Classification of connective tissues

Connective tissue

- Connective tissue proper
  - Fibrous CT
    - Loose CT
    - Dense CT
      - Regular
      - Irregular
  - CT with special properties
    1. Reticular CT
    2. Mucous CT
    3. Pigment CT
    4. Adipose CT
- Skeletal connective tissue
  - Cartilage
  - Bone

Three components of **any** type of connective tissue

- **1. Cells**
- **2. Fibers**
- **3. Ground substance**

Extracellular matrix

Connective tissue proper
Fibrous connective tissue
Cells

Fibroblast differon

- **Young fibroblasts** – low-differentiated cells, can be divided by mitosis, with low level of synthesis
- **Mature fibroblasts** – highly-differentiated cells, specialized on the synthesis of the extracellular matrix, have developed rough ER and Golgi complex (for protein synthesis), are not divided
- **Fibrocytes** – definitive (old) form of fibroblasts, with low level of synthesis
- **Myofibroblasts** – combine the characteristics of two cells: smooth muscle cell (actin and myosin filaments) and fibroblast (Golgi complex and rough ER). Participate in the healing of wounds and in the uterus during the pregnancy.
- **Fibroclasts** – have numerous lysosomes and destroy the extracellular matrix.

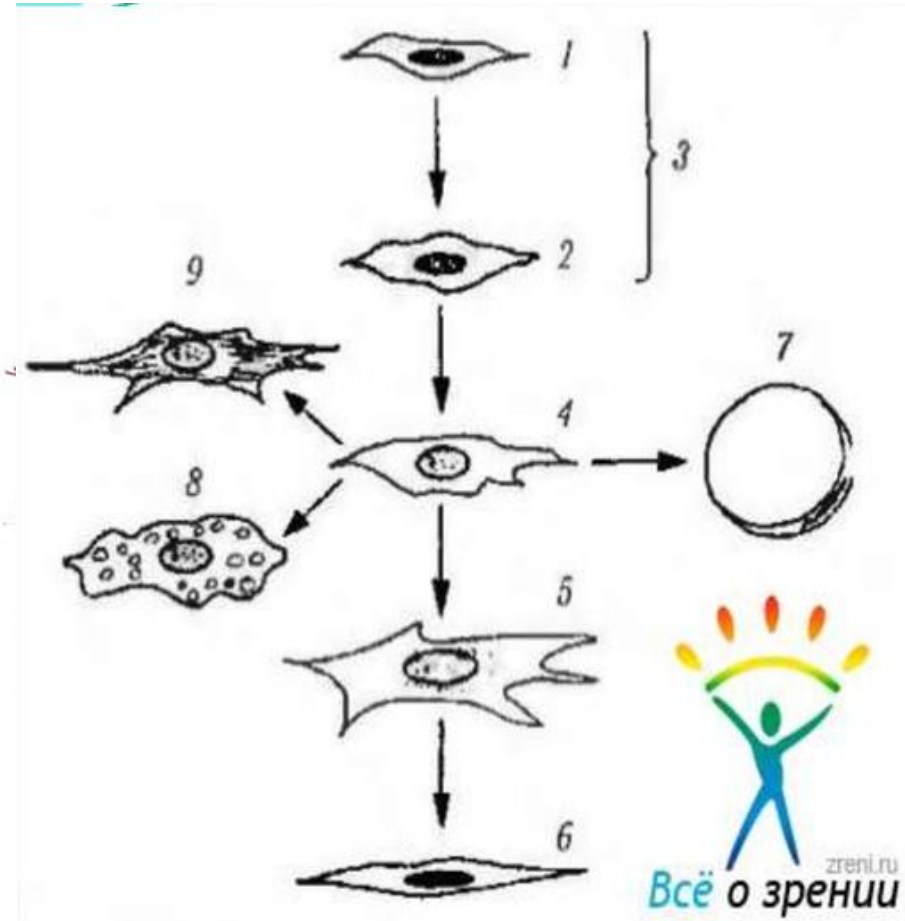
Cells of the hematogenic origin

- **Macrophages** (originate from monocytes of blood): activate T-helper cells, produce cytokines
- **Plasma cells** (originate from B-lymphocytes of blood): produce antibodies
- **Mast cells** (tissue basophils): contain granules with histamine and heparin, responsible for allergic reactions

Connective tissue proper
Fibrous connective tissue
Other Cells

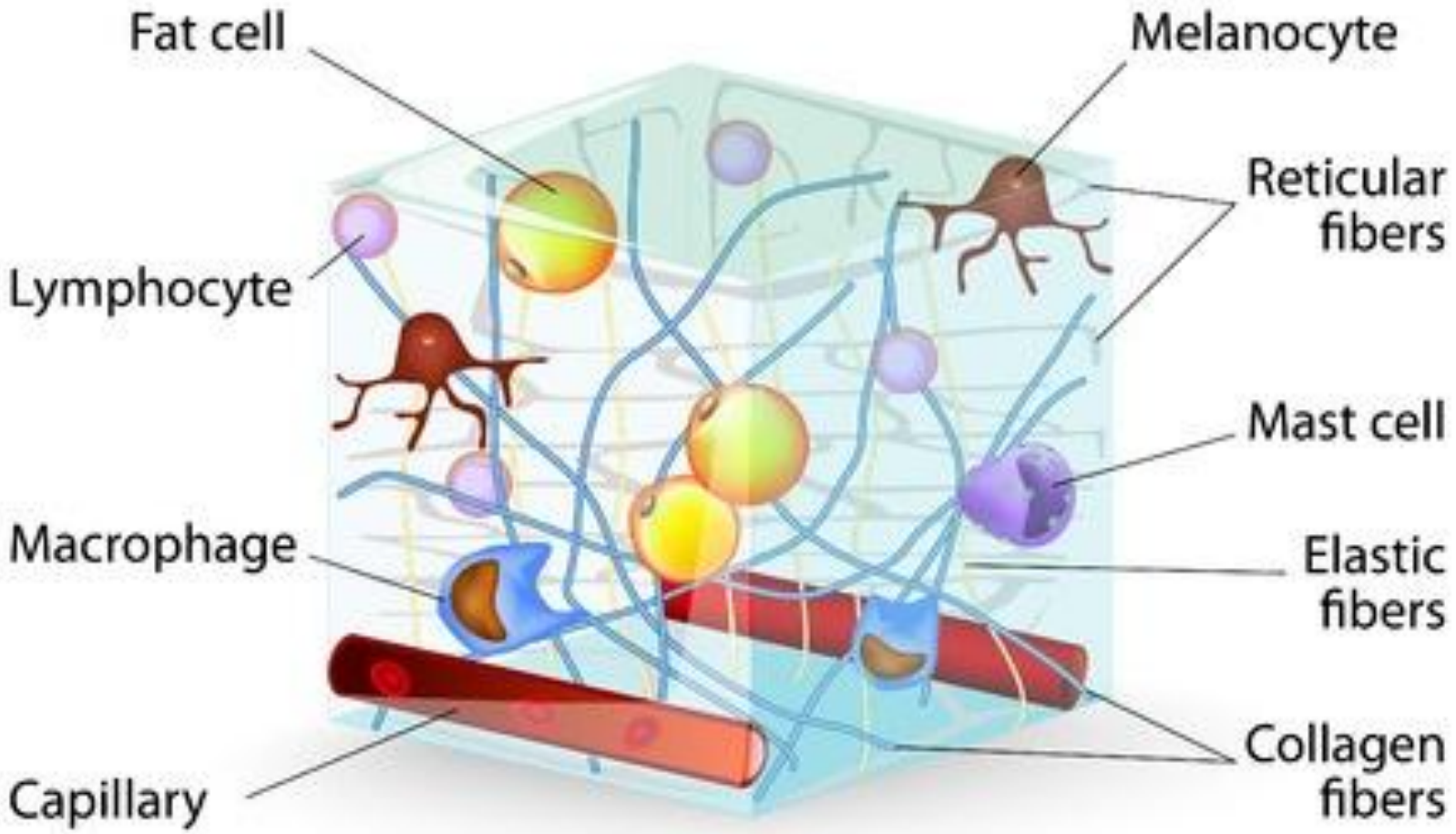
- **Adipocytes** – fat cells, contain one large fat droplet, the nucleus and organelles are moved to the periphery;
- **Pigment cells** – arise from the neural crests, contain the brown pigment called **melanin;**
- **Adventitial cells** – low-differentiated cells, can transform into any cell of the fibroblast differon (**not hematogenic cell!);**
- **Pericytes** – cells which accompany blood capillaries

Connective tissue proper
Fibrous connective tissue
Cells

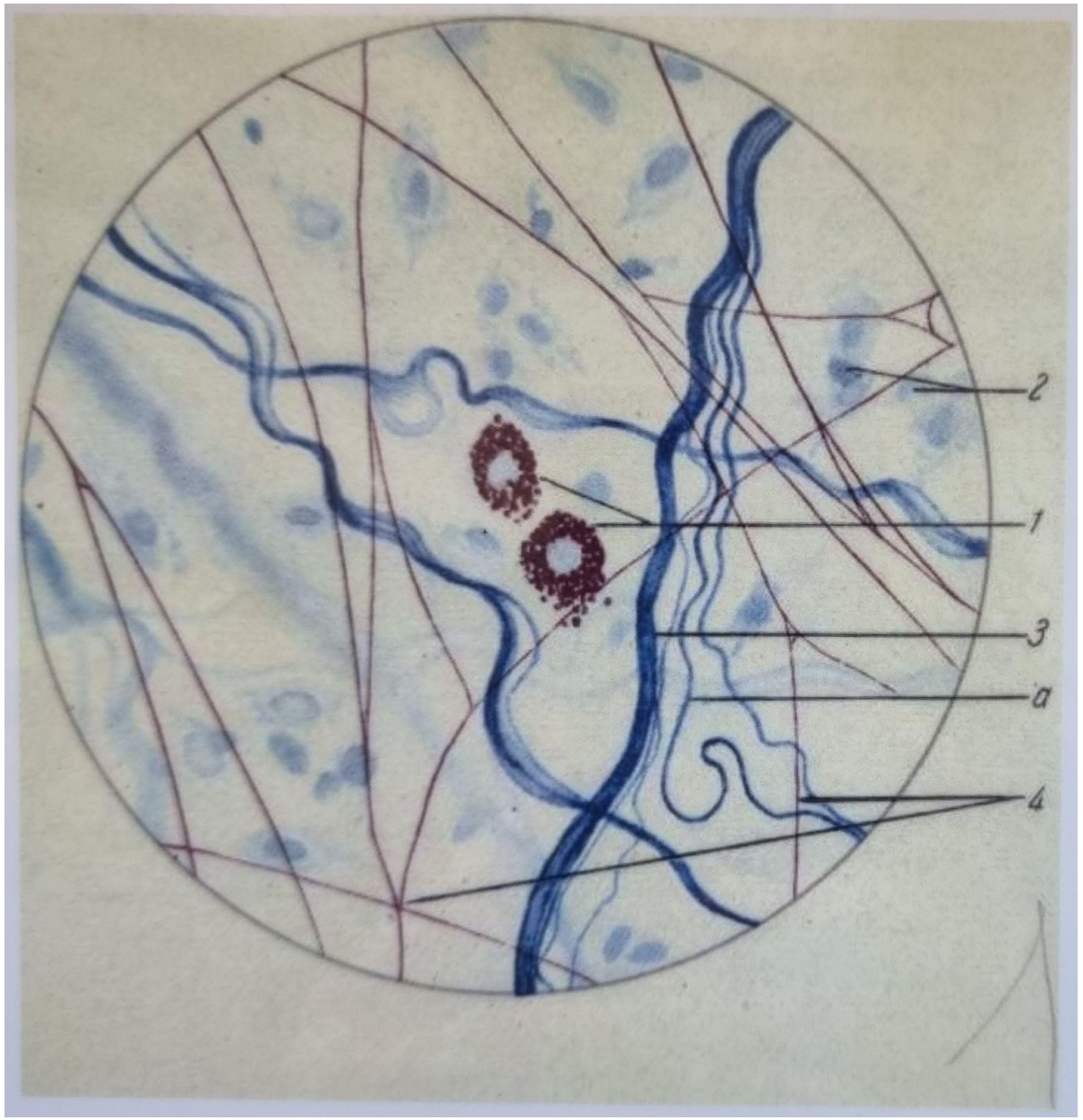


1. Stem cell
2. Semi-stem cell
3. Adventitial cell
4. Young fobroblast
5. Mature fibroblast
6. Fibrocyte
7. Adipose cell
8. Fibroclast
9. Myofibroblast

CONNECTIVE TISSUES



Connective tissue



1. Mast cells
2. Fibroblast
3. Collagen fiber

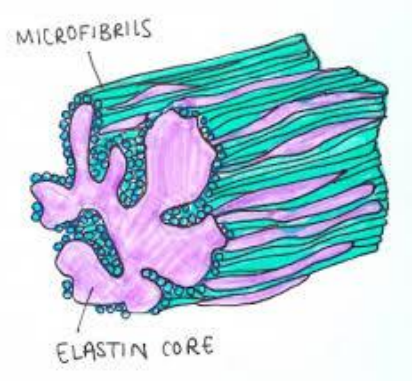
a) fibril

1. Elastic fiber

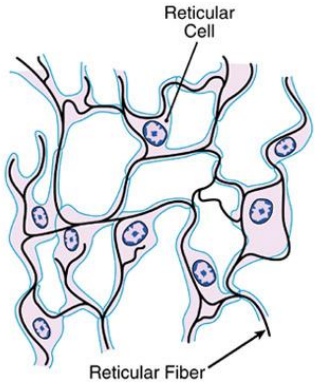
Connective tissue proper
Fibrous connective tissue
Fibers

- Collagen: built from the collagen protein, tough and strong, characterized by four levels of organization

- Elastic – built from the elastin protein, flexible, consists of two components (inner elastin core and outer fibrills)



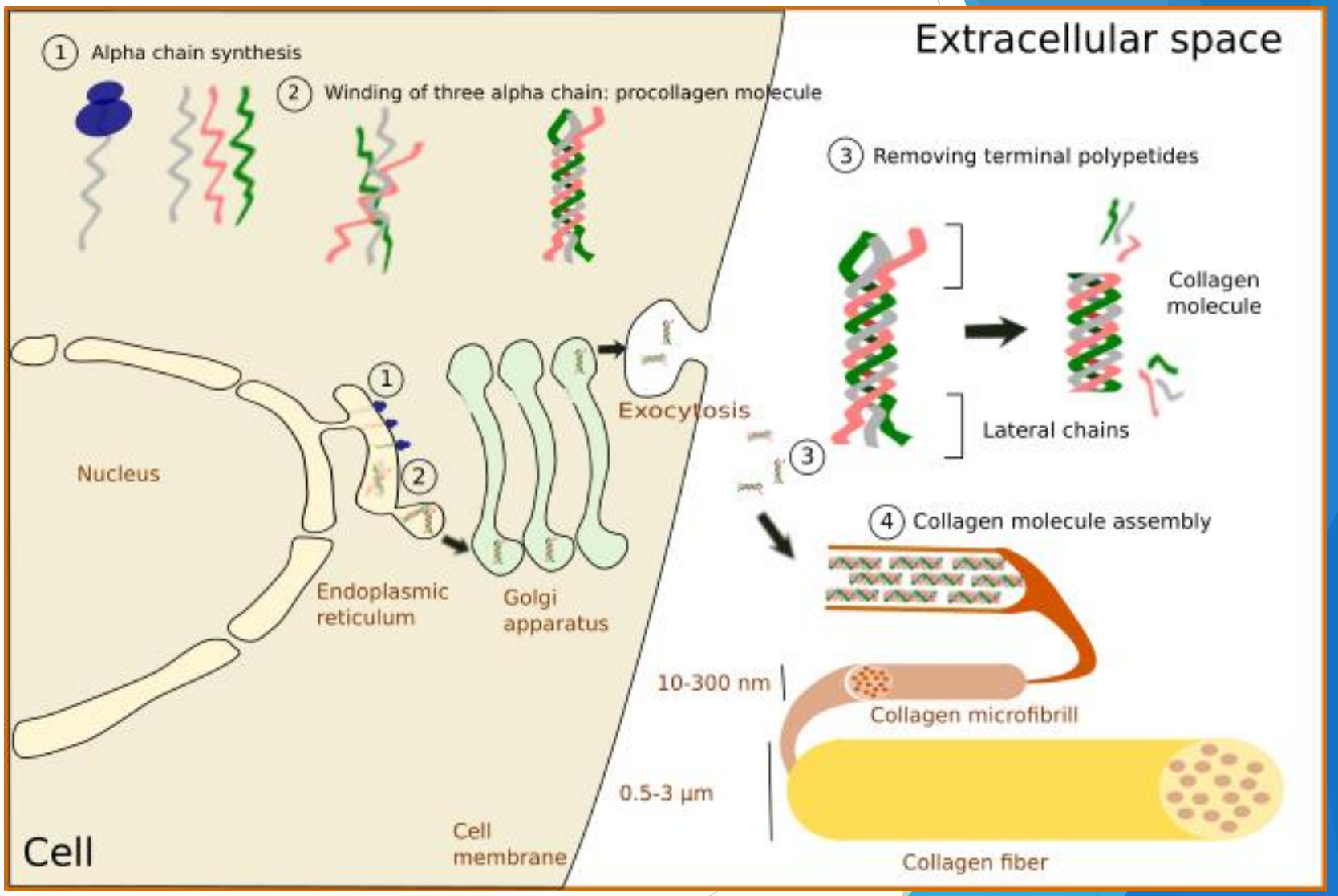
- Reticular – build of the collagen protein (type III), form networks



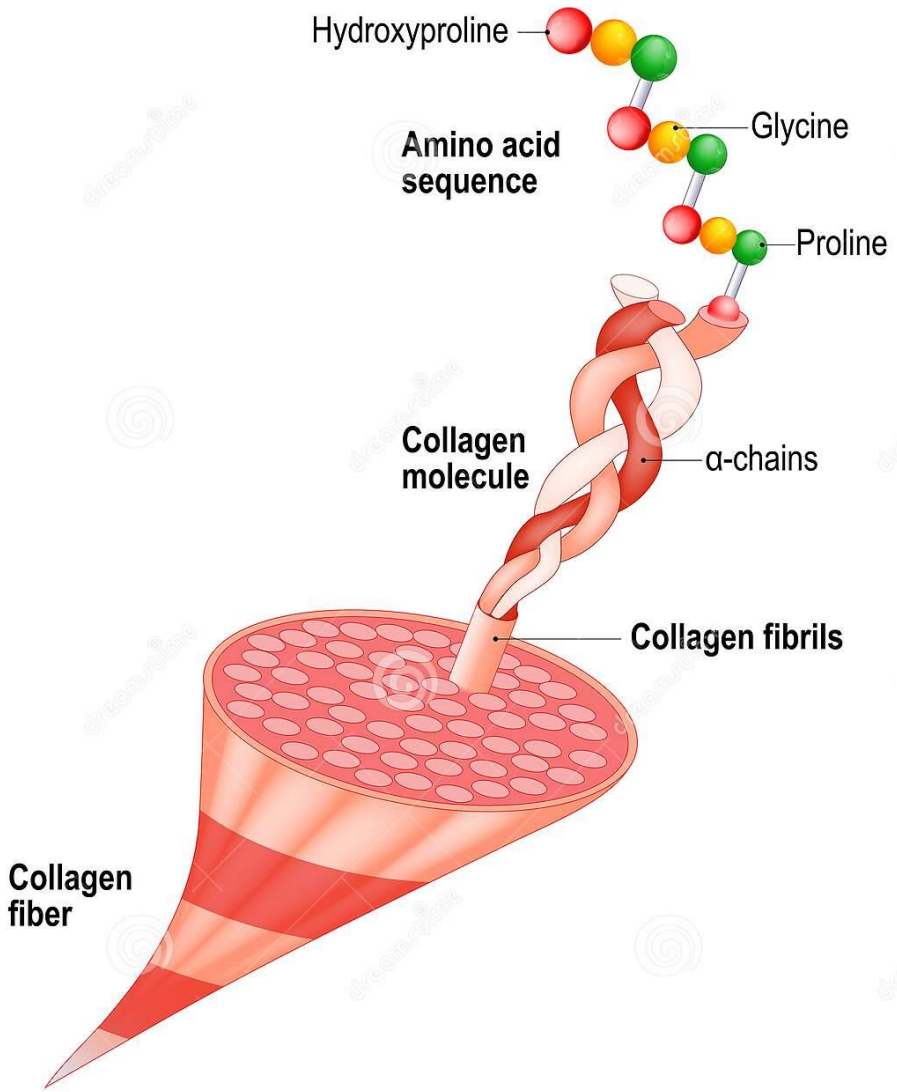
All fibers of CT are produced by fibroblasts

Levels of organization of collagen fibers

1. **Molecular level** (protofibrils). Each chain consists of glycine, proline and lysine aminoacids.
2. **Supramolecular level** (prortofibrils + hydrogen bonds =microfibril)
3. **Fibrilar level** (microfibrils + GAG, glycoproteins = fibril)
4. **Formation of collagen fibers**



Collagen


Hydroxyproline
Glycine
Amino acid sequence
Proline
Collagen molecule
α-chains
Collagen fibrils
Collagen fiber

Levels of organization of elastic fibers

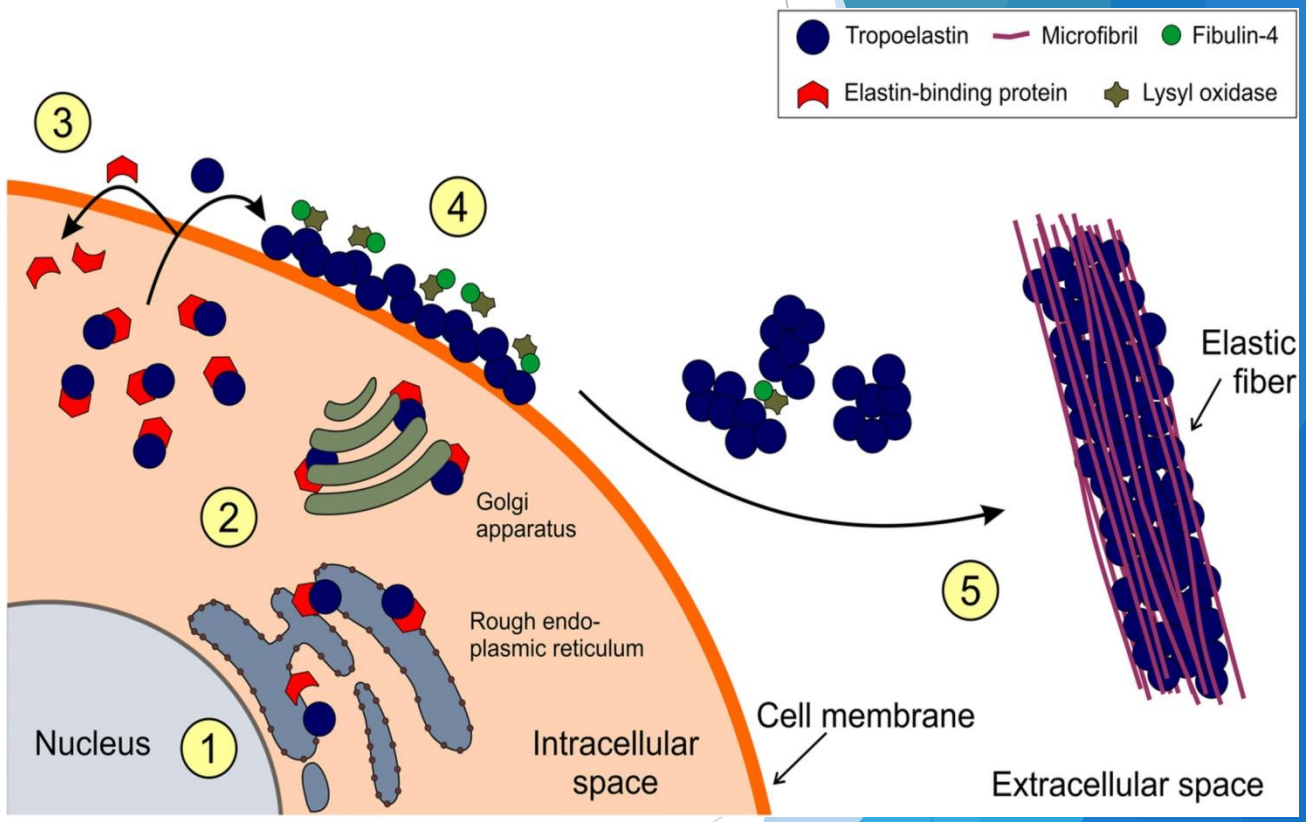
1. **Molecular level.** Molecules of elastin form globule.

Elastin molecule is represented by proline, glycine, desmosine, isodesmosine.

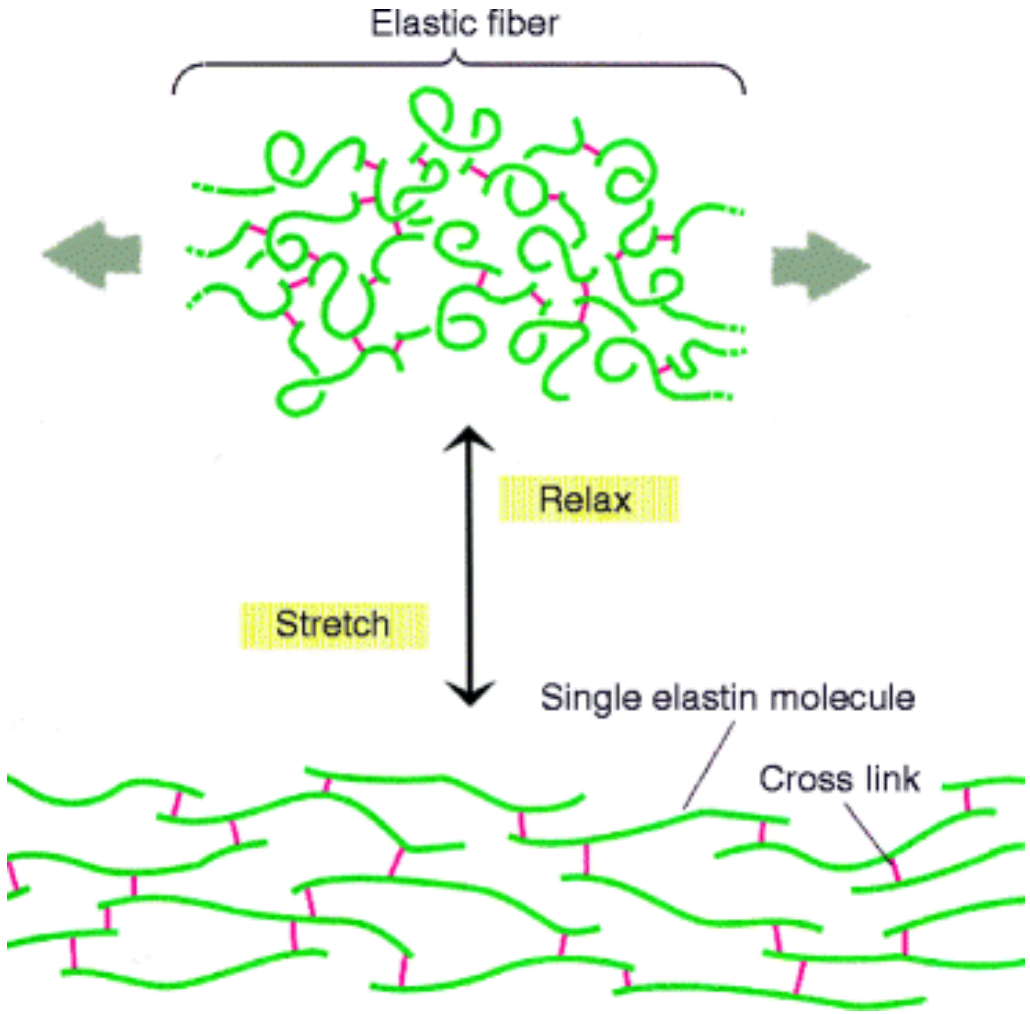
2. **Supramolecular level** (globules form tropoelastin)

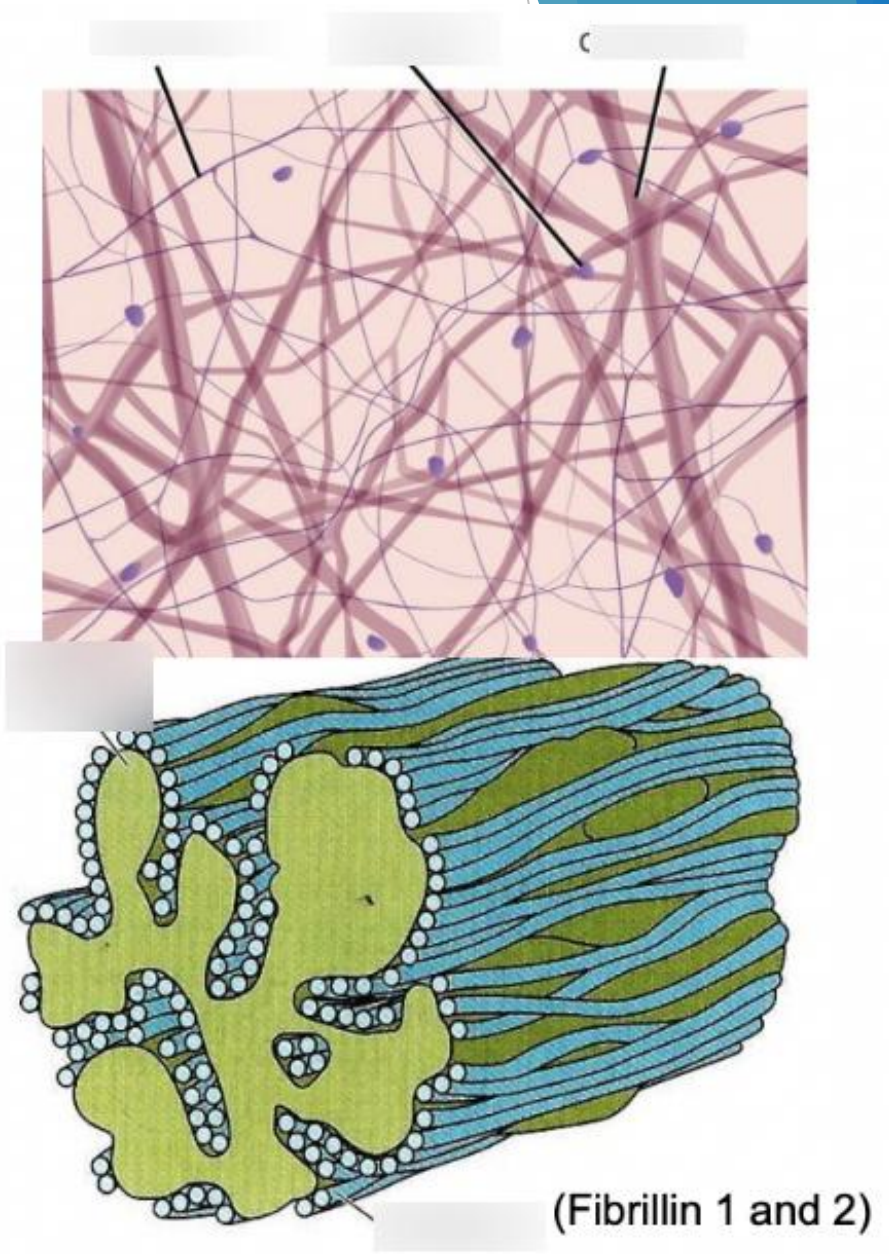
3. **Fibrilar level** (tropoelastin + glycoproteins (fibrillin)=microfibril)

4. **Formation of elastic fibers.** Elastic fiber represents as cylinder filled with elastin (amorphous component-90%) and surrounded by microfilaments (10%)



Elastic fiber





Ground substance

- Water
- Glycosaminoglycans. There are two types:

a) Sulfated: heparin sulfate, chondroitin sulfate.

b) Non-sulfated: hyaluronic acid

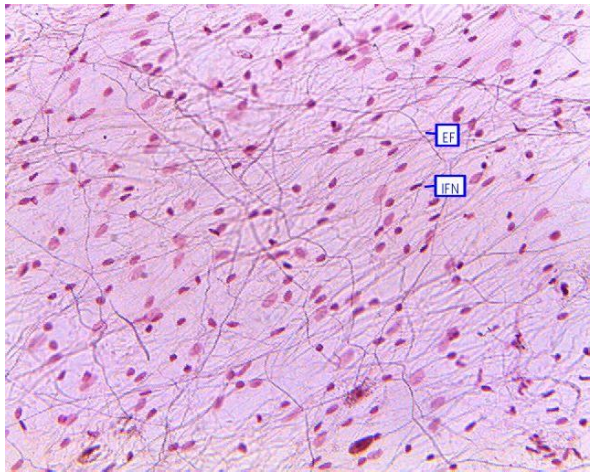
- Glycoproteins
- Proteoglycans
- Mineral substances

- *Differs among the different types of connective tissue*
- *Is responsible for the mechanical properties of the connective tissue*

Connective tissue proper
Fibrous connective tissue
Loose CT VS Dense CT

Loose connective tissue

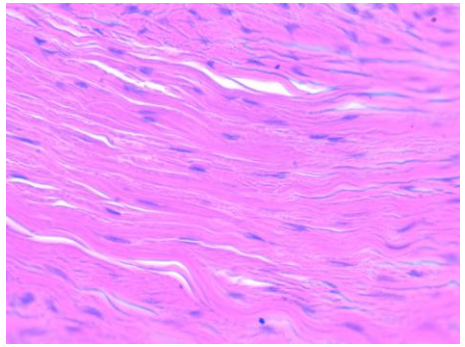
- A lot of different cells
- A lot of ground substance
- Small amount of fibers



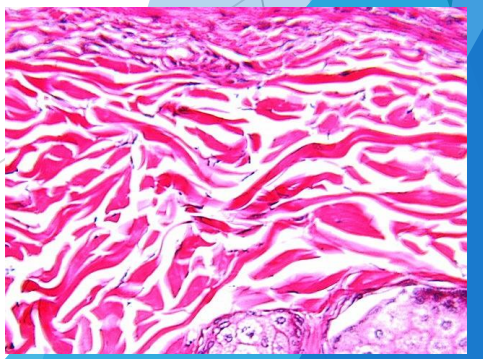
Dense connective tissue

- Small number of cells
- Little ground substance
- A lot of fibers

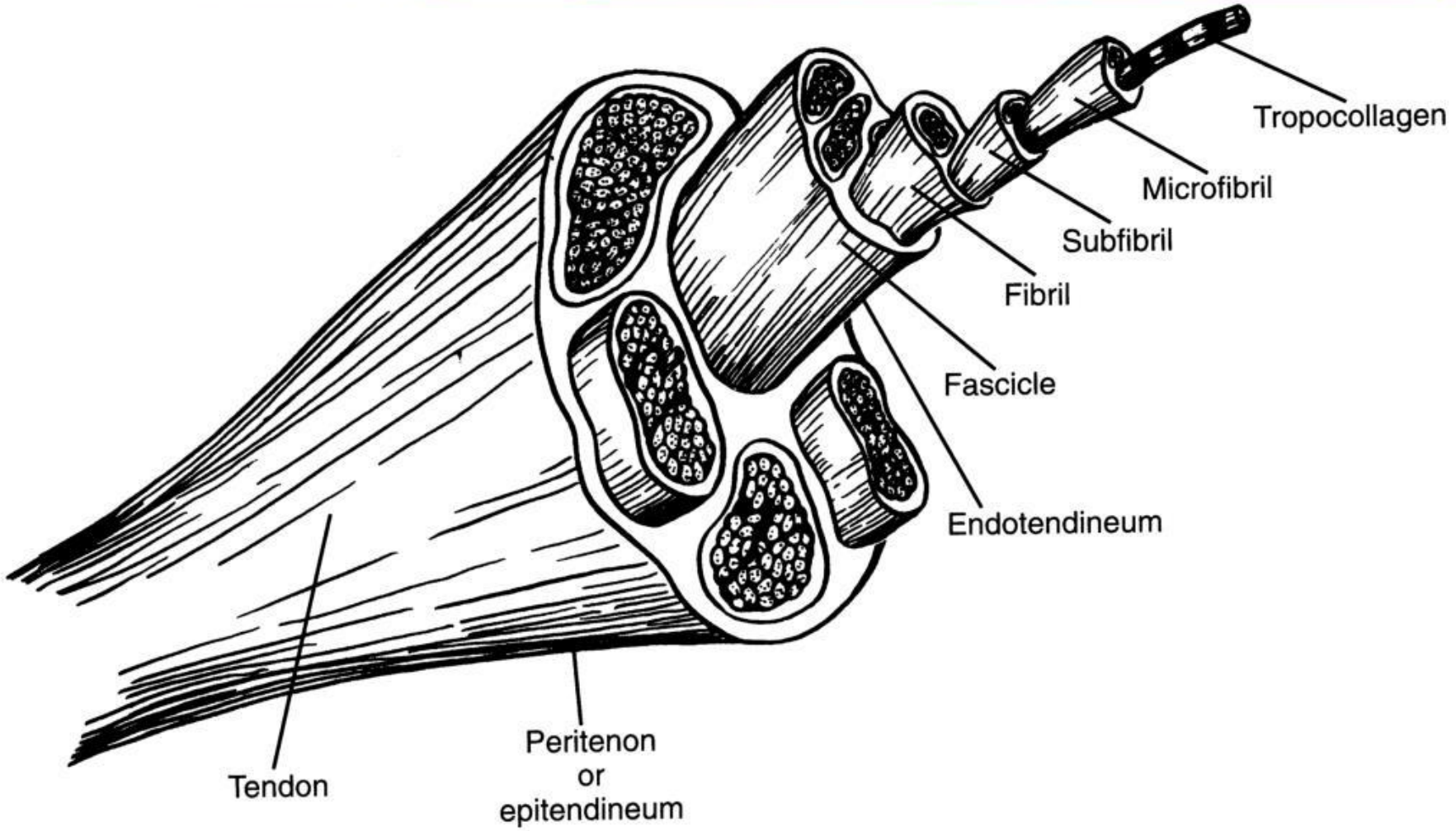
Fibers are parallel (dense regular CT) – tendons, ligaments, aponeuroses



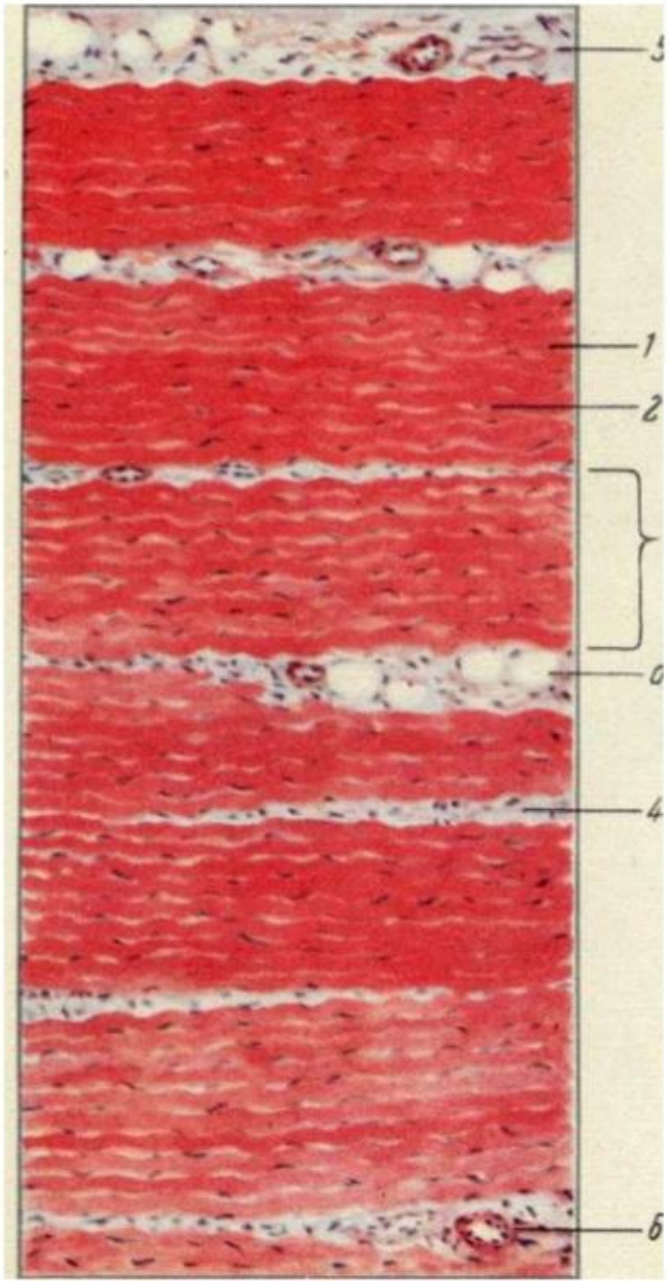
Fibers are in different directions (dense irregular CT) – dermis of the skin, capsules of organs)

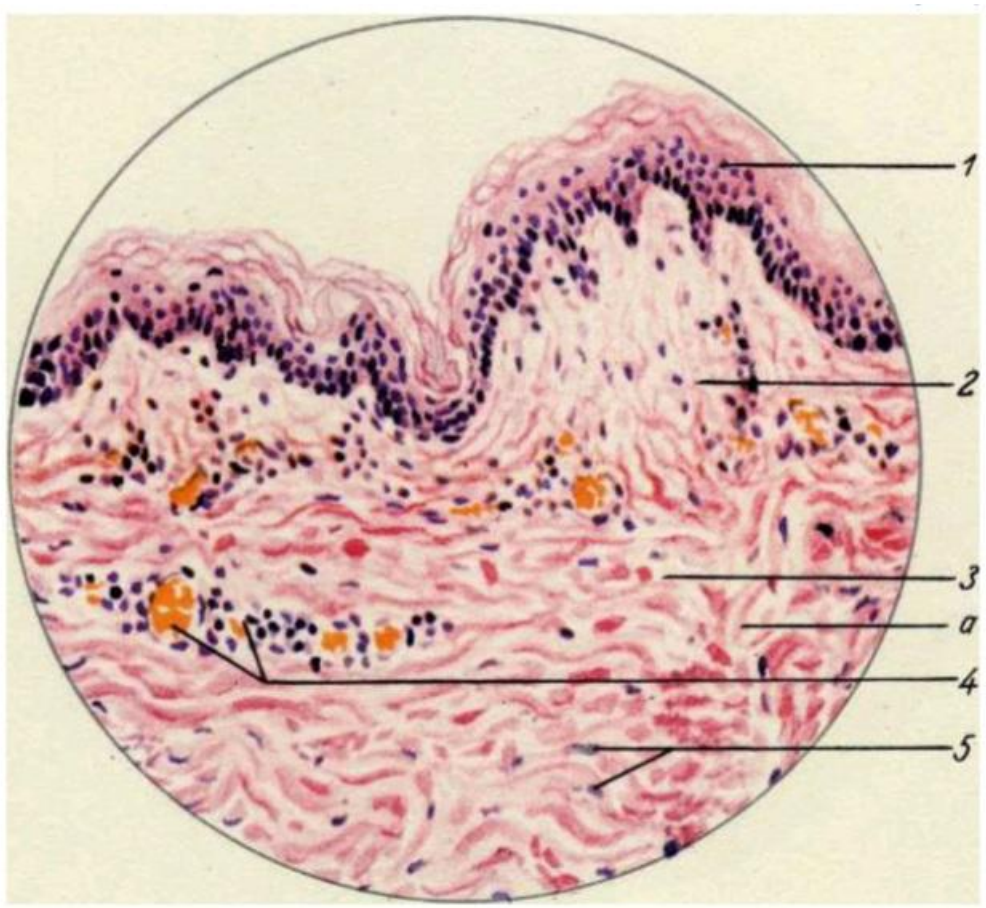


Ligament/Tendon Schematic



Dense regular and irregular connective tissue





Connective tissues with special properties

- Reticular connective tissue – consists of reticular cells and reticular fibers, found in hematopoietic organs (red bone marrow, spleen etc.)

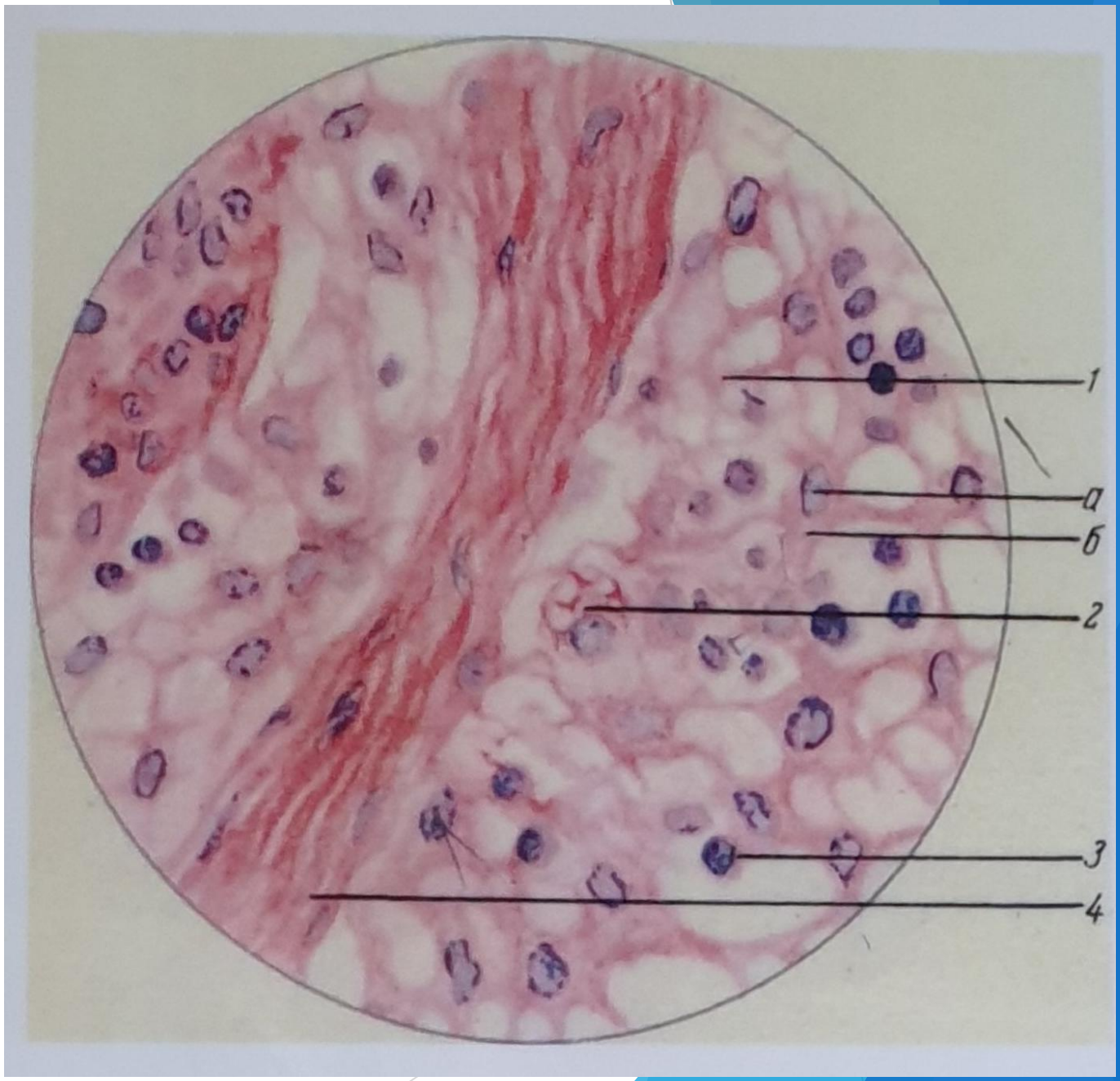
- Pigment tissue – contains numerous pigment cells (melanocytes); found in the iris of the eye, skin of the scrotum, anus, areola of the breast, nevus

- Mucous connective tissue – found in the umbilical cord of the fetus, prevents umbilical vessels form clamping; rich in hyaluronic acid
- Adipose tissue:
- White adipose tissue: adipocytes contain one large fat droplet
- Brown adipose tissue: adipocytes contain a lot of small fat droplets and mitochondria; high oxidative capacity: found only in fetus and newborns

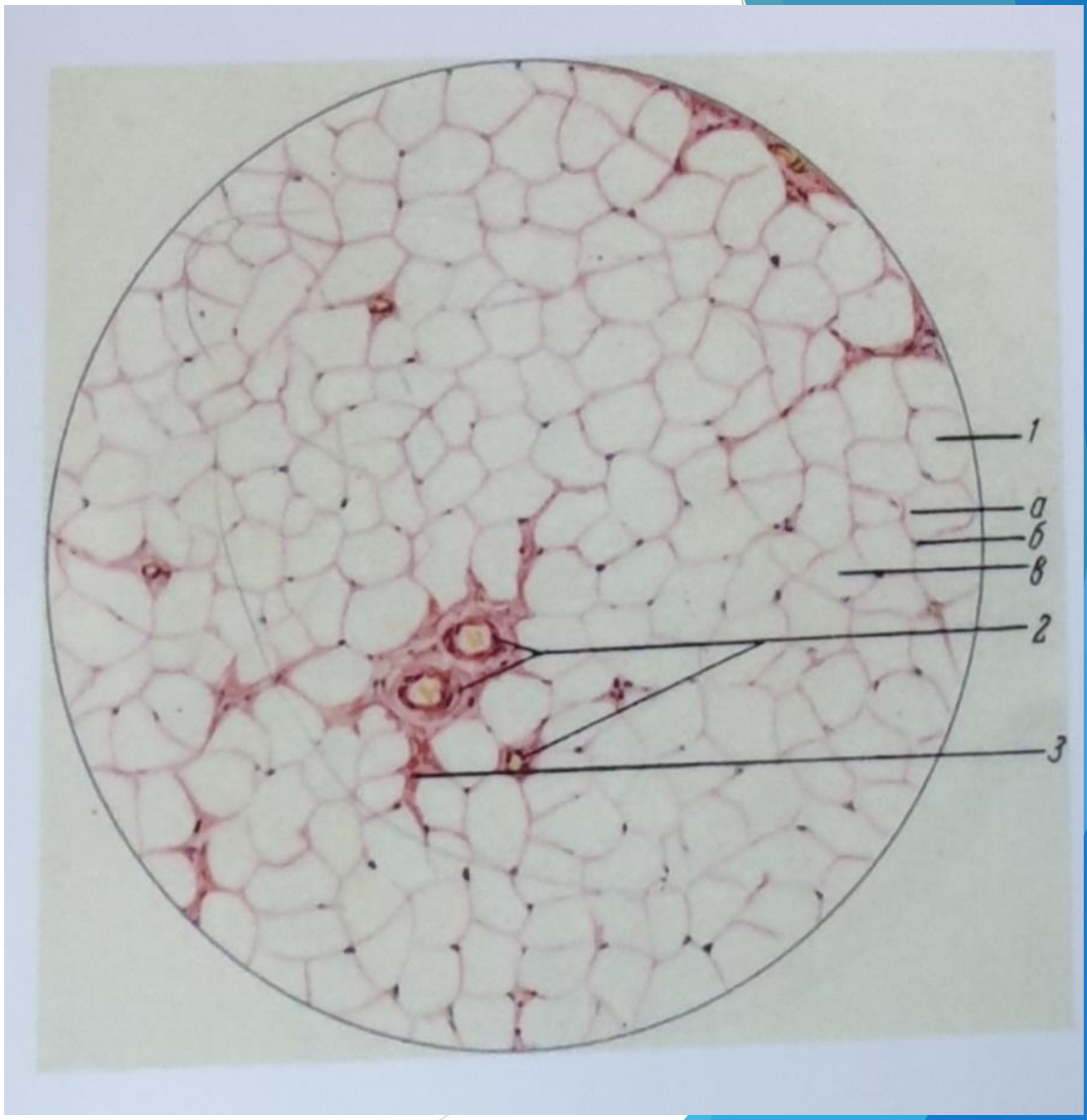
White fat

Brown fat

Reticular connective tissue



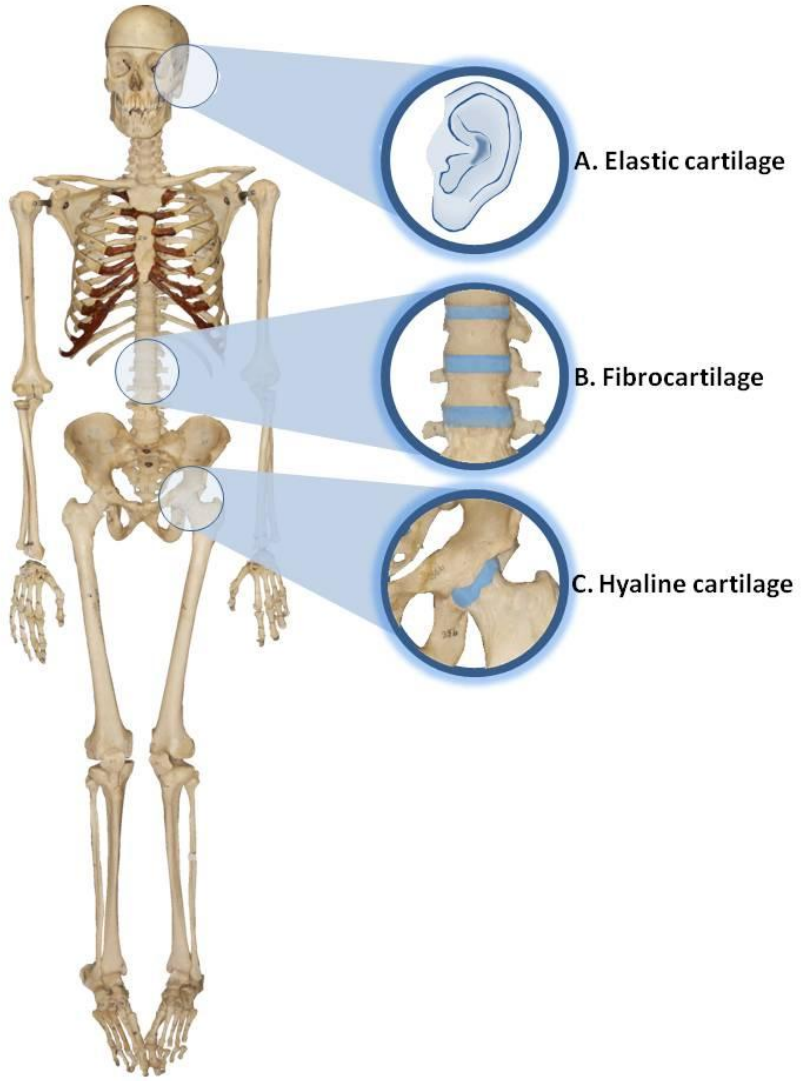
White adipose tissue



Skeletal connective tissues

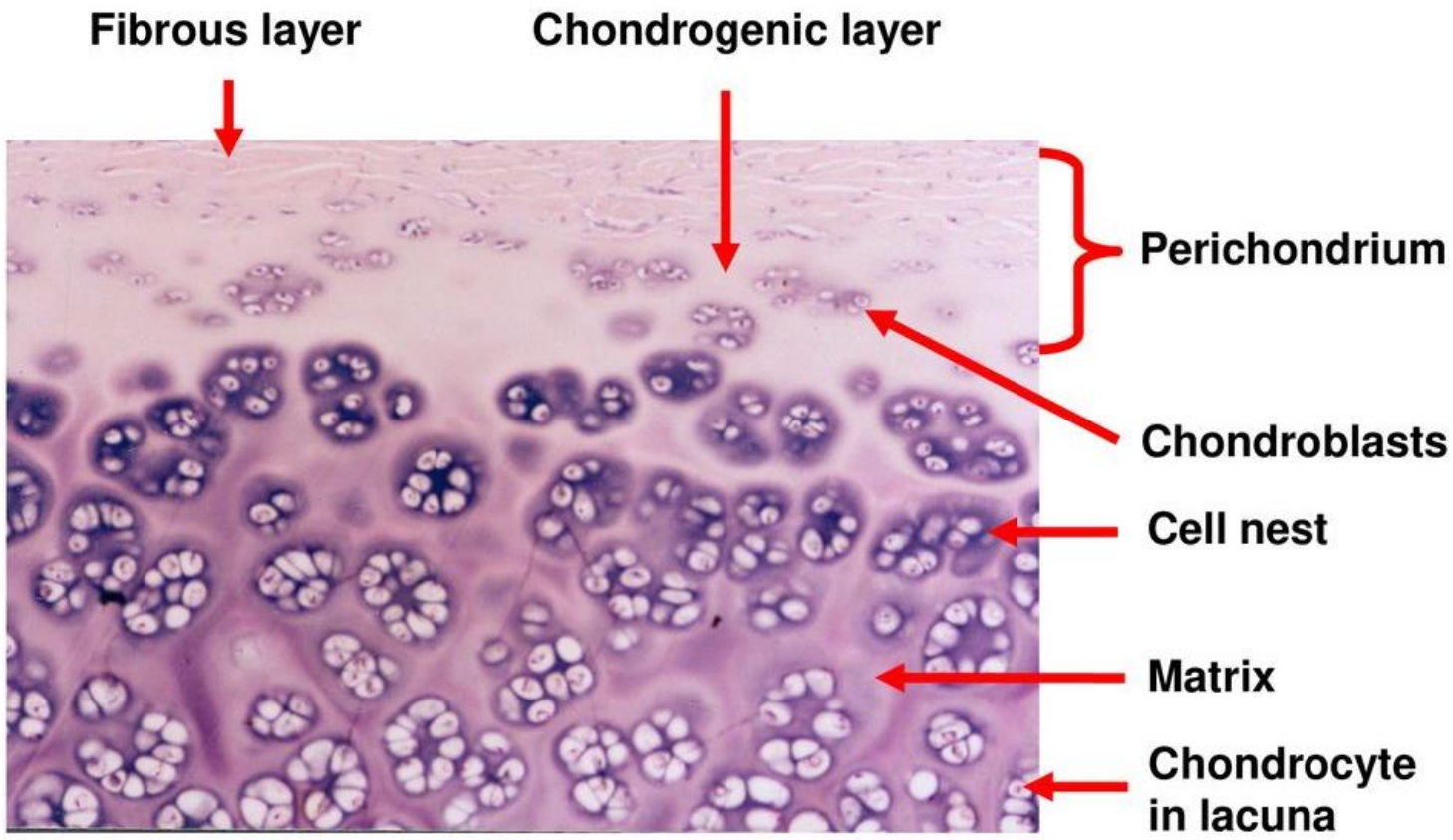
Skeletal connective tissues
Cartilage
General characteristics

- Consists of cells, fibers and ground substance
- No blood vessels
- Covered by perichondrium (except fibrocartilage), which provides nutrition, regeneration and growth
- Two types of growth: appositional (external) and interstitial (internal)
- Three types of cartilage: hyaline, elastic and fibrocartilage



Perichondrium

1) **Outer fibrous layer** – DCT
2) **Inner cellular layer-** chondroprogenitor cells and chondroblasts



Cells of cartilage

- Chondroblasts – located in the inner layer of perichondrium, produce extracellular matrix of cartilage
- Chondrocytes type I – located right under the perichondrium, are divided by mitosis and form isogenous groups
- Chondrocytes type II – located in the middle layers of cartilage, produce extracellular matrix of cartilage
- Chondrocytes type III – old cells, located in the deep layers of cartilage, do not divide and do not produce extracellular matrix

Type of cartilage	Hyaline	Elastic	Fibrocartilage
Perichondrium	+	+	-
Cells	Chondrocytes, which form isogenous groups (3-4 cells) and located in lacunae	Chondrocytes, which form isogenous groups (2-3 cells) and located in lacunae	Chondrocytes, which form isogenous groups (1-2 cells) and located in lacunae
Fibers	Collagen type II	Elastic (mostly) + Collagen type II	Collagen type I + Collagen type II
Ground substance	70-80% of water, chondronectin, glycosaminoglycans (GAG), proteoglycans	Less GAGs and chondronectin than in hyaline cartilage	The smallest amount of GAGs and chondronectin
Localization	Ribs, joints, respiratory tract	Ear	Intervertebral discs, Transition between hyaline cartilage and ligaments

Hyaline cartilage

Localization: ribs, joints, resoiratory tract.

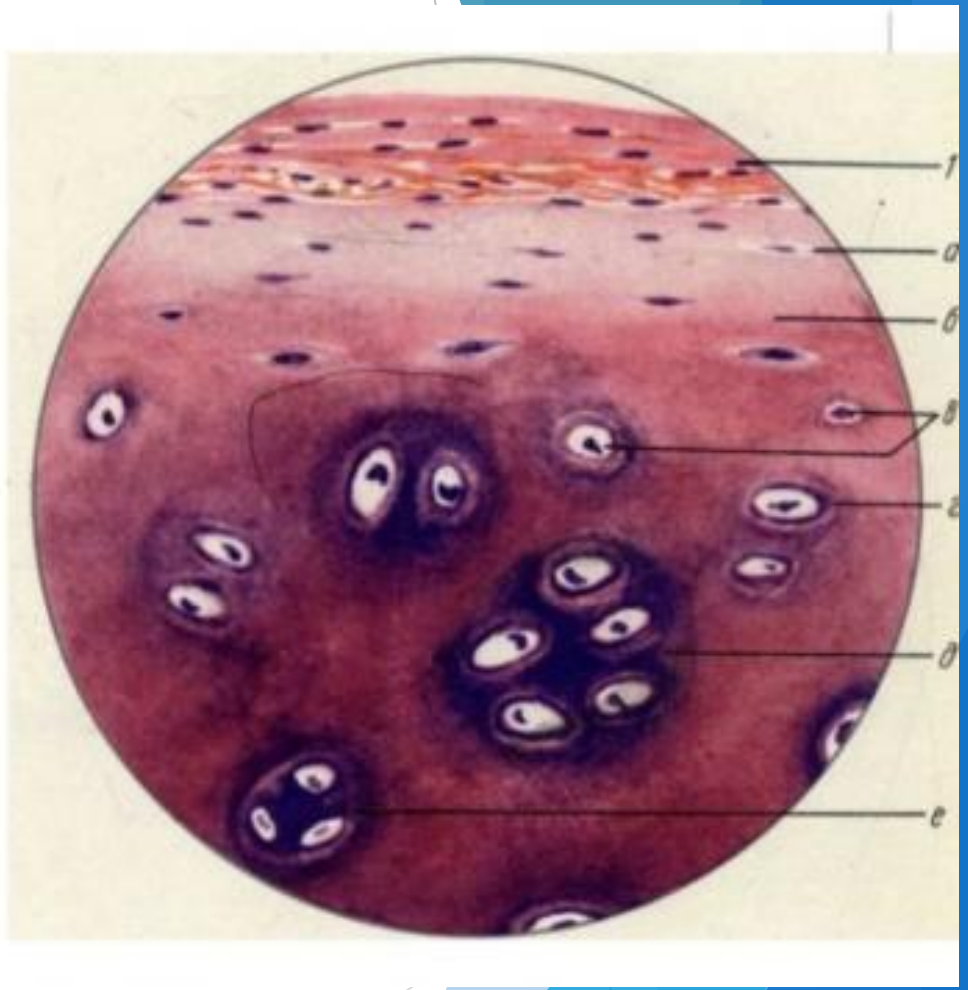
Cells: 3-4 chondrocytes are located in the lacunae

Extracellular matrix:
collagen II,
70-80% of water,
chondronectin, GAG,
proteoglycans

Гиалиновый (стекловидный) хрящ ребра. Окраска ематоксилин-эозином. Увеличение: объектив 40, окуляр 10.

1 — надхрящница: *а* — молодые хряще¬вые клетки, *б* — основное межклеточное вещество, *в* — хрящевые клетки, *г* — хря¬щевая капсула, *д* — клеточные терри¬тории, *е* — изогенная группа клеток.

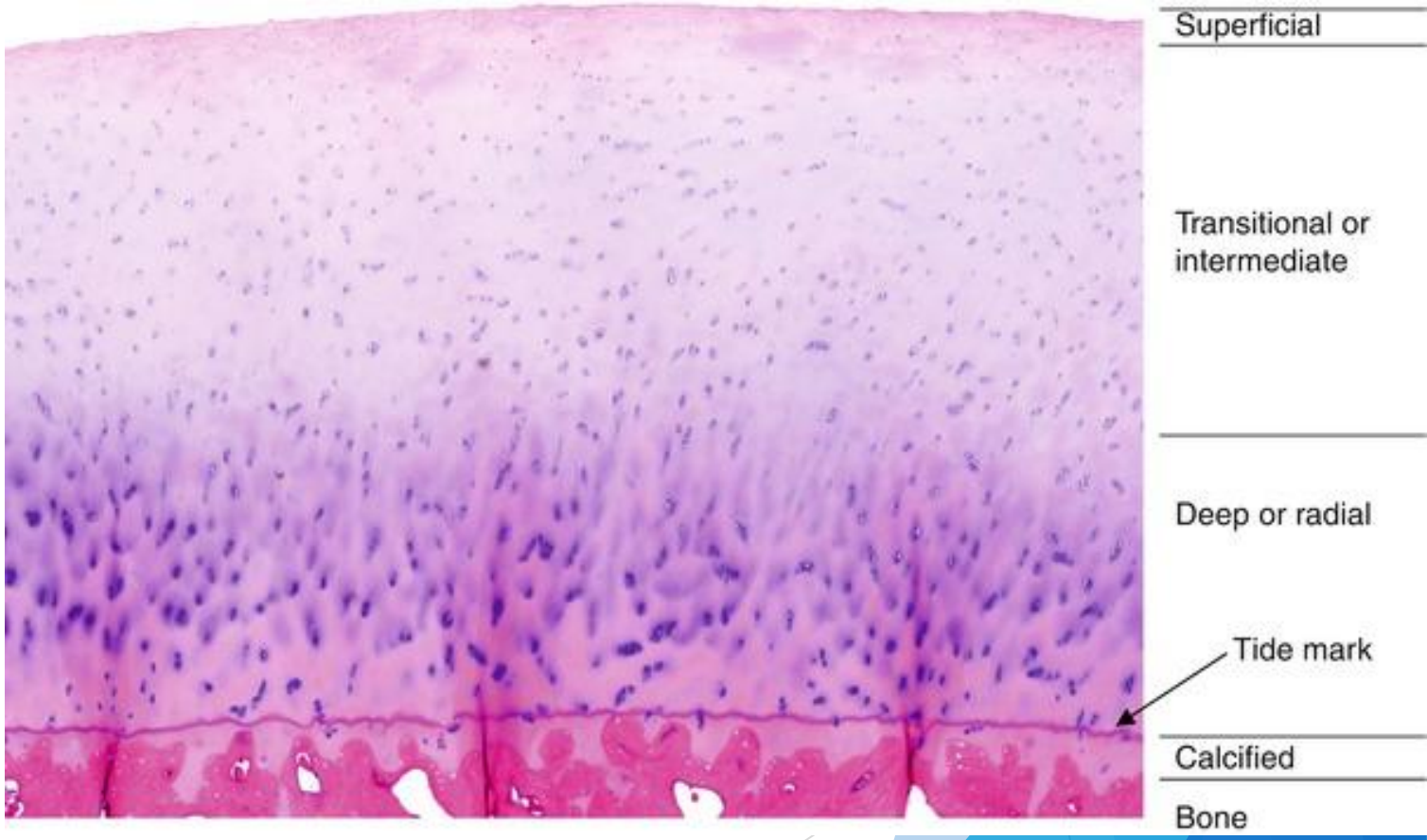
Hyaline cartilage. HE. HM.
1. perichondrium
a. young cells of cartilage
б. extracellular matrix
в. chondrocytes
г. capsula of mature cells
e. isogenous group of cells



Articular cartilage

- **Localization:** covers articular surfaces
- No perichondrium
- **Zones:**

1. **The outer zone:** contains young immature flattened cells arranged parallel to the free surface.
2. **The medium zone:** round chondrocytes, collagen fibers arranged in a oblique orientation.
3. **The deep zone:** small cells form columns that are directed perpendicularly to the articular surface.
4. **Calcified zone:** calcified cartilage, here found blood vessels.Tidemark is heavily calcified line.

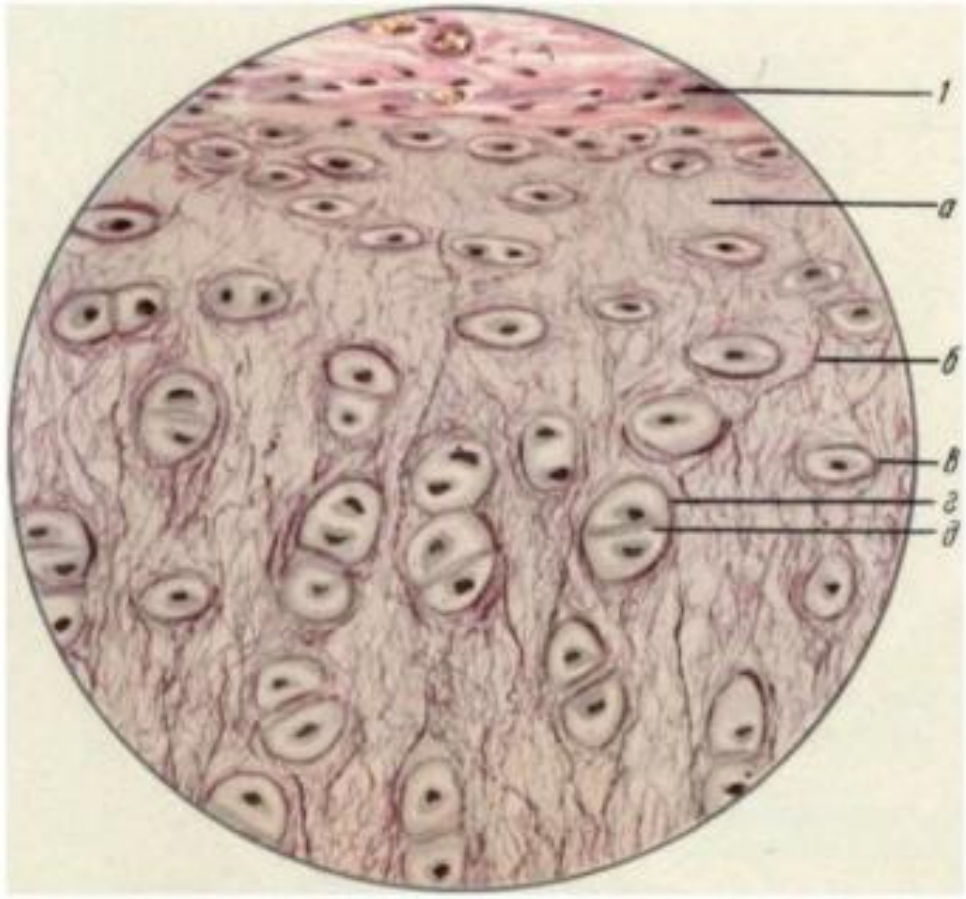


Elastic cartilage

Localization: ear

Cells: 2-3 chondrocytes are locate in the lacunae

Extracellular matrix: elastic, collagen II, less GAG, chondronectin

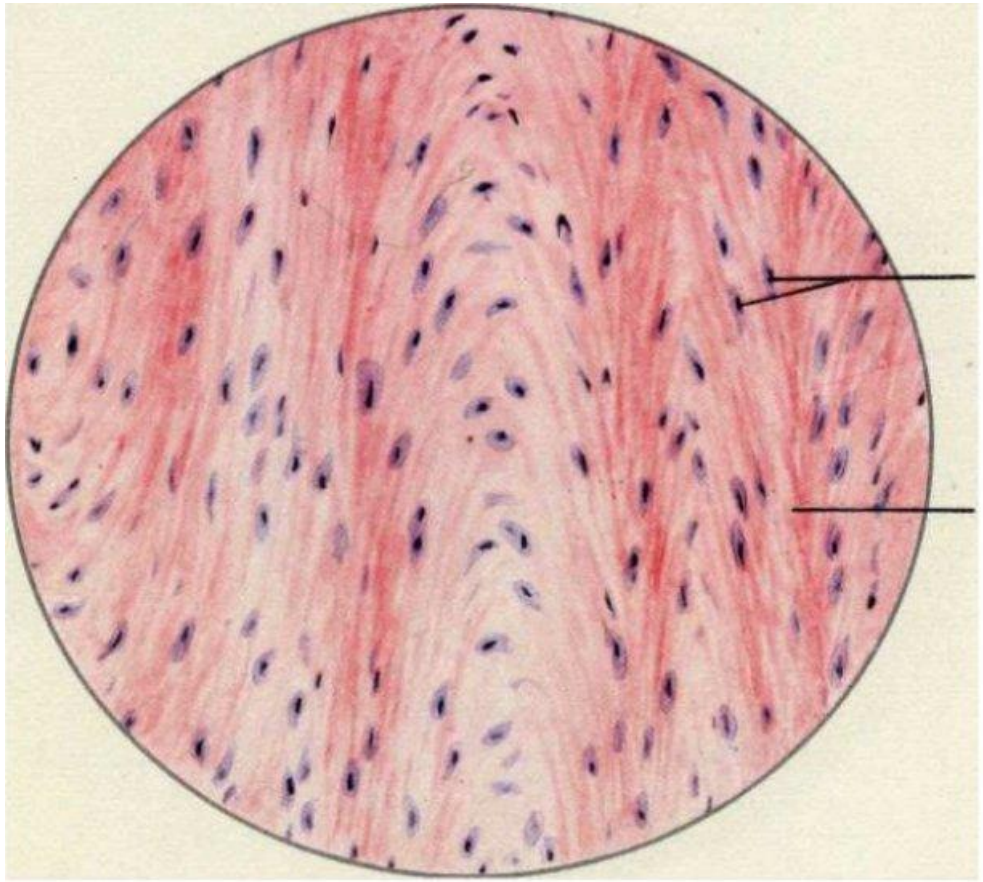


Elastic cartilage. H.Orcein. H. M.
1. perichondrium
а. extracellular matrix
б. elastic fibers
в. cell of cartilage
г. capsule of mature cells
д. isogenous groupe of cells

Эластический хрящ ушной раковины. Окраска гематоксилином и орсеином. Увеличение: объектив 40, окуляр 10.
1 — надхрящница: *а* — основное ве¬щество, *б* — эластические волокна, *в* — хрящевая клетка, *г* — хрящевая капсула, *д* —

Fibrocartilage

- **Localization:** vertebral discs, slightly movable joints, places where tendon attaches to bones.
- **Cells:** 1-2 chondrocytes in the lacunae
- **Extracellular matrix:** collagen type I,II, small amount of GAG and chondronectin



Волокнистый хрящ. Ок¬раска гематоксилин-эозином. Уве¬личение: объектив 40, окуляр 10.

1 – хрящевые клетки;

2–коллагеновые волокна.

Fibrocartilage. HE.HM.
1. chondrocytes
2. bundles of collagen fibers

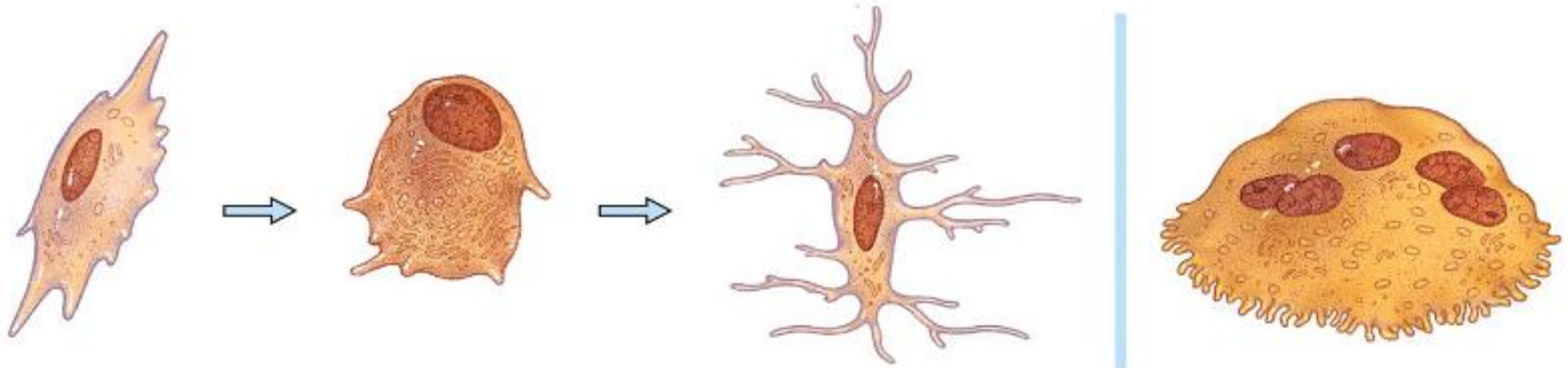
Skeletal connective tissues
Bone tissue
General characteristics

- Consists of cells, fibers and extracellular matrix
- Contains blood vessels
- Two types of bone : woven bone and lamellar bone (compact and spongy)

Cells of the bone tissue

- Ostoprogenitor cells – immature cells, located in periosteum differentiate into osteoblasts
- Osteoblasts – mature cells, located in periosteum, produce extracellular matrix
- Osteocytes – definitive form of the osteoblasts, located in the bone lacunae
- Osteoclasts – produced in the red bone marrow (hematogenic origin), destroy extracellular matrix

Cells of the bone tissue



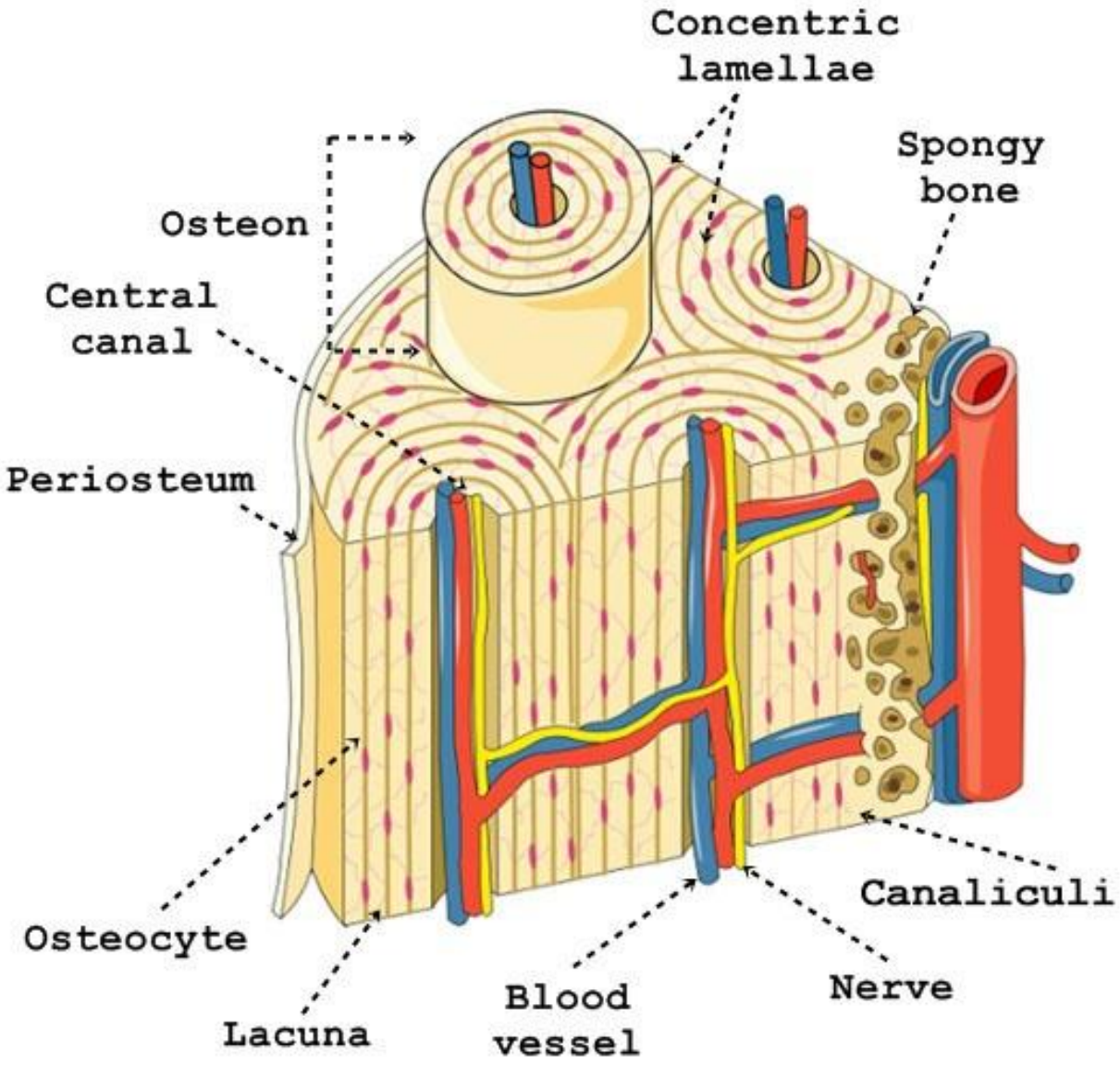
Osteogenic cell (develops into an osteoblast)

Osteoblast (forms bone matrix)

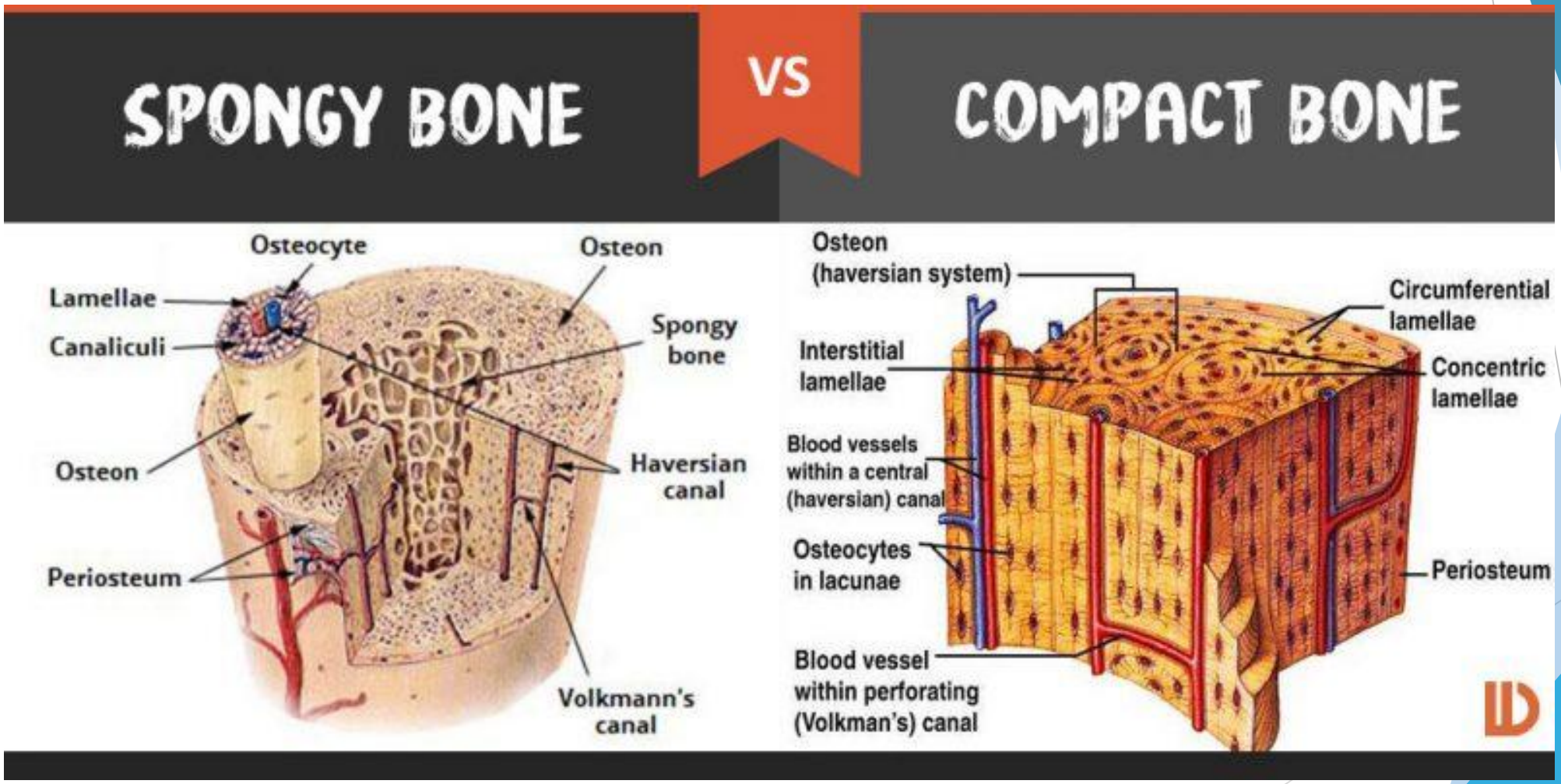
Osteocyte (maintains bone tissue)

Osteoclast (functions in resorption, the breakdown of bone matrix)

Compact bone



Spongy bone


SPONGY BONE
VS
COMPACT BONE
Osteocyte
Osteon
Lamellae
Canaliculi
Spongy bone
Osteon
Haversian canal
Periosteum
Volkmann's canal
Osteon (haversian system)
Circumferential lamellae
Interstitial lamellae
Concentric lamellae
Blood vessels within a central (haversian) canal
Osteocytes in lacunae
Periosteum
Blood vessel within perforating (Volkman's) canal