Bones and Skeletal Tissue

The human skeleton is from either membranes or cartilage.

It consists of 206 bones divided into two categories:

- Axial skeleton
- Appendicular skeleton

Classification of Bones

Long bones

- Have a shaft and two ends
- Named according to shape and not size
- Femur, Humerus, phalanges

Short bones

- Shaped like cubes
- Carpals and tarsals
- Sesamoid bone is a special type of short bone that forms in a tendon e.g. patella

Flat bones

- Thin, broad and a bit curved
- Provide protection for delicate body organs and an extensive surface for muscle attachment
- Some skull bones, scapula, rib, sternum

Irregular bones

- Complex shape that do not fit any of the categories above
- Vertebrae and hip bones

Functions of Bone

Support

- Structural support for the whole body

Protection

- Vital organs like the brain and spinal cord

Movement
• Levers for muscle to provide movement as they contract and relax

Mineral storage
• Calcium and phosphates, lipids in the bone marrow

Blood cell production
• Hemopoiesis

**Bone Structure**

Gross anatomy
• Bone is composed to two types of tissue
• Relative amount of both tissues depend on the function of the bone

Compact bone
• Dense and solid
• Always found on the exterior bone surface

Spongy bone
• Relatively porous
• Located in the bone interior

**Bone Structure**

Periosteum
• Connective tissue wrapping around bone
• Has an outer fibrous layer and an inner cellular layer

Functions:
• Separates bone from surrounding tissue
• Pathway for blood and nerve supply
• Provide assistance during bone growth and repair
• Plays a role in joint formation because of its close proximity to muscles and tendons
• Fiber (Sharpey’s fibers) penetrate the substance of the bone and anchor the periosteum to the bone. These fibers plays a role in fractures when sufficient force is applied

Endosteum
• Lines the medullary canal (cavity)
• Trabeculae of spongy bone
• Inner surface of central canal

Long Bones

• Example: Humerus
• Has two parts called the shaft (diaphysis) and two enlarged ends (epiphysis)
• Medullary cavity is located inside the shaft
• Contains bone marrow (loose CT)
• Yellow bone marrow (fat)
• Red bone marrow (mature and immature RBCs)

Epiphysis

• May be involved in a joint
• Articular surface is lined by cartilage (hyaline cartilage)
• Epiphysial line is the border between the diaphysis and the epiphysis
• Epiphyseal line is remnant of the epihyseal plate
• Epiphyseal plate is a cartilaginous layer that allows for growth of the bone during development

Flat Bones

• Example: parietal bones
• Layer of spongy bone (diploë) is sandwiched between two plates of compact bone
• Marrow cavity is undefined
• Bone marrow (red) is present

Bone Cells

Osteoprogenitor cells

• Stem cells that divide to produce osteoblasts
• Located on the inner lining of the periosteum, lining of the medullary cavity and lining vascular passages that extend through the matrix
• Play a role in bone tissue repair

Osteoblasts

• Deposit new bone matrix (osteogenesis)
• Becomes osteocytes once entrapped in pockets called lacunae within the matrix
• Canaliculi are communications between lacunae and surrounding vasculature
Osteocytes

- Mature bone cells and the most abundant
- Neighboring cells are connected by gap junctions
- Cells project cytoplasmic extensions into canaliculi that aid in nutrient transport throughout the bone
- Monitor and maintain the protein and mineral content of bone matrix
- Plays a role in bone repair

Osteoclast

- Large and multinucleated cells derived from hematopoietic stem cells that differentiate into macrophages
- Play a role in bone resorption (breakdown)
- Use enzymes and acids to release minerals from bone by dissolving the matrix (osteolysis)

Compact Bone

- Basic functional unit is the osteon or Haversian system
- Each osteon has a central canal (Haversian canal) that contains blood vessels and runs along the long axis of bone
- Osteocytes are arranged in concentric layers, around the central canal, called lamellae (concentric lamellae)
- Volkmann’s canal
- Runs perpendicular to and link the central canals
- Interstitial lamellae
- Lamellae that fills the spaces between osteons
- Circumferential lamellae
- Located along the surface of the bone covering the entire circumference of the bone

Function of Compact Bone

- Provide strength
- Osteons are good at resisting forces applied along their axis
- Arranged parallel to the long axis of bones
- Enables shaft resist tension and compression
- Arrangement is vulnerable to shear forces
Spongy Bone (Cancellous)

- Matrix forms struts and plates (Trabeculae) allowing open spaces within the bone
- Found in areas not subjected to enormous stress or areas the receive stress from multiple directions
- Presence of spongy bone creates room for other tissues (bone marrow) and reduce the overall weight of the bone
- Osteon is absent and nutrients reach osteocytes by diffusing from the blood vessels in the endosteum

Chemical Composition of Bone

Bone matrix is made up of two major components

Inorganic

- Makes up approx. 65% of bone mass
- Composed of substances called hydroxyapatite
- Hydroxyapatite is made up of calcium phosphate \([\text{Ca}_3(\text{PO}_4)_2]\) and calcium hydroxide
- Provides strength and resistance to compression

Organic

- Makes up approx. 35% of bone mass
- Called osteoid
- Major component is collagen fibers
- Provides resistance to tensile force

Postnatal Bone Growth

- Cartilage cells at the growth zone of the epiphyseal plate multiply and push plate away from the center of the diaphysis
- Older cells closer to the diaphysis enlarge, surrounding matrix calcifies and chondrocytes die (transformation zone)
- Transformation zone is invaded by osteoblasts and osteoclasts to form spongy bone (osteogenic zone)
- Osteoclast break down spongy bone to enlarge marrow cavity
- Growth in length continues until epiphyseal plate is calcified
Appositional growth

- Growth in bone diameter
- Osteoblasts secrete matrix on external bone surface and increase bone
- Osteoclasts remove matrix from the endosteal surface to increase bone cavity
- Rate of osteoblast activity is slightly greater
- Process may continue throughout life

Bone Homeostasis

- About 6% of adult bone mass is recycled every week
- Spongy bone is entirely replaced after 3-4 years
- Compact bone is replaced about every 10 years

Factors Involved in Bone Homeostasis

- Mechanical Stress
- Vitamin A, B, C, and D
- Minerals
- Hormones
- Growth hormones
- Thyroid hormone
- Sex hormones
- Parathyroid hormone
- Calcitonin