Connective Tissue and Bone

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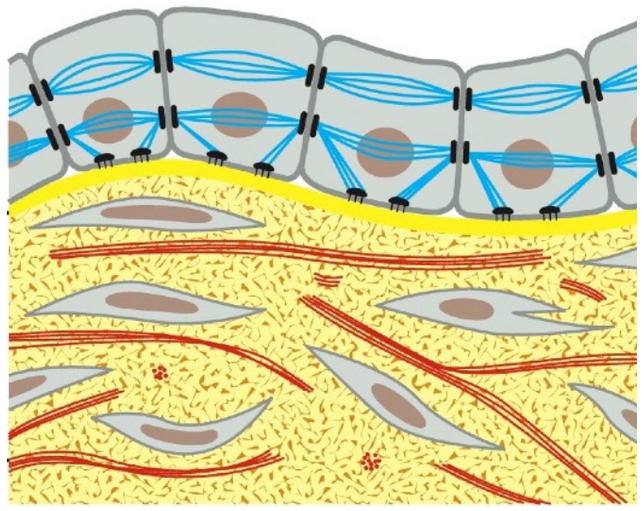
What we will talk about…

- Types and functions of connective tissue
- Cells of connective tissue
- Composition and structure of bone
- Cells that control the shape and integrity of bone
- Development of bone

Connective tissue serves a variety of functions throughout the body.



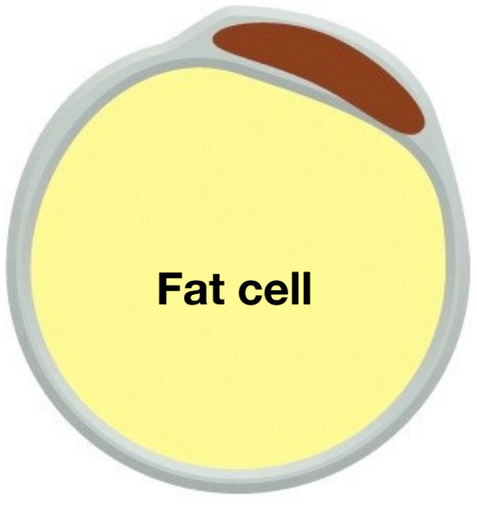
Resist stress

Immunity

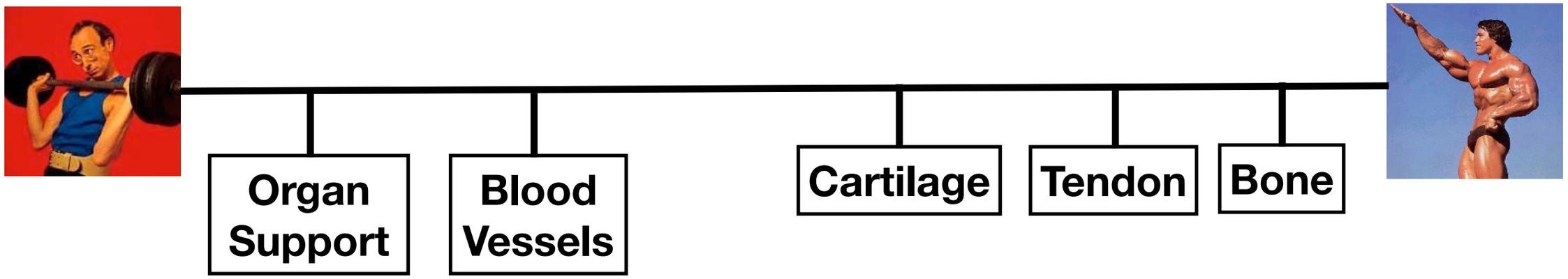
Connective Tissue

Organize tissues

Metabolic

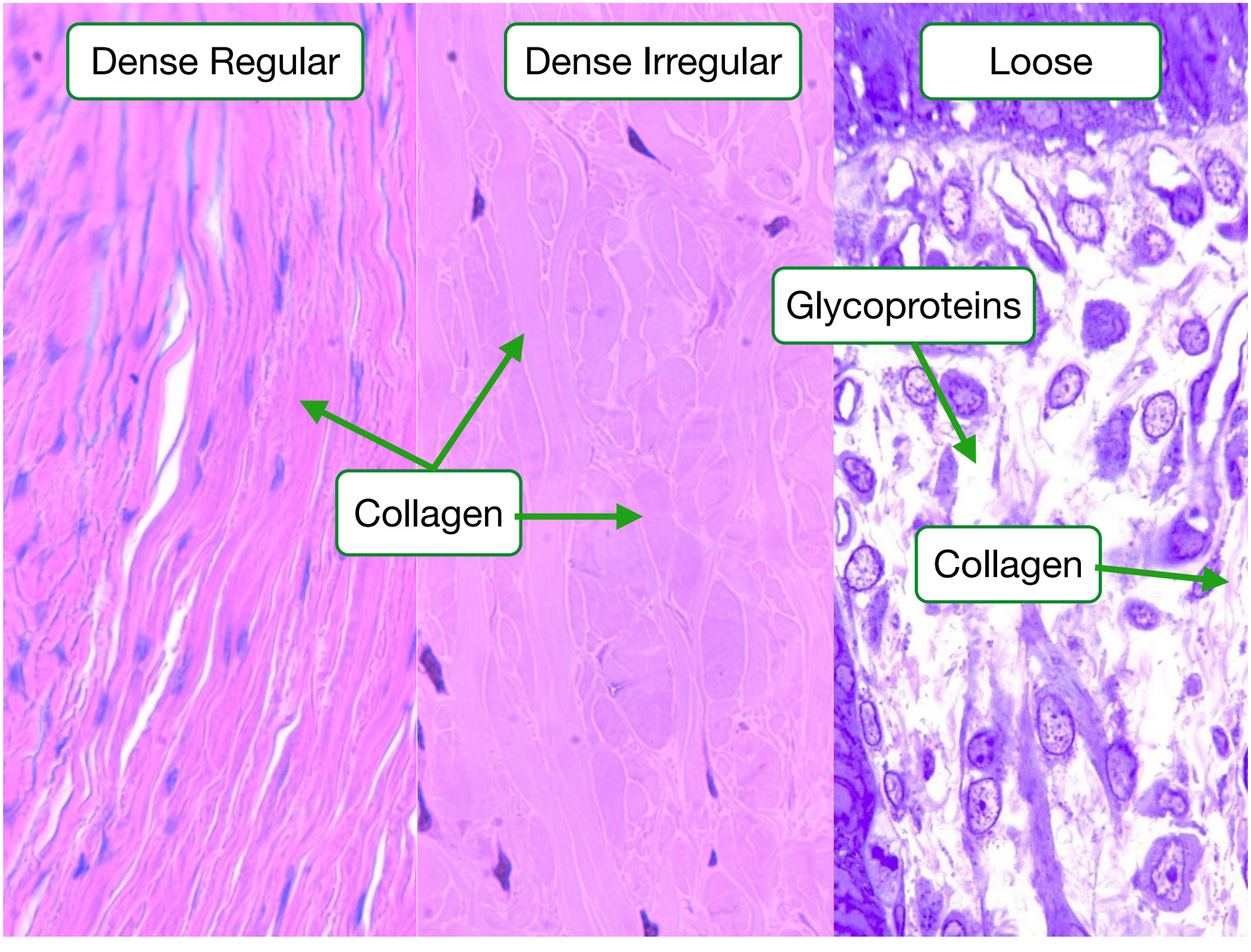


Connective tissue can generate a range of mechanical strengths.

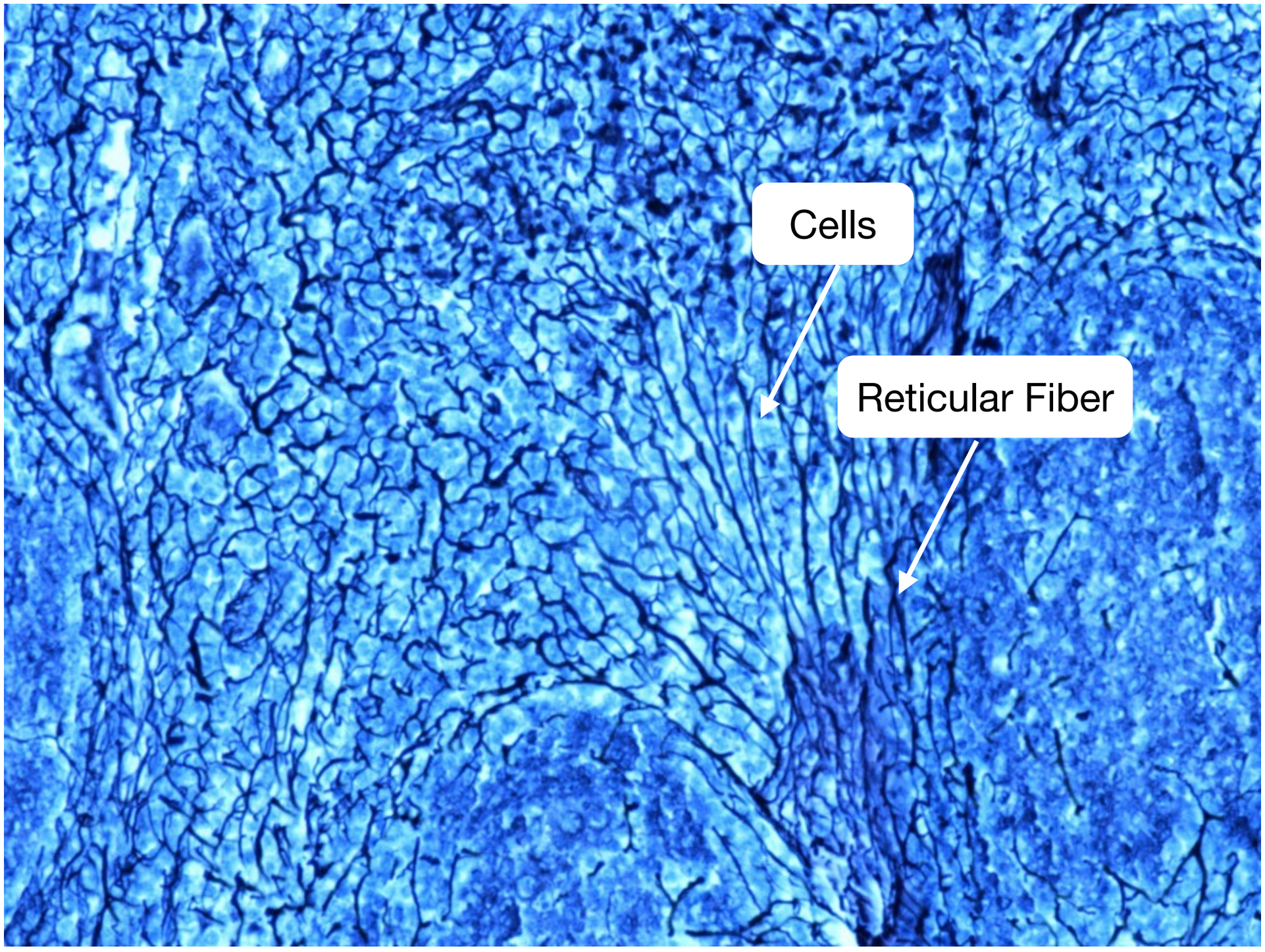


Connective tissue resists tension and compression.

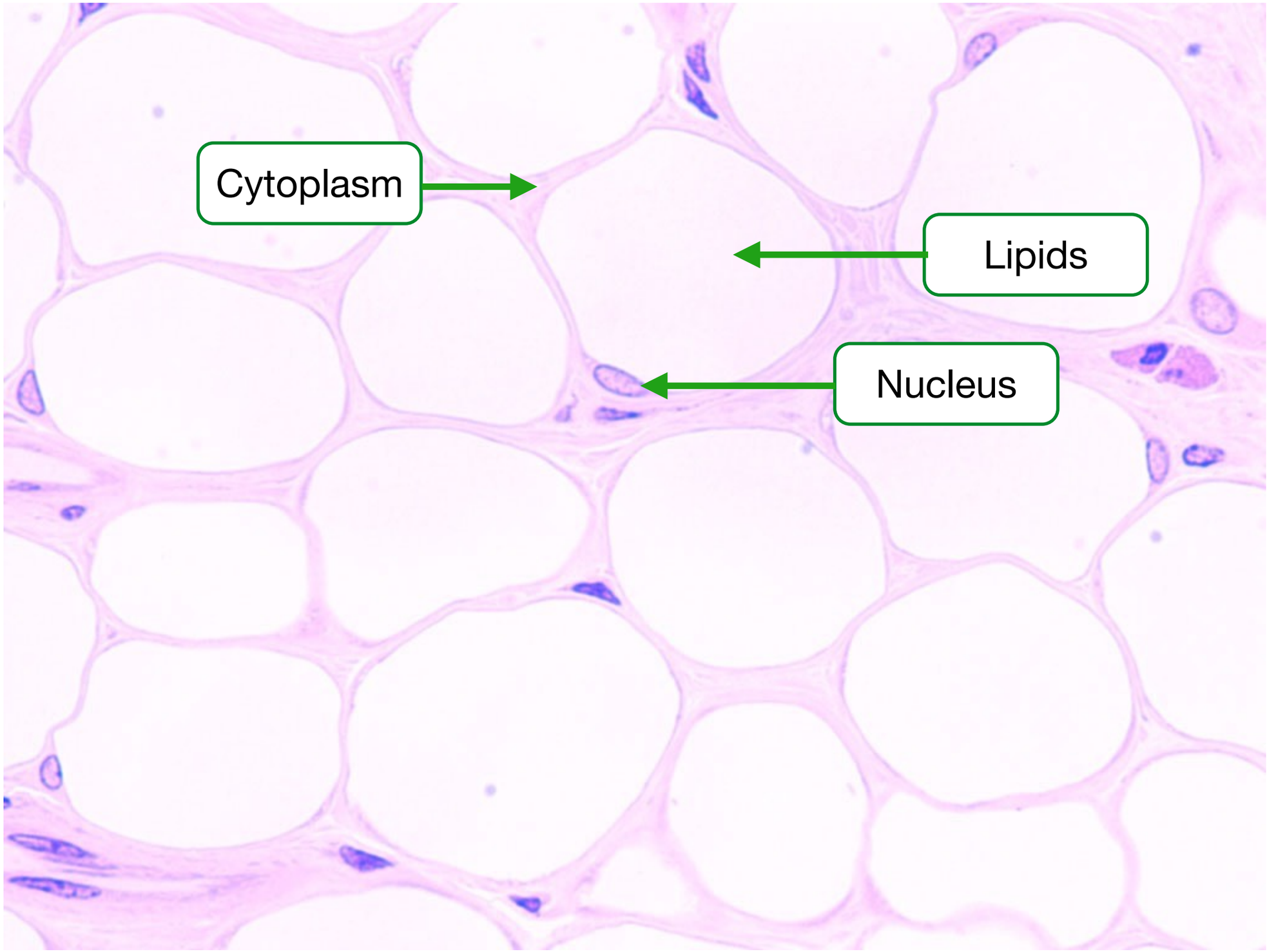
Connective tissue can be classified based on the amount and organization of collagen.



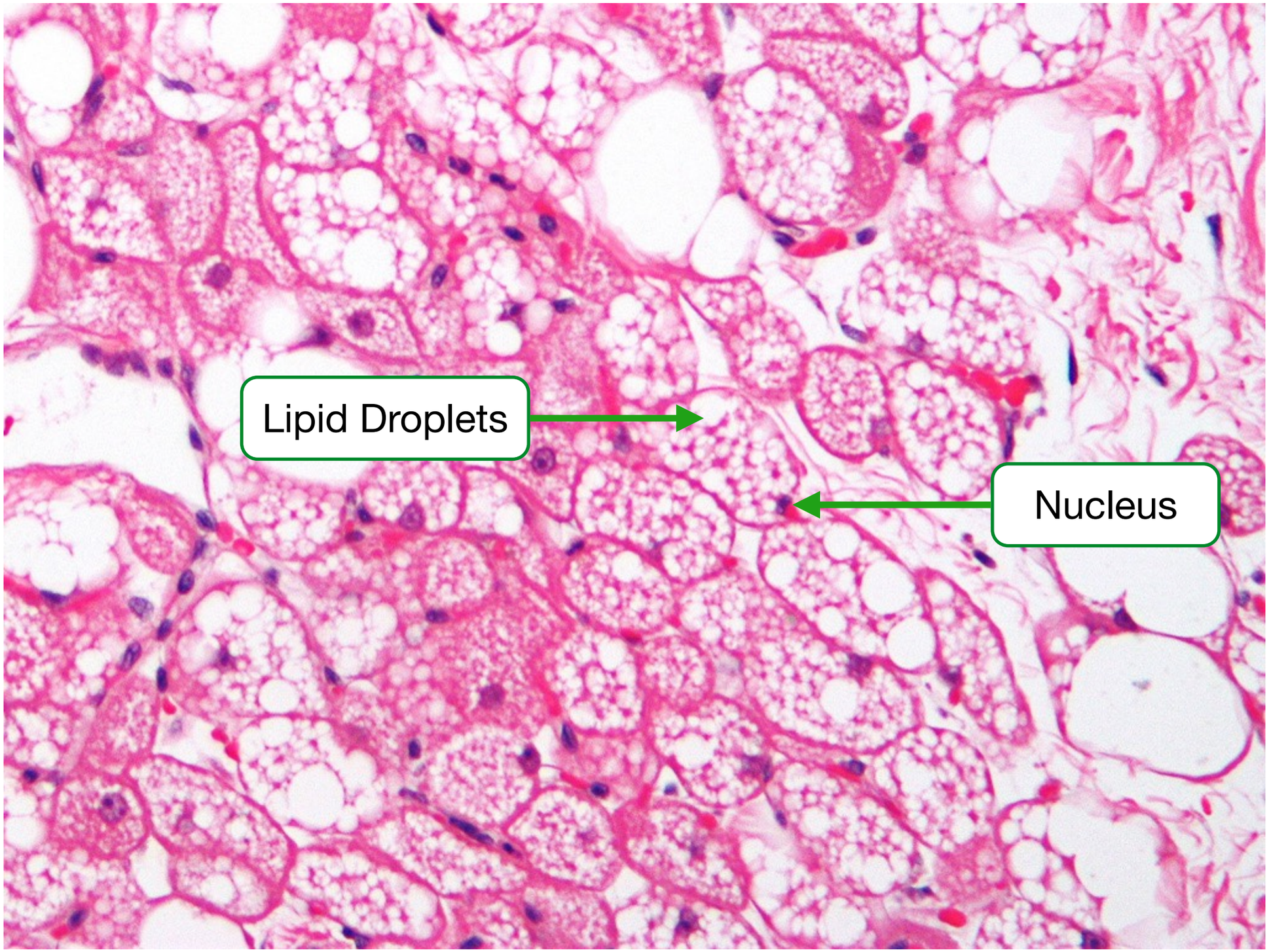
Reticular fibers are composed of type III collagen and organize cells in organs.



Adipose tissue contains adipocytes that store large amounts of lipid and triglycerides.

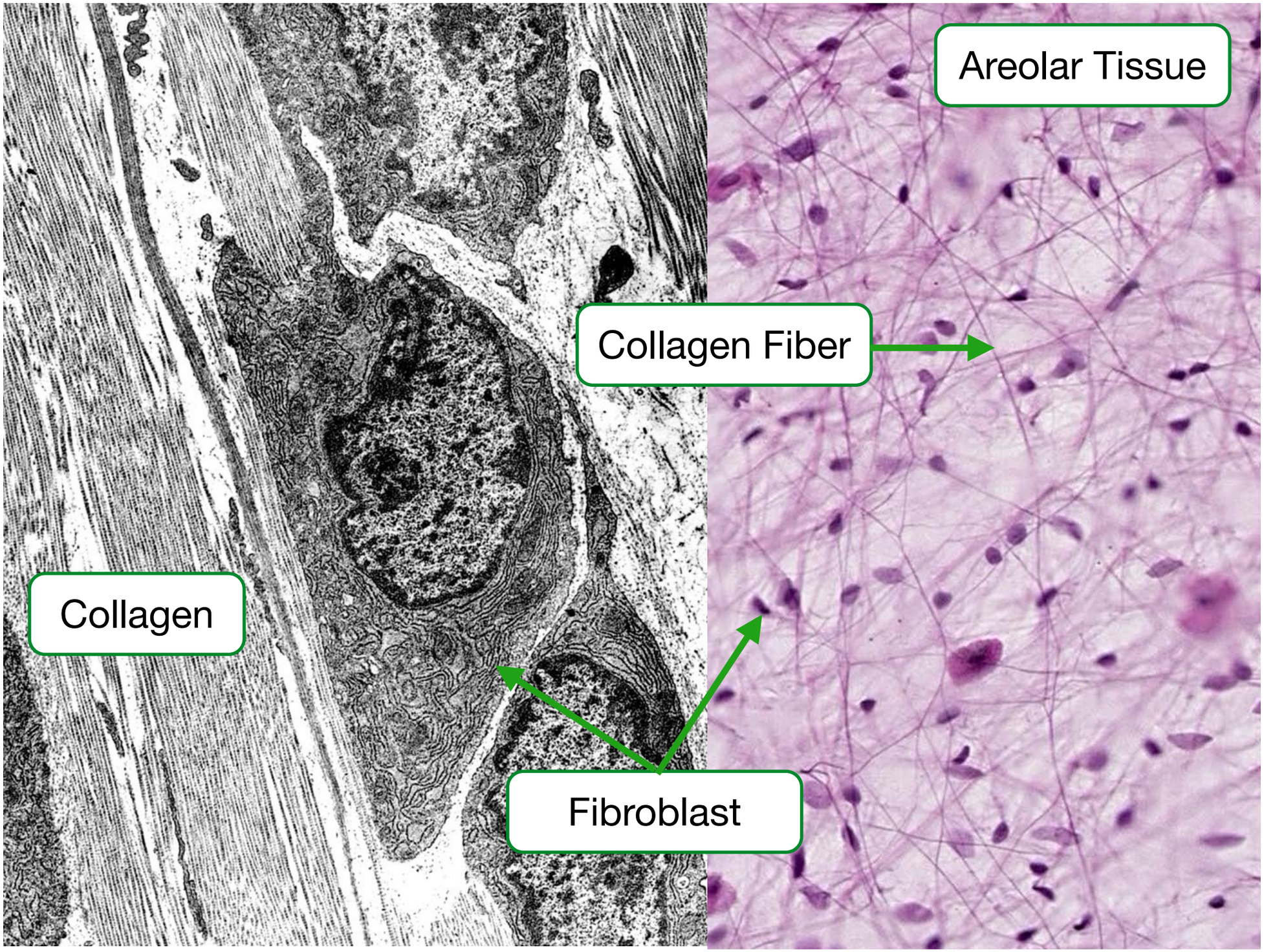


Brown fat stores lipids and triglycerides and generates heat.

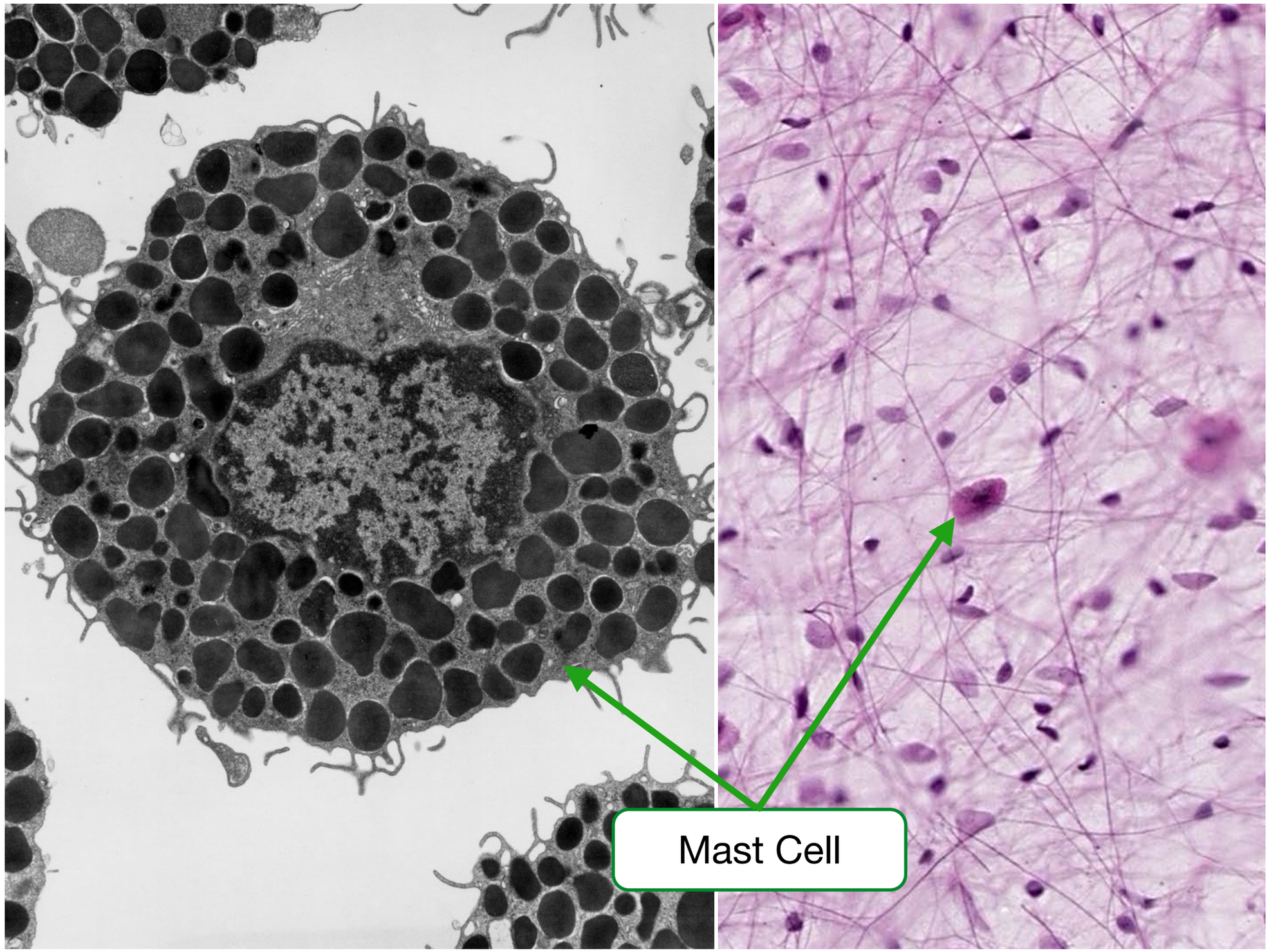


Cells of connective tissue

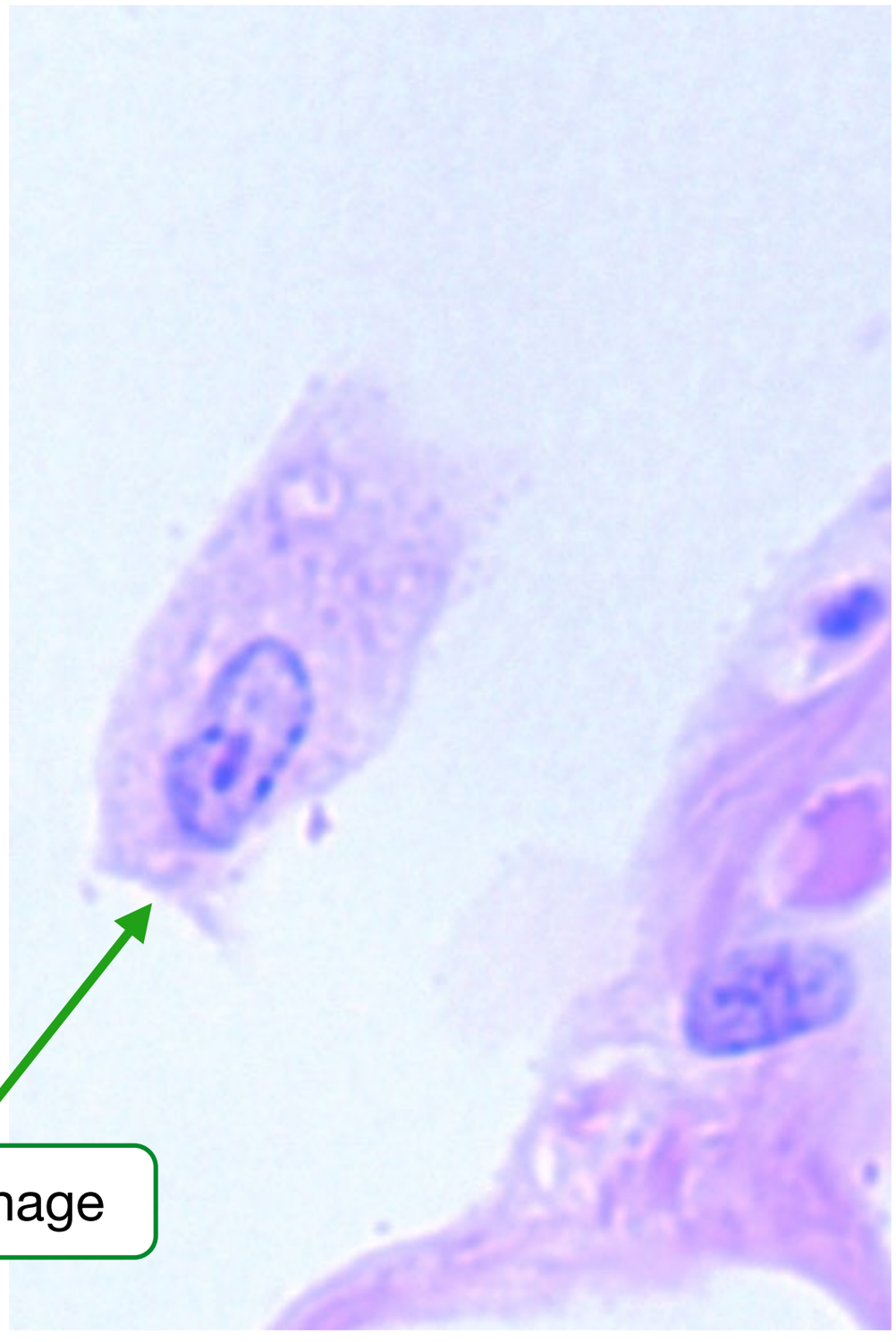
Fibroblasts are prominent in connective tissue and synthesize most of the protein components.



Mast cells store and release histamine during an immune response



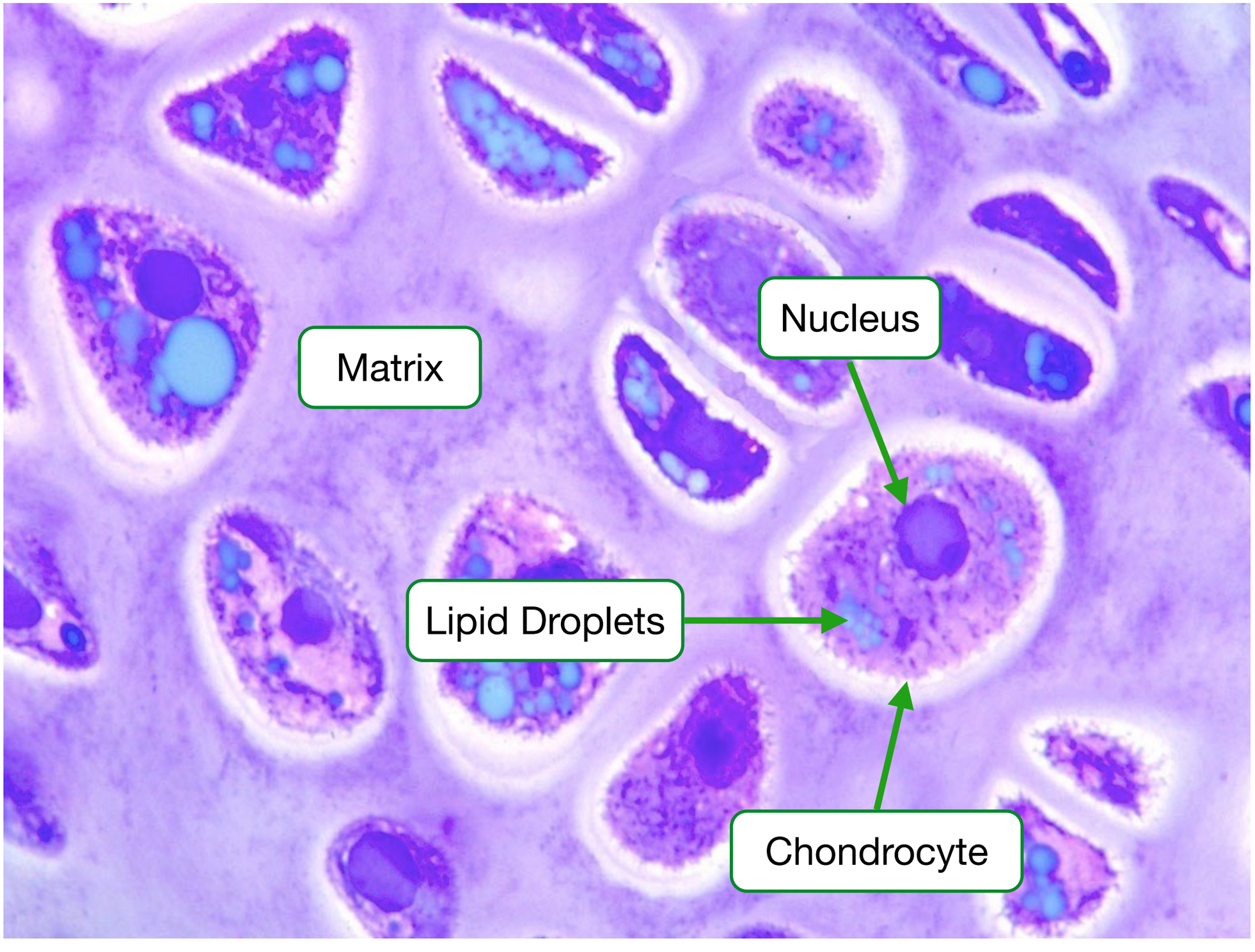
Macrophage engulf foreign particles and cellular debris.



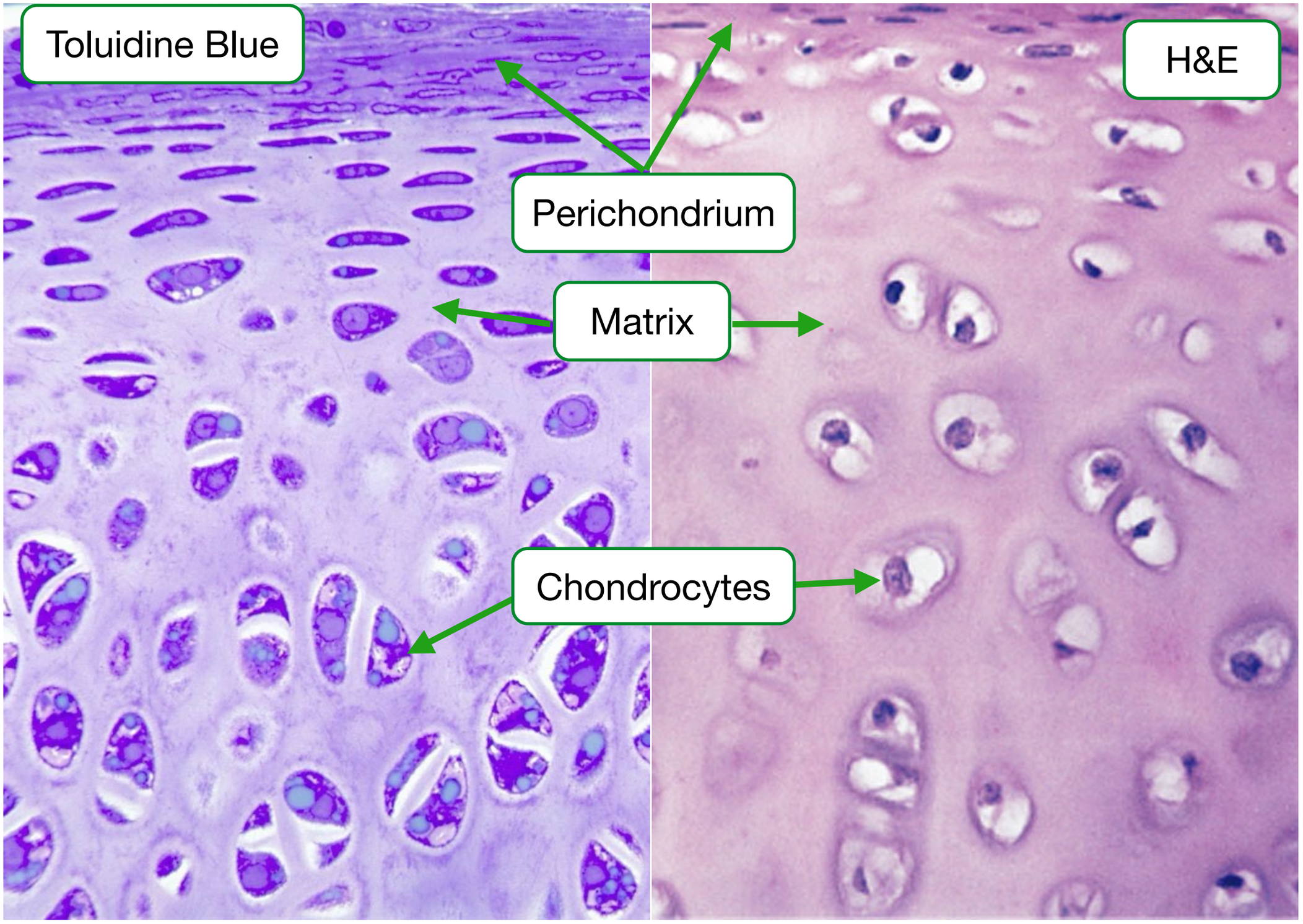
Macrophage

Cartilage

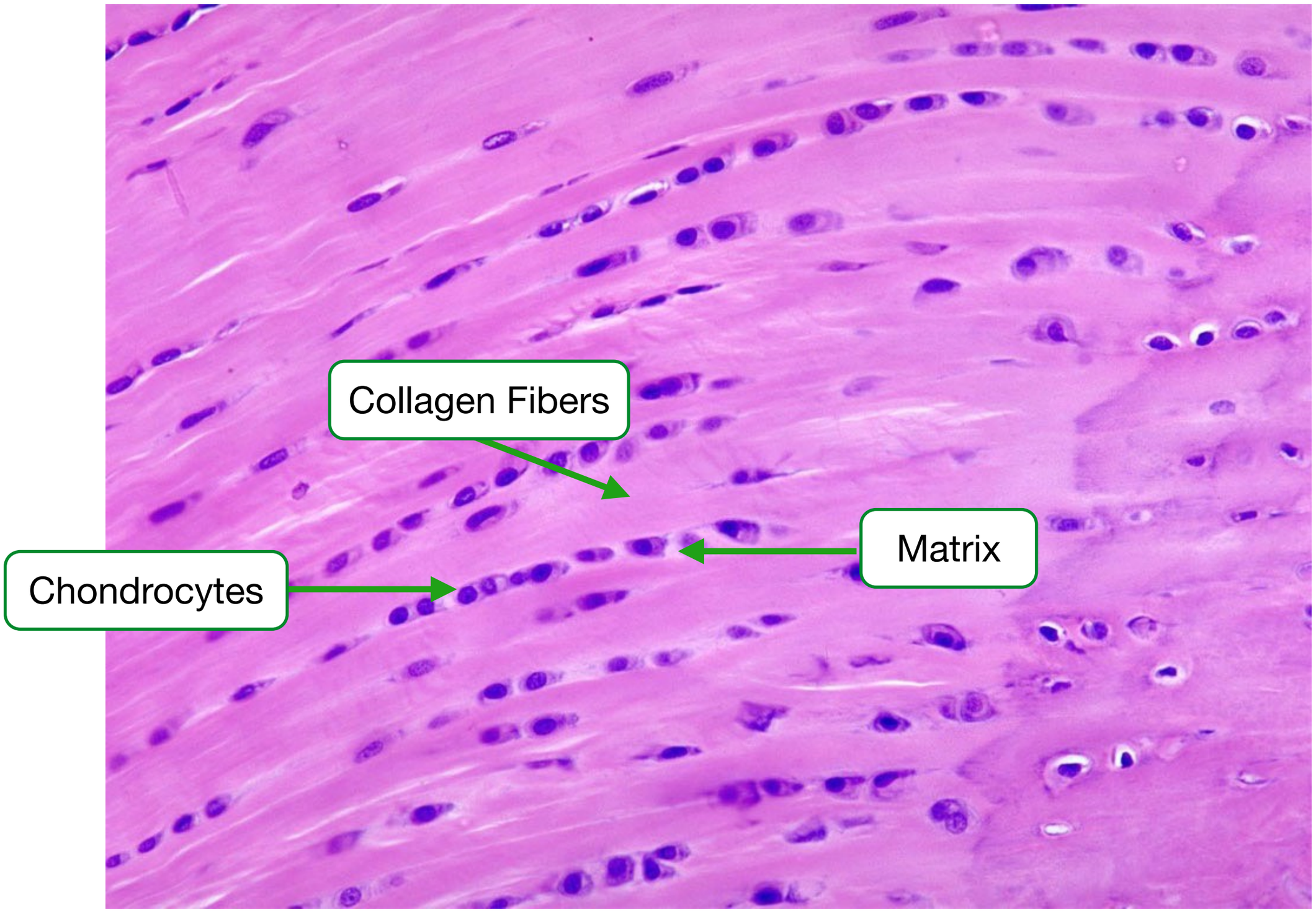
Chondrocytes synthesize cartilage which resists compression.



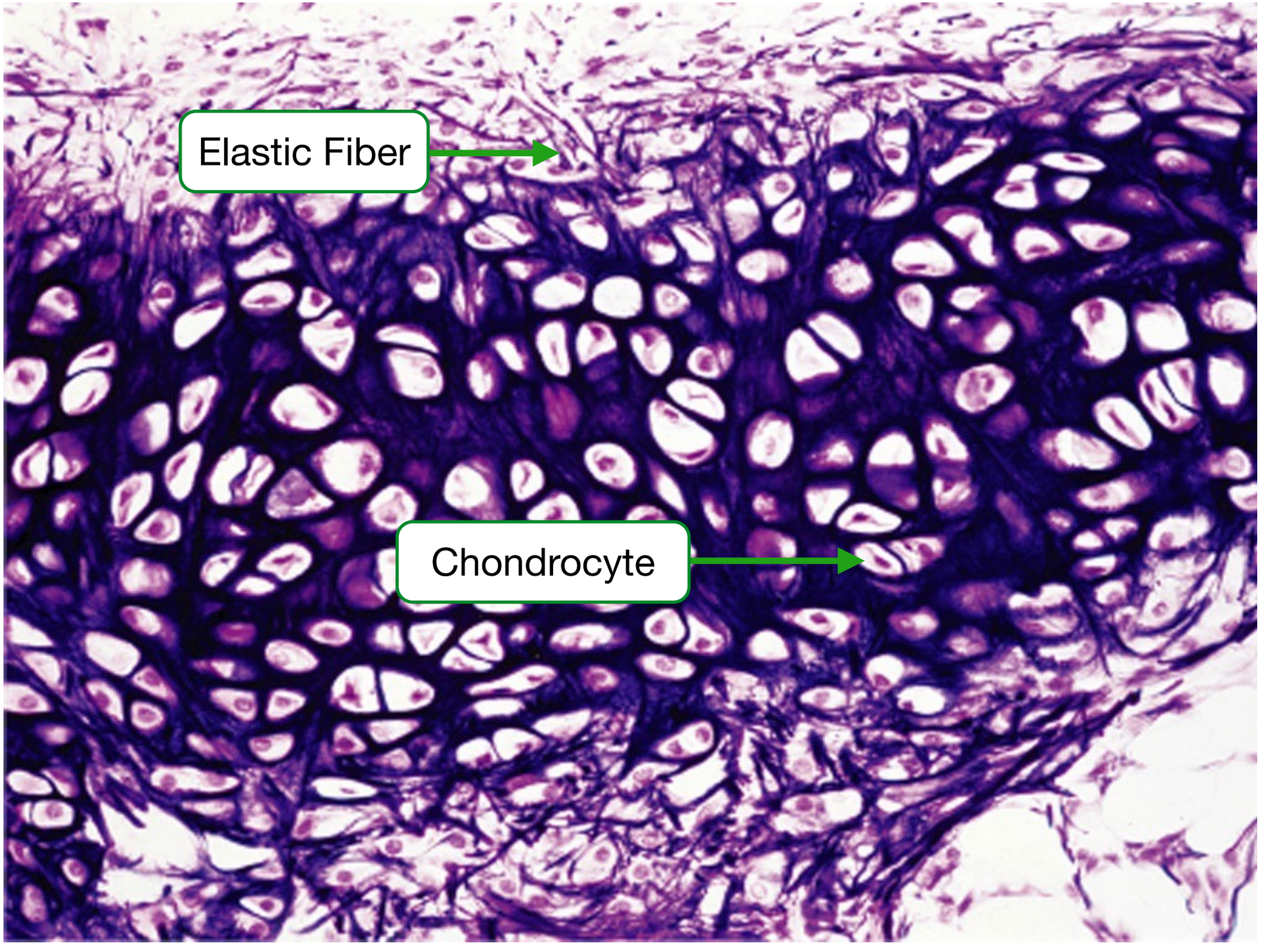
Hyaline cartilage contains type II cartilage and glycosaminoglycans.



Fibrocartilage contains a large amount of type I collagen.

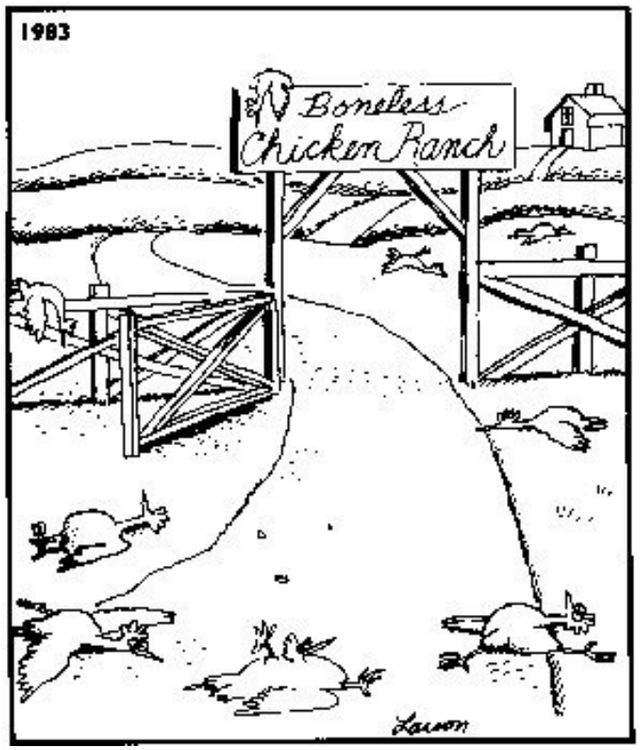


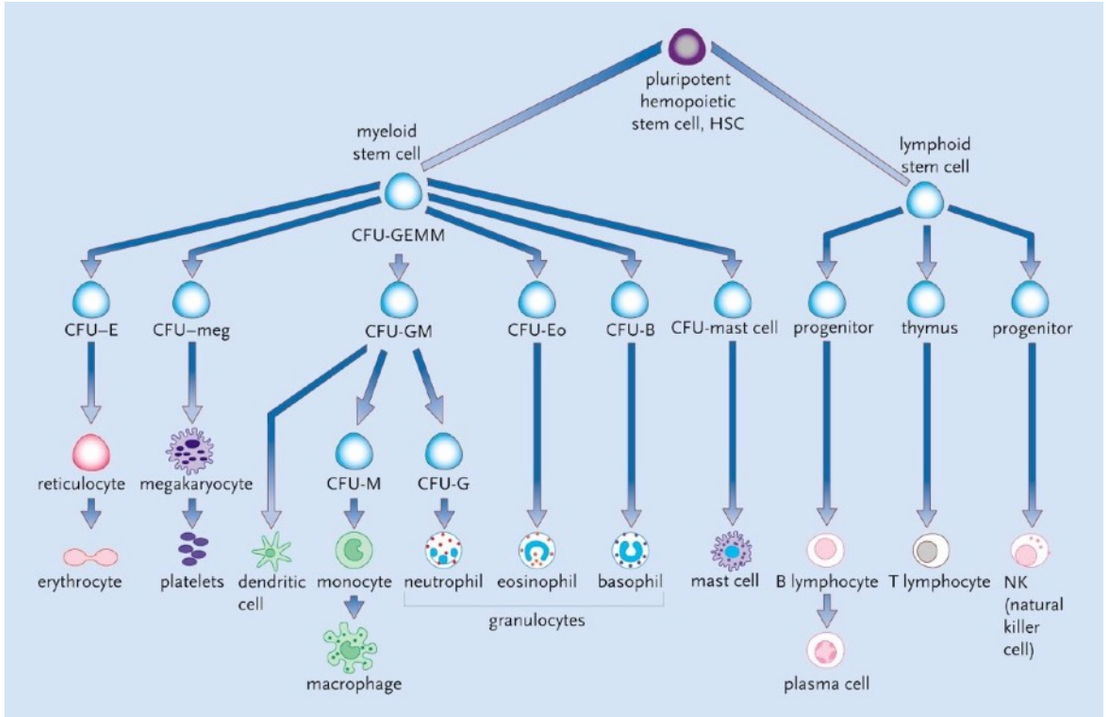
Elastic cartilage contains elastic fibers and type II collagen.

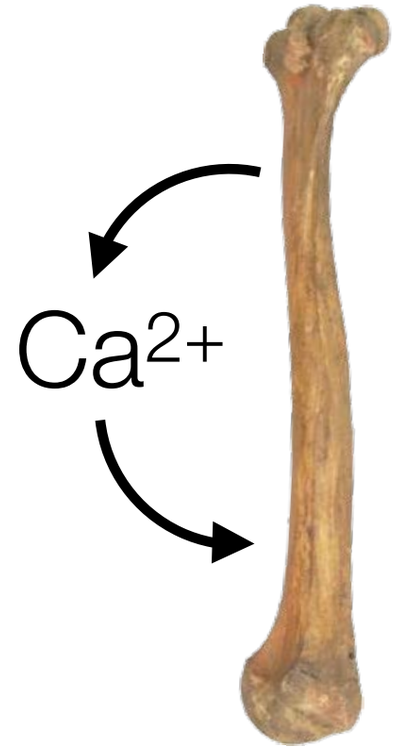


Bone

Bone serves mechanical, metabolic and cellular functions.

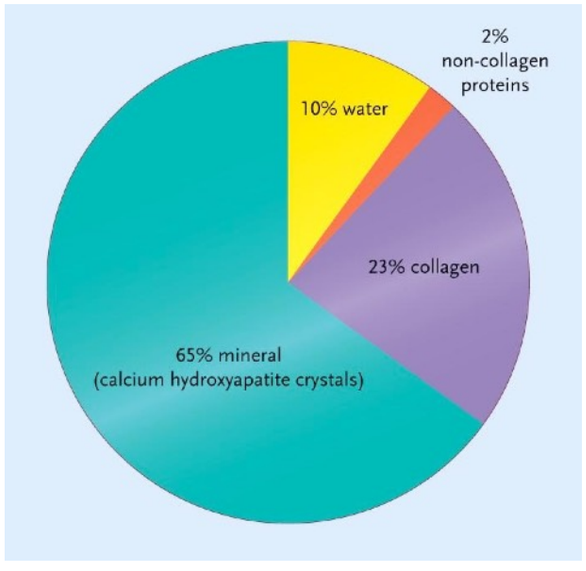




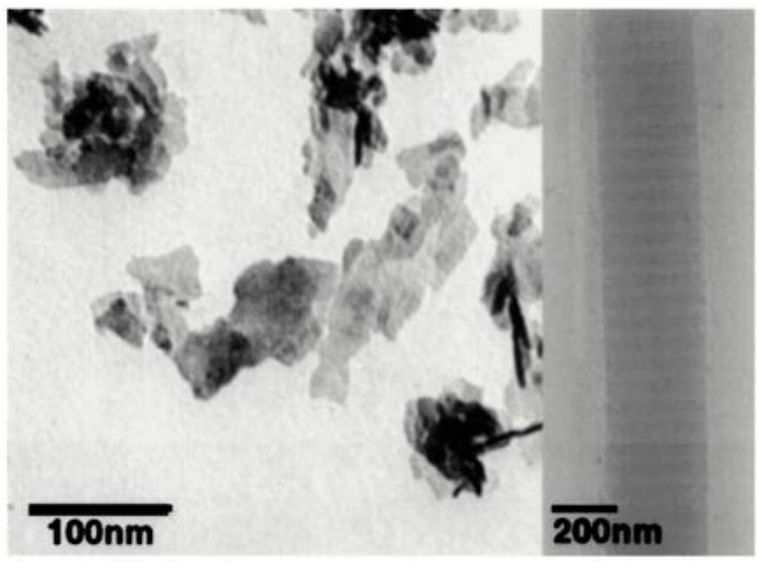


The major structure components of bone are calcium-phosphate crystals and type I collagen.

Composition of bone

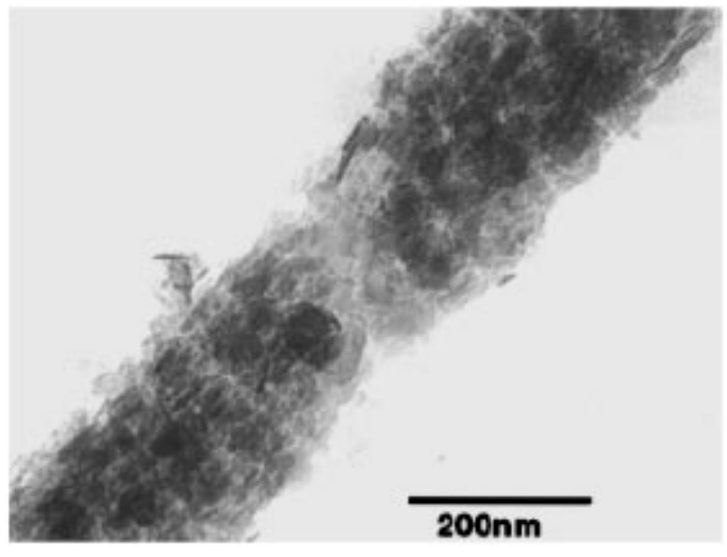


Ca^{2+} cyrstals

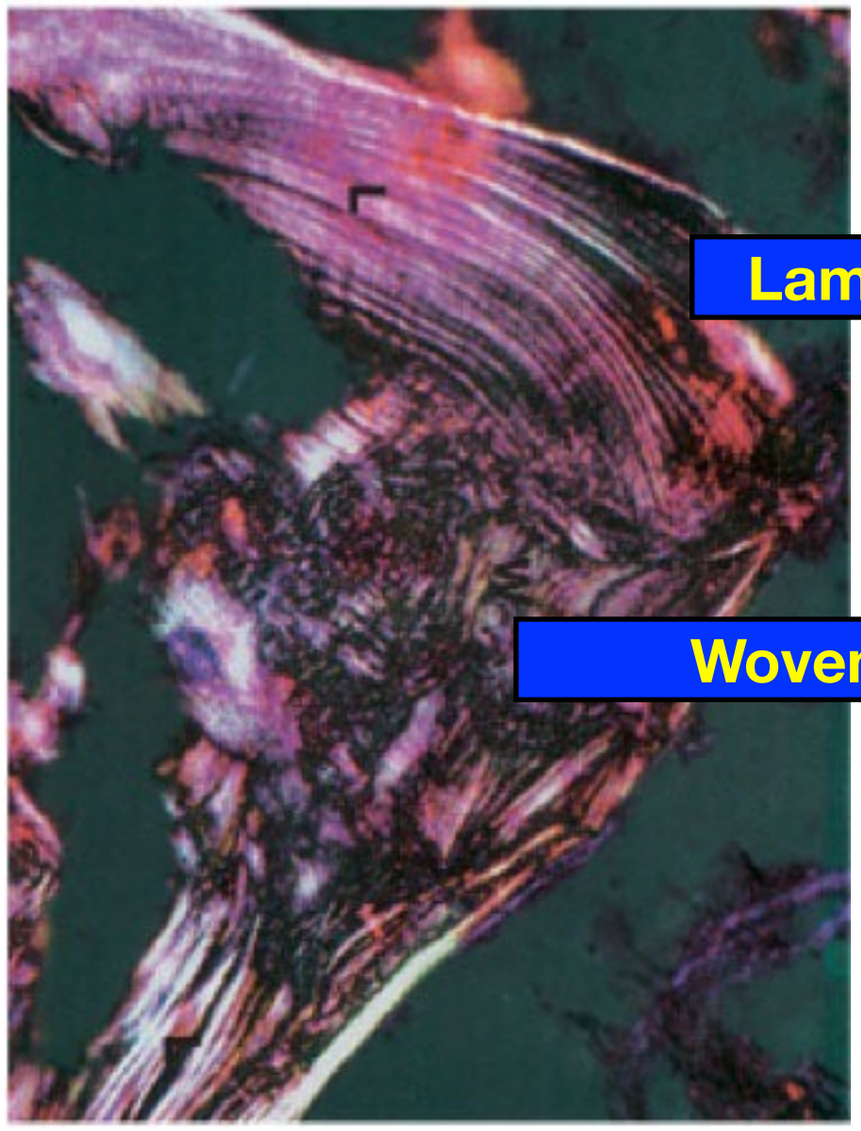


Collagen Fibril

Mineralized collagen fibril

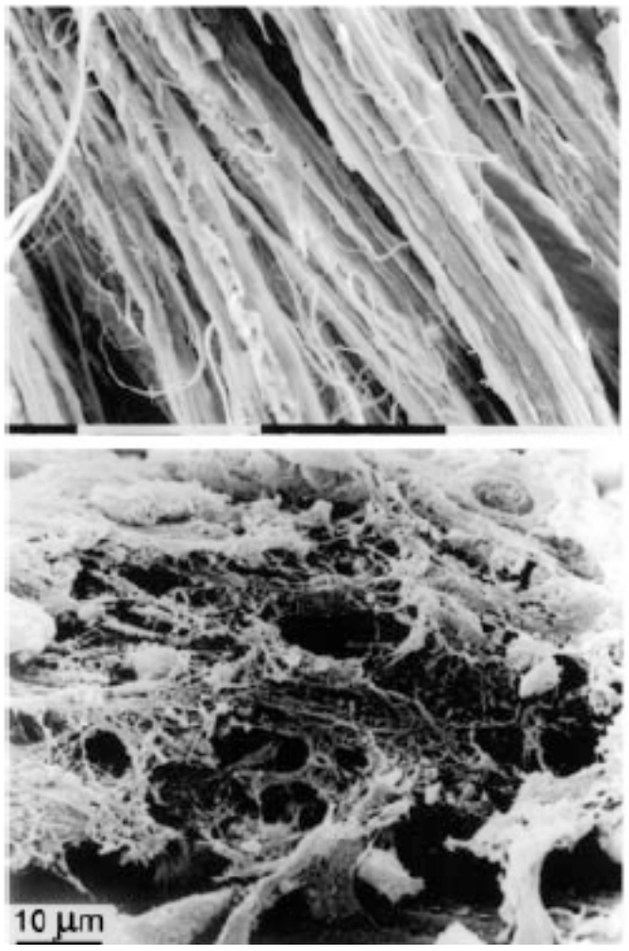


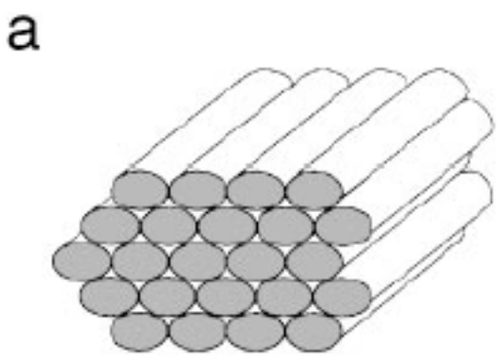
Bone can be arranged in lamellar or woven forms.



Lamellar

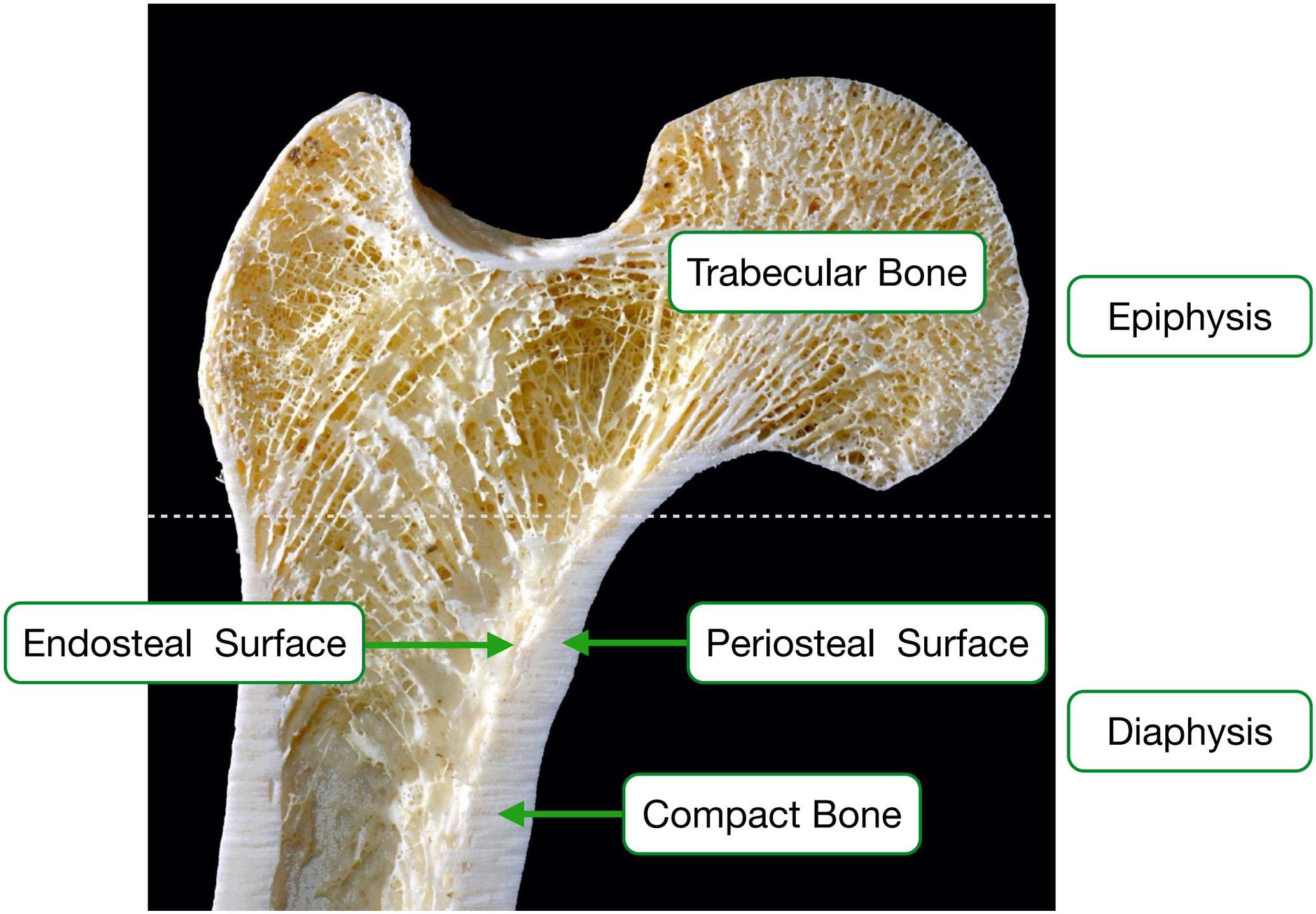
Woven



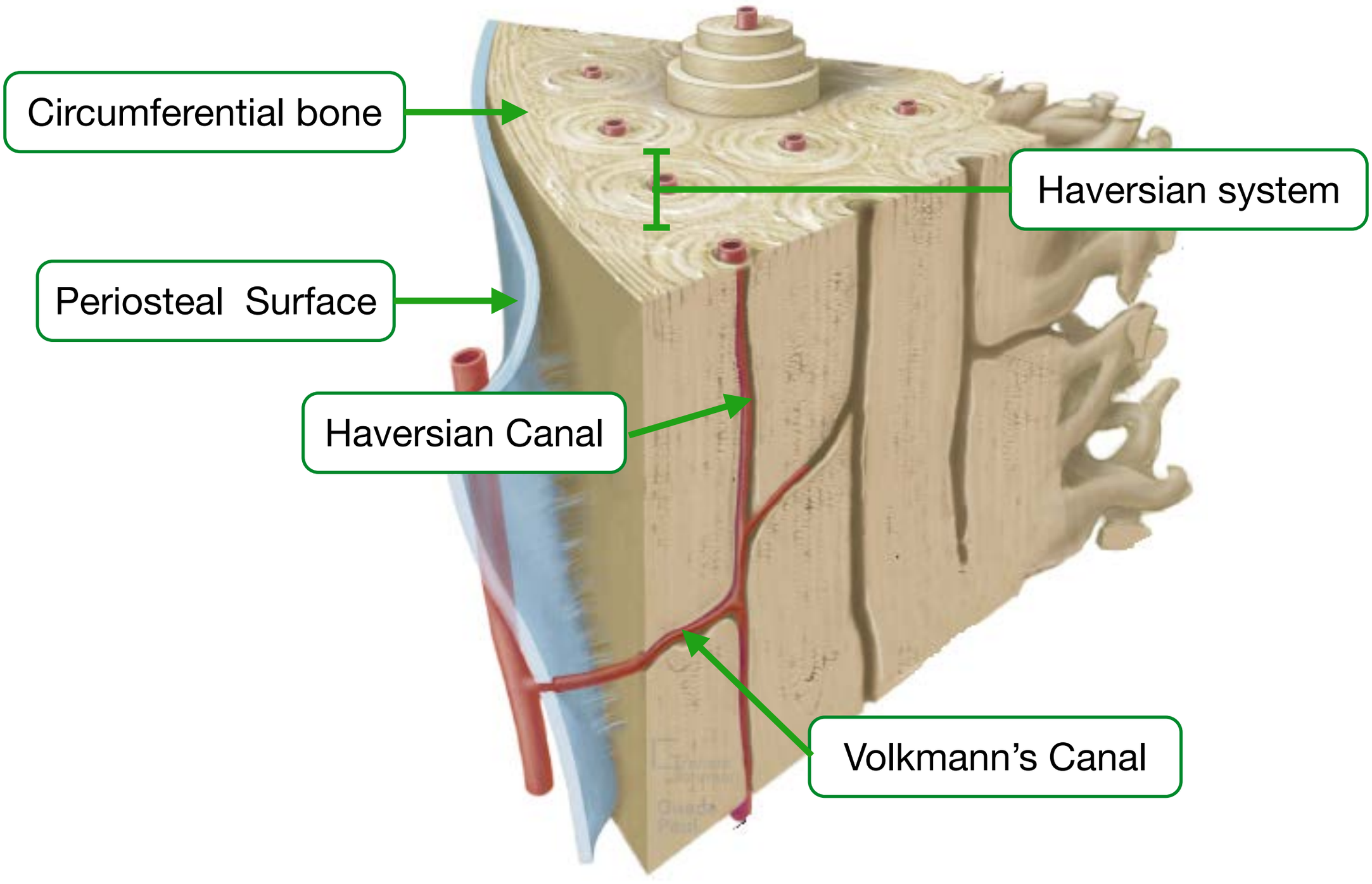


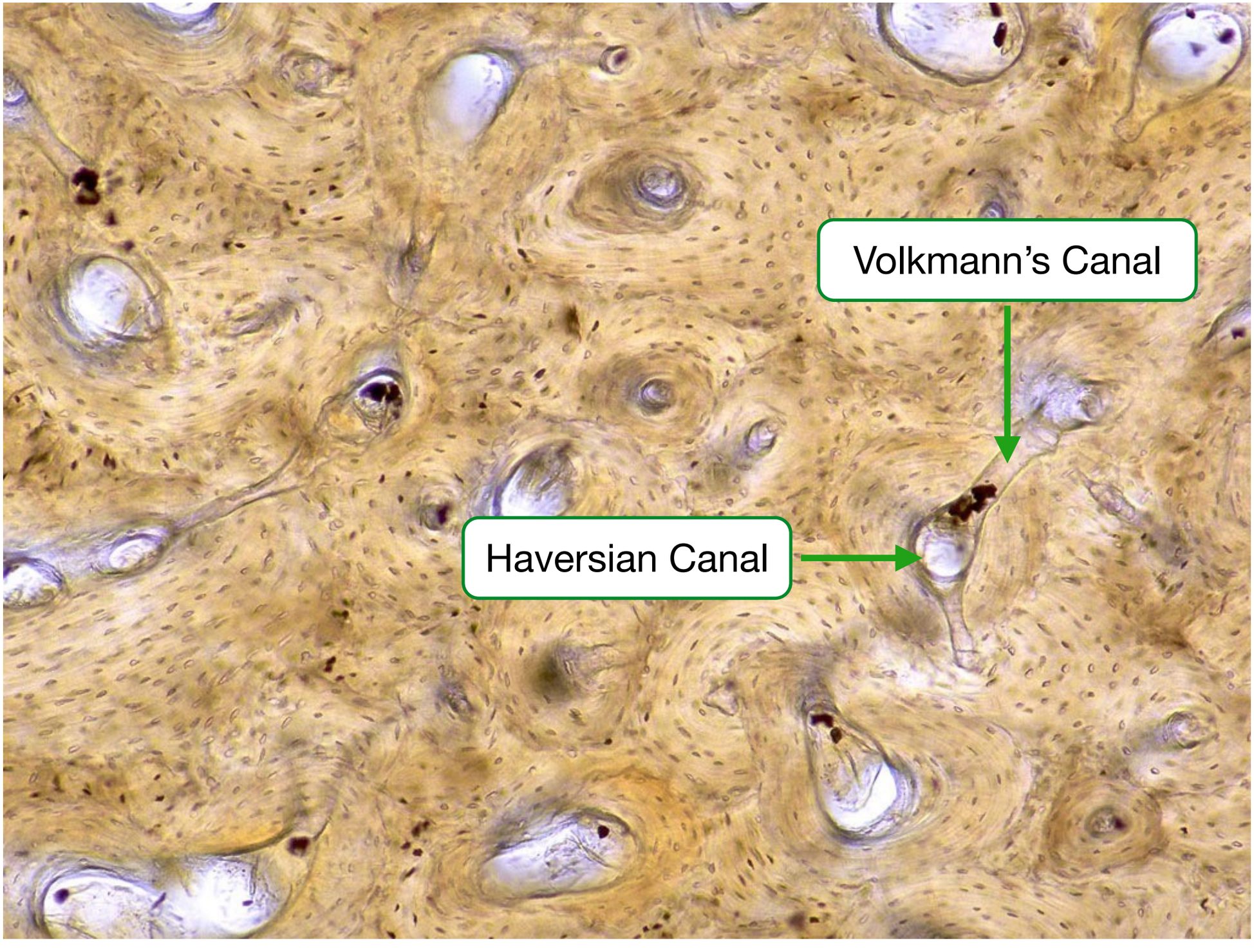
Architecture of bone

Compact bone and trabecular bone are two structures in most bones.



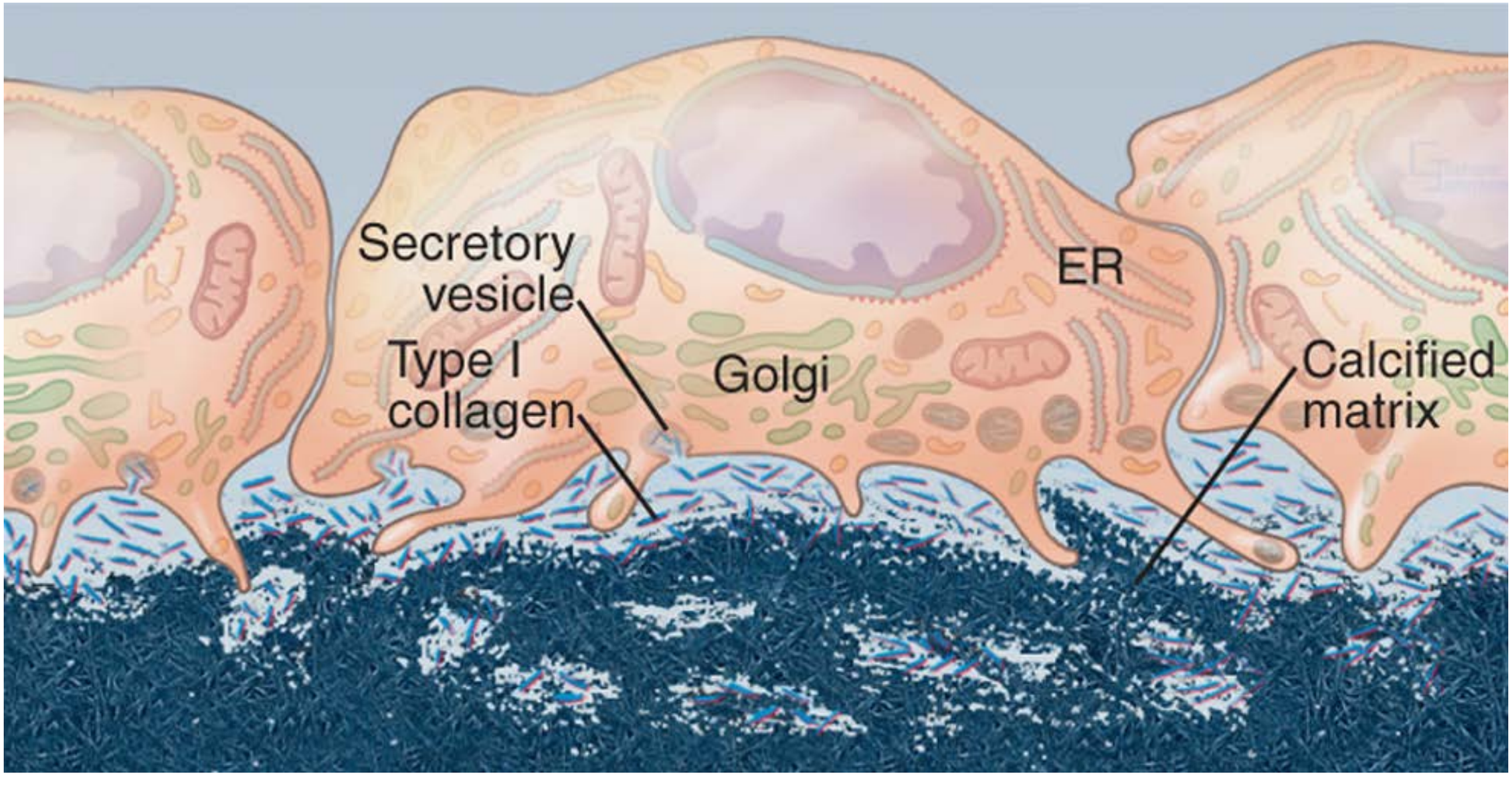
Compact bone is organized into circumferential lamellae and Haversian systems.



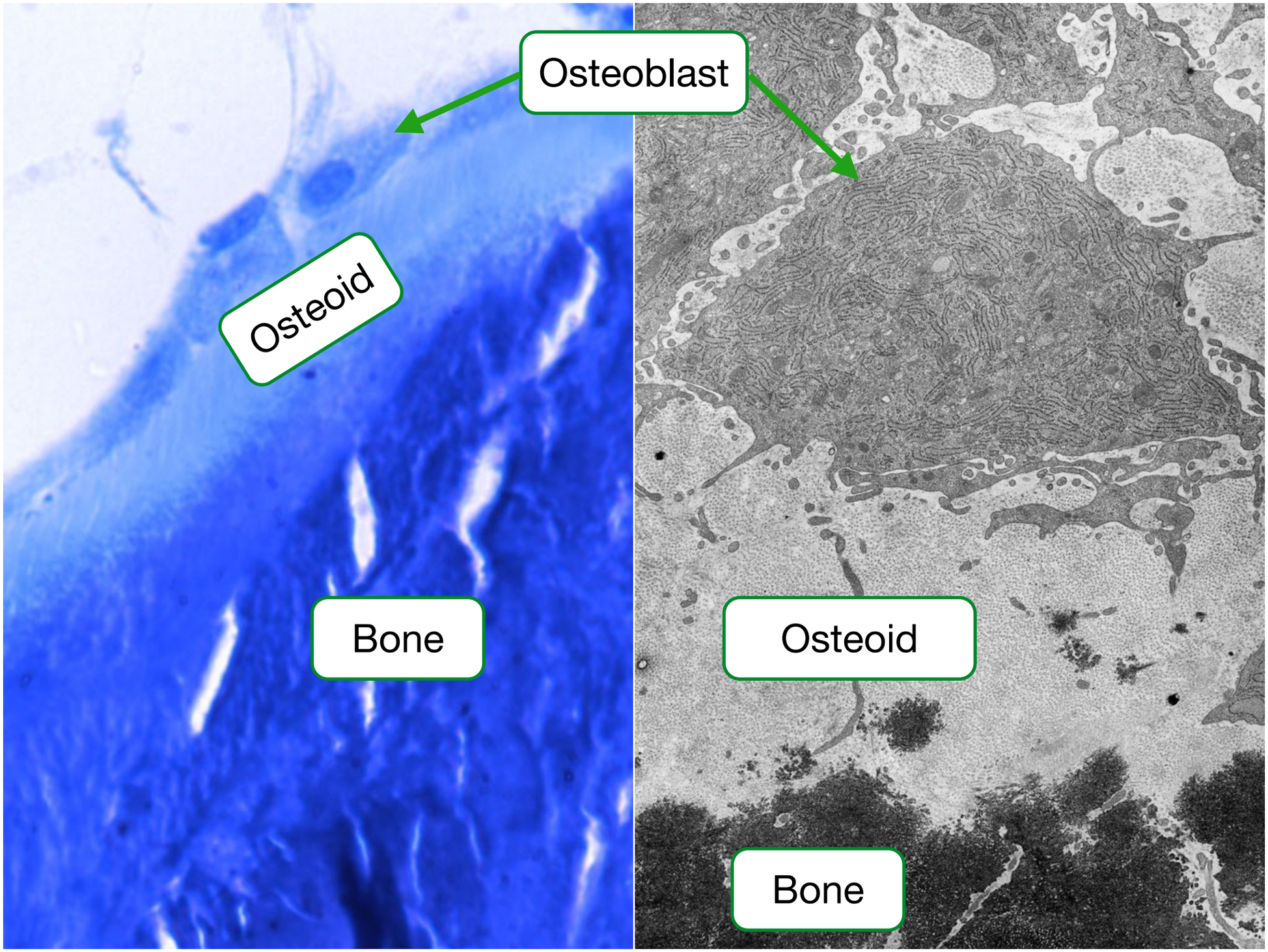

Volkmann's Canal
Haversian Canal

Bone Cells

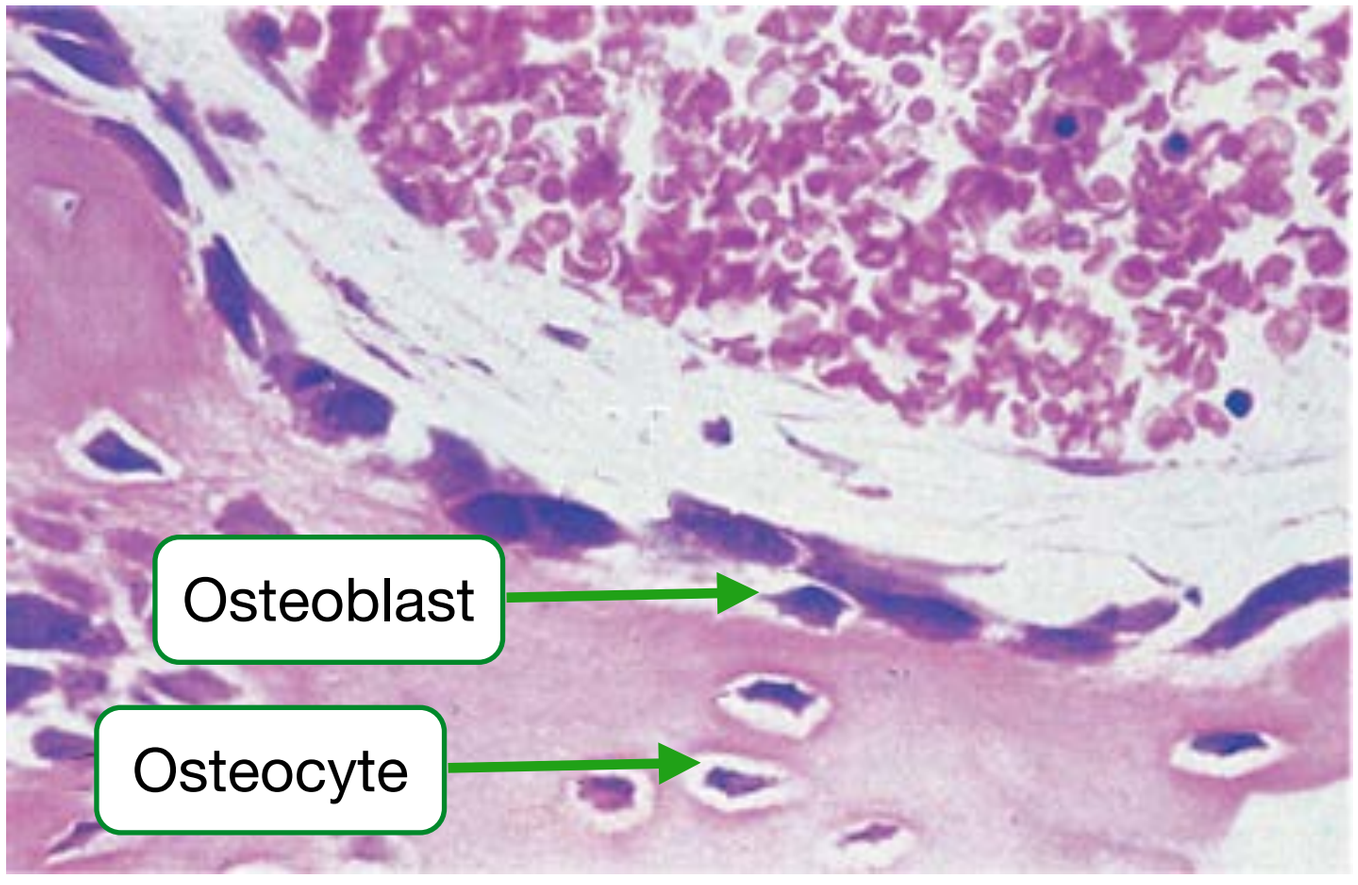
Osteoblasts secrete collagen and catalyze the crystallization of calcium on collagen fibers.



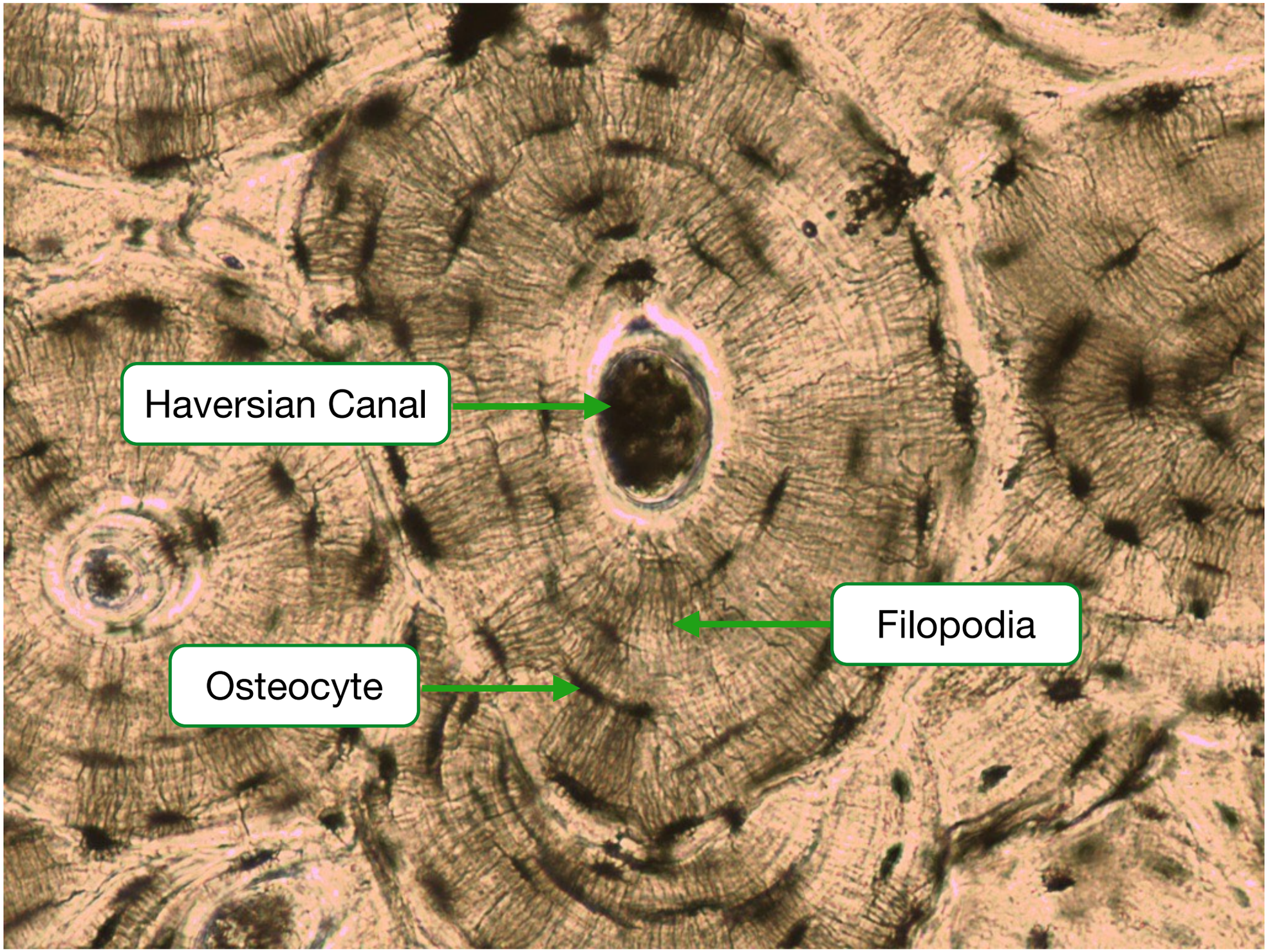
Osteoblasts synthesize osteoid that mineralizes into bone.



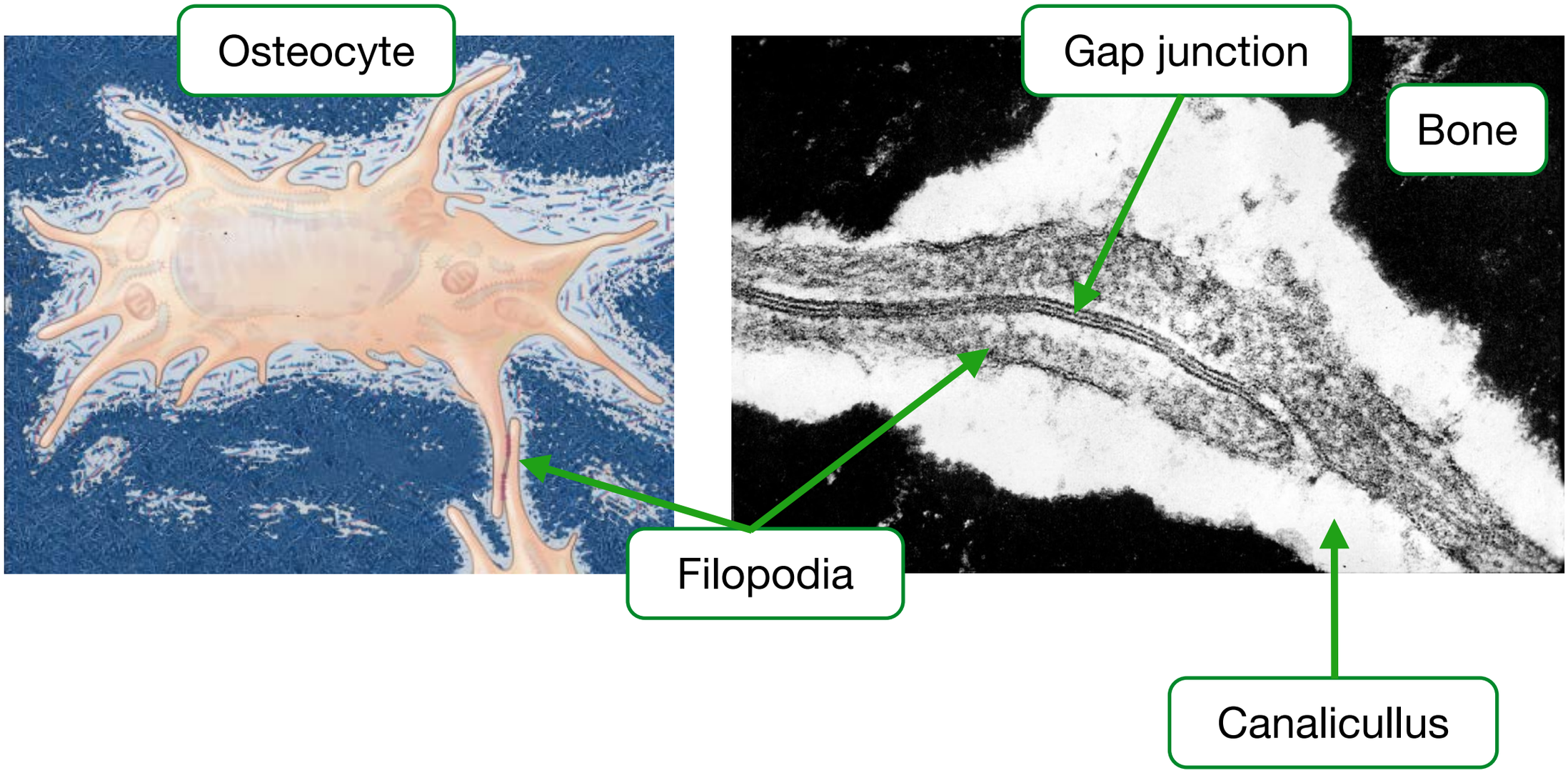
Osteocytes are osteoblasts that become trapped in bone matrix.



Ground section of Haverisan System showing osteocytes and their filopodia

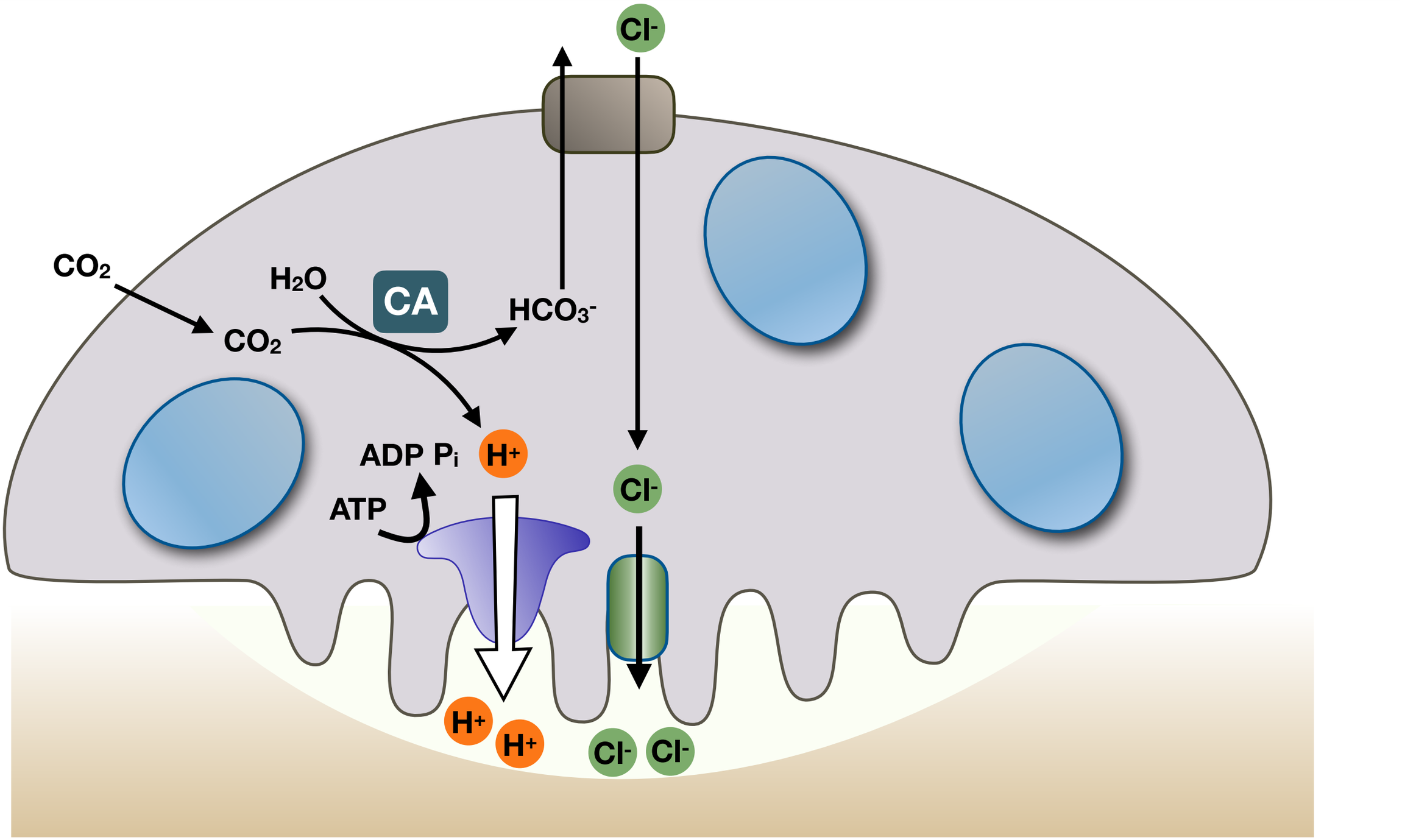


Osteocytes communicate via gap junctions on filopodia.

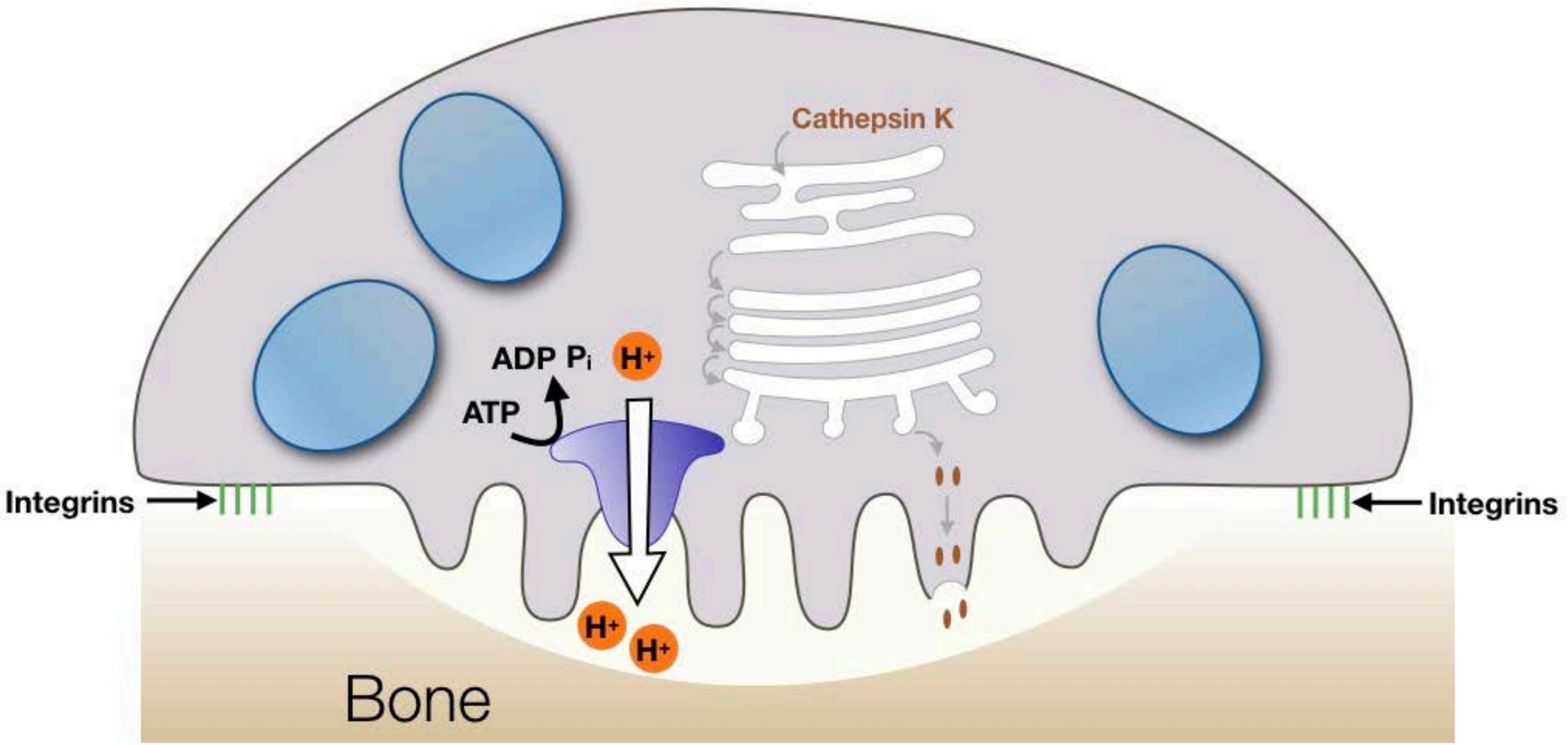


Osteoclasts

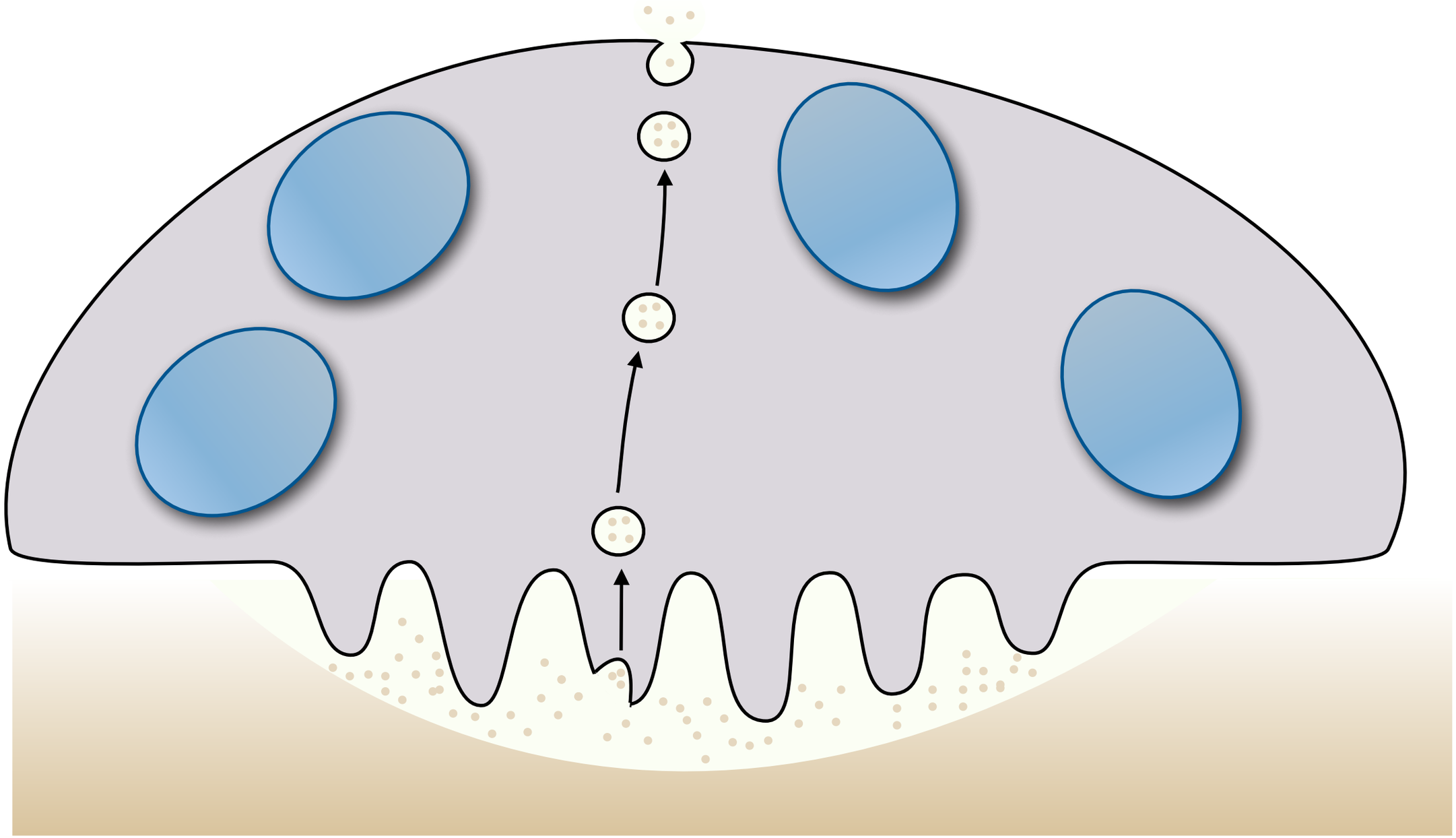
Osteoclasts secrete acid on bone to dissolve calcium-phosphate crystals.



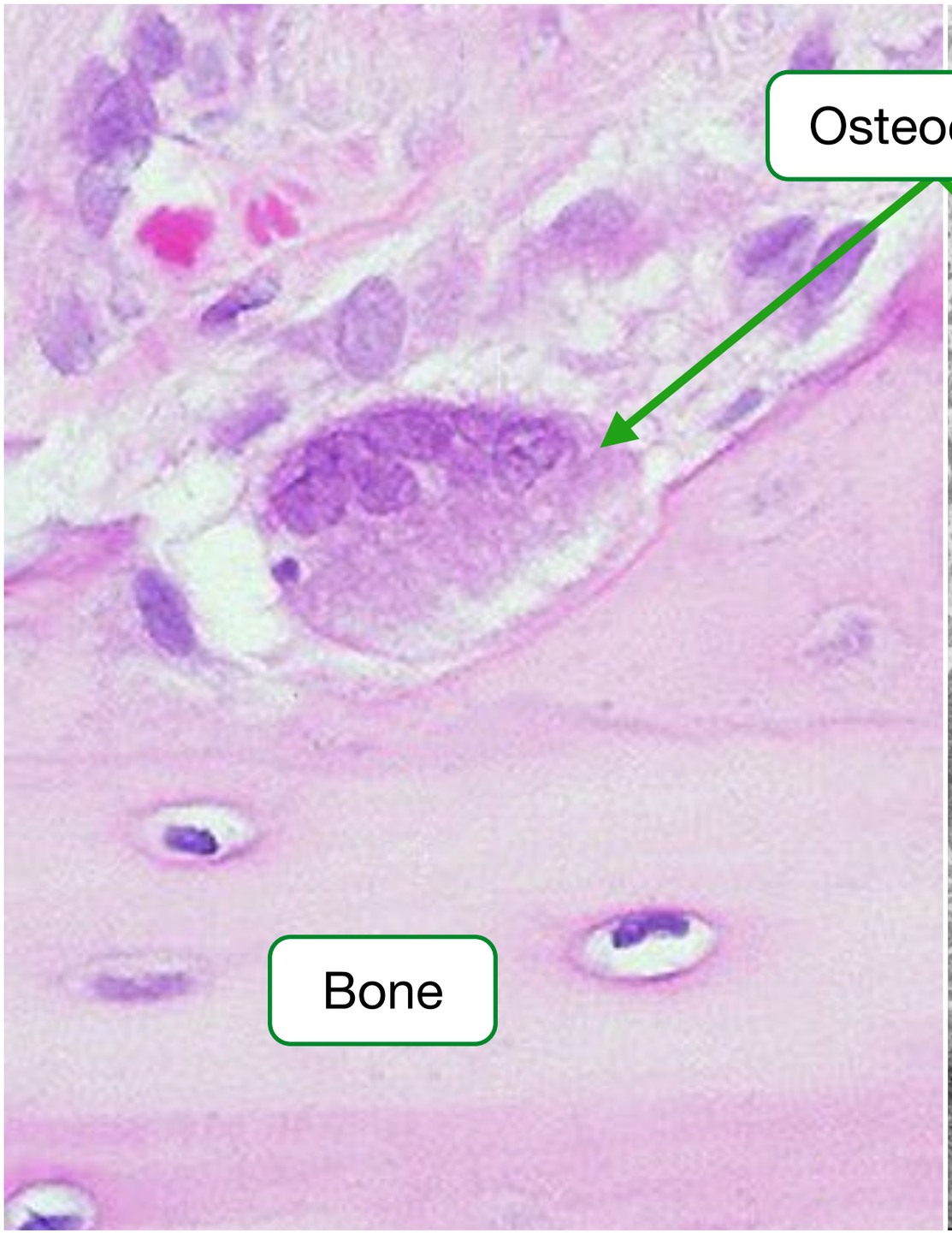
Osteoclasts secrete cathepsin K onto bone to digest collagen.

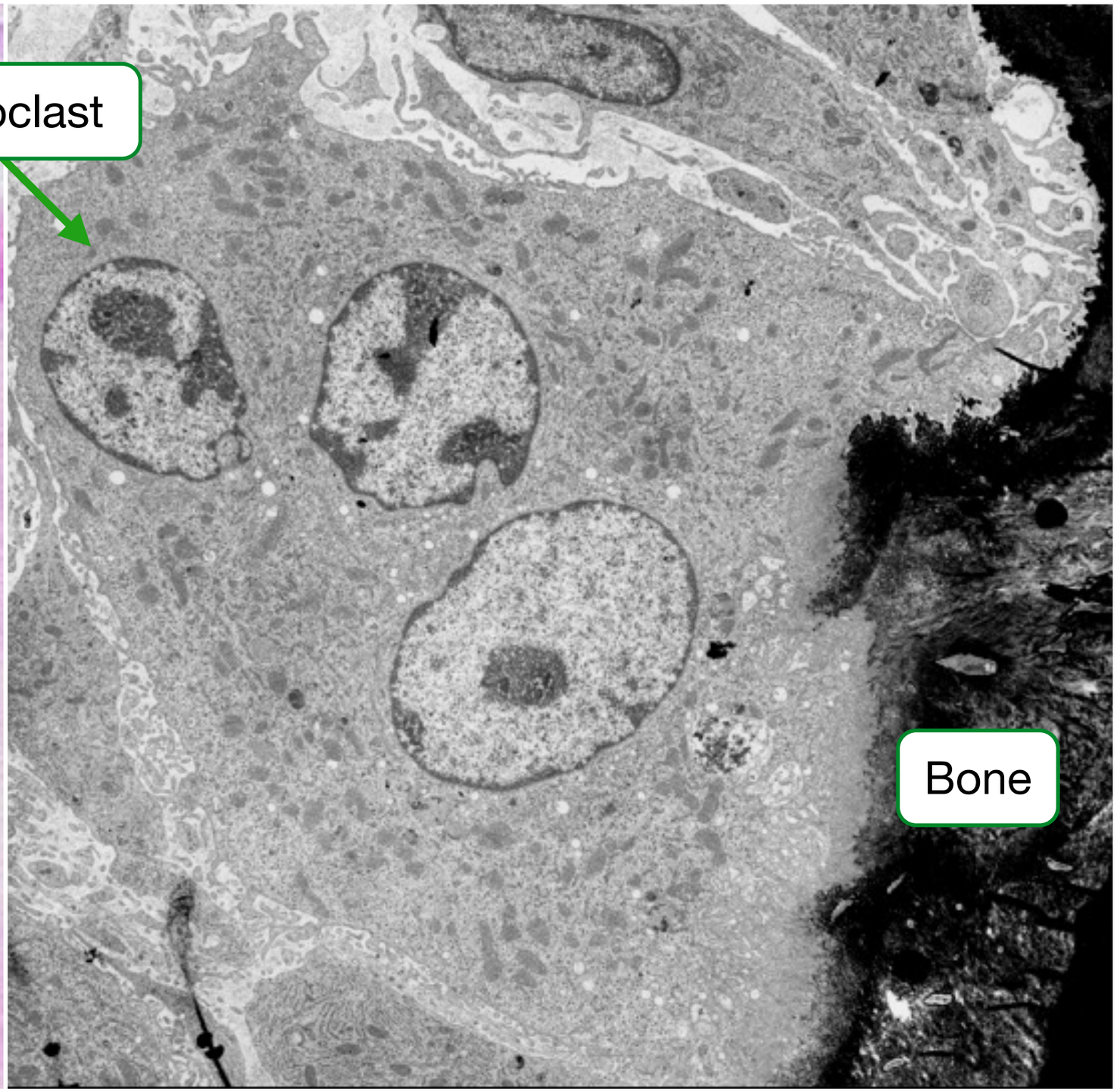


Transcytosis delivers digested bone matrix components to basal side of osteoclasts.



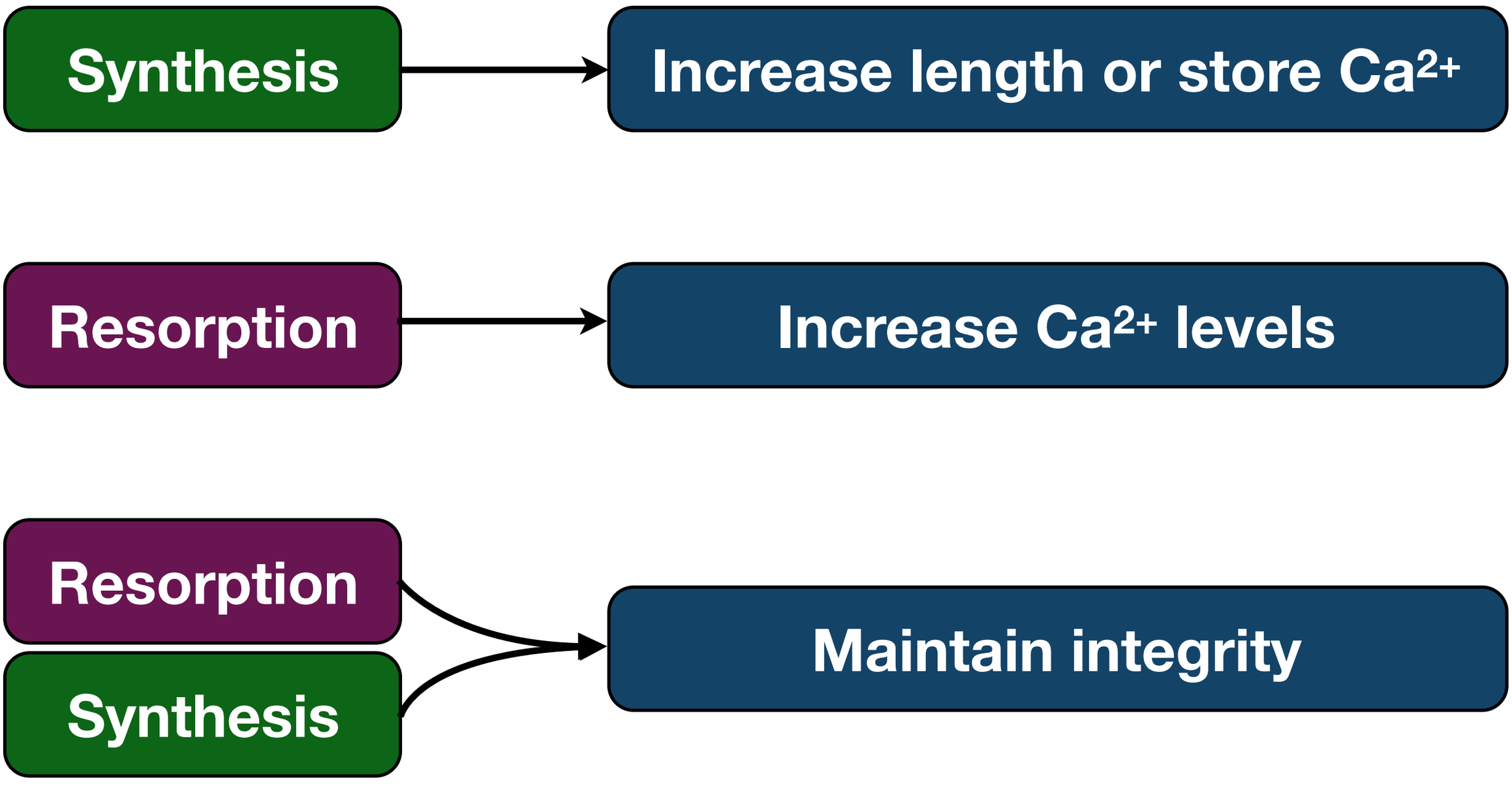
Histological image and electron micrograph showing an osteoclast



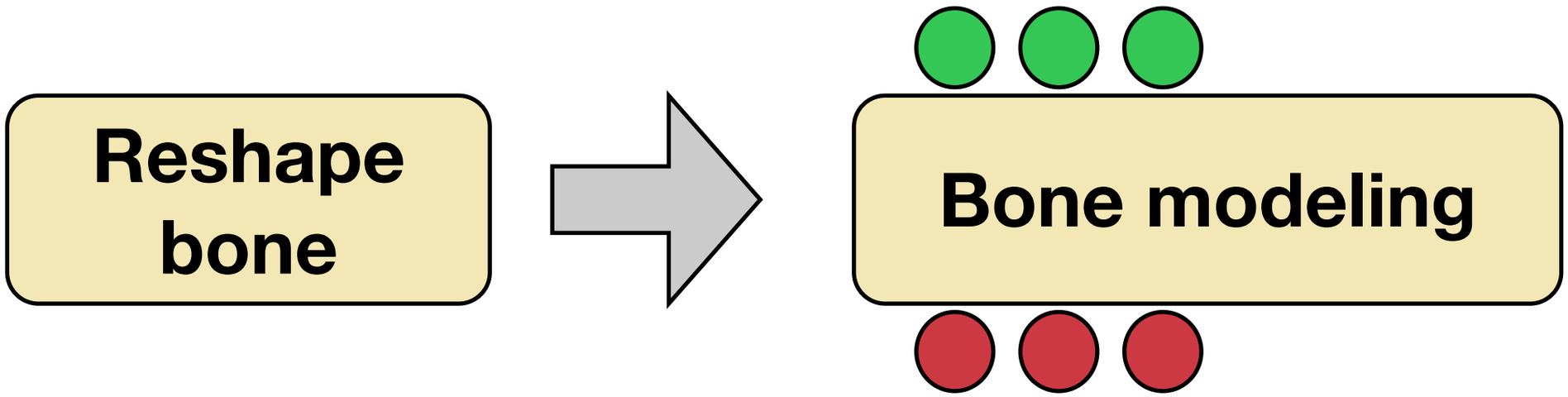


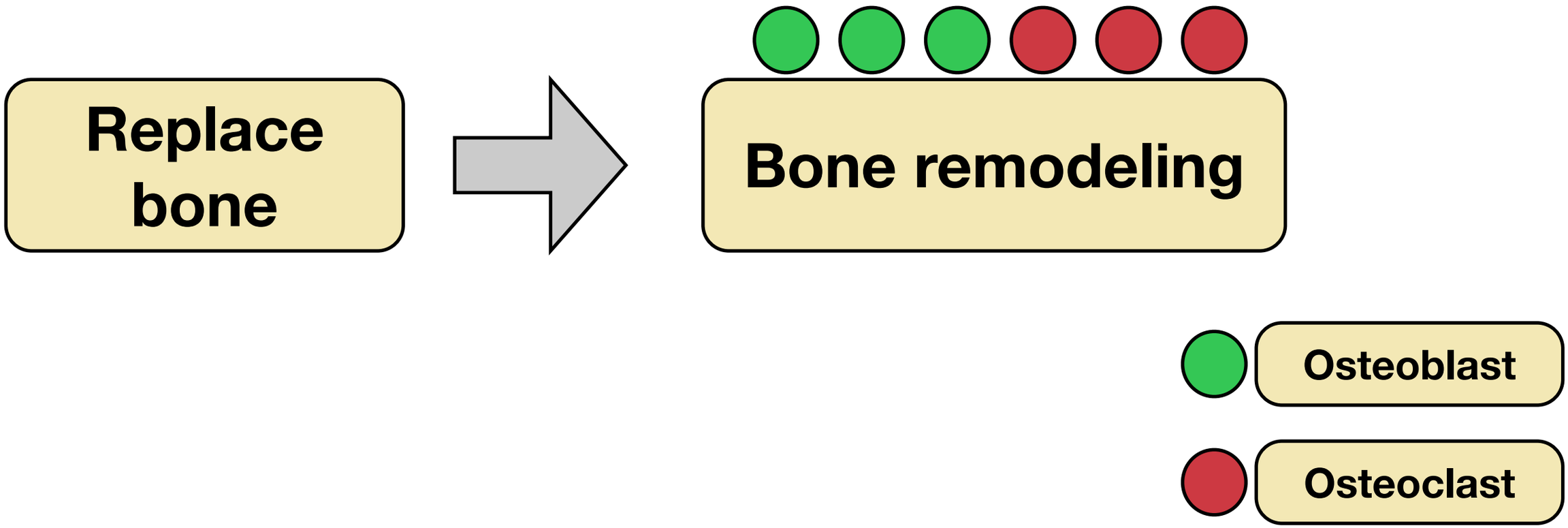
Dynamics of bone turnover

Bone is a dynamic material that undergoes synthesis and resorption.



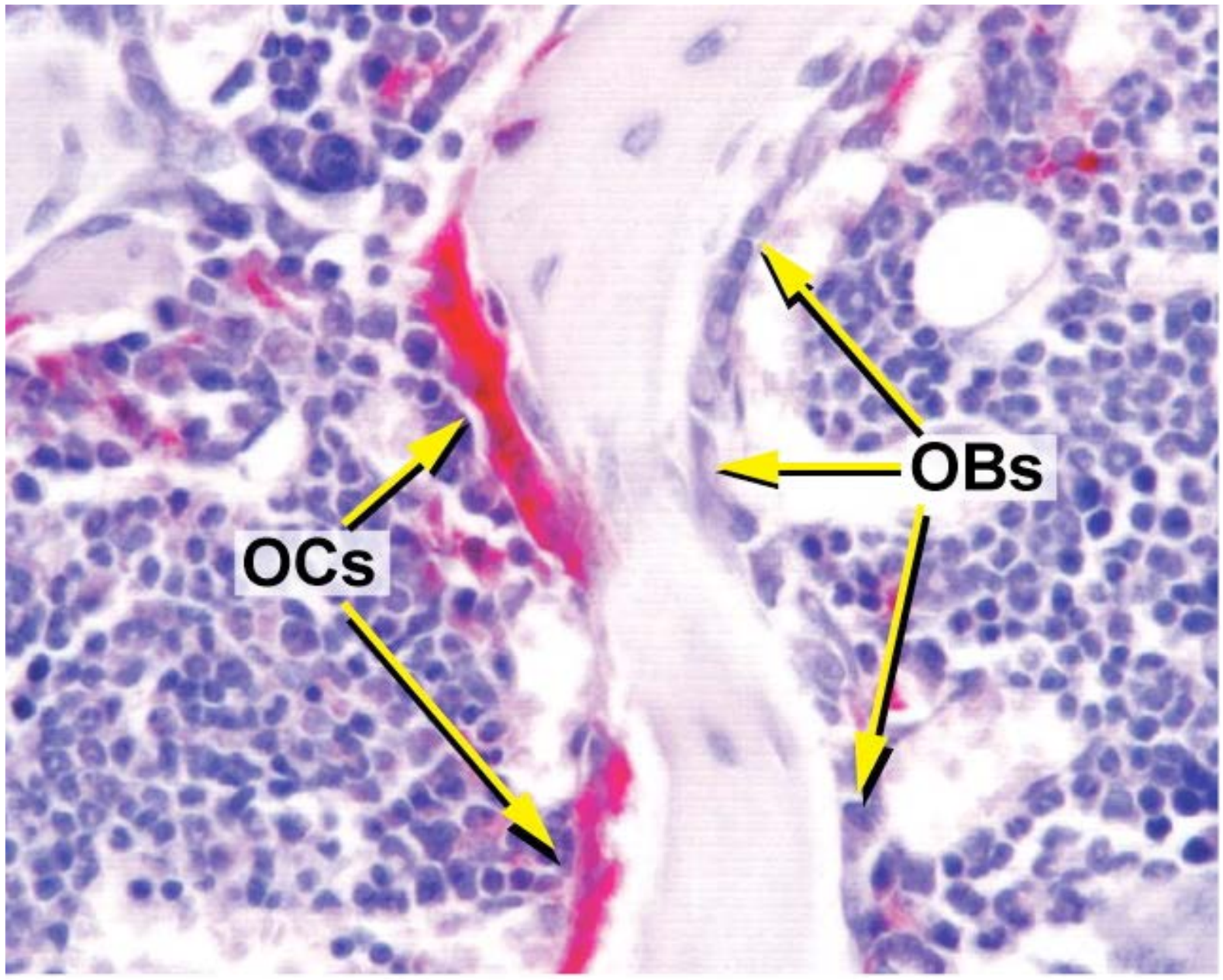
Osteoblasts and osteoclasts reshape bone and replace old bone.



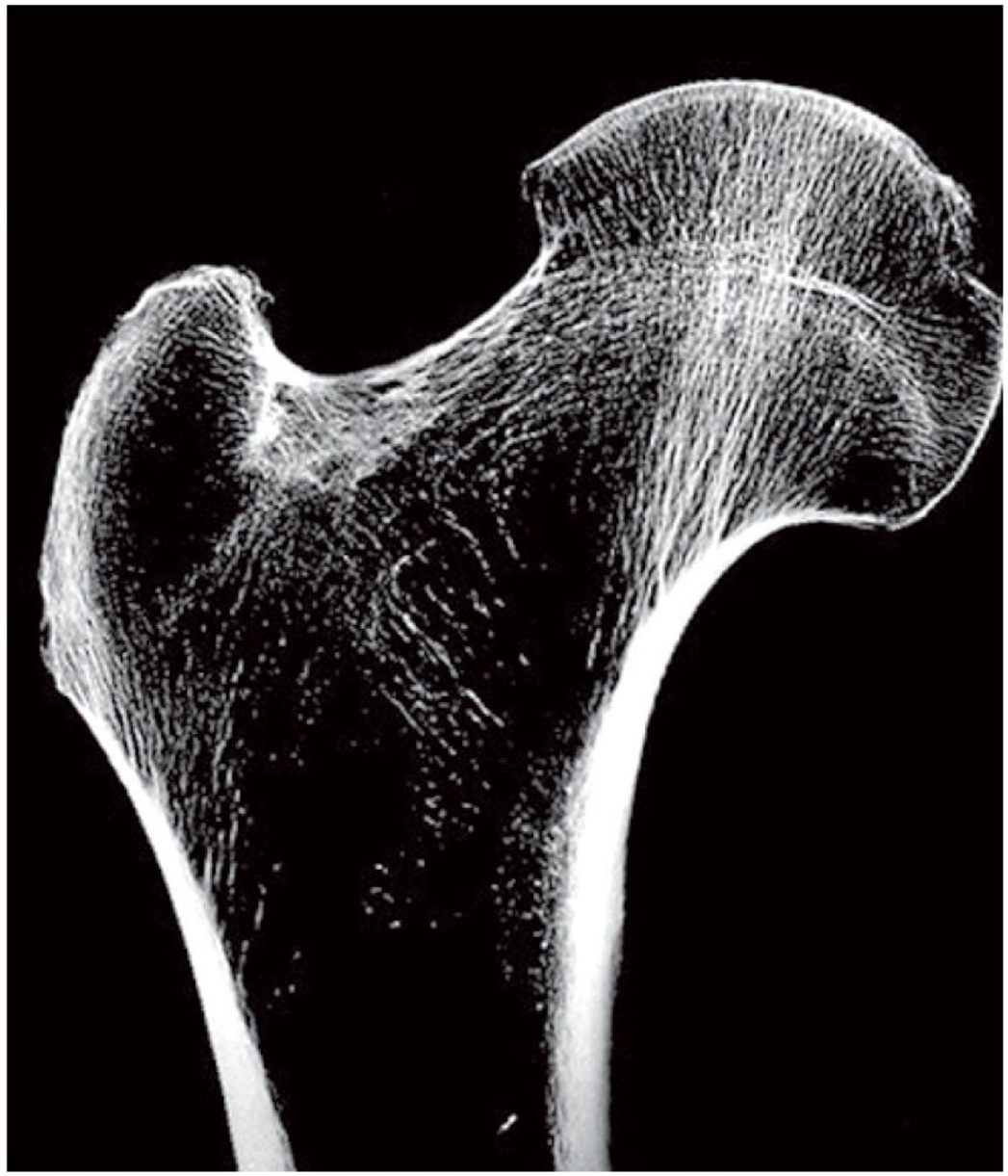


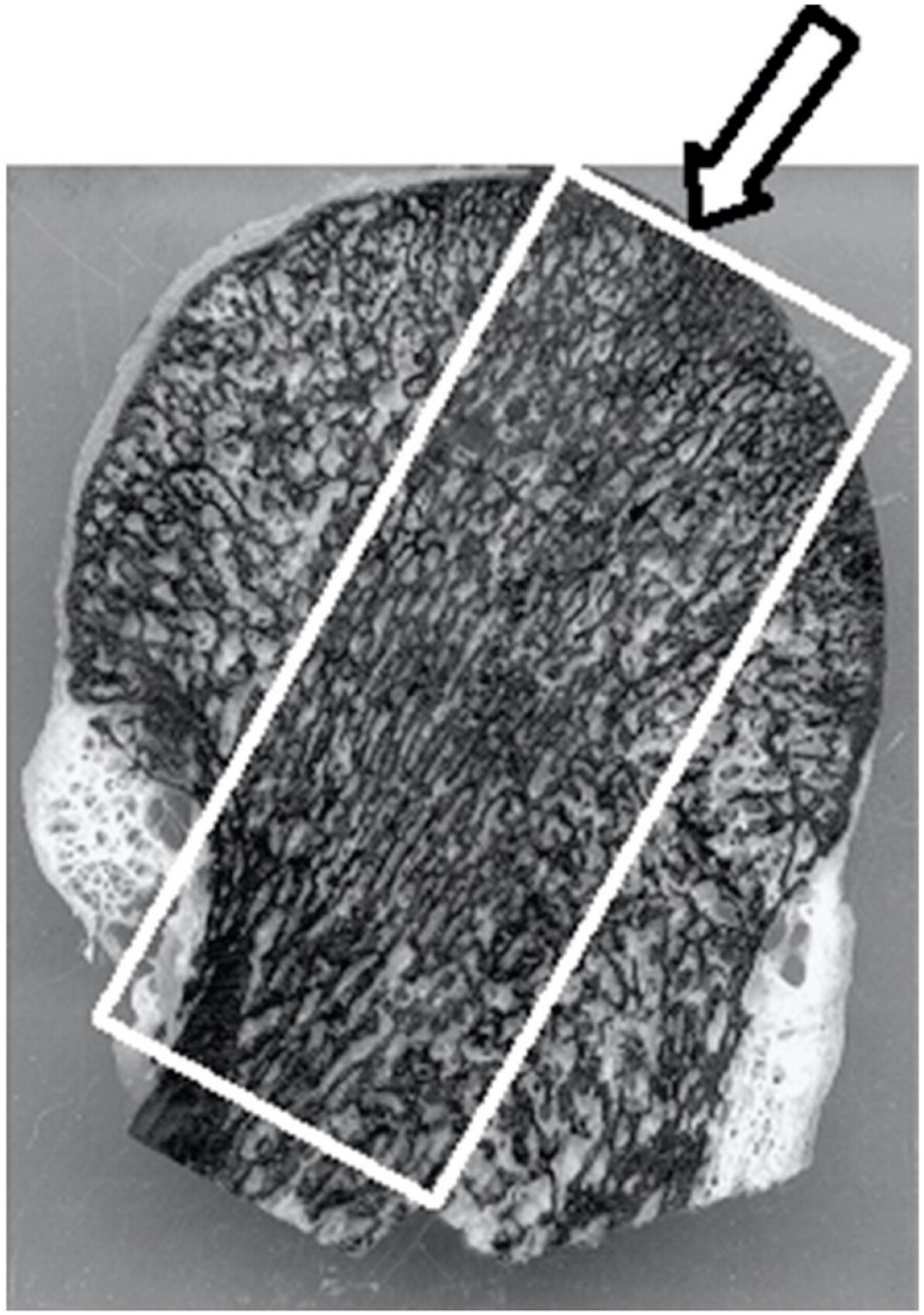
Bone modeling

Bone modeling shapes bone with osteoblasts and osteoclasts working on different surfaces.

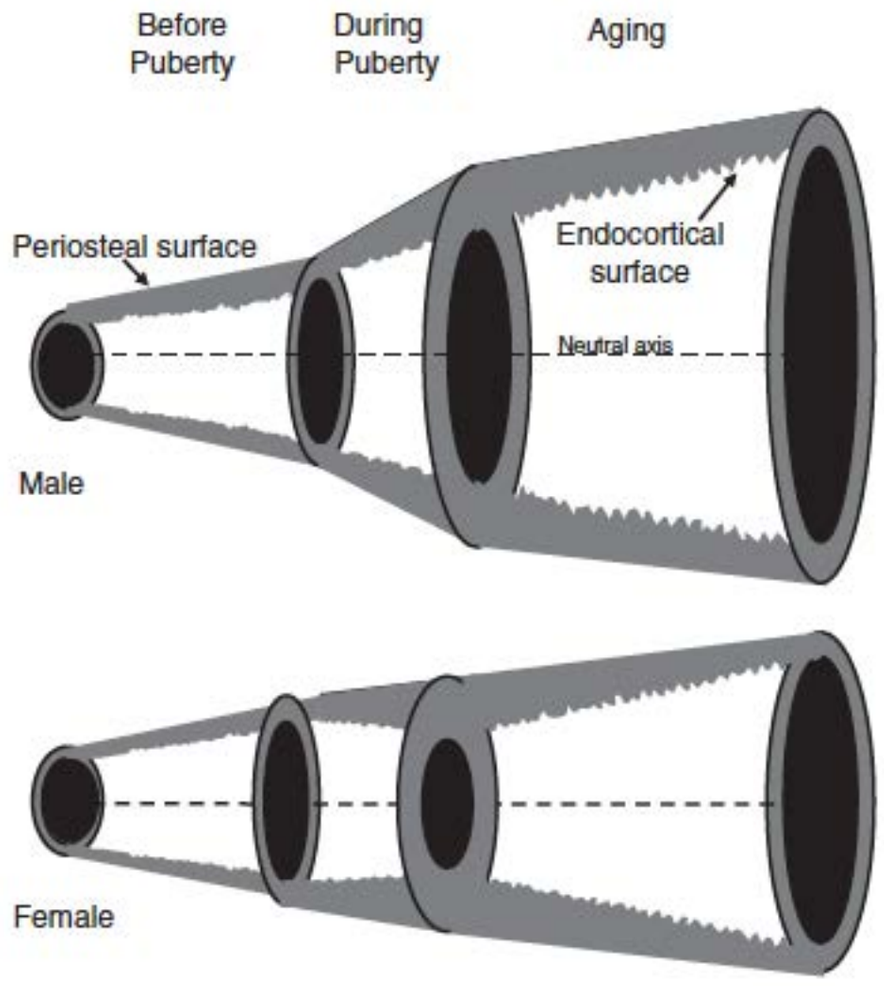


Trabecular bone aligns along lines of stress.



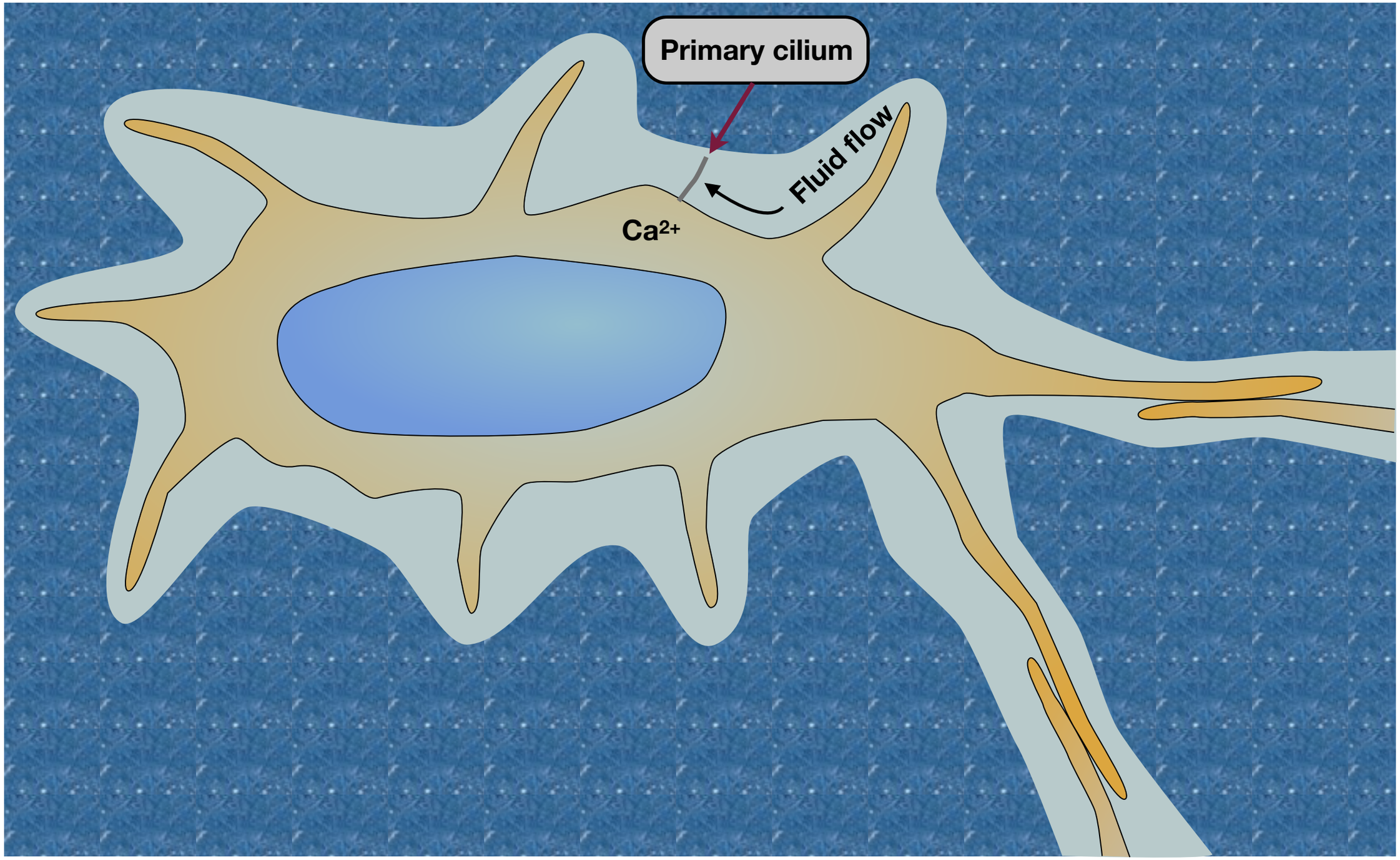


Periosteal apposition and endocortical resorption increase diameter of bone.



Seeman (2008) *J Bone Miner Metab* **26** 1-8

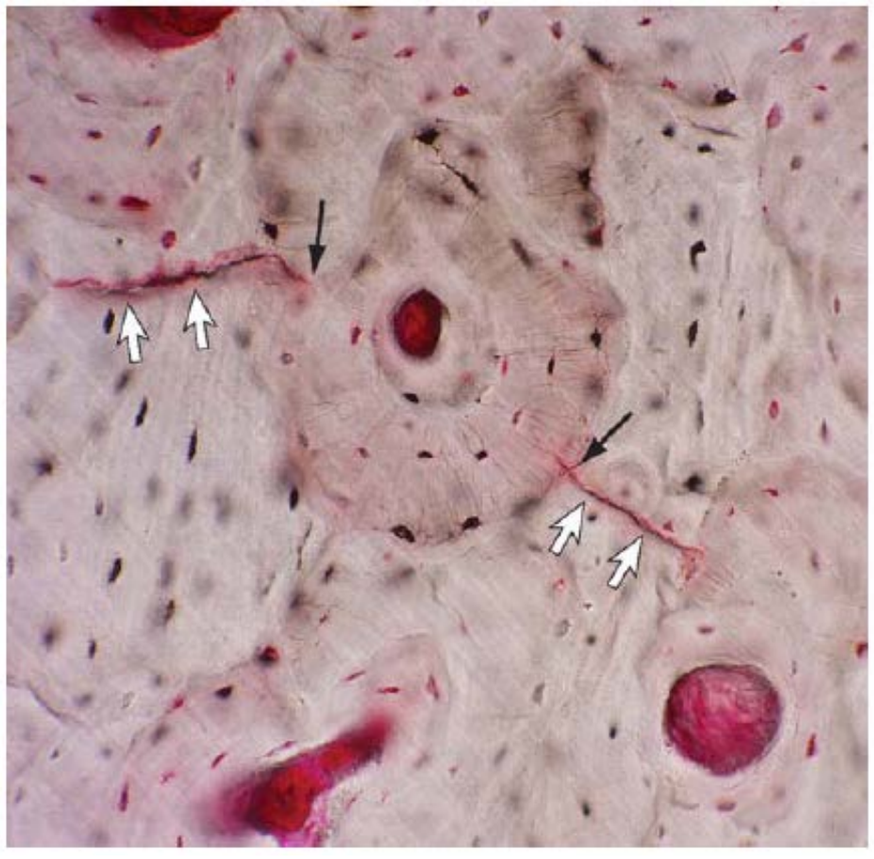
Osteocytes use a primary cilium to detect mechanical stress in bone.



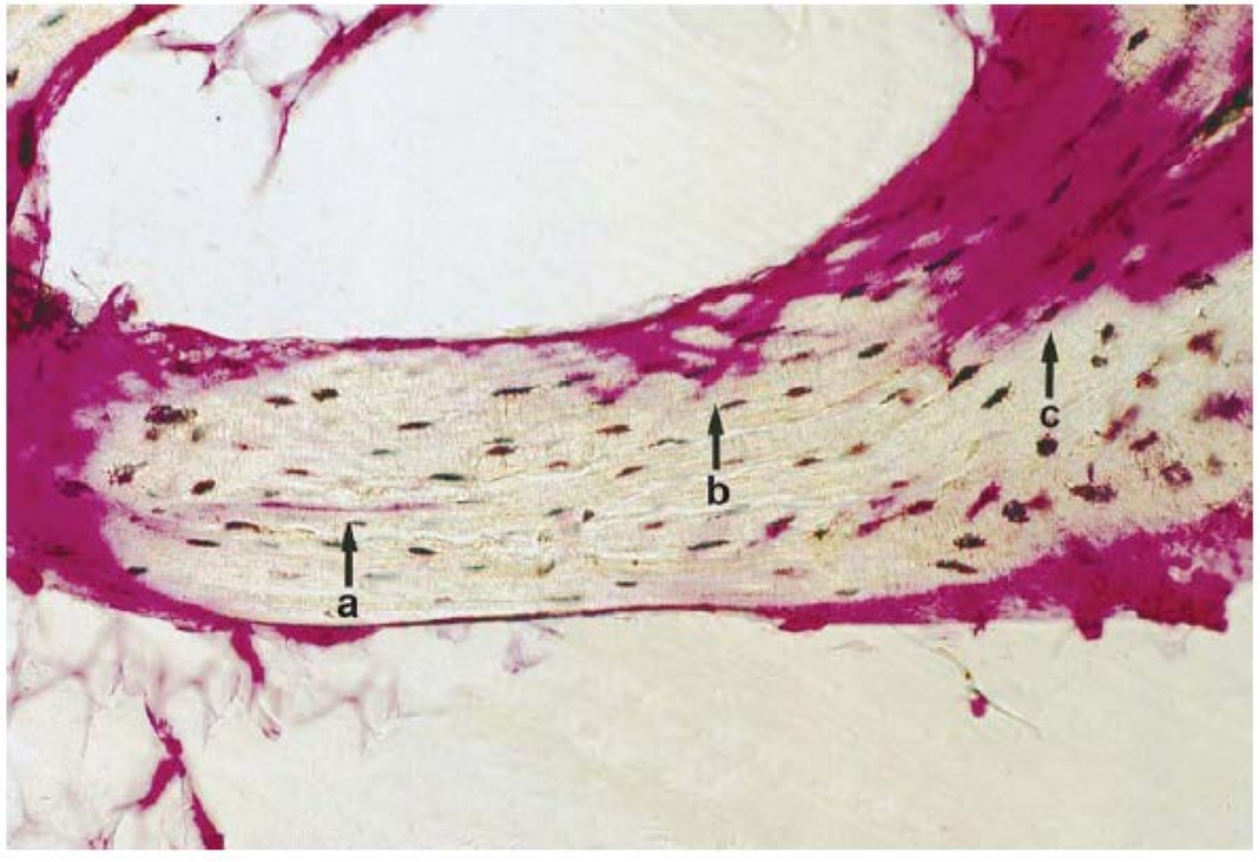
Bone remodeling

Bone remodeling removes old bone and replaces it with new bone.

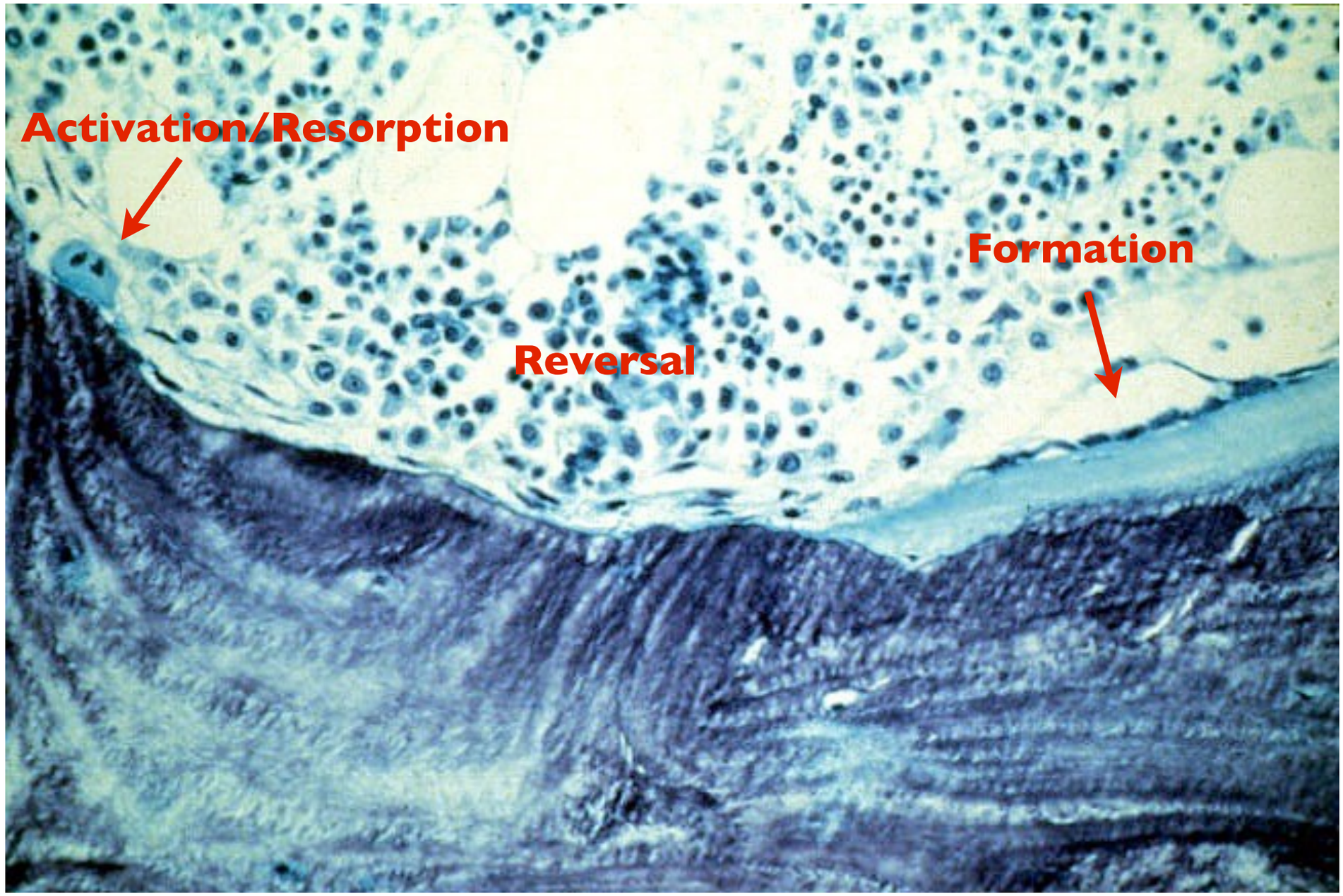
Compact bone



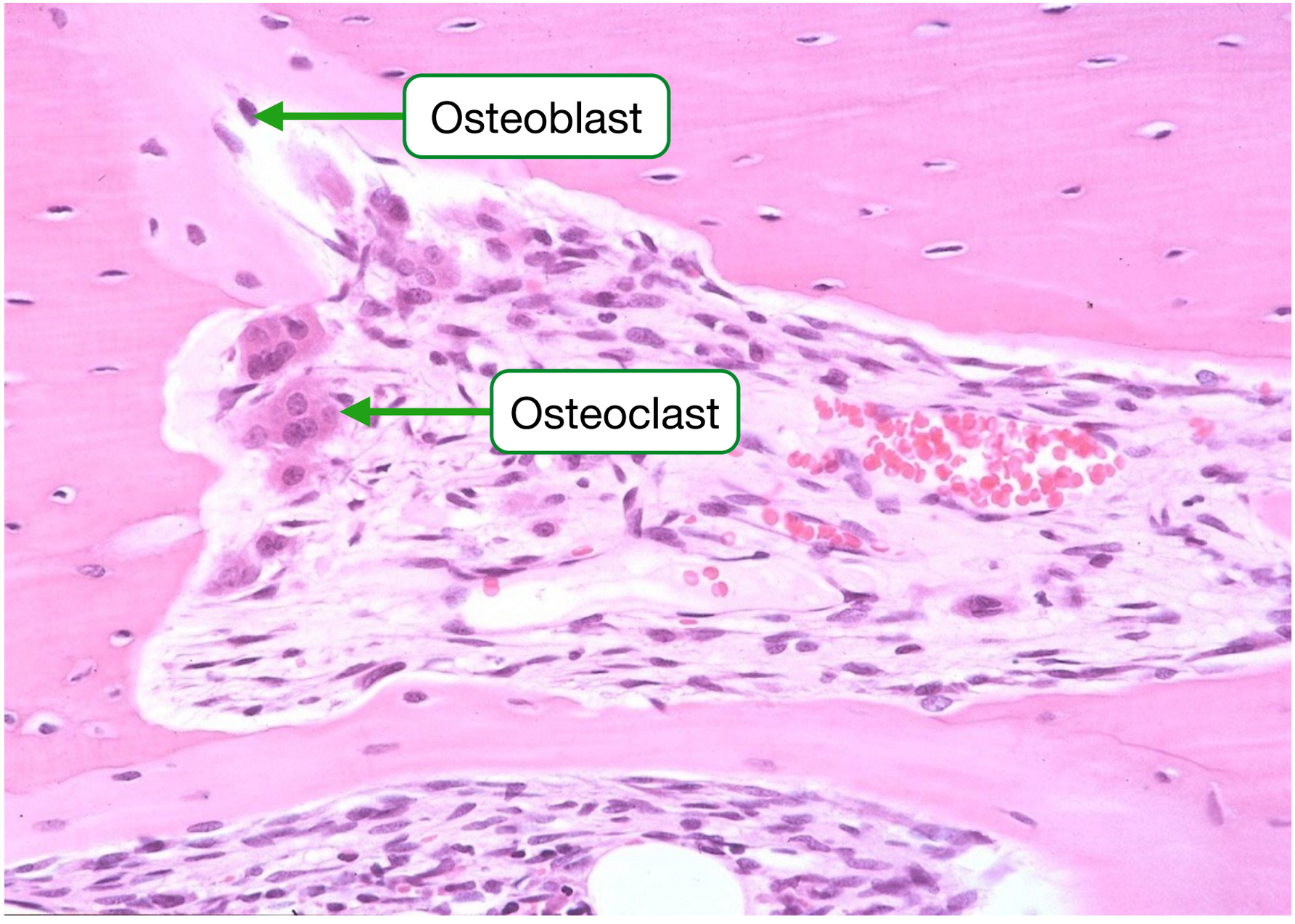
Trabecular bone



Remodeling repairs bone with osteoclasts and osteoblasts working on the same surface.

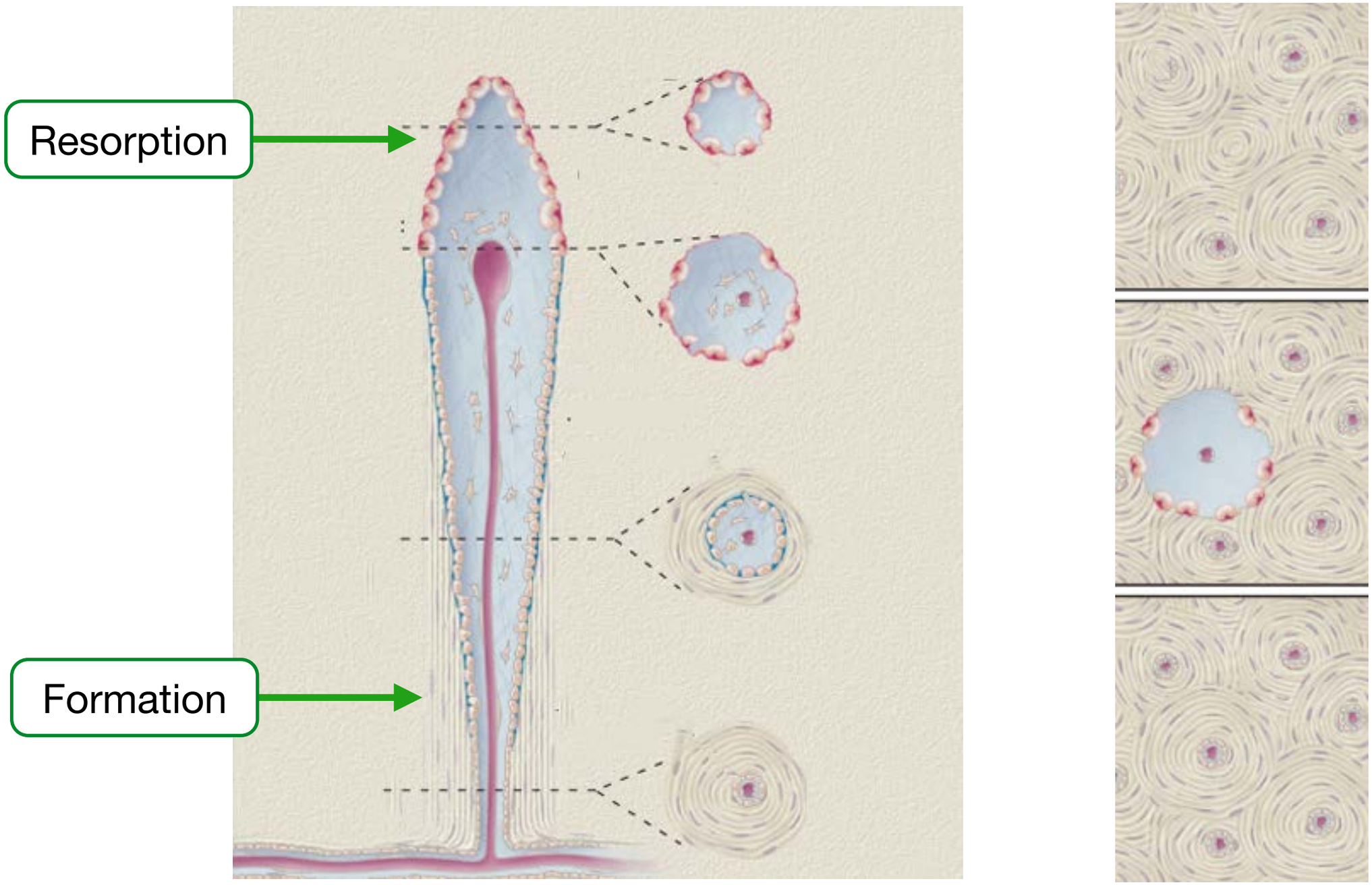


Basic multicellular unit consists of osteoclasts, osteoblasts that remodel compact bone.



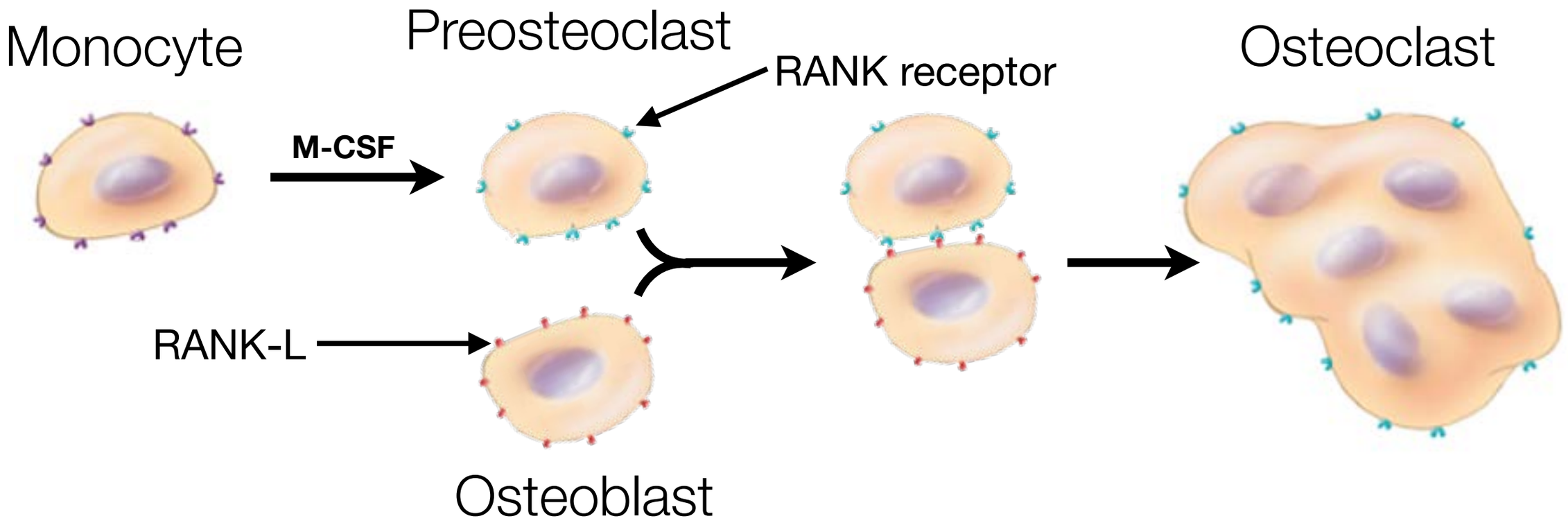
Kerr *Atlas of Functional Histology 1st edition*

Remodeling erodes old Haversian Systems while forming new canals.

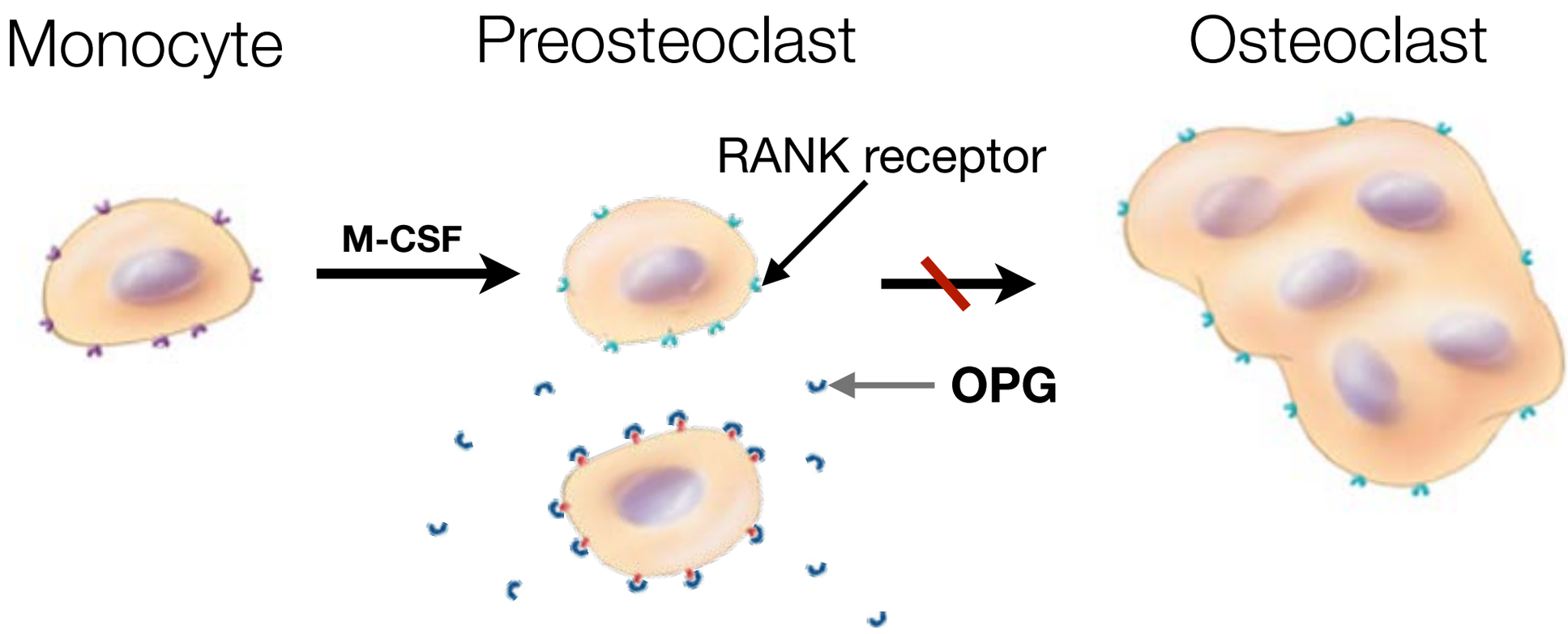


Development of osteoclasts

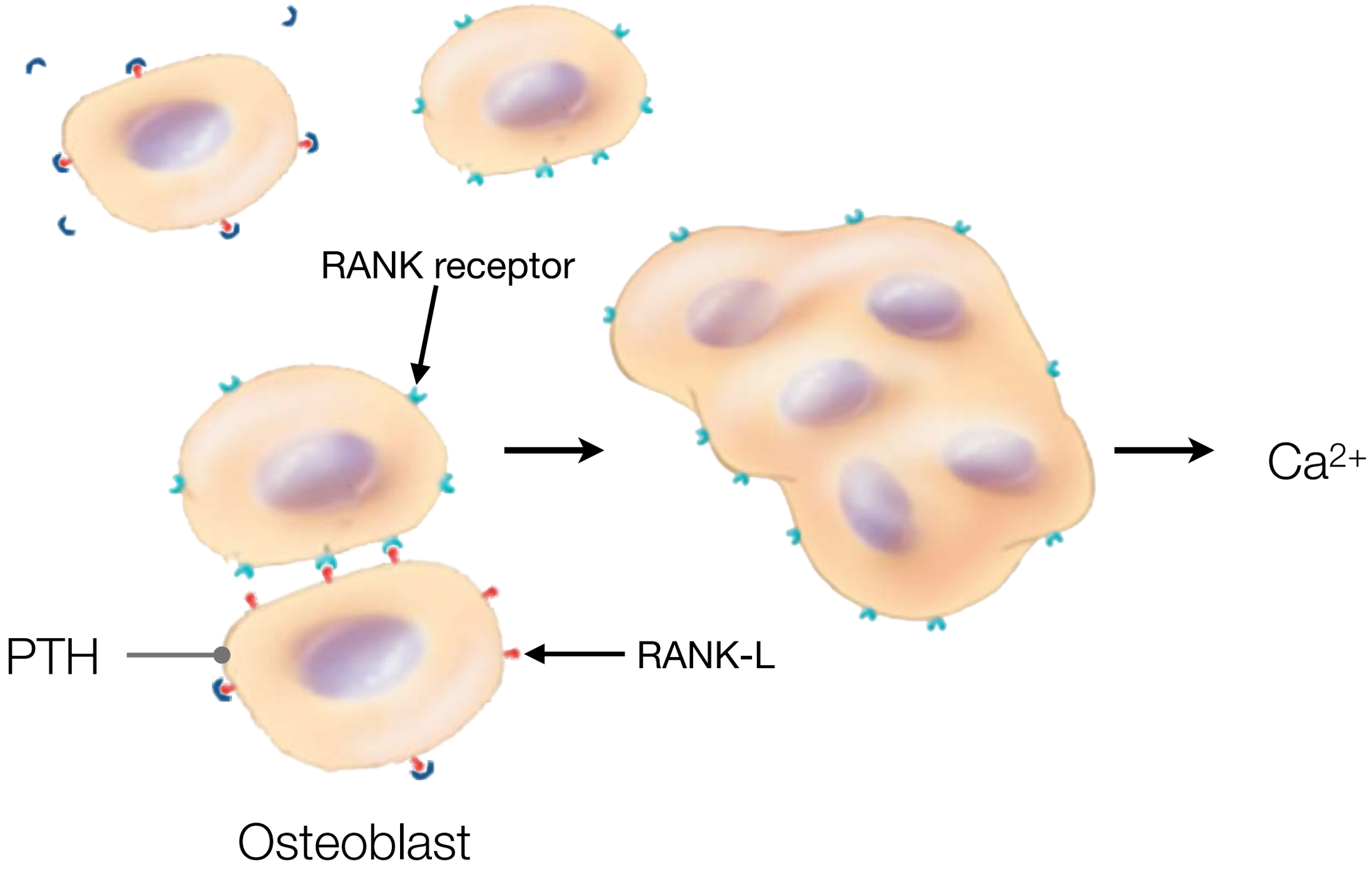
Pre-osteoclasts are activated by M-CSF and RANK ligand on the surface of osteoblasts.



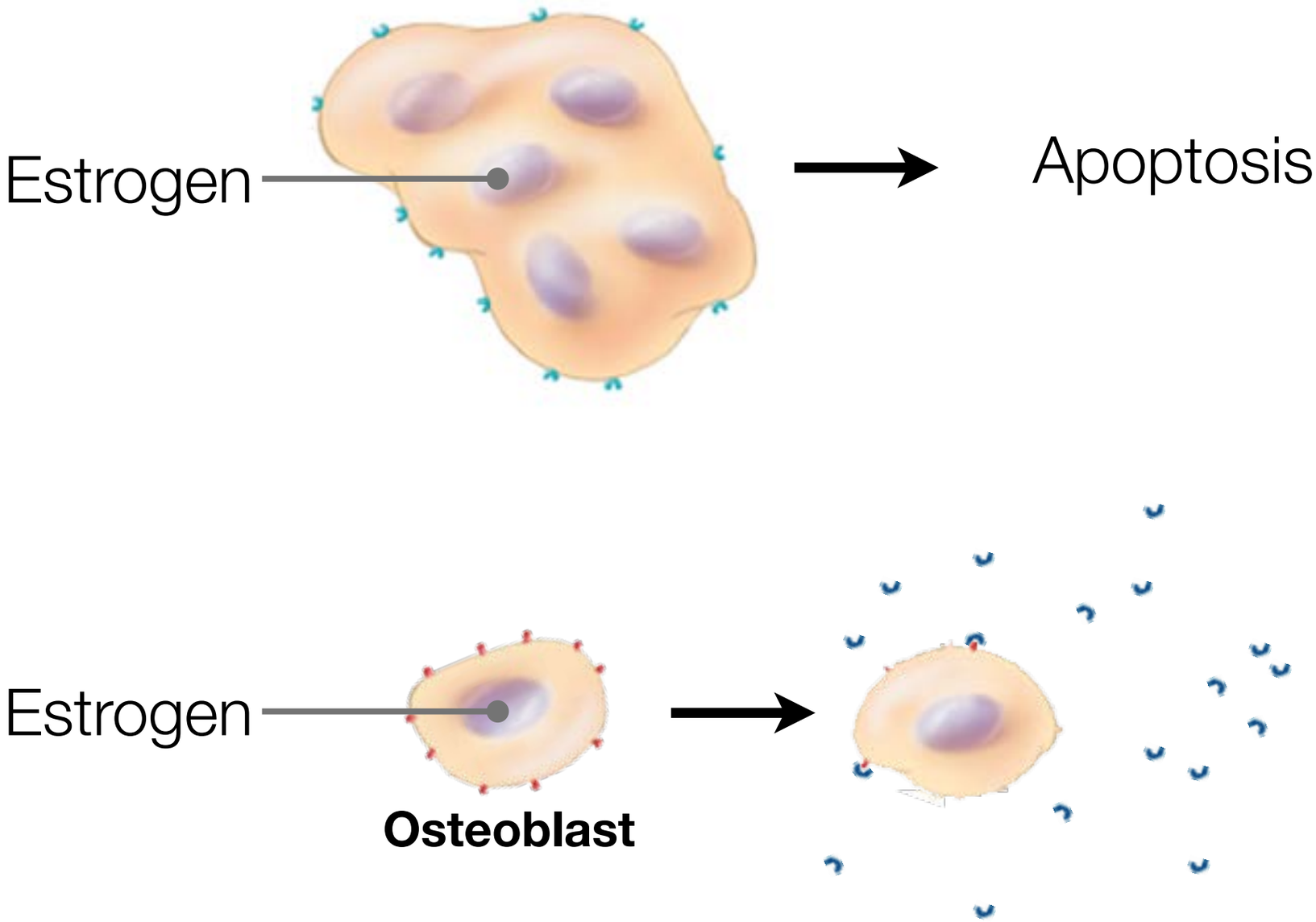
Osteoprotegerin is a decoy receptor for RANKL that prevents activation of preosteoclasts.



Parathyroid hormone stimulates osteoblasts to increases RANKL and decrease OPGs.

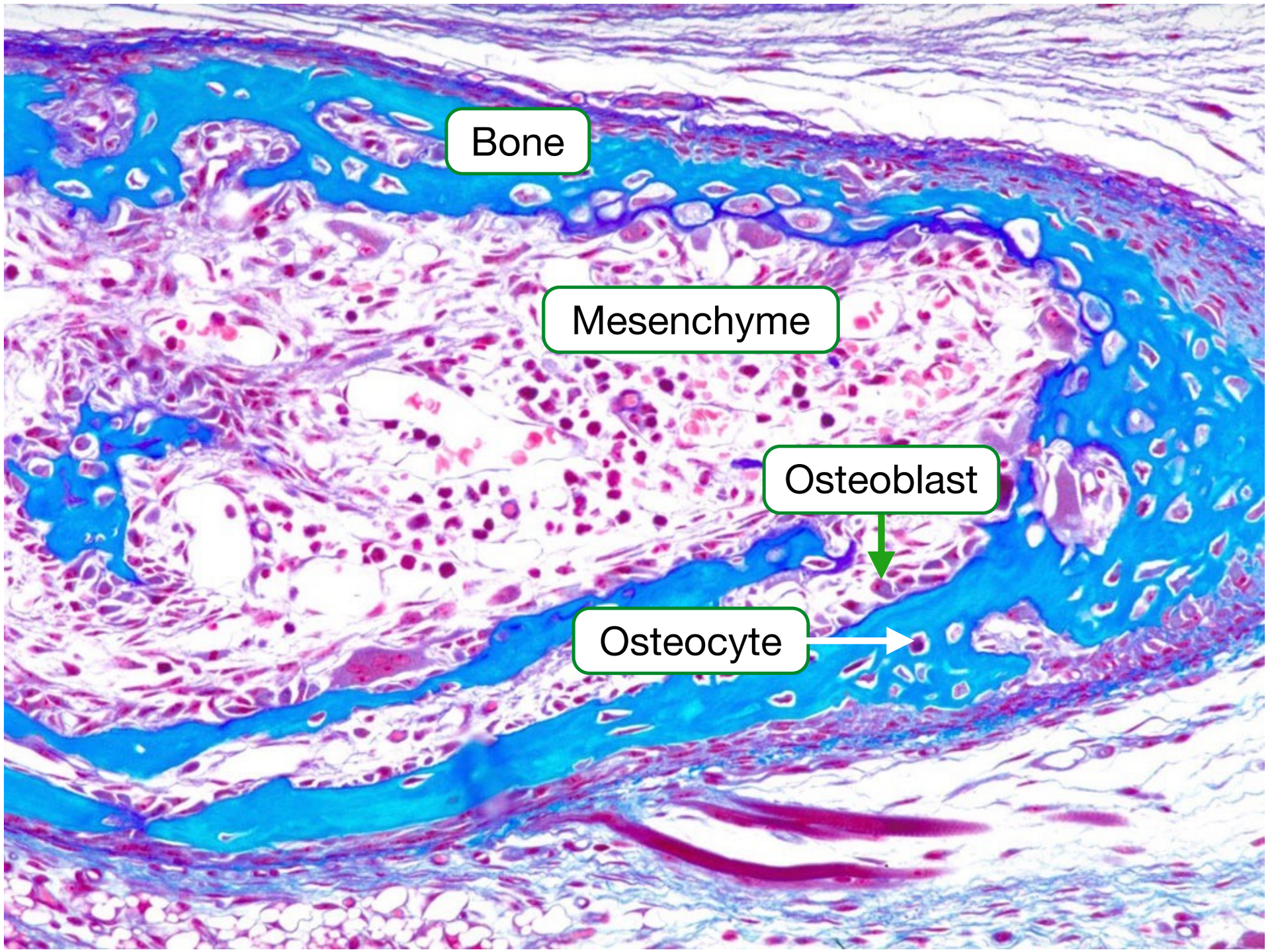


Estrogen has direct and indirect effects on the development and lifespan of osteoclasts.

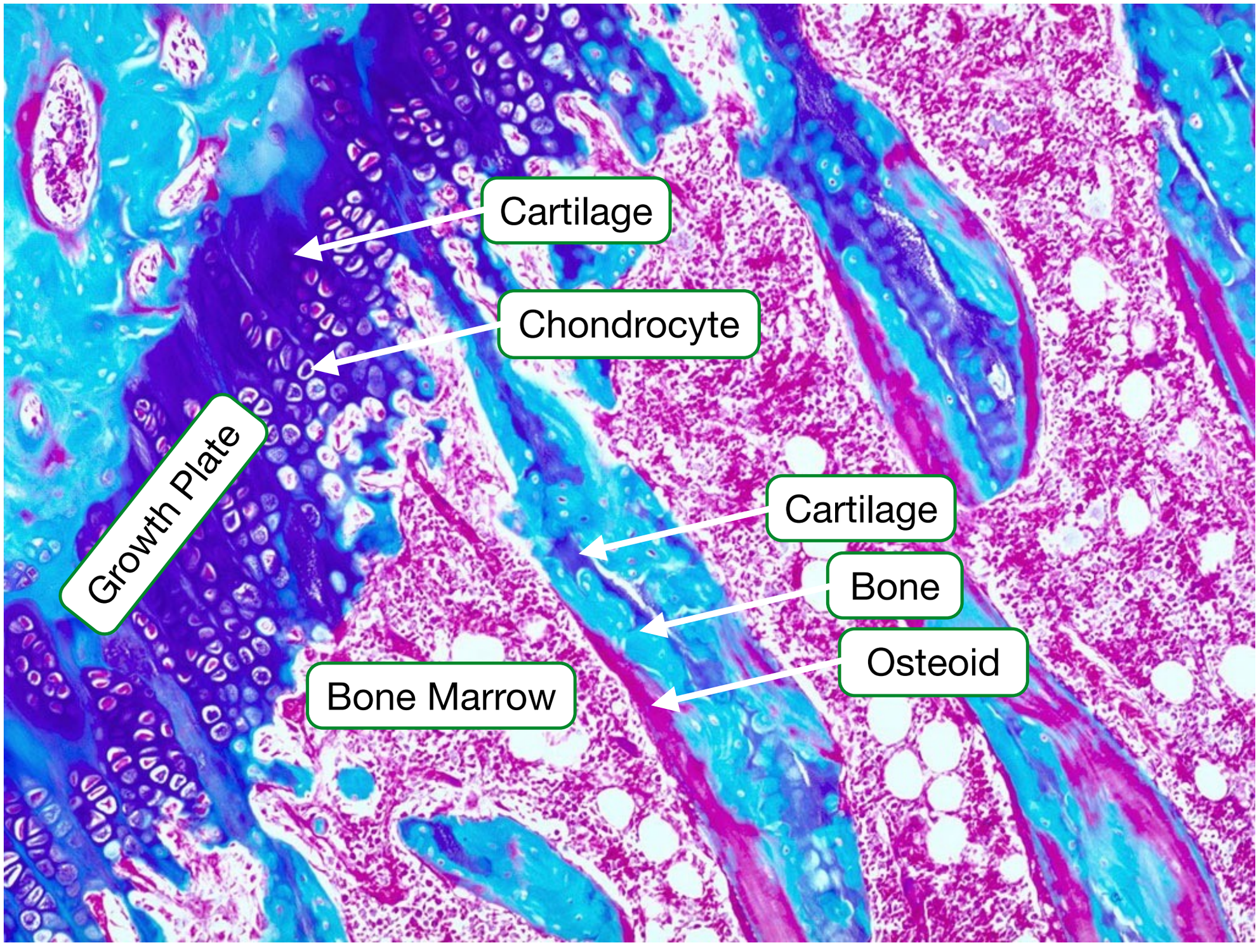


Bone development

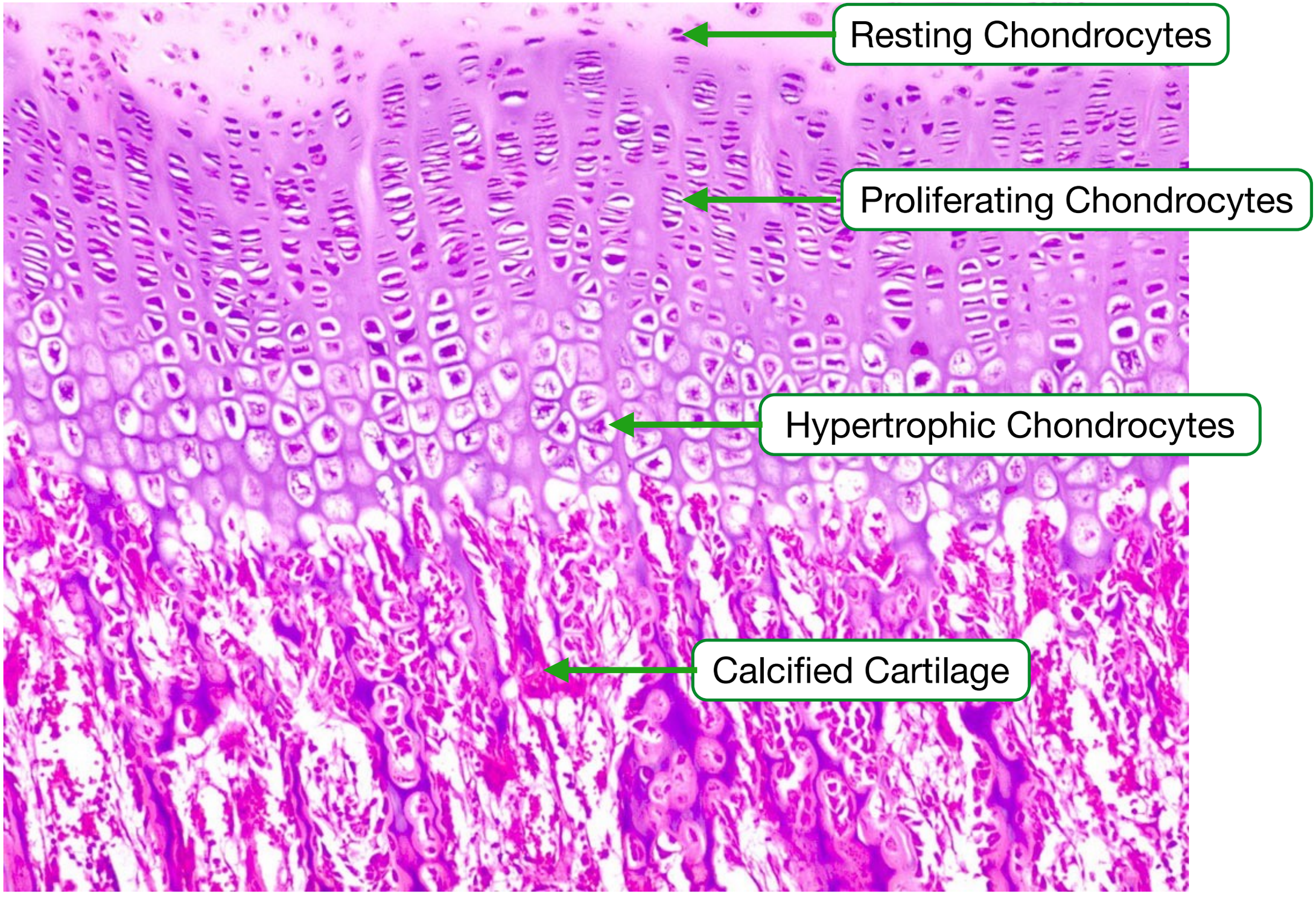
Intramembraneous ossification involves bone formation on mesenchymal tissue.



Endochondrial ossification is bone formation on cartilage.



The developmental sequence of chondrocytes drives bone formation in growth plates.



Take home points...

- The properties of connective tissue is determined by the and arrangement type of ECM components and the cellular composition.

- Bones contain of compact bone and trabecular bone.

- Osteoblasts synthesize bone and osteoclasts dissolve bone.

- Osteocytes are mechanical sensors that regulate bone synthesis and absorption.

- Bone modeling reshapes bone and bone remodeling replaces old bone.

- Increased activity and numbers of osteoclasts leads to osteoporosis.