Chapter 5

The Skeletal System

Osseous Tissue and Skeletal Structure

Lecture Presentation by
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Introduction

• The skeletal system is made of:
  • Skeletal bones
  • Cartilage
  • Ligaments
  • Connective tissue to stabilize the skeleton
• Bones are dynamic organs, which consist of several tissue types
Introduction

• Functions of the Skeletal System
  • Support
    • Provides the framework for the attachment of other organs
  • Storage of minerals
    • Calcium ions: 98 percent of the body’s calcium ions are in the bones
    • Phosphate ions
  • Blood cell production
    • Bone marrow produces erythrocytes, leukocytes, and platelets
Introduction

• Functions of the Skeletal System (continued)
  • **Leverage**
    • Muscles pull on the bones to produce movement
  • **Protection**
    • Ribs protect heart and lungs
    • Skull protects the brain
    • Vertebrae protect the spinal cord
    • Pelvic bones protect the reproductive organs
Structure and Function of Bone

• Bones (Osseous Tissue)
  • Supporting connective tissue
    • Specialized cells
    • Solid matrix
  • Outer lining
    • Called the periosteum
  • Inner lining
    • Called the endosteum
Structure and Function of Bone

• The Histological Organization of Mature Bone
  • The matrix of bone
    • Calcium phosphate eventually converts to hydroxyapatite crystals
    • Calcium phosphate makes up 2/3 of the bone mass
    • Hydroxyapatite crystals resist compression
Structure and Function of Bone

• The Histological Organization of Mature Bone
  • Collagen fibers
    • Make up 1/3 of the bone matrix
    • Contribute to the tensile strength of bones
    • Collagen and hydroxyapatite make bone tissue extremely strong
  • Bone cells
    • Contribute only 2 percent of the bone mass

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Structure and Function of Bone

• The Cells of Mature Bone
  • **Osteocytes**
    • Mature bone cells
    • Maintain the protein and mineral content of the matrix
    • Cause the release of calcium ions from the bone to the blood
    • Sit in depressions called **lacunae**
    • Matrix layer associated with osteocytes is **lamellae**
    • Small channels extending from the osteocytes to the bone capillaries are called **canaliculi**
Structure and Function of Bone

• The Cells of Mature Bone
  • **Osteoblasts**
    • Immature bone cells
    • Found on the inner and outer surfaces of bones
    • Produce **osteoid**, which is involved in making the matrix
    • Osteoblasts are involved in making new bone. This is a process called **osteogenesis**
• The Cells of Mature Bone (continued)

  • **Osteoprogenitor cells**
    • These are bone stem cells
    • Found on the innermost layer of the periosteum and the inner lining of the endosteum
    • Differentiate to form new osteoblasts
    • Heavily involved in the repair of bones after a break
Structure and Function of Bone

• The Cells of Mature Bone (continued)
  • **Osteoclasts**
    • Multinucleated cells
    • Secrete acids, which dissolve the bones thereby causing the release of stored calcium ions and phosphate ions into the blood
    • This process is called **osteolysis**
Figure 5.1 Histological Structure of a Typical Bone

**Osteocyte:** Mature bone cell that maintains the bone matrix

**Osteoblast:** Immature bone cell that secretes organic components of matrix

**Osteoclast:** Multinucleate cell that secretes acids and enzymes to dissolve bone matrix.

**Endosteum**

**Osteoprogenitor cell:** Stem cell whose divisions produce osteoblasts

**Medullary cavity**

**Matrix**

**Lacunae**

**Canaliculi**

**Central canals**

**Concentric lamellae**

**Osteon**

A scanning electron micrograph of several osteons in compact bone.

A thin section through compact bone; in this procedure the intact matrix and central canals appear white, and the lacunae and canaliculi are shown in black.

A single osteon at higher magnification.
Structure and Function of Bone

- Two Types of Osseous Tissue
  - **Compact bone** (dense bone)
    - Compact bones are dense and solid
    - Forms the walls of bone
  - **Spongy bone** (trabecular, or cancellous, bone)
    - Open network of plates
    - Surrounds the medullary cavity
      - Medullary cavity consists of bone marrow
Structure and Function of Bone

- Compact Bone (details)
  - Consists of osteons
    - Basic functional unit of bone
    - Consists of:
      - Central canal
      - Canaliculi
      - Osteocytes
      - Lacunae
      - Lamellae
Figure 5.2a-c The Internal Organization in Representative Bones

(a) Gross anatomy of the humerus.

(b) Diagrammatic view of the histological organization of compact and spongy bone.

(c) The organization of collagen fibers within concentric lamellae.
Figure 5.2a The Internal Organization in Representative Bones

- Spongy bone
- Blood vessels
- Compact bone
- Medullary cavity
- Endosteum
- Periosteum

Gross anatomy of the humerus.
The organization of collagen fibers within concentric lamellae.
Diagrammatic view of the histological organization of compact and spongy bone.
Structure and Function of Bone

• Spongy Bone (details)
  • **Spongy bone**
    • Arranged in parallel struts
    • Forms branching plates called *trabeculae*
    • Trabeculae form an open network
    • Creates the lightweight nature of bones
Location and structure of spongy bone. The photo shows a sectional view of the proximal end of the femur.
Structure and Function of Bone

- Functional Differences between Compact and Spongy Bone
  - **Compact bone**
    - Conducts stress from one end of the long bone to the other end of the long bone
      - Generates tremendous strength from end to end
    - Weak strength when stress is applied to the side
    - Osteon arrangement is parallel to the bone axis
      - Generates tremendous strength from end to end
Structure and Function of Bone

• Functional Differences between Compact and Spongy Bone
  • Spongy bone
    • Trabeculae create strength to deal with stress from the side
    • Trabeculae are oriented along the stress lines
    • Has extensive cross-bracing
    • Also supports yellow marrow in the shaft of the bone
    • Also supports red marrow in the epiphysis of the bone
The femur, or thigh bone, in posterior and sectional views. The femur has a diaphysis (shaft) with walls of compact bone and epiphyses (ends) filled with spongy bone. A metaphysis separates the diaphysis and epiphysis at each end of the shaft. The body weight is transferred to the femur at the hip joint. Because the hip joint is off center relative to the axis of the shaft, the body weight is distributed along the bone so that the medial portion of the shaft is compressed and the lateral portion is stretched.
An intact femur chemically cleared to show the orientation of the trabeculae in the epiphysis.
A photograph showing the epiphysis after sectioning.
Structure and Function of Bone

- Functional Differences between Compact and Spongy Bone
  - **Epiphysis** (ends of the long bones)
    - Consists of red marrow
  - **Diaphysis** (shaft of the long bones)
    - The medullary cavity of the diaphysis consists of yellow marrow
  - **Metaphysis**
    - Narrow growth zone between the epiphysis and the diaphysis
Structure and Function of Bone

• The Periosteum and Endosteum
  • Periosteum
    • Outer surface of the bone
    • Isolates and protects the bone from surrounding tissue
    • Provides a route and a place for attachment for circulatory and nervous supply
    • Actively participates in bone growth and repair
    • Attaches the bone to the connective tissue network of the deep fascia
Structure and Function of Bone

- The Periosteum and Endosteum
  - **Endosteum**
    - Inner surface of bone
    - Lines the medullary cavity
    - Consists of *osteoprogenitor cells*
    - Actively involved in repair and growth
The periosteum contains outer (fibrous) and inner (osteogenic) layers. Collagen fibers of the periosteum are continuous with those of the bone, adjacent joint capsules, and attached tendons and ligaments.
Bone Development and Growth

• Before six weeks of development, the skeleton is hyaline cartilage
  • Cartilage cells will be replaced by bone cells
  • This is called **ossification**

• **Osteogenesis**
  • Bone formation

• **Calcification**
  • The deposition of calcium ions into the bone tissue
Bone Development and Growth

• There are two types of ossification
  • **Intramembranous ossification**
    • Involved in the development of clavicle, mandible, skull, and face
  • **Endochondral ossification**
    • Involved in the development of limbs, vertebrae, and hips
• Intramembranous Ossification
  • Mesenchymal cells differentiate to form osteoblasts
  • Osteoblasts begin secreting a matrix
    • Osteoblasts become trapped in the matrix
    • Osteoblasts differentiate and form osteocytes
    • More osteoblasts are produced, thus move outward
  • Blood vessels are trapped by the formation of spicules
Mesenchymal tissue becomes highly vascularized, and the mesenchymal cells aggregate, enlarge, and then differentiate into osteoblasts. The osteoblasts then cluster together and start to secrete the organic components of the matrix. The resulting osteoid then becomes mineralized through the crystallization of calcium salts. The location where ossification begins is called an ossification center.
As ossification proceeds, osteoblasts that become surrounded by osteoid differentiate into osteocytes. These cells will remain trapped within tiny spaces known as lacunae (singular: lacuna). The developing bone grows outward from the ossification center into small struts called spicules. Although osteoblasts are still being trapped in the expanding bone, mesenchymal cell divisions continue to produce additional osteoblasts.
Bone growth is an active process, and osteoblasts require oxygen and a reliable supply of nutrients. As blood vessels branch within the region and grow between the spicules, the rate of bone growth accelerates. As spicules interconnect, they trap blood vessels within the bone.
Continued deposition of bone by osteoblasts creates a bony plate that is perforated by blood vessels. As adjacent plates fuse together, the bone structure becomes increasingly complex.

**Formation of Spongy Bone**
Bone Development and Growth

• Endochondral Ossification
  • Chondrocytes near the center of the diaphysis increase in size
  • Blood vessels begin to grow around the cartilage
  • The perichondrial cells begin to form the periosteum
    • A thin layer of compact bone begins to form
Bone Development and Growth

• Endochondral Ossification
  • Cartilage cells die and are replaced by osteoblasts
    • Osteoblasts begin to form spongy bone
      • This is the primary ossification center
  • The cartilage in the metaphysis region is invaded by osteoblasts
  • An increase in bone length and diameter begins

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Figure 5.7.1 Endochondral Ossification (2 of 3)

1. As the cartilage enlarges, chondrocytes near the center of the shaft increase greatly in size, and the surrounding matrix begins to calcify. Deprived of nutrients, these chondrocytes die and disintegrate, leaving cavities within the cartilage.

2. Blood vessels grow around the edges of the cartilage, and the cells of the perichondrium begin differentiating into osteoblasts. The perichondrium has now been converted into a periosteum, and the blood supply to the periosteum increases, and capillaries and osteoblasts migrate into the heart of the cartilage, invading the spaces left by the disintegrating chondrocytes. The calcified cartilaginous matrix then breaks down, and osteoblasts replace it with spongy bone. Bone development proceeds from this primary ossification center in the shaft, toward both ends of the cartilaginous model.

3. While these changes are underway, the blood supply to the periosteum increases, and capillaries and osteoblasts migrate into the heart of the cartilage, invading the spaces left by the disintegrating chondrocytes. The calcified cartilaginous matrix then breaks down, and osteoblasts replace it with spongy bone. Bone development proceeds from this primary ossification center in the shaft, toward both ends of the cartilaginous model.

4. While the diameter is small, the entire shaft is filled with spongy bone, but as it enlarges, osteoclasts erode the central portion and create a medullary cavity. The bone of the shaft becomes thicker, and the cartilage of the metaphysis is invaded by osteoblasts that produce columns of bone. Further growth involves two distinct processes: an increase in length and an enlargement in diameter (Figure 5.9).
Bone Development and Growth

• Endochondral Ossification
  • Osteoblasts begin to migrate into the epiphysis region
    • This is the secondary ossification center
  • Osteoblasts begin to replace cartilage with bone
  • This results in pushing the epiphysis away from the diaphysis thus resulting in longer bones
Capillaries and osteoblasts then migrate into the centers of the epiphyses, creating **secondary ossification centers**. The time of appearance of secondary ossification centers varies from one bone to another and from individual to individual. Secondary ossification centers may be present at birth in both ends of the humerus (arm), femur (thigh), and tibia (leg), but the epiphyses of some other bones remain cartilaginous through childhood.

Within the epiphyseal cartilage, the chondrocytes are organized into zones.

**Chondrocytes at the epiphyseal side of the cartilage continue to divide and enlarge.**

**Chondrocytes degenerate at the diaphyseal side.**

Osteoblasts migrate upward from the diaphysis, and the degenerating cartilage is gradually replaced by bone.

The epiphyses eventually become filled with spongy bone. The epiphysis and diaphysis are now separated by a narrow **epiphyseal cartilage**, or **epiphyseal plate**, within the metaphysis. Osteoblasts invade the shaft side of the epiphyseal cartilage, replacing the cartilage with bone, at the same rate that the epiphyseal cartilage enlarges through the interstitial growth. This enlargement pushes the epiphysis away from the diaphysis, and the length of the bone increases.

At maturity, the rate of epiphyseal cartilage enlargement slows and the rate of osteoblast activity accelerates. As a result, the epiphyseal cartilage gets narrower and narrower, until it ultimately disappears. This event is called **epiphyseal closure**. The former location of the epiphyseal cartilage becomes a distinct **epiphyseal line** that remains after epiphyseal growth has ended. A thin cap of the original cartilage model remains exposed to the joint cavity as the **articular cartilage**. This cartilage prevents damaging bone-to-bone contact within the joint.
Bone Development and Growth

• Increasing the Diameter of a Developing Bone
  • Appositional growth
    • Inner layer of the periosteum differentiates to form osteoblasts and adds bone matrix to the surface
    • This forms circumferential lamellae to the outer surface
  • Osteons form
  • Bone continues to enlarge in diameter
Figure 5.9 Appositional Bone Growth

1. Bone formation at the surface of the bone produces ridges that parallel a blood vessel.

2. The ridges enlarge and create a deep pocket.

3. The ridges meet and fuse, trapping the vessel inside the bone.

4. Bone deposition proceeds inward toward the vessel, beginning the creation of a typical osteon.

5. Additional circumferential lamellae are deposited and the bone continues to increase in diameter.

6. Osteon is complete with new central canal around the blood vessel. Second blood vessel becomes enclosed.

Three-dimensional diagrams illustrate the mechanism responsible for increasing the diameter of a growing bone.

A bone grows in diameter as new bone is added to the outer surface. At the same time, osteoclasts resorb bone on the inside, enlarging the medullary cavity.
Bone Development and Growth

• Epiphyseal Plate
  • Area of cartilage in the metaphysis
  • Cartilage near the diaphysis is converted to bone
  • The width of this zone gets narrower as we age
  • Marks the former location of the epiphyseal cartilage
Figure 5.8 Epiphyseal Cartilages and Lines

(a) X-ray of the hand of a young child. The arrows indicate the locations of the epiphyseal cartilages.

(b) X-ray of the hand of an adult. The arrows indicate the locations of epiphyseal lines.
Bone Development and Growth

• There are four major sets of blood vessels associated with the long bones
  • Nutrient vessels
  • Metaphyseal vessels
  • Epiphyseal vessels
  • Periosteal vessels
Bone Development and Growth

• Nutrient Vessels
  • Enter the diaphysis and branch toward the epiphysis
    • Enter through the nutrient foramen of the bone
  • Penetrates the shaft and enters the medullary cavity
    • Divides into ascending and descending branches to go toward the epiphysis regions
    • Vessels branch to form perforating vessels
Bone Development and Growth

• **Metaphyseal Vessels**
  • Supply nutrients to the diaphyseal edge of the epiphysis

• **Epiphyseal Vessels**
  • Supply nutrients to the cavities of the epiphysis

• **Periosteal Vessels**
  • Supply nutrients to the superficial osteons
Figure 5.10 Circulatory Supply to a Mature Bone

- Epiphyseal artery and vein
- Metaphyseal artery and vein
- Metaphyseal artery and vein
- Nutrient artery and vein
- Periosteal arteries and veins
- Periosteum
- Compact bone
- Medullary cavity
- Nutrient foramen
- Branches of nutrient artery and vein
- Connections to superficial osteons
- Metaphysis
- Epiphyseal line
- Articular cartilage
- Periosteum
Bone Development and Growth

• Bone Innervation
  • Nerves penetrate the bone with the nutrient artery
    • Innervates throughout the periosteum
    • Innervates the endosteum
    • Innervates the medullary cavity
    • Innervates the epiphysis
Bone Development and Growth

- Factors Regulating Bone Growth
  - Nutrition
  - Calcium ions
  - Phosphate ions
  - Magnesium ions
  - Citrate
  - Carbonate ions
  - Sodium ions
  - Vitamins A, C, D (calcitriol)
Bone Development and Growth

• Factors Regulating Bone Growth (continued)
  • Hormones
    • Parathyroid gland releases parathyroid hormone
    • Stimulates osteoclasts
    • Stimulates osteoblasts
    • Increases calcium ion absorption from the small intestine to the blood
    • Reduces the rate of calcium ion loss from the kidneys
Bone Development and Growth

- Factors Regulating Bone Growth (continued)
  - Hormones
    - Thyroid gland releases **calcitonin**
      - Inhibits osteoclasts
      - Increases rate of calcium ion loss in the urine
      - Removes calcium ions from blood and adds it to bone
    - Thyroid gland releases **thyroxine**
      - Maintains normal activity in the epiphyseal region
Bone Development and Growth

• Factors Regulating Bone Growth (continued)
  • Hormones
    • Pituitary gland releases growth hormone (somatotropin)
    • Stimulates bone growth
    • Maintains normal activity of the epiphyseal cartilage
Bone Development and Growth

• Factors Regulating Bone Growth (continued)
  • Hormones
    • Estrogen and testosterone stimulate osteoblast activity
      • Osteoblast activity produces bone faster than epiphyseal cartilage expansion
    • Ultimately the epiphyseal cartilage narrows and bone growth ceases (about age 25)
Bone Maintenance, Remodeling, and Repair

• Remodeling of Bone
  • Realignment of teeth can change the shape of tooth sockets
  • Increased muscular development
    • Bone changes occur due to stress
  • Different features develop on the bone
    • Attachment of ligaments
    • Attachment of tendons
  • Stressed bones become thicker and stronger
• Remodeling of Bone
  • Inactivity of bones can cause degeneration
  • After a few weeks, unstressed bones can lose about a third of their mass
Bone Maintenance, Remodeling, and Repair

• Injury and Repair
  • Fractures
    • Transverse fractures
      • Break transverse to the long axis
    • Displaced fractures
      • Produces new and abnormal bone arrangements
    • Compression fractures
      • Bones “jam” together
    • Spiral fractures
      • Bones twist along the length of the bone
Bone Maintenance, Remodeling, and Repair

• Injury and Repair
  • Fractures
    • Epiphyseal fractures
      • Fractures within the epiphyseal region
    • Comminuted fractures
      • The fractured area shatters into many bony fragments
    • Greenstick fractures
      • Only one edge of the bone breaks while the other edge bends
Bone Maintenance, Remodeling, and Repair

• Injury and Repair
  • Fractures
    • Colles fracture
      • A break at the distal portion of the radius
    • Pott fracture
      • Occurs at the ankles and affects both the tibia and the fibula
Bone Maintenance, Remodeling, and Repair

• Injury and Repair
  • When a bone is broken, bleeding occurs
  • A network of spongy bone forms
  • Osteoblasts are overly activated, thus resulting in enlarged callused area
  • This area is now stronger and thicker than normal bone
Immediately after the fracture, extensive bleeding occurs. Over a period of several hours, a large blood clot, or fracture hematoma, develops.

An internal callus forms as a network of spongy bone unites the inner edges, and an external callus of cartilage and bone stabilizes the outer edges.
The cartilage of the external callus has been replaced by bone, and struts of spongy bone now unite the broken ends. Fragments of dead bone and the areas of bone closest to the break have been removed and replaced.

A swelling initially marks the location of the fracture. Over time, this region will be remodeled, and little evidence of the fracture will remain.
Bone Maintenance, Remodeling, and Repair

• Aging and the Skeletal System
  • When we’re young, osteoblast activity balances with osteoclast activity
  • When we get older, osteoblast activity declines
    • Osteoclast activity maintains its previous level of activity
  • When osteoclast activity is faster than osteoblast activity, bones become porous
Aging and the Skeletal System
- As women age, estrogen levels drop
- Osteoclast control is lost
  - Osteoclasts are overactive
- Bones become porous
  - This is osteoporosis
Clinical Note 5.3 Osteoporosis and Age-Related Skeletal Abnormalities

Normal spongy bone  SEM × 25

Osteomyelitis of great toe

Spongy bone in osteoporosis  SEM × 21

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Anatomy of Skeletal Elements

• There are seven broad categories of bones according to their shapes
  • Sutural bones
  • Irregular bones
  • Short bones
  • Pneumatized bones
  • Flat bones
  • Long bones
  • Sesamoid bones
Sutural Bones
Sutural (Wormian) bones are small, flat, oddly shaped bones found between the flat bones of the skull in the suture line. They develop from separate centers of ossification, regarded as a type of flat bone.

Pneumatized Bones
Pneumatized bones are bones that are hollow or contain numerous air pockets, such as the ethmoid.

Short Bones
Short bones are boxlike in appearance. Their external surfaces are covered by compact bone, but the interior contains spongy bone. Examples of short bones include the carpal bones (wrists) and tarsal bones (ankles).

Irregular Bones
Irregular bones have complex shapes with short, flat, notched, or ridged surfaces. Their internal structure is equally varied. The vertebrae that form the spinal column and several bones in the skull are examples of irregular bones.

Flat Bones
Flat bones have thin, roughly parallel surfaces of compact bone. In structure a flat bone resembles a spongy bone sandwich; such bones are strong but relatively light. Flat bones form the roof of the skull, the sternum, the ribs, and the scapulae. They provide protection for underlying soft tissues and offer an extensive surface area for the attachment of skeletal muscles. Special terms are used when describing the flat bones of the skull such as the parietal bones. Their relatively thick layers of compact bone are called the internal and external tables, and the layer of spongy bone between the tables is called the diploë.

Pneumatized Bones
Pneumatized bones are bones that are hollow or contain numerous air pockets, such as the ethmoid.

Long Bones
Long bones are relatively long and slender. They have a diaphysis, two metaphyses, two epiphyses, and a medullary (marrow) cavity, as detailed in Figure 5.3. Long bones are found in the upper and lower limbs. Examples include the humerus, radius, ulna, femur, tibia, and fibula.

Sesamoid Bones
Sesamoid bones are usually small, round, and flat. They develop inside tendons and are most often encountered near joints at the knee, the hands, and the feet. Few individuals have sesamoid bones at every possible location, but everyone has sesamoid patellae, or kneecaps.
Anatomy of Skeletal Elements

• Bone markings include:
  • Projections
  • Depressions
    • Fossa
  • Openings
    • Sinuses/canals/fissures/foramen
  • Processes
    • Trochanter/crest/spine/line/tubercle/tuberosity/head/neck/facet/condyle/trochlea
Figure 5.12 Examples of Bone Markings (Surface Features) (1 of 2)

**Elevations and Projections**

<table>
<thead>
<tr>
<th>Process</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Any projection or bump</td>
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<tr>
<td>Ramus</td>
<td>An extension of a bone making an angle to the rest of the structure</td>
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</tbody>
</table>

**Openings**

<table>
<thead>
<tr>
<th>Sinus or antrum</th>
<th>A chamber within a bone, normally filled with air</th>
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</thead>
<tbody>
<tr>
<td>Meatus or canal</td>
<td>A passageway through the substance of a bone</td>
</tr>
<tr>
<td>Fissure</td>
<td>An elongated cleft</td>
</tr>
<tr>
<td>Foramen</td>
<td>A rounded passageway for blood vessels and/or nerves</td>
</tr>
</tbody>
</table>

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Figure 5.12 Examples of Bone Markings (Surface Features) (2 of 2)

**Processes formed where tendons or ligaments attach**

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trochanter</td>
<td>A large, rough projection</td>
</tr>
<tr>
<td>Crest</td>
<td>A prominent ridge</td>
</tr>
<tr>
<td>Spine</td>
<td>A pointed process</td>
</tr>
<tr>
<td>Line</td>
<td>A low ridge</td>
</tr>
</tbody>
</table>

**Processes formed for articulations with adjacent bones**

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>The expanded articular end of an epiphysis, often separated from the shaft by a narrower neck</td>
</tr>
<tr>
<td>Neck</td>
<td>A narrower connection between the epiphysis and diaphysis</td>
</tr>
<tr>
<td>Facet</td>
<td>A small, flat articular surface</td>
</tr>
<tr>
<td>Condyle</td>
<td>A smooth, rounded articular process</td>
</tr>
<tr>
<td>Trochlea</td>
<td>A smooth, grooved articular process shaped like a pulley</td>
</tr>
</tbody>
</table>

**Depressions**

- Sulcus: A narrow groove
- Fossa: A shallow depression

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Integration with Other Systems

- Bones are not Inert
- Bones are Dynamic Structures
  - Attached to the muscles
  - Under physiological control via the endocrine system
  - Digestive and excretory system
    - Provides calcium and phosphate needed for growth
  - Serves as a store of calcium, phosphate, and other minerals