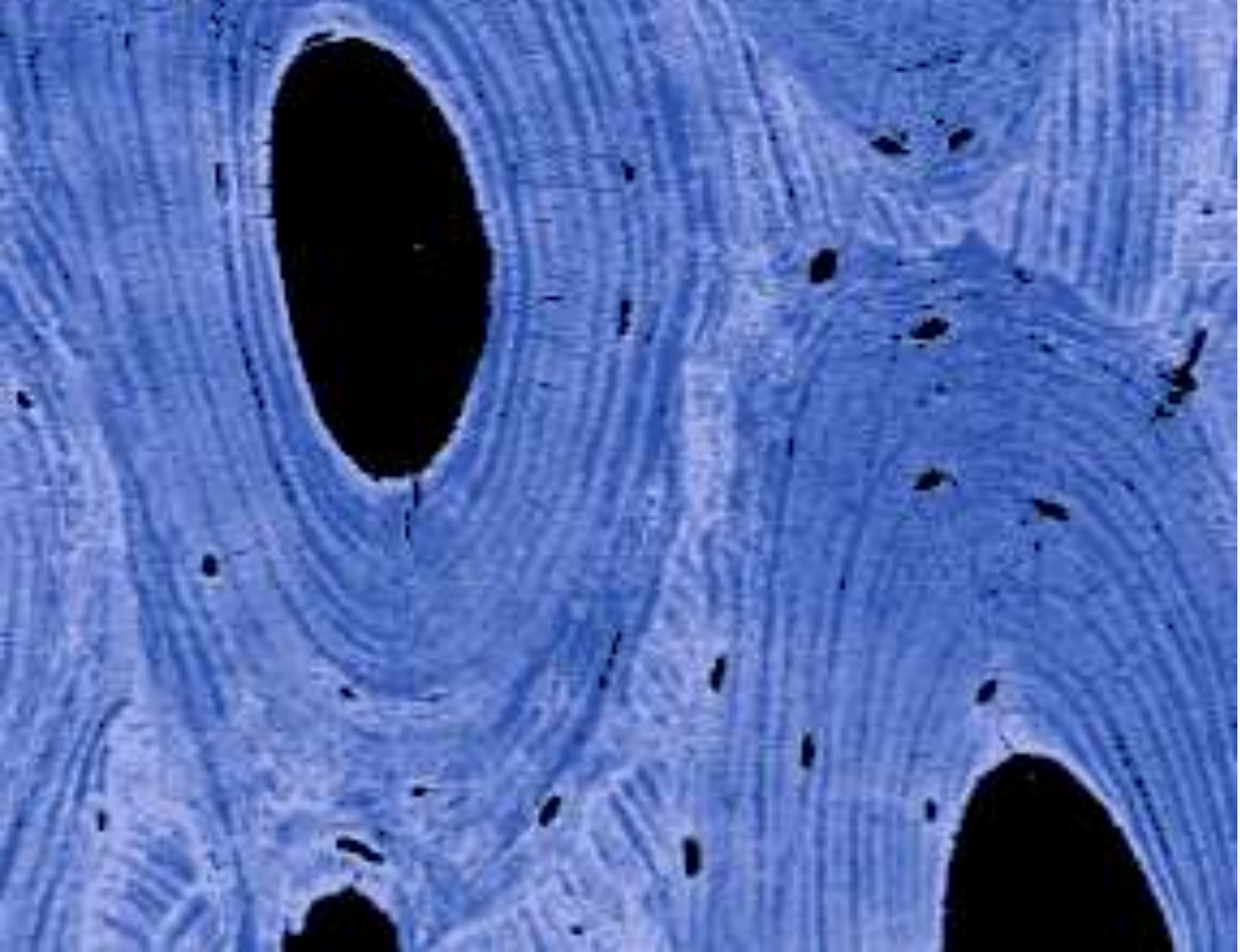
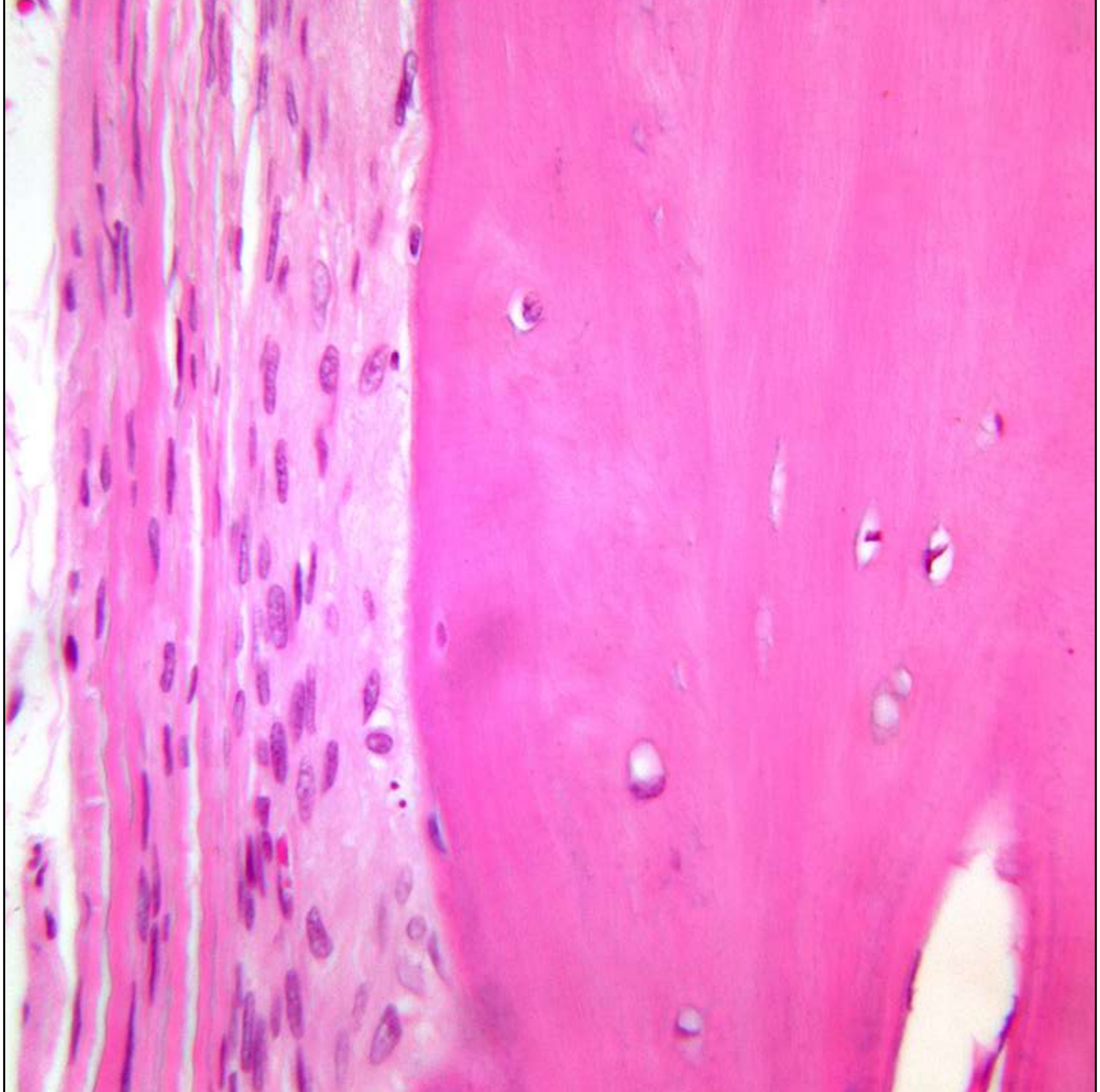
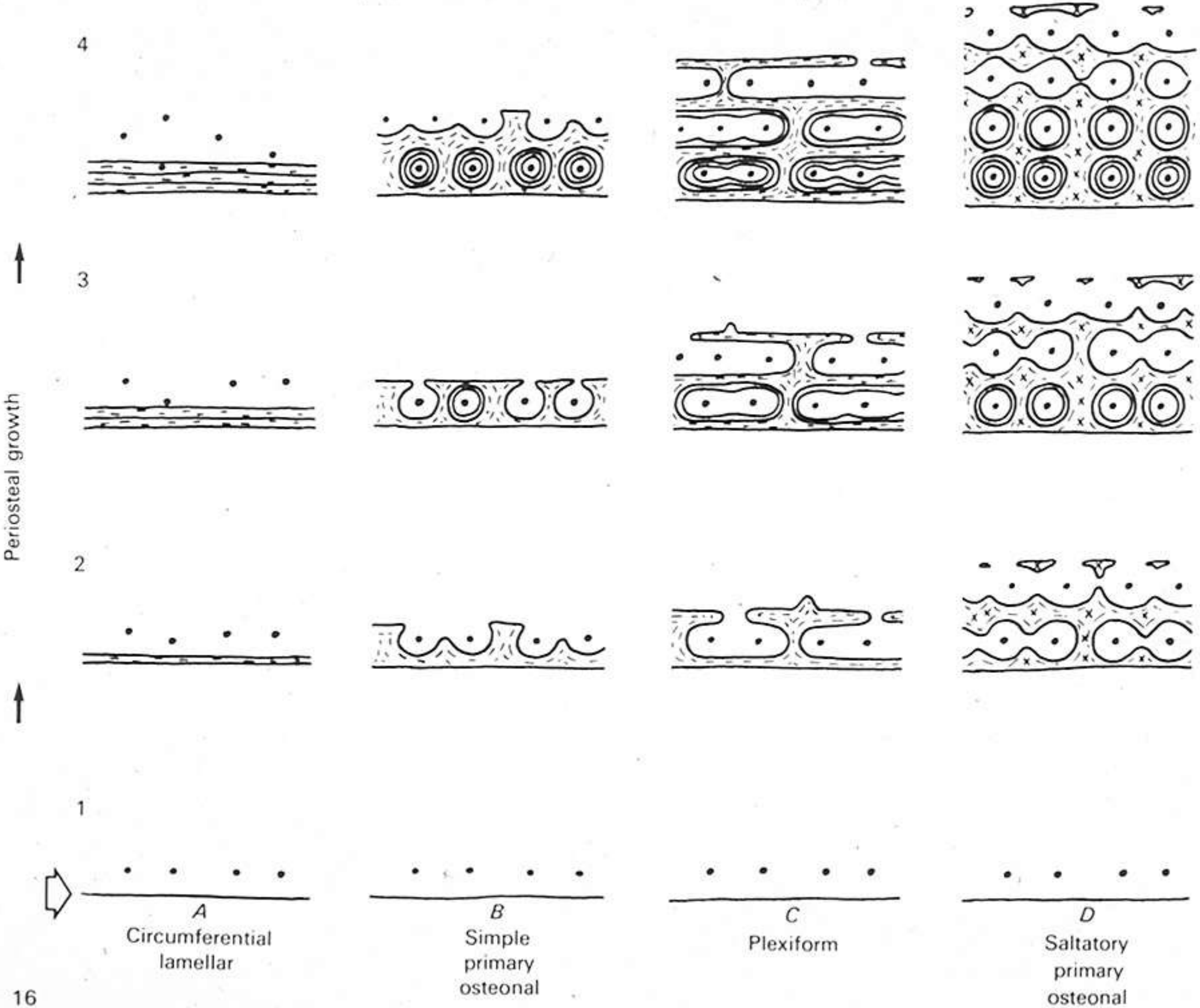
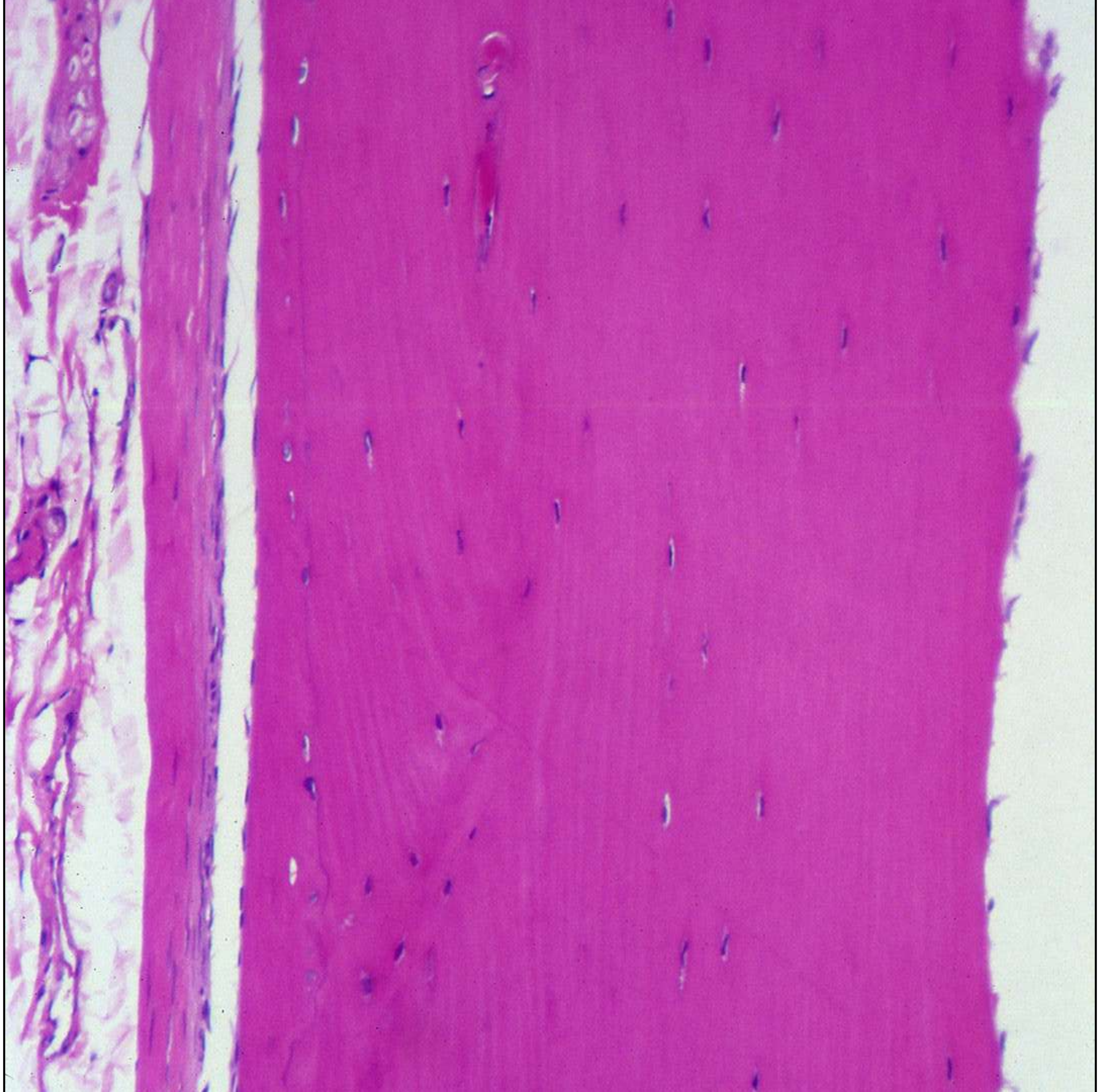
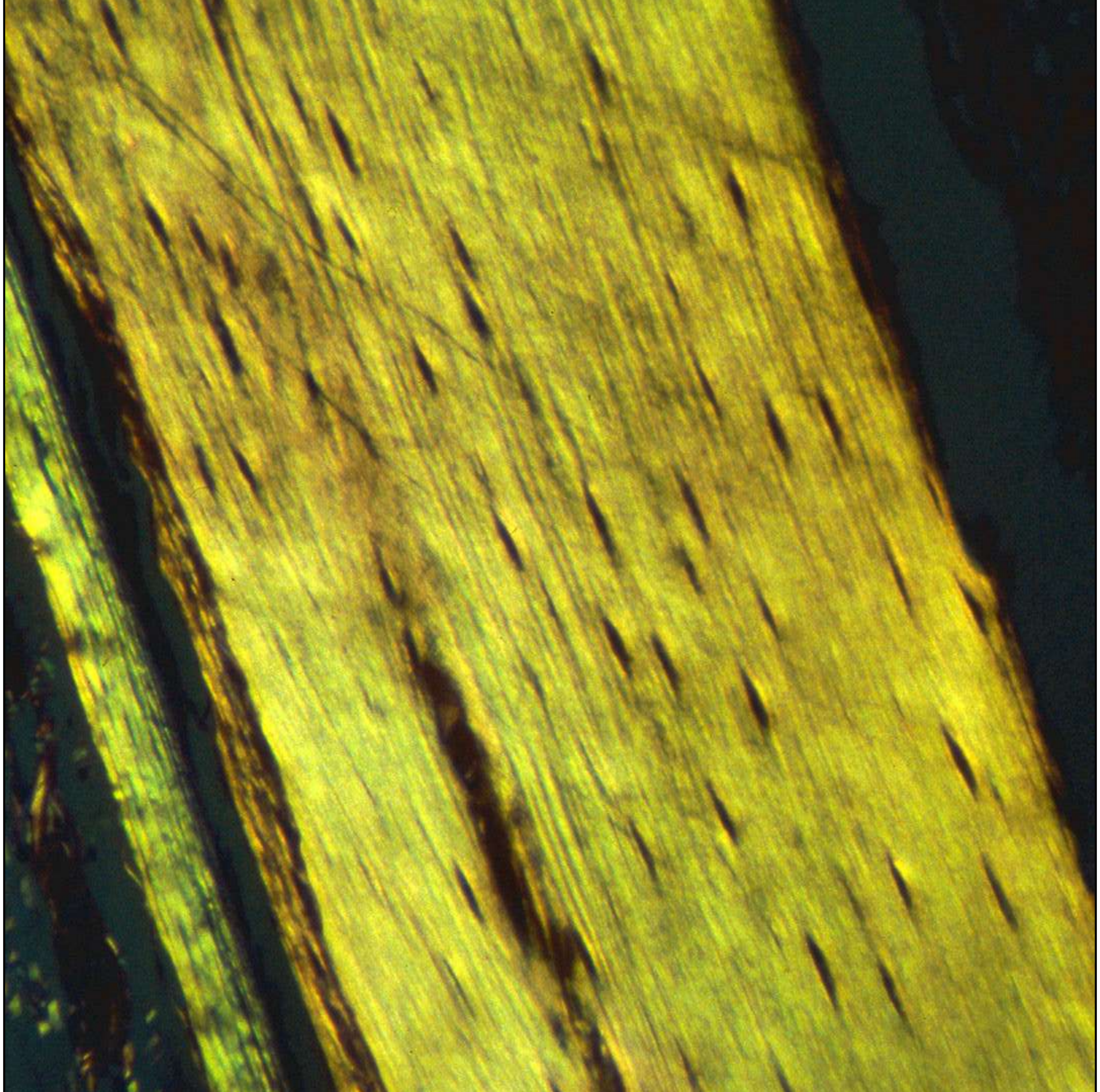
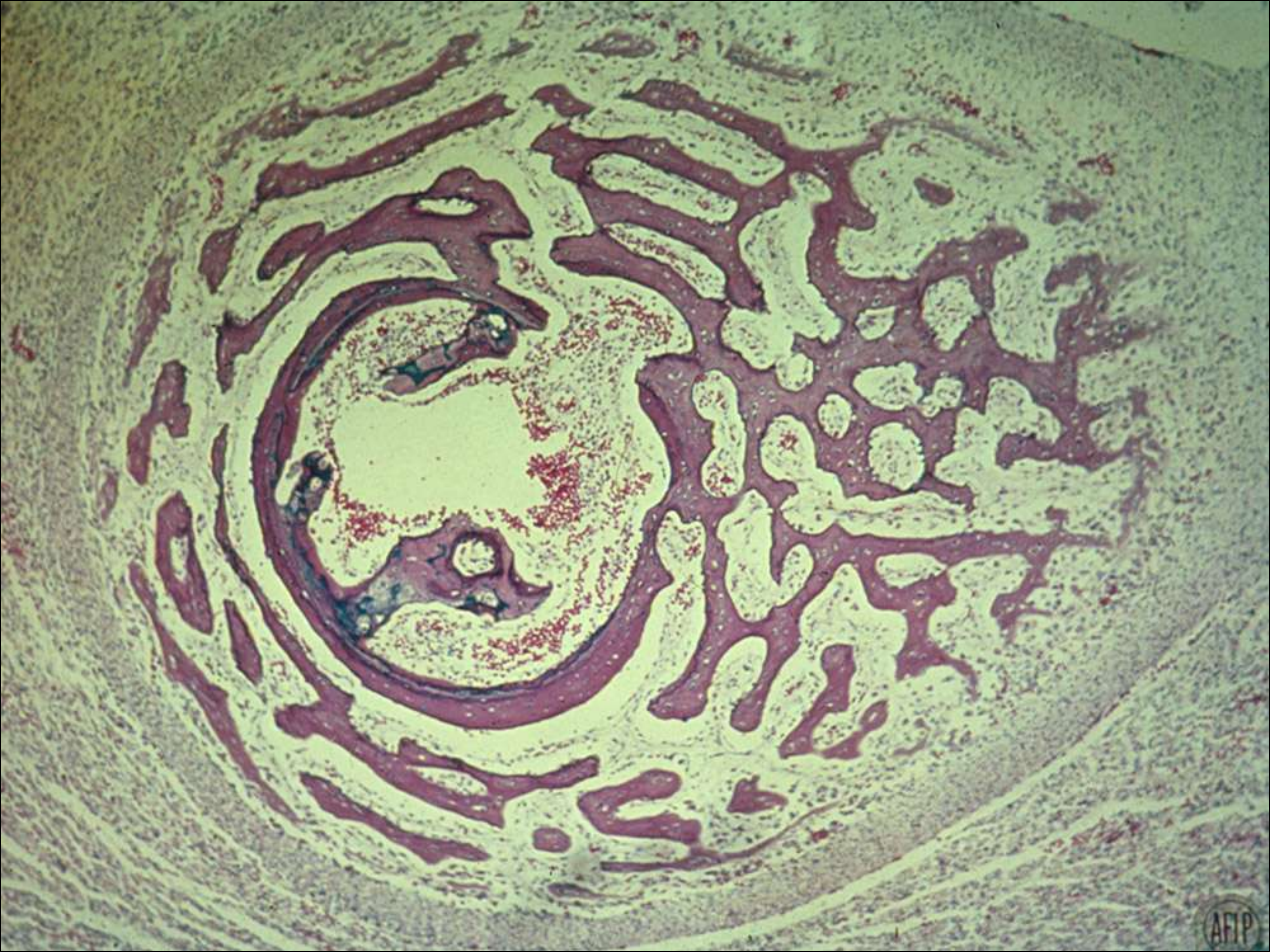


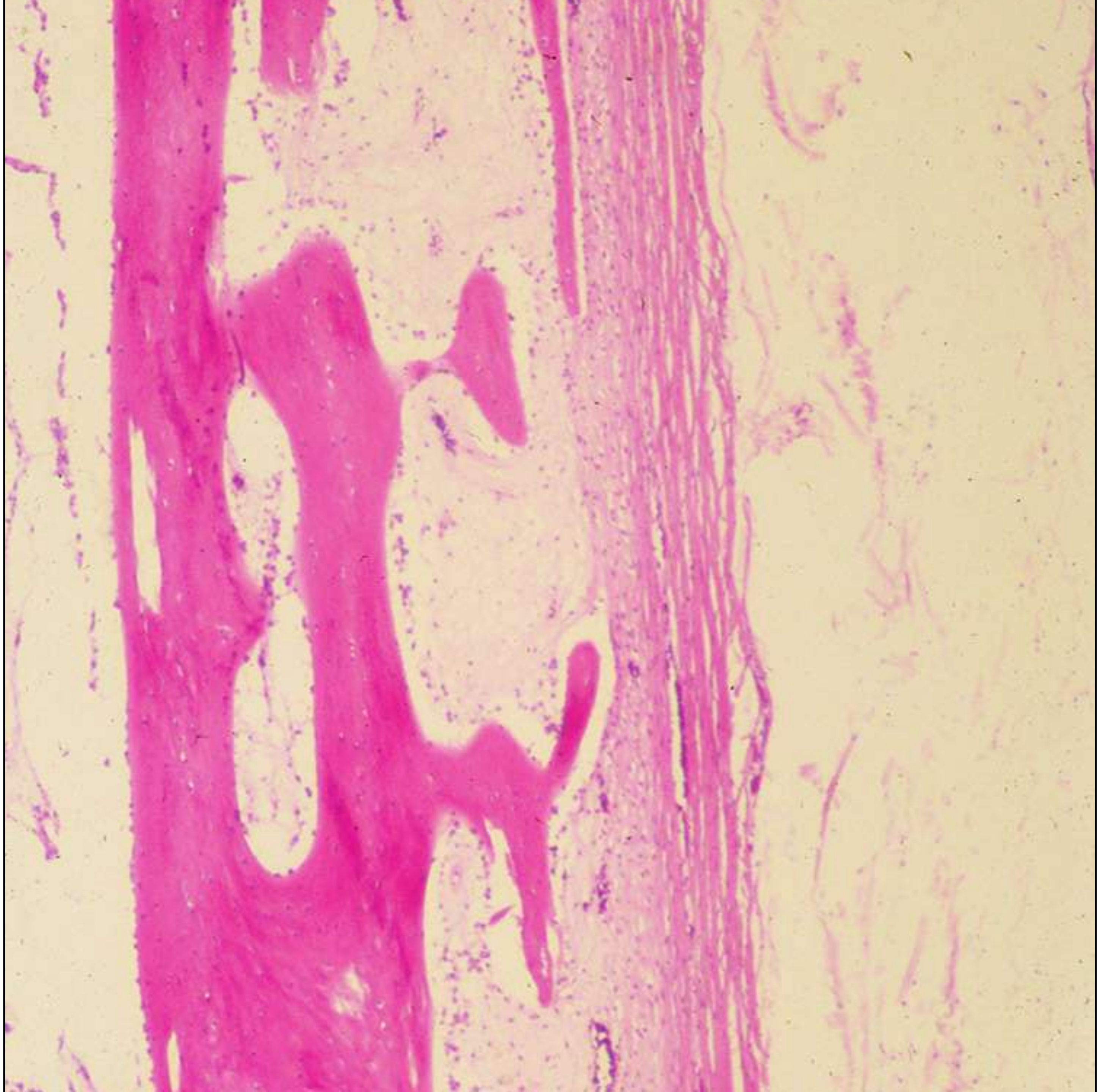


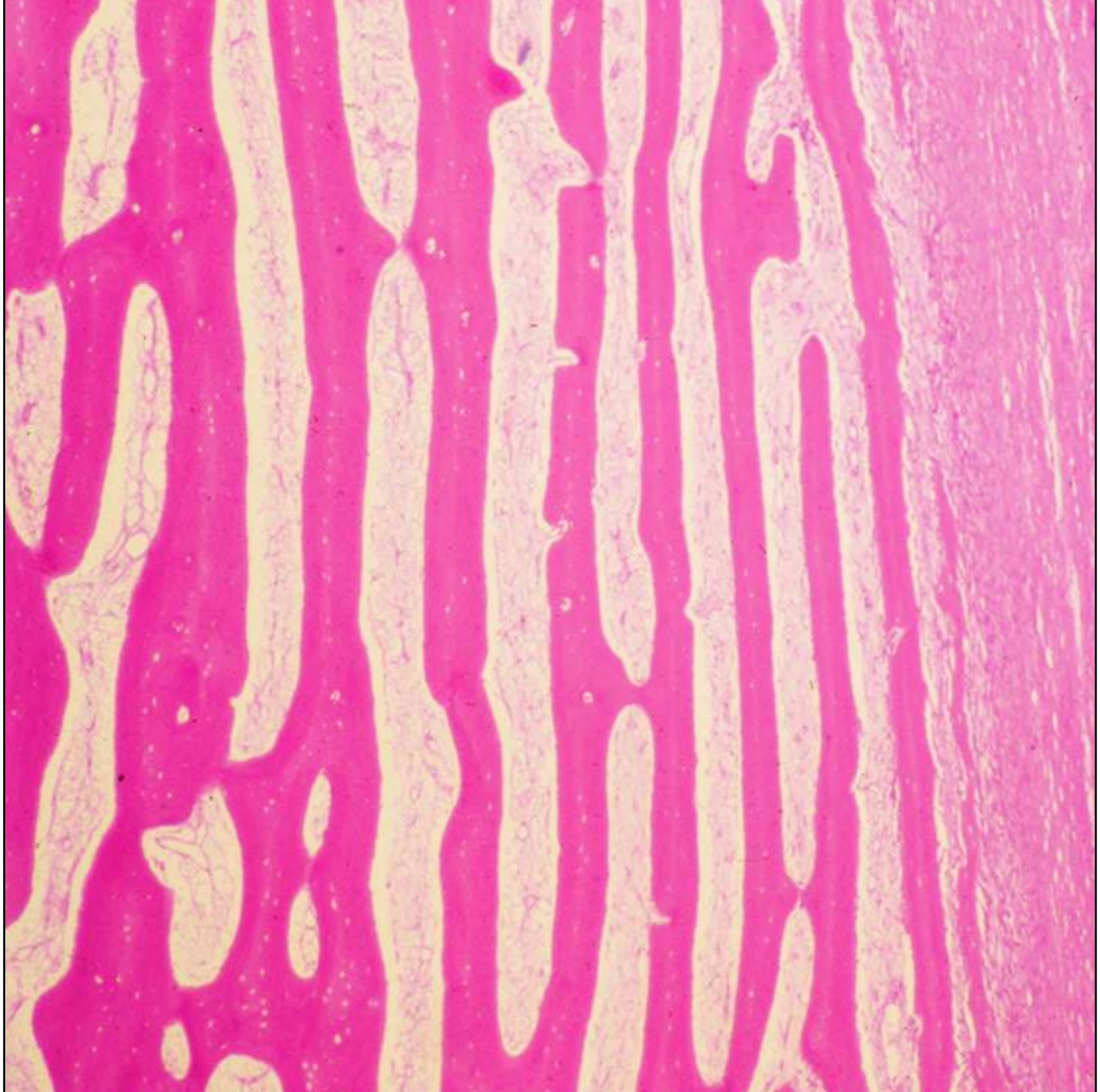

4
3
2
1
Periosteal growth
A
Circumferential lamellar
B
Simple primary osteonal
C
Plexiform
D
Saltatory primary osteonal

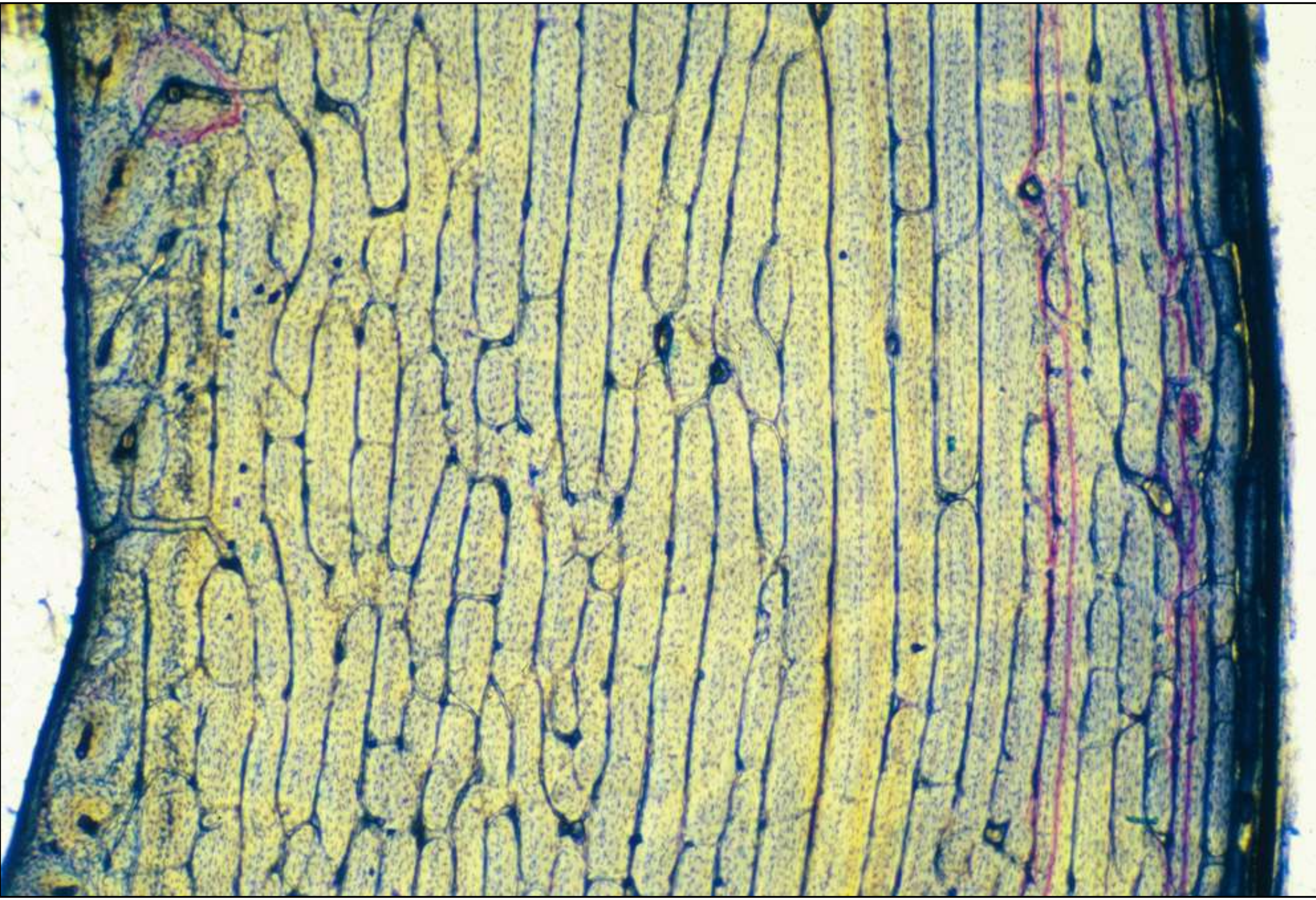


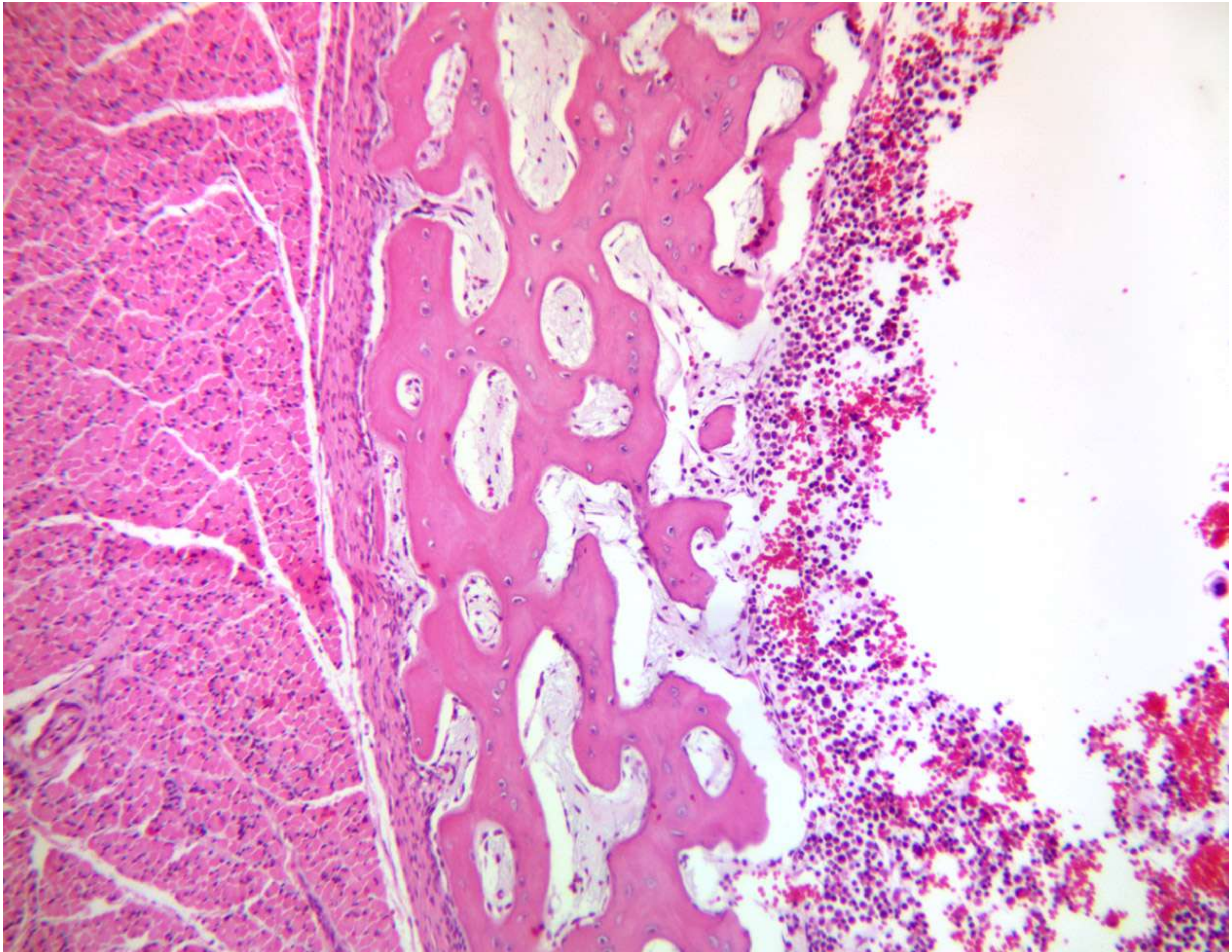


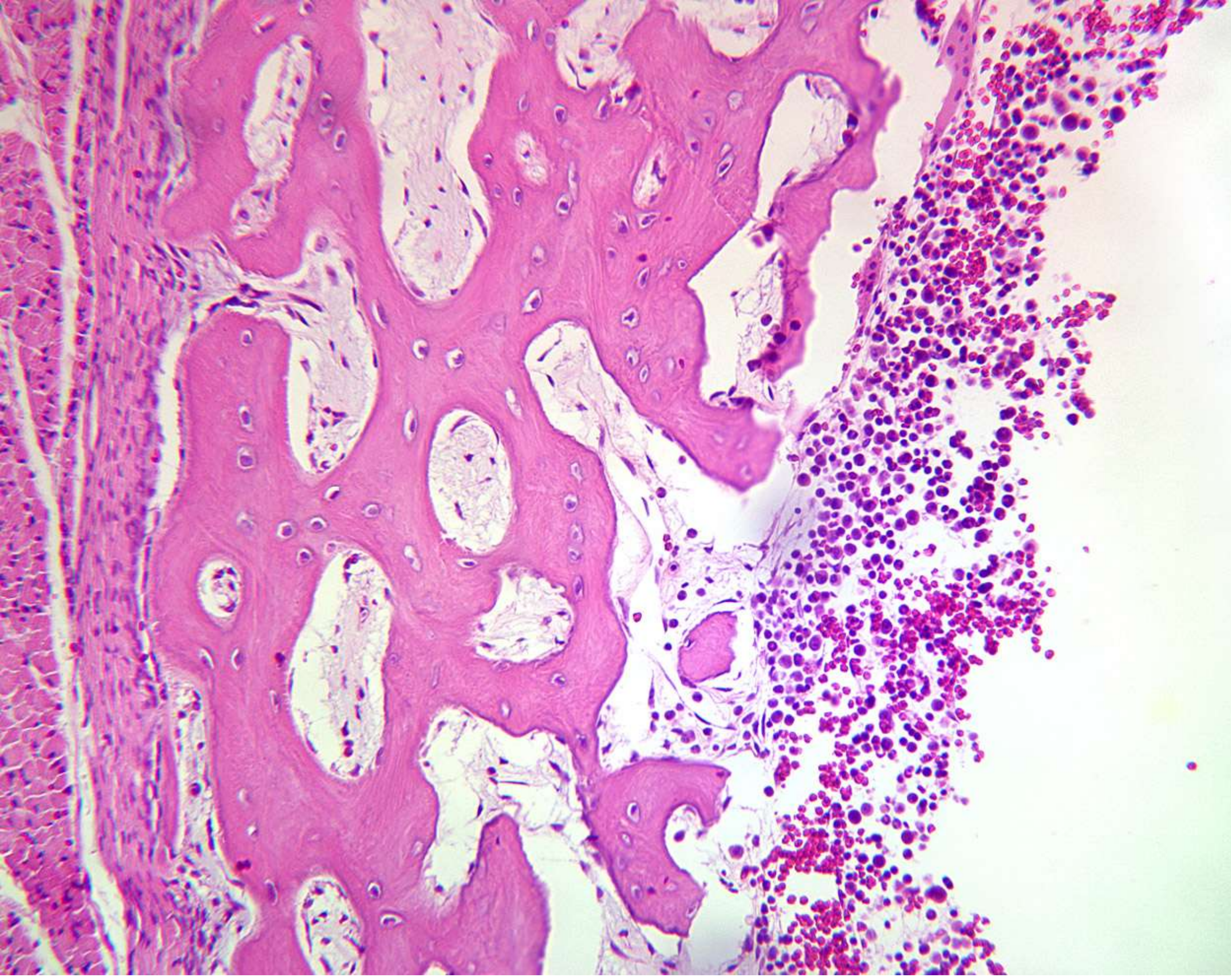

AFIP

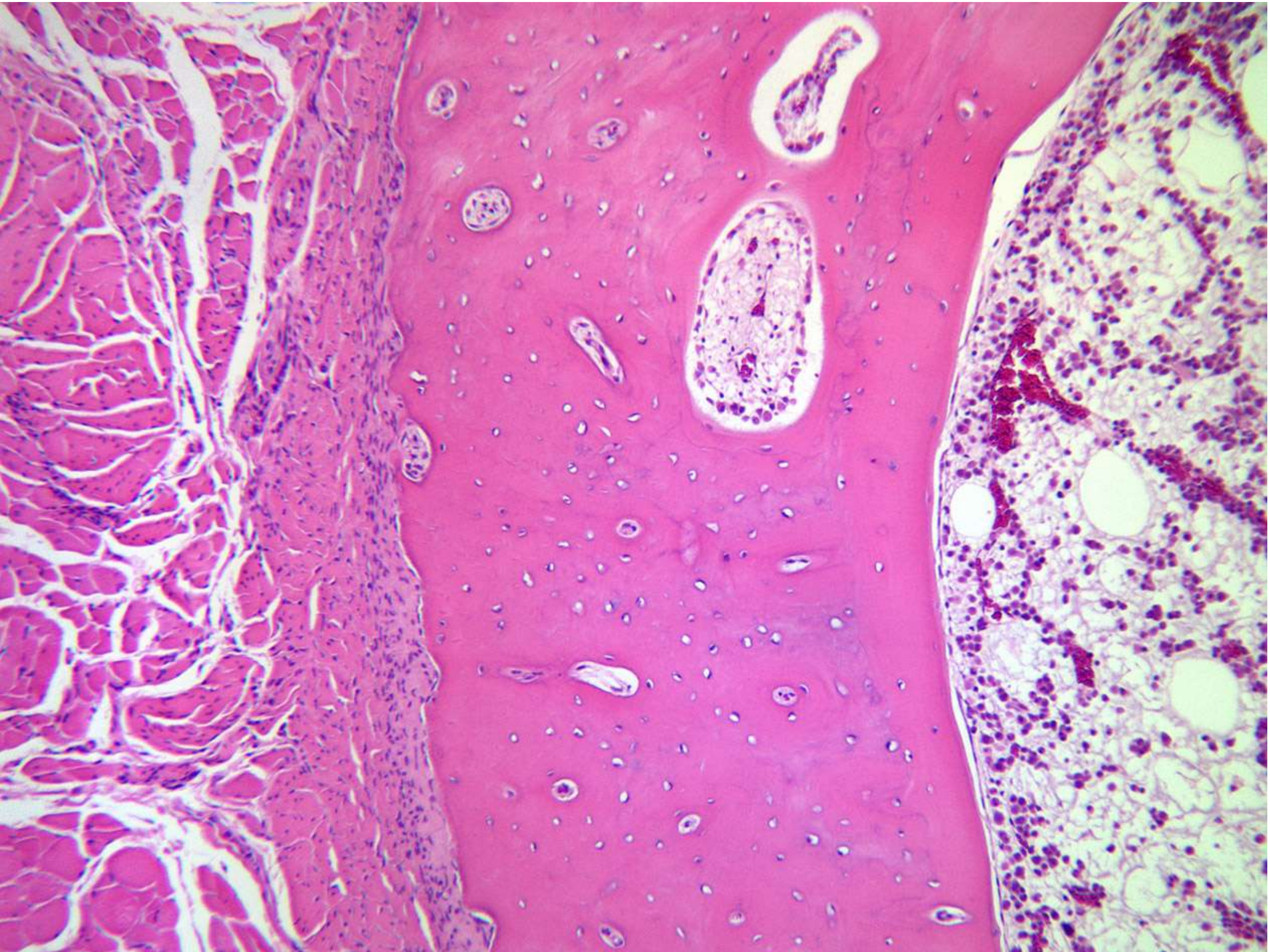


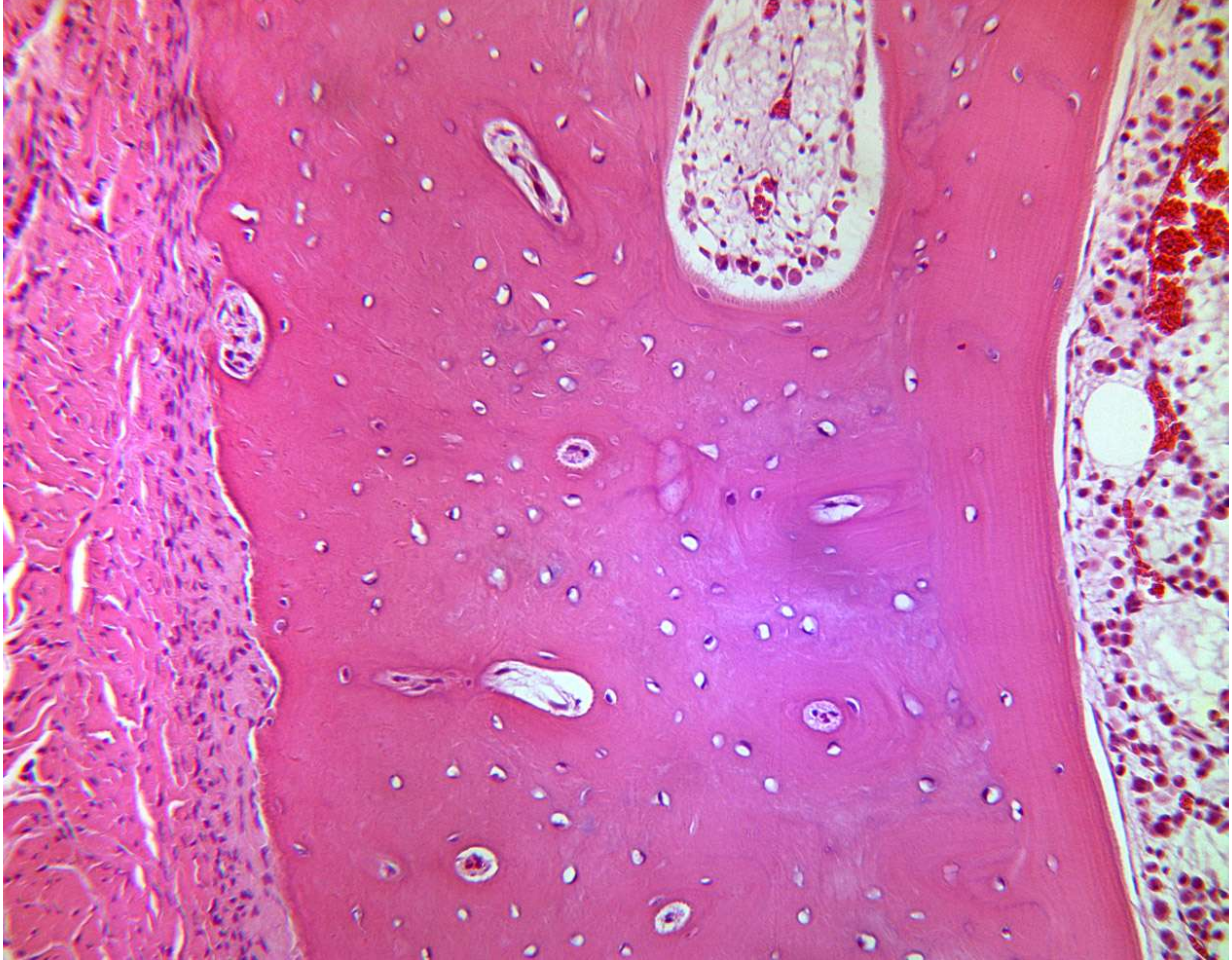




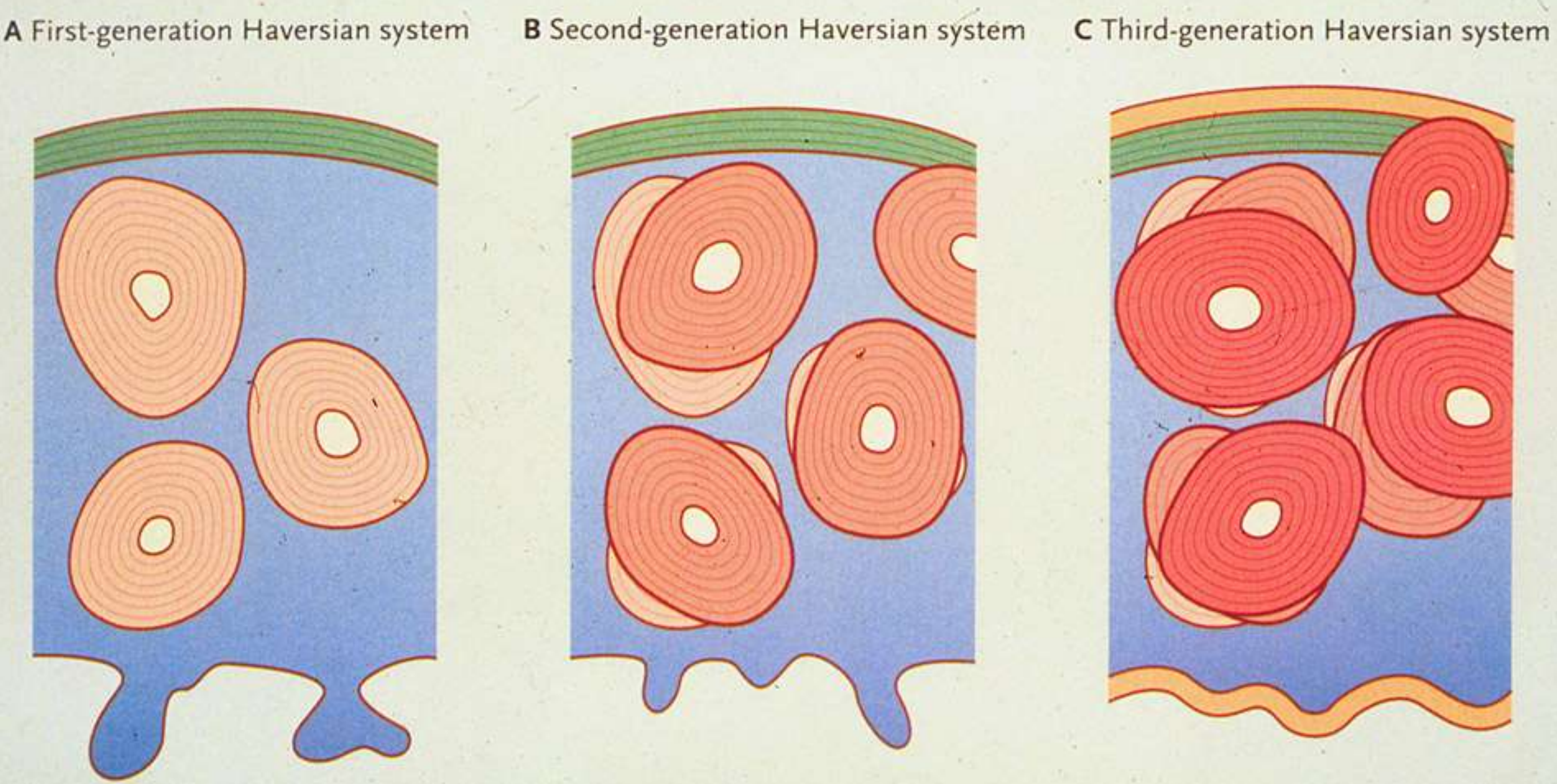








Primary and Secondary Remodeling


A First-generation Haversian system
B Second-generation Haversian system
C Third-generation Haversian system

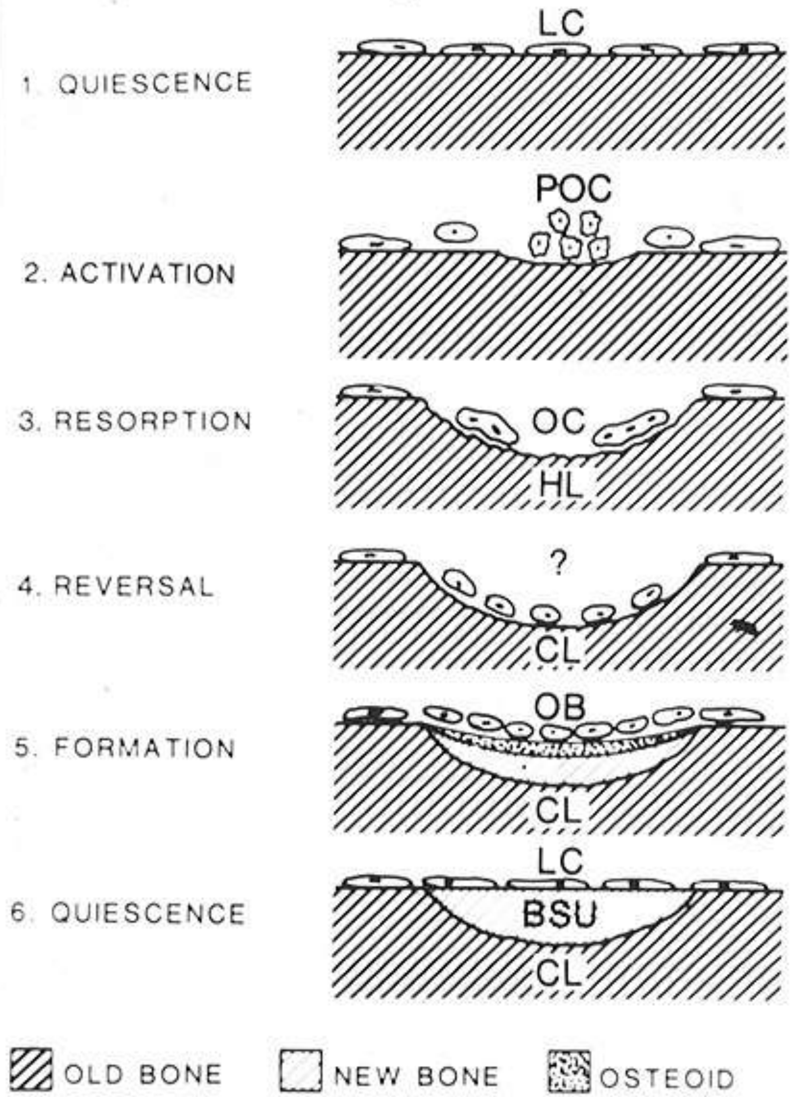
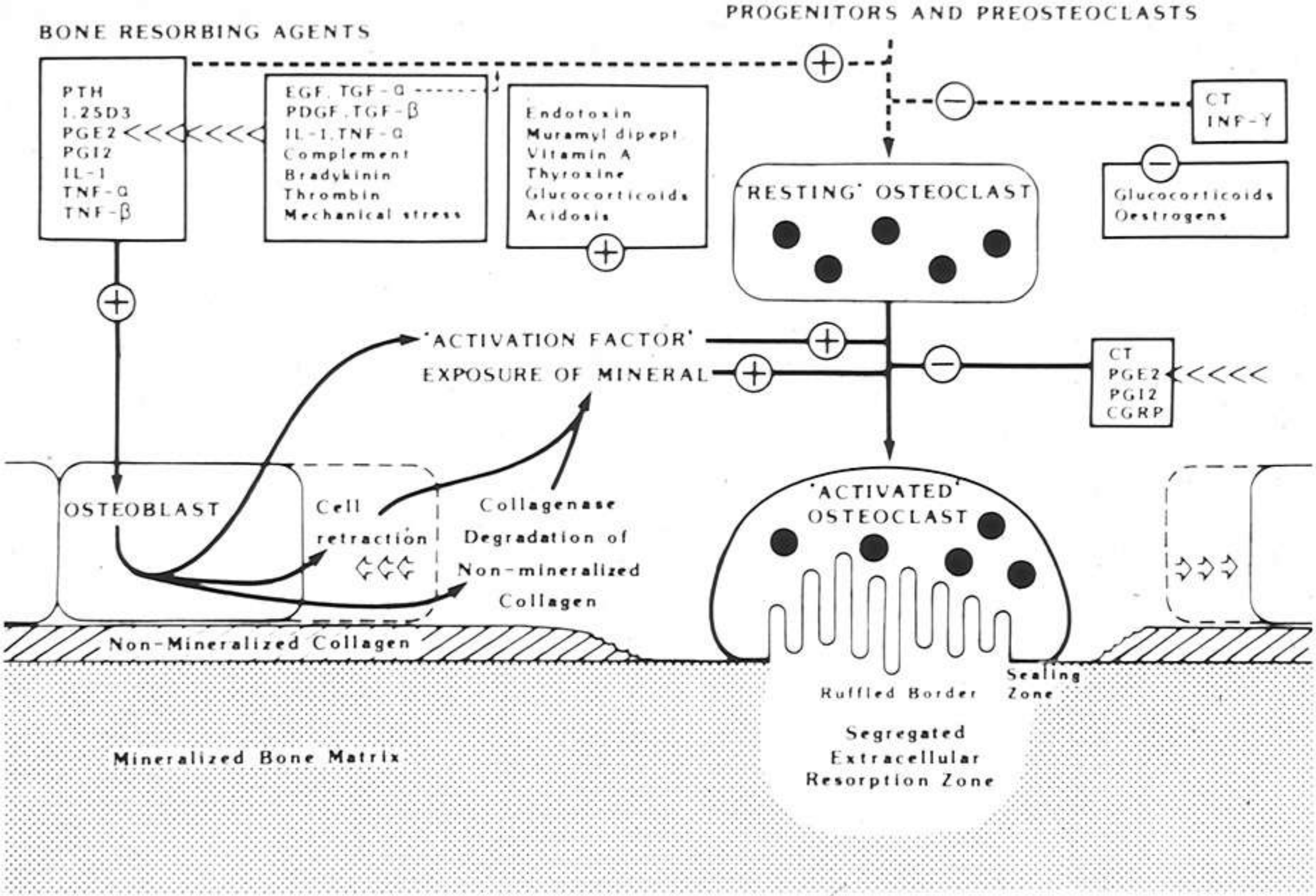
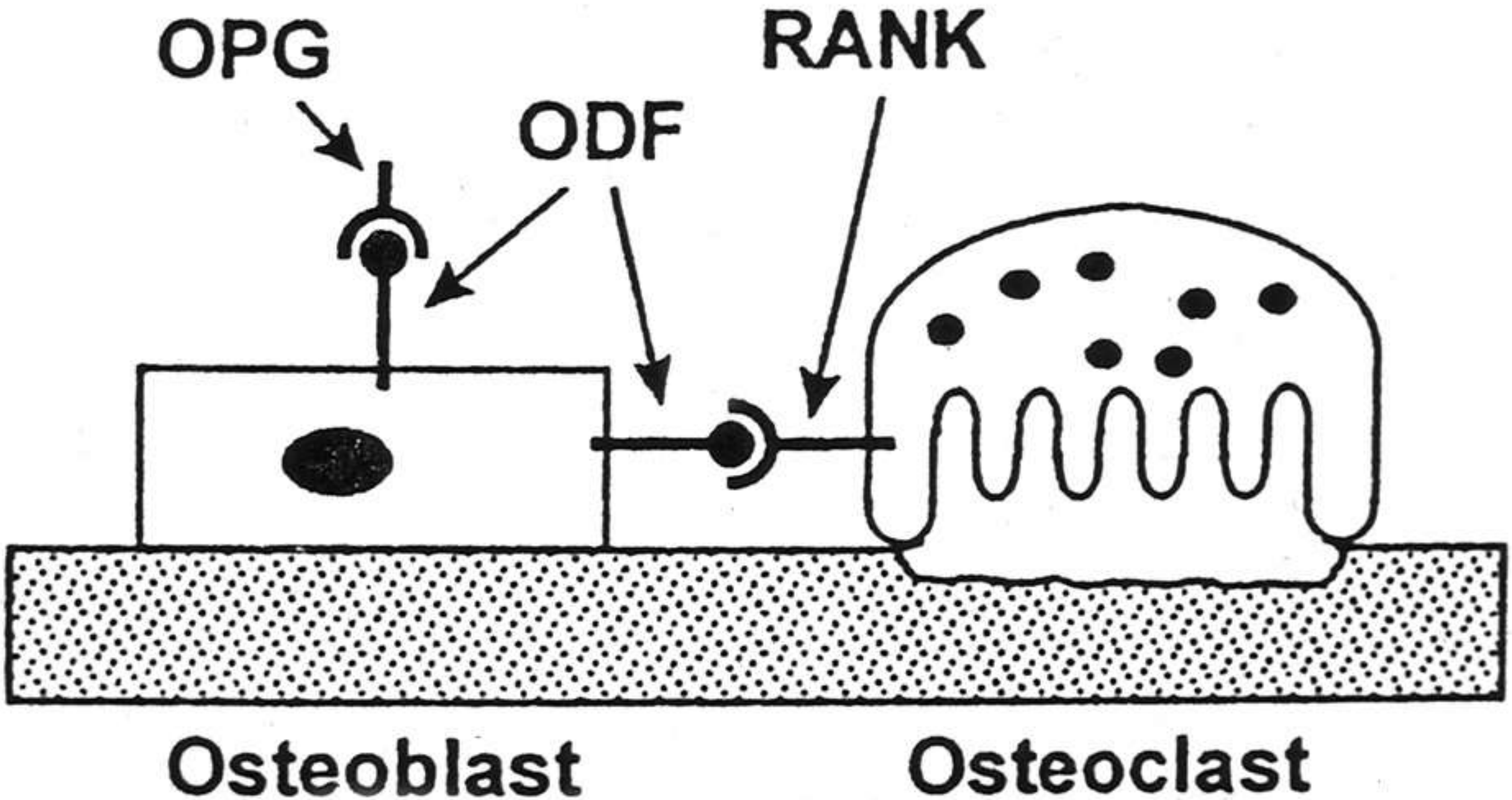
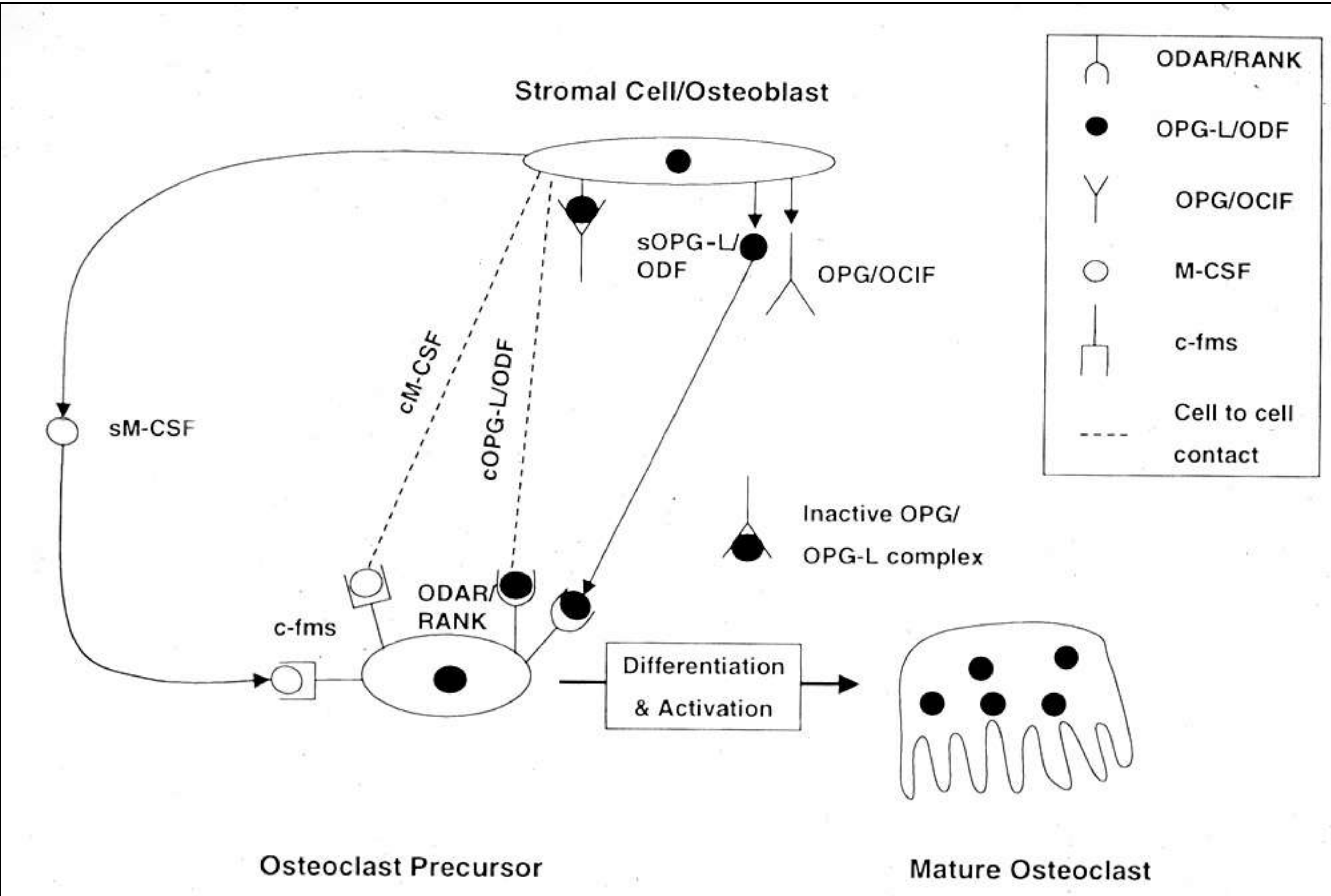


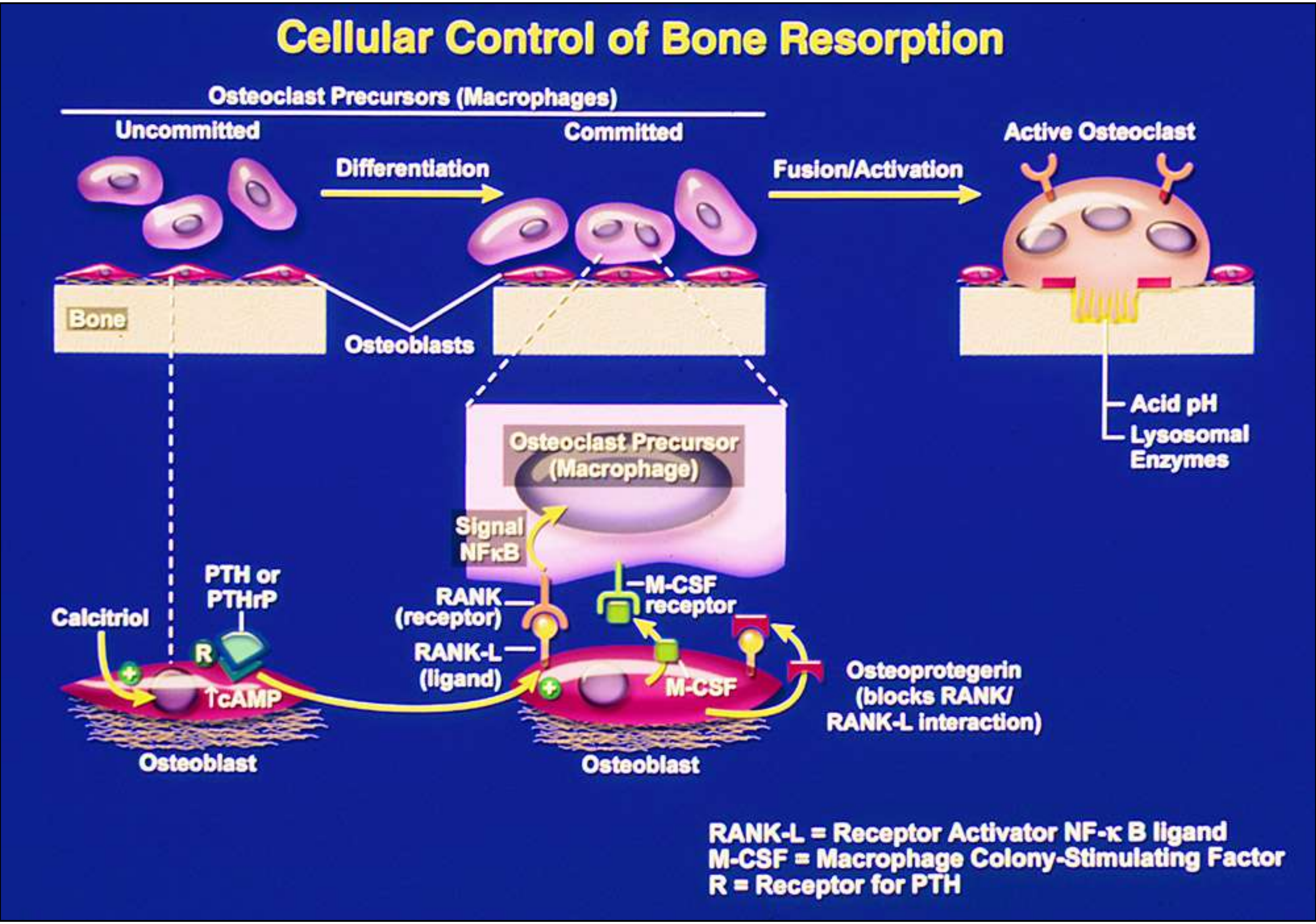
Fig. 1. The normal remodeling sequence in adult bone. Schematic representation of successive events on the endosteal surface. LC—lining cell. POC—preosteoclast (mononuclear). OC—osteoclast (multinucleated). HL—Howship's lacuna. CL—cement line. OB—osteoblast. BSU—bone structural unit. (Modified from Resident and Staff Physician (December 1981, 60–62) with permission.)

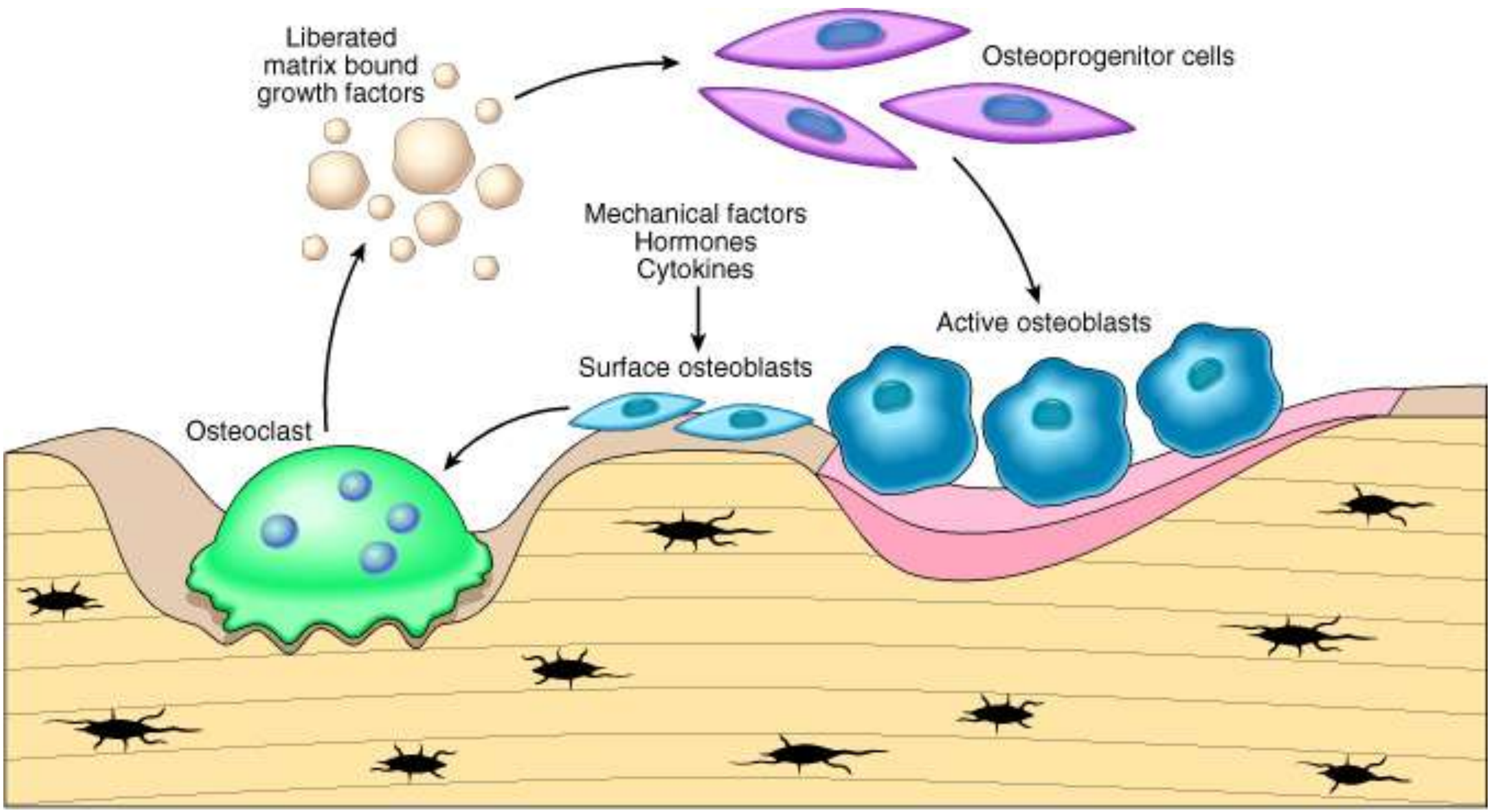

BONE RESORBING AGENTS
PROGENITORS AND PREOSTEOCLASTS
PTH
1,25D3
PGE2
PGI2
IL-1
TNF-α
TNF-β
EGF, TGF-α
PDGF, TGF-β
IL-1, TNF-α
Complement
Bradykinin
Thrombin
Mechanical stress
Endotoxin
Muramyl dipept
Vitamin A
Thyroxine
Glucocorticoids
Acidosis
CT
INF-γ
'RESTING' OSTEOCLAST
Glucocorticoids
Oestrogens
'ACTIVATION FACTOR'
EXPOSURE OF MINERAL
CT
PGE2
PGI2
CGRP
OSTEOBLAST
Cell
retraction
Collagenase
Degradation of
Non-mineralized
Collagen
'ACTIVATED'
OSTEOCLAST
Non-Mineralized Collagen
Sealing
Zone
Ruffled Border
Segregated
Extracellular
Resorption Zone
Mineralized Bone Matrix


OPG
RANK
ODF
Osteoblast
Osteoclast



Stromal Cell/Osteoblast
sOPG-L/
ODF
OPG/OCIF
cM-CSF
cOPG-L/ODF
sM-CSF
c-fms
ODAR/
RANK
Differentiation
& Activation
Inactive OPG/
OPG-L complex
Osteoclast Precursor
Mature Osteoclast
ODAR/RANK
OPG-L/ODF
OPG/OCIF
M-CSF
c-fms
Cell to cell
contact


Cellular Control of Bone Resorption
Osteoclast Precursors (Macrophages)
Uncommitted
Committed
Active Osteoclast
Differentiation
Fusion/Activation
Bone
Osteoblasts
Acid pH
Lysosomal Enzymes
Osteoclast Precursor (Macrophage)
Signal NFκB
RANK (receptor)
RANK-L (ligand)
M-CSF receptor
PTH or PTHrP
Calcitriol
R
↑cAMP
M-CSF
Osteoprotegerin (blocks RANK/ RANK-L interaction)
Osteoblast
Osteoblast
RANK-L = Receptor Activator NF-κ B ligand
M-CSF = Macrophage Colony-Stimulating Factor
R = Receptor for PTH


Liberated
matrix bound
growth factors
Osteoprogenitor cells
Mechanical factors
Hormones
Cytokines
Active osteoblasts
Surface osteoblasts
Osteoclast

Slide 28.5

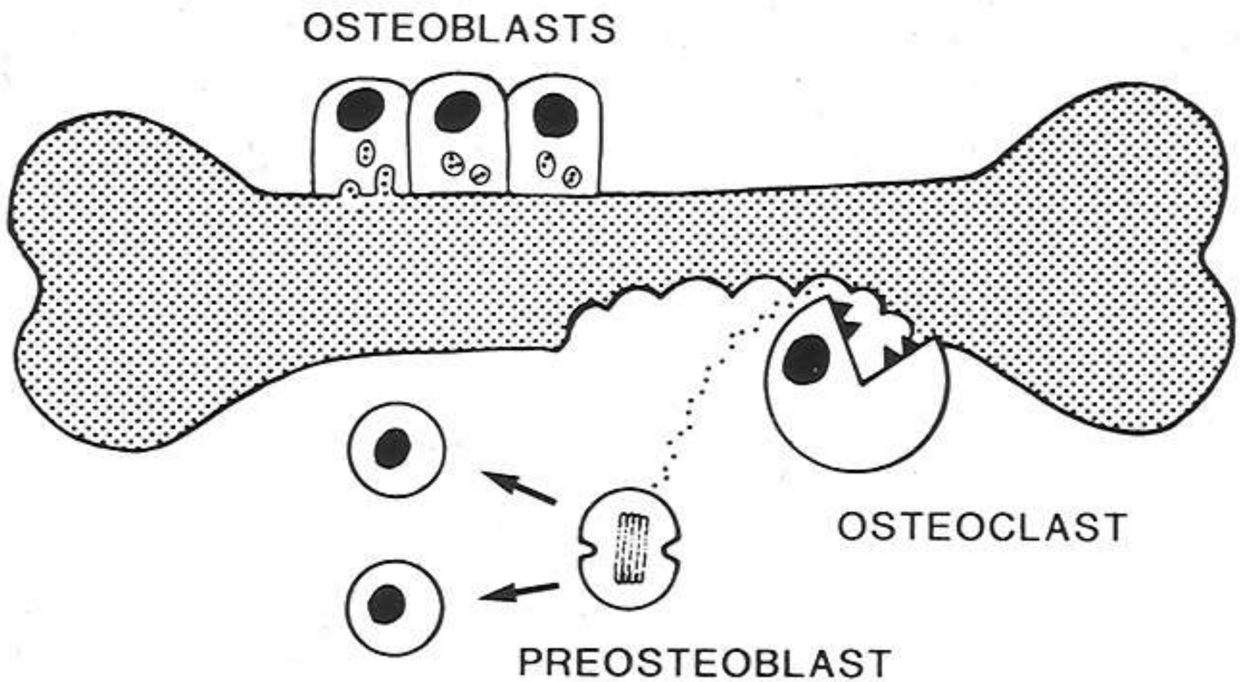


Fig 5. Model of osteoblast-derived mitogenic activity as a delayed paracrine effector of bone volume, illustrating how mitogenic activity might be synthesized by osteoblasts, deposited in bone, and released by osteoclastic resorption to promote the proliferation of osteoprogenitor cells, increasing osteoblast number and thereby effecting site-specific bone replacement.

Transforming Growth Factor Beta

* produced by osteoblasts
* activated by acidification
* released by osteoclasts
* inhibitory to osteoclasts
* stimulatory to osteoblasts

What cell really completes the resorption?

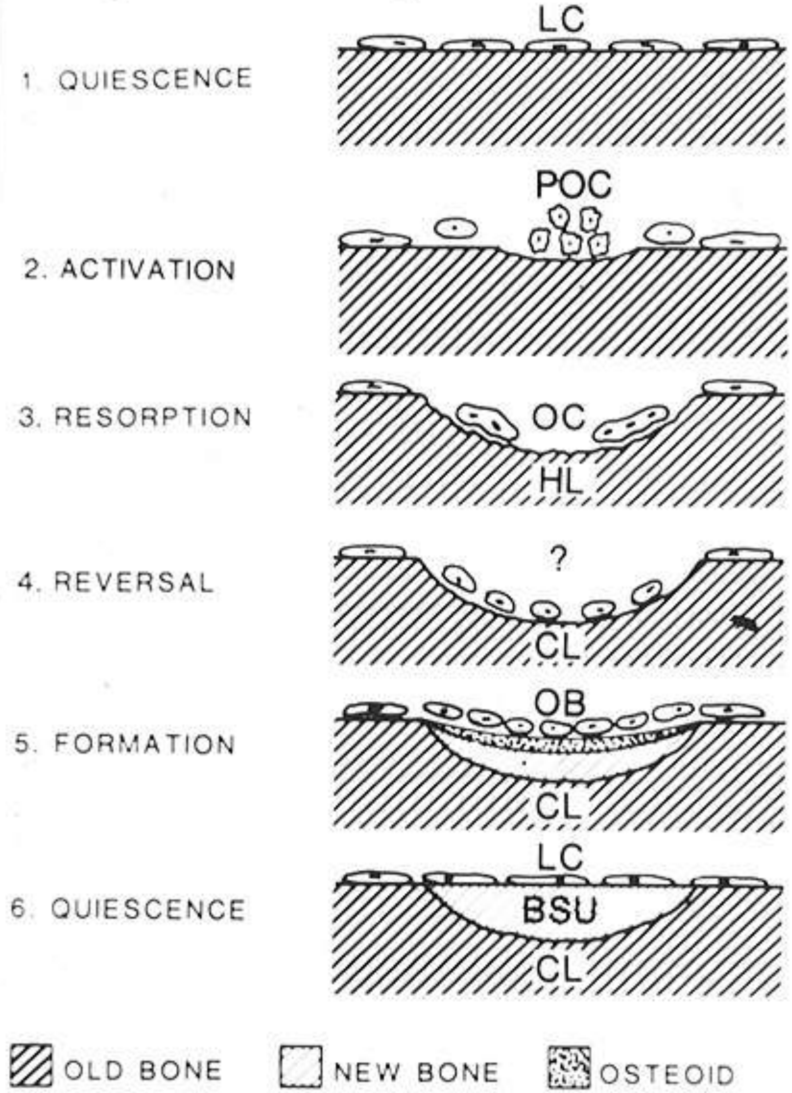


Fig. 1. The normal remodeling sequence in adult bone. Schematic representation of successive events on the endosteal surface. LC—lining cell. POC—preosteoclast (mononuclear). OC—osteoclast (multinucleated). HL—Howship's lacuna. CL—cement line. OB—osteoblast. BSU—bone structural unit. (Modified from Resident and Staff Physician (December 1981, 60–62) with permission.)

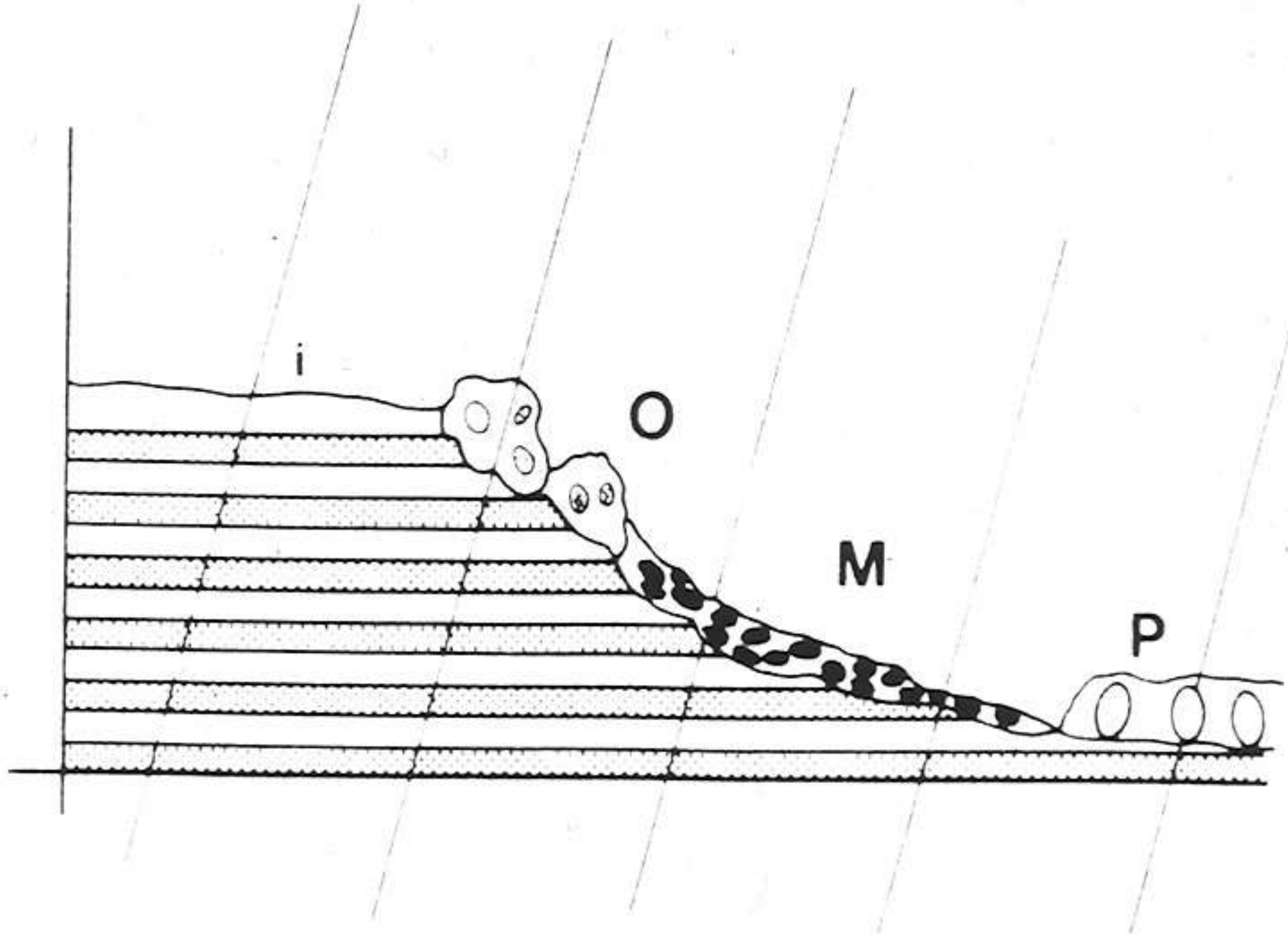


Fig. 1. Sampling design used in this paper. One testline intersects (*i*) with osteoclasts (O) at a depth of 2.5 laminae, two testlines intersect with mononuclear cells (M) at depths of 8 and 10 laminae, respectively, and one testline intersects with preosteoblast-like cells (P) at a depth of 11 laminae.

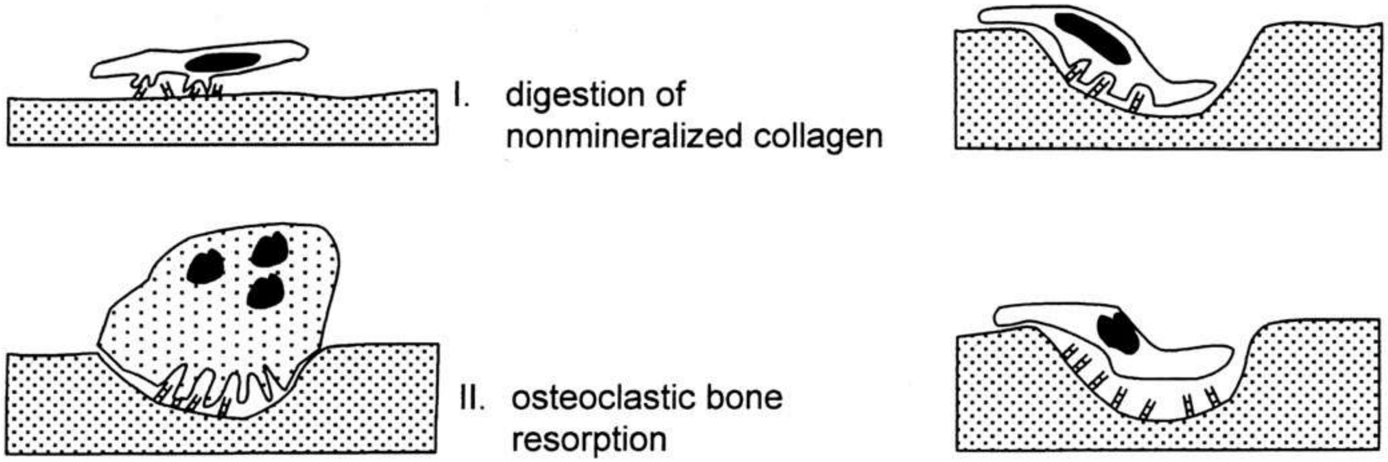


FIG. 10. Schematic presentation of the proposed sequence of events involved in coupling bone resorption and bone formation. (I) Before osteoclastic attachment, bone lining cells "clean" the bone surface from protruding nonmineralized collagen fibrils. (II) Osteoclasts attach to the bone surface, digest bone, and withdraw. (III) Bone lining cells occupy the Howship's lacunae and digest the leftovers. (IV) Bone lining cells form a cement line and deposit a thin layer of collagen at the bottom of the pit. This activity is probably followed by retrieval of the bone lining cell and formation of new bone by osteoblasts.

Cement Lines

- Proteglycan rich
- Mineral rich
- Collagen poor

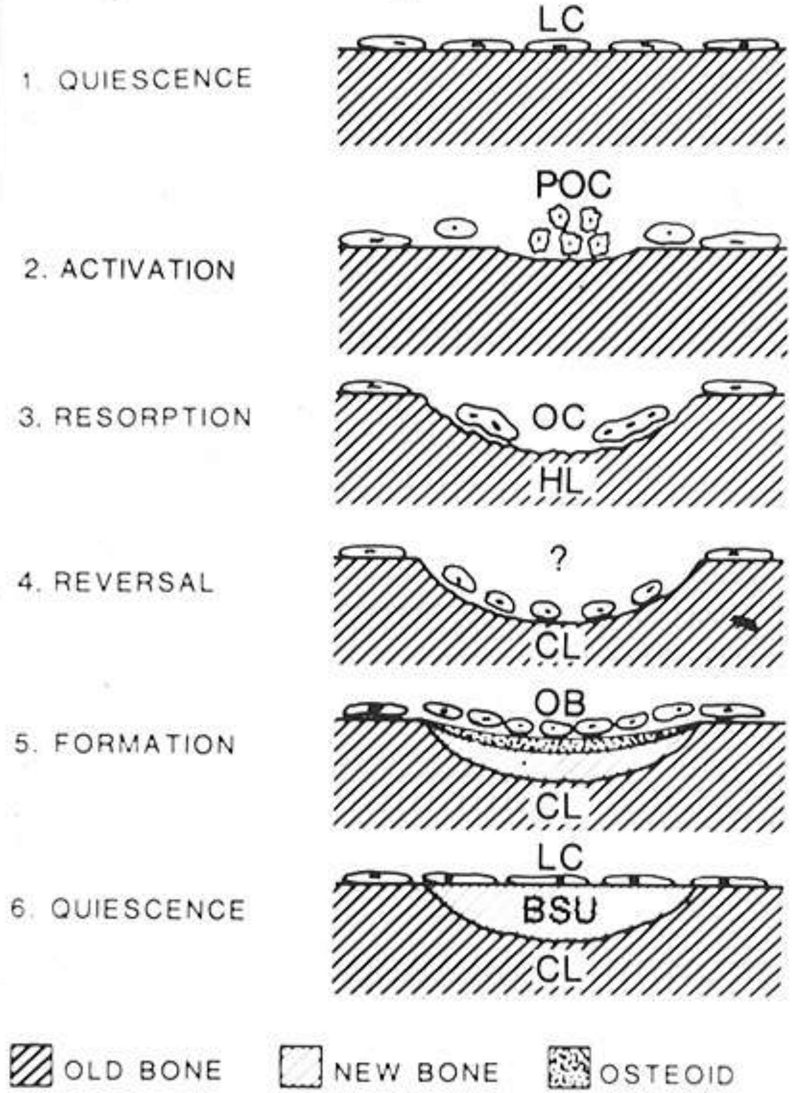
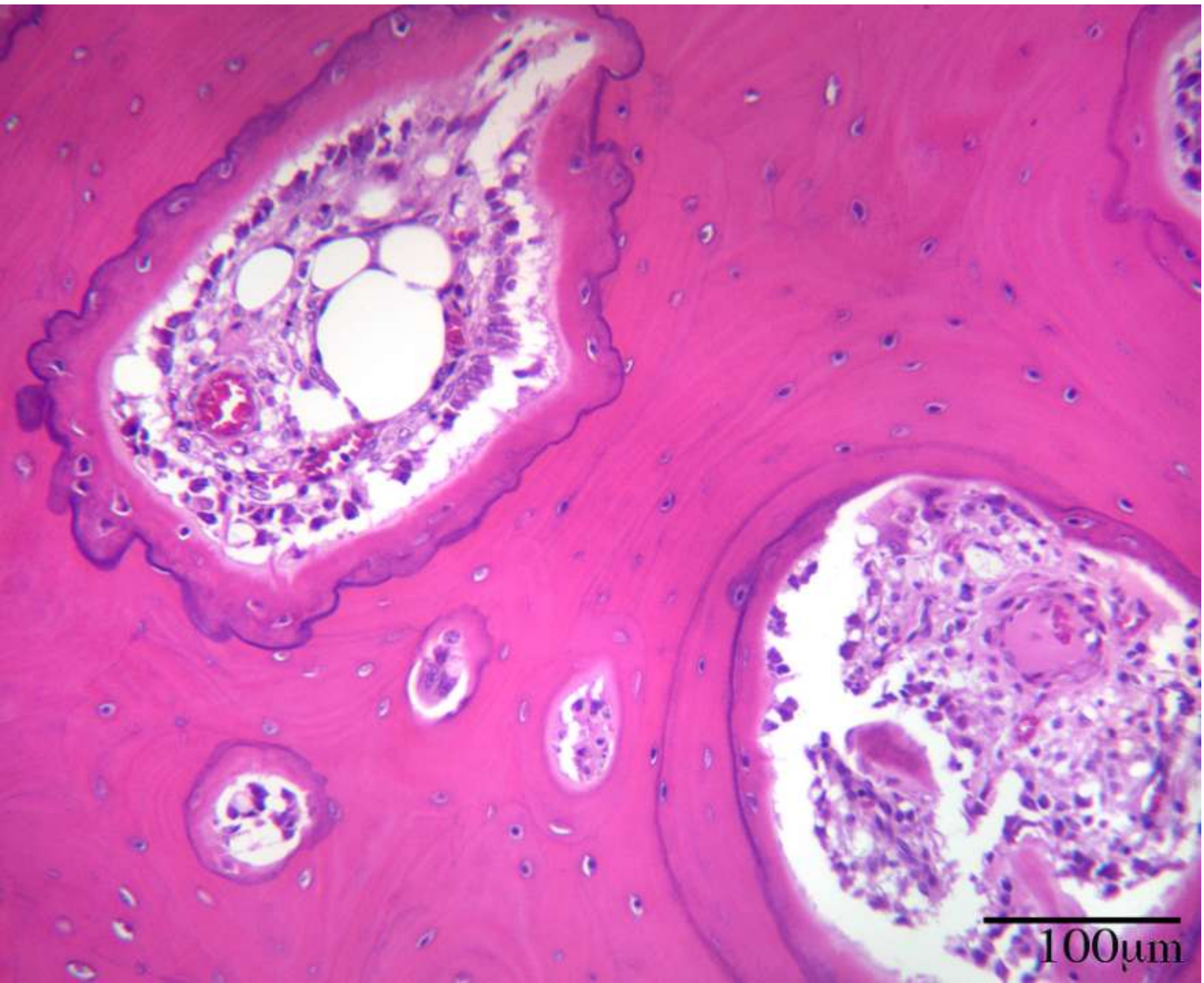
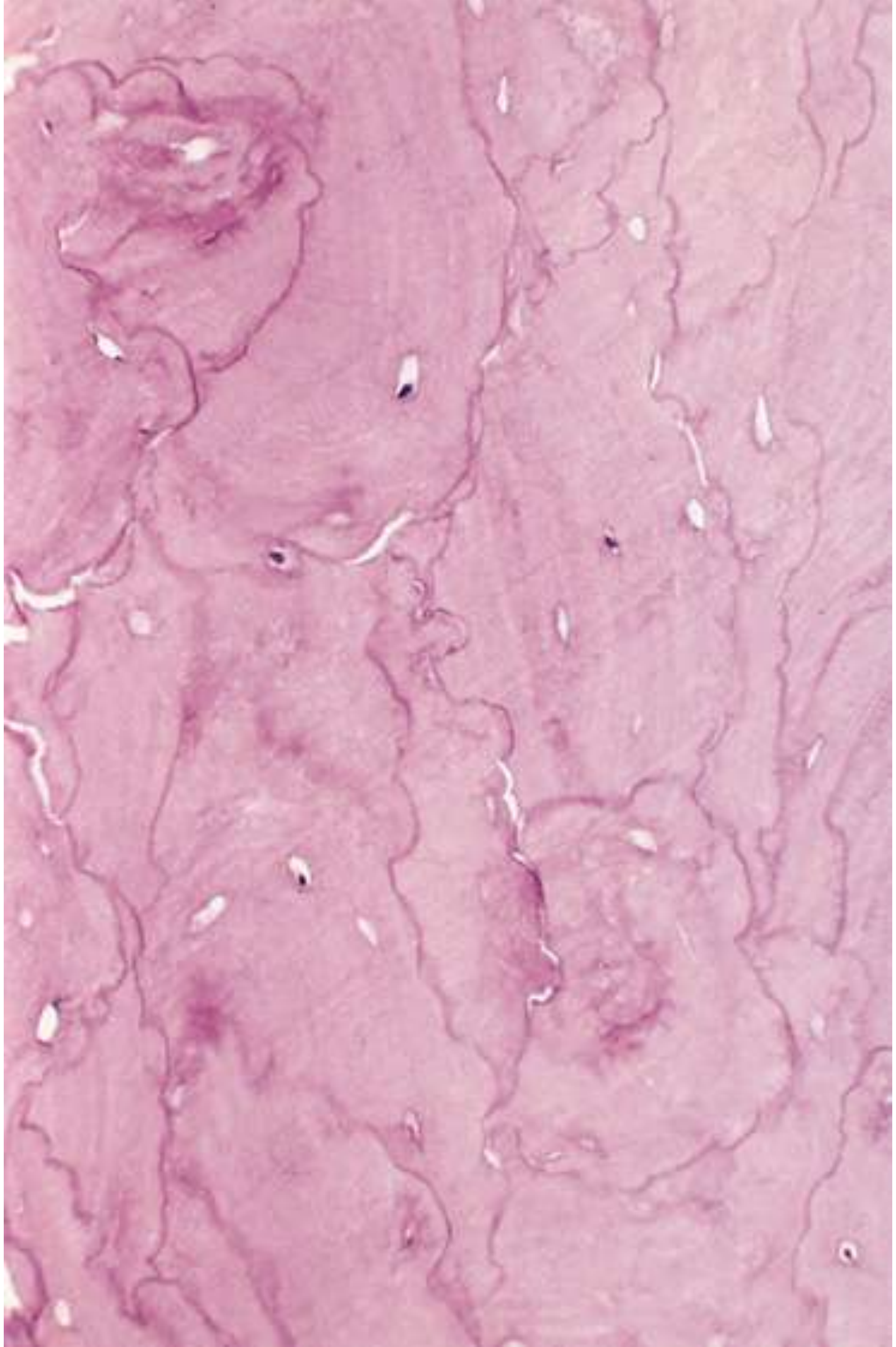


Fig. 1. The normal remodeling sequence in adult bone. Schematic representation of successive events on the endosteal surface. LC—lining cell. POC—preosteoclast (mononuclear). OC—osteoclast (multinucleated). HL—Howship's lacuna. CL—cement line. OB—osteoblast. BSU—bone structural unit. (Modified from Resident and Staff Physician (December 1981, 60–62) with permission.)


100μm

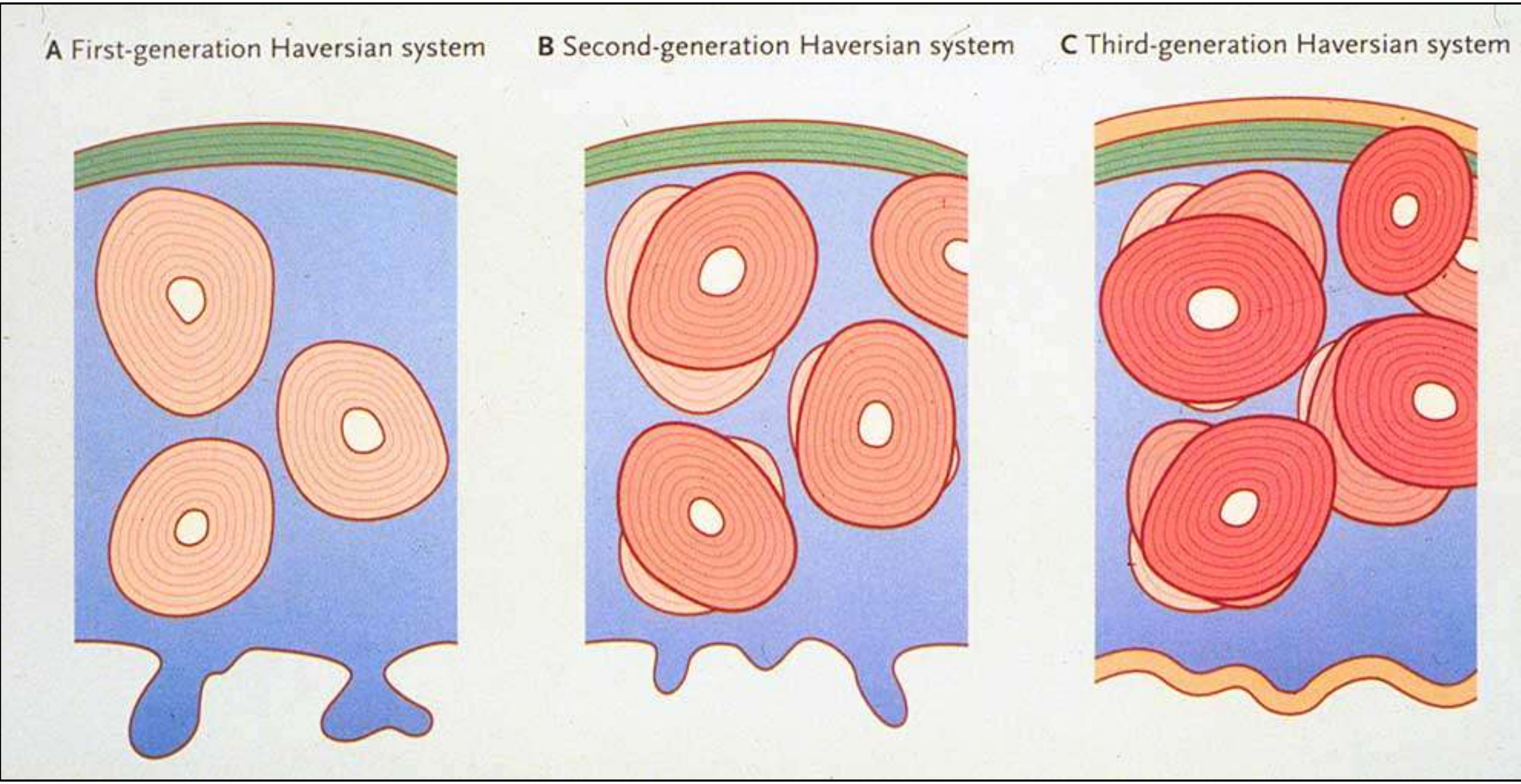


Slide 28.13

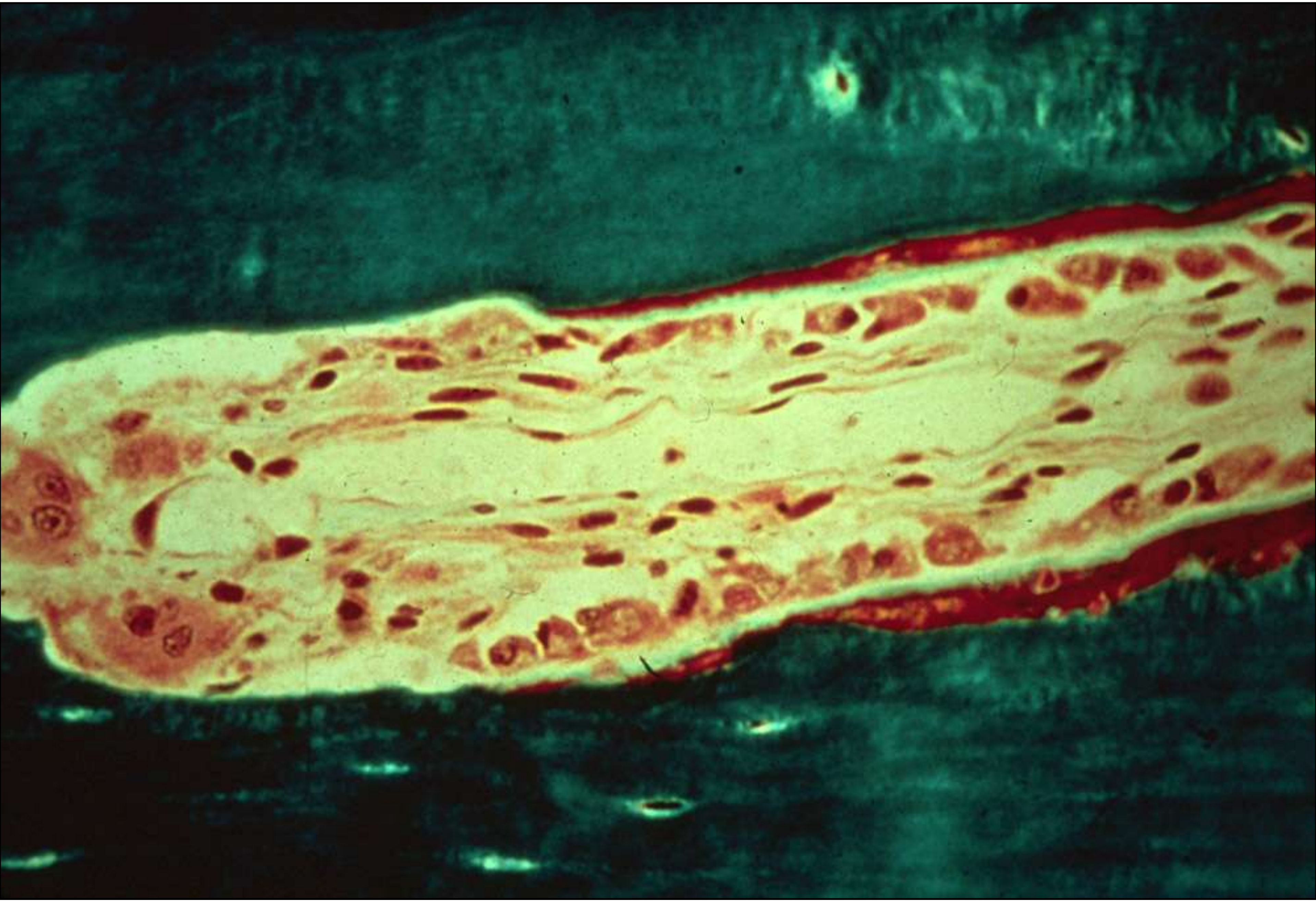
Remodeling Units

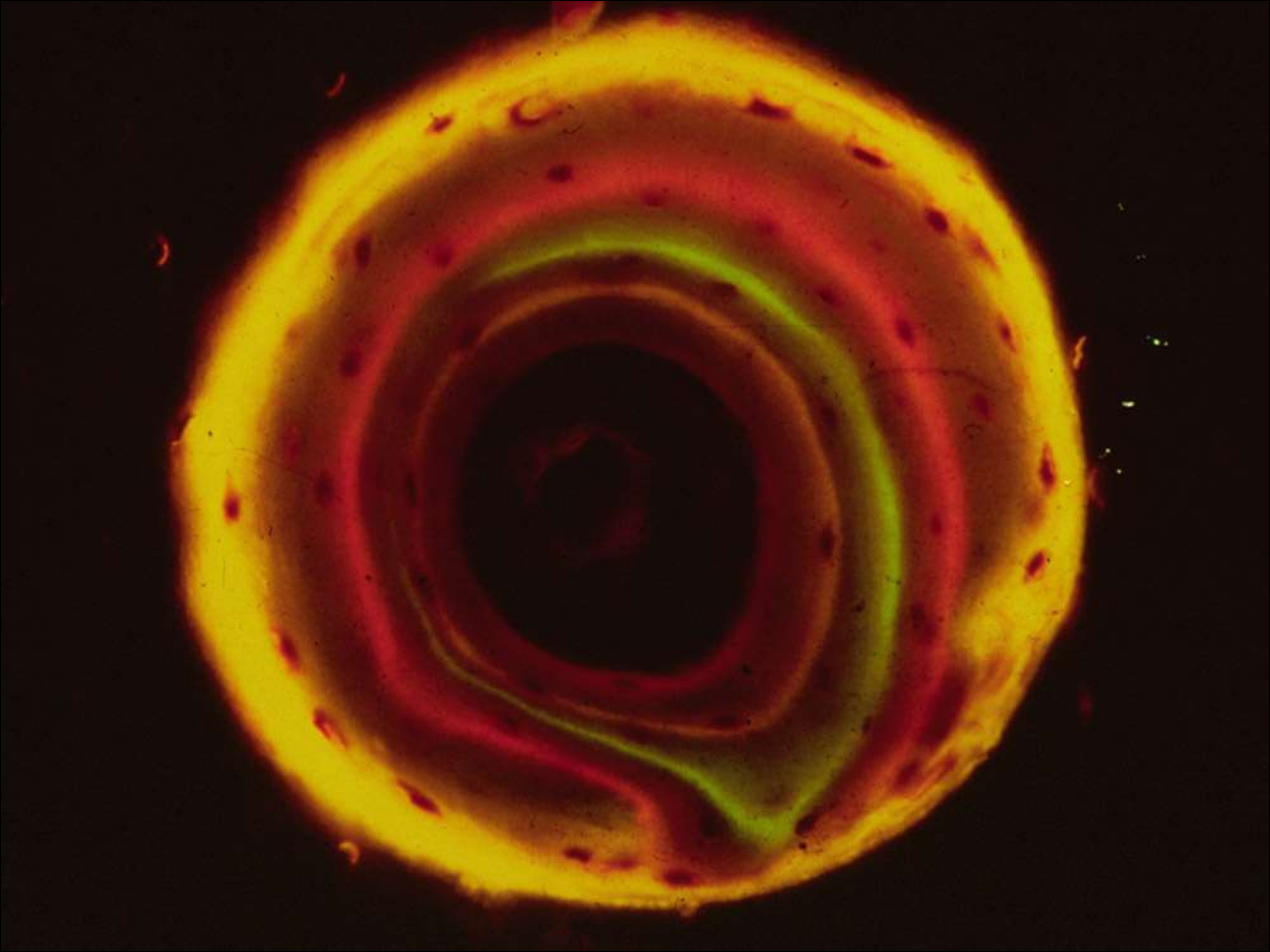
Osteon – cortical bone

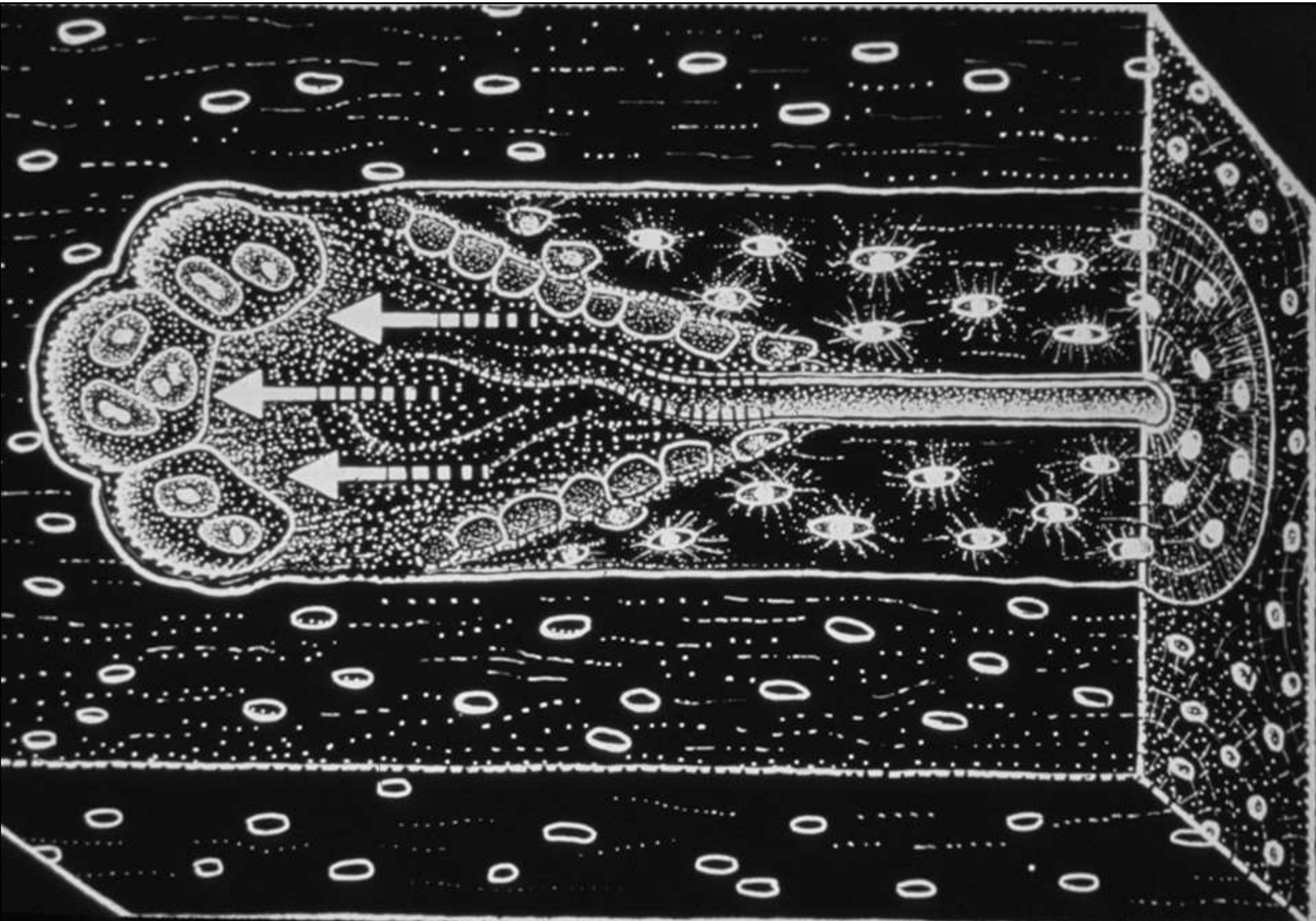
Basic Structural Unit (BSU) – trabecular bone

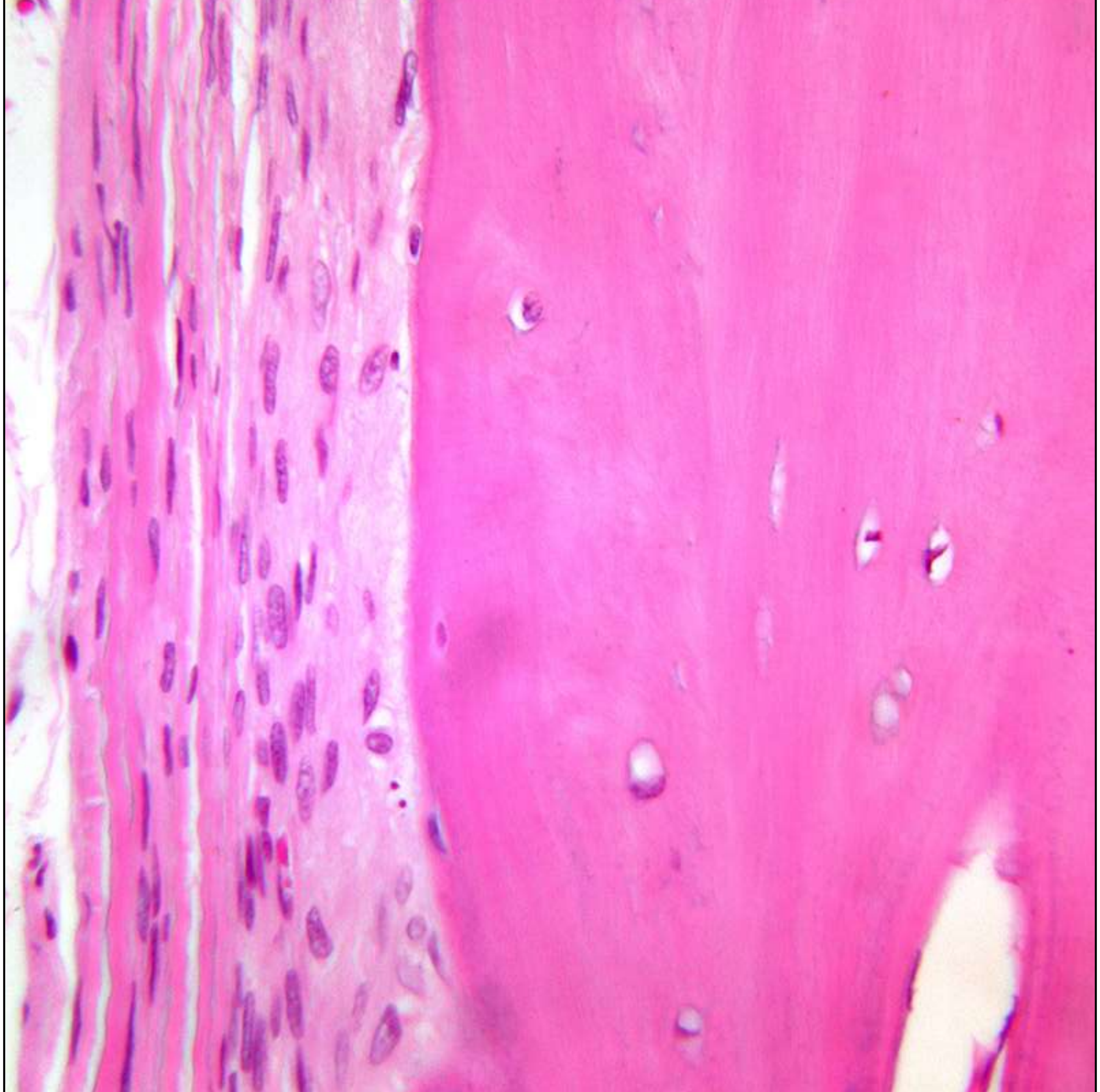

A First-generation Haversian system
B Second-generation Haversian system
C Third-generation Haversian system

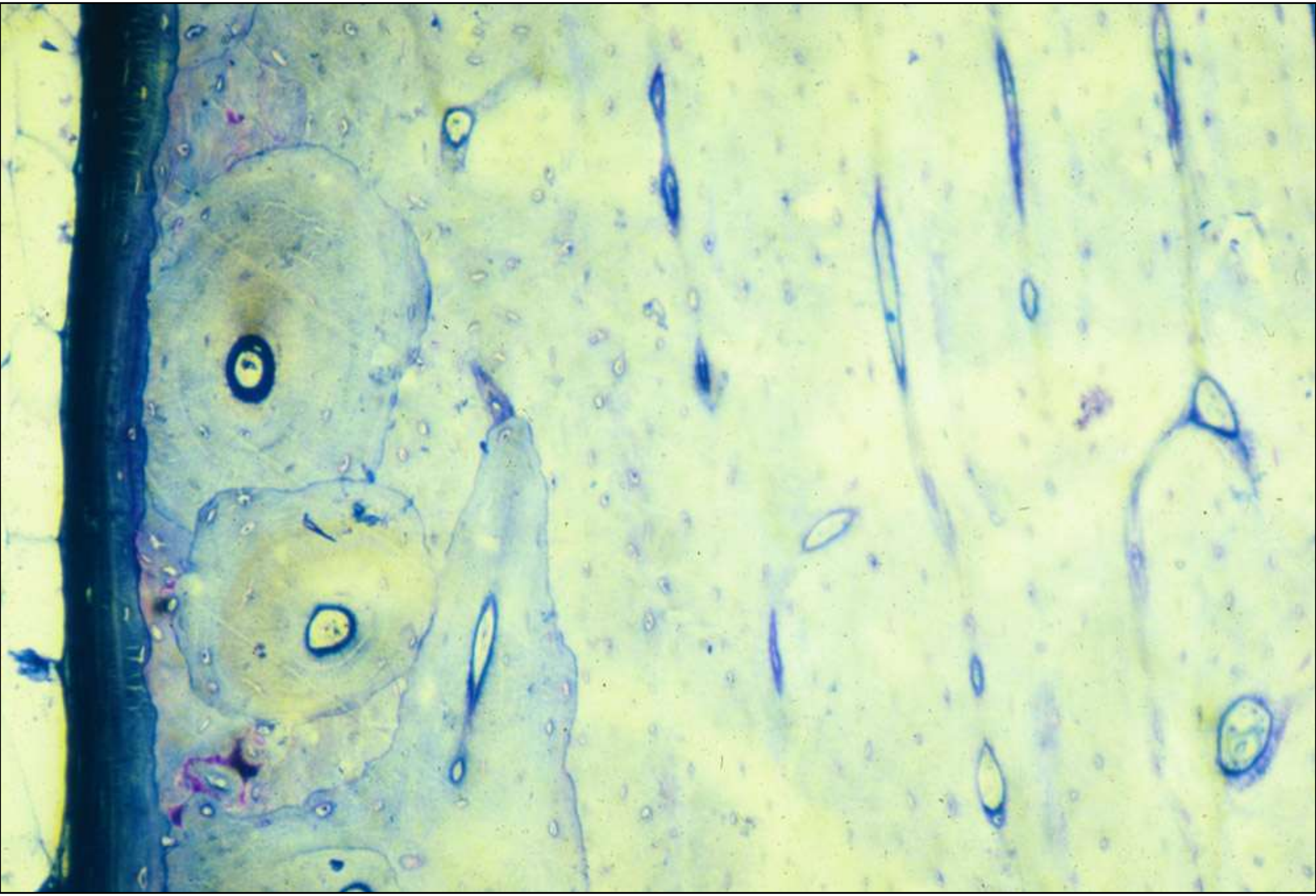

4
3
OL
N
2
1
O
I
T
IL
P
HC
VC

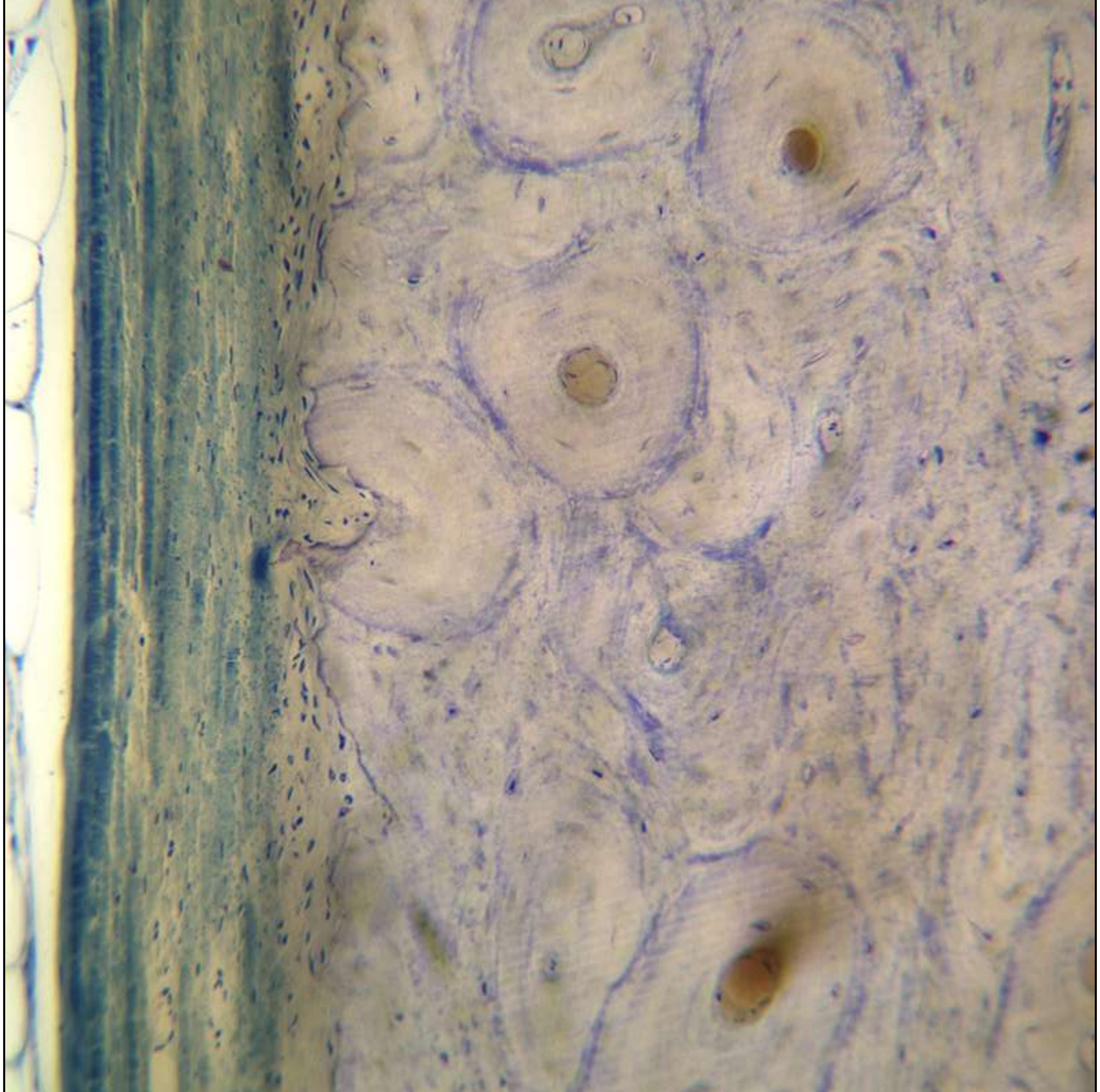


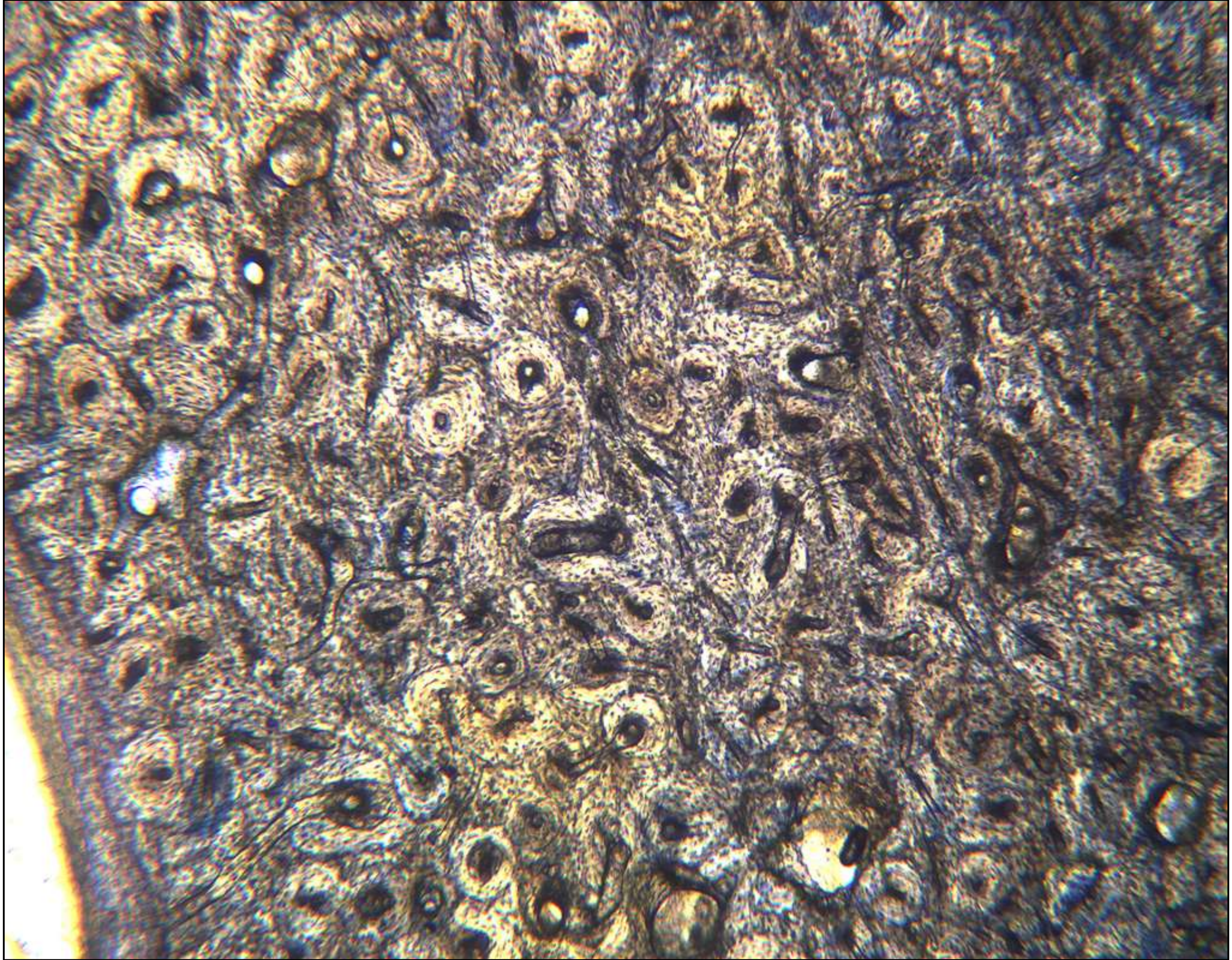


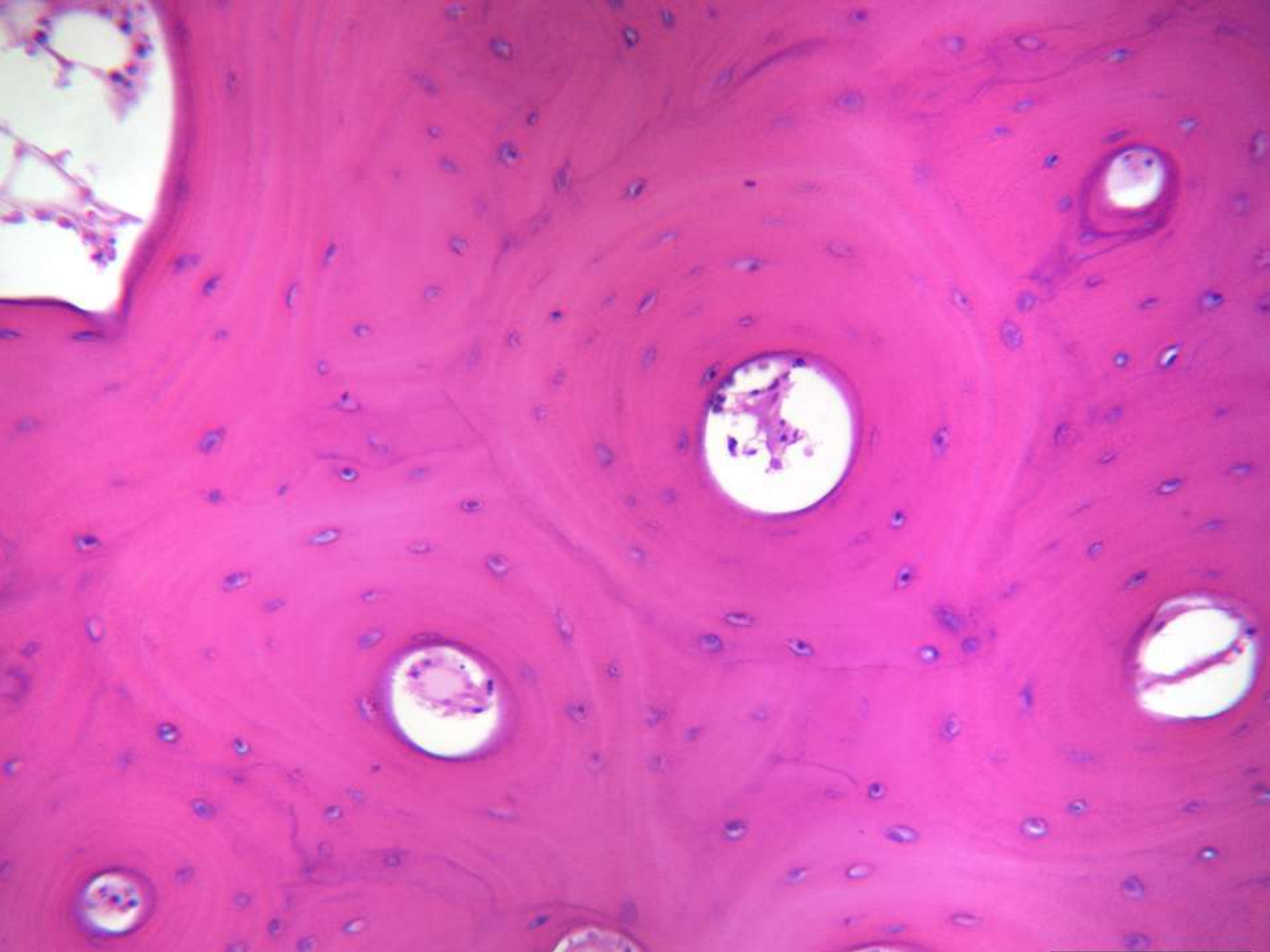




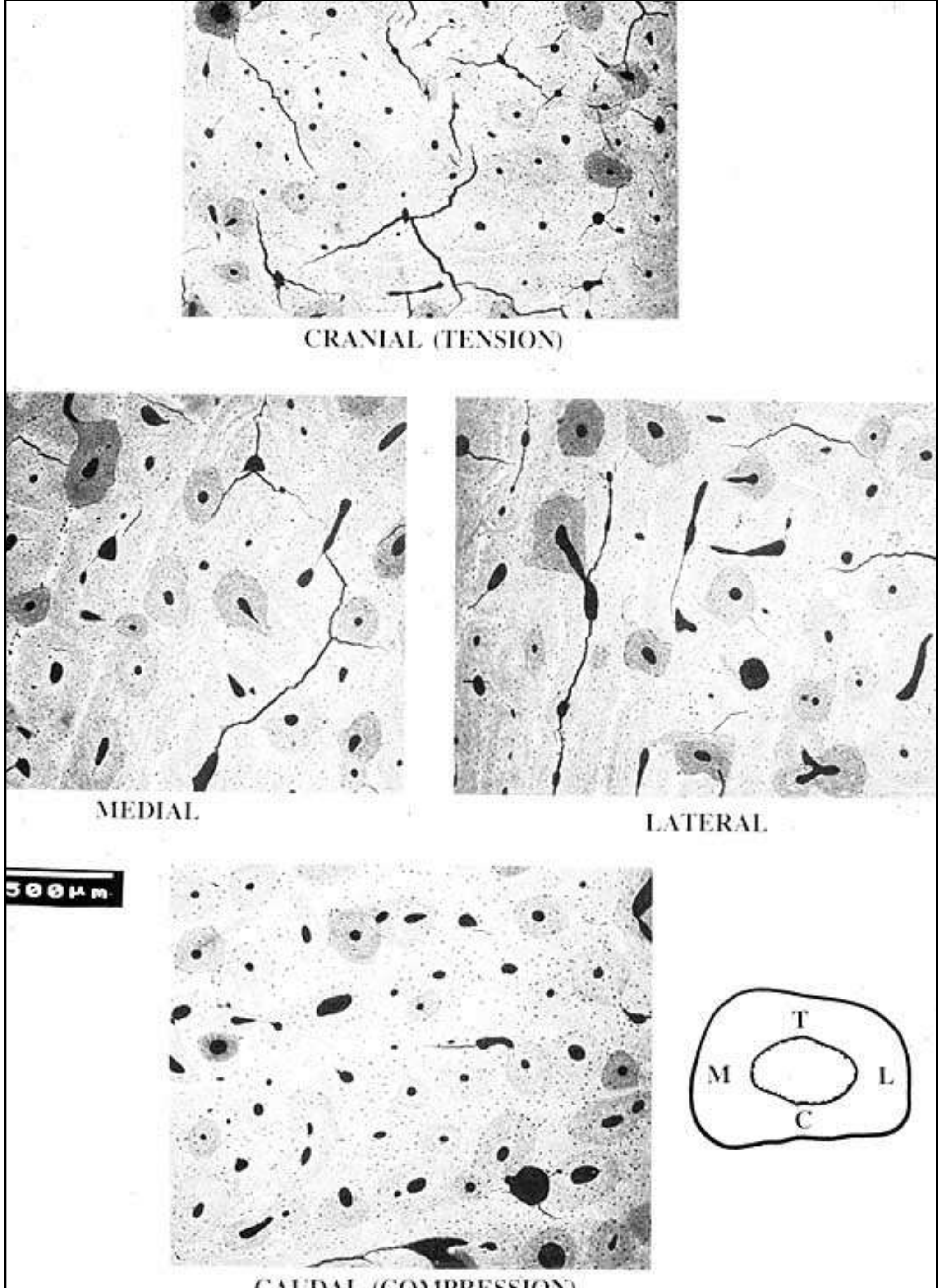


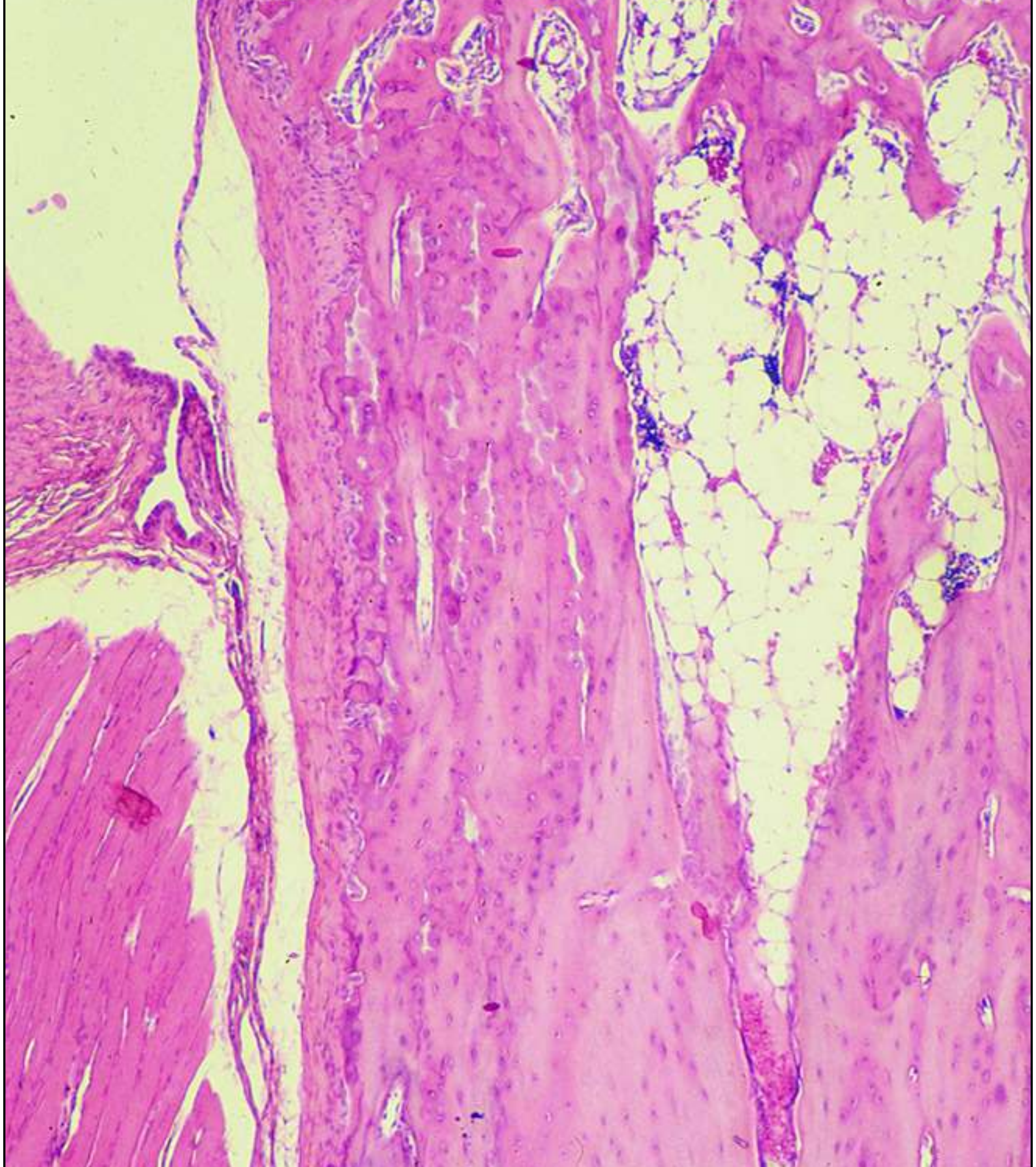


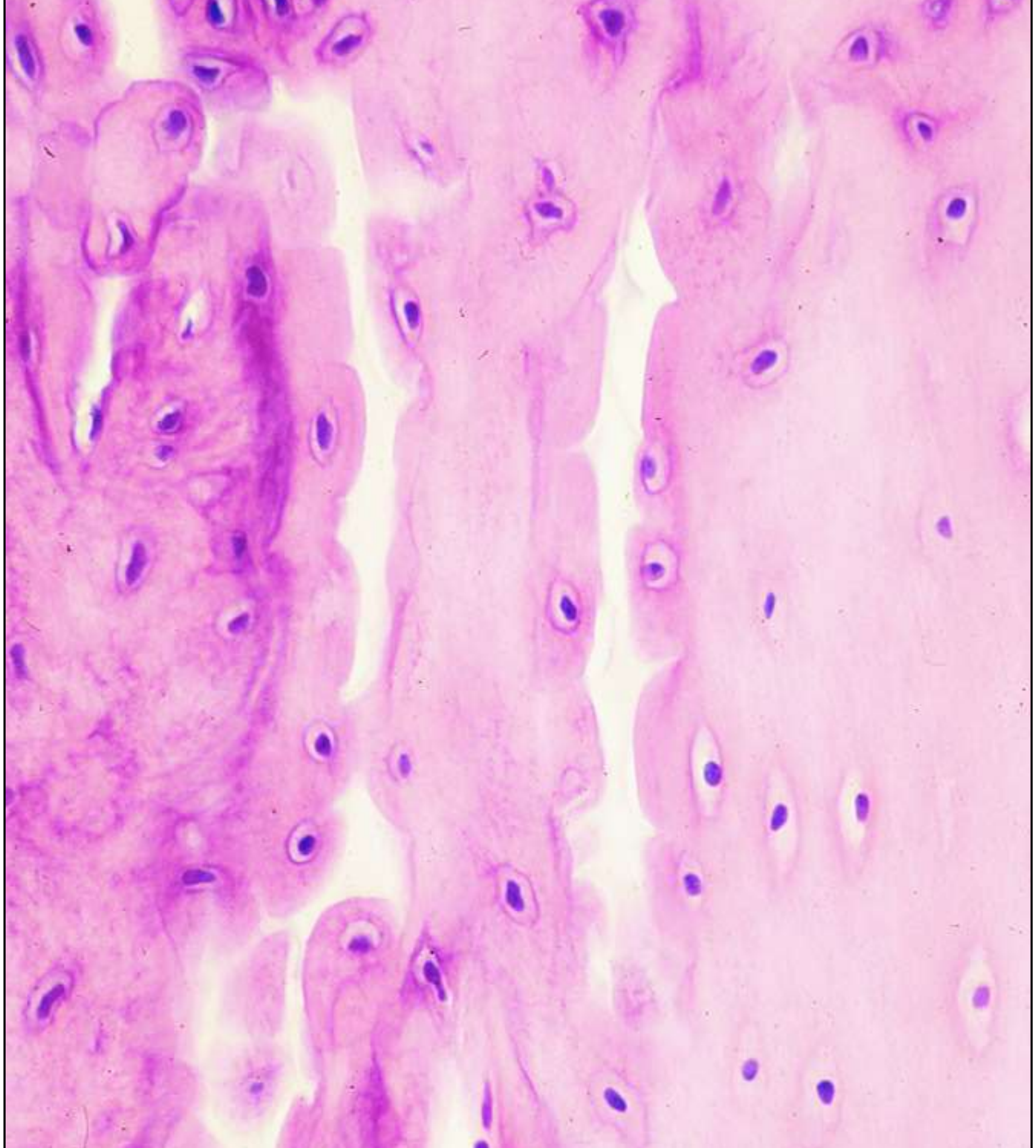




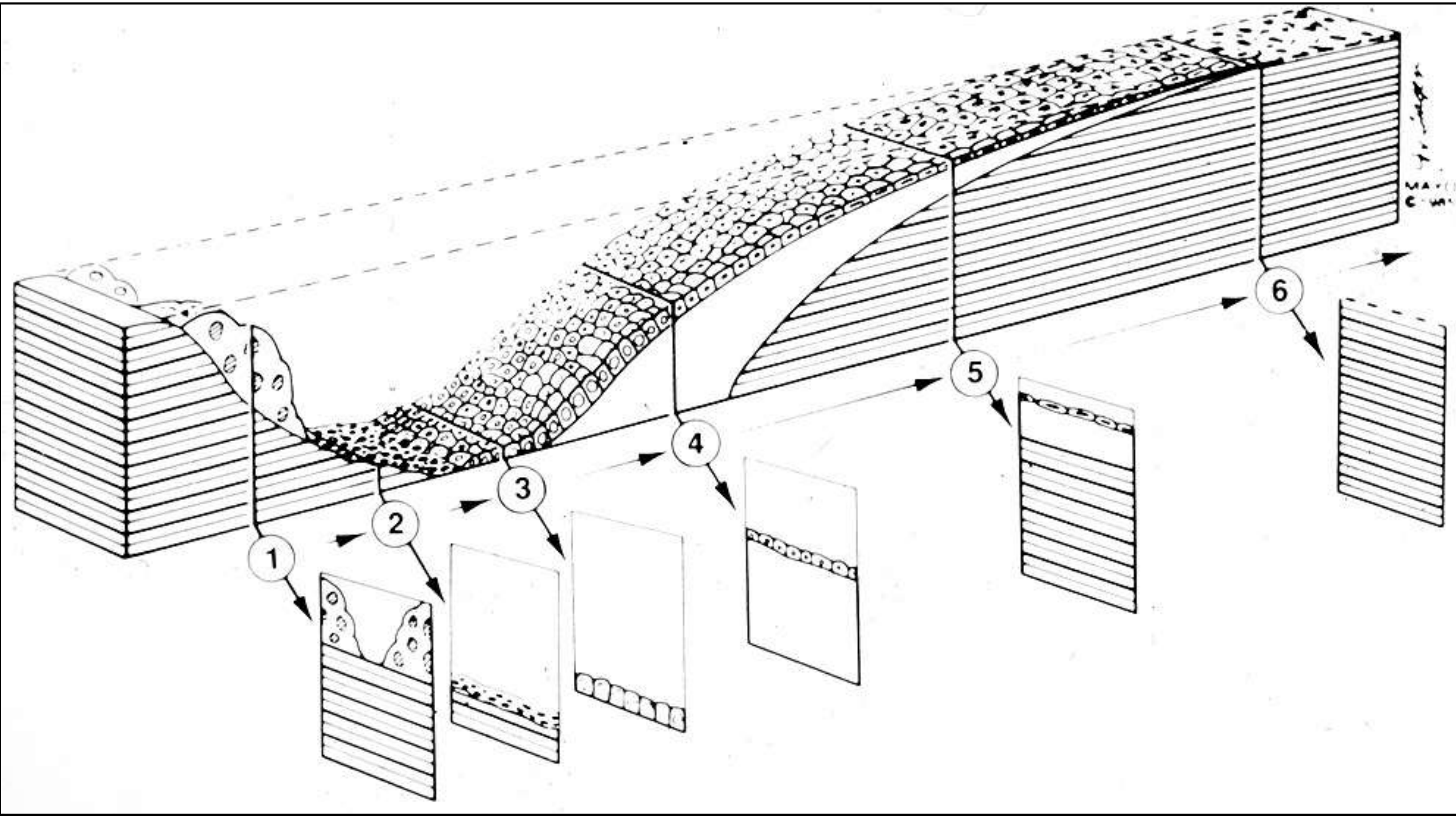
4
3
OL
N
2
1
O
I
T
IL
P
HC
VC

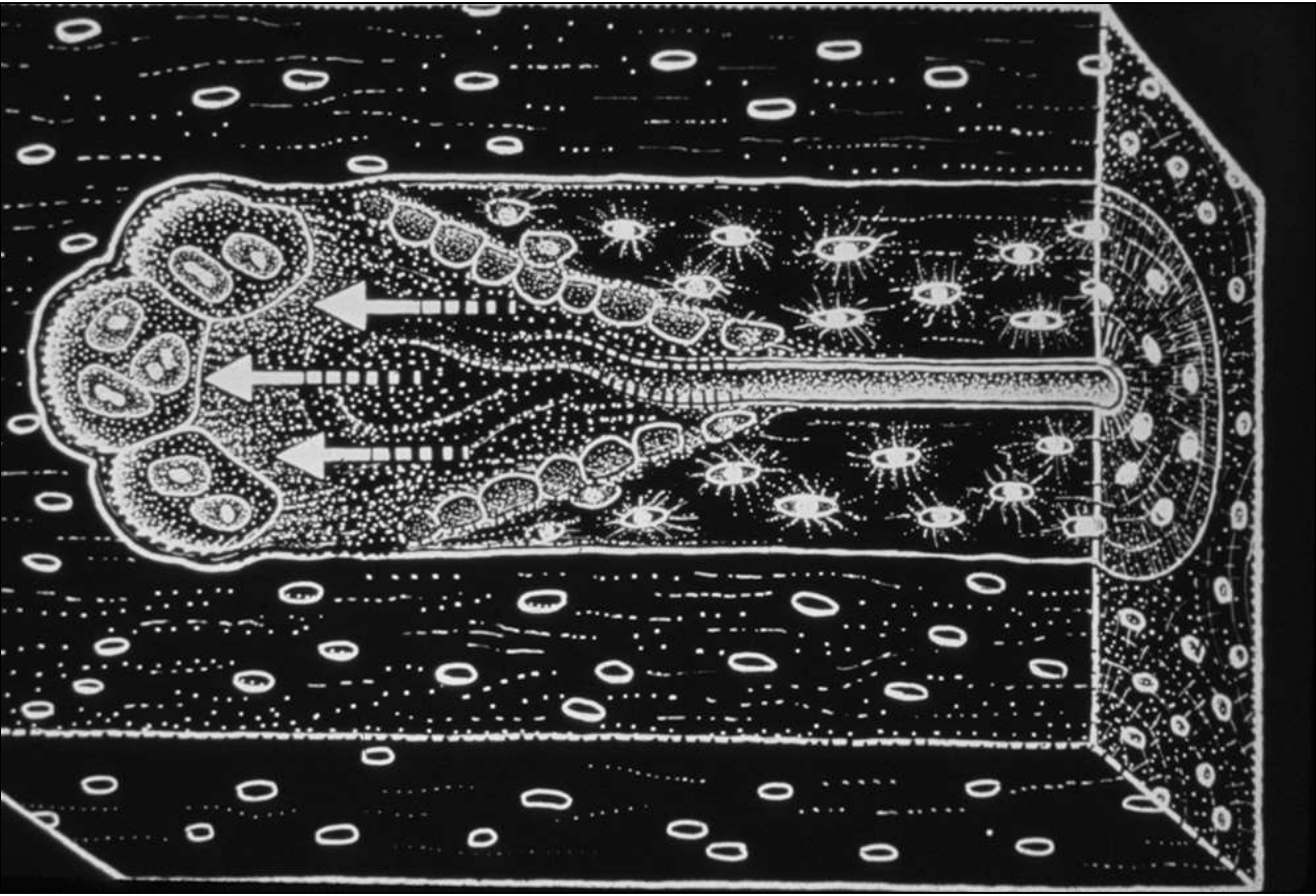

CRANIAL (TENSION)
MEDIAL
LATERAL
500µm
CAUDAL (COMPRESSION)
T
M
L
C

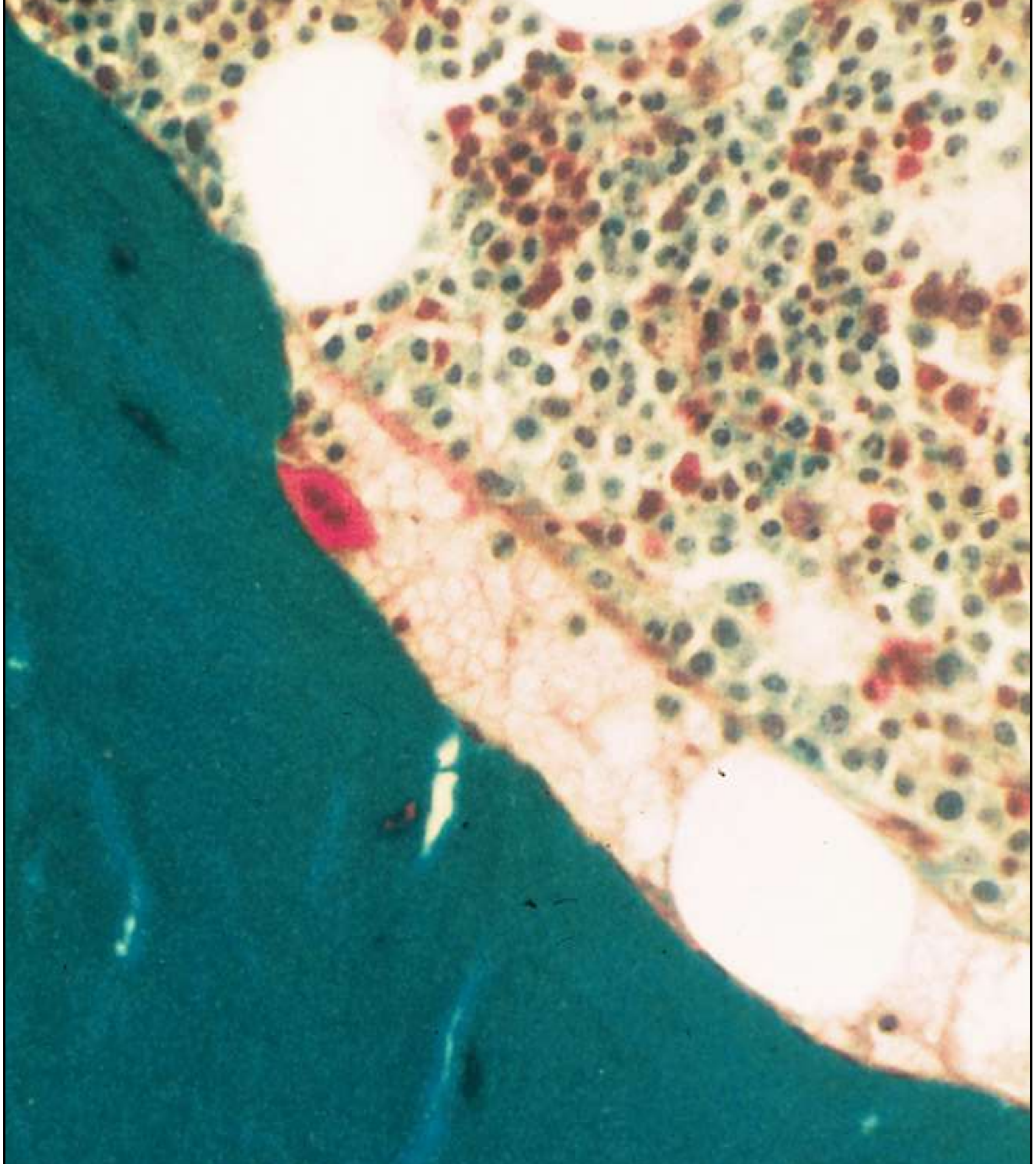


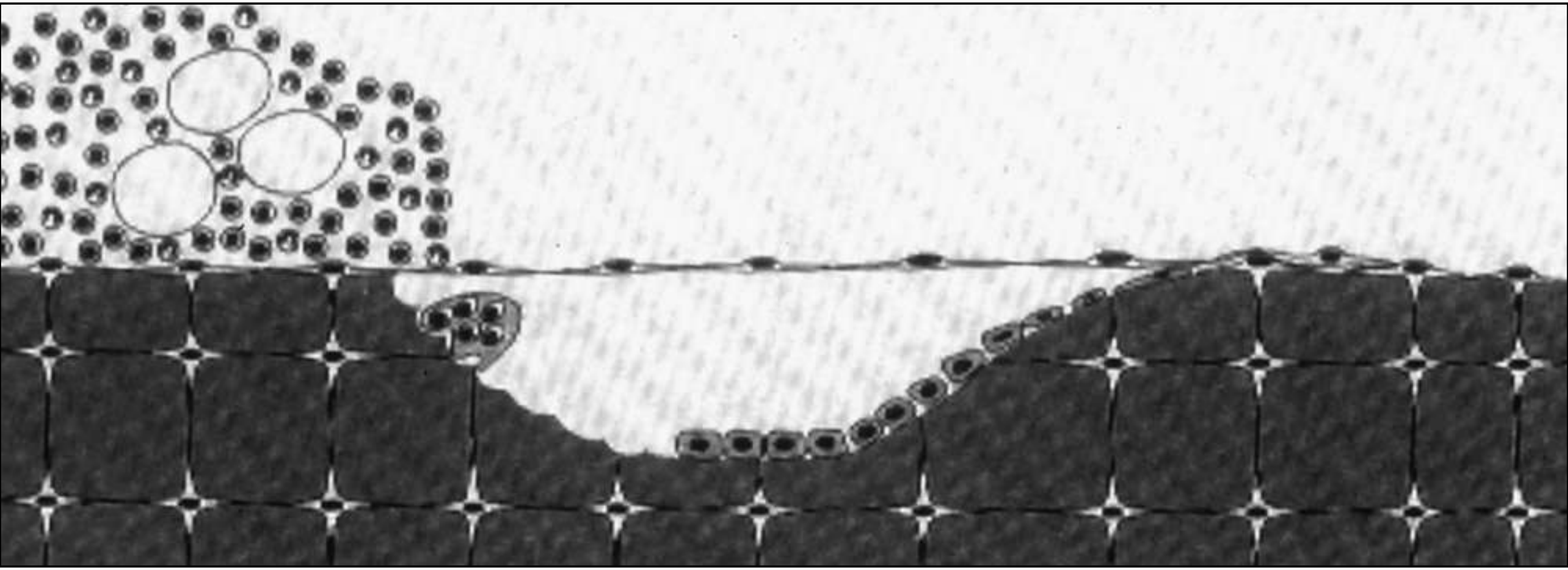


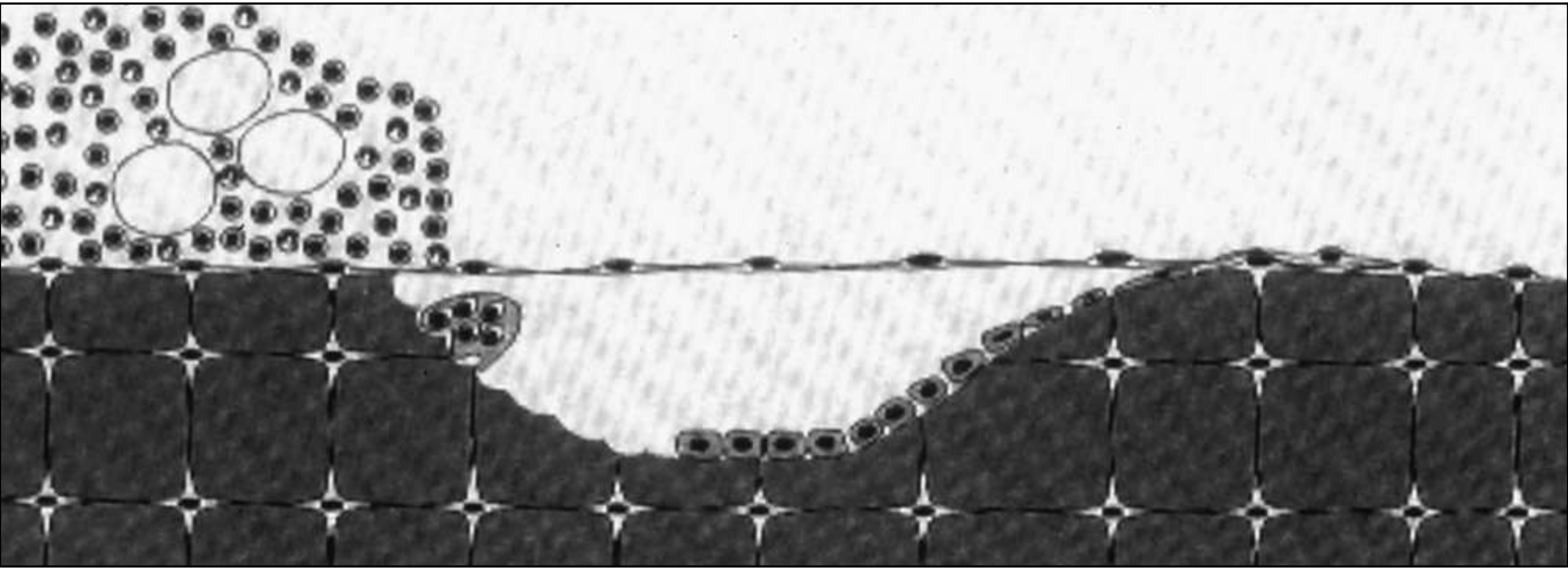

4
3
2
1
N
OL
O
T
IL
I
P
HC
VC


1
2
3
4
5
6



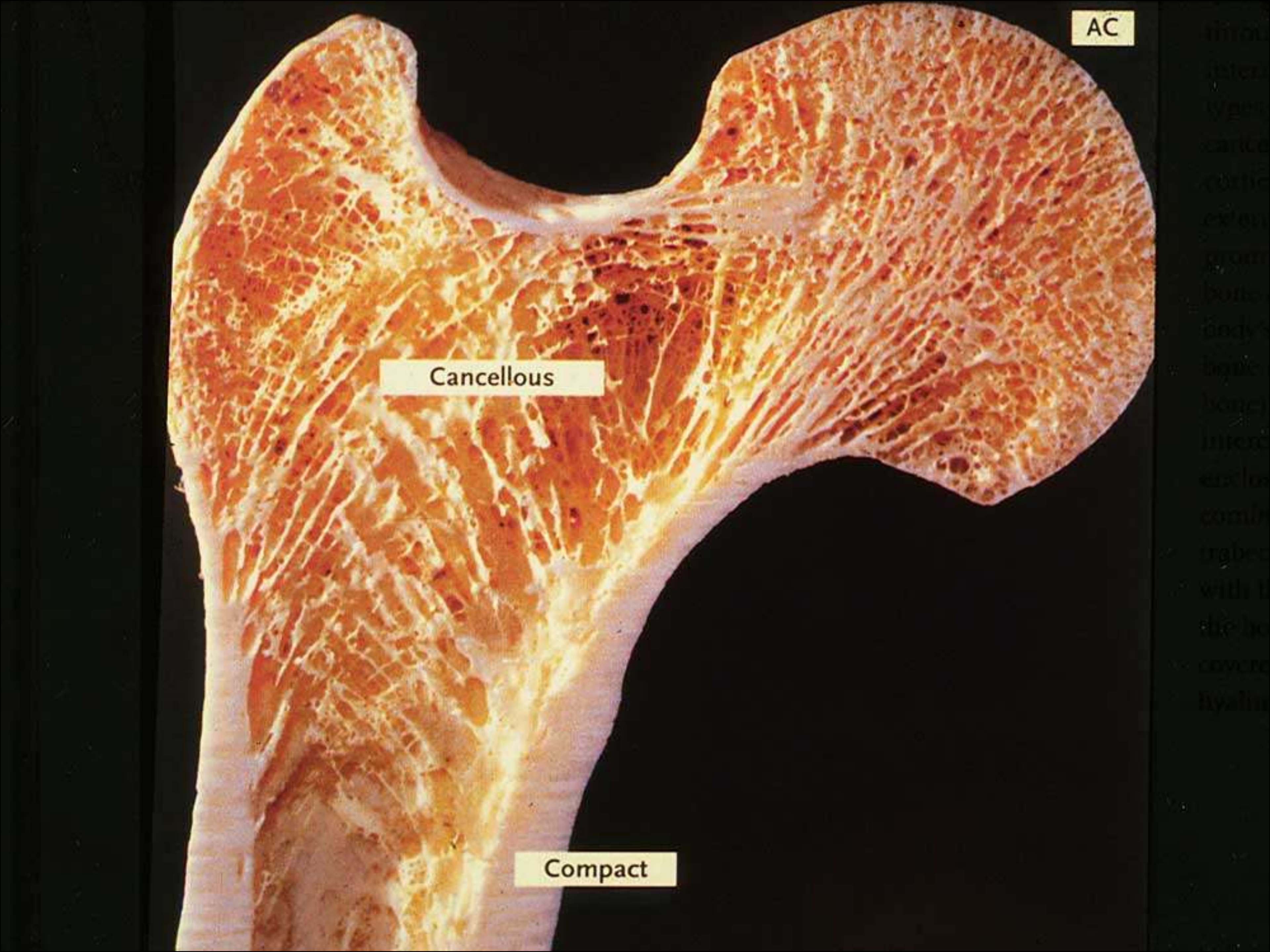


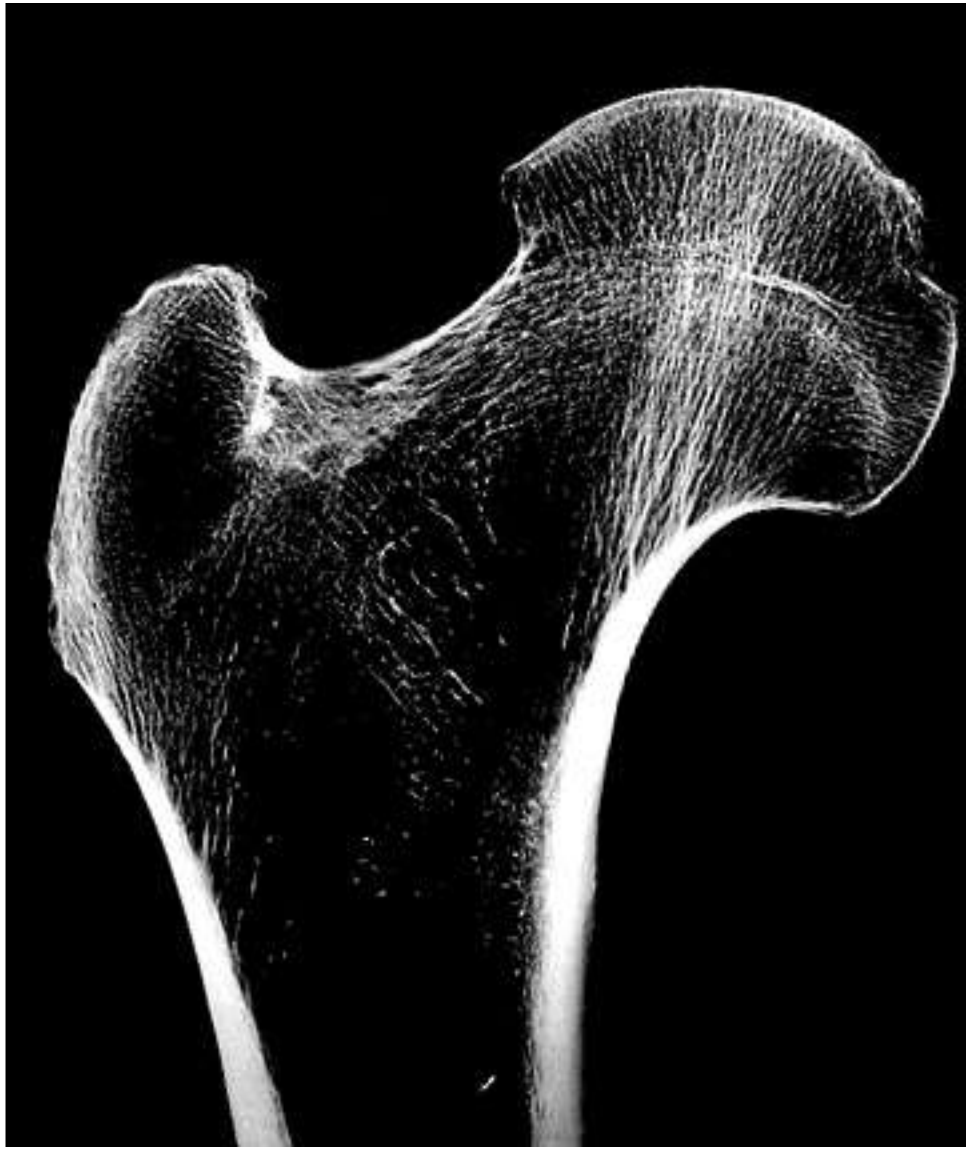




Modeling

Change in shape or size


AC
Cancellous
Compact



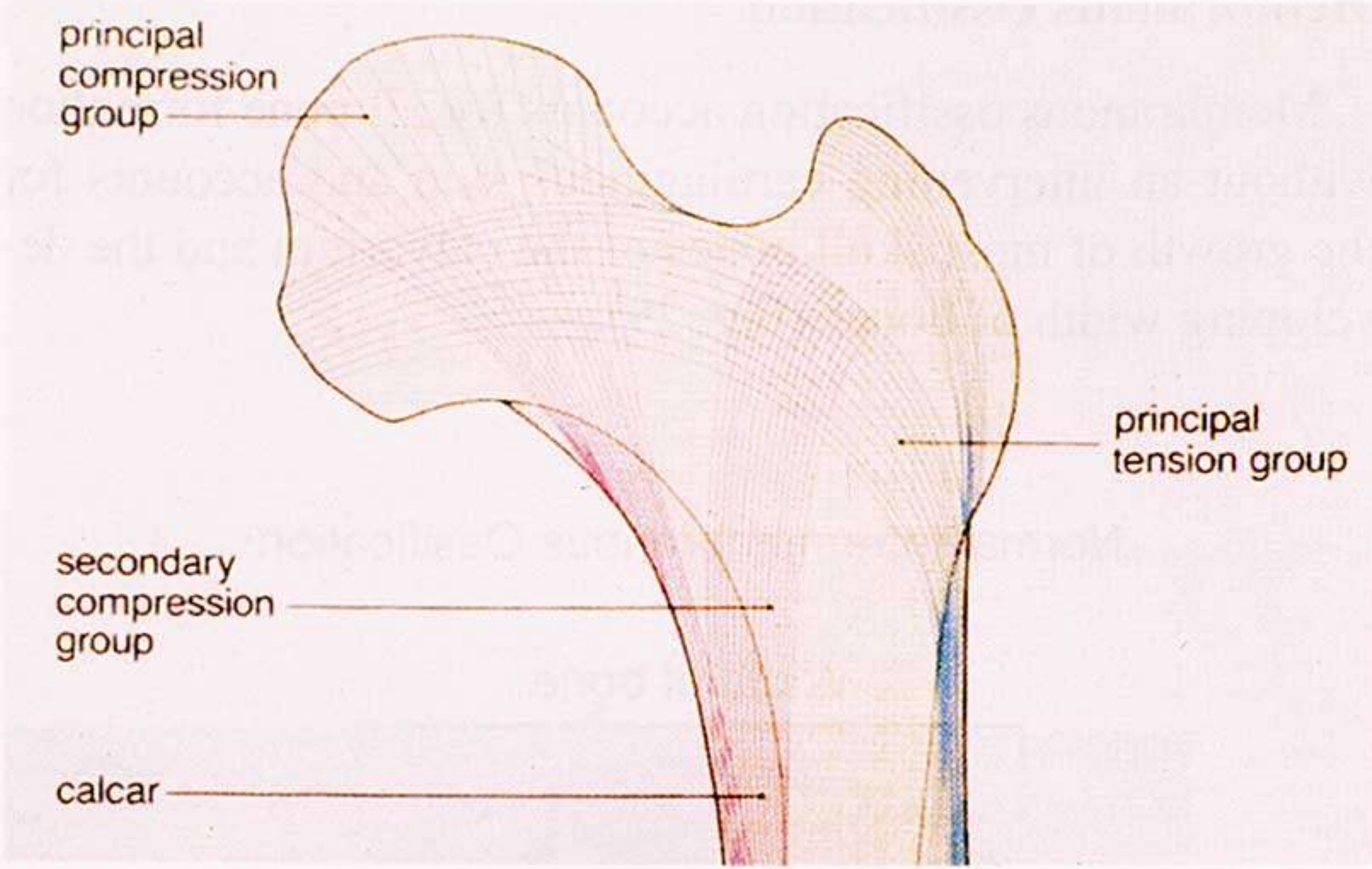
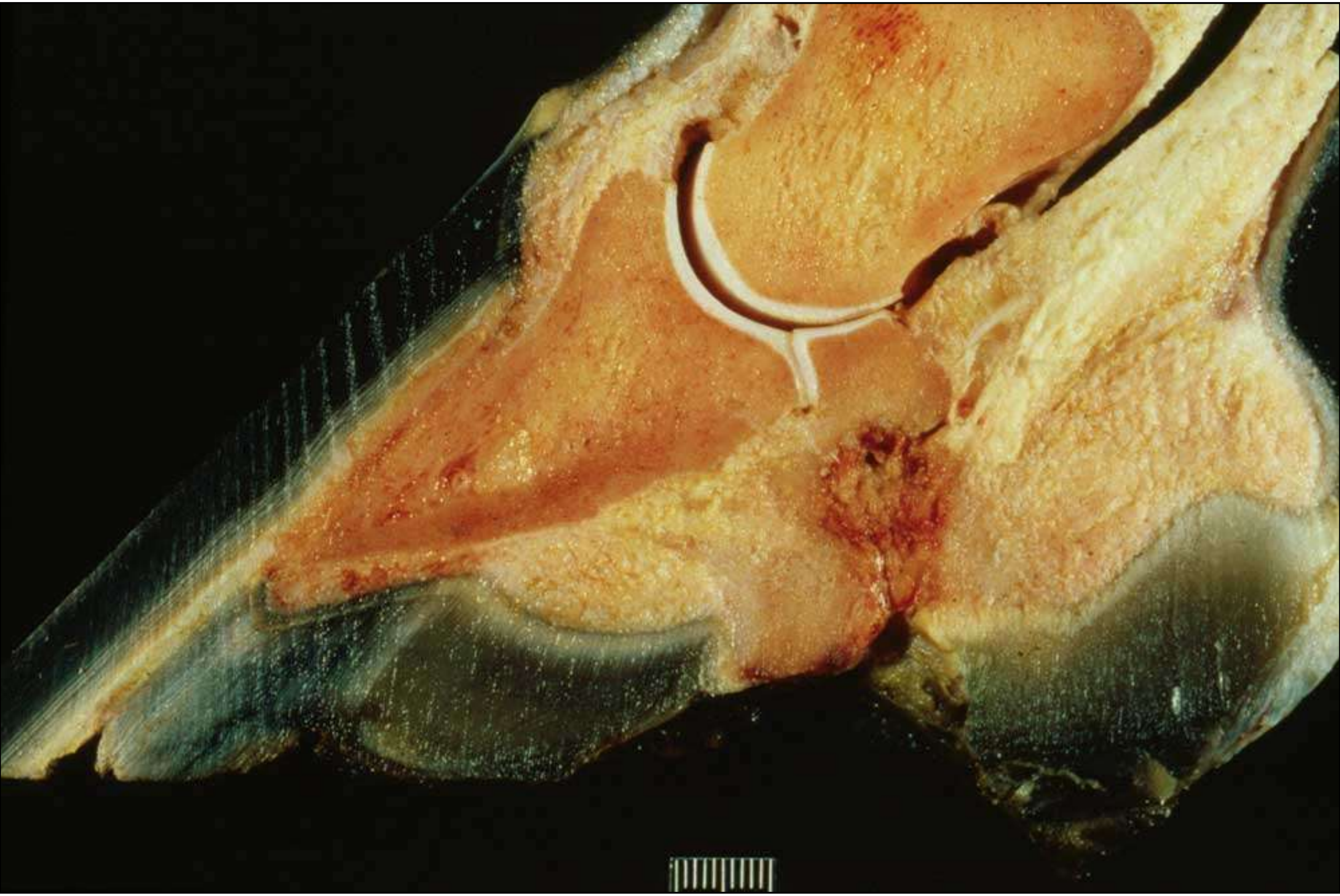
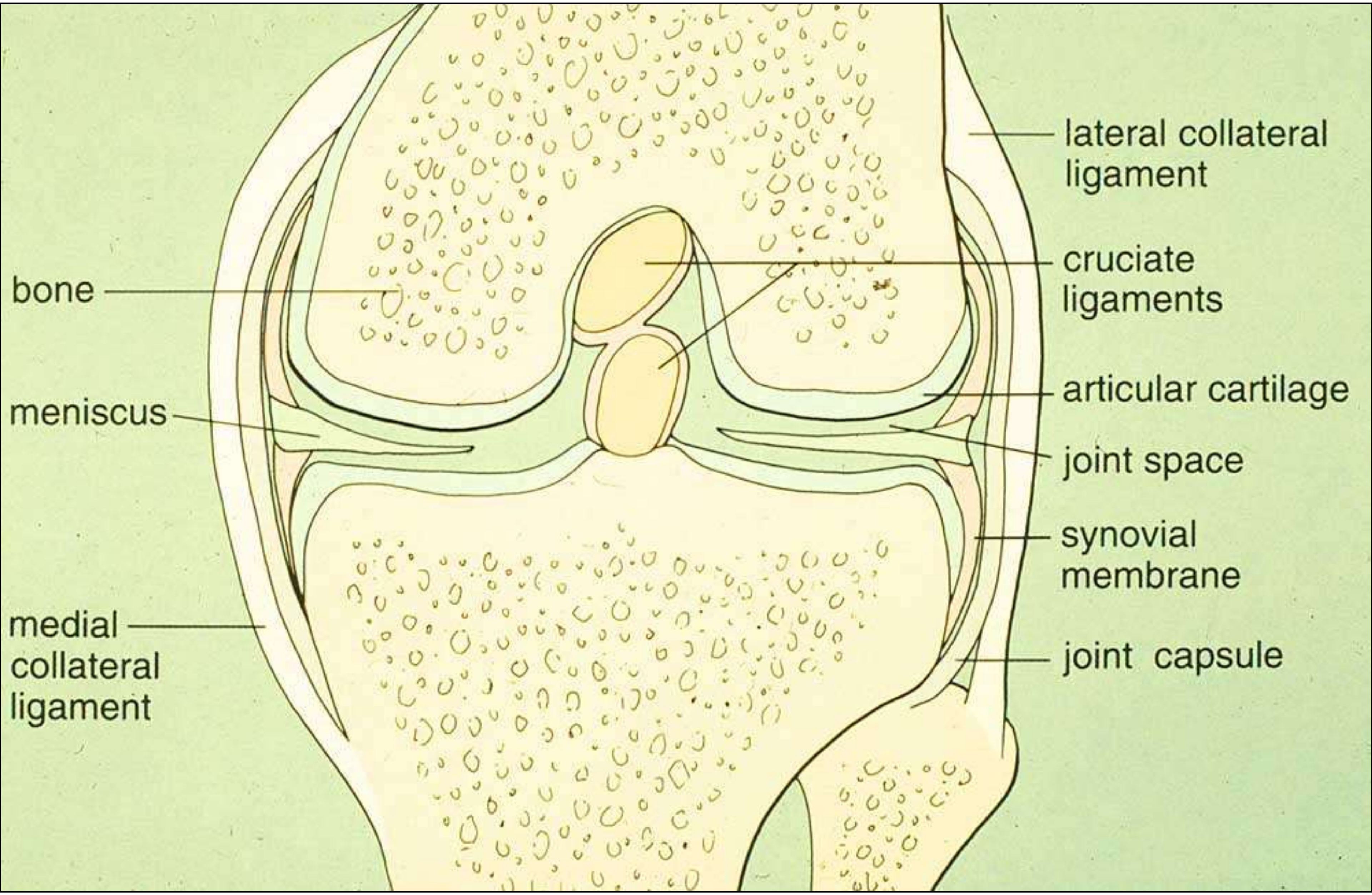


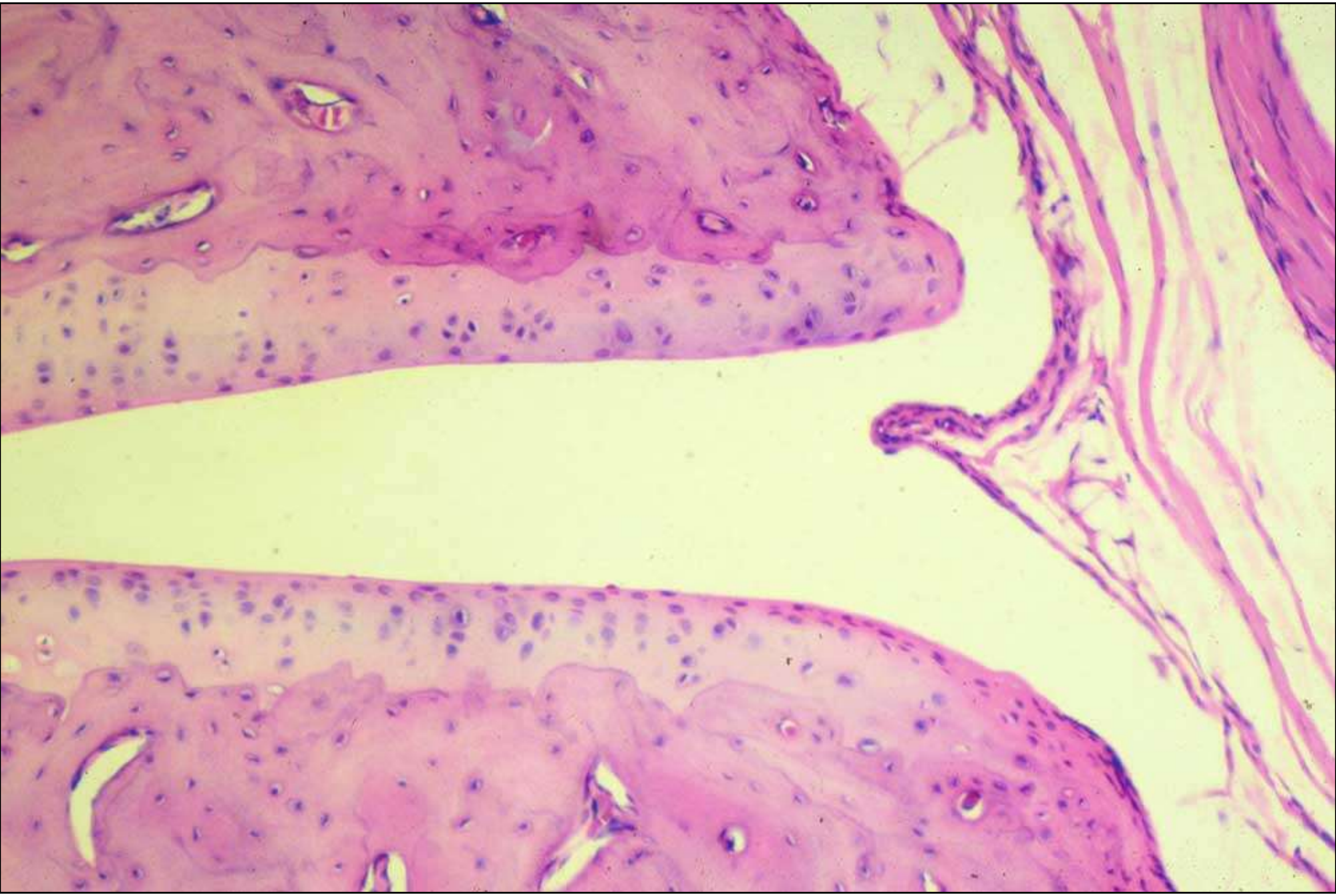
FIG. 31. Bone modeling: the trabecular structure of the proximal femur is a composition of arcades of cancellous bone that "model" or "shape" the internal architecture of bone along compressive and tensile stresses produced during weight bearing.

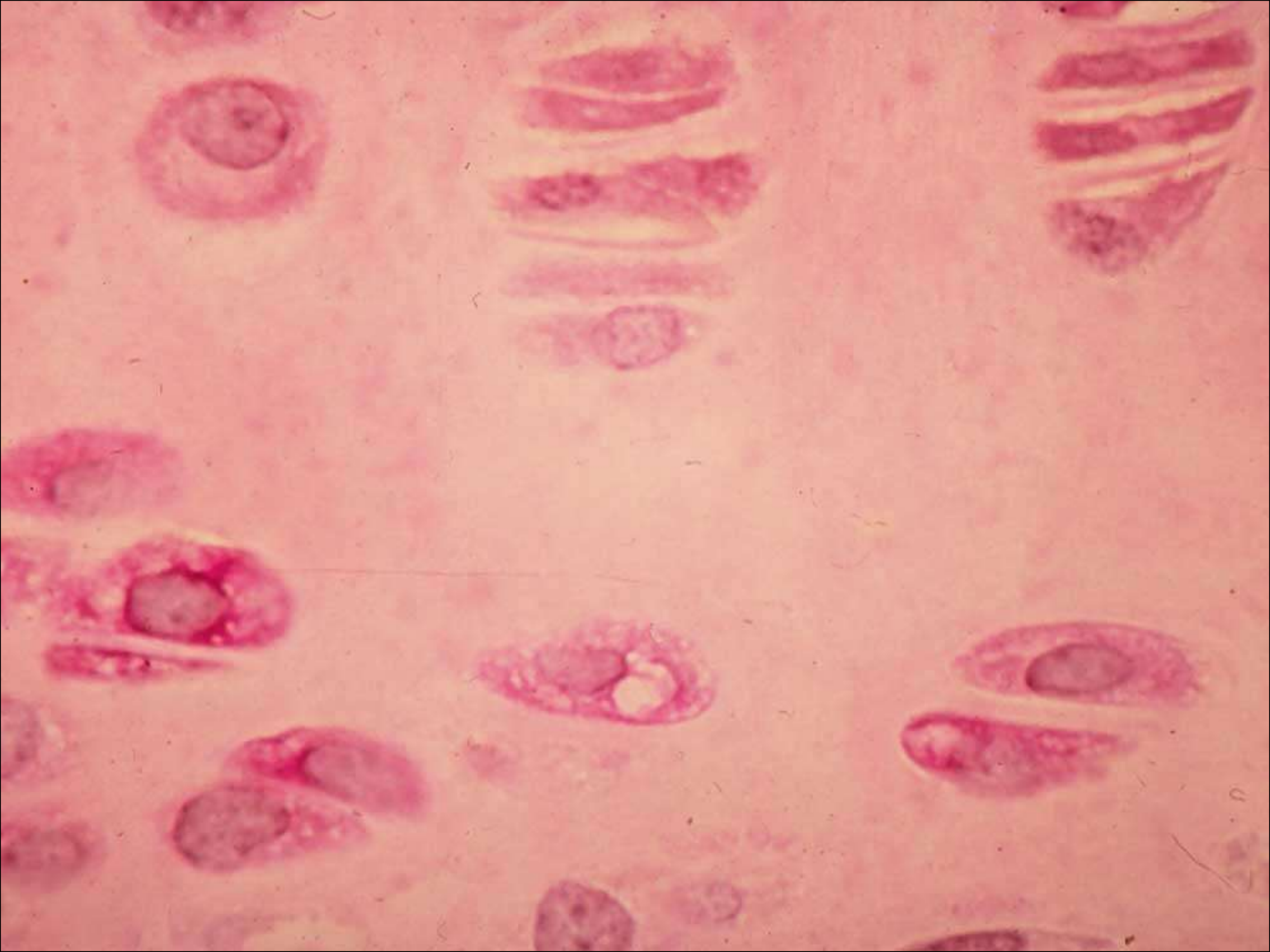
Articular Cartilage

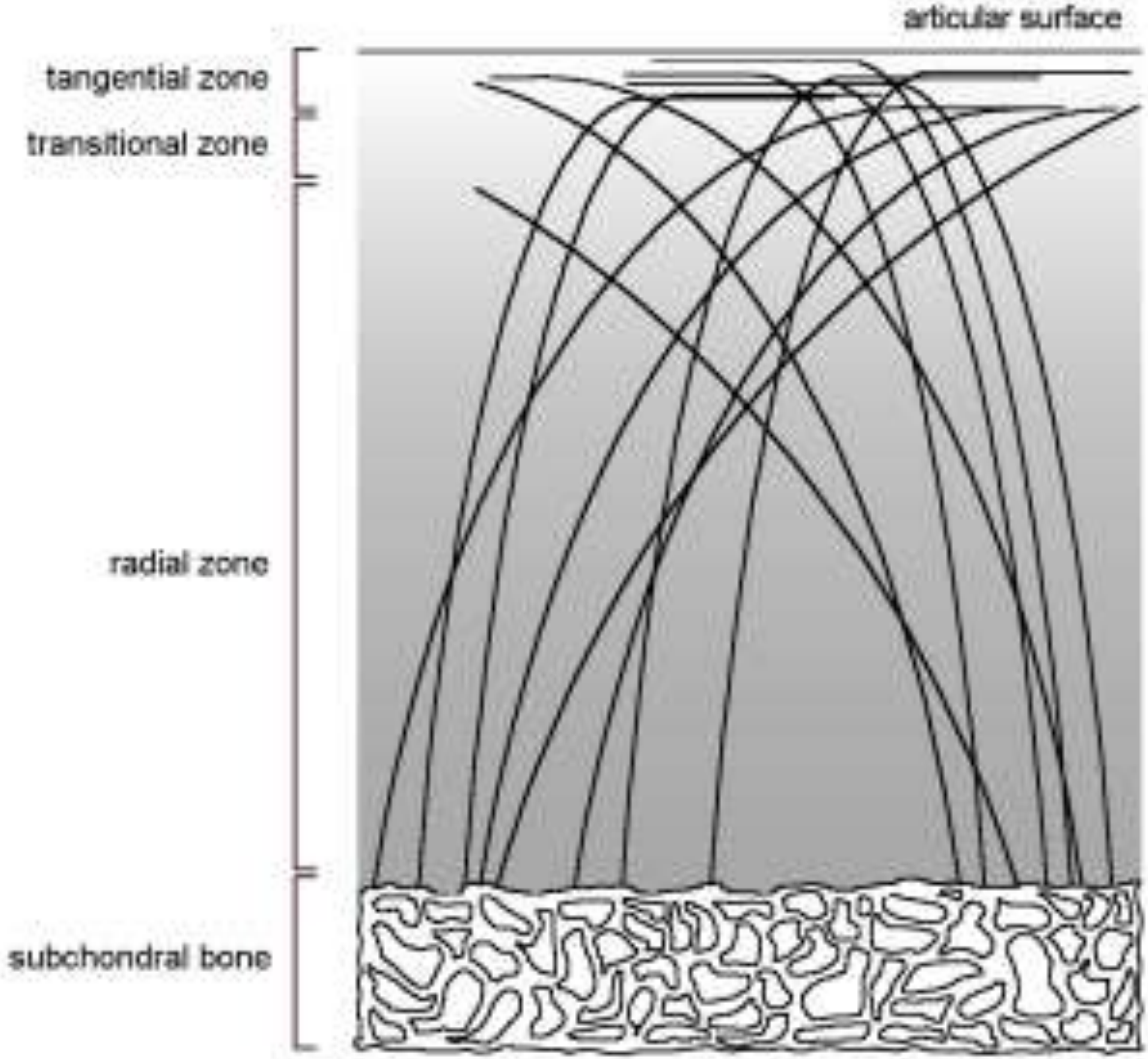


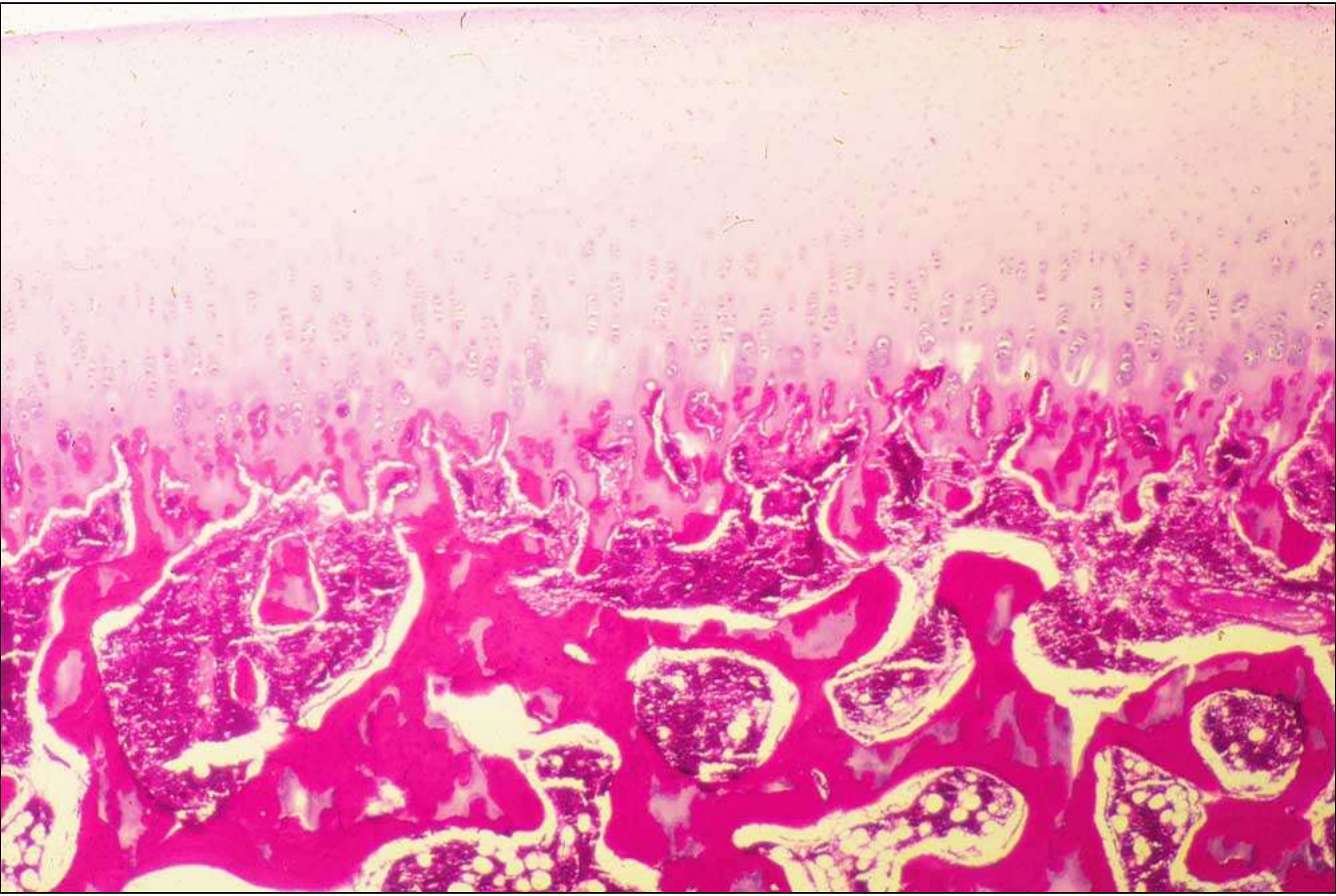


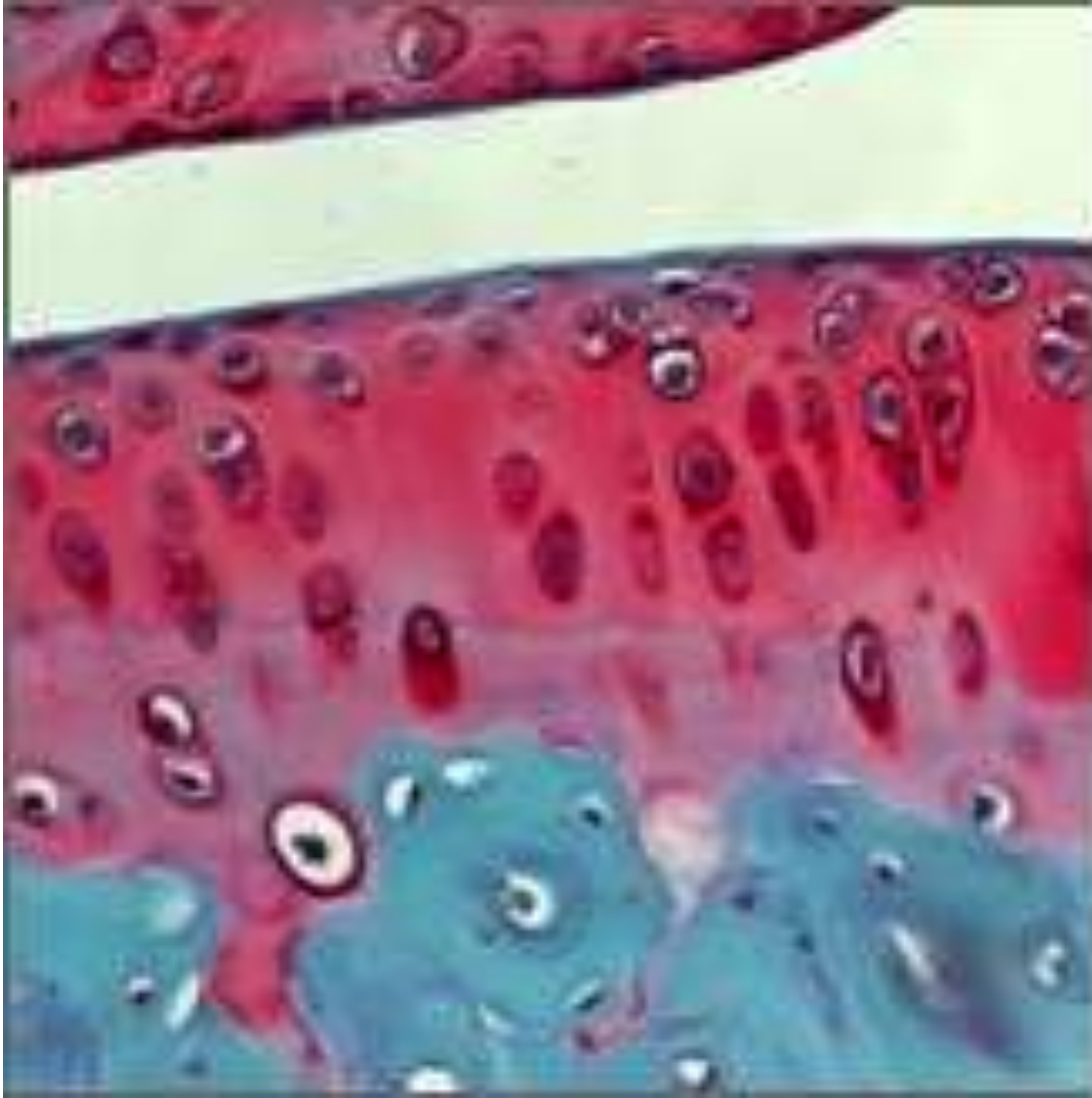
lateral collateral ligament
cruciate ligaments
bone
articular cartilage
meniscus
joint space
synovial membrane
medial collateral ligament
joint capsule

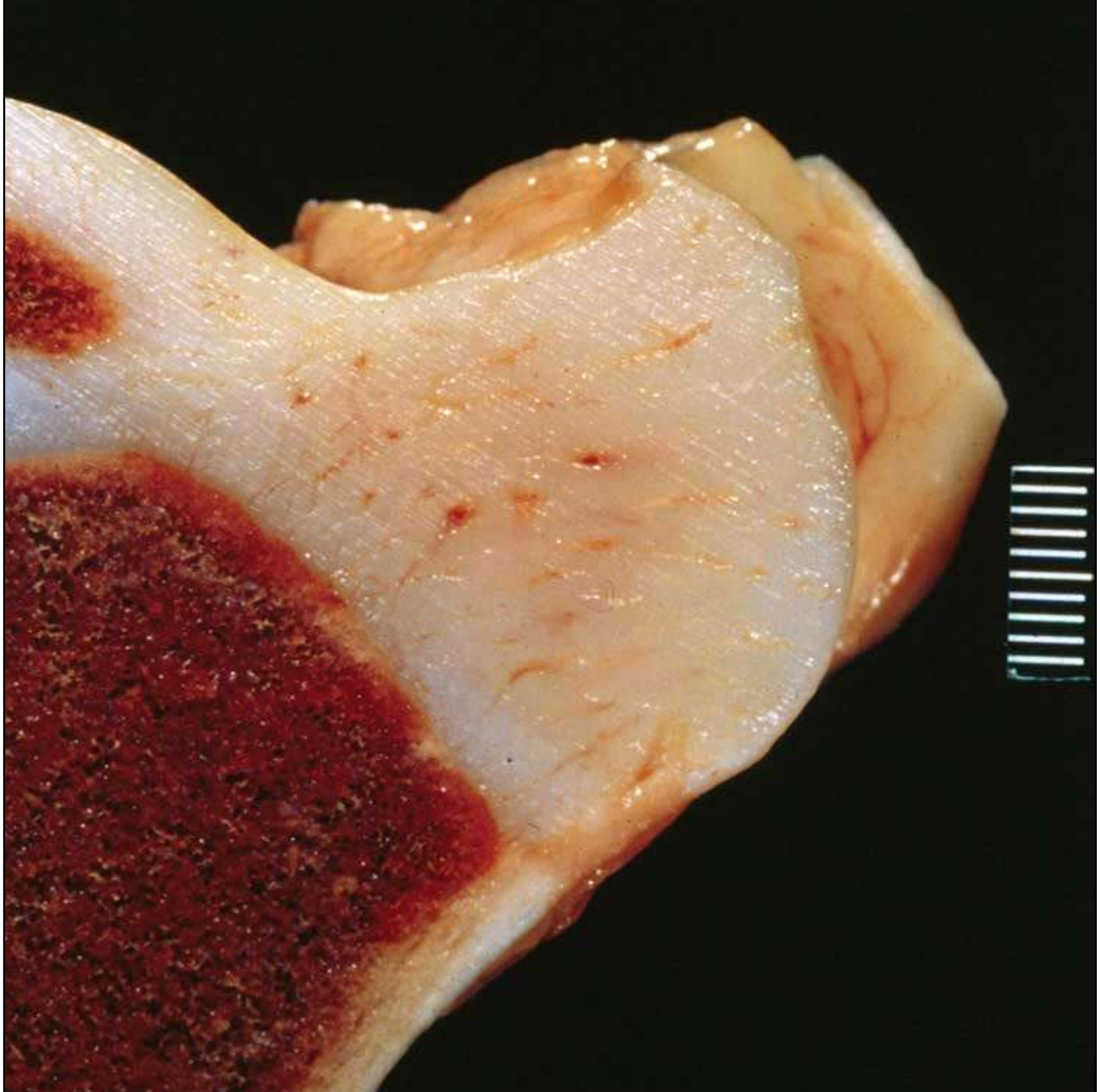


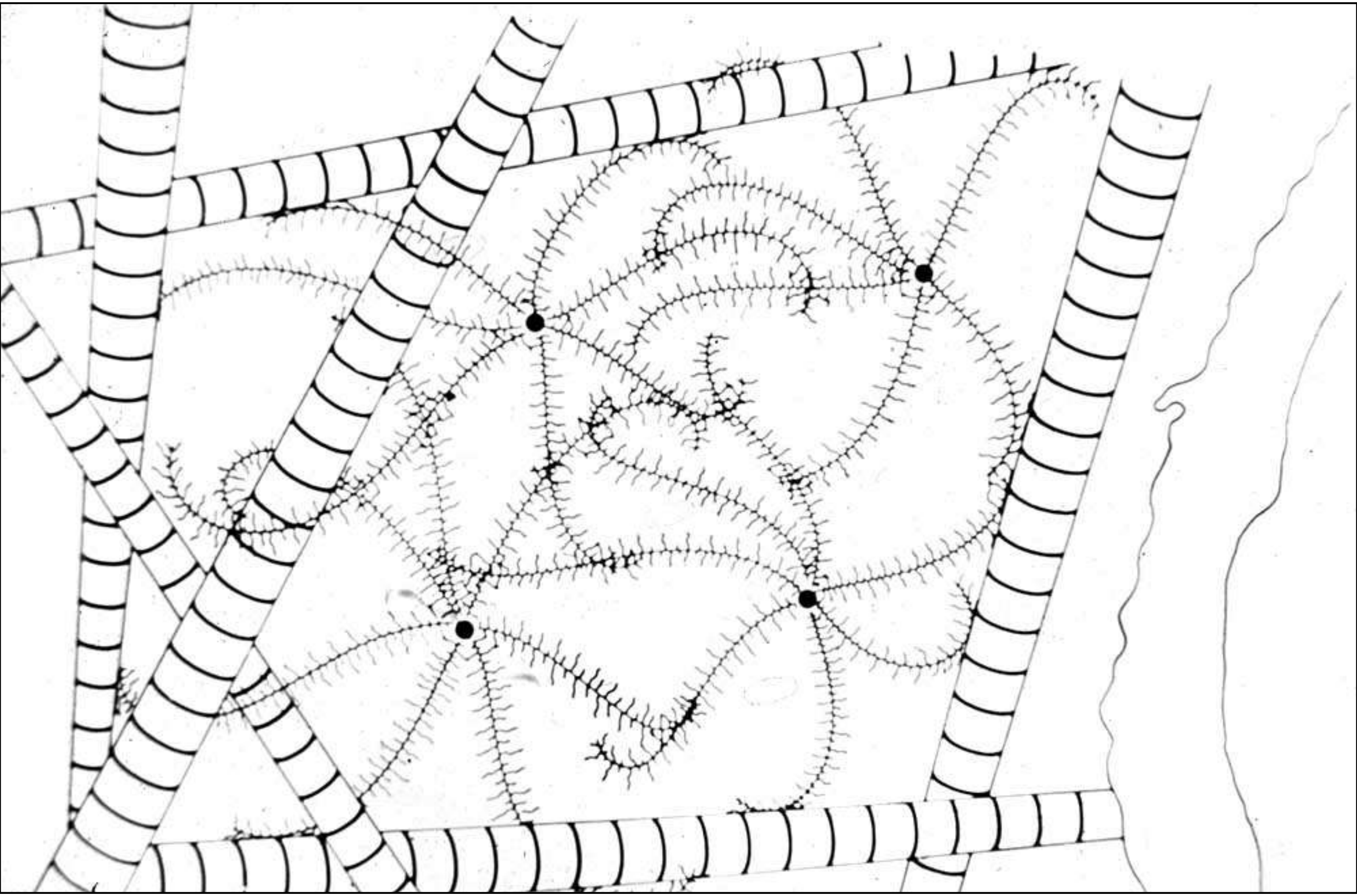


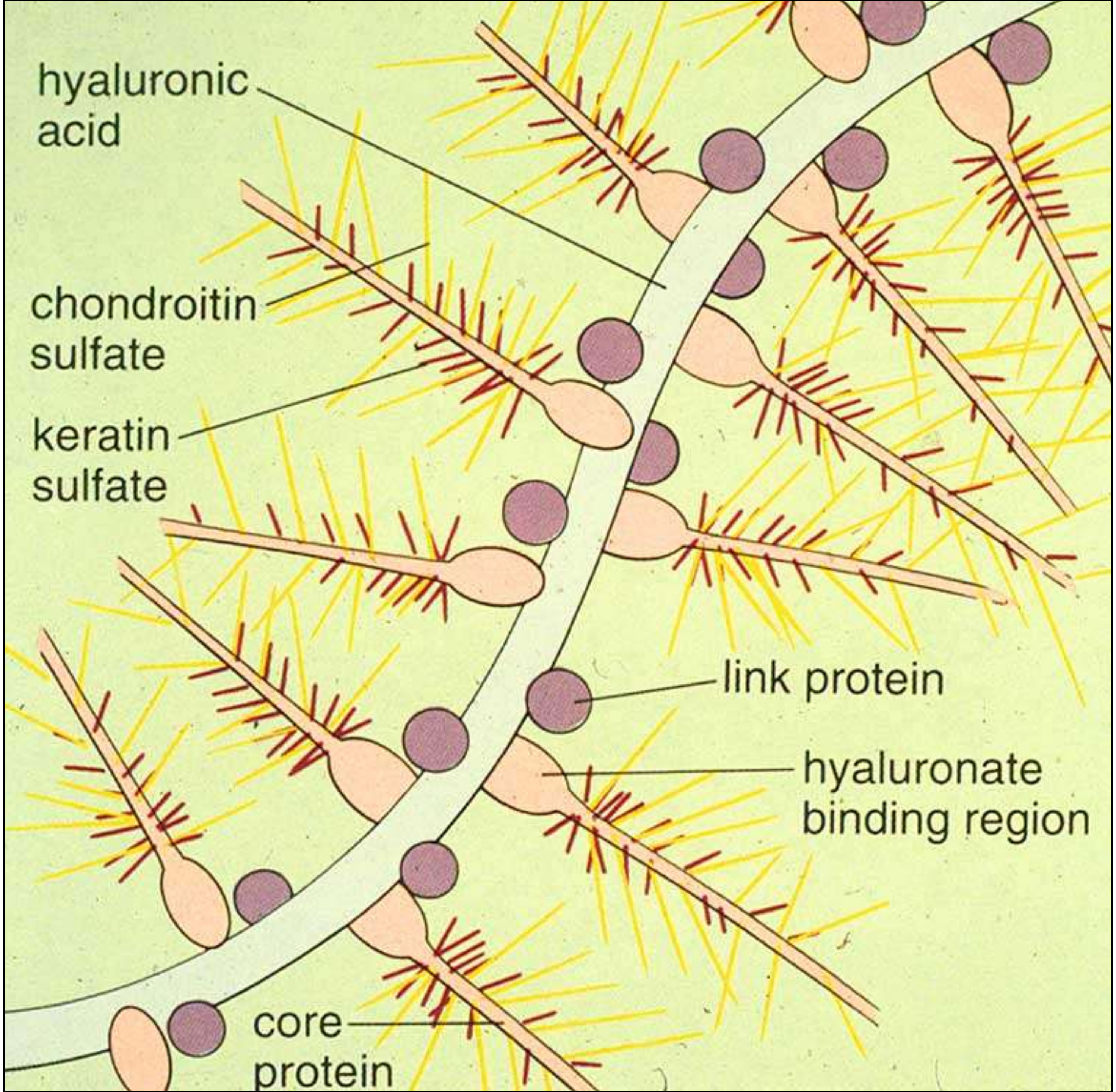

articular surface
tangential zone
transitional zone
radial zone
subchondral bone

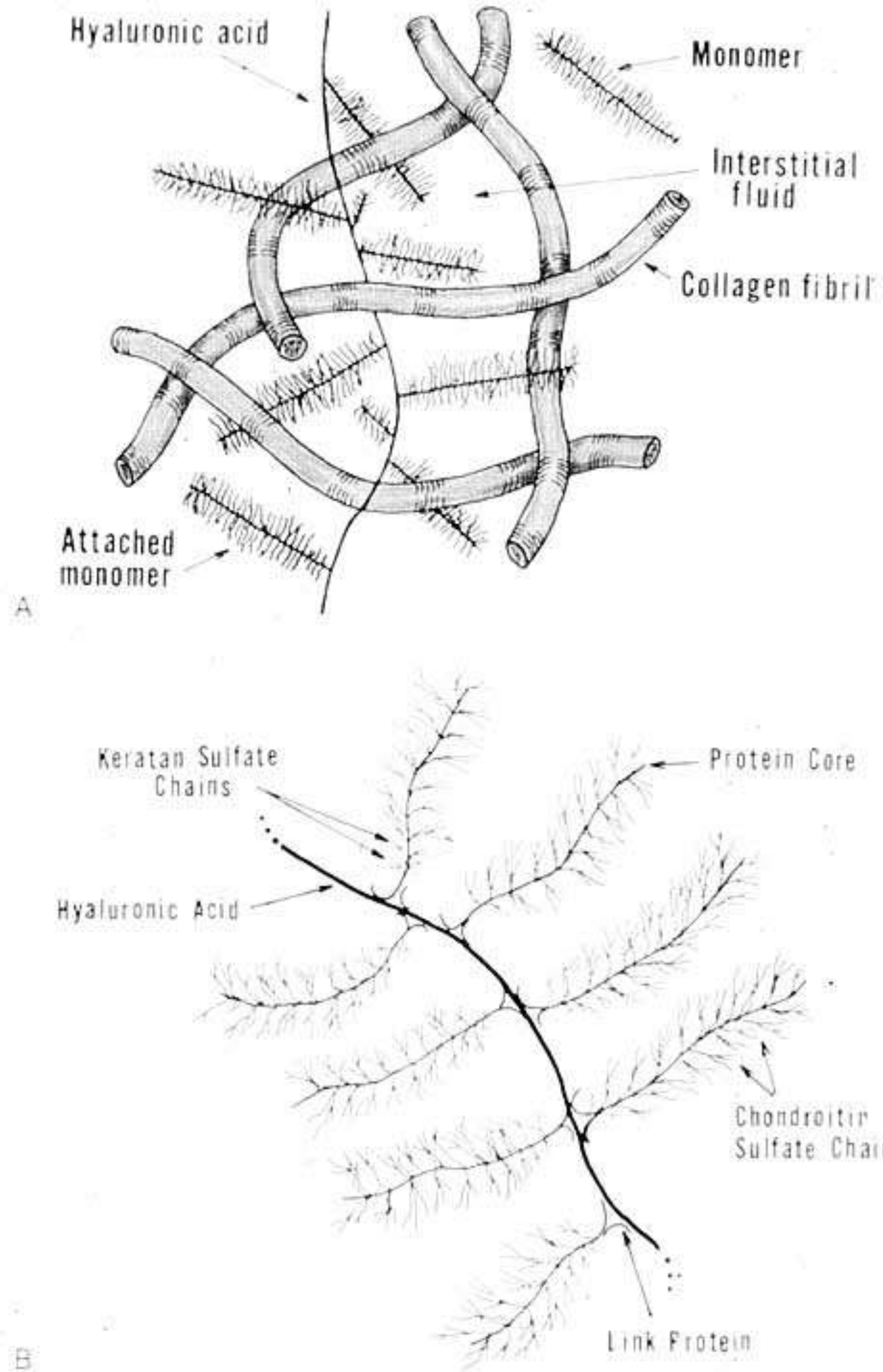









hyaluronic acid
chondroitin sulfate
keratin sulfate
link protein
hyaluronate binding region
core protein


Hyaluronic acid
Monomer
Interstitial fluid
Collagen fibril
Attached monomer
A
Keratan Sulfate Chains
Protein Core
Hyaluronic Acid
Chondroitin Sulfate Chains
Link Protein
B

MATRIX PROTEOGLYCANS

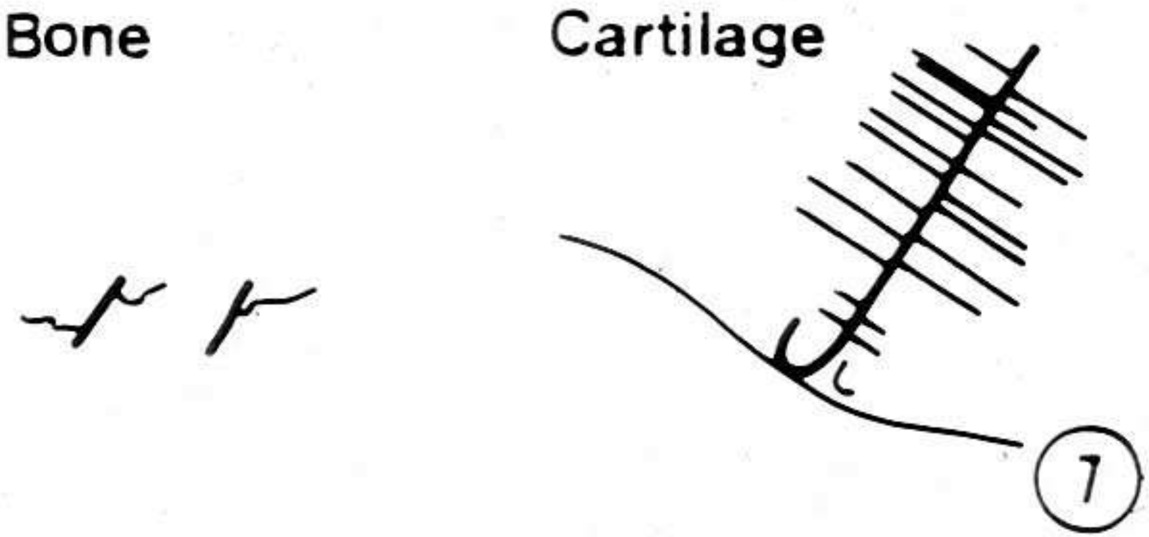
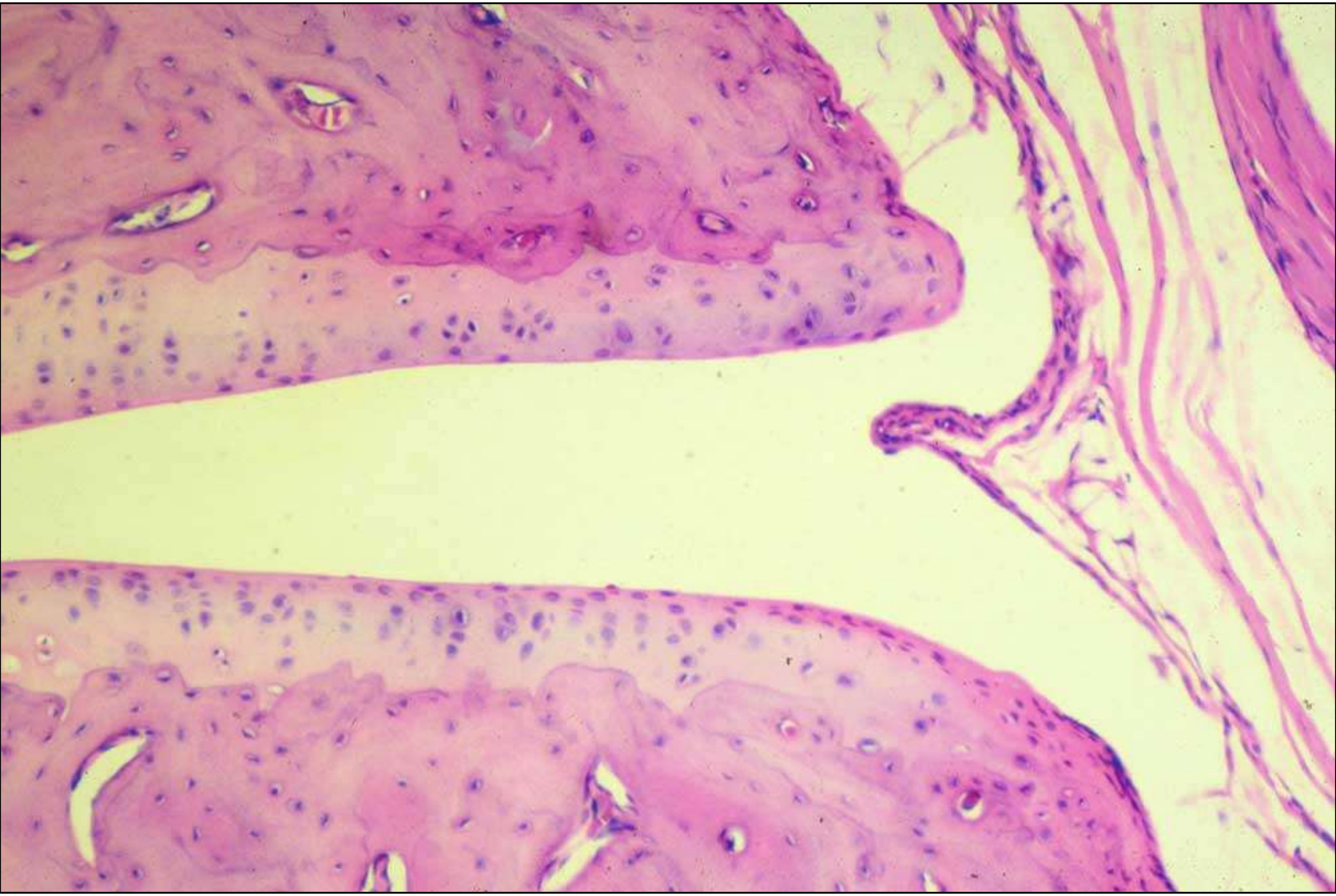
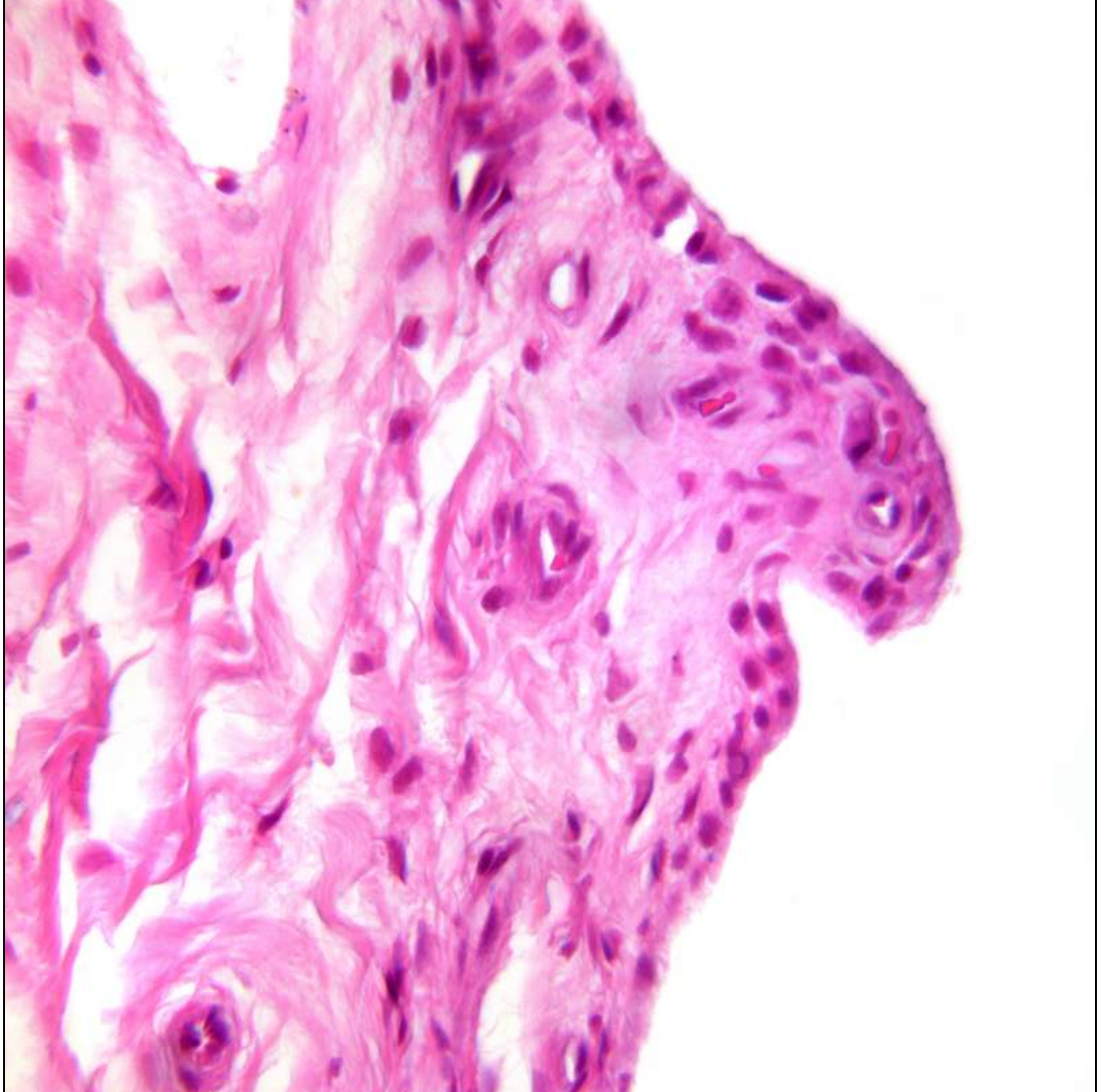
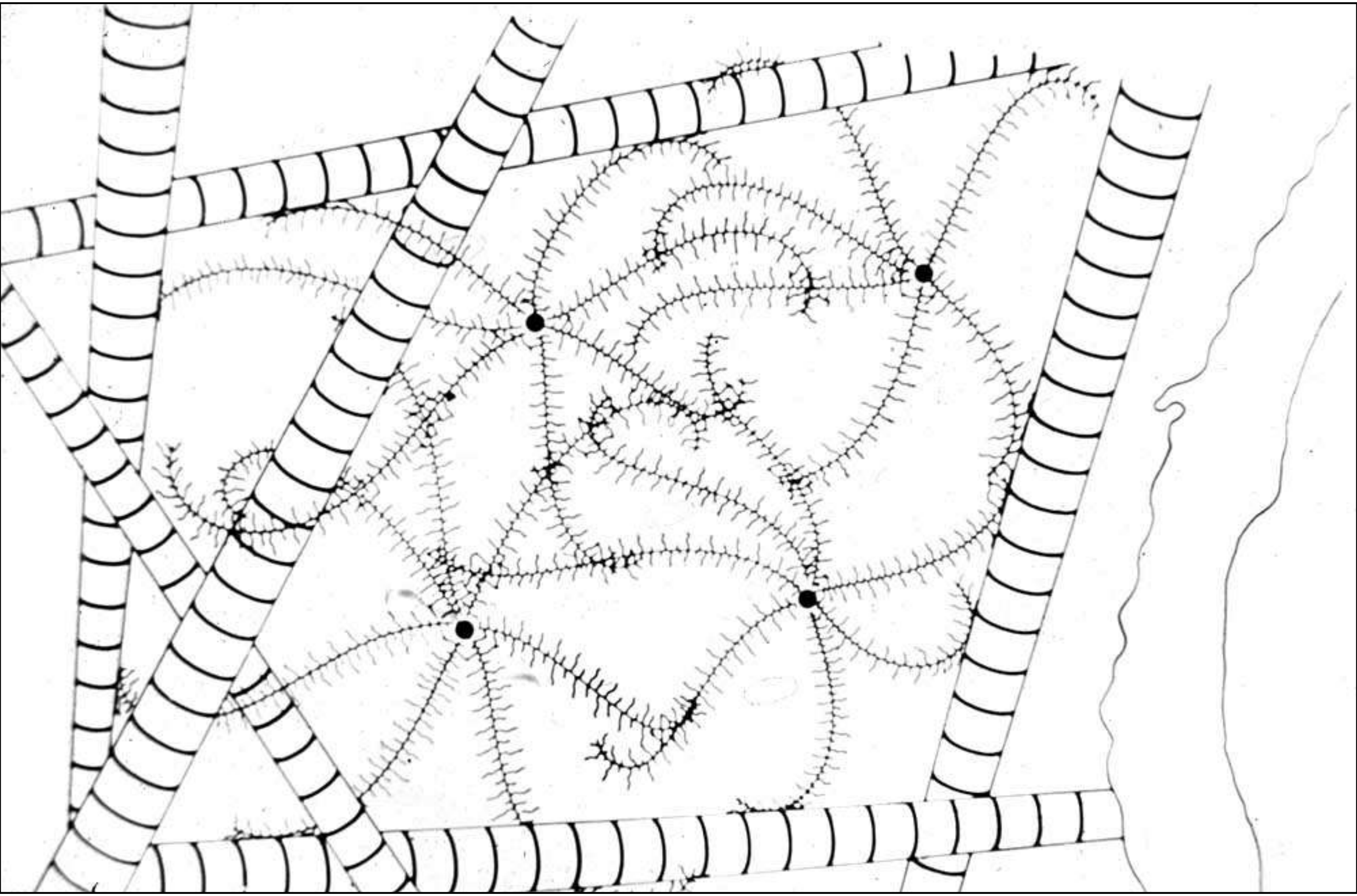
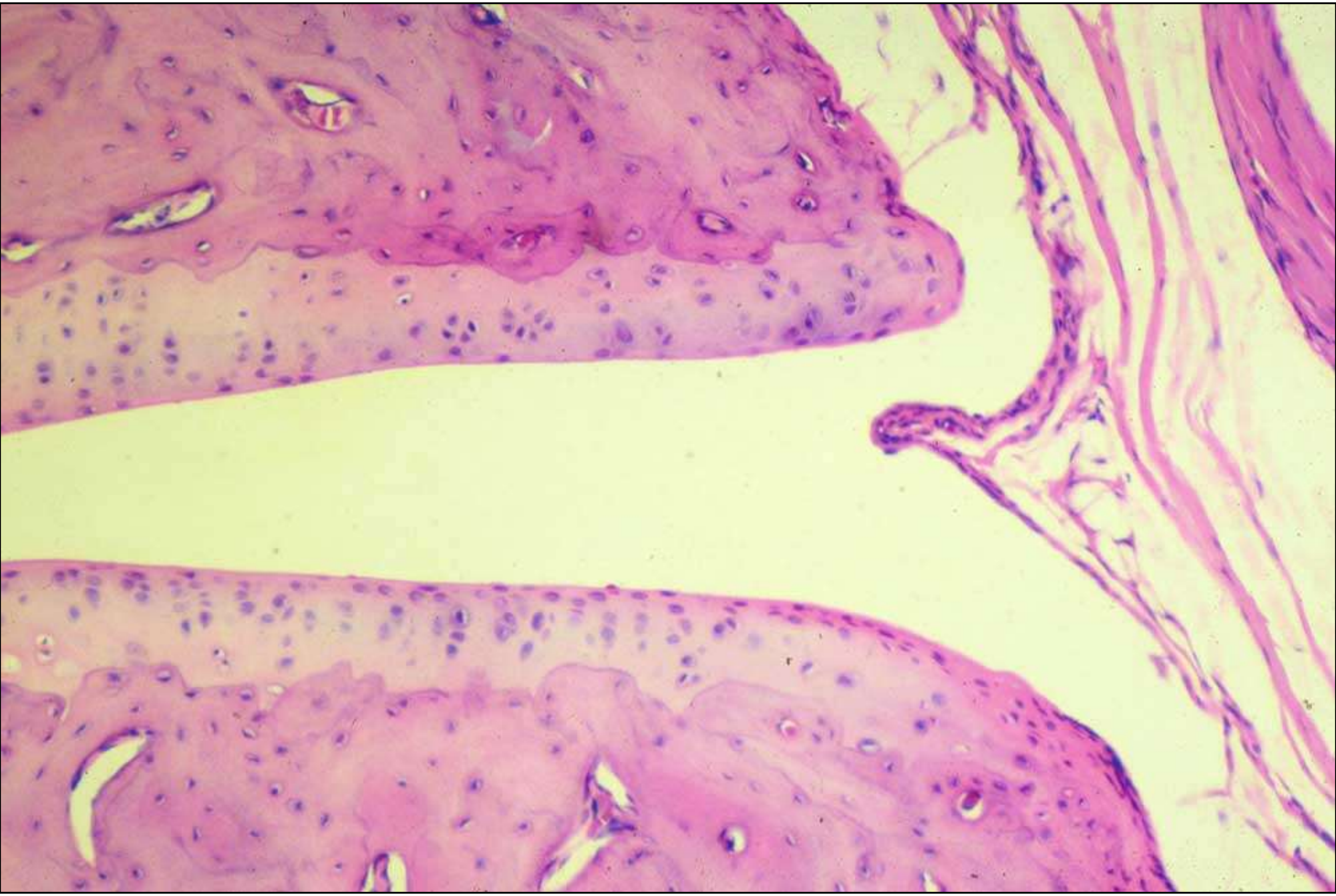


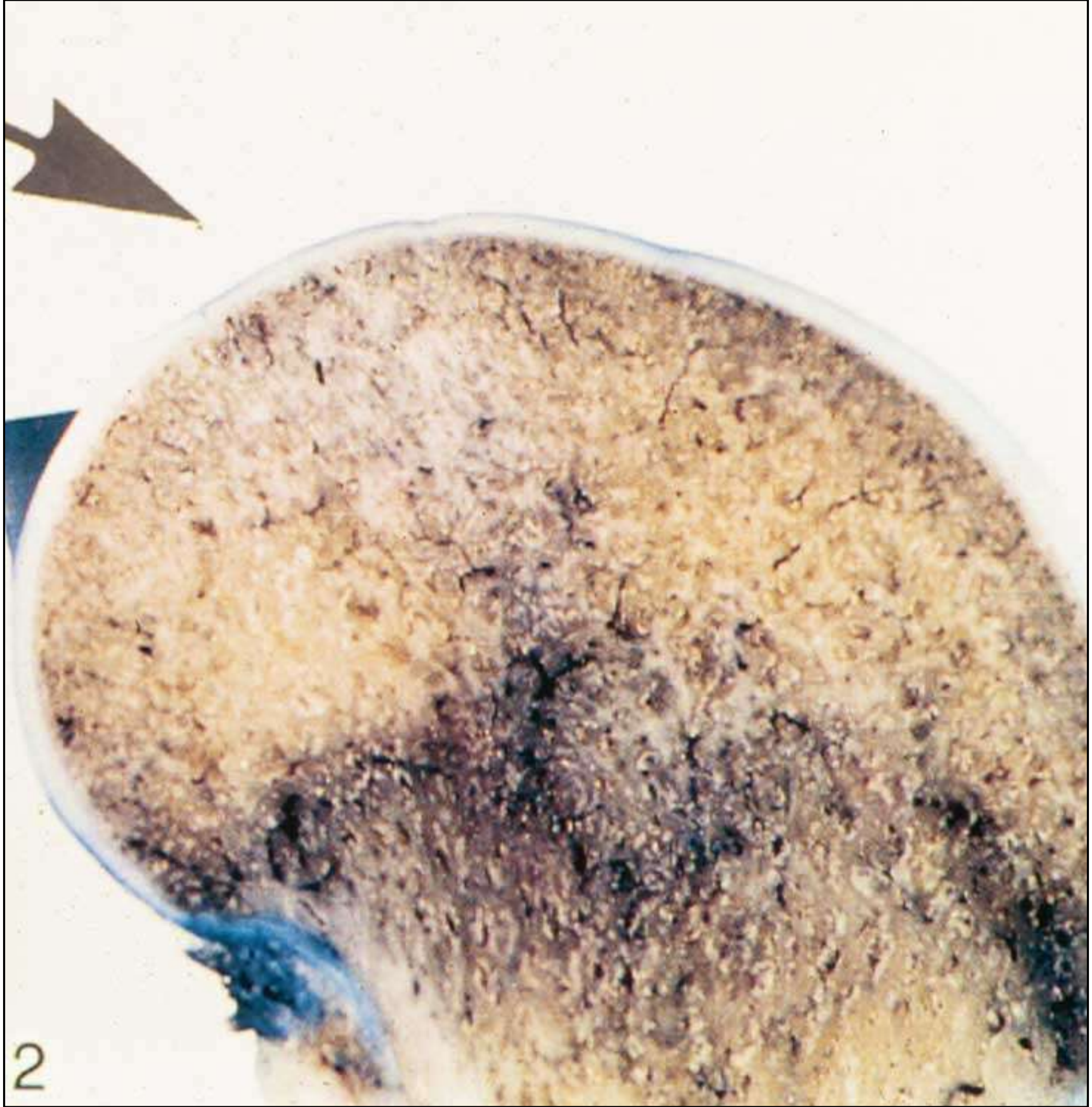
Fig. 7. Proteoglycans in cartilage and bone differ significantly in both size and components. The bone variety has a smaller core protein with one or two glycosaminoglycan (GAG) side chains. The cartilage variety is heterogeneous with respect to both number and length of GAG side chains.











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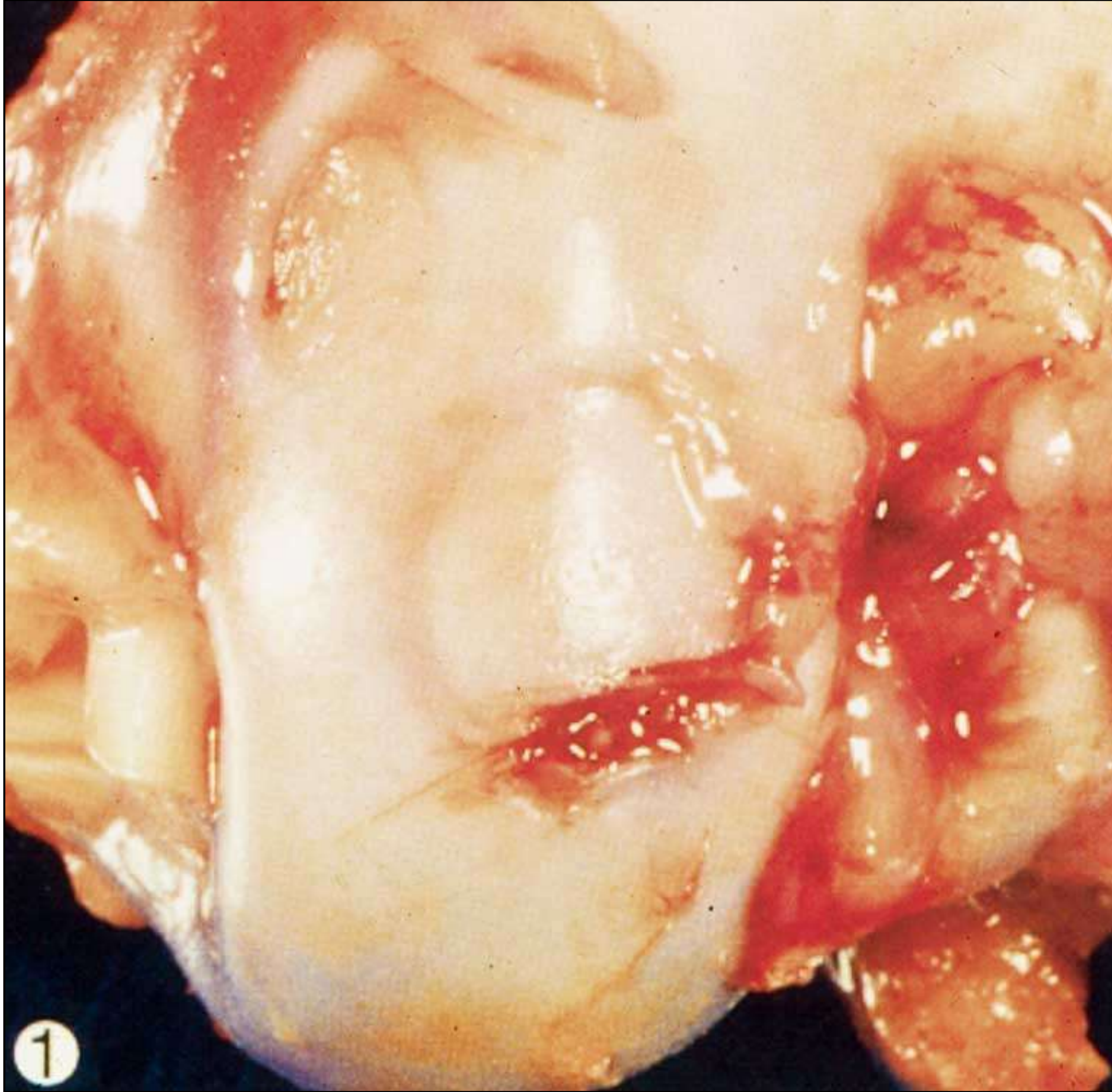

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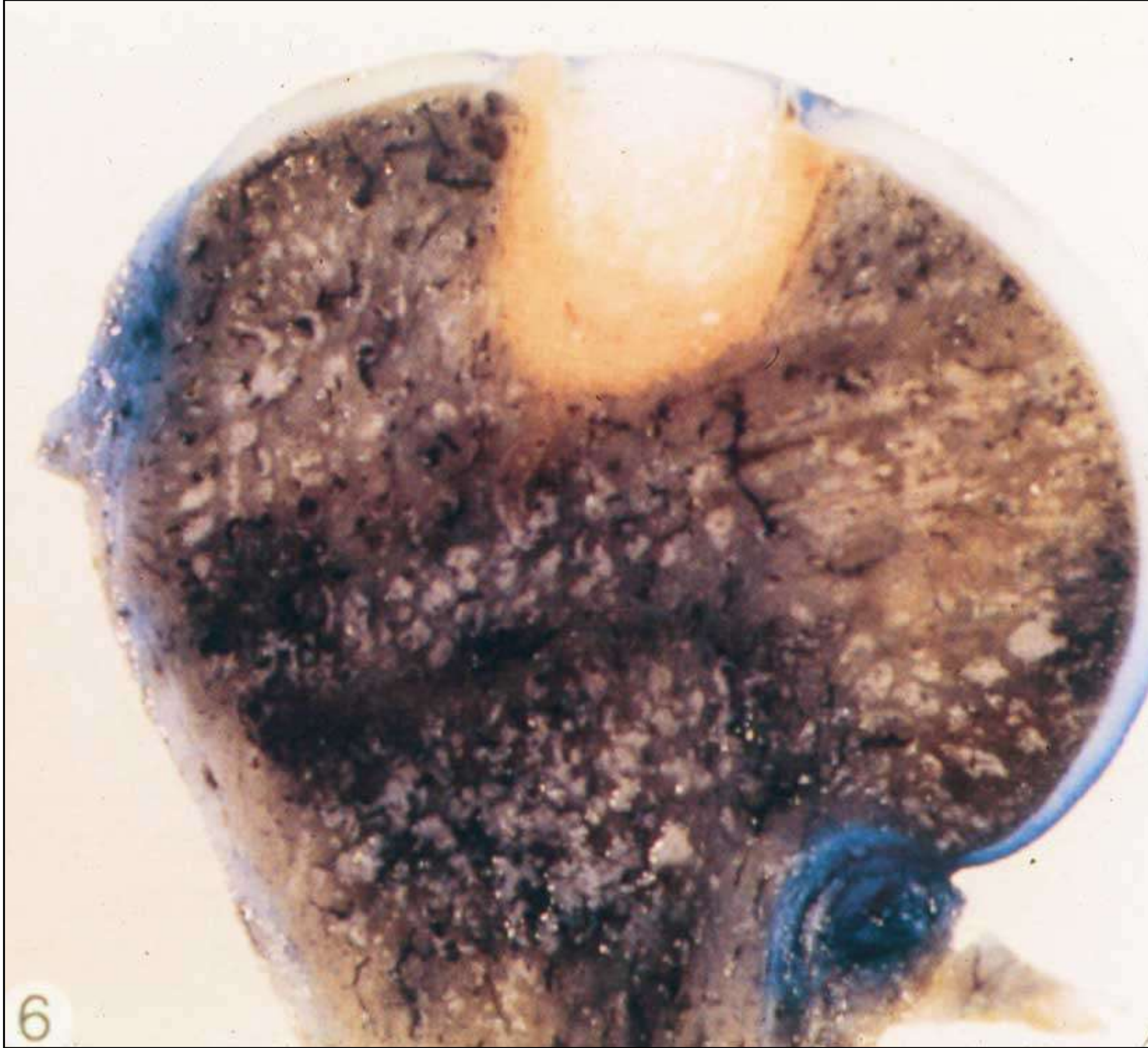

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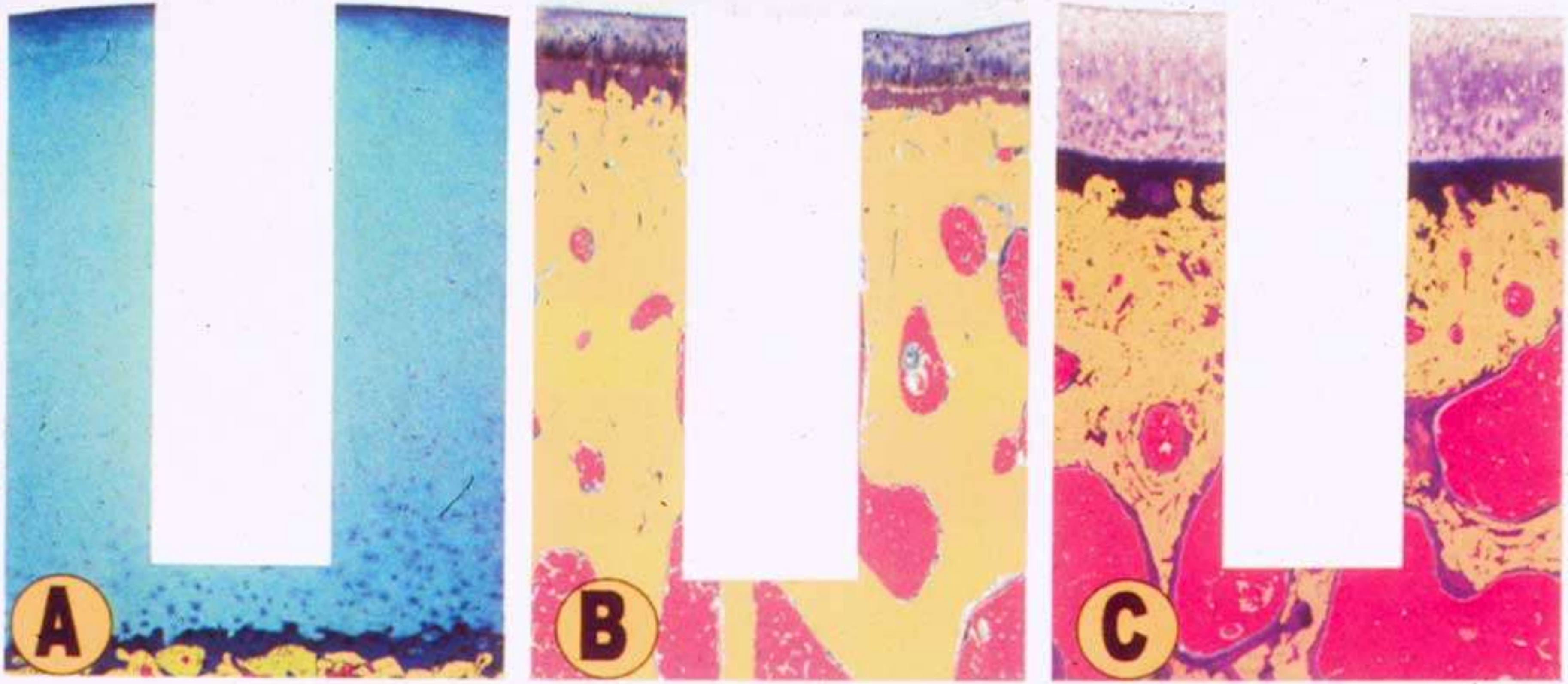
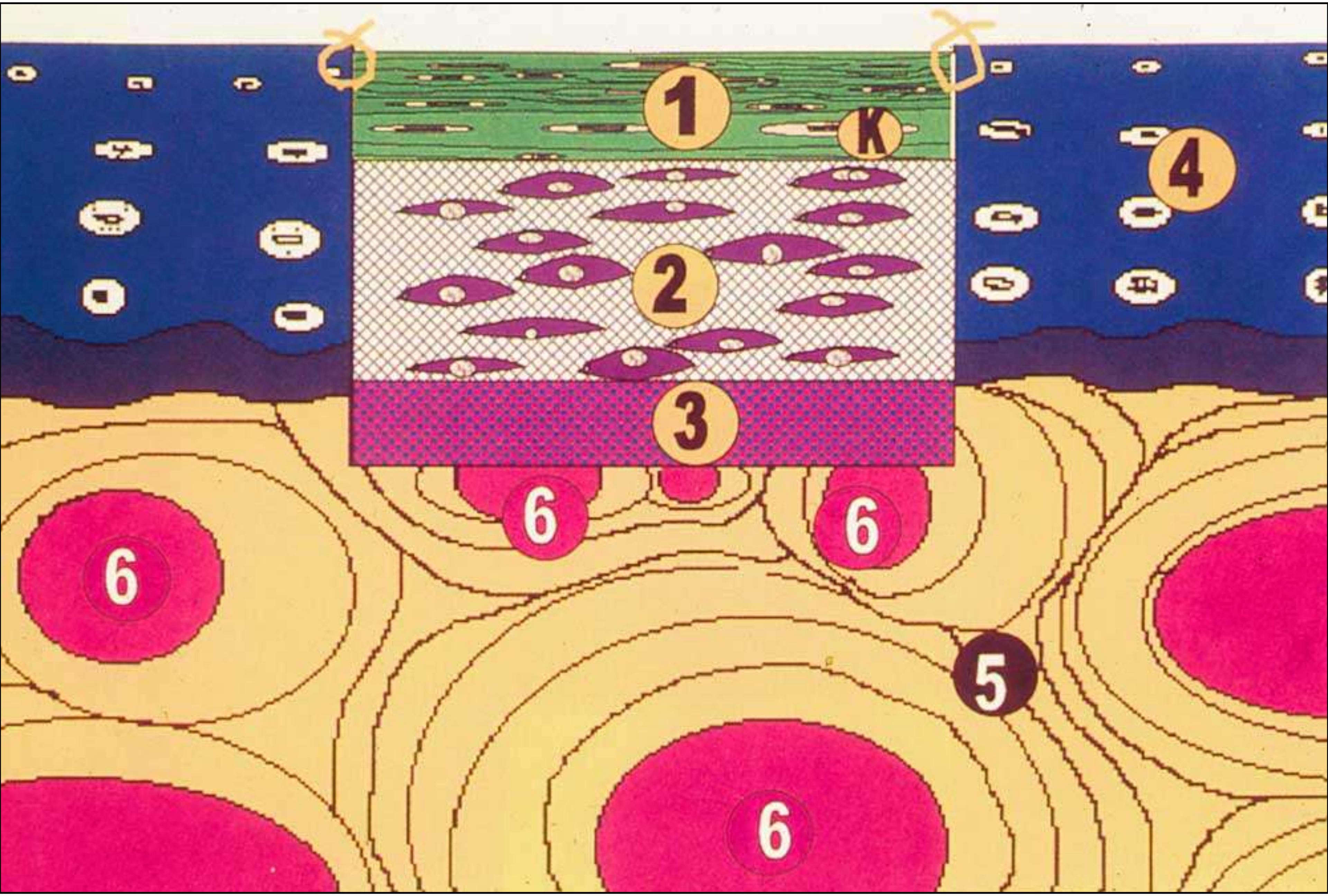


Fig 5A–C. Schematic representations of similar sized defects superimposed on light micrographs of (A) human, (B) rabbit and (C) goat articular cartilage (with varying portions of the underlying subchondral bone), represented at the same magnification. Because the thickness of the articular cartilage layer in humans is several times greater than that in goats, and many times greater than that in rabbits, the biologic environment surrounding each defect differs. In the human, the defect is a partial thickness defect, and, as such, it is surrounded exclusively by cartilage tissue. In the rabbit and goat, lesions of the same dimensions are full thickness defects; approximately 95% and 85% of their volumes, respectively, are surrounded by bone and bone marrow tissue. In these two latter cases, bleeding from the bone marrow vascular spaces will furnish the defects with an abundant supply of signaling substances and cells which the partial thickness human defect will not be accessible to.

Cartilage and Subchondral Bone Thickness (mm)
McIlwraith VCOT 19:142, 2006

Species	AC	TMAC	SB
Human	2.5	0.2	0.4
Equine	2.0	0.2	0.5
Dog	0.6	0.1	0.3
Rabbit	0.3	0.1	0.3
Sheep	0.5	0.2	0.3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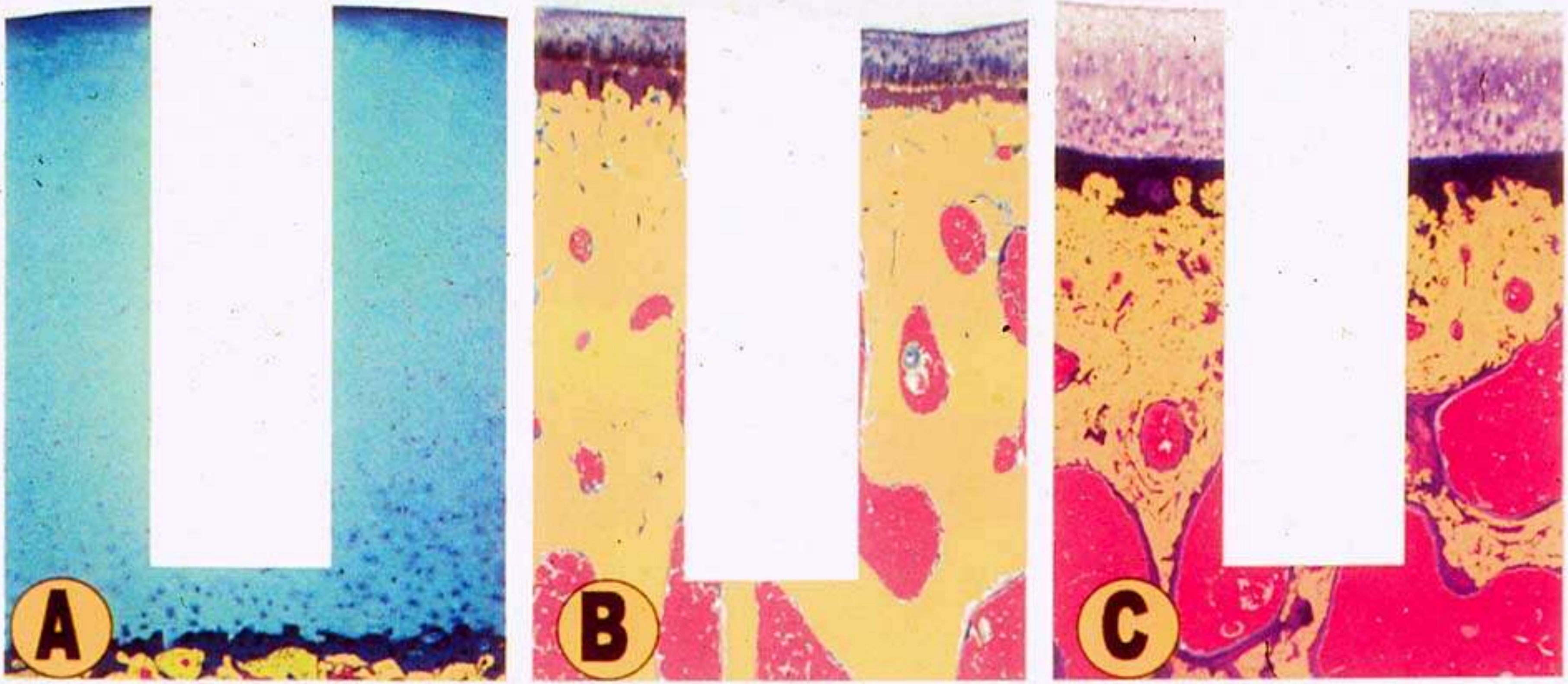

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Synovial Fossa