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Human Anatomy



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Cartilage and Bone Connective Tissue

General Osteology /Arthrology

Definitions:

- Osteology: the study of bones
 - Bones: organs of the skeletal system
- Skeletal System: bones and associated cartilages
- Arthrology: the study of joints
 - Point of movement (fulcrum)
- Endoskeleton: internal skeleton
 - endo- = inside
 - Versus exoskeleton

Skeletal System

- Composed of dynamic living tissues
 - Osseous tissue, cartilage, fibrous CT, blood, nervous tissue.
- Continually rebuilds and remodels itself
 - Changes over a lifetime
- Interacts with all of the other organ systems.
- Includes:
 - bones of the skeleton
 - Cartilage
 - Ligaments
 - other connective tissues that stabilize or connect the bones.

Skeletal System

Functions:

- Supports our weight.
- Interacts with muscles to produce movements.
- Protection
- Blood cell formation
 - Red bone marrow
- Mineral storage
 - Calcium
 - phosphate

Cartilage Connective Tissue

Characteristics:

- Weaker than bone
- More flexible than bone
- Cells in an abundant matrix.
- Cell Types
 - Chondroblasts
 - Chondrocytes in lacunae
- Avascular

3 Major Functions of Cartilage

- Supporting soft tissues.
- Providing a gliding surface at articulations (joints)
- Providing a model for the formation of most of the bones in the body.

Types of Cartilage

- Three types of cartilage:
 - Hyaline cartilage
 - Most abundant kind
 - Has a perichondrium (membrane)
 - Associated with synovial joints
 - Most bones first modeled in hyaline cartilage
 - Fibrocartilage
 - Has collagen fibers
 - Intervertebral discs, pubic symphysis
 - Elastic cartilage
 - Has elastic fibers
 - Ear, respiratory tubing

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Articular cartilage Costal cartilage Cartilage of intervertebral disc Pubic symphysis Hyaline cartilage

Growth Patterns of Cartilage

- Two main types:
 - Interstitial Growth
 - Appositional Growth.
- Interstitial Growth.
 - Chondrocytes in lacuna undergoes mitosis.
 - Two chondrocytes in one lacuna
 - Will push apart, form separate lacuna

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Growth Patterns of Cartilage

- Appositional Growth.
 - Undifferentiated cells divide (mitosis)
 - One daughter cell remains a stem cell, one differentiates into a committed cell.
 - Committed cell further differentiates into chondroblast
 - Located at edge of cartilage
- Both types common during growth
- Later, mostly appositional
- In adult, usually no growth unless for repair

Bone

- Bones are organs
- Bones are composed of all tissue types.
- Their primary component is osseous connective tissue.
- The matrix is sturdy and rigid due to calcification (also called mineralization).

Functions of Bone

- Support.
- Protection.
- Movement
- Hemopoiesis
- Storage of minerals.
- Energy Reserves (marrow)

Support and Protection

- Bones provide structural support and serve as a framework for the entire body.
- Bones protect many delicate tissues and organs from injury and trauma.

Movement

- Muscles attach to the bones of the skeleton
 - contract and pull on bone
 - functions as a series of levers.

Hemopoiesis

- Blood cell production in red bone marrow
 - Iocated in some spongy bone.
- Red bone marrow contains stem cells
 - form all of the blood cell types.

Storage of Mineral and Energy Reserves

- More than 90% of the body's reserves of the minerals calcium and phosphate are stored and released by bone.
 - Calcium: needed for
 - muscle contraction
 - blood clotting
 - nerve impulse transmission.
 - Phosphate: needed for
 - ATP utilization
 - structure of nucleic acids (DNA, RNA)

Classification of Bone by Organization

- Axial
 - Skull
 - Vertebral column
 - Thorax
 - Sternum
 - ribs
- Appendicular
 - Pectoral
 - Girdle
 - appendage
 - Pelvic
 - Girdle
 - appendage

Classification of Bone by Shape

- Long
- Short
- Flat
- Irregular
- Surface features vary



.

Structure of Long Bone

- Diaphysis
- Epiphysis
 - proximal
 - distal
- Metaphysis
- Epiphyseal line
- Articular cartilage
- Medullary cavity



Structure of Long Bone

- Endostium: lines marrow cavity, incomplete
 - Osteoprogenitor cells
 - Osteoblasts
 - Osteoclasts
- Periostium: covers bone everywhere but articular surfaces
 - Two layers
 - Fibrous layer: outermost, dense irregular CT
 - Site of tendon attachment
 - Inner layer: next to compact bone
 - Osteoblasts present in young bone
 - Anchored to bone by perforating fibers (collagen)



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Flat Bones of the Skull

- Two layers of compact bone
 - Inner table
 - Outer table
- Region of spongy bone sandwiched between them
 - Called the diploe
- Both layers of compact bone are covered by periosteum

1 Flat bone of skull Periosteum Spongy bone (diploë) Periosteum Compact bone

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Four Types of Bone Cells

- Osteoprogenitor cells
 - stem cells derived from mesenchyme which produce other stem cells and osteoblasts
- Osteoblasts
 - produce new bone, and once osteoblasts become entrapped in the matrix they produce and secrete, they differentiate into osteocytes
- Osteocytes
 - mature bone cells
- Osteoclasts: not derived form osteoprogenitors
 - Related to macrophages
 - Formed from multiple cells; are multinucleated
 - are involved in bone resorption



Osteoclasts

- Located in Howship's lacuna
- Ruffled edge contacts bone
- Secrete hydrochloric acid
 - Dissolves minerals
 - osteolysis
- Lysosomes
 - Secrete enzymes that dissolve matrix



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Composition of Bone Matrix

- Organic components: one third
 - Cells
 - Collagen fibers
 - Ground substance
- Inorganic components: two thirds
 - Calcium phosphate
 - Hydroxyapatite crystals: calcium phosphate and calcium hydroxide

Types of Osseous Tissue

- Compact
 - Dense, cortical
- Spongy
 - Cancellous, trabecular

Compact Bone Microanatomy

- Osteon (Haversian) system: basic unit
 - Central (Haversian) canal
 - Concentric lamellae
 - Contain collagen fibers
 - Osteocytes
 - Lacunae
 - Canaliculi: permit intercellular communication
- Cylinder that runs with long axis of long bone

Compact Bone Microanatomy

- Perforating canals (Volkmann canals)
 - Contain blood vessels, nerve
 - Run perpendicular to central canals, connect them
- Circumferential lamellae
 - Internal to periostium
 - External circumferential lamellae
 - Internal to endosteum
 - Internal circumferential lamellae
 - Run the entire circumference
- Interstitial lamellae
 - Remains of osteons

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Spongy Bone Microanatomy

- No osteons
- In trabeculae:
 - Parallel lamellae
 - Osteocytes in lacunae
 - canaliculi





Ossification

- Osteogenesis: bone formation and development
- Begins in the embryo: By the eighth through twelfth weeks:
 - the skeleton begins forming:
 - from mesenchyme
 - or from a hyaline cartilage model of bone.
 - These models are replaced by hard bone
- Continues during childhood and adolescence.
- In the adult, ossification continues.

Intramembranous Ossification

- Also called dermal ossification
- Produces:
 - the flat bones of the skull (cranial vault)
 - some of the facial bones (zygomatic bone, maxilla), the mandible (lower jaw)
 - the central part of the clavicle (collarbone).
- It begins when mesenchyme becomes thickened and condensed with a dense supply of blood capillaries.

Intramembranous Ossification

- Desification centers for within thic ened regions of mesenchyme
 Ossification centers form in thickened mesenchyme
 Osteoprogenitors develop, become osteoblasts
 - 2. Osteoid (bone matrix) calcifies
 - Trapped osteoblasts become osteocytes



Intramembranous Ossification

- 3. Woven bone (primary bone) forms, periostium forms (from mesenchyme)
- 4. Lamellar bone (secondary bone) replaces woven bone; compact and spongy bone form

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display. oven bone and surrounding periosteum Mesenchyme form condensing to form the periosteum Blood vessel Trabecula of woven bone amellar bone replaces Periosteum woven bone as compact and spongy bone form Osteoprogenitor cell Compact bone Spongy bone

Endochondral Ossification

- Begins with a hyaline cartilage model
- Produces most of the other bones of the skeleton
- Long bone will be used as an example.

Endochondral Ossification

- Steps:
 - . Cartilage model develops:
 - Chondroblasts become
 - chondrocytes
 - Perichondrium develops
- 2. Cartilage calcification, bone collar develops in shaft
 - Chondrocytes hypertrophy, then die
 - Blood vessels grow toward cartilage
 - Osteoblasts under perichondrium form bone
- 3. Primary Ossification center forms:
 - Periosteal bud: osteoblasts and blood vessels
 - 12th week: most have formed



Endochondral Ossification

- Steps:
- 3. Secondary Ossification centers:
 - In epiphysis
 - Some form post-natally
- 4. Cartilage replaced by bone
 - Except articular cartilage, epiphyseal plate
- 5. Epiphyseal plate ossifies:
 - Forms epiphyseal line
 - Between 10 and 25
 - Last... clavicle



Epiphyseal Plate Morphology

- Hyaline cartilage
- 5 zones: from epiphysis to diaphysis
- Zone of resting cartilage
 - Small chondrocytes in cartilage matrix
 - Looks like healthy cartilage
 - Secures epiphyseal plate to epiphysis
- Zone of proliferating cartilage
 - Chondrocytes here are undergoing rapid mitosis
 - Stack up in columns

Epiphyseal Plate Morphology

Zone of hypertrophic cartilage

- Chondrocytes stop dividing
- Start hypertrophy
- Absorb matrix
- Zone of calcified cartilage
 - Few cells thick
 - Calcification of matrix
 - Kills the chondrocytes
- Zone of ossification
 - Invasion by capillaries and osteoprogenitor cells

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Bone Growth

- Interstitial growth occurs in the epiphyseal plate as chondrocytes undergo mitosis
 - Growth in length
- Appositional growth occurs within the periosteum.
 - Growth in diameter, thickness

Bone Remodeling

- The continual deposition of new bone tissue and the removal (resorption) of old bone tissue.
 - helps maintain calcium and phosphate levels in body fluids, and can be stimulated by stress on a bone
 - occurs at both the periosteal and endosteal surfaces of a bone
- Relative rates differ with age, bone

Blood Supply and Innervation

- Bone is highly vascularized, especially in regions containing red bone marrow.
- Kinds of blood vessels
 - Nutrient artery and the nutrient vein
 - supply the diaphysis of a long bone
 - Metaphyseal blood vessels
 - Diaphyseal face of epiphyseal plate
 - Periosteal blood vessels
 - Supply superficial osteons on diaphysis.

Metaphyseal Articular cartilage artery Periosteum Periosteal arteries Cellular layer Periosteum Fibrous layer Nutrient artery (in nutrient foramen) Branch of nutrient artery Medullary cavity-(contains yellow bone marrow) Compact bone Metaphyseal artery Epiphyseal line Articular cartilage

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Effects of Hormones

- Control and regulate growth patterns in bone by altering the rates of both osteoblast and osteoclast activity.
- Growth hormone (Pituitary gland): affects bone growth by stimulating the formation of another hormone, somatomedin which is produced by the liver.
- Somatomedin: directly stimulates growth of cartilage in the epiphyseal plate.

Effects of Hormones

- Thyroid hormone (Thyroid gland): stimulates bone growth.
- Growth hormone and thyroid hormone regulate and maintain normal activity at the epiphyseal plates until puberty.
- Calcitonin (Thyroid gland): inhibits osteoclast activity.
- Parathyroid Hormone (Parathyroid gland): increases blood calcium levels, stimulates osteoclast activity
- Sex Hormones: gonads
 - Increase rate of bone formation
 - Production associated with puberty

Effects of Vitamins

- Vitamin A: activates osteoblasts
- Vitamin C: normal synthesis of collagen
- Vitamin D: absorption and transport of calcium and phosphate



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	General Structure	Anatomical Term	Description	
	Articulating surfaces	Condyle	Large, smooth, rounded articulating oval structure	
		Facet	Small, flat, shallow articulating surface	
		Head	Prominent, rounded epiphysis	
		Trochlea	Smooth, grooved, pulley-like articular process	
	Depressions	Alveolus	Deep pit or socket in the maxillae or mandible	
		Fossa	Flattened or shallow depression	
		Sulcus	Narrow groove	
	Projections for tendon and ligament attachment	Crest	Narrow, prominent, ridgelike projection	
		Epicondyle	Projection adjacent to a condyle	
		Line	Low ridge	
		Process	Any marked bony prominence	
		Ramus	Angular extension of a bone relative to the rest of the structure	
		Spine	Pointed, slender process	
		Trochanter	Massive, rough projection found only on the femur	
		Tubercle	Small, round projection	
		Tuberosity	Large, rough projection	
	Openings and spaces	Canal (meatus)	Passageway through a bone	
		Fissure	Narrow, slitlike opening through a bone	
		Foramen	Rounded passageway through a bone	
		Sinus	Cavity or hollow space in a bone	60