B.Sc. (H) Biochemistry
IInd Year, IVth Sem
Human Physiology
Bone Structure and Formation
Lecture-1

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Functions of skeletal system

1. **Support**: Structural support for entire body and framework to support organs
2. **Storage of minerals and lipids**: Calcium and phosphate stores, yellow bone marrow ahs lipid as energy reserves

Functions of skeletal system……

3. **Blood cell Production**: red bone marrow in the internal cavities is the site for the blood cell production
4. **Protection**: Soft organs like heart lungs and protected in cage like structure formed by ribs (bones)
5. **Leverage**: Skeletal muscles are attached to the bones which help in the movement of fingers to the entire body

Classification of bones

- There are typically 206 bones which can be categorized into 6 categories according to their shapes
- 1. **Sutural bones**, or wormian bones, as they name suggest they are for the connection between two bones. Basically found in between of flat bones of skull. Their borders are irregular and are like jigsaw puzzle and have variable size

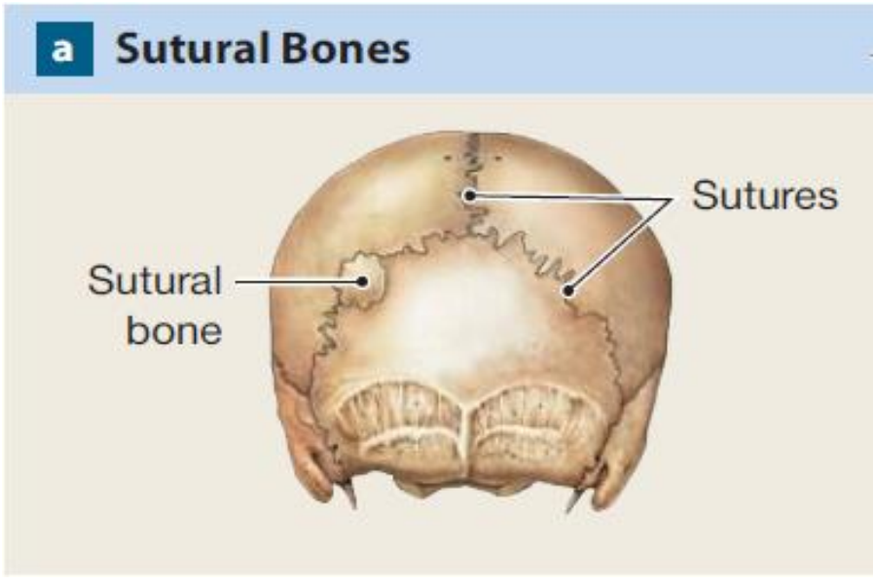


Fig: 6.1, Martini and Nath

2. Irregular bones

- They have irregular shapes with short, flat, notched or ridged surfaces. Exaples are spinal vertebrae, bone of pelvis and skull bones

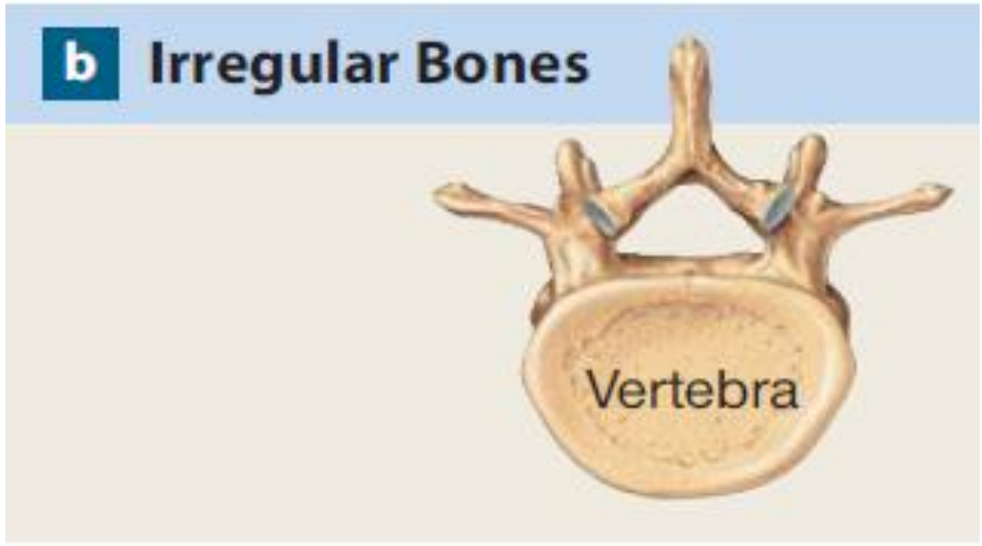


Fig: 6.1, Martini and Nath

3. Short bones

- They are small and boxy. Examples are short bones of wrists (carpal bones) and ankle bones (tarsal)

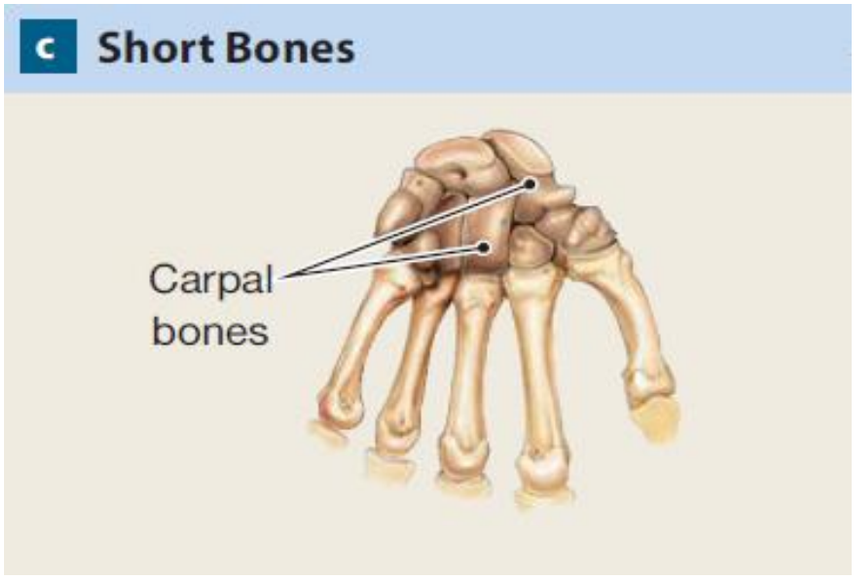


Fig: 6.1, Martini and Nath

4. Flat bones

- They have thin parallel surfaces. They form room of the skull, the sternum, the ribs and the scapulae. Provide protection and attachment surface for the skeletal muscle

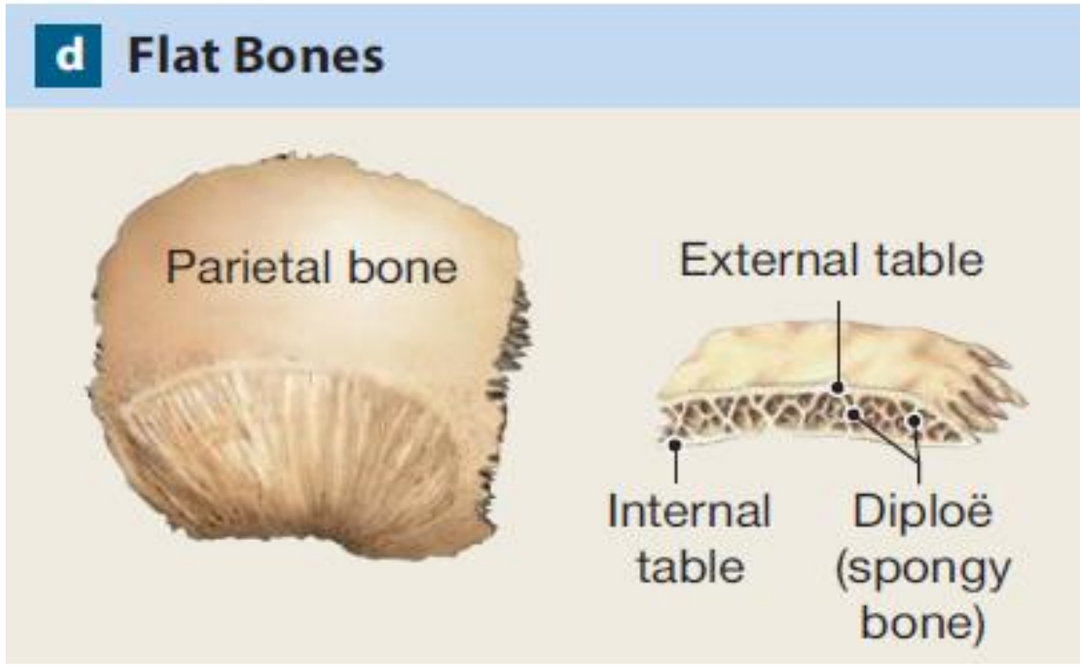


Fig: 6.1, Martini and Nath

5. Long bones

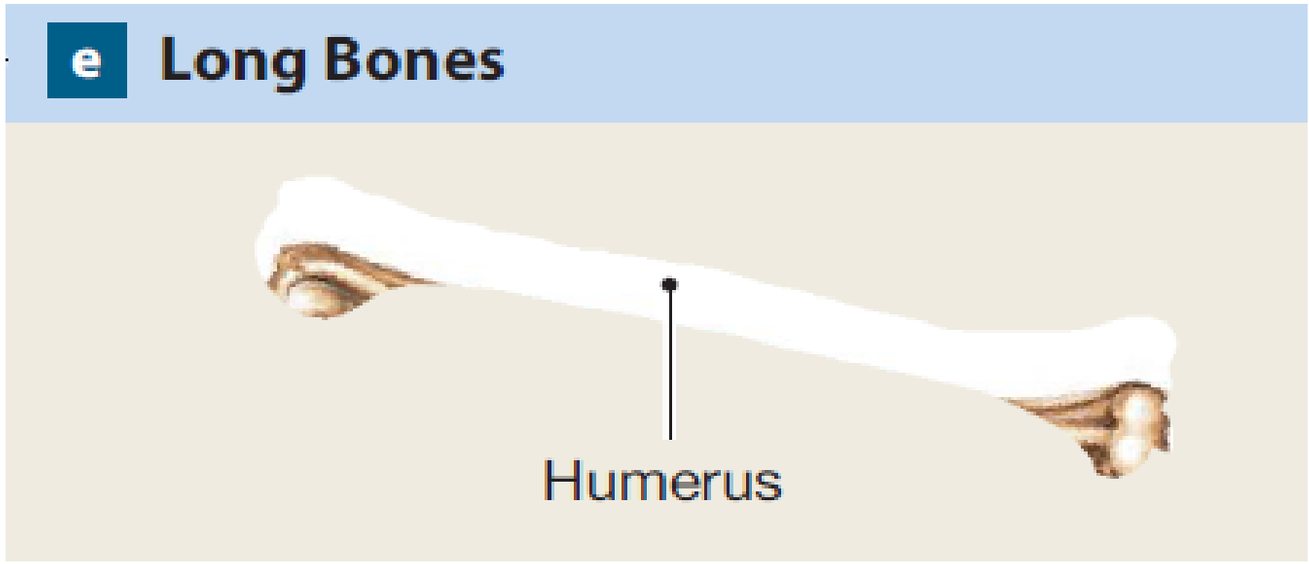


Fig: 6.1, Martini and Nath

- These bones are long and slender. They are located in arms, forearm, thigh, leg, palms, soles, fingers and toes. Femur is the largest and heaviest bone of the body

6. Sesamoid bones

- They have shape like sesame seed. Theyare small and flat and found in variety of locations. Their number can vary so that total number of bones can also vary individually. Commonly found near joints of knees, hands and the feet

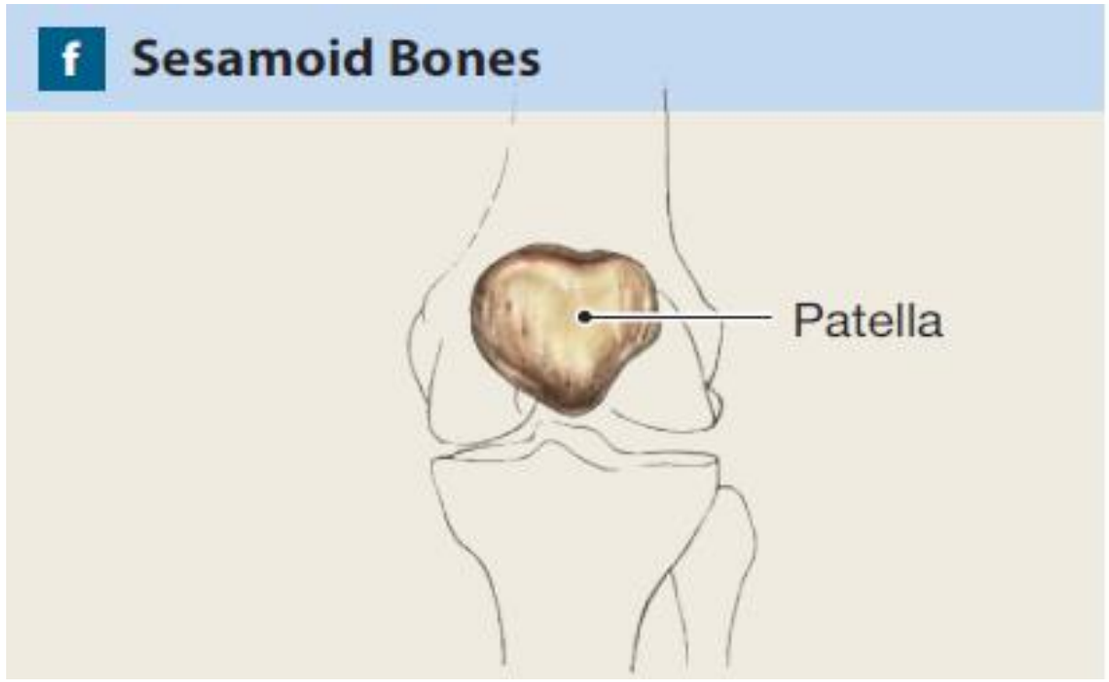
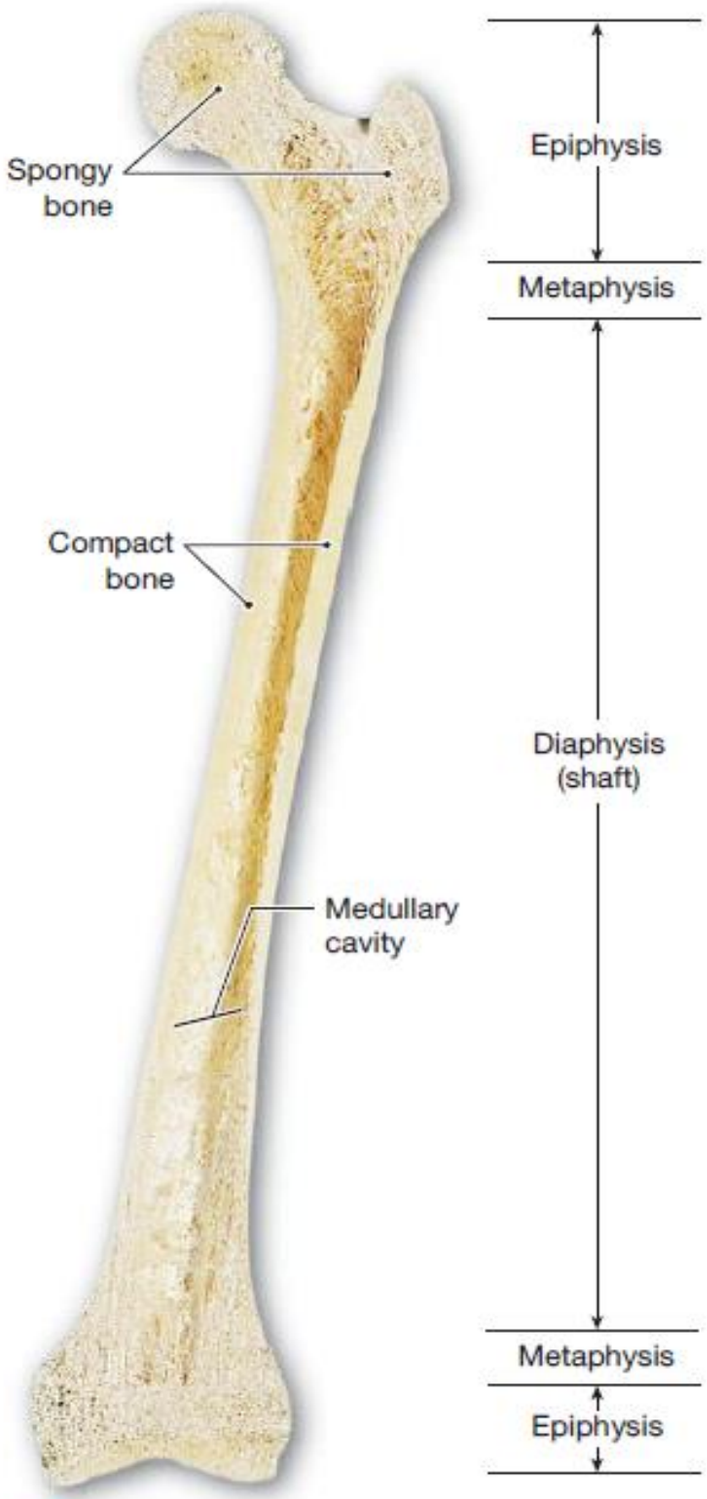
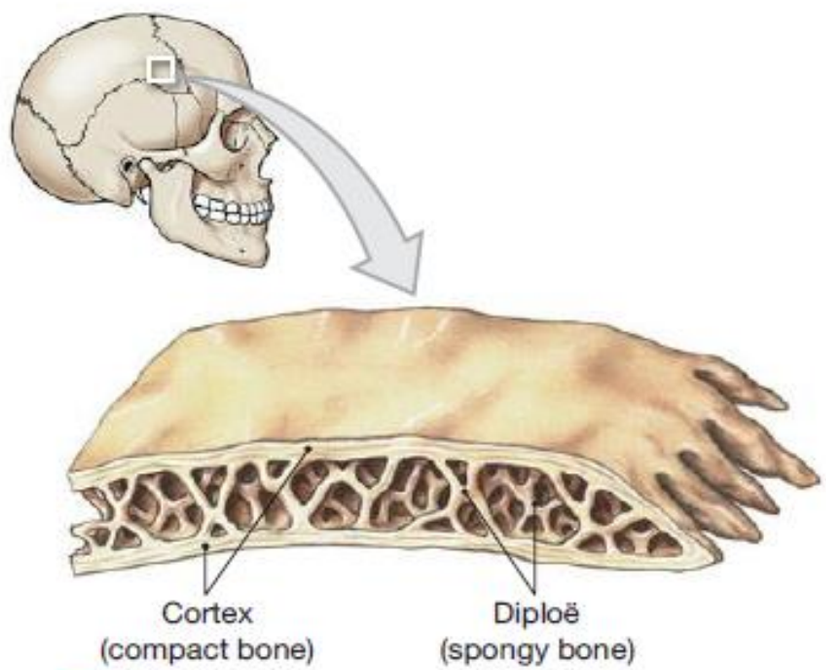


Fig: 6.1, Martini and Nath

Bone structure



a The structure of a representative long bone (the femur) in longitudinal section



b The structure of a flat bone (the parietal bone)

Fig: 6.1, Martini and Nath

Bone structure……

- A typical bone for example femur has one elongated tubular shaft called diaphysis which is having at both ends on expanded are known as epiphysis. Epiphysis is connected to diaphysis at both ends with a narrow zone called as metaphysis.
- Diaphysis has a wall made up of compact bone or dense bone which surrounds medullary (marrow)cavity.

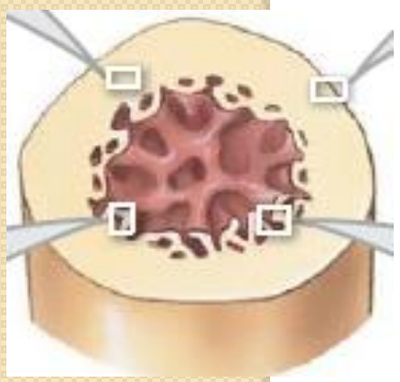


Fig: 6.1, Martini and Nath

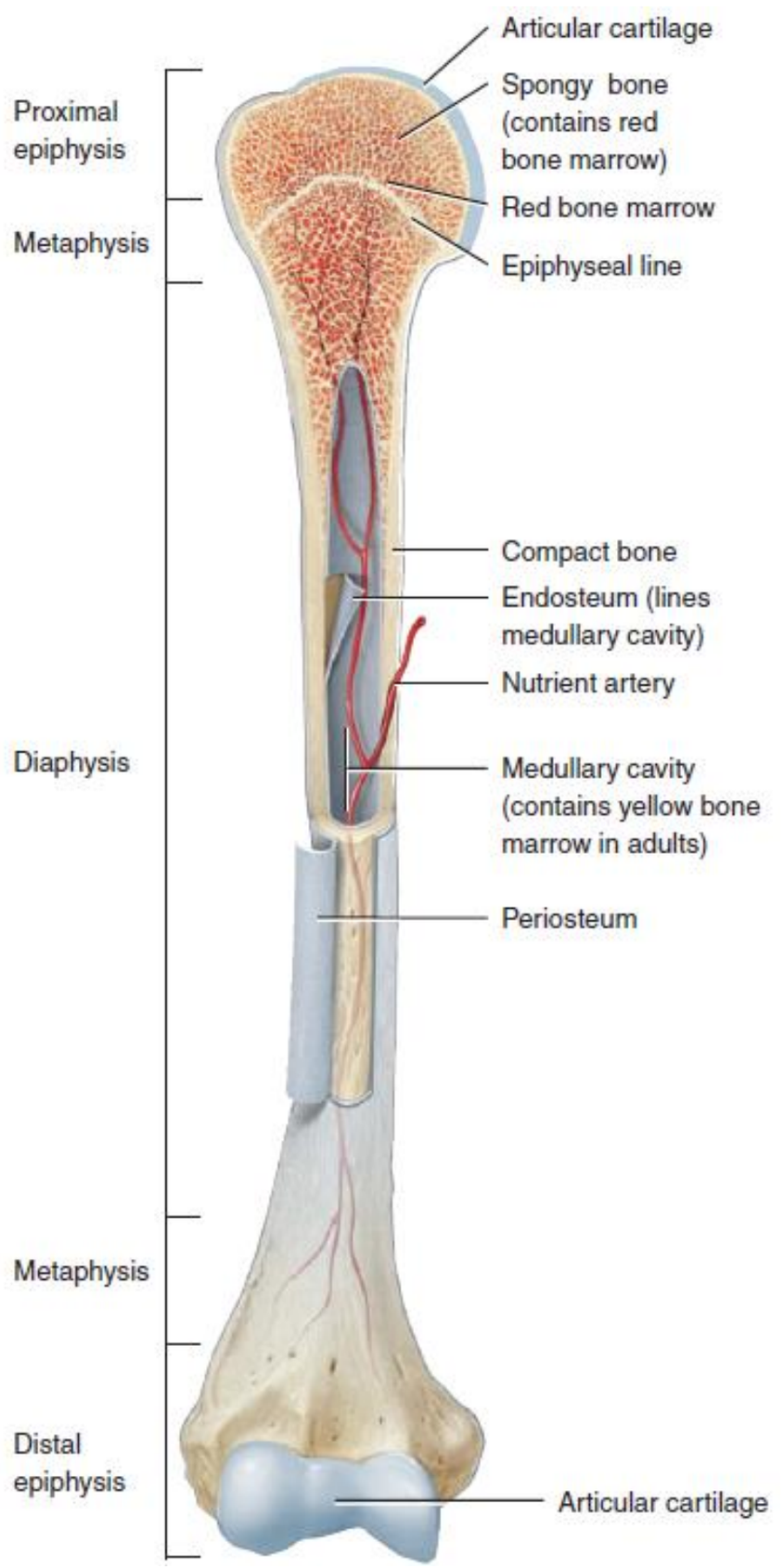


Fig: 6.1Tortora and Grabowski

Epiphysis

- Epiphysis is made up of spongy bone (cancellous or trabecular bone)
- Spongy bone has network of struts and plates which resembles latticework with a thin covering or cortex of compact bone (cortical bone)

Flat bones

- Found in skull such as parietal bones
- It is having sandwich like structure, compact bone covering a core of spongy bone. This spongy layer in cranium is called diploe (two fold). Bone marrow is present in spongy bone but there is no medullary cavity like diaphysis of long bones

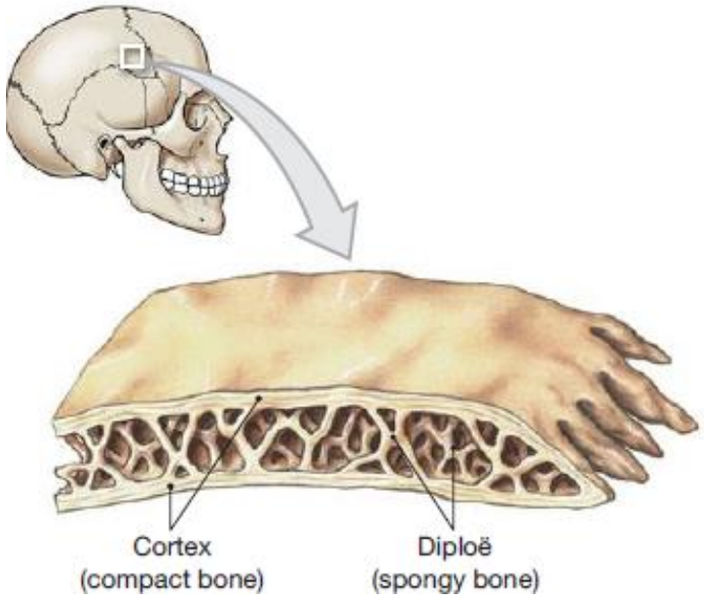
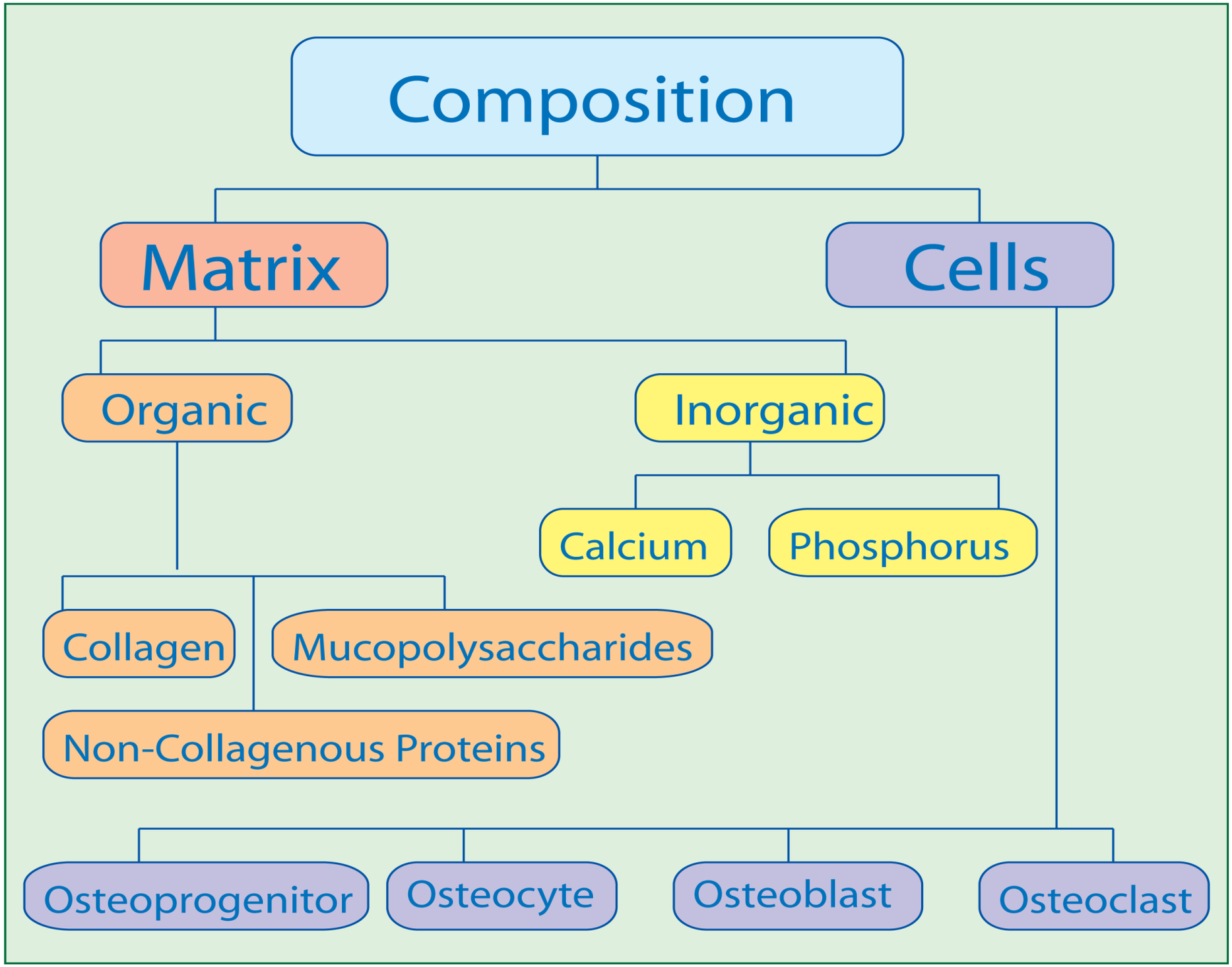


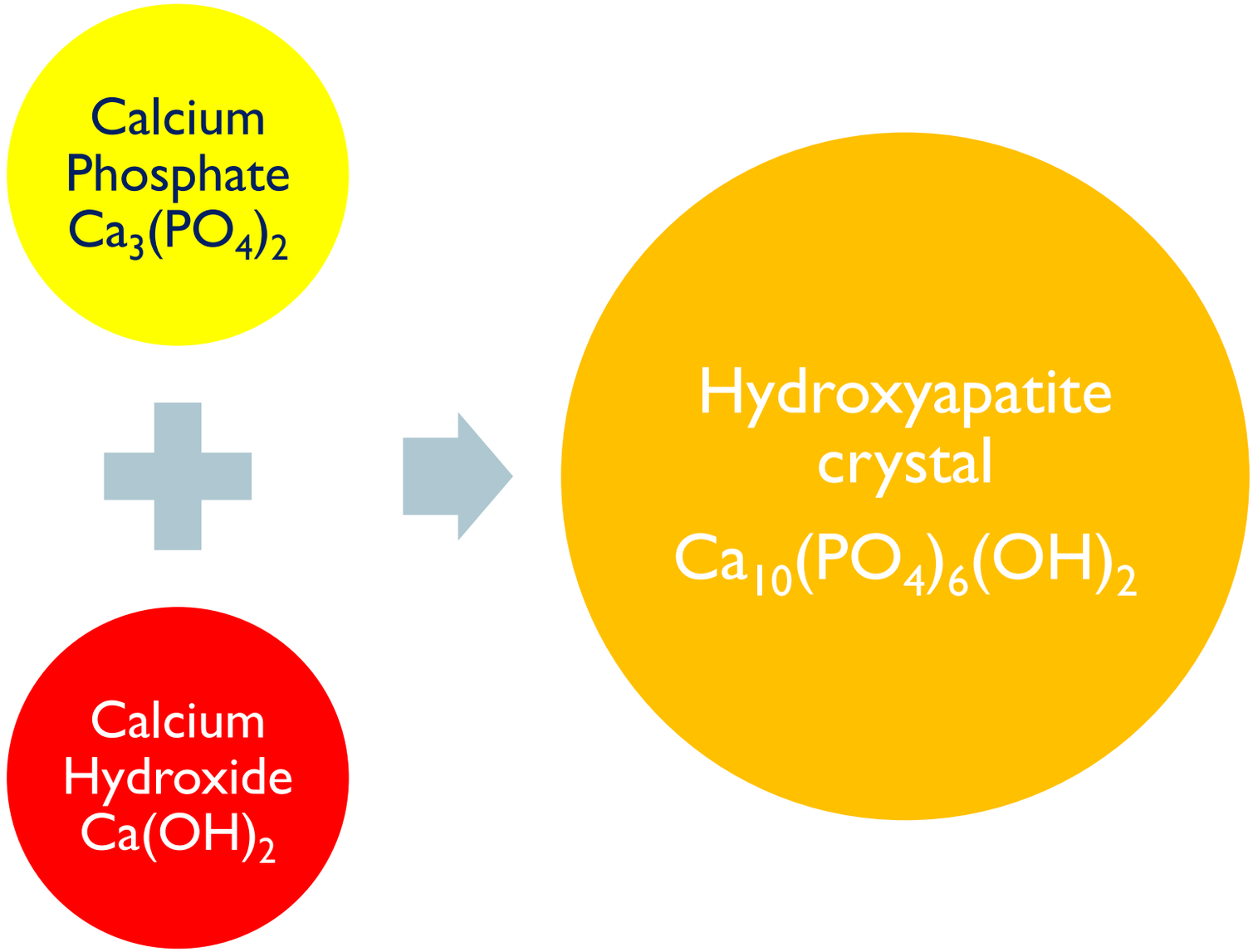
Fig: 6.1, Martini and Nath

Bone composition



Ref: https://commons.wikimedia.org/wiki/File:Composition_of_bone.png

Bone matrix


Calcium Phosphate
$Ca_3(PO_4)_2$
Calcium Hydroxide
$Ca(OH)_2$
Hydroxyapatite crystal
$Ca_{10}(PO_4)_6(OH)_2$

- Hydroxiapatite crystals combine with other calcium salts like calcium corbonate ($CaCO_3$) and ions such as sodium, magnesium and fluoride.

Calcium phosphate (2/3)

Collagen (1/3)

Cells (2%)

- Crystals are very hard, but relatively inflexible and quite brittle. They can withstand compression, but likely to shatter when exposed to bending, twisting or sudden impacts.
- Collagen fibers are relatively quite strong and when subjected to tension are relatively strong (stronger than steel).
- The composition of the matrix in compact bone is the same as in spongy bone. The collagen fibers provide an organic framework on which hydroxyapatite crystals can form

Bone cells

- Four types of cell
- Osteocytes: mature bone cells, most abundant. Each osteocyte occupies a lacuna, a pocj=ket sandwich between layers of matrix. The layers are called lamellae.
- Osteocytes don’t divide and a lacuna never contains more than one osteocyte.
- Narrow passageway (canaliculi) penetrate the lamellae, radiating through the matrix and connecting lacunae with one another and with sources of nutrients such as blood vessel in the central canal.

Osteocytes…..

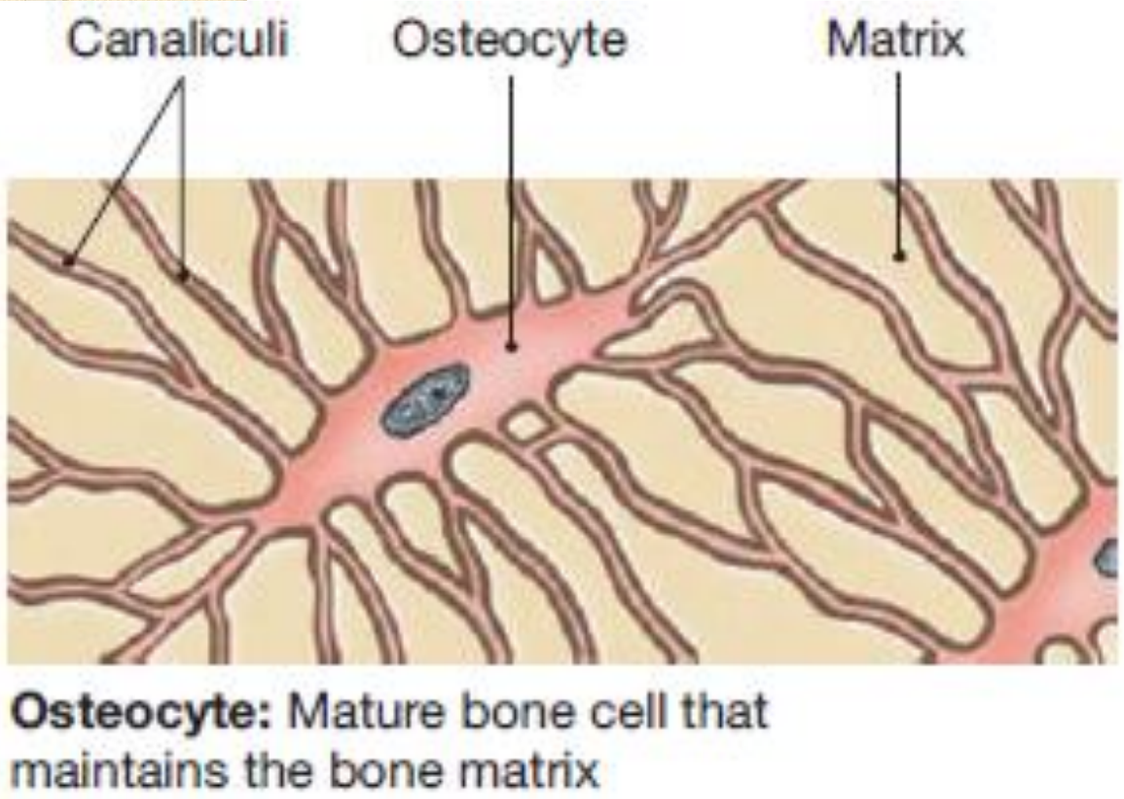


Fig: 6.3, Martini and Nath

- Canaliculi contain cytoplasmic extensions of osteocytes. Neighbouring osteocytes are linked by gap junctions, which permit the exchange of ions and small molecules like ntrients and hormones between the cells.
- The interrstitial fluid that surrounds the osteocytes and their extensions provides an additional route for the diffusion of nutrients and waste products.

Functions of osteocytes

1. Maintenance of protein and mineral content of the surrounding matrix

- Osteocytes secrete chemicals that dissolve the adjacent matrix, and minerals released enter the circulation.
- Osteocytes then rebuild the matrix, stimulating the deposition of new hydroxyapatite crystals. The turn over rate varies from bone to bone.

Functions of osteocytes……

2. **Repair of the damaged bones**

If released from their lacunae, osteocytes can get converted to a less specialized cell like osteoblast or osteoprogenitor cells

Osteoblasts

- They produce new bone matrix and the process is called as ossification or osteogenesis
- Osteoblasts make and release proteins and other organic componenets of the matrix
- Without calcium salts, this matrix is called the osteoid

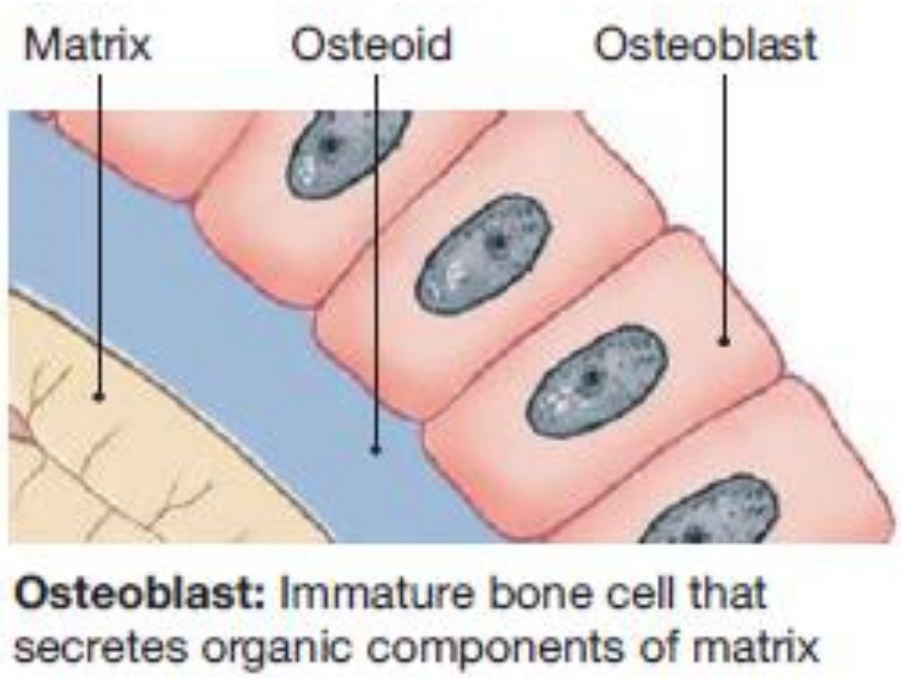


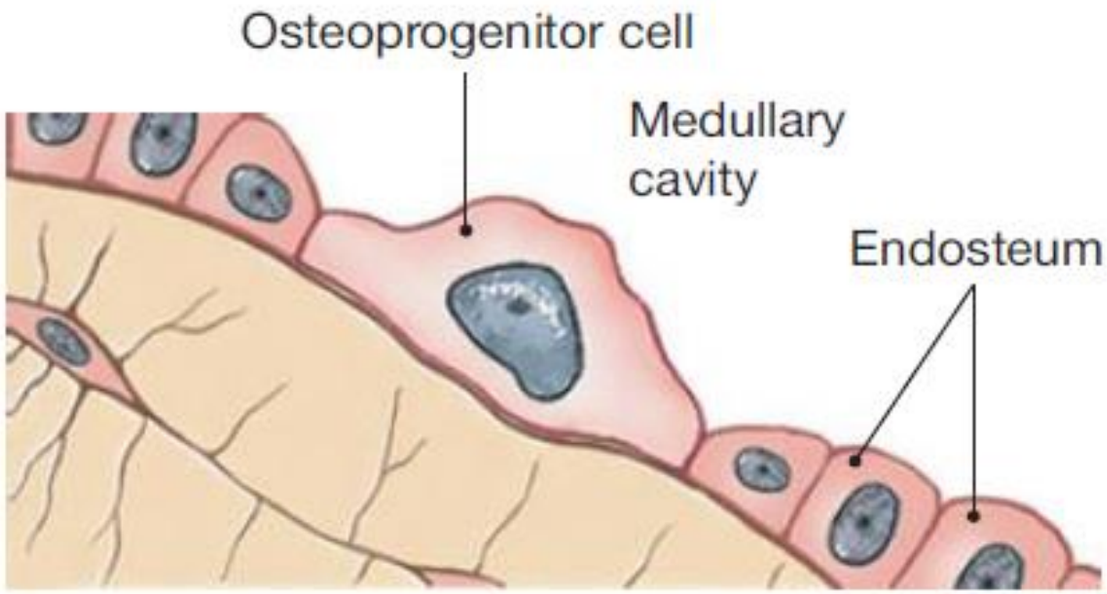
Fig: 6.3, Martini and Nath

Osteoblasts…..

- Osteoblasts assist in deposition of salts in organic matrix to convert osteoid into bones.
- When osteoblasts gets surrounded by matrix, they convert into osteoblast

Osteoprogenitor cells

- These cells are like stem cells (mesenchymal cells) which divide and give rise to osteoblast.
- Important for the maintenance of the osteoblast and repair of fracture.

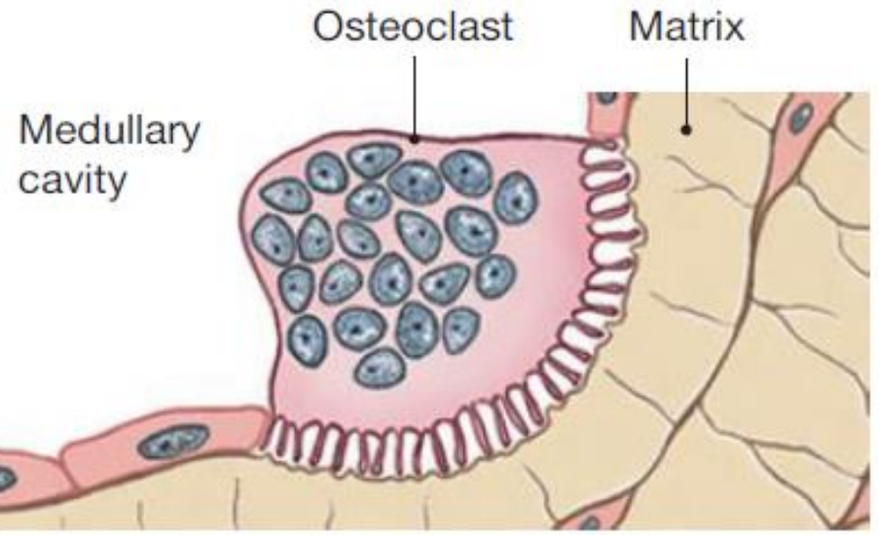


Osteoprogenitor cell: Stem cell whose divisions produce osteoblasts

Fig: 6.3, Martini and Nath

Osteoclasts cells

- They remove and recycle bone matrix.
- Giant cells with 50mor more nuclei
- Derived from stem cells which produce monocytes and macrophages
- Osteolysis (resorption) Acid and proteolytic enzymes secreted by these cells dissolve and the matrix and release the minerals
- Important for the regulation of calcium and phosphate minerals in the body fluids

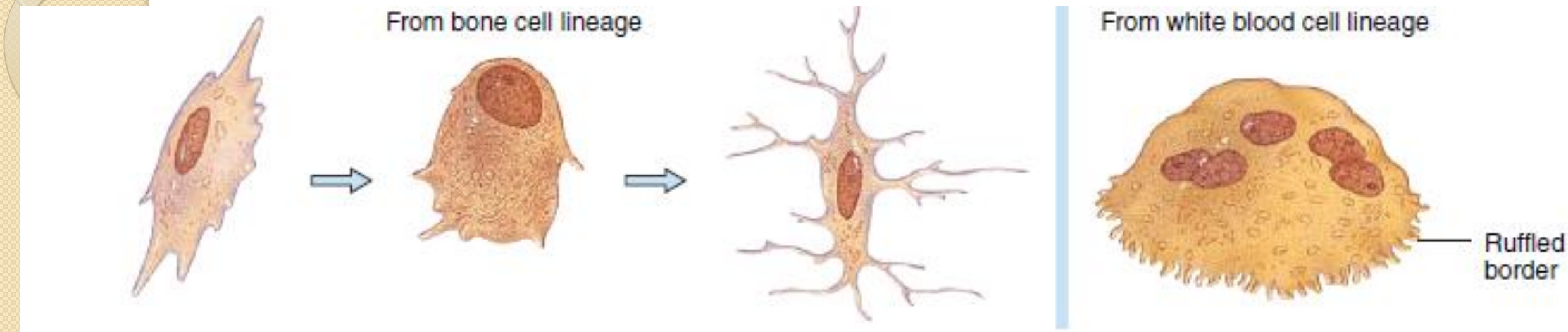


Osteoclast: Multinucleate cell that secretes acids and enzymes to dissolve bone matrix

Fig: 6.3, Martini and Nath

- Osteoclasts are constantly removing matrix and osteoblasts are always adding to it.
- A fine balance is required in two kind of activities of two cells.
- Strength training makes the bones stronger while less activity makes bone weak.

Origin of Cells of Bone



OSTEOPROGENITOR CELL
(develops into an osteoblast)

OSTEOBLAST
(forms bone extracellular matrix)

OSTEOCYTE
(maintains bone tissue)

OSTEOCLAST
(functions in resorption, the breakdown of bone extracellular matrix)

SEM x8000

SEM x4000

SEM x2700

Tortora, 14th Edition

References

- Fundamental of Anatomy and Physiology (2018), 11th ed., Martini, F.H. and Nath, J.L., Pearson Publications (San Francisco), ISBN: 10:1-292-22986-1/ISBN: 13: 978-1-292-22986-7.

- Principles of Anatomy & Physiology (2014), 14th ed., Tortora, G.J. and Grabowski, S., John Wiley & sons, ISBN-13: 978-1118344392/ISBN-10: 1118344391