Ch. 5

THE SKELETAL SYSTEM
Functions of Bones

• Support
  • For the body and soft organs

• Protection
  • For brain, spinal cord, and vital organs

• Movement
  • Levers for muscle action
Functions of Bones

• Storage
  • Minerals (calcium and phosphorus) and growth factors

• Blood cell formation (hematopoiesis) in marrow cavities

• Triglyceride (energy) storage in bone cavities
Classification of Bones by Shape

• Long bones
  • Longer than they are wide
  • All limb bones except carpals and tarsals, patella

• Short bones
  • Cube-shaped bones (in wrist and ankle)
  • Sesamoid bones (within tendons, e.g., patella)
Classification of Bones by Shape

- Flat bones
  - Thin, flat, slightly curved
  - Examples: Sternum, scapulae, ribs most skull bones

- Irregular bones
  - Complicated shapes
  - Examples: coxal, vertebrae
(a) Long bone (humerus)

(b) Irregular bone (vertebra), right lateral view

(c) Flat bone (sternum)

(d) Short bone (talus)
Bone Markings: Projections

- Sites of muscle and ligament attachment
  - Tuberosity—rounded projection
  - Crest—narrow, prominent ridge
  - Trochanter—large, blunt, irregular surface
  - Tubercle—small rounded projection
  - Epicondyle—raised area above a condyle
  - Spine—sharp, slender projection
  - Process—any bony prominence
Bone Markings: Projections

- Projections that help to form joints
  - Head
    - Bony expansion carried on a narrow neck
  - Facet
    - Smooth, nearly flat articular surface
  - Condyle
    - Rounded articular projection
  - Ramus
    - Armlike bar
Bone Markings: Openings

- Meatus
  - Canal-like passageway
- Sinus
  - Cavity within a bone
- Fossa
  - Shallow, basinlike depression
- Groove
  - Furrow
- Fissure
  - Narrow, slitlike opening
- Foramen
  - Round or oval opening through a bone
Bone Textures

• Compact bone
  • Dense outer layer of bone
  • Composed of osteons

• Spongy bone
  • Internal to compact bone & composed of trabeculae
Membranes of Bone

• Periosteum
  • Surrounds entire outer surface of compact bone, except joint surfaces
  • Contains: Osteoblasts and osteoclasts
  • Secured to compact bone by Sharpey’s fibers

• Endosteum
  • Lines internal surfaces of bone and also contains osteoblasts and osteoclasts
Structure of a Long Bone

• Diaphysis (shaft)
  • Compact bone collar surrounds medullary (marrow) cavity
Structure of a Long Bone

- Epiphyses
  - Expanded ends
- Spongy bone interior
- Epiphyseal line (remnant of growth plate)
- Articular (hyaline) cartilage on joint surfaces
Structure of Short, Irregular, and Flat Bones

• Endosteum covered spongy bone surrounded/sandwiched by compact bone covered in periosteum
Microscopic Anatomy of Bone: Compact Bone

• Haversian system, or osteon—structural unit
  • Lamellae
    • Weight-bearing portion
    • Column-like matrix tubes
  • Central (Haversian) canal
    • Contains blood vessels and nerves
Structures in the central canal

- Artery with capillaries
- Vein
- Nerve fiber

Collagen fibers run in different directions

Twisting force

Lamellae
Microscopic Anatomy of Bone: Compact Bone

- Perforating (Volkmann’s) canals
  - At right angles to the central canal
  - Connects blood vessels and nerves of the periosteum and central canal
- Lacunae—small cavities that contain osteocytes
- Canaliculi—hairlike canals that connect lacunae to each other and the central canal
Nerve
Vein
Artery
Canaliculus
Osteocyte in a lacuna

Lamellae
Central canal
Lacunae

(b)
Microscopic Anatomy of Bone: Spongy Bone

• Composed of trabeculae
• No osteons
• Spaces between trabeculae are filled with bone marrow
Chemical Composition of Bone: Organic

- Bone cells (osteoblasts, osteocytes, osteoclasts)
- Osteoid—organic bone matrix secreted by osteoblasts and:
  - Ground substance
  - Collagen fibers
Chemical Composition of Bone: Inorganic

• Hydroxyapatites (mineral salts)
  • 65% of bone by mass
  • Mainly calcium phosphate crystals
  • Responsible for hardness and resistance to compression
Bone Formation, Growth and Remodeling

• Ossification- bone tissue formation

• Stages

  • Bone formation—begins in the 2nd month of development
  • Postnatal bone growth—until early adulthood
  • Bone remodeling and repair—lifelong
Bone collar forms around hyaline cartilage model.

Cartilage in the center of the diaphysis calcifies and then develops cavities.

The periosteal bud invades the internal cavities and spongy bone begins to form.

The diaphysis elongates and a medullary cavity forms as ossification continues. Secondary ossification centers appear in the epiphyses in preparation for stage 5.

The epiphyses ossify. When completed, hyaline cartilage remains only in the epiphyseal plates and articular cartilages.
Growth in Length of Long Bones

- Interstitial growth:
  - $\uparrow$ length of long bones
Growth in Width of All Bones

- Appositional Growth
  - Bones must widen as they lengthen, but must continue to widen after interstitial growth has ended
Control of Remodeling

- What controls continual remodeling of bone?
  - Hormonal mechanisms that maintain calcium homeostasis in the blood
  - Mechanical and gravitational forces
Hormonal Control of Blood Ca\textsuperscript{2+}

- Primarily controlled by parathyroid hormone (PTH)
  \[ \downarrow \text{Blood Ca}^{2+}\text{ levels} \]
  \[ \downarrow \]
  Parathyroid glands release PTH
  \[ \downarrow \]
  PTH stimulates osteoclasts to degrade bone matrix and release Ca\textsuperscript{2+}
  \[ \downarrow \]
  \[ \uparrow \text{Blood Ca}^{2+}\text{ levels} \]
Osteoclasts degrade bone matrix and release Ca^{2+} into blood.

Parathyroid glands release parathyroid hormone (PTH).

Stimulus: Falling blood Ca^{2+} levels

Calcium homeostasis of blood: 9–11 mg/100 ml
Response to Mechanical Stress

• Curved bones are thickest where they are most likely to buckle
• Trabeculae form along lines of stress
• Large, bony projections occur where heavy, active muscles attach
1. Hematoma forms

- Torn blood vessels hemorrhage
- Clot (hematoma) forms and site becomes swollen, painful, and inflamed
A hematoma forms.
Stages in the Healing of a Bone Fracture

2. The Break is Splinted by a soft callus
   - Phagocytic cells clear debris
   - Fibroblasts secrete collagen fibers to connect bone ends = soft callus
   - Osteoblasts begin forming spongy bone within 1 week
   - New blood vessels grow into injured area
Internal callus (fibrous tissue and cartilage)

External callus

New blood vessels

Spongy bone trabecula

② Fibrocartilaginous callus forms.
Stages in the Healing of a Bone Fracture

3. Bony callus formation

- New trabeculae form a bony or hard callus
- Bony callus formation continues until firm union is formed in ~2 months
Bony callus forms.
Stages in the Healing of a Bone Fracture

4. Bone remodeling
   • In response to mechanical stressors over several months
   • Final structure resembles original
4 Bone remodeling occurs.
Homeostatic Imbalances

• Read about Osteoporosis and focus on its risk factors, symptoms and characteristics
(a) Normal bone

(b) Osteoporotic bone

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THE SKELETON
The Skeleton

- Two Major Divisions of the Skeletal System: Axial and Appendicular

- The Axial Skeleton Includes Three Regions:
  - Skull and associated bones (aud. ossicles and hyoid)
  - Vertebral column
  - Thoracic cage
The Skull

• Two sets of bones

1. Cranial bones (8)
   • Enclose the brain in the cranial cavity
     • Calvaria:
     • Cranial base: anterior, middle, and posterior cranial fossae
The Skull

2. Facial bones

- Cavities for: special sense organs for sight, taste, and smell
- Provide sites of attachment for: teeth and muscles of facial expression
- All skull bones are joined by: sutures except temperomandibular joint (TMJ)
Bones of cranium (cranial vault)

- Coronal suture
- Squamous suture
- Lambdoid suture
- Facial bones
(b) Superior view of the cranial fossae

Anterior cranial fossa

Middle cranial fossa

Posterior cranial fossa
Frontal Bone

- Forms most of forehead
- Superior wall of orbits
(a) Anterior view

- Parietal bone
- Squamous part of frontal bone
- Frontal bone
- Frontonasal suture
- Supraorbital foramen (notch)
- Supraorbital margin
Parietal Bones and Major Associated Sutures

- Superior and lateral aspects of cranium
- Four sutures mark the articulations of parietal bones with frontal, occipital, and temporal bones:
  1. Coronal suture—between parietal bones and frontal bone
  2. Sagittal suture—between right and left parietal bones
  3. Lambdoid suture—between parietal bones and occipital bone
  4. Squamous (squamosal) sutures—between parietal and temporal bones on each side of skull
Coronal suture

Parietal bone

Temporal bone

Lambdoid suture

Squamous suture

Occipital bone

Frontal bone

Sphenoid bone (greater wing)

(a) External anatomy of the right side of the skull
Occipital Bone

- Most of skull’s posterior wall and posterior cranial fossa
- Articulates with 1st vertebra at occipital condyles
- Contains the foramen magnum
Lambdoid suture
Occipital bone
Superior nuchal line
External occipital protuberance
Sagittal suture
Parietal bone
Occipital condyle

(b) Posterior view
(a) Inferior view of the skull (mandible removed)
Temporal Bones

- Inferior to parietal bones
  - External acoustic canal leads to eardrum
  - Zygomatic process joins with cheek bone
  - Mastoid process is a rough projection posterior to ext. acoustic canal
  - Styloid process is a sharp needlelike projection; attachment for many neck muscles
- Mandibular fossa for mandible
Sphenoid Bone

• Complex, bat-shaped bone

• Three pairs of processes: greater & lesser wings, pterygoid processes

• Contains the: sella turcica (for pituitary)
Figure 7.7a

(a) Superior view of the skull, calvaria removed

- Frontal bone
- Olfactory foramina
- Temporal bone (petrous part)
- Sphenoid
  - Lesser wing
  - Greater wing
- Parietal bone
- Occipital bone
- Foramen magnum
- Foramen rotundum
- Foramen ovale
- Foramen spinosum
- Foramen lacerum

View
(b) Posterior view
Ethmoid Bone

• Superior part of nasal septum = perpendicular plate
• Contains crista galli and cribriform plate for olfactory fibers to pass
Figure 7.4a
(a) Anterior view
Hypophyseal fossa
Middle cranial fossa
Temporal bone (petrous part)
Posterior cranial fossa
Parietal bone
Occipital bone

(a) Superior view of the skull, calvaria removed
Mandible

• Lower jaw

• Temporomandibular joint: only freely movable joint in skull
  • Mandibular condyle articulates w/ the mandibular fossa of temporal bone
Maxillary Bones

• Medially fused to form upper jaw
• Carry teeth in the alveolar margin
Figure 7.11b

Articulates with frontal bone

Alveolar margin

(b) Maxilla, right lateral view
Figure 7.4a

(a) Anterior view

- Parietal bone
- Nasal bone
- Sphenoid bone
- Temporal bone
- Ethmoid bone
- Lacrimal bone
- Zygomatic bone
- Frontal bone
- Inferior nasal concha
- Vomer
- Maxilla
Zygomatic Bones

• Cheekbones

• Inferolateral margins of orbits
Zygomatic bone

(a) Anterior view
Nasal Bones and Lacrimal Bones

• Nasal bones
  • Form: bridge of nose

• Lacrimal bones
  • In medial walls of orbits
  • Lacrimal fossa houses lacrimal sac
Figure 7.5a

(a) External anatomy of the right side of the skull

Lacrimal bone
Lacrimal fossa
Palatine Bones and Vomer

- Palatine bones
  - Posterior one-third of hard palate

- Vomer
  - Lower part of nasal septum
(a) Inferior view of the skull (mandible removed)
• Inferior Nasal Conchae Form part of lateral walls of nasal cavity
Orbits

• Encase: eyes and lacrimal glands
• Sites of attachment for: eye muscles
• Formed by: parts of seven bones
(b) Contribution of each of the seven bones forming the right orbit

- Sphenoid bone
- Frontal bone
- Ethmoid bone
- Lacrimal bone
- Maxillary bone
- Zygomatic bone
- Optic canal
- Superior orbital fissure
Hyoid Bone

• Not a bone of the skull
• Does not articulate directly with another bone
• Site of attachment for muscles of swallowing and speech
Figure 7.12

Greater horn

Lesser horn

Body
THE SKELETAL SYSTEM: THE AXIAL SKELETON (CONT.)
Vertebral Column

- Transmits weight of trunk to lower limbs
- Flexible curved structure containing 26 irregular bones (vertebrae)
  - Cervical vertebrae (7)—vertebrae of the neck
  - Thoracic vertebrae (12)—vertebrae of the thoracic cage
  - Lumbar vertebrae (5)—vertebra of the lower back
  - Sacrum—bone inferior to the lumbar vertebrae
  - Coccyx—terminus of vertebral column
Vertebral Column: Curvatures

- Increase the resilience and flexibility of the spine
  - Primary curvatures
    - Thoracic and sacral
    - Present at birth
  - Secondary curvatures
    - Cervical and lumbar
    - Form after birth (holding head upright, walking upright)
Cervical curvature (concave)

Thoracic curvature (convex)

Lumbar curvature (concave)

Sacral curvature (convex)

Coccyx

Anterior view

Right lateral view
General Structure of Vertebrae

- **Body**
  - Anterior, weight-bearing region
- **Vertebral arch**
  - Formed from: pedicles and laminae
- **Vertebral foramen**
  - Together make up vertebral canal for spinal cord
General Structure of Vertebrae

- Seven processes per vertebra:
  - Spinous process—projects posteriorly
  - Transverse processes (2)—project laterally
  - Superior articular processes (2)—protrude superiorly
  - Inferior articular processes (2)—protrude inferiorly
Cervical Vertebrae

- $C_1$ to $C_7$: smallest, lightest vertebrae
- $C_3$ to $C_7$ share the following features
  - Bifid spinous processes are (except $C_7$)
  - Transverse foramen in: each transverse process
(a) Cervical vertebrae

- Dens of axis
- Transverse ligament of atlas
- $C_1$ (atlas)
- $C_2$ (axis)
- $C_3$
- Inferior articular process
- Bifid spinous process
- Transverse processes
- $C_7$ (vertebra prominens)
Cervical Vertebrae

• $C_1$ (atlas) and $C_2$ (axis) have unique features

• Atlas ($C_1$)
  • No body or spinous process
  • Consists of: anterior and posterior arches
  • Superior articular facets articulate with occipital condyles
Cervical Vertebrae

• **Axis (C₂)**
  
  • Dens projects superiorly into the anterior arch of the atlas
Inferior articular process

Transverse process

Dens

Posterior

Spinous process

Lamina

Pedicle

Superior articular facet

Body

(c) Superior view of axis (C2)
Thoracic Vertebrae

- $T_1$ to $T_{12}$
- All have costal facets for ribs
(b) Thoracic vertebrae

- Transverse process
- Spinous process
- Superior articular process
- Transverse costal facet (for tubercle of rib)
- Body
- Inferior demifacet (for head of rib)
- Inferior articular process
Lumbar Vertebrae

- \( L_1 \) to \( L_5 \)
- Short, thick pedicles and laminae
(c) Lumbar vertebrae

Superior articular process
Transverse process
Spinous process
Body
Intervertebral disc
Inferior articular process

Figure 7.20c
Sacrum and Coccyx

- Sacrum
  - 5 fused vertebrae ($S_1$–$S_5$)
  - Forms: posterior wall of pelvis
  - Sacral Canal
  - Articulates with $L_5$ superiorly, and with coxal bones laterally

- Coccyx
  - Tailbone
  - 3–5 fused vertebrae
  - Articulates superiorly with: sacrum
Figure 7.21a

(a) Anterior view

Body of first sacral vertebra

Coccyx
Sacral canal
Facet of superior articular process
Coccyx
(b) Posterior view
Thoracic (Rib) Cage

• Composed of
  • Thoracic vertebrae
  • Sternum
  • Ribs and their costal cartilages
Sternum

- Three fused bones
  - Manubrium (superior)
  - Body (middle)
  - Xiphoid process (inferior)
Ribs and Their Attachments

• 12 pairs
  • All attach posteriorly to thoracic vertebrae
• Pairs 1 through 7
  • True ribs
  • Attach directly to the sternum by individual costal cartilages
Ribs and Their Attachments

- Pairs 8 through 10
  - False ribs
    - Attach indirectly to sternum by joining costal cartilage of rib above
- Pairs 11–12
  - Floating ribs
  - No attachment to sternum
Figure 7.22a

(a) Skeleton of the thoracic cage, anterior view

- True ribs (1–7)
- False ribs (8–12)
- Floating ribs (11, 12)
- Jugular notch
- Clavicular notch
- Manubrium
- Sternal angle
- Body
- Xiphisternal joint
- Xiphoid process
- Sternum
- Intercostal spaces
- Costal cartilage
- Costal margin
- L1 Vertebra
(b) Superior view of the articulation between a rib and a thoracic vertebra
THE SKELETAL SYSTEM: THE APPENDICULAR SKELETON
Pectoral Girdle (Shoulder Girdle)

- Clavicles and the scapulae
  - Attach the upper limbs to the axial skeleton
  - Provide attachment sites for muscles that move the upper limbs
(a) Articulated pectoral girdle
Clavicles

- Acromial end (lateral end) articulates with the scapula
- Sternal end (medial) articulates with the sternum
Acromial (lateral) end

Sternal (medial) end

Anterior

Posterior

(b) Right clavicle, superior view
Scapulae (Shoulder Blades)

• On dorsal surface of rib cage
• Glenoid cavity houses the head of humerus
• Spine is on posterior aspect
• Three fossa are the site of origin for the rotator cuff muscles: supraspinous, infraspinous and subscapular fossa
Figure 7.25a
(a) Right scapula, anterior aspect

- Superior border
- Glenoid cavity
- Lateral border
- Subscapular fossa
- Medial border
(b) Right scapula, posterior aspect
Figure 7.25c

(c) Right scapula, lateral aspect

- Coracoid process
- Glenoid cavity
- Infraglenoid tubercle
- Supraglenoid tubercle
- Supraspinous fossa
- Infraspinous fossa
- Subscapular fossa
- Spine
- Acromion
- Subscapular fossa
- Inferior angle
- Posterior
- Anterior

Infraspinous fossa

Supraspinous fossa
The Upper Limb

• Arm
  • Humerus
• Forearm
  • Radius and ulna
• Hand
  • 8 carpal bones in the wrist
  • 5 metacarpal bones in the palm
  • 14 phalanges in the fingers
Humerus

• Largest, longest bone of upper limb
• Head of Humerus articulates with: glenoid cavity of scapula
• Contains: Greater and Lesser Tubercles
• Articulates inferiorly with radius and ulna via the capitulum and trochlea
Bones of the Forearm

- Ulna
  - Medial bone in forearm
  - Contains olecranon process and trochlear notch
- Radius
  - Lateral bone in forearm
  - Contains radial head and ulnar notch
Radial notch of the ulna
Olecranon process
Trochlear notch
Coronoid process
Head of radius
Interosseous membrane
Ulna
Radius

(a) Anterior view  (b) Posterior view
(c) Anterior view at the elbow region

(d) Posterior view of extended elbow
Hand: Carpus

- Eight bones in two rows
- Only scaphoid and lunate articulate with radius to form wrist joint
Hand: Metacarpus and Phalanges

- **Metacarpus**
  - Five metacarpal bones (#1 to #5) form the palm

- **Phalanges**
  - Each finger (digit), except the thumb, has three phalanges—distal, middle, and proximal
  - The thumb (pollex) has no middle phalanx
Figure 7.28a-b

- **Trapezoid**
- **Trapezium**
- **Scaphoid**

**Metacarpals**

**Carpals**
- Trapezium
- Trapezoid
- Scaphoid

**Radius**

**Phalanges**
- Distal
- Middle
- Proximal

**Ulna**

(a) Anterior view of left hand

(b) Posterior view of left hand

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Pelvic (Hip) Girdle

• Consists of Two coxal bones
  • Attaches lower limbs to the axial skeleton with strong ligaments
  • Transmits weight of upper body to lower limbs
• Each coxal bone consists of three fused bones:
  • Ilium-
  • Ischium-
  • Pubis-
(a) Lateral view, right hip bone
Figure 7.29

- Coxal bone
- Ilium
- Pubic bone
- Ischium
- Sacrum
- Coccyx
- Iliac fossa
- Sacroiliac joint
- Anterior superior iliac spine
- Pelvic brim
- Acetabulum
- Pubic symphysis
- Pubic arch
Comparison of Male and Female Pelves

- Female pelvis
  - Adapted for childbearing
  - True pelvis: (inferior to pelvic brim) defines birth canal
  - Cavity of the true pelvis is broad, shallow, and has greater capacity
Comparison of Male and Female Pelves

• Male pelvis
  • Adapted for support of male’s heavier build and stronger muscles
  • Cavity of true pelvis is narrow and deep
<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>FEMALE</th>
<th>MALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>General structure and functional</td>
<td>Tilted forward; adapted for childbearing; true pelvis defines the birth</td>
<td>Tilted less far forward; adapted for support of a male's heavier build</td>
</tr>
<tr>
<td>Bone thickness</td>
<td>Less; bones lighter, thinner, and smoother</td>
<td>Greater; bones heavier and thicker, and markings are more prominent</td>
</tr>
<tr>
<td>Acetabula</td>
<td>Smaller; farther apart</td>
<td>Larger; closer</td>
</tr>
<tr>
<td>Pubic angle/arch</td>
<td>Broader (80° to 90°); more rounded</td>
<td>Angle is more acute (50° to 60°)</td>
</tr>
<tr>
<td>Anterior view</td>
<td></td>
<td></td>
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</tbody>
</table>

![Comparison of the Male and Female Pelves Diagram](image)
The Lower Limb

• Three segments of the lower limb
  • Thigh: femur
  • Leg: tibia and fibula
  • Foot: 7 tarsal bones in the ankle, 5 metatarsal bones in the metatarsus, and 14 phalanges in the toes
Femur

• Largest and strongest bone in the body
• Femoral head articulates proximally with the acetabulum of the hip and distally with the tibia and patella
• Contains greater and lesser trochanters, medial and lateral condyles and patellar surface
(a) Patella (kneecap)

(b) Femur (thigh bone)
Bones of the Distal Leg

• Tibia
  • Medial leg bone
  • Articulates with femur, fibula and talus
  • Contains medial and lateral condyles, medial malleolus and anterior crest

• Fibula
  • Lateral leg bone (Not weight bearing; no articulation with femur)
  • Articulates with tibia at proximal and distal ends and with talus
  • Contains fibular head and lateral malleolus
Lateral condyle

Proximal tibiofibular joint

Medial condyle

Interosseous membrane

Fibula

Tibia

Distal tibiofibular joint

(a) Anterior view
Foot: Tarsals

• Seven tarsal bones form the posterior half of the foot

• Talus transfers most of the weight from the tibia to the calcaneus
Foot: Metatarsals and Phalanges

- Metatarsals:
  - Five metatarsal bones (#1 to #5)

- Phalanges (The 14 bones of the toes)
  - Each digit (except the hallux) has three phalanges—proximal, middle, distal
  - The great toe (Hallux) has no middle phalanx
Medial cuneiform
Intermediate cuneiform
Navicular
Talus
Trochlea of talus

(a) Superior view

Distal
Middle
Proximal

Phalanges
Metatarsals
Tarsals

Calcaneus
Cuboid
Navicular
Lateral cuneiform

1 2 3 4 5
(b) Medial view

Animation: Rotatable bones of the foot
Joints (Articulations)

- Articulation—site where two or more bones meet
- Functions of joints:
  - Give skeleton mobility
  - Hold skeleton together
Functional Classification of Joints

• Based on amount of movement allowed by the joint

• Three functional classifications:
  • Synarthroses—immovable
  • Amphiarthroses—slightly movable
  • Diarthroses—freely movable
Structural Classification of Joints

• Based on material binding bones together and whether or not a joint cavity is present

• Three structural classifications:
  • Fibrous
  • Cartilaginous
  • Synovial
Fibrous Joints

- Bones joined by dense fibrous connective tissue
- No joint cavity
- Most are synarthrotic (immovable)
- Three types: Sutures, Syndesmoses, Gomphoses
Fibrous Joints: Sutures

• Found only in skull

• Rigid, interlocking joints containing short connective tissue fibers

• Allow for growth during youth

• In middle age, sutures ossify
(a) Suture

Joint held together with very short, interconnecting fibers, and bone edges interlock. Found only in the skull.
Fibrous Joints: Syndesmoses

• Bones connected by ligaments (bands of fibrous tissue)

• Movement varies from immovable to slightly movable

• Examples:
  • Distal tibiofibular joint
(b) Syndesmosis

Joint held together by a ligament. Fibrous tissue can vary in length, but is longer than in sutures.
Cartilaginous Joints

• Bones united by cartilage, no joint cavity
• Examples
  • Intervertebral discs, pubic symphysis
(b) Symphyses

Bones united by fibrocartilage

- Body of vertebra
- Fibrocartilaginous intervertebral disc
- Hyaline cartilage
- Pubic symphysis
Synovial Joints

• All are diarthrotic

• Include all limb joints; most joints of the body
Synovial Joints

Four Distinguishing features:

1. Articular cartilage: hyaline cartilage
2. Articular (joint) capsule:
3. Joint (synovial) cavity: small potential space - encloses synovial fluid
4. Reinforcing ligaments
Synovial Joints: Friction-Reducing Structures

- **Bursae:**
  - Flattened, fibrous sacs lined with synovial membranes that contain synovial fluid
Subacromial bursa

Cavity in bursa containing synovial fluid

Humerus resting

Humerus moving
Classification of Synovial Joints

- Six types, based on shape of articular surfaces:
  - Plane
  - Hinge
  - Pivot
  - Condyloid
  - Saddle
  - Ball and socket
Plane Joints

- Nonaxial joints
- Bones move by short gliding movements
a Plane joint (intercarpal joint)
Hinge Joints

- Uniaxial joints
- Bones move by flexion and extension only
b Hinge joint (elbow joint)
Pivot Joints

- Uniaxial movement only
- Bones rotate around a central axis
Pivot joint (proximal radioulnar joint)
Condyloid Joints

• Biaxial joints

• Permit flexion, extension, adduction, abduction
Condyloid joint (metacarpophalangeal joint)
Saddle Joints

• Biaxial

• Allow greater freedom of movement than condyloid joints
e Saddle joint (carpometacarpal joint of thumb)
Ball-and-Socket Joints

• Multiaxial joints

• The most freely moving synovial joints
Ball-and-socket joint (shoulder joint)