



# Musculoskeletal System

Doctor 2019 | Medicine | JU

**NO.1**

## Pathology

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## ➤ Bone functions

### 1- Mechanical support.

### 2- Forces transmission.

- If you carry something in your head, this weight will be equally distributed on all your bony structures.

### 3- Protection.

- Brain is protected by the skull. Pelvic organs are protected by pelvic bones.

### 4- Mineral homeostasis.

- Calcium and phosphorus metabolism is mainly controlled by the physiology of the bones.

### 5- Hematopoiesis.

- The bone marrow is one of the main sources of Hematopoiesis.

✚ Any disease of a bone ---> most of its functions will be affected.

## ➤ Bone structure

**1- Matrix** [osteoid 35% and minerals 65%( calcium, phosphorous and others) ].

- **Osteoid:** organic type I collagen [the major component of osteoid and one of the strongest types of collagen] and glycosaminoglycans & other proteins.

- **Inorganic hydroxyapatite**  $[Ca_{10}(PO_4)_6(OH)_2]$

- **Woven & lamellar bone** ---> depending on the type of matrix and the arrangement of the matrix and the cells.

**2- Cells** ---> swim in the matrix in certain order.

- **Osteoblasts:** form bones ---> the major component of bone cells.

- **Osteoclasts:** resorb bones [the bone eating cells] ---> originate from the macrophage-monocyte system.

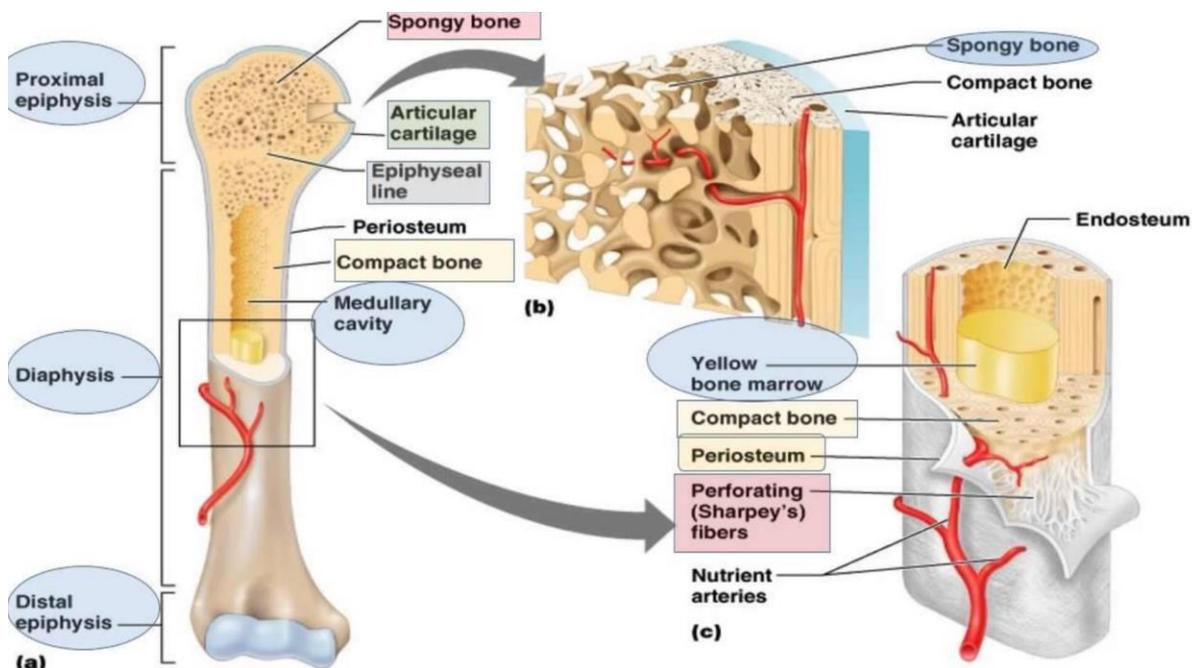
- **Osteocytes:** mature bone cells ---> less active, smaller in size than osteoclasts and osteoblasts and do not have too many cytoplasmic organelles for metabolic activity.

✚ The Balance between bone formation [osteoblasts] and bone resorption [osteoclasts] is very critical in the understanding of many diseases like **osteoporosis** [the bone and the bone matrix

gets less and the bone becomes weaker and exposed to many diseases and fractures].

## ➤ The histology of the bone

- ❖ **Proximal and distal Epiphysis.**
  - ❖ **Epiphyseal plate:** where the growth occurs.
  - ❖ **Periosteum:** the outer part of the bone which contains nerves [any irritation of periosteum will cause pain].
  - ❖ **Compact bone:** below the periosteum and before getting into spongy bone marrow [it is very hard].
  - ❖ **Medullary cavity:** which contains bone marrow particles where the major Hematopoiesis occurs.
  - ❖ **Diaphysis:** the area located between proximal and distal epiphysis.
  - ❖ **The endosteum:** The inner part of the compact bone.
- ✚ There are certain fractures diseases affect the proximal epiphysis, some of them affect Diaphysis and some of them affect metaphysis.



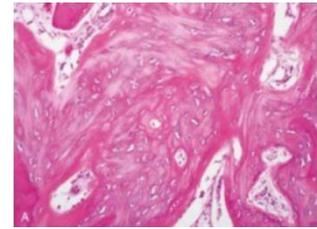
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Structure of a Typical Long Bone

## ➤ Woven & Lamellar bone

### 1- Woven bone

- ✓ More cellular and disorganized.
- ✓ The trabeculae are wider.
- ✓ The arrangement between cells  
And type 1 collagen is haphazard.
- ✓ In early young born in children and in certain diseases.



✚ In adults, if you see woven bone something wrong or abnormal is going on, whether it is malignancy or fracture site.

### 2- Lamellar bone

- ✓ The cells are more linear and organized
- ✓ Less cells
- ✓ main structure of mature long bones
- ✓ More collagen [strong]

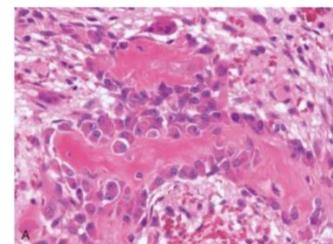


Doctor said that he will give us the following pictures and ask which is lamellar and which is woven also ask when or where would you see this and that...

## Osteoblasts & Osteoclasts.

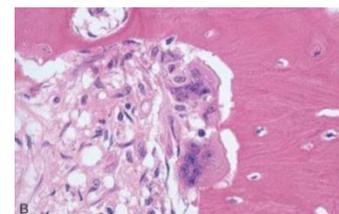
### 1-Osteoblasts

- ✓ Smaller Cells
- ✓ The nuclear cytoplasmic ratio a little bit high  
(larger than osteoclasts).
- ✓ Mono nuclear cells
- ✓ Located around the area where osteoid has been formed



### 2- Osteoclasts

- ✓ Big cells
- ✓ They eat up mature bone [forming white pits]
- ✓ Multi nucleated giant cells [each osteoclast can have up to 100-150 nuclei]



## ➤ The development of the bone

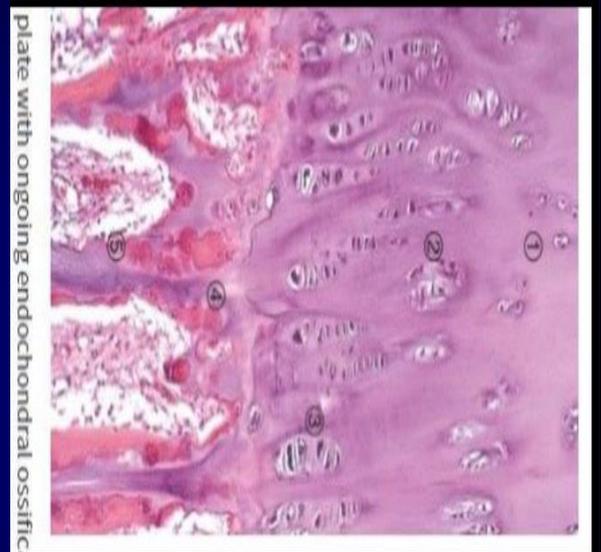
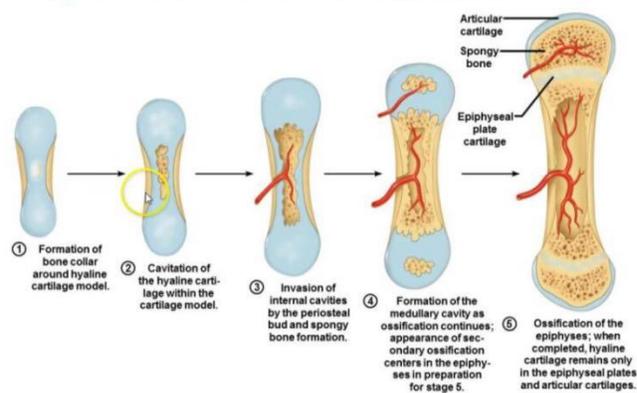
- There are two major ways where the development of bone occurs:

### 1- Endochondral ossification

From its name, indicates formation of bone from young mature cartilage from in utero until mature bone in adults. It is the main process where long bone is formed. This process starts with cartilage and then the endochondral ossification starts in the center until most of your long bone is replaced by mature bone and there is only a remnant of articular cartilage at both ends.

# LONG BONES

## Stages of Endochondral Ossification



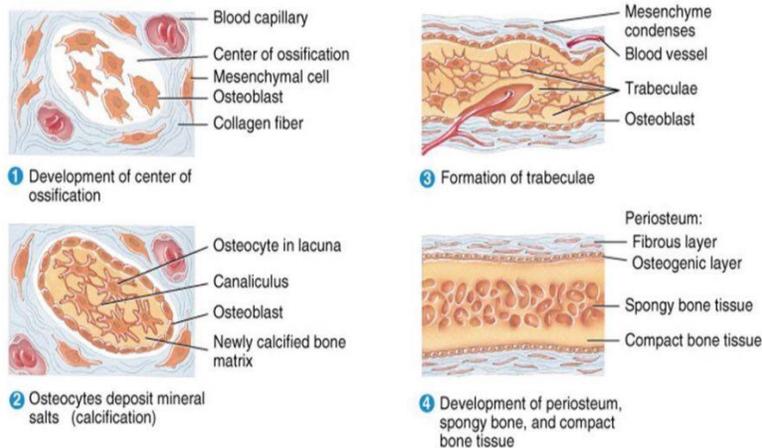
### 2- Intra-membranous ossification

Formation of flat bones like a clavicle, scapula, pelvic bone doesn't require Cartilage and the bone is formed by intra-membranous ossification.

In this process we don't pass through cartilage formation, it starts with soft tissue membranes with stem cells between them.

# FLAT BONES

## Intramembranous Ossification



### ➤ Homeostasis & remodeling

- ✓ Continuous and dynamic complex process even in adult mature skeleton (microscopic level).
- ✓ Peak bone mass is reached in early adulthood after completion of skeletal growth [between (20-30)]. Then it starts to decrease depending on nutrition and athletic activity.
- ✓ Resorption > bone formation on 4th decade [the main pathogenesis of the major metabolic syndrome of osteoporosis].

More Resorption

**+ Osteoclast differentiation**

**PTH** Parathyroid Hormone

**IL-1**

**Steroids**

People who are taking steroids are advised to take vitamin d and calcium products.

**- Osteoclast differentiation**

**BMPs (bone morphogenic proteins)**

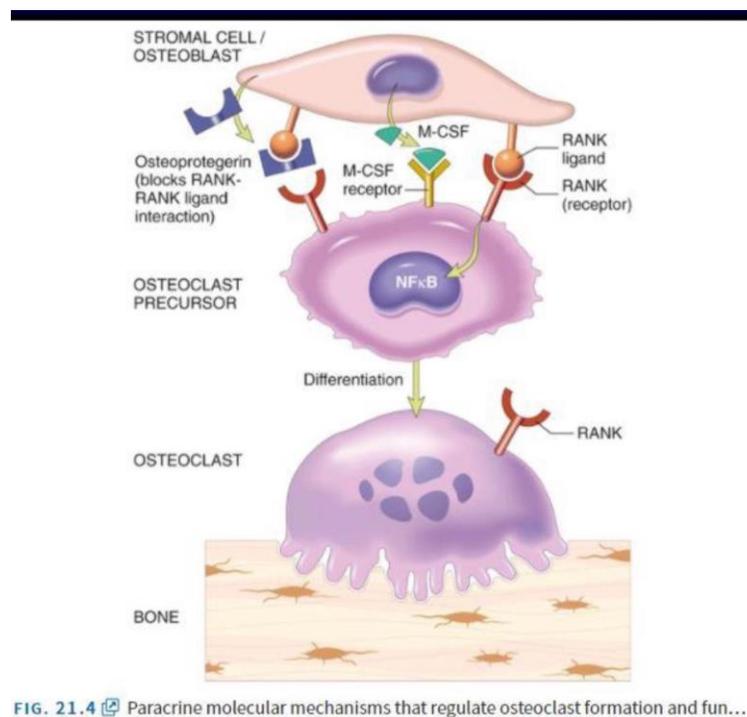
**Sex hormones (estrogen & test.)**

Used by athletes to increase bone and muscle mass.

Less Resorption

**This Table is Extremely Important**

- ✓ **Macrophages-colony stimulating factors (M-CSF)** are cytokines secreted by stromal cells (undifferentiated) upon specific stimulation **RANK ligand**.
- ✓ **RANK ligand** and its receptors are one of the current target for treatment by specific drugs that enhance its action or block the receptor of this ligand.
- ✓ This stimulation makes the stem cell active so it will be differentiated into osteoclast precursor then it will be converted into mature osteoclast that goes to the bone and does its function (bone resorption). In the mature osteoclast, the cytoplasm will increase and the size of nucleus will decrease.
- ✓ There is another endogenous factor can block this process by blocking the **RANK-RANK ligand receptor interaction** which is **osteoprotegerin**, so it inhibits the maturity of osteoclast.
- ✓ There is endogenous balance between these two processes, and you can alter this balance with or against osteoclastic activity according to your needs.



The End