

Bone 1

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Bone tissue

- Bone is a specialized connective tissue composed of calcified extracellular material (as a major component and it is characterized with hardness, calcification and mineralized (has minerals Ca^{+2} ...)), the bone matrix, and following three major cell types:

□ **Osteocytes**, which are found in cavities (lacunae) between bone matrix layers (lamellae), with cytoplasmic processes in small canaliculi that extend into the matrix

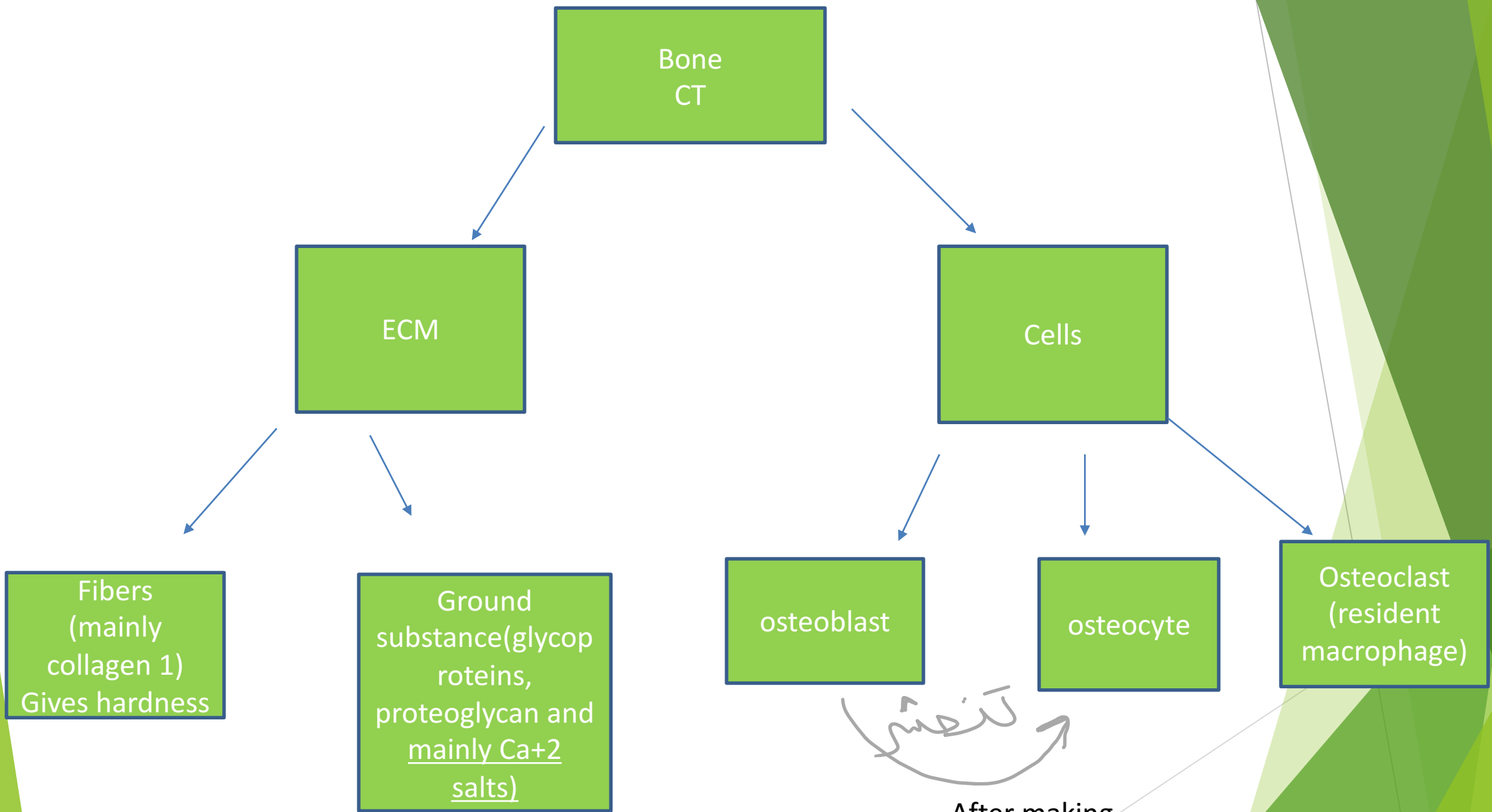
□ **Osteoblasts**, growing cells which synthesize and secrete the organic components of the matrix

□ **Osteoclasts**, (a type of macrophage in bones) which are giant, multinucleated cells involved in removing calcified bone matrix and remodeling bone tissue

↳ origin: monocyte in bone marrow

origin: mesenchymal cells

osteo: bone



تنعش

After making
ECM and
trapping in it

epiphysis ←

Diaphysis

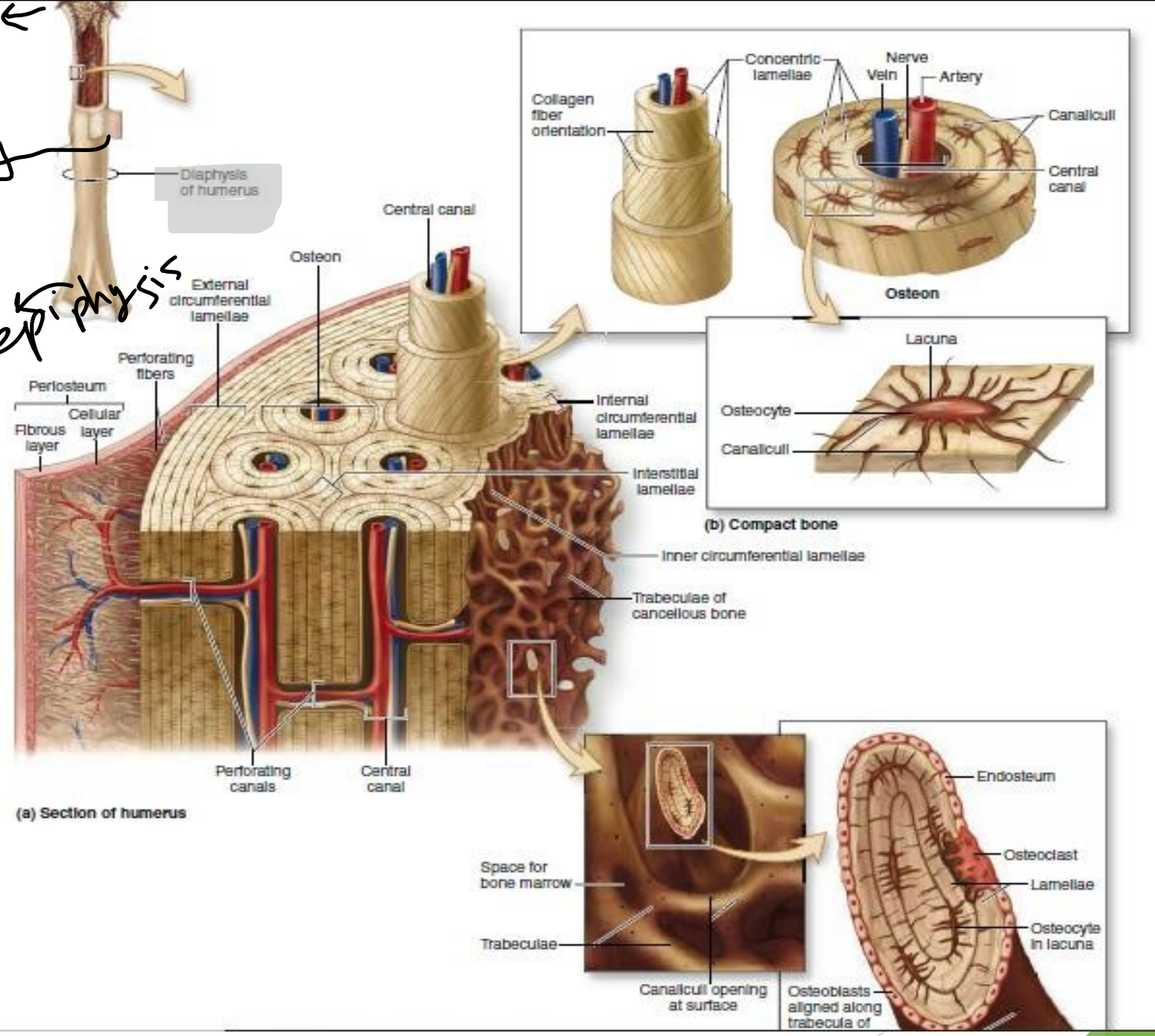
يتكون بس قشرة صغيرة (الحافة)

اما cavity الداخلي ما يكون فاضي

بكون فيو bone marrow

epiphysis ←

Long bone:
2 ends(epiphysis)
Shaft(diaphysis)

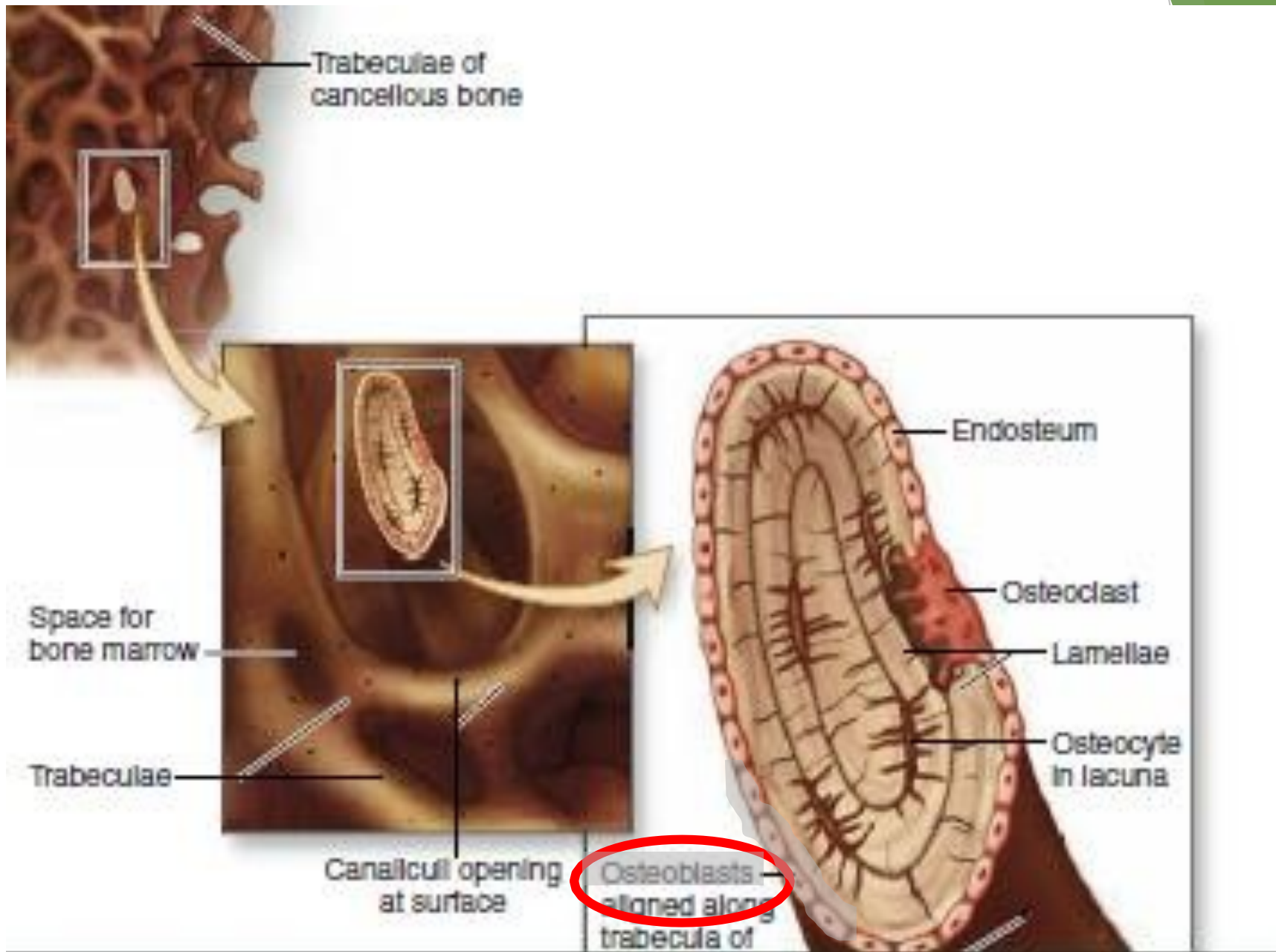


Diaphysis is packed
While epiphysis has spaces

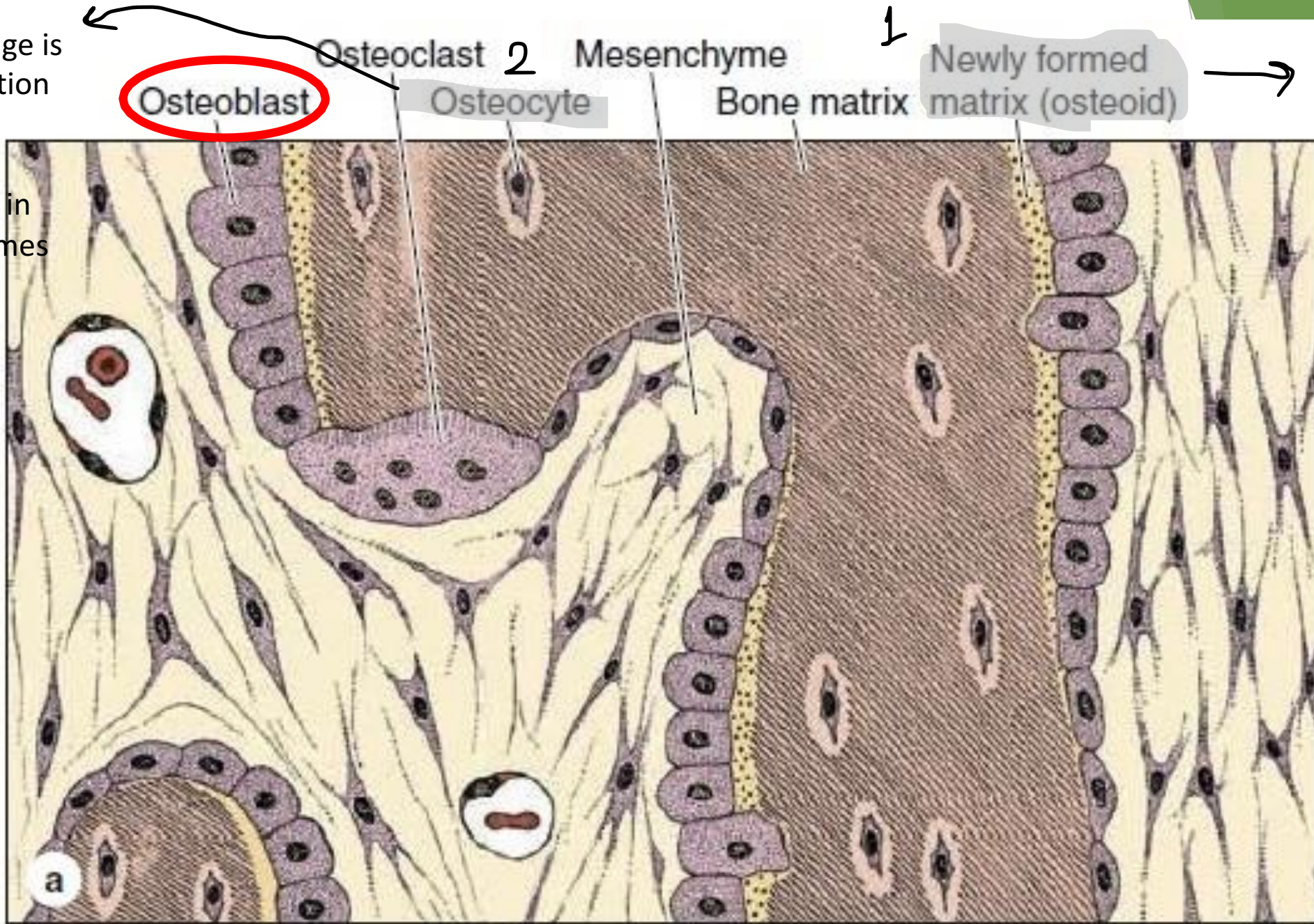
Osteoblast:
1) lines marrow cavity
2) Forms organic compound of ECM (proteoglycan and glycoprotein)

Osteoblasts

- Originate from **mesenchymal stem cells**
- They produce the organic components of bone matrix, **including type I collagen fibers, proteoglycans, and matricellular glycoproteins such as osteonectin.**
- Active osteoblasts are located exclusively at the surfaces of bone matrix, forming a single layer of cuboidal cells joined by adherent and gap Junctions
- When their synthetic activity is completed, some osteoblasts differentiate as osteocytes entrapped in matrix-bound lacunae, and the majority undergo apoptosis.



The 2nd stage is mineralization
When osteoblast entrapped in ECM becomes osteocyte



The first stage in forming osteocyte by osteoblast
Presenting in making only organic material (mainly collagen 1)

Bone formation

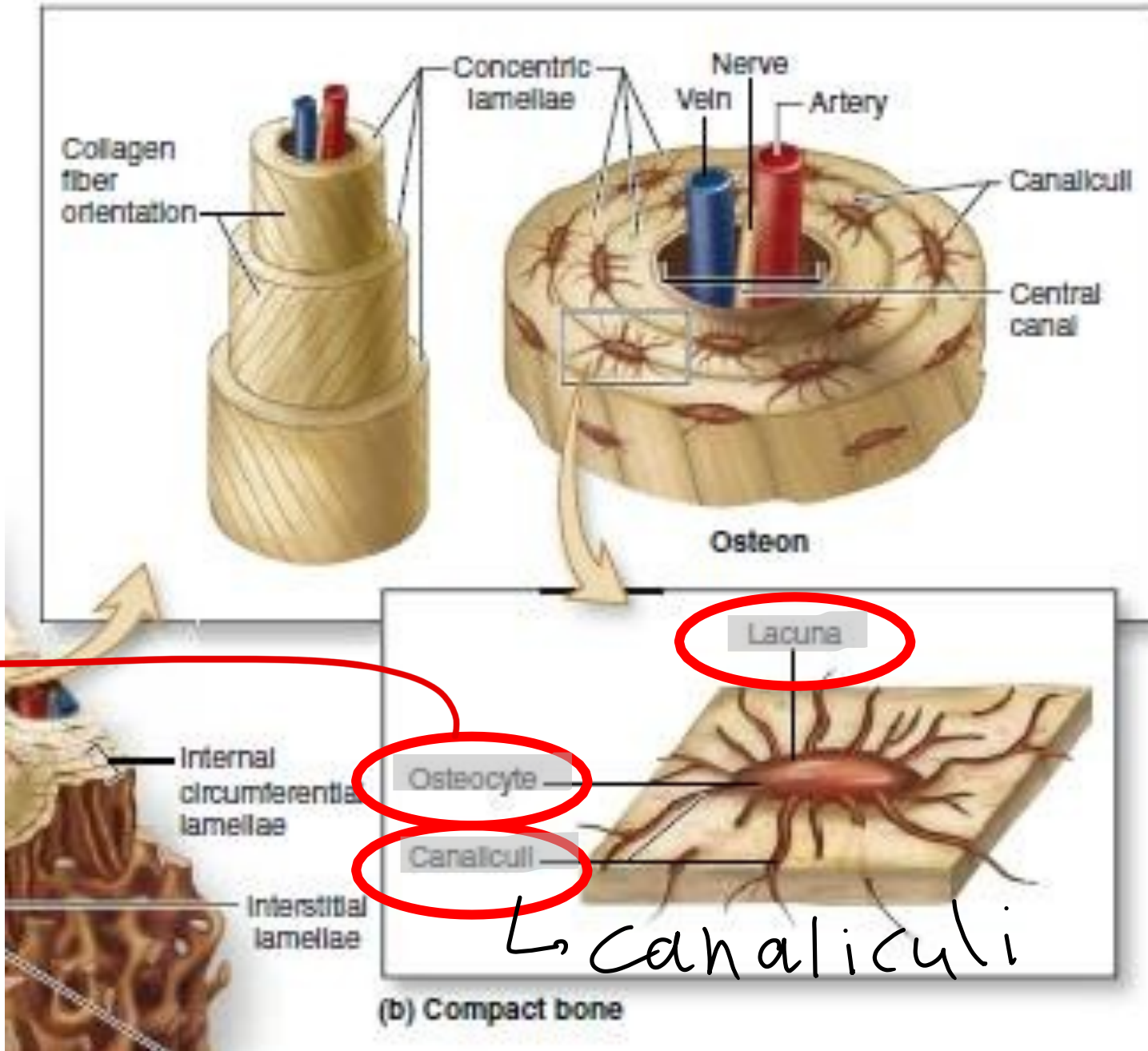
- 1
 - Matrix components are secreted at the cell surface producing a layer of unique collagen-rich material called **osteoid**
 - This process is completed by subsequent deposition of calcium salts into the newly formed matrix
- 2 **(mineralization)**

Osteocytes

- Some osteoblasts become surrounded by the material they secrete and then differentiate as **osteocytes** enclosed singly within the **lacunae** spaced throughout the mineralized matrix.
- During the transition from osteoblasts to osteocytes, the cells extend many long processes, which also become surrounded by calcifying matrix.
- The processes come to occupy the many **canaliculi** (the space where processes of osteocytes locate) radiating from each lacuna

cells don't live single they communicate intercellularly Each cell sends processes that need more space so they pass through canaliculi

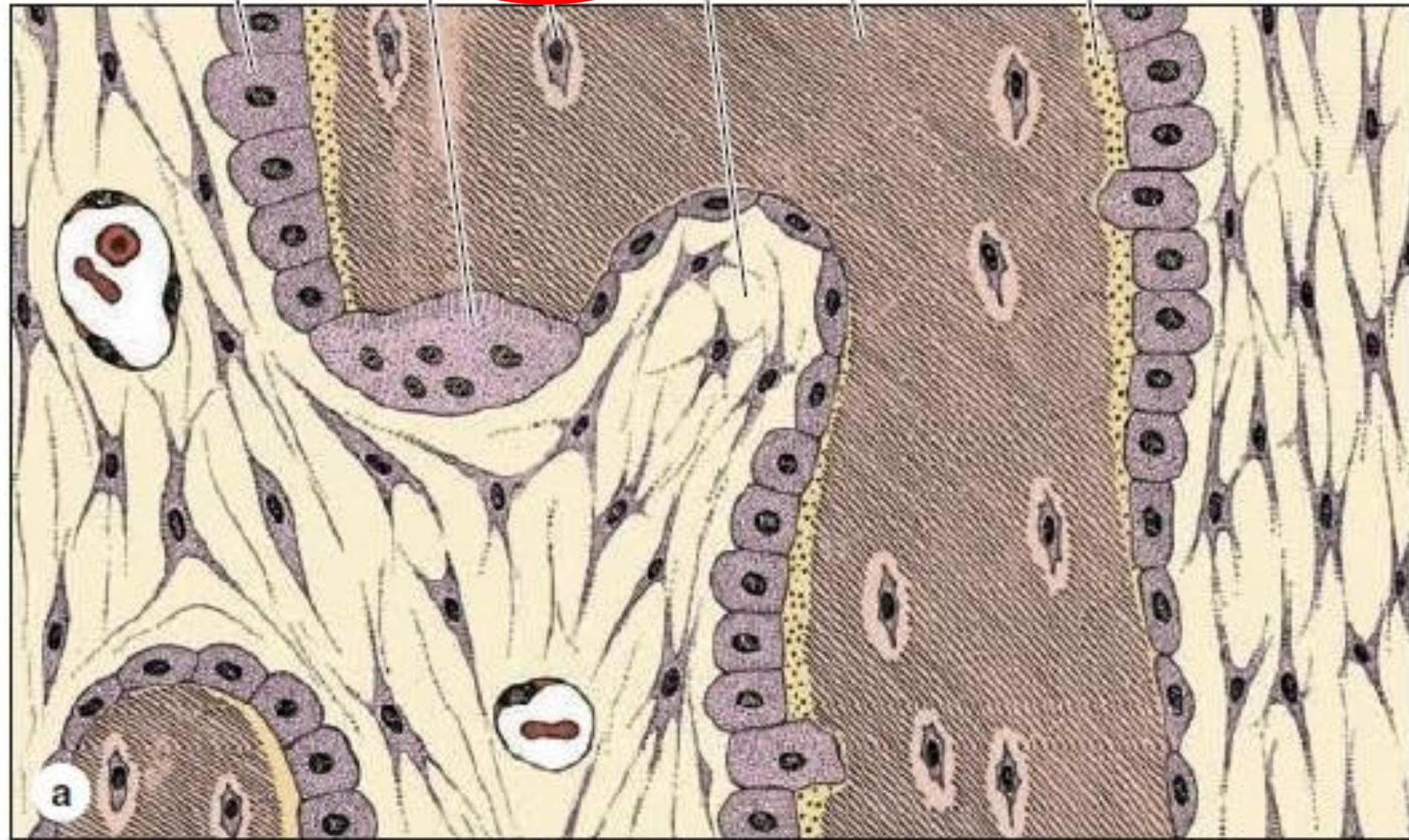
they don't produce osteoids

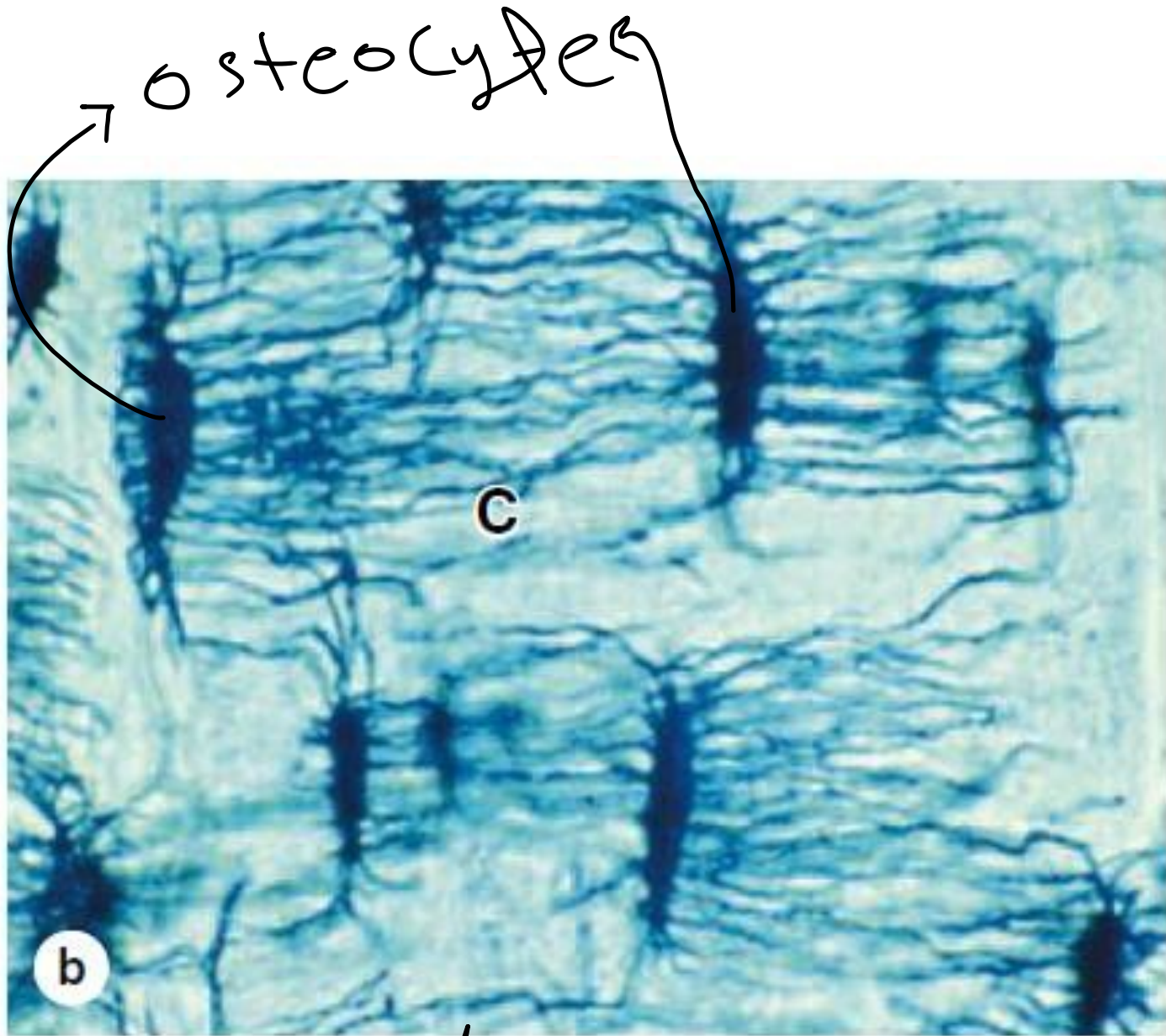


(b) Compact bone

produce
osteoids ←

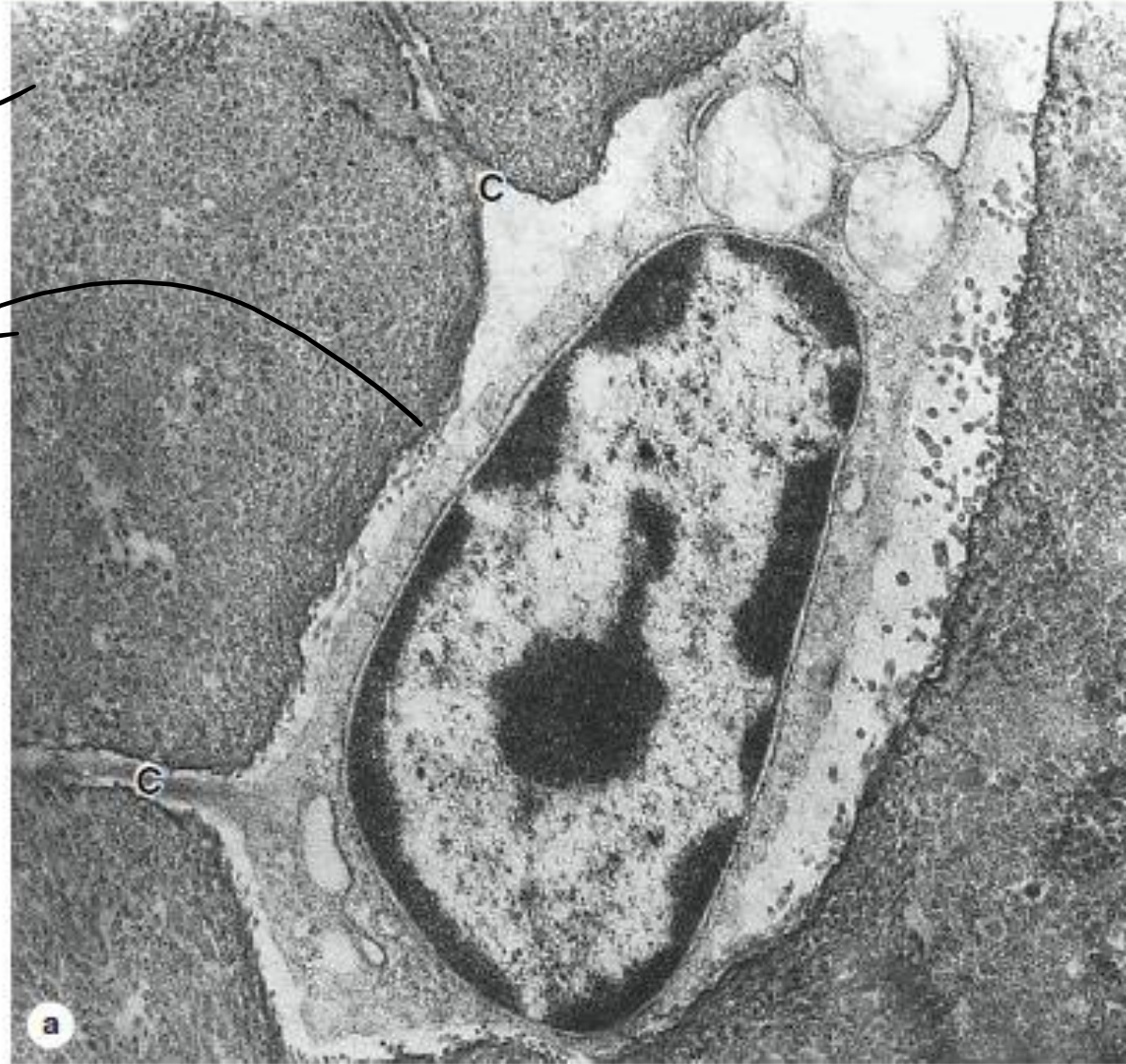
Osteoclast Mesenchyme
Osteoblast **Osteocyte** Bone matrix Newly formed
matrix (osteoid)





LM

osteocyte



EM

Osteocytes are less active in synthesis proteins and organic components
They are heterochromatin
Less Golgi
Less RER
Less euchromatin
Function : maintaining the valance(matrix) in bones

Osteoblasts vs osteocytes

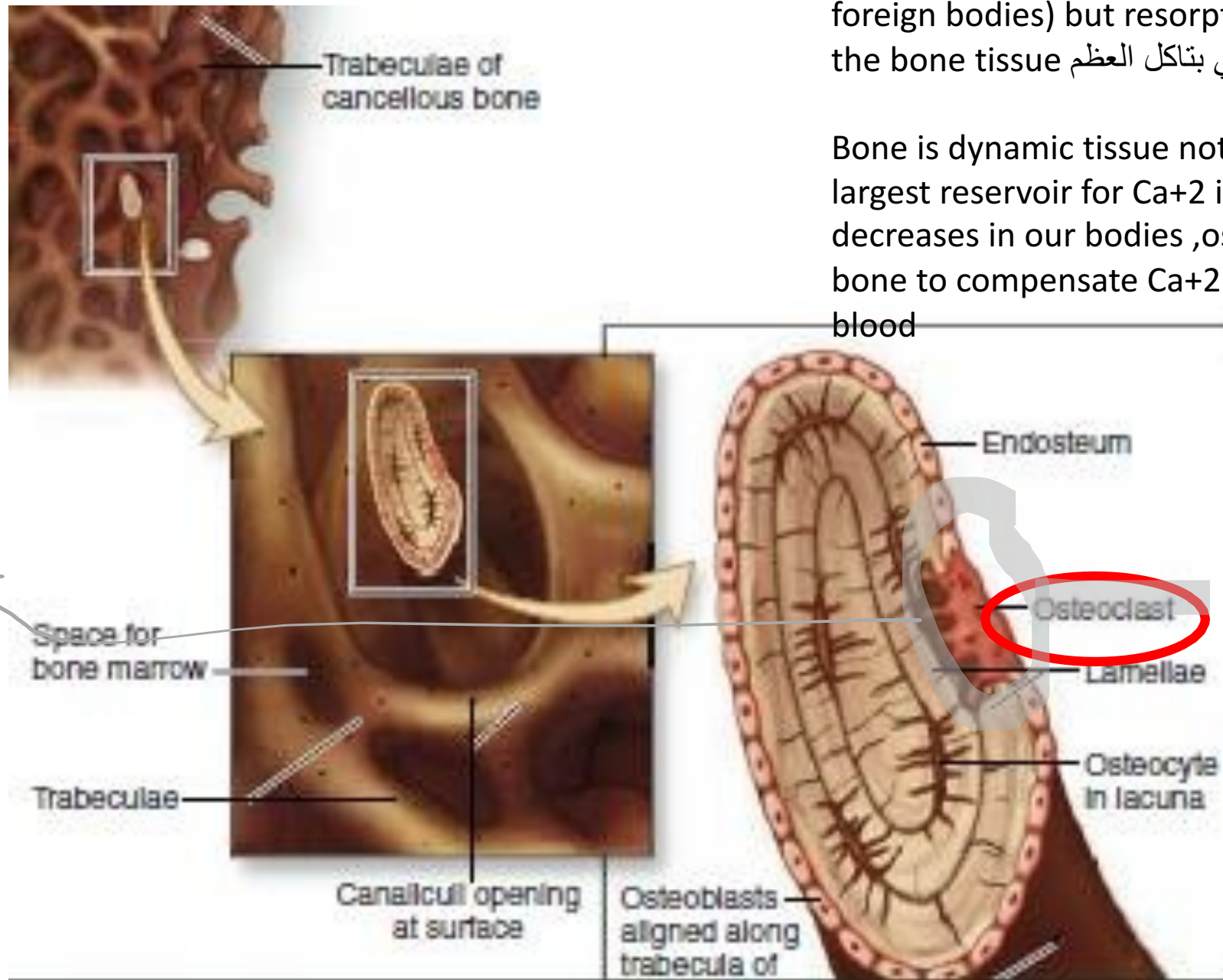
- Osteocytes are the most abundant cells in bone.
- Osteocytes exhibit significantly less RER, smaller Golgi complexes, and more condensed nuclear chromatin than osteoblasts
- Osteocytes maintain the calcified matrix, and their death is followed by rapid matrix resorption

bone formation (القول عن) osteoblasts and then the osteocytes maintaining the bone matrix.

osteoclast ← bone resorption (القول عن)

Osteoclasts

- Osteoclasts are very large, motile cells with multiple nuclei
- They are essential for matrix **resorption during bone growth and remodeling.**
- The **large size** and **multinucleated** condition of osteoclasts are due to their origin from the fusion of bone marrow-derived monocytes
- Osteoclasts on the bone surface lie within cavities in the matrix known as **resorption lacunae (or Howship lacunae).**



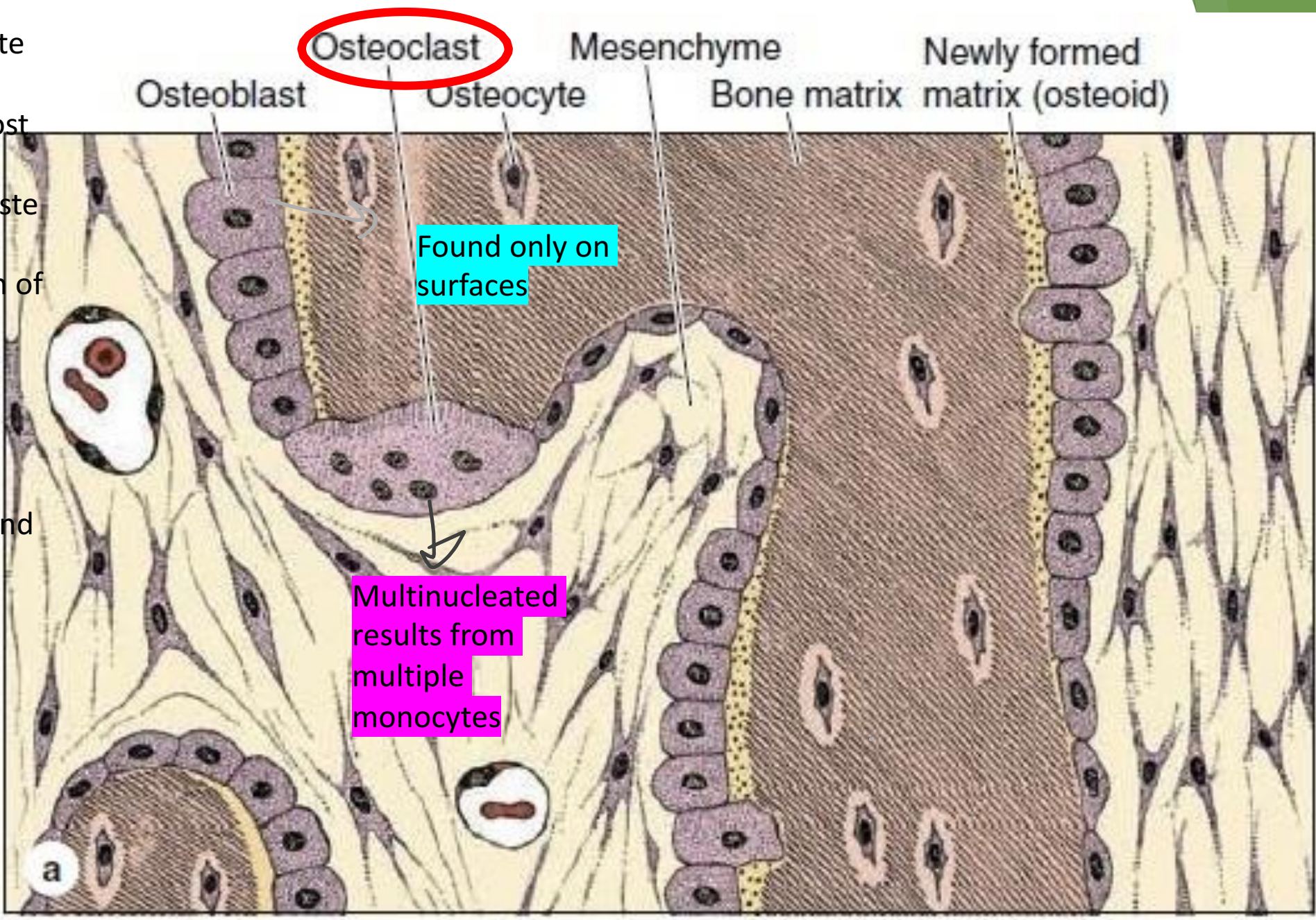
Osteoclast is a macrophage (doesn't attack foreign bodies) but resorption and hydrolyzing the bone tissue يعني يتاكل العظم

Bone is dynamic tissue not static and it is the largest reservoir for Ca^{+2} in our bodies ,if Ca^{+2} decreases in our bodies ,osteoclast will resorb bone to compensate Ca^{+2} and transport it to blood

Osteoclast is beside osteoblast on surface It has its own lacunae and it is called (resorption, howship lacunae) to identify it from the lacunae of osteocyte

On other hand : exercising in gym for example: cause resistance training ,muscles are attached to bones , so pulling bones which causes more formation to resist tension by increasing bone formation and density
By osteocyte

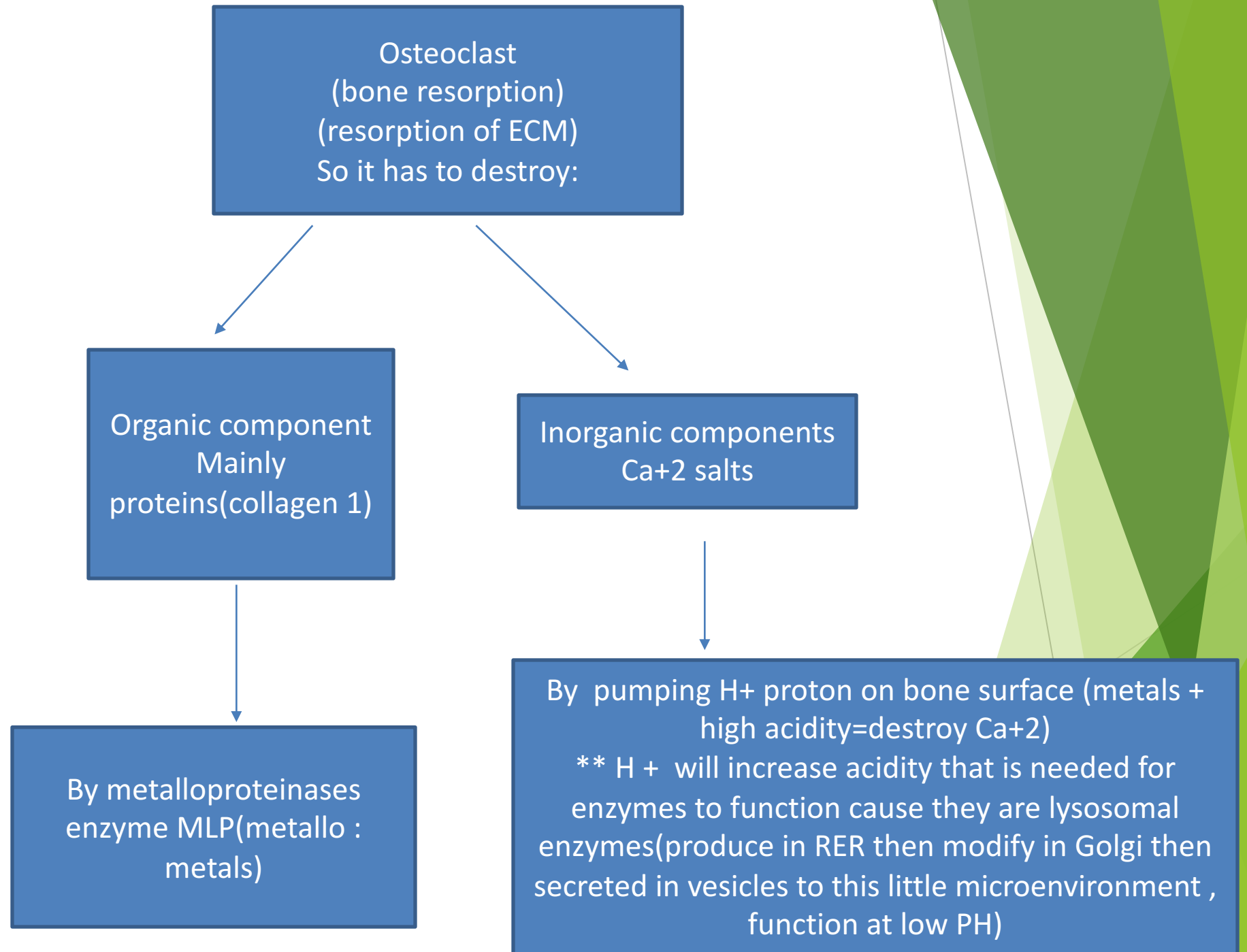
Bone is in dynamic state
 Undergoes resorption(osteoclast) and formation(osteocyte)
 The function of osteocyte is opposite to osteoclast
 The first maintains bone ECM and the second resorpe it



Osteoblast is found in lining cavities only
 Osteocytes are most abundant
 osteoclast هو ماتت
 رح اتفوز
 Osteocyte
 يعني العظم بضل

Bone resorption

- In an active osteoclast the membrane domain that contacts the bone forms a circular **sealing zone** which binds the cell tightly to the bone matrix and surrounds an area with many surface projections, called **the ruffled border**.
- This circumferential sealing zone allows the formation of a specialized microenvironment between the osteoclast and the matrix in which bone resorption occurs
- Into this subcellular pocket the osteoclast pumps **protons** to acidify and promote dissolution of the adjacent hydroxyapatite, and releases matrix **metalloproteinases** and other **hydrolytic enzymes** from lysosome-related secretory vesicles for the localized digestion of matrix proteins

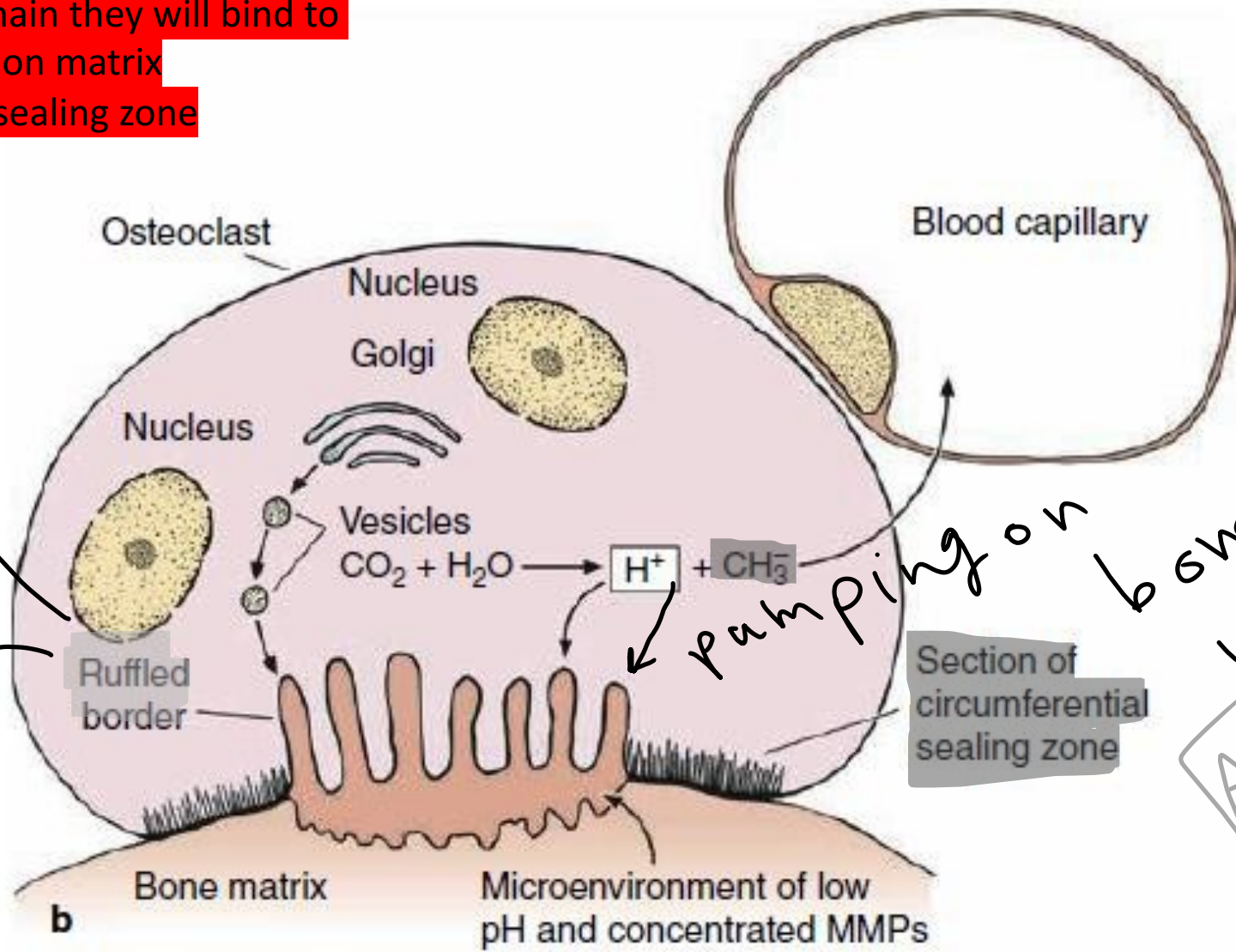


What makes the H⁺ pass to the pump without sealing or losing ATP:

- 1) The anion (CH₃⁻) goes directly to capillary, cause if they remain they will bind to accumulated H⁺ on matrix
- 2) circumferential sealing zone

Increase surface area, it contains H⁺ pumps
Note: more ruffles..more active

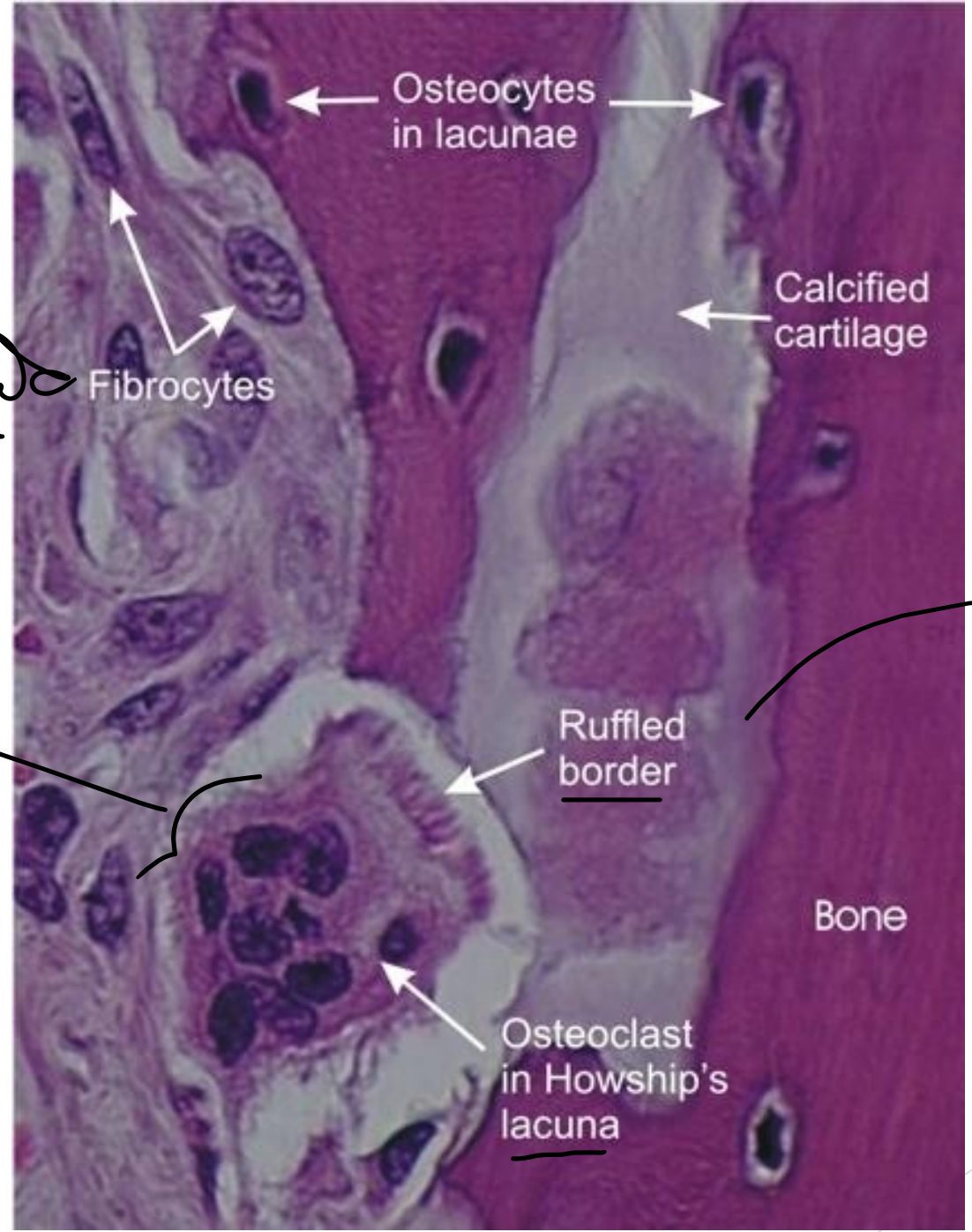
irregular surface



pumping on bone matrix using matrix

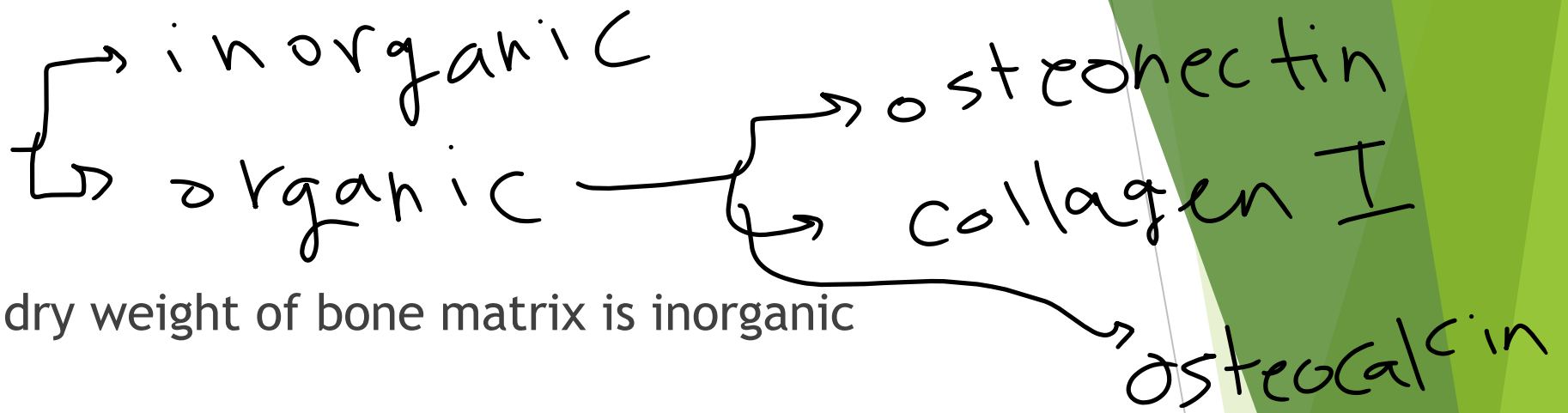
ATP

multinucleated



it's
exists
individually
that the
osteoclast
is active

Bone matrix



- About 50% of the dry weight of bone matrix is inorganic materials.
- Calcium hydroxyapatite is the most abundant inorganic material
- The organic matter embedded in the calcified matrix is 90% type I collagen, but also includes mostly small proteoglycans and multiadhesive glycoproteins such as osteonectin (it is adhesive glycoprotein)
- Calcium-binding proteins, notably osteocalcin (not adhesive protein but Ca^{+2} binding protein, holding and maintaining Ca^{+2}), promote calcification of the matrix
- The association of minerals with collagen fibers during calcification provides the hardness and resistance required for bone function

13. All of the following statements about bone cells are correct EXCEPT:

- a) Osteoblasts produce type I collagen
- b) Osteocytes are often grouped in nests inside lacunae as a result of earlier mitoses
- c) Osteoblasts are mononucleate cells

- d) Osteoclasts form the ruffled border that opposes the surface of the bone tissue
- e) Some osteoblasts turn into osteocytes while the new bone is being formed

Answer: b

6. Osteocytes maintain contact with the blood vessels of the central canal through

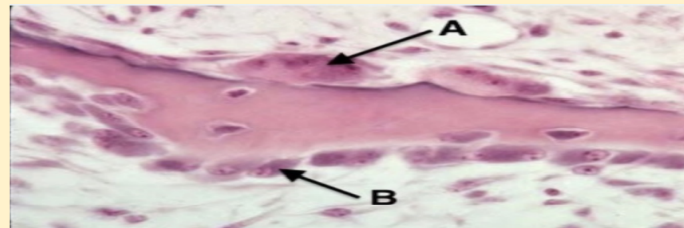
- a) Concentric lamellae
- b) Interstitial lamellae
- c) Canaliculi
- d) Perforating fibers
- e) Periosteum

Answer: c

29. Which of the following cells is located in Howship's lacuna?

- a) Chondroblast
- b) Osteogenic cell
- c) Osteoblast
- d) Osteocyte
- e) Osteoclast

59. Practical: Identify A:



- a) Osteoblast
- b) Chondrocyte
- c) Osteoclast
- d) Fibrocyte
- e) Osteocyte

Answer: c

"لا يكف
الله نفساً إلا
وسعها"

التزويج
بس صحتك
ع