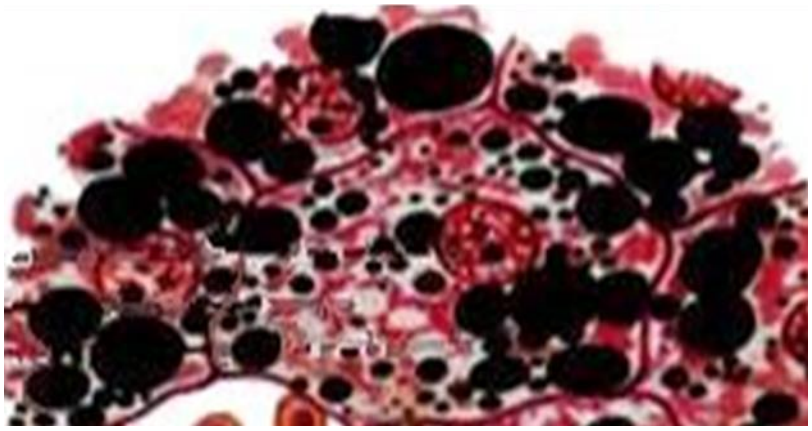

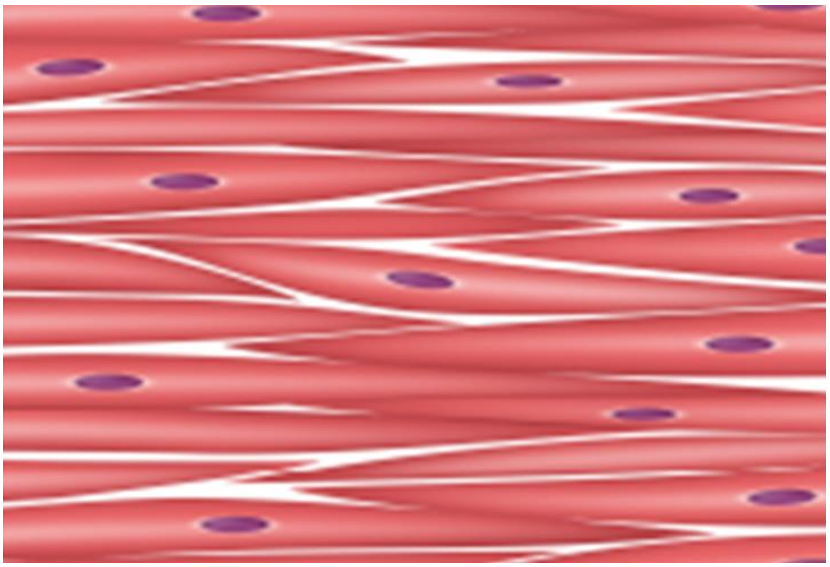

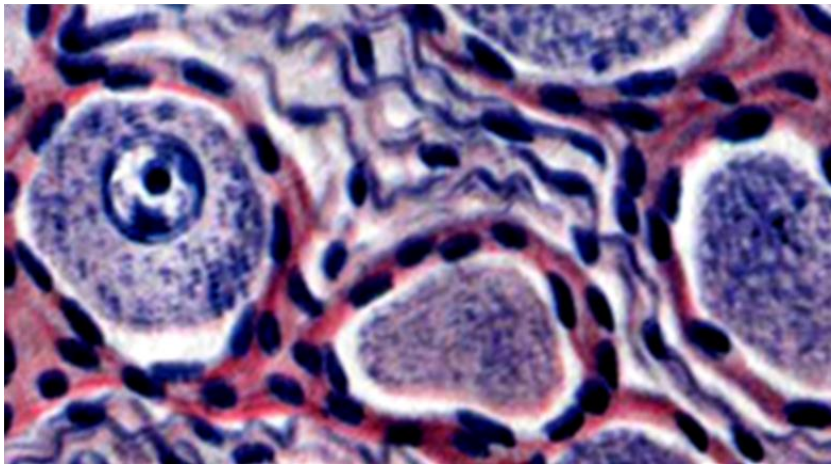

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Cytology

Study guide

Under the editorship L. I. Kiptenko

Ministry of Education and Science of Ukraine
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Recommended by the Academic Council of Sumy State University

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This manual is intended for the students of medical higher educational institutions of IV accreditation level, who study Histology, Cytology and Embryology in English language.

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CONTENTS

Topic: The basic of Histological Techniques

General appearance and structure of the microscope

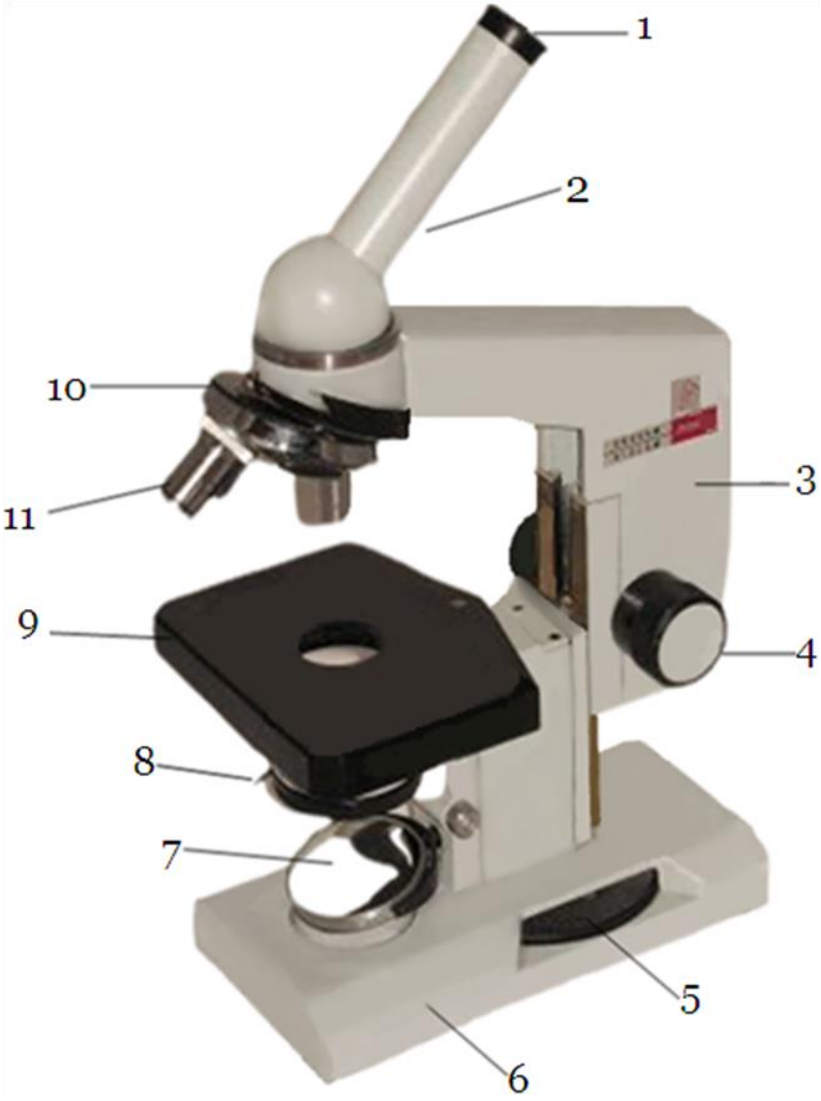


Figure 1 – The C11 model of the light microscope for student use (LOMO plant, Russia)

1 – Ocular lens, or eyepiece.
2 – The tube.
3 – The tube holder.
4 – The coarse (gross) focus adjustment.
5 – The fine focus adjustment.
6 – The base (platform).
7 – The mirror.
8 – The condenser.
9 – The mechanical stage.
10 – The turret, or revolving nosepiece.
11 – The objective lenses.

The microscope is an instrument designed to observe objects that are too small to be seen with the naked eye.

Parts of the Compound Microscope

1. *Ocular lens* or *eyepiece*. The objective lens forms an image of the specimen that is too small to be viewed easily by eye. A second lens called the ocular is used to magnify the primary image from the objective and to project into your retina, a photographic plate, or digital camera. The combination of two lenses in series, objective and ocular, leads to the term "compound microscope". We use oculars with magnifying power 7x, 10x, and 15x.

2. The *tube houses* a prism that deflects a light beam by an angle of 45°. The optical tube length on most biomedical microscopes is 160 millimetres, but tube geometry varies. The body tube is the tube that supports the ocular lenses and extends down to the nosepiece.

4. The *coarse (gross) focus adjustment* knob is used for initial focusing at low power. It should be used ONLY at low magnification (4x). The coarse focus knob is the larger of the two focus knobs.

5. The *fine focus adjustment* knob is the smaller of the two focus knobs. The fine focus knob is used at all magnifications and is the ONLY focusing knob used in magnifications greater than low power. Remember: compound microscopes are par–focal which means you only need to do minimal focus adjustments when you change power. If you are turning the fine focus many times and your image is not coming into focus, something is wrong.

6. The *base* is the broad, flat, lower support of the microscope.

7. The *mirror* has two sides – *flat* and *concave.* Concave side of the mirror is used for diffused light (sky) or a bulb, when you work with low-power objectives. Flat side is used for diffused light or a bulb, when you work with high–power objectives, and for special illuminators.

8. The *condenser* contains a system of lenses that focuses light on the specimen. It is a structure mounted beneath the stage that condenses or narrows the beam of light and directs the light through the slide specimen. The condenser adjustment knob moves the

condenser vertically. For most routine microscopy, the condenser should be in the uppermost position.

The *iris diaphragm* is mounted immediately below the condenser. Locate the lever used to regulate the iris diaphragm. Adjusting the size of the opening regulates the amount of light that can pass into the condenser. The main function of the iris diaphragm is to maximize resolution and image contrast by properly channeling the light rays passing through the specimen. With each new slide, the diaphragm will need to be readjusted. Play with the lever to see what setting works best for the slide you are viewing.

9. The *stage* is the platform that supports the specimen. It is usually quite massive to minimize vibration. The stage has an opening for the illuminating beam of light to pass through. A stage platform has two spring–loaded metal *clips* that are used to hold the specimen slide in place. Most stages have special mechanisms that can move the specimen slide and rotate the stage around the optical axis, but the stage of the *C11* model is fixed.

10. The *turret* or *revolving nosepiece*. Most microscopes have several objective lenses mounted on a rotating turret to facilitate changing lenses. The objective lenses screw into the turret that is attached to the head. The objectives are mounted in ascending order of magnification so the user can easily change to progressively higher power lenses. A click stop identifies the correct vertical position for each lens as it swings into place. When the turret is rotated, it should be grasped by the glittering edge, and not by the objectives. Using the objectives as handles can de–centre and possibly damage them.

11. The *objective lenses (11)* enlarge and project the illuminated image of the object in the direction of the eyepiece. The objective lens is the single most important component of the microscope. Together with the condenser, it determines the resolution (see below) that the microscope is capable of.

There are two types of objectives: *dry objectives* (with air between specimen and lens) and *immersion objectives* (with liquid between specimen and lens). Dry objectives do not capture high angle rays that bend away from the optic axis at the glass–air interface.

Possible Problems

It is important to know that many factors can affect microscope performance.

A dirty objective lens is the most common cause of rapid determination of image quality. This may be caused by dragging a dry objective through immersion oil, getting a fingerprint on an objective, or an accumulation of dust on the lens surface. Proper cleaning technique can restore image quality, but it is always best to keep objective lenses clean in the first place.

You may use a dirty eyepiece. A fingerprint on an eyepiece can reduce image quality significantly. When the eyepiece becomes dirty, you must clean it properly with a moistened cotton swab (№ 6).

To avoid tissue digestion by enzymes present within the cells (autolysis) or by bacteria and to preserve the structure and molecular composition, pieces of organs should be treated before or as soon as possible after removal from the animal's body. This treatment – fixation – can be done by chemical or, less frequently, physical methods. Special fixatives, such as acetic acid, formaldehyde, and glutaraldehyde are used to coagulate protein, to fix and to preserve the tissue. The water is extracted from tissues by bathing them successively in a graded series of mixtures of ethanol and water (usually from 70 % to 100 % ethanol). The process of fixation and staining kills the tissue and the cells. In such a situation, the study of cells and tissues cannot take place in actual living conditions. Artefacts, distortions, and loss of components due to the preparation process are almost always present. Artefact (or artifact) is something unnaturally present through extraneous influences. A simple example of an artefact is an air bubble trapped under the coverslip of a slide. An additional structure can appear due to defects in the staining procedure. Techniques are so good that the introduction of any artefact in the specimen will be reduced to the minimum.

Rules of working with a light microscope

1. Put a microscope on your working place.
2. Arrange the objective of a low magnification opposite to the object–table opening at the distance 1.5 cm away.
3. Light up the visual field using a mirror.
4. Put a specimen on the microscope table. Place the section opposite to the microscope frontal lens.
5. Look from the side, lower the microscope tubus down, leave a minimal lumen between the objective and the specimen (up to 1 cm).
6. Look through the objective and slowly raise the tubus up by means of macroscrew until the appearance of the object under observation.
7. Observe the whole specimen while observing it under a high magnification.
8. Choose the most particular portion while studying the specimen under a high magnification.
9. Look through the objective and raise slowly the tubus by means of microscrew until the appearance of image.
10. Raise the tubus by turning the macroscrew, remove the specimen from the object–table.

The basic of Histological Techniques

The main object in histological studies is preparation for microscopy. Very often this preparation is a thin section of an organ or a tissue. The section must be:

a) thin and translucent

b) visible in the microscope (stained)

There are three main techniques used for preparing microscopical from organs:

1. The paraffin technique (is the most common method).
2. The celloidin technique (is the most perfect method).
3. The freezing technique (is the faster method).

Medical uses of microtechniques

1. For learning purposes.

2. To differentiate (between) normal and cancer tissue before operations.

The Paraffin Techniques

1. Obtaining the tissue from the body.

Main requirements:

a) fresh pieces of tissue without postmortem change

b) small pieces – 5×5×5 mm (for better penetration of the necessary substances)

2. Fixation of the tissue.

It is necessary

– to prevent (autolysis = postmortal destruction)

– to prevent decay (bacterial decay)

– to stop reactions of metabolism

– to fix structures and molecules

– to facilitate the process of cutting and staining

The most common fixatives:

a) solution which contains 10 % formol saline

b) picric acid

c) glacial acetic acid

The tissue must remain in the fixative minimum 24 hours, maximum – years.

3. Washing.

We wash the fixed tissues 24 hours in running tap water to remove excessive fixative.

4. Dehydration.

This process is performed through six stages: putting the fixed tissue in 50 % alcohol, then in 70 %, 80 %, 90 %, 96 % and 100 % alcohol (absolute alcohol). Such gradual dehydration prevents shrinkage of tissues.

5. Hardening of the tissues:

a) we treat the tissues with xylol or benzol (the tissues become translucens)

b) we treat the tissues with paraffin – xylose (in the thermostat at 56° C)

c) the tissues are infiltrated impregnated with paraffin – wax in the thermostat 56° C

d) we cool the tissue with the paraffin until the paraffin is hard

6. Section or cutting of the paraffin block.

We can cut the paraffin block with the tissue with the help of a microtome into sections 5 mkm (an average diameter of a cell). The cut sections form a ribbon on the knife adge/blade.

7. Mounting of the cut sections on glass slides.

We put the thin paraffin sections on clean glass slides smeared with albumin glycerin (proportion is 1 to 1). Then we dry the stuck section in the thermostat at 37° C.

Advantages of the paraffin technique:

1. The whole preparation process takes a short time (not more than two days).
2. It gives a serial (or a ribbon) of sections.
3. It gives very thin sections.
4. We can stain the paraffin section very easily (the paraffin section can be easily stained).

Disadvantages of the paraffin technique:

1. The heat of the oven may damage the tissue.
2. The fixative dissolves the fat contained in the cell.
3. The heat destroys enzymes, so this technique cannot be used to demonstrate enzyme activity of tissues.

The Freezing Technique

Fresh pieces of tissue are frozen and are cut with a freezing microtome in the cryostat apparatus within a few minutes.

Advantages of the freezing technique:

Rapid diagnosis of tumours during the operation.

The chemical composition chemistry of tissues is preserved (because we do not use heat).

This technique is used to demonstrate enzyme activity.

Disadvantages of the freezing technique:

1. It doesn't give the opportunity to get a series of sections.
2. It doesn't give the opportunity to get thin sections.
3. It is difficult to stain the section.

How to stain sections

There are three groups of stains:

1. *Acid* stains: as eosin, acid fuchsin. They dye alkaline structures of the cells (mainly cytoplasm) with a red colour. The structures of the cell are oxyphilous (that is, they are like acid stains)

2. *Basic* stains: as hematoxylin, toluidine blue methylene or carmine. They dye acide structures with a blue colour. The nucleus contains the most acide structures (nucleic acids). The structures of the nucleus are basophilic (they are like basic stains).

3. *Neutral* stains: as Leishman stain which is usually used to stain blood cells. It is formed of eosin and methylene blue dissolved in absolute methyl alcohol. It stains both the nuclei and cytoplasm of the white blood cells.

Topic: Introduction to a course of Histology, Cytology and Embryology. Cell membrane and cytoplasm

Histology is a science about the structure, development, and life activity of the tissue of vegetative and animal organisms.

Cytology is a science about the structure and functions of the cells.

Embryology is a study about an embryo, its development, structure and functions.

Cell is an elementary structural, functional and genetic unit, which composes all plant and animal organisms.

Some cells have the nucleus. They are called eukaryotic. Others have no nucleus. They are called prokaryotic.

Eukaryotic cells consist of three main parts:

1. nucleus;
2. cytoplasm;
3. cell membrane.

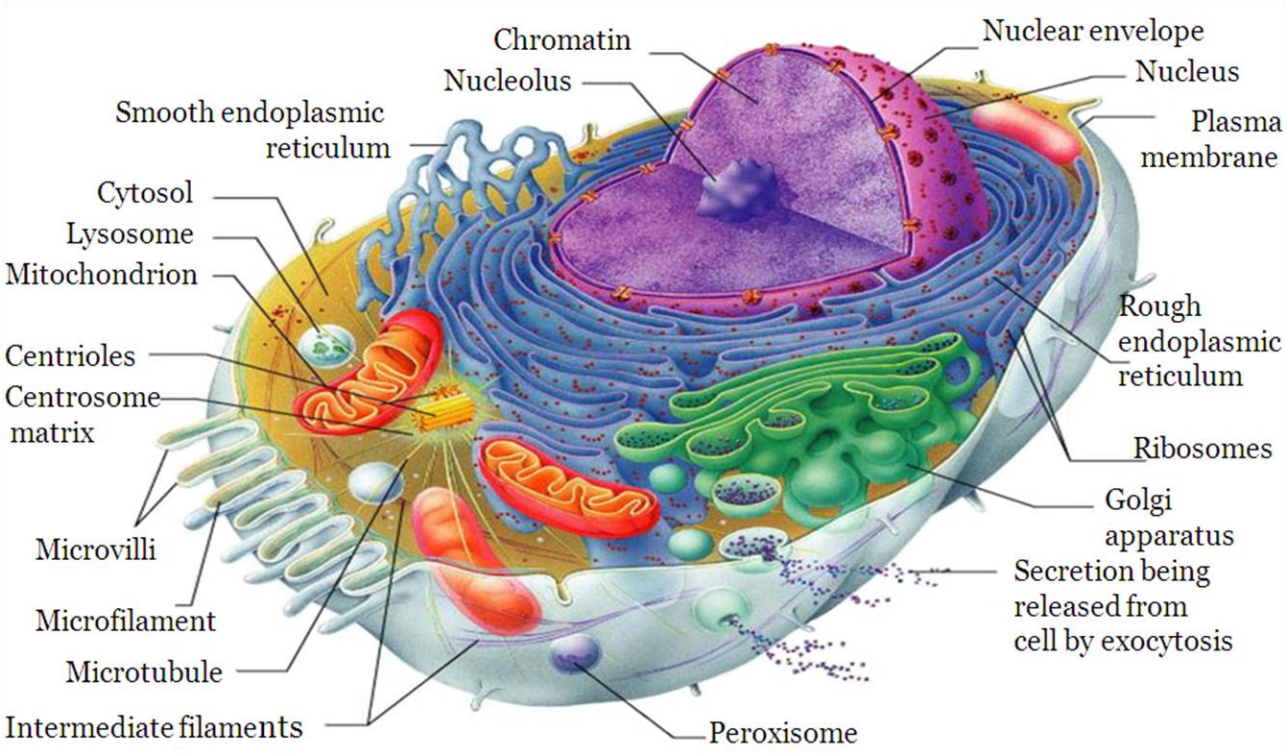


Figure 2– Eukaryotic cell

Plasmalemma

Plasmalemma is a cell membrane, which separates cell cytoplasm from the environment.

The structure of the plasmalemma

Plasmalemma has three–layer structure. The middle layer is represented with an elementary biological membrane. It is composed of two layers of lipid molecules; protein molecules are located among lipids.

Some protein molecules are totally embedded in the lipid portion, they are called integral. Others are partly embedded in half of the lipid portion, they are called half integral.

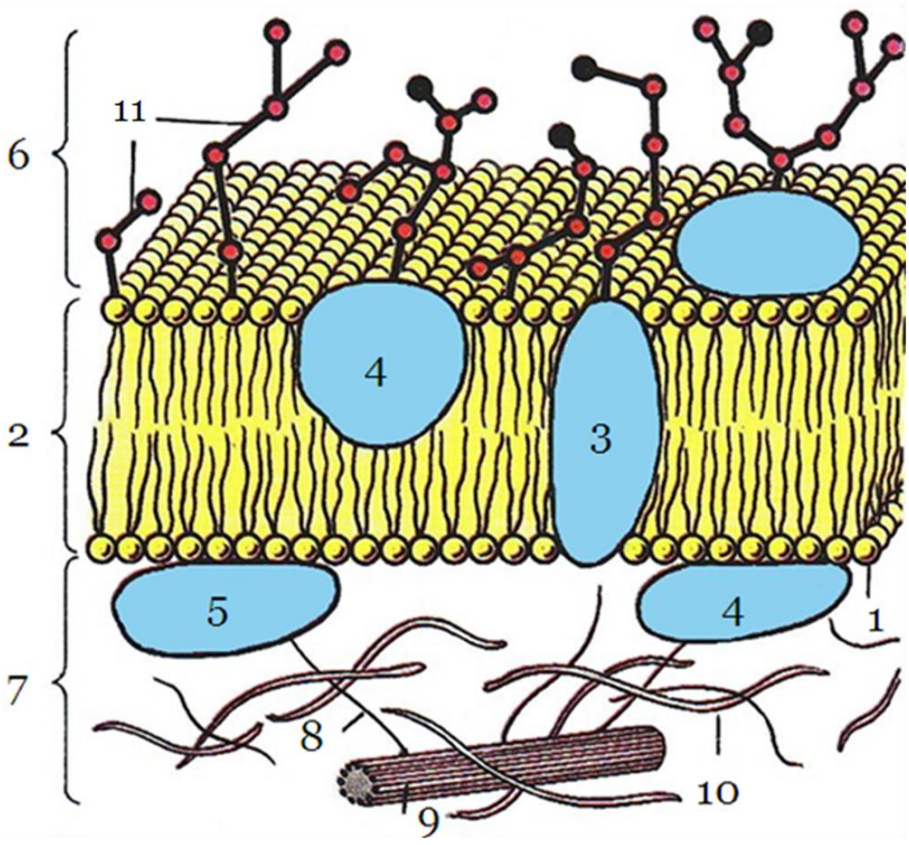


Figure 3 – Structure of the plasmalemma

1 – lipid molecule; 2 – elementary biological membrane; 3 – integral proteins; 4 – half integral proteins; 5 – peripheral proteins; 6 – glycocalyx; 7 – cortical layer; 8 – microfilaments; 9 – microtubules; 10 – microfilaments; 11 – glycolipids.

The upper layer of plasmalemma is called *glycocalyx*. It is composed of carbohydrates (the chains of oligosaccharides). The carbohydrates are connected with protein or lipid molecules. Such substances are called glycoproteins and glycolipids. The third layer of the plasmalemma is called the cortical one. It consists of the peripheral proteins, microtubules and microfilaments.

The functions of the plasmalemma

1. Receptive function (interaction with hormones, mediators, and other chemical factors).

2. Transport function (transport of the substances into the cell is called *endocytosis*, from the cell – *exocytosis*.

– *Endocytosis* – the invaginated cell membrane fuses to form an *endocytotic vesicle* or *endosome,* which is a small, spherical membrane–bound body. The membrane and any material incorporated into such a vesicle can then be processed within the cell.

– *Exocytosis* is the reverse of endocytosis, and describes the fusion of a membrane–bound vesicle with the cell surface to discharge its contents into the extra–cellular space).

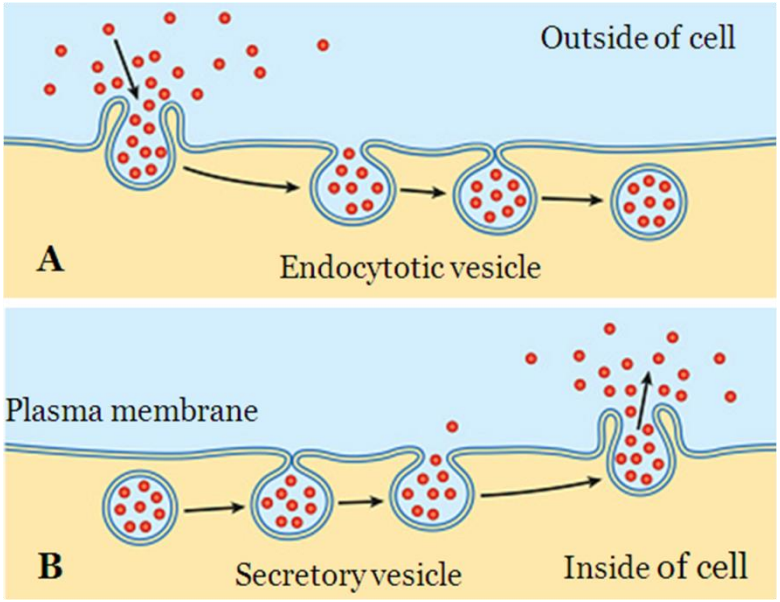


Figure 4 – Endocytosis (A) and exocytosis (B)

3. The formation of the intercellular contacts:

– *Simple contact* – membranes of two cells are at a distance of 10 – 12 nm in such a manner that the glycocalyx of one cell adjoins with glycocalyx of another cell. The basic function is metabolism and information interchange between cells.

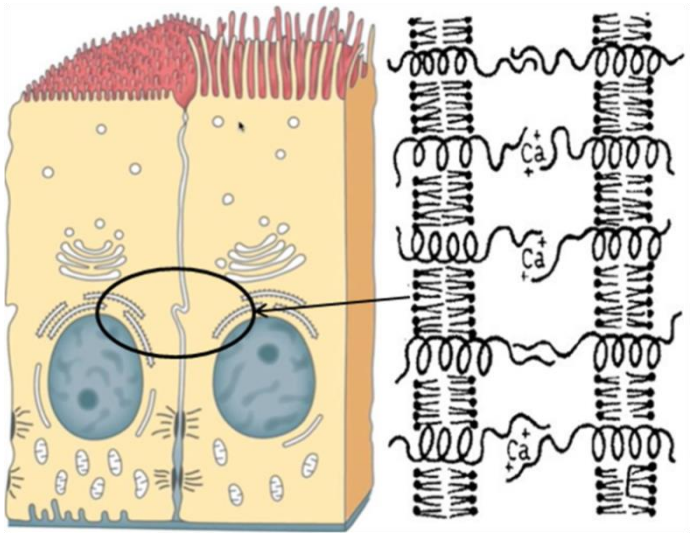


Figure 5 – Simple contact

– *Zonular occludentes* – also known as tight junctions. Zonula occludens are located between adjacent plasma membranes most typically near the apices of epithelial cells. At the fusion sites *occludins* trans–membrane junctional proteins, lies.

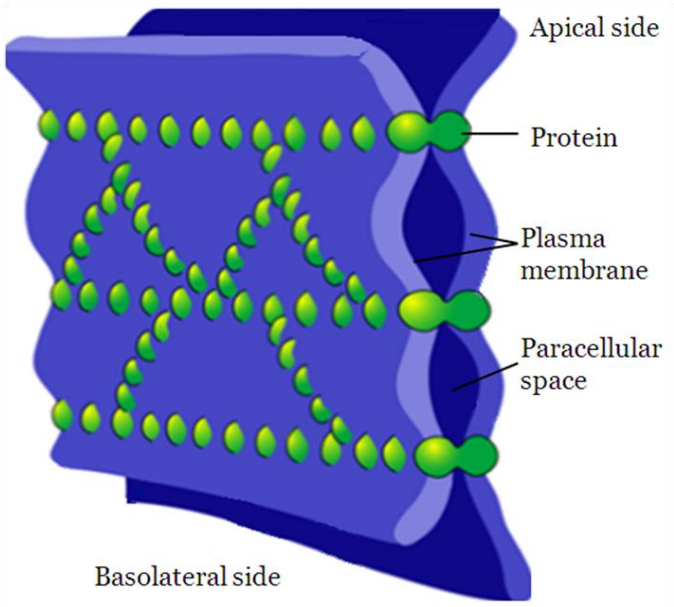


Figure 6 – Zonula occludens

Occludin has more active role because these are the proteins that are probably responsible for the obliteration of the intercellular space by forming the tight junction. These junctions act as barriers that prevent the movement of molecules into the intercellular spaces.

– *Zonular adherents* are belt–like junctions that assist adjoining cells to adhere to one another. This junction not only joins the cell membranes to each other but also links the cytoskeleton of the cells via the trans–membrane linker proteins. Apart from epithelial cells zonular adherents are also seen between smooth muscle cells, and between myocytes of cardiac muscle in the region of intercalated discs.

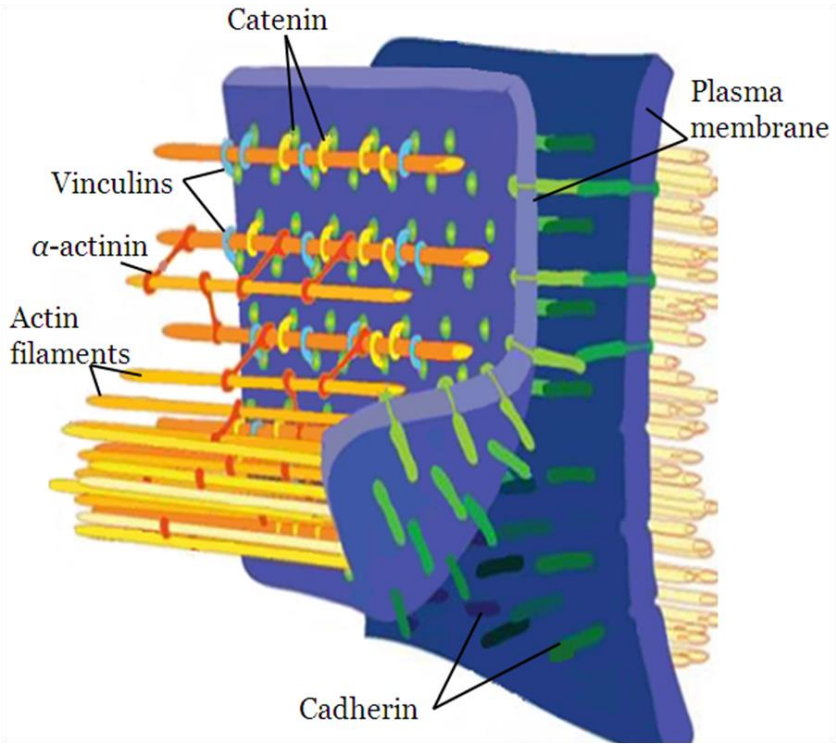


Figure 7 –Adherens junction

– *Desmosomes.* This is the most common type of tight junction between adjoining cells. At the side of a desmosome the plasma membrane (of each cell) is thickened because of the presence of a dense layer of protein on its inner surface. The region of the gap is rich in a glycoprotein called *desmoglein.* The thickened areas of two membranes are held together by intermediate filaments of cytokeratin that appear to pass from one membrane to the other across the gap. Desmosomes are present where strong anchorage between cells is needed.

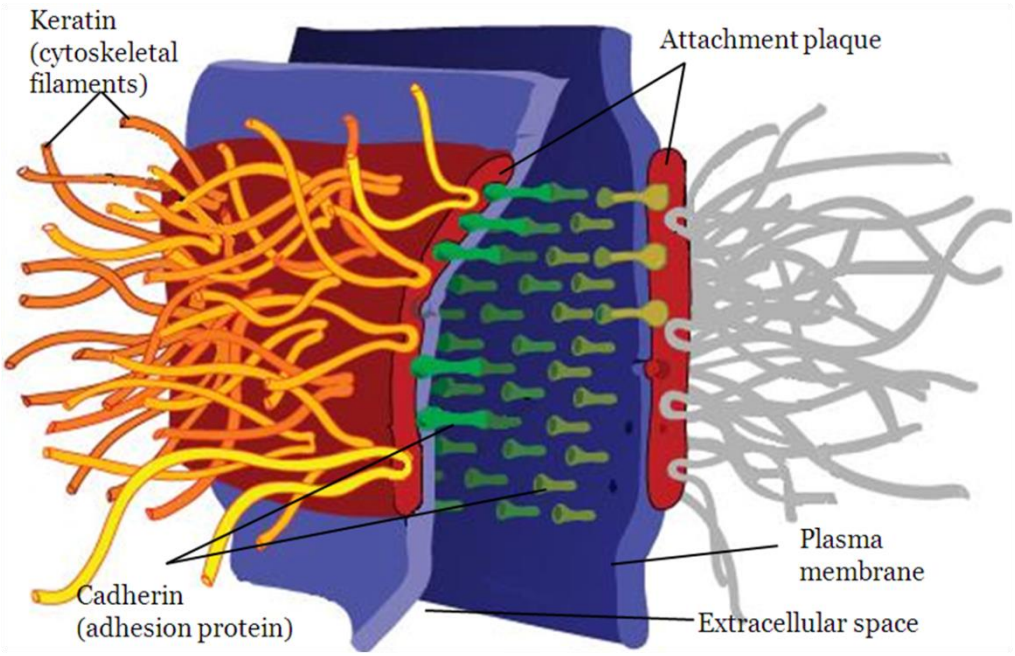


Figure 8 – *Desmosome*

– *Gap junctions,* also called *nexus* or *communicating junctions,* are regions of intercellular communication. They are widespread in epithelial tissues, in cardiac muscle cells, smooth muscle cells and neurons.

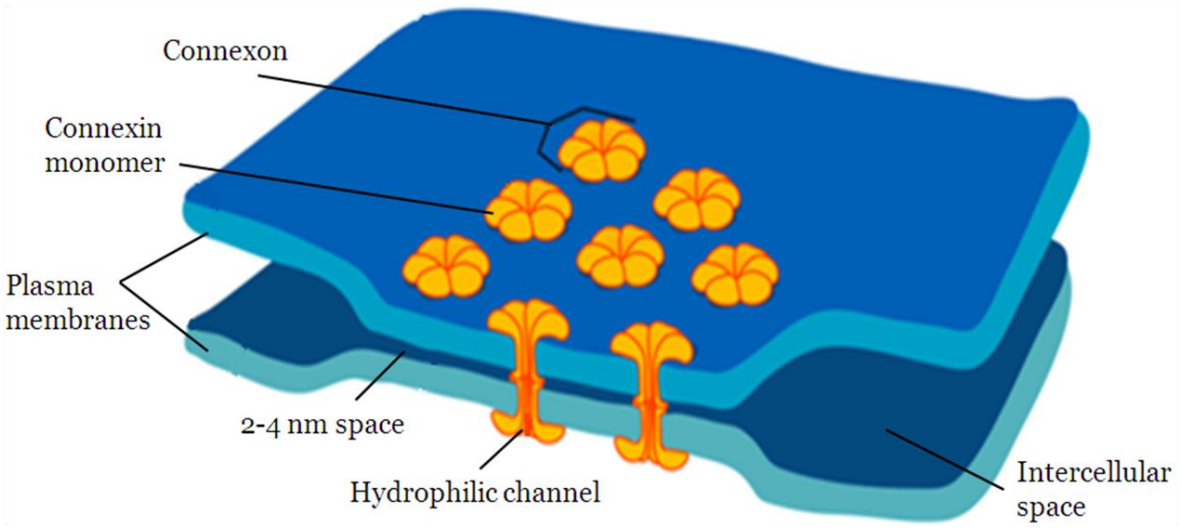


Figure 9 – Gap junction

Gap junctions are built by six closely packed trans–membrane proteins connexins that assemble to form structures called *connexons,* aqueous pores through the plasma membrane extending into the intercellular space. The two connexons fuse, forming the functional communication channel. The hydrophilic channel permits the passage of ions, amino acids, small molecules and hormones.

– *Synapse* – type of contact between two nervous cells or between a nervous cell and a muscle. Nervous impulses pass through synapses.

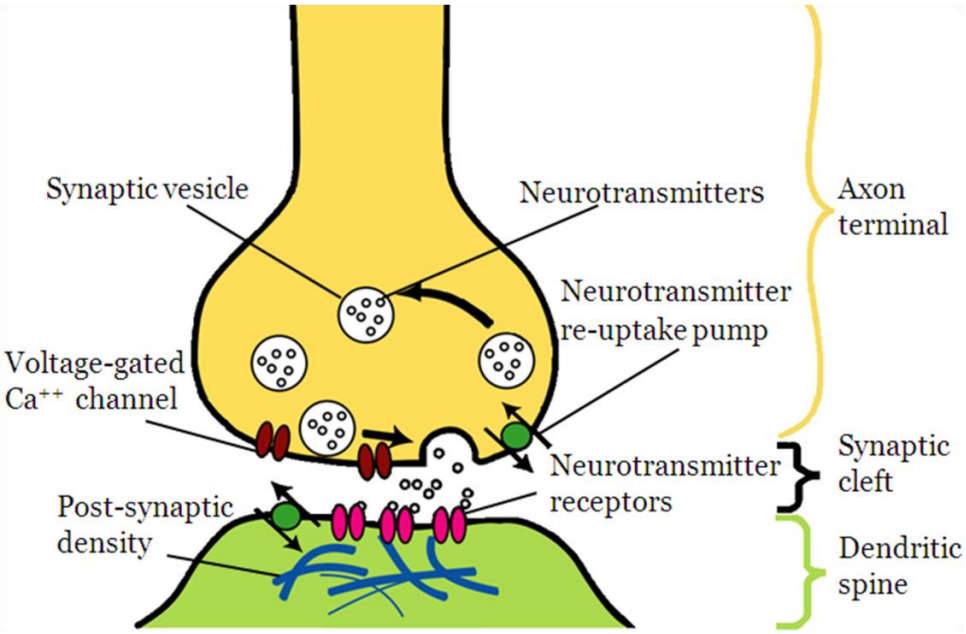
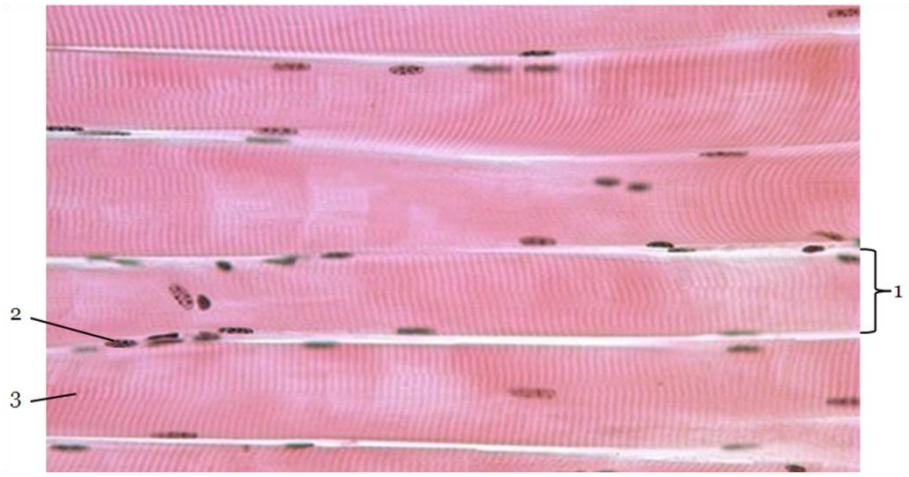


Figure 10 – Synapse

Except for cells, multicellular organisms contain noncellular structures, which always are derivatives of cells or products of their secretion. The *symplasts, syncytium, are* postcellular structures.



Slide 1 – Symplast

1 – muscle fiber; 2 – nuclei of muscle fiber; 3 – striations.

The *symplast* is a large formation with a big mass of cytoplasm and a plenty of nucleus (more than ten). Examples of symplasts are striated muscle fibers and the external layer of placenta trophoblast.

The *syncytium* is a formation, where connection between cells as cytoplasmic processes remains after cell divisions. There distinguish true and false syncytium. A true syncytium is one of stages in formation of man's sex cells when spermatogones remain connected by bridges from cytoplasm. False syncytium is, for example, mesenchymal and a reticular tissue in which cells are bridged in a uniform net by means of the processes.

Cytoplasm

The structural components of the cytoplasm are hyaloplasm (cell matrix), organelles and inclusions, which are shipped into it.

Organelles are microstructures. They are constantly present in the cell cytoplasm and they do vitally important functions. They are subdivided into:

1) organelles of the general importance, they are in all cells;
2) special organelles, they are in some cells and they do special functions.

Topic Organelles of the general importance

1. Mitochondria

Mitochondria are composed of two membranes. The outer membrane is smooth, and the inner membrane is folded inward.

The folds are called cristae. Intermembrane cavity is situated between membranes.

Matrix is situated inside the mitochondria. Proteins–enzymes are located in it. They provide synthesis of the ATP (adenosinetriphosphate). The molecules of own deoxyribonucleic acid (DNA), ribosomes and different kinds of the RNA are situated in the matrix.

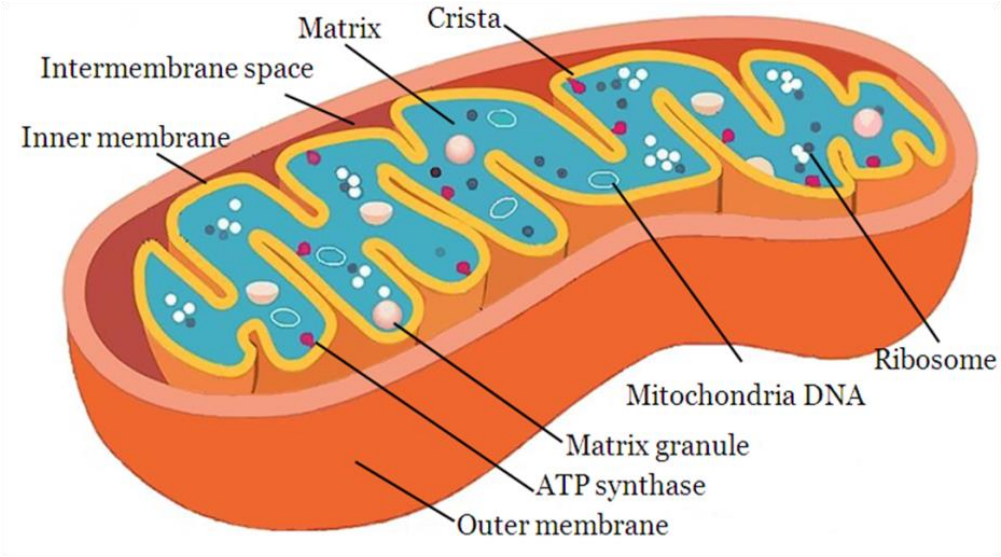


Figure 11 – Mitochondria

Functions:

1. synthesis of the ATP molecules (synthesis of the energy);
2. accumulation of the calcium ions;
3. synthesis of the steroid hormones.

2. Lysosomes

The main function is splitting of the various biopolymers (cell digestion). The main enzyme, which splits substances is acid phosphatase.

Lysosomes are subdivided into:

– primary (enzymes, which split substances, are in inactive condition);

– secondary or phagosome (enzymes are active and split biopolymers);

– residual bodies contain un split rests.

Autophagocytosis is splitting (digestion) of the cell's own structures.

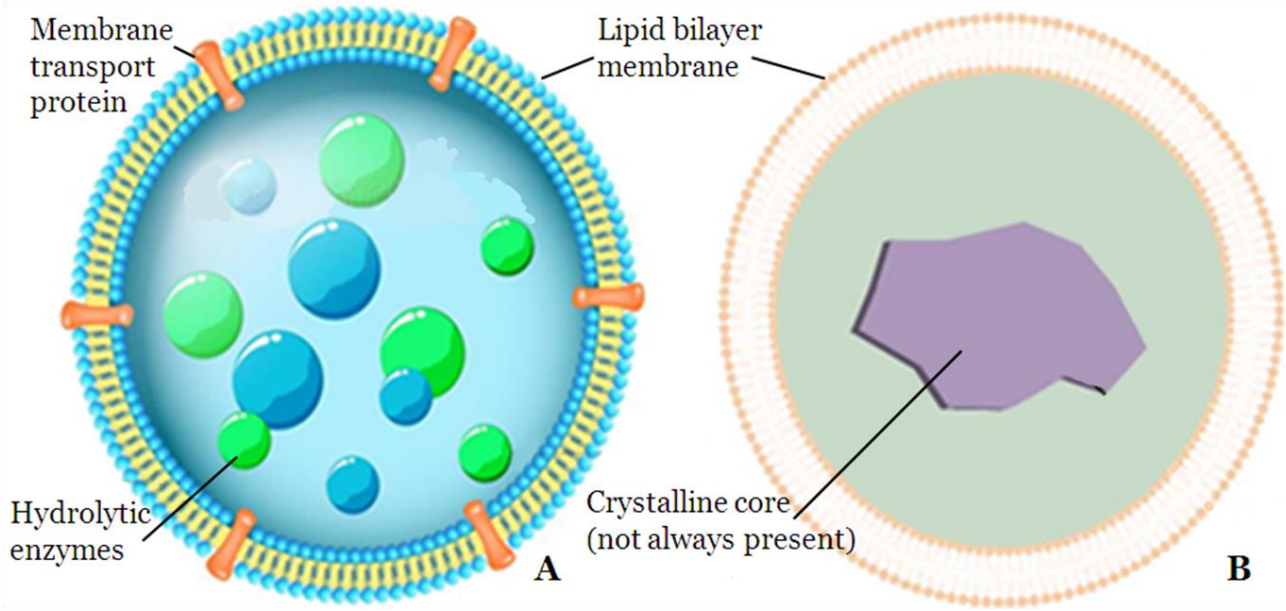


Figure 12 – Lysosome (A) and Peroxisome (B)

3. Peroxisome

Membrane–bound organelles, they take part in the detoxification of the cell (release the cell from toxic substances). The main enzyme is catalase. It splits ethyl alcohol, uric acid, hydrogen peroxide.

4. Endoplasmic Reticulum (ER)

Granular (rough) ER is composed of the flattened membrane cisterns and tubules. Ribosomes and polysomes on the outer surface of them. 1

Function: synthesis of the proteins for the cell (proteins of the plasmalemma, proteins–enzymes) and proteins for the export.

Agranular (smooth) ER has no ribosomes on its surface.

Functions:
1) metabolism of the lipids;
2) metabolism of the carbohydrates;
3) accumulation of the calcium ions;
4) detoxification of the harmful substances.

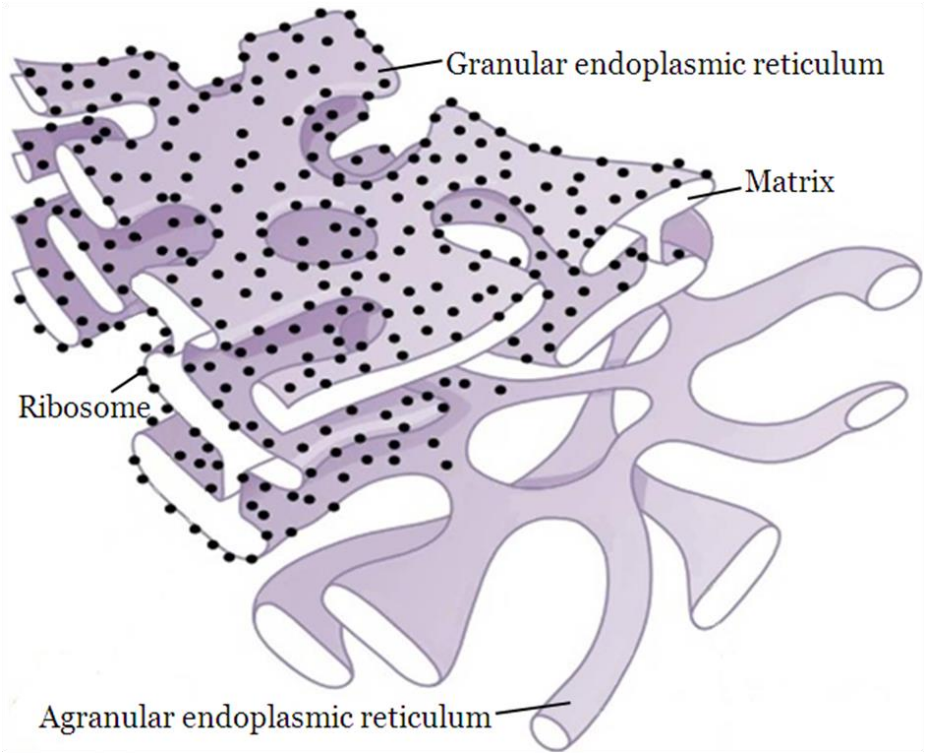


Figure 13 – Endoplasmic Reticulum

5. Ribosomes

They are not enclosed by a membrane. The function is the synthesis of the proteins. They connect aminoacids and form polypeptide chains. Ribosomes consist of two units: small and large. Ribosomes are composed of ribosomal RNA (ribosomal ribonucleic acid) and proteins. Several ribosomes, when they are on the common messenger RNA, form polysomes.

6. Golgi Bodies

It is membranous organelle. It is composed of stacks of cisterns with membranous sacs at the ends. The complex of these elements is called dictyosome.

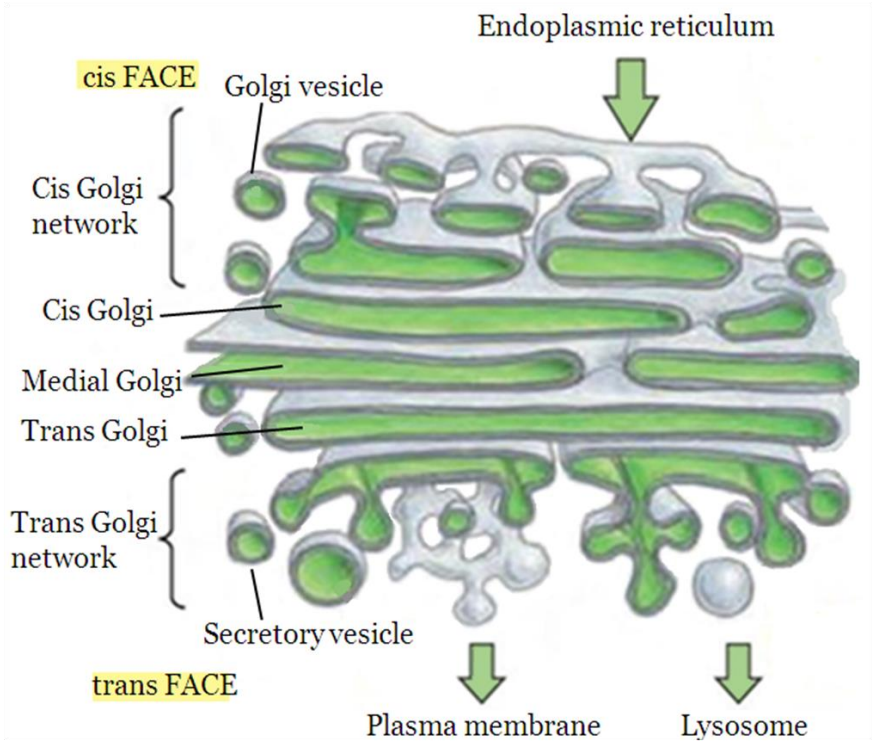


Figure 14 – Golgi apparatus

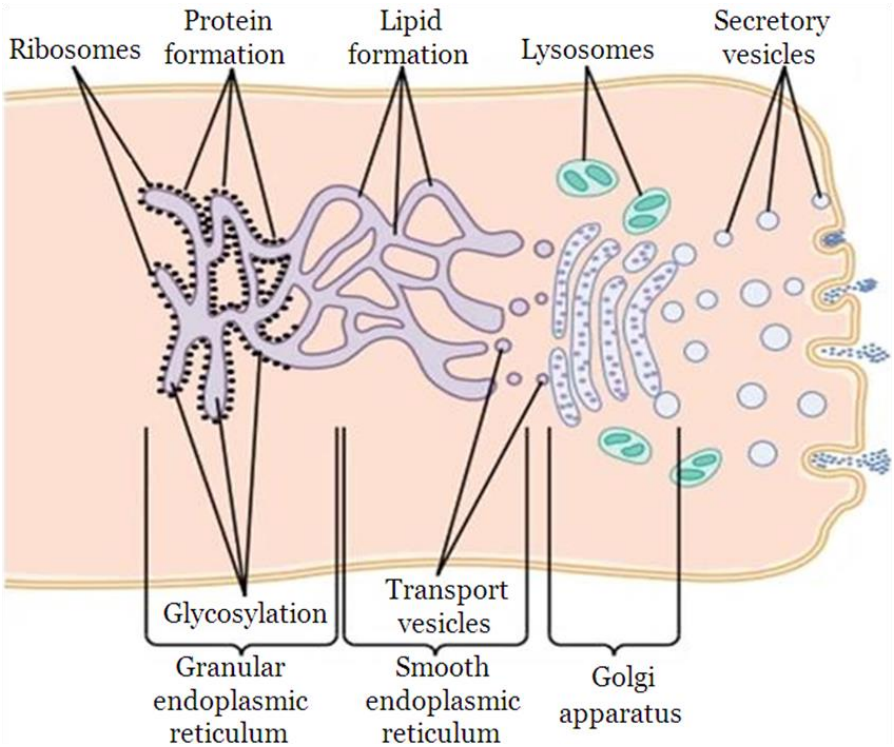


Figure 15 – Cell vacuolar system

Functions:

1) accumulation and ripening of the products of the synthetic activity of a cell;

2) synthesis of the polysaccharides and connecting with the proteins (glycosylation);

3) removing the secretion substances for cell limits.

Topic Special organelles. Cytoskeleton

7. Microfilaments

They are not membranous organelles; they are a structure part of the cytoskeleton of the cell. Microfilaments are composed of proteins: actin, myosin, tropomyosin.

Functions:

1) shortening of the muscle cells;

2) they compose cortical layer of the plasmalemma;

3) moving of the organelle inside the cell.

8. Microtubules

They look like hollow cylinders with diameter 25 nm (nanometer), and thickness of the wall – 5 nm. A wall is composed of thirteen strings, which are composed of tubulin protein molecules.

Functions:

1) providing the transport inside the cell;

2) they form a cytoskeleton of the cell (maintain the shape of the cell);

3) they construct other organelles such as: centrioles, cilia;

4) providing the locomotion of other organelles.

9. Cytocentrum (centrosome)

Function – providing divergence of the chromosome during the cell division. It consists of two centrioles. Two centrioles form the diplosome. Centrosphere is situated near centrioles. Centrioles contain nine triplets of parallel microtubules. The triplets are connected by protein dynein. During the preparation of a cell to division, the doubling of centrioles and their divergence to poles takes place.

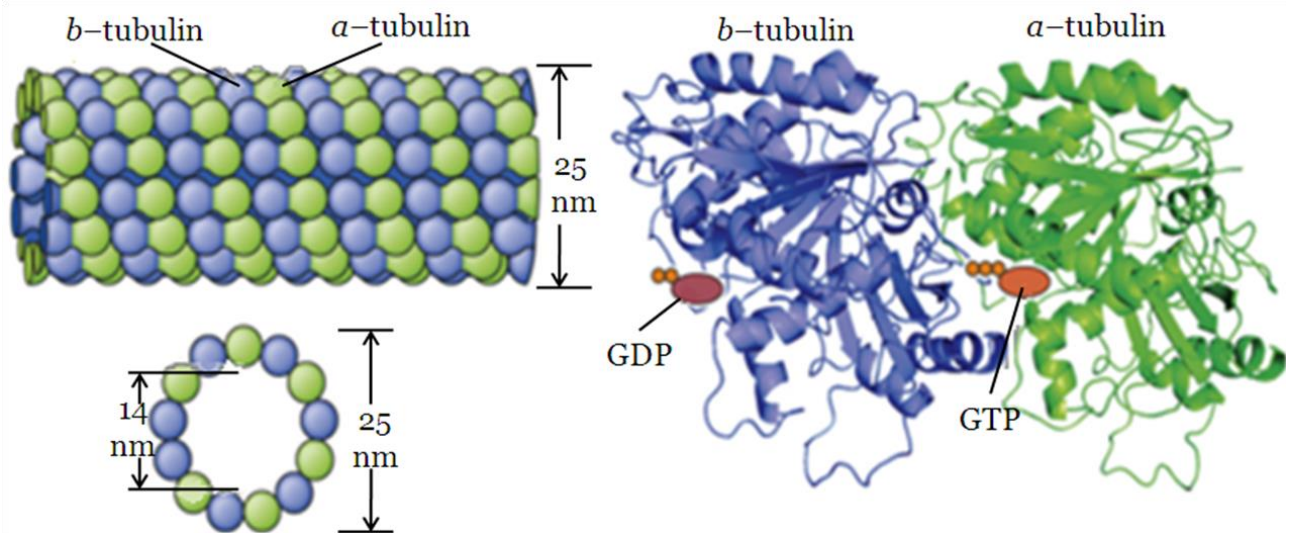


Figure 16 – Microtubule

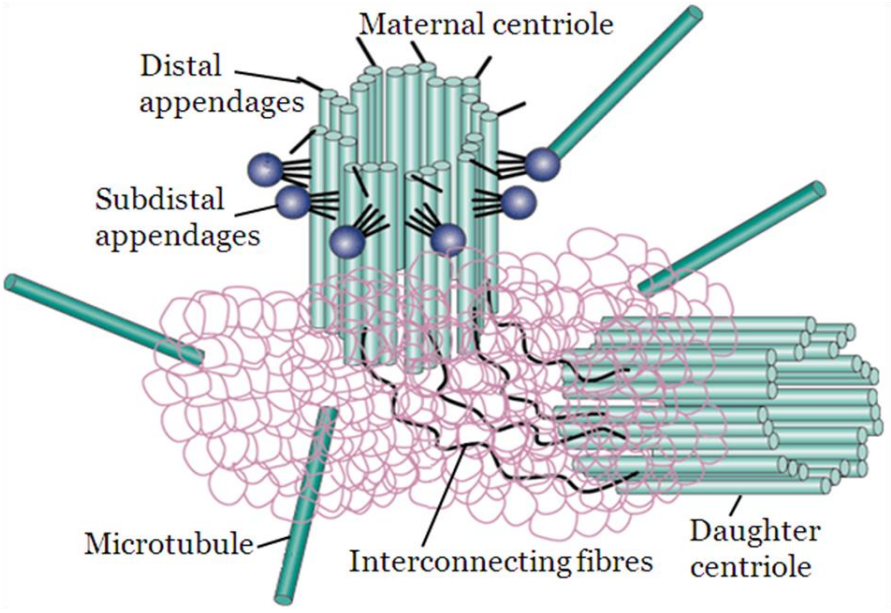


Figure 17 – Cytocentrum

10. Cilia and Flagella

They are organelles of special importance. They take part in the processes of locomotion. They are sprouts of cytoplasm; the base of which are microtubules. They are called axial strings or axonemes. The length of cilia is 2–10 mc (micrometer), the length of flagella is 50–70 mc. Axonema contains nine pairs of peripheral microtubules and one more pair is situated in the centre. It can be described with a formula (9×2) + 2.

The basal body is situated at the base of cilia, in a place where it passes to a cytoplasm. It contains nine triplets of microtubules. Basal body and axoneme are connected between themselves: two microtubules of each triplet of basal body enter a duplet of axonemal microtubules.

Cells, which have cilia and flagella, can move in a space or transport substances.

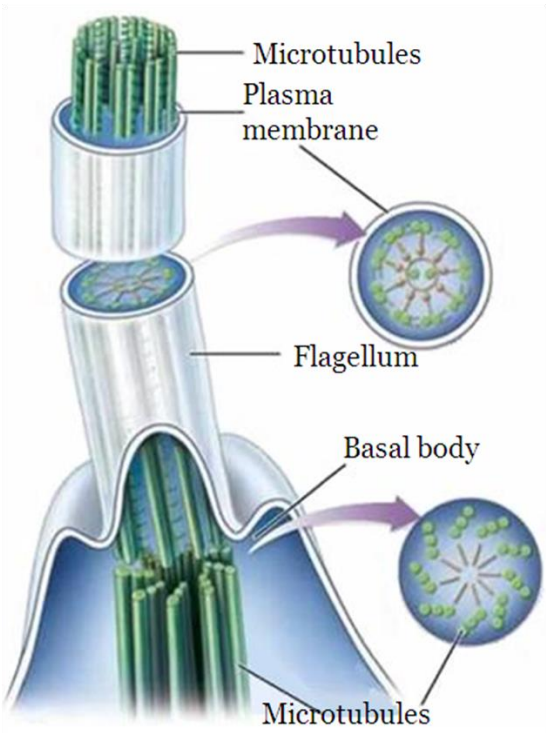


Figure 18 – Ultrastructure of Cilia and Flagella

11. Inclusions

Inclusions – temporary components of the cytoplasm, formed as a result of a cell vital activity.

Inclusions can be:

1) trophic:

a) lipid inclusions

b) carbohydrate (granules of glycogen);

2) secretory – membranous vesicles with cell secretory products;

3) excretory – contain harmful products of metabolism, be removed from the cell;

4) pigmentary – congestion of endogenous or exogenous pigments.

Endogenous: hemoglobin, melanin (secretion in the pigmentary cells), aging pigment.

Exogenous: dyes, particles of dust.

Questions to the topics

Theme 1: Introduction to a course of Histology, Cytology and Embryology. Cell membrane

1. Give definition of Histology.
2. Give definition of Cytology.
3. Give definition of the Embryology.
4. Give definition of the Cell.
5. The structure of the Plasmalemma.
6. Characteristic functions of the plasmalemma:
a) receptive function;
b) transport function.
7. The structure of intercellular contacts:
a) simple contact;
b) zonular occludents;
c) synapse;
d) desmosome;
e) zonular adherents;
f) gap junctions.
8. The characteristic and structure of symplast and syncytium.

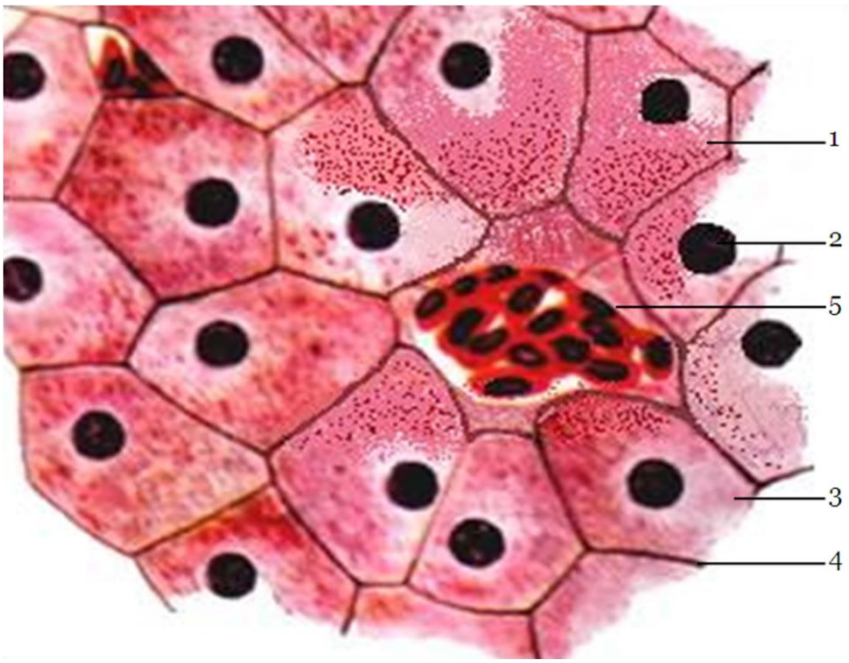
Theme 2: The structure of the Cytoplasm. Organelles of the general importance

1. The structure of the Cytoplasm.
2. The structure and functions of Mitochondria.
3. The structure and functions of Lysosomes and Peroxisomes.
4. The structure and functions of Agranular Endoplasmic Reticulum.
5. The structure and functions of Granular Endoplasmic Reticulum.
6. The structure and functions of Ribosomes.
7. The structure and functions of Golgi Bodies.

Theme 3: The structure of the Cytoplasm. Special organelles

1. The structure and functions of Microfilaments.
2. The structure and functions of Microtubules.
3. The structure and functions of Cytocentrum (centrosome).
4. The structure and functions of Cilia and Flagella.
5. Name types of Inclusions and their functions.

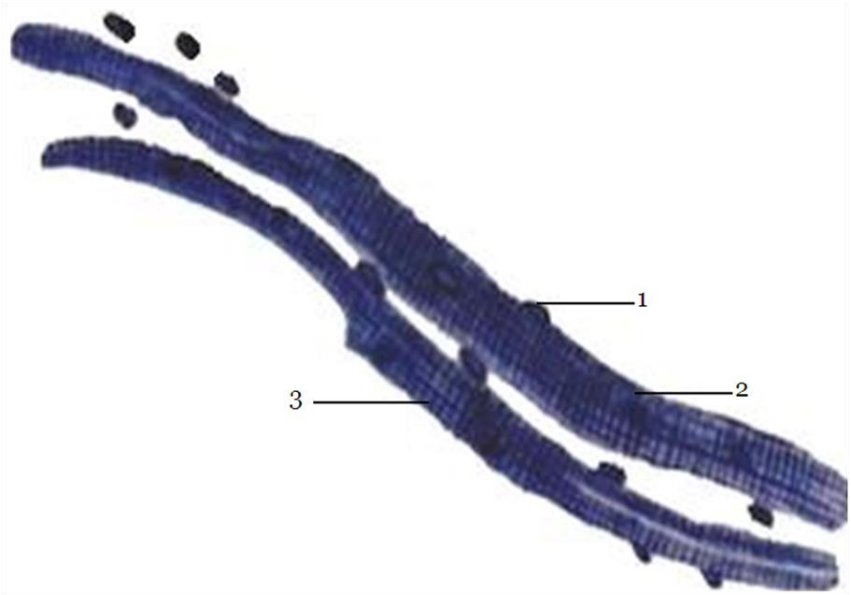
Practical part



Slide 1 – Liver cells (hepatocytes)

Staining: hematoxylin–eosin.

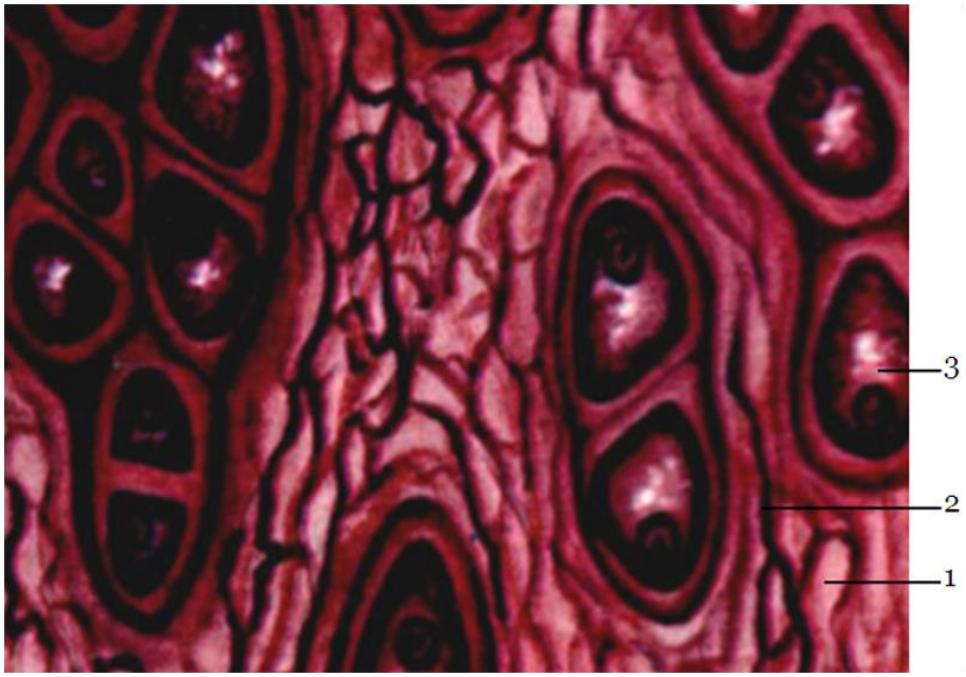
1 – hepatocyte; 2 – nucleus; 3 – cytoplasm; 4 – cell membrane; 5 – capillaries.



Slide 2 – Symplast

Staining: iron hematoxylin.

1 – nucleus; 2 – muscle fibre; 3 – striations.



Slide 3 – Extracellular substance (elastic cartilage)

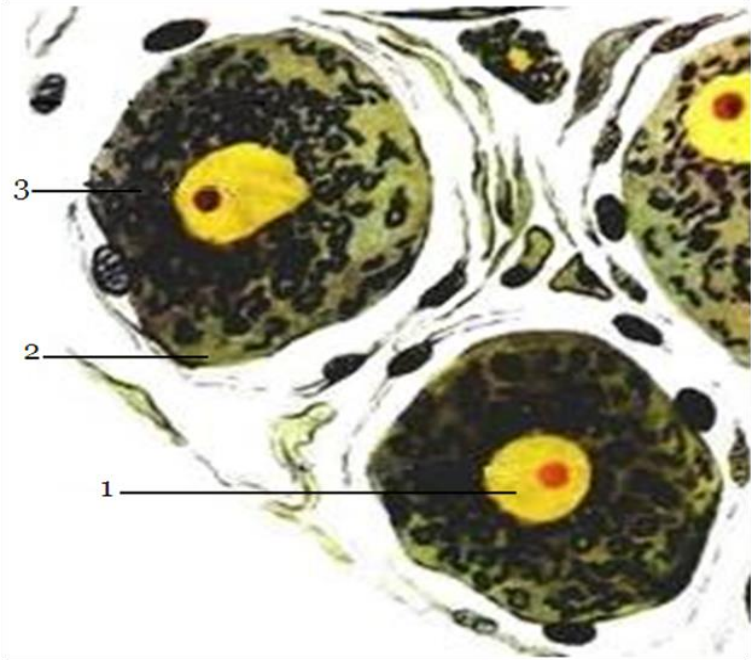
Staining: orsein.

1 – basal substance; 2 – network of elastic fibres; 3 – chondrocytes.

Slide 4 – Mitochondria

Staining: hematoxylin–eosin.

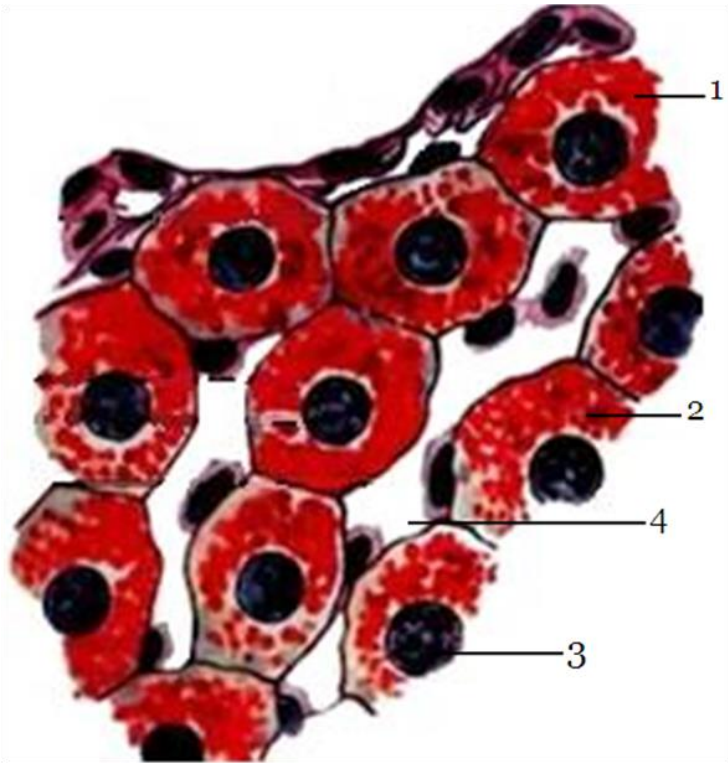
1 – mitochondria; 2 – nucleus; 3 – lumen of the tubules kidney.



Slide 5 – Golgi apparatus in the nerve cell of spinal ganglia

Staining: osmium – impregnated.

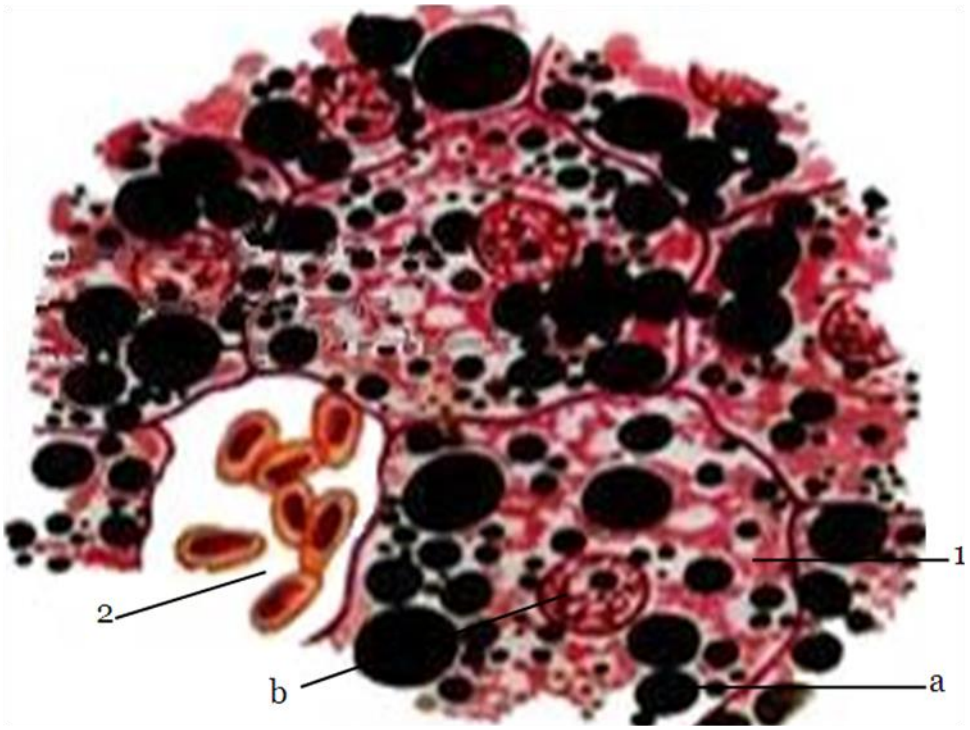
1 – nucleus; 2 – cytoplasm; 3 – Golgi apparatus.



Slide 6 – Glycogen inclusions in the liver cells

Staining: Best's method.

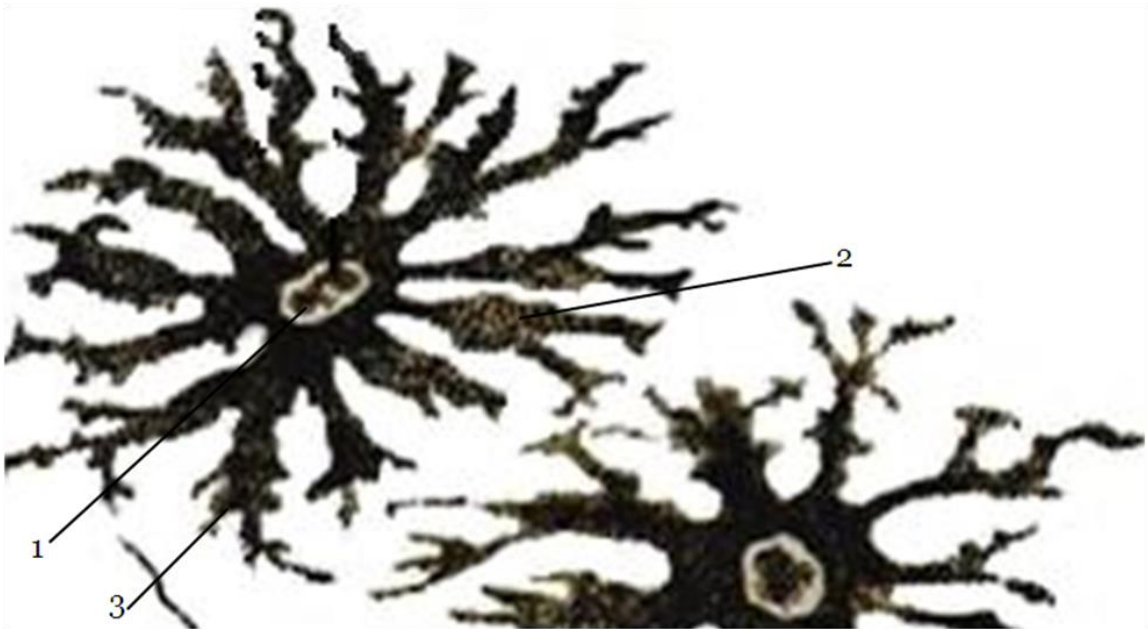
1 – hepatocyte; 2 – glycogen granules; 3 – nucleus; 4 – capillaries.



Slide 7 – Lipid inclusions in the liver cells

Staining: safranin and osmium – impregnated.

1 – hepatocyte: a – lipid inclusions; b – nucleus; 2 – capillaries.



Slide 8 – Pigment inclusions in the melanocytes

Staining: slide is not stained.

1 – nucleus; 2 – pigment granules in the cytoplasm; 3 – cell processes.

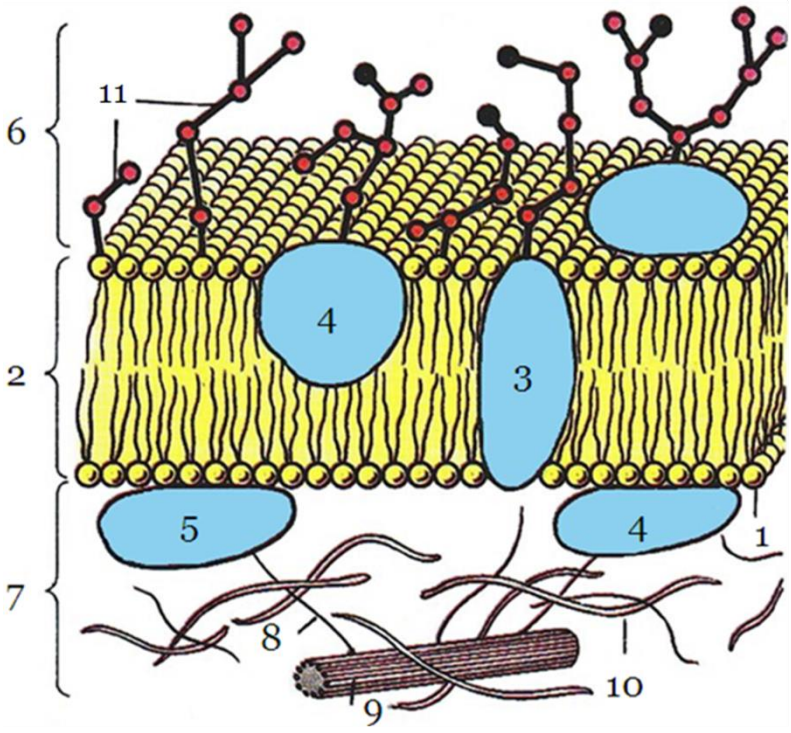


Figure 1 – Structure of the plasmalemma

1 – lipid molecule: a) head; b) tail; 2 – elementary biological membrane; 3 – half integral proteins; 4 – integral proteins; 5 – peripheral proteins; 6 – glycocalyx; 7 – cortical layer; 8 – microfilaments; 9 – microtubules; 10 – glycoproteins; 11 – glycolipids.

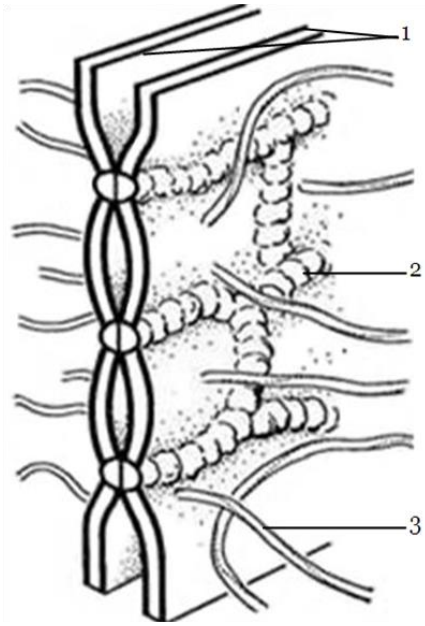


Figure 2 – Zonula occludens

1 – plasmalemma; 2 – integral proteins; 3 – microfilaments.

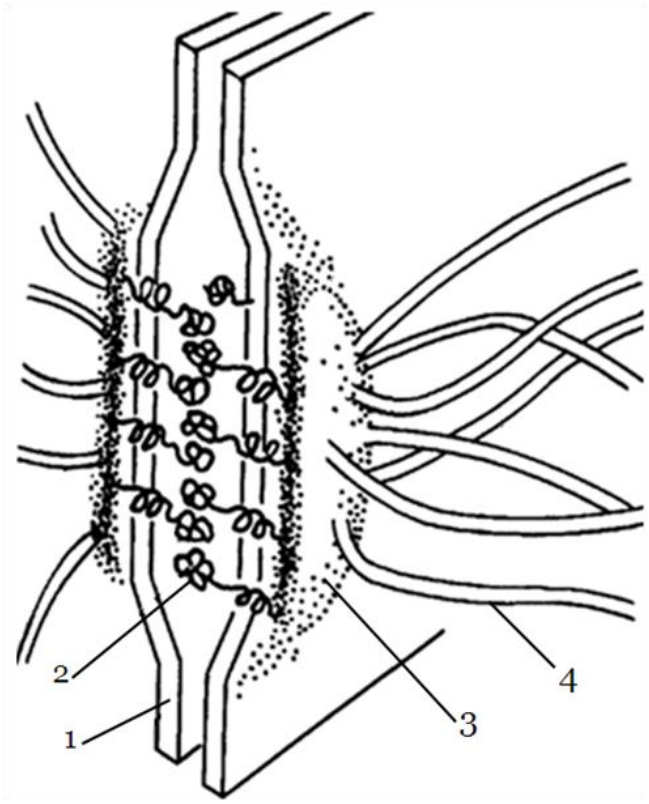


Figure 3 – Desmosome

1 – plasmalemma; 2 – linker glycoproteins; 3 – cytoplasmic plaque; 4 – intermediate filaments.

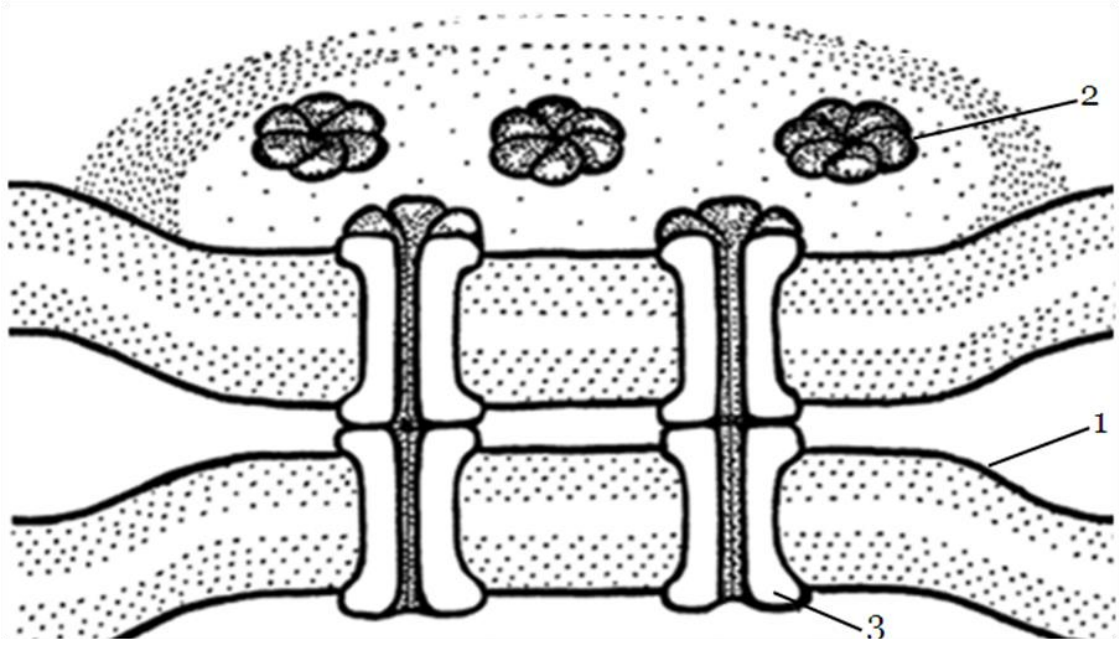


Figure 4 – Gap junction (nexus)

1 – plasmalemma; 2 – integral proteins; 3 – connexons.

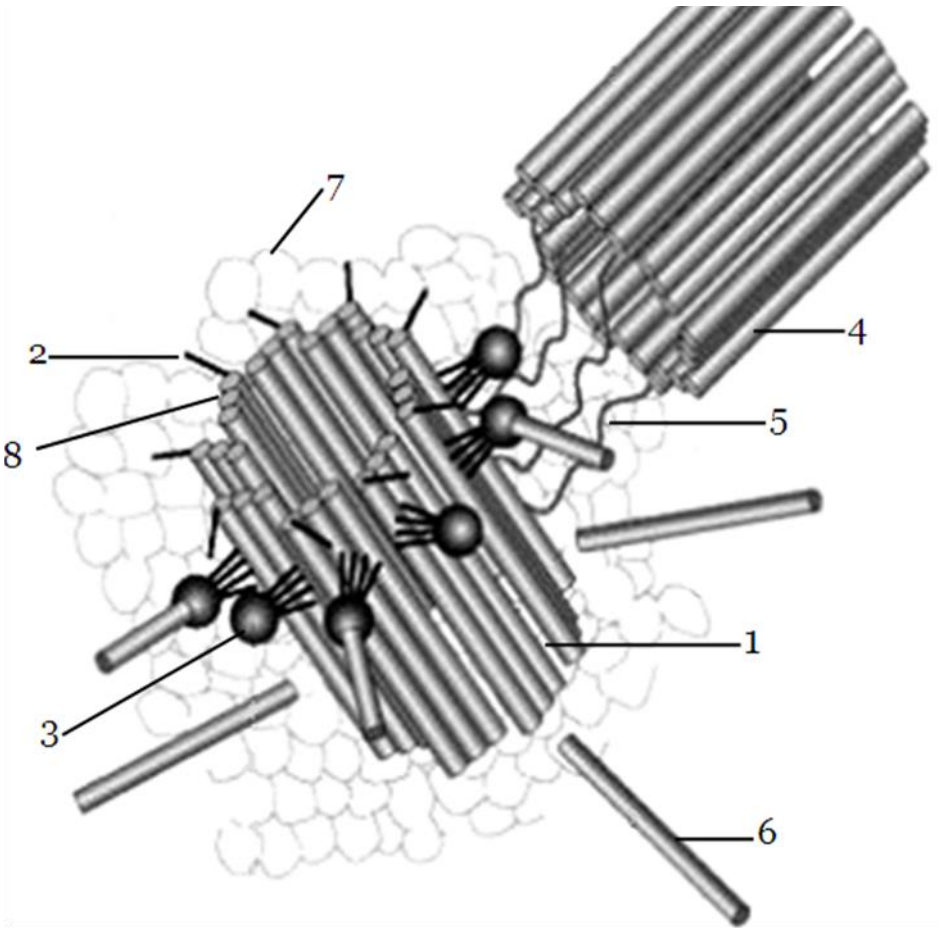


Figure 5 – Centrosome

1 – maternal centriole; 2 – distal appendages; 3 – subdistal appendages; 4 – daughter centriole; 5 – interconnecting fibres; 6 – microtubule; 7 – PCM; 8 – triplets of microtubules.

Topic: The nucleus of the cell. Reproduction of cells. Aging and death of cells

Nucleus is the most important component of the cell, containing its genetic apparatus.

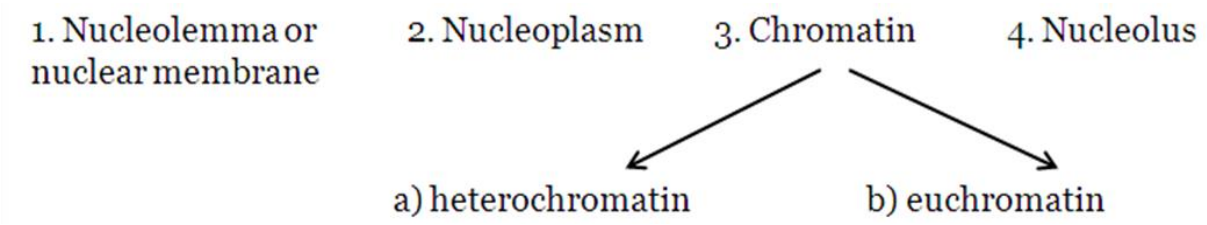
The nucleus functions:

1. Storage of genetic information (containing DNA constant structure).

2. Reproduction and transmission of genetic information (duplication of genetic material and division between daughter cells).

3. Realization of genetic information (formation of protein synthesis apparatus).

Nucleus structure of interphase cell



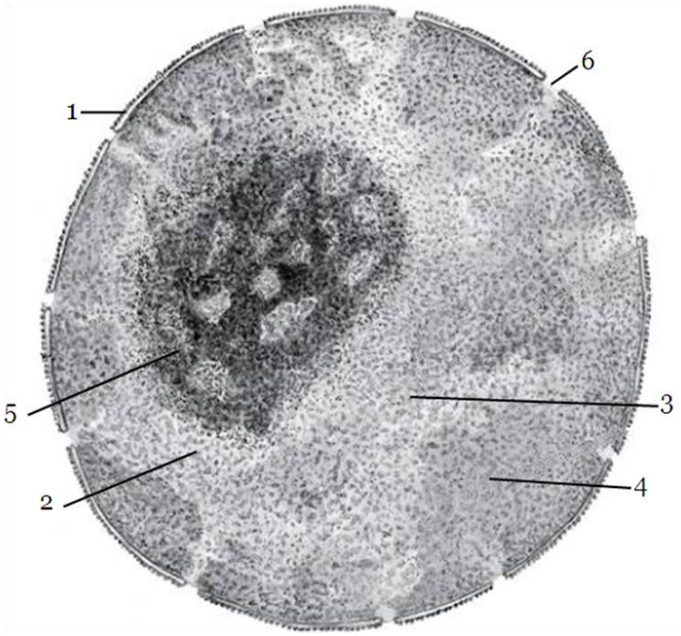


Figure 1 – Interphase nucleus

1 – nucleolemma; 2 – nucleoplasm; 3 – euchromatin; 4 – heterochromatin; 5 – nucleolus; 6 – nuclear pore.

Nucleus is separated from the cytoplasm by the nucleolemma. It has such morphological features:

1) It consists of two biomembranes – inner (7 – 8 nm) and outer (7– 8 nm).

2) Membranes of the nucleolemma are separated by perinuclear space (20 – 60 nm).

3) There are nuclear pores in the nuclear envelope for the communication between cytoplasm and nuclear cavity. These pores are formed as a result of confluence of inner and outer membranes.

4) Nuclear pores contain fibrillar–globular molecular complexes forming the diaphragms. They permit and regulate the exchange of macromolecules and ribosomal subunits, the substances between nucleus and cytoplasm. The more nuclear pores are, the more intensively bioenergetic processes in the cell occur.

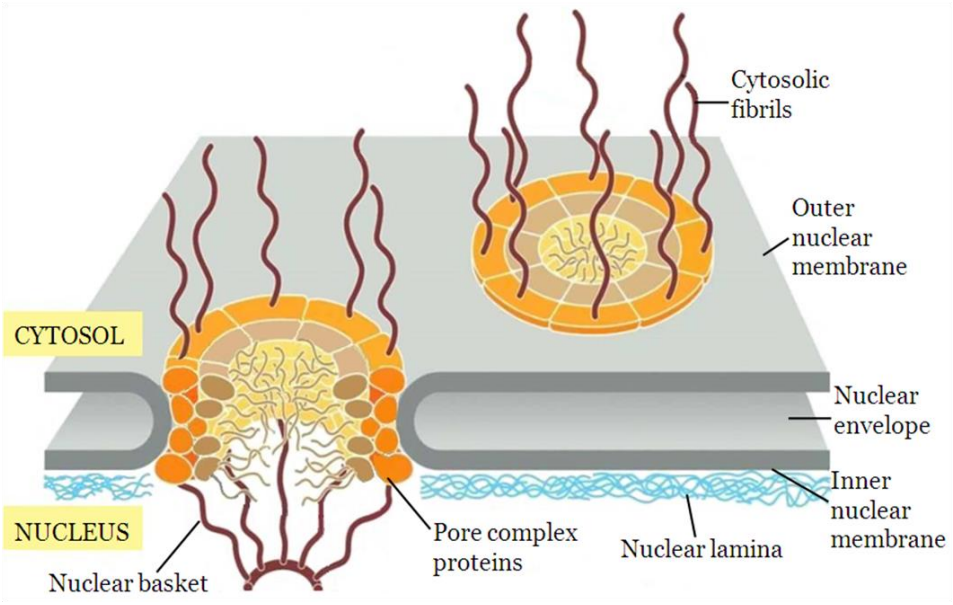


Figure 2 – Nuclear pore complex

The nucleus contains:

1. Nucleoplasm. This is a fluid part of the nucleus with nuclear structure here. Nucleoplasm is like hyaloplasm according to its features.

2. Chromatin is the structural manifestation of chromosomes in interphase. Chromosome is the structural and functional unit of the

nucleus. It is connected with the storage and transmission of genetic information. The molecule of DNA is the molecular base of chromosome. The genetic information is recorded in this molecule.

Interphase chromosome structure

Each chromosome contains one long DNA molecule (consisting of a double helix) and DNA – connecting proteins – *histones*. DNA molecules are coiled on the histone proteins. Histones are situated along DNA not evenly, but in the form of blocks consisting of eight histone molecules. The protein block is called *core.* The site of the DNA strand on the histone core is called *nucleosome*.

Nucleosomes form chromatin fibril. Chromatin fibril represents a beaded strand, where each bead is a nucleosome. Additional condensation of chromatin fibril leads to the formation of a loop *domain.* Condensed sites of chromosomes are formed, which are different from decondensed sites with less compact envelope of chromatin fibril. The presence of condensed and decondensed sites are characteristic for interphase chromosomes.

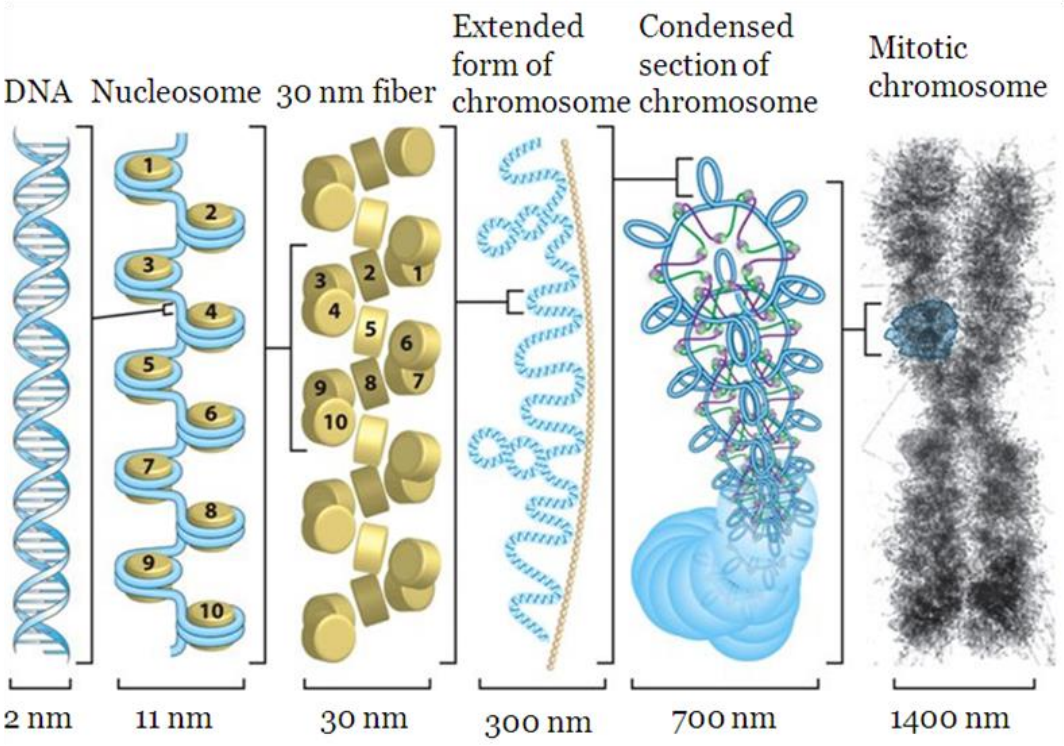
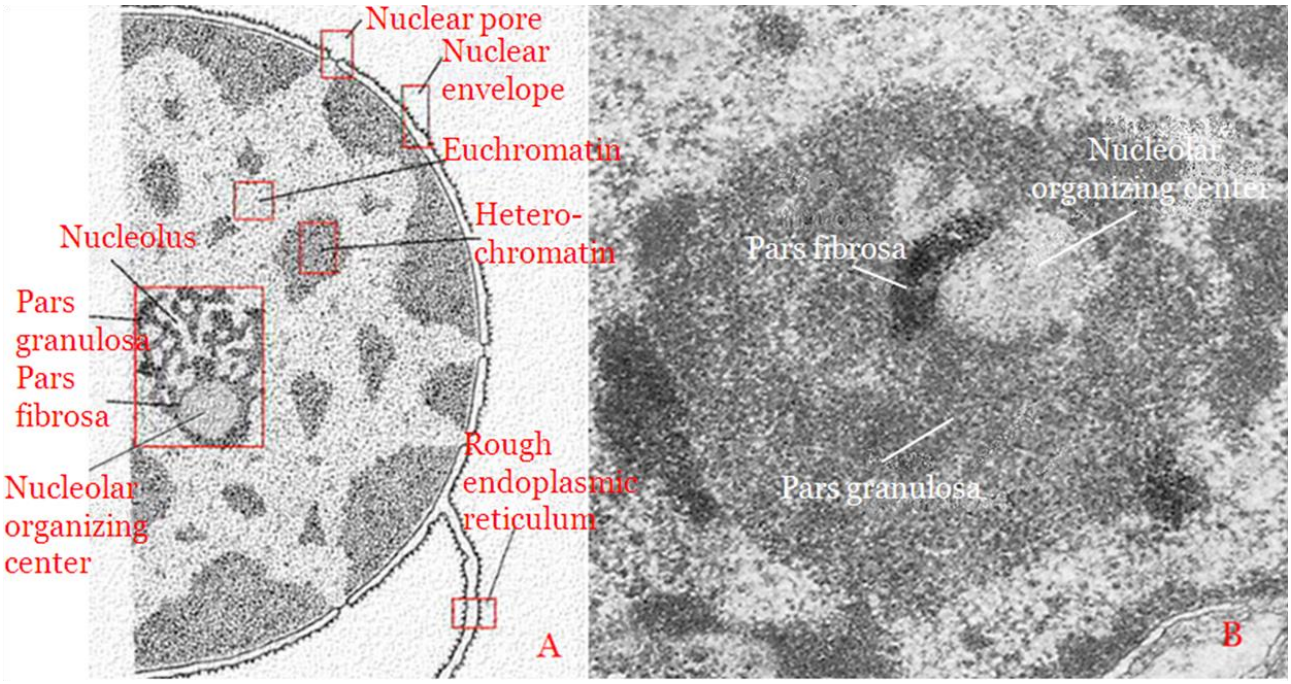


Figure 3 – DNA packaging into chromatin and chromosome

In the microscopic preparations the condensed sites represent *heterochromatin (nonactive)* and decondensed ones *euchromatin (active),* with which the information needed for the protein synthesis replicates.

Structure of nucleolus

Nucleolus is the derivative of chromosomes. It consists of repeatedly replicated sites of DNA. Nucleolus is the place formation of ribosomal RNA and ribosomes. It consists of fibrillar and granular components. Fibrillar components are ribonucleoprotein aceous bands, which are precursors of ribosomes, and granulars are ribosome subunits, which are forming.



Slide 1 – Ultrastructure of the nucleus (A) and nucleolus (B)

Cell cycle

Cell like any biological system has the beginning and end of its existence. Life cycle of any cell begins with its formation as a result of division of precursor cell and consists of two main phases:

1) interphase (G1, S, G2 periods);

2) mitosis.

Interphase is the whole life period of a cell from its formation until its division. There are three periods in the interphase: postmitotic,

synthetic and premitotic. The length of each period is determined by the genetic programme.

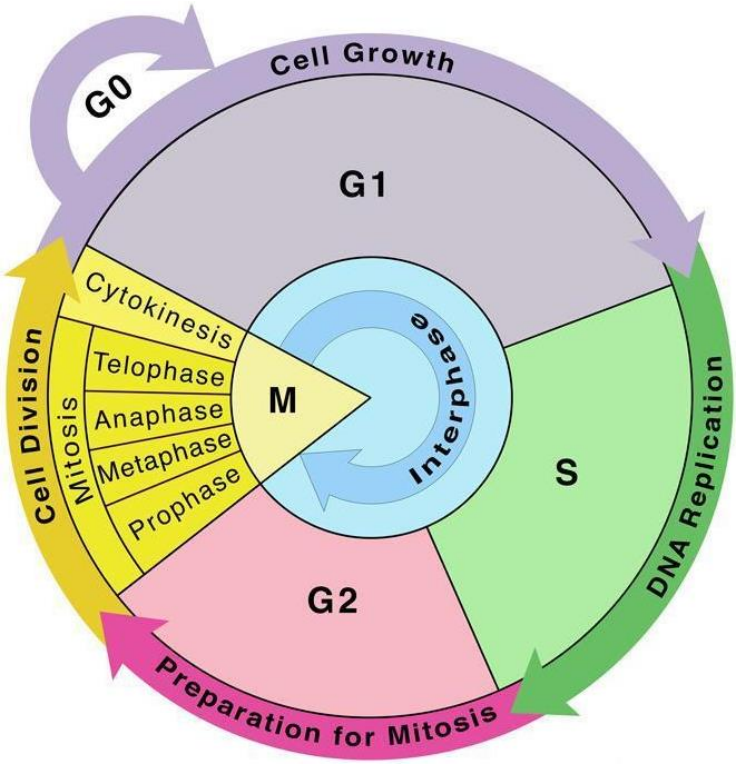


Figure 4 – Cell cycle

Postmitotic (presynthetic) G1. This period is characterized by the cell growth, its differentiation, acquiring specific external and internal structure and carrying out its main functions. This is the period of intensified growth of a young cell thanks to synthesis and accumulation of cell protein. The growth period completes in a certain period of time and the cell begins to fulfill the full volume of its functions. Under the influence of special inductors a part of the cells enters the S phase.

Synthetic period (S). During this period of DNA molecules replication takes place, and hence, the number of chromosomes increases as well. At the end of this period the nucleus has not 2n (sets) but 4n (sets) of genetic material.

During the S period centrioles duplication of cellular centre occurs. In this period autosynthesis prevails over heretosynthesis. Autosynthesis is the period when synthesized protein is used by the cell itself and heretosynthesis is the period when proteins leave the cell. S–period is followed by G2 period.

Premitotic (postsynthetic) period G2. During this period heretosynthesis stops completely and synthesis of tubulin protein molecules occurs. The tubulin protein is necessary for formation of division spindles. G2 period is followed by mitosis.

In weakening of inductor action the cell can reduce biosynthetic processes considerably and turn into a condition of relative rest G0. These are cells that stop dividing temporarily or completely. There are several types of cells in the G0 period.

The *first type* is the stem cells of various tissues (for example hemopoiesis). These are low differentiated cells, which are capable of dividing for a long time. They leave the cycle and enter the G0 period. The cells, which lose their ability to divide during their differentiation, concern the *second type.* These cells, for example high specialized blood cells, perform their functions for a certain period of time and then die. But there is a group of cells, which under special conditions can enter the cycle again and divide, for example liver cells.

The third type of cells during the G0 period is highly differentiated cells, which completely lose the ability to divide. Their life period is equal to the life period of the organism itself, for example nerve cells, cardiomyocytes.

Mitosis

Mitosis or kariokinesis or indirect cell division. Somatic cells of the organism are divided in this way. Mitosis consists of four phases: prophase, metaphase, anaphase and telophase.

Prophase. During prophase chromosomes become coiled or condensed. Each of these chromosomes consists of two DNA molecules. The formation of the division spindle occurs as a result of divergency of centriole cellular centres to the poles of the cell. The division spindle is formed by polymerization of tubulin and is situated between centrioles. At the termination of prophase nucleolus disappears, nucleolemma destroyed and condensed chromosomes enter the cytoplasm.

Metaphase. All chromosomes move towards the equator of the cell. In the middle of the metaphase chromosomes are aligned along the equator and attached to the microtubules of the spindle by their centromeres (primary strangulation) and free ends of the chromosome face the cytolemma. At this stage one can see the mother aster.

Anaphase. All sister chromatids (daughter chromosomes) in all chromosomes lose connection between themselves in the region of centromeres and begin moving toward the opposite poles of the cell.

Telophase. When the chromosomes have diverged and stopped, telophase begins. Nucleolemma formation around every complex chromosome and formation of new nucleoli occurs. The division of cell body – cytokinesis, occurs by indrawing of cytolemma along the equatorial plate. As a result two new cell bodies of equal size are formed. At the end of telophase chromosomes become decondensed, formation of membranous and nonmembranous structures of the cell occur. These processes mean the beginning of the first life period of a new cell – G1 of interphase.

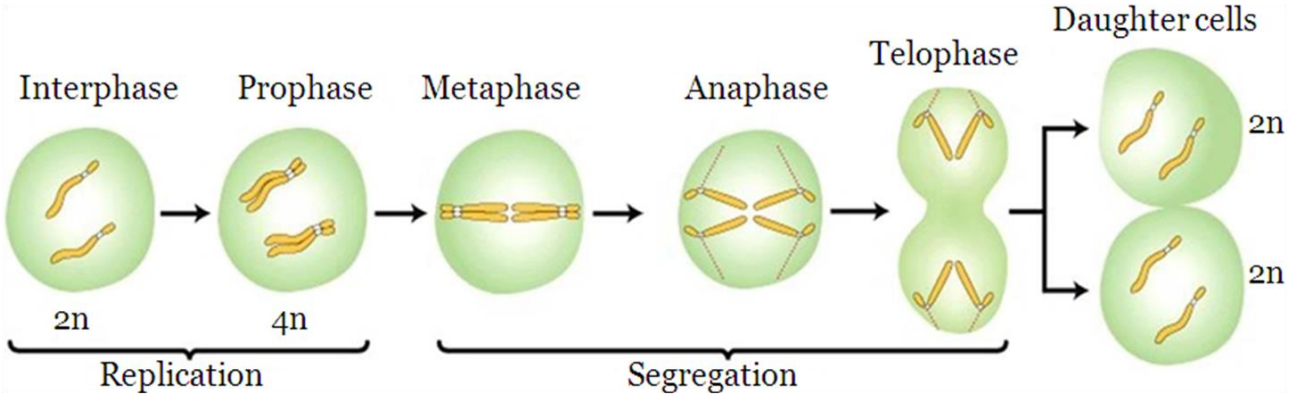


Figure 5 – Mitosis

Polyploidy

Polyploidy is the formation of cells with increased content of DNA. Appearance of polyploid somatic cells can be seen during the cytokinesis blockade. As a result two nuclei cells are formed, for example liver cells.

Endoreduplication

Several cycles of DNA reduplication without subsequent mitosis occurs. This leads to an increase of DNA numbers in the nucleus. Such polyploid bone nuclei are in megakariocytes (cells of red marrow).

Meiosis

Meiosis is a specialized type of cell division that produces the germ cells – ova and spermatozoa. This process has two crucial results: 1) reduction in the number of chromosomes from the *diploid* (*2n*) to the *haploid* (*1n*) number, and 2) recombination of genes, genetic variability and diversity of gene pool.

Meiosis is divided into two separate divisions.

Meiosis I (Reductional division)

Meiosis begins at the conclusion of interphase in the cell cycle. In gametogenesis, when the germ cells are in the *S phase* of the cell cycle preceding meiosis, the amount of DNA is doubled to *4n* (sets) and the chromosome number is also doubled to *4n*.

Prophase I

Prophase of meiosis I lasts for a long time and is subdivided into the five phases.

1. Leptotene. Individual chromosomes, composed of two chromatids begin to condense, forming long strands in the nucleus.

2. Zygotene. Homologous pairs of chromosomes approximate each other, lining up in register (gene locus to gene locus), and make the *synaptonemal complex,* forming tetrad of chromatids.

3. Pachytene. Chiasmata (crossing over sites) are formed, exchange of genetic material occurs between homologous chromosomes.

4. Diplotene. Chromosomes begin to separate, revealing chiasmata.

5. Diakinesis. Chromosomes condense maximally and nucleolus disappears.

Metaphase I. During metaphase I homologous chromosomes align as pairs on the equatorial plate.

Anaphase I. Homologous chromosomes migrate away from each other, going to opposite poles. Each chromosome still consists of two chromatids.

Telophase I. Telophase I is similar to the telophase of mitosis. The chromosomes reach the opposing poles and cytokinesis occurs, giving

rise to two daughter cells. Each cell possesses 23 chromosomes, the haploid (*1n*) number, but because each chromosome is composed of two chromatids, the DNA content is still diploid. Each of the two newly formed daughter cells enters meiosis II.

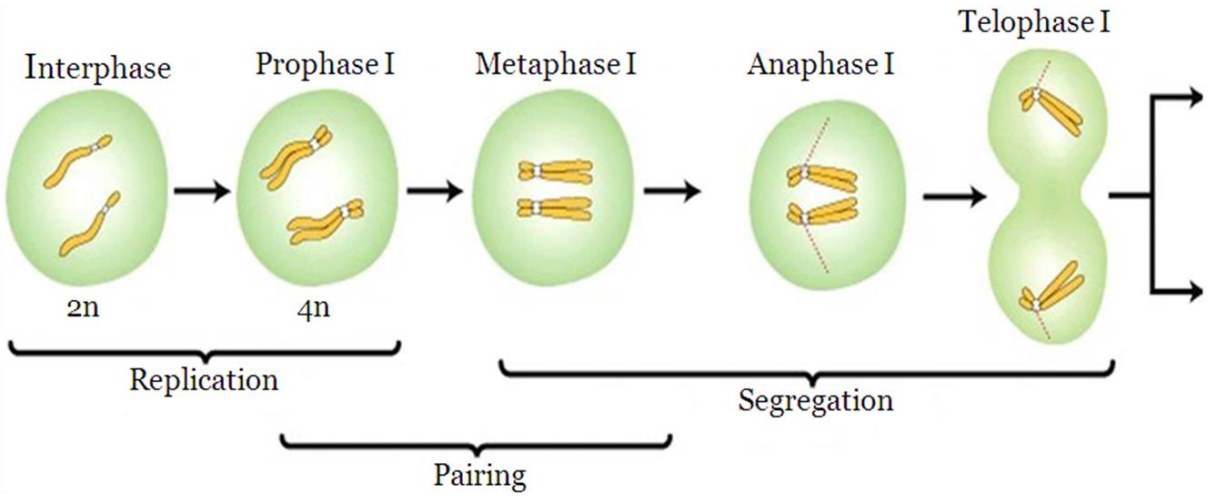


Figure 6 – Meiosis I

Meiosis II (Equatorial Division)

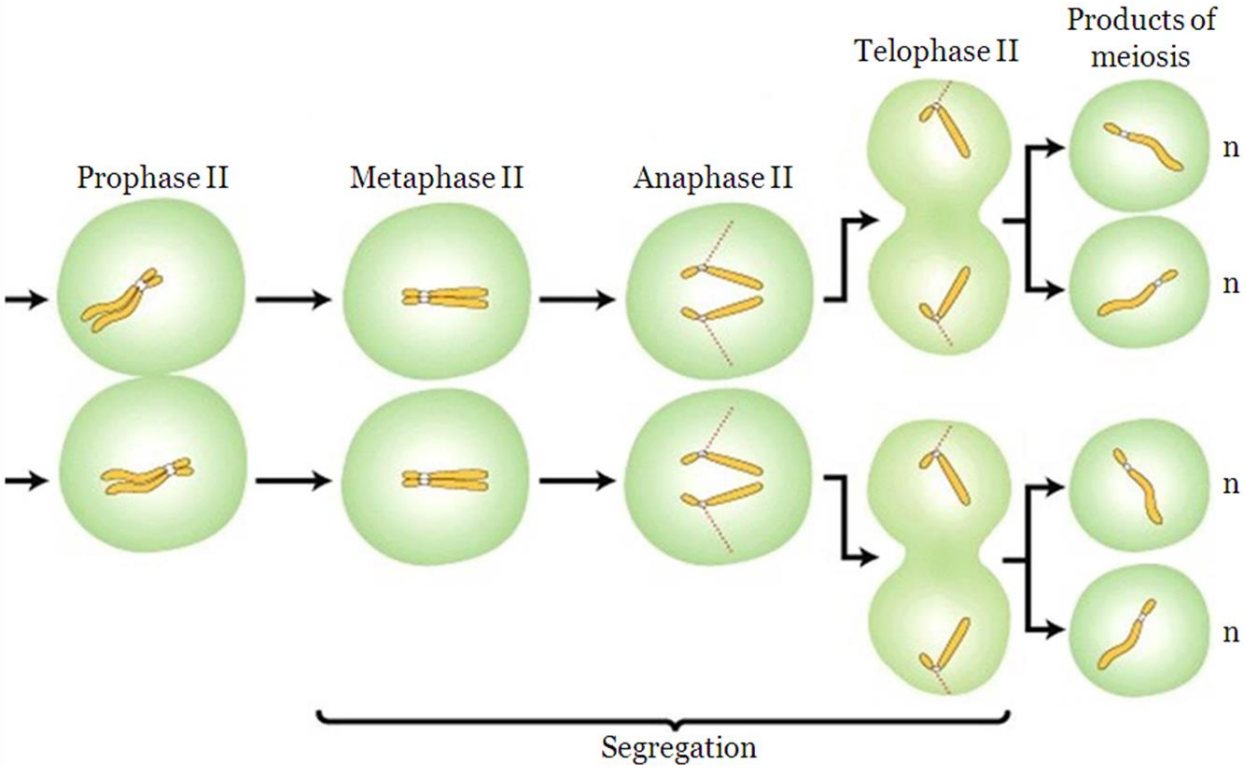


Figure 7 – Meiosis II

The equatorial division is not preceded by an S phase. It is very much like mitosis and is subdivided into *prophase II, metaphase II,*

anaphase II, telophase II, and cytokinesis. The chromosomes line up on the equator, followed by the chromatids migrating to opposite poles, and cytokinesis divides each of the two cells, giving a total of four daughter cells from the original diploid germ cell. Each of the four cells contains a haploid amount of DNA content and a haploid chromosome number.

Unlike the daughter cells resulting from mitosis, each of which contains the diploid number of chromosomes and is an identical copy of the other, the four cells resulting from meiosis contain the haploid number of chromosomes and are genetically distinct because of reshuffling of the chromosomes and crossing over.

Cell death

There are two forms of cell death: necrosis and apoptosis. Necrosis is caused by various external factors, chemical or physical, which influence the cell directly or indirectly and cause its death. Apoptosis is the programmed cell death.

Questions to the topics

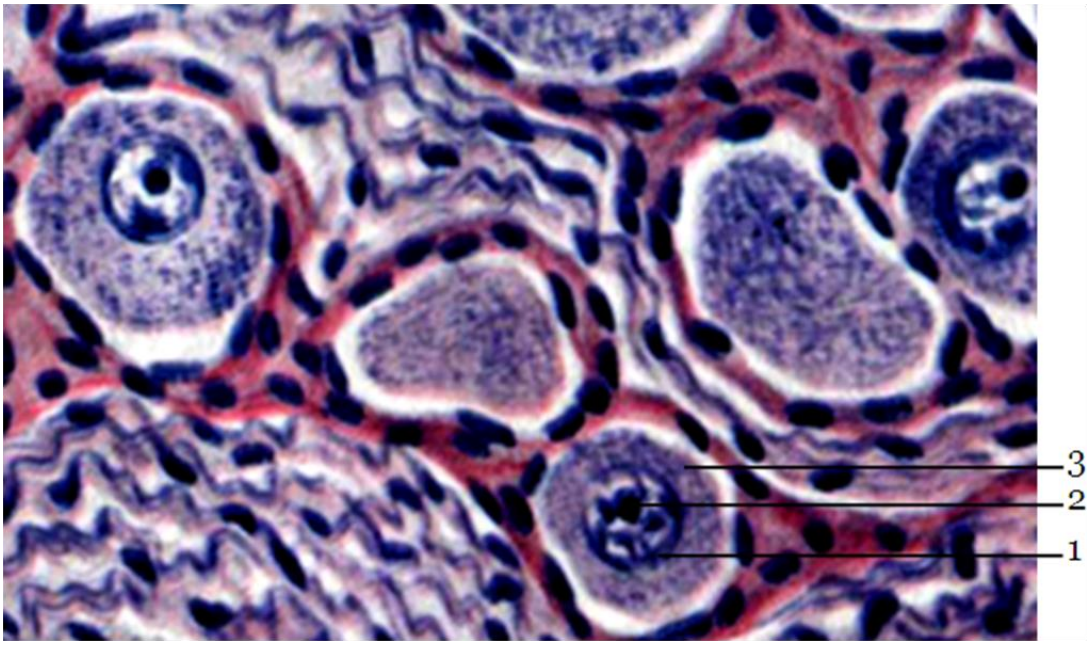
Theme 4: The Nucleus of the cell

1. The functions of the Nucleus.
2. Nucleus structure of interphase cell.
3. The structure and functions of Nuclear Pores.
4. The structure of Interphase Chromosomes.
5. The structure of Nucleolus.

Theme 5: Reproduction of the cells. Aging and death of cells

1. Cell cycle definition.
2. Stages of interphase, characteristic features:
a) postmitotic period G1;
b) synthetic period S;
c) premitotic period G2.
3. Stages of mitosis:
a) prophase;
b) metaphase;
c) anaphase;
d) telophase.
4. Characteristics of polyploidy and endoreduplication.
5. Meiosis peculiarities:
a) reductional division;
b) equatorial division.
6. Aging and death of cells. Necrosis and apoptosis.

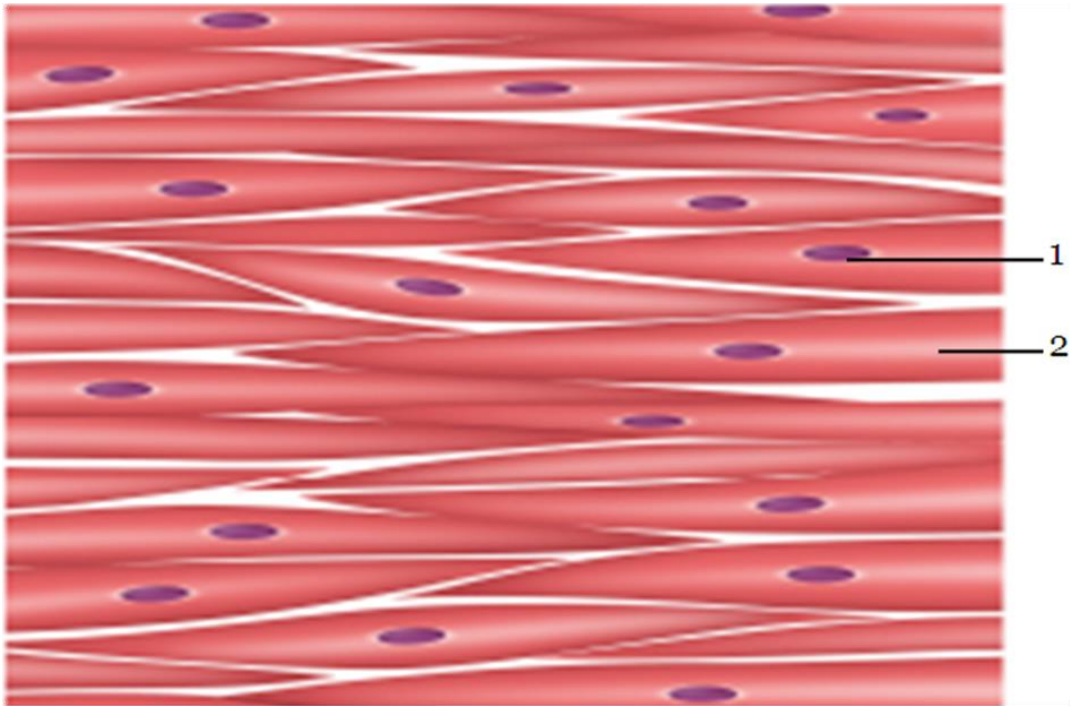
Practical part



Slide 1 – Cell with a round form of the nucleus

Staining: hematoxylin–eosin.

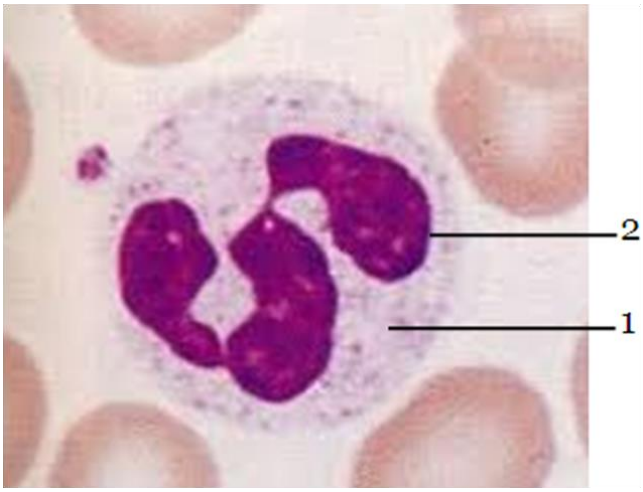
1 – nucleus; 2 – nucleolus; 3 – cytoplasm.



Slide 2 – Cell with a rod like nucleus

Staining: hematoxylin–eosin.

1 – nucleus; 2 – cytoplasm.



Slide 3 – Cell with a segmented nucleus

Staining: hematoxylin–eosin.

1 – cytoplasm; 2 – nucleus may have three to seven lobes connected by thin strands of nucleoplasm.

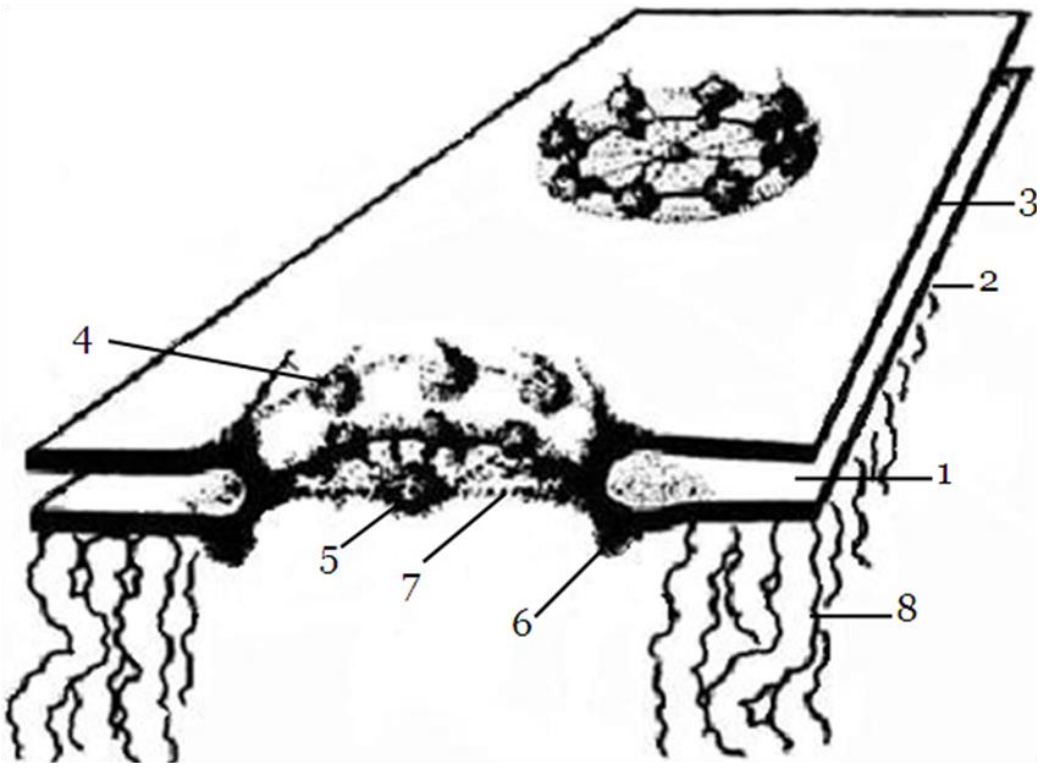
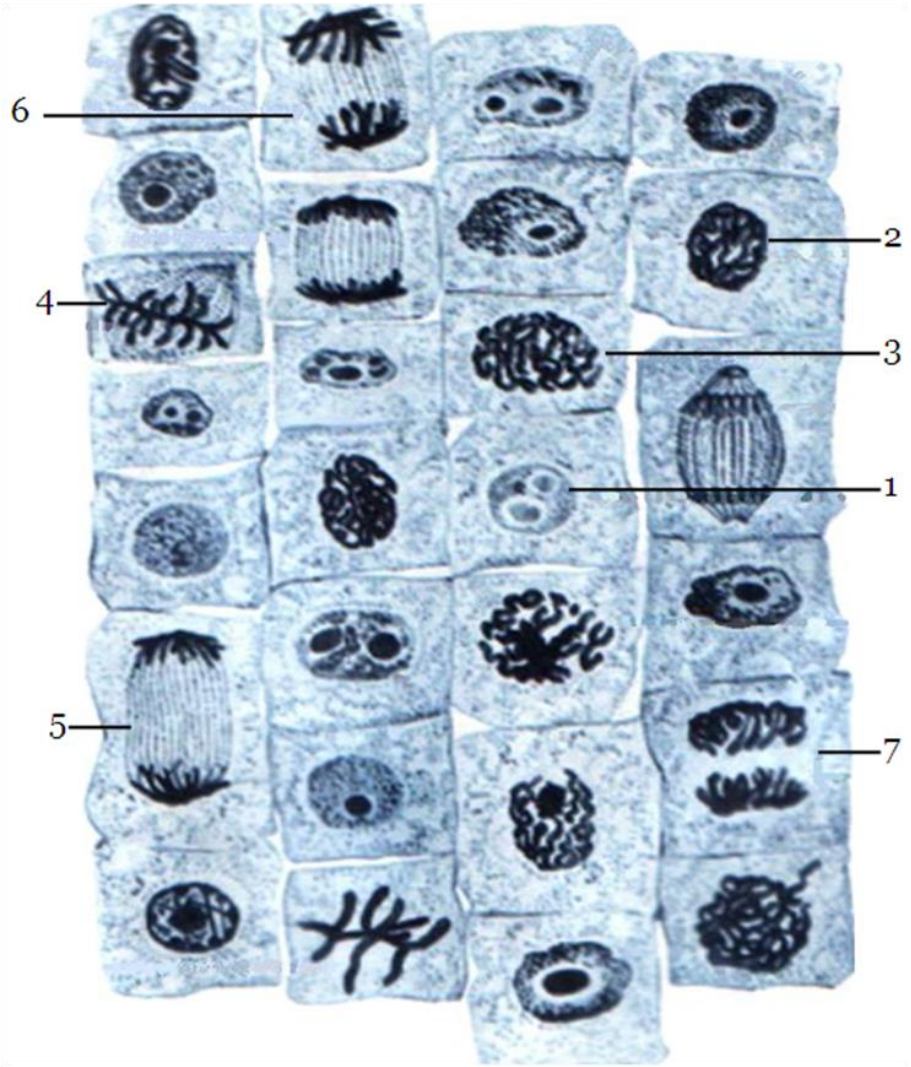


Figure 1 – Structure of nuclear pores

1 – perinuclear space; 2 – an inner membrane of a nuclear envelope; 3 – an outer membrane of a nuclear envelope; 4 – peripheral granules; 5 – central granule; 6 – fibrillar–globular molecules; 7 – diaphragm of pore; 8 – fibrils of chromatin.



Slide 4 – Mitosis

Staining: iron hematoxylin.

1 – interkines; 2 – early prophase; 3 – late prophase; 4 – metaphase; 5 – microtubules of spindle; 6 – anaphase; 7 – telophase.

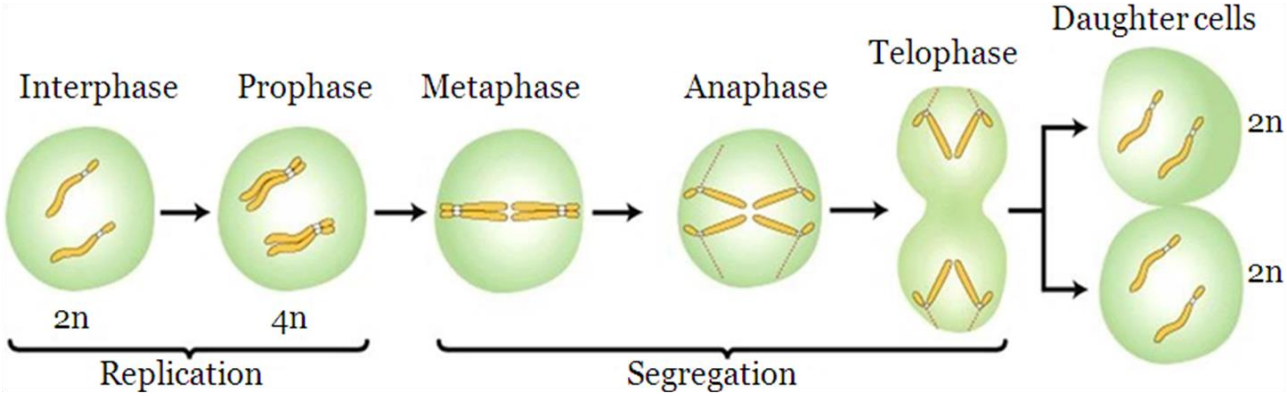


Figure 2 – *Mitosis*

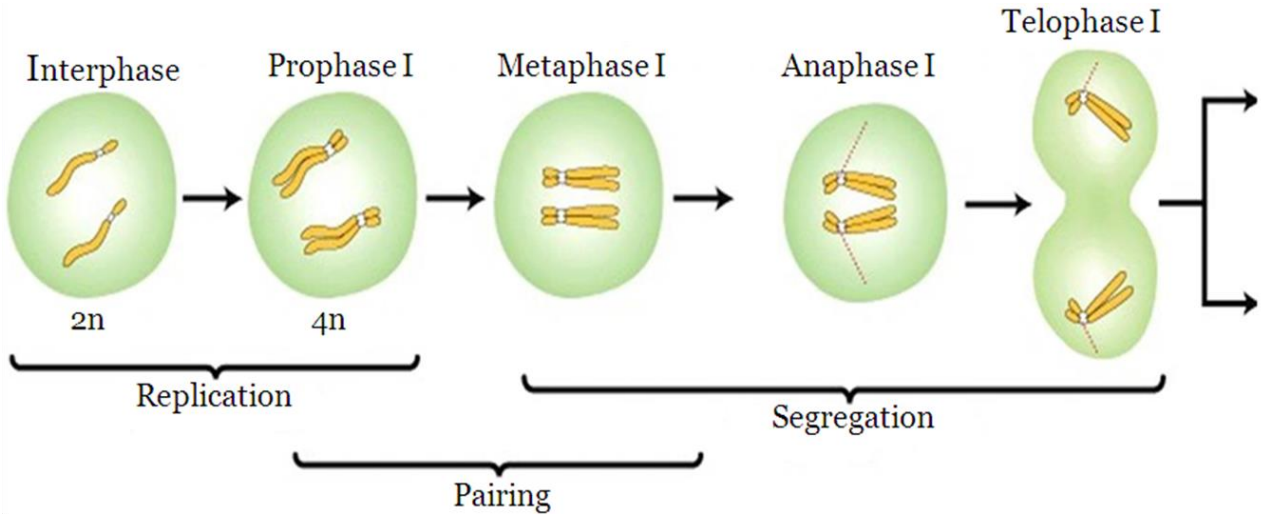


Figure 3 – Meiosis I

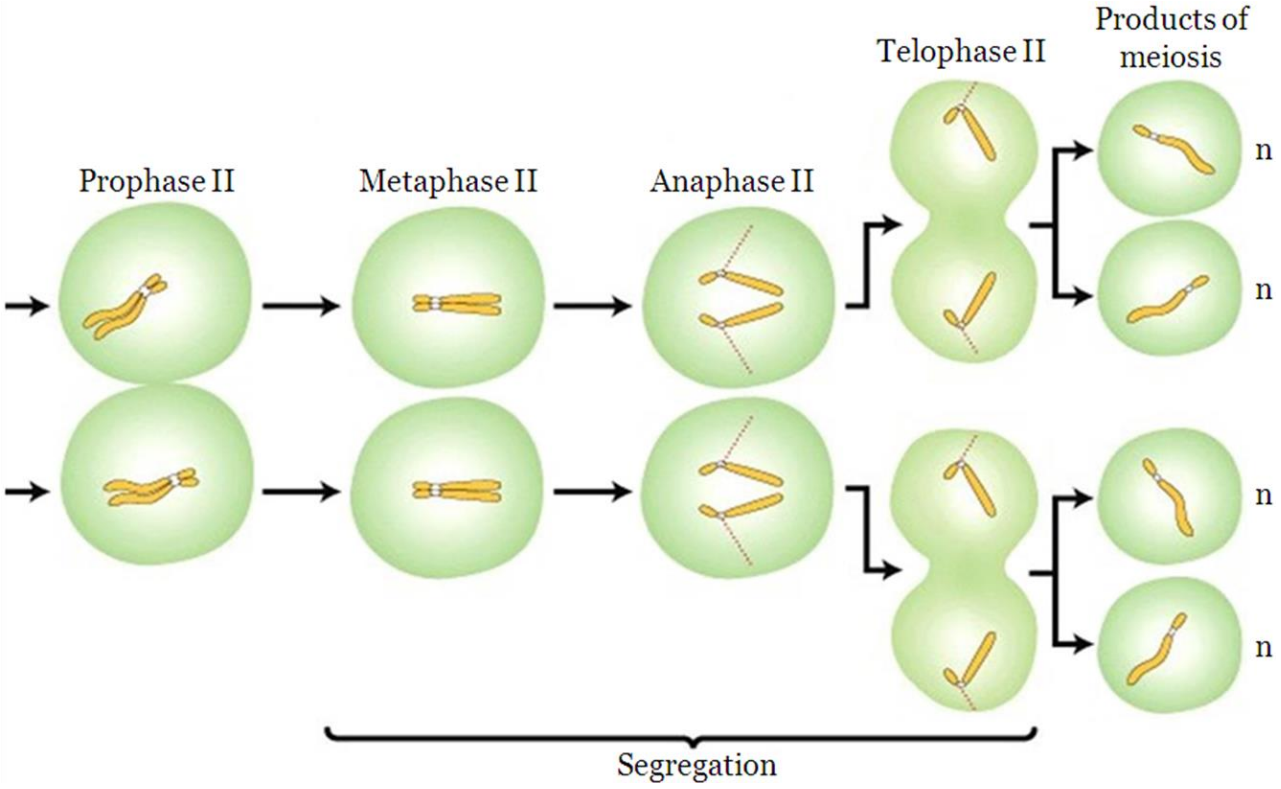
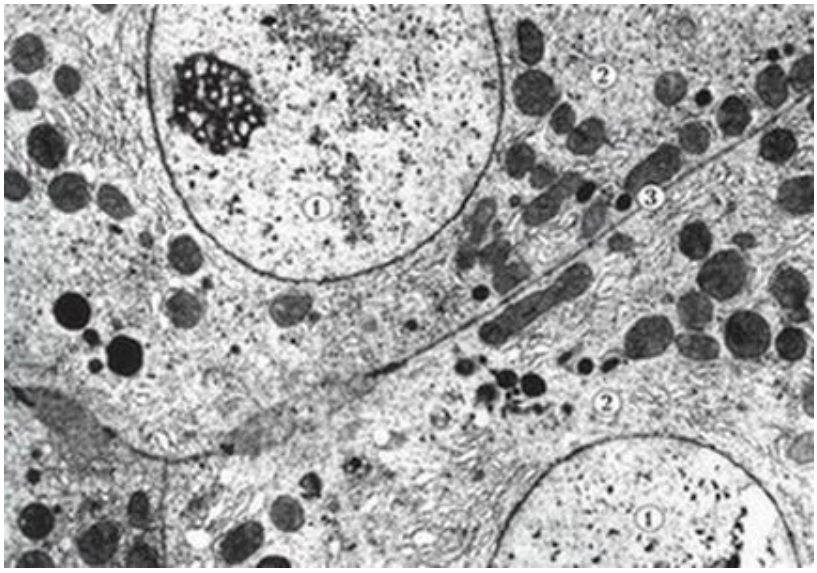


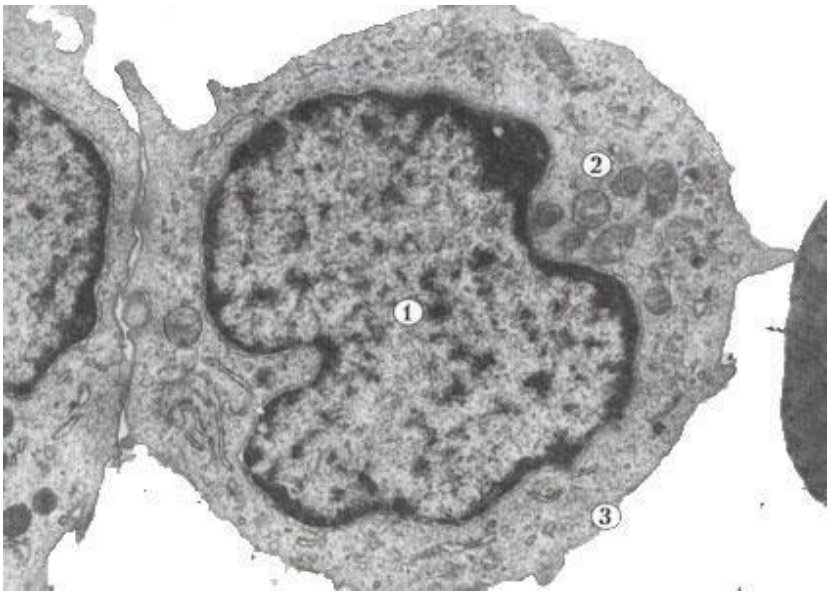
Figure 4 – Meiosis II

Electron Micrographs



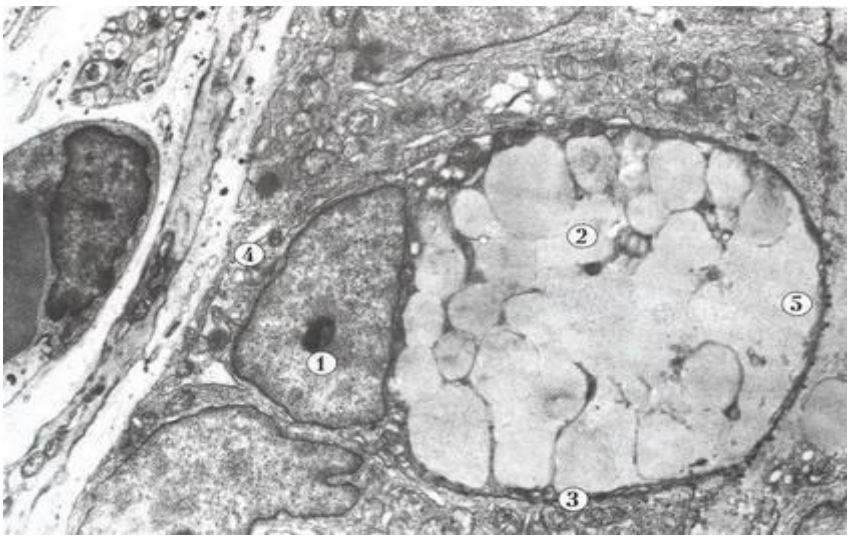
Ultrastructure 1 – Tightly attached cells of the liver (hepatocytes)

1. Nucleus.
2. Cytoplasm
3. Cell membranes of adjacent cells and narrow intercellular space.



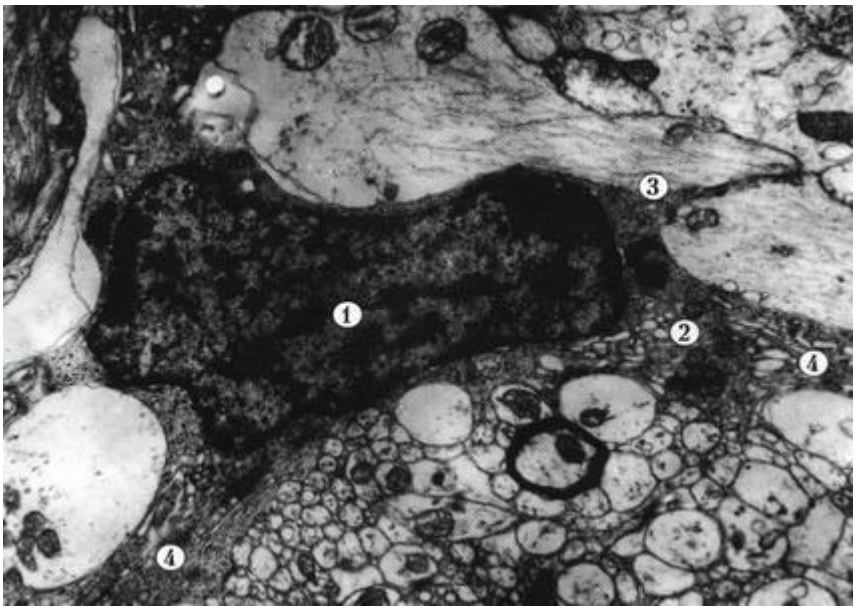
Ultrastructure 2 – Round–shaped cell (lymphocyte)

1. Nucleus.
2. Cytoplasm.
3. Plasmalemma.



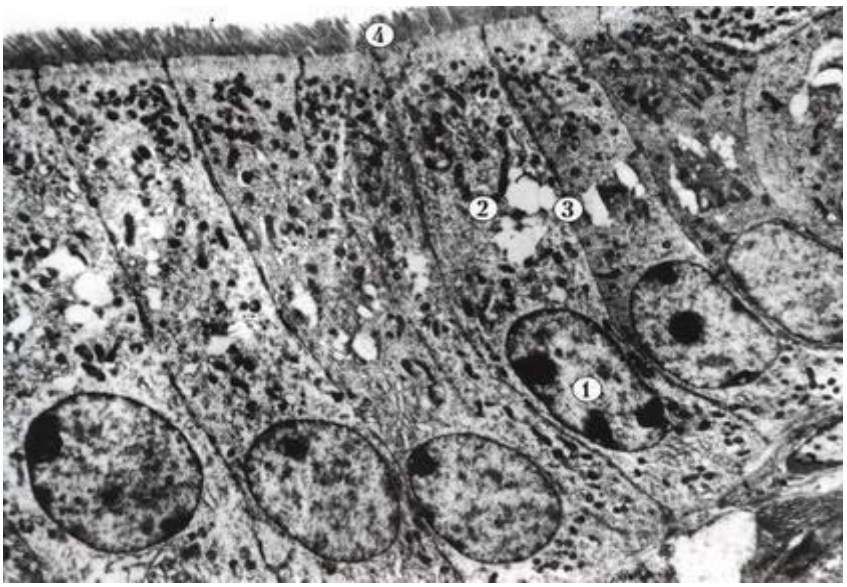
Ultrastructure 3 – Goblet cell (exocrinocyte)

1. Nucleus.
2. Cytoplasm with the secretory granules.
3. Plasmalemma.
4. Basal pole.
5. Apical pole.



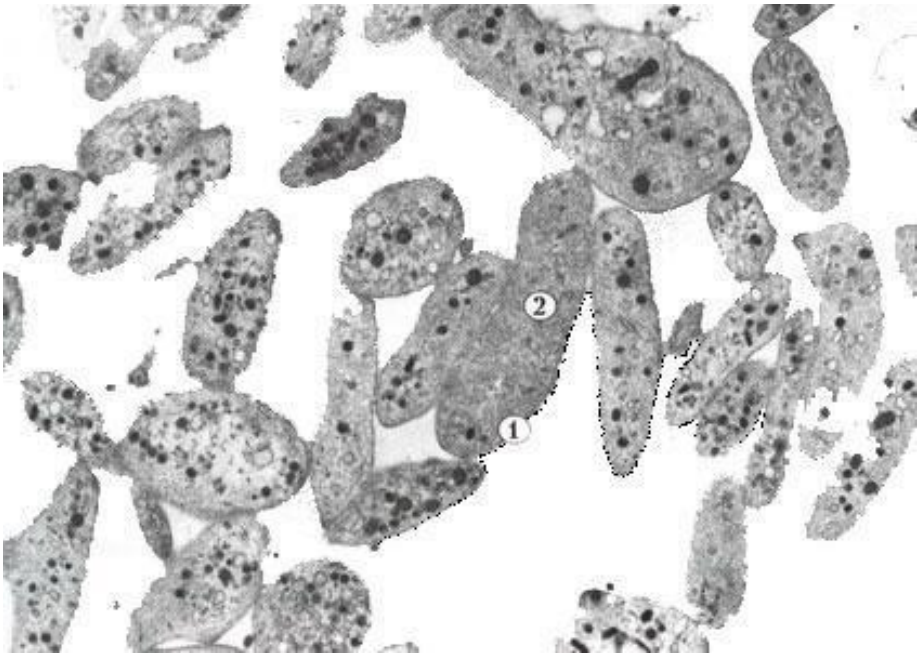
Ultrastructure 4 – Cell with the processes (neuron)

1. Nucleus.
2. Cytoplasm.
3. Plasmalemma.
4. Process.



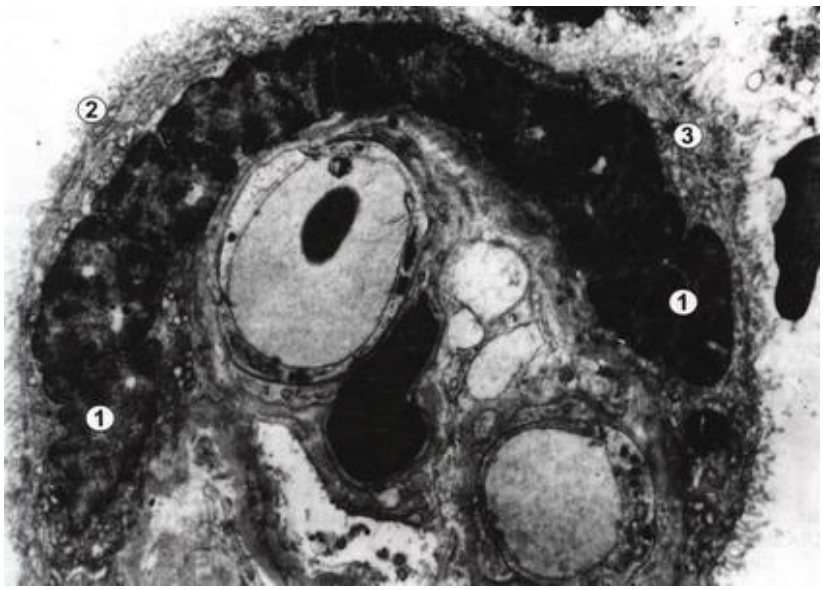
Ultrastructure 5 – Columnar cells (absorptive cells)

1. Nucleus.
2. Cytoplasm.
3. Plasmalemma.
4. Microvilli on the apical pole.



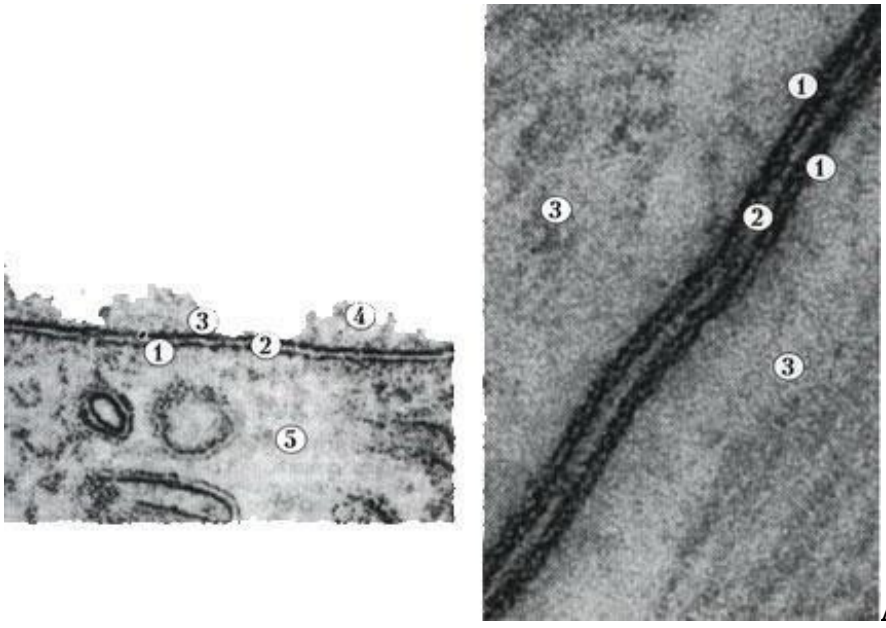
Ultrastructure 6 – Thrombocytes

1. Plasmalemma.
2. Cytoplasm.



Ultrastructure 7 – Multinuclear structure – symplast (chorionic villi)

1. Nucleoli.
2. Plasmalemma.
3. Cytoplasm.

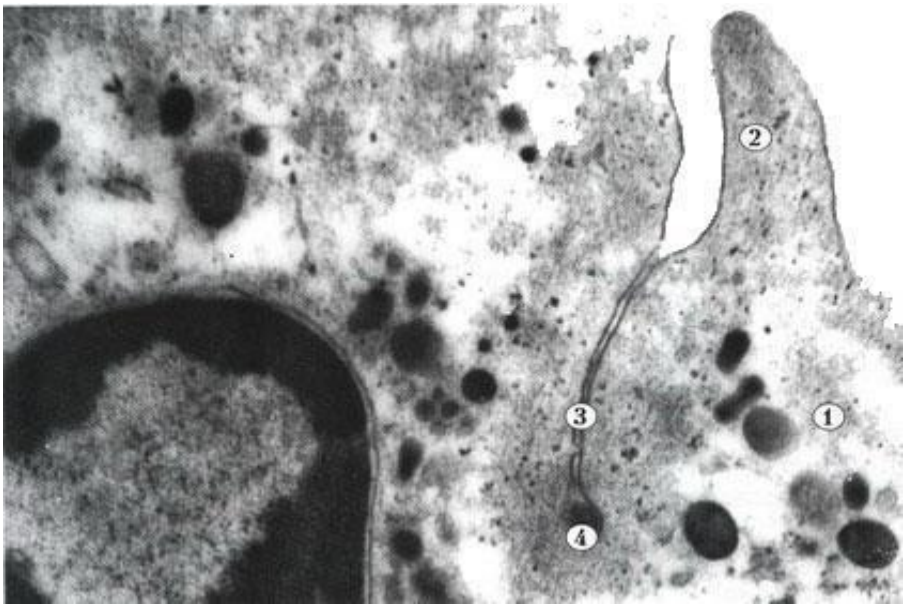


A

Ultrastructure 8 – Electron image of plasmalemma (trilaminar structure)

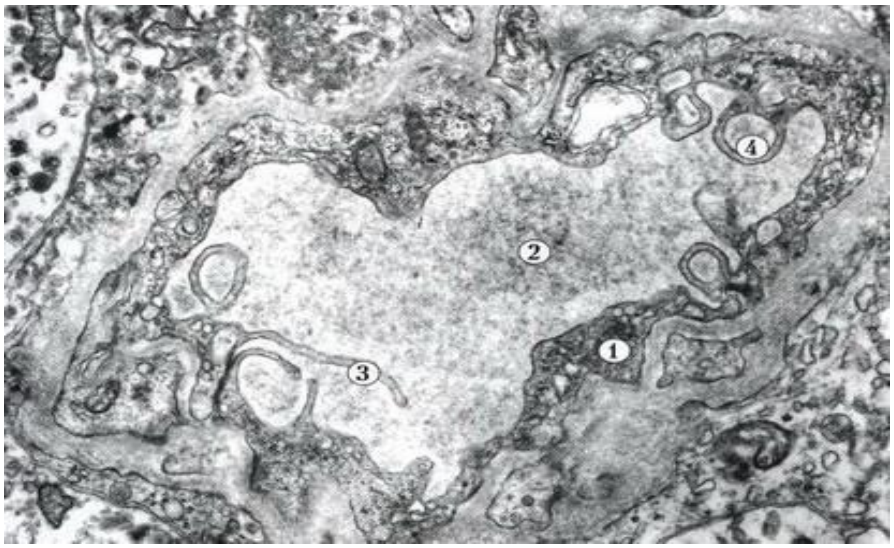
A – free surface of the cell:

1. Inner dense layer.
2. Intermediate electron lucid layer.
3. Outer dense layer.
4. Glycocalyx.
5. Cytoplasm.



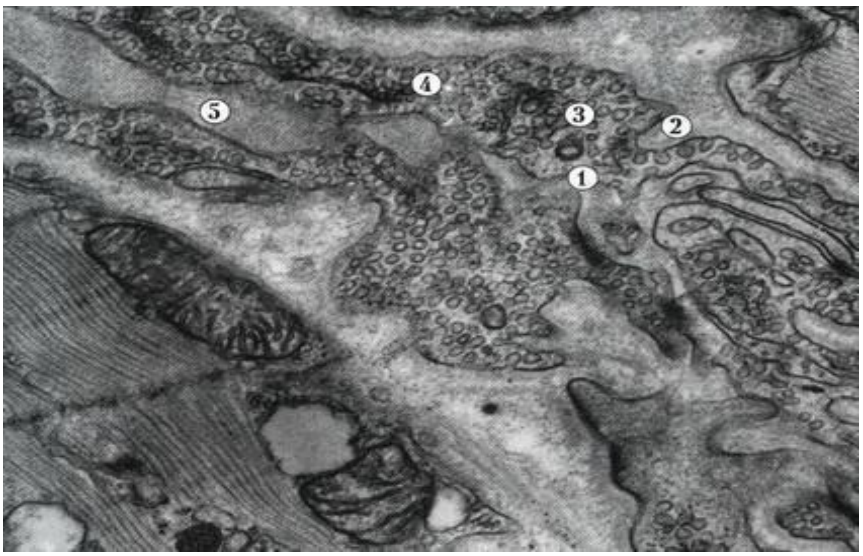
Ultrastructure 9 – Phagocytosis

1. Cell's cytoplasm.
2. Projection of the cytoplasm.
3. Invagination of the cell membrane.
4. Phagocytic material.



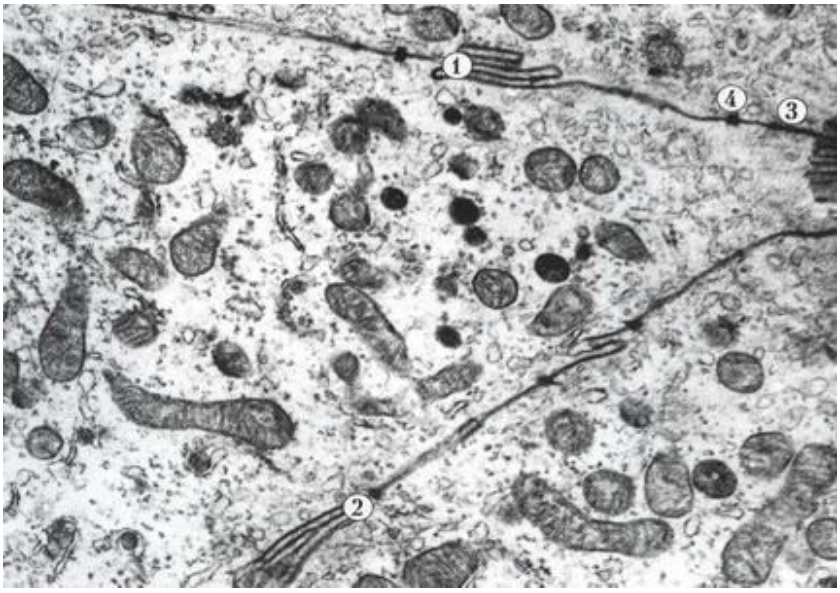
Ultrastructure 10 – Macropinocytosis by microvilli of endothelial cells of blood capillary

1. Cytoplasm of endothelial cells.
2. Lumen of capillary.
3. Microvillus.
4. Vacuole.



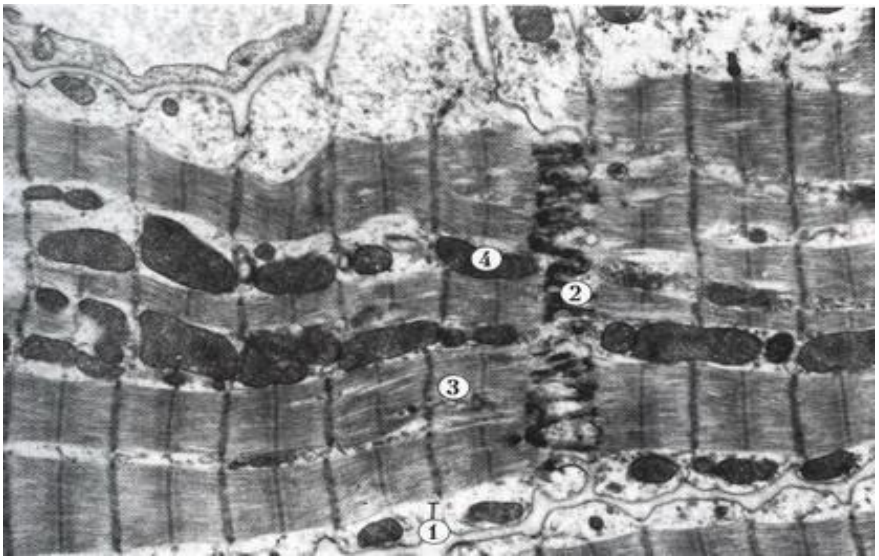
Ultrastructure 11 – Micropinocytosis in endothelial cells of blood capillary

1. Plasmalemma of endothelial cells.
2. Caveolae.
3. Pinocytotic vesicles.
4. Cytoplasm of endothelial cells.
5. Lumen of capillary.



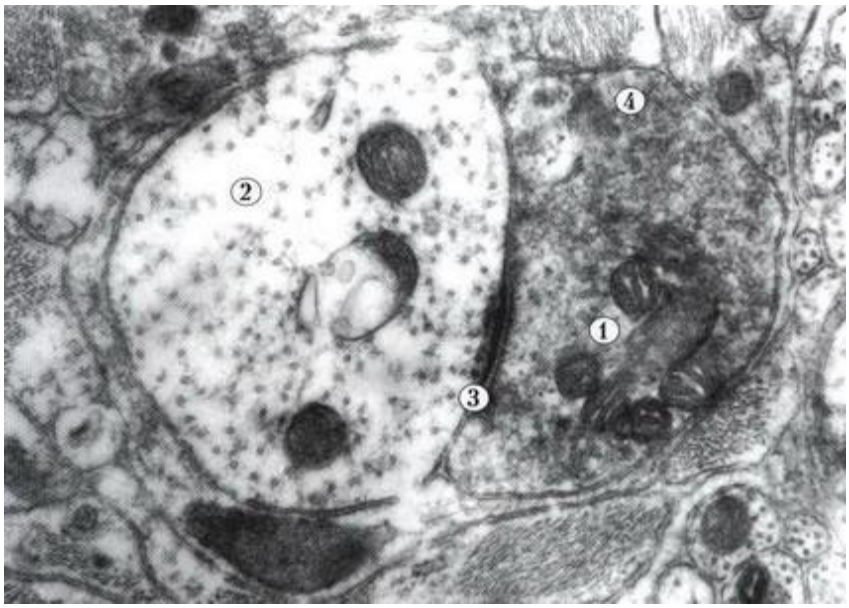
Ultrastructure 12 – System of intercellular junctions

1. Digital junction.
2. Digital cellular lock.
3. Tight junction (zonula occludens).
4. Desmosome.



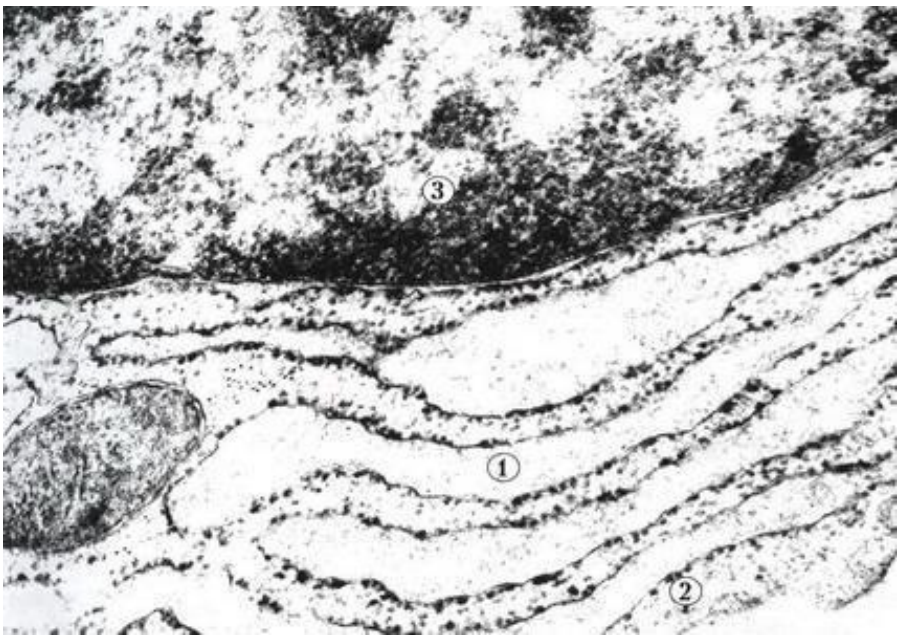
Ultrastructure 13 – Intercalated disc. Connection between cardiac muscle cells

1. Plasmalemma.
2. System of desmosomes and gap junctions (nexuses).
3. Myofibrils.
4. Mitochondrion.



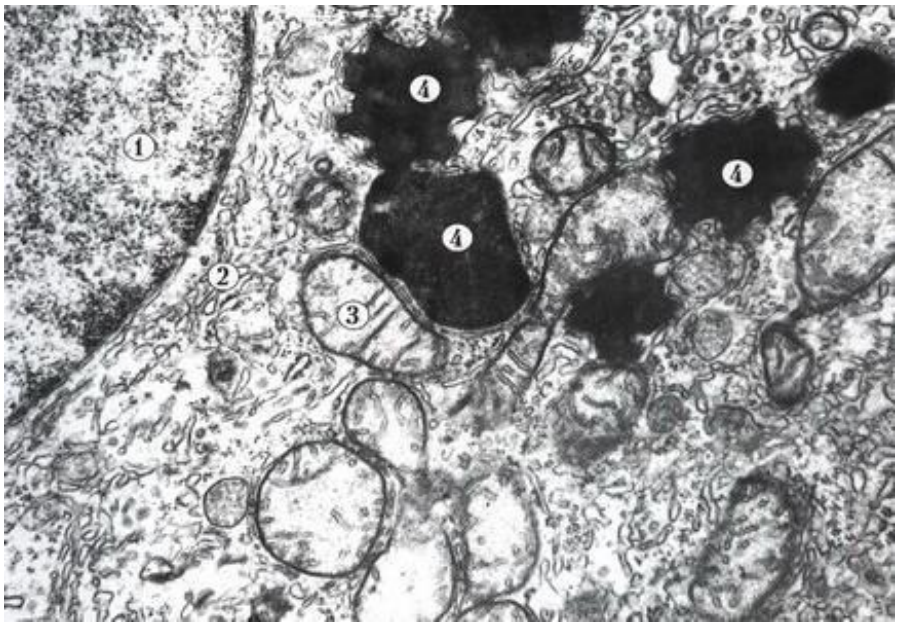
Ultrastructure 14 – Specialized connection between nervous cells – synapse

1. Presynaptic pole.
2. Postsynaptic pole.
3. Synaptic cleft.
4. Synaptic vesicles.



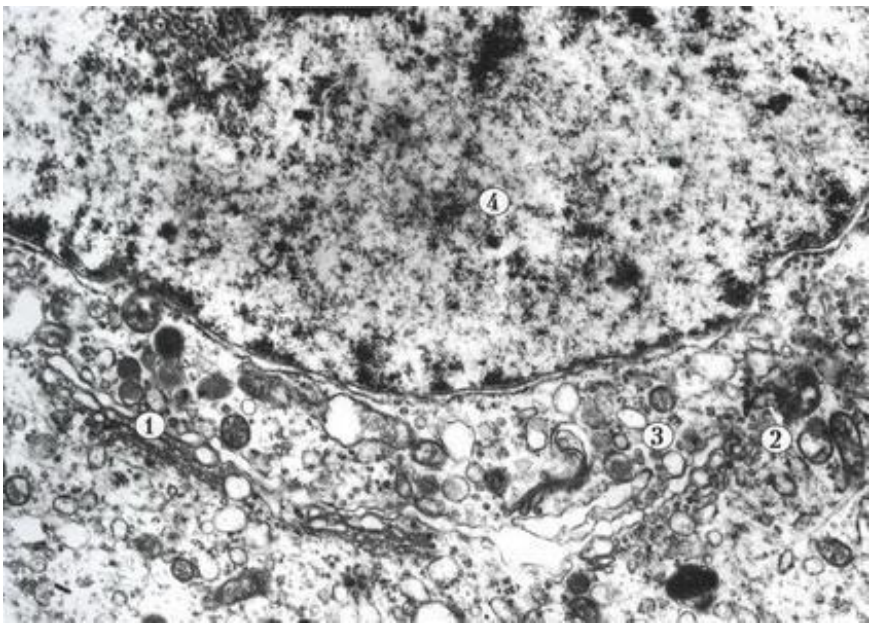
Ultrastructure 15 – Rough endoplasmic reticulum

1. Cisternae.
2. Ribosomes.
3. Fragment of the nucleus.



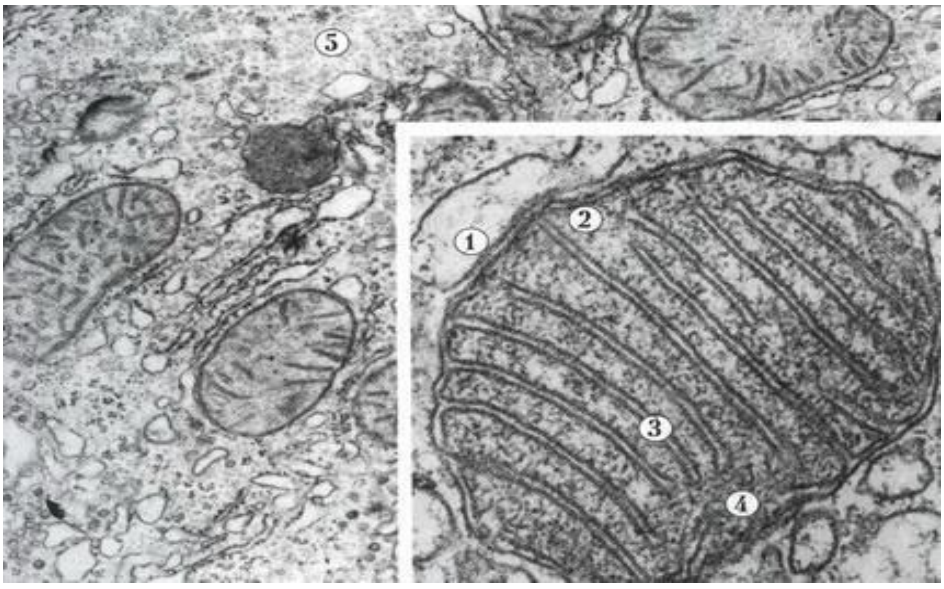
Ultrastructure 16 – Smooth endoplasmic reticulum

1. Fragment of the nucleus.
2. Cisternae of the endoplasmic reticulum.
3. Mitochondrion.
4. Liposome.



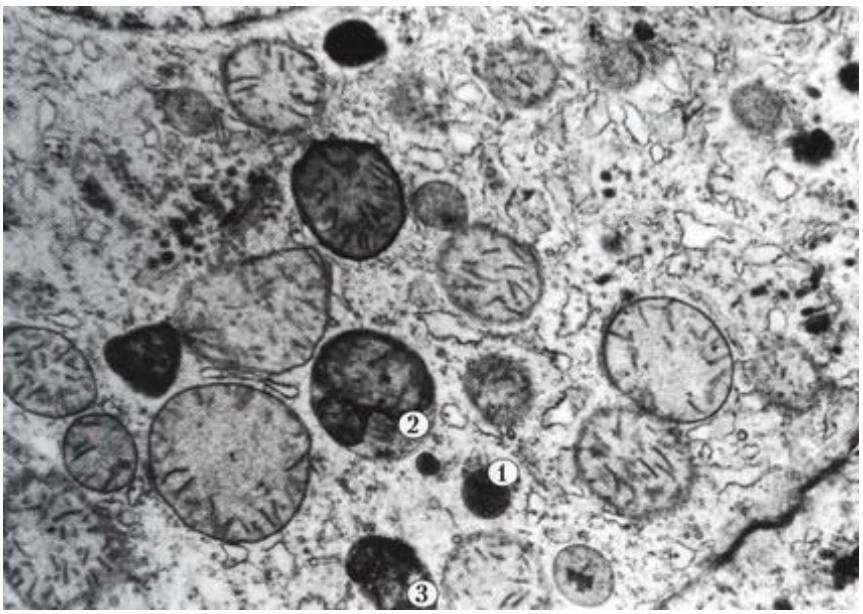
Ultrastructure 17 – Golgi complex

1. Cisternae.
2. Vesicles.
3. Vacuoles.
4. Fragment of the nucleus.



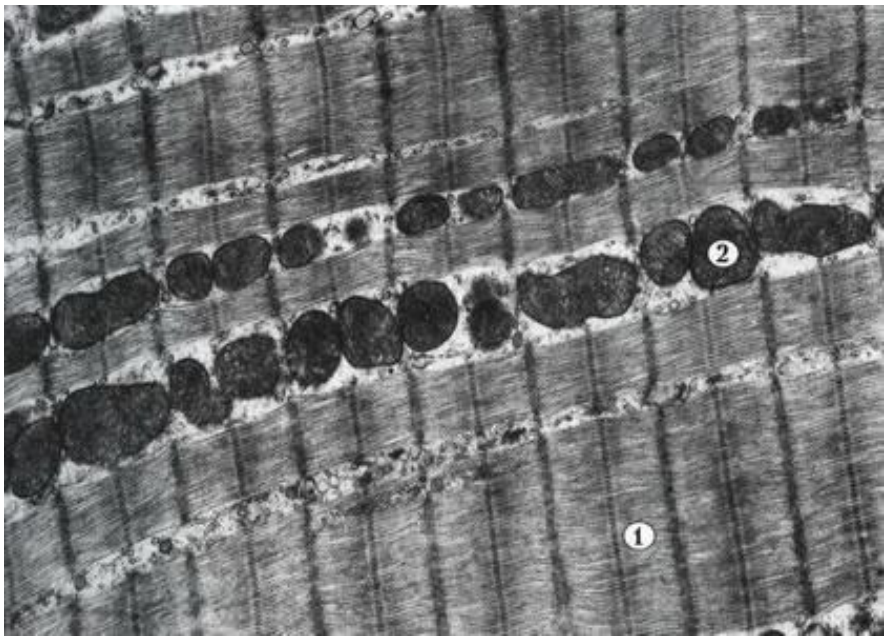
Ultrastructure 18 – Mitochondrion

1. Outer membrane.
2. Inner membrane.
3. Cristae.
4. Mitochondrial matrix.
5. Hyaloplasm.



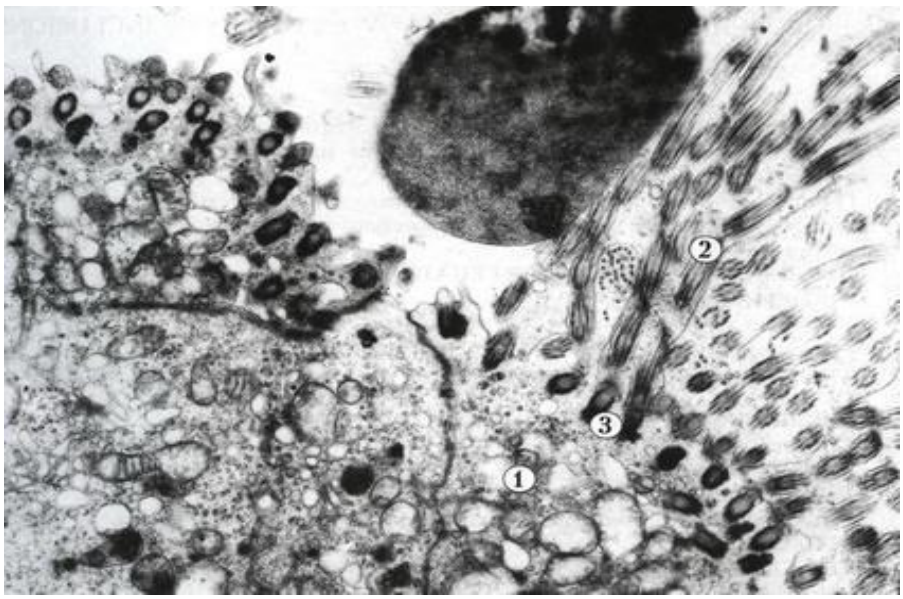
Ultrastructure 19 – Lysosomes

1. Primary lysosome.
2. Secondary lysosome (autophagosome).
3. Residual body.



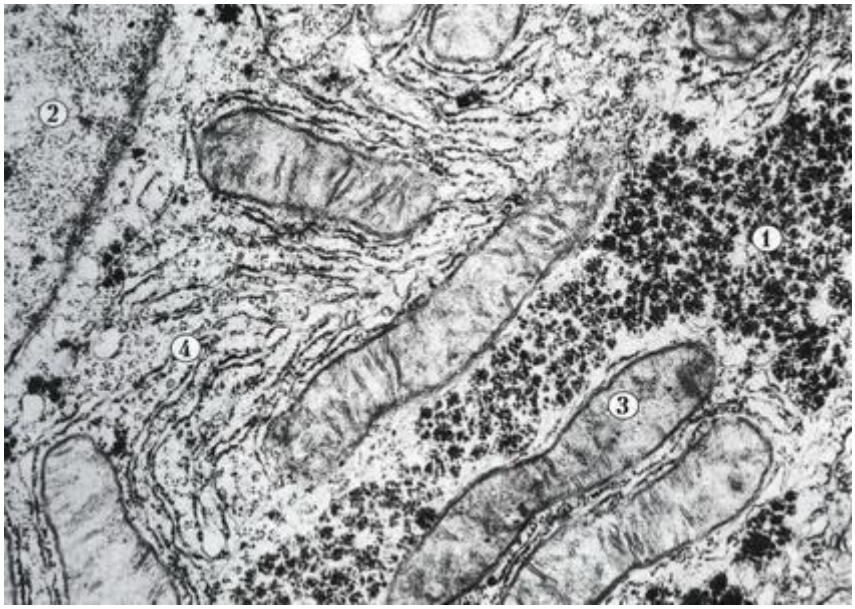
Ultrastructure 20 – Myofibrils in the cytoplasm of the cardiac muscle cell

1. Myofilaments of myofibrils.
2. Mitochondria.



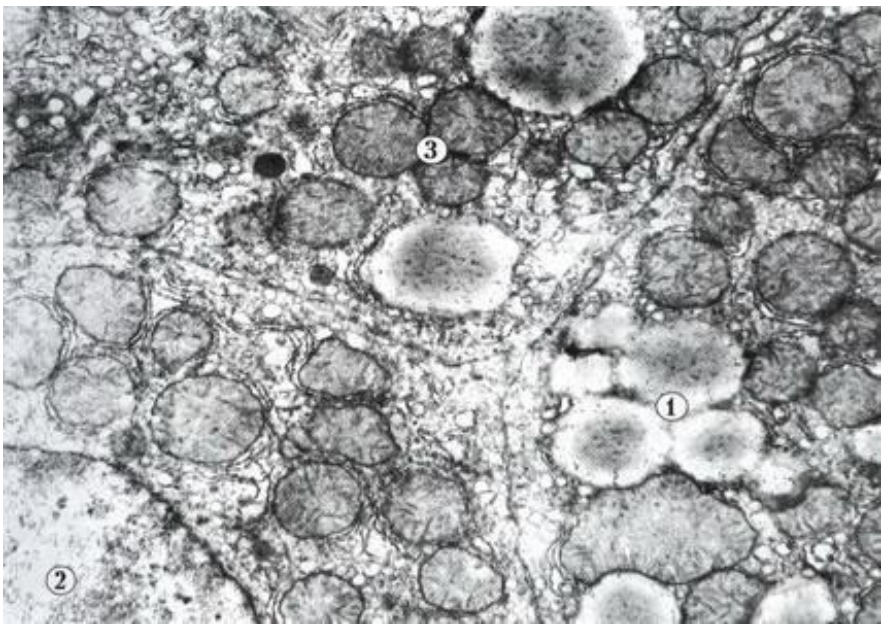
Ultrastructure 21 – Cilia (ciliated columnar cells apical surface of the mucus epithelial lamina of nasal cavity)

1. Apical pole of the cell.
2. Cilia.
3. Basal corpuscle.



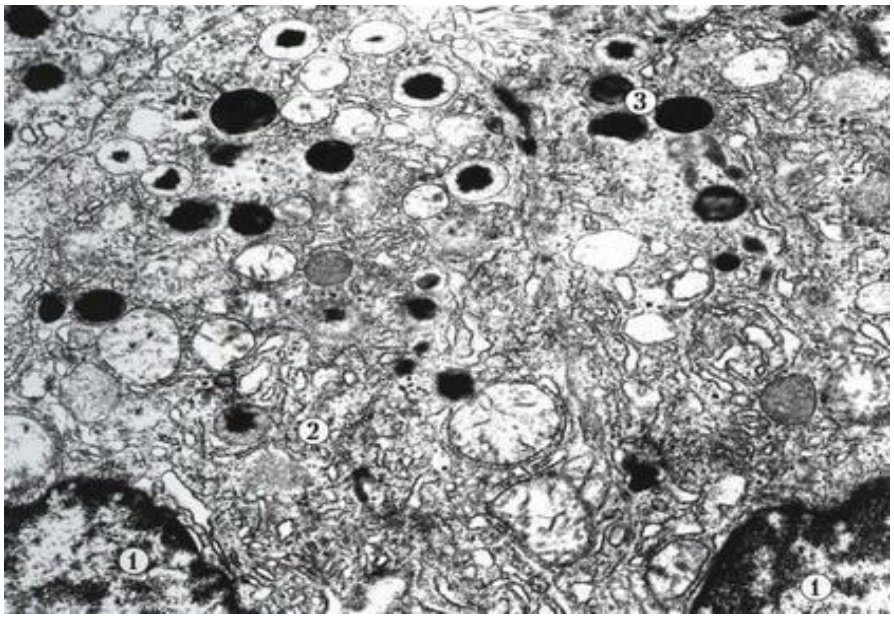
Ultrastructure 22 – Inclusions of glycogen in hepatocytes (liver)

1. Glycogen granules.
2. Fragment of the nucleus.
3. Mitochondrion.
4. Rough endoplasmic reticulum.



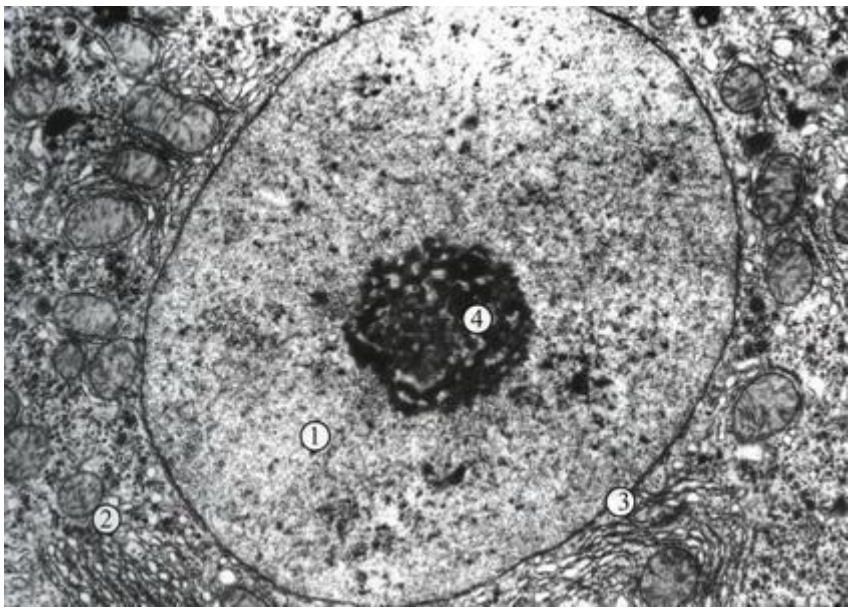
Ultrastructure 23 – Inclusion of lipid in cytoplasm of the hepatocytes

1. Lipid droplets.
2. Fragment of the nucleus.
3. Mitochondria.



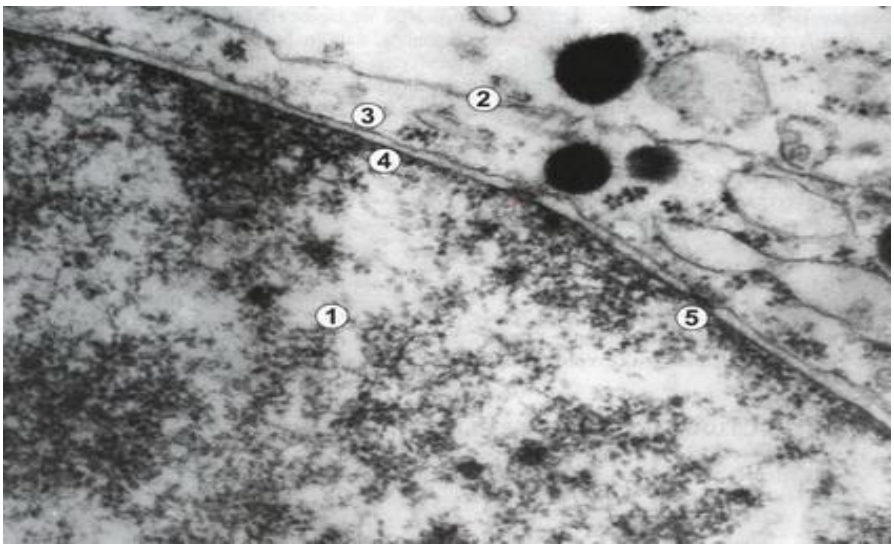
Ultrastructure 24 – Secretory inclusions in pancreatic acinar cells (pancreas)

1. Nucleus.
2. Cytoplasm.
3. Secretory inclusions in the apical pole of the cell.



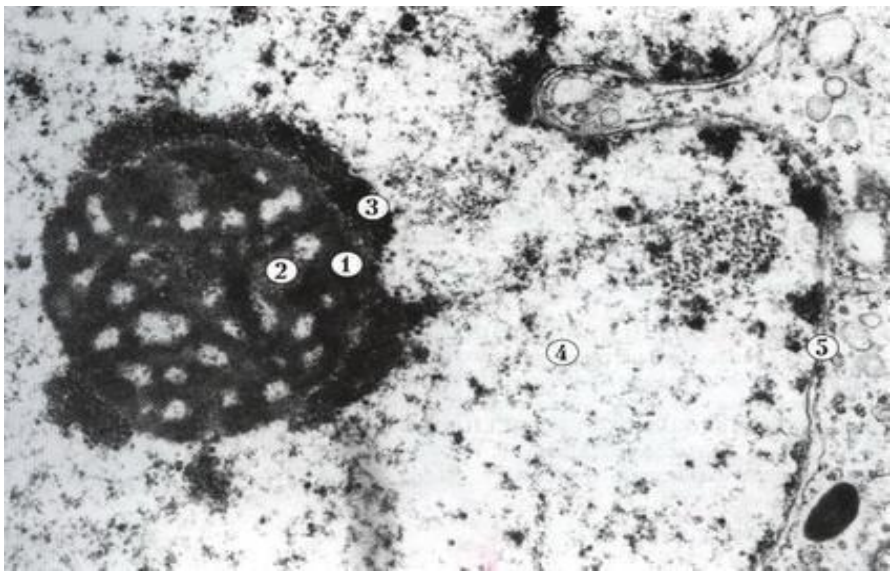
Ultrastructure 25 – Round–shaped nucleus

1. Nucleoplasm.
2. Cytoplasm.
3. Nuclear envelope.
4. Nucleolus.



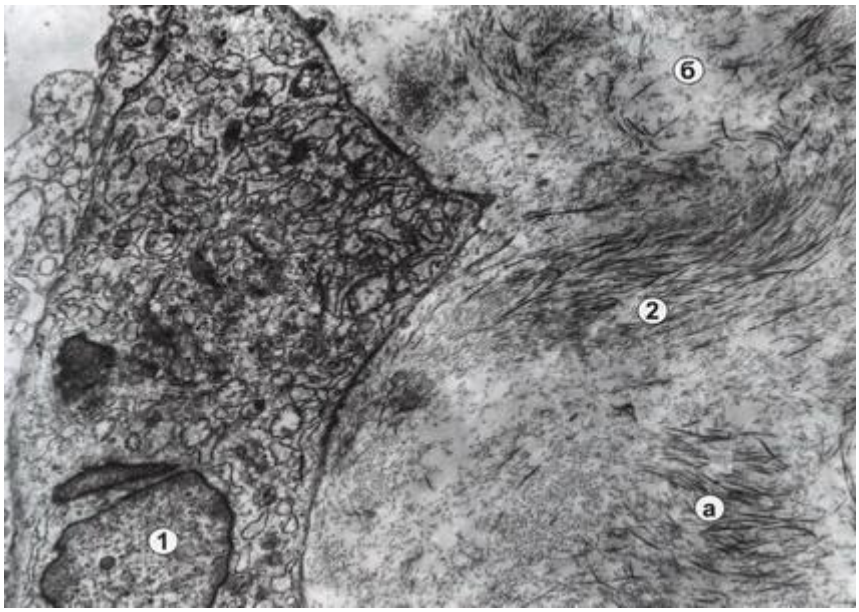
Ultrastructure 26 – Fragment of the nucleus

1. Nucleoplasm.
2. Cytoplasm.
3. Outer membrane of the nuclear envelope.
4. Inner membrane of the nuclear envelope.
5. Nuclear pore.



Ultrastructure 27 – Structure of the nucleolus

1. Pars fibrosa.
2. Pars granulosa.
3. Nucleolar associated heterochromatin.
4. Nucleoplasm.
5. Nuclear envelope.



Ultrastructure 28 – Intercellular substance (loose connective tissue)

1. Cell (fibroblast).
2. Intercellular substance:

a) fibrous elements;

b) amorphic component.

Questions to the module «Cytology»

1. The structure of the Plasmalemma.
2. The characteristic of receptive and transport functions of the plasmalemma.
3. The structure of intercellular contacts: Simple contact, Zonular occludentes, Synapse.
4. The structure of intercellular contacts: Desmosome, Zonular adherents, Gap junctions.
5. The characteristic and structure of symplast and syncytium.
6. The structure and functions of Mitochondria.
7. The structure and functions of Lysosomes and Peroxisomes.
8. The structure and functions of Agranular Endoplasmic Reticulum.
9. The structure and functions of Granular Endoplasmic Reticulum and Ribosomes.
10. The structure and functions of Golgi Bodies.
11. The structure and functions of Microfilaments and Microtubules.
12. The structure and functions of Cytocentrum (centrosome).
13. The structure and functions of Cilia and Flagella.
14. Name types of Inclusions and their functions.
15. Reproduction of cells definition.
16. Cell cycle definition.
17. Stages of interphase, characteristic features.
18. Stages of mitosis.
19. The characteristic of polyploidy (endoreduplication).
20. Meiosis peculiarities.
21. Aging and death of cells. Necrosis and apoptosis.

Test items for licensing examination «Krok 1»

1. Golgi complex exports substances from a cell due to the fusion of the membrane saccule with the cell membrane. The saccule contents flows out. What process is it?

+ Exocytosis
– Endocytosis
– Active transport
– Facilitated diffusion
– All answers are false

2. Life cycle of a cell includes the process of DNA autoreduplication. As a result, monochromatic chromosomes turn into bichromatic ones. What period of cell cycle does this phenomenon fall into?

+ S
– M
– G0
– G2
– G1

3. During the postsynthetic period of mitotic cycle the synthesis of proteins – tubulines, which take part in the mitosis formation, was destroyed. It can cause the impairment of:

+ Chromosome despiralization
– Chromosome spiralization
– Duration of mitosis
– Chromosome separation
– Cytokinesis

4. The study of mitotic cycle phases of onion root revealed the cell, in which the chromosomes are situated in the equatorial plane, forming a star. What is cell mitosis?

+ Metaphase
– Anaphase
– Prophase
– Telophase
– Interfase

5. Low level of albumins and fibrinogen was detected in the patient's blood. Decreased activity of what organelle of the liver hepatocytes can cause it?

+ Granular endoplasmic net
– Mitochondrions
– Golgi complex
– Agranular endoplasmic net
– Lysosomes

6. The cell of the laboratory animal was overdosed with Roentgen rays. As a result albuminous fragments formed in the cytoplasm. What cell organoid will take part in their utilization?

+ Lysosomes
– Endoplasmic reticulum
– Ribosome
– Golgi complex
– Cells centre

7. A tissue sample of a benign tumor was studied under the electron microscope. A lot of small (15–20 nm) spherical bodies, consisting of 2 unequal subunits, were detected. These are:

+Microtubules
– Golgi complex
– Mitochondria
– Ribosomes
– Smooth endoplasmic reticulum

8. Oval and round organelles with double was are seen at the electron micrograph. The outer membrane is smooth, the inner membrane folded into cristae contains enzyme ATPase synthetase. These are:

+ Mitochondria
– Ribosomes
– Centrioles
– Golgi complex
– Lysosomes

9. While studying maximally spiralized chromosomes of human karyotype the process of cell division was stopped in the following phase:

+Prophase
– Telophase
– Interphase
– Metaphase
– Anaphase

10. While studying maximally spiralized chromosomes of human karyotype the process of cell division was stopped in the following phase:

+ Metaphase
– Anaphase
– Interphase
– Prophase
– Telophase

11. Moving of the daughter chromatids to the poles of the cell is observed in the mitotically dividing cell. On what stage of the mitotic cycle is this cell?

+ Anaphase
– Metaphase
– Prophase
– Telophase
– Interfase

12. In the course of practical training students studied a stained blood smear of a mouse with bacteria phagocytized by leukocytes. What cell organelle completes digestion of these bacteria?

+ Lysosomes
– Granular endoplasmic reticulum
– Ribosomes
– Mitochondrions
– Golgi apparatus

13. In the course of practical training students studied a stained blood smear of a mouse with bacteria phagocytized by leukocytes. What cell organelle completes digestion of these bacteria?

+ Golgi apparatus
– Lysosomes
– Ribosomes
– Granular endoplasmic reticulum
– Mitochondrions

14. Labeled aminoacid alanine and tryptophan were introduced to a mouse in order to study localization of protein biosynthesis in its cells. Around what organelles will the accumulation of labeled amino acids be observed?

+ Ribosomes
– Cell center
– Lysosomes
– Golgi apparatus
– Agranular endoplasmic reticulum

15. Ultramicroscopical examination of «dark» hepatocyte population in the cell cytoplasm detected a developed granular endoplasmic reticulum. What function has this organelle in these cells?

+Synthesis of blood plasma proteins
– Calcium ion depositing
– Deintoxicative function
– Carbohydrate synthesis
– Bile production

16. Hypertrichosis of auricles is caused by a gene that is localized in the Y–chromosome. Father has this feature. What is the probability of giving birth to a boy with such an anomaly?

+100%
– 0%
– 25%
– 35%
– 75%

17. Normal, actively dividing cells of human red bone marrow are analyzed. What number of cells' chromosomes is typical for the G1 period?

+ 46
– 48
– 23
– 45
– 47

18. While examining the amniotic fluid collected with the help of amniocentesis (puncture of amniotic membrane) cells with sex chromatin containing nuclei (Barr's bodies) were detected. What does this fact indicate?

+ Development of a female fetus
– Development of a male fetus
– Genetic disorders in embryonic development
– Trisomy
– Polyploidy

19. In a cell the synthesis of histone proteins was artificially blocked. What cell structure will be damaged?

+ Nuclear chromatin
– Nucleolus
– Golgi apparatus
– Cell membrane
– Nuclear envelope

20. A chemical agent influenced cell plasmalemma. Consequently, the cell changed its form. Which layer of plasmalemma takes part in this process?

+ Cortical
– Glycocalyx
– Bilipidic
– Hydrophilic
– Hydrophobic

21. In a histological specimen is observed a human somatic cell in the metaphase of mitotic cell division. How many chromosomes form

the metaphase plate, taking into account that every chromosome contains two sister chromatids?

+ 46
– 92
– 23
– 48
– 24

22. A patient with poisoning has been hospitalized. It is detected that hepatic detoxification mechanisms are disordered. Which hepatocytes organelles have primarily caused the process?

+ Smooth endoplasmic reticulum
– Mitochondria
– Rough endoplasmic reticulum
– Golgi apparatus
– Ribosomes

23. Cytochemical investigation has shown high concentration of hydrolytic ferments in the cytoplasm of cells. The activity of which organelles does this fact indicate?

+ Lysosome
– Mitochondria
– Polysomes
– Endoplasmic reticulum
– Centrosome

24. There is a large quantity of carbohydrates in the dietary intake of a human. What structures will be seen in the cytoplasm of hepatocytes?

+ Glycogen granules
– Fat drops
– One large fat drop
– Increase of free ribosomes quantity
– Lipofuscin inclusions

25. In the course of a scientific experiment a researcher destroyed a structure of one of cell parts, which broke cell division capacity. Which structure has been affected?

+ Centrosome
– Glycocalyx
– Golgi apparatus
– Microfibrils
– Mitochondria

26. Tumor cell culture was acted on with colchicine that blocks the synthesis of tubulin–proteins, which form spindle apparatus. What stage of cellular cycle will be affected?

+ Mitosis
– G1 phase
– S phase
– G2 phase
– G0 period

27. Prolonged influence of toxic substances on the organism led to considerable protein synthesis decrease in hepatocytes. Which organelles have suffered from intoxication most of all?

+ Rough endoplasmic reticulum
– Mitochondria
– Microtubules
– Lysosomes
– Smooth endoplasmic reticulum

28. A ribosomal structure has been affected in a cell. What processes will suffer first of all?

+ Synthesis of protein
– Synthesis of nucleic acids
– Synthesis of carbohydrates
– Synthesis of lipids
– Synthesis of mineral substances

References

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3. Histology Laboratory Drawing. URL: https://open.umich.edu/find/open–educational–resources/medical/histology–laboratory–drawings.

4. The Magscope Histology Slide Bank. URL: http://louis.oercommons.org/courses/the–magscope–histology–slide–bank/.

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Електронне навчальне видання

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