Physiology of Bone

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At the end of this lecture the student • should be able to:-

- Define bone & differentiate between types of bone (cortical & trabecular)
- State Ca^{++} concentration and its forms in the ECF ; its relation to PO_4
- Differentiate between the types of bone cells & appreciate their functions .
- Describe bone formation & remodeling
- Understand what is osteoporosis
- Appreciate the effects of different hormones on bone

• Functions of bone

- Bone is a living, growing tissue which has several functions :

✓ Protects vital organs

✓ Provides support for soft tissues

✓ Allows & facilitates movement

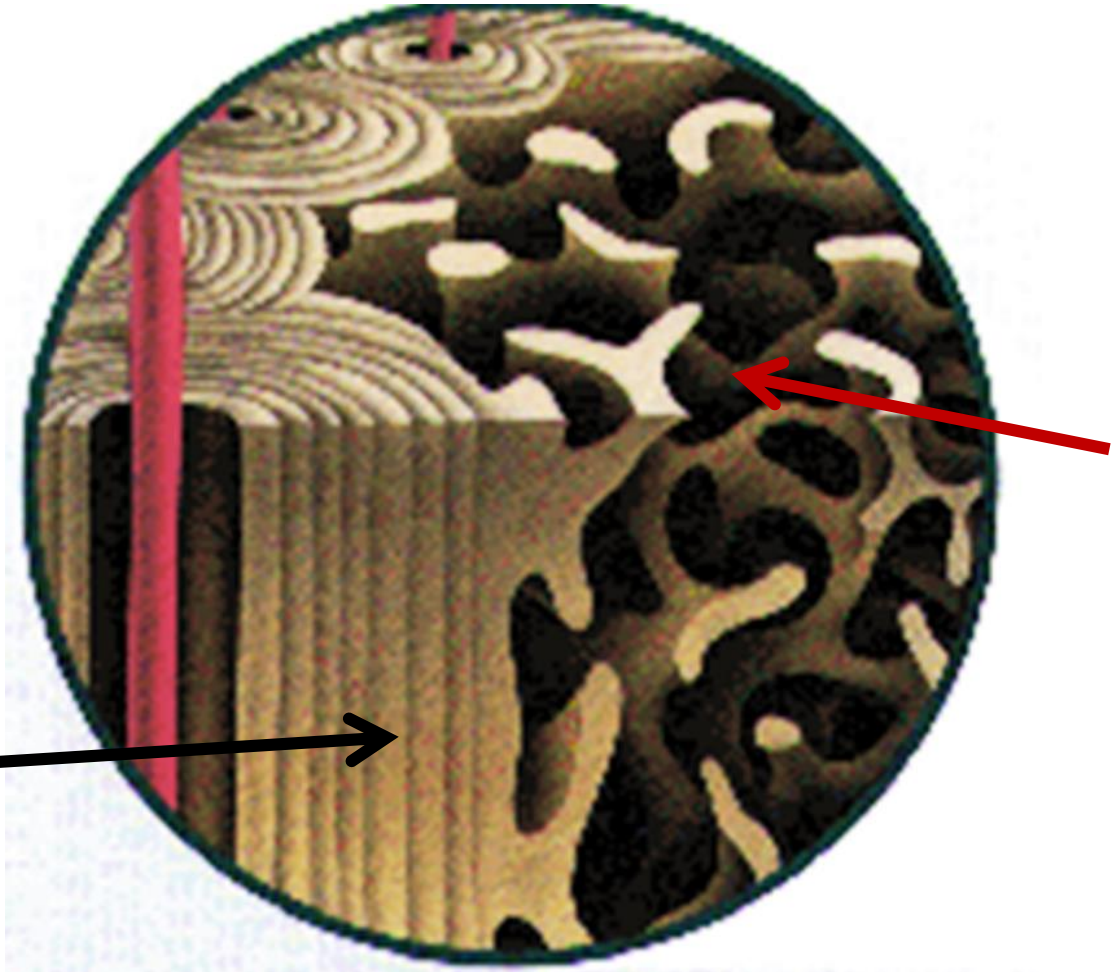
✓ Contains bone marrow

✓ Reservoir for Calcium & Phosphate

• Structure of Bone

(1) Organic matrix made of collagen , called osteoid , makes 30% of bone , on which is laid the→

(2) Inorganic (mineral) bone component → called hydroxyapatite , made of $CaPO_4$ crystals , that constitutes the remaining 70% of bone

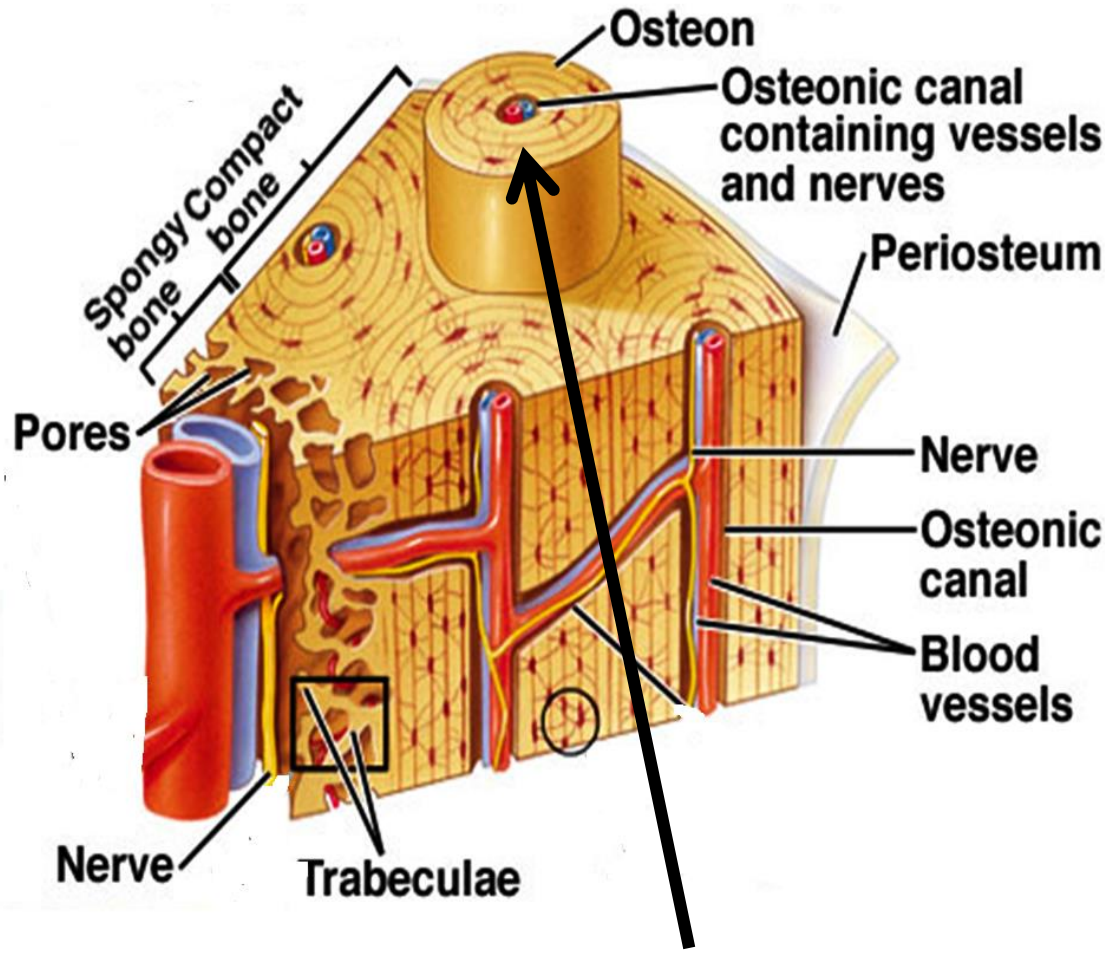


Bone is 2 types :

(1) Cortical (Compact) Bone

- Also called compact bone
- Forms a protective outer shell of bone .
- Comprises 80 % of total body bone mass
- Has a slow turnover rate
- Has high resistance to bending and torsion

- It is composesd of overlapping circular structures (formations) called Harvesian Systems or Osteons .



- Each osteon has a central canal called Osteonic Canal or Haversain Canal
- The Osteonic Canal contain blood vessels (capillaries, arterioles, venules), nerves and lymphatics.
- Between Harvesian systems are concentric layers of mineralized bone called interstitial lamellae

(B) Trabecular Bone

- Comprises 20% of total bone mass
- Present in the interior of bones & has spongy appearancfe .
- Though it represents only 20% of the skeletal mass, it has 5 times greater surface area than cortical bone
- Because of its large surfac, it has faster turnover rate than cortical bone ; hence it is more important than cortical bone in terms of calcium turnover
- Compared to cortical bone , it is:

(1) less dense,

(2) more elastic and

(3) has a higher turnover rate than compact bone .

✓ The center of the bone contains red, yellow marrow, bone cells and other tissues.

Extracellular Fluid (ECF) Calcium

- Ca^{++} level in plasma is 8.5-10 mg/dL .
- It exists in 3 fractions :
- (1) Ionized calcium → 50% of total ECF calcium
- (2) Protein-bound calcium → 40% of total ECF calcium
    - Most of this is bound to albumin,
    - And much less is bound to globulins
- (3) The remaining 10% of plasma calcium bound to citrate & phosphate
- Only the free, ionized Ca^{2+} { (1) above } is biologically active.

- Binding of calcium to albumin is pH-dependent :
- Alkalosis increases calcium binding to protein → thereby decreases ionized calcium level
- Calcium is tightly regulated with Phosphorous in the body.
- PO_4 plasma concentration is 3.0-4.5 mg/dL.

- **Bone Cells**

- There are 3 types of bone cells:

(1) Osteoblast :

- bone-forming cell .
- secretes osteoid (bone matrix , mainly collagen) on which Ca^{++} and PO_4 are precipitated .
- Stimulated by anabolic steroids

(2) Osteoclast :

- Bone-resorbing (removing) cell,stimulated by PTH

(3) Osteocyte :

- Transfers of calcium from canaliculi to the ECF

Bone Formation & Mineralization

- First osteoblasts synthesize bone matrix (osteoid , mainly collagen) →
- which will then be mineralized by deposition of Calcium Phosphate on it
- This mineralization is dependent on Vitamin D
- Alkaline phosphatase and osteocalcin play roles in bone formation
- Their plasma levels are indicators of osteoblast activity

- **Bone Resorption (Osteolysis)**

- Involves BOTH →
- (1) calcium exraction (demineralization) , & then →
- (2) removal of the osteoid matrix
- Cells responsible for resorption are osteoclasts
- Bone resorptopn is stimulated by parathyroid hormonne (PTH) , which stimulates osteoclasts → leads to release of calcium from bone into the ECF

Bone Remodeling

- This refers to the continuous processes of bone absorption (by osteoclasts) & then its deposition (by osteoblasts) .
- This results in a 10% turnover of the adult bone mass per year
- Endocrine signals to resting osteoblasts generate paracrine signals to osteoclasts
- Osteoclasts digest and resorb and area of mineralized bone.
- Then local macrophages clean up debris.
- Then osteoblasts are recruited to site and deposit new matrix which will be mineralized.
- New bone replaces previously resorbed bone.
- **Bone remodling affected by;-**
  1-mechanical stress on bone stimulates formation of stronger bone
  2- PTH and 1,25 Dihydroxycholecalciferol(active Vit D) stimulate activity & formation of osteoclasts
  3- Calcitonin inhibits activity of osteoclasts

Osteoporosis

- Men have more total bone mass than women .
- During childhood, bone formation exceeds resorption, and the total bone mass peaks at 25-35 years of age .
- Therefter , because of falling levels of the anabolic steroids (oestrogen & progesterone , which stimulate osteoblasts) , we get osteoporosis , which means reduced bone density and mass
- This leads to increased susceptibility to fracture.
- Osteoporosis occurs earlier in life for women than men (especially women around menopause) . But eventually both genders succumb to it

- Thanks