Chapter 12
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Skeletal System
Points to ponder

• What are the five functions of the skeletal system?
• What are the parts of a long bone?
• How do bones grow, remodel, and repair?
• How are hormones involved in bone growth?
• What is osteoporosis?
• How are age, gender, and ethnicity determined through skeletal remains?
• What are the components of the axial and appendicular skeletons?
• What are synovial joints and what kind of angular movements do they allow?
What are the functions of the skeletal system?

1. Supports the body
2. Protects the soft body parts
3. Produces blood cells
4. Stores minerals (calcium and phosphate) and fat
5. Allows for movement by attaching muscles
What is the anatomy of a long bone?

- **Diaphysis** – shaft of the bone made of compact bone and filled with yellow marrow

- **Epiphysis** – ends of the bone made mostly of spongy bone

- **Articular cartilage** – hyaline cartilage found on the ends of long bones

- **Yellow bone marrow** – stores fat
What is the anatomy of a long bone?

- **Red bone marrow** – makes blood cells, found in spongy bone and flat bones

- **Periosteum** – living, outer covering of fibrous connective tissue

- **Ligaments** – fibrous connective tissue that connects bones
What is the anatomy of a long bone?

Figure 12.1 The anatomy of a long bone.
More detail on bone...

- **Compact bone**
  - is composed of osteons with a central canal containing blood vessels.
  - contains living bone cells called osteocytes in chambers called lacunae.

- **Spongy bone**
  - is made of plates with spaces filled with red bone marrow.
12.1 Overview of the Skeletal System

More detail on bone...

Figure 12.1 The anatomy of a long bone.
Where are the 3 types of cartilage found?

- **Cartilage** is flexible connective tissue categorized based on the type and arrangement of matrix fibers.

- Types
  - Hyaline cartilage: ends of long bones, nose, ends of ribs, larynx and trachea
  - Fibrocartilage: disks between vertebrae and in the knee stronger than hyaline cartilage
  - Elastic cartilage: ear flaps and epiglottis; more flexible than hyaline cartilage
12.2 Bones of the Axial Skeleton

The 206 bones of the skeleton

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Figure 12.2 The axial and appendicular skeletons.
The axial skeleton

- **Skull** – made of cranium and facial bones
- **Hyoid bone**
- **Vertebral column** – vertebrae and intervertebral disks
- **Rib cage** – ribs and sternum
The skull and the cranium

• The cranium
  – protects the brain.
  – is composed of eight bones.
  – has some bones that contain the sinuses.
12.2 Bones of the Axial Skeleton

The skull and the cranium

Figure 12.3 The bones of the skull.
Bones of the face and the hyoid bone

• Facial bones
  – Mandible
  – Maxillae
  – Zygomatic bones
  – Nasal bones

• Hyoid
  – Only bone that does not articulate with another bone
12.2 Bones of the Axial Skeleton

Bones of the face and the hyoid bone

Figure 12.4 The bones of the face and the location of the hyoid bone.
The vertebral column

• Types of vertebrae
  – 33 vertebrae
    • Cervical (7)
    • Thoracic (12)
    • Lumbar (5)
    • Sacrum (5 fused)
    • Coccyx (4 fused into tailbone)

• Intervertebral disks
  – Fibrocartilage between vertebrae
12.2 Bones of the Axial Skeleton

The vertebral column

Figure 12.5 The vertebral column.
The rib cage

• Rib(s)
  – Protect the heart and lungs
  – Flattened bone originating from the thoracic vertebrae
  – 12 pairs
    • 7 pairs true ribs
    • 3 pairs false ribs
    • 2 pairs floating ribs

• Sternum
  – Known as the breastbone
The rib cage

Figure 12.6 The thoracic vertebrae, ribs, and sternum.
The appendicular skeleton

- Pectoral girdle and upper limb
- Pelvic girdle and lower limb
12.3 Bones of the Appendicular Skeleton

The appendicular skeleton

- Pectoral girdle
  - Scapula and clavicle

- Upper limb
  - Arm and hand bones

Figure 12.7 The bones of the pectoral girdle and upper limb.
12.3 Bones of the Appendicular Skeleton

The appendicular skeleton

- Pelvic girdle
  - Coxal bone

- Lower limb
  - Leg and foot bones

Figure 12.8 The coxal bones and bones of the pelvis and lower limb.
Skeletal remains

- Characteristics to be determined
  - Age is approximated through dentition, studying areas of bone ossification, and joint condition.
  - For gender, it is best to use the pelvic bone, but the thickness of long bones or skull characteristics may also be used.
  - Ethnicity is difficult to tell, but skull characteristics are most useful.
Types of joints (where bones meet bones)

- **Fibrous** – usually immovable such as the **sutures** between cranial bones

- **Cartilaginous** – tend to be slightly movable such as the intervertebral disks

- **Synovial** – freely movable joints such as the ball-and-socket hip and shoulder joints, and the hinge knee and elbow joints
Anatomy of a synovial joint

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Figure 12.9  The structure of a synovial joint.

a. A gymnast depends on flexible joints.

b. Generalized synovial joint

c. Ball-and-socket joint

d. Hinge joint

a: © Gerard Vandystadt/Science Source

12.4 Articulations
12.4 Articulations

Summary of synovial joints movements

- **Flexion** – decrease in joint angle
- **Extension** – increase in joint angle
- **Adduction** – body part moves toward midline
- **Abduction** – body part moves away from midline
Summary of synovial joints movements

- **Rotation** – body part moves around its own axis
- **Supination** – hand faces anterior or downward
- **Pronation** – hand faces posterior or downward
- **Circumduction** – body part moves so that a cone shape is outlined
Summary of synovial joints movements

- **Inversion** – sole of foot turns inward
- **Eversion** – sole of foot turns outward
12.4 Articulations

Visualizing synovial joints movements

Figure 12.10 Synovial joints allow for a variety of movement.
What are the important cells in bone growth, remodeling, and repair?

- **Osteoblasts** – bone-forming cells
- **Osteocytes** – mature bone cells that maintain bone structure derived from osteoblasts
- **Osteoclasts** – bone-absorbing cells
- **Chondrocytes** – cartilage-forming cells
How does bone develop?

- **Ossification** is the formation of bone in 2 distinct ways.

  1. **Intramembranous ossification** – bone development between sheets of fibrous connective tissue; used in flat bones

  2. **Endochondrial ossification** – cartilage is replaced by bone; used by most bones
How does endochondral ossification occur?

1. The cartilage model – chondrocytes lay down hyaline cartilage in the shape of the future bones

2. The bone collar – osteoblasts secrete bone matrix and results in a collar made of compact bone

3. The primary ossification center – osteoblasts are brought interiorly by blood and lay down spongy bone
How does endochondral ossification occur?

4. The medullary cavity and secondary ossification sites – spongy bone of the diaphysis is absorbed by osteoclasts becoming the medullary cavity and secondary ossification centers form in the epiphyses after birth.

5. The epiphyseal (growth) plate – a cartilage band that acts as a growth plate that allows bones to lengthen.
Visualizing endochondral ossification

12.5 Bone Growth and Homeostasis

Figure 12.11 Bone growth by endochondral ossification.
How do bones lengthen?

Figure 12.12 Increasing bone length.
How do hormones affect bone growth?

- Vitamin D is converted to a hormone that allows calcium absorption in the intestine.

- Growth hormone (GH) stimulates general bone growth and the epiphyseal plates.

- Sex hormones increase growth during adolescence.
What is bone remodeling and what is its role in homeostasis?

• The process of bone renewal, often called bone remodeling, recycles as much as 18% of bone each year.

• Remodeling allows bones to respond to stress.

• It regulates the calcium in the blood through hormones.
  – Parathyroid hormone (PTH) increases blood calcium by accelerating bone recycling.
  – Calcitonin decreases blood calcium.
Bone remodeling

- Diameter increases as bone absorption inside the shaft is matched by bone formation outside the shaft.

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Figure 12.13  Bone remodeling.
Osteoporosis

• Osteoporosis is a condition where bones are weakened due to a decreased bone mass.

• Bone reabsorption exceeds absorption usually by age 40.

• Risk factors include: women, white or Asian, thin, family history, early menopause, smoking, diet low in calcium, excessive caffeine or alcohol consumption, and a sedentary lifestyle.
Osteoporosis

• Osteoporosis can lead to fractures and other complications.

• It can be treated with drugs, hormones, and lifestyle change.
Steps in bone repair

• Hematoma (6-8 hours) – blood clot formed between broken bones

• Fibrocartilaginous callus (3 weeks) – cartilaginous callus forms between broken bones

• Bony callus (3-4 months) – cartilaginous callus is turned to bone

• Remodeling – old bone tissue is replaced by new bone tissue
12.5 Bone Growth and Homeostasis

Bone repair

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Figure 12.14  Bone repair following a fracture.