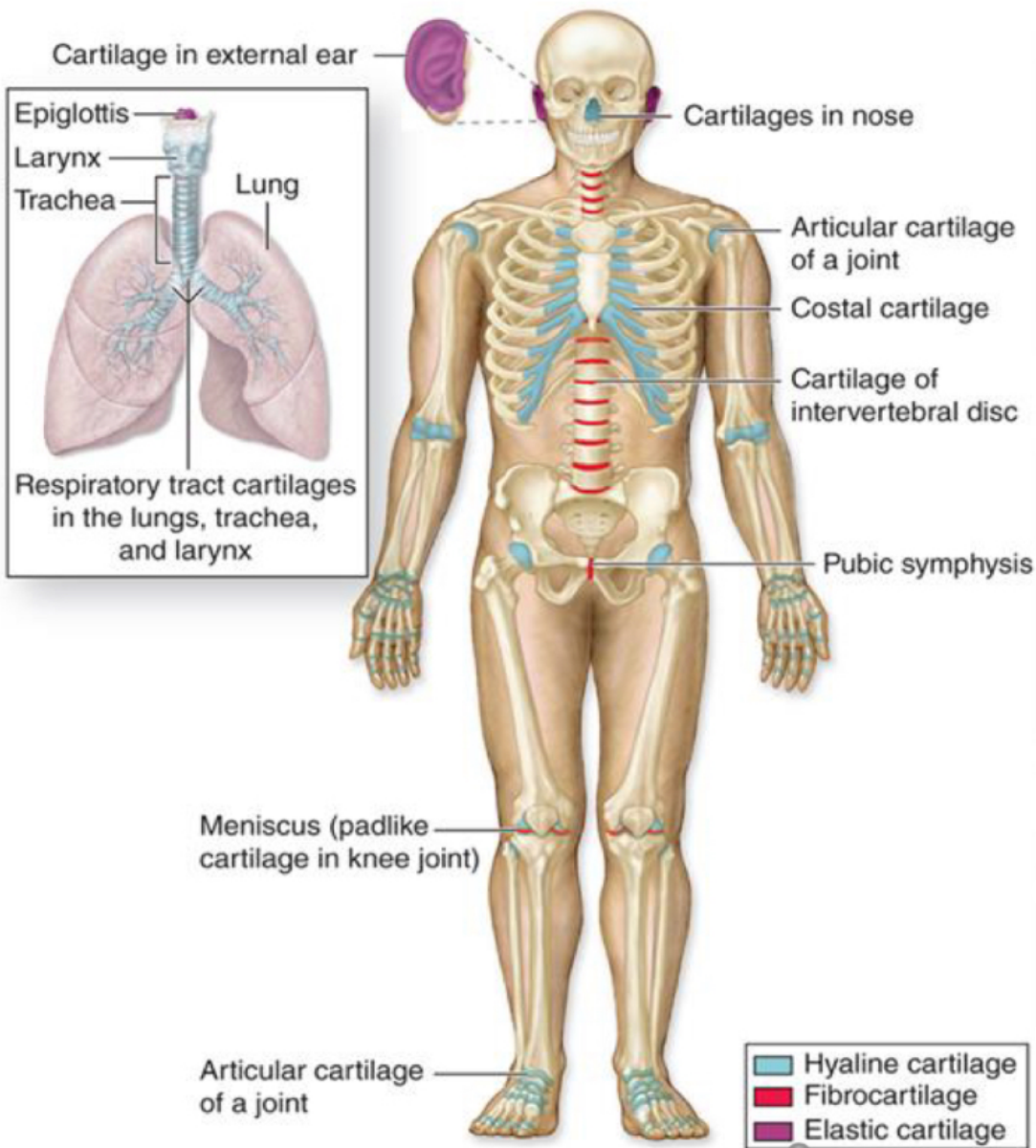


Cartilages types according to ECM

	Hyaline cartilage	Elastic cartilage	Fibrocartilage
Fresh cartilage color	🟦🟦 Bluish-white	🟡🟡 Yellow	—
ECM rich in	Collagen fibers But, the ground substance rich in Hyaluronic acid	Elastic fibers	Collagen fibers
How chondrocytes arranged	Round or oval	—	Axially in the lacunae
Perichondrium	✅	✅	NO PERICHONDRIUM
Location	-Articular surfaces in some joints -Airway passages (nose, cricoid and thyroid cartilages of LARYNX & trachea) -Costal cartilages -Epiphyseal growth plate	-Auricle of ear -Wall of external auditory canal -Auditory tube -Epiglottis & cuneiform cartilages of LARYNX	-Intervertebral discs -Pubic symphysis -Menisci of the knee joint

THE MOST COMMON TYPE



Bone tissue and ossification (summary)

Done by :Anas Zakarneh

Bone: structural type of CT... Charactized by presence of **calcified extracellular matrix (bone matrix)** with 3 type

help bone to grow

1. osteoblast ..2. osteocytes ..3. osteoclasts

kind of bone

cells degrade bone to initiate normal bone,

Function of bones :1. support fleshy tissue

2. Protect vital organ ..eg: skulls protect brain/ thoracic cage protect heart /vertebral column protect the spinal cord

3. store and release of Ca^{+2} and PO_4 ions

4. some bone contain red marrow (site of formation of blood cells.

5. act as levers that multiply force of contraction muscles

TYPES OF BONE CELLS

*Responsible for formation of organic matrix of bone and. Subsequent deposition of minerals
#form single layers of cell on the surface

Osteoblasts

#active cell are **cuboidal or low columnar** with basophilic cytoplasm .

#Inactive cells are flattened and less basophilic.

#Secrete organic matrix from its surface in contact with old bone ,creating an area of yet unmineralized bone called **osteoid**.

#later ,will deposit the inorganic component to form the bone matrix .

#**osteoblast** will eventually be surrounded by the matrix it produced and it will convert into an **osteocytes**



osteocytes

Osteocytes

#osteocytes :flattened ,almond shaped featuring cytoplasmic processes with reduced rough endoplasmic reticulum and golgi complex and **darker nuclei**

#involve in the **maintenance** of the bony matrix

#Each osteocytes is located within a lacuna ..its processes are located in bony canals called **canaliculi**

#processes of osteocytes are connected with each other by **gap junction** ,allowing transport of nutrient between cells .this is vital(main)cause the passage of nutrients through **calcified matrix is difficult** .

#large /motile /multinucleated cells .

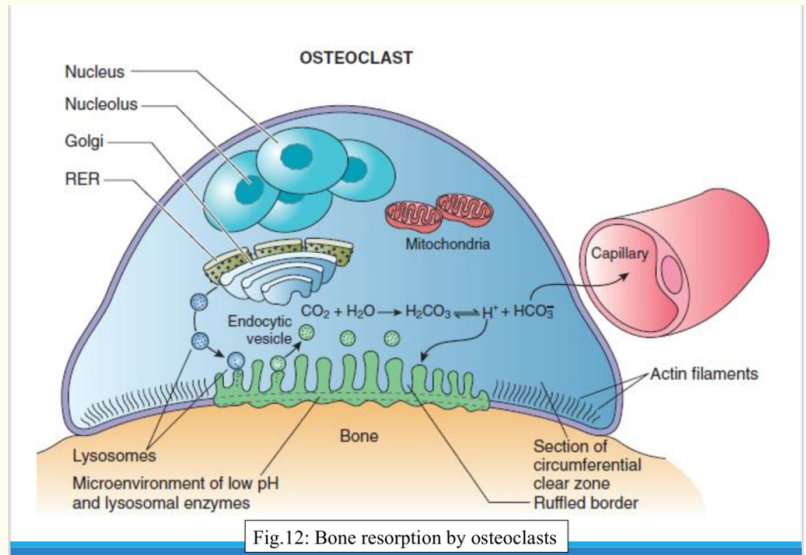
Osteoclasts

#formed by the union of several **bone marrow** derived mononucleated

#Responsible for the resorption of bone

Process of resorption

1. osteoclast works in a specified depression called :**resorption bay**(howship`s lacuna)
2. their cell membrane facing the matrix is thrown into folds called the **ruffled border** (to increase surface area.
3. around the ruffled border the cytoplasm is rich in **actin filaments** which help in adhering the cell to the matrix (this area is called **circumferential dhesion /clear zone**.
4. into the subcellular space thus formed ,H+ ions are pumped and lysosome fuse with the cell membrane and release their secretions(including collagenases)to the outside .in this way,the collagen and hydroxyapatite of the matrix are dissolved



حسيتها مهمه

Disease	Pathology	Notes
Osteitis fibrosa cystica	Increased level of PTH causes excessive stimulation of osteoclasts that leads to increased resorption. Cysts are formed within the bone.	<ul style="list-style-type: none"> - Bones are decalcified and liable for fracture. - High Ca^{2+} level in blood increases risk of renal stones.
Osteopetrosis (Marble bone disease)	Genetic disorder in which there's abnormality in osteoclasts that leads to decreased resorption.	<ul style="list-style-type: none"> - Bones are thicker and appear denser on X-rays. - The bone marrow cavity is narrowed → anemia and increased risk of infection.



BONE MATRIX

A)

- #**inorganic components**:(50%of dry weight of bone)
- #Mainly hydroxyapatite crystal
- #various ions and compounds

B)

- Organic components:**
- #Fibers:collagen
- #Ground substance :proteoglycans and multiadhesive glycoproteins
- #ca+2 binding proteins
- #alkaline phsophatase in matrix vesicles (which increase po4 concentration)

Note *

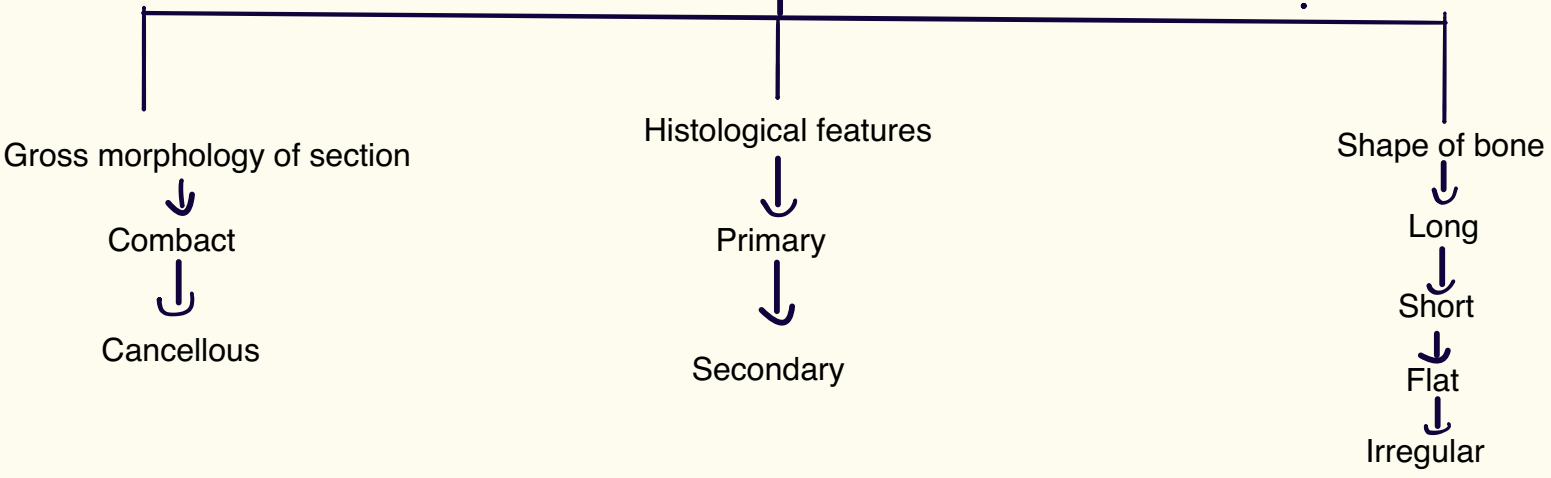
#in the matrix ,association of **minerals** with **collagen** fibers is responsible for 1.hardness..2.resistance of bone

if ca+2 removed ,the bone will maintain its shape and become flexible as a **tendon**

#if collagen is removed ,the bone maintains its shape but become fragile and easily broken .

Endosteum	Periosteum
<p>thin layer that lines the inner surface of the bone .</p> <p>#Formed of a single layer of osteoprogenitor Cells with osteoblasts</p>	<p>#CT layer that cover outer surface of the bone</p> <p>#consist of an outer layer of dense fibrous tissue with fibroblast and inner single layer of osteoprogenitor cells</p> <p>#a number of collagen fiber pass from this layer To the bone matrix attaching them together (called perforating fibers)</p>

CLASSIFICATION OF BONE



ACCORDING TO GROSS MORPHOLOGY	ACCORDING TO SHAPE
<p>#in a section ,a part of the bone appers As a dense area with generally no cavities .this called compact bone</p> <p>#Another part has several inter connected Cavities .this called spongy (cancellous)bone</p> <p>#Histoogically ,both the compact Bone and the trabeculae of the spongy bone have the same Features .</p>	<p>#long bones:</p> <ul style="list-style-type: none"> *Have a tubular shaft ,the diaphysis and an expanded at each end. *the shaft has a central cavity for the bone marrow(marrow or medullary cavity) *the shaft is mostly composed of compact bone with a thin layer of spongy bone surrounding The cavity. *The epiphesis are composed of cancellous bone surrounded by a thin layer of compact bone <p>#Short bone</p> <ul style="list-style-type: none"> *Are composed of spongy bone completely surrounded by a thin layer of compact bone <p>#flat bone</p> <ul style="list-style-type: none"> *Consist of 2 thin layer of compact bone (plates /tables)separated by a layer of spongy bone called dipole

ACCORDING TO HISTOLOGICAL FEATURES

Primary (woven)bone

- *characterized by the **irregular** arrangement of its collagen fibers
- *osteocytes are more abundant and its appears Less dense on **x-rays** due to **less mineral content**
- *it is **1st type** of bone to appear during embryonic development and in fracture repair
- *it replaced by secondary bone ,except in areas of **tendon attachment ,tooth sockets and near the Suture of the skull bones**

Secondary (lamellar) bone

- *Characterized by the arrangement of the matrix into multiple layer called **lamellae**
- *the osteocytes are located inside **lacunae** found Between the lamellae

THE LAMELLAE ARRANGED AS

A) **Parallel** layers just inside the periosteum (The **external** circumferential lamellae) or around the bone marrow Cavity (The **internal** circumferential lamellae)

B) concentric layers around a central canal Forming an **osteon** (Haversian system). This canal contain **blood vessels ,nerves ,and loose areolar CT.**

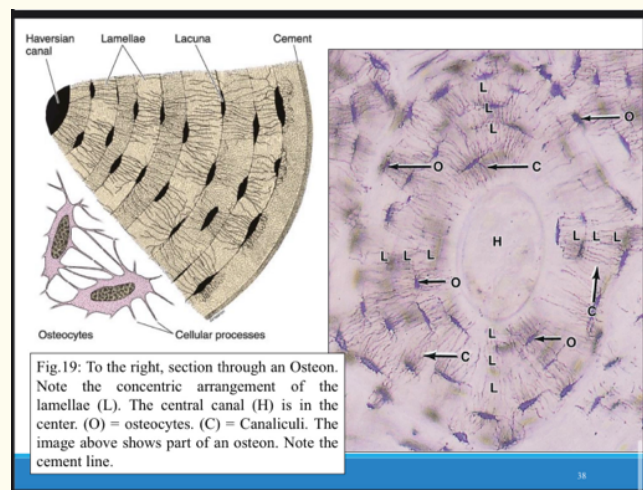
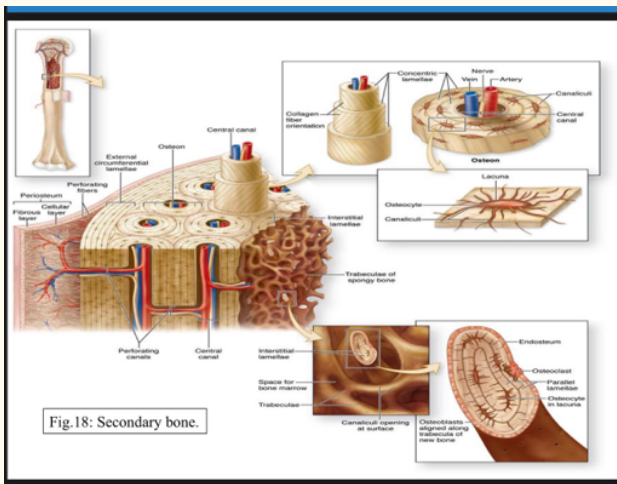
The outer layer of the osteon is rich In **collagen** and is called the **cement line.**

the collagen fibers in each lamella are **parallel** to each other and **helically** arranged . The collagen fibers in adjacent lamellae are at right angles to each other.

the central canals are connected to the periosteum,the bone marrow cavity , and to each Other by transverse (or oblique) perforating canals.

C) **irregularly** shaped groups of lamellae Called **interstitial lamellae.**

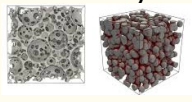
They found between the previous two and represent the remnants Of osteons that have been resorbed.



Ossification

The process by which new bone tissue is formed...its 2 types

- 1.intramembranous : the formation of bone from a group (membrane)
Of **mesenchymal** cell(خلايا جذعية).process by which most of the **flat** bone are formed
- 2.endochondral :is the formation of bone matrix of a pre -existing hyaline cartilage model of the bone .**long and short** bone are mostly formed by this method

Intramembranous ossification	Endochondral ossification
<p>a) in ossification center some mesenchymal cells differentiate into osteoblasts</p> <p>b)the osteoblast will form osteoid which will later become calcified</p> <p>*some osteoblasts will be surrounded by the bone matrix forming osteocytes in lacunae</p> <p>C)woven bone is formed at first .several centers will fuse forming trabeculae surrounding cavities containing blood forming and mesenchymal cells</p> <p>D)lamellar bone replaces the woven bone as compact bone surrounds the spongy bone</p> <p>E) the remaining non-calcified mesenchymal Tissue will form the periosteum and endosteum</p>	<p>1)a hyaline cartilage model of the bone is formed .cells in the perichondrium will differentiate to osteoblasts that will form a bone collar around the diaphysis of the model. #This will prevent passage of nutrients from the perichondrium to the chondrocytes</p> <p>2)chondrocytes will hypertrophy ,enlarging their lacunae and compressing the cartilage matrix between them #The compressed matrix will be calcified and the chondrocytes will die forming a porous structure</p>  <p>3)osteoclasts will dig tunnels (تحفر انفاق)through the calciified matrix Through these tunnels ,blood vessels and osteoprogenitor cells from the perichondrium (now called periosteum)will reach the matrix</p> <p>4)the osteoprogenitor cells will form osteoblasts that line the cavities of the porous structure. osteoblasts will produce primary bone which will later cover into secondary bone.</p> <p>5)ossification in the diaphysis is called primary ossification center.later in life secondary ossification centers appear in the epiphyses by a similar process</p> <p>6)cavities will be formed during this process and this will be filled with bone marrow</p>

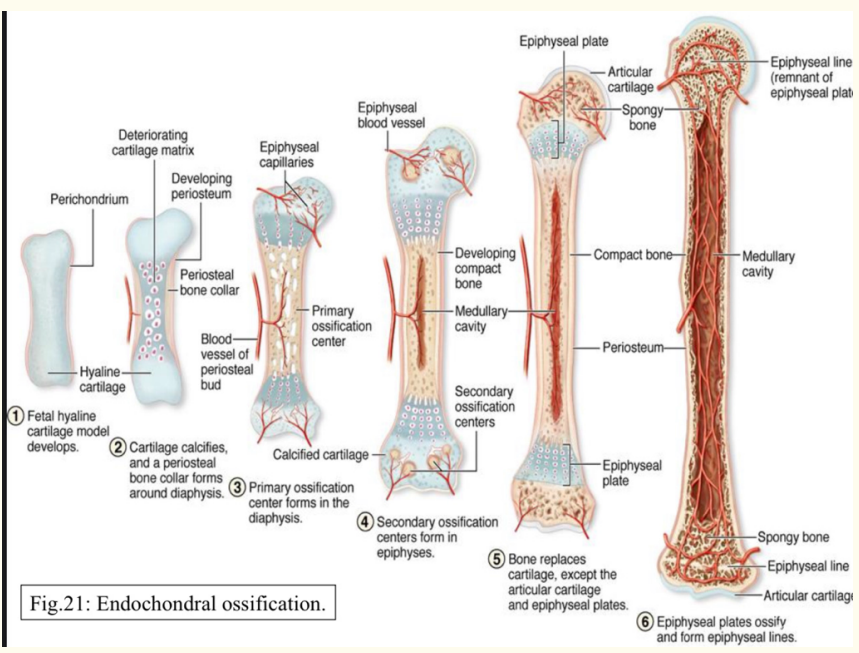


Fig.21: Endochondral ossification.

The hyaline cartilage remains in 2 are:

1. Articular cartilage :this persists throughout life
- 2.epiphyseal plate : disappears during adulthood

Bone remodeling (remodeling cone)

- *It's occurs **through life**
- *osteoclasts resorb old bone forming a **tunnel** (cutting cone)
- *The tunnel is invaded by **osteoprogenitor** cells and sprouting loops of capillaries from the endosteum or periosteum
 - *Osteoblasts develop, line the wall of the tunnel, and begin to secrete **osteoid** in a cyclic manner, forming a new **lamella** to the inside of the older ones trapping osteocytes inside lacunae (closing cone)
- *The tunnel becomes constricted with multiple **concentric** layers of matrix, and its lumen finally becomes as the **central canal of a mature osteon**.

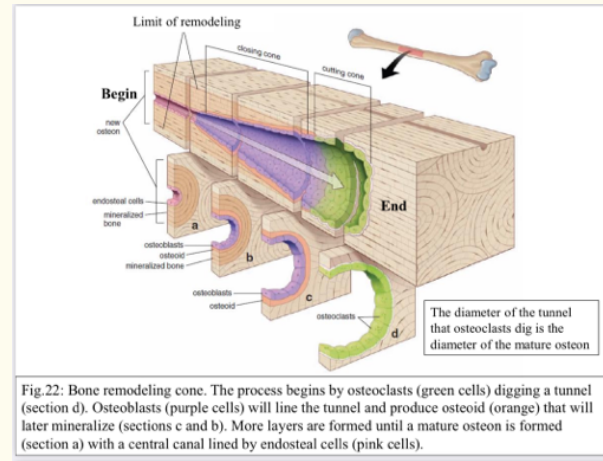


Fig. 22: Bone remodeling cone. The process begins by osteoclasts (green cells) digging a tunnel (section d). Osteoblasts (purple cells) will line the tunnel and produce osteoid (orange) that will later mineralize (sections c and b). More layers are formed until a mature osteon is formed (section a) with a central canal lined by endosteal cells (pink cells).

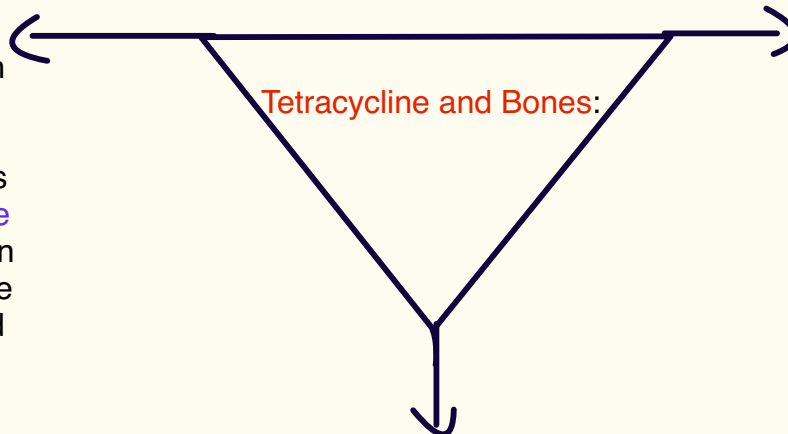
BONE GROWTH AND REPAIR

- Repair of bone is usually very well because bones are **well vascularized**.
- Bone growth is affected by several hormones in the body, like **growth hormone**.

Increase in **width** of bone can occur throughout life by **appositional growth from the periosteum**.

Increase in length of bones occur at site of **epiphyseal** plate before they're closed. After closure of the plates during **adulthood**, **no further increase in bone length can occur**. The time of closure of the plate is specific for the bone. This can be used to determine the age of the person

Tetracycline binds with great affinity with **Ca²⁺** in recently deposited bone matrix. Based on this interaction, a method was developed to **measure the rate of bone apposition**, an important parameter in the study of bone growth and the diagnosis of bone growth diseases.



Tetracycline is administered **twice** to a patient, with an interval of **5 days between injections**. A bone biopsy is then performed and the sections are studied by means of fluorescence microscopy. **The distance between the two fluorescent layers is proportional to the rate of bone apposition**.



Tetracycline must not be given to a **pregnant or lactating women or to a child whose teeth are erupting**, because it may bind to **Ca²⁺** of the newly forming teeth of the child leading to the permanent discoloration of the teeth.

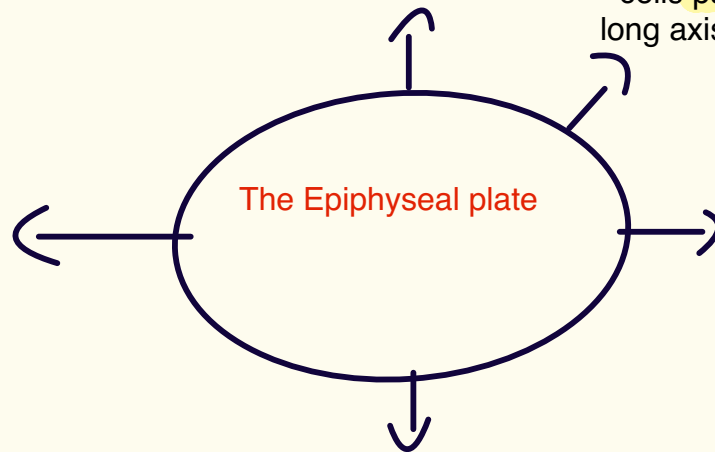
Epiphyseal cartilage is divided into 5 zones starting from the epiphyseal side of cartilage:

1. **The resting zone:** consists of hyaline cartilage with typical chondrocytes.

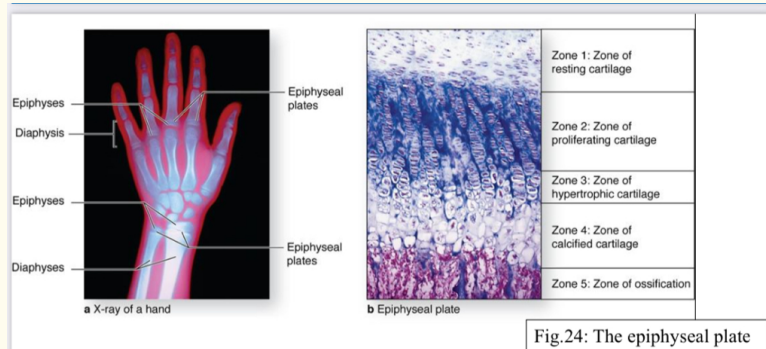
2. **Proliferative zone:** chondrocytes divide rapidly and form columns of stacked cells parallel to the long axis of the bone.

3. **The hypertrophic zone:** contains enlarged chondrocytes. The matrix is reduced to thin septa between the chondrocytes.

4. **The calcified zone:** Death of chondrocyte with calcification of the thin septa of cartilage matrix.



5. **The ossification zone:** Blood capillaries and osteoprogenitor cells originating from the periosteum invade the cavities left by the chondrocytes. The osteoprogenitor cells form osteoblasts which will deposit bone matrix.



- Before closure, each layer converts to the next at the same rate, with the formation of new cartilage in zone 1 and new bone in zone 5. Therefore, there's no change in the relative size of the plate. The plate moves away from the center of the bone thus increasing bone length. The chondrocytes in the plate will, eventually, start to die without forming new cartilage. The dead cartilage is replaced by bone until all the plate becomes ossified at the time of closure.

SYNOVIAL MEMBRANE

❖ The synovial membrane, may contain areolar, fibrous or adipose tissue depending on the joint.

❖ The synovial membrane has phagocytic synoviocytes that are round and located near the cavity. They engulf debris resulting from wear and tear.

The membrane also contains fibrocytic synoviocytes that produce hyaluronic acid (and other components of the extracellular matrix of the membrane). These are located deeper in the membrane.