfaces)
Figure 8.13  The Radioulnar Joints

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.14a,b The Joints of the Wrist and Hand

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.14c  The Joints of the Wrist and Hand

(c) Ligaments of the wrist, anterior (palmar) view
Figure 8.14d  The Joints of the Wrist and Hand
# Representative Articulations

## Table 8.4 Articulations of the Pectoral Girdle and Upper Limb

<table>
<thead>
<tr>
<th>Element</th>
<th>Joint</th>
<th>Type of Articulation</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sternum/clavicle</td>
<td>Sternoclavicular</td>
<td>Planar diarthrosis (a double &quot;plane joint,&quot; with two joint cavities separated by an articular cartilage)</td>
<td>Protraction/retraction, depression/elevation, slight rotation</td>
</tr>
<tr>
<td>Scapula/clavicle</td>
<td>Acromioclavicular</td>
<td>Planar diarthrosis</td>
<td>Slight gliding movement</td>
</tr>
<tr>
<td>Scapula/humerus</td>
<td>Glenohumeral (shoulder)</td>
<td>Ball-and-socket diarthrosis</td>
<td>Flexion/extension, adduction/abduction, circumduction, rotation</td>
</tr>
<tr>
<td>Humerus/ulna and humerus/radius</td>
<td>Elbow (humeroulnar and humeroradial)</td>
<td>Hinge diarthrosis</td>
<td>Flexion/extension</td>
</tr>
<tr>
<td>Radius/ulna</td>
<td>Proximal radioulnar</td>
<td>Pivot diarthrosis</td>
<td>Rotation</td>
</tr>
<tr>
<td>Radius/carpal bones</td>
<td>Distal radioulnar</td>
<td>Pivot diarthrosis</td>
<td>Pronation/supination</td>
</tr>
<tr>
<td>Carpal bone/carpal bone</td>
<td>Intercarpal</td>
<td>Condylar diarthrosis</td>
<td>Flexion/extension, adduction/abduction, circumduction</td>
</tr>
<tr>
<td>Carpal bone/first metacarpal bone</td>
<td>Carpometacarpal of thumb</td>
<td>Saddle diarthrosis</td>
<td>Flexion/extension, adduction/abduction, circumduction, opposition</td>
</tr>
<tr>
<td>Carpal bones/metacarpal bones II–V</td>
<td>Carpometacarpal</td>
<td>Planar diarthrosis</td>
<td>Slight flexion/extension, adduction/abduction</td>
</tr>
<tr>
<td>Metacarpal bones/phalanges</td>
<td>Metacarpophalangeal</td>
<td>Condylar diarthrosis</td>
<td>Flexion/extension, adduction/abduction, circumduction</td>
</tr>
<tr>
<td>Phalanx/phalanx</td>
<td>Interphalangeal</td>
<td>Hinge diarthrosis</td>
<td>Flexion/extension</td>
</tr>
</tbody>
</table>

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.15  The Hip Joint (Lateral View)
Figure 8.15  The Hip Joint (Anterior View)
Figure 8.15   The Hip Joint (Posterior View)
Figure 8.16  Articular Structure of the Hip Joint (Sectional View)
Figure 8.16  Articular Structure of the Hip Joint (X-ray)
Figure 8.16 Articular Structure of the Hip Joint (Coronal Section)

- Gluteus minimus muscle
- Fibrous cartilage pad of acetabulum
- Acetabular labrum
- Articular cartilage of femoral head
- Head of femur
- Greater trochanter
- Neck of femur
- Articular capsule
- Iliopsoas muscle
- Pectineus muscle
- Vastus lateralis muscle
- Adductor longus muscle
- Vastus medialis muscle

(c) Coronal section through the hip
Figure 8.17  The Knee Joint, Part I (Anterior View)
Figure 8.17    The Knee Joint, Part I (Parasagittal Section)
Figure 8.17  The Knee Joint, Part I (X-ray, Partially Flexed Knee)
Figure 8.17   The Knee Joint, Part I (MRI of Right Knee Joint)
Figure 8.18  The Knee Joint, Part II (Posterior View, Superficial Layer)
Representative Articulations

Figure 8.18  The Knee Joint, Part II (Posterior View, Deep Layer)

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Figure 8.18  The Knee Joint, Part II (Anterior Views, Flexed Knee)
### TABLE 8.5 Articulations of the Pelvic Girdle and Lower Limb

<table>
<thead>
<tr>
<th>Element</th>
<th>Joint</th>
<th>Type of Articulation</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacrum/hip bones</td>
<td>Sacro-iliac</td>
<td>Planar diarthrosis</td>
<td>Gliding movements</td>
</tr>
<tr>
<td>Hip bones/hip bones</td>
<td>Pubic symphysis</td>
<td>Amphiarthrosis</td>
<td>None*</td>
</tr>
<tr>
<td>Hip bones/femur</td>
<td>Hip</td>
<td>Ball-and-socket diarthrosis</td>
<td>Flexion/extension, adduction/abduction, circumduction, rotation</td>
</tr>
<tr>
<td>Femur/tibia</td>
<td>Knee</td>
<td>Complex, functions as hinge</td>
<td>Flexion/extension, limited rotation</td>
</tr>
<tr>
<td>Tibia/fibula</td>
<td>Tibiofibular (proximal)</td>
<td>Planar diarthrosis</td>
<td>Slight gliding movements</td>
</tr>
<tr>
<td></td>
<td>Tibiofibular (distal)</td>
<td>Planar diarthrosis and amphiarthrotic syndesmosis</td>
<td>Slight gliding movements</td>
</tr>
<tr>
<td>Tibia and fibula with talus</td>
<td>Ankle, or talocrural</td>
<td>Hinge diarthrosis</td>
<td>Dorsiflexion/plantar flexion</td>
</tr>
<tr>
<td>Tarsal bone to tarsal bone</td>
<td>Intertarsal</td>
<td>Planar diarthrosis</td>
<td>Slight gliding movements</td>
</tr>
<tr>
<td>Tarsal bones to metatarsal bones</td>
<td>Tarsometatarsal</td>
<td>Planar diarthrosis</td>
<td>Slight gliding movements</td>
</tr>
<tr>
<td>Metatarsal bones to phalanges</td>
<td>Metatarsophalangeal</td>
<td>Condylar diarthrosis</td>
<td>Flexion/extension, adduction/abduction</td>
</tr>
<tr>
<td>Phalanx/phalanx</td>
<td>Interphalangeal</td>
<td>Hinge diarthrosis</td>
<td>Flexion/extension</td>
</tr>
</tbody>
</table>

*During pregnancy, hormones weaken the symphysis and permit movement important to childbirth (see Chapter 28).*
Figure 8.19  An Arthroscopic View of the Interior of an Injured Knee, Showing a Damaged Meniscus
Figure 8.20a  The Joints of the Ankle and Foot, Part I

Tibialis posterior muscle
Flexor hallucis longus muscle
Calcaneal tendon
Talocrural joint
Subtalar joint
Talocalcaneal ligament
Talus
Talonavicular joint
Cuneonavicular joint
Tarsometatarsal joint
Metatarsal bone (II)
Metatarsophalangeal joint
Interphalangeal joint
Calcaneus
Navicular
Medial cuneiform
Tendon of flexor digitorum brevis muscle
(a) Ankle and foot, longitudinal section
Figure 8.20b  The Joints of the Ankle and Foot, Part I
Representative Articulations

Figure 8.21a  The Joints of the Ankle and Foot, Part II (Superior Views)

(a) Superior view
Figure 8.21c  The Joints of the Ankle and Foot, Part II (Lateral View)
Figure 8.21  The Joints of the Ankle and Foot, Part II (Posterior View of Coronal Section)
Figure 8.21  The Joints of the Ankle and Foot, Part II (Medial Views)

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
Aging and Articulations

- **Rheumatism**—pain and stiffness affecting the skeletal system, the muscular system, or both
- **Arthritis**—includes all rheumatic diseases that affect synovial joints
- Both conditions are common among older individuals.
Bones and Muscles

- Skeletal and muscular systems are structurally and functionally interdependent.
  - Considered to be part of a single musculoskeletal system.