Bone2

Hanan Jafar. BDS.MSc.PhD

Writer: Noor Abu Hantash

Corrector: Toleen Haddad

Quick revision

Bone is special type of CT , with mineralized ECM and 3 types of cells:
Osteoblast that originates from mesenchymal cells (osteoprogenitor cells ,step further from mesenchyme)) and produces organic material(osteoid)
Then it calcifies Ca+2 in ECM (inorganic materials) when osteoblast becomes trapped in its lacunae it becomes osteocyte(that maintains Ca+2 in ECM)and the 3rd type is osteoclast that resorps bone
*bone is dynamic : it is produced(bone formation) and destructed(bone resorption)

- If blood needs Ca+2… osteoclast is active
- If bone needs Ca+2 … osteocyte is active

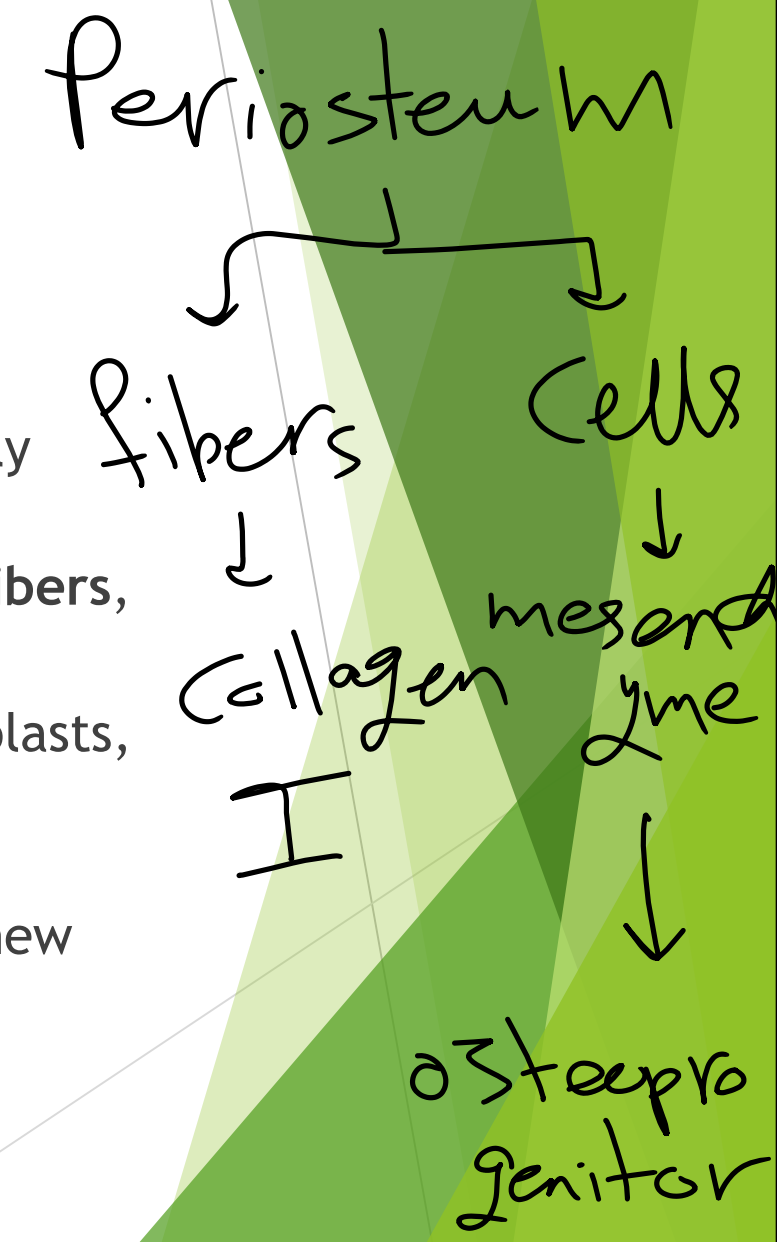
Endosteum and Periosteum

- bone tissue is supported by regular CT from outside (periosteum: dense regular CT,peri: surround whole bone tissue) and from inside: endosteum (en : inside) , lines bone cavity)

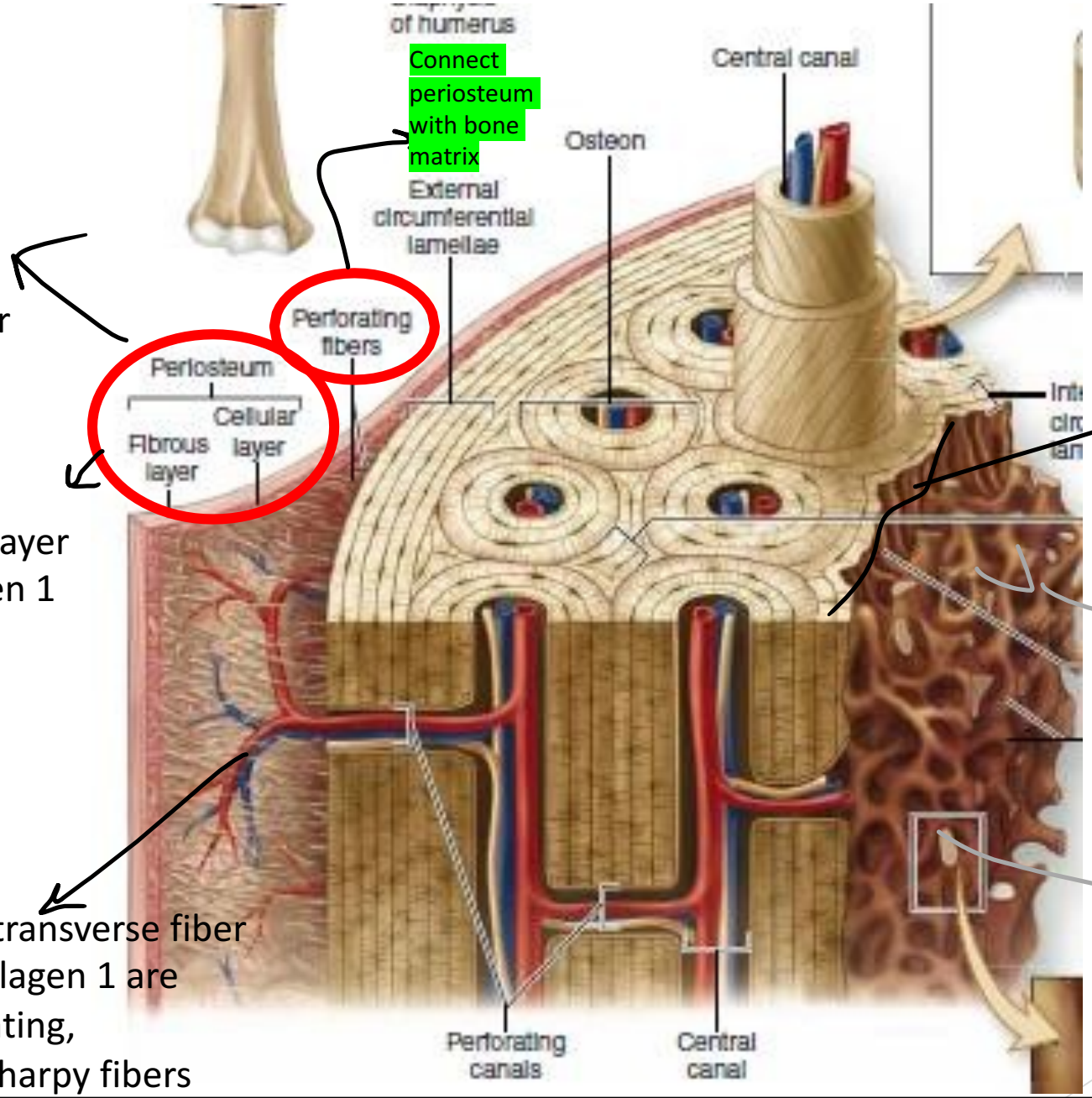
All bones are lined on their internal and external surfaces by layers of connective tissue containing osteogenic cells—**endosteum** on the internal surface surrounding the marrow cavity and **periosteum** on the external surface.

Periosteum (should be attached to bone because we need to protect it)

- The **periosteum** is organized much like the perichondrium of cartilage, with an outer fibrous layer of dense connective tissue PERIOSTEUM not calcified it is not a part of CT, containing mostly bundled type I collagen, but also fibroblasts and blood vessels.
- Bundles of periosteal collagen, called **perforating** (or **Sharpey**) **fibers**, penetrate the bone matrix and bind the periosteum to the bone.
- The periosteum's inner layer is more cellular and includes osteoblasts, bone lining cells, and mesenchymal stem cells referred to as **osteoprogenitor cells.**
- With the potential to proliferate extensively and produce many new osteoblasts, osteoprogenitor cells play a prominent role in bone growth and repair.



nner layer
t has
mesenchymal
cells then
osteoprogenitor
And lined with
osteoblast



endosteum

Outer layer
Collagen 1

Trabeculae(معناها متاهة)

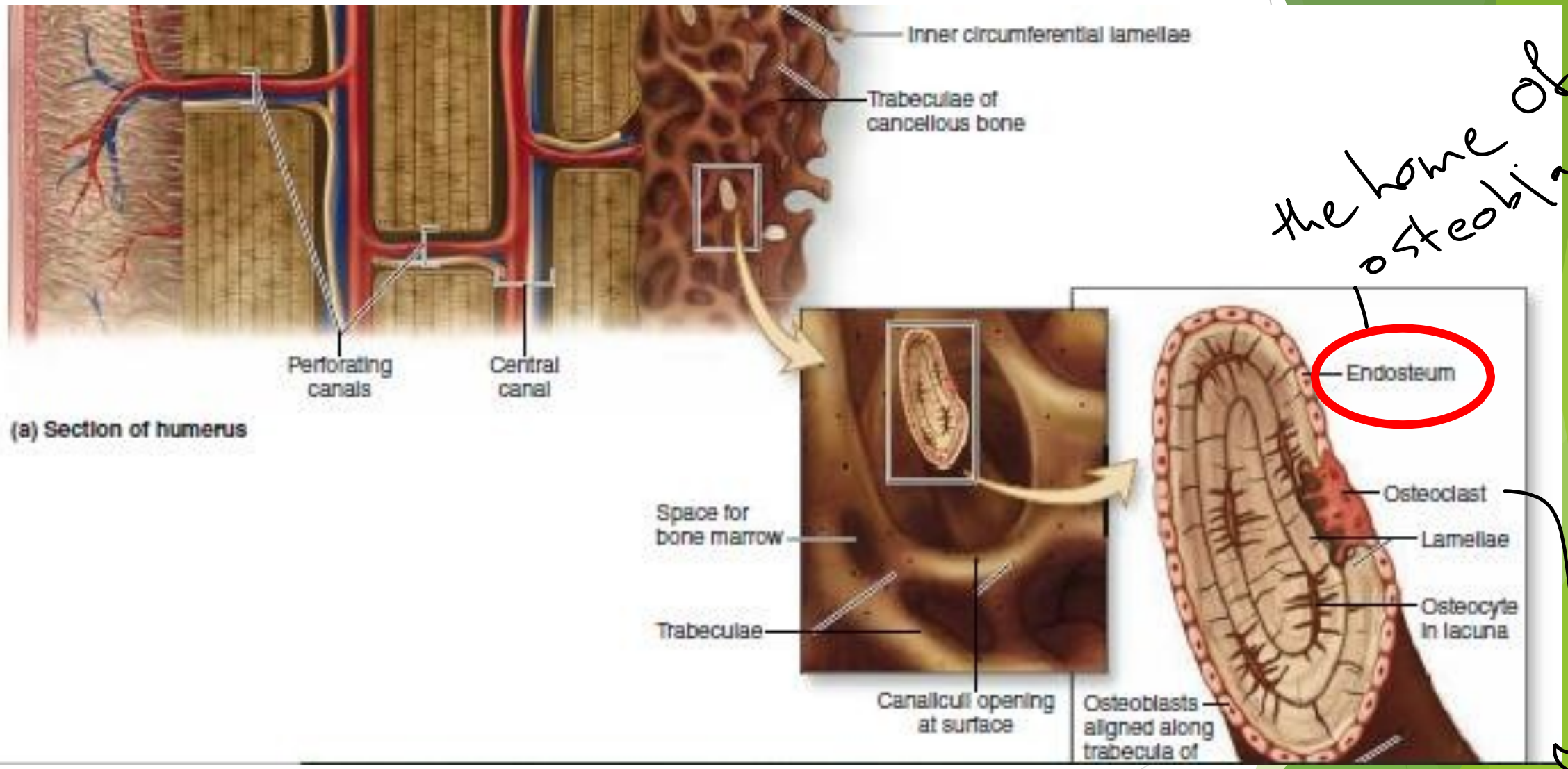
Horizontal or transverse fiber bundles of collagen 1 are called penetrating, perforating , sharpy fibers

These spaces aren't real spaces they are filled with bone marrow نخاع العظم أو نقي العظم

Endosteum(it is rich in cells(mesenchymal ,osteoprogenitor, osteoblast it has collagen fibers but not bundles so it isn't strong as periosteum cause it functions in lining not in protection)

- Internally the very thin **endosteum** covers small **trabeculae** of bony matrix that project into the marrow cavities
- The endosteum also contains osteoprogenitor cells, osteoblasts, and bone lining cells, but within a sparse, delicate matrix of collagen fibers.

It is the home of osteoprogenitor and osteoblast…it regenerates them



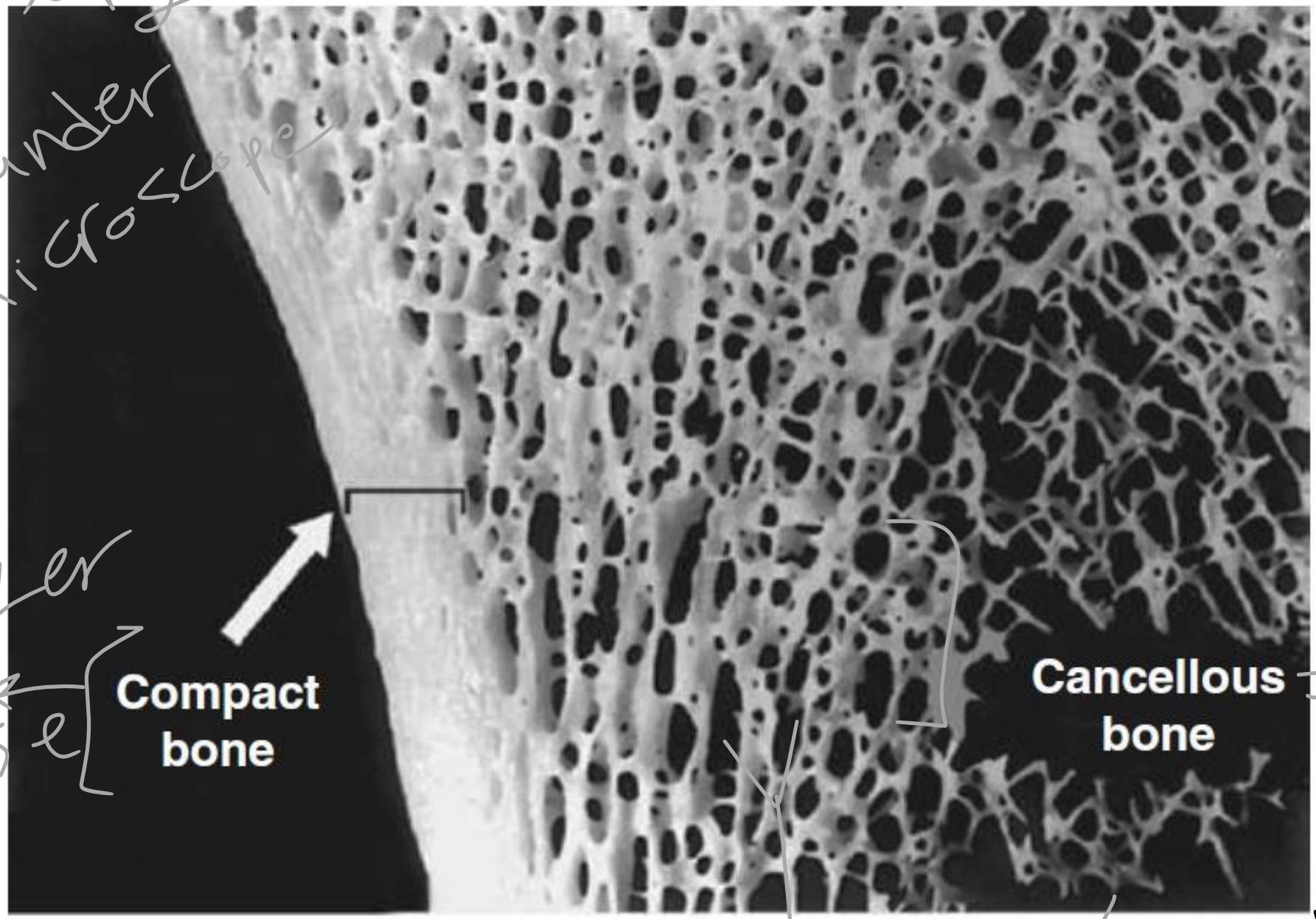
the home of osteoblast

on surface

Types of Bone

- Gross observation of a bone(بالعين المجردة ,macroscopy)in cross section shows a dense area near the surface corresponding to **compact (cortical) bone**, which represents 80% of the total bone mass, and deeper areas with numerous interconnecting cavities, called **cancellous (trabecular) bone(spongy bone)**, constituting about 20% of total bone mass.

= macroscopy
= not under microscope



outer layer condense

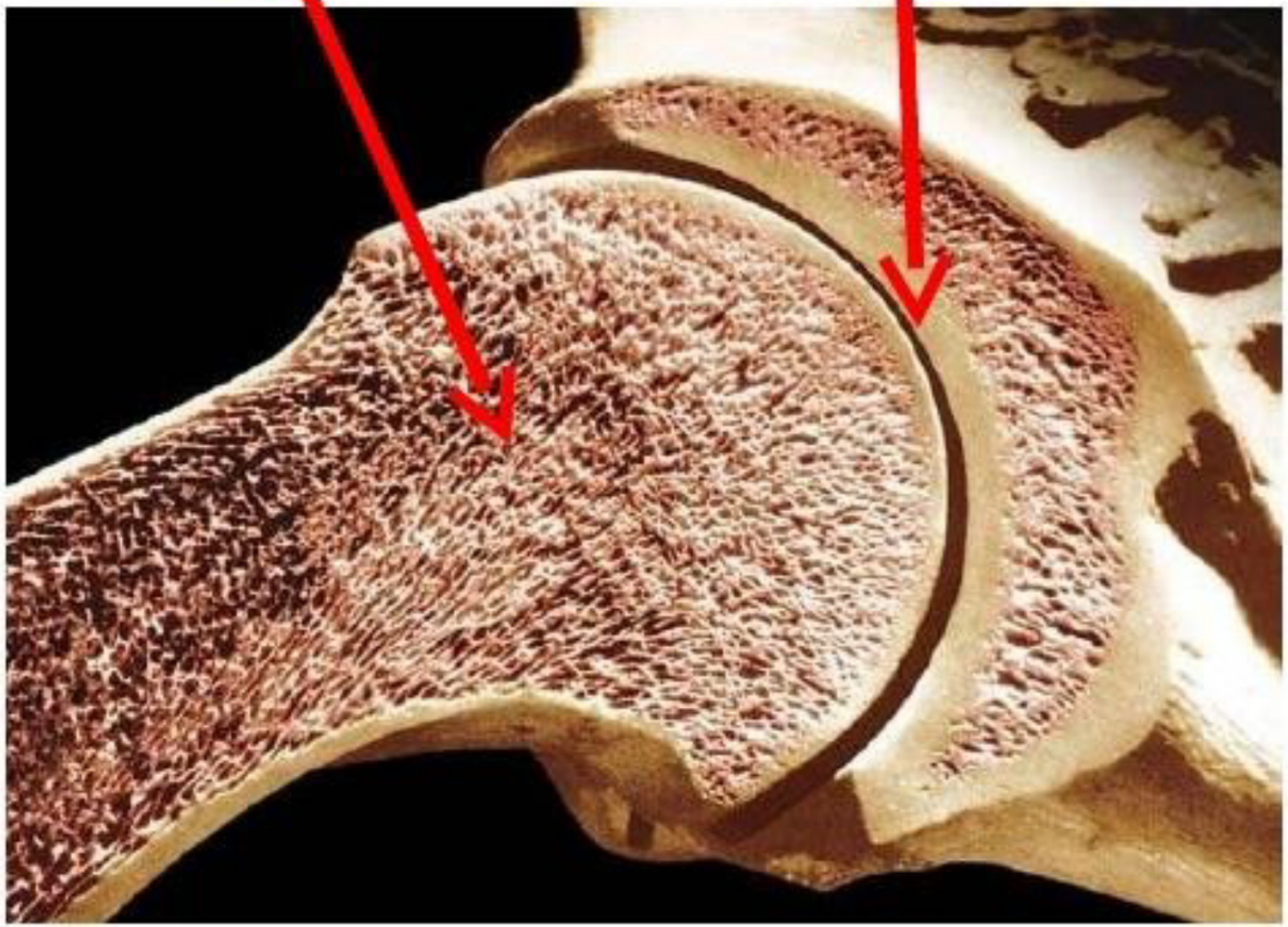
pores / poroys tissue

= Spongy = trabicula

gross observation

Spongy Bone

Compact Bone



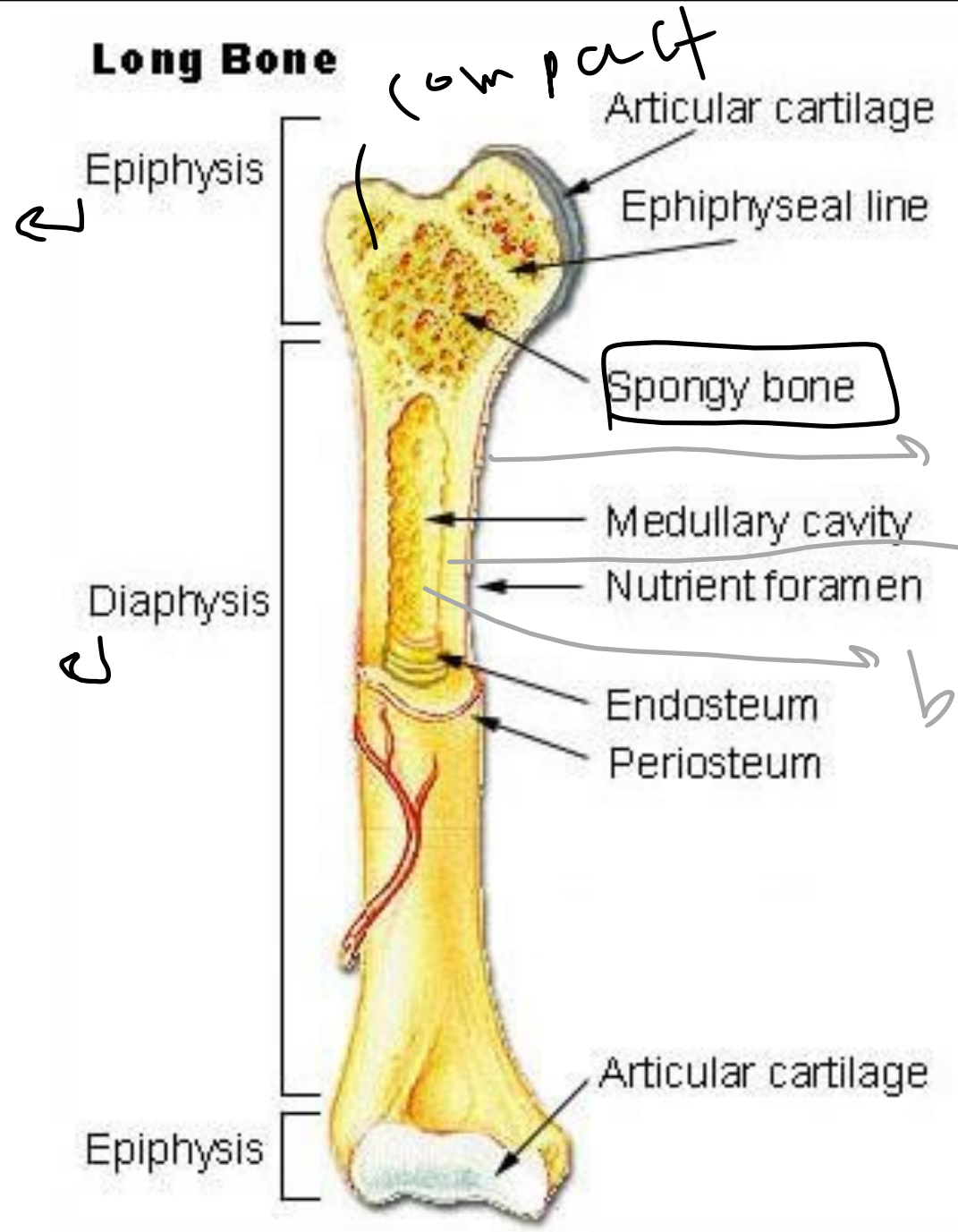
As can be seen from this picture, under normal magnification spongy bone looks porous, while compact bone looks solid.

Correlation between Anatomy and Histology

- In long bones, the bulbous ends—called **epiphyses** —are composed of cancellous bone covered by a thin layer of compact cortical bone.
- The cylindrical part—the **diaphysis**—is almost totally dense compact bone, with a thin region of cancellous bone on the inner surface around the central **marrow cavity**
- Short bones such as those of the wrist and ankle usually have cores of cancellous bone surrounded completely by compact bone.
- The flat bones that form the calvaria (skull) have two layers of compact bone called **plates**, separated by a thicker layer of cancellous bone called the **diploë** **(only in skull it is called dipole) but in other flat bone it has the same arrangement also)**

Outside→compact bone
Inside→ the core→spongy

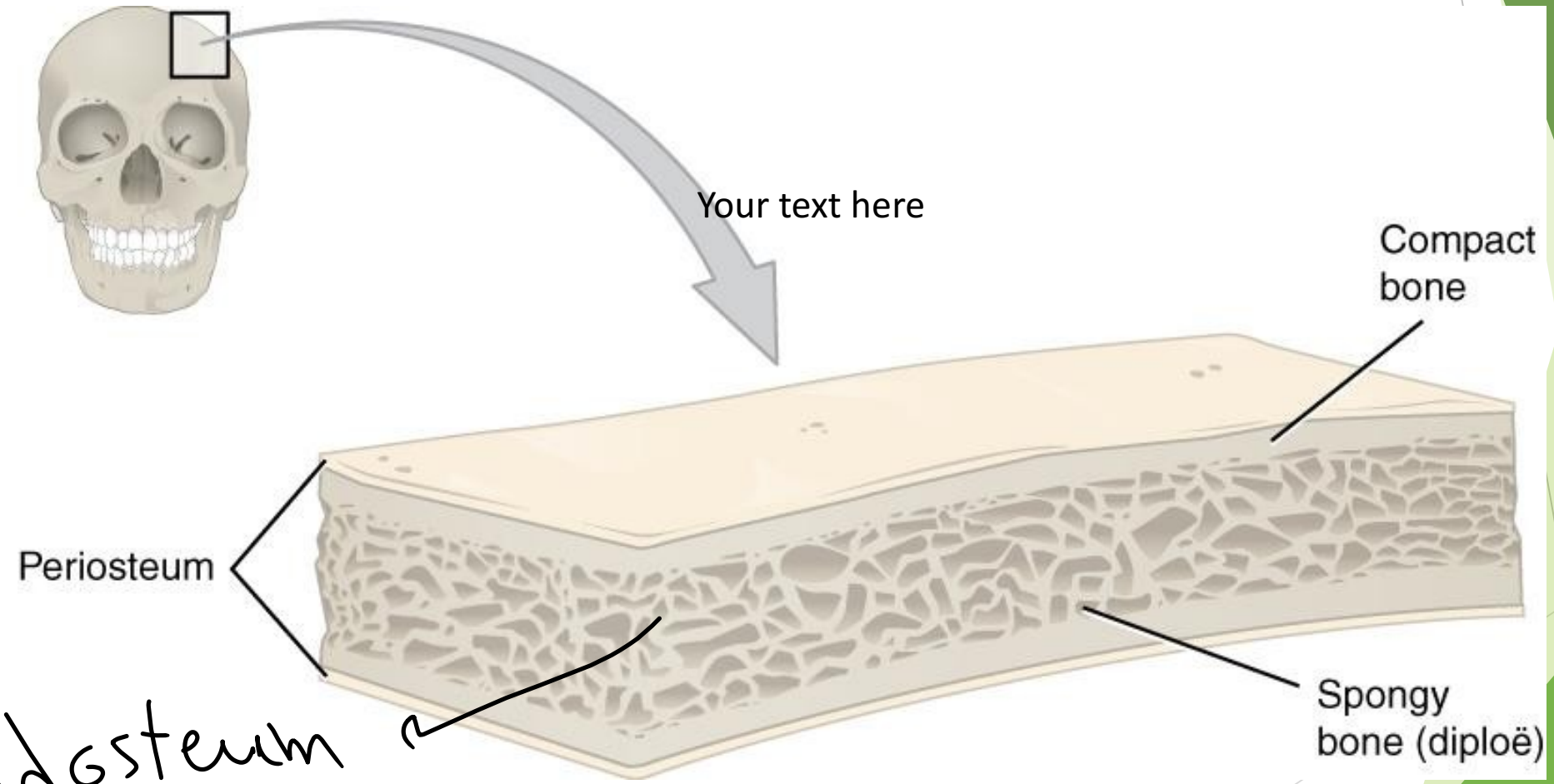
Outside→ compact
Small area→ spongy
The core→ bone marrow



Flat bone(head bone, scapula)

Outside → compact surrounded by periosteum

Inside→ spongy→ it is very thick



endosteum

in skull / spongy is called diploë

Organization of Bone

#osteoid → woven → lamellar bone

- At the microscopic level both compact and cancellous bone typically show two types of organization: (shows 2 lamelli طبقات)
  - **lamellar bone**,(more cells ,found in adult) which is mature with matrix existing as discrete sheets, forms mot bone, it is compacted layer includes both compact and spongy bones
  - **woven bone**,(less cells , found in children , they are still in growth) newly formed with randomly arranged components, newly bone , randomly arranged ,when bone started to be formed it was irregular and randomly arranged then osteoblasts , osteoclasts and osteocytes arrange ECM into layers

يعني اول ما بلشت اتصنع صارت تصنع سرسع سريع فما كانوا مرتبين كانوا woven

بعدين رتبتهم لطبقات فصاروا lamellar

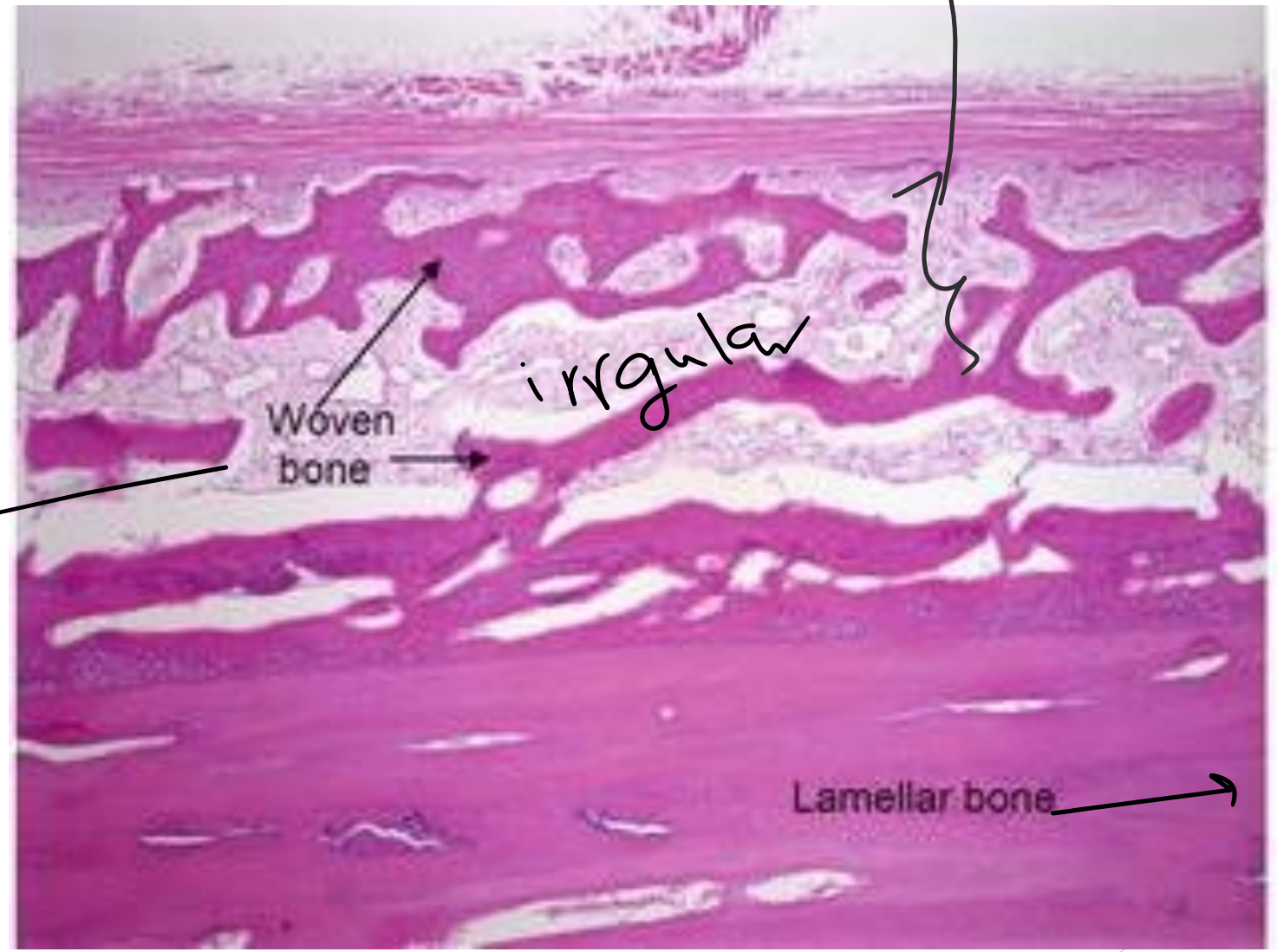
Lamellar bone

- Most bone in adults (80%), compact or cancellous, is organized as **lamellar bone**, characterized by multiple layers or **lamellae** of calcified matrix
- The lamellae are organized as parallel sheets (cancellous) or concentrically around a central canal (compact)(cylindrical)

Woven bone (high concentration of organic materials and Low Ca+2 deposition

- **Woven bone** is nonlamellar and characterized by random disposition of type I collagen fibers and is the first bone tissue to appear in embryonic development and in fracture repair.
- Woven bone is usually temporary and is replaced in adults by lamellar bone, except in a very few places in the body, for example, near the sutures of the calvaria and in the insertions of some tendons.
- In addition to the irregular, interwoven array of collagen fibers, woven bone typically has a lower mineral content (it is more easily penetrated by x-rays) so it appears less dense and a higher proportion of osteocytes than mature lamellar bone.
- These features reflect the facts that immature woven bone forms more quickly but has less strength than lamellar bone.

cartilage replaced with bone



it's closed to woven

irregular

newly born bone

This makes sense cause it has osteoprogenitor cells that produce osteoblasts that are needed in making woven bone

layer = mature & organized

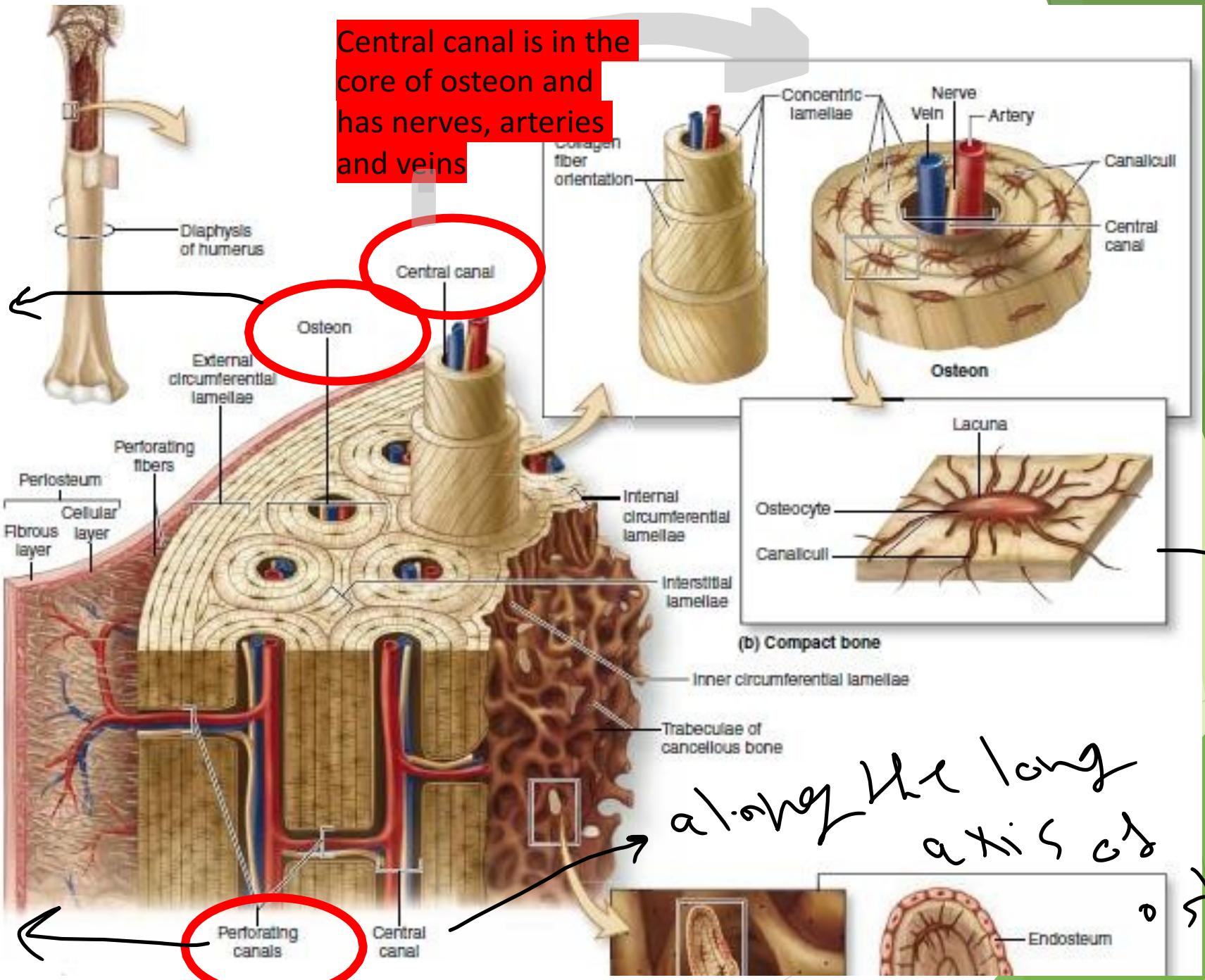
Havarsian system

- An **osteon (or Haversian system)** refers to the complex of concentric lamellae, surrounding a central canal that contains small blood vessels, nerves, and endosteum(found only in compact bone while spongy is in form of layers)
- Between successive lamellae are lacunae, each with one osteocyte, all interconnected by the canaliculi containing the cells' processes
- Processes of adjacent cells are in contact via gap junctions, and all cells of an osteon receive nutrients and oxygen from vessels in the central canal
- The outer boundary of each osteon is a layer called the cement li which includes many more non-collagen proteins in addition to mineral and collagen
- Haversian canals also communicate with one another through transverse **perforating canals** (or **Volkmann canals**)

Note:
Osteon: haversian system
Osteoid: the first form of organic materials in bone

Osteon= haversian system (organic + inorganic) Concentrical lamellae around the central canal it is found in compact bone only While spongy bones are parallel layers

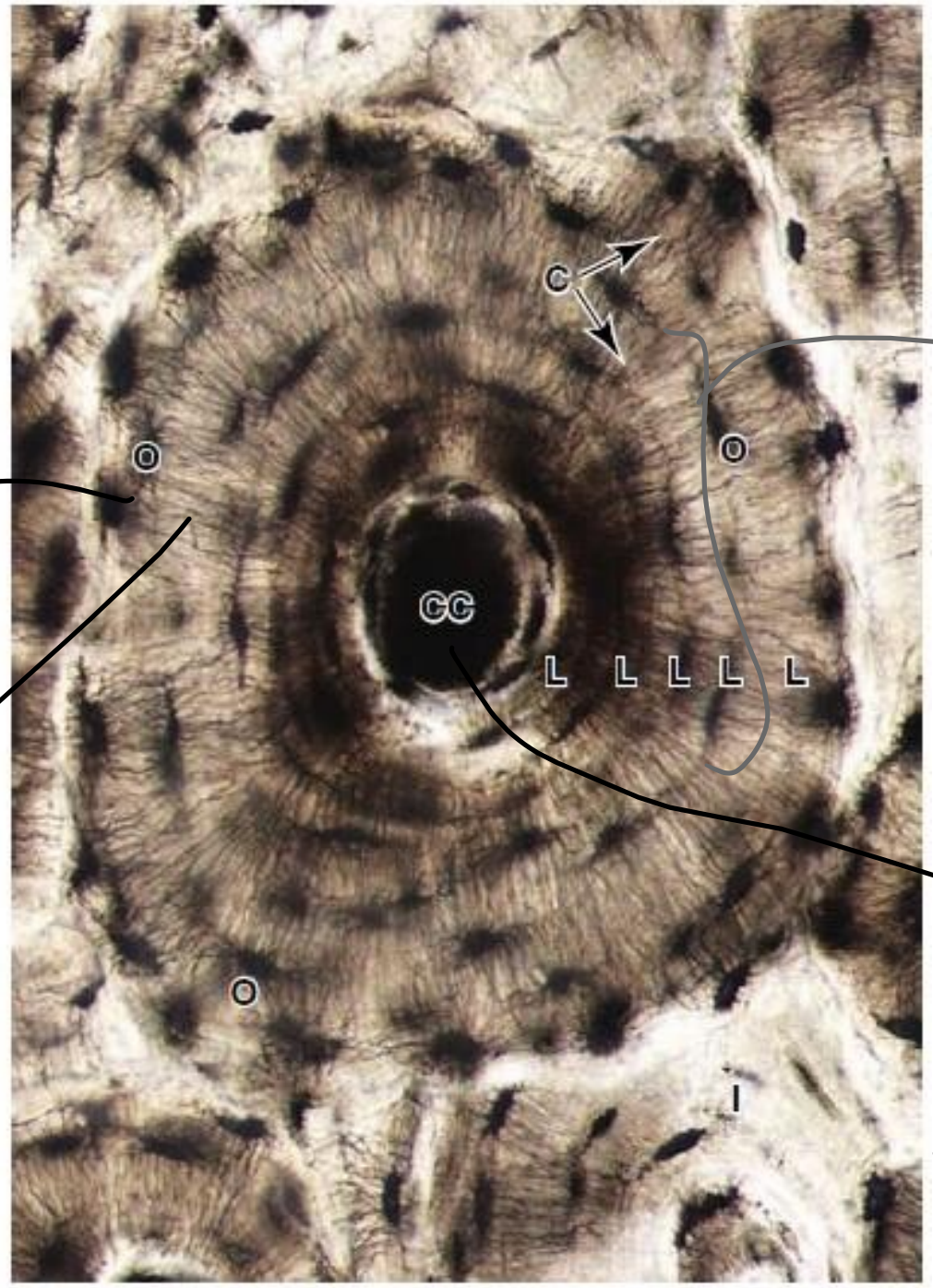
Central canal is in the core of osteon and has nerves, arteries and veins



It is the trapped osteocyte with processes embedded in their canaliculi

volkmann Horizontal Connections between adjacent central canals of adjacent osteons or havarsian

along the long axis of osteon



Osteon

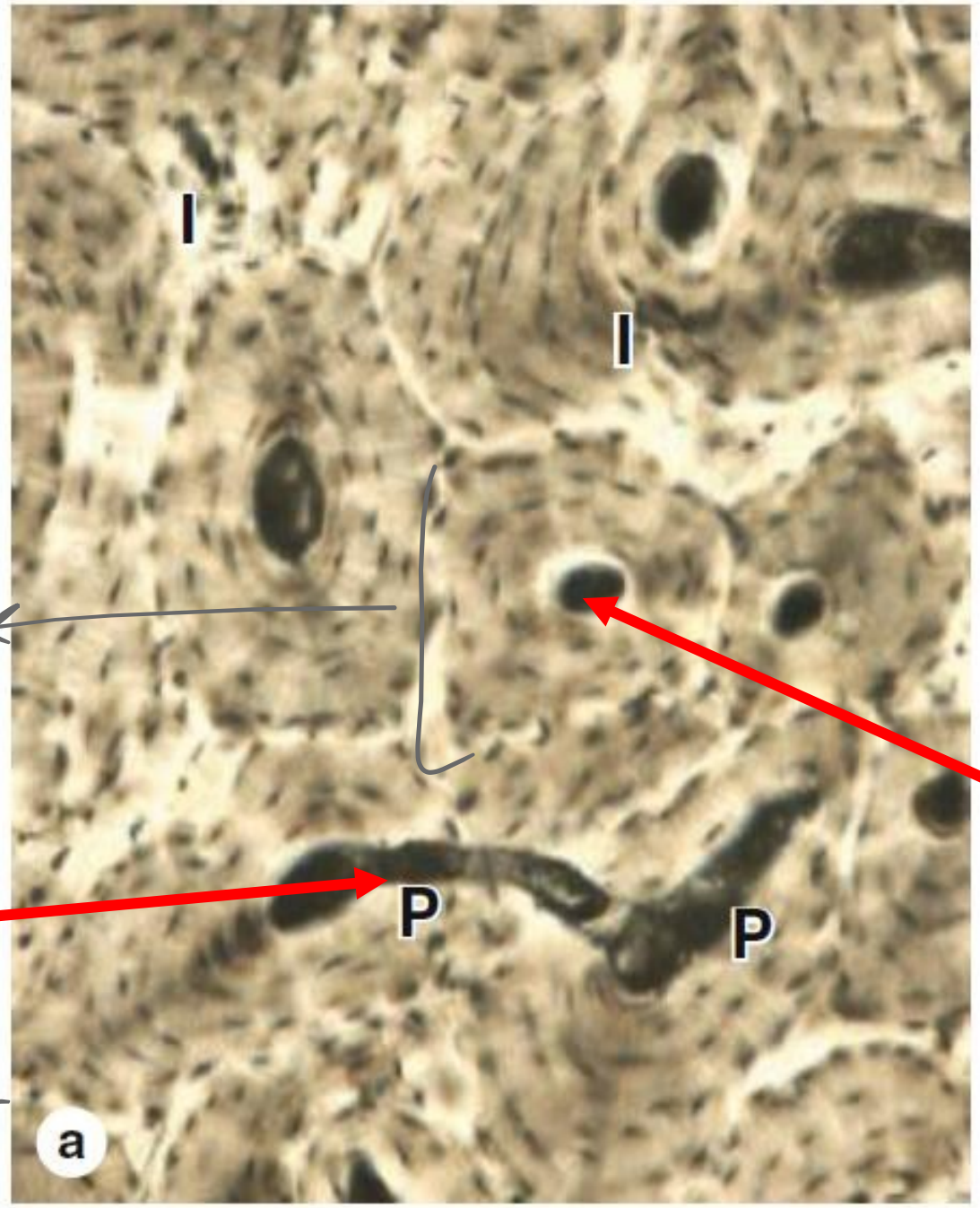
Osteocyte in its own lacunae

Processes in canaliculi

Cc: central canal

Some note about preparation:
No stain
black

LM



osteon

= Volkman's canal

= perforating canal

Havarsian canal

Table 8–1 Summary of bone types and their organization.

Type of Bone	Histological Features	Major Locations	Synonyms
Woven bone, newly calcified	Irregular and random arrangement of cells and collagen; lightly calcified	Developing and growing bones; hard callus of bone fractures	Immature bone; primary bone; bundle bone
Lamellar bone, remodeled from woven bone	Parallel bundles of collagen in thin layers (lamellae), with regularly spaced cells between; heavily calcified	All normal regions of adult bone	Mature bone; secondary bone
Compact bone, ~80% of all lamellar bone	Parallel lamellae or densely packed osteons, with interstitial lamellae	Thick, outer region (beneath periosteum) of bones	Cortical bone
Cancellous bone, ~20% of all lamellar bone	Interconnected thin spicules or trabeculae covered by endosteum	Inner region of bones, adjacent to marrow cavities	Spongy bone; trabecular bone; medullary bone

Lamellar bone is more acidophilic

Osteoid : only organic materials
Woven has organic and inorganic materials (Ca+2 is deposited but lightly calcified)

Interstitial lamellae

- Scattered among the intact osteons are numerous irregularlyshaped groups of parallel lamellae called **interstitial lamellae**.
- These structures are lamellae remaining from osteons partially destroyed by osteoclasts during growth and remodeling of bone

They are products of bone remodeling

يعني

osteon

ضل يلف يلف

بس في اشياء ما لفت

They are interstitial lamellae

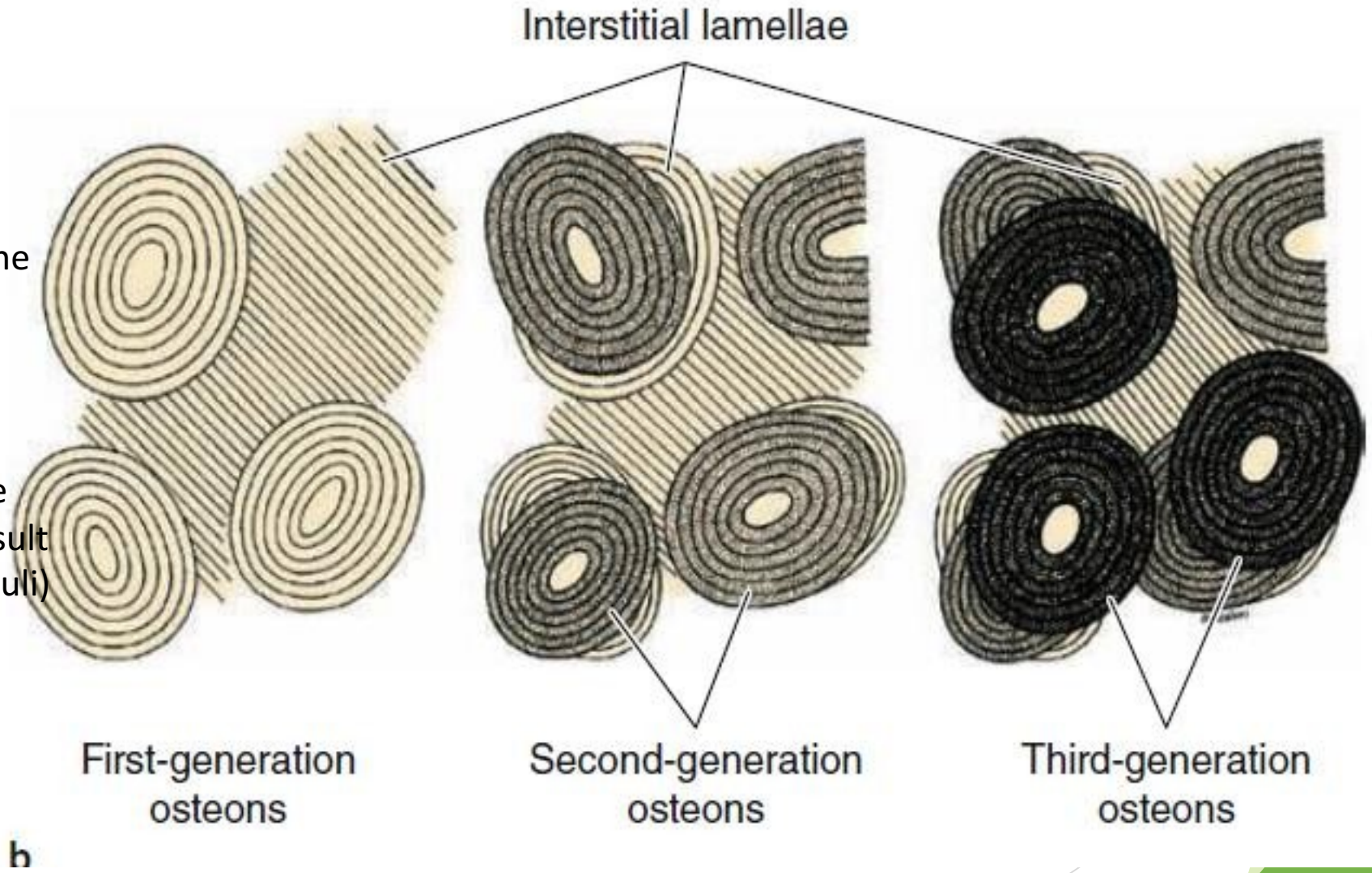
As a result of the dynamic state of bone

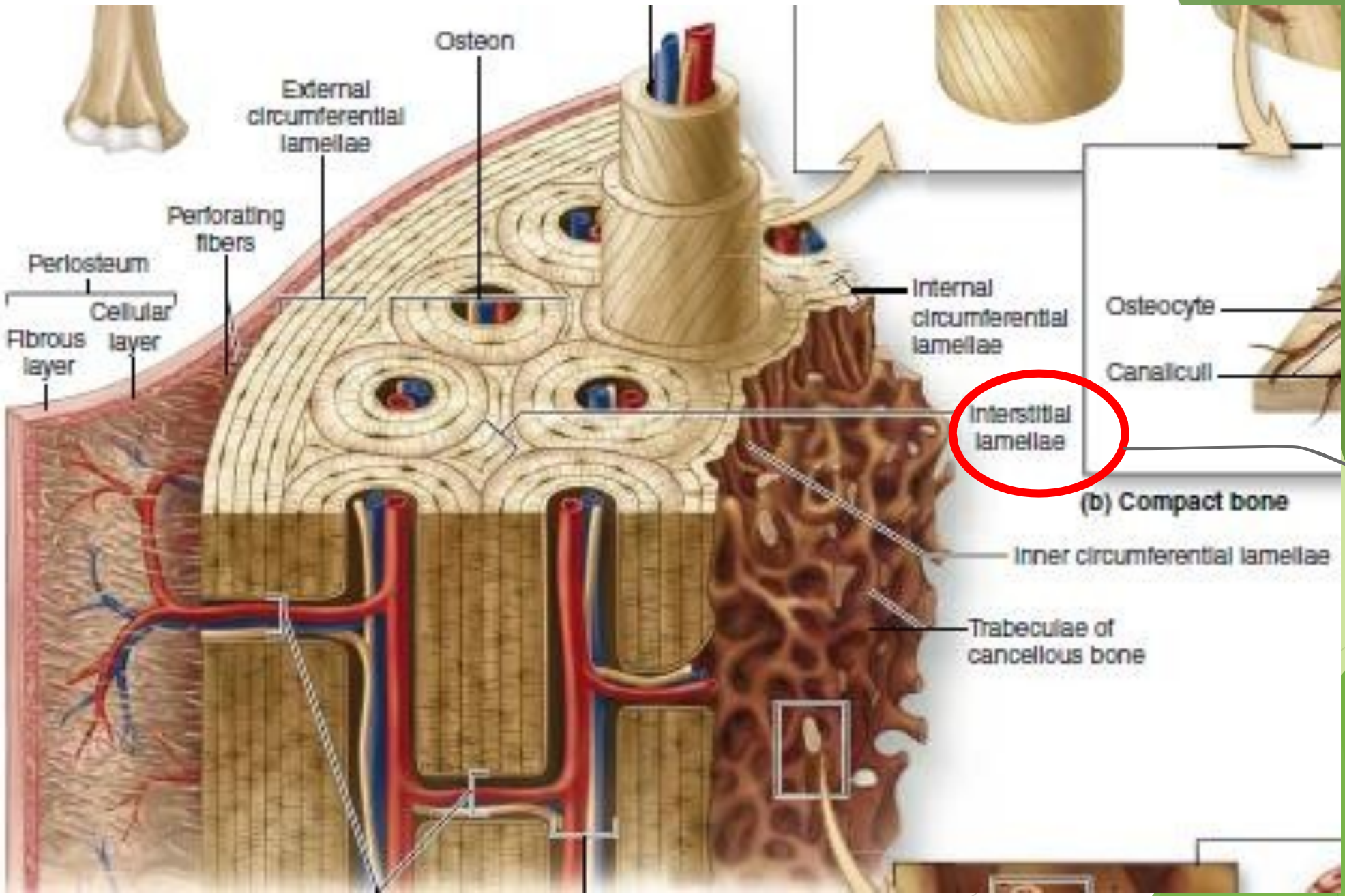
Bone is dynamic:

Formation

Remodeling(to make strength and as a result to physiological stimuli)

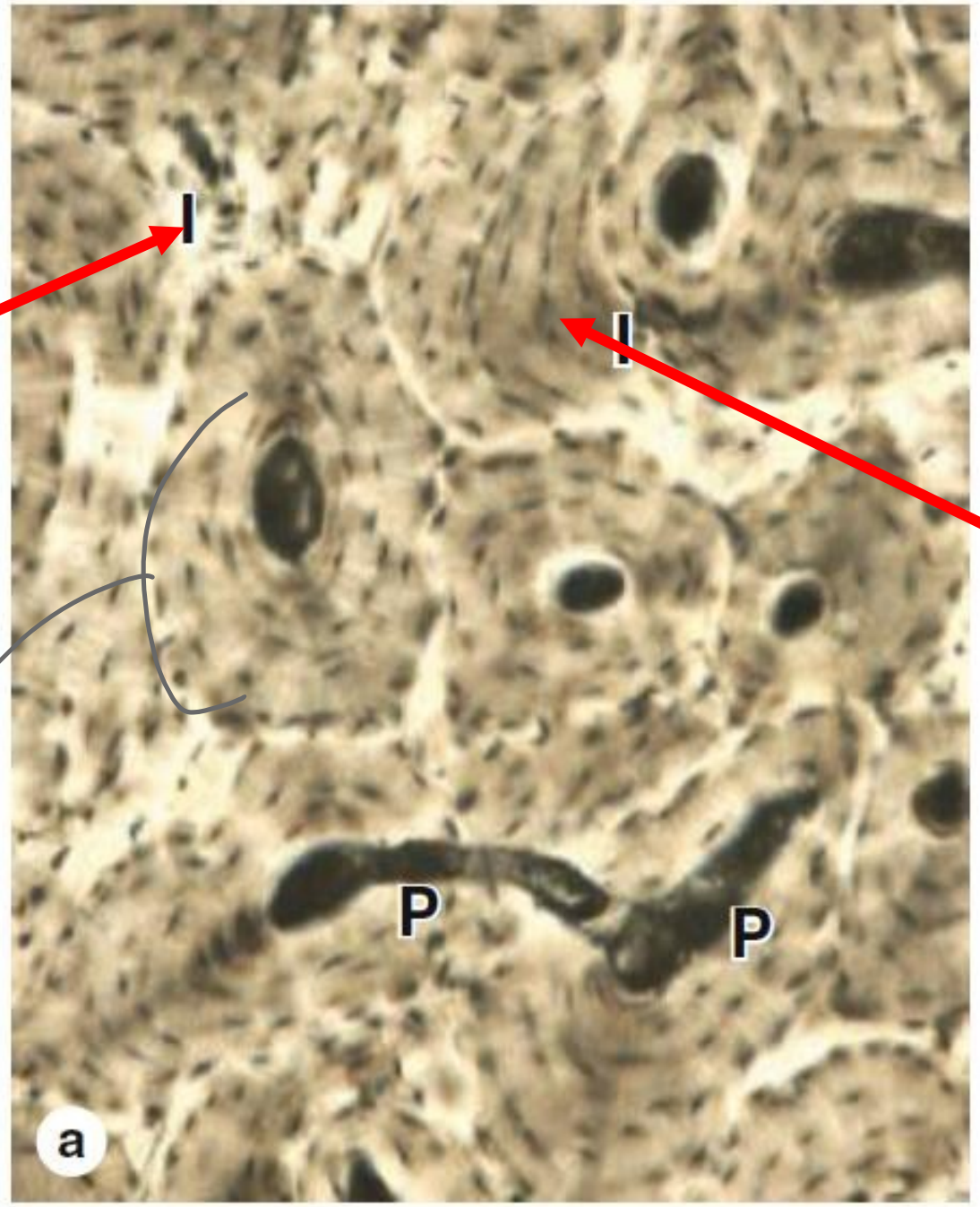
resorption





They are not incorporated in lamellae

Interstitial lamellae : not part of osteon

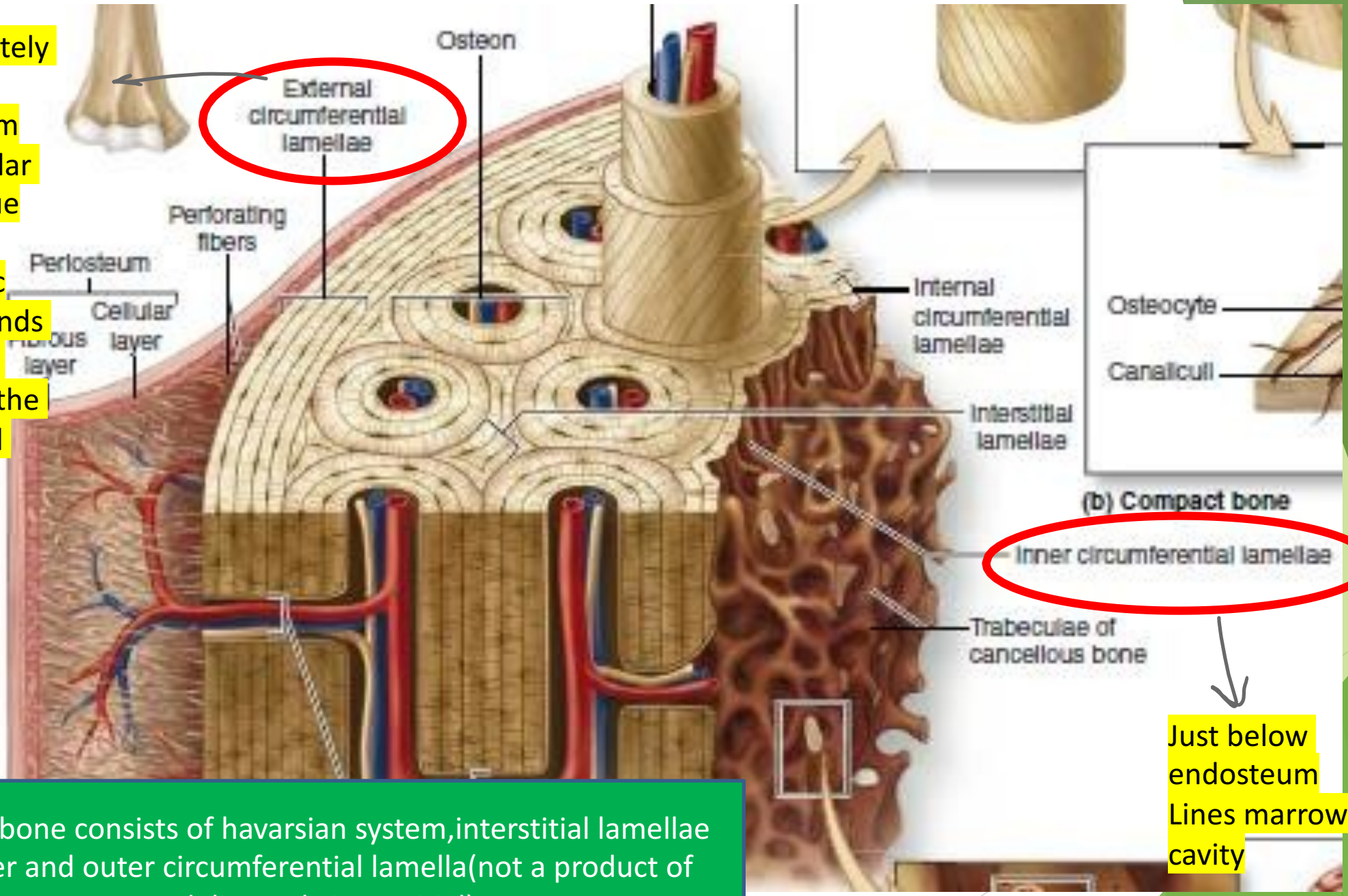


osteon

Circumferential lamellae

- Compact bone includes parallel lamellae organized as multiple **external circumferential lamellae** immediately beneath the periosteum and fewer **inner circumferential lamellae** around the marrow cavity(below endosteum)
- The lamellae of these outer and innermost areas of compact bone enclose and strengthen the middle region containing vascularized osteons.

*Immediately below periosteum
*It is regular bone tissue
*It is non concentric
*It surrounds the entire bone not the CC(central canal)



Just below endosteum
Lines marrow cavity

Compact bone consists of havarsian system,interstitial lamellae and inner and outer circumferential lamella(not a product of remodeling only interstitial)

Bone remodeling

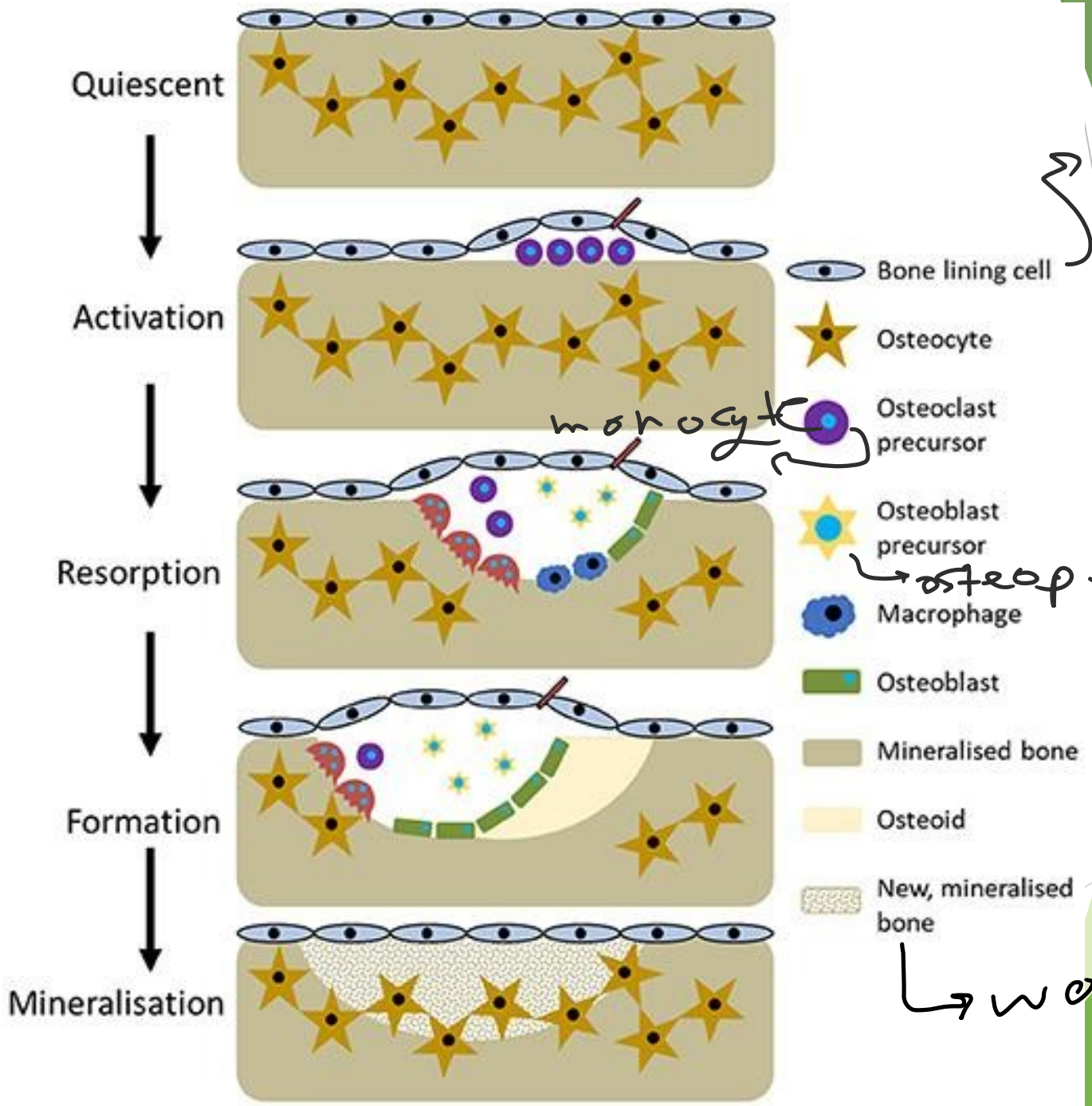
- **Bone remodeling** occurs continuously throughout life.
- In compact bone, remodeling resorbs parts of old osteons and produces new ones.
- Osteoclasts remove old bone and form small, tunnel-like cavities.
- Such tunnels are quickly invaded by osteoprogenitor cells from the endosteum or periosteum and sprouting loops of capillaries.
- Osteoblasts develop, line the wall of the tunnels, and begin to secrete osteoid in a cyclic manner, forming a new osteon with concentric lamellae of bone and trapped osteocytes.
- In healthy adults 5%-10% of the bone turns over annually.

The big restore of Ca+2 is bone

The bone is inactive then it opposes stimulus so it starts remodeling
So the monocytes (the precursor of osteoclast)fuse together to make giant osteoclast that attacks the bone matrix

Then osteoprogenitor sends osteoblasts and they start forming bone
First form is only organic → osteoid
Then it calcifies ECM(depositing Ca+2)
To produce (woven bone)
Then woven regulates and gives lamellar bone

<u>Bone formation: osteoid then calcification while mineralization is Ca+2 deposition</u>



periosteum including osteoprogenitor
osteoblast
monocyte
osteoprogenitor
woven bone

4 Preparation for histological examination

1

- Because of its hardness, bone cannot be sectioned routinely. (we cant use microtome)
- Bone matrix is usually softened by immersion in a decalcifying solution (acid solution) before paraffin embedding to remove Ca+2 salts and leave cells and collagen 1 then we complete with regular preparation (staining…) (Decalcified section)
- If a bone is decalcified by a histologist, its shape is preserved but it becomes soft and pliable like other connective tissues. Because of its high collagen content, decalcified bone matrix is usually acidophilic

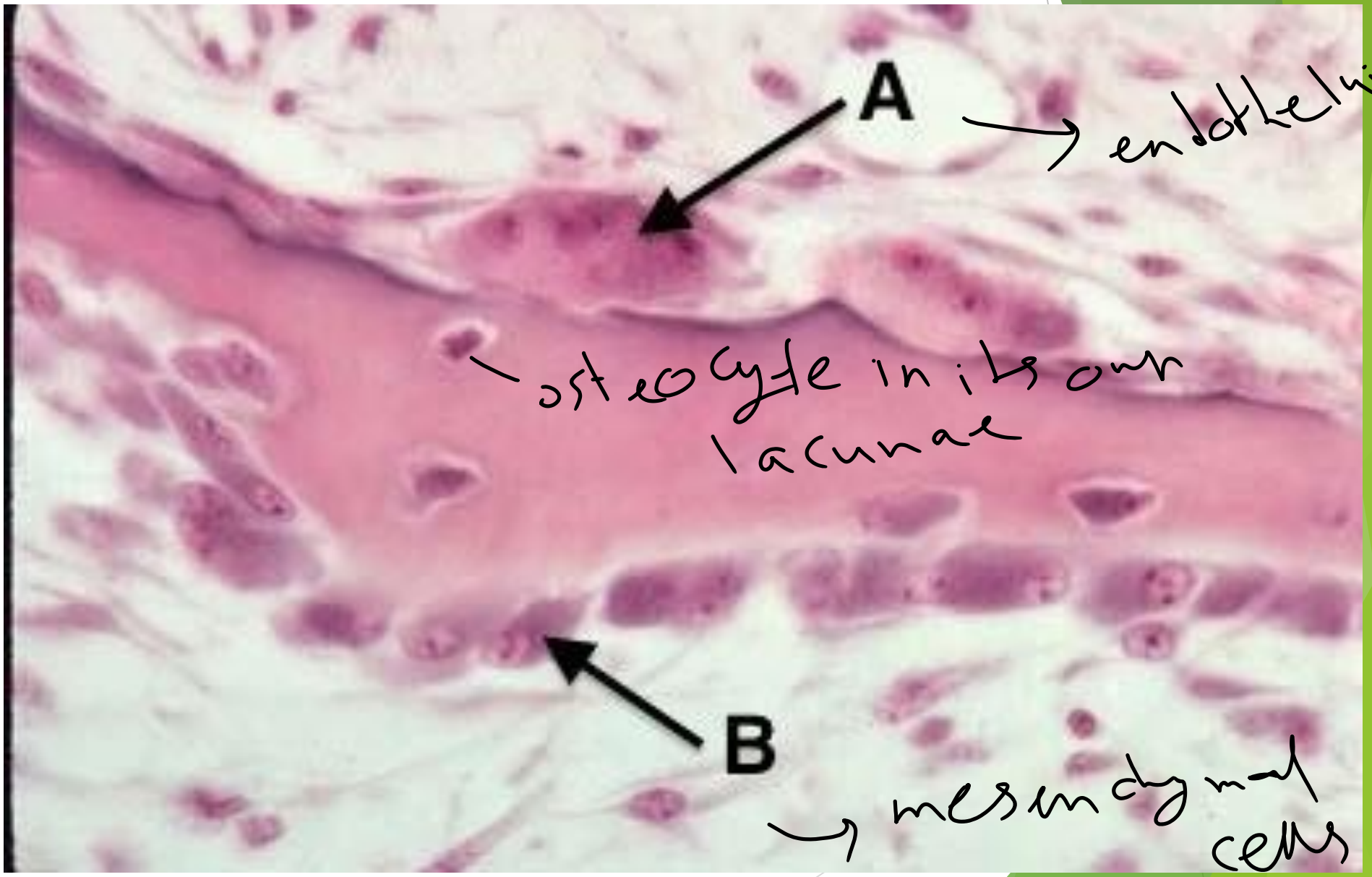
2

- Alternatively, bone can be embedded in plastic after fixation and sectioned with a specialized microtome (Ground section)

V3 of grind معناها
يحفّ او يبشر
بالتالي العظم محفوف
We don't need staining we use it to see architecture and organization of ECM and bones

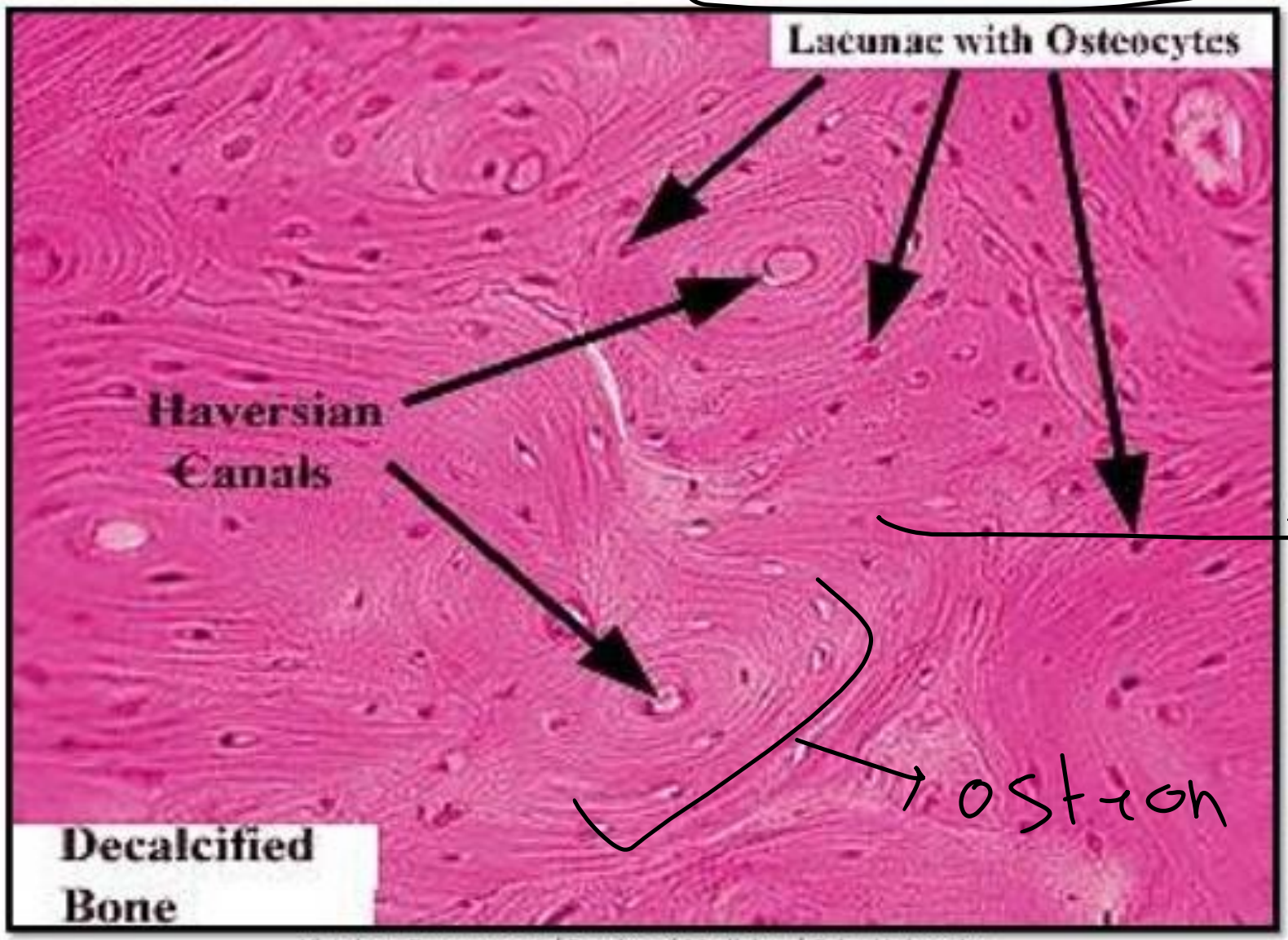
A: Osteoclast(on one side making resorption)
B: Osteoblast(on other side making formation)

Decalcified section
Regular H&E
It is acidophilic because it is rich in collagen but without Ca+2



Concentric

L.M. Decalcified Compact Bone

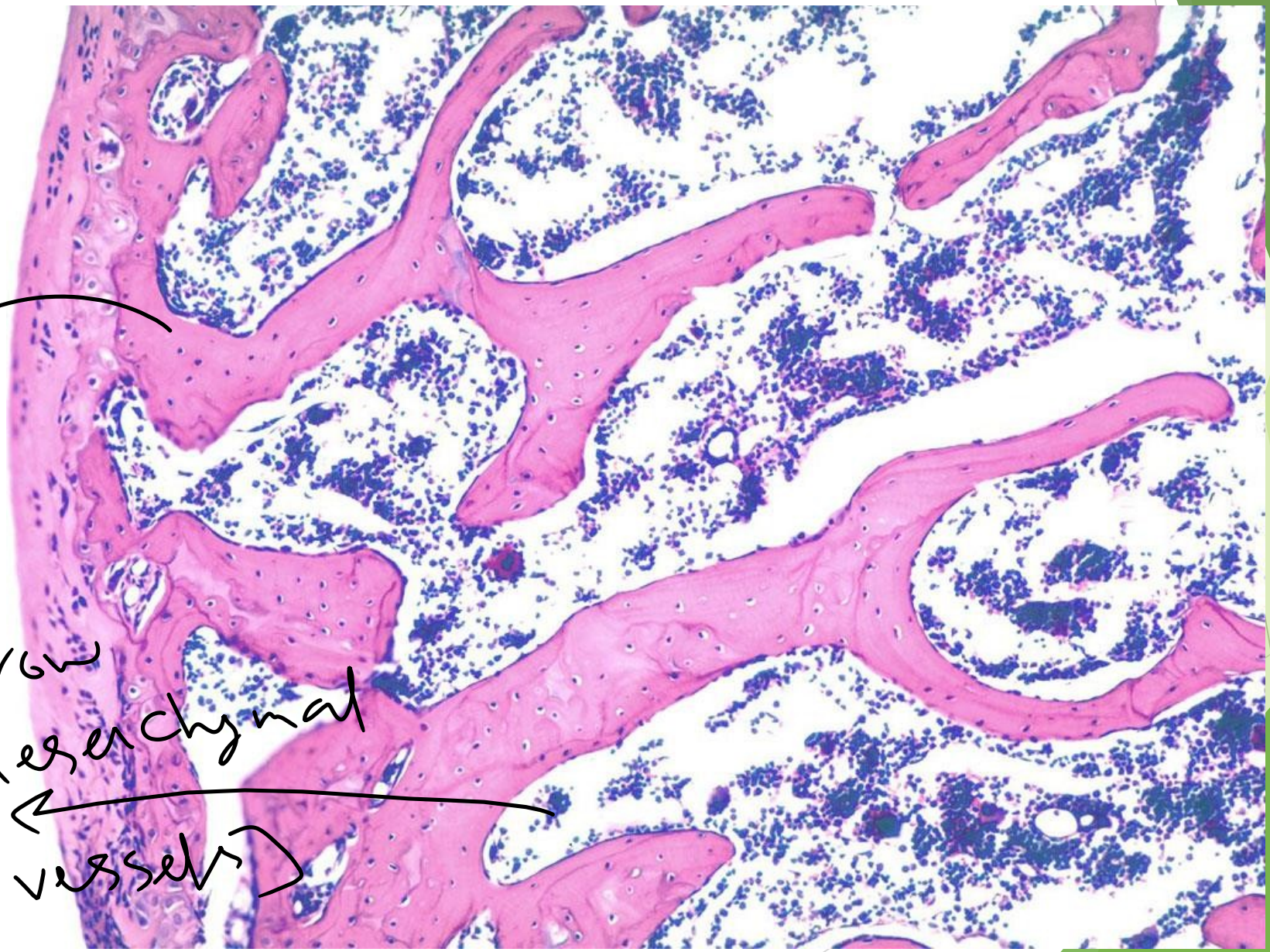


there are osteons

interstitial lamellae

osteon

Decalcified trabecular bone = spongy → parallel layers



spongy

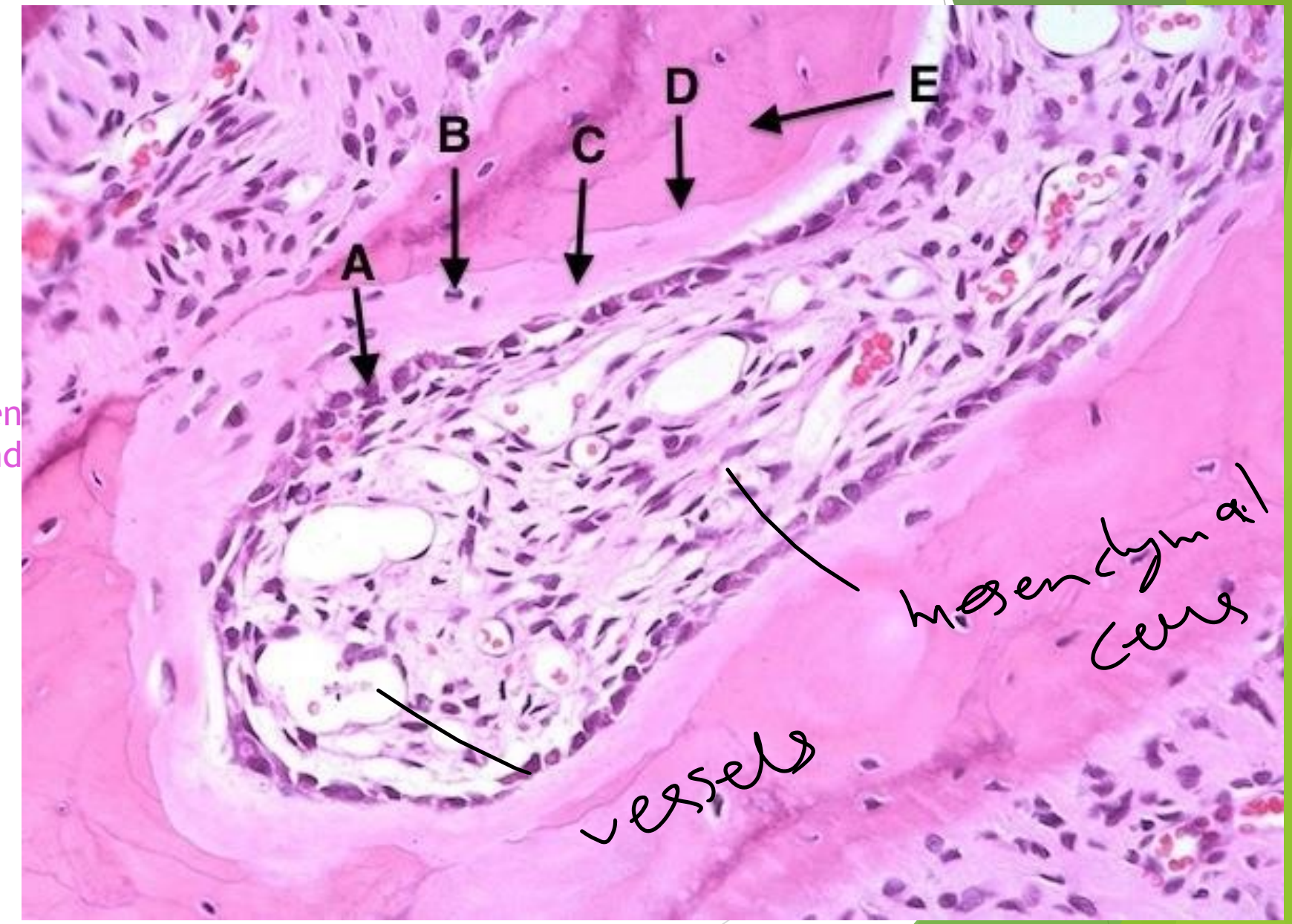
bone marrow (rich in mesenchymal cells & vessels)

Decalcified section

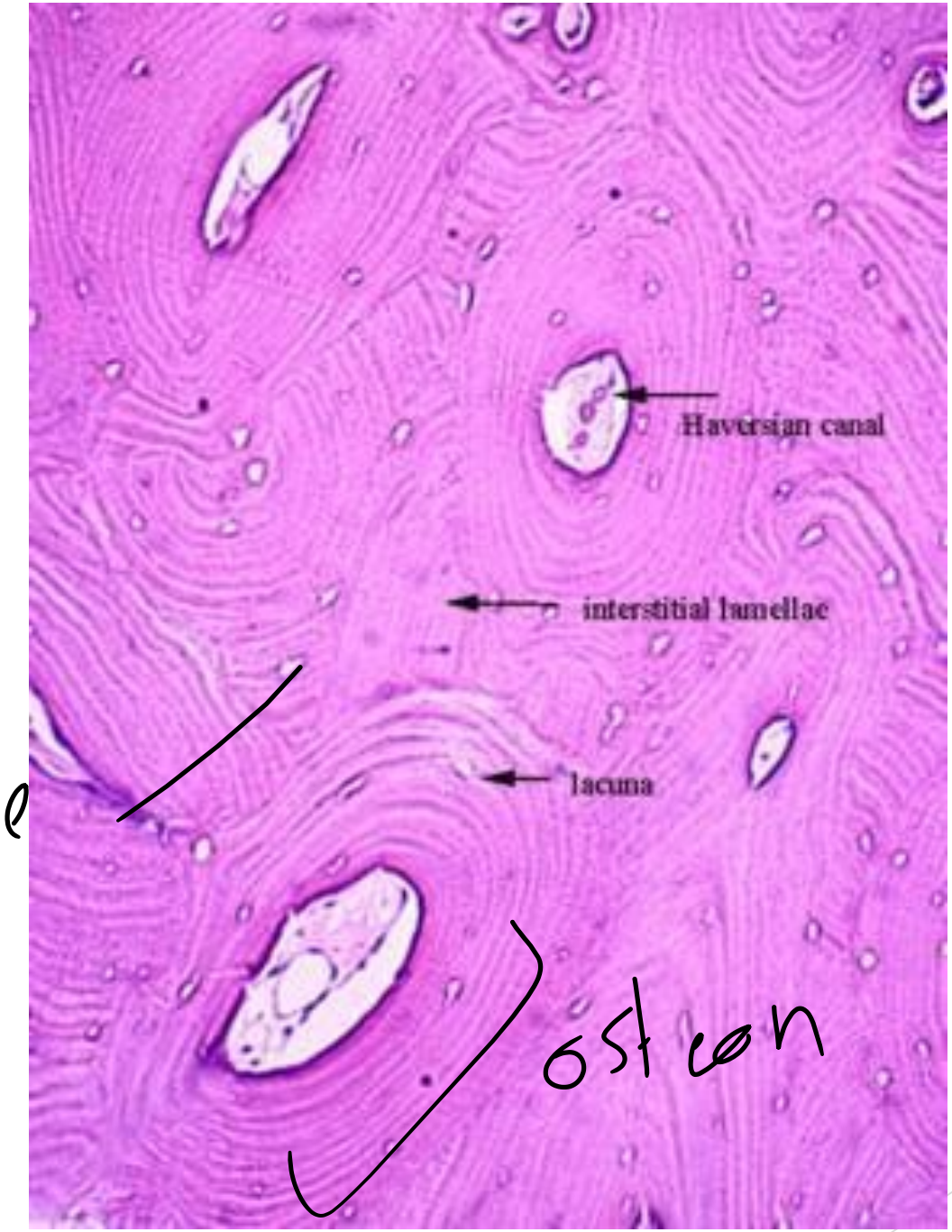
A: Osteoblast
B: Osteocyte
C:Osteoid(newlyformed bone,less acidophilic because it is only organic without collagen yet)

D: Cement line(the line between the adult bone(lamellar) and newly formed bone(woven)

E: Bone(adult bone)



It appears crushed
مفعوصة
Cause we remove minerals Ca+2 that give hardness

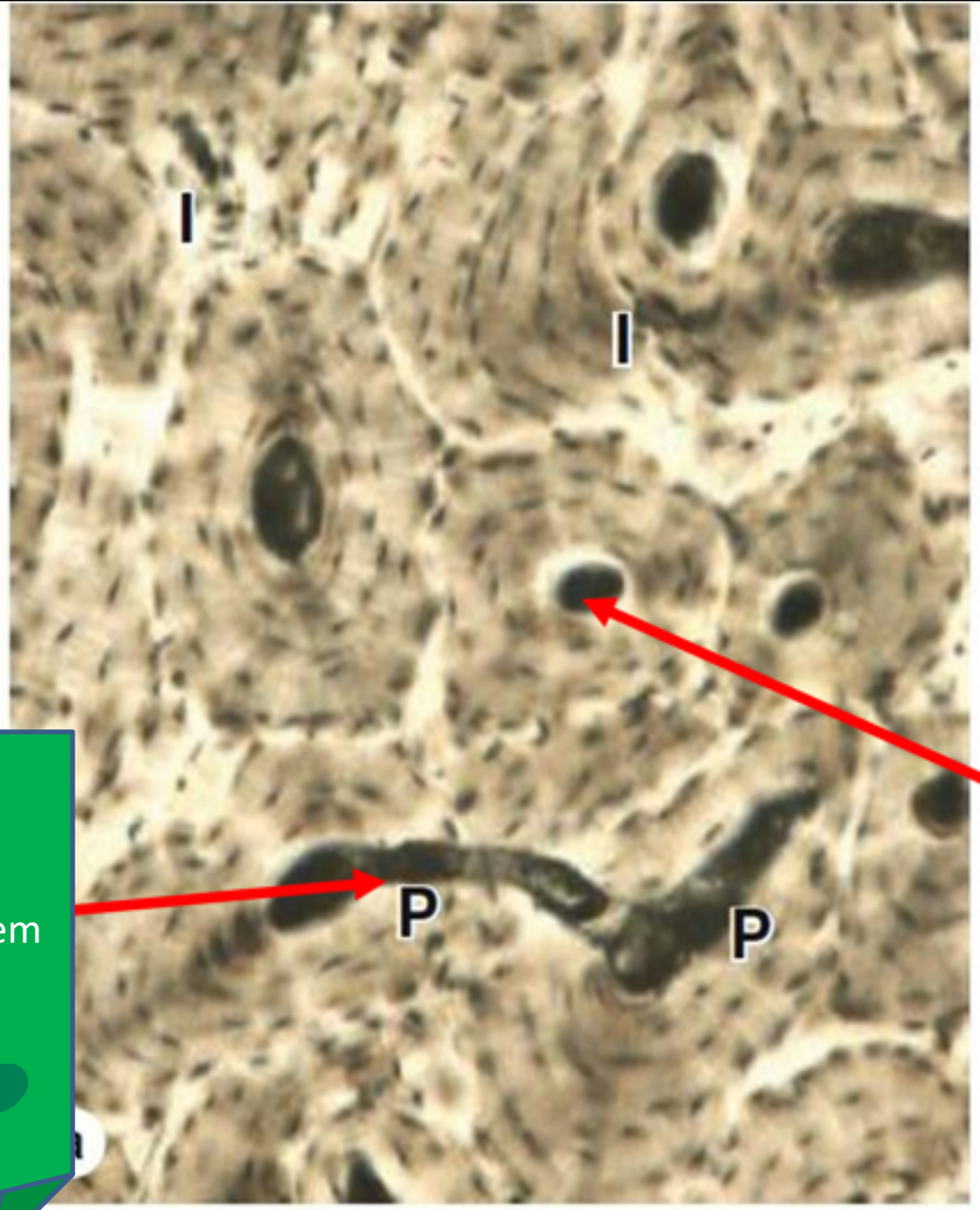


Decalcified section

osteocyte

osteon

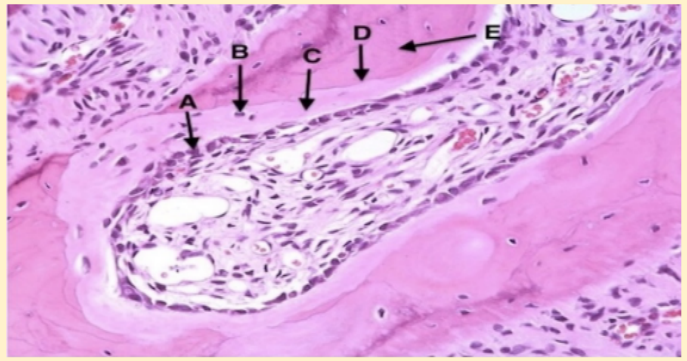
It is ground section
Without colour
To see organization and architecture
It preserves the inorganic component (Ca+2)



Layers arrangement in bone:
1)Periosteum
2)External circumferential lamellae
3)Compact bone (osteon)between them interstitial lamellae

4(inner circumferintial lamella
5)endosteum
6)bone

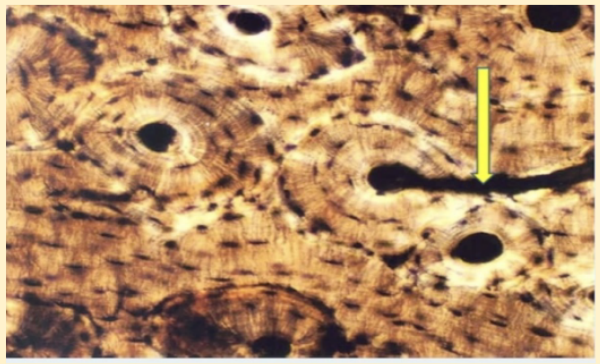
50. Practical: Choose the WRONG statement regarding this section:



a) It is a trabecular bone
b) Arrow A points at a bone forming cell
c) It is a decalcified bone section
d) Arrow B points at a cell located within lacuna
e) Arrow C points at the mineralized bony matrix

Answer: e

49. Practical: Identify the yellow labeled structure:



a) Lamella
b) Central canal
c) Lacuna
d) Volkmann's canal
e) Osteon

Answer: d

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

1.An osteon is:

a.A cylinder of bone tissue surrounding a central canal
b.A porous bone composed of trabeculated bone tissue
c. Involved in the formation of outer circumferentia lamellae
d. The basic structural unit of spongy bone
e. Composed of woven bone

Answer: a

19.Which of the following are found in compact bone and cancellous bone?

a) Lacunae
b) Circumferential lamellae
c) Haversian canals
d) Trabeculae
e) Volkmann's canals

Answer: a