

Lecture 2 - Bones

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- Osteology - the study of bone
- Skeletal system - composed of bones, cartilages and ligaments
 - Forms strong flexible framework of the body
 - Cartilage is the forerunner of most bones (a flexible connective tissue composed of collagen and elastin fibres and proteoglycans covering many joint surfaces of mature bone)
- Ligaments - hold bones together at the joints
- Tendons - attach muscle to bone
- The adult skeleton can be divided into the axial skeleton (80 bones, skull ribs, spine) and the appendicular skeleton (126 bones, limbs)

Functions of the Skeleton:

- Support
- Protection (brain, heart, lungs, spinal cord)
- Movement (limb movements, breathing)
- Leverage (act as levers with skeletal muscles to move body)
- Electrolyte balance (calcium and phosphate ions)
- Storage of minerals (e.g. calcium)
- Blood formation (blood cells produced in red bone marrow)

Classification of Bones by Shape:

- Flat - parietal bone of skull
- Sutural - skull bones
- Irregular - vertebra
- Short - carpal bones
- Long - humerus, tibia
- Sesamoid - patella

Four bone cell types:

1. Osteoprogenitor cells

- Stem cells that differentiate into osteoblasts (immature bone cell that secretes organic components of matrix)

2. Osteoblasts

- Bone forming cells (osteogenesis or ossification)
- Stress and fractures stimulate stem cells to rapidly multiply and increase numbers of osteoblasts
- Secrete biochemical signals that may regulate bone remodelling

3. Osteocytes

- Some reabsorb (dissolve) bone matrix
- Others rebuild (deposit) bone matrix
- Thought to be mechanosensor cells (strain sensors) that control the activity of osteoblasts and osteoclasts

4. Osteoclasts

- Bone dissolving cells found on the bone surface
- Can contain 50 or more nuclei

- Bone matrix is composed of collagen fibres, which provides flexibility and resists tension, and calcium phosphate, which provides strength and resists compression
- Removal of inorganic component (calcium phosphate) makes bones flexible
- Removal of organic component (collagen) makes bones brittle
- Rickets - soft bones due to deficiency of calcium salts
- Osteogenesis imperfecta - brittle bone disease, excessively brittle bones due to lack of protein

and collagen

- Osteomalacia - softening of the bones, occurs in adults with Vitamin D deficiency

- Two types of bones - compact and spongy

Compact:

- Functional unit is osteon
- Strong along its length
- Much denser, harder, stronger and stiffer than spongy bone

Spongy:

- Located where bones are not heavily stressed
- Greater surface area compared to compact bone - ideal for metabolic activity e.g. exchange of calcium ions
- Less dense, softer, weaker and less stiffer than compact bone
- Highly vascular and often contains red bone marrow where the production of blood cells occurs (hematopoiesis)

General features of Bones:

- Outer shell is compact bone
- Diaphysis (shaft) - cylinder of compact bone to provide leverage
- Medullary cavity (marrow cavity) - space in the diaphysis of a long bone that contains bone marrow
- Epiphysis - enlarged ends of a long bone
- Epiphyseal plate (growth plate) - area of hyaline cartilage that separates the marrow spaces of the epiphysis and diaphysis (enables growth in length)

- Appositional bone growth - increases bone diameter of existing bones
- Red marrow (myeloid tissue) - hemopoietic tissue produces red and white blood cells and platelets
- Red marrow is found in the skull, vertebrae, ribs, sternum, and the heads of the humerus and femur
- Yellow marrow - found in adults, red marrow turns into fatty yellow marrow, and no longer produces blood cells

Bone Remodelling:

- Activation - preosteoclasts are stimulated and differentiate under the influence of cytokines and growth factors into mature active osteoclasts
- Resorption - osteoclasts digest mineral matrix (old bone)
- Reversal - end of resorption
- Formation - osteoblasts synthesise new bone matrix
- Quiescence - osteoblasts become resting bone lining cells on the newly formed bone surface

- Osteoblasts > Osteoclasts = increased bone mineral content (more bone builders than bone dissolvers)
- Osteoblasts < Osteoclasts = decreased bone mineral content (more bone dissolvers than bone builders, e.g. long periods of bed rest reduce bone density significantly)