ORAL BIOLOGY AND PHYSIOLOGY

COURSE CODE: 1601106

2 credit Units

BONE METABOLISM

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Week 13, Lecture 2

Intended Learning Outcomes

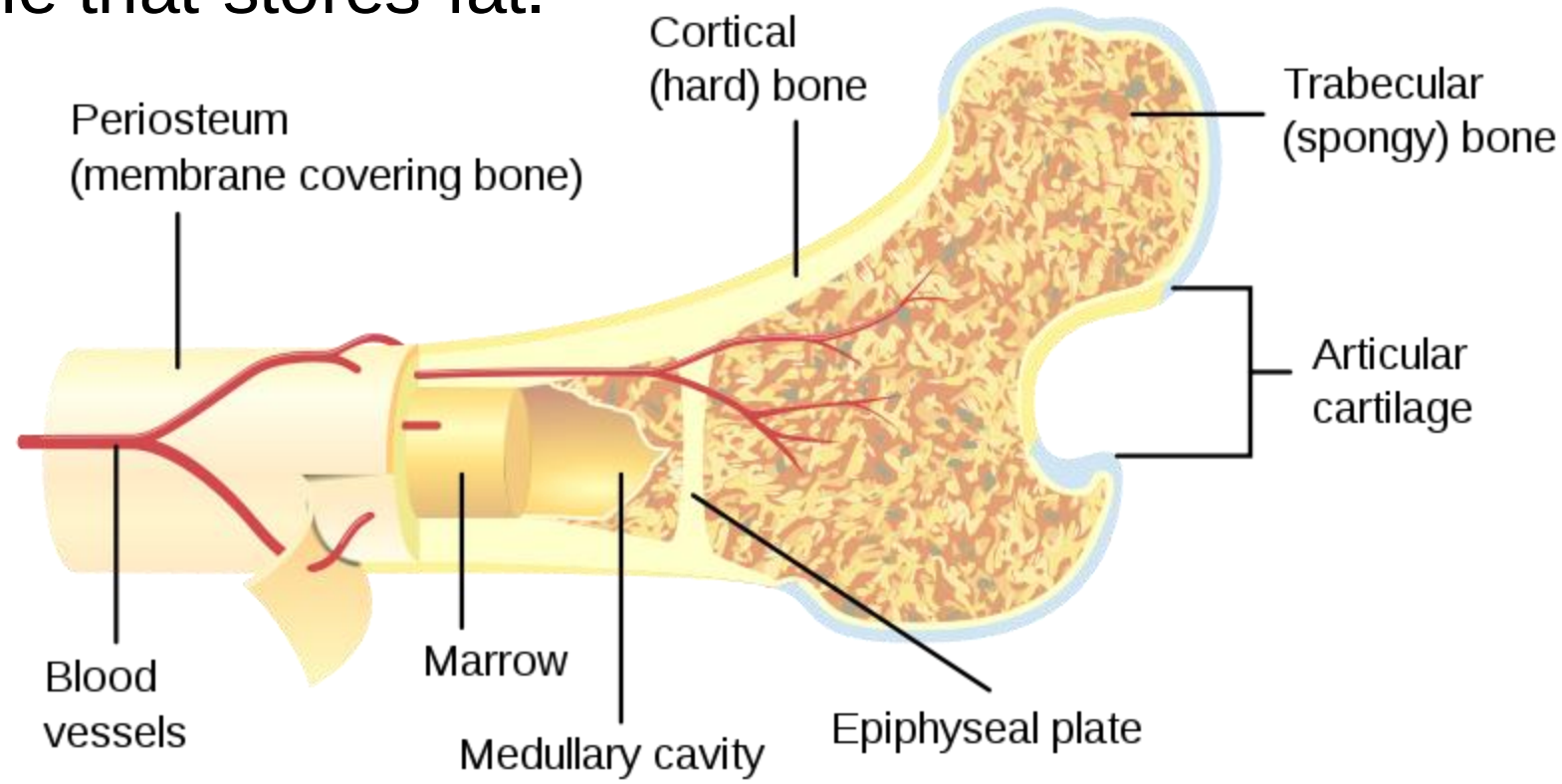
- Define bone and differentiate cortical & trabecular bone (sites and function of each).
- Identify the bone cells and the function of each.
- Define bone remodelling and explain the mechanism of bone formation.
- Discuss the effect of different hormones on bone physiology.

PHYSIOLOGY OF BONE

Bone or osseous tissue is a specialized rigid connective tissue that forms the skeleton. It consists of special type of cells and tough intercellular matrix of ground substance. The matrix is formed by organic substances like collagen and it is strengthened by the deposition of mineral salts like calcium phosphate and calcium carbonate. Throughout life, the bone is renewed by the process of bone formation and bone resorption.

Difference between cortical & trabecular bone

The key difference between trabecular and cortical bone is that the trabecular bone is the more porous inner regional layers of the body that produces red blood cells while the cortical bone is the rigid outer regional layers of the bone that stores fat.



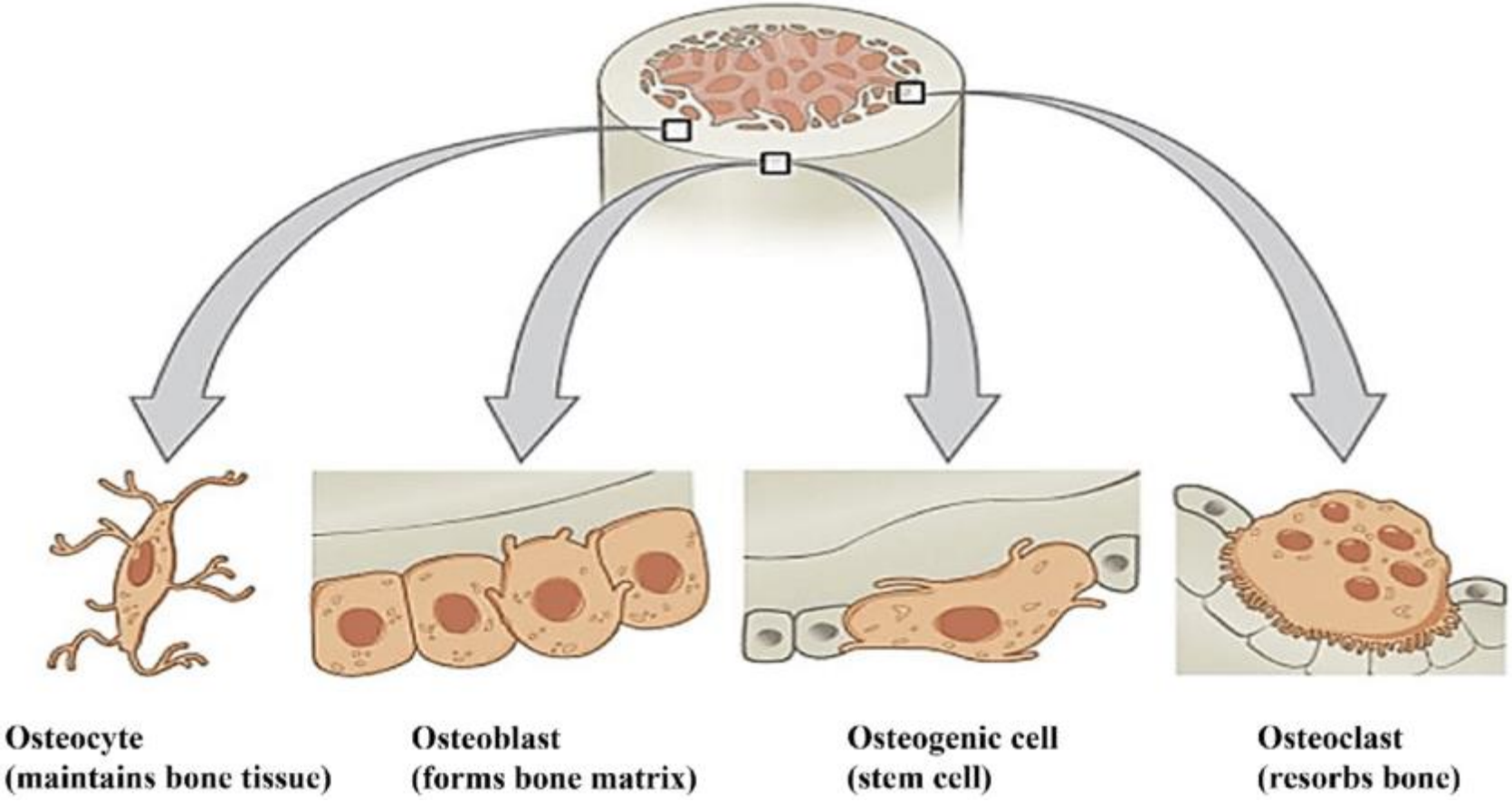
FUNCTIONS OF BONE

1. **Protective function:** Bone protects the soft tissues and vital organs of the body.
2. **Mechanical function:** It supports the body and brings out various movements of the body.
3. **Metabolic function:** It is responsible for metabolism and homeostasis of calcium and phosphate in the body.
4. **Hematopoietic function:** Red bone marrow in the bones is the site of production of blood cells.

CELL TYPES OF BONE

Bone has three major types of cells:

1. Osteoblasts.
2. Osteocytes.
3. Osteoclasts.



CELL TYPES OF BONE

1- Osteoblasts

Osteoblasts are the bone cells that are concerned with bone formation. These cells are situated in the outer surface of bone, the marrow cavity and epiphyseal plate. The osteoblasts arise from the giant multinucleated primitive cells called the osteoprogenitor cells.

CELL TYPES OF BONE

Functions of osteoblasts

i. Are responsible for the synthesis of bone matrix.

ii. Are rich in the enzymes alkaline phosphatase, which is necessary for deposition of calcium in the bone matrix (calcification).

iii. Synthesize the proteins called matrix Gla-protein and osteopontin, which are involved in the calcification.

Fate of osteoblasts

After taking part in bone formation, the osteoblasts differentiate into osteocytes, which are trapped inside the lacunae of calcified bone.

CELL TYPES OF BONE

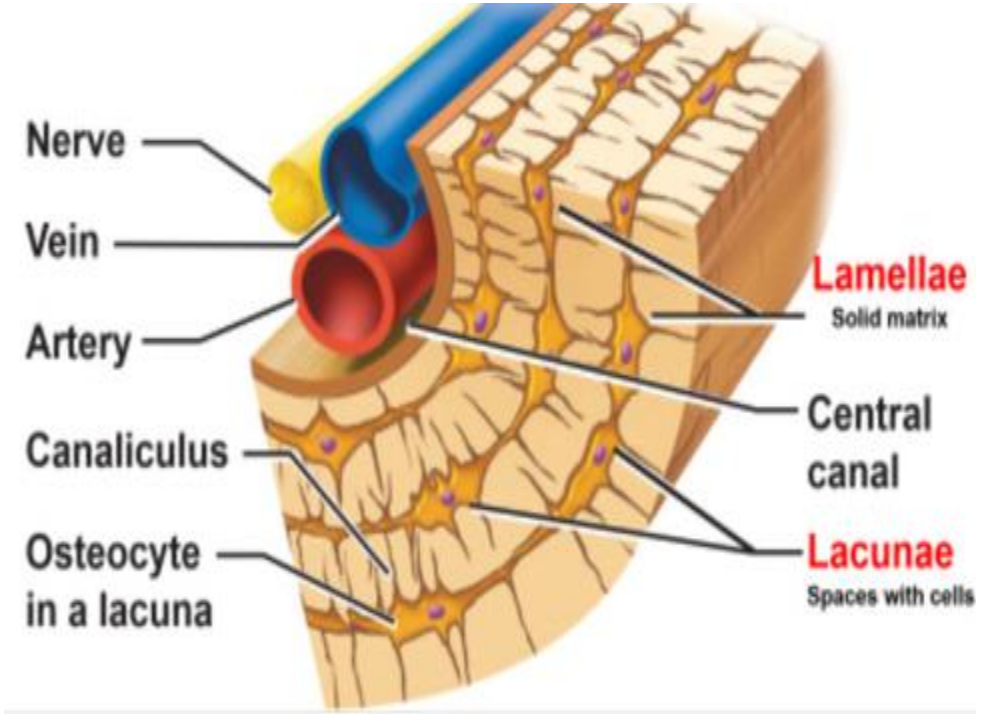
2. Osteocytes

Osteocytes are the cells concerned with maintenance of bone. Osteocytes are small flattened and rounded cells embedded in the bone lacunae. These bone cells are the main cells of developed bone and are derived from the matured osteoblasts.

Functions of osteocytes

i. Help to maintain the bone as living tissue because of their metabolic activity.

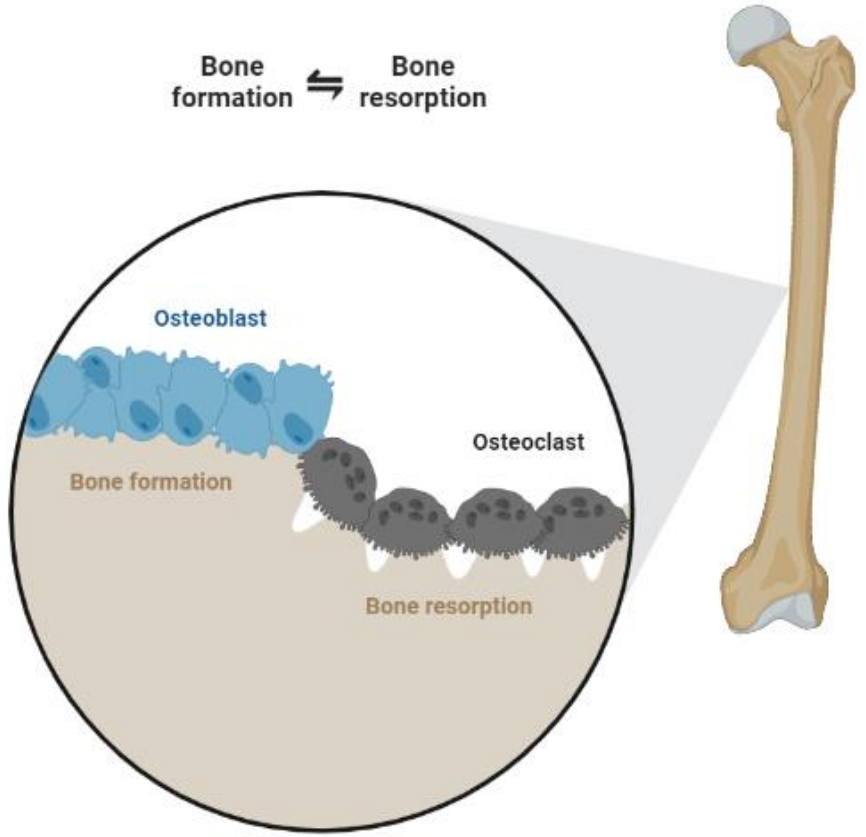
ii. Maintain the exchange of calcium between the bone and ECF.



CELL TYPES OF BONE

3. Osteoclasts

Osteoclasts are the bone cells that are concerned with bone resorption. Osteoclasts are the giant phagocytic multinucleated cells found in the lacunae of bone matrix. These bone cells are derived from hematopoietic stem cells.



Functions of osteoclasts

i. Responsible for bone resorption during bone remodeling.

ii. Synthesis and release of lysosomal enzymes necessary for bone resorption into the bone resorbing compartment.

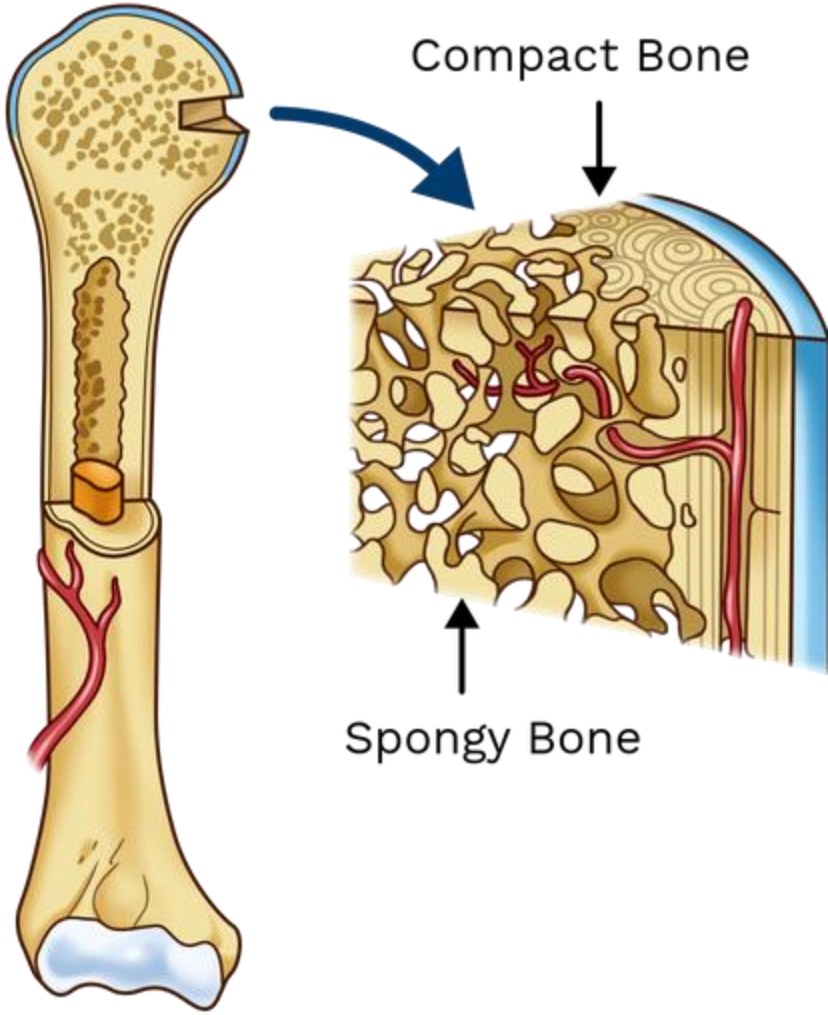
BONE REMODELING

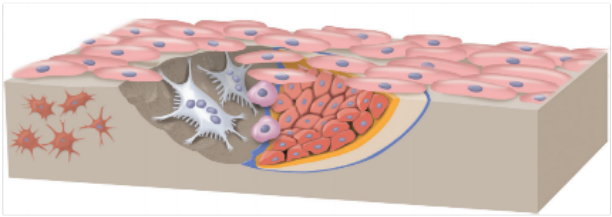
Bone remodeling is a dynamic lifelong process in which old bone is resorbed and new bone is formed. Usually, it takes place in groups of bone cells called the basic multicellular units (BMU). The entire process of remodeling extends for about 100 days in compact bone and about 200 days in spongy bone.

Bone remodeling includes two processes:

1. *Bone resorption:* Destruction of entire bone matrix and removal of calcium (osteoclastic activity). Osteoclasts are responsible for this.

2. *Bone formation:* Development and mineralization of new matrix (osteoblastic activity). Osteoblasts are responsible for this.





BONE REMODELING

Significance of Bone Remodeling

In children:

1. Thickness of bone increases.
2. Bone obtains strength in proportion to the growth.
3. Shape of the bone is re-altered in relation to the growth of the body.

In adults:

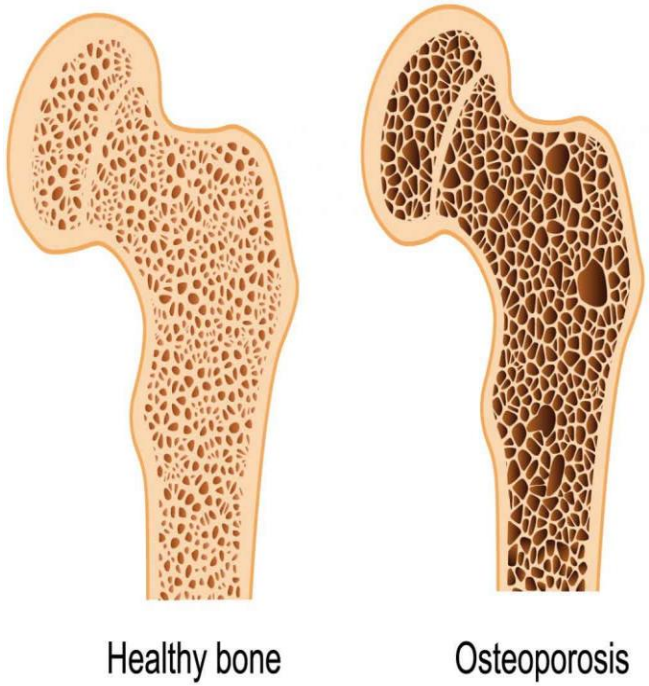
1. It is responsible for the maintenance of toughness of bone.
2. Ensures the mechanical integrity of skeleton throughout life.
3. Plays important role in calcium homeostasis.

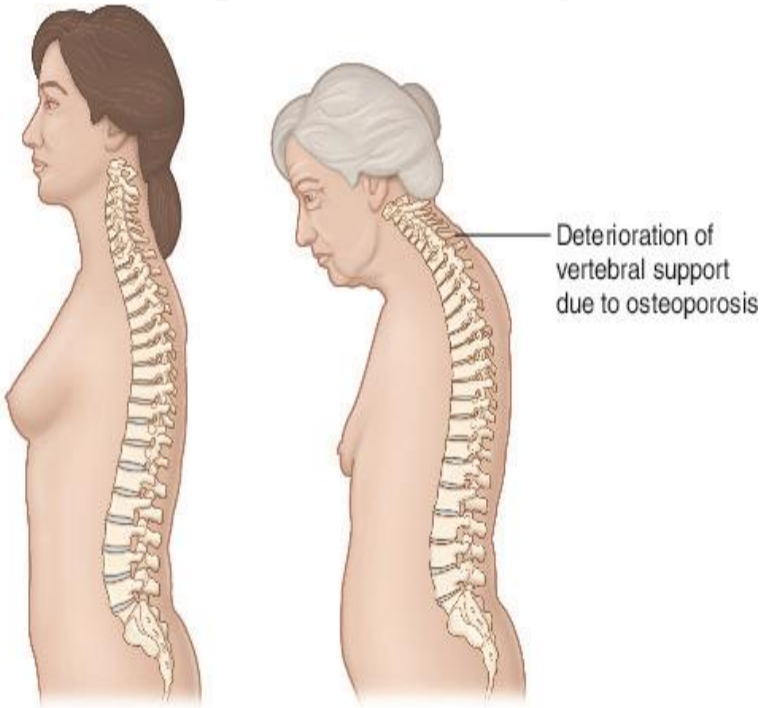
APPLIED PHYSIOLOGY
DISEASES OF BONE

1. Osteoporosis

Osteoporosis is the bone disease characterized by the loss of bone matrix and minerals. The meaning of the word osteoporosis is ‘porous bones’. It occurs due to excessive bone resorption and decreased bone formation.

The loss of bone matrix and minerals leads to loss of bone strength associated with architectural deterioration of bone tissue. Ultimately, the bones become fragile with high-risk of fracture. Commonly affected bones are vertebrae and hip. Osteoporosis is common in women after 60 years.



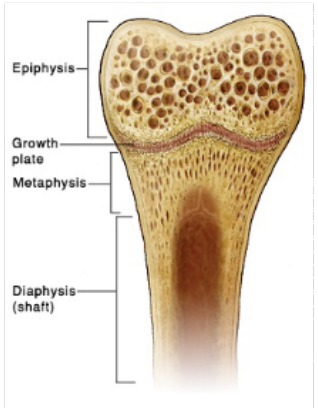


DISEASES OF BONE

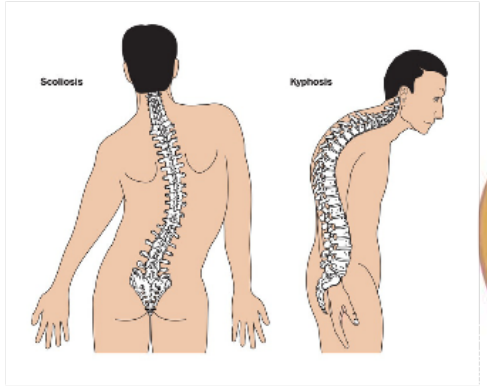
2. Rickets

Rickets is the bone disease in children characterized by inadequate mineralization of bone matrix. It occurs due to vitamin D deficiency. Vitamin D deficiency develops due to insufficiency in diet or due to inadequate exposure to sunlight.

The deficiency of vitamin D affects the reabsorption of calcium and phosphorus from renal tubules resulting in calcium deficiency. It causes inadequate mineralization of epiphyseal growth plate in growing bones. This defect produces various manifestations.



DISEASES OF BONE



Manifestations of rickets

i. Collapse of chest wall: called pigeon chest.

ii. Kyphosis: The excess curvature of upper back bone

iii. Stunted growth

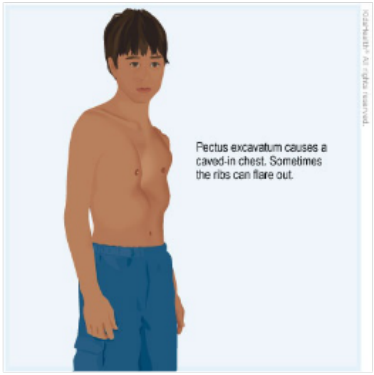
iv. Wide elbow and wrist joints.

v. Scoliosis: The lateral curvature of spine.

vii. Bowing of hands and legs.

viii. Enlargement of liver and spleen.

ix. Tetany in advanced stages.



DISEASES OF BONE

3. Osteomalacia

The rickets in adults is called osteomalacia or adult rickets. It occurs because of deficiency of vitamin D. It also occurs due to prolonged damage of kidney (renal rickets).

The characteristic features of osteomalacia:

i. Vague pain.

ii. Tenderness in bones and muscles.

iii. Myopathy leading to waddling gait. The feet are wide apart and walk resembles that of a duck.

iv. Occasional hypoglycemic tetany.

Effect of different hormones on bone physiology.

Hormone	Major Effects on Skeletal Growth
Estrogen	Up-regulates osteoblasts Up-regulates chondrocytes at moderate levels Down-regulates chondrocytes at high levels Down-regulates osteoclasts
Testosterone	Up-regulates chondrocytes and osteoblasts at moderate levels
Vitamin D	Up-regulates osteoblast and chondrocytes
Thyroid Hormone	Up-regulates osteoblasts and chondrocytes at normal levels Up-regulates osteoclasts at high levels
Parathyroid Hormone	Up-regulates osteoclasts
Growth Hormone	Up-regulates osteoblast, chondrocyte, and osteoclast activity
IGF-I	Up-regulates osteoblasts and chondrocytes
Calcitonin	Down-regulates osteoclasts Up-regulates osteoblasts
Cortisol	Down-regulates osteoblasts and chondrocytes Up-regulates osteoclasts
Insulin	Up-regulates osteoblasts and chondrocytes

Useful links

https://www.youtube.com/watch?v=ZTBH61OQZTU

https://www.youtube.com/watch?v=hf91ntbiKHk