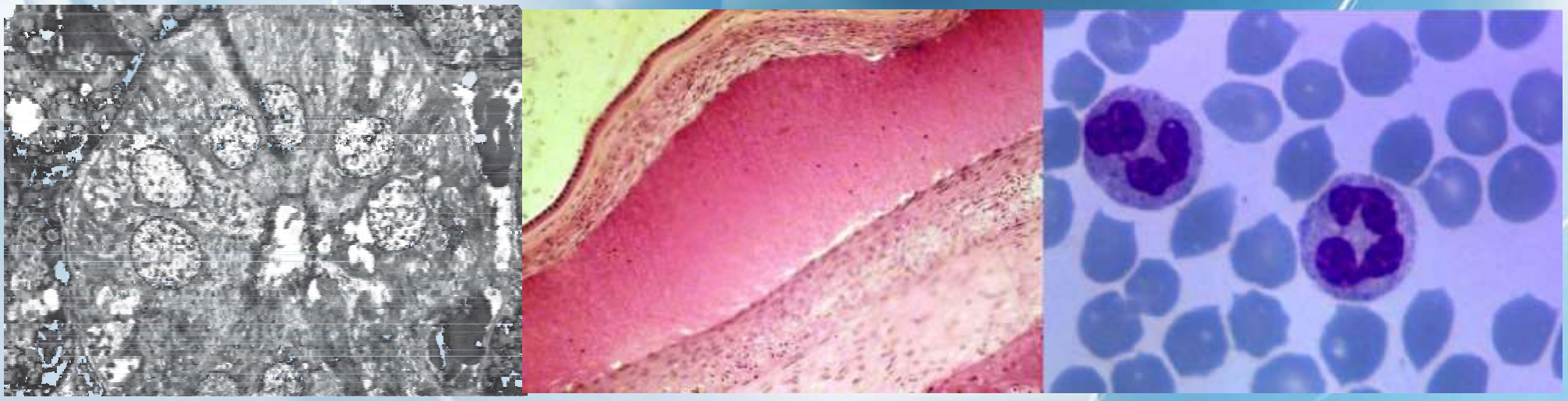
MINISTRY OF HEALTH OF UKRAINE
UKRAINIAN MEDICAL STOMATOLOGICAL ACADEMY

Department of histology, cytology and embryology

GENERAL HISTOLOGY IN FIGURES AND DIAGRAMS



POLTAVA 2020

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General histology in figures and diagrams

POLTAVA 2020

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Recommended by the Academic Board of the Ukrainian Medical Stomatological Academy as a textbook for English-speaking students in speciality 222 - Medicine in a higher educational institutions of the Ministry of Health of Ukraine (dated 21 of october2020 y., minutes of the meeting №. 2).

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Textbook for students of the faculty of training foreign students in the specialty 222 - Medicine.

The material of the textbook glossary, tables, diagrams, microphotographs and electrograms. Provides systematization of knowledge of students, facilitates preparation for employment, gives the chance to make the analysis of structural features of various tissues, promotes development of knowledge, abilities and skills, knowledge.

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Рекомендовано вченою радою Української медичної стоматологічної академії як навчальний посібник для англомовних студентів, які навчаються за спеціальністю 222 - Медицина закладів вищої освіти МОЗ України (від 21 жовтня 2020 р., протокол засідання № 2).

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Навчальний посібник для студентів факультету підготовки іноземних студентів за спеціальністю 222 - Медицина.

Матеріал навчального посібника включає словник, таблиці, схеми, мікрофотографії та електронограми. Забезпечує систематизацію знань студентів, полегшує підготовку до занять, дає змогу зробити аналіз структурних особливостей різних тканин, сприяє виробленню знань, умінь і навичок, передбачених програмою.

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Basic Provisions of the Cell Theory

1. The cell is the elementary unit of life.

2. The cell is either a unicellular organism or the element of a multicellular organism.

3. All eukaryotic cells have essentially the same structure (plasmolemma, cytoplasm, nucleus, nucleolus).

4. The cell is formed from the cell only.

5. Multicellular organisms are developed from the ultimate stem cell (the zygote).

6. All cells of a multicellular organism are totipotent, i.e., in their genome, they contain inherited information about the particular organism as a whole, about its past, present and future.

7. The phenotype of the cell is determined by its genotype, and the amount of use of cell information depends on the specific conditions of influence of various magnetic inductors, location of the cell in the spatio-temporal coordinate system of the body, the activity of homeotic genes that determines the cell memory of positional information.

CYTOLOGY TERMINOLOGY

ACIDOPHILIA (from Latin *acidus*, acidic and Greek *philia*, love) is the property of cellular structures to be colored by acidic dyes. Synonyms: oxyphilia, eosinophilia (fig. 1).

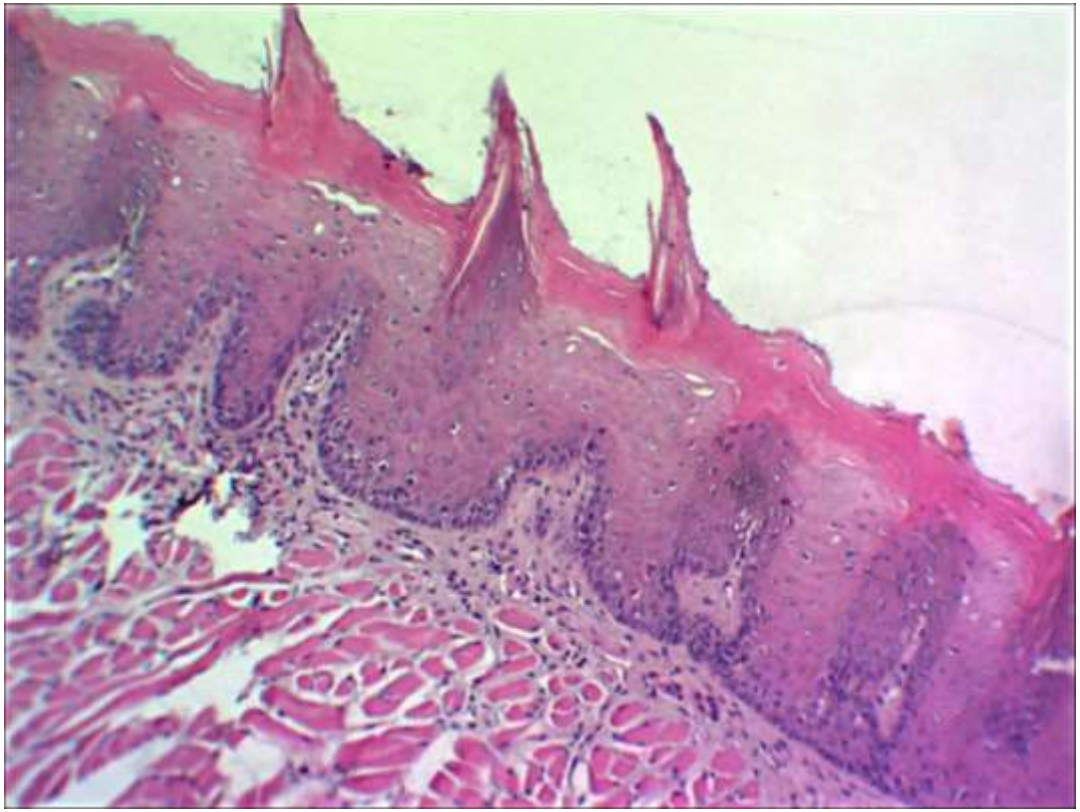


Fig. 1. Dorsal surface of the rat. Epidermal squamae's and muscle tissue are colored in a pink color. Hematoxylin and eosin staining. Magn. x 100.

ADAPTATION OF THE CELL (from Latin *adaptation*, "adaptation") is adaptation of the cell to life in specific environmental conditions.

ALTERATION OF THE CELL (from Latin *alteration*, alteration) is deterioration of the cell physiological state, alteration of its structure under the influence of the damaging factor.

AMOEBOID MOVEMENT (from Greek *amoibe*, amoeba, *-ideas*, similarity) is amoebae- like movement of the cell by the formation of pseudopodia; is characterized by high variability in the shape of the cell being moved.

AMORPHOUS SUBSTANCE (from Greek *a*, without, *morphe*, shape) is relatively shapeless, structureless substance, semi-liquid viscous gel, consisting of macromolecules of mainly polysaccharides and related cellula r fluid.

ANABOLISM OF THE CELL (from Greek *anabole*, upward) is the set of metabolic reactions that lead to assimilation (digestion, accumulation, synthesis) of organic substances in the cell, in contrast to catabolism.

ANISOCYTOSIS (from Greek *anisos*, unequal and *cytos*, cell) is the condition when cells are not even in size. It is sharply manifested, for example, among red blood cells in diseases of the red blood. Microcytosis, macrocytosis, megalocytosis, i.e., reduced, enlarged and giant forms of red blood cells, are distinguished (fig. 2).

APOPTOSIS is a programmed cell death as a result of activation of killer genes. It is active, genetically controlled process, regulated by the internal program that is triggered by external factors.

ARGYROPHILIA (from Greek *argyros*, silver and *philia,* love*)* is the specific property of some components of the cell to precipitate metallic silver from silver nitrate, being colored black or dark brown. Argyrophilic: reticular fibers, neurofibrils, Golgi complex and some other structures (fig.3).

ATP (adenosine triphosphoric acid) is a compound of adenine, ribose, and three phosphate groups linked by macroergic bonds. When one group is splitted off, one part of the energy is released and ATP is transformed into

ADP (adenosine diphosphoric acid), similarly, the second part of energy is released and ADP is converted into its

AMP (adenosine monophosphoric acid). ATP is synthesized in mitochondria.

ATROPHY OF THE CELL (from Greek *atrophia; a*, absence, deficiency, and trophe, nutrition) is reduction in size of cell under the action of damaging factors, without profound disruption of cellular metabolism.

AUTOLYSIS OF THE CELL (from Greek *autos*, itself and *lysis*, dissolution) is a post-mortem change of the cell with the subsequent dissolution of its structures under the action of its own lytic enzymes, which are released from lysosomes.

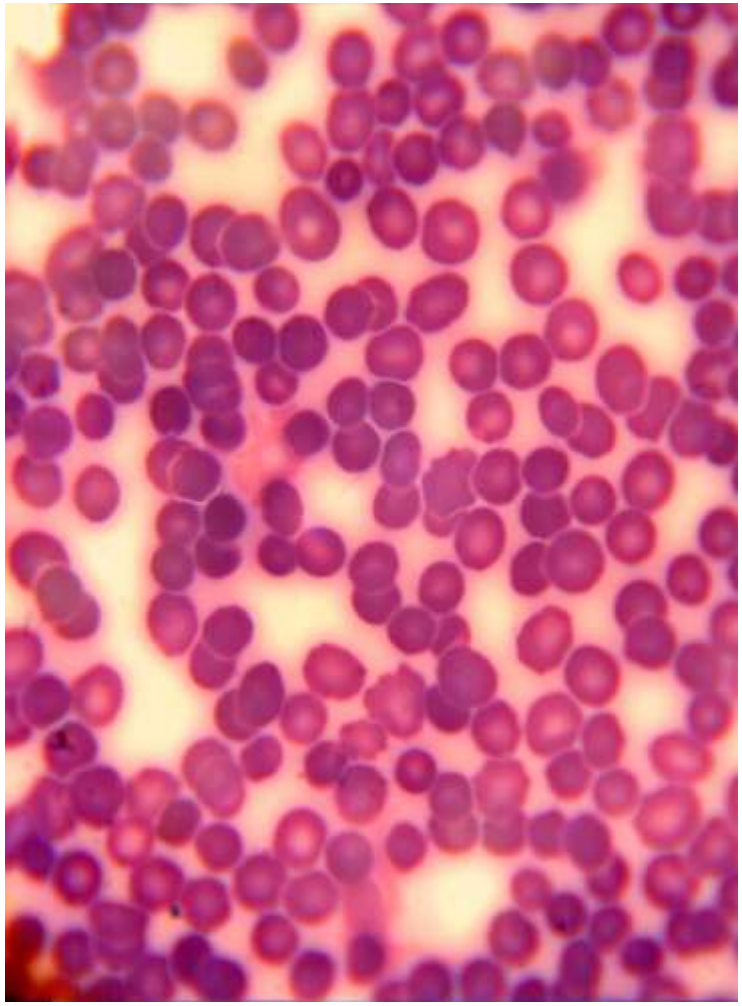


Fig. 2. Human blood smear. Erythrocytes of different sizes. Romanovsky-Himza staining. Magn. x 1000.

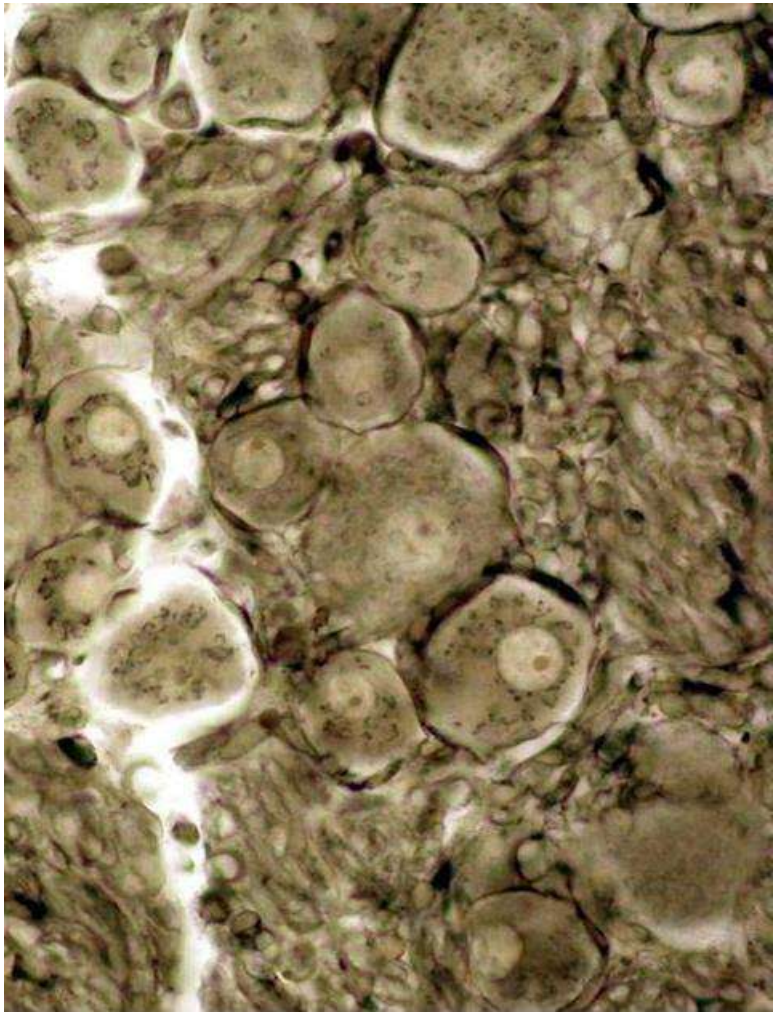


Fig. 3. Spinal ganglia. Myelin sheaths and Golgi complexes in the cytoplasm of neurons are colored dark brown. Silver nitrate staining. Magn. x 400.

AUTOPHAGOCYTOSIS (from Greek *autos*,itself, *phago*, digest, *cytos*, cell) is the splitting off of the cell's own macromolecular complexes by lysosomes (fig. 4).

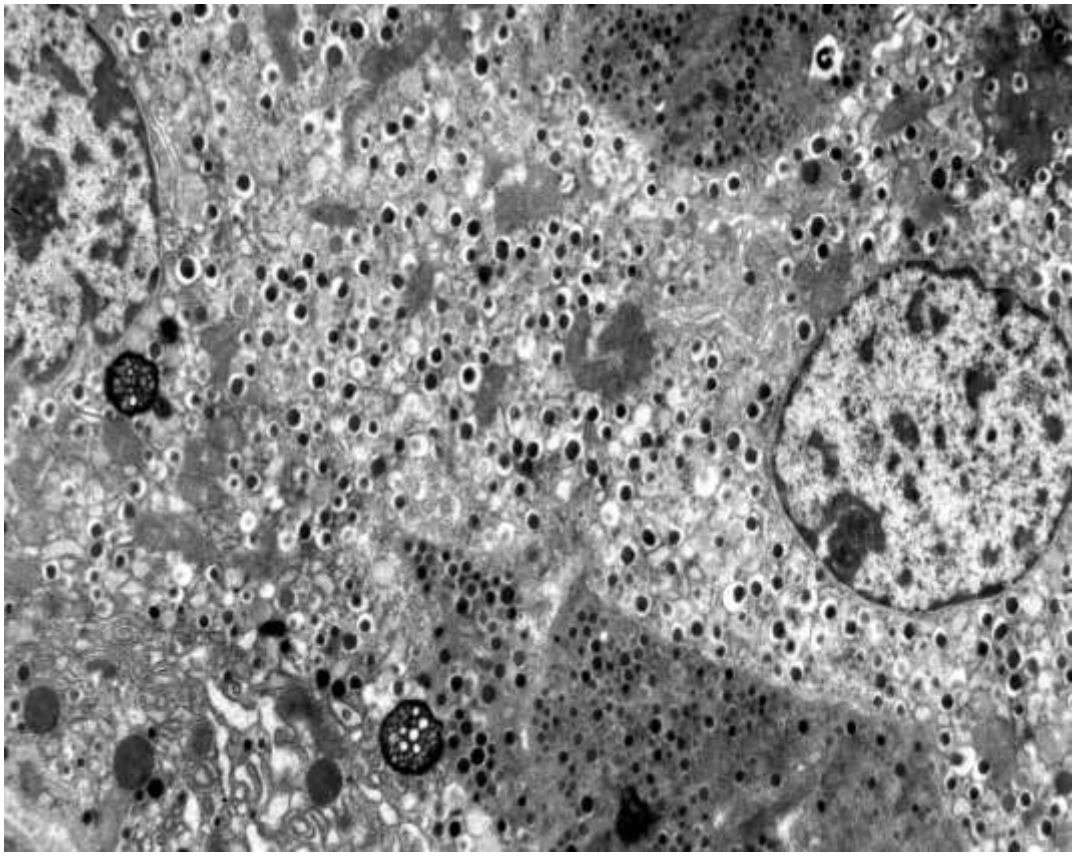


Fig. 4. Autophagosomes in pancreatic endocrinocytes. Electronogram. X 5000.

AZUROPHIL GRANULATION is nonspecific reddish-violet granulation of white blood cells caused by peculiar staining of their lysosomes.

AZUROPHILIA (from *azure*, name of the color and Greek *philia*, love) is the tendency of the cell to stain with azure in a red-violet tone (fig. 5).

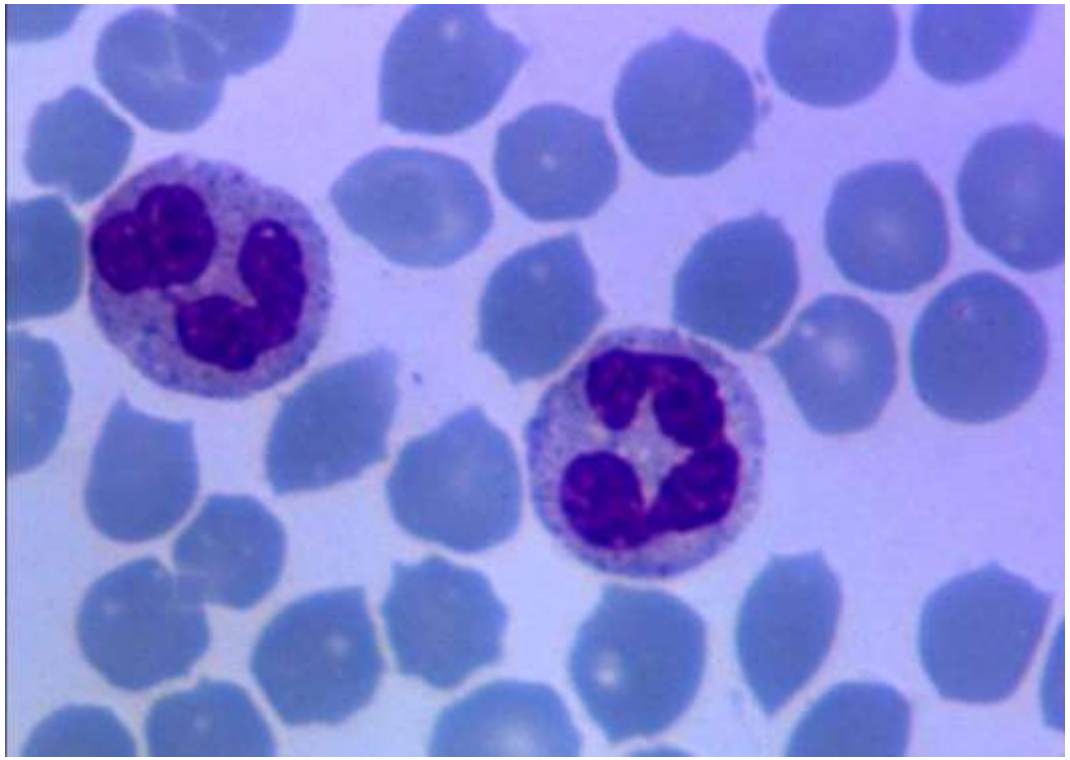


Fig. 5. Blood smear. Azurophilic granules in the cytoplasm of neutrophilic granulocytes. Romanovsky-Himza staining. Magn. x 1000.

BASOPHILIA (from Greek, *basis*, base and *philia*, love) is the property of cellular structures to be stained with basic dyes (for example, hematoxylin, azure, safranin, etc.). Basically, basophilia is associated with an increased content of different types of RNA in the cell cytoplasm, which is characteristic of cells that intensively synthesize protein (young, poorly differentiated cells; actively growing and dividing cells; in pathology - especially tumor cells) (fig. 6).

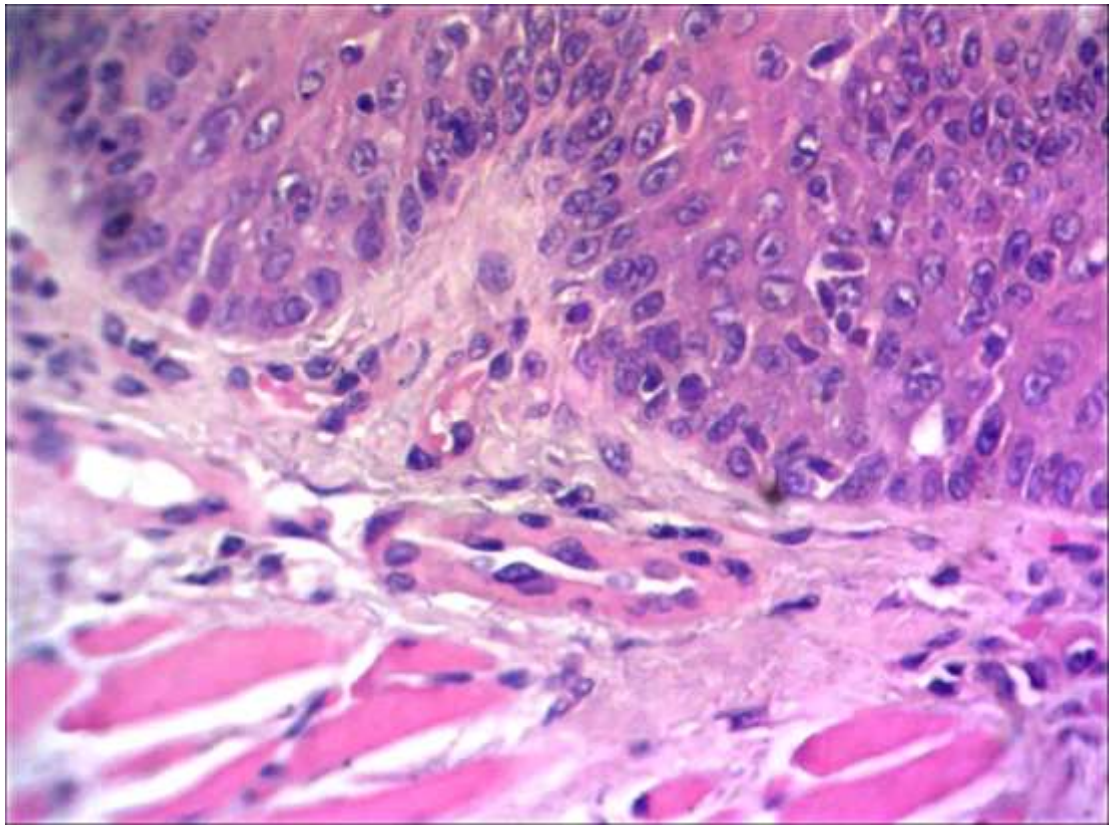


Fig. 6. Mucous membrane of the tongue. The cell nuclei are colored blue. Hematoxylin and eosin staining. Magn. x 400.

CELL (from Latin *cellula*, a cell and Greek *cytos*, a cell) is elementary structural and functional unit of living matter, self-regulating and self-reproducing. It consists of the nucleus, organelles and cytoplasm (fig. 7).

CELL CYCLE (from Greek *cyclos*, circle) is the life time of a cell from division to the next division or from division to its death. It consists of two consecutive stages: 1. Mitosis and 2. Interphase. The second part of the cycle, the interphase, consists of three periods: post-mitotic G1, during which the daughter cells grow up and form to the mother

cell; synthetic S, during which the amount of DNA is doubled (to the tetraploid set); premitotic G2 when the cell prepares for new mitosis.

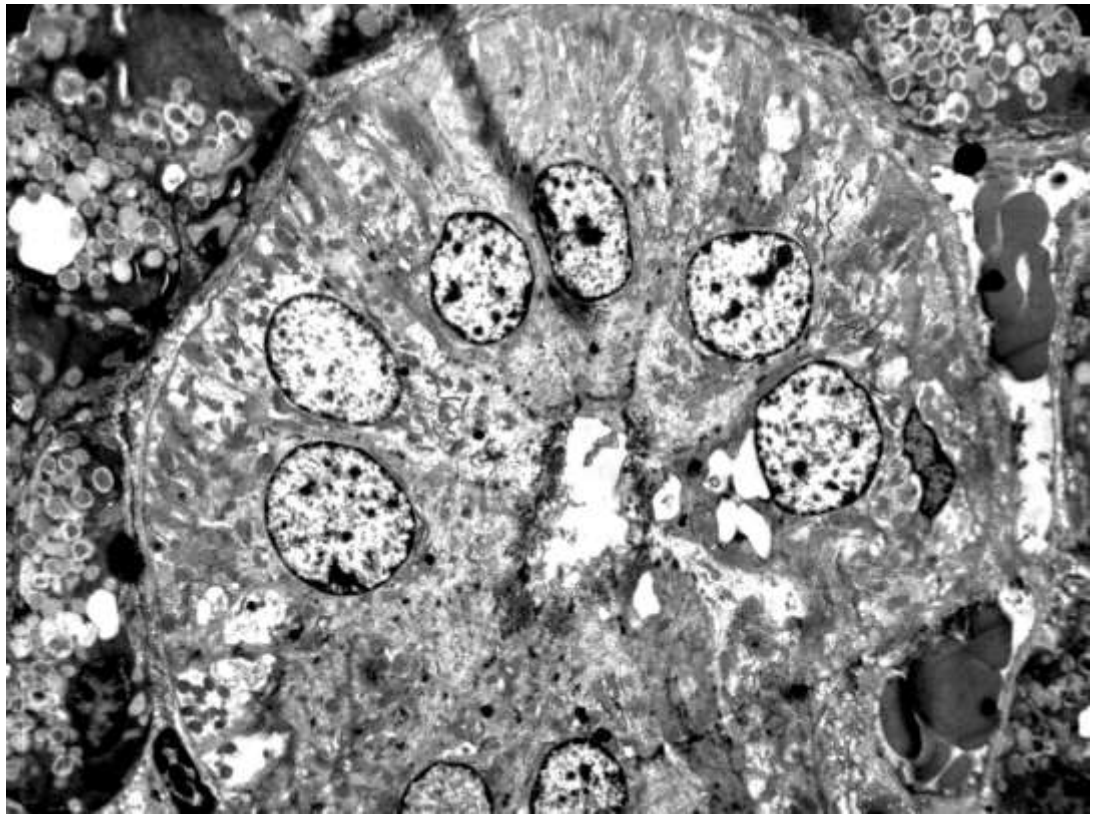


Fig. 7. Striated duct cells of rat salivary gland. Euchromatin predominates in the nuclei. There are many mitochondria in the cytoplasm. Electronogram. Magn. x 5000.

CELL DEGENERATION (from Latin *degeneration*, devolution) is a physiological (in the course of functioning, cytogenesis) or pathological (under the influence of damage) process of cell degeneration and death, which usually ends with autolysis.

CELL DETERMINATION (from Latin *determinate*, definition, restriction) is the process of cell development in

certain specialized directions under the influence of genetic and external (microenvironment) factors (monocyte - macrophage).

CELL GENERATION (CELL POPULATION) (from Latin *generatio*, generation, creation) is a group of cells that has arisen as a result of successive reproductions of one initial ancestral cell (chondroblasts - chondrocytes).

CELL METABOLISM (from Latine *metabole,* transformation, change) is intracellular metabolism, most pronounced in the interphase period. It consists of the processes of synthesis (anabolism) and disintegration (catabolism) of organic compounds.

CELL NUCLEUS (karyon) is a component of a cell that contains hereditary information. Its functions are: preservation of genetic information; enzymatic repair and DNA replication; recombinati on of genetic material in meiosis; realization of genetic information by synthesis of all types of RNA (information, ribosomal and transport) and transport of hereditary information to daughter cells during mitosis (fig. 8, 9).

CELL PROLIFERATION (from Latin *proles*, branch and *ferre*, to carry) is an increase in the number of cells due to their division (mitosis, amitosis, meiosis).

CELL REGENERATION is the restoration of the integrity of cells that were damaged in the course of performing their physiological functions (physiological regeneration) or after exposure to a pathogenic factor (reparative regeneration).

CELL POLARITY is the presence in cells of asymmetrically differentiated parts: the basal (associated with the basement membrane) and the apical. It is characteristic of epithelial cells (Fig. 10).

CELLULAR CHEMOTAXIS (from Latin *chemia*, chemistry and *taxis*, direction, displacement) is directed movement of free cells (spermatozoa, leukocytes) along the concentration gradient towards the source of c hemical substance (positive chemotaxis) or in the opposite direction (negative chemotaxis).

CELLULAR DETRITUS (from Latin *detritus*, erased) is the small particles of organic matter formed as a result of decomposition of tissue cells, which are then phagocytosed by macrophages (fig. 11).

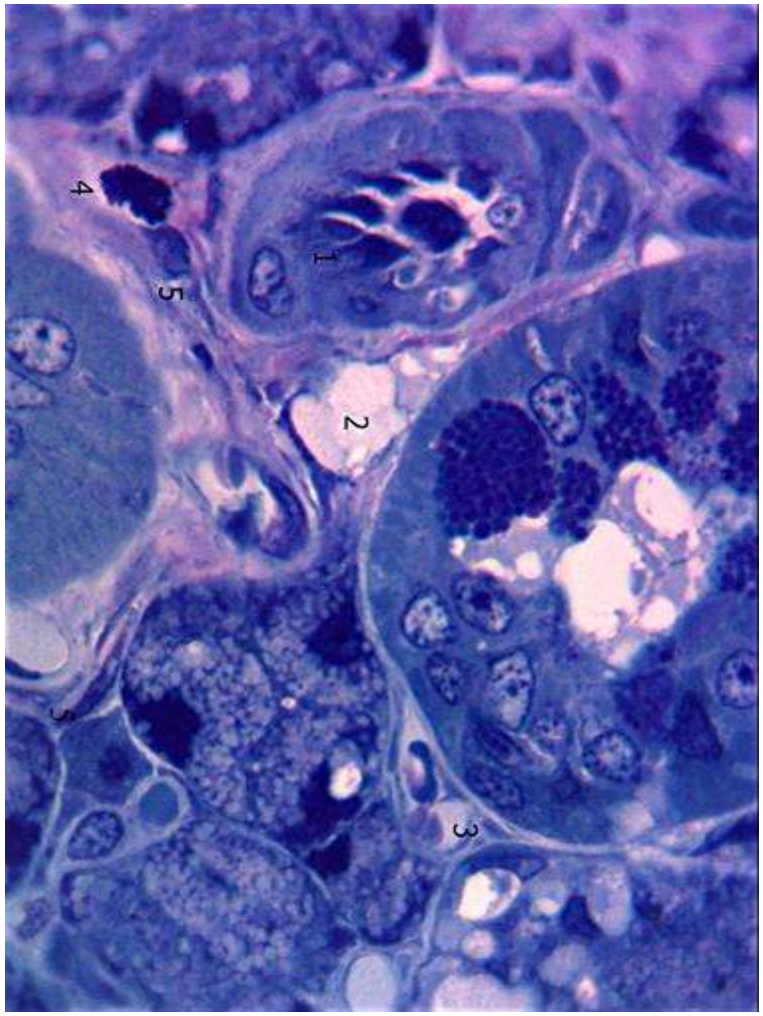


Fig. 8. Granular duct and end-pieces of rat salivary gland. In the nuclei of cells, euchromatin predominates, and in the nuclei of end-pieces' epitheliocytes, heterochromatin predominates. Toluidine blue staining. Magn. x 1000.

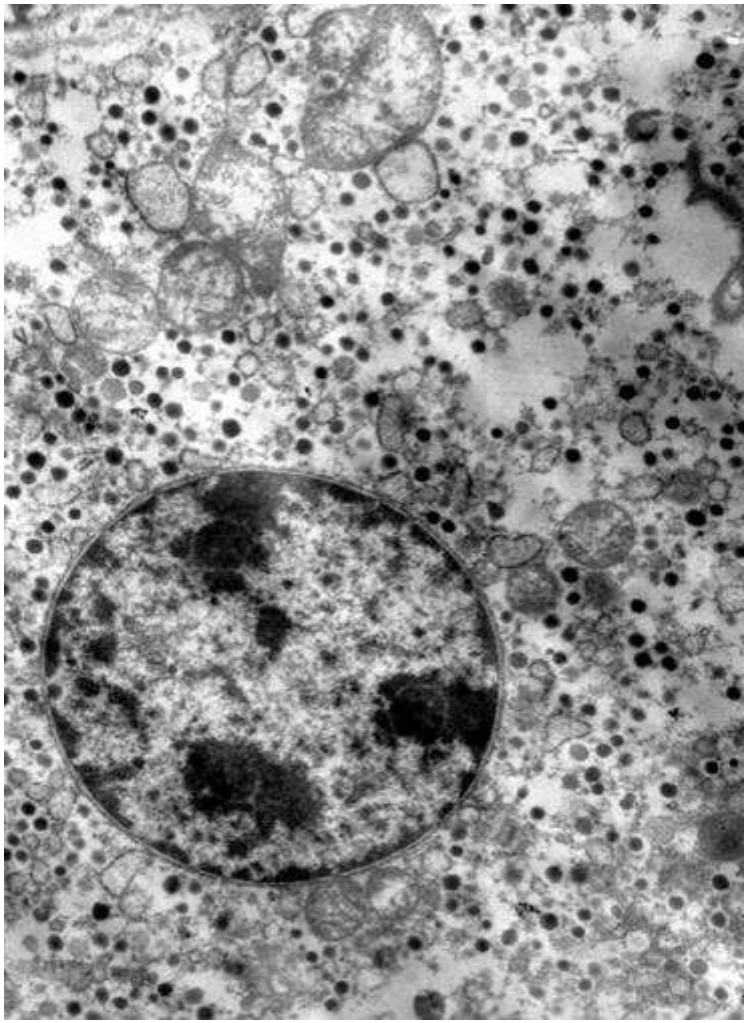


Fig. 9. Endocrinocyte nucleus of the pancreas. Hetero- and euchromatin, perinuclear space, in the cytoplasm - mitochondria and secretory granules are visible. Electronogram. X 5000.

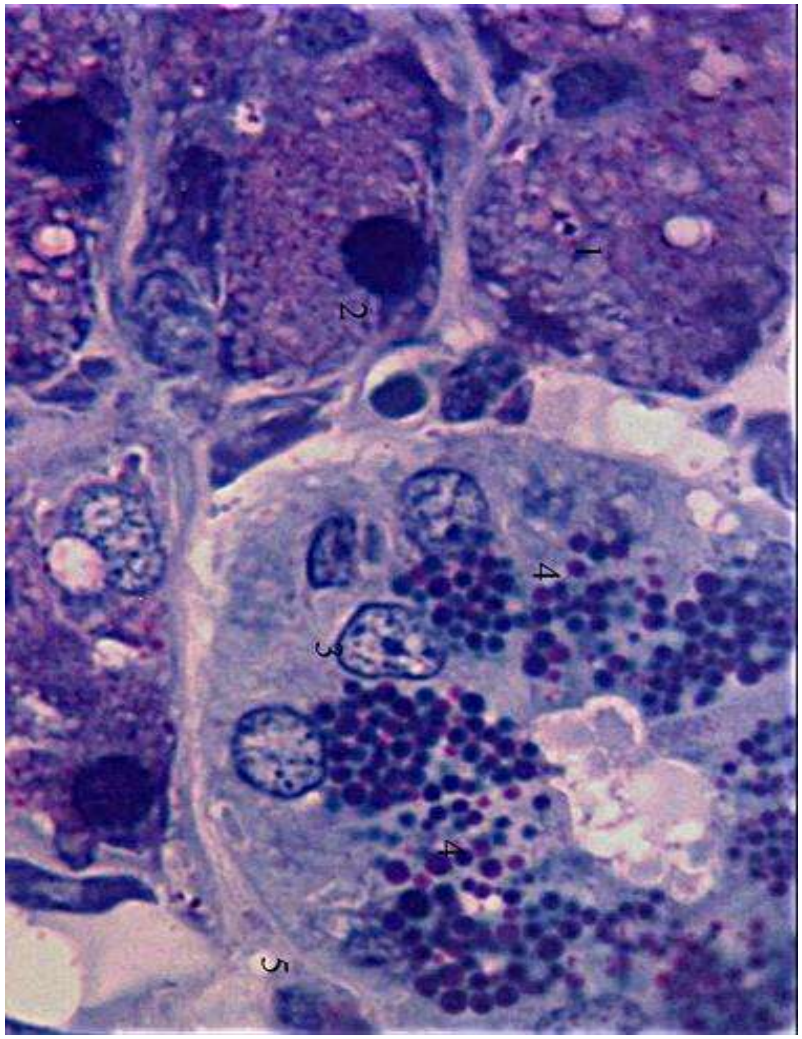


Fig. 10. Granular duct and end-pieces of rat salivary gland. Nuclei of cells in the basal part, secretory granules – in the apical part of the cells Toluidine blue staining. Magn. x 1000.

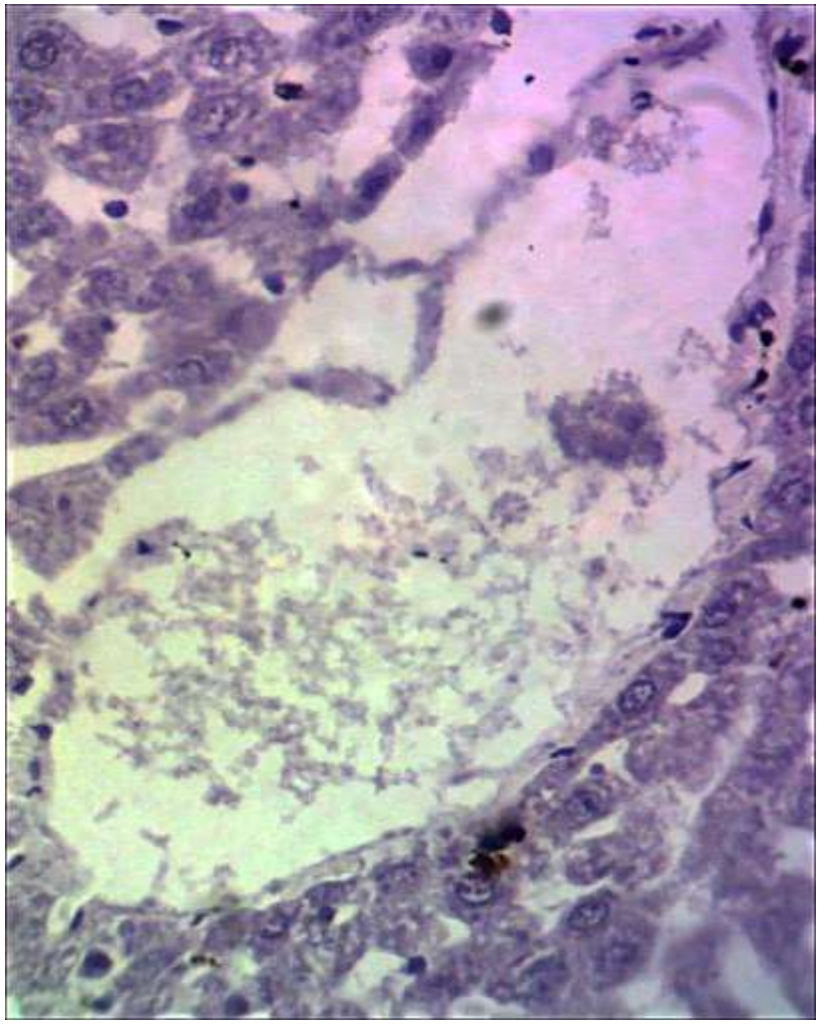


Fig. 11. Cellular detritus and leukocytes in the lumen of the central vein of the rat liver. Doxorubicin-induced liver damage. Hematoxylin and eosin staining. Magn. x 400.

CELLULAR DIFFERENTIATION (from Latin *differentia*, difference) is the formation of groups of heterogeneous, differently specialized cells from the relatively homogeneous cells that is connected with the manifestation (expression) of alternative properties of genes under the influence of regulating factors.

CELLULAR INTEGRATION (COOPERATION) is the association of cells in the system; the relationship is structural and functional (cellular cooperation in the immune response: lymphocytes, macrophages, granulocytes, mast cells).

CELLULAR SECRETION is removal of substances (products of secretion) from a cell. For example: hormones, enzymes, secretion of salivary glands and other biologically active substances (fig. 12).

CENTROSOME is the cell center. A non-membrane organelle formed by two centrioles and localized near the nucleus. Each centriole consists of 9 triplets of parallel microtubuli. Sister centrioles are located inter-perpendicularly. In the prophase of mitosis they are involved in the formation of the division spindle (fig. 13).

CHROMATIN (from Greek *chroma*, color) is a nucleoprotein constructed from DNA, histone protein and RNA in 1:1, 3:0.2 ratio. It has several levels of structural organization. Somatic chromatin and sex chromatin is distinguished. Sex chromatin is determined in the interphase nucleus of cells (Barr's body) of the female body (fig. 14).

CILIA are thin protrusions of the cytoplasm, which structured component is a complex system of microtubules. Inside each cilium there is an axonema, an axial thread. It is made up of 9 pairs of peripheral and one pair of centra l microtubules [9 × 2 + 2 formula]. At the base of the cilum is a basal body. The length of the cilia is from 5 to 10 μm, the diameter is about 200 nm.

CUTICLE OF THE CELL (from Latin *cuticula*, skin) is a protective covering on the surface of epithelial cells, lining the urinary tract; consists of dense substances produced by the cell.

CYTOPLASMIC INCLUSIONS are products of metabolism not constantly available in the cytoplasm. It is the consequence of secretion, excretion, phagocytosis, pinocytosis. The following inclusions are distinguished: trophic (fat, protein, glycogen), pigment (hemoglobin, melanin, lipofuscin), secretory (enzymes, mucus, hormones), excretory (urea, bile acids) and foreign phagocytic particles (dust, grains of sand, nicotine) (fig. 15).

DESMIN (from Greek *desmos*, link) is a specific protein of intermediate (foot) microfilaments of muscle cells.

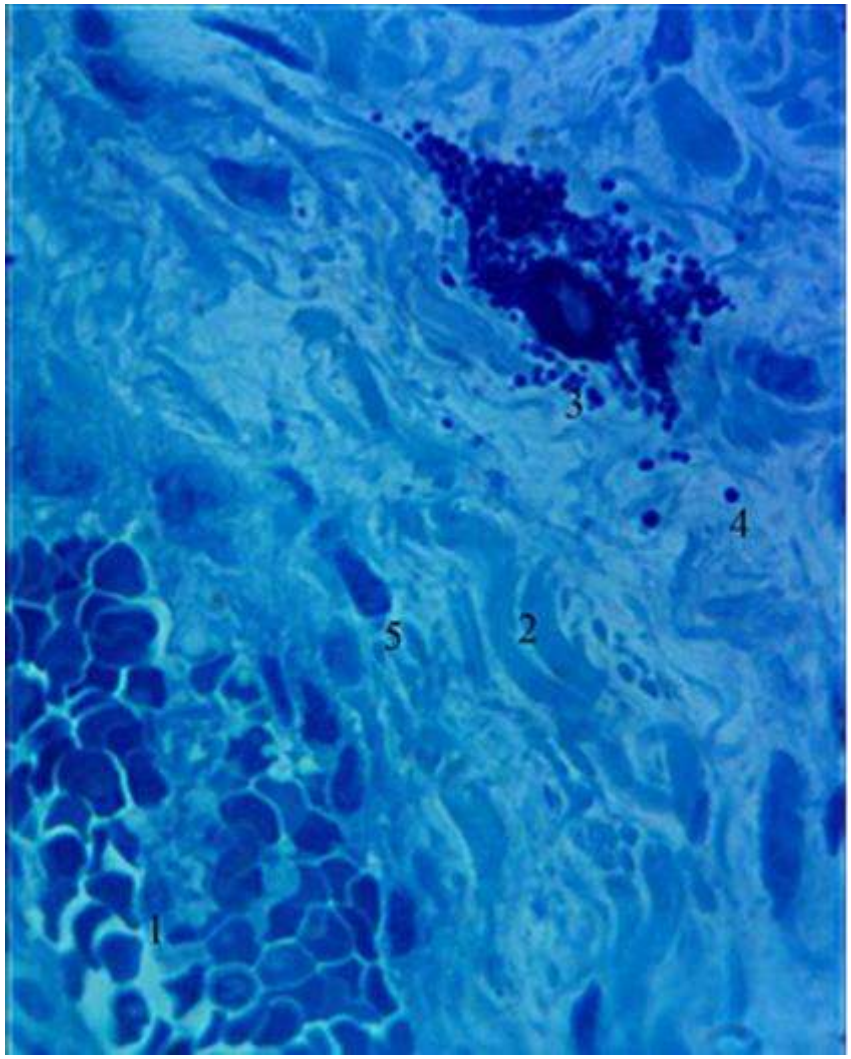


Fig. 12. Secretory granules of a mast cell. Stage of secretory granules extrusion. Methylene blue staining. Magn. x 1000.

Fig. 13. Centriole. Electronogram. Magn. x 15000.

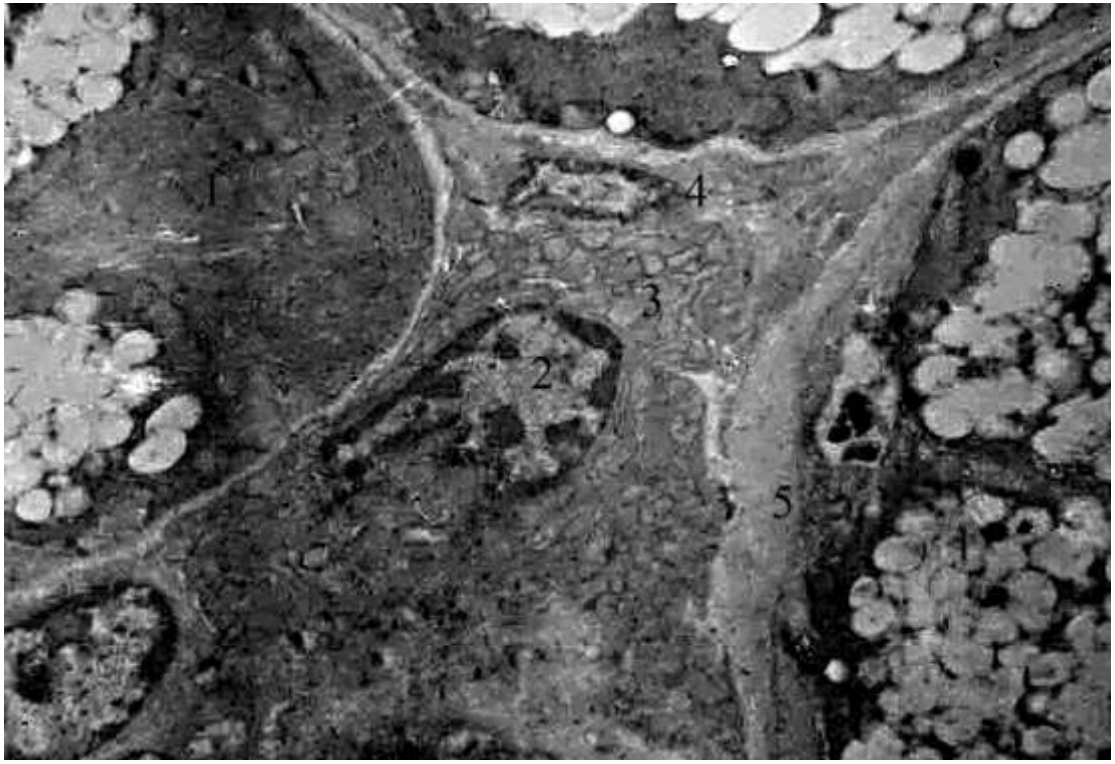


Fig. 14. Plasma cell nucleus. Dark is heterochromatin, light is euchromatin. Electronogram. Magn. 5000.

DESMOSOME (from Greek *desmos*, link and *soma*, body) is an adhesive type of intercellular contacts, in the formation of which electron-dense plates participate in the membranes of adjoining cells with attached tonofilaments of the cytoplasm. In the intercellular space an electron-dense plate is formed, bounded by filaments with compactions in membranes. It is the strongest intercellular contact. It is found in the skin epidermis, epithelium of the renal tubules and in the myocardium (fig. 16).

DIAPEDESIS (from Greek *dia*, through, *pedao*, jump) is an active passage of blood cells through the gaps between capillary endothelial cells into adjacent connective tissue.

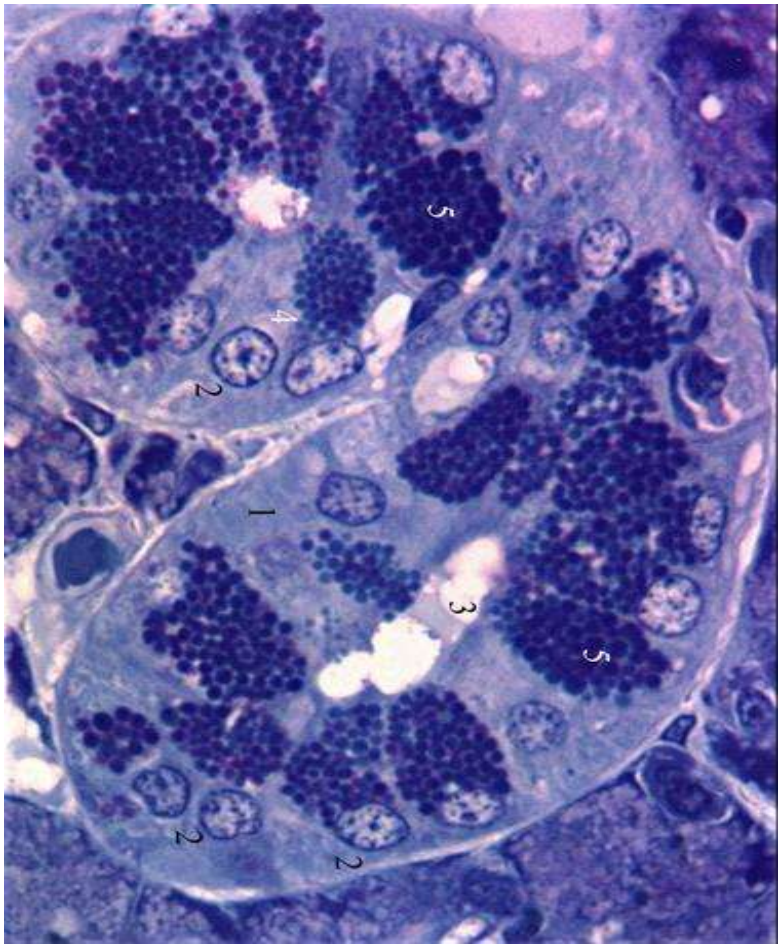


Fig. 15. Secretory inclusions in the cytoplasm of the granular ducts' cells of the rats' salivary gland. Toluidine blue staining. Magn. x 1000.

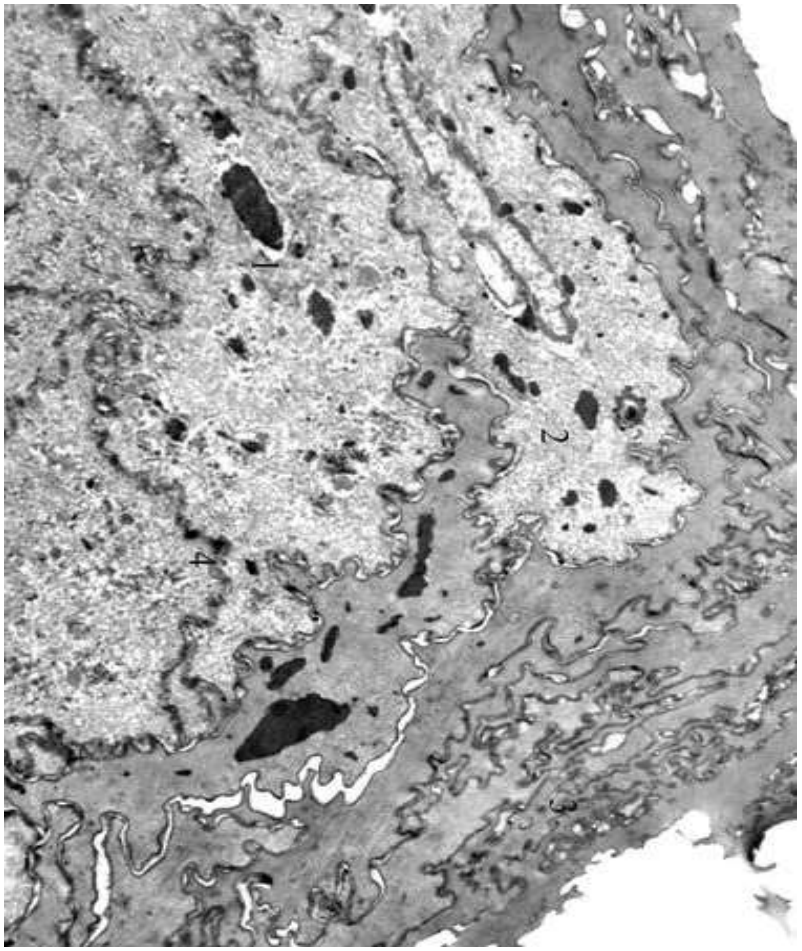


Fig. 16. Desmosomes in the granular epithelium of the dorsum of the tongue. Keratogialin granules are visible. The horny scales have a complex surface microrelief. Electronogram. X 3200.

DICTYOSOMES (from Greek *diktion*, net, *soma*, body) are the former name of individual sections of the Golgi

apparatus, which are visible in the light microscope on sections impregnated with osmium or silver salts (fig. 17).

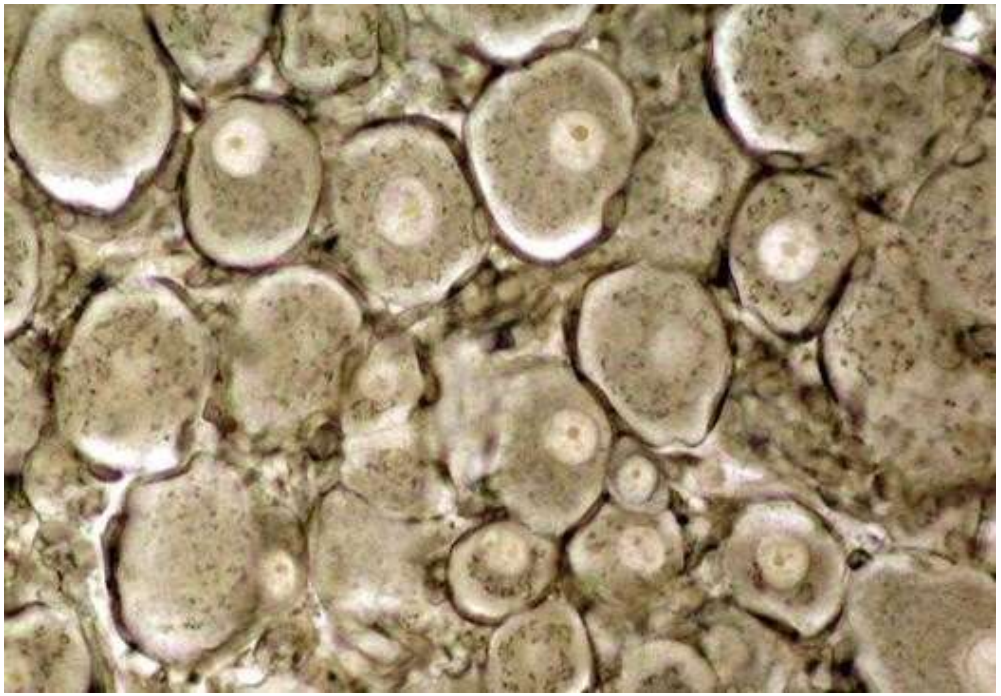


Fig. 17. Dictyosomes of the Golgi complex around the nucleus in the neurocytes of the spinal ganglion. Silver impregnation. Magn. X 1000.

DIPLOIDY (from Greek *diploos*, double), synonyms: diploid set of chromosomes, double, complete, paired; it is the presence in a human cells of a complete set, i.e. 23 pairs of homologous chromosomes (46 chromosomes). It is characteristic of the zygote and all somatic cells of the human body and animals (fig. 18).

DYSTROPHY (from Greek *dys*, prefix indicates disorder, disturbance and *trophe*, nutrition) is metabolic disorders in the cell. Depending on the mechanism of the development, cell dystrophy, caused by excessive accumulation of metabolic products (protein, fat, carbohydrate, pigment dystrophy) in the cytopla sm , and functional dystrophy caused, by hyperactivation of cellular organelles (mitochondrial, contractile) are distinguished.

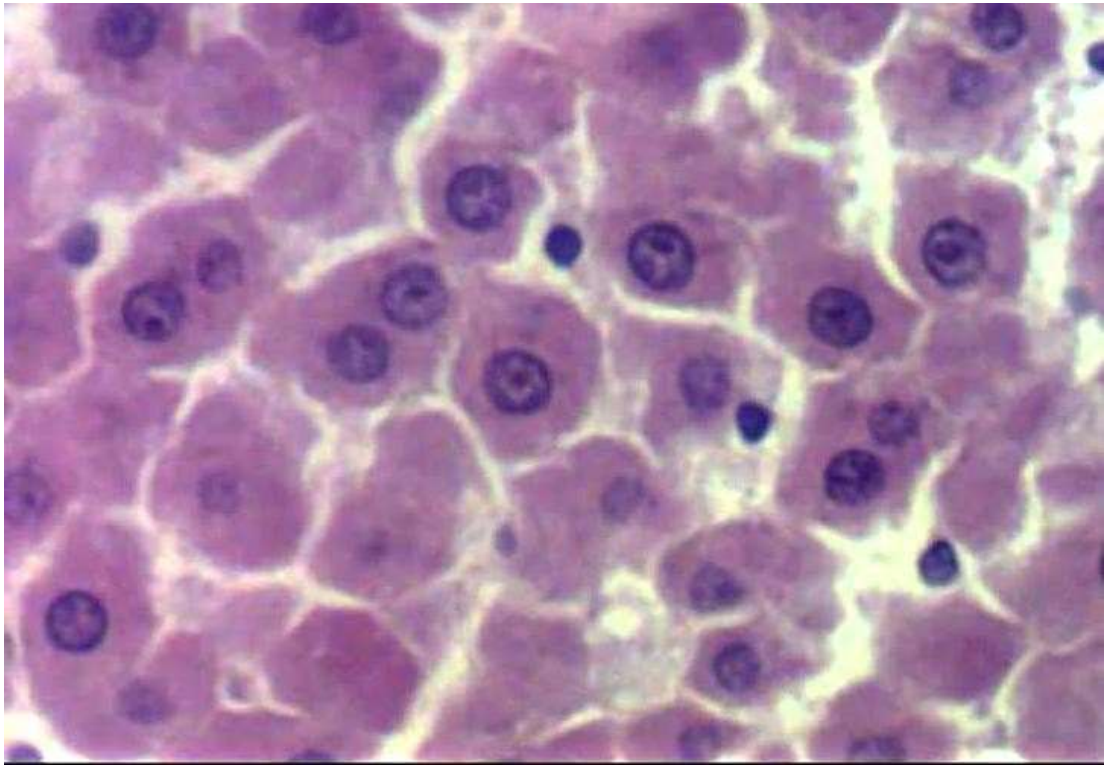


Fig. 18. Diploid nuclei of hepatocytes. Hematoxylin-eosin staining. Magn. x 1000.

ELEMENTARY BIOLOGICAL MEMBRANE (from Latin *membrane*, partition) is the main component of the plasmolemma. It is formed from the biolipid layer, which contains integral and semi-integral proteins (liquid-mosaic structure model) (fig. 19).

ENDOCYTOSIS (from Greek *endos*, inside and *cytos*, cell) is the flow of substances into the cell with the active participation of its plasmolemma with the formation of vesicles.

ENDOMITOSIS is the process of formation of polyploid nuclei in cells due to repeated (n> 1) repetition of the S - period of interphase.

ENDOPLASMIC RETICULUM (*reticuhim endoplasmaticae*) is a membrane organelle. It consists of membrane

tubules, follicles, cysterns. The following is distinguished: 1) smooth or agranular (from *a*, negative particle and *granulum*, a grain) endoplasmic reticulum (lipids and carbohydrates are synthesized here, detoxification of harmful chemicals occurs, calcium ions are deposited); 2) rough or granular (from *granulum*, a grain) endoplasmic reticulum to which membrane ribosomes are attached from the side of the hyaloplasm (protein molecules are synthesized) (fig. 20).

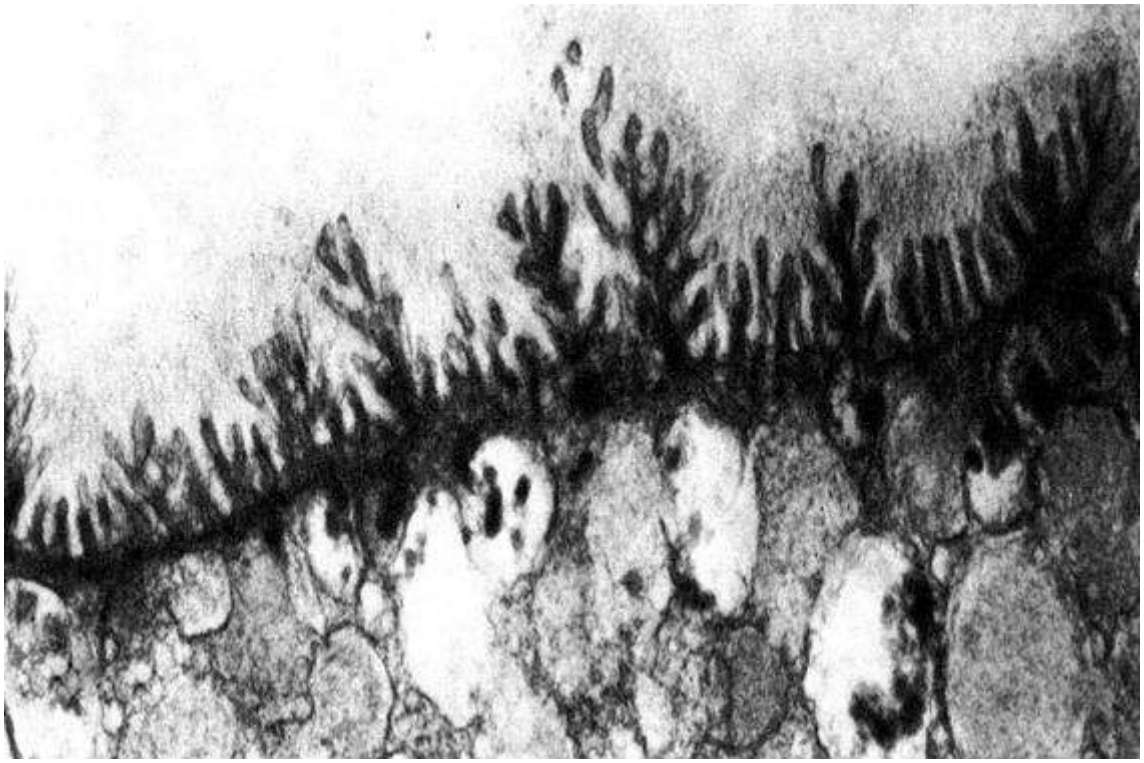


Fig. 19. Elementary biological membrane. Electronogram. Magn. x 25000.

ENZYMES (from Latin, *fermentum*, ferment) are biological catalysts of biochemical reactions of protein nature. Enzymes can be of either anabolic or catabolic action. Anabolic enzymes promote the formation of complex substances from simple ones, and catabolic enzymes, on the contrary, catalyze the processes of decomposition of complex substances to relatively simple organic and inorganic compounds.

EUCHROMATIN is an active chromatin, areas of chromatin (chromosome substances) that retain the despiralized state of elementary dezoxyribonucleoprotein filaments (DNPs) in the resting nucleus, i.e. in the interph ase (unlike the other areas, heterochromatin) (fig. 21).

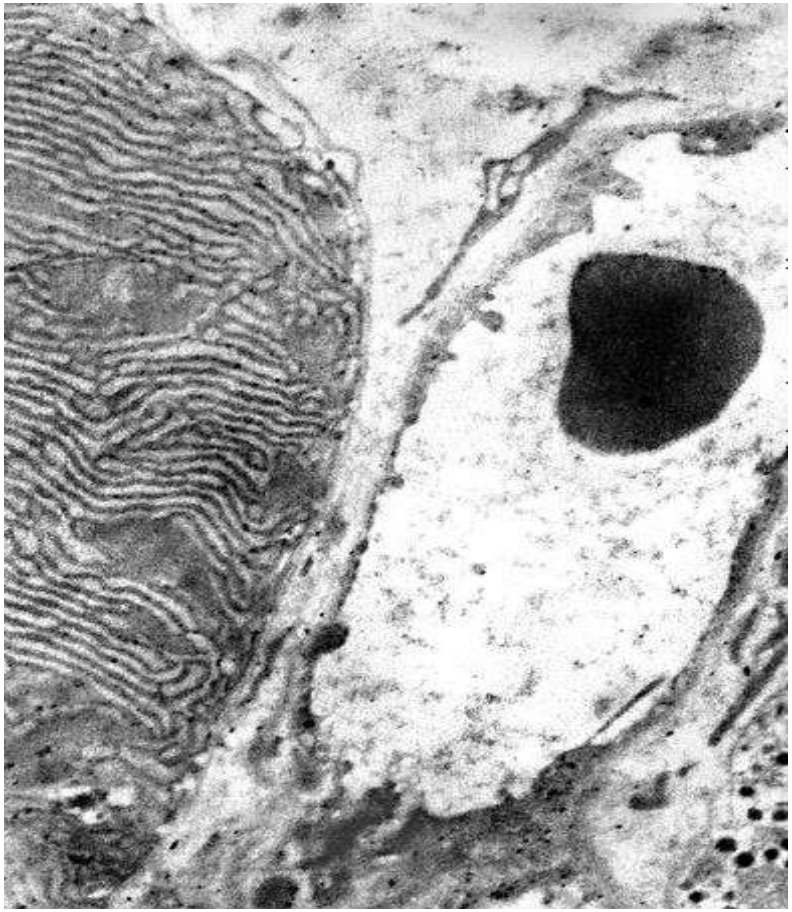


Fig. 20. Granular endoplasmic reticulum in the exocrinocyte of the pancreas. Above is a venule with an erythrocyte in the lumen. Electronogram. X 8000.

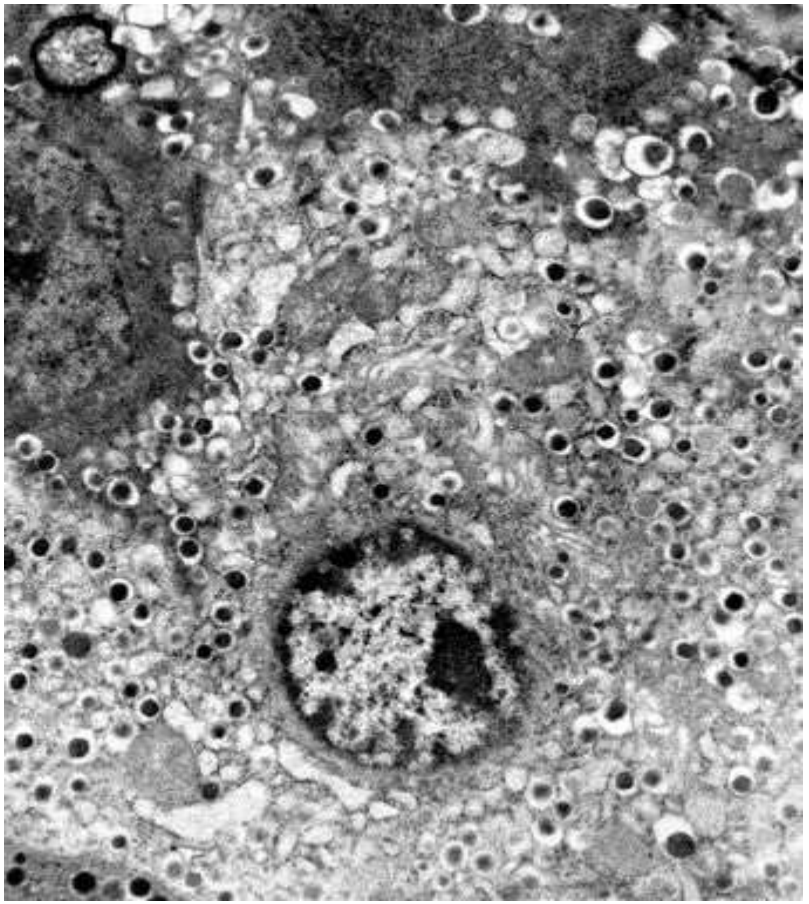


Fig. 21. Rounded nucleus of pancreatic endocrinocyte with a predominance of euchromatin. Electronogram. X 5000.

EUKARYOTES (from Greek *eu*, true, distinct and *karyon*, nucleus) are the cells consisting of a nucleus in which hereditary genetic information is localized in the form of a DNA + protein complex. The nucleus is separated from the cytoplasm by a nuclear membrane with pores. Through them, information is exchanged between the cytoplasm and the nucleus.

EXCRETION (from Latin *ex*, external and *cretio*, separate) is excretion of substances, the end products of intracellular metabolism from the cell. For example: urea through the renal filtration barrier.

EXOCYTOSIS (from Greek *exos*, external, *cytos*, cells) is a process of excretion of substances from the cell into the extracellular space.

GLYCOCALYX (from Greek *glycos*, sweet and *calix*, cover) is a supramembranous layer of a cell membrane or cytolemma. It is formed by carbon-containing particles of glycoprotein and glycolipid membrane molecules that project beyond its outer surface. It is considered a factor of cell adhesion, cell interrecognition, interaction with microenvironment. In this case, each cell type has its own unique set and arrangement of carbohydrate components (fig. 22).

GOLGI APPARATUS (GOLGI COMPLEX) is a membrane organelle of cells that consists of a system of cisternae, saccules, vesicles. It involves the processes of accumulation and isolation of products of secretion, as well as the formation of primary lysosomes (fig. 23).

GRANULE (from Latin *granulum*, grain) is the dense orbicular bodies in the cytoplasm of cells. It can be lysosomes, ribosomes, secretion granules (fig. 24).

HAPLOIDY (from Greek, *haploos*, single, simple), synonym for "haploid set of chromosomes" is a single set of chromosomes in which each chromosome occurs only in the singular (1n). Haploid sets have sperm cells and egg cells, called gametes.

HEMIDESMOSOMA is one of the forms of epithelial cells' adhesion to the basement membrane.

HERTWIG INDEX (from Latin *index*, parameter) is the nuclear-cytoplasmic ratio obtained from the division of the volume of the nucleus by the volume of the cytoplasm.

HETEROCHROMATIN is inactive chromatin, chromatin portions that are in the condensed (compact) state during

the cell cycle (fig. 25).

Fig. 22. Glycocalyx. Electronogram. Magn. x 25000.

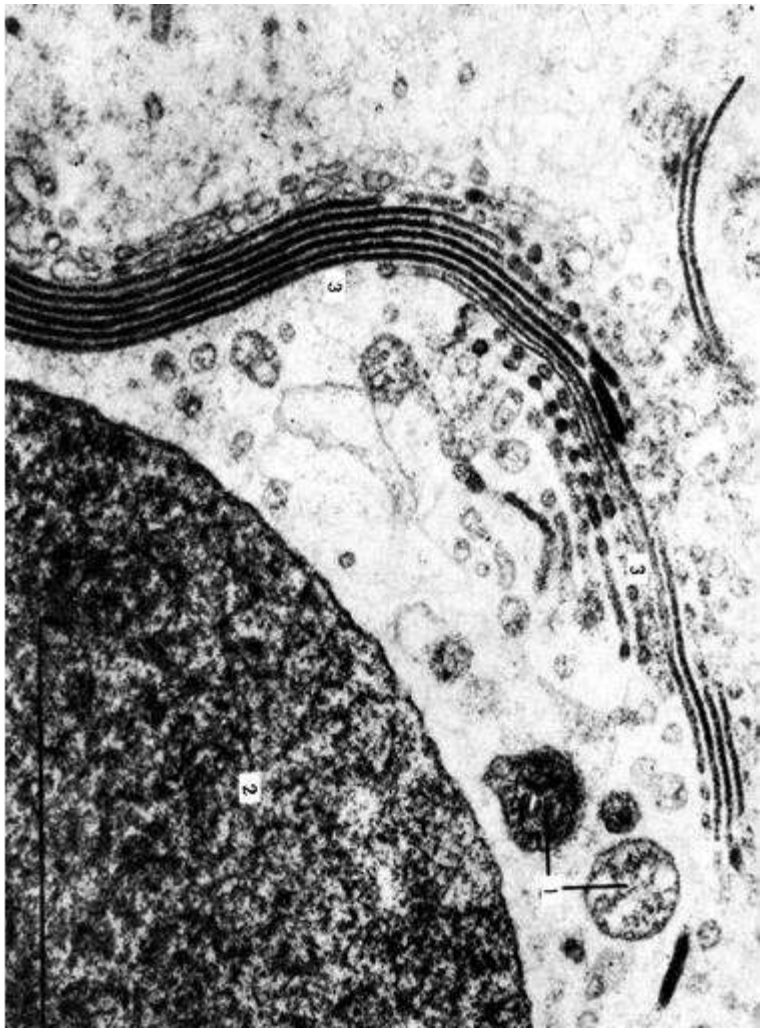


Fig. 23. Golgi apparatus (golgi complex). Electronogram. Magn. x 25000.

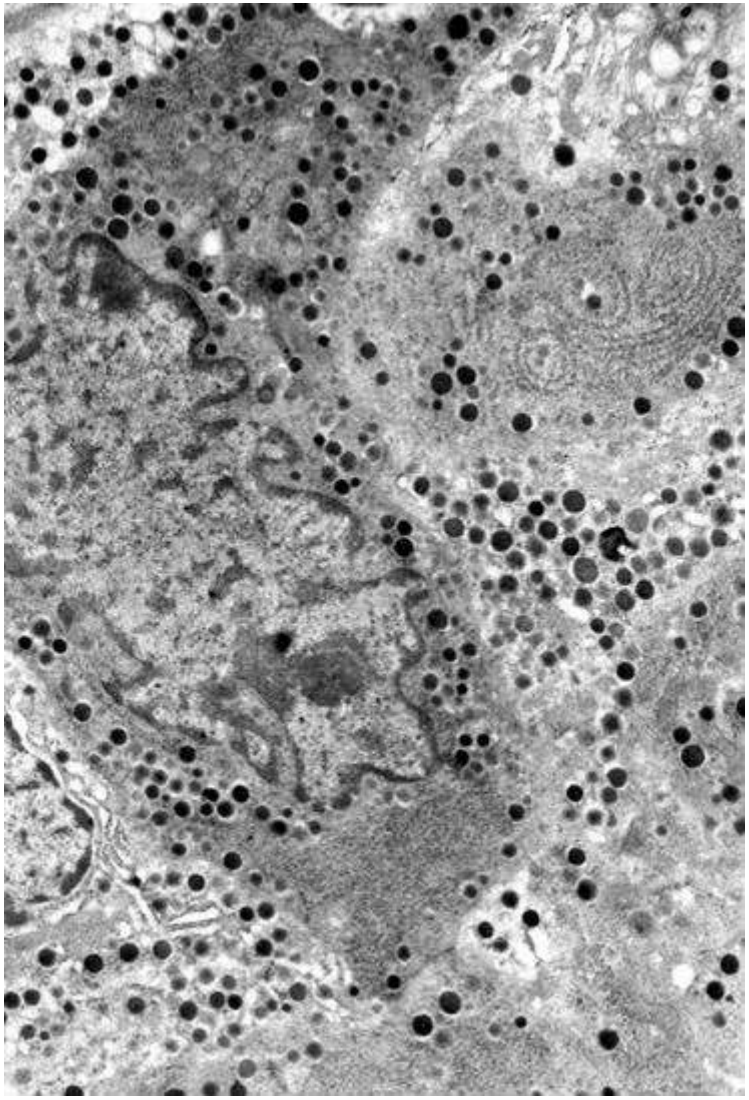


Fig. 24. Secretory granules in the cytoplasm of pancreatic endocrinocytes. Electronogram. X 5000.

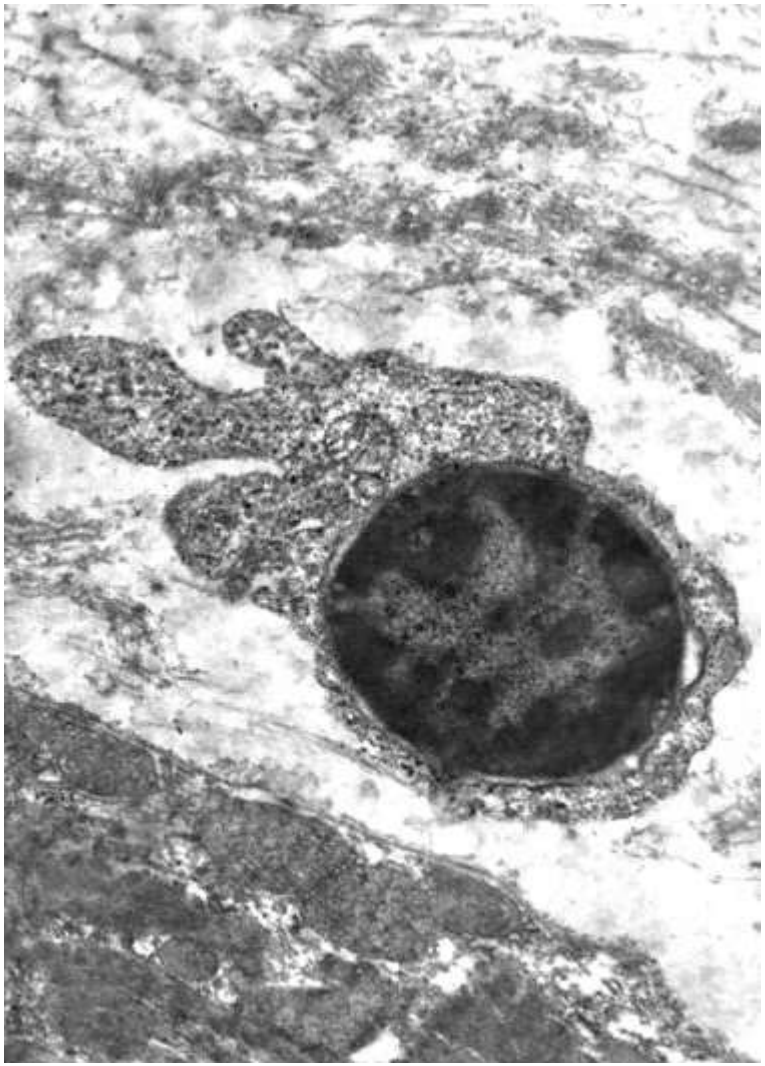


Fig. 25. The predominance of heterochromatin in the nucleus of the plasma cell. Electronogram. X 8000.

HETEROPLOIDY (from Greek *heteros*, other and *ploos*, to form) is odd increase or decrease in number of individual chromosomes in a set.

HYALOPLASM (from Greek *giyalos*, glass), synonym: cytoplasmic matrix; it is optically transparent liquid mass of cytoplasm, located between the structural components (organelles and inclusions).

HYPERPLASIA (from Greek *hyper*, super and *plasis*, to form) is an excessive increase in the number of cells due to their intensive reproduction (mitosis, amitosis).

HYPERTROPHY (from Greek *hyper*, super and *trophe*, nutrition) is an increase in volume of cells (and tissues) caused by growth of mass of cells, and not as a result of their reproduction.

HYPOTROPHY (from Greek *hypo*, under, below and *trophe*, nutrition) is a decrease in volume of cells (or tissues) due to deterioration of their nutrition.

INTERDIGITATION (from Latin *inter*, between, *digiti*, fingers) is a type of intercellular contacts. Cells are interconnected by means of microscopic digitate extensions, which enter between the same formations of the neighboring cell (fig. 26).

INTERPHASE (from Latin *inter*, between, and *phasis*, occurrence), the synonyms are "interkinesis" (from Latin *inter*, between, and *kinesis*, movement) and "interkaryokinesis" (from Latin *inter*, between, and *kinesis*, movement and Greek *karyon*, nucleus) is the resting phase between successive mitotic divisions of a cell and / or from the moment of division of the cell to its death. The interphase consists of three periods:

- post-mitotic period, G1. During this period, the growth and functioning of daughter cells occurs.
- pre-mitotic period, G2. During this period, i-RNA, p-RNA, and specific proteins tubulins, which are essential in preparation for cell division during next mitosis, are synthesized.
- synthetic period, S. During this period hereditary information is replicated in the nucleus (for example, 2p → 4p).

KARYOLYSIS (from Greek *karyon*, nucleus, *lysis*, dissolution) is gradual enzymatic destruction of the nucleus under the influence of lysosomal enzymes. It is one of the consecutive stages of cell necrosis.

KARYOPIKNOSIS (from Greek *karyon*, nucleus and *pyknosis*, compaction) is a degenerative reduction of the size of the nucleus due to its compaction and shrinkage (fig. 27).

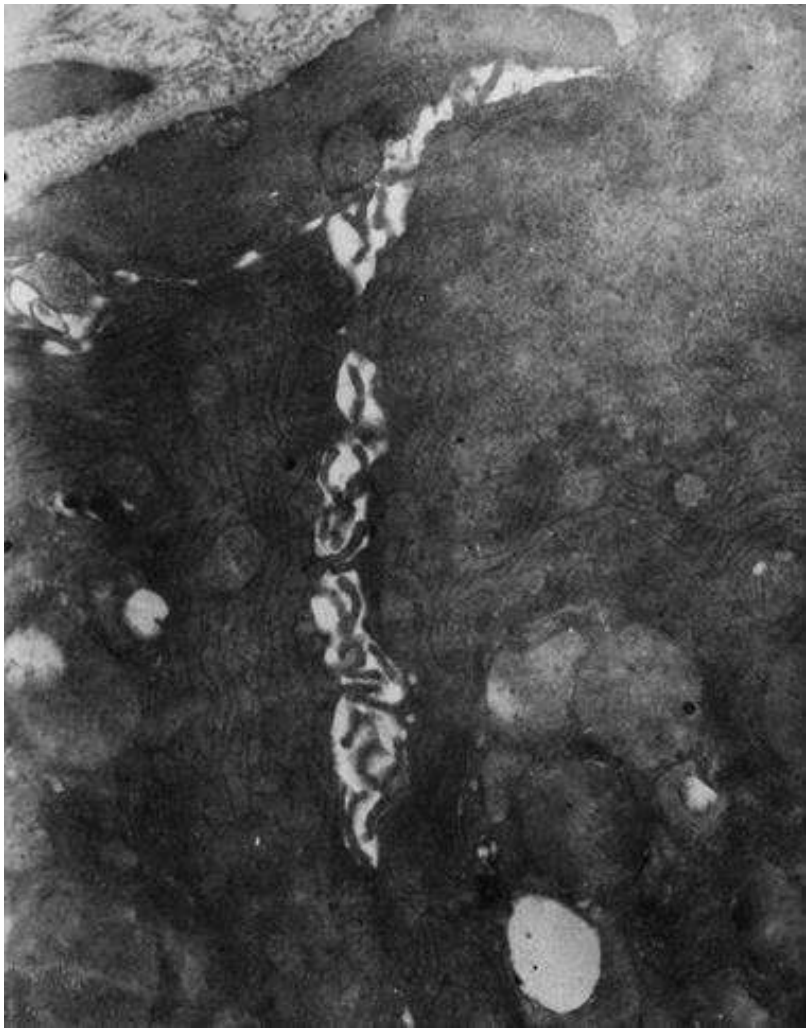


Fig. 26. Interdigitations in intercellular spaces between epitheliocytes. Electronogram. Magn. x 3000.

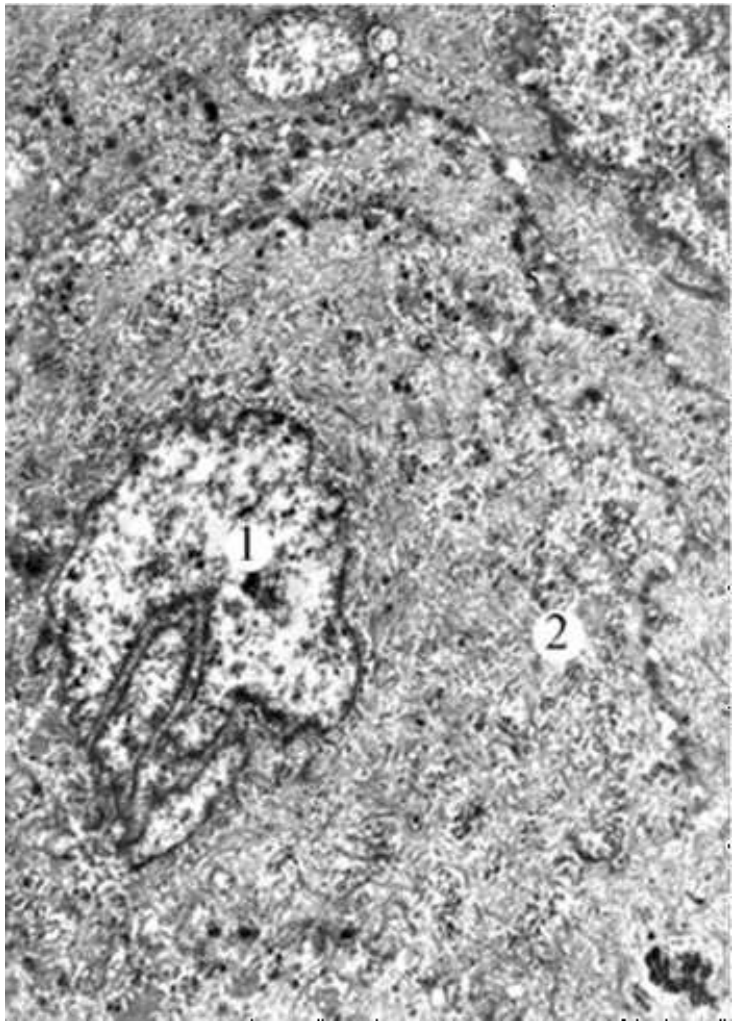


Fig. 27. Fragmentation of the keraitnocyte's nucleus in the granular layer of the mucous membrane's epithelium of the tongue's dorsal surface. Electronogram. Magn. 4000.

KARYOPLASM (from Greek *karyon,* nucleus and *plasma,* something formed, decorated), synonyms: nuclear sap, nucleoplasm, nuclear matrix. It is liquid-viscous content of the nucleus, similar to the cytoplasmic hyaloplasm in which the structural and function elements of chromatin are located.

KARYORRHEXIS (from Greek *karyon,* nucleus and *rhexis*, rupture) is the fragmentation of the nucleus into the lumps in the process of cell autolysis.

KERATIN (from Greek *keras,* horn) - 1. Horny substance in the cytoplasm of keratinized cells. 2. Protein of intermediate microfilaments of epithelial cells that give them shape; the supporting cytoskeleton that forms them (fig.28).

LYSOSOME (from Greek *lysis*, dissolution, and *soma,* body) is a membrane organelle of a cell with the function of dissolution of biopolymers of different chemical composition. For this purpose, hydrolytic enzymes (about 60 species) are contained in the lysosomes. Primary, secondary (phagosomes, autophagosomes) lysosomes, residual corpuscles are distinguished.

MATRIX (from Latin *matrix,* a mother) is a viscous substance of the nucleus (karyoplasm), cytoplasm (hyaloplasm), membrane organelles.

MICROFILAMENTS (from Greek *micros*, small and Latin *filum*, filament) are submicroscopic non-membranous structures, fibrils consisting of proteins (for example: actin, myosin, tropomyosin, alpha-actinin). The form the contractile cell apparatus and are involved in the formation of the cytoskeleton.

MICROTUBULI (from Greek *micros*, small and *tubulus*, a tube) are submicroscopic non-membranous organelles made of proteins called tubulins. They form a division spindle (*fusus divisionis*), providing cell mobility and are involved in the formation of the cytoskeleton.

MITOCHONDRION (from Greek *mitos,* filament and *chondros*, grain) is a membrane-type organelle in which ATP molecules are formed due to oxidative formation. It has a double membrane: external (protective) and internal (functional). The inner membrane forms numerous folds, crysts, on the surface of which the redox enzymes are localized. The mitochondrial matrix contains soluble enzymes; it contains mitochondrial DNA: a substrate of cytoplasmic heredity (fig. 29).

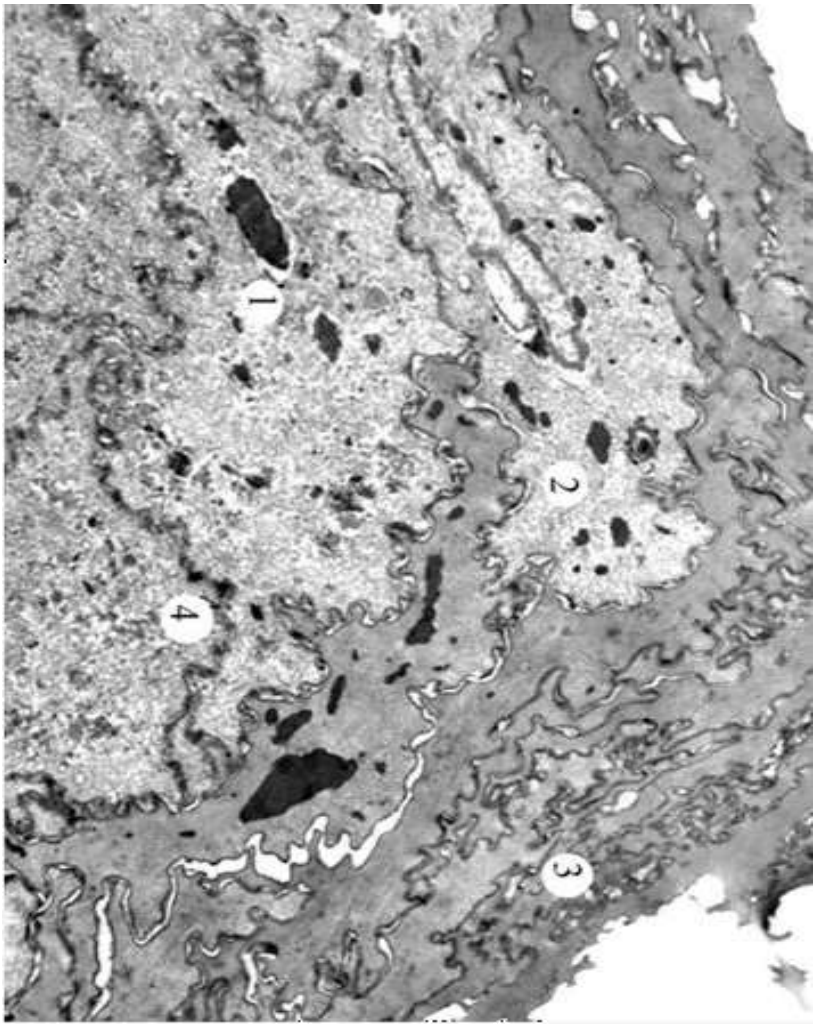


Fig. 28. Horny squames and keraitnocytes in the mucous membrane's epithelium of the tongue's dorsal surface. Electronogram. Magn. 3200.

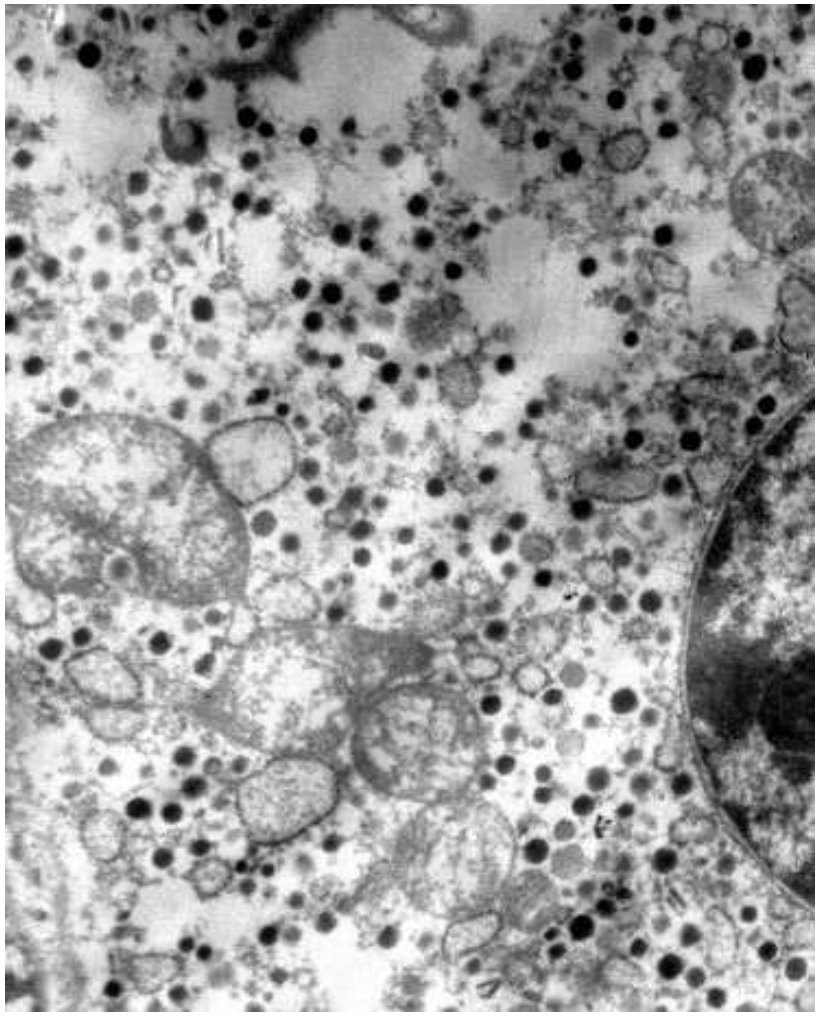


Fig. 29. Mitochondria and secretory granules in the endocrinocyte of the pancreas. Electronogram.

MITOSIS (from Greek *mitos*, filament) is the ability of a cell for division into two almost equal daughter cells with an identical set of hereditary information. During mitosis, the cell undergoes several consecutive continuous phases of division:

- **MITOTIC PROPHASE** (from Latin *pro*, before and Greek *phasis*, stage) is the first phase of mitosis, consisting of two stages. During the first stage, chromosomes, coiled into a ball, (the stage of a tight ball) appear in the nucleus of the dividing cell. In the second stage (loose ball) fragmentation of the nuclear envelope occurs and chromosomes loosely flow on the cytoplasm and the mitotic spindle is formed(fig. 30) ;
- **MITOTIC METAPHASE** (from Greek *meta*, among, after and *phasis*, stage) is the subsequent stage of mitosis after prophase, during which the chromosomes, attaching their centromeres to the ductible microtubules of mitotic spindle, are located in the middle of the cell, forming the equatorial plate (a monaster) (fig. 31);

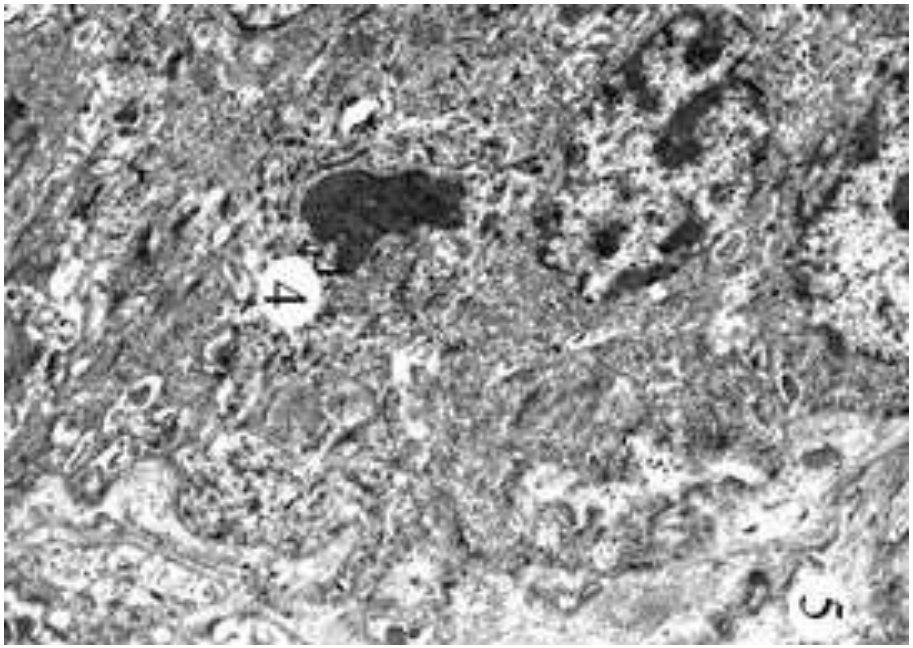


Fig. 30. Prophase of mitosis in the basal layer of the epithelium. Electronogram. Magn. X 2400.

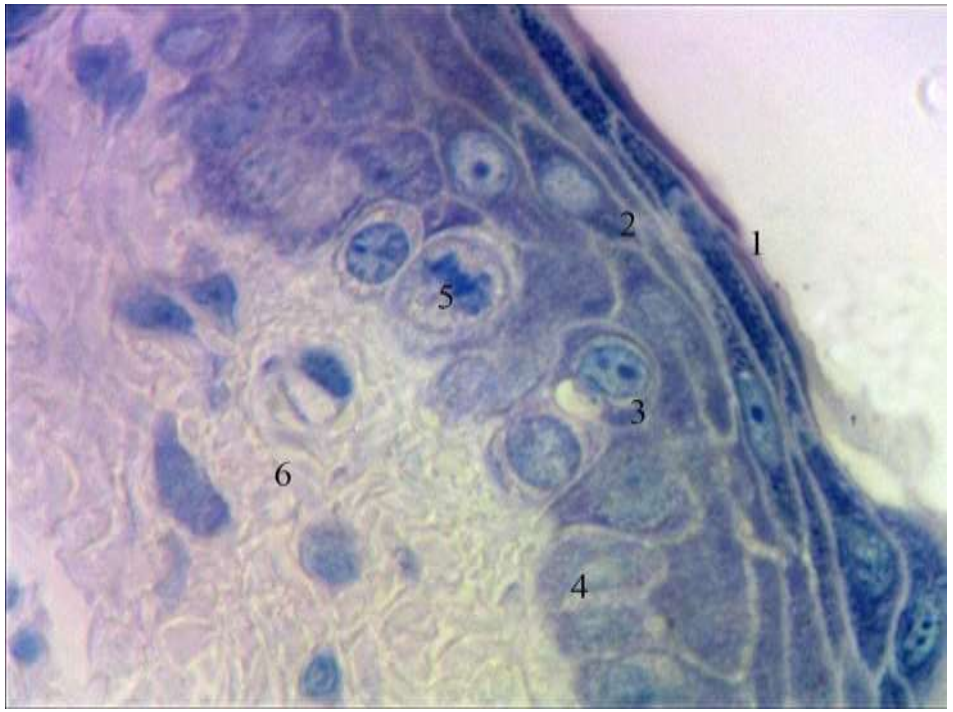


Fig. 31. Metaphase of mitosis in the basal layer of the epithelium. Toluidine blue staining. Magn. x 1000.

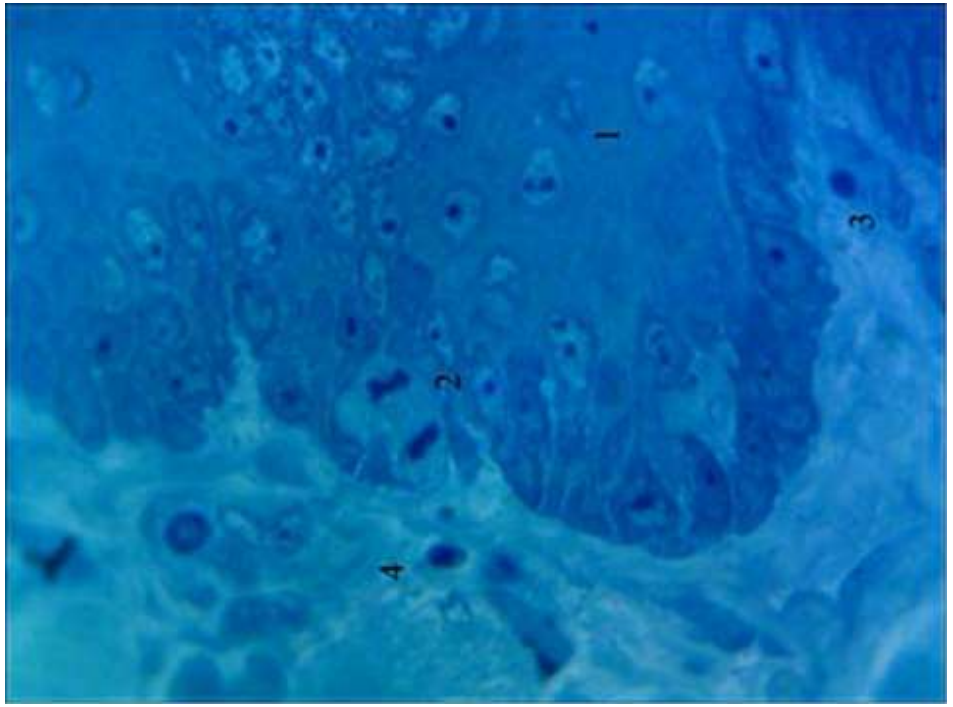


Fig. 32. Anaphase of mitosis in the basal layer of the epithelium. Methylene blue staining. Magn. x 400.

- **MITOTIC ANAPHASE** (from Greek *ana*, up and *phasis*, stage) is the next stage of mitosis following the metaphase stage, during which the longitudinal half of metaphase chromosomes, doubled chromatids, are quickly separated along the ductible filaments of the achromatin spindle in the direction to its poles (fig. 32);
- **MITOTIC TELOPHASE** (from greek *telos*, end and *phasis*, stage) is the final stage of mitosis, during which chromosomes in the daughter cells are despiralized and transformed into chromatin lumps; the nucleolus is formed and the nuclear envelope and organelles become visible.

MYOFIBRILS (from Greek *myos*, muscle and *fibrilla*, fibril) are non-membranous specialized organelle of muscle

cells that performs contractile function and is formed from actin and myosin proteins (fig. 33).

NECROSIS (from Greek *necrosis*, death) is a death of cells under the influence of extreme damaging factors of the environment. For example: overheating (hyperthermia, t> 39°C), overcooling (hypothermia, t≦0°C), oxygen deficiency (hypoxia), circulatory disorders (ischemia).

NEUROFIBRIL (from Greek *neuron*, nerve and *fibrilla*, fiber) is a special organelle of the nerve cells, called neurons. These are thin fibrils with a diameter of 0.3 - 0.5 microns, which form a net in the perikaryon and run parallel to the neuron processes; their role is to maintain the dynamic shape of the nerve cells (fig. 34).

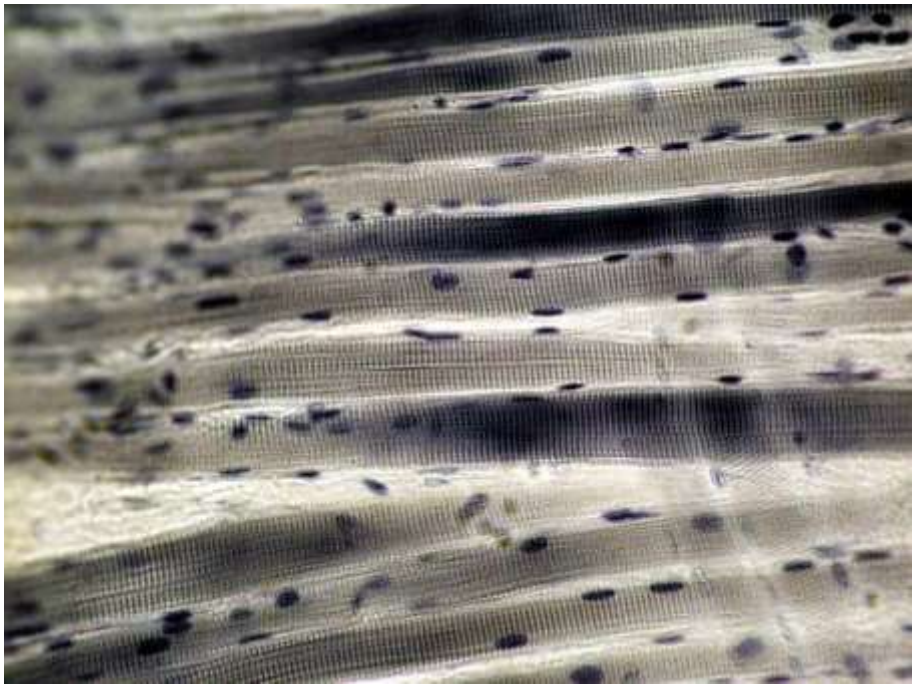


Fig. 33. Myofibrils in skeletal muscle fiber. Hematoxylin staining. Magn. x 400.

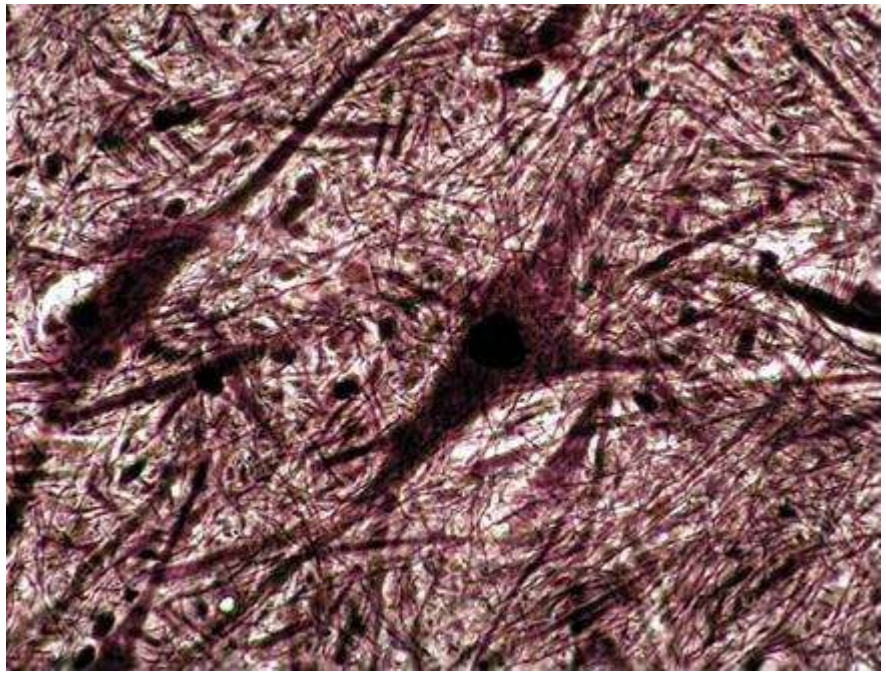


Fig. 34. Neurofibrils in the cytoplasm of the neurocyte of the cerebral cortex. Impregnation with silver. Magn. 400.

NEUTROPHILIA (from Latin *neutrum*, neutral and *philia*, love) is a property of cellular components to acquire intermediate combined color due to staining with a mixture of acidic and basic stains (Fig. 35).

NEXUS, GAP JUNCTION (from Greek *nexus*, gap) is a communicative intercellular junction formed from each cell. Connexin consists of 3 integral proteins from each cell. It is found between cells of all types of tissues.

NUCLEAR ENVELOPE (*karyolemma*) separates the contents of the nucleus from the surrounding cytoplasm. Thickness is 7 - 8 nm. It consists of 2 biological membranes: internal and external. At the sit es of local contact of these membranes, nuclear pores are formed (fig. 36).

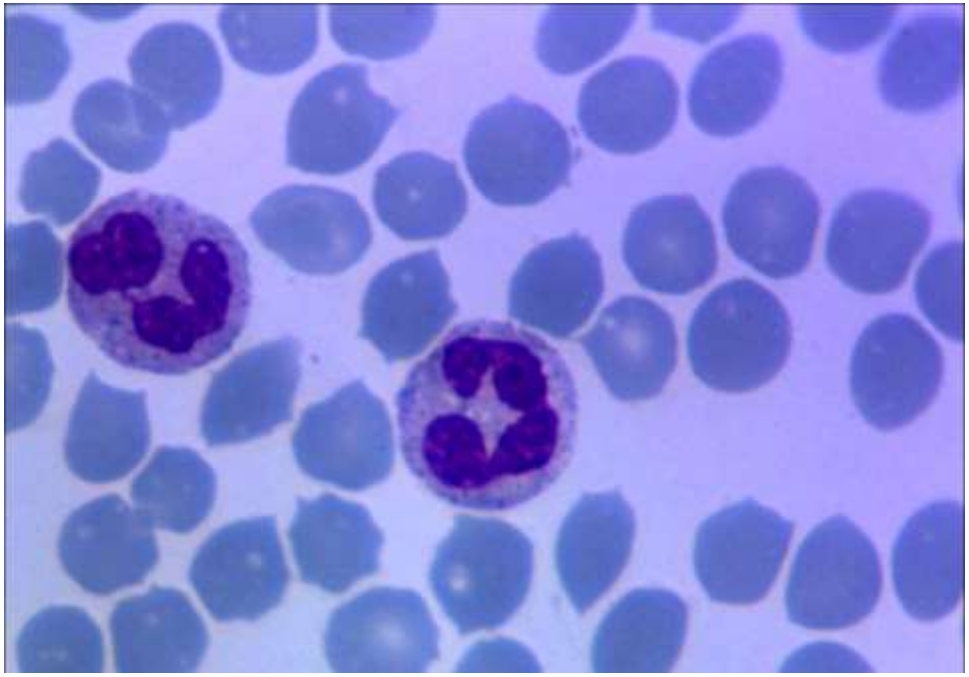


Fig. 35. Neutrophilic granulocytes in a human blood smear. Hematoxylin and eosin staining. Magn. x 1000.

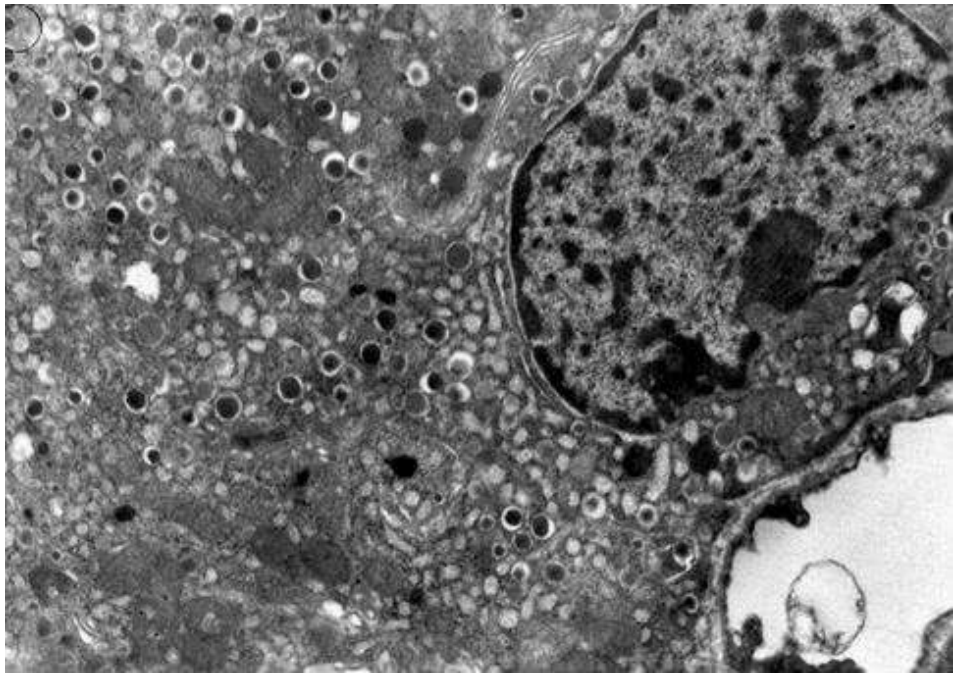


Fig. 36. The nuclear membrane and perinuclear space in the endocrinocytes of the pancreas. The cisterns of the Golgi complex are visible near the nucleus.
Electronogram. x 5000.

NUCLEOLUS is a dense, commonly rounded, structure inside a cell nucleus (there may be several nucleoli in the nucleus). Fibrillar component (DNA) and granular component (areas of amplification - the formation of multiple copies of R-RNA) is distinguished (fig. 37).

ORGANELLA (from Greek, *orgaella*, organ) is cytoplasmic structural elements that are constantly present in the cytoplasm of cells, having specific structure and functions. Common organelles are divided into membranous (endoplasmic reticulum, mitochondria, lysosomes, Golgi complex) and non-membranous (ribosomes, cytocentrum, microtubules, microfilaments). Special organelles are tono-, myo- and neurofibrils, cilia and filaments (see fig. 36).

PERINUCLEAR SPACE (from Greek *peri*, near and Latin *nucleus*, nucleus) is the space between the outer and inner leaves of the nuclear envelope of 20-60 nm wide, filled with the matrix (fig. 38).

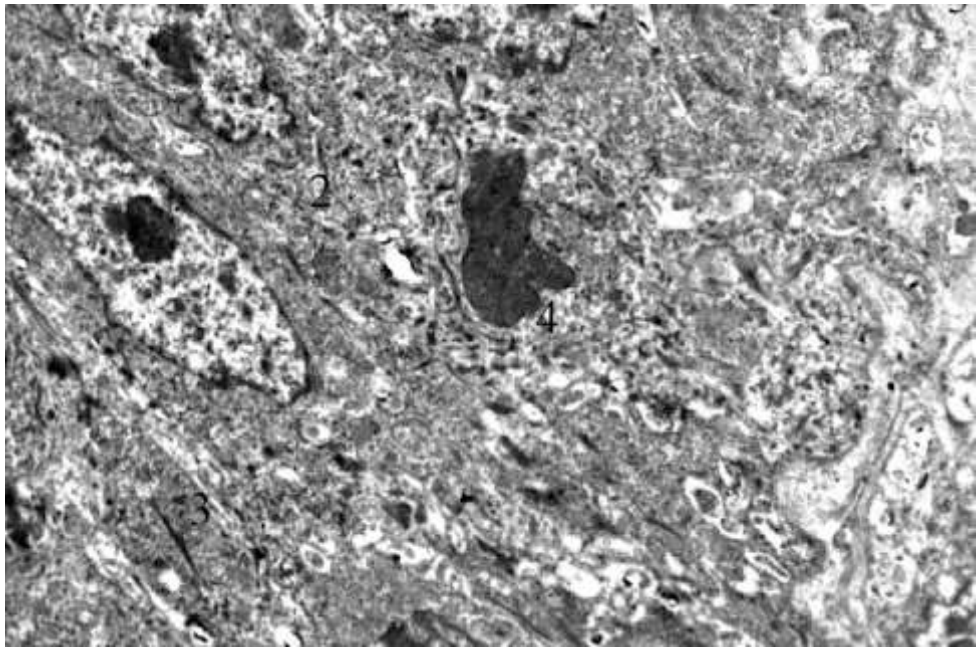


Fig. 37. On the left is the nucleolus in the center of the nucleus. Electronogram. x 2400.

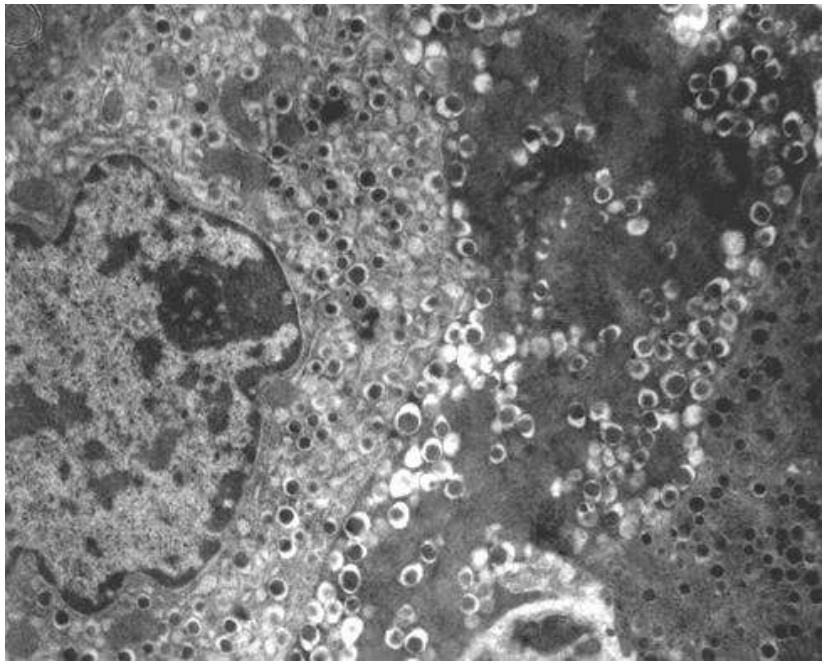


Fig. 38. The light rim around the nucleus is the perinuclear space. Electronogram. x 5000.

PEROXISOME (from Greek *peroxys*, peroxide and *soma*, body) is a submicroscopic key membrane organelle. It was discovered in the early 60's. It is a membrane sac filled with the matrix with enzymes present in it, the main of which is catalase. Enzyme systems of peroxisomes have a protective value: they break down poisonous metabolic products (hydrogen peroxide, ethyl alcohol, uric acid). They are also involved in the regulation of lipid metabolism.

PHAGOCYTOSIS is the process of engulfing of foreign substances (microorganisms, detritus) by a cell via endocytosis.

PHAGOSOME is a foreign substance framed by a cell membrane that is engulfed via phagocytosis.

PINOCYTOSIS (from Greek *pino*, drink, *cytos*, cell) is the absorption of liquid by a cell from the outside with the participation of the cytoplasmic membrane, which, surrounding the droplet of the liquid, ingests it inside the cell.

PLASMOLEMMA is a biological membrane that bounds a cell and provides its connection with the environment. The elementary biological membrane, supramembrane complex (glycocalyx) and submembrane complex (cytoskeleton) are distinguished (see cell membrane).

POIKILOCYTOSIS (from Greek *poikilos*, variable and *cytos*, cell) is variation in cell shape (characteristic of erythrocytes - echinocytes, poikilocytes, spherocytes) (fig. 39).

POLYPLOIDY (from Greek poly, many and *ploos*, to add) is the presence in the nuclei of cells more than two complete haploid sets of chromosomes (n = 2, 3, 4, ...). It is most often the result of endomitosis. It is observed in human liver cells.

PROKARYOTES (from Latin *pro*, to and Greek *karyon*, nucleus) are cells that do not have a morphologically separated nucleus from the cytoplasm (bacteria, blue - green algae).

PSEUDOPODIA (from Greek *pseudos*, false and *pus, podos*, leg) are formed during amoeboid movement of the cell. In this case, cells are moved by overfilling of the cytoplasm into the formed protrusions, pseudopodia (macrop hages, fibroblasts, granulocytes).

REPRODUCTIVE CELLS (gametae) are developed in the sexual glands. Female reproductive cells (ovocytes) and male reproductive cells (spermatozoa) have a haploid set of chromosomes (fig. 40).

RESIDUAL CORPUSCLES are biomembrane-bound small, dense, particles, remained after lysis by enzymes of the

phagocytized cell material. The corpuscles can be accumulated in cells and / or be removed from them by exocytosis.

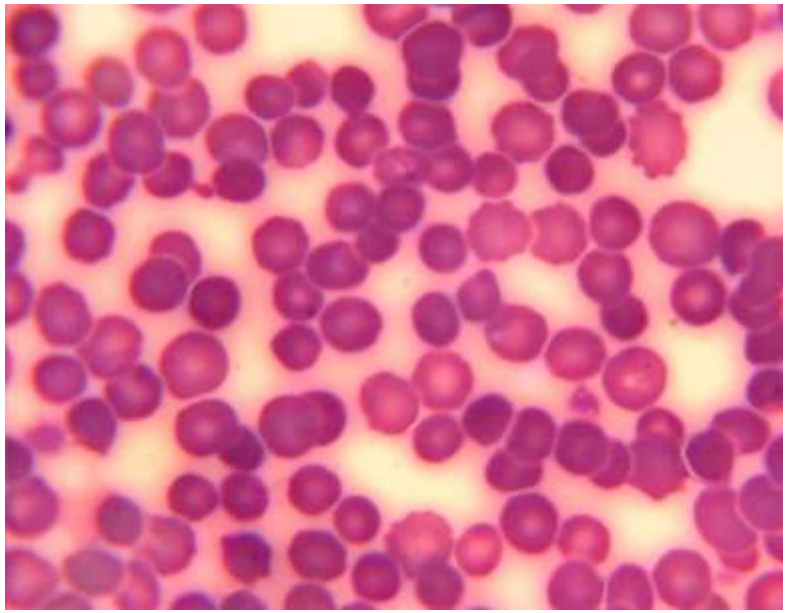


Fig. 39. Echinocytes and spherocytes in a human blood smear. Romanovsky-Himza staining. Magn. x 1000.

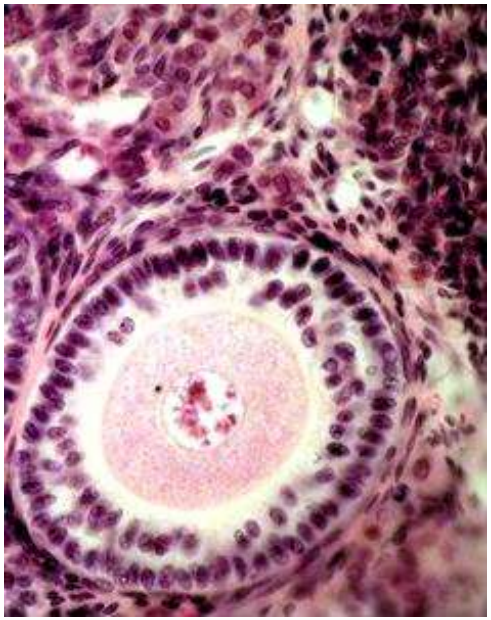
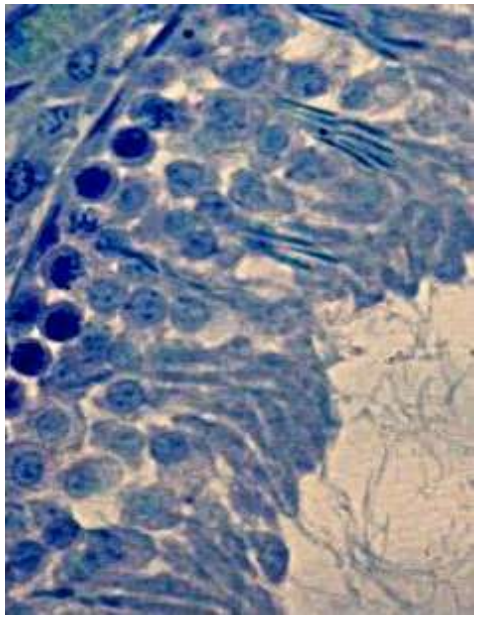


Fig. 40. Oocyte in the ovary. Hematoxylin and eosin staining. Magn. x 400.



Sperm in the testicle. Metylene blue staining. Magn. x 400.

RIBOSOME is a non-membrane general purpose organelle. On the ribosomes, according to the code of information RNA, the combination of various amino acids (are brought to the ribosome by transport RNA) into protein molecules. Free ribosomes (single and polyribosomes, connected by a molecule of i-RNA) and bound ribosomes, localized on the endoplasmic reticulum, are distinguished. Free ribosomes synthesize proteins for the cell, and ribosomes, attached to the endoplasmic reticulum, synthesize lysosomal enzymes and secreted proteins, excreted by the cell.

SOMATIC CELLS (from Greek *soma*, body) are all cells of an organism except reproductive cells. Under normal conditions they have a diploid set of chromosomes in the interphase.

TIGHT JUNCTIONS (*zonula occludens*) are achieved by the maximum approximation of plasmolemmas of adjacent cells. Such junction occurs between enterocytes, hepatocytes, epidermocytes. This is an insulating (impermeable) junction.

TONOFILAMENTS are thin fibers (filaments) of 10 nm thick made up of keratin protein; intermediate microfilaments of epithelial cells forming their cytoskeleton. They are involved in the formation of desmosomes and hemidesmosomes.

TRANSCYTOSIS is excretion from cells of substances that do not change their chemical properties in the course of intracellular metabolism (e.g., water). It is one of the types of exocytosis.

TUBULIN is a protein of microtubuli and filaments of the division spindle that is synthesized by a cell during the G1 interphase period.

VACUOLE (from Latin, *vacuus*, empty) is a round cavity, bounded by a membrane and filled with liquid homogeneous contents. The size and chemical composition of the vacuole content may be different. It can be pinocytotic vesicles, sections of the Golgi complex, vesicles of the endoplasmic reticulum in the process of biosynthesis of substances (fig. 41).

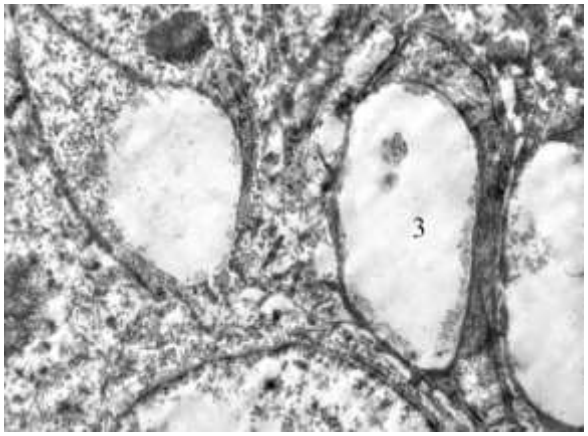


Fig. 41. Vacuoles in the cytoplasm of keratinocytes. Electronogram. x 3200.

VIMENTIN is a protein that is part of the connective tissue cells cytoskeleton elements.

EMBRYOLOGY TERMINOLOGY

ACROSOME is the product of the Golgi apparatus. The flattened membrane sac contains enzymes capable of loosening the lining that covers the egg. It is located on the anterior pole of the nucleus of spermatozoon in the area of the head and covers it in the form of a sheath.

ACROSOME REACTION is outflow of enzymes (hyaluronidase and trypsin) from sperm acrosome that b reak down contacts between follicular cells that form a membrane around the egg cell.

ADHESION is the implantation phase, when blastocyst attaches to the endometrial surface (day 5).

ALLANTOIS (from Greek *allantoides*, sausage) is an extraembryonic organ. It is a finger-shaped outgrowth of the endoderm that grows into the amniotic strand. Its role is crucial in providing nourishment and respiration to the embryo and the place for the accumulation of vital products in the early stages of embryogenesis. In t he human it serves for the sprouting of blood vessels from the embryo into the chorionic villi, a source of development of the urogenital sinus. It is reduced at month 2 of embryogenesis.

AMNION is a complete membrane that closely covers the embryo, which, starting from day 7 of embryogenesis, is involved in the production and absorption of amniotic fluid. It consists of 2 parts: inner or epithelial and outer or connective tissue (fig. 42).

AMNIOTIC STRAND is a band of the extraembryonic mesoderm that extends from the amniotic and yolk sacs (vesicles) to the trophoblast and is the basis of future umbilical cord.

AMNIOTIC VESICLE is a cavity surrounded by an amnion (amniotic) membrane and filled with a fluid in which the embryo and fetus develop.

ASYNCHRONOUS CLEAVAGE is when the light blastomeres are divided much faster than the dark ones.

BLASTOCELE is a cavity inside a blastocyst filled with fluid.

BLASTOCYST is the early stage of embryonic development of a multicellular embryo. At this stage, the embryo consists of: internal cells (embryoblast), central cavity (blastocele) and external cells (trophoblast).

BLASTODERM is a cluster of embryo cells at the stage of blastula.

BLASTOMERES are the cells formed by cleavage of a fertilized ovum. Light and dark blastomeres are distinguished. The embryoblast is developed from the dark blastomeres, and the trophoblast is formed from the light blastomeres .
BLASTULA is the early stage of embryonic development. It is the multicellular embryo that was formed after cleavage of a fertilized ovum.
BRANCHED CHORION is a part of the chorion in the placenta. Symplastic layer of trophoblast is strongly developed in the villi (fig. 43).

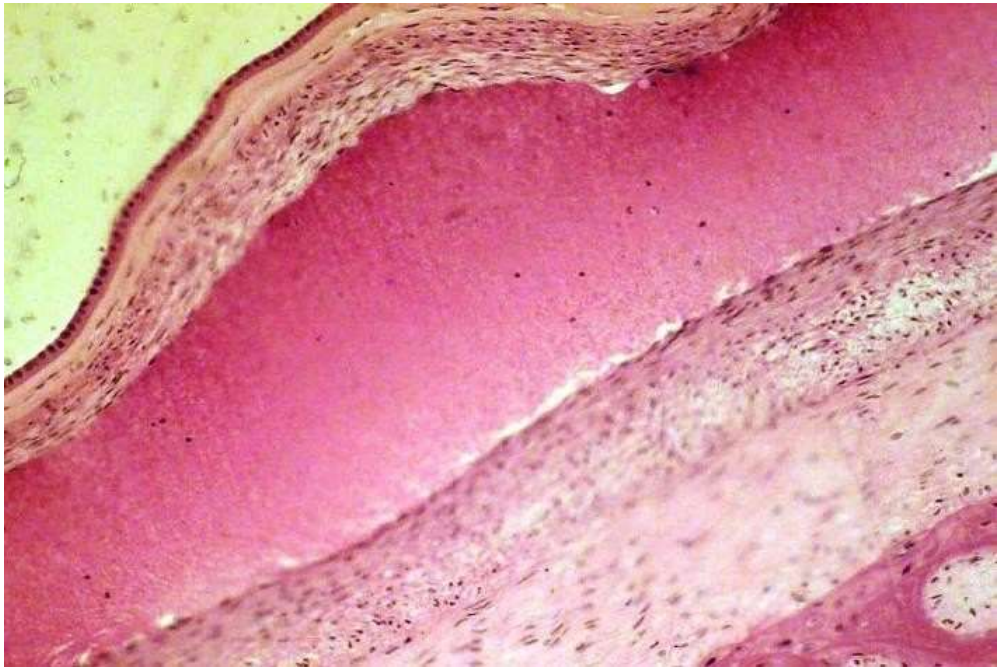


Fig. 42. Allantois and chorion of placenta. Hematoxylin and eosin staining. Magn. x 400.

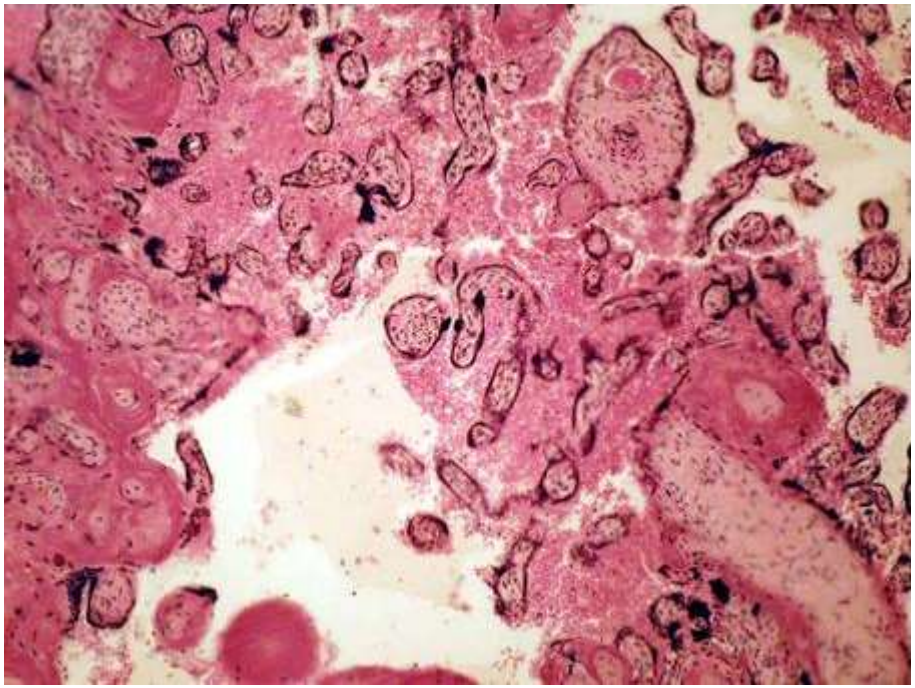


Fig. 43. Villi of branched chorion in placenta Hematoxylin and eosin staining. Magn. x 400.

CAPACITATION is the process of activation of spermatozoa inside the female reproductive tract under the in fluence of mucous secretion of glandular cells.

CAVITATION is the formation of a cavity in the center of the embryonic nodule due to accumulation of liquid and relocation of cells of the embryonic shield.

CHEMOTAXIS is the ability of cells to move in the direction of the source of chemical signals of stimuli. **CHORD** is nonsegmented solid cellular mesodermal strand located between the endoderm and the neural tube. **CHORION** is a membrane that arises from the trophoblast and extraembryonic mesoderm.

CLEAVAGE is the period of embryonic life, consisting of several consecutive mitotic divisions of the zygote into cells (blastomeres) without their further growth, resulting in the formation of a multicellular embryo called the morula (fig. 44).

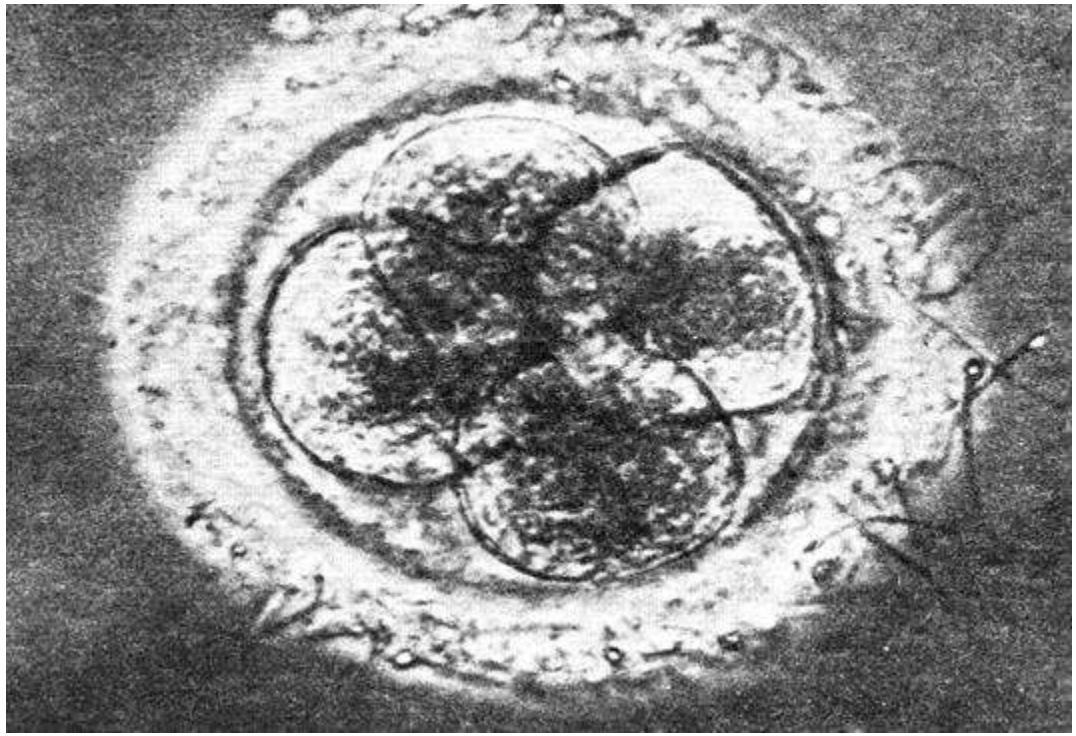


Fig. 44. Blastula. Cleavage. Electronogram. Magn. x 15000.

CORTICAL GRANULES are the complex of glycosaminoglycans located along the cortex, the region furthest from the oocyte's center, which provide the formation of an impenetrable fertilizati on membrane.

CORTICAL REACTION is the release of cortical granule material beyond the oocyte after fertilization, resulting in swelling of the fertilization membrane, which impedes the penetration of other spermatozoa into the ovum.

COTYLEDON is a structural and functional unit of the placenta, responsible for the branching of a single stem villus located in the lacunae washed by the blood of the maternal body.

CRITICAL PERIODS OF DEVELOPMENT is a period of increased sensitivity of germ cells, embryo and fetus to the effect of damaging environmental factors.

Fertilization: 12 - 24 hours.

Implantation: 40 hours.

Terminal: 1 week

Embryonic: 2-6 weeks

Neofetal: 7-9 week

Early fetal: 10-28 weeks

Late fetal: 29 - 40 weeks

Intranatal: delivery

CYTOTROPHOBLAST is a cellular layer of the trophoblast covering the chorionic villi.

DECIDUAL MEMBRANE is the functional layer of the uterine mucosa during pregnancy and childbirth.

DELAMINATION or a splitting apart into layers. It is one of the means of gastrulation, in which the blastomeres of the wall of the blastula (embryonic shield) are divided tangentially, which leads to the formation of two layers of cells of the primary ectoderm and the primary endoderm (outer leaf and inner leaf) (fig. 45).

DENUDATION is the separation of contacts between the follicular cells of the granular zone and the pellucid zone of the female reproductive cell complex and denudation of the oocyte.

DERMATOME is the outer part of the somite formed due to differentiation of the mesoderm. It is the source of development of dermis (the true skin).

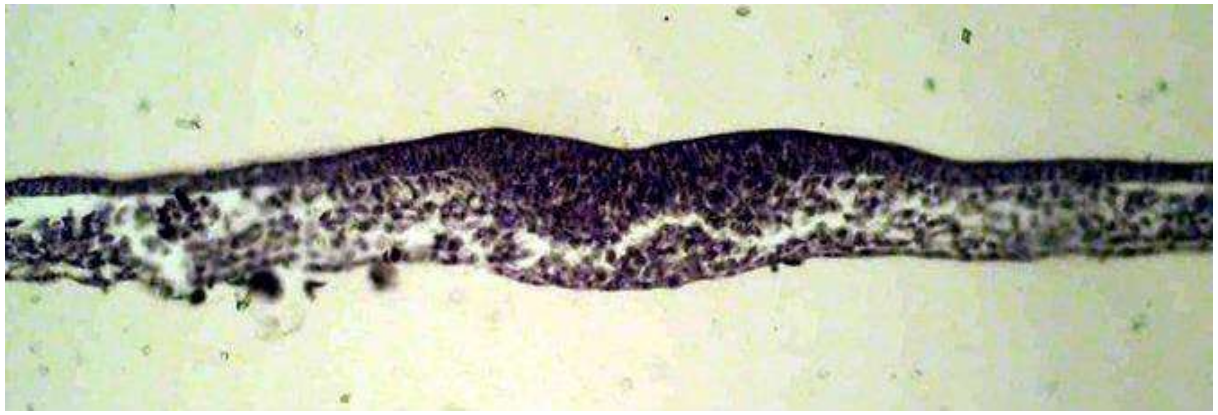


Fig. 45. Embryo after delamination. Hematoxylin and eosin staining. Magn. x 400.

DIFFERENTIATION is a change in cell structure associated with their specialization.

ECTODERM is the external embryonic leaf. It is low differentiated material from which the skin epithelium and nervous system are formed.

EJACULATION is the action of ejecting semen from the body.

EMBRYO is a multicellular organism that develops inside the maternal body. In humans, the embryonic period lasts from 1 to 9 weeks of embryogenesis.

EMBRYOBLAST is an internal cell mass of the blastocysts formed by large dark blastomeres, of which the embryo and some extraembryonic organs (amnion, allantois, and yolk sac) are developed.

EMBRYOLOGY is a general biological science concerned with the study of embryos and their development.

EMBRYONAL PERIOD OF DEVELOPMENT is the early period of individual development of a body or development of an embryo (2 - 9 weeks).

EMBRYONIC ECTODERM is an outer embryonic leaf. Part of the cells of the embryonic nodule is delaminated into the outer side of the blastocyst and forms the embryonic ectoderm. It occurs in the first phase of gastrulation, until the end of day 7 after fertilization.

EMBRYONIC ENDODERM is an inner embryonic leaf. Part of the cells of the embryonic nodule is delaminated towards the blastocyst's hollow and forms the embryonic endoderm. It occurs in the first phase of gastrulation, until the end of day 7 after fertilization.

EMBRYONIC LEAVES are embryonic sources for development of tissues and organs primordia. The outer leaf is ectoderm, the middle leaf is mesoderm, the inner leaf is endoderm.

EMBRYONIC NODULE is a group of embryoblast cells located inside the trophoblast at one of the poles of the blastocyst in the form of a nudule.

EMBRYONIC SHIELD or embryonic disc is embryo cells from which the embryo's own body is subsequently formed.

ENTODERM is the inner embryonic leaf. It is low differentiated material from which the epithelium of the primary intestine and its derivatives are formed.

EPIBLAST is a layer of embryoblast cells facing the trophoblast, or primary ectoderm. It corresponds to the bottom of the amniotic vesicle.

EQUAL CLEAVAGE occurs when blastomeres are cleaved at the same time. As a result, blastomeres of the same size are formed.

EXTRACORPOREAL FERTILIZATION is artificial insemination, i.e., fertilization that occurs outside the body of the mother.

EXTRAEMBRYONIC ECTODERM is part of the wall of the amniotic vesicle, except its bottom. It gives rise to the epithelium of the amnion.

EXTRAEMBRYONIC ENDODERM is the lateral and lower part of the wall of the yolk bladder. It gives growth to the epithelium of the yolk sac.

EXTRAEMBRYONIC ORGANS are temporary (provisional) organs. They involve chorion, amnion, yolk sac and allantois. They develop in the process of embryogenesis outside the body of the embryo and perform functions that ensure its growth and development.

FEMALE PRONUCLEUS is swollen nucleus of an ovum (1n) during fertilization

FEMALE REPRODUCTIVE CELL COMPLEX is the metaphase II oocyte, surrounded by follicular cells. In the process of ovulation, this cell complex exits the ovary and enters the abdominal cavity, from which it moves into the fallopian tube, where fertilization occurs.

FERTILIZATION is the process of merging two germ cells (one male and one female gametes) into one new cell, a zygote.

FERTILIZATION MEMBRANE provides monospermy during fertilization. It is formed by macromolecule biopolymers of cortical granules in the interaction with the glycocalyx of the oocyte plasmolemma, that is, due to the cortical reaction.

FETAL MEMEBRANES are membranes that ensure vital activity of the fetus. They involve amnion, chorion and placenta.

FETAL PERIOD is the period of embryogenesis from week 9 of the development until birth.

FETAL PORTION OF THE PLACENTA is the portion of the placenta formed by the chorionic villi, derivatives of the trophoblast and extraembryonic mesenchyme.

FIBRINOID is an oxyphilic mass that is the product of plasma coagulation and the disintegration of the trophoblast that covers its villi in the second half of pregnancy.

FOLLICULAR CELLS are cells that surround an egg in the process of its growth and maturation. They secrete substances and estrogen hormone that are absorbed by the egg during growth.

GAMETES (from Greek, *gamein,* to marry) are haploid (1n), in contrast to somatic cells, mature male (sperm cells) and female (egg cells) germ cells. They are formed in the body of the parental generation.

GAMETOBLASTS are primary germ cells (gonocytes). They are formed in the wall of the yolk sac on week 3 of embryonic development and then migrated to the gonad anlage.

GAMETOGENESIS (PROGENESIS) is the process in which male and female germ cells are formed.

GASTRULA is an embryo at the stage following the blastula (fig. 46).

GASTRULATION is the period of embryogenesis during which extraembryonic (provisional) organs are formed and the embryo becomes three-layered (ectoderm, endoderm, mesoderm). It covers day 7 to day 17 of embryogenesis.

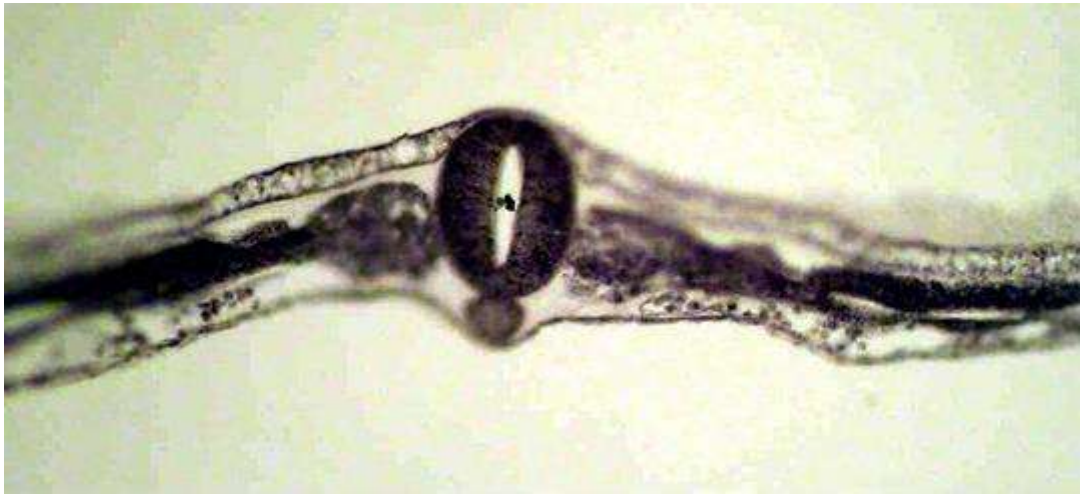


Fig. 46. Third stage of the gastrulation.

GENERAL EMBRYOLOGY concerns the most common issues and the broadest patterns of individual development.
GERMINAL STREAK is an oblong thickening of the embryonic shield, elongated along the medial line from the dorsal edge of the shield towards the anterior one. It is formed as a result of moving of cells of the outer layer of the shield towards the future posterior end.
HEMATOTROPHIC PERIOD is the period of embryo and fetal nutrition due to maternal blood. It lasts from the moment of embryo contacted with maternal blood until birth.
HEMOCHORIAL BARRIER delimits maternal blood from fetal blood. It consists of the endothelium of capillaries, chorion, their basement membrane, adjacent connective tissue, basement membrane of the trophoblast epithelium, cytotrophoblast, syncytiotrophoblast. The main function is to provide homeostasis and immunological tolera nce in the mother-fetal system.
HISTIOTROPHIC PERIOD is the period of embryo nutrition due to the absorption of nutrients from the products of secretion of uterine glands and products of endometrial tissue trophoblast destruction. It continues until the trophoblast dissolves the wall of the blood vessels of the endometrium and makes contact with the maternal blood.

HYPOBLAST is a layer of cells that cleaves from an embryonic nodule that faces the blastocyst cavity. This is the primary endoderm or the primary inner leaf.

IMMIGRATION is one of the means of gastrulation, in which part of the blastomeres of the blastula wall moves inside the embryo, forming the inner layer.

IMPLANTATION is the process of attaching a multicellular embryo to the uterine wall and immersing it in the mucous membranes. It occurs on dasy 7 - 8 after fertilization. Implantation has 2 phases: adhesion and invasion.

INVAGINATION is one of the ways of formation of organ rudiments of an embryo, e.g., a nerve tube.

INVASION (ingrowth). Implantation phase when the blastocyst grows into the uterine mucosa.

MALE PRONUCLEUS is swollen nucleus of spermatozoon (1n) during fertilization.

MATERNAL PORTION OF THE PLACENTA is the altered basal part of the endometrium. It is formed by the basal plate of the uterine mucosa, connective tissue septa that separate cotyledons from each other, as well as by lacunae, filled with maternal blood.

MESENCHYMA is an embryonic connective tissue that fills the space between embryonic leaves (ectoderm and endoderm). It is the precursor to the development of various types of connective tissue, bone tissues (cartilage and bone), vascular endothelium, smooth muscle cells, microglia.

MESODERM is the middle embryonic leaf. In the process of development it gives rise to somites (sclerotome, myotome, dermatome), nephrotomes, lateral mesoderm, splanchnotom.

MONOSPERMY is penetration of only one spermatozoon into the ovum during fertilization. It is provided by cortical reaction, change of charge of an egg plasmolemma.

MORPHOGENESIS is the formation of the spatial organization of the body and its parts.

MORULA is a multicellular embryo in which a compact cluster of blastomeres is observed.

MYOTOME is the part of a somite located between the sclerotome and dermatome. It is the precursor to the skeletal transversal striated muscle tissue.

NEPHROTOMES are small sections of mesoderm between the splanchnotome and somites. They give rise to the pronephros canaliculi and the primary kidney.

NEURAL PLATE is the layer of ectoderm cells located above the chord.
NEURULATION is the process of formation of a nerve tube. It occurs immediately after the end of the gastrulation process (from day 16 to day 23 of the development) by invagination.
NEWBORN is a baby in the first 10 days of life after birth.
ONTOGENESIS is the development of an individual organism from the moment of fertilization till birth.
OOCYTES are female germ cells in the stage of differentiation. The primary oocyte is formed during the growth period of ovogenesis and the secondary oocyte is formed in the period of maturation.
OOGONIA are cells that are formed during the ovogenesis in reproduction of primary germ cells.
OOLEMMA is a cytolemma or primary membrane of an ovum.
ORGANOGENESIS is the process of formation of organs from embryonic rudiments.
OVOGENESIS is the process of reproduction and maturation of female germ cells in the ovaries. It has three periods: reproduction, growth, maturation.
OVOPLASM is the cytoplasm of an ovum.
OVULATION is the release of the secondary oocyte from the ovary into the abdominal cavity.
OVUM is a female reproductive cell. The nucleus of an ovum contains 23 chromosomes (22 somatic and one gametal), i.e., their haploid set.
PARIETRAL LEAF OF THE MESODERM is one of the two leaves of the splanchnotome adjacent to the cutaneous ectoderm.
PARTIAL CLEAVAGE (meroblastic). It occurs when only a part of blastomeres is cleaved.
PELLUCID ZONE is an extracellular zone that is formed around an egg due to the activity of oocyte and follicular cells. It is rich in glycosaminoglycans.
PENETRATION is the insertion of the head and intermediate part of the spermatozoon into the cytoplasm of the secondary oocyte.
PHYLOGENESIS is the evolutionary development of organisms, their species, genera, families, series, classes, types, kingdoms.

PLACENTA is an extraembryonic organ that ensures permanent connection between the mother and the fetus.

POLYSPERMIA is penetration of several spermatozoa into oocyte's cytoplasm during fertilization.

POSTEMBRYONIC PERIOD OF DEVELOPMENT is postpartum period of individual development.

PRIMARY CHORIONIC VILLI (*villi primarii*) are the tree-structured branching of the trophoblast at the site of its contact with the uterine mucosa. Upon implantation, they provide the embryo with maximal contact with maternal body.

PRIMITIVE NODE is thickening of the embryonic shield at the anterior end of the germinal streak.

RHEOTAXIS is the ability of spermatozoa to move against the flow of products of the secretion of epitheliocytes of the fallopian tubes and uterine glands.

SCLEROTOM is the medioventral part of somites, which forms the skeletogenic mesenchyme, which gives rise to the cartilage and bone tissues of the axial skeleton of the body.

SECONDARY CHORIONIC VILLI are epithelio-mesenchymal villi that are formed while the extraembryonic mesoderm grows into them.

SMOOTH CHORION is a part of the chorion with the surface that contacts the parietal membrane of the falling uterus. It is presented mainly by the chorial epithelium and connective tissue.

SOMITE is a cluster of cells of a segmented mesoderm located symmetrically from a neural tube. It is subdivided into metamerically located areas (dorsal segments: dermatome, myotome, sclerotome).

SPECIFIC EMBRYOLOGY is embryology of individual tissue groups. Human embryology is one of the important parts of it.

SPERMATIDS are cells, formed as a result of the period of maturation of spermatogenesis. They have a haploid chromosome set. There are two types of spermatozoa: the first one carries the X-chromosome and can give rise to a female embryo; the second one carries the Y-chromosome and can give rise to a male embryo as a result of fusion with the egg.

SPERMATOCYTES are male reproductive cells resulting from meiosis

SPERMATOGENESIS is the development of mature spermatozoa in the male reproductive glands, testes. It has 4

periods: reproduction, growth, maturation and formation.

SPERMATOGONIA are reproductive cells at the stage of reproduction (I-stage of spermatogenesis), which are formed in the male reproductive glands. They are divided by mitosis, have a double set of chromosomes (2n). They are reproduced for almost all their lives until old age.

SPERMATOZOA are mature male germ cells. The nucleus of a spermatozoon contains 23 chromosomes, one of which is reproductive, the other are autosomes. They are formed by spermatogenesis, have a haploid set of chromosomes and are capable of fertilization.

SPLANCHNOTOM is a non-segmented ventral mesoderm. It is splitted into two leaves: visceral and parietal. An epithelium, lining the serous membranes (mesothelium), is formed from the splanchnotom.

SYMPLASTOTROPHOBLAST is the outer layer of the trophoblast, growing strongly, loses its cellular structure and acquires a symplastic structure (the solid mass of the cytoplasm containing numerous nuclei scattered on it).

SYNGENESIS is reproduction in which the daughter's organism arises from the fusion of the reproductive cells (female and male) after fertilization.

SYNKARYON is a fusion of two pronuclei, which leads to the restoration of the diploid set of chromosomes.

TERATOLOGY is the scientific study of congenital abnormalities and abnormal formations.

TOTAL CLEAVAGE (holoblastic). It occurs when the cleavage furrow passes through the entire zygote. **TROPHOBLAST** is light blastomeres surrounding germ material. It is the outermost of the fetal membranes, which directly contact the tissues of the uterine mucosa and provides nutrition to the embryo.

TRUNCAL FOLD is a fold by which the body of the embryo is separated from the extraembryonic (provisional) organs.

UMBILICAL CORD is extraembryonic organ formed from the mesenchyme of the amniotic strand and the vitelline caulis, covered with an amniotic epithelium. It contains the main blood vessels that provide b lood circulation between the fetus and the fetal part of the placenta (fig. 48).

UNEQUAL CLEAVAGE occurs when blastomeres are cleaved at different speed rate, resulting in small (dark) and round (light) blastomeres.

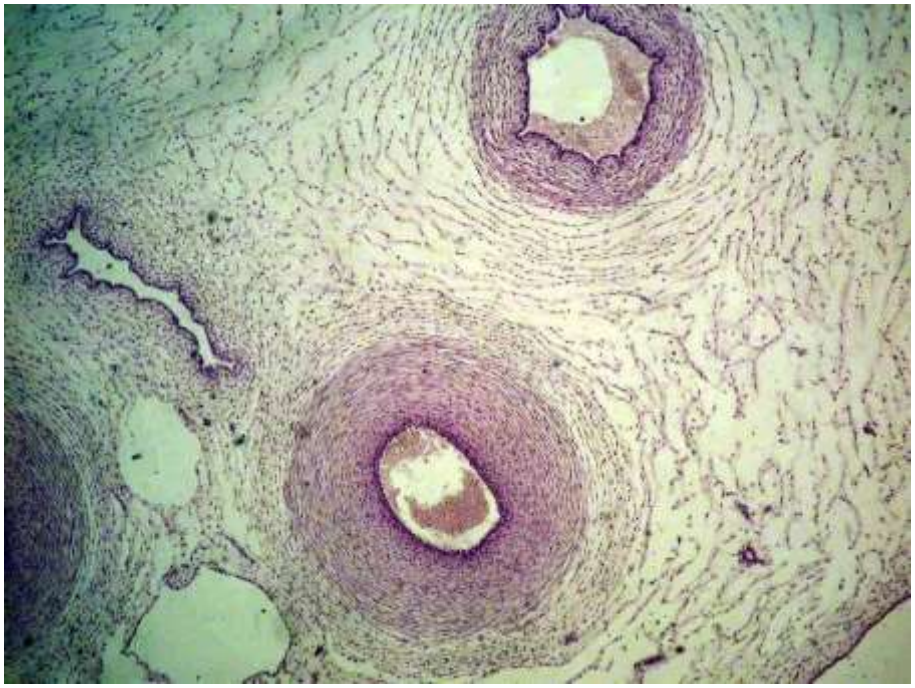


Fig. 48. Umbilical cord. Hematoxylin and eosin staining. Magn. x 400.

VISCERAL LEAF OF THE MESODERM is one of the two leaves of the splanchnotome adjacent to the endoderm. It consists of dark and light blastomeres.

VITELLINE ENDODERM is the cells that form the wall of the yolk sac with the exception of hypoblast.

VITELLINE FOLLICLE is formed by the extraembryonic endoderm and extraembryonic mesoderm. Primary germ cells (gonocytes) and blood stem cells (BSC) are formed in the wall of the yolk sac. Participates in th e hematopoiesis of the embryo from 7 to 8 weeks, and then is atrophied.

YOLK is inclusion of the ooplasm. It is a nutrient that manifests itself in the form of granules or larger balls and plates formed by phospholipids, proteins and carbohydrates.

ZYGOTE is a diploid cell resulting from the fusion of two haploid gametes; a fertilized ovum.

GENERAL HISTOLOGY TERMINOLOGY

CLASSIFICATION OF TISSUES

Type I. Epithelial tissues.
Type II. Internal tissues.
Type III. Muscle tissues.
Type IV. Nervous tissues.

TYPE I. EPITHELIAL TISSUES

COVERING EPITHELIUM covers the surface of the body, organs and separates the internal environment of the body from the external one (fig. 49).

GLANDULAR EPITHELIUM is a type of epithelial tissue when epithelial cells (glandulocytes) synthesize and secrete substances, called secret, that are actively involved in various processes of the body (fig. 50).

KERATINIZED STRATIFIED SQUAMOUS EPITHELIUM covers the surface of the skin and is called the epidermis. Its outer corneous layer consists of dead cells (horny scales). In the thick skin there are 5 layers: stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum (fig. 51).

LINING EPITHELIUM lines the cavities of tubular organs, nephrons, blood and lymphatic vessels, brain ventricles, central canal of the spinal cord (fig. 52).

NON-KERATINIZED STRATIFIED SQUAMOUS EPITHELIUM consists of three layers: basal, spinous and a layer of squamous cells. It lines the mucous membrane of the oral cavity, esophagus, outer layer of the cornea, vagina (fig. 53).

SIMPLE COLUMNAR EPITHELIUM consists of columnar cells. There are three types of columnar epithelium:

- brush border epithelium, when the cells have a prominent absorbing brush border, which consists of numerous microvilli. Such cells are found in the mucous membrane of the small and large intestine, gallbladder, lining the bile

ducts of the liver, ducts of the pancreas (fig. 54);

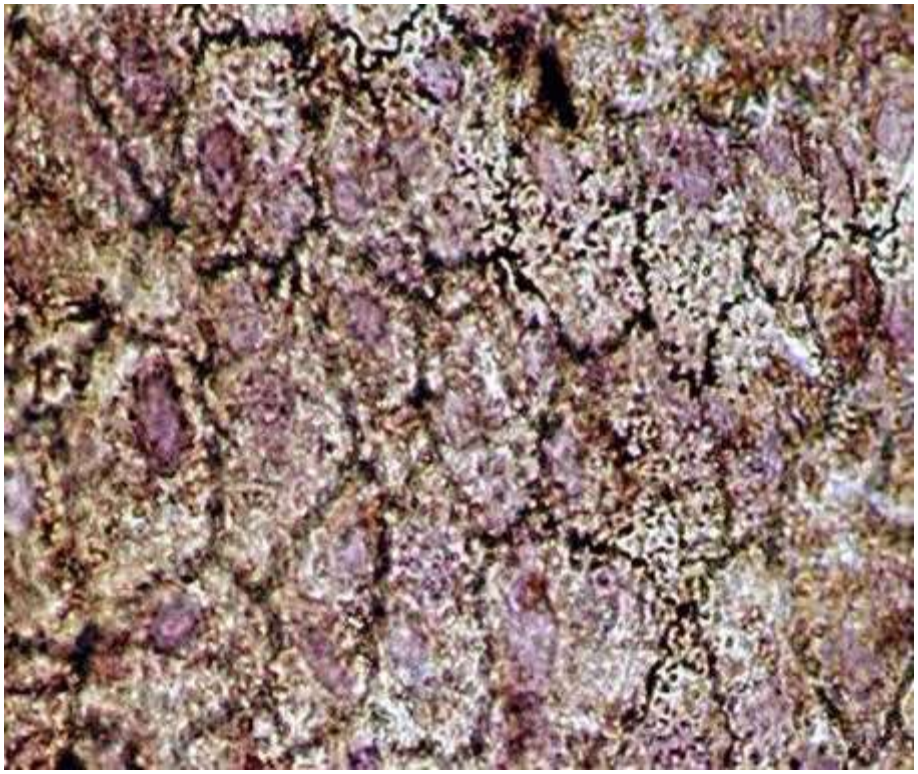


Fig. 49. Simple squamous epithelium (mesothelium) of the peritoneum, which covers the organs of the abdominal cavity. Hematoxylin-eosin staining. X 400.

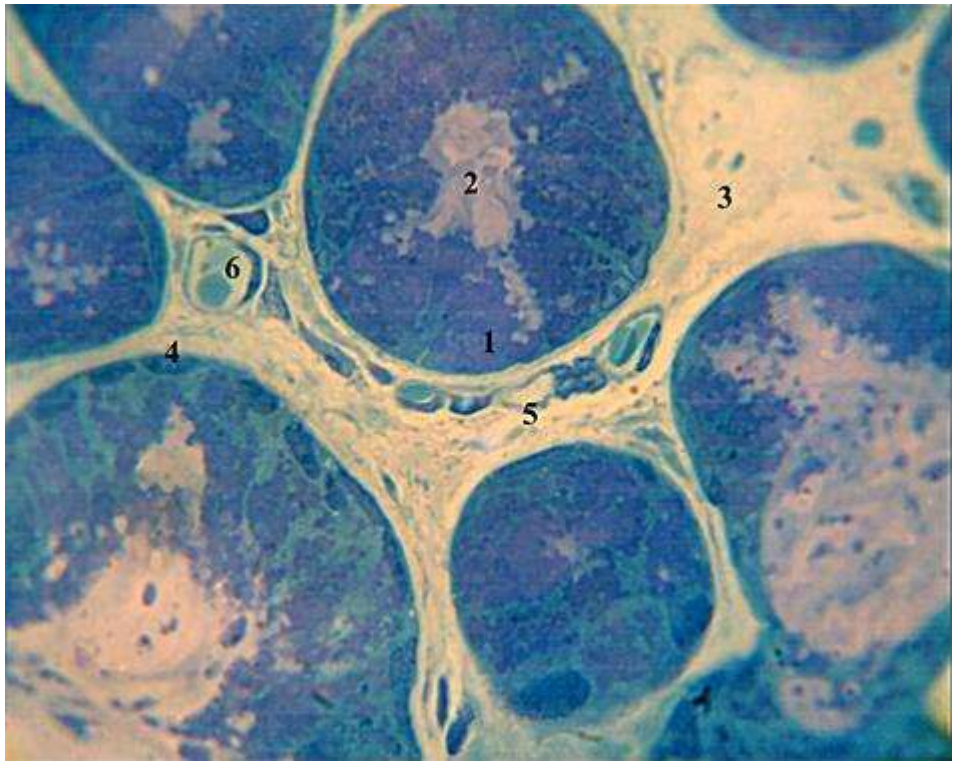


Fig. 50. Secretory epithelium of the end-pieces of the palatine glands. Basophilic secretory granules are visible in the apical cytoplasm. Toluidine blue staining. Magn. x 1000.

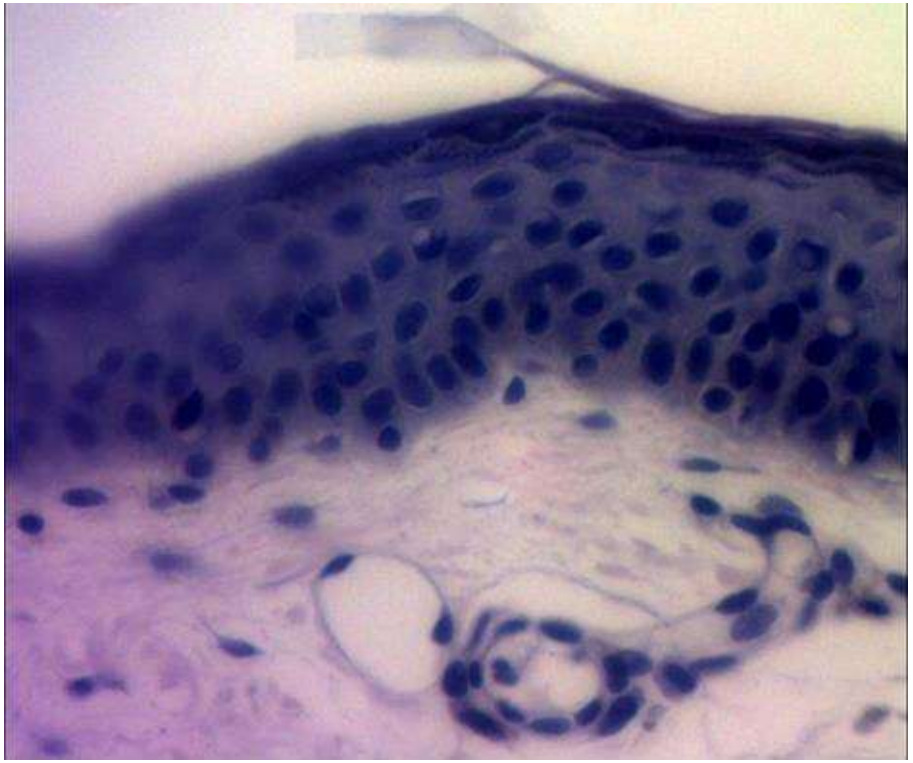


Fig. 51. Keratinized stratified squamous epithelium of the skin. Hematoxylin and eosin staining. Magn. x 1000.

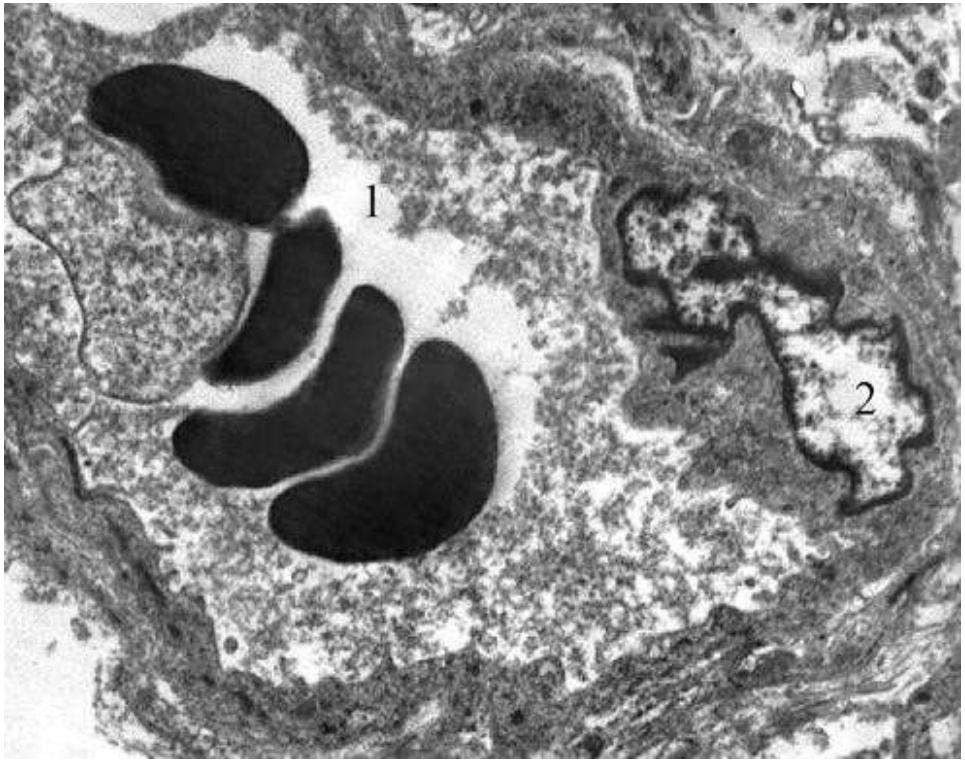


Fig. 52. Endotheliocyte. The nucleus protrudes into the lumen of the venule, has an elongated shape and an uneven contour. Erythrocytes are visible in the lumen.
Electronogram. x 3200.

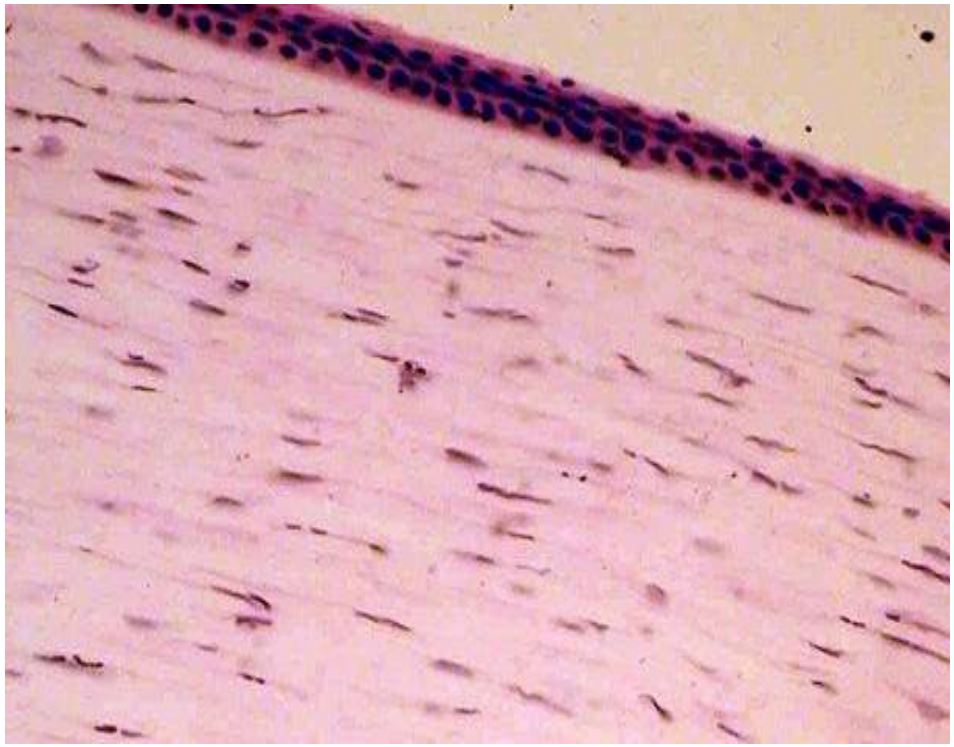


Fig. 53. Non-keratinized stratified squamous epithelium of the cornea. Hematoxylin and eosin staining. Magn. x 400.

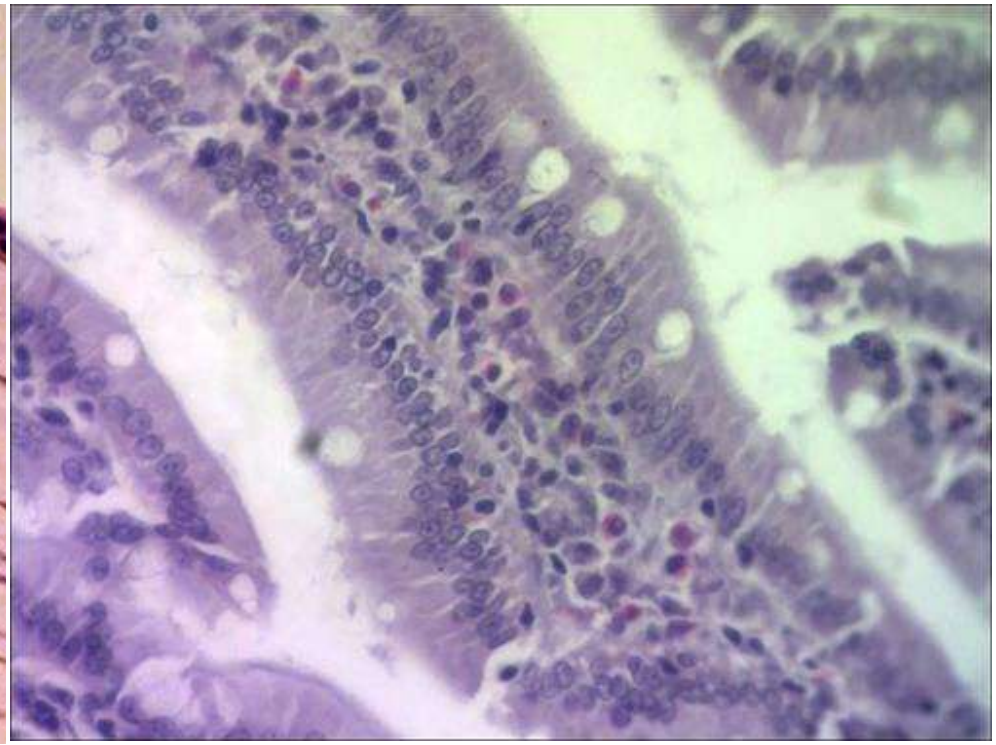


Fig. 54. Villus of the duodenum. In the epithelium, covering the surface of the villi, brush border and goblet cells are visible. Hematoxylin and eosin staining. Magn. x 400.

- ciliated epithelium, when on the apex of the cells are the cilia that promote the movement of the egg on the fallopian tubes; cleaning of the upper respiratory tract from foreign particles (dust, smoke, microorganisms) (fig. 55).
- glandular epithelium, when the cells lines inside the wall of the stomach, cervical canal and produce mucous secret (fig. 56);

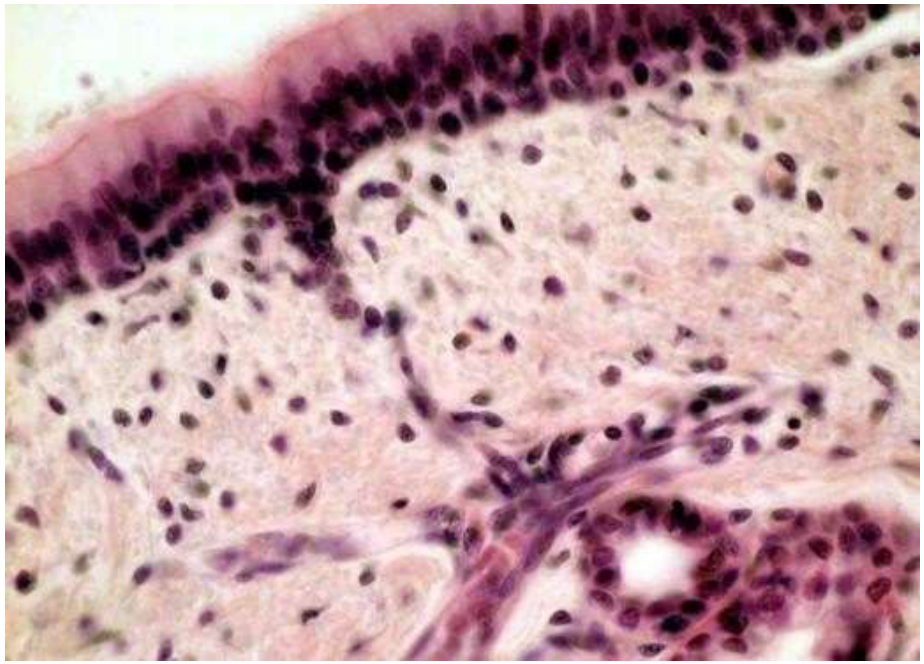


Fig. 55. Ciliated epithelium of the trachea. Hematoxylin and eosin staining. Magn. x 400.

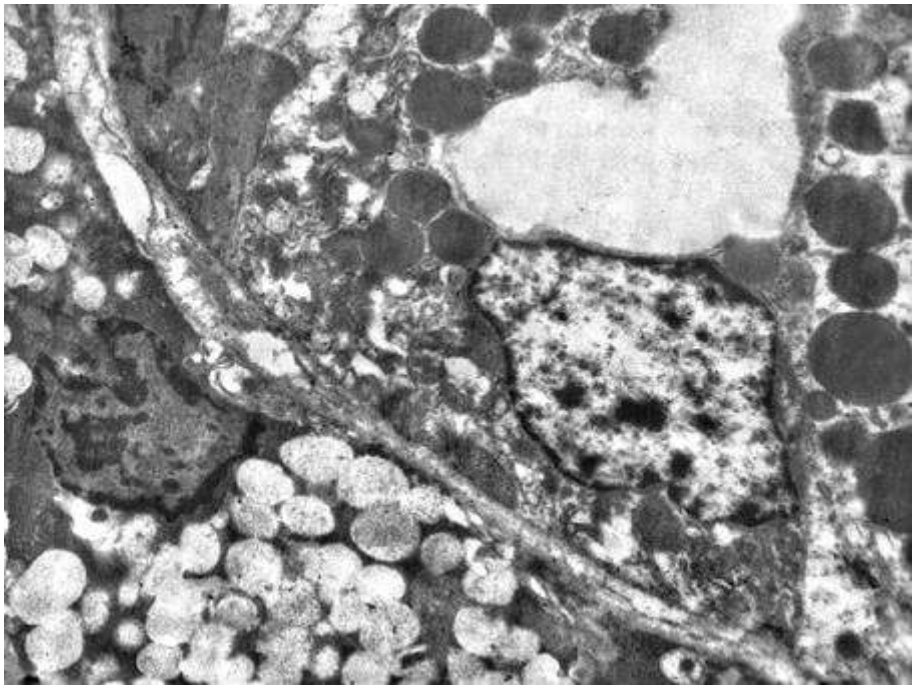


Fig. 56. Submandibular salivary gland. In secretory epithelial cells, protein (dark) and mucous (light) secretory granules are visible. Electronogram. Magn. x 7000.

SIMPLE CUBOIDAL EPITHELIUM consists of cuboidal cells. For example: epithelium of renal tubules (fig. 57).
SIMPLE SQUAMOUS EPITHELIUM consists of squamous polygonal cells. For example: mesothelium of the omentum, vascular endothelium. (See lining epithelia).
STRATIFIED COLUMNAR AND CILIATED EPITHELIUM Nuclei in the cells are located at different distances from the basement membrane, which gives the impression of multiple layers. It lines mainly the mucous membrane of respiratory system (fig. 58).

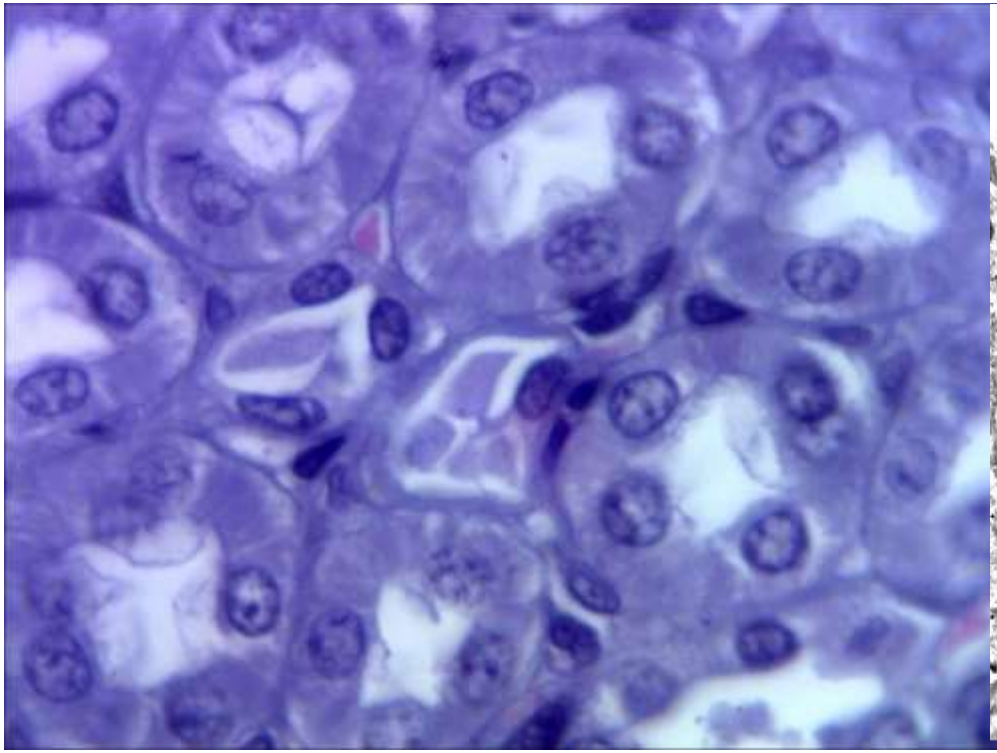


Fig. 57. Epithelium of renal tubules. Hematoxylin and eosin staining. Magn. x 400.

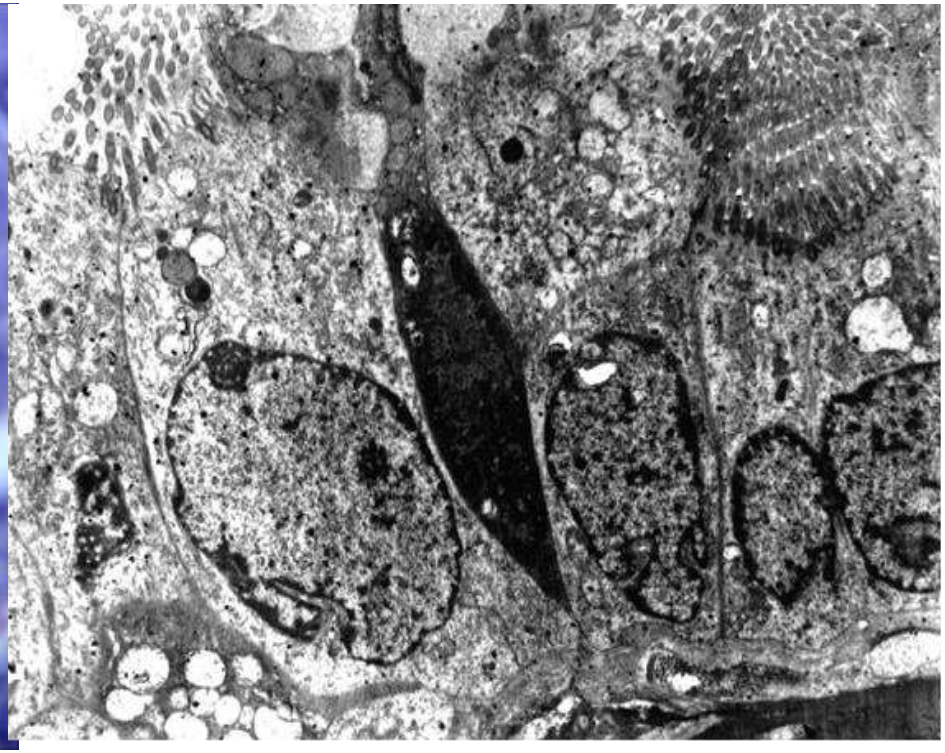


Fig. 58. Epithelia of the trachea. Electronogram. Magn. x 8000.

TRANSITIONAL EPITHELIUM As a result of stretching and contraction of the organ, the morphology of the epithelial layer also changes: from being stratified it turns into bi-layered and vice versa. The epithelium lines the urinary tract (calices, ureters, bladder, urinary tract) (fig. 59).

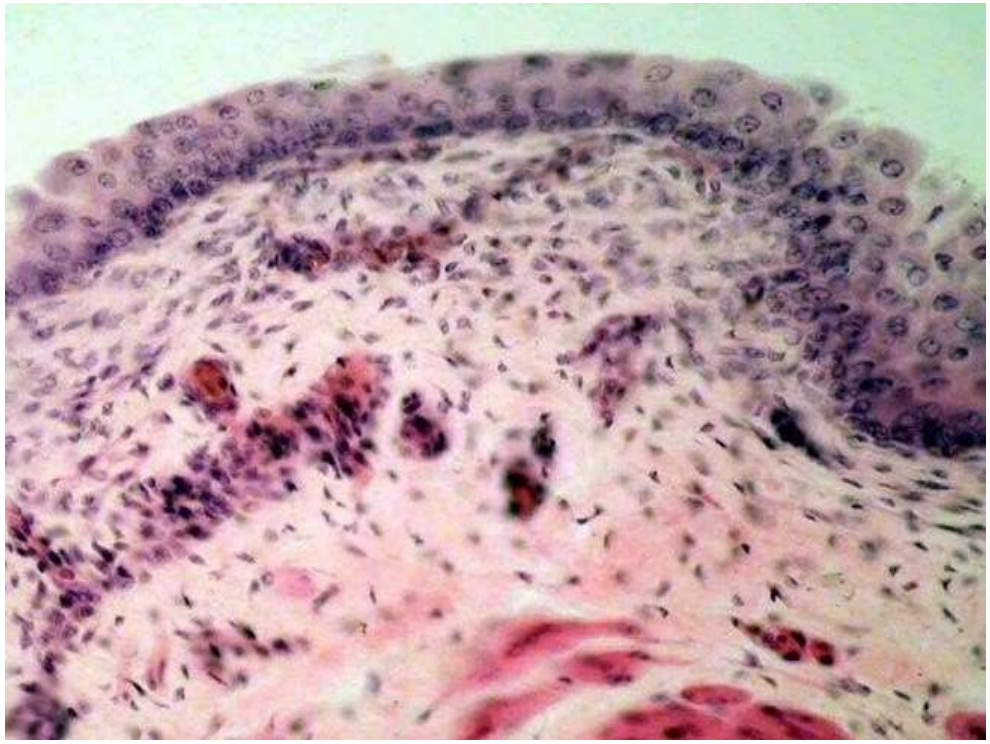


Fig. 59. Transitional epithelium of the bladder. Hematoxylin and eosin staining. Magn. x 400.

TYPE II. INTERNAL TISSUES

ADVENTITIAL CELL is a poorly differentiated cell of the fibroblastic differon that accompanies small blood vessels (fig. 60).

BASOPHILIC GRANULOCYTES. The cell nuclei are weakly lobed, the cytoplasm is filled with numerous large granules that are stained with the main dyes. Cell function is the synthesis and secretion of biologically active substances, including heparin, histamine (fig. 61) .

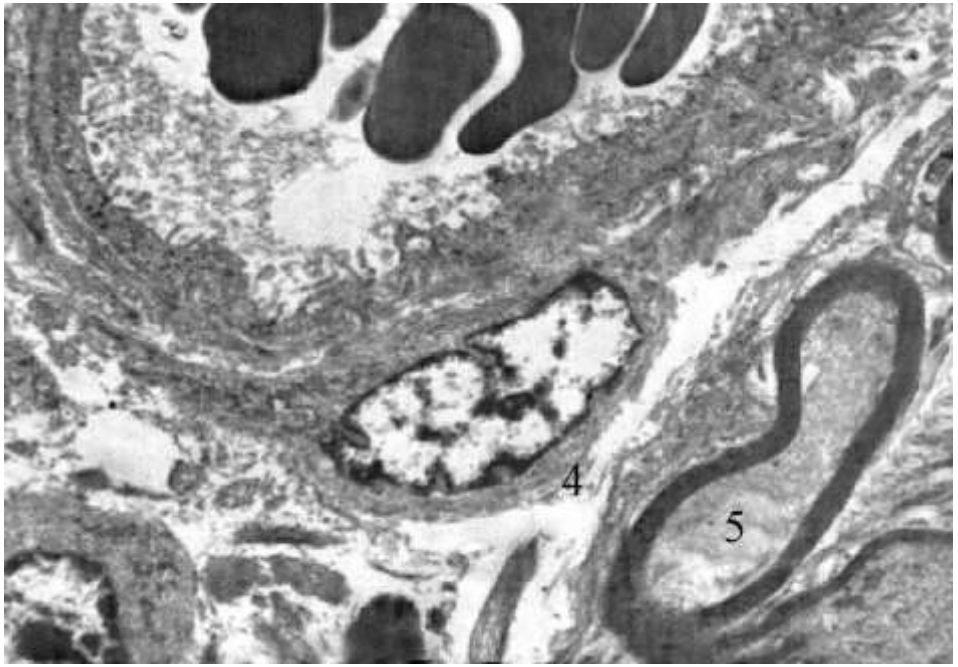


Fig. 60. Adventitial cell in the wall of the venule. Electronogram. Magn. x 3200.

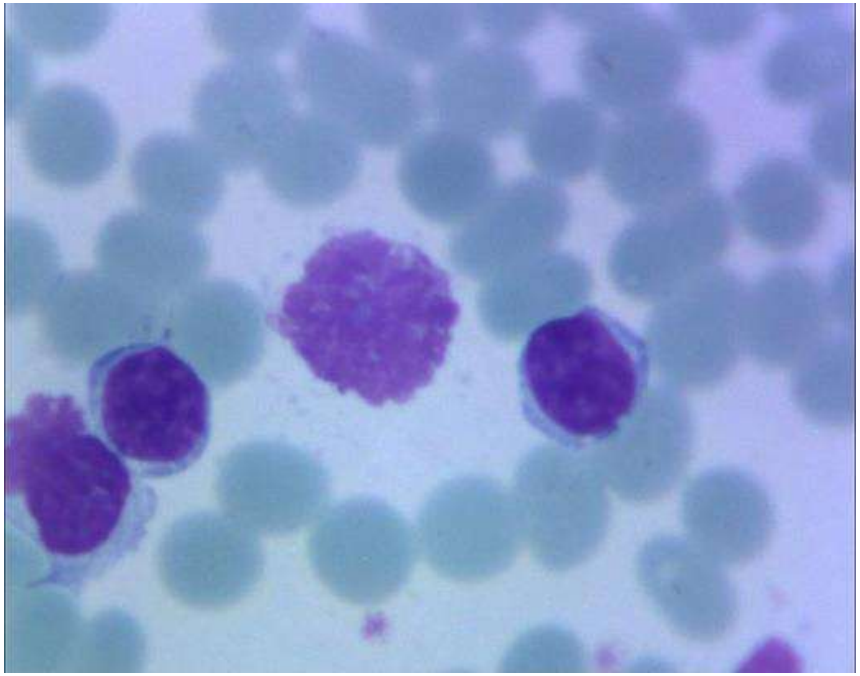


Fig. 61. Basophilic granulocytes. Romanovsky-Himza staining. Magn. x 1000.

BLOOD AND LYMPH is tissues that have a liquid consistency and consist of two main components: the plasma (intercellular fluid) and the formed elements suspended in it. Blood corpuscles include the red blood cells, white blood cells (granulocytes and agranulocytes), thrombocytes (platelets). Formed elements of the lymph are T and B - lymphocytes, plasmocytes.

BONE TISSUES together with cartilaginous tissues form a subtype of skeletal or supporting tissues. This type of tissues also consists of cells (osteoblasts, osteocytes, osteoclasts) and intercellular fluid (osteoid), rich (up to 70%) in inorganic compounds (various calcium salts, phosphates, microelements). There are two types of bone tissue: nonlamellar and lamellar (fig. 62).

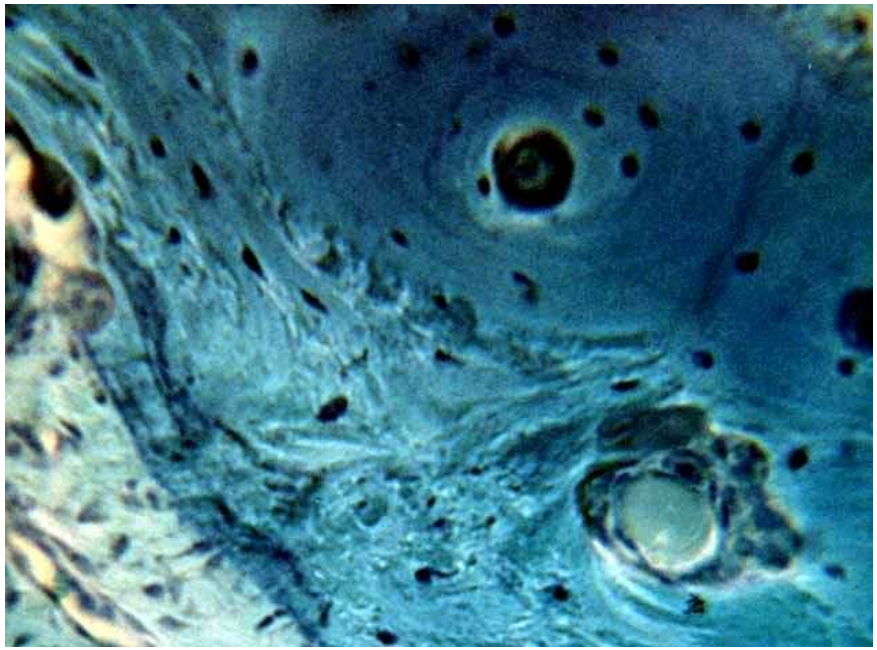


Fig. 62. Bone tissue of the alveolar process. Metylene blue staining. Magn. x 1000.

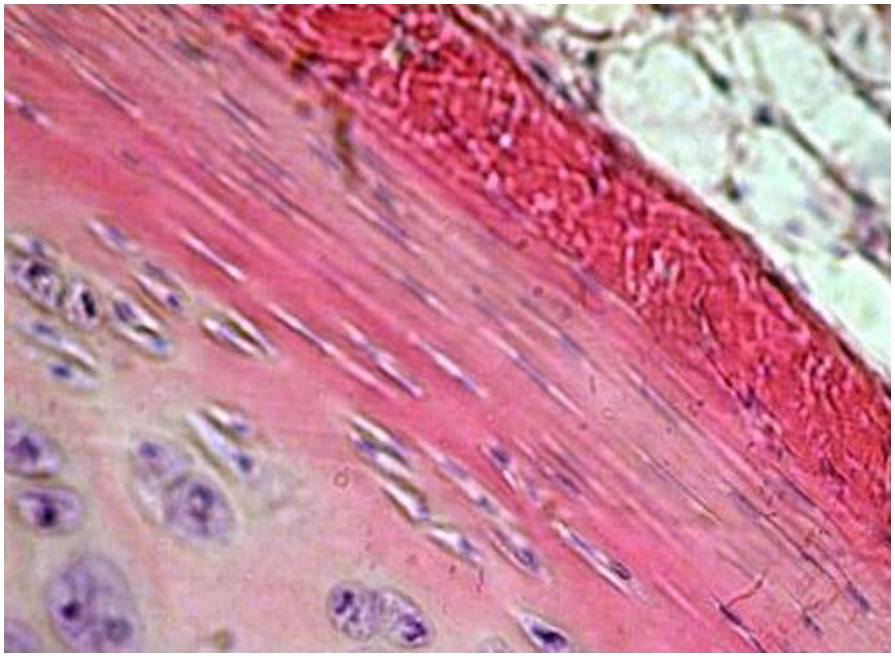


Fig. 63. In the surface layers of the cartilage, twisted basophilic bodies of chondroblasts are visible. Hematoxylin and eosin staining. Magn. x 400.

CHONDROBLASTS are young growing cells of the cartilage. They produce intercellular fluid. Mitotic distribution of peripherally located chondroblasts and accumulation of matrix components promotes a peripheral (appositional) growth of cartilaginous tissue (fig. 63).

CHONDROCYTES are the dominant cellular element of cartilaginous tissue. These cells synthesize and secrete components of the matrix into the extracellular space. Cartilaginous tissue growth is due to the division of chondroblasts and accumulation around the matrix cells (fig. 64).

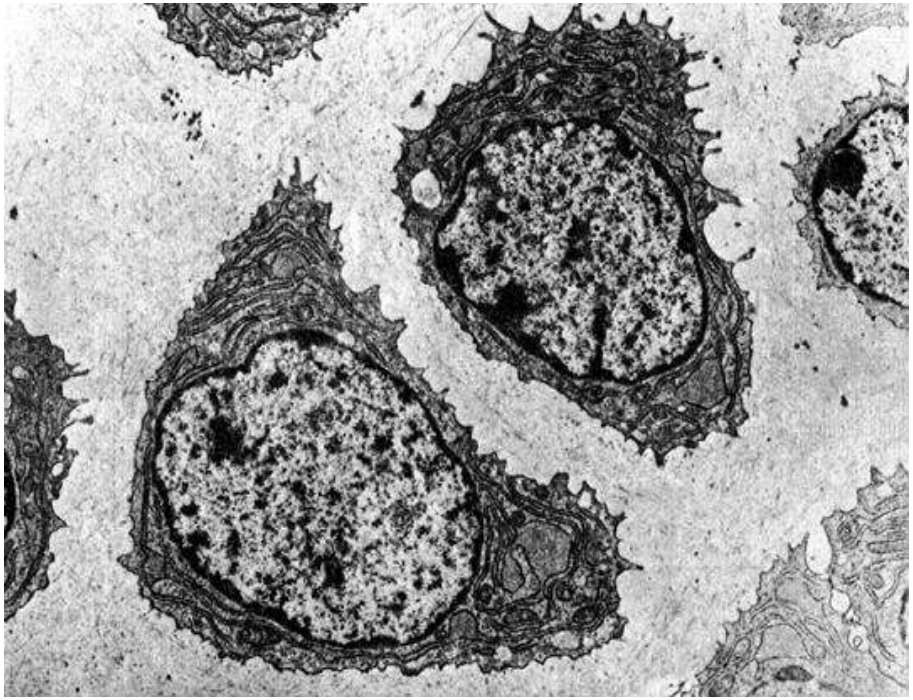


Fig. 64. Chondrocytes in the cartilage. Electronogram. Magn. x 15000.

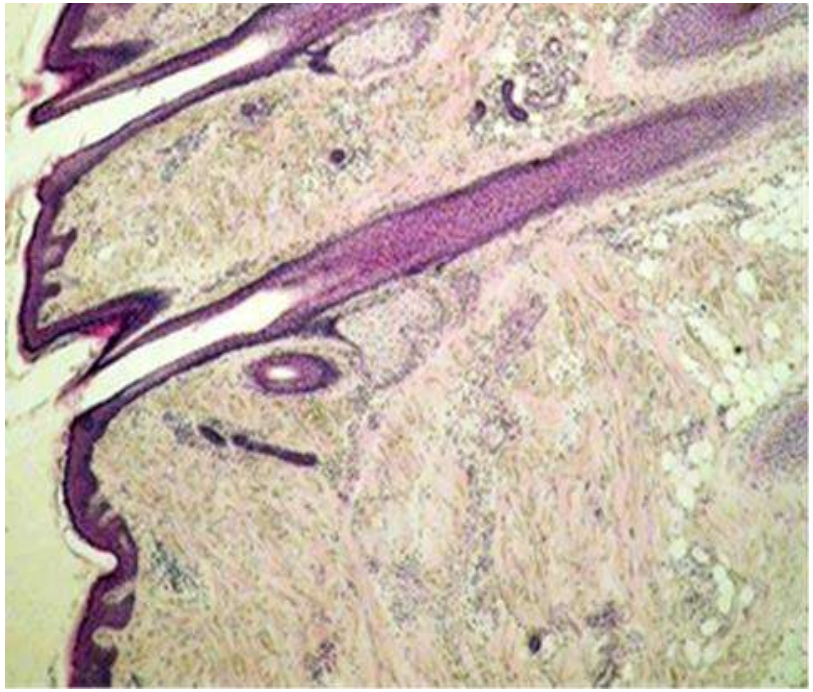


Fig. 65. In the lower right corner of the image, a dense immature collagen connective tissue of the derm reticular layer is visible. Hematoxylin and eosin staining. Magn. x 400.

CONNECTIVE TISSUE CELLS are heterogeneous connective tissue cells, derived from mesenchyme.

DENSE IMMATURE COLLAGEN CONNECTIVE TISSUE. The cellular elements of this tissue are fibroblasts and fibrocytes. The extracellular component is represented by disorganized bundles of collagen fiber. This tissue forms the reticulate layer of the dermis (fig. 65).

DENSE MATURE COLLAGEN CONNECTIVE TISSUE. The cellular elements of this tissue are fibroblasts, fibrocytes, and the main non-cellular component is represented by the well-organized collagen fibers. This tissue forms the tendons, ligaments, fasciae, the protein membrane of the testis and ovary (fig. 66).

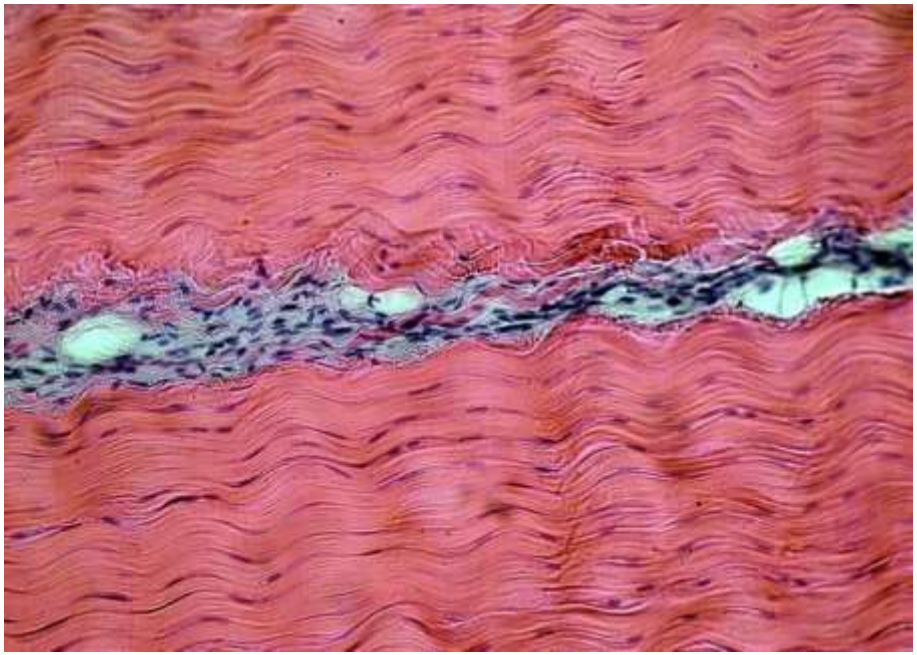


Fig. 66. Dense mature collagen connective tissue of the tendon. Hematoxylin and eosin staining. Magn. x 400.

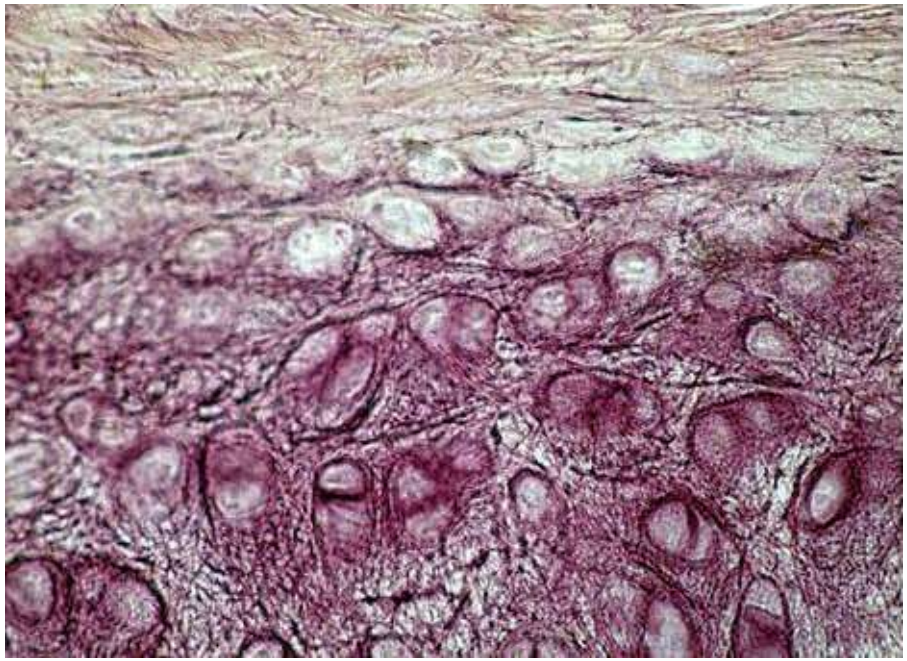


Fig. 67. Elastic cartilaginous tissue in the ear. Orsein staining. Magn. x 400.

ELASTIC CARTILAGINOUS TISSUE is a kind of cartilaginous tissue. Basically, the structure of the elastic cartilage is similar to a hyaline one. This tissue is very elastic, in its intercellular fluid numerous elastic fibers and less

collagen fibers are found. In this tissue no calcification occurs. Cells are chondrocytes, chondroblasts, chondroclasts; intercellular fluid is chondroid. Elastic cartilage is found in the ear, epiglottis, corniculate (Santorini's) and cuneiform (Morgagni's) cartilages (fig. 67).

ELASTIC CONNECTIVE TISSUE. The cellular elements of this tissue are fibroblasts and fibrocytes. The main extracellular components are elastic fibers. Depending on the organ in which the elastic tissue is l ocated, the elastic fibers form:

EOSINOPHILIC GRANULOCYTES are large cells (12 - 14 μ) with lobed nucleus. They contain granules, stained with acid dyes. Their function is to participate in allergic reaction (fig. 68).

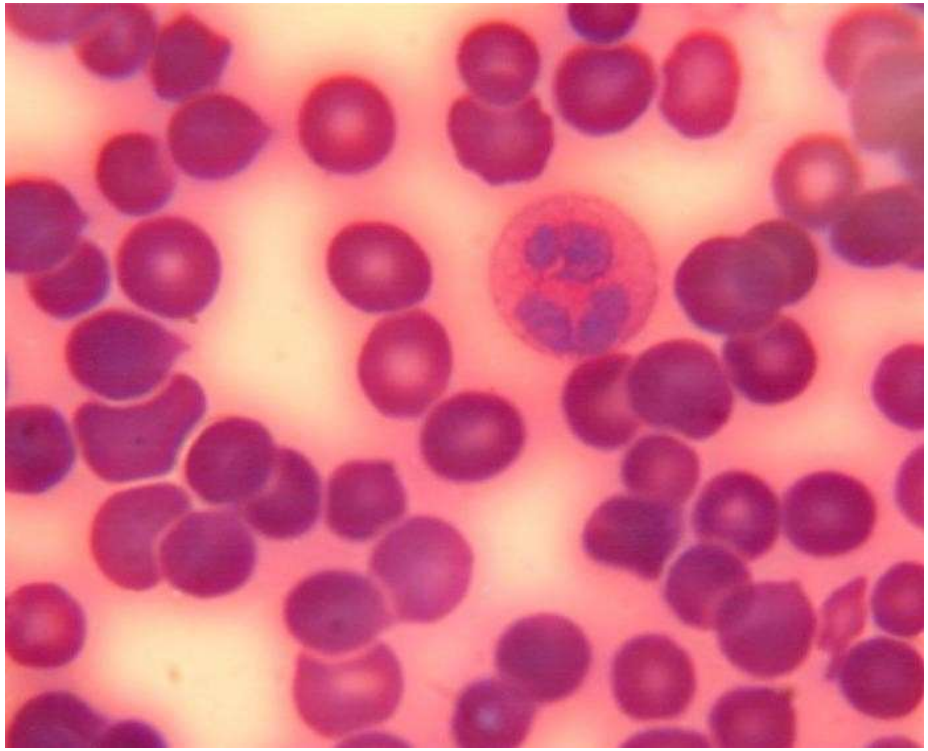


Fig. 68. Eosinophilic granulocytes in the blood smear. Romanovsky-Himza staining. Magn. x 1000.

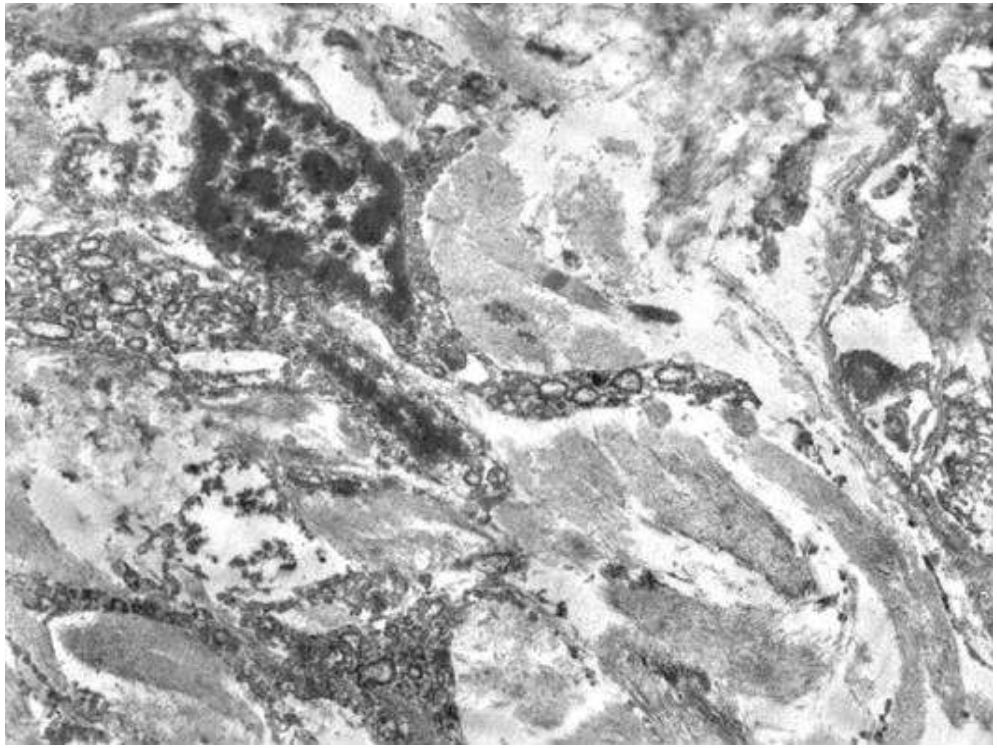


Fig. 69. The body of the fibroblast with long processes, around - collagen fibers. Electronogram. Magn. x 4000.

FIBROBLAST is the cell that produces proteins (tropocollagen, elastin, fibronectin) and glycosaminoglycans, from which fibers and the main substance of connective tissue are formed in the extracellular fluid. Fibroblasts are capable of mitosis. They are more often spindle-shaped (fig. 69).

FIBROCYTE is a mature cell of connective tissue that is not capable of mitosis. The main function is to maintain the stability of the structural organization of the intercellular fluid.

FIBROUS CARTILAGE TISSUE in its structure occupies an intermediate position between a dense mature fibrous connective tissue and hyaline cartilaginous tissue. In the intercellular fluid, the collagen fibers are arranged parallel to each other, and the cells are localized in specific cavities, lacunae. The fibrous cartilage forms the symphy ses of the pubic bones and the intervertebral discs located at the sites of tendon junction transition into hyaline cartilage (fig. 70).

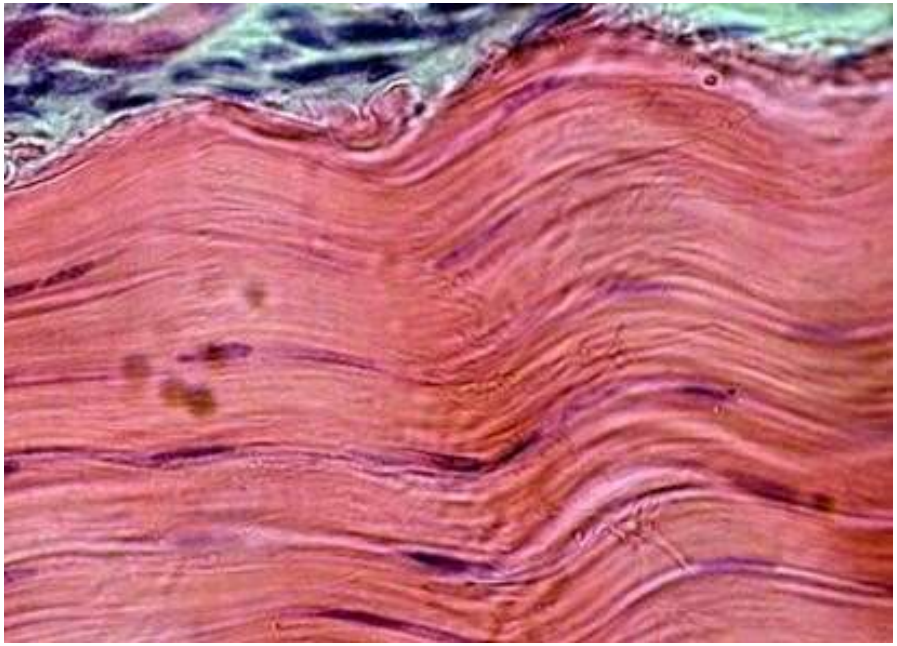


Fig. 70. Fibrous cartilage tissue. Hematoxylin and eosin staining. Magn. x 400.

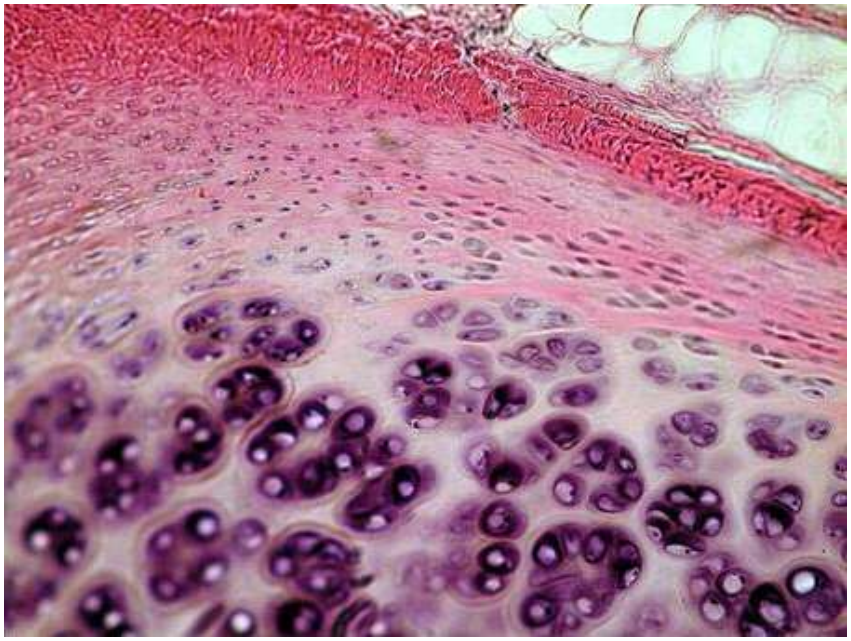


Fig. 71. Hyaline cartilaginous tissue. Hematoxylin and eosin staining. Magn. x 400.

HYALINE CARTILAGINOUS TISSUE is a type of cartilaginous tissue in which cells (chondrocytes, chondroblasts, chondroclasts) and intercellular fluid, chondroid are found. Hyaline cartilage is found on many joint surfaces, in the ribs, at the joints of the epiphysis and metaphysis of the tubular bones, in the respiratory organs (fig. 71).

INTERCELLULAR SUBSTANSE consists of amorphous substance and various fibers:

- collagen fibers, made from collagen protein;
- elastic fibers, made of elastin protein. The fibers can stretch and snap back to their original length when relaxed;
- elastic lamina;
- elastic reticulum;
- fenestrated elastic membrane.
- reticular fibers are formed by type III collagen; when branching, they create a spatial reticulum.
- the basic substance contains water, carbohydrate compounds, in particular glycosaminoglycans, hyaluronic acid, chondroitin sulfates, non-collagen proteins;

LAMELLAR BONE TISSUE is formed mainly by the gradual replacement of nonlamellar bone tissue. Lamellar bone tissue is characterized by a strictly parallel arrangement of bundles of collagen fibers, forming the bone lamella. There are compact bone tissue, in which the lamellae are arranged parallel to each other (there are no hollows between the adjacent lamellae) and spongy bone tissue, in which the bone lamellae are located at an angle to each other (hollows between the bone trabeculae in which the red bone marrow is located) are formed. From the lamellar bone tissue the diaphyses of long (tubular) bones are formed. Epiphyses of tubular bones and central parts of flat bones are formed from the spongy bone tissue (fig. 72).

LIPOCYTE (ADIPOCYTE) is a cell in the cytoplasm of which lipids (fats) and fat-soluble vitamins are accumulated (fig. 73).

Fig. 72. Lamellar bone tissue. Staining by Shmorl. Magn. x 400

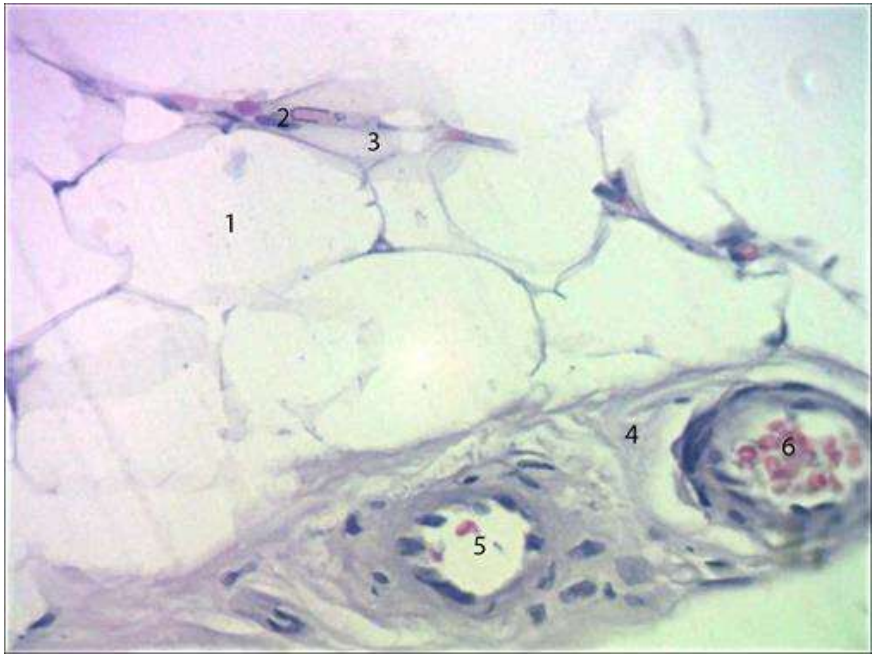


Fig. 73. Adipocytes. In the layers of connective tissue, a vein and an artery are visible, in thinner ones - capillaries. Hematoxylin and eosin staining. Magn. x 400.

LOOSE CONNECTIVE TISSUE is aggregation of heterogeneous cells and the substance produced by them, which forms a dynamic integral unity. Intercellular fluid and heterogeneous cells are distinguished (fig. 74).

MACROPHAGE develops from monocytes. Functions: phagocytosis and participation in immune responses (fig. 75).

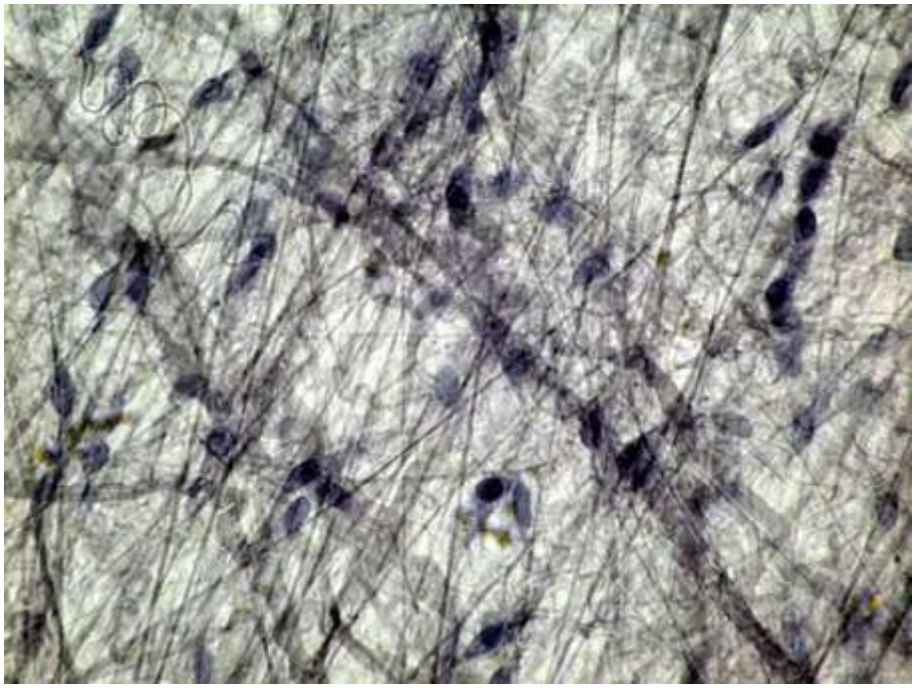


Fig. 74. Loose connective tissue. Hematoxylin staining. Magn. x 400.

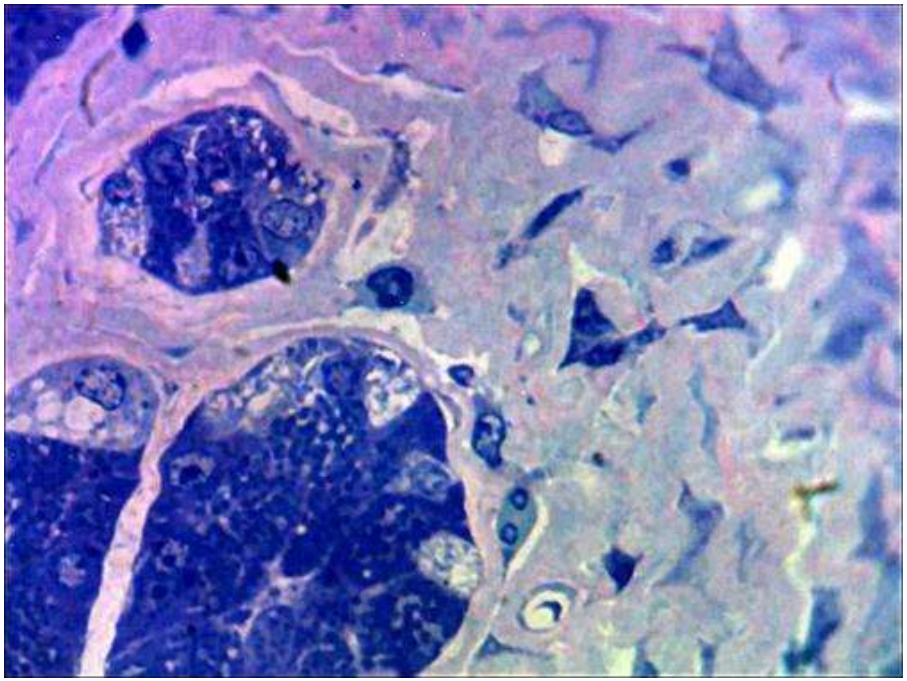


Fig. 75. In the center of the picture, a macrophage is seen in the lamina propria of the gastric mucosa. Toluidine blue staining. Magn. x 1000.

MAST CELL (TISSUE BASOPHIL) is the cell that synthesizes, accumulates and releases biologically active substances, namely, heparin, serotonin, histamine, dopamine into the extracellular fluid (fig. 76).

MONOCYTES are the largest leukocytes (18-20 μ in blood smears). Monocytes are the precursors of various macrophages (fig. 77).

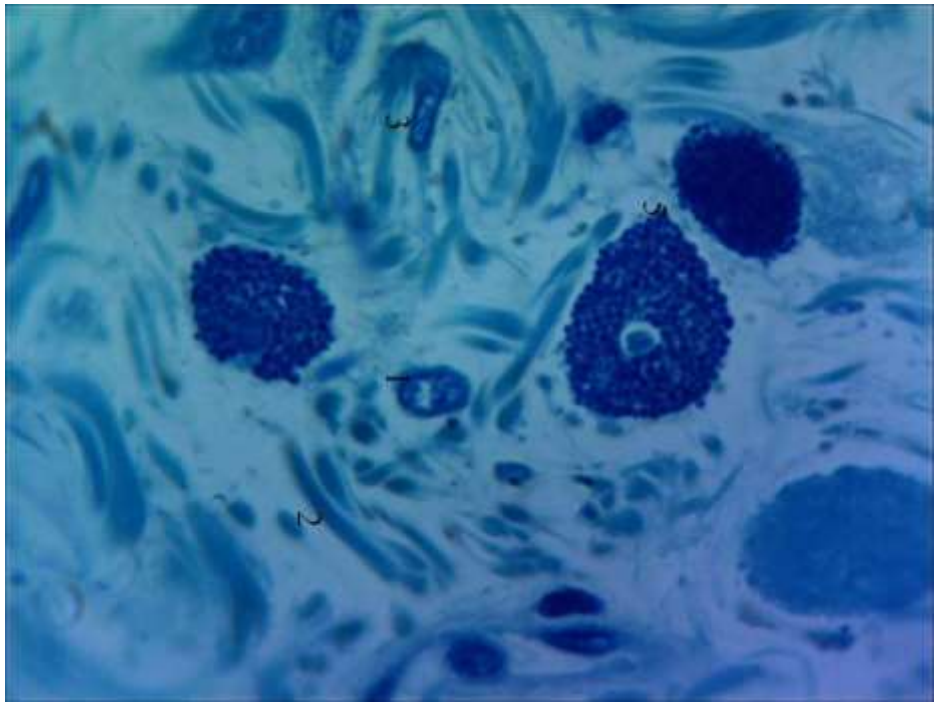


Fig. 77. Mast cells in connective tissue. Toluidine blue staining. Magn. x 1000.

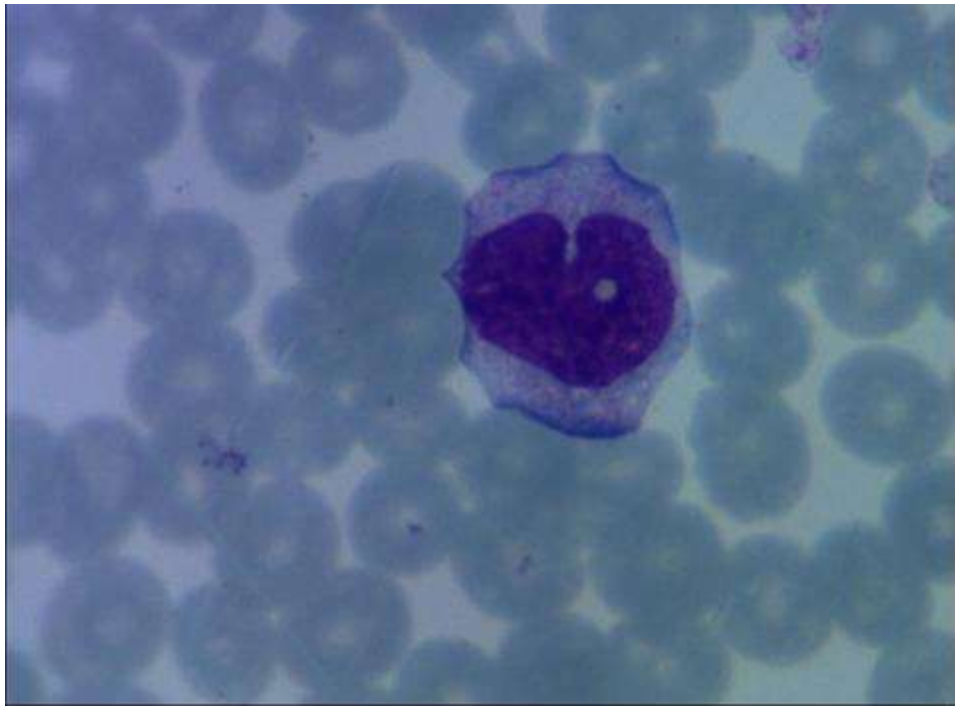


Fig. 77. Monocyte in the blood. Romanovsky-Himza staining. Magn. x 1000.

MUCOUS CONNECTIVE TISSUE is an embryonic form of loose connective tissue. It consists of the spindle-shaped cells of the fibroblastic differon and the jelly-like intercellular fluid. In the prenatal period, this tissue is found in the umbilical cord (fig. 78).

PIGMENT CONNECTIVE TISSUE is a type of connective tissue: loose or dense saturated with numerous melanin - phagocytic microphages, melanophores. Localized in the dermis, pia mater, choroid.

MULTILOCULAR ADIPOCYTE is characterized by a polygonal shape. The cytoplasm is filled with numerous small droplets of fat. The cells are rich in iron-containing cytochrome mitochondrial pigments.

NEUTROPHILIC GRANULOCYTES, when the nuclei of mature neutrophils consist of 2-5 lobes, connected by

chromatin. They contain granules stained with acid and basic dyes. They are responsible for phagocytosis of bacteria (fig. 79).

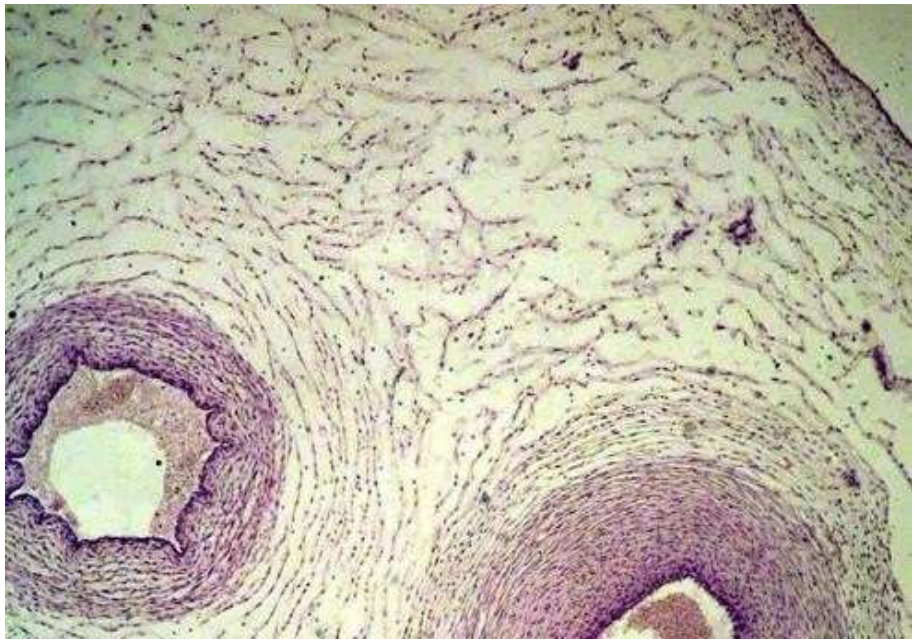


Fig. 78. Mucous connective tissue of the umbilical cord. Hematoxylin and eosin staining. Magn. x 400.

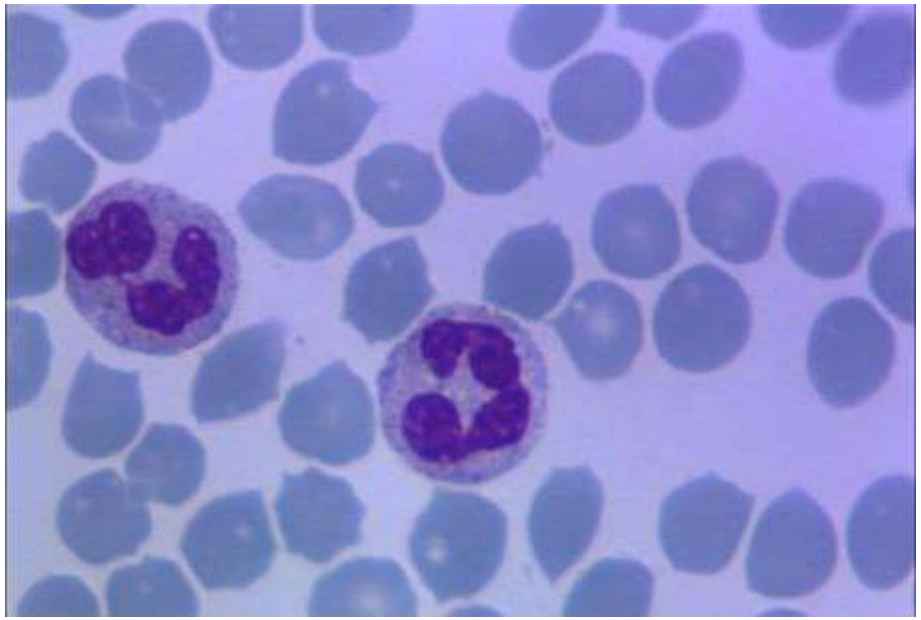


Fig. 79. Neutrophilic granulocytes. Romanovsky-Himza staining. Magn. x 1000.

NONLAMELLAR BONE TISSUE is formed in the process of embryogenesis, forms the flat bones of the embryo and is subsequently replaced by mature (lamellar) bone tissue. It is characterized by a relatively large number of cellular elements (osteoblasts, osteocytes, osteoclasts) and the chaotic arrangement of collagen fibers in an amorphous substance. In the mature organism it is determined in the areas of the seams of the skull, at the sites of a ttachment of tendons to the bones.

OSTEOBLASTS are cells that form the intercellular substance of bone tissue. In the adult body they are involved in the regeneration of bone tissue, and are located in the periosteum. They arise from the mesenchyme (fig. 80).

OSTEOCLASTS are multinucleate cells whose main function is the resorption (destruction) of calcified cartilage and bone. Osteoclast is a symplast formed by the fusion of numerous macrophages (fig. 81).

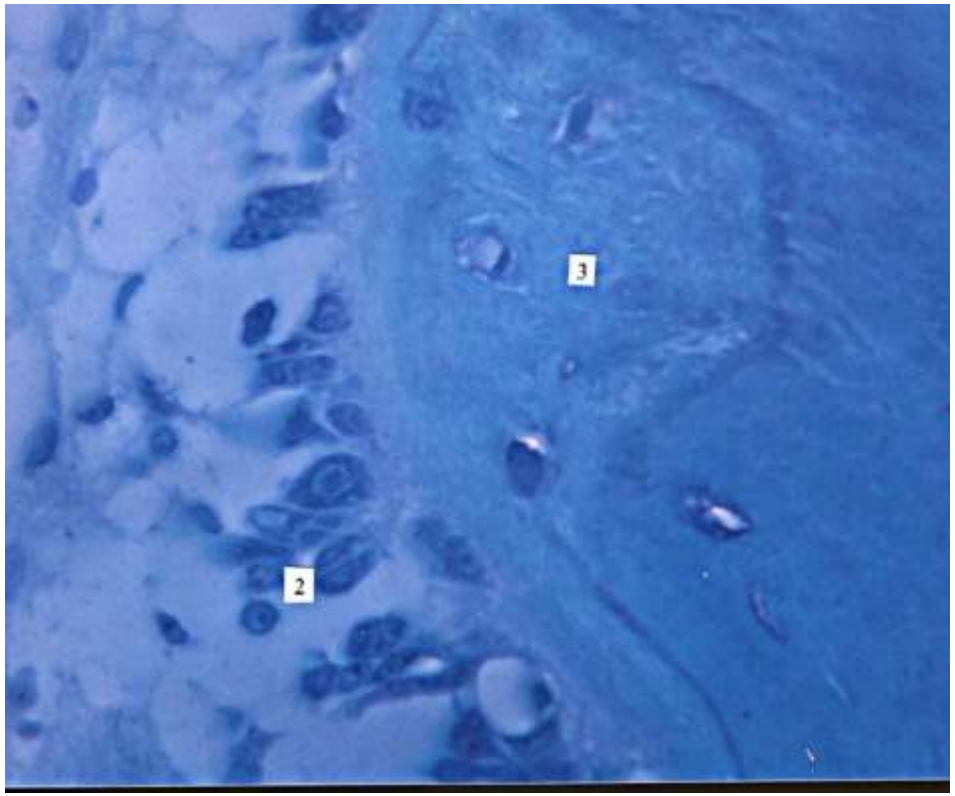


Fig. 80. Osteoblasts on the surface of the cortical plate of the alveolar process of the lower jaw. Methylene blue staining. Magn. x 1000.

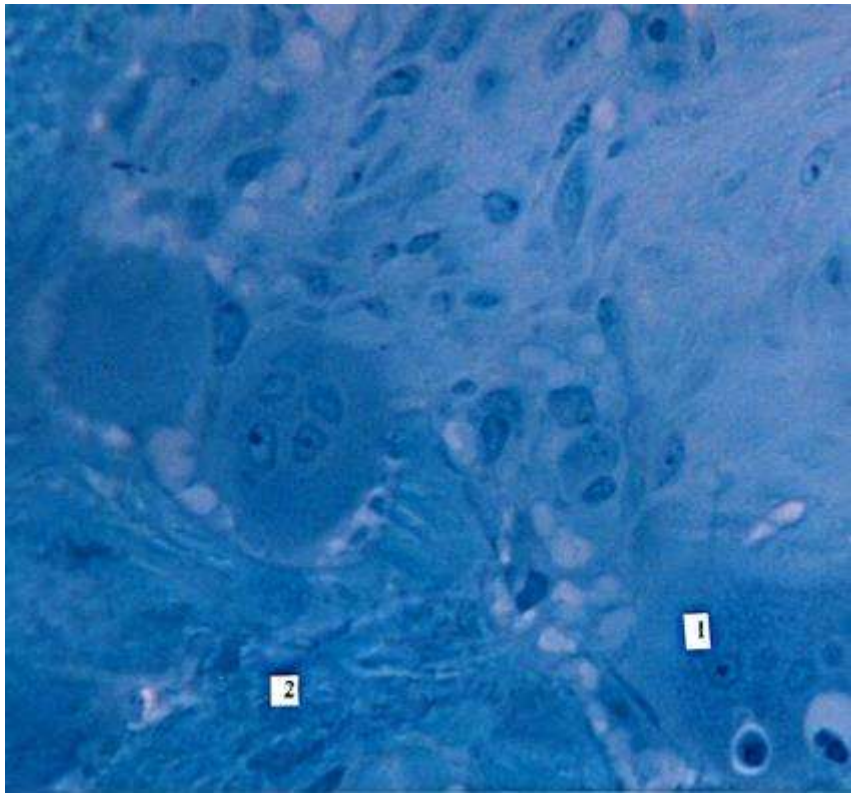


Fig. 81. Osteoclasts are multinucleated cells on the surface of the cortical plate of the alveolar process of the lower jaw. Methylene blue staining. Magn. x 1000.

OSTEOCYTES are highly differentiated mononucleate cells located in bone lacunae. The processes of osteocytes lie in the bone tubules. The latter are in contact with the perivascular space of the bone vessels, participating in the

metabolism between osteocytes and blood through tissue fluid. They arise from osteoblasts (fig. 82).

PERICYTE is a cell located in the basal layer of the blood capillaries.

PIGMENT CELL (MELANOCYTE) is spindle-shaped. It produces melanin, which absorbs ultraviolet radiation and thus protects the hereditary apparatus of cells from the effects of solar radiation.

PIGMENT CELL is a cell, which cytoplasm contains a pigment, for example, melanin, lipofuscin.

PLASMA CELL develops from B-lymphocytes due to antigen-dependent differentiation. It participates in reactions of humoral immunity, producing antibodies (γ - globulins) against foreign proteins, microorganisms and their toxins (fig. 83).

Fig. 82. Osteocytes - cells with processes are located between the bone plates and are colored crimson. Staining by Shmorl. Magn. x 400.

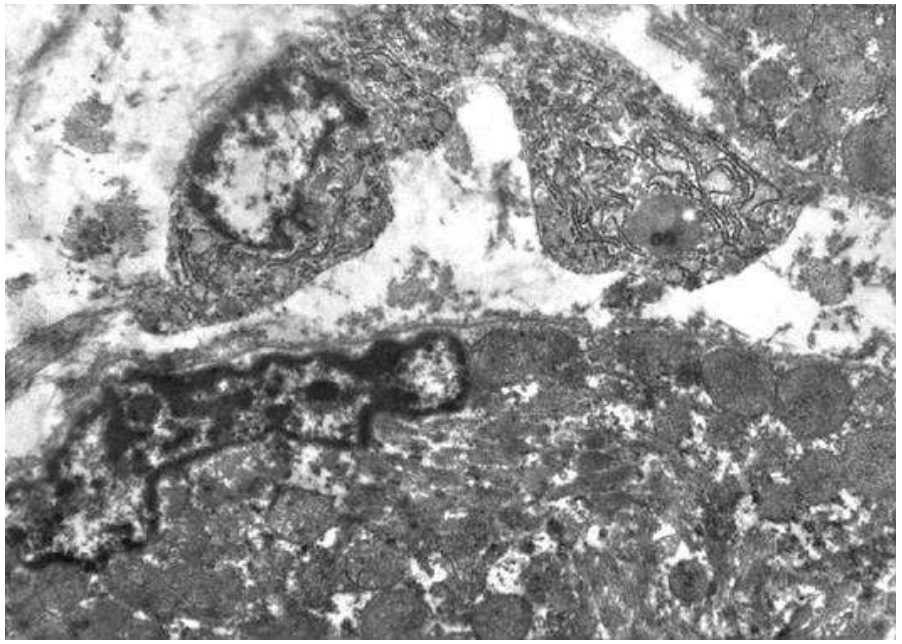


Fig. 83. Plasma cell in the lingual mucosa. Electronogram. Magn. x 4800.

RED BLOOD CELLS (erythrocytes) are akaryocytes the main function of which is to transport oxygen, carbon dioxide and various biologically active substances. According to the shape (poikilocytosis), akaryocytes are divided into: discocytes (biconcave disc), spherocytes (spherical shape), echinocytes (thorny projections). By their size (anisocytosis) they divided into normocytes d = 7, 8 μ; microcytes d <7 μ; macrocytes d> 9 μ (fig. 84).

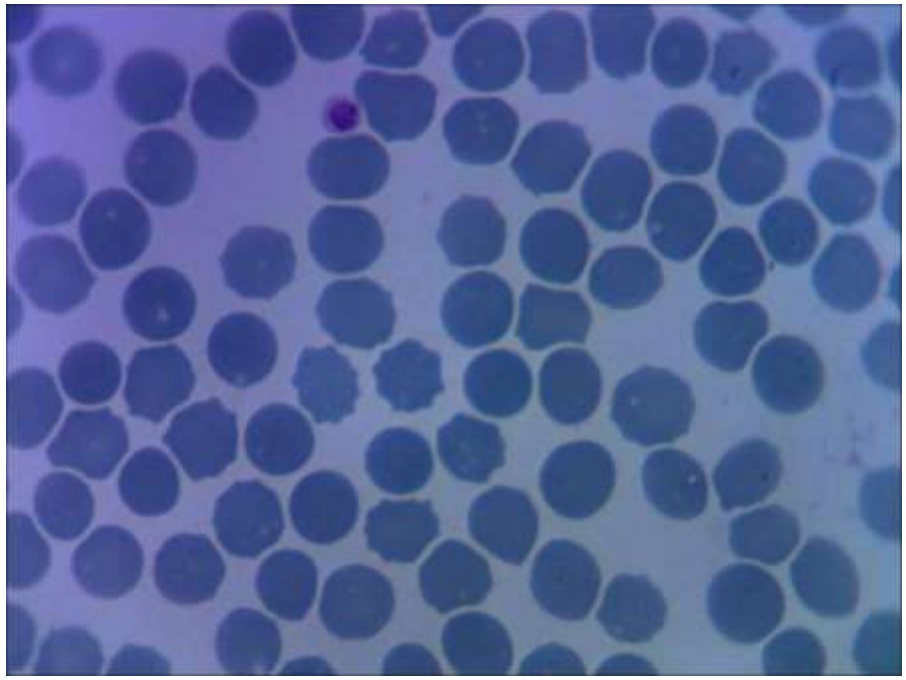


Fig. 84. Erythrocytes. Romanovsky-Himza staining. Magn. x 1000.

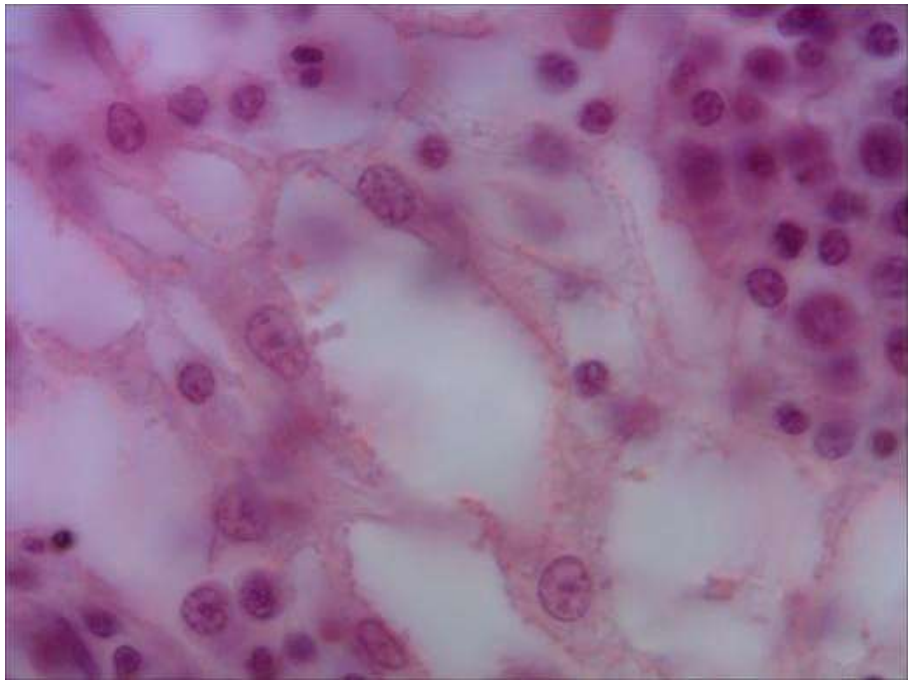


Fig. 85. Reticular cells form the tender stroma of lymphoid organs, communicating with processes. Hematoxylin and eosin staining. Magn. x 400.

RETICULAR CELL is spindle-shaped. They form a cellular reticulum when contacting with their processes (fig. 85).
RETICULAR CONNECTIVE TISSUE. The cellular elements of this tissue are reticular cells, and the main extracellular component is represented by numerous reticular fibers and tissue fluid. It forms the stroma (fibrous

framework) of hemopoietic organs and host defense (red bone marrow, spleen, lymph nodes).
This tissue forms elastic ligaments. It is the dominant tissue component of the wall of the main blood vessels. In the aorta it forms numerous elastic laminae and fenestrated elastic membranes.
THROMBOCYTES (platelets) are akaryotic fragments of the cytoplasm of the mast cells of the bone marrow, megakaryocytes. The major function of platelets is to contribute to hemostasis (fig. 86).

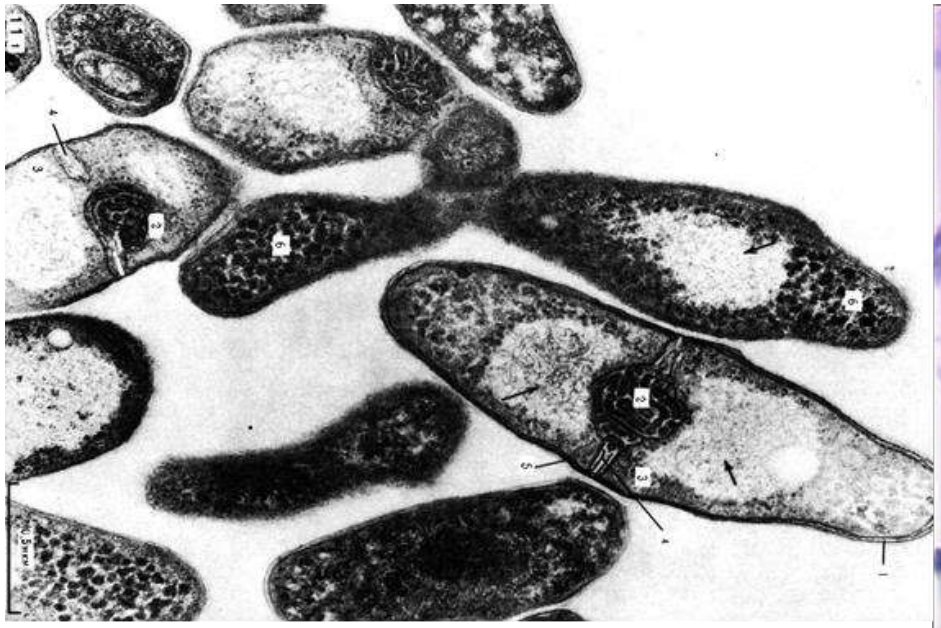


Fig. 86. Thrombocytes. Electronogram. Magn. x 5000.

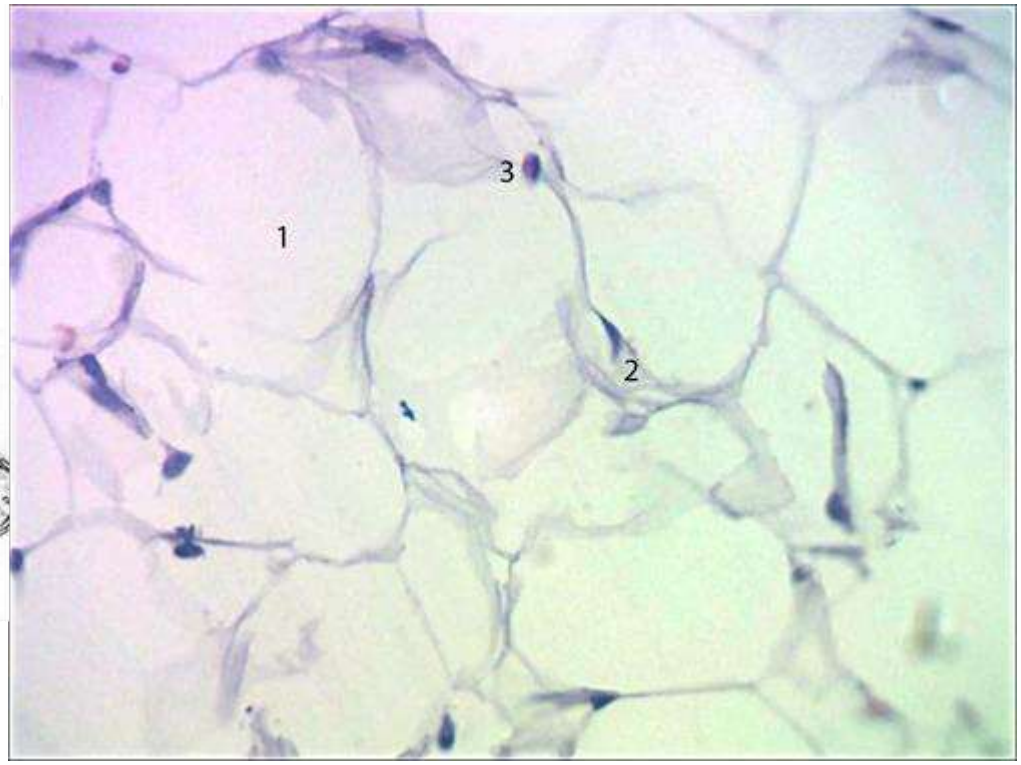


Fig. 87. White adipose tissue. Hematoxylin and eosin staining. Magn. x 400.

WHITE ADIPOSE TISSUE (white fat) is a type of adipose tissue. It is formed by adipocytes located in the subcutaneous tissue, omentum, mesentery and accompanies large blood vessels, forming a protective layer of some

internal organs. Each adipocyte is surrounded by a network of reticular fibers, as well as blood and lymphatic capillaries (fig. 87).

WHITE BLOOD CELLS (lymphocytes) are a group of cells with orbicular, sometimes bean-shaped nuclei and basophilic cytoplasm involved into immune responses. Small, medium and large lymphocytes are distinguished by morphology and B-, NK-, O- and T-lymphocytes by their functions.

TYPE III. MUSCULAR TISSUE

CARDIOMYOCYTES are uni-, often binucleate, muscle cells, with the dominant complex "myofibrils + mitochondria", accounting for up to 80% of myocyte volume. High heart rate causes a high content of mitochondrial (energy-forming) structures in cells, accounting for 30 to 40% of myocyte volume. Each myocyte has a sarcolemma (basement membrane + plasmolemma). Contractile, pacemaker and secretory cardiomyocytes are distinguished (fig. 88).

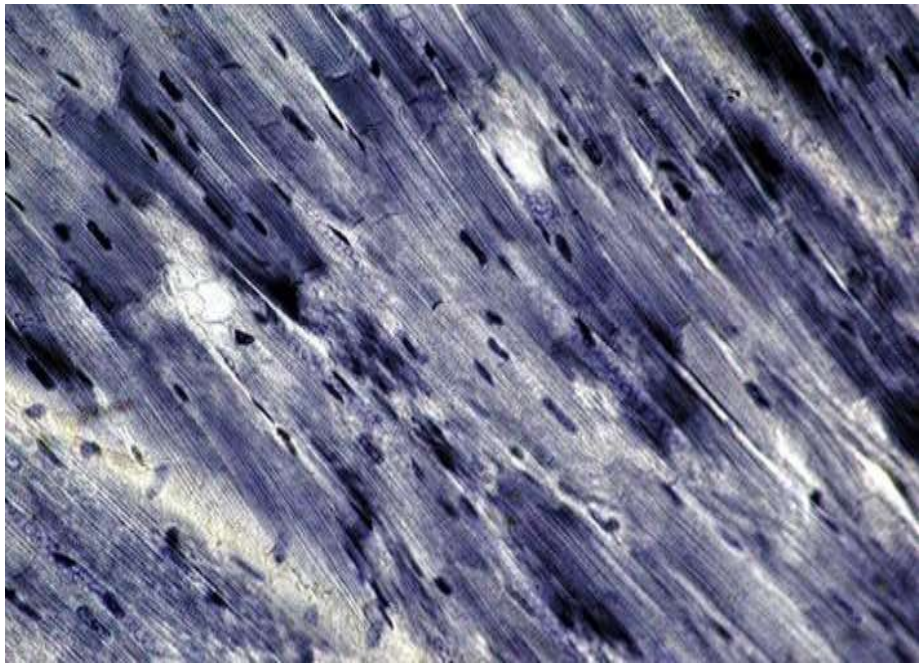


Fig. 88. Cardiomyocytes. Hematoxylin staining. Magn. x 400.

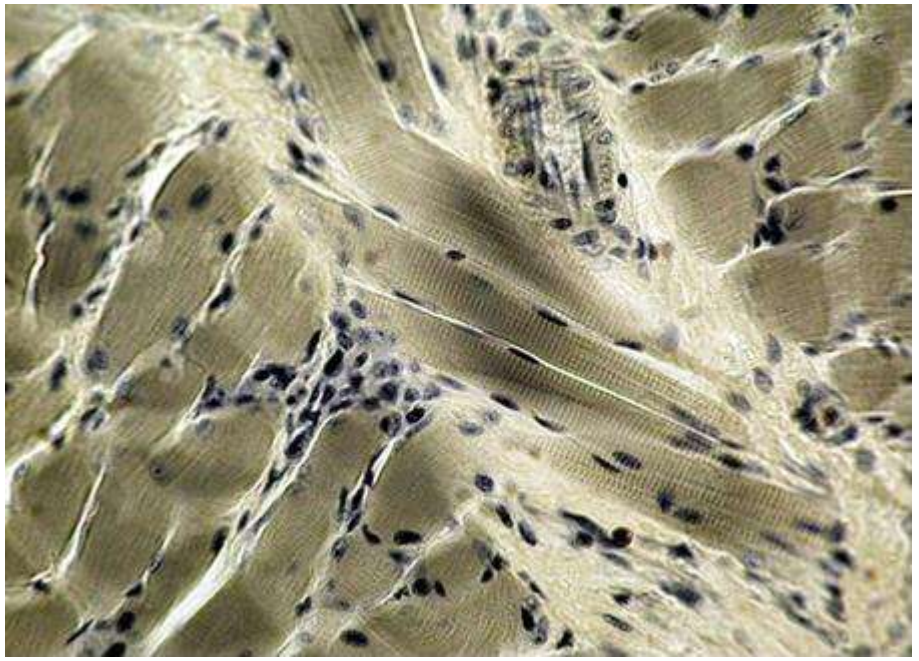


Fig. 89. Skeletal muscle fibers. Hematoxylin staining. Magn. x 400.

CONTRACTILE CARDIOMYOCYTES are muscle cells of mainly cylindrical branched shape, joined into cardiac muscle fibers by intercellular junctions (intercalated discs). They make up ventricular myocardium, interventricular

septum, papillary muscles.

MUSCLE FIBER is a structural and functional unit of skeletal muscle tissue formed by myoblasts (more than 1000), fused in embryogenesis (fig. 89).

MYOFIBRILS are structural and functional units of the contractile apparatus of muscle fibers, consisting of thick and thin myofilaments that are part of sarcomeres.

MYOSATELLOCYTES are cambial cells of skeletal muscle tissue that lie between the plasmolemma of the musc le fiber and its basement membrane.

PACEMAKER CARDIOMYOCYTES are specific cardiac muscle cells that carry the electrical impulses from pacemaker cells to contractile cardiomyocytes.

SARCOPLASMATIC RETICULUM is a type of smooth endoplasmic reticulum representing a system of tubules and flattened cisterns. It surrounds myofibrils and is a depot of calcium ions. The latter is necessary to initiate the act of "contraction –relaxation".

SECRETORY CARDIOMYOCYTES are the cardiac muscle cells that make up a compact and trabecular atrial myocardium and contain atrial granules. The granules contain natriuretic factor, which enhances the excretion of water and salts. Atrial natriuretic factor is excreted from the secretory cardiomyocytes into the blood capillaries by exocytosis, and then with the movement of blood is transferred to the kidneys, adrenal glands and affects the renin - angiotensin-aldosterone vasoconstriction system.

SMOOTH MUSCLE TISSUE is a type of muscle tissue formed by numerous smooth myocytes that form longitudinal structures: smooth muscle fiber. It is found in the walls of the organs of the digestive, respiratory, urinary, genital system, blood and lymphatic vessels. It is located in the capsules of the spleen, lymph nodes, in the dermis of the skin. The embryonic source of development of this tissue is mesenchyme (fig. 90).

SMOOTH MYOCYTE is elongated and spindle-shaped and contains thick and thin myofilaments, located, for the most part, longitudinally, along the lateral surface of cells, and aggregation of general-purpose organelles.

STRIATED CARDIAC TISSUE is built of cardiomyocytes that anastomose with each other, creating a ribbon -like structure. Cardiomyocytes are connected to each other by intercalated disks.

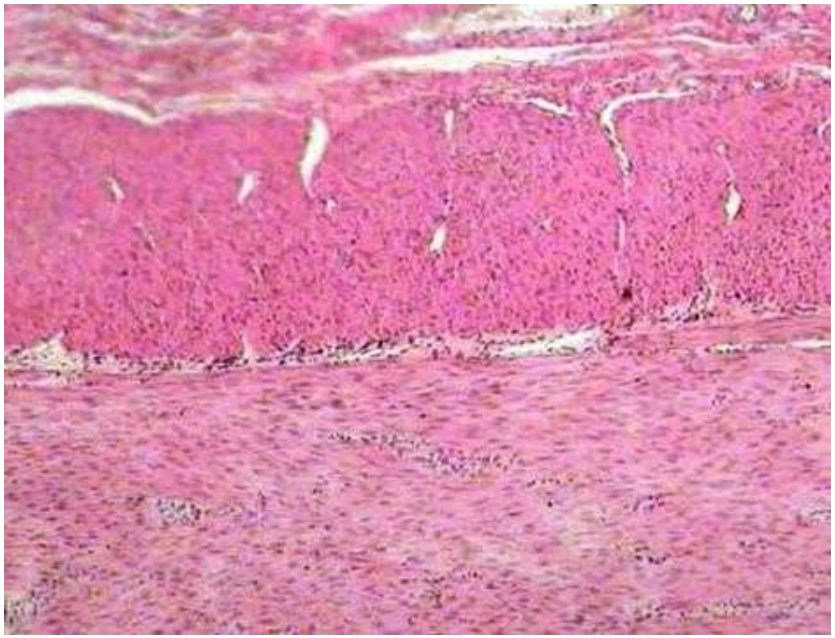


Fig. 90. Smooth muscle tissue of the bladder. Hematoxylin and eosin staining.
Magn. x 400.

STRIATED SKELETAL MUSCLE TISSUE is a muscle tissue formed by numerous muscle fibers, which are symplasts and myosatellocytes. The latter are considered as a cambial element of this tissue. Almost all skeletal muscles are formed from the muscle tissue that is part of the musculoskeletal system of the human and animal body. The embryonic source of tissue development is myotomes of mesoderm somites.

TYPE IV. NERVOUS TISSUE

ASSOCIATIVE/INTERCALATED NEURON is a nerve cell that provides communication between neurons.
ASTROCYTES are star-shaped cells that form a support for neurons, entwine neurons, blood vessels, ependymal cells of the ventricles of the brain. The functions of astrocytes: leading pathways for migration of undifferentiated neurons into the CNS in embryogenesis; transport of metabolites from capillaries to neurons; regulation of the chemical composition of the intercellular fluid. Protoplasmic and fibrous astrocytes are distinguished.
AXOAXONAL SYNAPSE is synapses between axons of different neurons; perform a deceleration function.
AXODENDRITIC SYNAPSE is synapses between the axon of one neuron and the dendrites of another neuron.
AXON, NEURITE is a long, usually unbranched extension that conducts groups of signals from the perikaryon. The length of the axon is from a few millimeters to tens of centimeters.
AXOSOMATIC SYNAPSE is a synaptic contact between the axon of one neuron and the perikaryon of another on e.
BIPOLAR NEURON is a nerve cell with a single axon and branched dendrite (e.g., olfactory receptor nerve cells).
DENDRITE is a branched extension of a neuron that receives impulses and conducts them to the body (perikaryon) of a nerve cell.
DENDRODENDRITIC SYNAPSE is synaptic contact between dendrites of neurons.
EPENDYMOCYTES are cells of predominantly cubic shape, forming an epithelioid layer that lines the central canal and ventricles of the brain. The cells have well-developed cilia and numerous vesicles in the cytoplasm. They form a permeability barrier.
FIBROUS ASTROCYTES are cells with long, slightly branched extensions, localized in the white matter.
MACROGLIA are numerous gliocytes of nerve tissue, different in structure and function, which develop from the nerve tube and form ependymal glia, astrocytic glia and oligodendroglia (fig. 91).
MICROGLIA are numerous microgliacytes (glial macrophages) of nervous tissue that have a monocytic origin (derived from mesenchyme) and can phagocytize. They can be considered as immunocompetent cells that perform a protective function in the central nervous system.

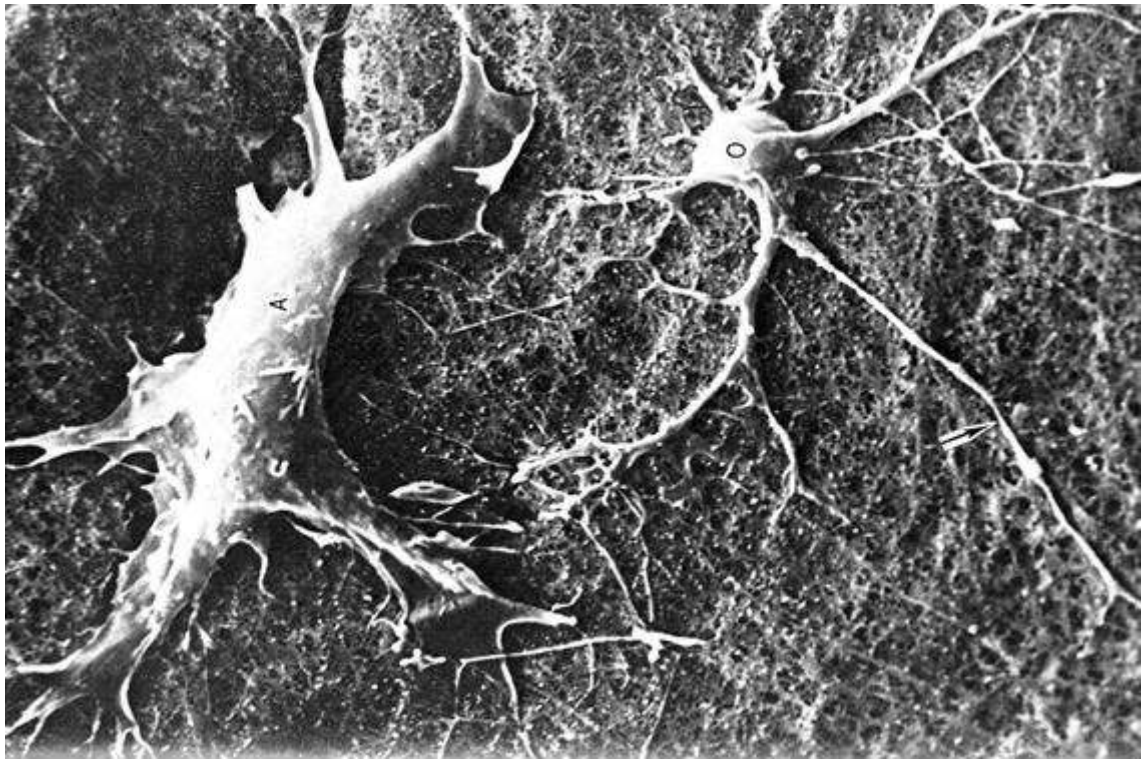


Fig. 91. Astrocyte and oligodendrocyte. Scanogram. Magn. x 25000.

MOTOR/EFFERENT NEURON is a nerve cell, the axon of which transmits a nerve impulse from the perikaryon to the active structure.

MULTIPOLAR NEURON is a nerve cell with three or more extensions (axon and several branched dendrites), such as motoneurons of the anterior horns of the spinal cord.

NERVOUS TISSUE is a cluster of neurons and gliacytes that make up a sophisticated spatial-temporal macro-microstructure, a single network with numerous junctions between cellular elements. It regulates and coordinates physiological processes at all levels of the ontogenesis, as well as perceives, stores, modifies information coming from the external and internal environment.

NEUROGLIA are numerous cellular elements located along the lateral surface of neurons and between neurocytes. Its main functions are to isolate receptive surfaces of neurons, as well as supporting, protective, trophic, secretory. All cellular elements of neuroglia are divided into two genetic types: gliacytes (macroglia) and glial macrophages (microglia).

NEUROMEDIATOR, NEUROTRANSMITTER is biologically active substance, which is synthesized in the perikaryon, and is excreted by the nerve ending and causes unidirectional transmission of nerve impulses in synapses. Excitatory and inhibitory neurotransmitters are distinguished.

NEURONS, NEUROCYTES are excitatory nerve tissue cells that perceive irritation, generate and transmit nerve impulses between themselves and to the cells of the active organs.

OLIGODENDROCYTES are the most numerous group of gliacytes. These cells isolate the body of neurons and their processes. In myelin nerve fibers oligodendrocytes form compact structures made of membranes that are helically twisted around the axon.

PERIKARYON, BODY OF A NEURON is the central segment of a neuron containing the nucleus, Golgi complex, granular endoplasmic reticulum, mitochondria, lysosomes, elements of the cytoskeleton.

PROTOPLASMIC ASTROCYTES are cells with numerous short and branched extensions, localized mainly in the gray matter.

PSEUDOUNIPOLAR NEURON is a nerve cell which has two contacting branches originated from the short extension of the perikaryon. Subsequently, they travel T-type and become an axon and a dendrite (e.g., neurons of spinal nodes).

RECEPTOR/AFFERENT/SENSORY NEURON is a nerve cell that receives a signal from the external or internal environment through a dendrite and transmits it via the axon to the intercalated (associative) or motor neuron.

SOMATOSOMATIC SYNAPSE is a synaptic contact between perikaryons of the neurons.

SYNAPSE is a specific intercellular contact that provides one-way transmission of nerve impulse from one neuron to another by means of biologically active substances, neurotransmitters.

UNIPOLAR NEURON is a nerve cell with one extension.

CYTOLOGY

<table>
<tr><th colspan="6">Cell</th></tr>
<tr><th colspan="2">Cell membrane
(plasmalemma)</th><th colspan="2">Nucleus</th><th colspan="2">Cytoplasm</th></tr>
<tr><th>Structure</th><th>Functions</th><th>Structure</th><th>Functions</th><th>Structure</th><th>Functions</th></tr>
<tr><td>50-60% proteins</td><td>barrier</td><td>chromatin</td><td rowspan="4">genetic information</td><td>organelles</td><td rowspan="4">active complex colloid system</td></tr>
<tr><td>30-40% lipids</td><td>receptor</td><td>nucleolus</td><td>hyaloplasm (cytosol)</td></tr>
<tr><td rowspan="2">5-10 % carbohydrates</td><td>transport</td><td>nucleoplasm</td><td rowspan="2">inclusions</td></tr>
<tr><td>firm connections</td><td>membranous nuclear envelope</td></tr>
</table>

<table>
<tr><th colspan="4">Cytoplasm</th></tr>
<tr><th colspan="2">Organelles</th><th>Hyaloplasm (cytosol)</th><th>Inclusions</th></tr>
<tr><th>membranuos</th><th>nonmembranous</th><td rowspan="8">water
electrolytes
nucleic acids
proteins
polysaccharides
enzymes</td><td>Fat droplets</td></tr>
<tr><td>Endoplasmic reticulum</td><td>microtubules</td><td>Glycogen granules</td></tr>
<tr><td>mitochondria</td><td>microfilaments</td><td rowspan="6">Pigmental inclusions (lipofuscin granules, melanin, hemosiderin granules).</td></tr>
<tr><td>lysosomes</td><td>centrioles</td></tr>
<tr><td>Golgi complex</td><td>ribosomes</td></tr>
<tr><td rowspan="2">peroxisomes</td><td>flagella</td></tr>
<tr><td>proteasomes</td></tr>
</table>

Membranous organelles		
Organelles	**Structure**	**Functions**
Rough endoplasmic reticulum (RER)	Complex of membranes which consists of channels that may have form of flattened sacs and of tubules which includes many ***ribosomes***.	Synthesize proteins. *Functions of proteins:* - intracellular storage (in lysosomes, specific granules of leucocytes). - intracellular storage of proteins before exocytosis (in the pancreas, some endocrine cells). - integral membrane proteins.
Smooth endoplasmic reticulum (SER)	Complex of membranes which consists of channels that may have form of flattened sacs and of tubules.	Carbohydrate metabolism. Lipid biosynthesis. Detoxification of potentially harmful compounds. Sequestration of Ca -ions.
Golgi apparatus(GA)	Small structure of irregular shape. Usually present near the nucleus. It is made up of membranes similar to those of SER. Membranes of GA form the walls of a number of flattened sacs that are stocked over one another. Towards their margins the sacs are continuous with small rounded vesicles.	Forms protein-carbohydrate complexes. Forms secretory vacuoles. Carbohydrate synthesis. Forms lysosomes.
Lysosomes	These vesicles contain about 40 different hydrolytic enzymes (proteases, lipases,	Destroy unwanted material present within a cell.

Types of lysosomes: 1. primary lysosome 2. secondary lysosome (phagolysosome and autophagosome) 3. residual bodies	phospolipases, sulfatases, ß-glucoronidase). Small membrane vesicle which has hydrolytic enzymes. ***Phagolysosome*** is a vacuole which is formed primary lysosome and outer iteam (bacteria). ***Autophagosome*** is a lysosome which consists of lysosomes enzymes and waste material (f.e. died organel). Membrane bound formations made of waste material that remained within the cell.	Help in «digesting» the material phagosomes as follows.
Peroxisomes (Microbodies)	Spherical membrane limited organelles approximately 0,5 mkm in diameter. Consists of basic enzymes (oxidize, catalase).	**Oxidize** removes hydrogen atoms that are transformed to molecular oxygen (O2). **Hydrogen** peroxide (H2O2) – potentially damaging substance to the cell which is immediately broken down by catalase.
Mitochondria	Consists of **two membrane** (smooth outer membrane and inner membrane).	Mitochondria's enzymes play an important role in Kreb's cycle.

	Inner membrane forms **cristae.** The space bounded by the inner membrane is filled by a granular material called the **matrix**. Matrix contains numerous **enzymes, RNA** and **DNA**.	**ATP** and **GTP** are formed in mitochondria from where they pass to go outer parts of the cell and provide energy for various cellular functions. In the mitochondria synthesize mitochondrial ribosomes and mitochondrial proteins.

Nonmembranous organels		
Organelles	**Structure**	**Functions**
Ribosomes	Present to RER, in the mitochondria, in the cytoplasm. Singly ribosomes – **monosomes.** Group of ribosomes – **polyribosomes.** Each ribosome consists of proteins and **RNA**.	Protein synthesis.
Proteasomes	are abundant cytoplasmic protein complexes. Are a cylindrical structure made of four stacked rings, each composed of seven proteins including proteases. At each end of the cylinder is a regulatoryparticle that contains **ATPase** and recognizes proteins with **ubiquitin** molecules attached. **Ubiquitin** is an abundant cytosolic 76-amino acid protein found in all cells.	They function to degrade denatured or otherwise nonfunctional polypeptides. Proteasomes also remove proteins no longer needed by the cell and provide an important mechanism for restricting activity of a specific protein.
Microtubules	are fine tubular structures. They have an outer diameter of **24 nm**, with a dense wall **5 nm thick** and a hollow lumen.	Form the **cytoskeleton** and the inner layer of the cell membrane.

	Microtubules are rigid structures which assemble from heterodimers of and tubulin. **Tubulin** (α and β) molecules are arranged to form 13 protofilaments.	Form the **centrosome**, **flagella**, **cilia**, **base** of the **cilia** and **mitotic spindle**.
Cilia	are motile processes, covered by cell membrane, with a highly organized microtubule core, each about 2–3 μm in length. consists of an **outer covering part** (extension of the cell membrane), an **inner core** (microtubules arranged in a definite manner) and **base** (basal body, which has structure like centriole). Inner core of cilia consists of central pair of tubules which is surrounded by nine pairs of tubules.	Movement of fluid, mucous, or small solid objects. Sensory function (olfactory cilia, kinocilia).
Flagella	are motile processes, covered by cell membrane, with a highly organized microtubule core and with a length close to 100 μm.	Motility
Centrosome	is the **microtubule-organizing center** for the mitotic spindle and consists of **paired centrioles**. The two centrioles in a centrosome exist at right angles to one another in a dense matrix of free tubulin subunits and other proteins. Each centriole consists of **nine microtubular triplets**.	At the onset of mitosis, the two daughter centrosomes move to opposite sides of the nucleus and become the two poles of the mitotic spindle of microtubules attaching to chromosomes.
Microfilaments	These organelles are the protein filaments the major proteins of which are **actin, troponin, tropomyosin**. In the cytoplasm they can be single, can form bundle or network. The filaments are flexible structures, with diameters invarious cells of **5-9 nm.**	These filaments are involved in all cell shape changes such as those during endocytosis, exocytosis, and cell locomotion. Microfilaments are intimately associated with several cytoplasmic

		organelles, vesicles, and granules and play a role in moving or shifting cytoplasmic components. Microfilaments are associated with myosin and form a "purse-string" ring of filaments whose constriction results in the cleavage of mitotic cells. In crawling cells actin filaments are organized into parallel contractile bundles called stress fibers.
Intermediate filaments	Intermediate filaments have an average diameter of 10-12 nm, between that of actin filaments and microtubules.	Serve to provide mechanical strength or stability to cells. Unlike the other two cytoskeletal polymers, intermediate filaments are composed of various protein subunits in different types of cells.

Intermediate Filaments

Types of intermediate filaments found in eukaryotic cells.

Filament Type	Cell	Examples
Cytokeratins	Epithelium	Both keratinizing and nonkeratinizing epithelia
Vimentin	Mesenchymal fibroblasts, cells chondroblasts, macrophages, endothelial cells	Vascular smooth muscle
Desmin	Muscle cells	Striated and smooth muscle (except vascular smooth muscle)

Glial fibrillary acidic proteins	Glial cells	Astrocytes
Neurofilaments	Neurons	Nerve cell body and processes

(1,2,3,4)

Nucleus		
Structure		**Functions**
Chromatin	deoxyribonucleic acid (**DNA**) histones – proteins There are two types of chromatin: **1) heterochromatin (condensering) –** inactive; **2) euchromatin (decondensering) –** active. During cell division the entire chromatin within the nucleus becomes very tightly coiled and takes on the appearance of a number of short, thick, rodlike structures called chromosomes.	genetic information
Nucleolus	It is a non-membrane intranuclear subcompartment. Nucleoli are made of **proteins**, **DNA** and **RNA** and form around specific chromosomal regions called nucleolar organizing regions. **Nucleolus** consists of **three parts**: 1) granular component (ribosome subunits), 2) fibrillar component (ribosomal RNA), 3) amorphous component (RNA genes (rRNA), proteins).	synthesis of ribosomal RNA formation of ribosomal subunits synthesis of nuclear proteins (histones)
Nucleoplasm	The spaces between the various constituents of the nucleus	Supports internal environment of the nucleus

	described above are filled by a base. The nucleoplasm includes 1) chromosomes 2) nucleolus 3) nucleotides (necessary for purposes such as DNA replication) 4) enzymes (which direct activities that take place in the nucleus). 5) nucleosol (the soluble, liquid portion of the nucleoplasm).	Provides implementation of all biochemical processes
Nuclear envelope	is a double membrane composed of an **outer** and an **inner phospholipid bilayer**. The thin space between the two layers connects with the lumen of the **rough endoplasmic reticulum (RER)**, and the outer layer is an extension of the outer face of the RER. The inner surface of the nuclear envelope has a protein lining called the **nuclear lamina**, which binds to chromatin and other contents of the nucleus. The entire envelope is perforated by numerous **nuclear pores**. Each **pore** is surrounded by an elaborate protein structure called the nuclear pore complex, which selects molecules for entrance into the nucleus.	Nuclear pores are fully permeable to small molecules up to the size of the smallest proteins, but they form a selective barrier against movement of larger molecules. Entering the nucleus through the pores are the nucleotide building blocks of **DNA** and **RNA**, as well as adenosine triphosphate, which provides the energy for synthesizing genetic material. **Histones** and other **large proteins** must also pass through the pores. These molecules have special amino acid sequences on their surface that signal admittance by the nuclear pore complexes. The complexes also regulate the export from the nucleus of RNA and subunits of ribosomes.

Cell cycle		
Phases of cell cycle	**Periods and phases of interphase and mitosis**	**Description**
Interphase	G1 (post-mitotic phase or pre-synthetic)	Rapid cell growth and metabolic activity RNA and protein synthesis
	S (synthetic phase)	DNA synthesis DNA is doubled RNA and protein are also synthesized
	G2 (post-synthetic or pre-mitotic)	RNA and protein synthesis continue Centrioles replicate Formation of a mitotic spindle
Mitosis	Prophase	Replicated chromatin condenses into discrete rod-shaped bodies, the chromosomes, each consisting of duplicate sister **chromatids** closely associated longitudinally. Nucleoli of the nucleus and the nuclear membrane disappear.
	Metaphase	The condensed chromosomes attach to microtubules of the mitotic spindle at large electron-dense protein complexes called **kinetochores**, which are located at a constricted region of each chromatid called the **centromere**. The chromosomes are moved to the equatorial part of cell. **Kinetochore** microtubules bound to sister chromatids are continuous with centrosomes at opposite poles of the mitotic spindle.
	Anaphase	Sister chromatids separate from each other and are slowly pulled at their kinetochores toward opposite spindle poles by kinesin motors moving along the microtubules. During spindle poles also move farther apart.
	Telophase	Two sets of chromosomes are at the spindle poles and begin reverting to

		their decondensed state. Microtubules of the spindle depolymerize and the nuclear envelope reassembles. A belt-like contractile ring, containing actin filaments associated with myosins, develops in the peripheral cytoplasm at the equator of the parent cell. During the end of telophase, constriction of this ring produces a cleavage furrow and progresses until the cytoplasm and its organelles are divided in two daughter cells, each with one nucleus.

(5)

Amitosis	
Amitosis is called also direct cell division	**Description**
	Cell division by **simple cleavage** of the nucleus and division of the cytoplasm without spindle formation or appearance of chromosomes.
	Has two stages like karyokinesis and cytokinesis.
	Amitosis also results in the formation of two identical cells

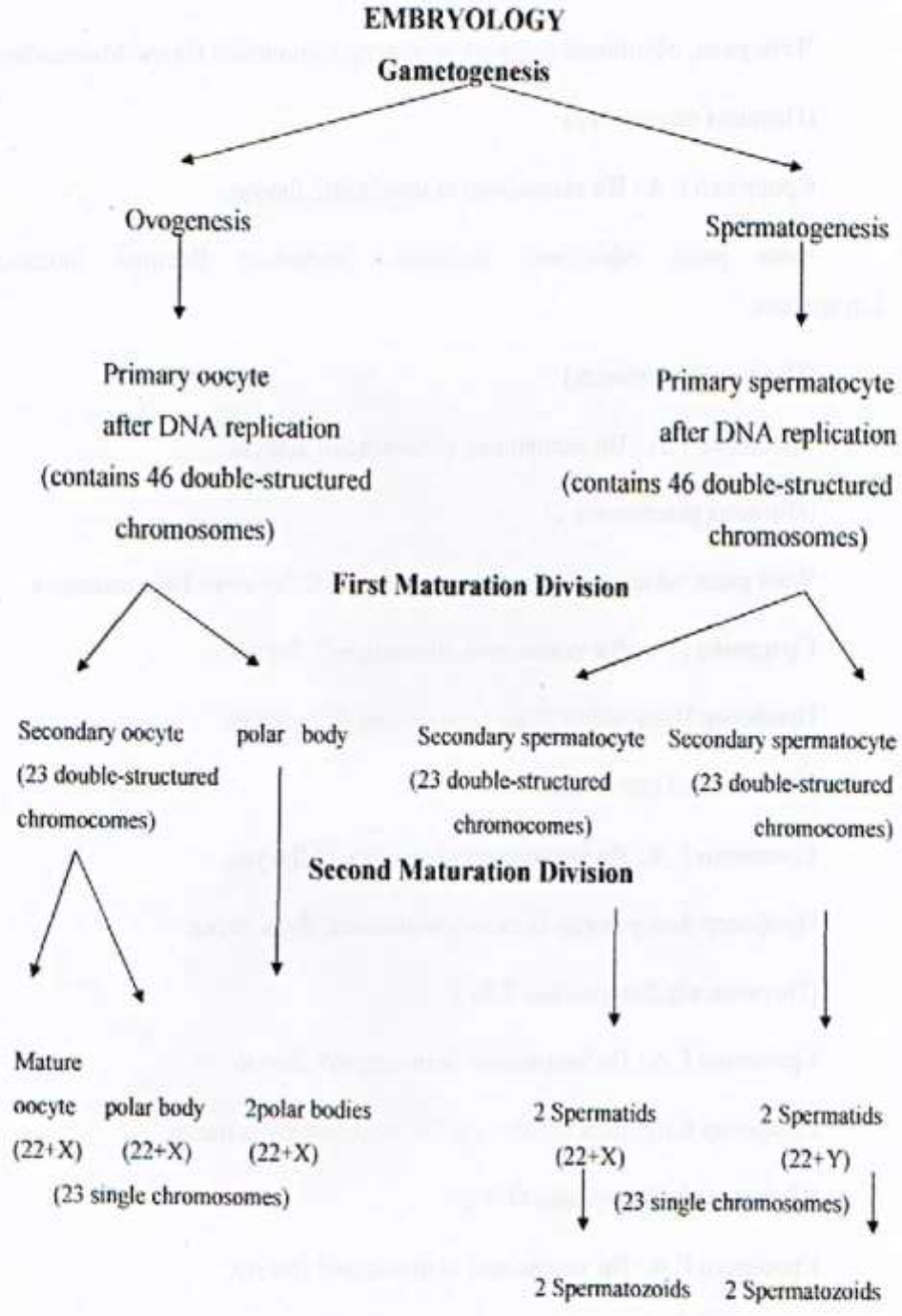
Differences between meiosis and mitosis (6)

	Mitosis	**Meiosis**
Definition	A process of asexual reproduction in which the cell divides into two, producing a replica with an equal number of chromosomes in each resulting diploid cell.	A type of cellular reproduction in which the number of chromosomes are reduced by half producing two haploid cells.
Occurs in	All organisms	Reproductive cells of humans, animals, plants and fungi.
Type of reproduction	Asexual	Sexual

Genetically	Produces identical organisms or cells	Different cells or organisms
Grossing over	No, crossing over cannot occur	Yes, mixing of chromo somes can occur
Pairing of Homologous chromosomes	No	Yes
Number of divisions	1	2
Number of daughter cells produced	2 Diploid cells	4 Haploid cells

Differences between mitosis and amitosis (7)

Mitosis	Amitosis
Mitosis is the usual process of cell division which involves splitting of parental cell into two daughter cells.	Amitosis is an unusual cell division which involves division of cytoplasm and nucleus by the appearance of a furrow which deepens to divide the cell into two individual cells.
Mitosis has different stage like prophase, metaphase, anaphase and telophase. Telophase is followed by cytokinesis.	Amitosis has two stage like karyokinesis and cytokinesis.
Mitosis involves formation of chromosomes and spindle fibres	Amitosis does not involve the formation of chromosomes and spindle fibres
Mitosis results in the offspring identical to the parent cell	Amitosis also results in the formation of two identical cells.
Mitosis occurs in the multicellular organisms	Amitosis is seen in some of the unicellular organisms
Mitosis take place mainly in plants and animals	Mitosis take place in fungi, amoeba, some bacteria



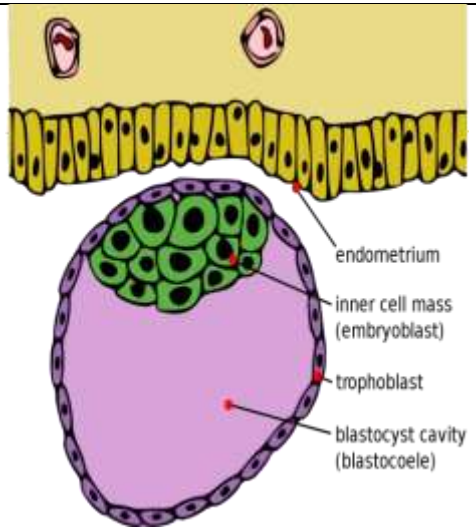
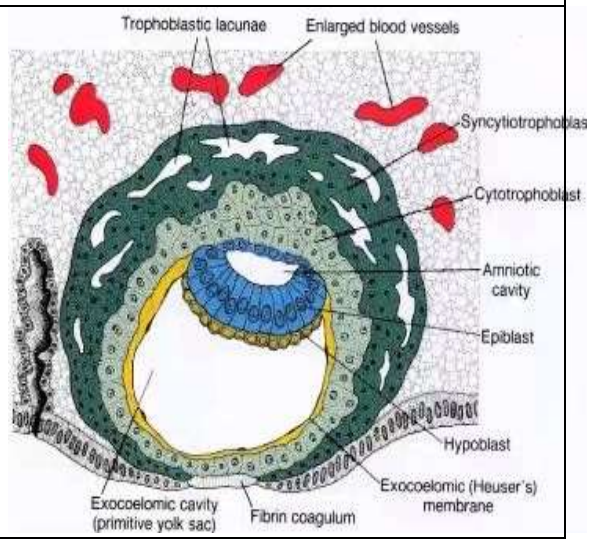
Sadler, T. (Thomas W.) Langman's medical embryology.12th ed. Baltimore, Philadelphia;2012. 384 p.

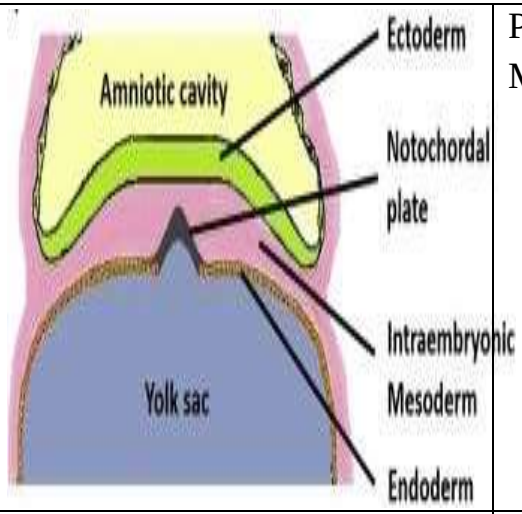
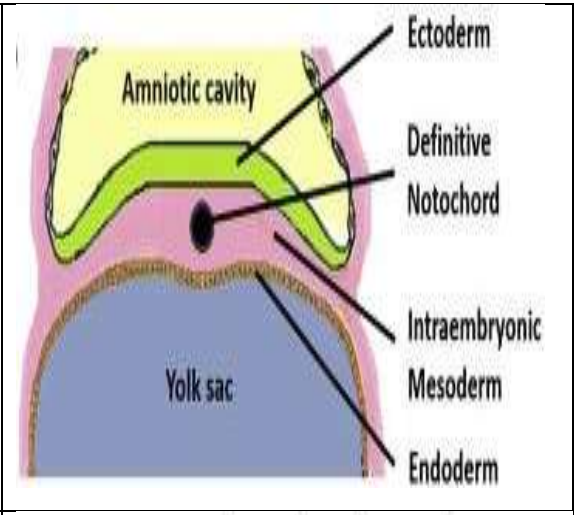
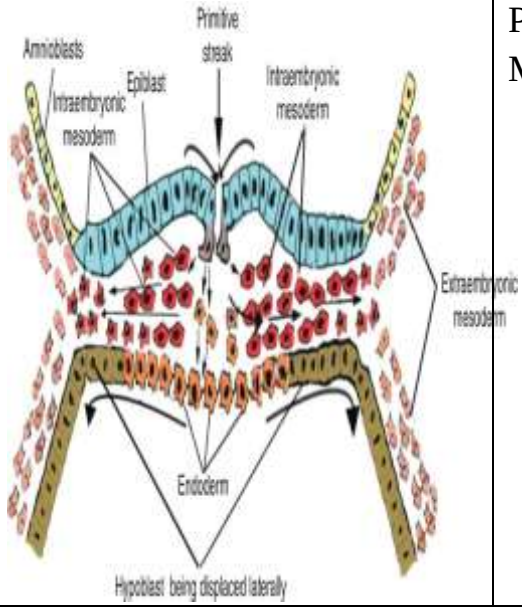
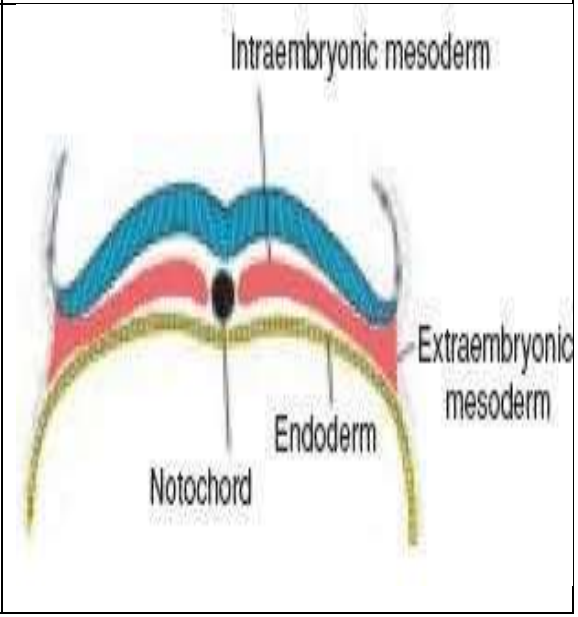
Summary of Key Events During the Embryonic Period

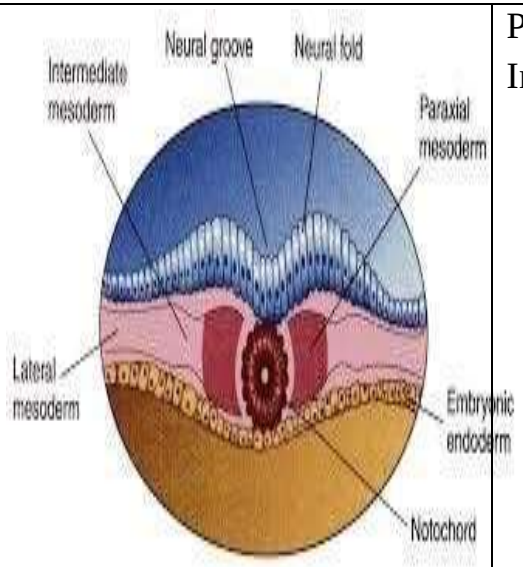
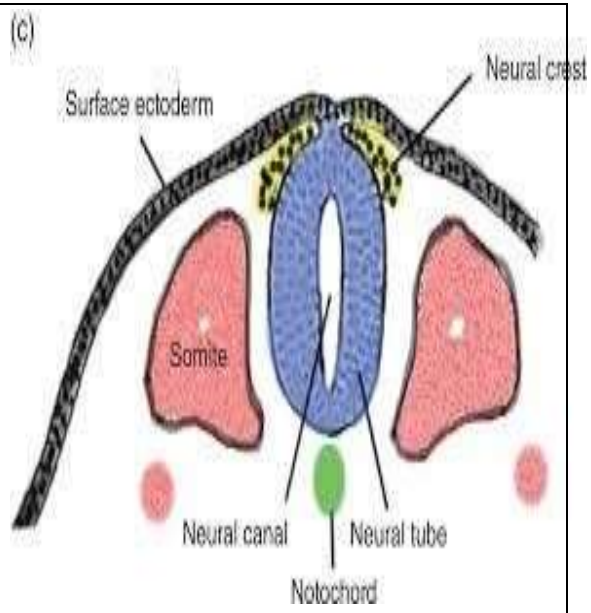
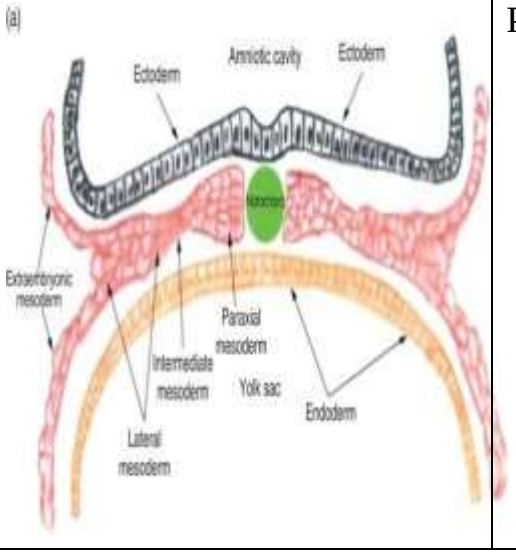
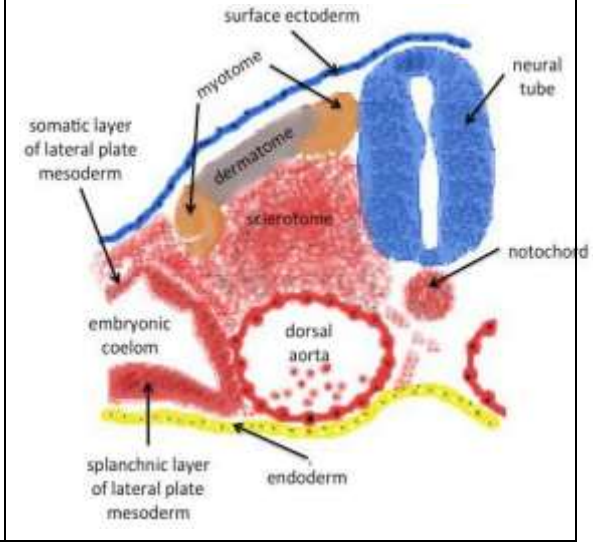
Days	Somites	Length (mm)	Characteristic Features
14-15	0	0,2	Appearance of primitive streak
16-18	0	0,4	Notochordal process appears; hemopoietic cells in yolk sac
19-20	0	1,0-2,0	Intraembryonic mesoderm spread under cranial ectoderm; primitive streak continues; umbilical vessels and cranial neural folds beginning to form
20-21	1-4	2,0-3,0	Cranial neural folds elevated and deep neural groove established; embryo beginning to bend
22-23	5-12	3,0-3,5	Fusion of neural folds begins in cervical region; cranial and caudal neuropores open widely; visceral arches 1 and 2 present; heart tube beginning to fold
24-25	13-20	3,0-4,5	Cephalocaudal folding under way; cranial neuropore closing or closed; optic vesicles formed; otic placodes appear
26-27	21-29	3,5-5,0	Caudal neuropore closing or closed; upper limb buds appear; three pairs of visceral arches
28-30	30-35	4,0-6,0	Fourth visceral arch formed; hind limb buds appear; otic vesicle and lens placode
31-35		7,0-10,0	Forelimbs paddle-shaped; nasal pits formed; embryo tightly C-shaped
36-42		9,0-14,0	Digital rays in hand and foot plates; brain vesicles prominent; external auricle forming from auricular hillocks; umbilical herniation initiated
43-49		13,0-22,0	Pigmentation of retina visible; digital rays separating; nipples and eyelids formed; maxillary swellings fuse with medial nasal swellings as upper lip forms; prominent umbilical herniation
50-56		21,0-31,0	Limbs long, bent at elbows, knees; fingers, toes free; face more human-like; tail disappears; umbilical herniation persists to end of third mont

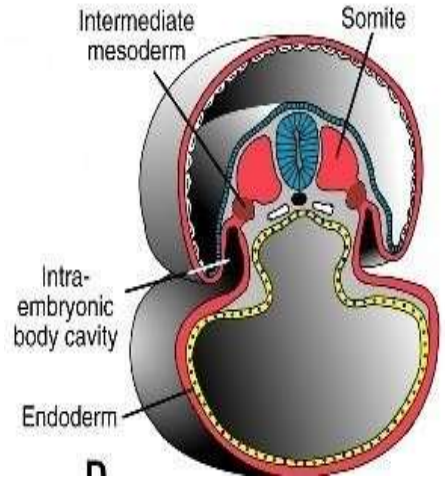
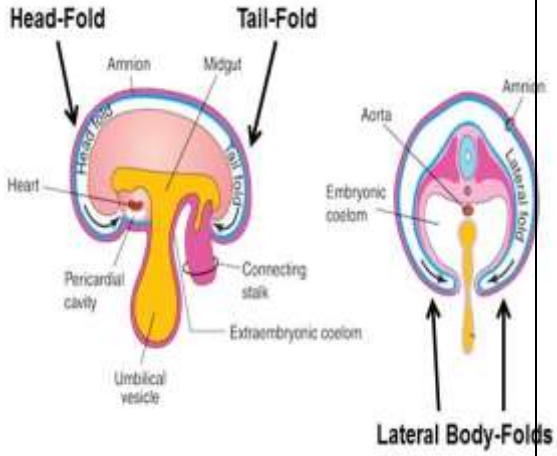
Sadler, T. (Thomas W.) Langman’s medical embryology.12th ed. Baltimore, Philadelphia;2012. 384 p.

Early stages of formation human's embryo. Gastrulation.

Stage and term	At the beginning of the stage	Mechanism of formation	Formation process	At the end of the stage
Formation of the two germ layers 5-7 day		Delamination	Formation of the **two germ layers (epiblast - ectoderm and hypoblast - endoderm)**	

Formation of the notochord 7-14 day		Proliferation Migration	Formation of the **notochord**	
Formation of the three germ layers 14-21 day		Proliferation Migration	Formation of the **three germ layers (ectoderm, mesoderm, endoderm**	

Neurulation 21-25 day		Proliferation Invagination	Formation of the **neural folds-neural groove-neural tube**	
Organization of the mesoderm 25-28 day		Proliferation	Formation of the **somites, intermediate mesoderm, lateral plate mesoderm**	

Formation of a trunk fold from 28 day		Proliferation	Formation of the **trunk fold and growth of the ends of the embryo**	

TISSUES

Kind of tissue		Cells	Intercellular substance	
			Fibers	***Amorphous substance***
Epithelial tissue (Epithelium)		Epithelial cells	–	–
Connective tissue	Loose	Fibroblasts	Collagen, elastane, disorderly	Water, ions, proteins
	Dense regular	Fibroblasts	Collagen, orderly	Water, ions, proteins
	Dense irregular	Fibroblasts	Collagen, disorderly	Water, ions, proteins
	Reticular	Reticulocytes	Reticular	Water, ions, proteins
	Adipose	Adipocytes	Loose connective tissue	
	Mucous	Mucocytes	Loose connective tissue	
	Pigmental	Melanocytes	Loose connective tissue	
Cartilage	Hyaline cartilage	Chondrocytes	Collagen, disorderly	Glycosaminoglycans (GAGs), proteoglycans
	Elastic cartilage	Chondrocytes	Elastane, collagen	
	Fibrocartilage	Chondrocytes	Collagen, orderly	
Bone	Lamellar	Osteocytes	Collagen, orderly	Hydroxyapatite, calcium phosphate
	Reticulofibrous (woven bone)	Osteocytes	Collagen, disorderly	
Blood		Erythrocytes		Water, ions, proteins
		Leukocytes		
		Platelets (thrombocytes)		
Muscle tissue	Skeletal muscle	Muscle fiber (myosimplast)	Loose connective tissue	
	Cardiac muscle	Cardiomyocyte	Loose connective tissue	
	Smooth muscle	Myocyte	Loose connective tissue	

Nervous tissue	Neurocyte (neuron)	Neuroglia

EPITHELIAL TISSUE (EPITHELIUM)

Features (signs)	does not contain blood vessels			
	does not contain an intercellular substance			
	there is a basement membrane			
	high regenerative capacity			
	asymmetry	Apical and basal part		
	intercellular junctions	All kinds		
	diffused nutrition from the connective tissue			
Classifications	Ontofilogenetic	Epidermal		
		Enterodermal		
		Nephrodermal		
		Ependymaglial		
		Angiodermal		
	Morphological	Simple	Single-row	Squamous
				Cuboidal
				Columnar
			Multi-row	
		Stratified	Keratinized	

			Nonkeratinized	
			Transitional	
	Functional	Covering		
		Glandular		

COVERING EPITHELIAL TISSUE

Simple epithelium	Single-row	Squamous		Mesothelium, endothelium
		Cuboidal		Epithelium of the tubules in the kidney
		Columnar		Epithelium of the intestines
	Multi-row	Ciliated pseudostratified columnar	Basal cells	Epithelium of the respiratory system
			Ciliated columnar cells	
			Goblet cells	
Stratified epithelium	Nonkeratinized squamous	Basal layer		Epithelium of oral cavity Corneal epithelium
		Intermediate layer		
		Surface layer		
	Keratinized squamous	Basal layer		Epithelium of skin
		Stratum spinosum		
		Stratum granulosum		
		Stratum lucidum		
		Stratum corneum		
	Transitional	Basal layer		Epithelium of the urinary tract
		Intermediate layer		
		Surface layer		

GLANDS

Depending on the ducts 1	Endocrine	Follicular glands	Thyroid gland
		Trabecular glands	Adrenal gland
	Exocrine	Single-layer	Liver, pancreas
		Two-layer (layer of myoepitheliocytes)	Salivary glands, mammary glands
Depending on the ducts 2	Branched		
	Unbranched		
Depending on the ducts 3	Simple		
	Compound		
Depending on the secretory portions 4	Tubular		
	Acinar		
	Tubuloacinar		
Depending on the secretory portions 5	Serous		Parotid gland
	Mucous		
	Mixed	Serous demilune	Sublingual gland
Depending on the type of secretion	Apocrine		
	Merocrine		
	Holocrine		
Gland	Secretory portion of the exocrine gland	Mucous cell	
		Serous cell	
		Myoepithelial cell	
		Apudocyte	
	Secretory portion of the	Glandulocyte	

	endocrine gland	Apudocyte	
	Duct system	Intercalated	
		Striated	
		Intralobular	
		Interlobular	
		Main duct	

CONNECTIVE TISSUE

<table>
<tr><td>Features</td><td colspan="4">the most common tissue in the body (to 50% of body weight)
high content of intercellular substance
the main functional load falls on the intercellular substance
is the place for realization of reactions of immunity and inflammation
replaces defects after damage to organs and tissues</td></tr>
<tr><td rowspan="5">Component parts</td><td>Cells</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Intercellular substance</td><td rowspan="3">Fibers</td><td>collagen</td><td rowspan="4"></td></tr>
<tr><td>elastic</td></tr>
<tr><td>reticular</td></tr>
<tr><td>Amorphous ground substance</td><td>proteins, ions</td></tr>
<tr><td rowspan="7">Classification</td><td rowspan="3">Fibrous</td><td colspan="2">Loose</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Dense</td><td>Regular</td></tr>
<tr><td>Irregular</td></tr>
<tr><td rowspan="4">With special properties</td><td colspan="2">Reticular</td><td></td></tr>
<tr><td colspan="2">Adipose</td><td></td></tr>
<tr><td colspan="2">Pigmented</td><td></td></tr>
<tr><td colspan="2">Mucus</td><td></td></tr>
<tr><td rowspan="4">Connective tissue proper</td><td rowspan="4">Loose</td><td rowspan="4">Cells</td><td rowspan="3">Actually connective tissue cells</td><td>fibroblasts</td></tr>
<tr><td>fibrocytes</td></tr>
<tr><td>myofibroblasts</td></tr>
<tr><td>Migrating cells</td><td>lymphocytes</td></tr>
</table>

				macrophages
				plasmacytes
				leukocytes
				mast cells
			Cells of the vascular wall	endothelial cells
				adventitial cells
				pericyte
		Fibers	Collagen fibers **12 types:** 1. **I type -** in the skin, bones, cornea of the eye, in the sclera, in the wall of the arteries, etc. 2. **II type -** hyaline and fibrous cartilage, vitreous body, cornea. 3. **III type -** derma of the fetal skin, walls of large blood vessels, reticular fibers of the hematopoietic organs. 4. **IV type -** basal membra-nes, capsule of the lens. 5. **V type -** soft tissues,	Organization levels 1. molecular (cellular) **procolagen** **2.** supramolecular (extracellular) **protofibrils, microfibrils** 3. fibrillar level 4. fiber level

			placenta, vessels, chorion. 6. **VI type -** microfibrils in soft tissues and cartilage. 7. **VII type -** anchorant fibrils in the skin and epidermis. 8. **VIII type -** cornea, endothelium. 9. **IX type -** cartilage, vitreous body. 10. **X type -** hypertrophic zone of growth area. 11. **XI type -** cartilage, vitreous body. 12. **XII type -** soft tissues	
			Reticular	collagen type III, increased number of carbohydrates
			Elastic	Organization levels 1. molecular level – elastin

				2. supramolecular level – **protofibrils** 3. fibrillar level – microfibrils (glycoproteins are joined) 4. fiber level – fibers (90 % of elastin and 10 % of amorphous component).
		Amorphous ground substance	Gel-like hydrophilic substance	proteoglycans, lipids, albumins, globulins, minerals
	Dense regular (collagen fibers are well-ordered, located in accordance with the functional load on the organ) - ligaments, tendons, fascia, aponeuroses	Cells	Fibroblasts, fibrocytes	synthesis and support of metabolism of fibrous intercellular substance
		Fibers	Collagen fibers form bundles	1. I order - collagen fibers between layers of fibrocytes. 2. II order - a few fibers of I order are separated by a layer of loose connective tissue (endotendon). 3. III order - a few fibers of II order are separated by a

				peritendon.
			Elastic	out loop - the bundles are not clearly separated
	Dense irregular (the fibers are disordered) – reticule layer of the dermis	Cells	Fibroblasts, fibrocytes, melanocytes	contain melanin, but do not synthesize it
		Fibers	Collagen, elastic	wide- or narrow-mesh netting (depending on the load on the area)
Connective tissue with special properties	Reticular tissue	Cells	Reticulocytes	form a thin stroma of organs
		Intercellular substance	Argyrophilic	resistant to the action of weak alkalis and acids, contain anastomoses
	Adipose tissue	Cells	Adipocytes	accumulate fat.
		Intercellular substance	Loose connective tissue	provides the metabolism of fat cells
	Mucus tissue	Cells	Mucocytes	cells of the type of fibroblasts
		Intercellular	Collagen fibers and	provide a high-elastic cord

		substance	hyaluronic acid	and gel-like properties
	Pigmented tissue	Cells	Melanocytes	paint the skin
		Intercellular substance	Loose connective tissue	provides metabolism

CARTILAGE TISSUES

Properties	No blood supply Flexible and resistant to compressive forces Cells close together in groups, forming a 'nest' of 2-4 cells - isogenous groups Cambial elements are contained in the perichondrium Interstitial growth Appositional growth			
Components	Cells	chondroblasts	Young cells, capable of division, secrete extracellular matrix and fibers	
		chondrocytes	Mature cells, secrete extracellular matrix, make isogenous groups	
	Fibers	Collagen II type	Orderly arranged in a fibrocartilage Disordery – in hyaline	
		Elastic	Determine the elasticity of the cartilage of the auricle and nose	
	Amorphous ground substance	Hyaluronic acid Chondroitin sulfate Keratan sulfate	Give tissue elasticity due to a high degree of hydration	
Classification	Hyaline	The wall of the trachea, bronchi, joints of the ribs with the sternum, articular surfaces		
	Elastic	Auricle, auditory tube, nasal wings, cartilage of the larynx. Never calcified		
	Fibrocartilage	Intervertebral discs, tendon insertions		
Types of cartilage	Hyaline	Perichondrium	Outer fibrous layer	Provides nutrients to

				cartilage, secretes synovial fluid
			Inner chondrogenic layer	Physiological regeneration and growth by apposition type
		Cartilage proper	Chondrocytes	Single and isogenous groups
			Extracellular matrix	Collagen fibers, Chondromucoid
	Elastic	Perichondrium	Outer fibrous layer	Provides nutrients to cartilage
			Inner chondrogenic layer	Physiological regeneration and growth by apposition type
		Cartilage proper	Chondrocytes	Single and isogenous groups
			Extracellular matrix	Elastic fibers, Chondromucoid
	Fibrocartilage		Chondrocytes	Forms columns of cell
			Extracellular matrix	Collagen fibers parallel, thick bundles, Chondromucoid
Development of	1. Formation of a chondrogenic islet		Mesenchymal cells lose processes, begin active	

cartilage tissue		division and form a chondrogenic islet
	2. Differentiation of chondrocytes	Rebuilding metabolism for fiber synthesis
	3. Synthesis of extracellular matrix	Secretion of the fibrous component of cartilage
	4. Maturation of extracellular matrix	Impregnation of the intercellular substance by proteoglycan
	5. Formation of perichondrium	The formation of fibrous connective tissue around the cartilage (hyaline or elastic) from two layers - fibrous and cellular
Regeneration	Physiological	Formation of young cartilage by interstitial (internal) and appositional (from the perichondrium) growth
	Reparative	Due to the perichondrium (appositional growth)

BONE TISSUES

<table>
<tr><td>Properties</td><td colspan="4">High strength
Up to 70% of inorganic substances
Structural and functional units - osteons
Well-developed network of blood vessels</td></tr>
<tr><td rowspan="5">Components</td><td rowspan="3">Cells</td><td>Osteoblasts</td><td>Cambial cells</td><td>Periosteum, areas of regeneration</td></tr>
<tr><td>Osteocytes</td><td>Differentiated cells with processes</td><td>The main substance of bone</td></tr>
<tr><td>Osteoclasts</td><td>Multinucleated cells of macrophage origin (monocytes)</td><td>Bone resorption areas</td></tr>
<tr><td rowspan="2">Collagen fibers</td><td>Ordered</td><td>Concentrically around the capillaries</td><td>Lamellar bone</td></tr>
<tr><td>Disordered</td><td>In no particular order</td><td>Woven bone</td></tr>
<tr><td>Ground substance</td><td colspan="3">Organic and inorganic (up to 70%) compounds</td></tr>
<tr><td rowspan="3">Classification</td><td rowspan="2">Lamellar</td><td colspan="2">Compact</td><td>Tubular bones of the skeleton</td></tr>
<tr><td colspan="2">Spongy (Cancellous)</td><td>Ends of the long bones (the epiphyses), flat bones</td></tr>
<tr><td>Woven</td><td colspan="2"></td><td>In the embryonic period, the bones of the skull, in the postnatal period - the sutures of the skull, calluses</td></tr>
<tr><td rowspan="2">Types of bone tissues</td><td rowspan="2">Lamellar</td><td rowspan="2">Cells</td><td>Osteoblasts</td><td>Located around the blood vessels</td></tr>
<tr><td>Osteocytes</td><td>Located between the lamellae, within small cavities (lacunae)</td></tr>
</table>

			Osteoclasts	Located in areas of bone resorption
		Collagen fibers	Ordered	
	Woven	Cells	Osteoblasts	On the surface of the bone trabecula
			Osteocytes	In the thickness of the bone trabecula
			Osteoclasts	Located in areas of bone resorption
		Collagen fibers	Disordered	
Bone as an organ	Periosteum	Outer fibrous layer	Dense connective tissues	
		Inner layer	More cellular layer that contains the osteoprogenitor cells.	
	Compact bone	Outer circumferential lamellae	Located immediately beneath the periosteum	
		Osteons or Haversian systems	Consist of concentric lamellae of bone matrix surrounding a central canal, the osteonal (Haversian) canal, which contains the vascular and nerve supply of the osteon	
		Interstitial lamellae	Between the osteons are remnants of previous concentric lamellae	
		Inner circumferential lamellae	Located around the marrow cavity	
	Endosteum	Lining tissue of the compact bone facing the marrow cavity and the trabeculae of spongy bone Only one cell layer thick and consists of osteoprogenitor cells		
	Spongy bone	The tissue is arranged as trabeculae or spicules. Numerous interconnecting marrow spaces of various sizes are present among the bone tissue		

Development	Intramembranous ossification	Formation of osteogenic islets	An ossification center appears in the mesenchymal connective tissue. It consists of aggregated mesenchymal-derived osteoprogenitor cells that further differentiate into the osteoblasts.
		Formation of osteoid	Osteoblasts synthesize collagen fibers and non-mineralized amorphous matrix
		Osteoid mineralization	Mineralization of the amorphous matrix and collagen fibers. Transformation of osteoblasts into osteocytes. Formation of woven bone tissue.
		Formation of lamellar bone	Remodeling of the bone results in replacement of woven bone by the inner and outer layers of compact bone with spongy bone between them.
	Endochondral ossification	Cartilage model formation	Hyaline cartilage model with the general shape of the bone is formed
		Perichondral ossification of the diaphysis	The first sign of ossification is the appearance of a cuff of bone around the cartilage model

		Endochondral ossification of the diaphysis (primary ossification center)	Dystrophy and subsequent mineralization of cartilage tissue inside the diaphysis under the "bone cuff": Osteoclasts → resorption channels and in them the phases of osteohistogenesis → bone trabeculae → cancellous bone → the medullary part of the diaphysis is resorbed by osteoclasts in the longitudinal direction → a bone canal is formed → filled with bone marrow
		Endochondral ossification of the epiphyses (secondary ossification centers)	Dystrophy and subsequent mineralization of cartilage tissue inside the epiphyses. Osteoclasts → resorption channels and in them the phases of osteohistogenesis → bone trabeculae → cancellous bone → spread of bone formation to the periphery of epiphyses

		Formation of epiphyseal growth plate		The primary and secondary ossification centers are separated by the epiphyseal plate. Zone of epiphyseal growth plate: - zone of reserve cartilage - zone of proliferation - zone of hypertrophy - zone of calcified cartilage - zone of resorption
		Formation of long bone		The two ossification centers do not merge until the epiphyseal plate disappears when full stature is achieved
Regeneration	Physiological	Throughout life		
	Reparative	At the place of injury	Primary	With surgical matching of fragments (up to 0.5 years)
			Secondary	Through formation: cartilage tissue → woven bone → lamellar bone(1.5 years, in the elderly - up to 6 years)

MUSCLE TISSUE

<table>
<tr><td>Features</td><td colspan="4">Contraction (fast, tonic)
Peristalsis (smooth muscles)
The presence of special organelles - myofibrils (actin, myosin)</td></tr>
<tr><td rowspan="4">Components</td><td rowspan="3">Myocytes</td><td colspan="3">Smooth</td></tr>
<tr><td colspan="3">Cardiac</td></tr>
<tr><td colspan="2">Skeletal myosimplast</td><td>Myosatellitocytes</td></tr>
<tr><td colspan="4">Loose fibrous connective tissue, vessels, nerves</td></tr>
<tr><td rowspan="4">Classification (morphofunctional)</td><td rowspan="2">Striated</td><td>Skeletal</td><td colspan="2">Develops from myotomes</td></tr>
<tr><td>Cardiac</td><td colspan="2">Develops from the visceral part of the splanchnic mesoderm (splanchnopleura) (myocardial plate)</td></tr>
<tr><td>Smooth</td><td colspan="3">Develops from the mesenchyme, ectoderm, neuroectoderm</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="5">Classification (histogenetic)</td><td>Somatic type</td><td>From myotomes of somites of mesoderm</td><td colspan="2">Skeletal muscle tissue</td></tr>
<tr><td>Coelomic type</td><td>From cardiogenic area of splanchnopleura</td><td colspan="2">Cardiac muscle tissue</td></tr>
<tr><td>Mesenchymal type</td><td>From a mesenchyme</td><td colspan="2">Smooth muscle tissues of internal organs and vessels</td></tr>
<tr><td rowspan="2">Ectodermic type</td><td rowspan="2">From ectoderm</td><td colspan="2">Myoepithelial cells</td></tr>
<tr><td colspan="2">Muscles of iris (sphincter and dilator of pupillae)</td></tr>
</table>

Types of muscle tissues	Skeletal Muscle	Muscle fiber (myosymplast)	Long, cylindrical, striated fibers; arranged parallel and unbranched; many nuclei(multinucleate) just under plasma membrane	Voluntary movement of bones and joints, maintenance posture
		Myosatellitocytes	Myogenic stem cells residing between the myofiber plasmalemma and basal lamina, has a single nucleus with a chromatin network denser and coarser than that of muscle cell nuclei.	Regeneration
	Cardiac muscle	Cardiac myocytes	Short, striated, typically branched cells; only centrally located nucleus often surrounded by a white zone; intercalated discs between cells	Involuntary contractions pumping blood through heart and body

		Contractile	Basic part of a myocardium and are characterized by highly developed contractile system	Contraction
		Conductive	Weak development contractile system, a light sarcoplasm and large nucleus	Have ability to generation and conduction of electrical impulses through a conducting system of heart
		Secretory (endocrine)	Weak development of contractile system, contains granules with hormone (atrial natriuretic factor)	Acts on kidneys to cause sodium and water loss and decreases blood pressure
	Smooth muscle	Myocytes	Non-striated, short, overlapping, fusiform cells; one centrally located nucleus	Involuntary contractions that moves and propels materials through internal organs; labor contractions; blood pressure control; airflow control

Functional systems:	Skeletal muscle fibers	Cardiac muscle cell	Smooth muscle cell
contractile	Skeletal muscle fibers →myofibrils→myofilaments (actin and myosin). The smallest subunit is sarcomere (portion of a myofibril between two Z lines)	Contains contractile proteins with cross striations similar to that of skeletal muscle	Thin actin and thick myosin filaments which not form myofibrils
conducting system for contractile stimuli	-Transverse (T) tubules -Sarcoplasmic reticulum (forms flattened cisterns (terminal cisterns)). Each pair of terminal cisterns and a T-tubule form a triad near the junction of the I- and A-bands of each sarcomere.	-Transverse (T) tubules -Sarcoplasmic reticulum does not form terminal cisterns. Form diads composed of one T-tubule and one cytoplasmic cistern, which are found in range Z- lines.	Caveolae – numerous invaginations of plasmolemma (contain high concentrations of calcium, contact to elements of sarcoplasmic reticulum). T-tubules are absent.
supporting	-Special elements of cytoskeleton, providing locating of myofibrils inside a fiber -Basement membrane and sarcolemma connected to them	-Special elements of cytoskeleton, providing locating of myofibrils inside a fiber -Basement membrane and sarcolemma connected to them	-Sarcolemma and basement membrane, -System of elements of cytoskeleton -Dense bodies (oval structures laying along the lengthy axis of smooth cell in its sarcoplasm or connected with inner surface of a sarcolemma).

system of energy production	-Mitochondria -Trophic inclusions (glycogen)	-Mitochondria -Trophic inclusions (triglycerides, glycogen)	-Mitochondria -Trophic inclusions (glycogen, lipids)
Regeneration	Skeletal muscle tissue	Has regenerative capacity. The source of regenerating cells is the satellite cells.	
	Cardiac muscle tissue	No regenerative capacity, only at the intracellular level	
	Smooth muscle tissue	Has regenerative capacity. Mononucleated smooth muscle cells and pericytes from blood vessels undergo mitosis and provide for the replacement of the damaged tissue	

NERVOUS TISSUE

Features	Monitors and regulates the functions of the body Form the communication network of the nervous system by conducting electric signals across tissue		
Components	Nervous	Highly specialized nerve cells that generate and conduct nerve impulses	
	Neuroglia	Astrocytes -protoplasmic -fibrous	Provide nutrients to neurons, maintain ion balance, I take part in the formation of the blood-brain barrier
		Oligodendrocytes	Active in the formation and maintenance of myelin in the central nervous system
		Schwann cells	Form the myelin sheath in peripheral nervous system
		Ependymal cells	line the ventricles of the brain and the central canal of the spinal cord
		Microglia	Have phagocytotic properties
Classification of neurons (morphological)	Multipolar	Have one axon and two or more dendrites	More than 99% of the neurons in humans
	Bipolar	Have one axon and one dendrite	these are found in the retina of the eye and the olfactory system
	Pseudounipolar	Have one process, the axon that divides close to the cell body into two long axonal branches	Dorsal root ganglia
Classification of neurons	Sensory neurons (afferent neurons)	Transmit information from sensory receptors	Almost all sensory neurons are psedounipolar.

(functional)		in the skin, or the internal organs toward the central nervous system for processing.		
	Motor neurons (efferent neurons)	Transmit information away from the the central nervous system toward some type of effector.	Typically multipolar	
	Interneurons	Located between motor and sensory pathways		
Nerve fibers	Myelinated	-Nerve axon -Myelin sheath (neurilemma, sheath of Schwann, oligodendrocytes) with nodes of Ranvier and Schmidt-Lanterman clefts	Central nervous system (white matter), peripheral nervous system	Rapid conduction of action potential
	Unmyelinated	-Nerve axon -Schwann cells	central nervous system (gray matter), autonomic nervous system	Slow conduction of action potential
Nerve endings	Transneuronal contacts (synapses)	-presynaptic membrane -synaptic cleft	Provide a functional connection between neurons	

		-postsynaptic membrane	
	Receptor (sensory) endings	-free, -nonfree : -nonencapsulated, -encapsulated	Accept stimuli from an external and an internal environment, are available on dendrites
	Motor (efferent) endings	neuromuscular junction: -axon of motor neuron -synaptic cleft -muscle fiber	Transfer signals from nervous system to organs (muscles, glands), are available on axons.

LITERATURE

- Slípka J.: Outlines of histology. Karolinum 2004
- Slípka J.: Outlines of embryology. Karolinum 2012
- Junqueira L.C., Carneiro J., Kelley R.O.: Basic Histology. LANGE medical book, 2005.
- Ovalle W., Nahirney P.: Netter´s Essential Histology, 2nd edition, Elsevier 2013
- Gartner L.P., Hiatt J.L.: Color Atlas and Text of Histology. 6th edition. Wolters Kluwer, 2014.
- Ross M., Pawlina W.: Histology: a Text and Atlas with Correlated Cell and Molecular Biology. 6th edition. Wolters Kluwer, 2014.
- Young B., Woodford P., O´Dowd G.: Wheater´s Functional Histology. A text and colour atlas. 6th edition, Churchill Livingstone, 2013.
- Sadler T.: Langman´s Medical Embryology, 13th edition, Wolters Kluwer 2014
- Moore K.L., Persaud T.V.N., Torchia M.G.: Before We Are Born, 9th Edition. Elsevier, Philadelphia, 2016.
- Moore K.L., Persaud T.V.N., Torchia M.G.: The Developing Human, 10th Edition. Clinically Oriented Embryology. Elsevier, Philadelphia, 2016.
- Ovalle W., Nahirney P.: Netter´s Histology Flash Card Updated Edition, 1st edition, Elsevier 2013
- Lee L.: Lippincott's Pocket Histology. Wolters Kluwer, 2014.
- Lowe J.S., Anderson P.G. Human Histology, 4th Edition. Elsevier, Philadelphia, 2015.
- Cochard L.: Netter´s Atlas of Human Embryology, 1st edition, Saunders Elsevier 2012
- Carlson B.M.:Human Embryology and Developmental Biology, 5th edition, Saunders Elsevier 2013
- Barbara Young.: Wheater's Functional Histology, A Text and Colour Atlas: 6th edition, Elsevier Health Sciences, 2013
- Mescher.: Junqueira's Basic Histology, Text and Atlas, Fourteenth Edition, McGraw-Hill Education – Europe, 2015
- James Lowe.: Stevens & Lowe's Human Histology, 4th Edition, Elsevier Health Sciences, 2014
- Dongmei CuiJohn P., Naftel Jonathan D. FratkinWilliam DaleyJames C. Lynch.: Atlas of Histology, With Functional and Clinical Correlations, Lippincott Williams and Wilkins, 2010

- Pawlina & Ross.: Histology: A Text and Atlas, With Correlated Cell and Molecular Biology, Lippincott Williams and Wilkins, 2015

Nucleus (1, 2, 3, 4)

1. http://flebosclinic.com.ua/2019/12/24/yadertse-himichnij-sklad-struktura-znachennya-transkriptsiya-neribosomnyh-geniv-yadernij-bilkovij-matriks-yaderna-obolonka/
2. https://en.wikipedia.org/wiki/Nucleolus
3. https://en.wikipedia.org/wiki/Nucleoplasm
4. https://www.britannica.com/science/cell-biology/The-nuclear-envelope#ref313748
5. https://www.dictionary.com/browse/amitotic, https://en.wikipedia.org/wiki/Amitosis
6. https://www.quora.com/What-are-the-differences-in-the-process-between-mitosis-and-meiosis
7. https://www.nextgurukul.in/questions-answers-forum/question/academic/how-is-mitosis-different-from-amitosis/89048

Formation of the two germ layers

1 first figure https://en.wikipedia.org/wiki/Blastocyst

2 first figure https://quizlet.com/167264991/formation-of-germ-layers-flash-cards/

Formation of the notochord

1 first figure https://www.sciencedirect.com/topics/neuroscience/buccopharyngeal-membrane

2 first figure https://www.sciencedirect.com/topics/neuroscience/buccopharyngeal-membrane

Formation of the three germ layers

1 first figure https://pocketdentistry.com/2-development-of-the-head-face-and-mouth/

2 first figure http://prf.shmu.ac.ir/data/profinfo/5/1817290606/files/69080.pdf

Neurulation

1 first figure http://ksumsc.com/download_center/Archive/1st/435/1.%20Foundation%20B

2 first figure https://pocketdentistry.com/2-development-of-the-head-face-and-mouth/

Organization of the mesoderm

1 first figure https://quizlet.com/213252712/the-fourth-week-flash-cards/

2 first figure https://webcampus.drexelmed.edu/neurobio/embryology/page21/page22/

Formation of a trunk fold

1 first figure https://webcampus.drexelmed.edu/neurobio/embryology/page12/page24/

2 first figure https://www.memorangapp.com/flashcards/116130/1.16+-+Gastrointestinal+Embryology/

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