Chapter 5
The Skeletal System

Slides 5.1 – 5.77

Lecture Slides in PowerPoint by Jerry L. Cook

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The Skeletal System

- Parts of the skeletal system
  - Bones (skeleton)
  - Joints
  - Cartilages
  - Ligaments
- Divided into two divisions
  - Axial skeleton
  - Appendicular skeleton
Functions of Bones

- Support of the body
- Protection of soft organs
- Movement due to attached skeletal muscles
- Storage of minerals (Ca and P) and fats
- Blood cell formation - hematopoiesis
Bones of the Human Body

- The adult skeleton has 206 bones
- Two basic types of osseous - bone tissue
  - Compact bone
    - Dense and Homogeneous
  - Spongy bone
    - Small needle-like pieces of bone
    - Many open spaces
Classification of Bones

Bones are classified according to shape into four groups:

Long bones

- Typically longer than wide
- Have a shaft with heads at both ends
- Contain mostly compact bone
  - Examples: Femur, humerus
Classification of Bones

- Short bones
  - Generally cube-shape
  - Contain mostly spongy bone
    - Examples: Carpals, tarsals
  - Sesamoid bones – form within tendons
    - Examples: patella or kneecap
Classification of Bones on the Basis of Shape

(a) Long bone
(e.g., humerus of arm)

(b) Short bones
(e.g., carpals of wrist)

(c) Flat bone
(e.g., parietal bone of skull)

(d) Irregular bone
(e.g., vertebra)
Classification of Bones

- Flat bones
  - Thin and flattened
  - Usually curved
  - Thin layers of compact bone around a layer of spongy bone
    - Examples: Skull, ribs, sternum
Classification of Bones

- Irregular bones
  - Irregular shape
  - Do not fit into other bone classification categories
    - Example: Vertebrae and hip
Classification of Bones on the Basis of Shape

(a) Long bone (e.g., humerus of arm)
(b) Short bones (e.g., carpals of wrist)
(c) Flat bone (e.g., parietal bone of skull)
(d) Irregular bone (e.g., vertebra)

Figure 5.1
Gross Anatomy of a Long Bone

- **Diaphysis**
  - Shaft - length
  - Composed of compact bone
- **Epiphysis**
  - Ends of the bone
  - Composed mostly of spongy bone
Structures of a Long Bone

- **Periosteum**
  - Outside covering of the diaphysis
  - Fibrous connective tissue membrane

- **Sharpey’s fibers**
  - Secure periosteum to underlying bone

- **Arteries**
  - Supply bone cells with nutrients

Figure 5.2c
Structures of a Long Bone

- Articular cartilage
  - Covers the external surface of the epiphyses
  - Made of hyaline cartilage
  - Decreases friction at joint surfaces

Figure 5.2a
Structures of a Long Bone

- Medullary cavity
  - Cavity of the shaft
  - Contains yellow marrow (mostly fat) in adults
  - Contains red marrow (for blood cell formation) in infants

Figure 5.2a
Bone Markings

- Surface features of bones
- Sites of attachments for muscles, tendons, and ligaments
- Passages for nerves and blood vessels
- Categories of bone markings
  - Projections or processes – grow out from the bone surface
  - Depressions or cavities – indentations
Microscopic Anatomy of Bone

- Osteon (Haversian System)
  - A unit of bone

- Central (Haversian) canal
  - Opening in the center of an osteon
  - Carries blood vessels and nerves

- Perforating (Volkman’s) canal
  - Canal perpendicular to the central canal
  - Carries blood vessels and nerves
Microscopic Anatomy of Bone

Osteon (Haversian system)

Lamella

Osteocyte

Lamellae

Sharpey’s fibers

Compact bone

Blood vessel

Periosteum

Lacuna

Canaliculus

Central (Haversian) canal

Matrix

Blood vessel continues into medullary cavity containing marrow

Spongy bone

Central (Haversian) canal

Perforating (Volkmann’s) canal

Blood vessel

Figure 5.3
Microscopic Anatomy of Bone

- Lacunae
  - Cavities containing bone cells (osteocytes)
  - Arranged in concentric rings
- Lamellae
  - Rings around the central canal
  - Sites of lacunae

Figure 5.3
Microscopic Anatomy of Bone

- **Canaliculi**
  - Tiny canals
  - Radiate from the central canal to lacunae
  - Form a transport system
Changes in the Human Skeleton

- In embryos, the skeleton is primarily hyaline cartilage.
- During development, much of this cartilage is replaced by bone.
- Cartilage remains in isolated areas:
  - Bridge of the nose
  - Parts of ribs
  - Joints
Bone Growth

- Epiphyseal plates allow for growth of long bone during childhood
  - New cartilage is continuously formed
  - Older cartilage becomes ossified
    - Cartilage is broken down
    - Bone replaces cartilage
  - Process of bone formation – ossification done by bone-forming cells called osteoblasts
Bone Growth

- Bones are remodeled and lengthened until growth stops
  - Bones change shape somewhat
  - Bones grow in width – appositional growth
  - Growth due to growth hormones and sex hormones

- Bones are remodeled continually in response to:
  - Calcium levels in blood and pull of gravity and muscles on the bones
Long Bone Formation and Growth

Figure 5.4a
Long Bone Formation and Growth

Growth Bone grows in length because:

1. Cartilage grows here
2. Cartilage replaced by bone here
3. Cartilage grows here
4. Cartilage replaced by bone here

Remodeling Growing shaft is remodeled by:

1. Bone resorbed here
2. Bone added by appositional growth here
3. Bone resorbed here

Figure 5.4b
Types of Bone Cells

- Osteocytes
  - Mature bone cells
- Osteoblasts
  - Bone-forming cells
- Osteoclasts
  - Bone-destroying cells
  - Break down bone matrix for remodeling and release of calcium
- Bone remodeling is a process by both osteoblasts and osteoclasts
Bone Fractures

- A break in a bone

- Types of bone fractures
  - Closed (simple) fracture – break that does not penetrate the skin
  - Open (compound) fracture – broken bone penetrates through the skin

- Bone fractures are treated by reduction and immobilization
  - Realignment of the bone – either by physician’s hands or surgery
## Common Types of Fractures

<table>
<thead>
<tr>
<th>Fracture type</th>
<th>Illustration</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comminuted</td>
<td><img src="image" alt="Comminuted" /></td>
<td>Bone breaks into many fragments.</td>
<td>Particularly common in the aged, whose bones are more brittle.</td>
</tr>
<tr>
<td>Compression</td>
<td><img src="image" alt="Compression" /></td>
<td>Bone is crushed. (i.e., osteoporotic bones).</td>
<td>Common in porous bones</td>
</tr>
<tr>
<td>Depressed</td>
<td><img src="image" alt="Depressed" /></td>
<td>Broken bone portion is pressed inward.</td>
<td>Typical of skull fracture.</td>
</tr>
<tr>
<td>Impacted</td>
<td><img src="image" alt="Impacted" /></td>
<td>Broken bone ends are forced into each other.</td>
<td>Commonly occurs when one attempts to break a fall with outstretched arms</td>
</tr>
<tr>
<td>Spiral</td>
<td><img src="image" alt="Spiral" /></td>
<td>Ragged break occurs when excessive twisting forces are applied to a bone.</td>
<td>Common sports fracture.</td>
</tr>
<tr>
<td>Greenstick</td>
<td><img src="image" alt="Greenstick" /></td>
<td>Bone breaks incompletely, much in the way a green adults.</td>
<td>Common in children, whose bones are more flexible than those of adults.</td>
</tr>
</tbody>
</table>

Table 5.2

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Repair of Bone Fractures

- Hematoma (blood-filled swelling) is formed due to broken blood vessels
- Break is splinted by fibrocartilage to form a callus – cartilage matrix, bony matrix, collagen fibers – capillaries also form again
- Fibrocartilage callus is replaced by a bony callus made of spongy bone
- Bony callus is remodeled to form a permanent patch
Stages in the Healing of a Bone Fracture

1. Hematoma formation
2. Fibrocartilage callus formation
3. Bony callus formation
4. Bone remodeling

Figure 5.5
The Axial Skeleton

- Forms the longitudinal part of the body
- Divided into three parts
  - Skull
  - Vertebral column
  - Bony thorax
The Axial Skeleton

Figure 5.6

(a) Anterior view

(b) Posterior view

Skull
Cranium
Facial bones

Bony thorax (ribs and sternum)
Clavicle
Scapula
Sternum
Rib
Humerus
Vertebra
Radius
Ulna

Vertebral column
Carpals

Bones of pelvic girdle

Upper limb

Bones of pectoral girdle

Lower limb

Tarsals
Metatarsals
Phalanges

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The Skull

- Two sets of bones
  - Cranium
  - Facial bones
- Bones are joined by sutures – interlocking, immovable joints
- Only the mandible is attached by a freely movable joint
The Skull

Coronal suture
Parietal bone
Temporal bone
Lambdoid suture
Squamous suture
Occipital bone
Zygomatic process
External auditory meatus
Mastoid process
Styloid process
Mandibular ramus

Frontal bone
Sphenoid bone
Ethmoid bone
Lacrimal bone
Nasal bone
Zygomatic bone
Maxilla
Alveolar margins
Mandible (body)
Mental foramen

Figure 5.7
Bones of the Skull

Figure 5.11
Figure 5.9

Human Skull, Inferior View

- Maxilla
  - (palatine process)
- Palatine bone
- Hard palate
- Zygomatic bone
- Temporal bone
  - (zygomatic process)
- Vomer
- Mandibular fossa
- Styloid process
- Mastoid process
- Occipital condyle
- Temporal bone
- Parietal bone
- Maxilla
- Sphenoid bone
  - (greater wing)
- Foramen ovale
- Carotid canal
- Jugular foramen
- Occipital condyle
- Foramen magnum
Paranasal Sinuses

- Hollow portions of bones surrounding the nasal cavity
Paranasal Sinuses

- Functions of paranasal sinuses
  - Lighten the skull
  - Give resonance and amplification to voice
The Hyoid Bone

- The only bone that does not articulate with another bone

- Serves as a moveable base for the tongue and as an attachment point for neck muscles that raise and lower the larynx when we swallow and speak
The Fetal Skull

- The infant’s face is very small compared to the size of the cranium.
- The fetal skull is large compared to the infant’s total body length.
- Skull is unfinished at birth.
The Fetal Skull

- Fontanelles – fibrous membranes connecting the cranial bones
- Soft spots
- Allow the brain to grow and for easier delivery
- Convert to bone within 24 months after birth
The Vertebral Column – Spine

- Vertebrae separated by intervertebral discs
- The spine has a normal curvature
- Each vertebrae is given a name according to its location
- Before birth 33 : then 9 fuse
Structure of a Typical Vertebrae

Figure 5.16
Regional Characteristics of Vertebrae

Figure 5.17a, b
Regional Characteristics of Vertebrae

![Diagram of vertebrae regions](image)

Figure 5.17c, d

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Slide 5.45
The Bony Thorax

- Forms a cage to protect major organs
The Bony Thorax

- Made-up of three parts
  - Sternum
  - Ribs
  - Thoracic vertebrae
The Appendicular Skeleton

- 126 bones of the:
  - Limbs (appendages)
  - Pectoral girdle
  - Pelvic girdle
The Appendicular Skeleton

Figure 5.6c

(a) Anterior view
(b) Posterior view

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The Pectoral (Shoulder) Girdle

- Composed of two bones
  - Clavicle – collarbone and Scapula – shoulder blade
- These bones allow the upper limb to have exceptionally free movement due to:
  - Each shoulder girdle attaches to the axial skeleton at only one point
  - Loose attachment of the scapula allows it to slide back and forth against the thorax as muscles act
  - The glenoid cavity is shallow, and the shoulder joint is poorly reinforced by ligaments
Bones of the Shoulder Girdle

(a) Articulated pectoral girdle

Figure 5.20a, b

(b) Right clavicle

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Bones of the Shoulder Girdle

(c) Right scapula, posterior aspect

(d) Right scapula, anterior aspect

Figure 5.20c, d

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Bones of the Upper Limb

- The arm is formed by a single bone
  - Humerus
Bones of the Upper Limb

- The forearm has two bones
  - Ulna
  - Radius
Bones of the Upper Limb

- The hand
  - Carpals – wrist
  - Metacarpals – palm
  - Phalanges – fingers

Figure 5.22
Bones of the Pelvic Girdle

- Hip bones
- Composed of three pair of fused bones
  - Ilium
  - Ischium
  - Pubic bone
- The total weight of the upper body rests on the pelvis
- Protects several organs
  - Reproductive organs
  - Urinary bladder
  - Part of the large intestine
The Pelvis

Figure 5.23a

Coxal bone (or hip bone)

Ilium

Sacrum

Pubic bone

Coccyx

Ischium

Iliac crest

Sacroiliac joint

Pelvic brim

Ischial spine

Acetabulum

Pubic symphysis

(a)

Public arch

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Slide 5.57
The Pelvis

Figure 5.23b

Ilium
Anterior superior iliac spine
Anterior inferior iliac spine
Ala
Iliac crest
Acetabulum
Body of pubis
Pubis
Inferior ramus of pubis

Posterior superior iliac spine
Posterior inferior iliac spine
Greater sciatic notch
Ischial body
Ischial spine
Ischial tuberosity
Ischium
Ischial ramus

(b)
Gender Differences of the Pelvis

False pelvis

Inlet of true pelvis

Pelvic brim

Pubic arch (less than 90°)

Male

Figure 5.23c

False pelvis

Inlet of true pelvis

Pelvic brim

Pubic arch (more than 90°)

Female
Bones of the Lower Limbs

- The thigh has one bone
  - Femur – thigh bone
- The heaviest and strongest bone in the body

Figure 5.35a, b
Bones of the Lower Limbs

- The leg has two bones
  - Tibia
  - Fibula

Figure 5.35c
Bones of the Lower Limbs

- The foot
  - Tarsus – ankle
  - Metatarsals – sole
  - Phalanges – toes
Arches of the Foot

- Bones of the foot are arranged to form three strong arches
  - Two longitudinal
  - One transverse

Figure 5.26
Joints

- Articulations of bones
- Functions of joints
  - Hold bones together
  - Allow for mobility
- Ways joints are classified
  - Functionally
  - Structurally
Functional Classification of Joints

- Synarthroses – immovable joints
- Amphiarthroses – slightly moveable joints
- Diarthroses – freely moveable joints
Structural Classification of Joints

- **Fibrous joints**
  - Generally immovable
- **Cartilaginous joints**
  - Immovable or slightly moveable
- **Synovial joints**
  - Freely moveable
Fibrous Joints

- Bones united by fibrous tissue

Examples

- Sutures in skull
- Syndesmoses
  - Allows more movement than sutures because fibers are longer
  - Example: distal end of tibia and fibula

Figure 5.27d, e
Cartilaginous Joints

- Bones connected by cartilage

Examples
- Pubic symphysis - pelvis
- Intervertebral joints – spinal column
Synovial Joints

- Articulating bones are separated by a joint cavity
- Synovial fluid is found in the joint cavity

Figure 5.27f–h
Features of Synovial Joints

- Articular cartilage (hyaline cartilage) covers the ends of bones
- Joint surfaces are enclosed by a fibrous articular capsule
- Have a joint cavity filled with synovial fluid
- Ligaments reinforce the joint
Structures Associated with the Synovial Joint

- Bursae – flattened fibrous sacs
  - Lined with synovial membranes
  - Filled with synovial fluid
  - Not actually part of the joint and common where ligaments, muscles, skin, tendons, or bones rub together

- Tendon sheath
  - Elongated bursa that wraps around a tendon
The Synovial Joint

![Diagram of a synovial joint with labeled parts: Acromion of scapula, Ligament, Bursa, Ligament, Tendon sheath, Tendon of biceps muscle, Joint cavity containing synovial fluid, Articular (hyaline) cartilage, Synovial membrane, Fibrous articular capsule, Humerus.]

Figure 5.28

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Slide 5.72
Types of Synovial Joints Based on Shape

(a) Plane joint
(b) Hinge joint
(c) Pivot joint

Figure 5.29a–c
Types of Synovial Joints Based on Shape

(d) Condyloid joint
(e) Saddle joint
(f) Ball-and-socket joint

Figure 5.29d–f
Inflammatory Conditions Associated with Joints

- Bursitis – inflammation of a bursa usually caused by a blow or friction to the knee
- Tendonitis – inflammation of tendon sheaths - sprain
- Arthritis – inflammatory or degenerative diseases of joints
  - Over 100 different types
  - The most widespread crippling disease in the United States
Clinical Forms of Arthritis

- Osteoarthritis – wear-and-tear arthritis
  - Most common chronic arthritis
  - Probably related to normal aging processes

- Rheumatoid arthritis
  - An autoimmune disease – the immune system attacks the joints
  - Symptoms begin with bilateral inflammation of certain joints
  - Often leads to deformities
Clinical Forms of Arthritis

- **Gouty Arthritis - Gout**
  - Inflammation of joints is caused by an accumulation in blood and deposition of urate crystals (uric acid) from the blood
  - Usually affects only one joint
  - Can usually be controlled with diet