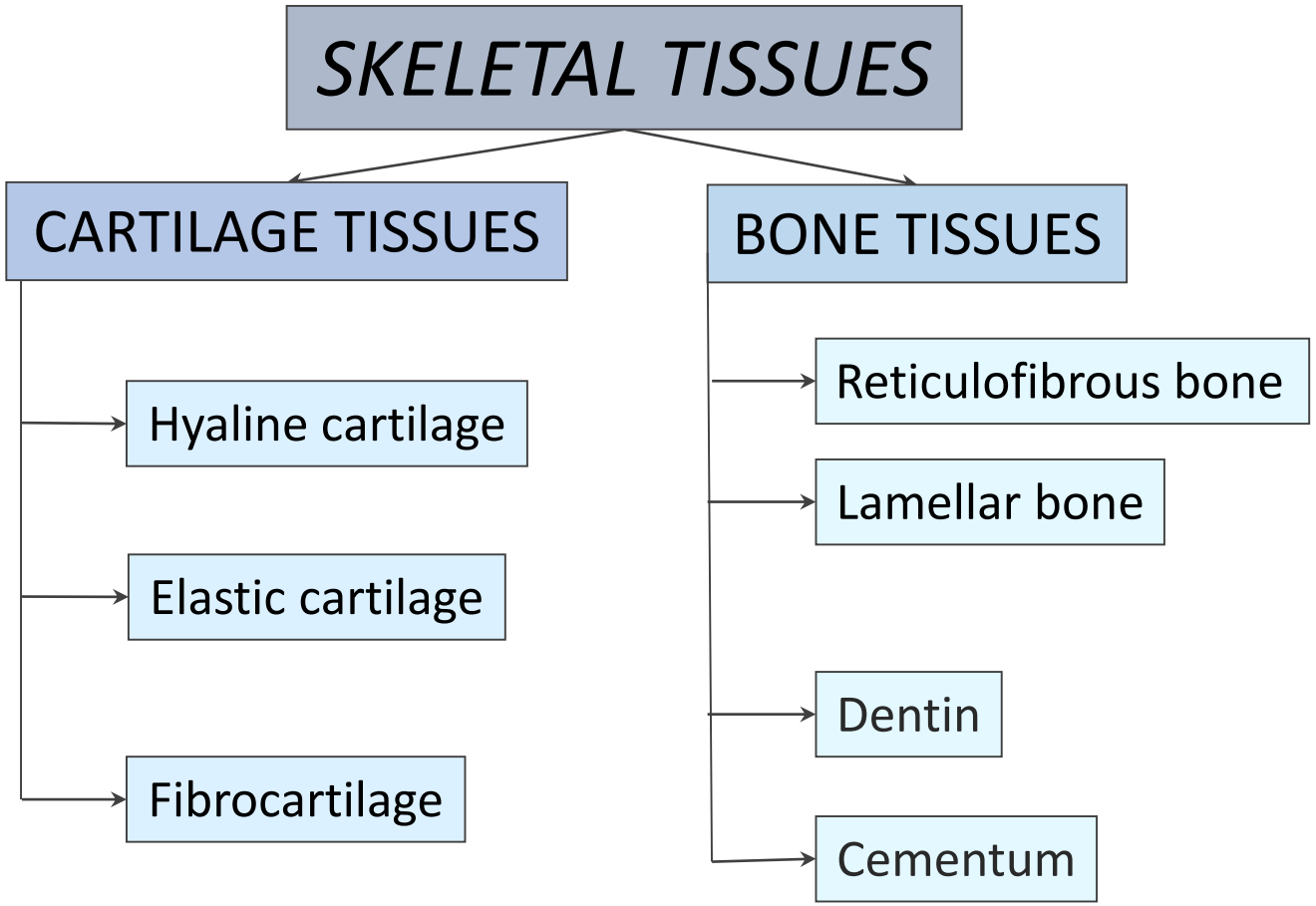
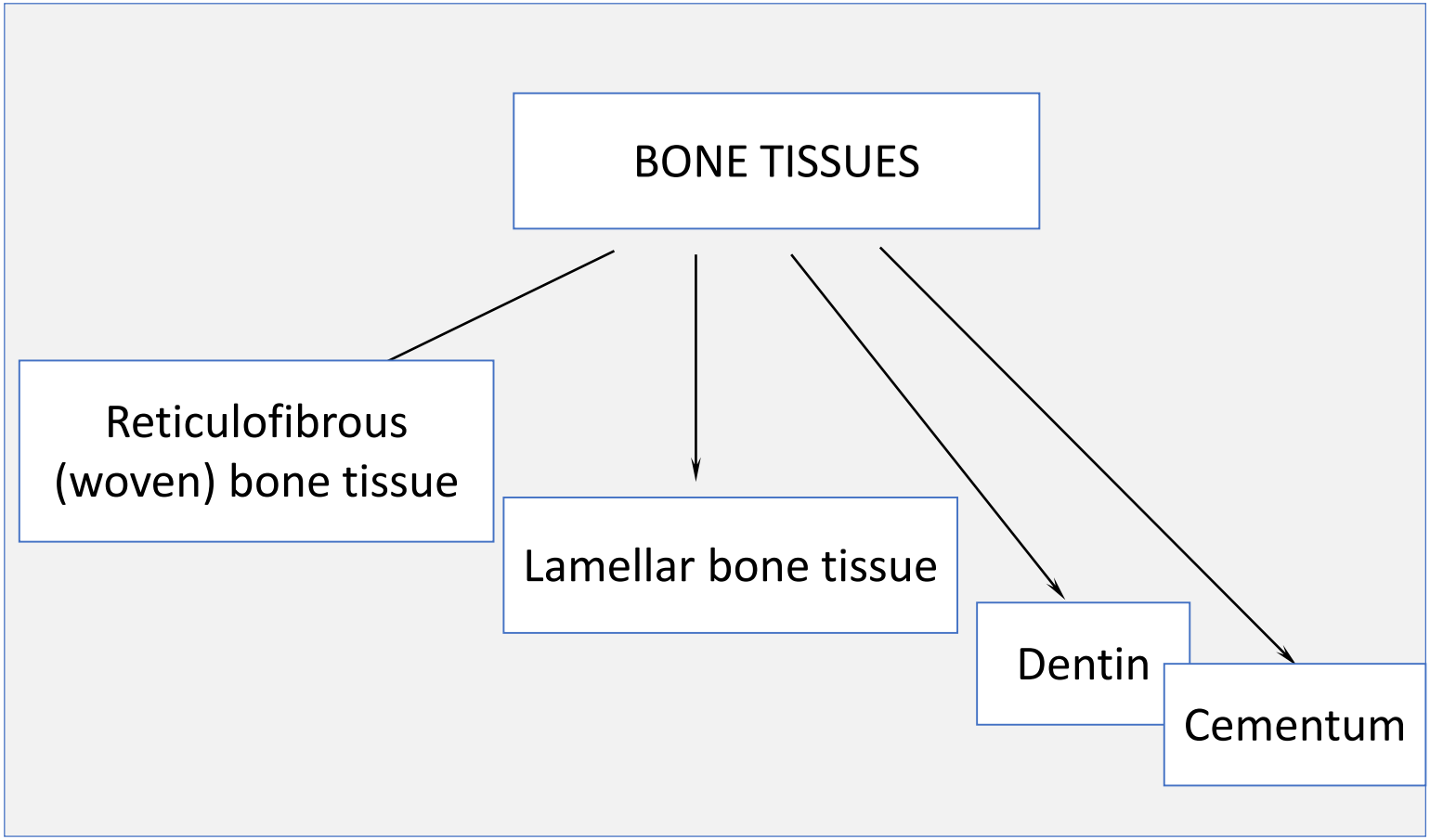
SKELETAL TISSUES
BONE TISSUES
OSTEOGENESIS

Department of Histology, Embryology, and Cytology
of the General Medicine Faculty, RNMR

SKELETAL CONNECTIVE TISSUES



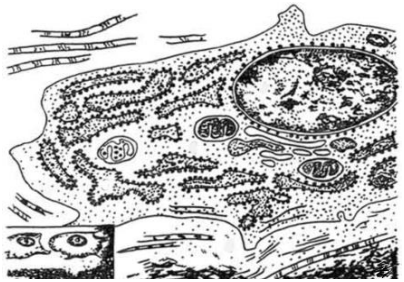
BONE TISSUES

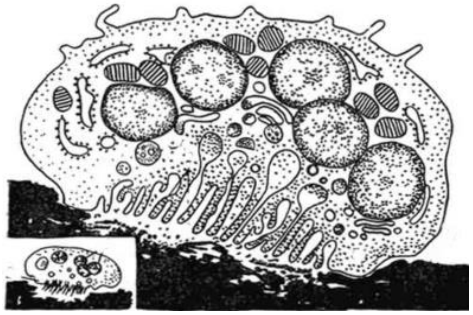


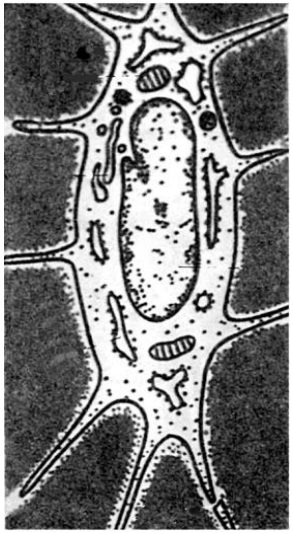
COMPOSITION OF BONE TISSUE

CELLS

- ✓ Osteoblasts
- ✓ Osteocytes
- ✓ Osteoclasts







EXTRACELLULAR MATRIX

- ➢ Water – 25%
- ➢ Inorganic substances – 50%

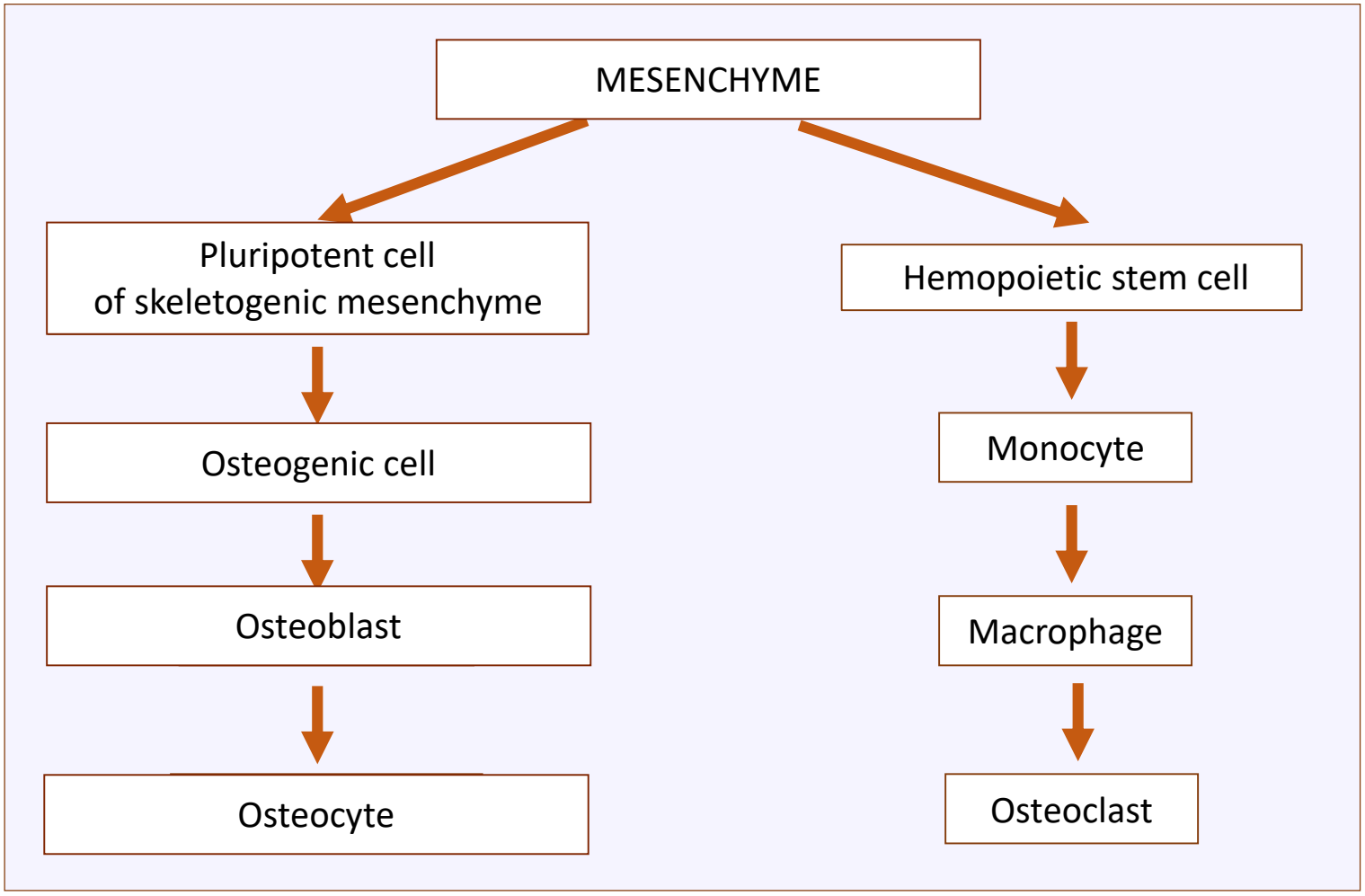
hydroxyapatite crystals= calcium phosphate

- ➢ Organic substances – 25%
  - ○ Proteoglycans –
    - Proteins
    - Glycosaminoglycans: - *hyaluronic acid,*
    - *chondroitin sulphate,*
    - *keratan sulfate*
  - ○ Glycoproteins -
    - *osteonectin*
    - *osteopontin*
  - ○ Fibers -
    - *Collagen type I*

(mineralized with 90-95% of calcium salts)

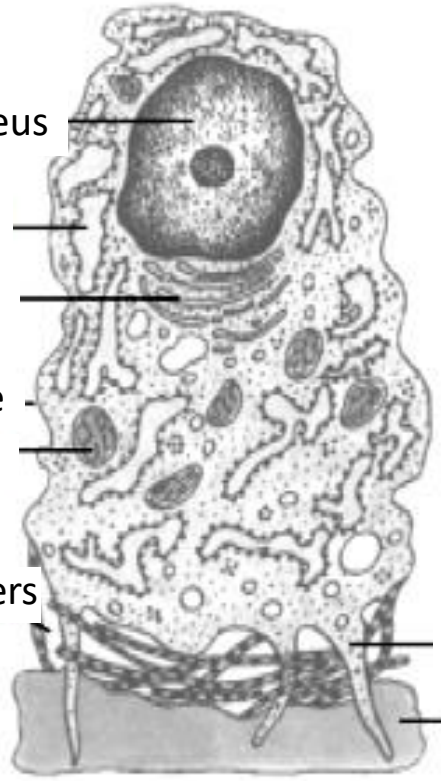
- *Collagens of other types*

DIFFERONS OF BONE TISSUE

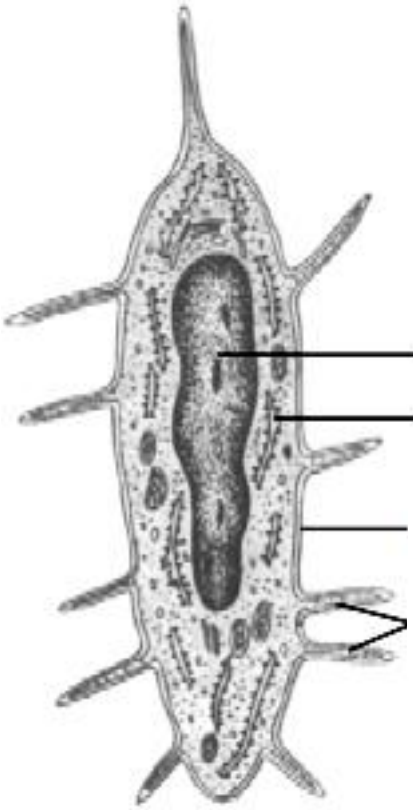


CELLS OF BONE TISSUE

OSTEOBLAST

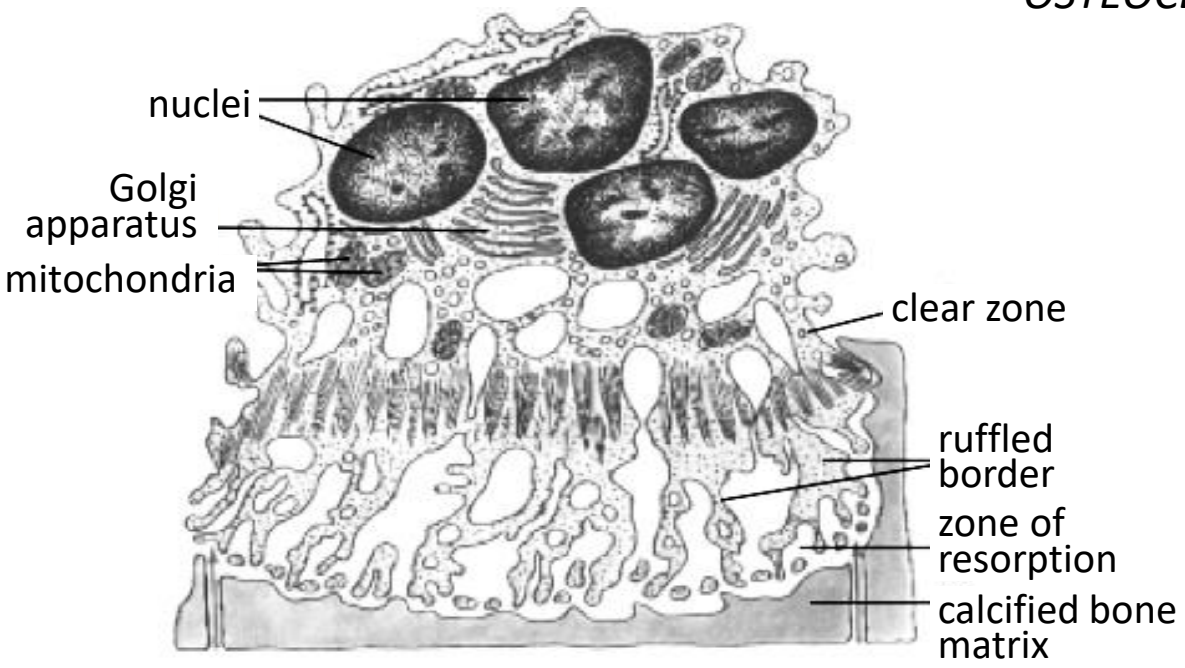


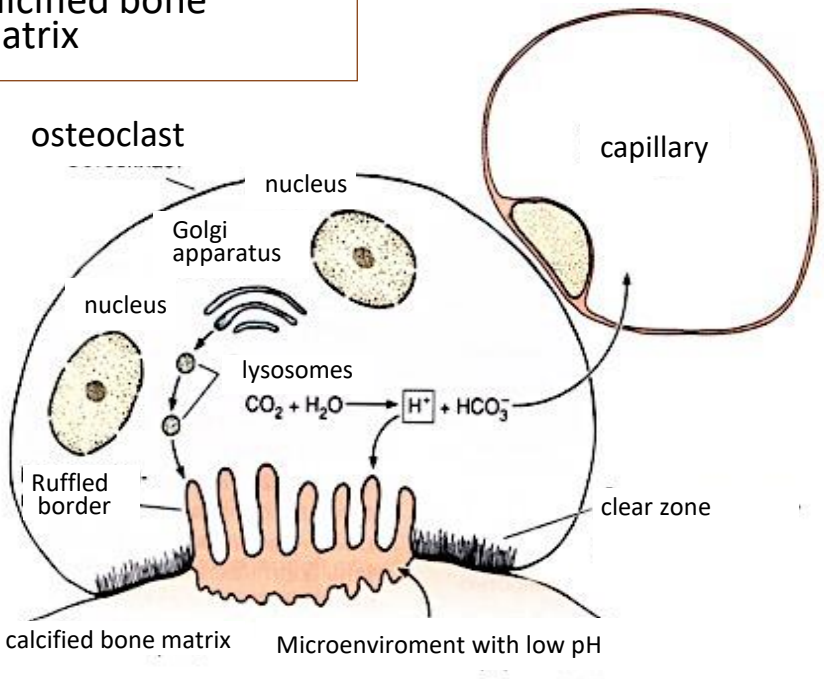
OSTEOCYTE



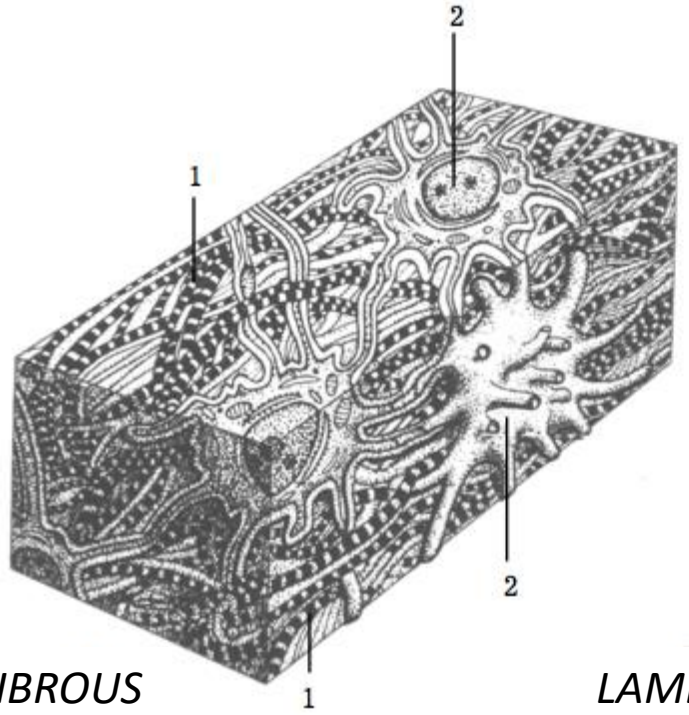
CELLS OF BONE TISSUE

OSTEOCLAST

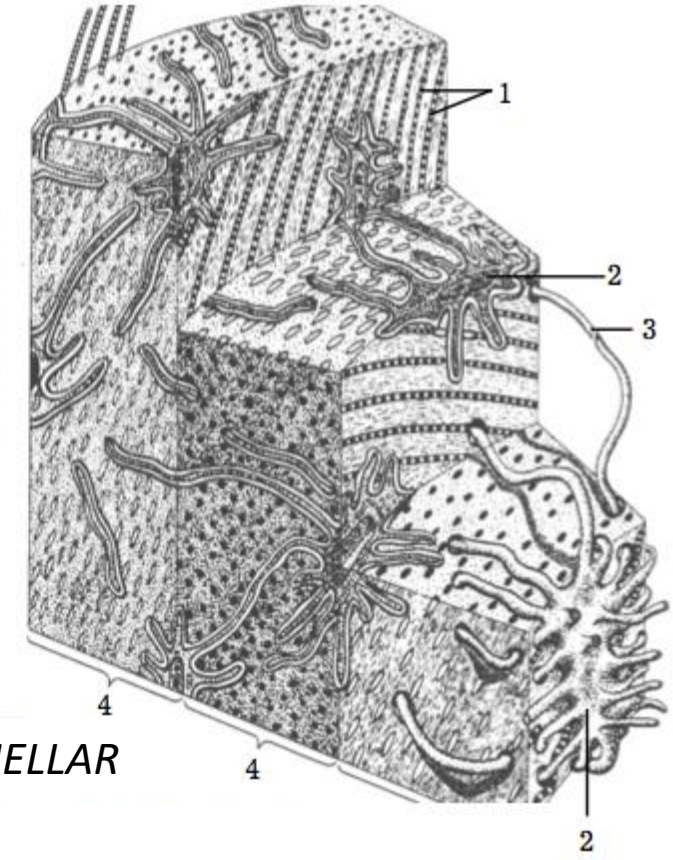




TYPES OF BONE TISSUE

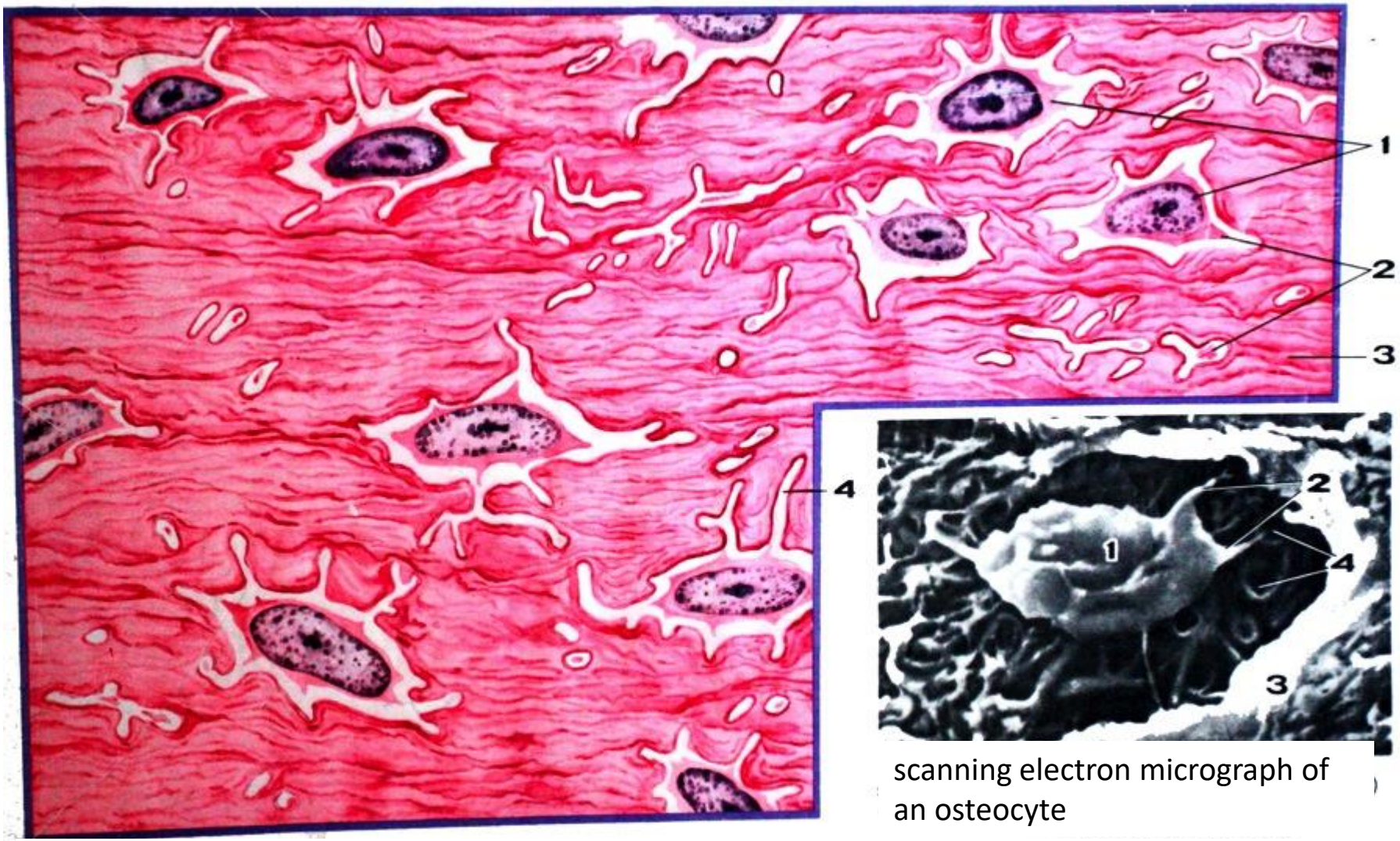


RETICULOFIBROUS



LAMELLAR

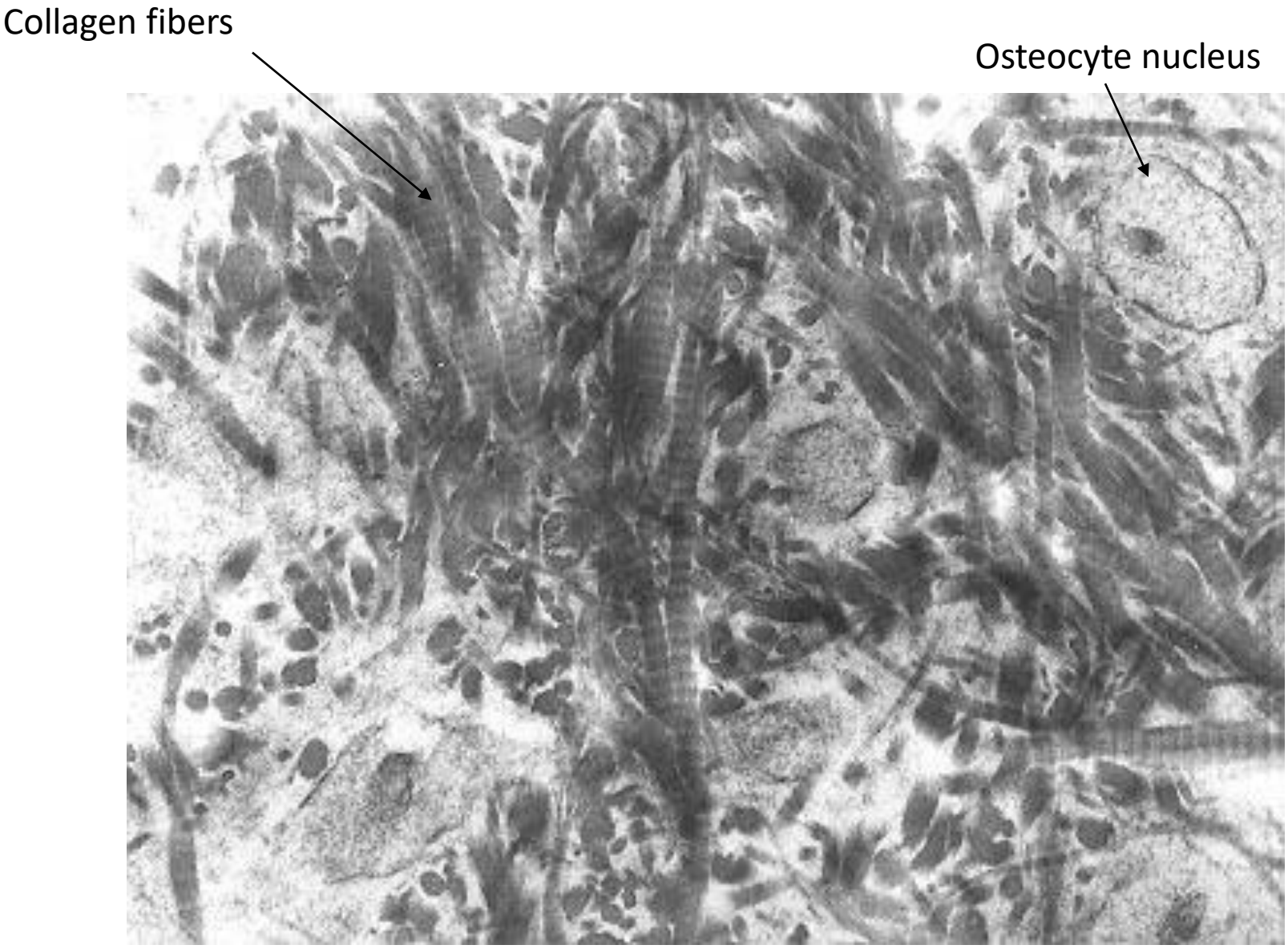
RETICULOFIBROUS BONE TISSUE



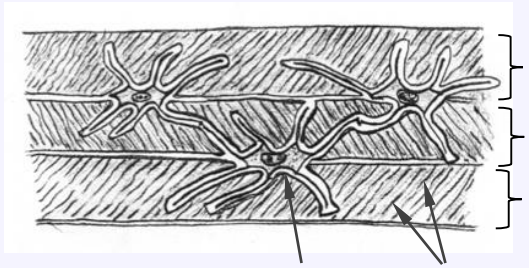
scanning electron micrograph of an osteocyte

1- OSTEOCYTES; 2- PROCESSES OF OSTEOCYTES; 3- EXTRACELLULAR MATRIX; 4- CANALICULI

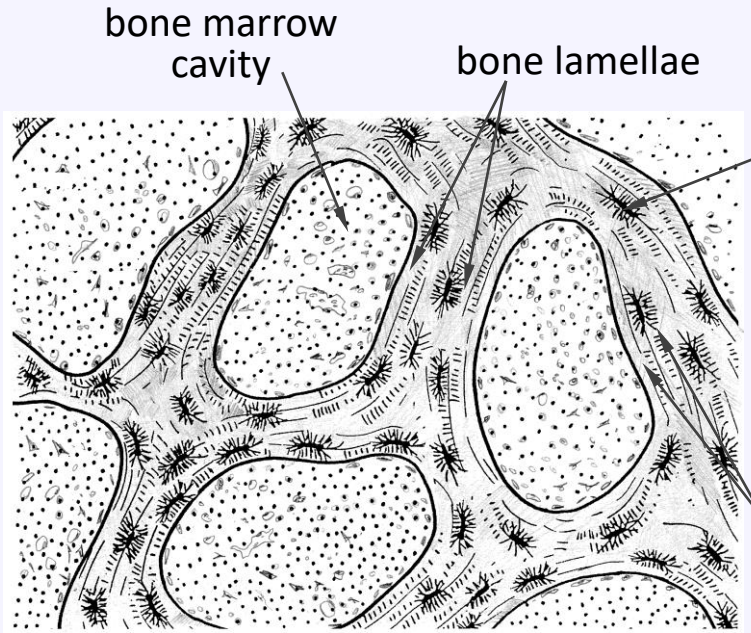
RETICULOFIBROUS BONE TISSUE



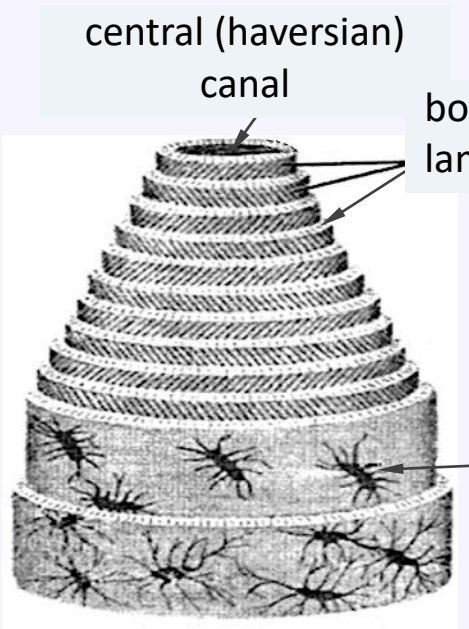
LAMELLAR BONE TISSUE



LAMELLAE OF COMPACT BONE

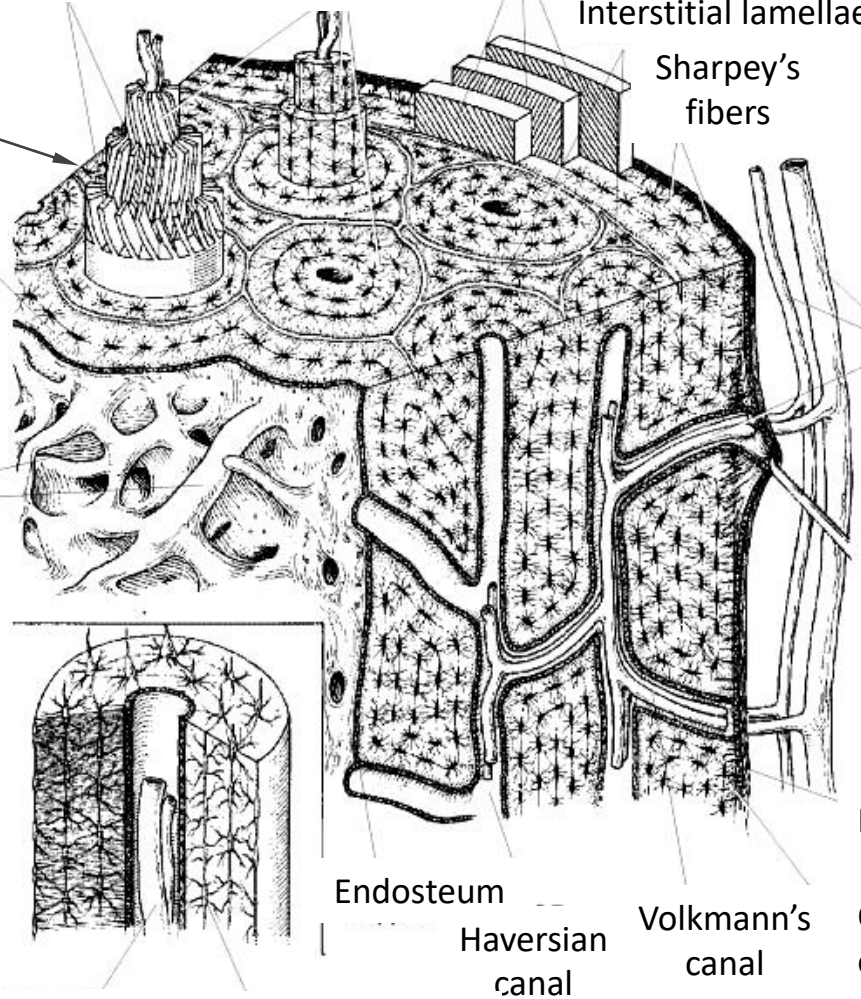


TRABECULAE OF CANCELLOUS BONE

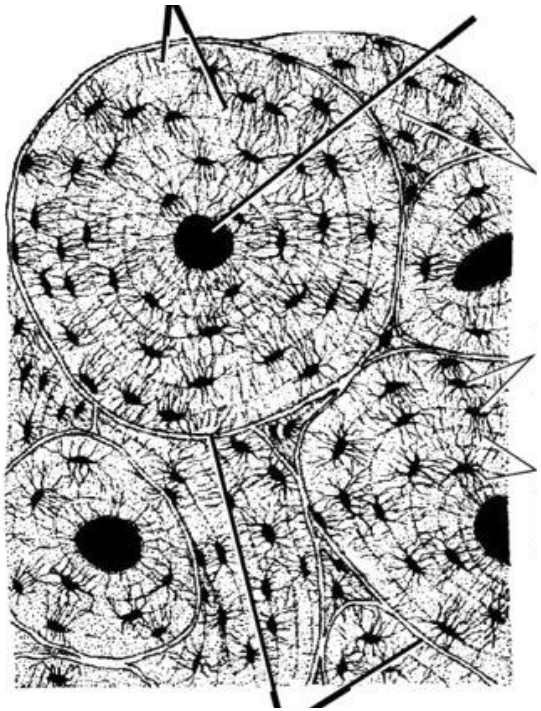


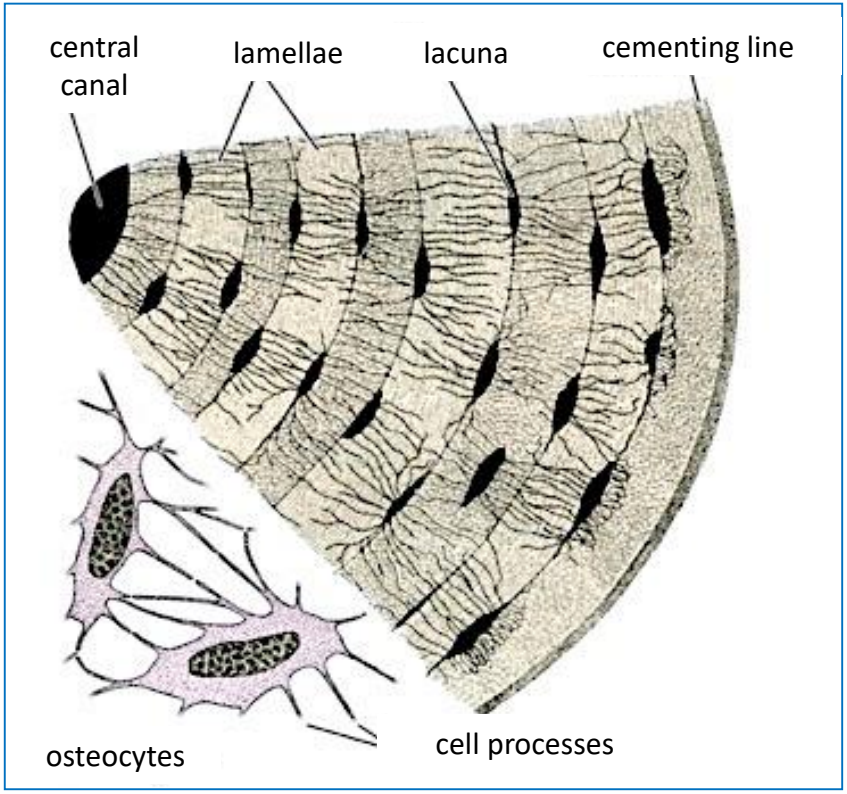
OSTEON OF THE COMPACT BONE

BONE AS AN ORGAN



LAMELLAR BONE TISSUE





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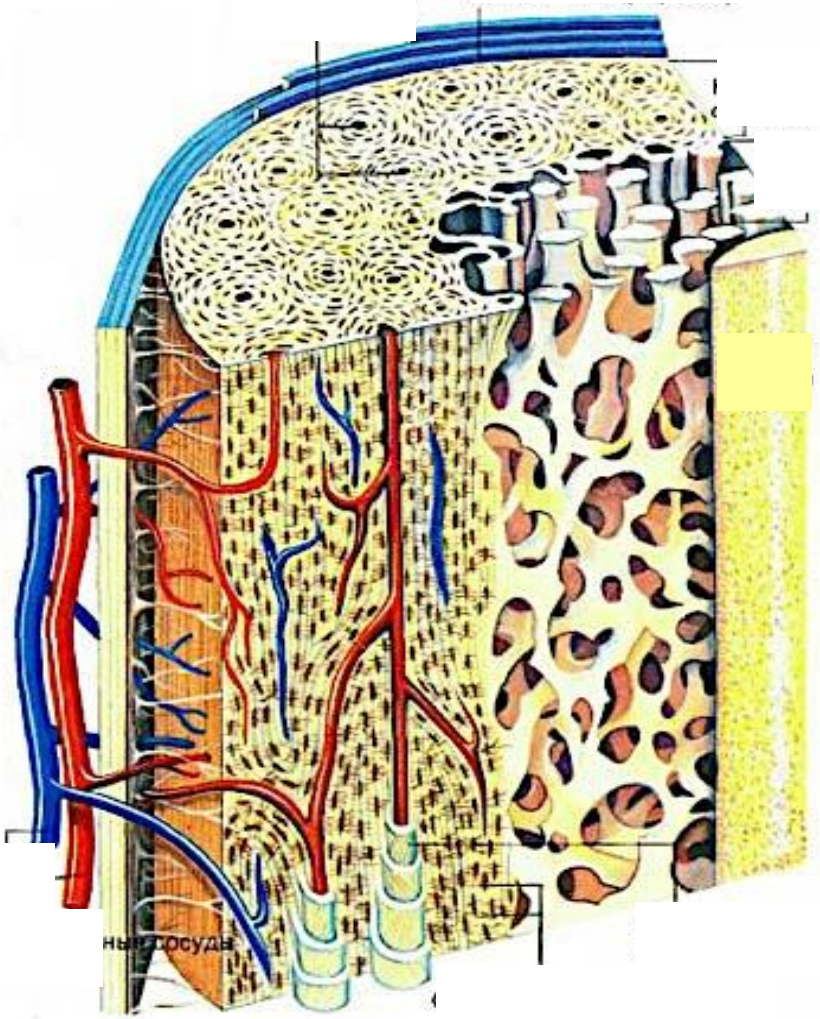


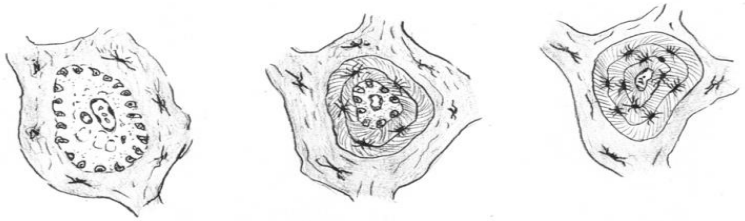
PERIOSTEUM – two layers

- Outer – fibrous
- Inner - osteogenic

osteogenic cells → osteoblasts → osteocytes → Outer circumferential lamellae

CENTRAL (HAVERSIAN) CANAL

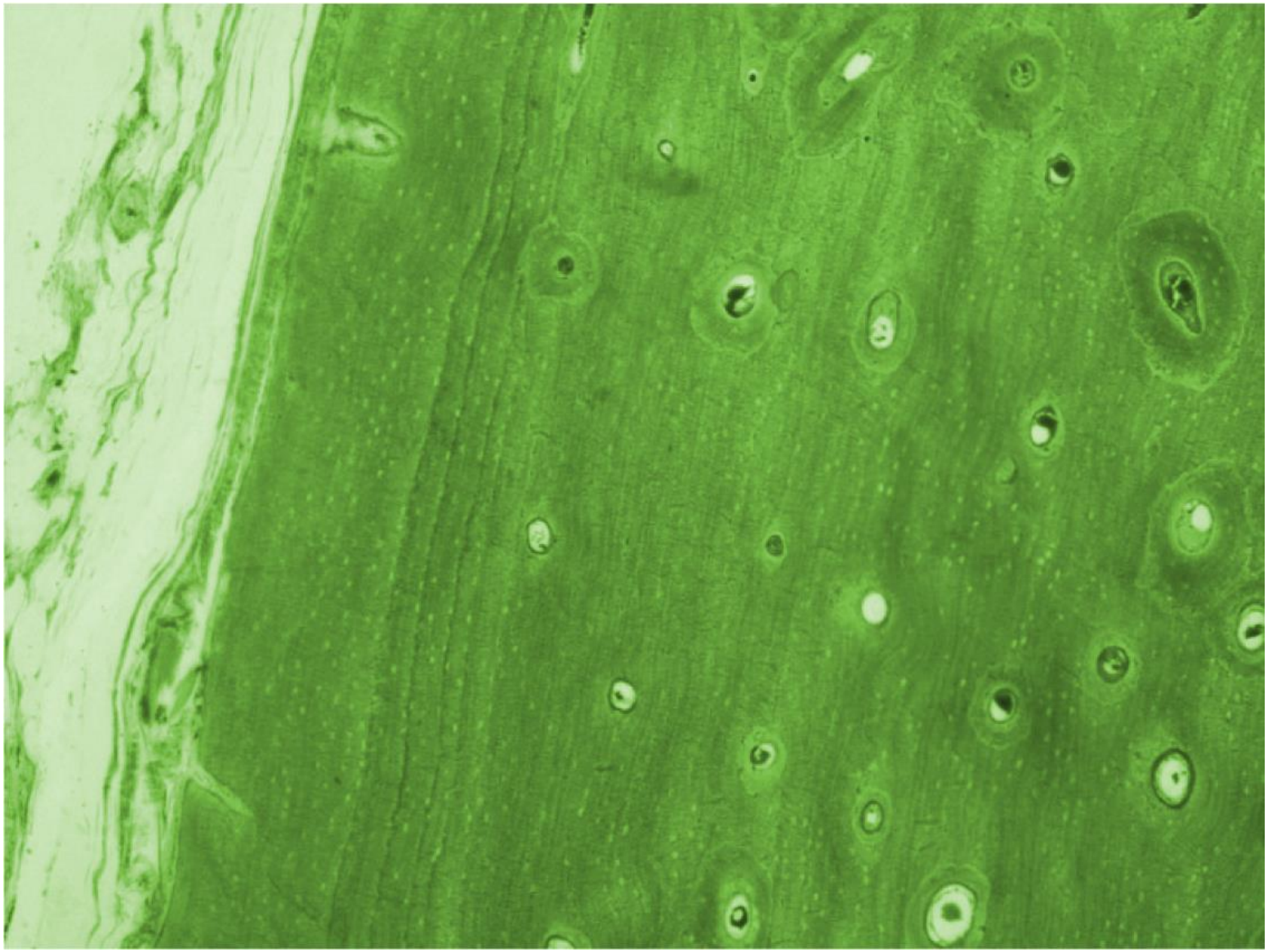
osteogenic cells → osteoblasts → osteocytes → concentric lamellae *(from inside)*



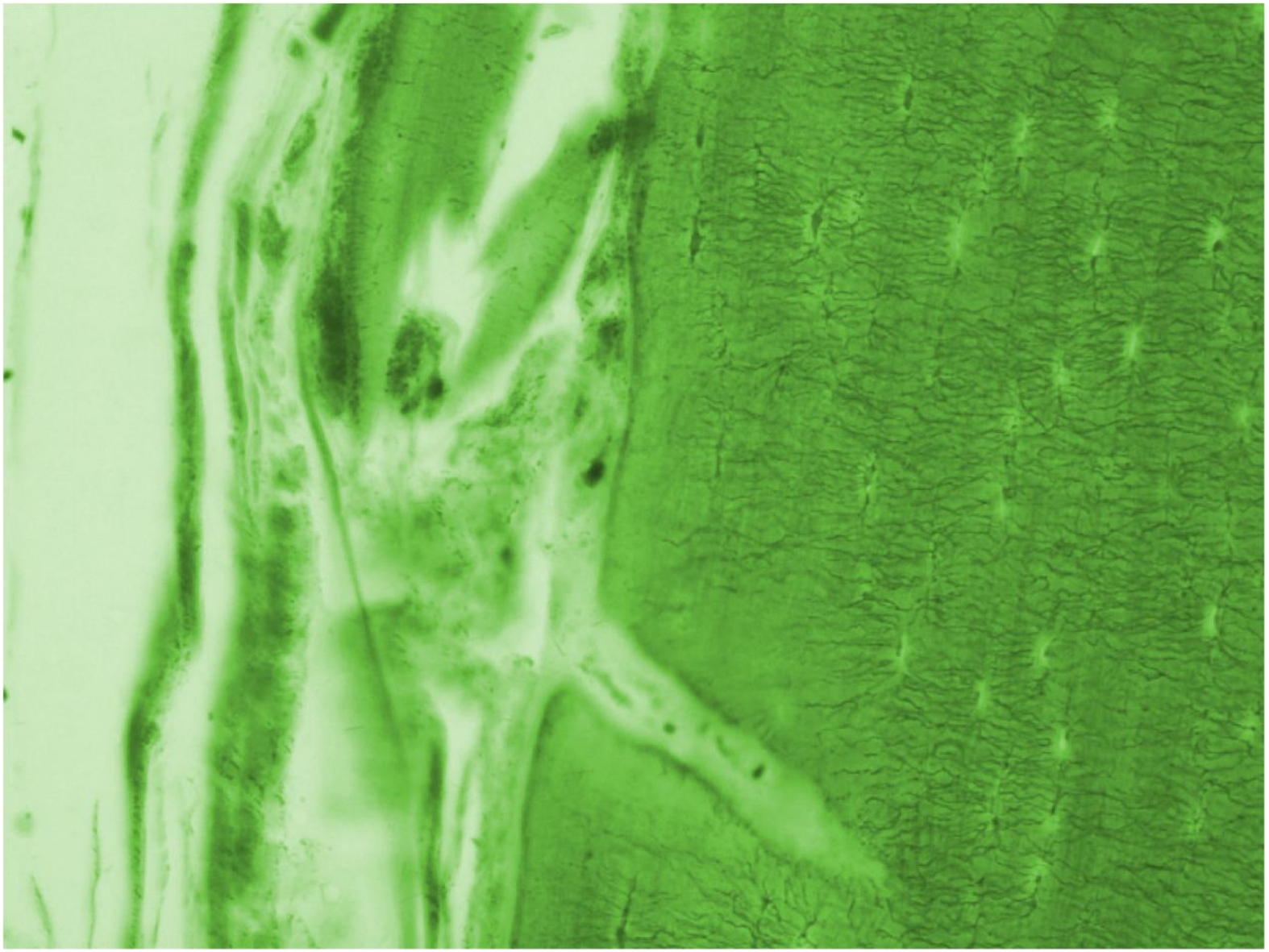
ENDOSTEUM – one layer

osteogenic cells → osteoblasts → osteocytes → inner circumferential lamellae

Slide №67 «Lamellar bone tissue. Long bone diaphysis in cross section, *Schmorl stained*»



Slide №67 «Lamellar bone tissue. Long bone diaphysis in cross section, *Schmorl stained*»



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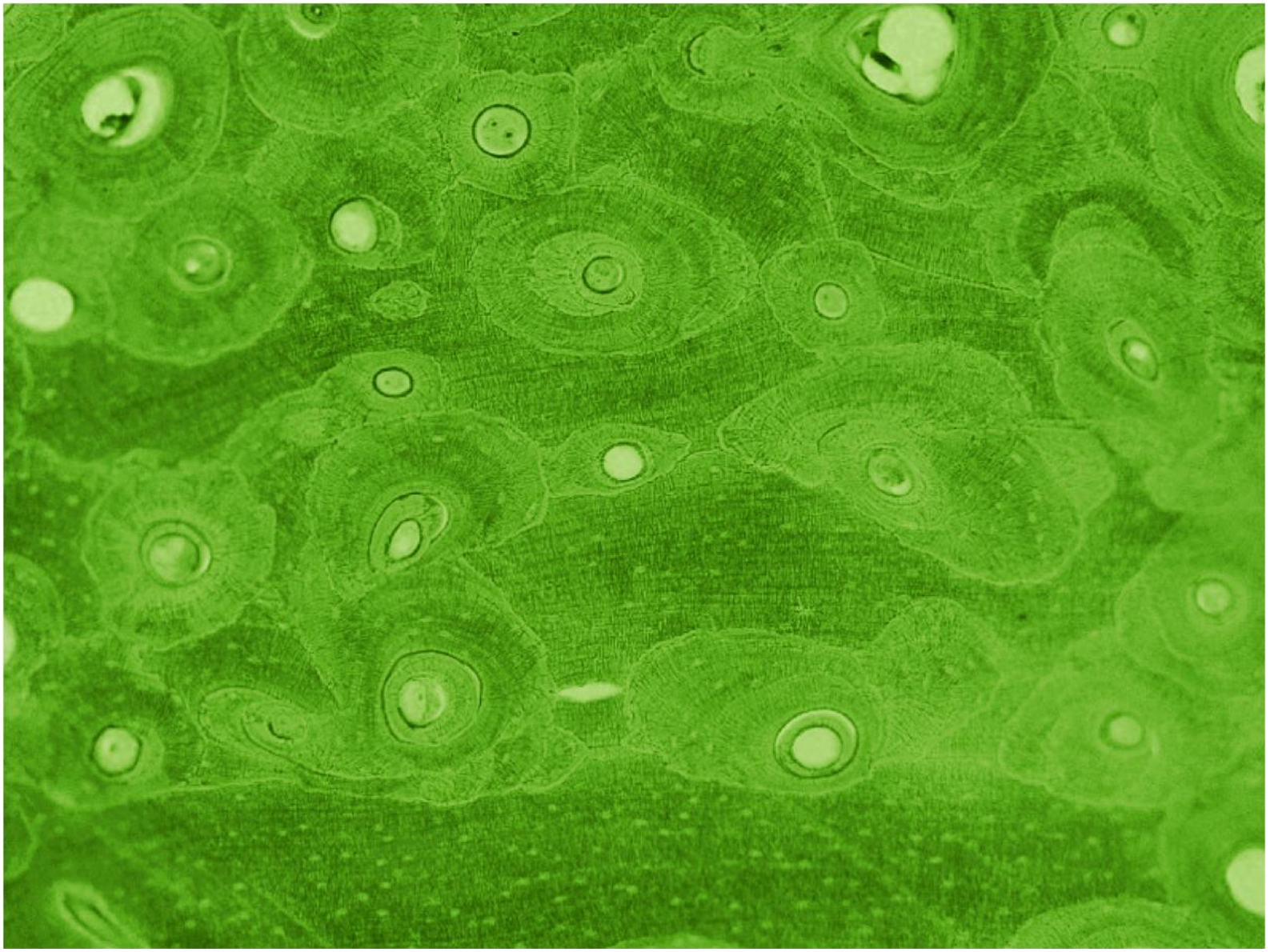

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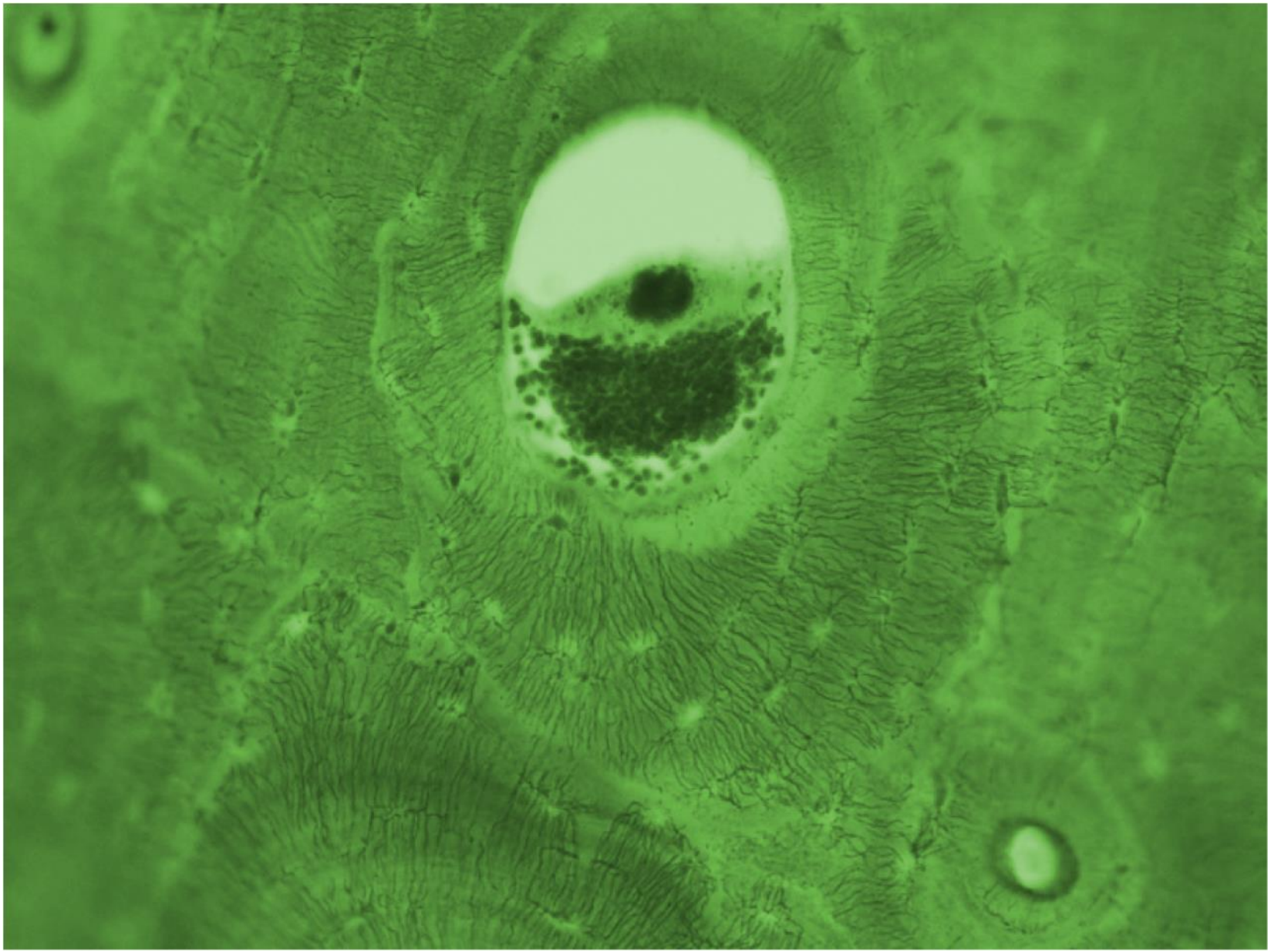

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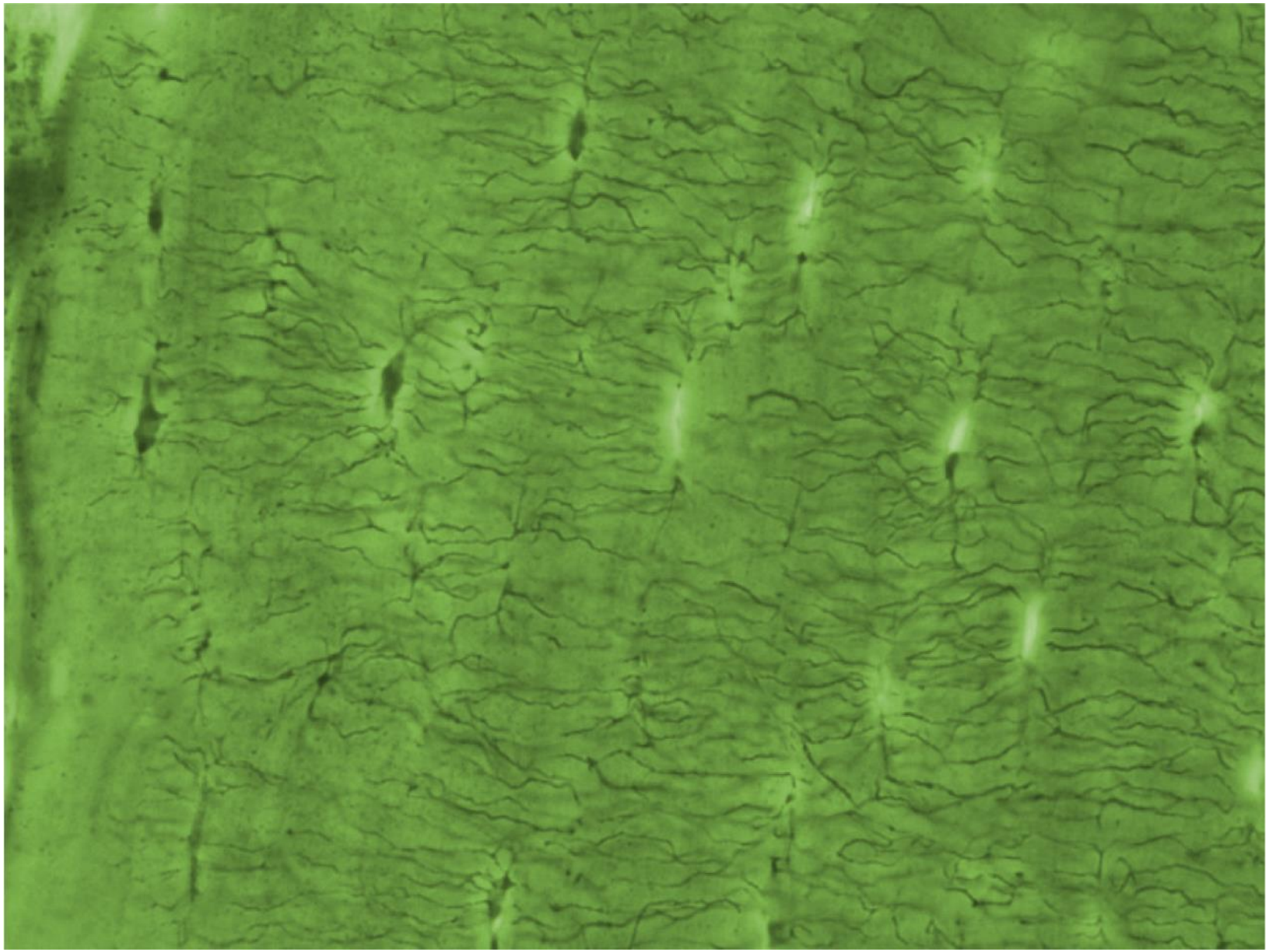

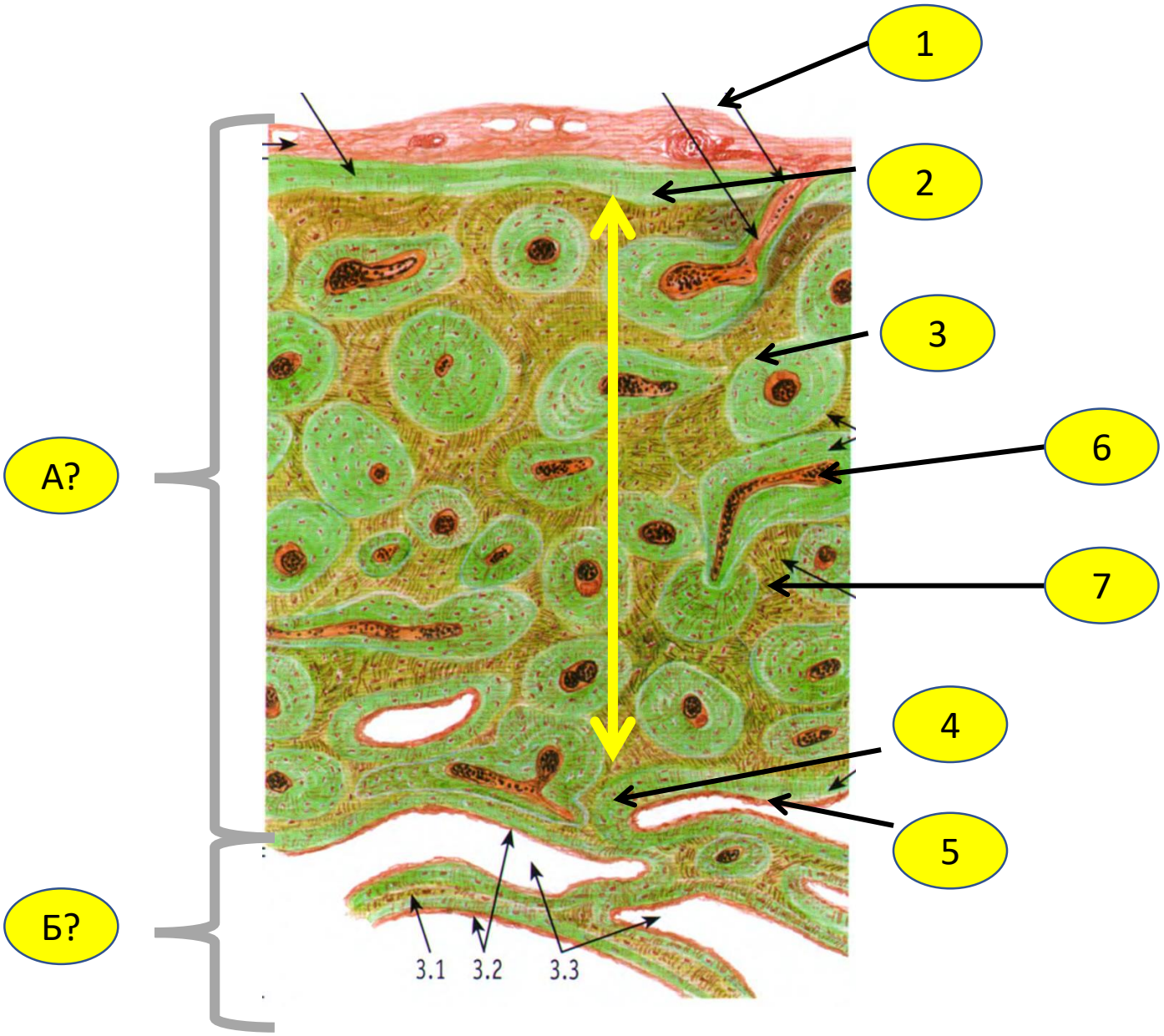
1
2
3
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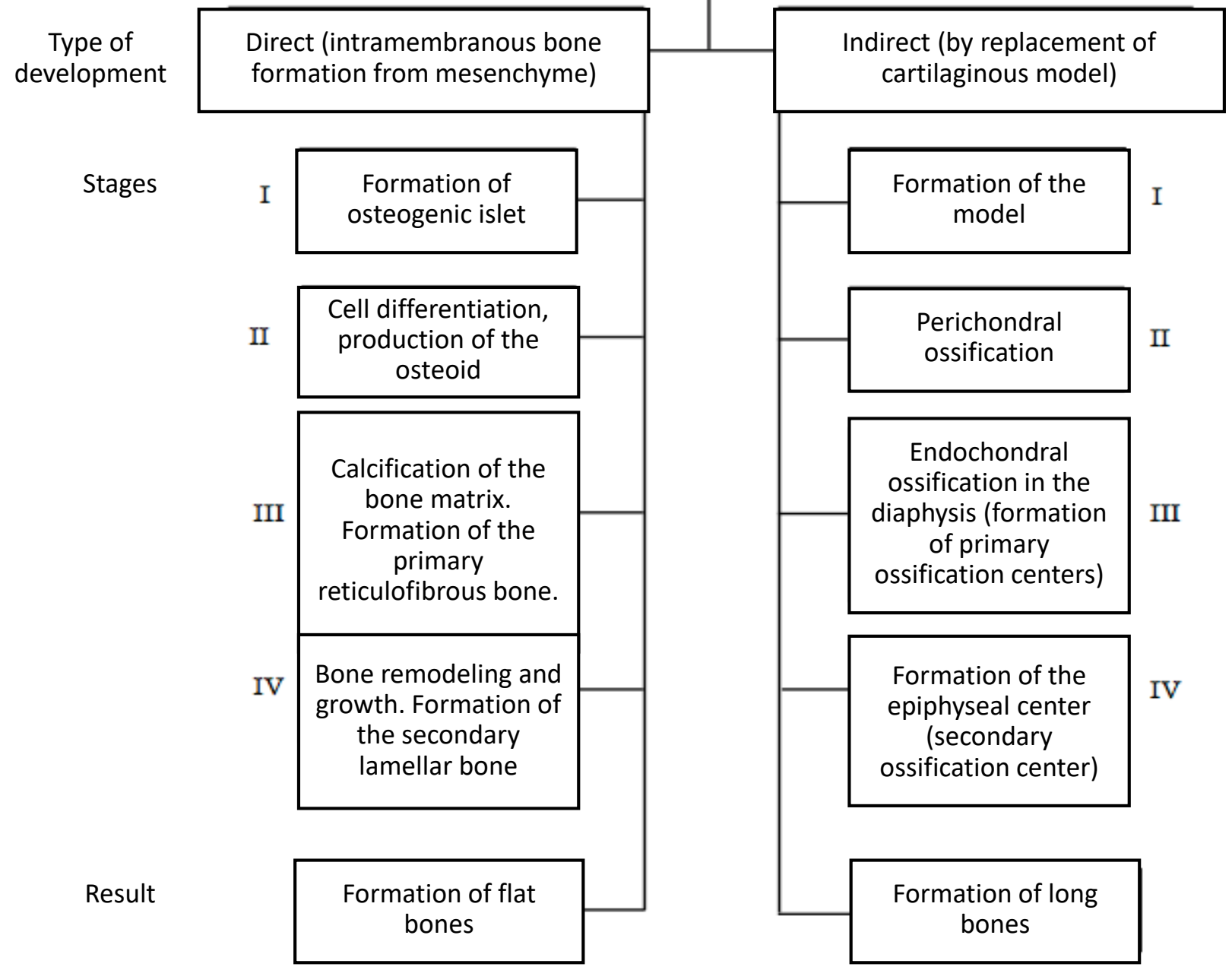
А?
Б?
3.1
3.2
3.3

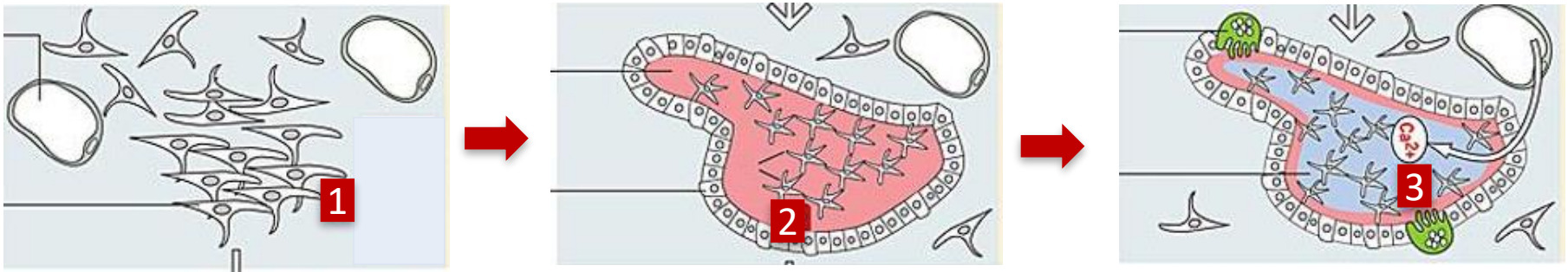
BONE DEVELOPMENT (OSTEOGENESIS)



INTRAMEMBRANOUS OSSIFICATION

4th week of development

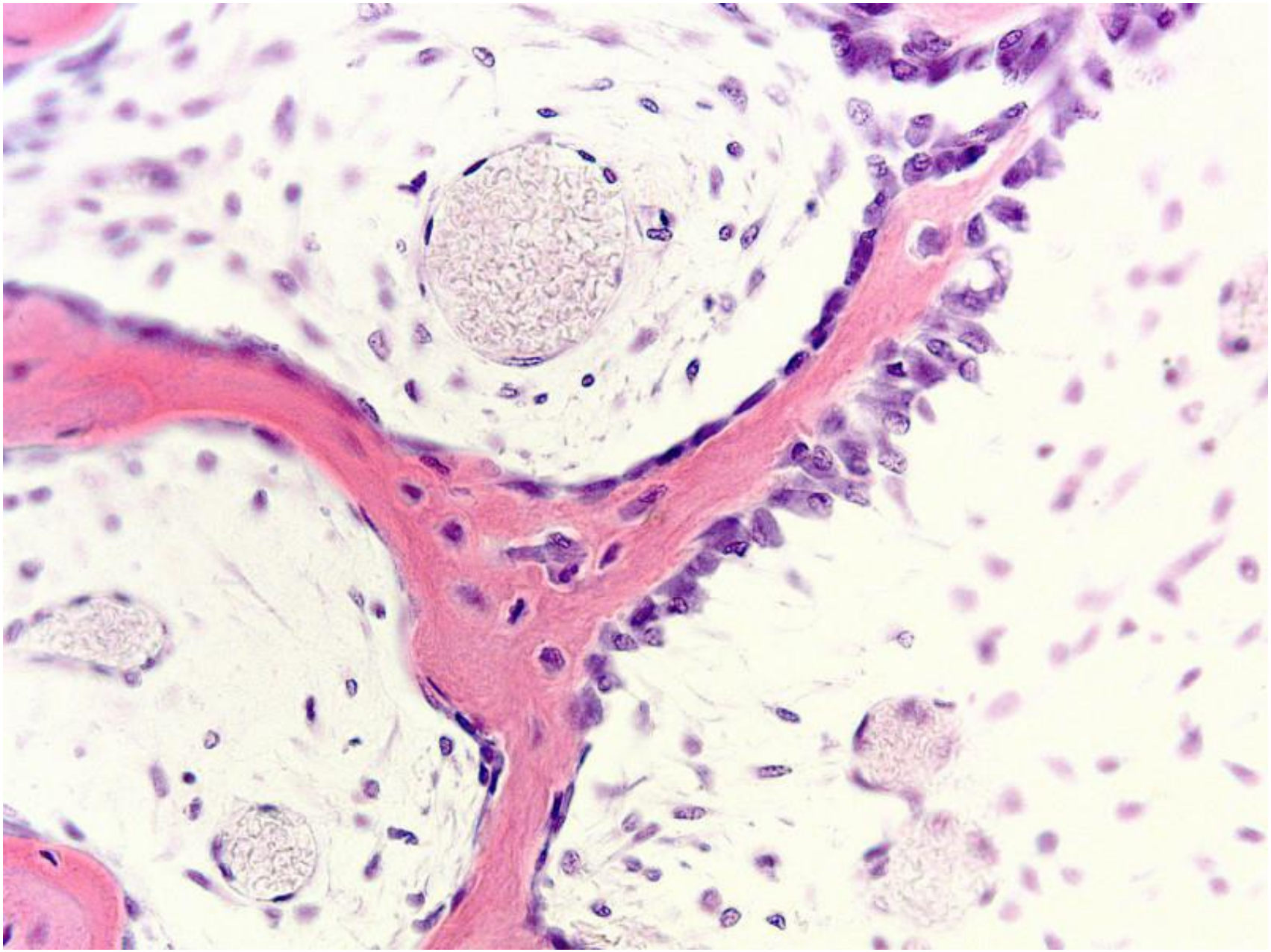
1. Formation of osteogenic islets – mesenchyme cells differentiate into osteogenic cells and further into osteoblasts
2. Formation of bone extracellular matrix – osteoblasts start to produce the components of bone matrix,
   - some osteoblasts become embedded into it, and these cells differentiate into osteocytes;
   - other osteoblasts remain on the surface of the forming bone spicule and retain their identity as osteoblasts
3. Calcification of bone matrix – as a result of impregnation of the matrix with the salts of calcium, a typical reticulofibrous bone tissue is formed
4. Bone remodeling and growth – later on, the reticulofibrous bone tissue is gradually destroyed to be replaced by newly formed portions of lamellar bone; osteogenic cells of the periosteum give rise to circumferential lamellae layer, while osteogenic cells that reside in the adventitia of ingrowing blood vessels give rise to osteons

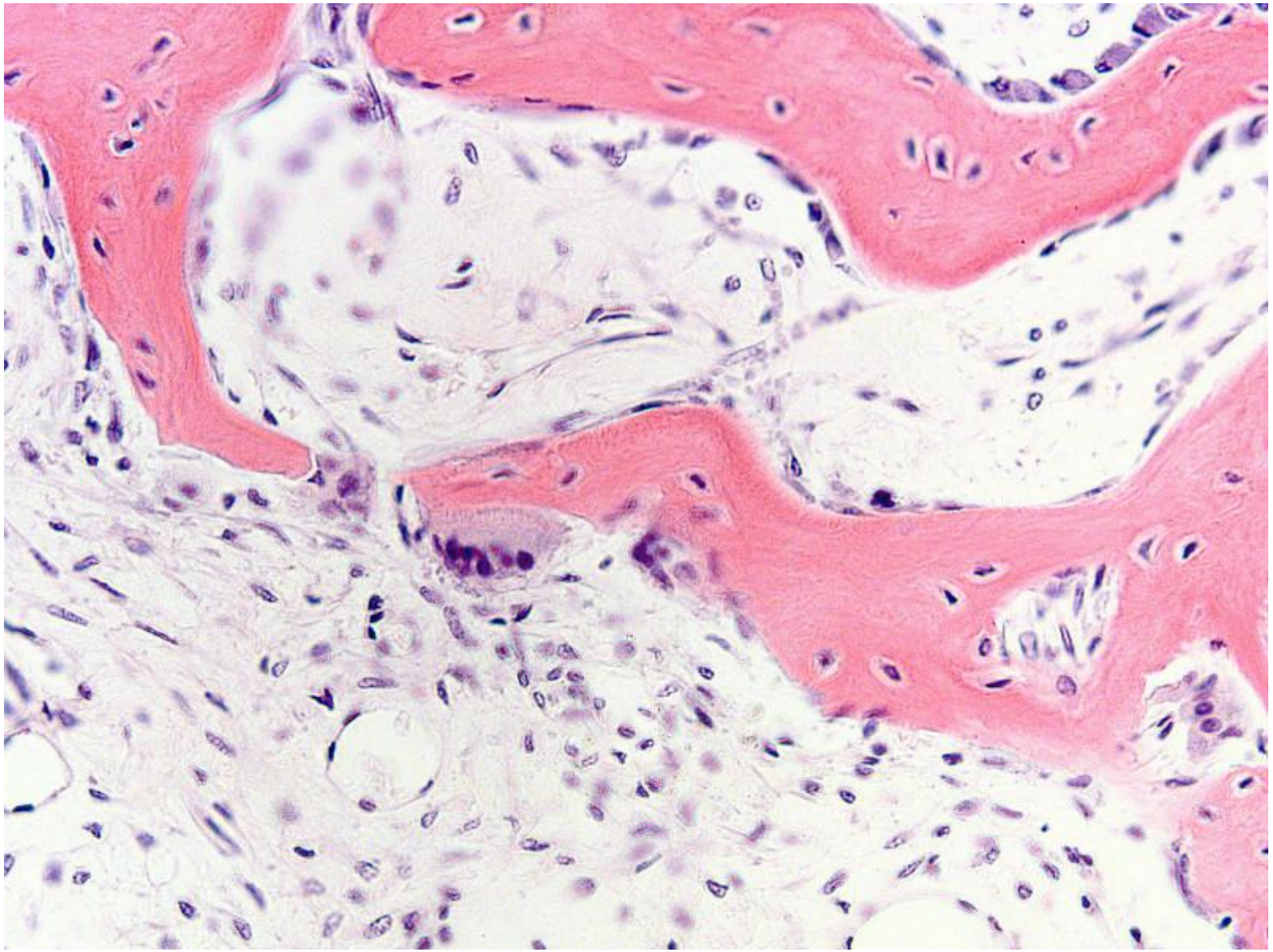


DIRECT OSTEOGENESIS

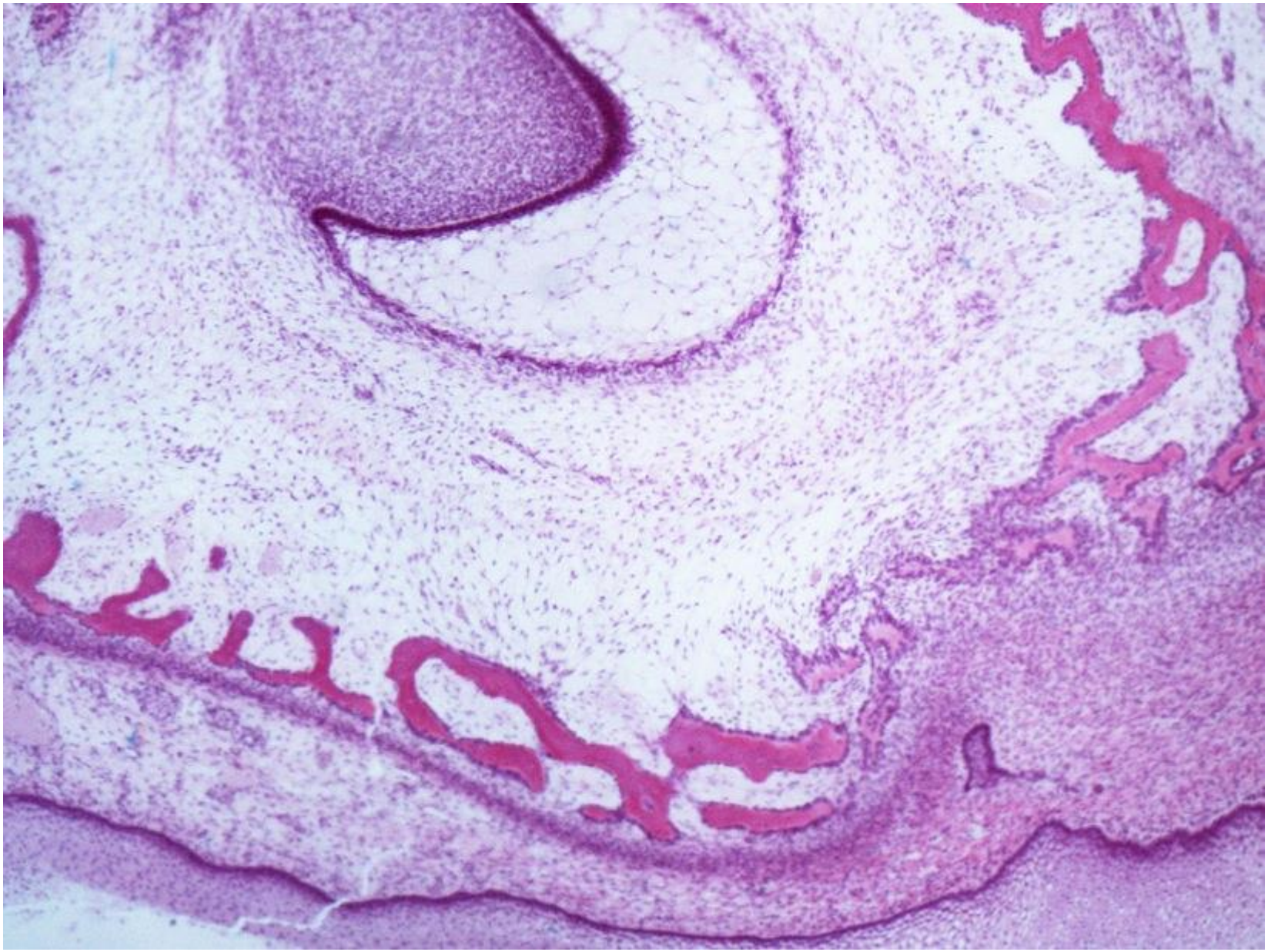
FORMATION OF RETICULOFIBROUS BONE TISSUE

1- mesenchyme, 2- osteoblasts, 3- osteoid (newly formed ground substance of the future matrix), 4- calcified bone matrix, 5- osteocytes, 6- osteoclast, 7- blood vessels, 8- osteogenic islet





Slide №68 «Direct development of bone tissue from mesenchyme. Intramembranous ossification, H&E»



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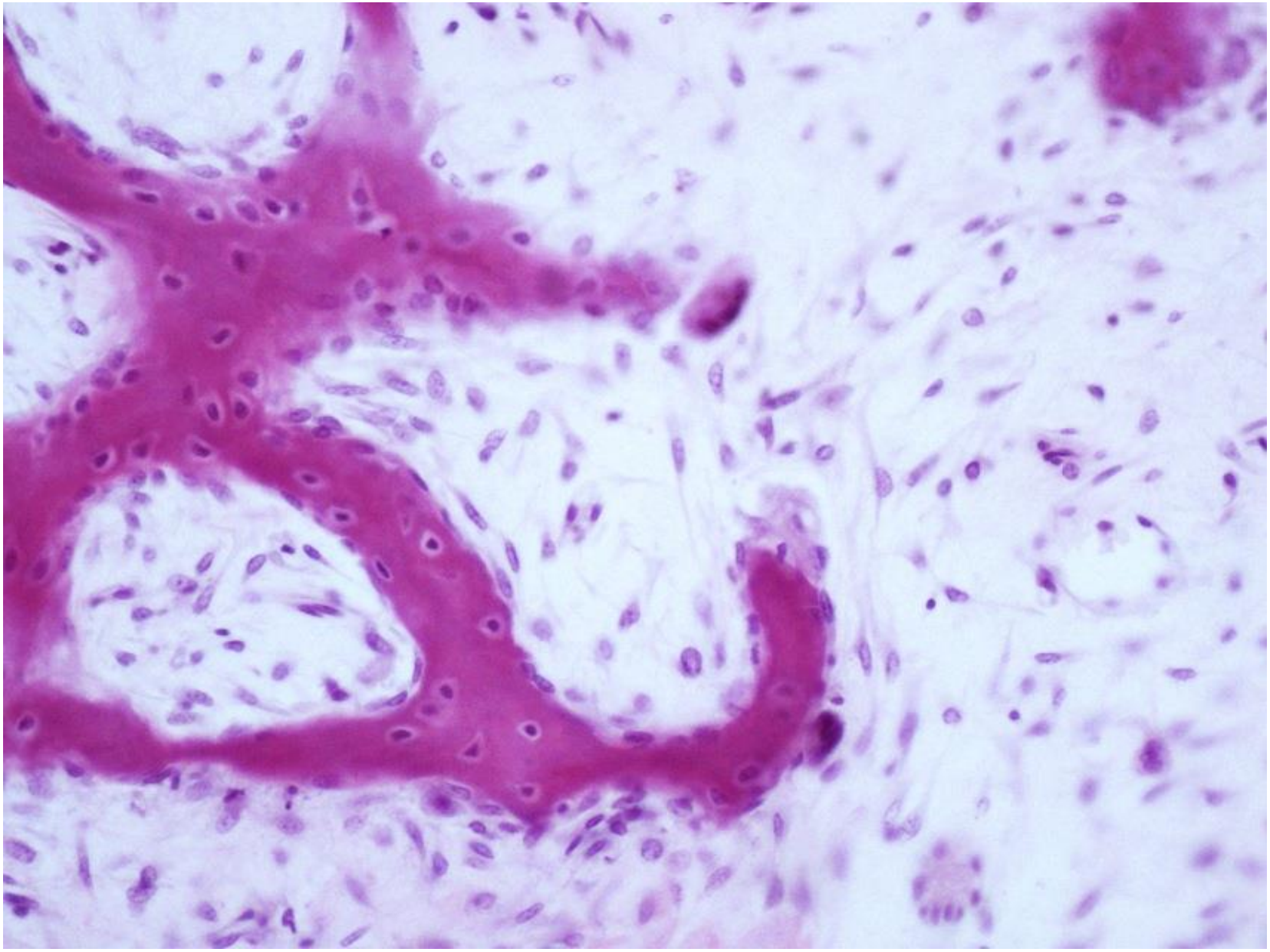

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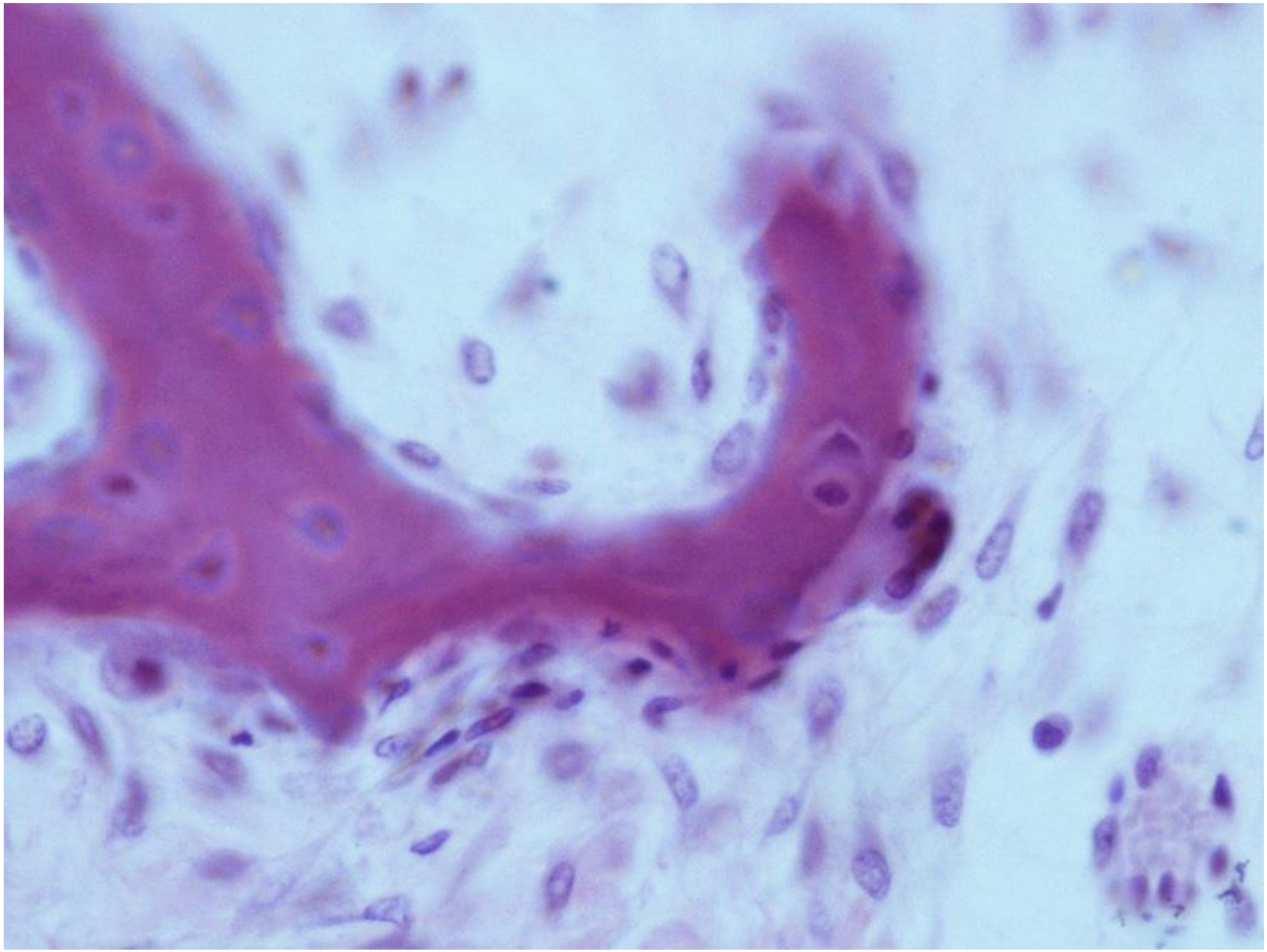
Intramembranous ossification, H&E»



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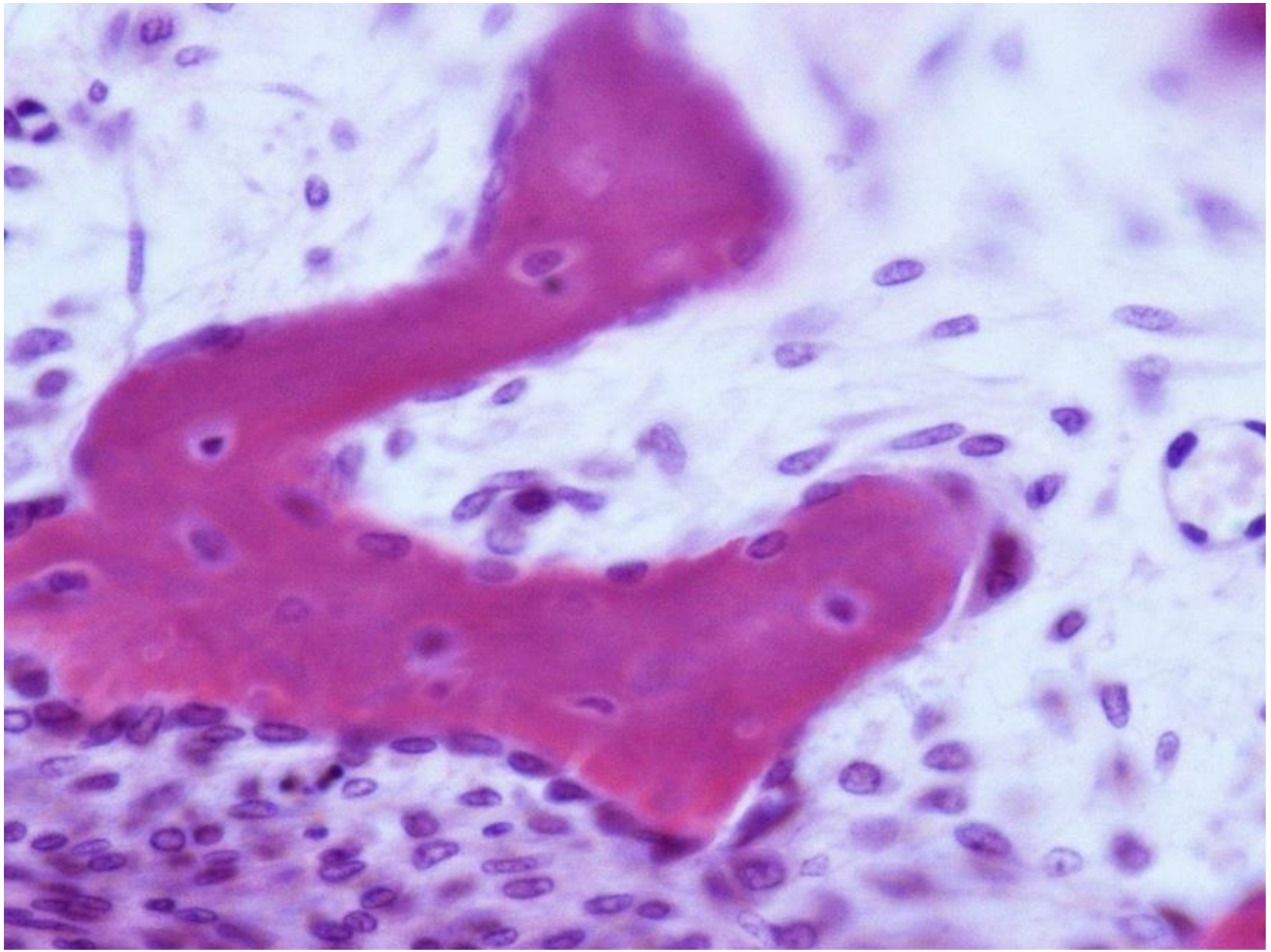


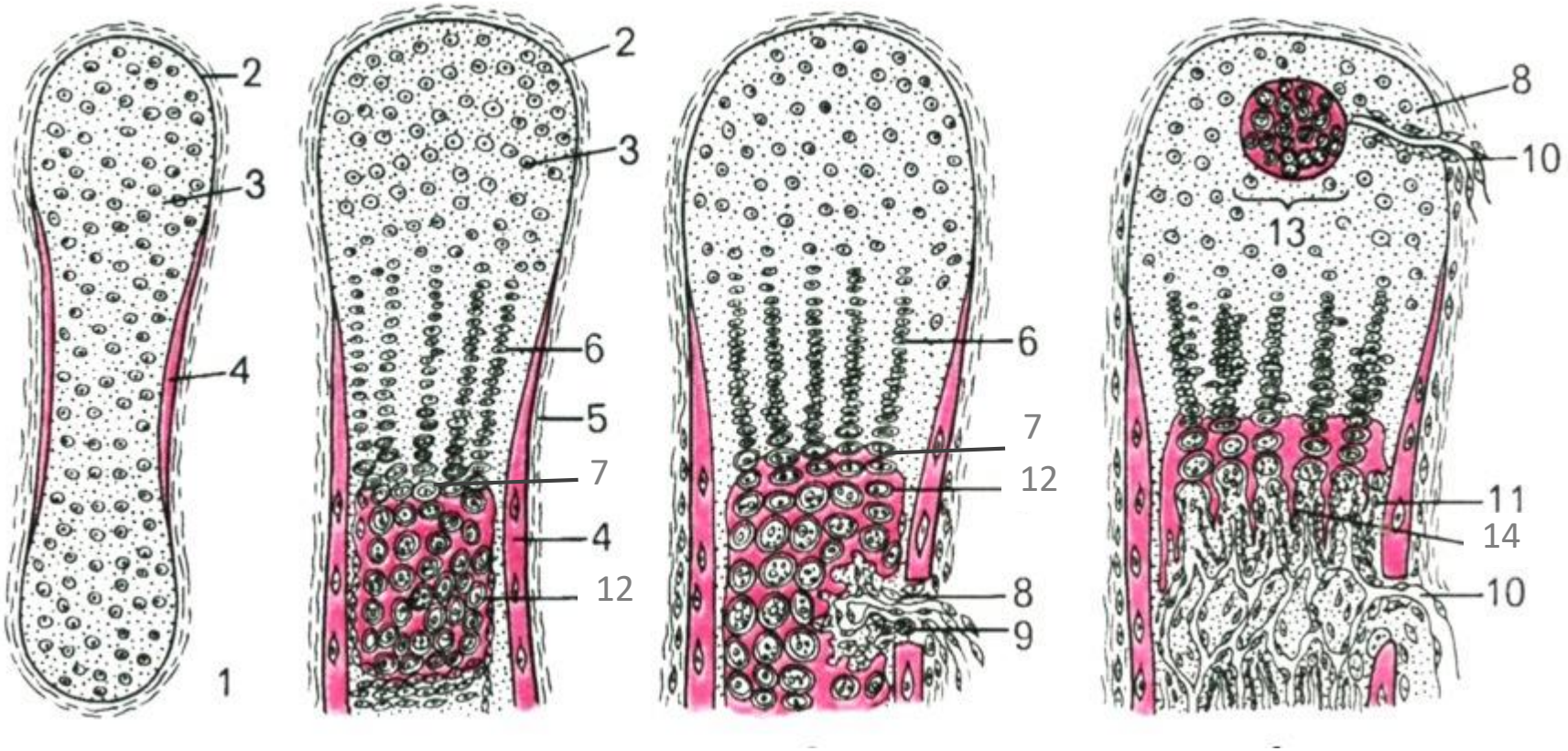
INDIRECT OSTEOGENESIS

8th week of development

1. Formation of a long bone model composed of the hyaline cartilage tissue.
2.Penetration of blood vessels from surrounding mesenchyme underneath the perichondrium results in formation of the perichondral bone collar composed of reticulofibrous bone tissue.
3. Dystrophic changes in the cartilage beneath the collar result in calcification of the cartilage tissue, death of the chondrocytes, destruction of the matrix, and formation of primary bone marrow cavities, thus promoting the further ingrowth of blood vessels. Mesenchyme cells migrate along these vessels and colonize the cavities, simultaneously differentiating into osteogenic cells. The endochondral bone formation propagates from the mid-diaphysis to epiphyses.
4. The epiphyses undergo ossification by similar mechanism that involves secondary epiphyseal ossification centers, which arise independently from the primary ossification center in the diaphysis. All ossification processes initially give rise to reticulofibrous bone tissue, which becomes replaced with lamellar bone tissue later in development.
5. The metaphyseal plate maintenance provides the means for further bone growth.

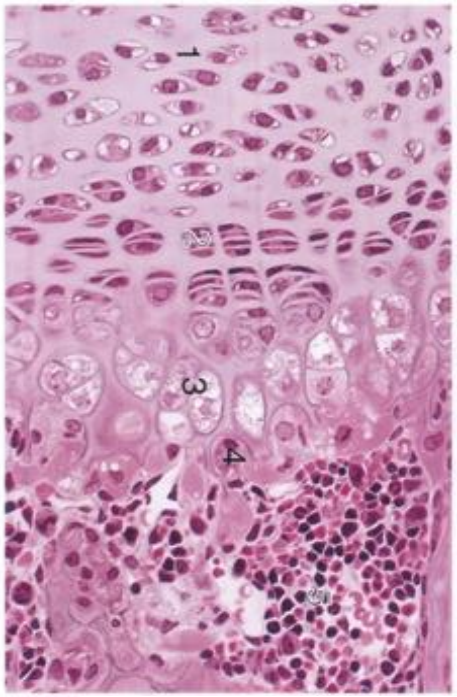
INDIRECT (ENDOCHONDRAL) OSTEOGENESIS

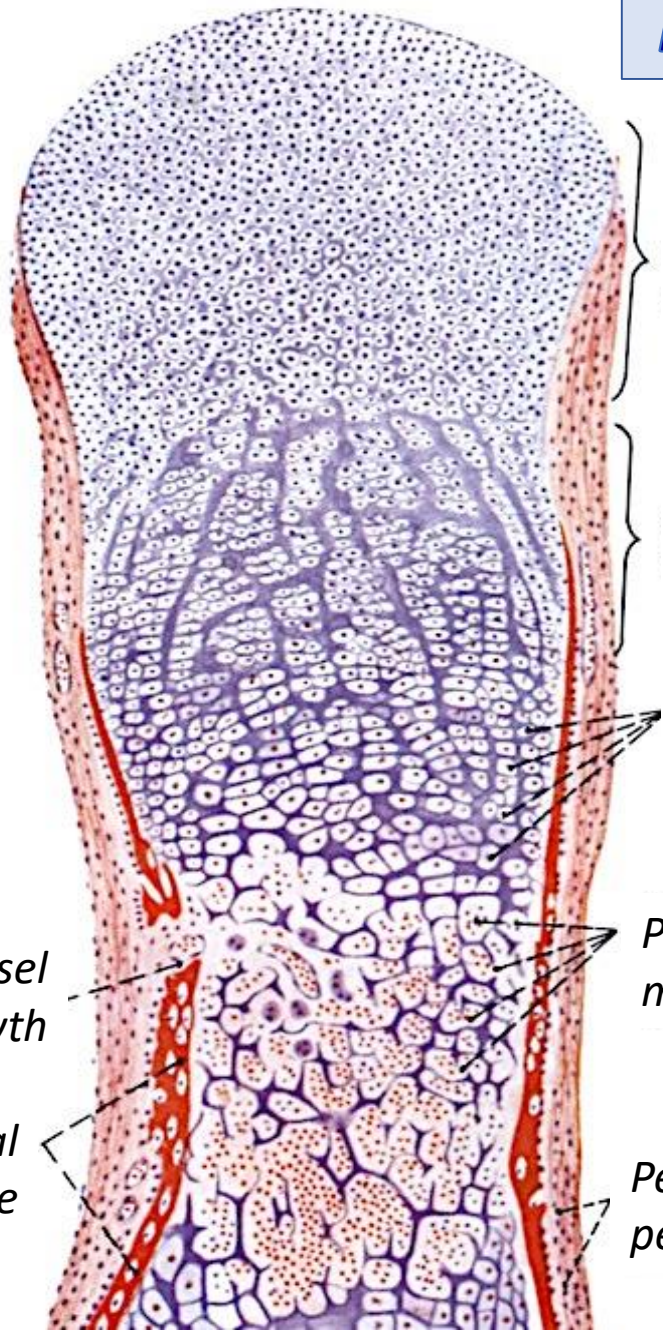
Formation of cartilaginous model and perichondral bone collar



1- primary cartilaginous model of long bone; 2- perichondrium; 3- cartilage tissue; 4- perichondral bone collar; 5- periosteum; 6- columns of chondrocytes; 7- zone of hypertrophic chondrocytes; 8- ingrowing mesenchyme with osteoclasts (9) and blood capillaries (10); 11- osteoblasts; 12- endochondrally formed bone tissue; 13- ossification center in the epiphysis, 14- zone of calcified cartilage

INDIRECT OSTEOGENESIS





Zone of reserve cartilage

Zone of proliferation

Zone of hypertrophy

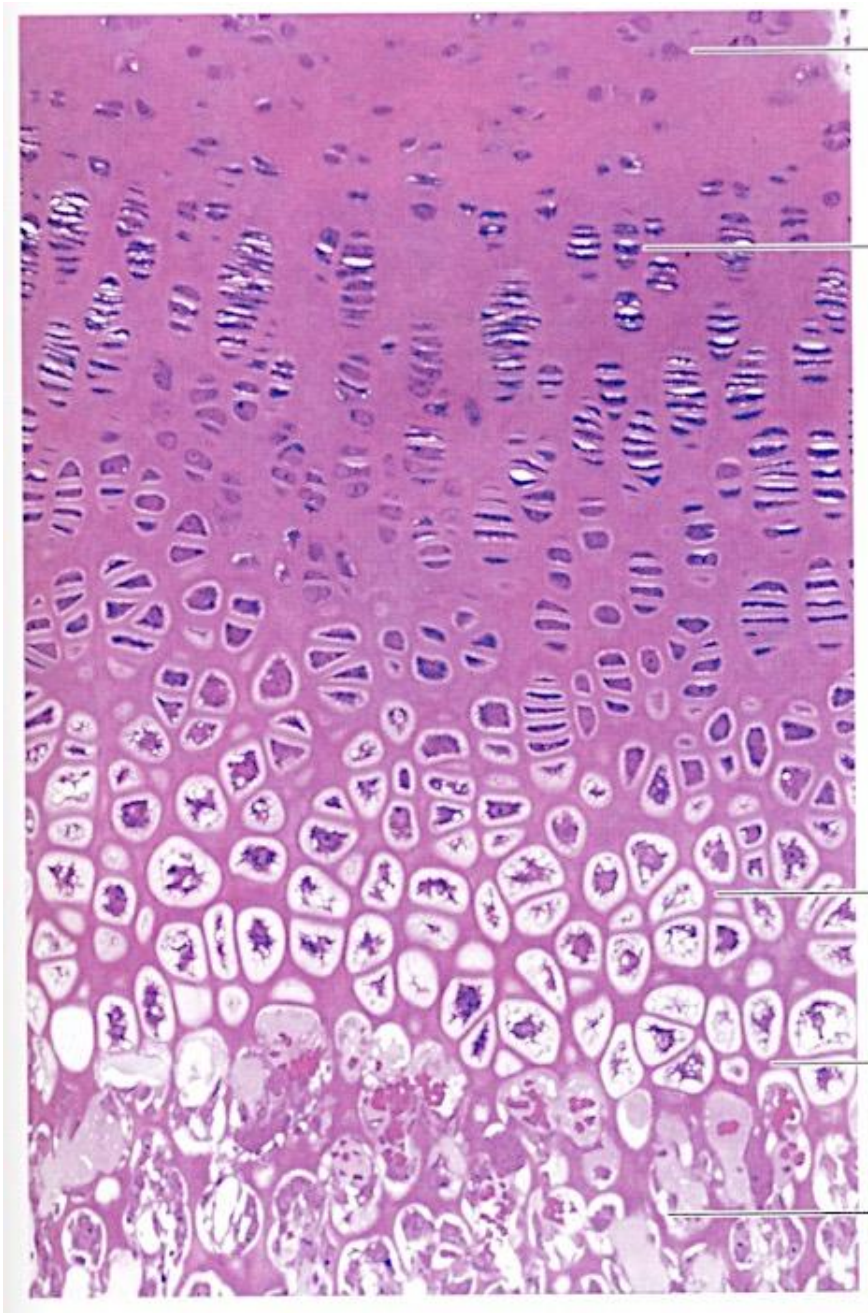
Primary bone marrow

Site of blood vessel ingrowth

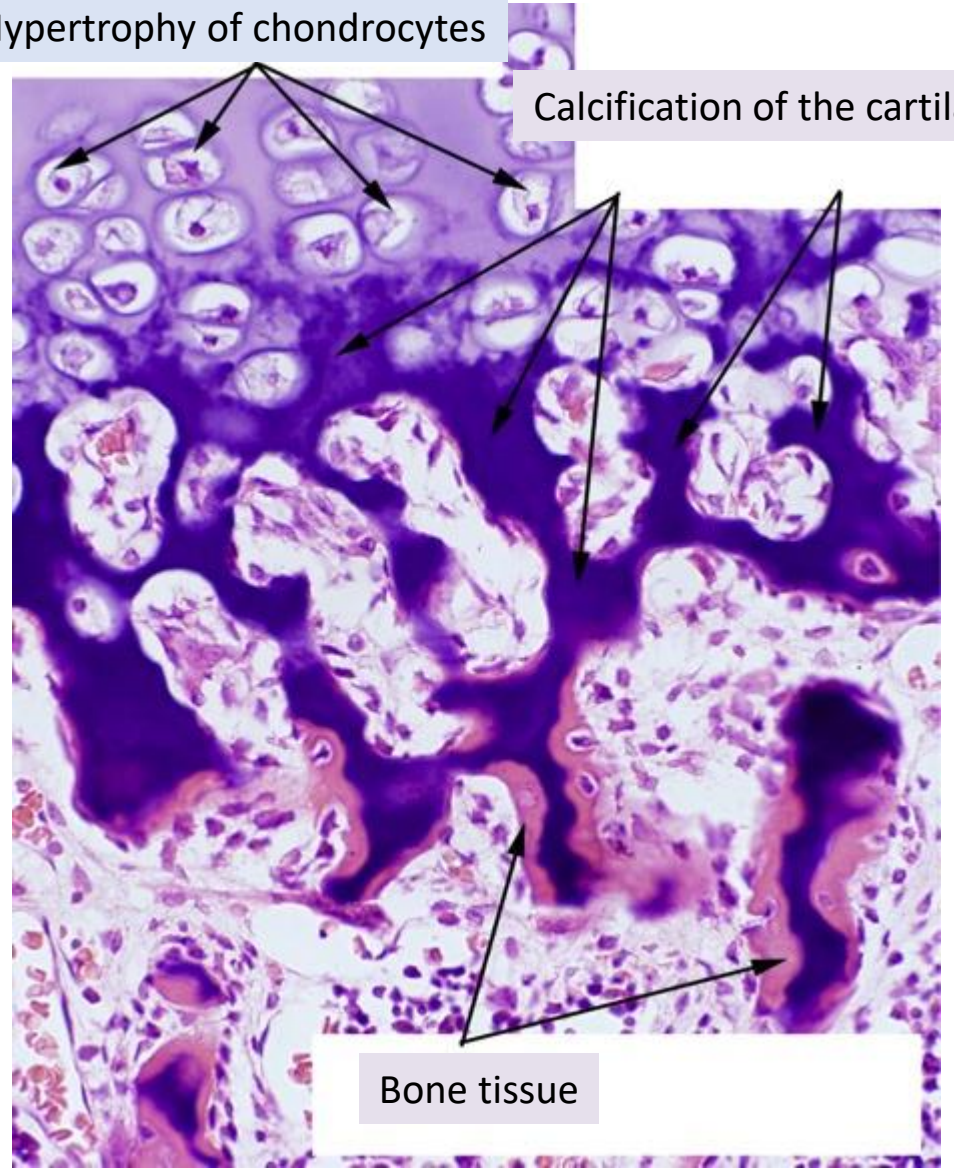
Perichondral bone

Perichondrium / periosteum

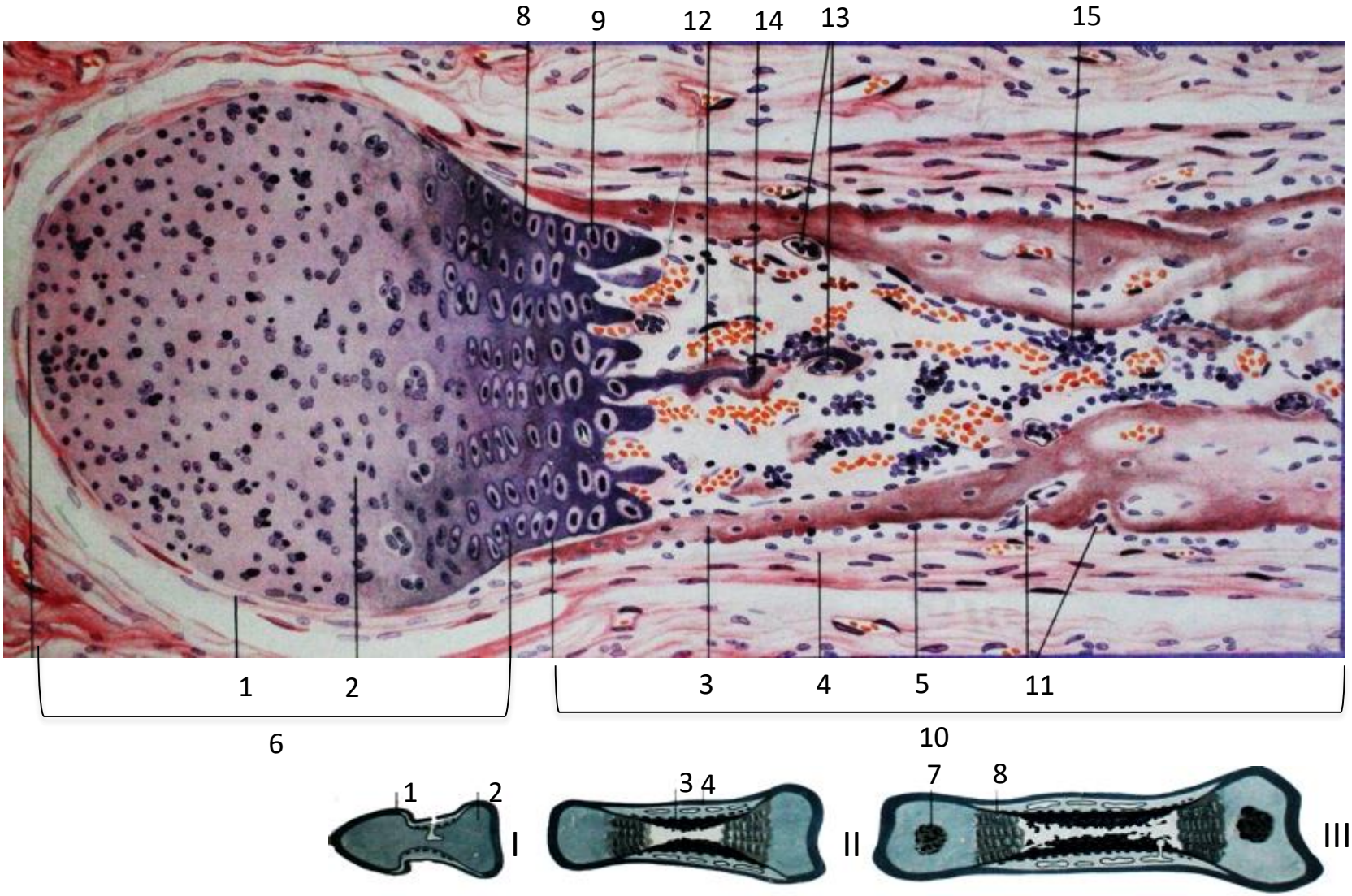
INDIRECT OSTEOGENESIS



INDIRECT OSTEOGENESIS



INDIRECT OSTEOGENESIS

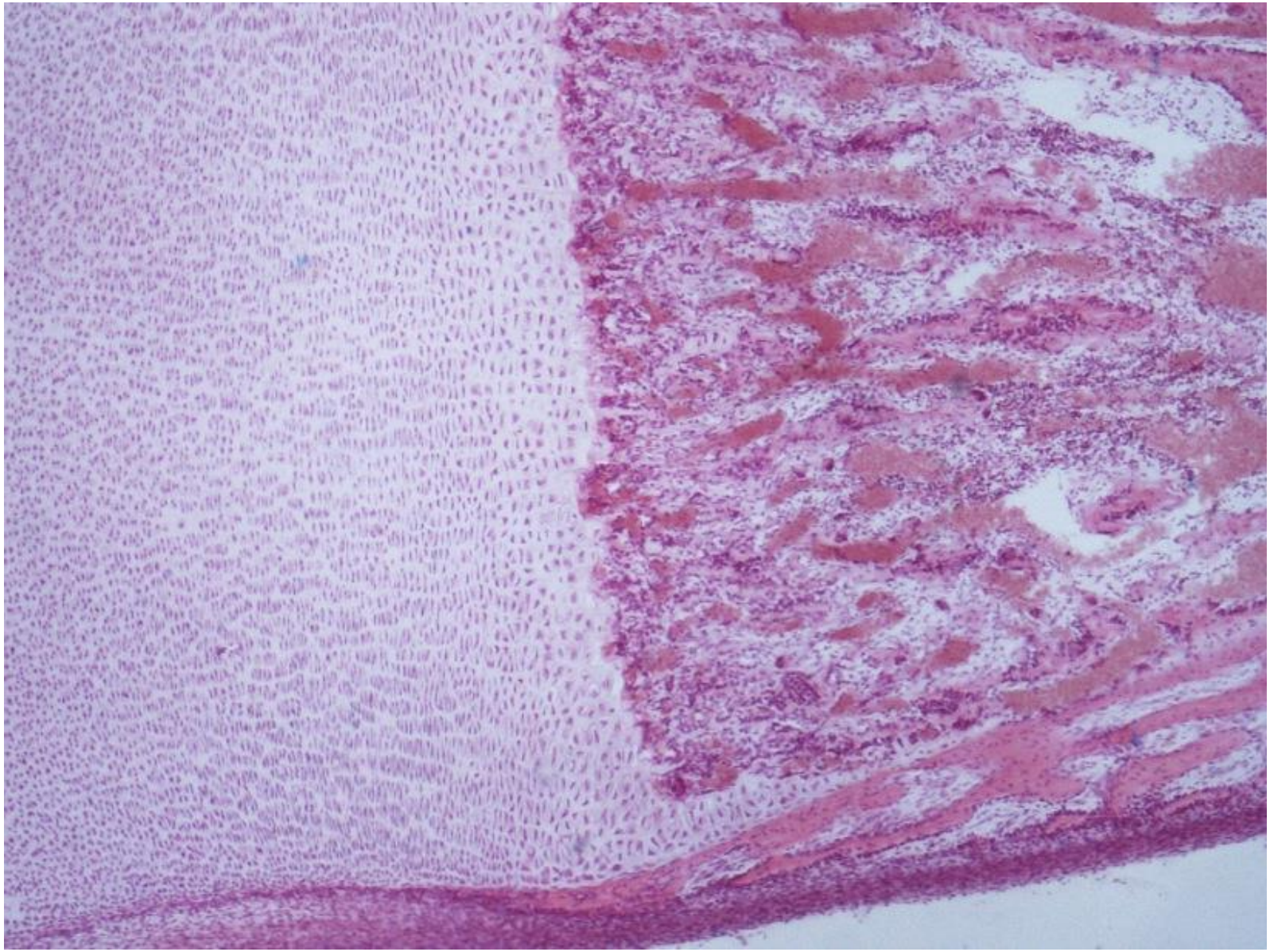


I, II, III – sequential stages of osteogenesis

1- perichondrium, 2- emryonic cartilage, 3- bone collar, 4- periosteum, 5- osteoblasts, 6- epiphysis, 7- epiphyseal «ossification center» , 8- epiphyseal plate, 9- hypertrophic chondrocytes, 10- diaphysis, 11- blood vessels, 12- endochondral bone, 13- osteoclasts, 14- calcified remnants of cartialge matrix, 15- developing bone marrow

Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue, H&E»

Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue. H&E»



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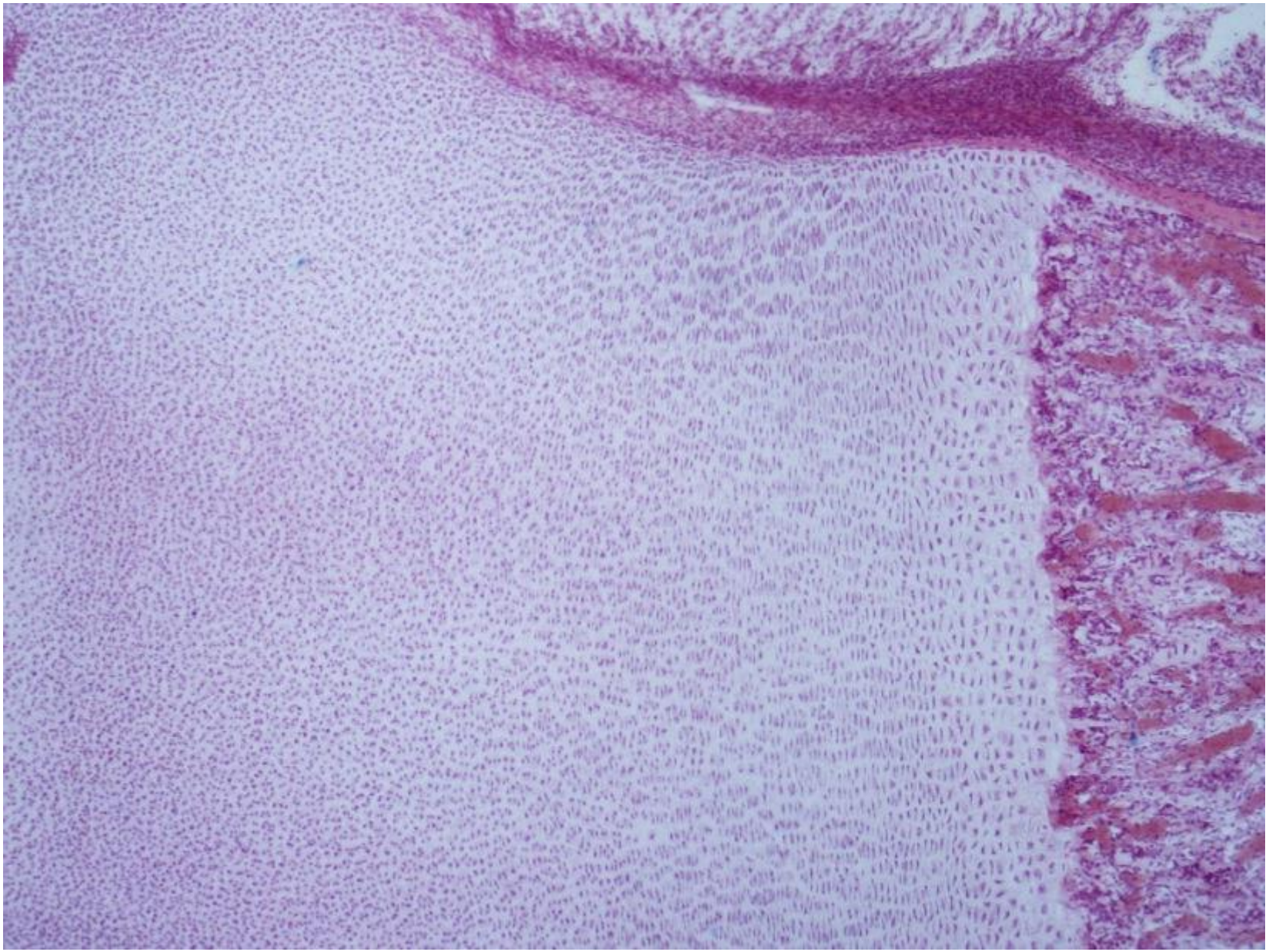

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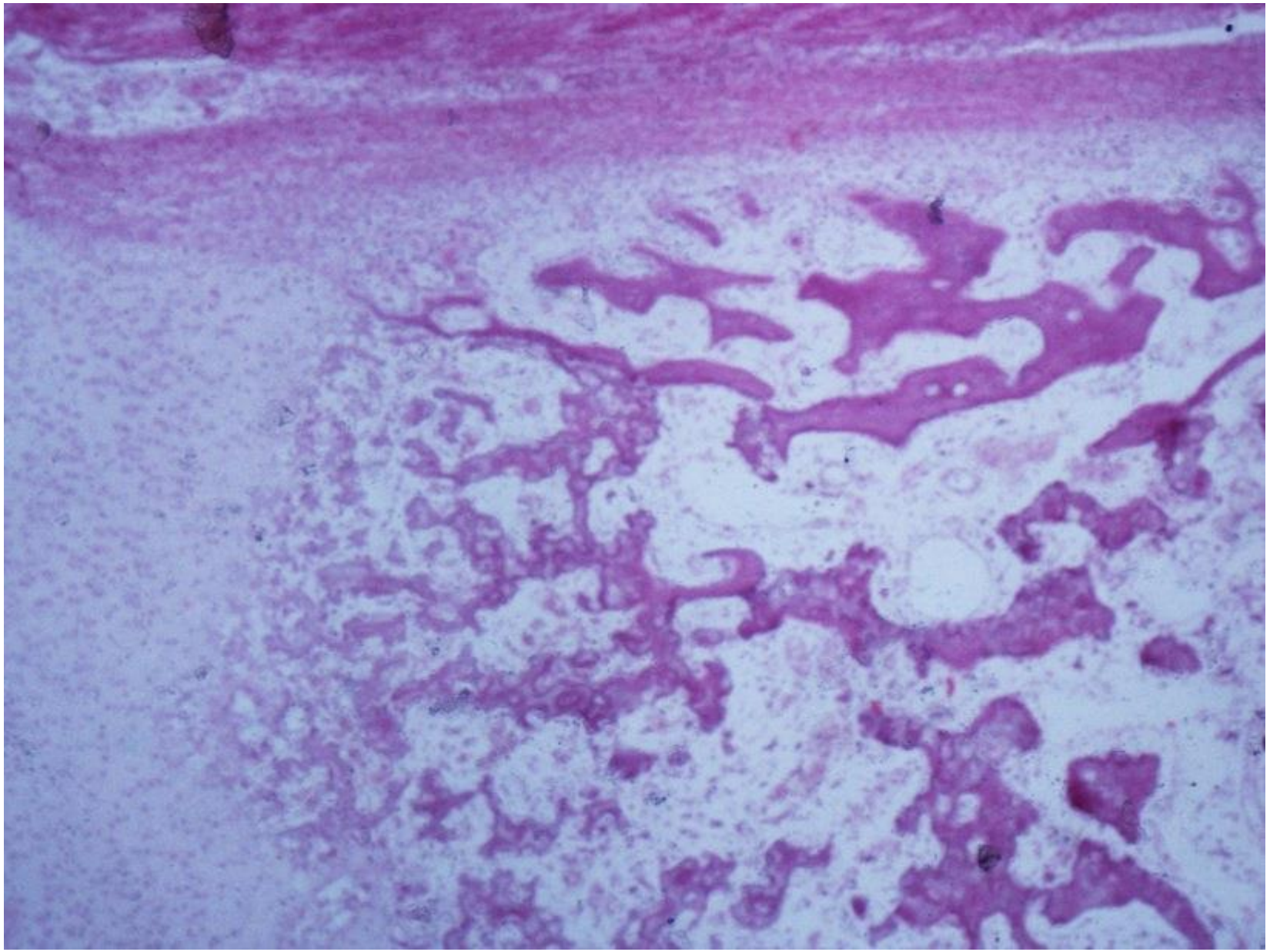

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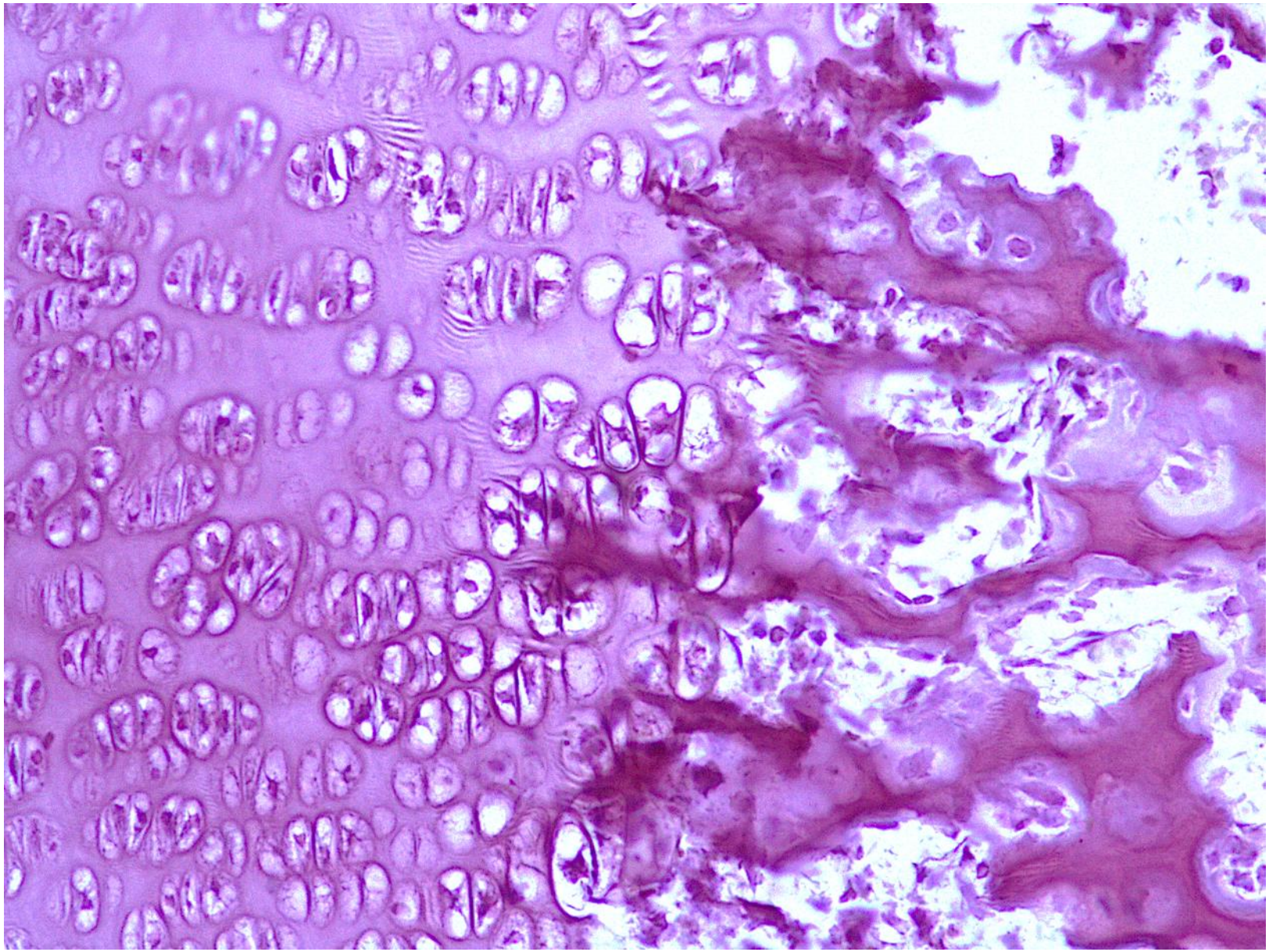
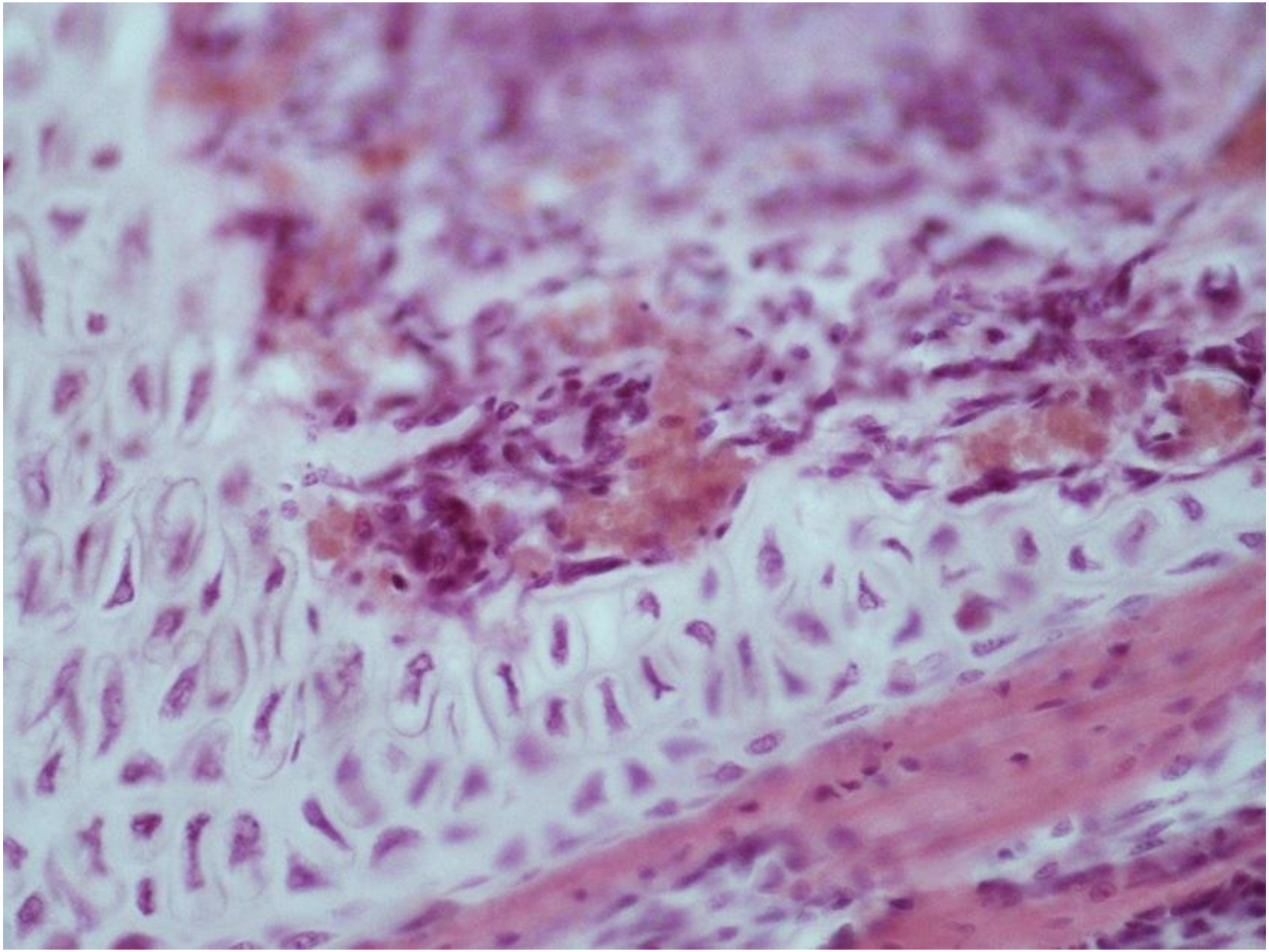
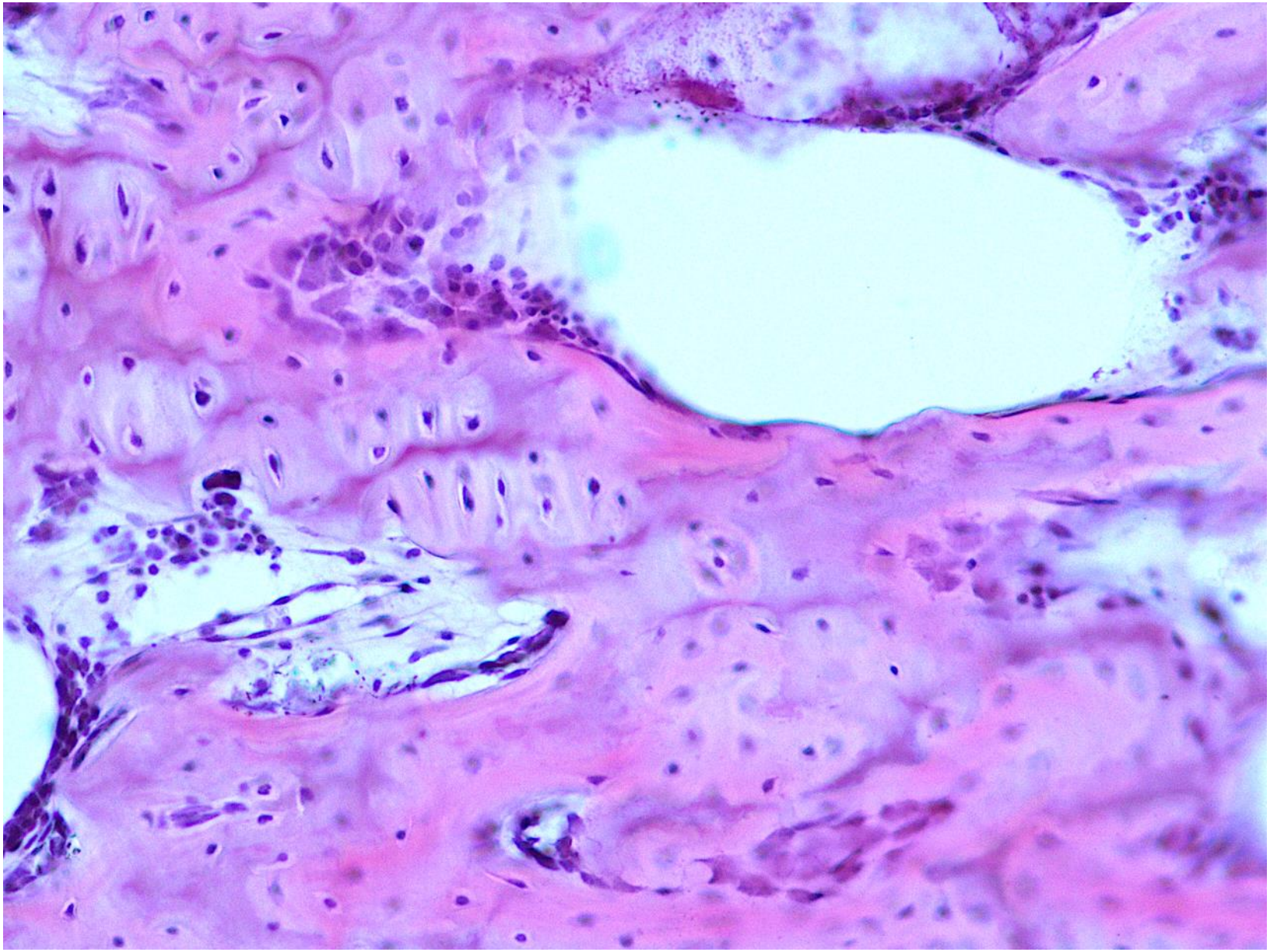


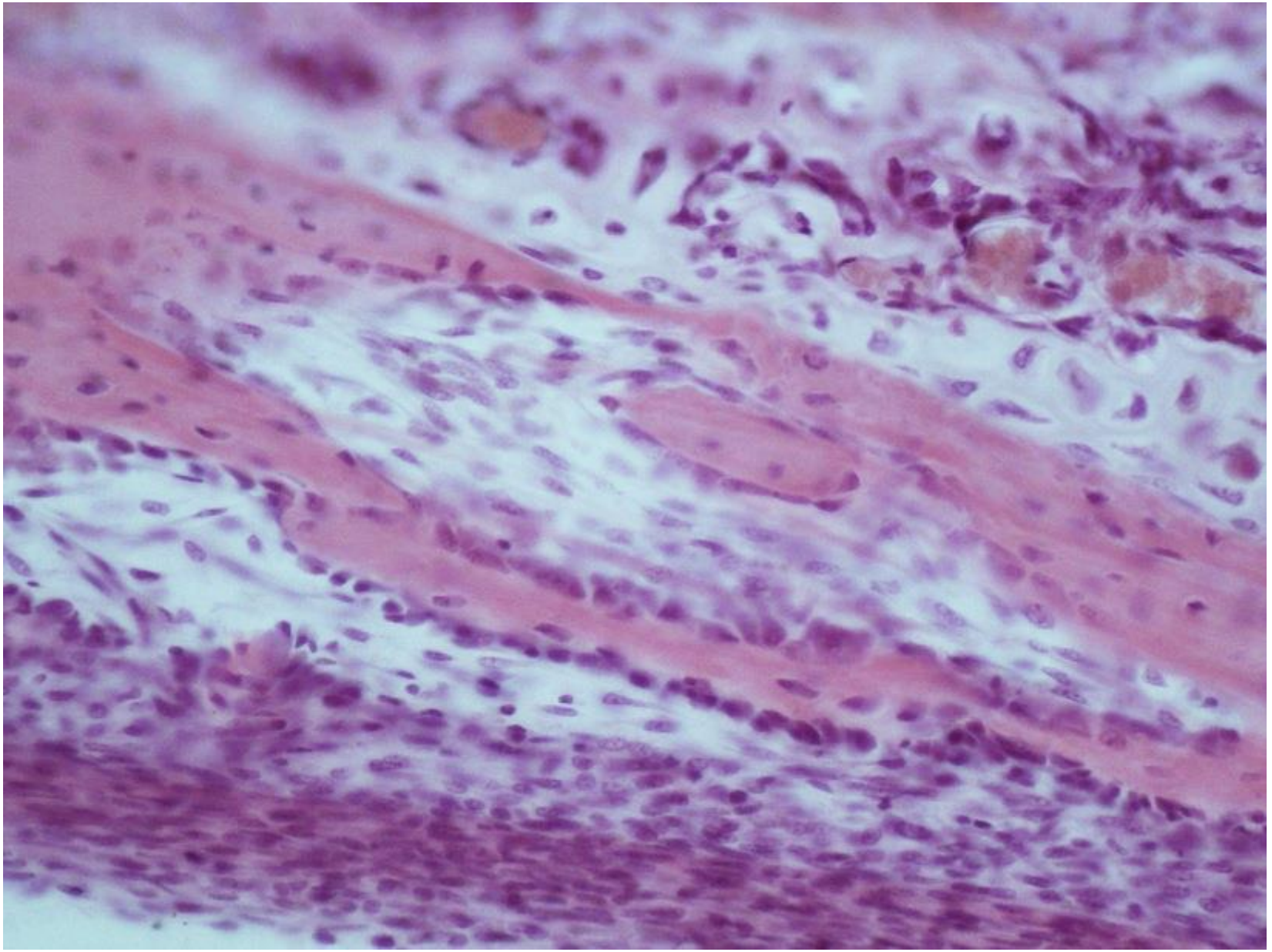
Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue, H&E»



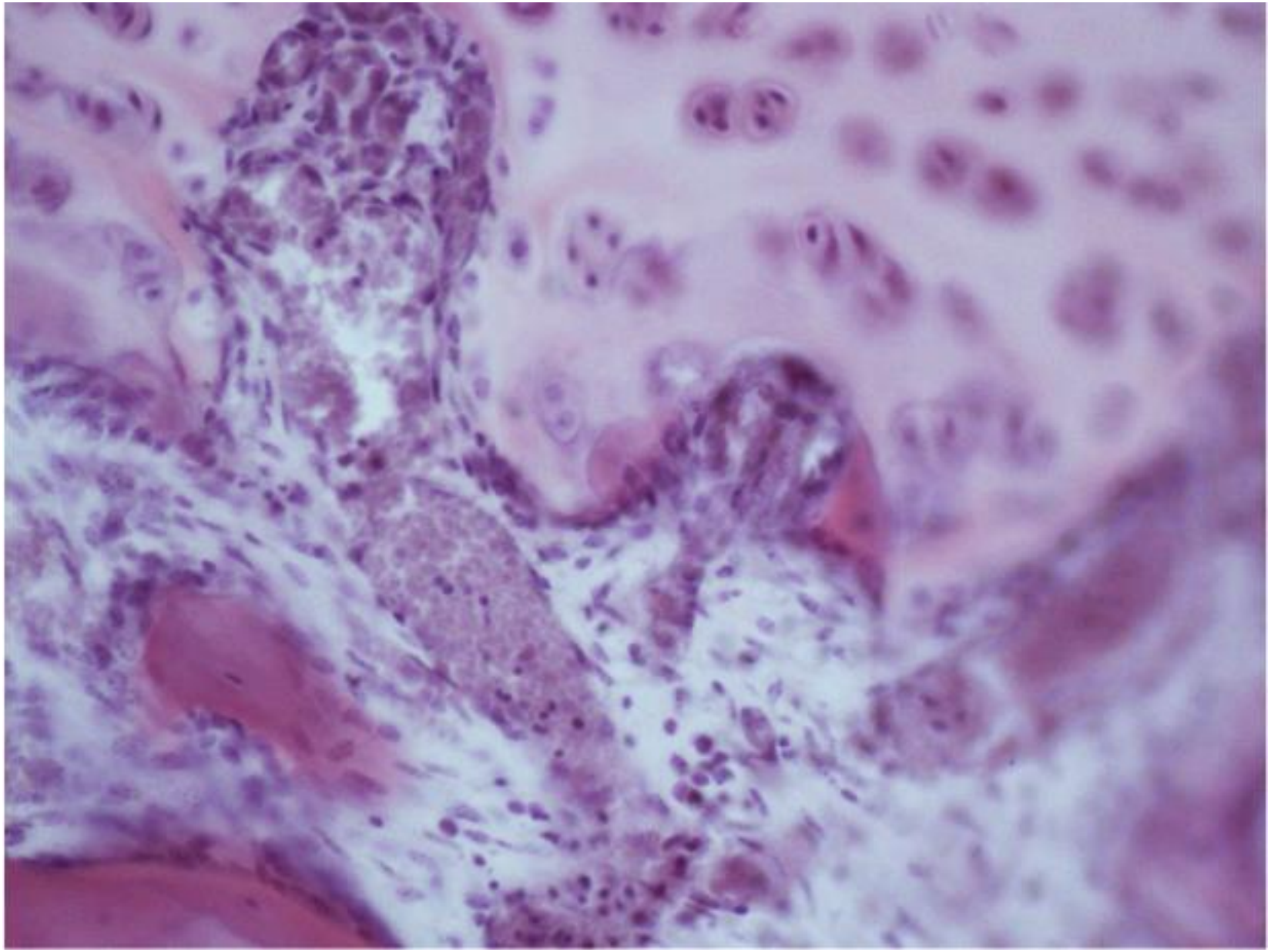
Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue, H&E»



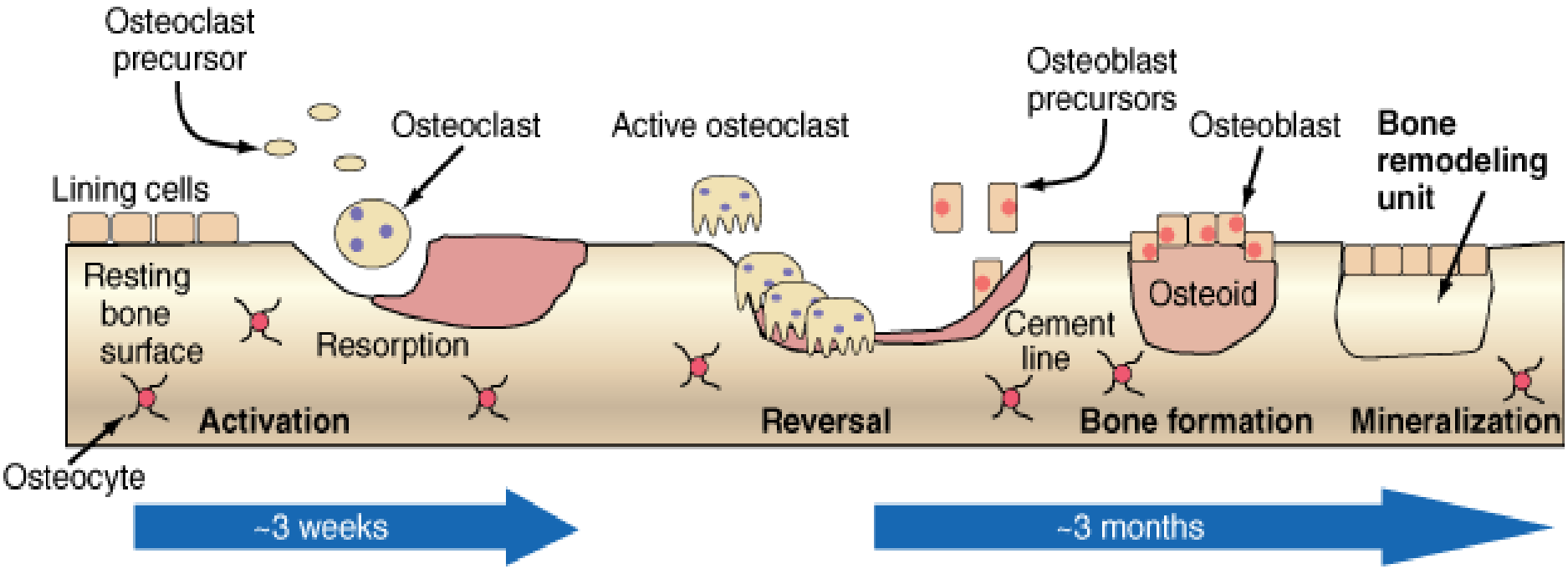
Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue, H&E»



Slide №69 «Indirect osteogenesis by replacement of cartilaginous model with bone tissue, H&E»



BONE REPAIR (FRACTURE HEALING)



BONE REPAIR (FRACTURE HEALING)