Chapter 5
The Skeletal System
The Skeletal System

- Parts of the skeletal system
  - Bones (skeleton)
  - Joints
  - Cartilages
  - Ligaments (bone to bone) (tendon = bone to muscle)

- Divided into two divisions
  - Axial skeleton
  - Appendicular skeleton – limbs and girdle
Functions of Bones

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

• The skeleton has 206 bones

• Two basic types of bone tissue
  • Compact bone
    • Homogeneous
  • Spongy bone
    • Small needle-like pieces of bone
    • Many open spaces

Figure 5.2b
Classification of Bones

- 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
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., carpal 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**
  - Composed of compact bone

- **Epiphysis**
  - Ends of the bone
  - Composed mostly of spongy bone

Figure 5.2a
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
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
- Three broad categories of bone markings
  - Projections for muscle attachment
  - Surfaces that form joints
  - Depressions or cavities – indentations
# Table 5.1 Bone Markings

<table>
<thead>
<tr>
<th>Name of bone marking</th>
<th>Description</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projections That Are Sites of Muscle and Ligament Attachment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuberosity</td>
<td>Large, rounded projection; may be roughened</td>
<td></td>
</tr>
<tr>
<td>Crest</td>
<td>Narrow ridge of bone; usually prominent</td>
<td></td>
</tr>
<tr>
<td>Trochanter (tro-kan’ter)</td>
<td>Very large, blunt, irregularly shaped process (the only examples are on the femur)</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td>Narrow ridge of bone; less prominent than a crest</td>
<td></td>
</tr>
<tr>
<td>Tubercle (too’ber-kł)</td>
<td>Small, rounded projection or process</td>
<td></td>
</tr>
<tr>
<td>Epicondyle</td>
<td>Raised area on or above a condyle</td>
<td></td>
</tr>
<tr>
<td>Spine</td>
<td>Sharp, slender, often pointed projection</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>Any bony prominence</td>
<td></td>
</tr>
</tbody>
</table>

![Bone Markings Illustration](image_url)
### TABLE 5.1 Bone Markings (continued)

<table>
<thead>
<tr>
<th>Name of bone marking</th>
<th>Description</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projections That Help to Form Joints</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>Bony expansion carried on a narrow neck</td>
<td></td>
</tr>
<tr>
<td>Facet</td>
<td>Smooth, nearly flat articular surface</td>
<td></td>
</tr>
<tr>
<td>Condyle (kon’dil)</td>
<td>Rounded articular projection</td>
<td></td>
</tr>
<tr>
<td>Ramus (ra’mus)</td>
<td>Armlike bar of bone</td>
<td></td>
</tr>
<tr>
<td><strong>Depressions and Openings Allowing Blood Vessels and Nerves to Pass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meatus (me-a’tus)</td>
<td>Canal-like passageway</td>
<td></td>
</tr>
<tr>
<td>Sinus</td>
<td>Cavity within a bone, filled with air and lined with mucous membrane</td>
<td></td>
</tr>
<tr>
<td>Fossa (fos’ah)</td>
<td>Shallow, basinlike depression in a bone, often serving as an articular surface</td>
<td></td>
</tr>
<tr>
<td>Groove</td>
<td>Furrow</td>
<td></td>
</tr>
<tr>
<td>Fissure</td>
<td>Narrow, slitlike opening</td>
<td></td>
</tr>
<tr>
<td>Foramen (fo-ra’men)</td>
<td>Round or oval opening through a bone</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1 (2 of 2)
Microscopy Anatomy of Bone

Bone Histology

- http://www.youtube.com/watch?v=PY5r_SJIG-A
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

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

Figure 5.3
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
Bone Growth

- Bones are remodeled and lengthened until growth stops
  - Bones change shape somewhat
  - Bones grow in width
Long Bone Formation and Growth

Figure 5.4a

In an embryo

- Bone
- Hyaline cartilage model
- Bone starting to replace cartilage
- Medullary cavity
- New center of bone growth

In a fetus

- Hyaline cartilage
- Spongy bone
- Epiphyseal plate cartilage
- Blood vessels
- New bone forming

In a child

- Articular cartilage
- Growth in bone width
- New bone forming

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1. Ridges in periosteum create groove for periosteal blood vessel.

2. Periosteal ridges fuse, forming an endosteum-lined tunnel.

3. Osteoblasts in endosteum build new concentric lamellae inward toward center of tunnel, forming a new osteon.

4. Bone grows outward as osteoblasts in periosteum build new circumferential lamellae. Osteon formation repeats as new periosteal ridges fold over blood vessels.

Figure 6-8  Principles of Anatomy and Physiology, 11/e © 2006 John Wiley & Sons
Ridges in periosteum create groove for periosteal blood vessel.
Periosteal ridges fuse, forming an endosteum-lined tunnel.
Osteoblasts in endosteum build new concentric lamellae inward toward center of tunnel, forming a new osteon.
Bone grows outward as osteoblasts in periosteum build new circumferential lamellae. Osteon formation repeats as new periosteal ridges fold over blood vessels.
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
Osteogenic cell (develops into an osteoblast)

Osteoblast (forms bone matrix)

Osteocyte (maintains bone tissue)

Osteoclast (functions in resorption, the breakdown of bone matrix)

Figure 6-2 Principles of Anatomy and Physiology, 11/e
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
Humerus

Radius

Ulna

Open fracture

Figure 6-9a Principles of Anatomy and Physiology, 11/e
# 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="image1.png" alt="Illustration" /></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="image2.png" alt="Illustration" /></td>
<td>Bone is crushed. (i.e., osteoporotic bones).</td>
<td>Common in porous bones.</td>
</tr>
<tr>
<td>Depressed</td>
<td><img src="image3.png" alt="Illustration" /></td>
<td>Broken bone portion is pressed inward.</td>
<td>Typical of skull fracture.</td>
</tr>
<tr>
<td>Impacted</td>
<td><img src="image4.png" alt="Illustration" /></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="image5.png" alt="Illustration" /></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="image6.png" alt="Illustration" /></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</td>
</tr>
</tbody>
</table>

Table 5.2

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Fractures are also categorized based on the shape of the break. There are eight main shapes or kinds of bone fractures.
• **Transverse fractures**: go more or less straight across the bone.
• **Oblique fractures**: are diagonal breaks across the bone.
• **Spiral fractures**: happen when one or both halves of the bone are twisted.
• **Comminuated fractures**: break the bone into more than two pieces.
• **Avulsion fractures**: mean pieces of the bone have been pulled apart.
• **Impacted fractures**: are the opposite of avulsion fractures. These happen when a piece of bone is pushed down into another piece of bone.
• **Fissure fractures**: are cracks in the bone.
• **Greenstick fractures**: happen when the bone bends and breaks partially, but not completely.
- **Transverse fractures**: go more or less straight across the bone.
- **Oblique fractures**: are diagonal breaks across the bone.
- **Spiral fractures**: happen when one or both halves of the bone are twisted.
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- **Impacted fractures**: are the opposite of avulsion fractures. These happen when a piece of bone is pushed down into another piece of bone.
- **Fissure fractures**: are cracks in the bone.
- **Greenstick fractures**: happen when the bone bends and breaks partially, but not completely.
Hematoma (blood-filled swelling) is formed

Break is splinted by fibrocartilage to form a callus

Fibrocartilage callus is replaced by a bony callus

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
The Skull

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

Figure 5.7

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

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Bones of the Skull

Coronal suture

Parietal bone

Nasal bone

Sphenoid bone

Ethmoid bone

Lacrimal bone

Zygomatic bone

Maxilla

Mandible

Frontal bone

Temporal bone

Optic canal

Middle nasal concha of ethmoid bone

Inferior nasal concha

Vomer

Alveolar margins

Figure 5.11
Human Skull, Superior View

- Frontal bone
- Cribiform plate
- Crista galli
- Ethmoid bone
- Sella turcica
- Foramen ovale
- Temporal bone (petrous portion)
- Internal acoustic meatus
- Parietal bone
- Occipital bone
- Foramen magnum

Figure 5.8
Human Skull, Inferior View

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

Figure 5.9
Paranasal Sinuses

- Hollow portions of bones surrounding the nasal cavity

Figure 5.10
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
The fetal skull is large compared to the infants total body length.
The Fetal Skull

- Fontanelles – fibrous membranes connecting the cranial bones
  - Allow the brain to grow
  - Convert to bone within 24 months after birth

Figure 5.13
The Vertebral Column

- Vertebrae separated by intervertebral discs
- The spine has a normal curvature
- Each vertebrae is given a name according to its location

Figure 5.14

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Structure of a Typical Vertebrae

- **Posterior**
  - Spinous process
  - Vertebral arch

- **Anterior**
  - Body
  - Vertebral foramen

- **Transverse process**
- **Lamina**
- **Superior articular process**
- **Pedicle**

Figure 5.16
The Bony Thorax

- Forms a cage to protect major organs
The Bony Thorax

- Made-up of three parts
  - Sternum
  - Ribs
  - Thoracic vertebrae

Figure 5.19a
The Appendicular Skeleton

- Limbs (appendages)
- Pectoral girdle
- Pelvic girdle
Figure 5.6c

The Appendicular Skeleton

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The Pectoral (Shoulder) Girdle

- Composed of two bones
  - Clavicle – collarbone
  - Scapula – shoulder blade
- These bones allow the upper limb to have exceptionally free movement
Bones of the Shoulder Girdle

Figure 5.20a, b

(a) Articulated pectoral girdle

(b) Right clavicle

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Bones of the Upper Limb

- The arm is formed by a single bone
  - Humerus

Figure 5.21a, b
The forearm has two bones:
- Ulna
- Radius
Bones of the Upper Limb

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

- Iliac crest
- Sacroiliac joint
- Pelvic brim
- Ischial spine
- Acetabulum
- Pubic symphysis

Coxal bone (or hip bone)

(a)

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Gender Differences of the Pelvis

Figure 5.23c
The thigh has one bone

- Femur – thigh bone

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

Figure 5.25
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 – synarthrosis or largely immovable.
Cartilaginous Joints – mostly amphiarthrosis

- Bones connected by cartilage

- Examples
  - Pubic symphysis
  - Intervertebral joints

Figure 5.27b, c
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 - Diarthroses

- 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

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

Figure 5.28
Types of Synovial Joints Based on Shape

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
- Tendonitis – inflammation of tendon sheaths
- 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
  - 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
**A Healthy Joint**

In a healthy joint, the ends of bones are encased in smooth cartilage. Together, they are protected by a joint capsule lined with a synovial membrane that produces synovial fluid. The capsule and fluid protect the cartilage, muscles, and connective tissues.

**A Joint With Osteoarthritis**

With osteoarthritis, the cartilage becomes worn away. Spurs grow out from the edge of the bone, and synovial fluid increases. Altogether, the joint feels stiff and sore.
Clinical Forms of Arthritis

- Gouty Arthritis
  - Inflammation of joints is caused by a deposition of urate crystals from the blood
  - Can usually be controlled with diet