Lecture 6

General med_2nd semester

General histology

- Tissues - definition, their origin and classification
- Connective and supporting tissue - general characteristics, components and classification of them
- The connective tissue proper - types, chief distribution, and function
- Supporting tissues: cartilage and bone - types, chief distribution, and function
- Histogenesis of bone tissue (ossification)

Tissues of the adult and their classification

tissue = a complex of similar cells specialized in common direction and able to perform a common function

4 primary (basic, fundamental) tissues

- **epithelial tissue (the epithelium)**
- **connective and supporting tissues**
- **muscle (muscular) tissue**
- **nerve tissue**

tissues form elementary building units of organs (main tissue + supporting tissue /-s)

the occurrence, arrangement and proportions of tissues in individual organs are different and are object of study in the microscopic anatomy

Epithelial tissue

is composed of cells that are in close apposition with one another; among cells there is present only a small amount of intercellular substance

epithelial cells are usually of regular form without extensive cytoplasmic processes

adhesion between cells is very strong

epithelia derive from the all germ layers

Connective and supporting tissues

unlike epithelia, contain **cells** that are separated from one another; the intervening spaces are occupied by the **intercellular substance (material)** produced by cells

the intercellular substance consists of two components:

fibers and **amorphous ground substance**

connective and supporting tissues are always of **mesenchymal origin**

Muscle tissue

is composed of elongated cells that are able to contract

for this function cells are well adapted as they contain contractile proteins: actin and myosin

cells or muscle fibers tend to be aggregated in bundles that are conspicuously different from the surroundings tissues

three types of muscle tissue are distinguished: **smooth, skeletal, cardiac**

smooth muscle tissue derives from the mesenchyme, skeletal and cardiac from the mesoderm

Nerve tissue

consists of **nerve cells, neurons**, and associated supporting cells of various type called **neuroglia**

neurons are highly specialized cells that have the ability to receive, generate and transmit nerve impulses

except microglia, both cell lines of the nervous tissue derive from the ectoderm (neuroectoderm)

Connective and supporting tissues - general characteristics, their components and classification

in adults they are classified in:

- connective tissues
- cartilage
- bone tissue

they posses three characteristics in common:

- they develop from the **mesenchyme** that is itself derived from the third germ layer or mesoderm,
- all they are composed of **cells** and relatively large amount of **intercellular substance** cells lie more or less scattered, sometimes not in contact, sometimes touching only at the ends of long cytoplasmic processes,
- the intercellular substance consists of **fibers** and **ground amorphous substance**

Functions:

- **mechanical function** - bones form the skeleton of body, skeleton of organs inclusively their stroma etc.)
- **nutritional function** - is maintained by the intercellular substance
- **defensive function** - some connective cells as **histiocytes, plasmocytes, leukocytes** mobilize to defend the body against bacteria and other foreign bodies
- function of **storage** - accumulation of stored material (fat in adipocytes)

FIBERS

are of three kinds distinguishable by their appearance and chemical reaction: **collagenous or white, reticular, and elastic**

White or collagenous fibers

are the most common

posses little elasticity, but offer great resistance to pulling force (several hundred kg/cm^2)

white fibers are dissolved by weak acids, and yield gelatin when boiled

fibers are 1-12 [redacted]m in thickness and consist of bundles of smaller parallel **fibrils** 0.3-0.5 [redacted]m thick

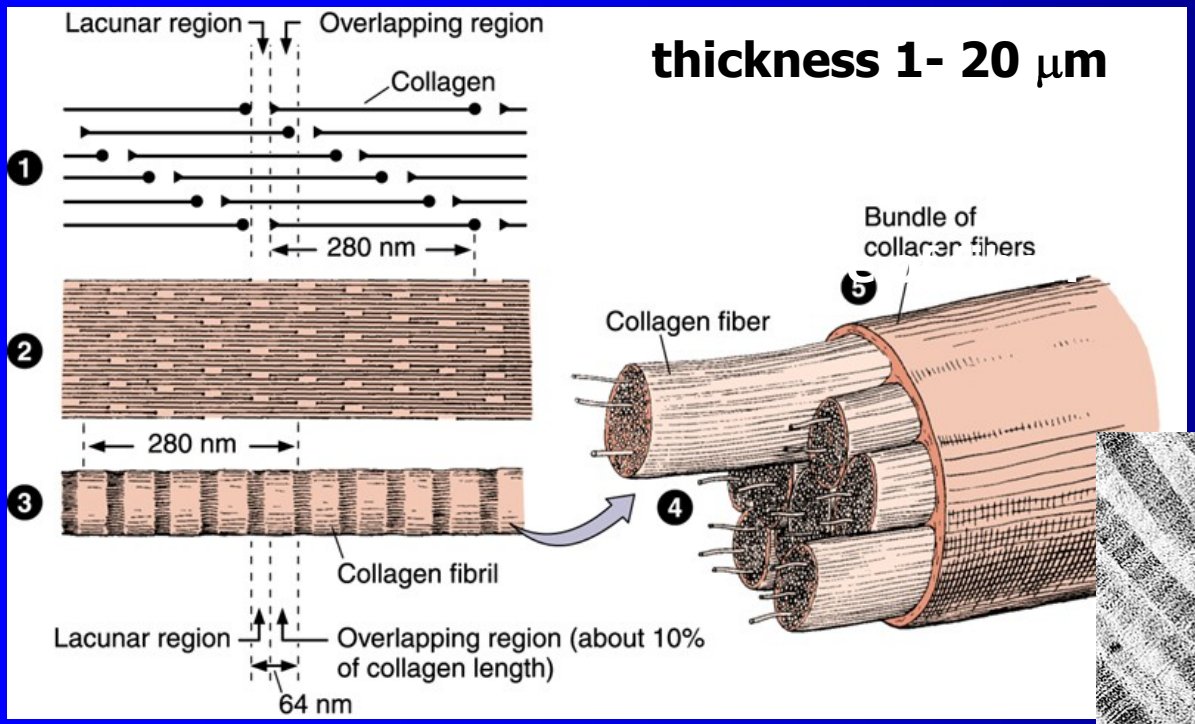
by electron microscope it has shown that each fibril consists of **microfibrils** (unit fibers of collagen) having diameter 40 to 100 nm

microfibrils reveal characteristic periodic cross bandings with an interval 64 nm in the mature microfibrils

each microfibril is made up of long polypeptide chains that consist of **tropocollagen**

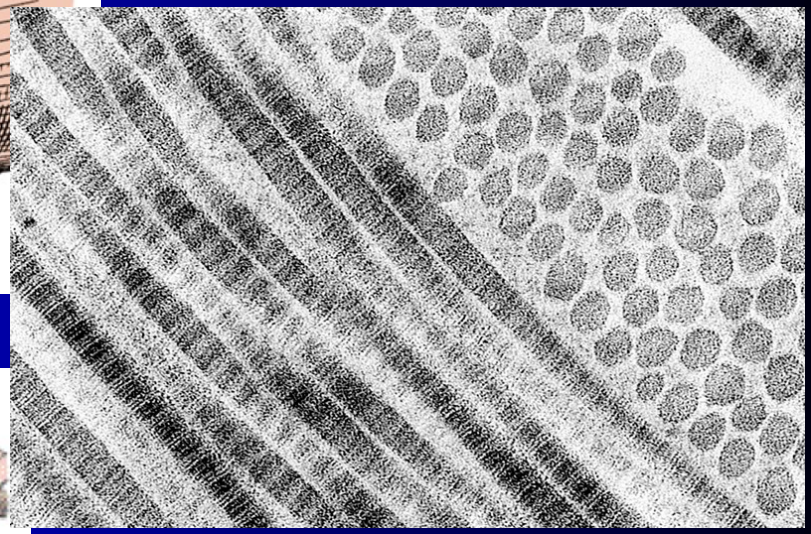
in tissue sections fibers are colored pink to red by H.E., more specifically they are stained by acid fuchsin (red) and anilin blue

structure of collagen fiber:

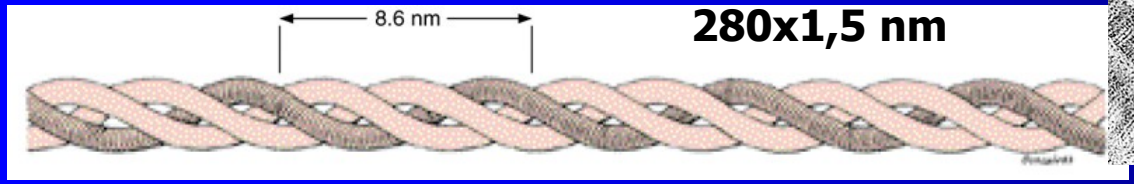


thickness 1- 20 μm

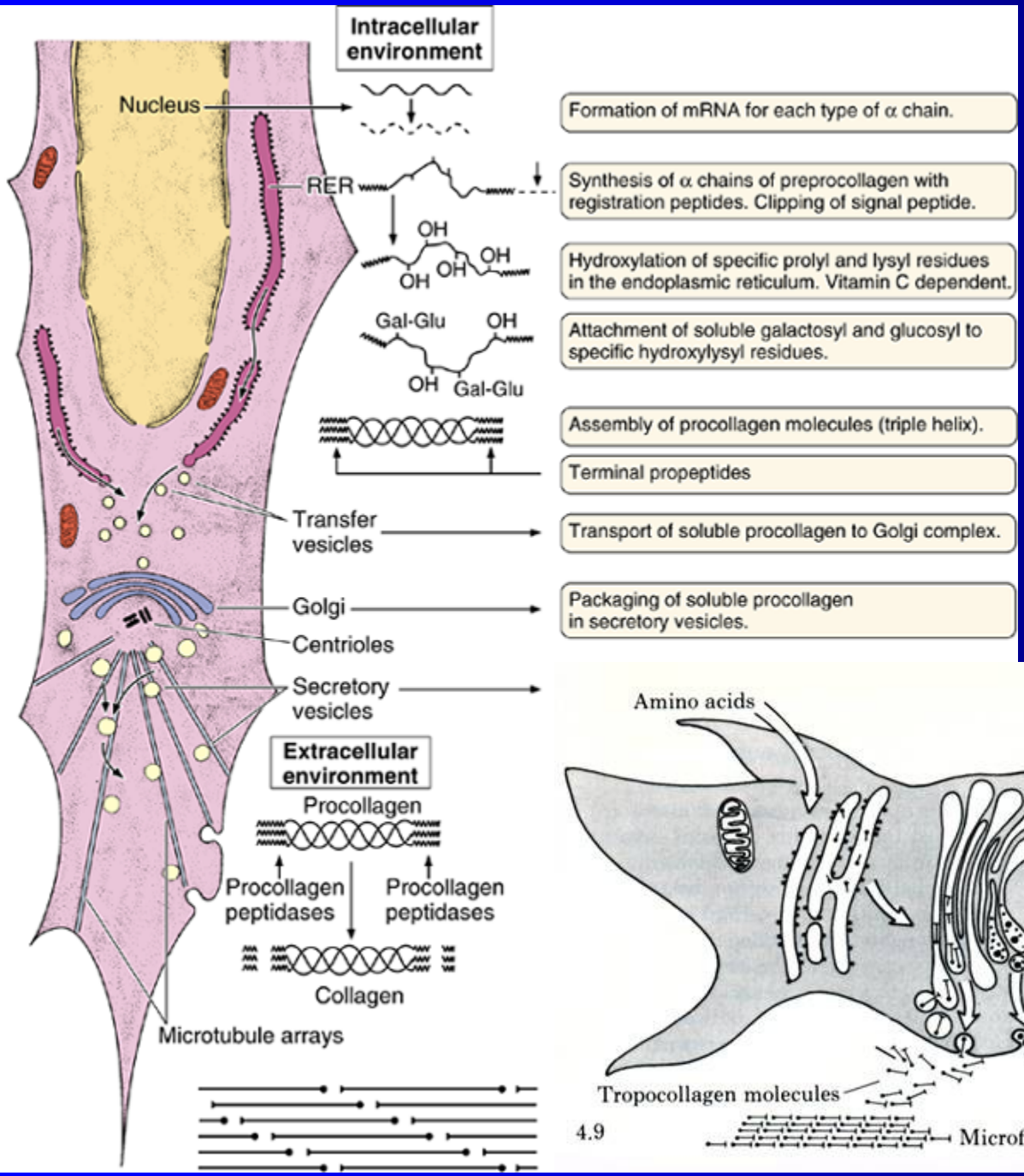
occurrence:
in all types of connective and suppurting tissue



macromolecule of tropocollage



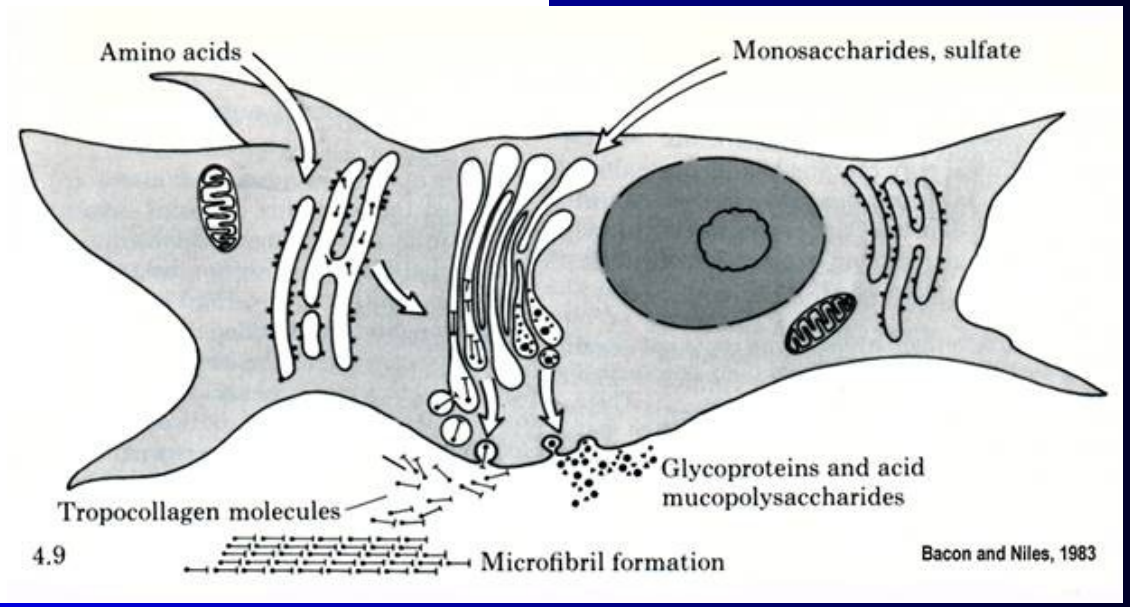
280x1,5 nm



synthesis of collagenous fibers:
fibroblasts, chodroblasts, osteoblasts, odontoblasts

procollagen

/enzyme procollagen peptidase
tropocollagen



Reticular fibers

similar to white fibers but are usually finer in caliber

do not stain appreciably with eosin, but have an affinity for silver salts (are termed as argyrophil)

chemically they are composed of molecules of tropocollagen like the white fibers

reticular fibers form a nestlike supporting framework of some lymphatic organs, they occur around small blood vessels, muscle and nerve fibers, and also the fat cells

Elastic fibers

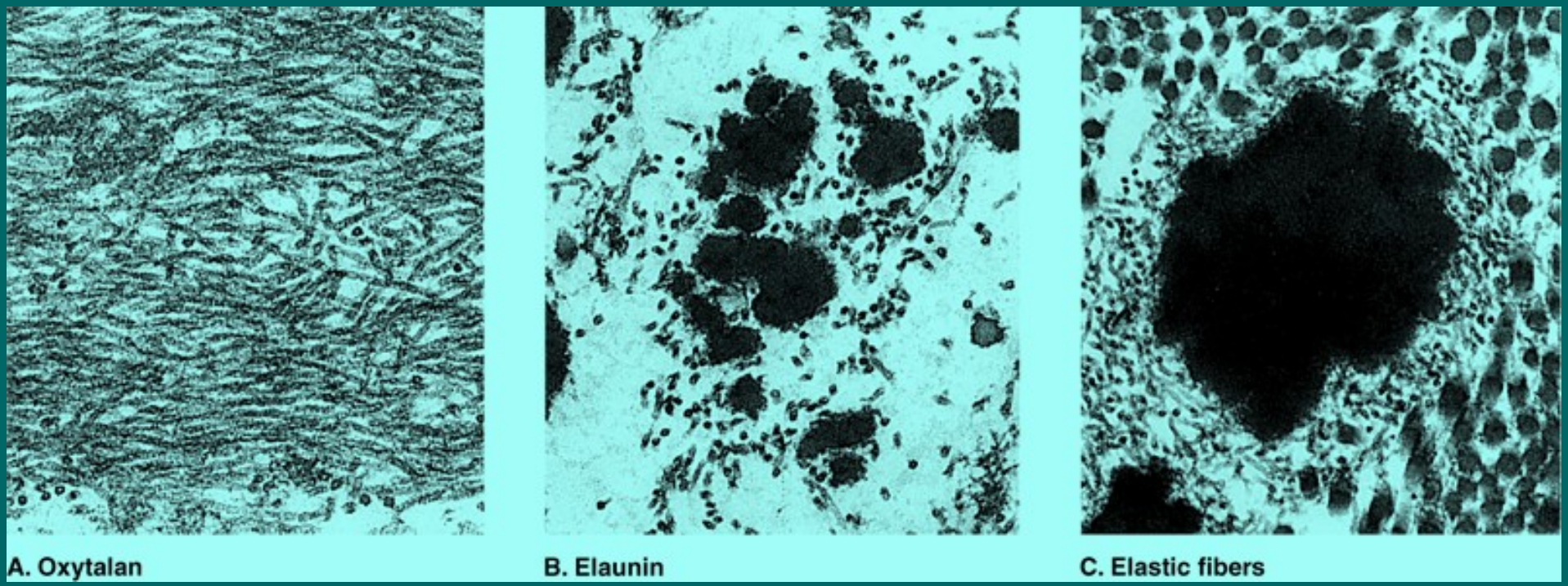
they stain unspecifically with eosin (pink) and selectively with orcein (brown) or resorcin-fuchsin (dark blue-purple)

characteristic of these fibers is elasticity, are branched and form networks, d. cca 1 [redacted]m,

fibres are composed of **glycoprotein microfibrils** and albumoid **elastin** that shows remarkable resistance to hot water, acids and alkalis

by electron microscopy elastic fibers consist of peripheral collection of thin tubular fibrils of 10 nm diameter that surround the central amorphous component

elastic fibers occur singly or in the form of sheets



Electron micrographs of developing elastic fibers. A: In early stages of formation, developing fibers consist of numerous small glycoprotein microfibrils. B: With further development, amorphous aggregates of elastin are found among the microfibrils. C: The amorphous elastin accumulates, ultimately occupying the center of an elastic fiber delineated by microfibrils. Note the collagen fibrils, seen in cross section.

GROUND SUBSTANCE

ground substance of connective tissue is a homogeneous semifluid material that surrounds the cells and fibers

is composed of **mucopolysaccharides** (newly glycosaminoglycans), **proteins** (**proteoglycans and glycoproteins**), **water**, and **minerals**

mucopolysaccharides: the commonest are **hyaluronate, chondroitin-4-sulfate, chondroitin-6-sulfate**

hyaluronate (hyaluronic acid) is very important because the viscosity of ground substance depends on the content of it

in preparations the ground substance seems to be structureless and stains metachromatically with the toluidine blue

the ground substance like as fibers is elaborated by endoplasmic reticulum of connective tissue cells, especially of fibroblasts

Connective tissue

cells, fibers, and ground substance

Connective tissue proper

- loose (areolar) connective tissue
- dense (fibrous) connective tissue
  - regular
  - irregular

Special connective tissues:

- mucous tissue (Wharton´s jelly)
- reticular tissue
- elastic tissue
- adipose tissue
  - white
  - brown

CONNECTIVE TISSUE CELLS

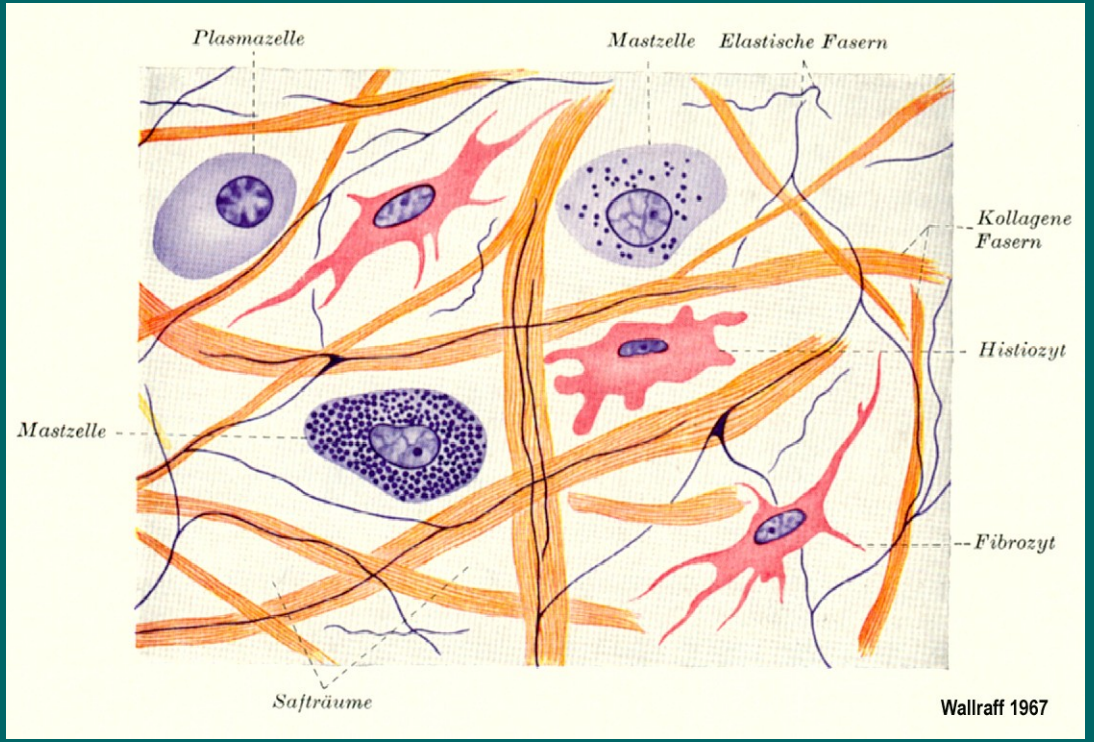
CT cells are classified as
fixed (non-mobile) cells - responsible for production extracellular components and
mobile (wandering) cells - involved in tissue reaction to injury and in defense reactions

Fixed cells: fibroblasts, reticular cells, adipocytes, undifferentiated cells

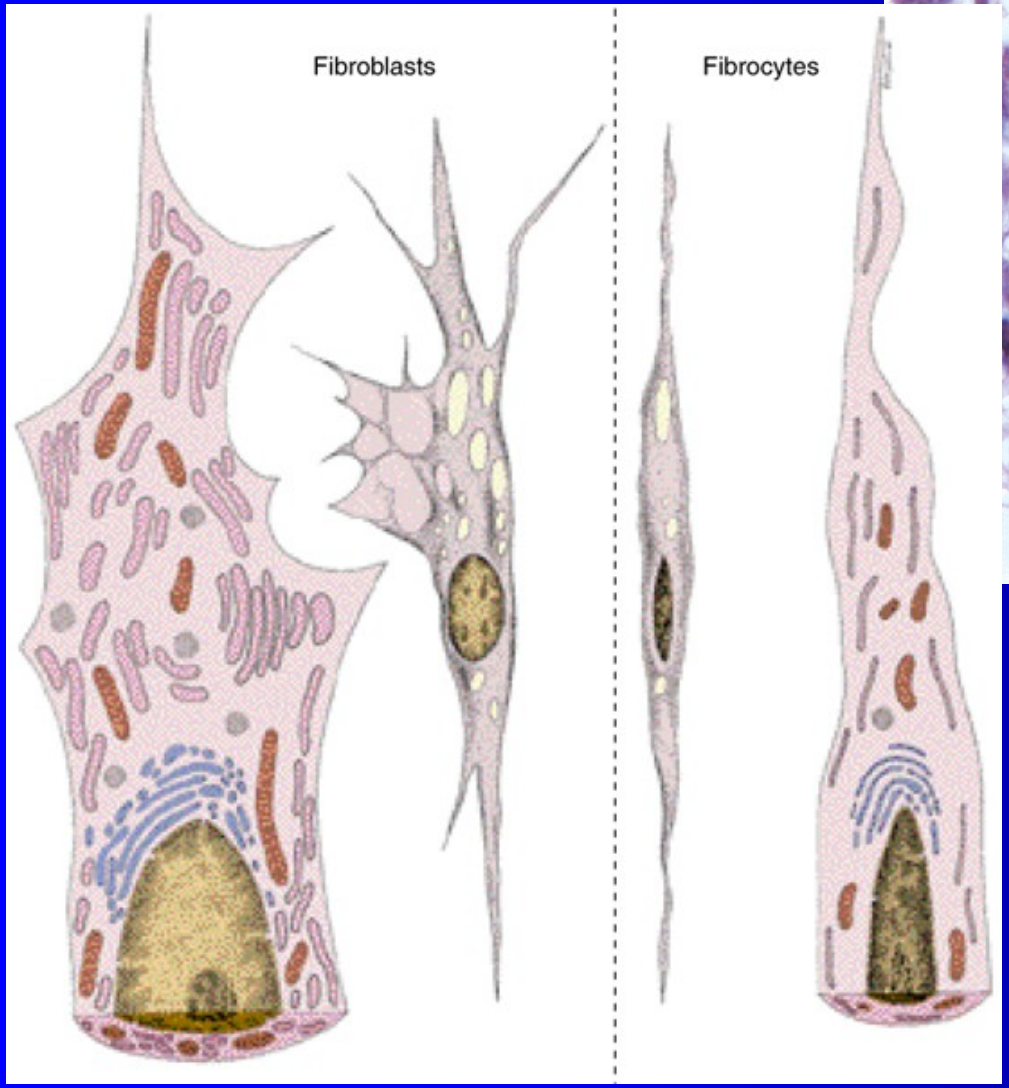
Fibroblasts
the most frequent CT cells
are relatively large flat or
branching cells that appear
fusiform or spindle shaped
in profile

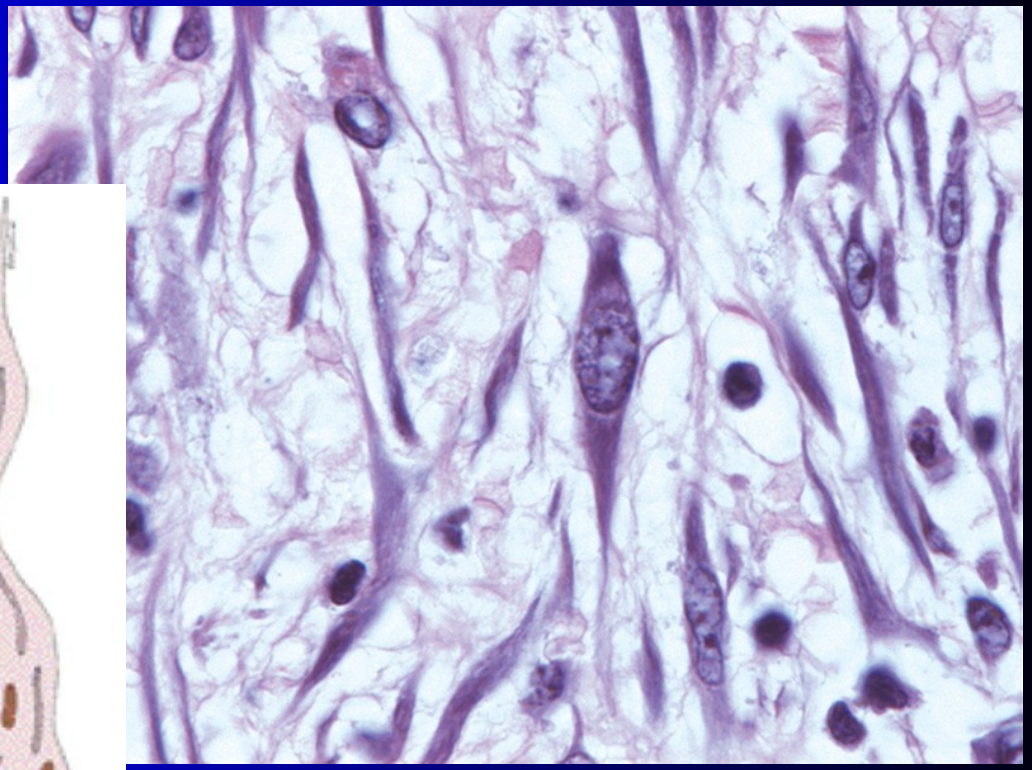
contain nucleus of oval or elongated shape with one
or two nucleoli and small amount
of finely granular chromatin

boundaries of fibroblasts are often indistinct in histological preparations



fibroblasts a fibrocytes





Reticular cells

are branching cells

the processes of which are generally in contact with each other

two types of reticular cells are known

nonphagocytic and phagocytic cells

the former produce reticular fibres, the latter take part in breakdown of the erythrocytes (eg., in the spleen).

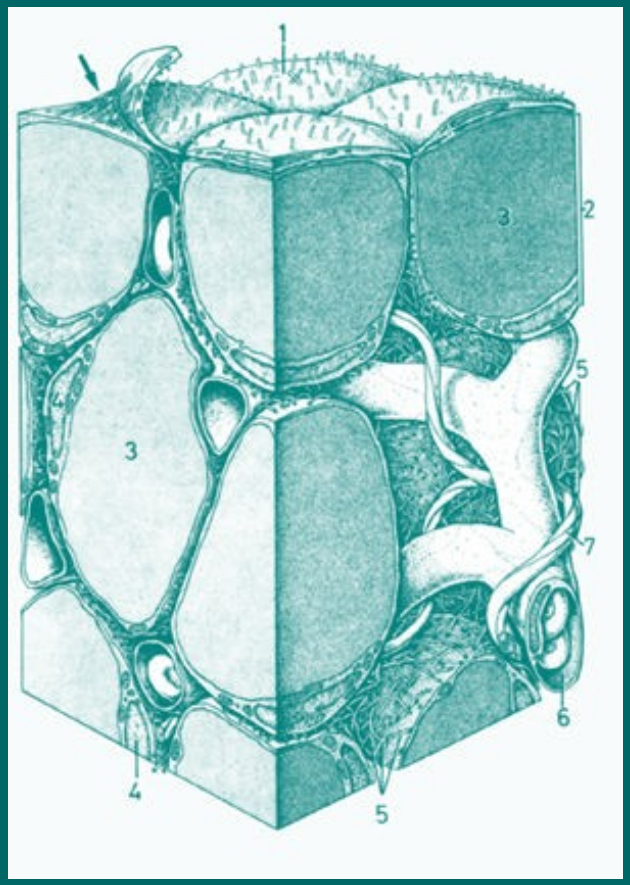
Fat (adipose) cells or **adipocytes**

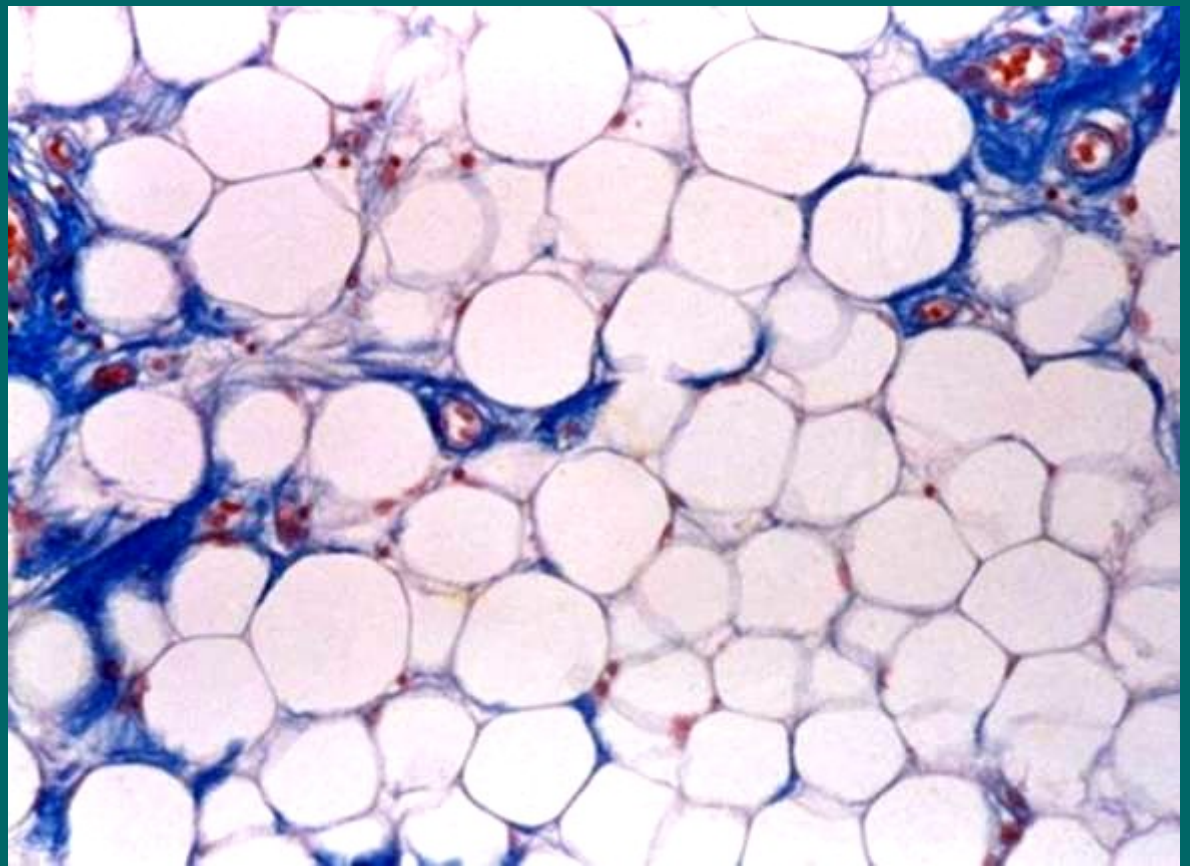
relatively large cells (diameter 40 to 80 mm) of oval shape

two types of adipose cells are described: **univacuolar fat cells** with one single large lipid droplet, the cytoplasm is reduced to only a thin rim, the nucleus is flat

multivacuolar fat cells that contain numerous small droplets of oil, their nucleus is located always centrally

in histological sections the lipid content of adipocytes is dissolved during dehydration and cells seem to be vacuolated.





Undifferentiated mesenchymal cells

are embryonic cells that persist to the adult age

are occurred along the capillaries

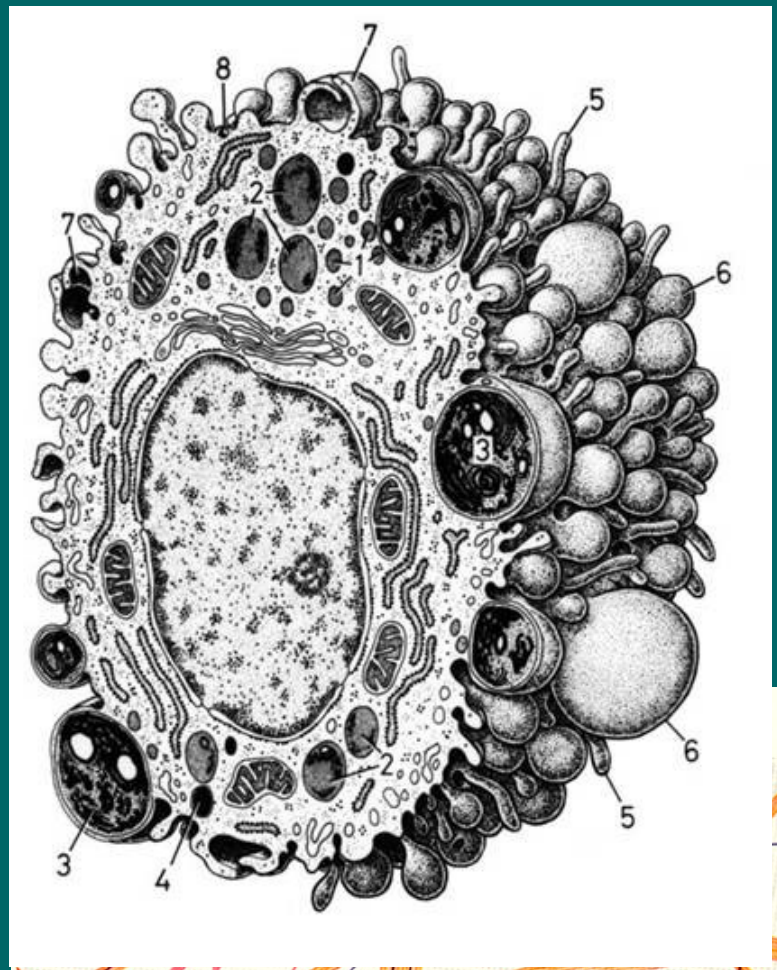
Mobile cells: histiocytes, mast cells, plasma cells leukocytes

Histiocytes (macrophages)

are irregularly shaped cells with processes that usually are short and blunt, nucleus is ovoid, sometimes indented, and smaller and more densely staining than that of the fibroblast, nucleoli are not conspicuous

the cytoplasm stains dark

macrophages are capable of amoeboid movement and phagocytosis

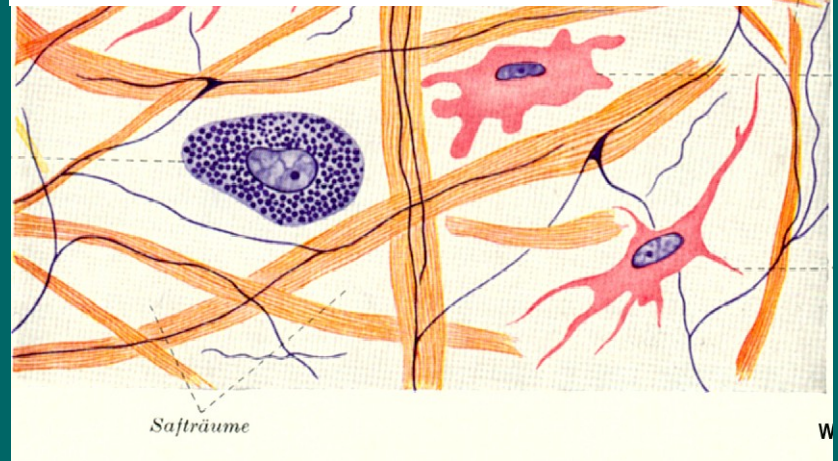


Mast cells (mastocytes)

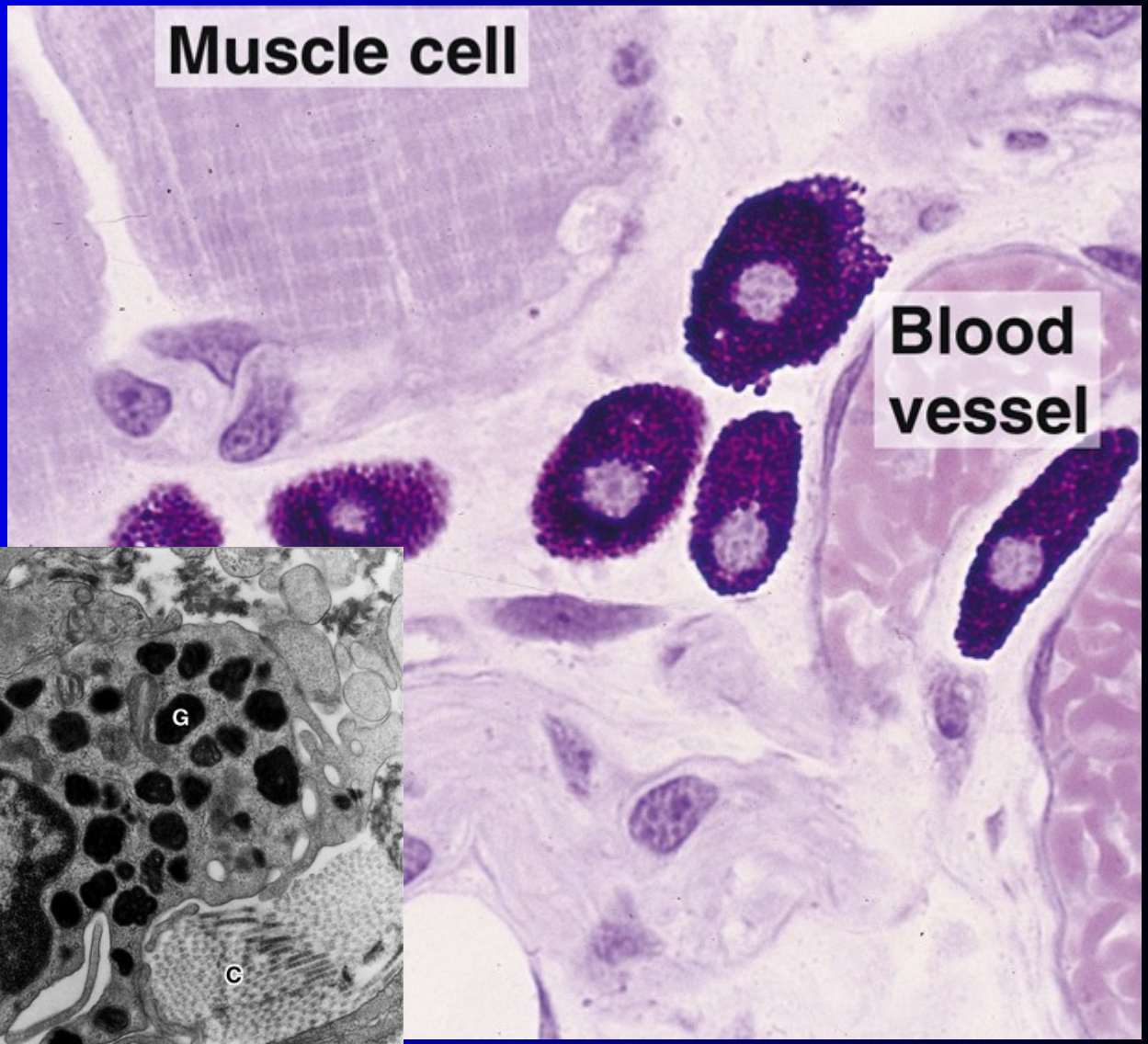
are irregularly oval in outline and occasionally have short pseudopodia, an indication of their slow mobility

cells contain cytoplasmic granules that are refractile and water-soluble and stain with basic and metachromatic dyes (as methylene blue or azure A)

contain heparin and also histamine an serotonin



mast cells



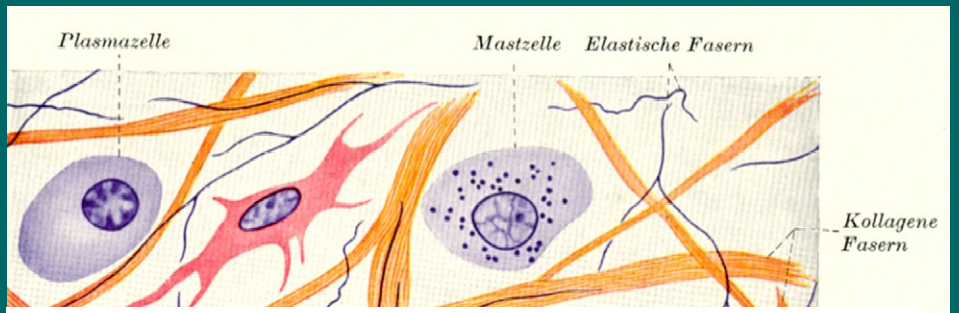
Plasma cells, plasmocytes

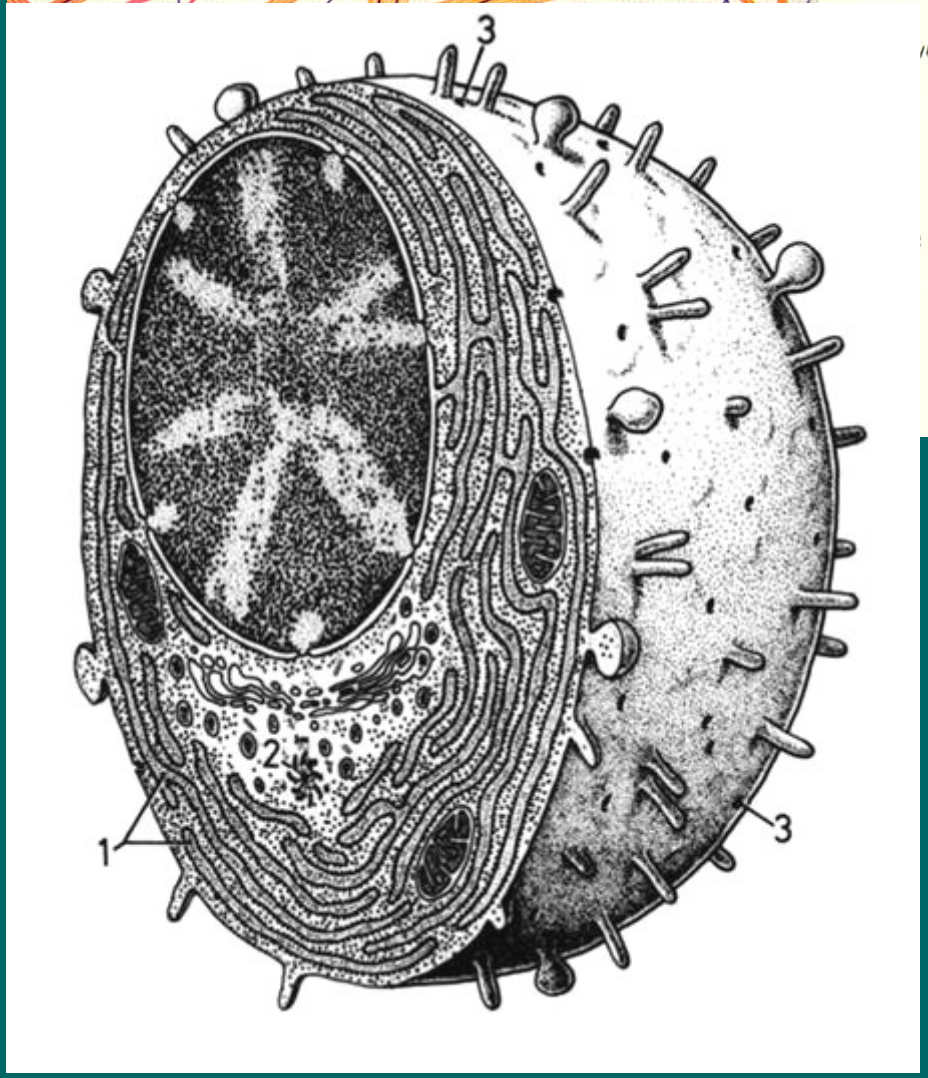
bear a resemblance to lymphocytes
compared with them, they are larger and have basophilic cytoplasm and a nucleus in eccentric position
chromatin occurs in coarse clumps peripherally and is often arranged in a pattern suggestive of the spokes of wheel or the hours on a clock

plasma cells are rare, but are more plentiful in sites of chronic inflamations

cells produce antibodies

Blood leukocytes
by lymphocytes, eosinophils, neutrophils and monocytes





Supporting tissues

are **cartilage** and **bone**

like connective tissue proper, the both are composed of cells, fibers and amorphous ground substance

but differ from the connective tissue proper in the rigidity of amorphous ground substance (matrix)

the ground substance of cartilage contains chondromucoid - the protein rich in chondroitinsulfate

the ground substance of bone chiefly osseomucoid that is impregnated with inorganic salts, especially with calcium phosphate and calcium carbonate

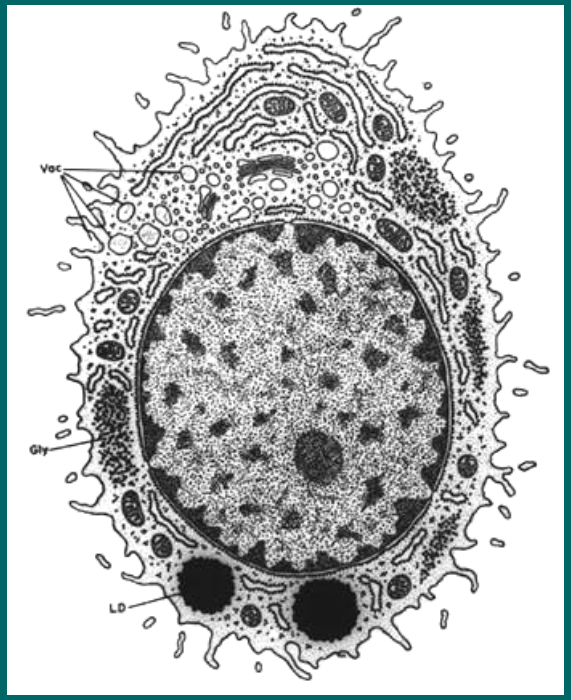
Cartilage

common characteristics of cartilage:

- is strong and some pliable tissue, that is **avascular**, has no lymphatic vessels and is **not innervated**

- cartilage cells are **chondrocytes** - they are large cells of rounded shape with a central spherical nucleus,
the cytoplasm is basophilic and rich in rough endoplasmic reticulum, glycogen, lipid droplets

cells are housed in small spaces within the matrix
known as lacunae



- fibers can be solely collagenous or a combination of collagenous and elastic depending upon the cartilage type

- the surface of the hyaline and elastic cartilage is enveloped by a connective tissue membrane - **the perichondrium**, from which the growth and nutrition of cartilage is provided

the fibrocartilage has no perichondrium

Classification of the cartilage:

- **hyaline cartilage**
- **yellow or elastic cartilage**
- **white (fibrous) cartilage or fibrocartilage**

Hyaline cartilage

is firm and slightly bluish

in the microscope, its **matrix appears clear (glasslike)** because fibers and ground substance have the same staining capacity and refractive index

in the adult, chondrocytes are arranged in groups, composed of 2, 4, or 8 cells that are of the same origin (cells of each group have been derived from the same parent cell) such cell groups are termed **isogenous groups** or cell nests

fibrous component is represented by very fine **collagenous fibers** that form a feltwork (in fresh preparations fibers are not visible as they are masked by glycosaminoglycans of the amorphous substance)

may be visualized by tryptic digestion or polarized light microscopy

an amorphous ground substance appears homogeneous and is composed of chondromucoid - is responsible for its basophilia and metachromasia

the ground substance immediately surrounding each group of isogenous cells usually stains more deeply than elsewhere

several isogeneous groups may unite in complexes termed as **territoria**

between territoria the matrix stains slightly and is called as **interterritorial matrix**

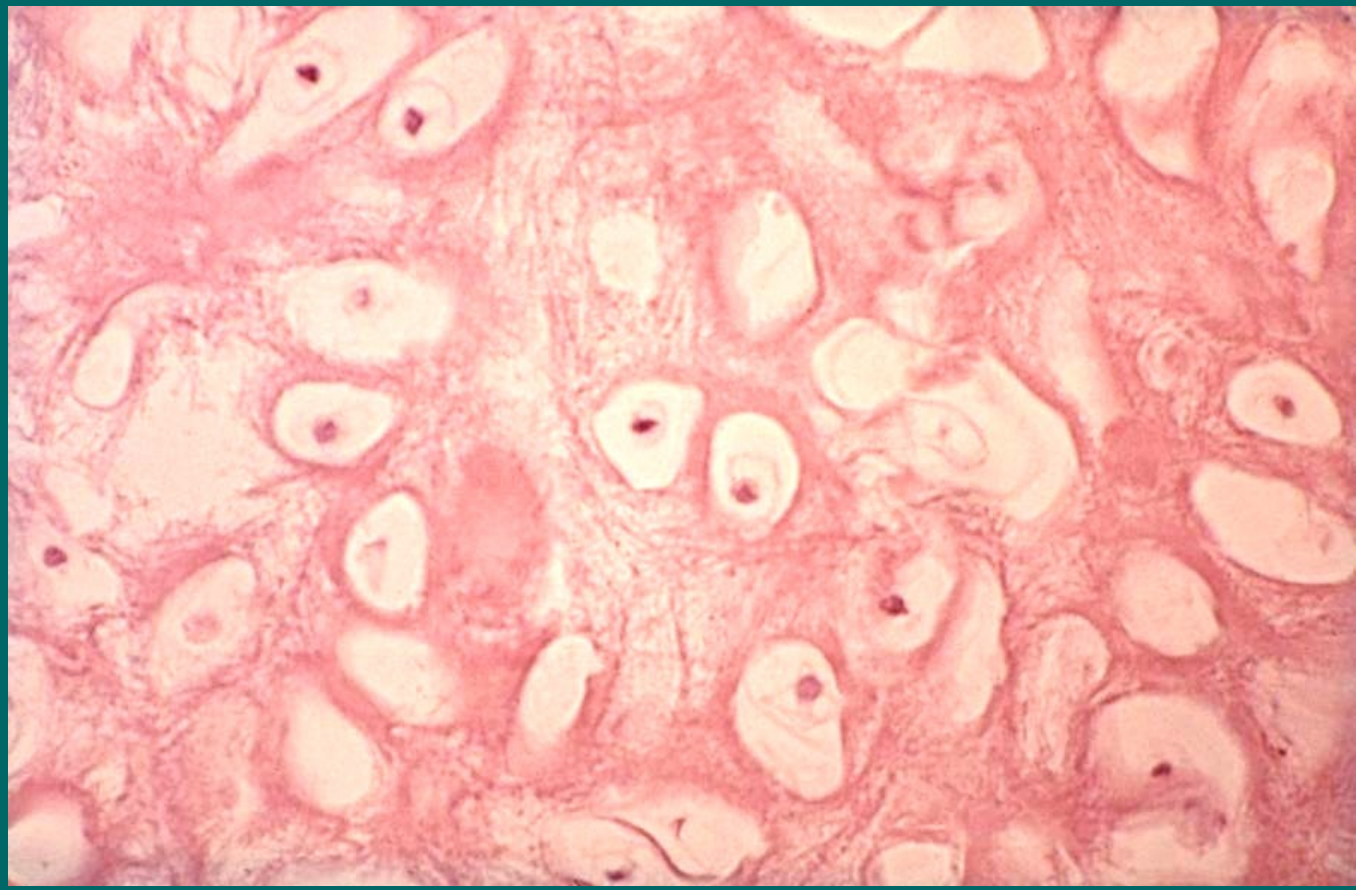
perichondrium

Elastic cartilage

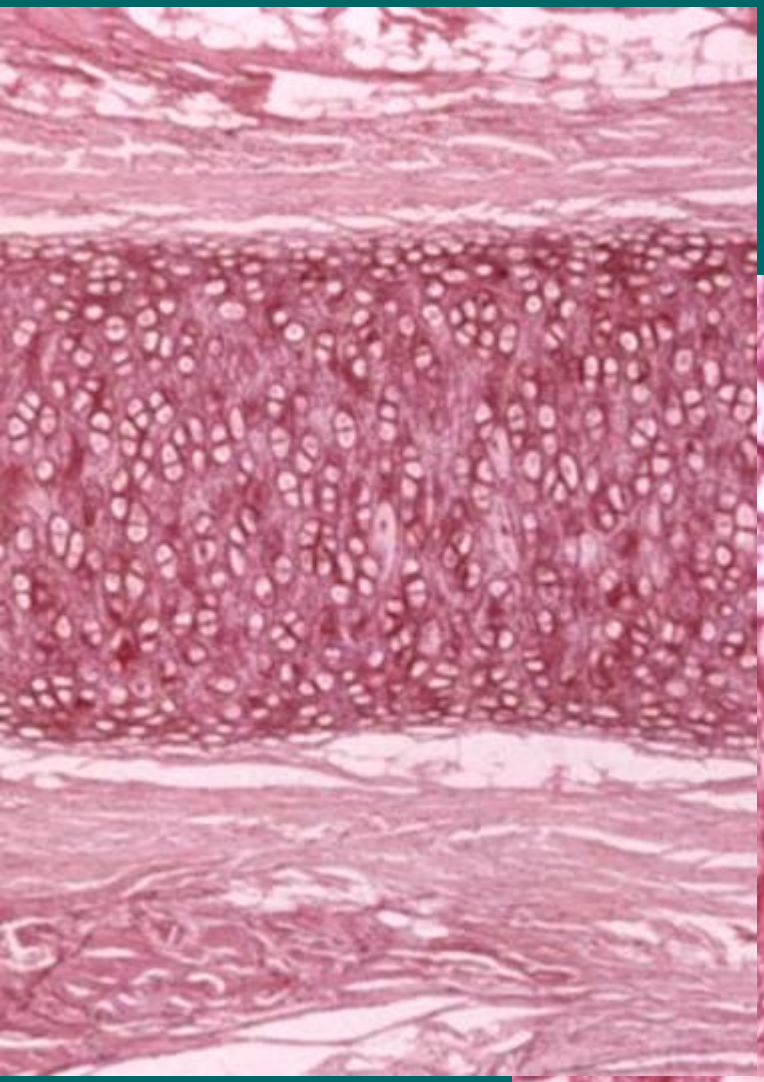
is usually **yellowish** in colour and opaque and more flexible than hyaline

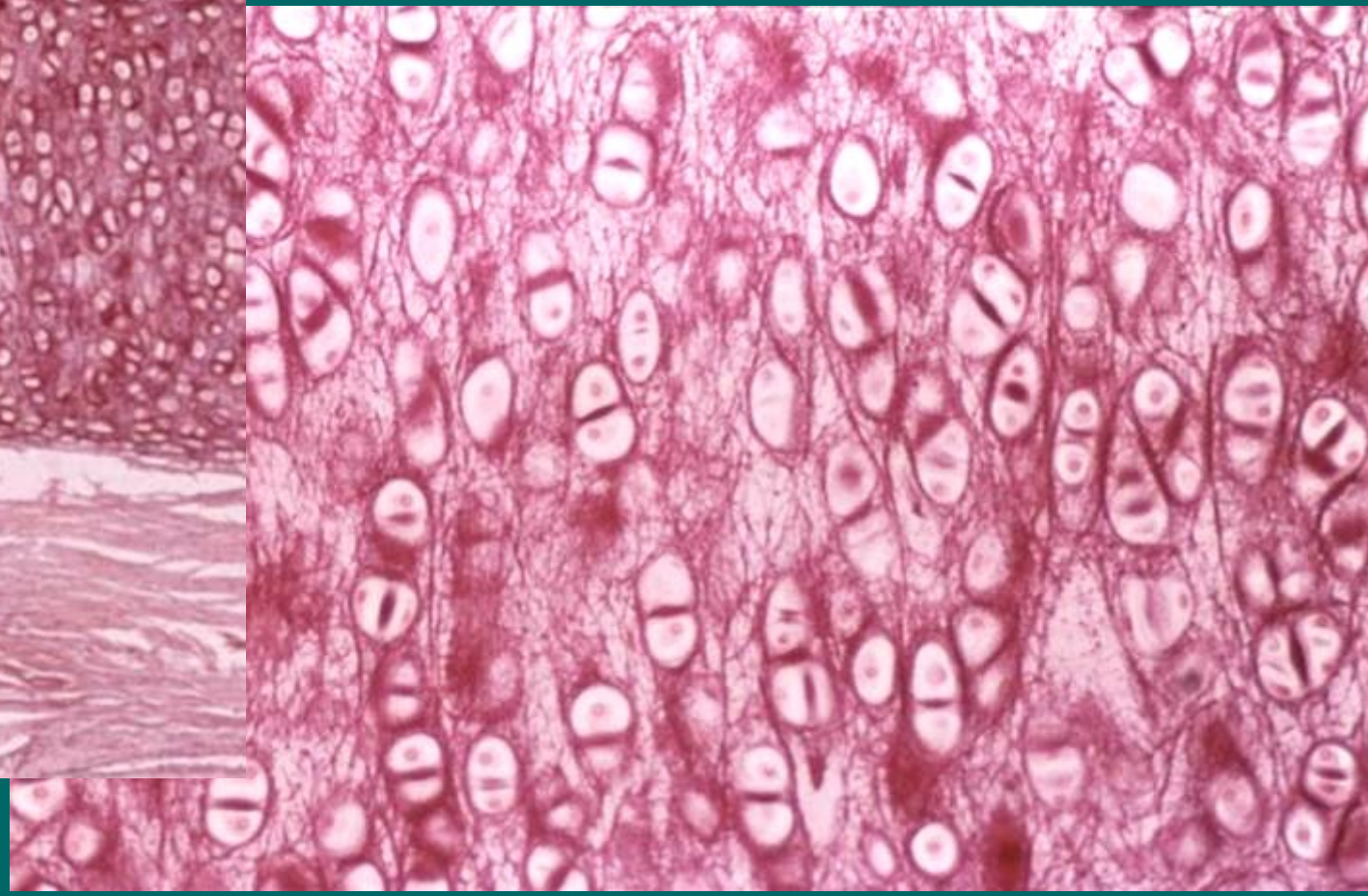
chondrocytes are numerous and scattered singly or in small isogenous groups of two or three cells that are surrounded by capsules of the intercellular substance, fibers: elastic and collagenous
the matrix (intercellular substance) shows characteristic fibrillar appearance in H.E. preparations this is caused by presence of elastic fibers that are never totally masked by amorphous ground substance

elastic fibers may be visualized by special dyes as orcein or resorcin-fuchsin



Elastic cartilage stained with orcein





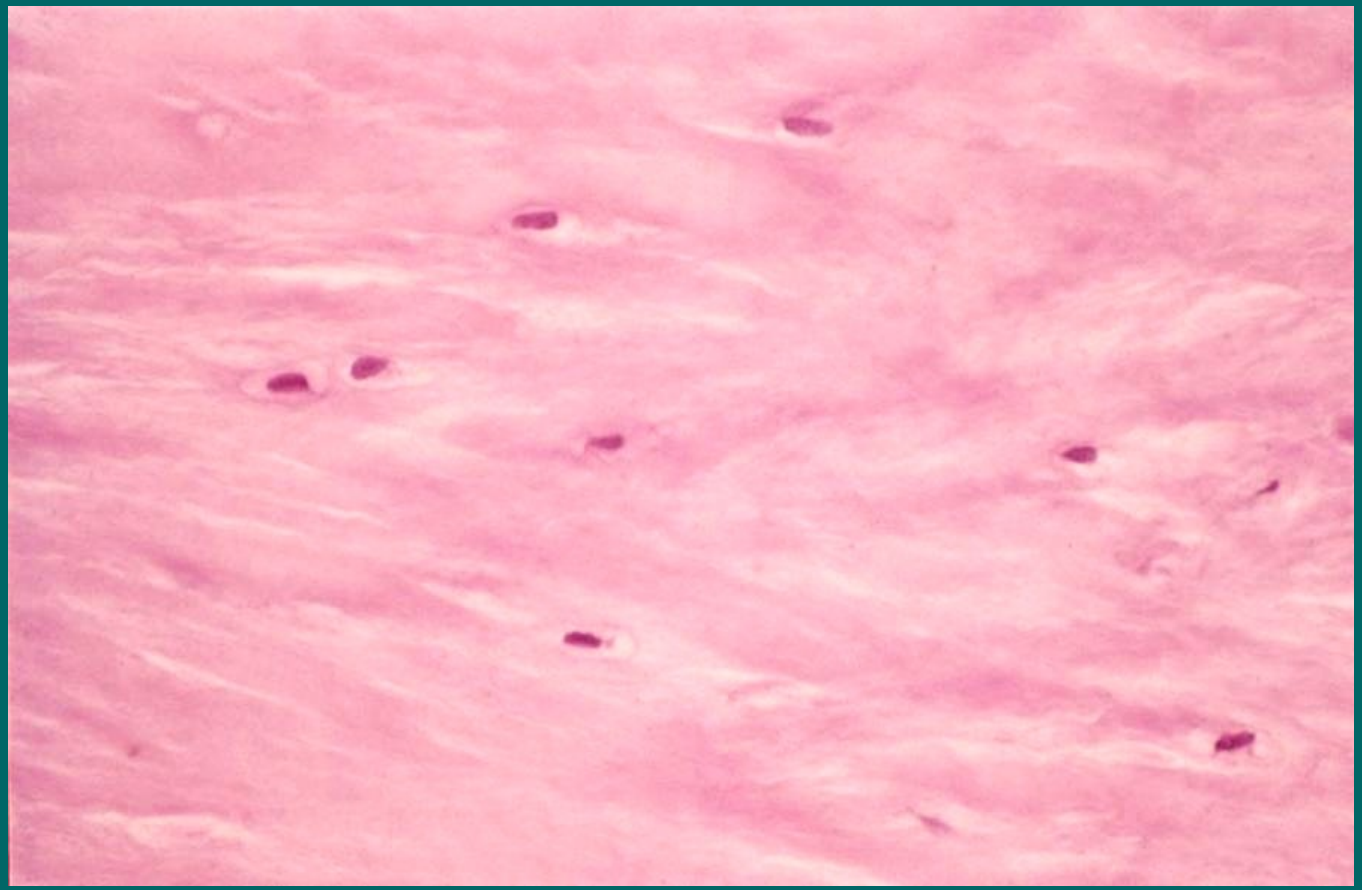
White (fibrous) cartilage or fibrocartilage

is a transitional tissue between hyaline cartilage and dense fibrous connective tissue of tendons and ligaments

the intercellular substance is composed of thick bundles of collagenous fibers running parallel with one another, chondrocytes are not numerous, rounded and are arranged singly or in pairs in rows between bundles of collagenous fibers

the amorphous ground substance is inconspicuous and found only in the immediate vicinity of the chondrocytes

fibrocartilage has **no true perichondrium**



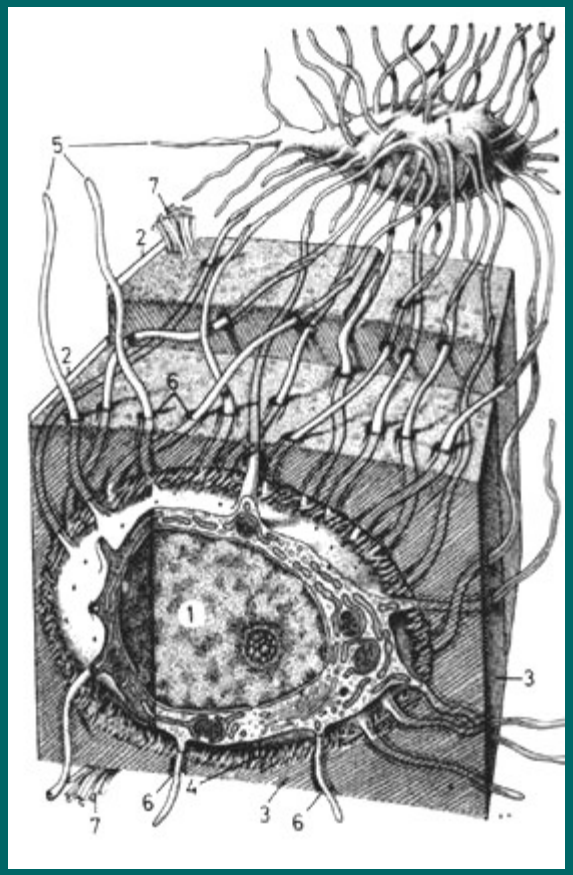
DISTRIBUTION OF CARTILAGE

HYALINE	ELASTIC	FIBROCARTILAGE
Fetal skeleton	**External acoustic meatus**	**Intervertebral discs**
		Pubic symphysis (symphysis pubis)
Costal cartilages	**Pinna of auricle**	
Nose	**Epiglottis**	**Temporomandibular joint**
Trachea + bronchi	**Eustachian tube**	
Articular cartilage	(pharyngotympanic tube)	

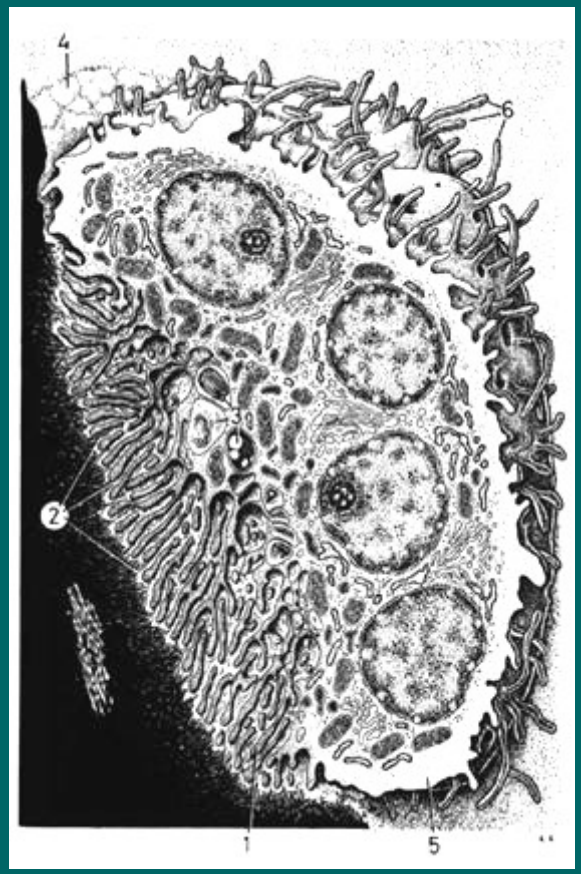
Bone (osseous tissue)

is a rigid form of supporting tissue that constitutes the skeleton of higher vertebrates
it consists of **cells, fibers** and **amorphous ground substance**
Cells:

osteoblast
osteocyte



osteoclast



Intercelular substance

contains collagenous fibers and amorphous ground substance (osseomucoid) that is impregnated by inorganic salts - calcium phosphate, calcium carbonate, calcium fluoride and magnesium fluoride

the inorganic salts are responsible for the rigidity and hardness of bone while the collagenous fibers contribute to the strength and resilience of bone

Sections of bone cannot be made in the ordinary way because the bone matrix shows the great hardness

two method are used to prepare bone for study in a routine: either bone is softened by the use of acids (**decalcification**), or pieces of bone are dried and ground very thin (**ground specimens**)

the latter method destroys the cells; the former destroys the inorganic part of intercellular substance, but osteocytes and collagenous groundwork are retained

Macroscopically, two types of bone are distinguished:

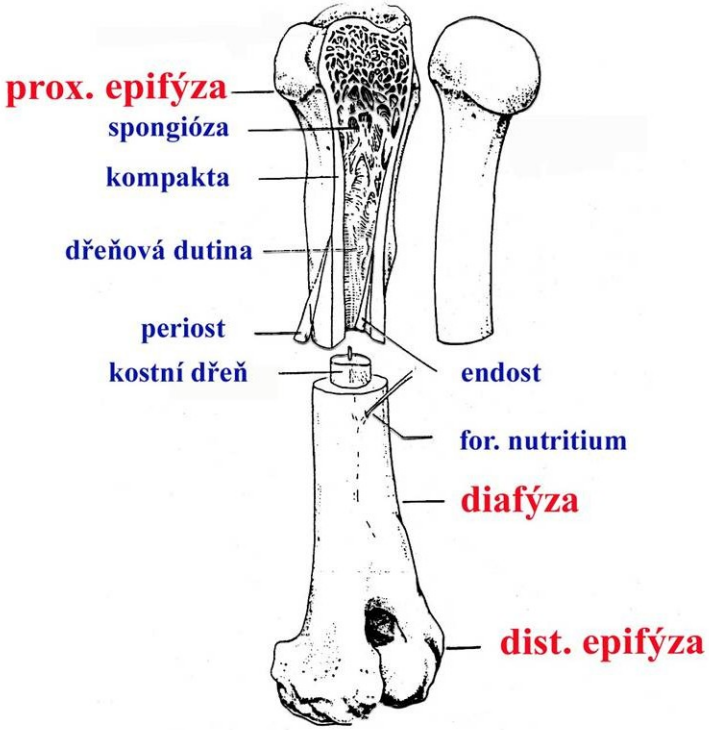
- **the compact (dense) -** is solid
- **the spongy (cancellous)** - consists of slender, irregular trabeculae or bars which branch and unite with one another to form a meshwork

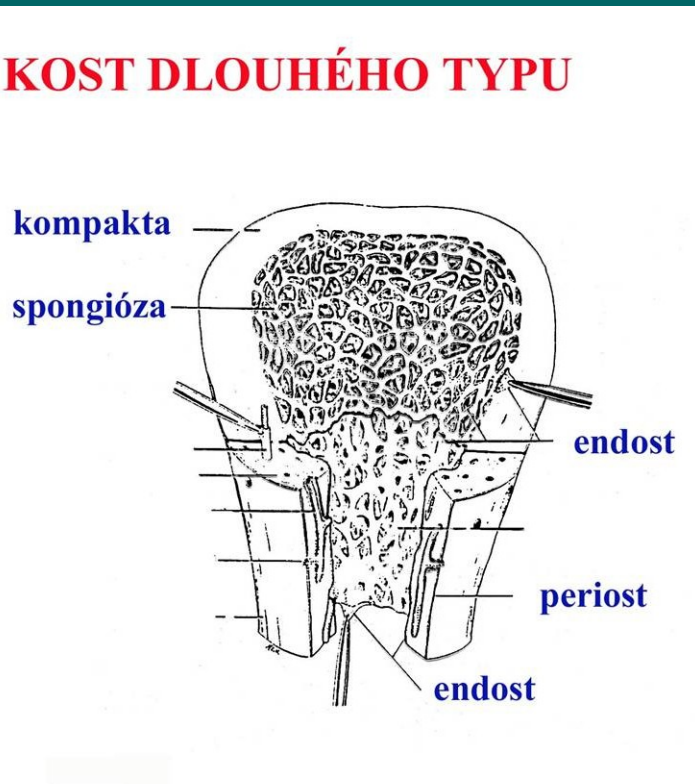
with few exceptions, both types occur in all bones

in typical long bones, the shaft (diaphysis) is chiefly compact bone that surrounds the medullary cavity while the epiphysis consists of spongy bone covered by a thin shell of compact bone

in flat bones, two plates of compact bone enclose a middle layer of spongy bone (**diploe**)

The external and internal surfaces are covered by a specialized connective tissue coats – **the periosteum** (good developed) and **the endosteum** (less obvious).





Microscopically, two types of osseous tissue are distinguished:

- **woven or irregular bone**
- **Haversian or lamellar (regular) bone**

the woven bone

resembles the fibrous (dense) connective tissue when is decalcified

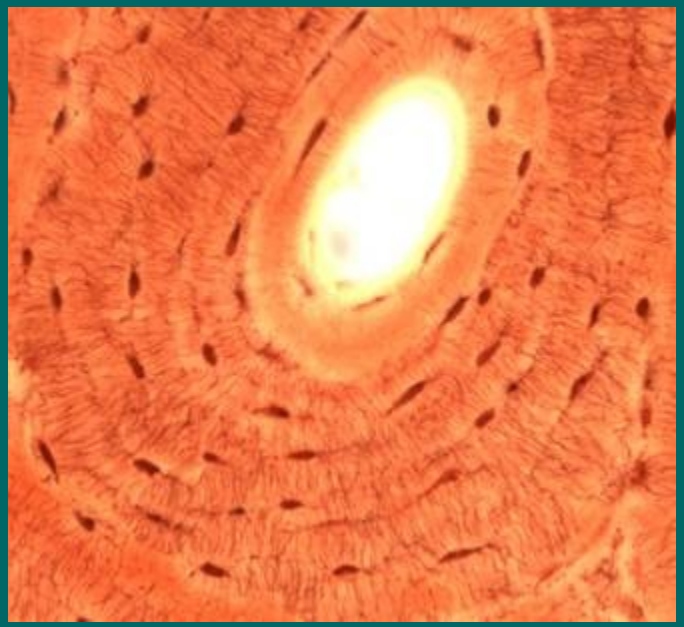
consists of not numerous osteocytes and calcified matrix with collagenous fibers without the precise orientation (fibers usually run in all directions or form a feltwork formations)

this bone occurs chiefly at **sites of insertion of muscles** to the skeleton; similar to the woven bone is the **cementum** of tooth

Haversian (lamellar) bone

is developmentally and functionally more perfect type of osseous tissue
the bone is composed of thin layers of bone matrix 3-7 [redacted] thick- termed as **lamellae**
each lamella consists of the collagenous fibers and calcified ground substance
fibers in any lamella are roughly parallel to each other and take spiral or helical course
(it is of interest that the fiber direction is always different in the adjacent lamellae; this alternating arrangement in fiber direction explains why lamellae appear to be so distinct, one from another

osteocytes are between the lamellae and are usually scattered singly
they occupy lenticular- shaped spaces known as **lacunae** and posses long processes that are housed in tiny canals or tunnels known as **canaliculi**



osteocytes with processes (HE)

Remember: compact and spongy bones described in the anatomy are always composed of the Haversian or lamellar type of osseous tissue

in the compact bone (three dimensional diagram), the lamellae are arranged in three different ways:

- the great majority of lamellae are arranged concentrically around longitudinal vascular channels within the bone and to form cylindrical units called **haversian systems or osteons**

osteons vary greatly in size, being made up of 4 to 20 lamellae

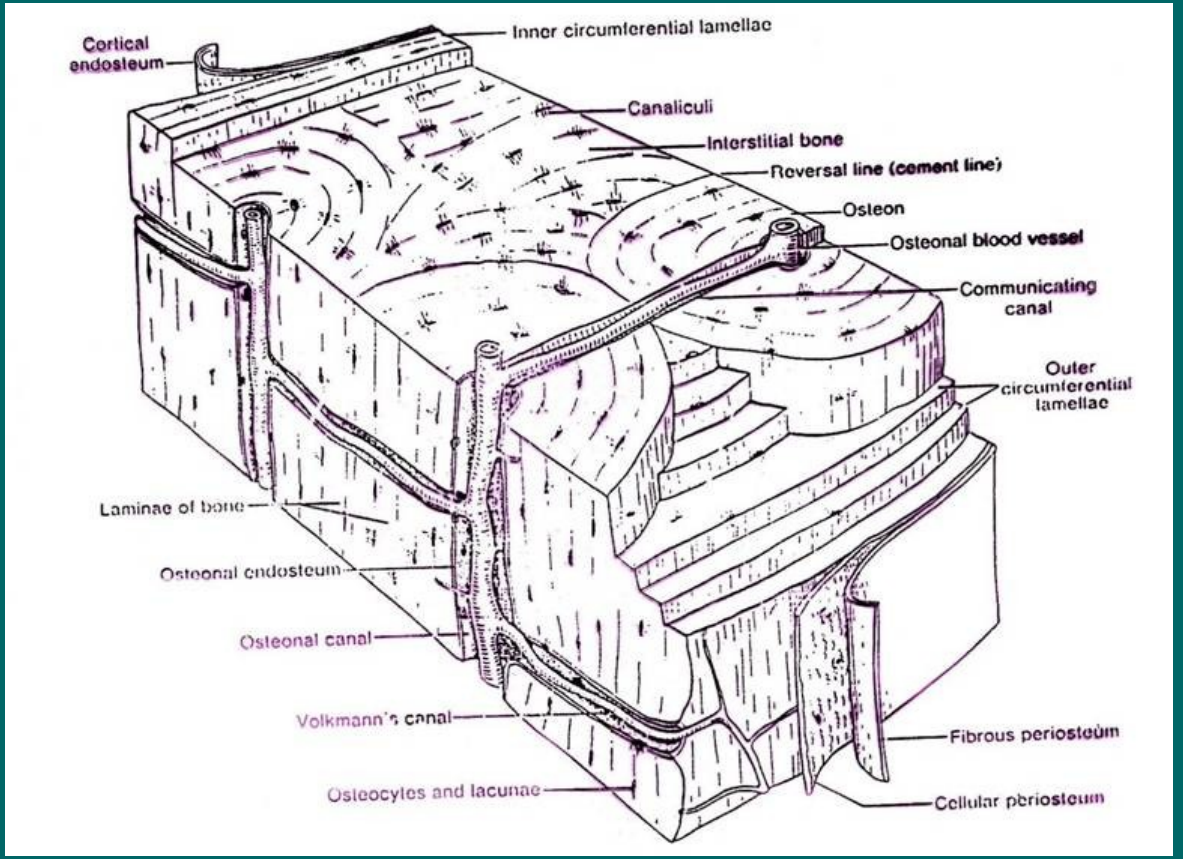
in cross sections, the haversian systems appear as concentric rings around circular opening (Haversian canal)

in longitudinal sections, lamellae are seen as closely spaced bands parallel to a long slit

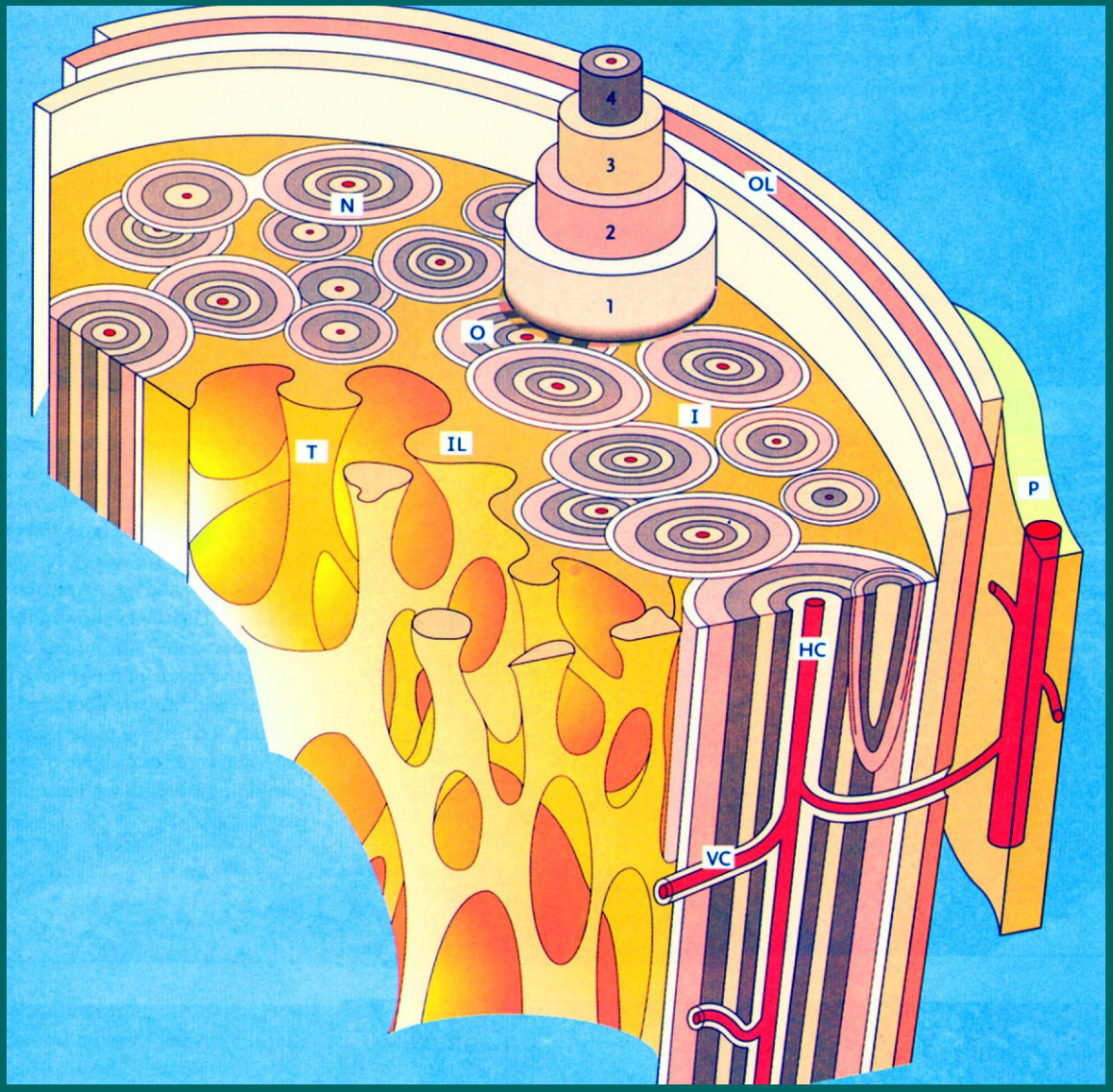
- besides the former lamellae, there are lamellae without any relations to blood vessels that form fields of varying size and irregular shape – **interstitial lamellae** or interstitial systems

they are supposed to be rests of old Haversian systems, that have been partially removed in the process of bone remodeling

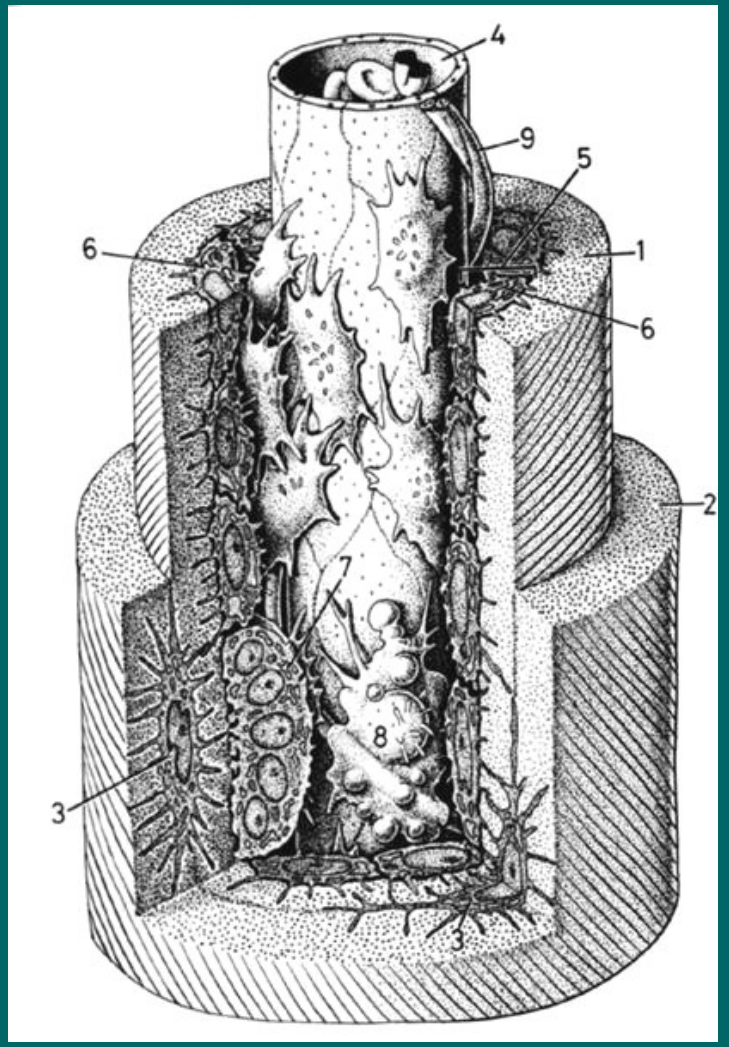
- at the external surface, immediately beneath the periosteum, and on the internal surface, subjacent the endosteum, the lamellae are arranged parallel to the periosteum or around the central cavity – **outer circumferential and inner circumferential lamellae**



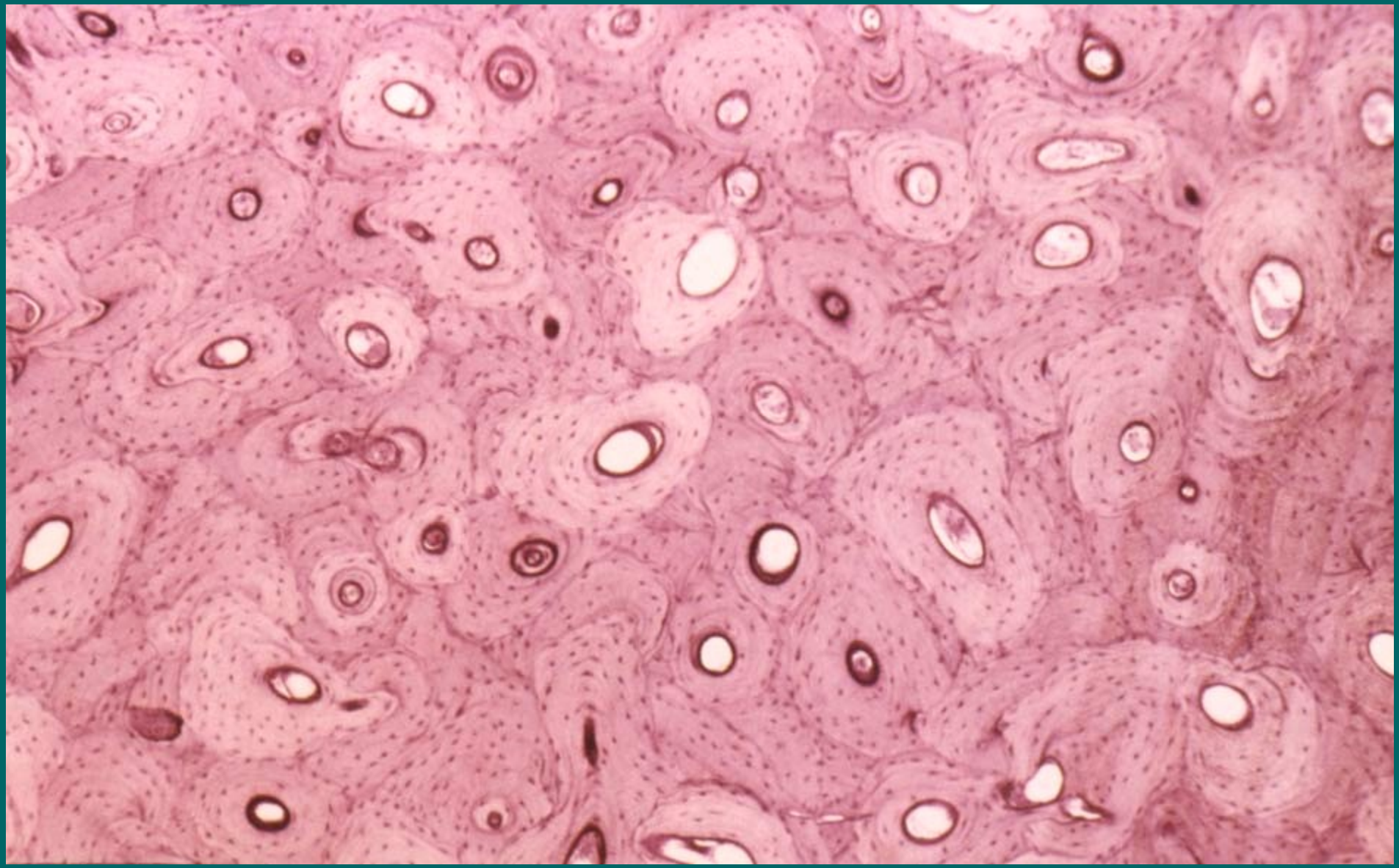
diaphysis
Haversian and Volkmans canals



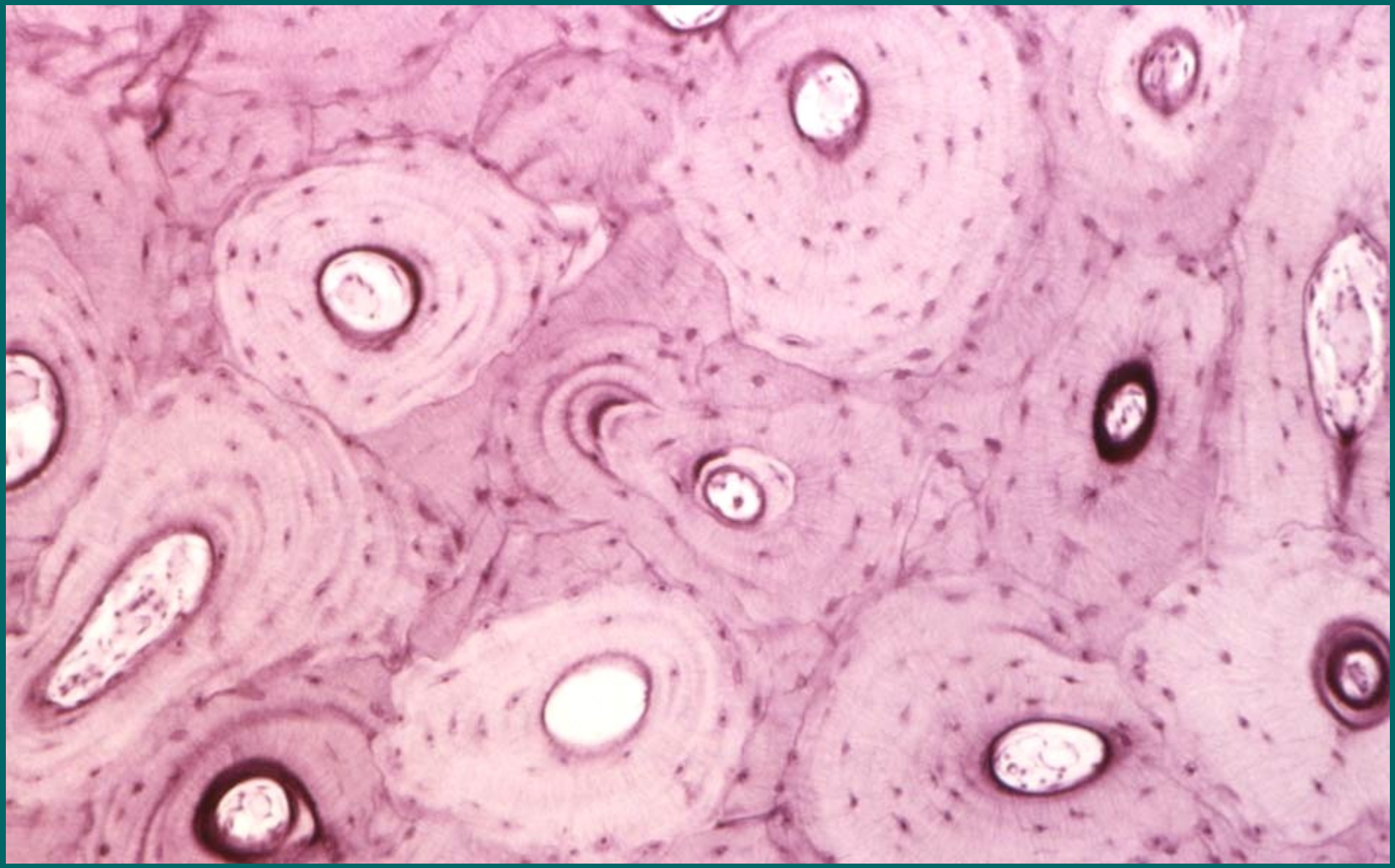
a model an osteon



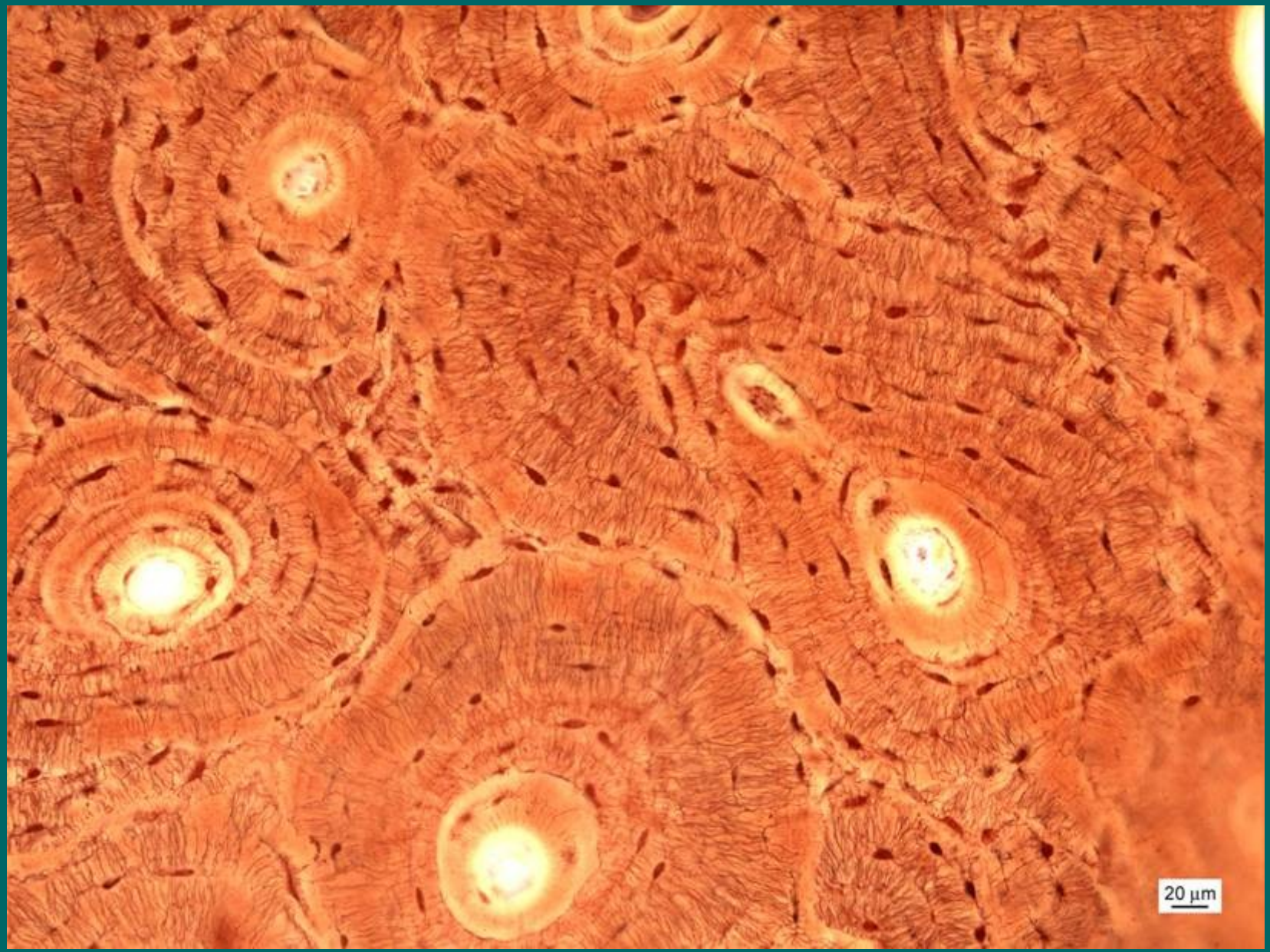
diaphysis transversally (HE)



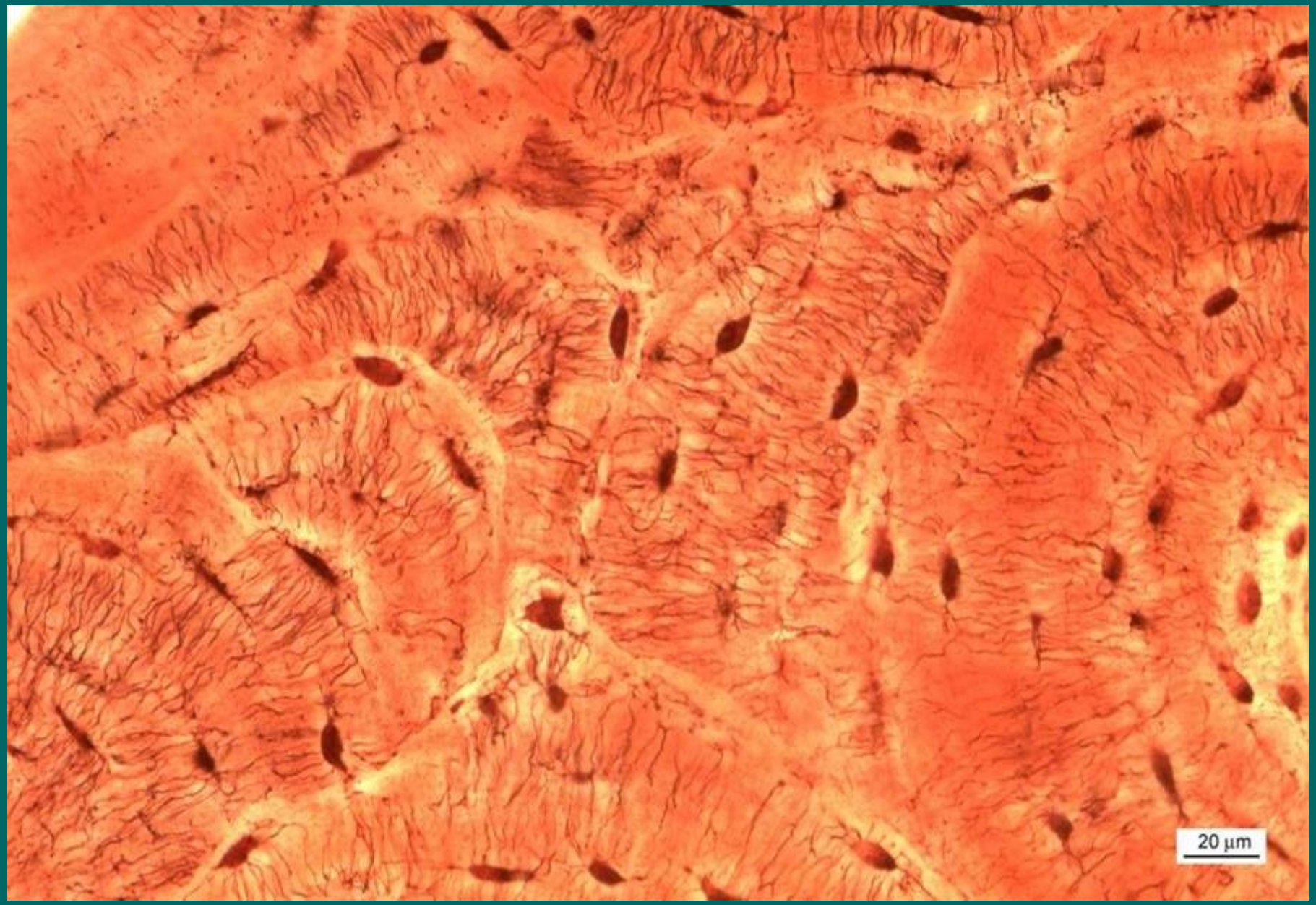
diaphysis transversally (HE)



diaphysis transversally (staining after Schmorl)



diaphysis transversally (staining after Schmorl)



According to relation to the lamellae, vascular channels of two types are distinguished in the compact bone:

- the **Haversian canals** located in the centers of haversian systems, they are 20 to 100 μm in diameter and contain one or two blood vessels

- the **Volkmann's canals** - they are not surrounded by concentrically arranged lamellae and traverse the bone in direction perpendicular or oblique to the Haversian canals

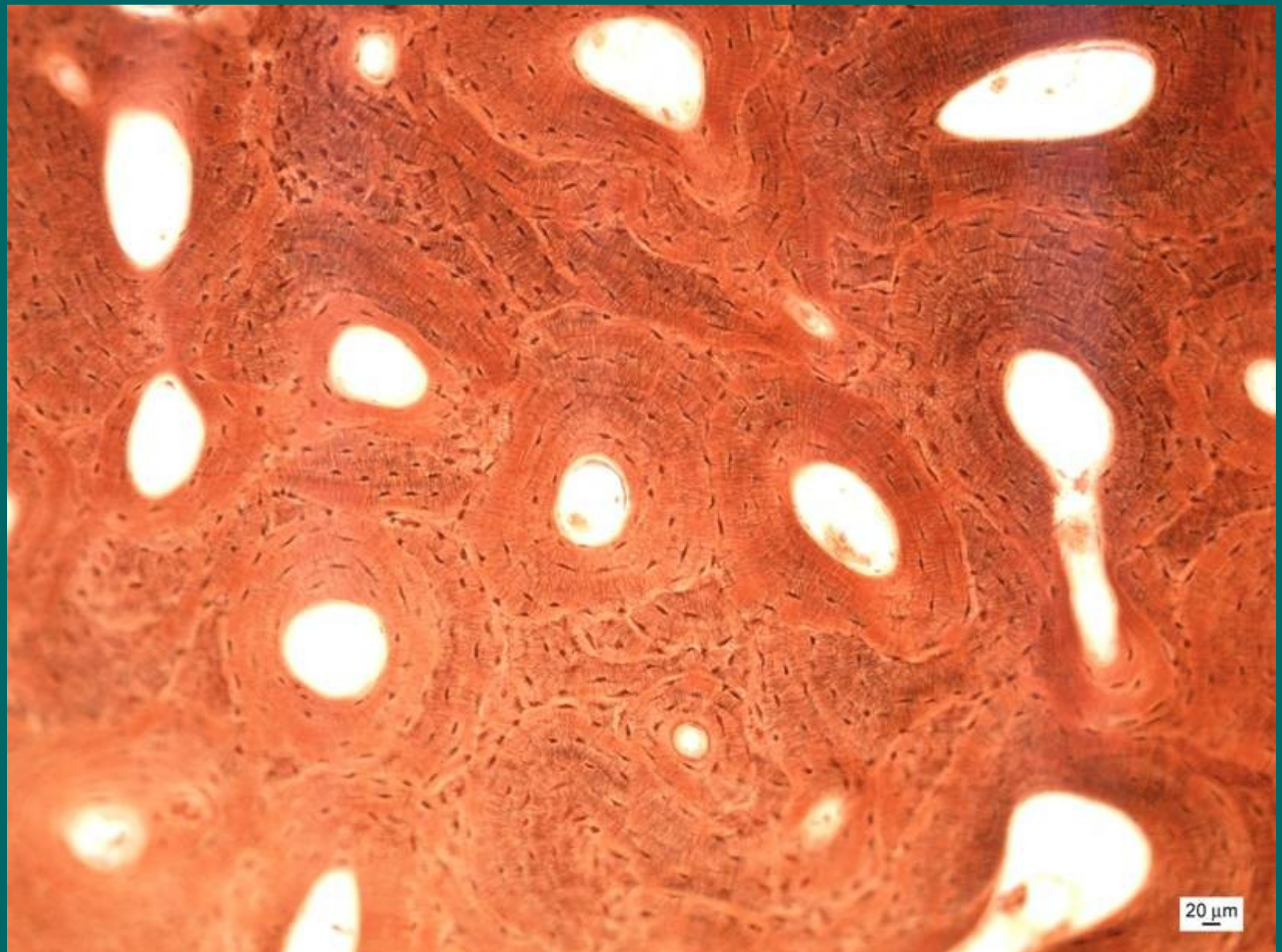
function of Volkmann's canals - connect Haversian canals with one other and provide their communication with the free surface of bone or with the marrow cavity

Spongy bone

composed of lamellae

as the trabeculae of cancellous bone are relatively thin, they may not contain complete haversian systems but only superficial or circumferential lamellae

diaphysis transversally (staining after Schmorl)



diaphysis transverally