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This manual is designed according to syllabus of biology for students of Medical faculty. It will be a guide to action for students during their practical work.

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TOPIC: THE STRUCTURE OF THE MICROSCOPE "BIOLAM P-11". RULES OF WORK WITH THE MICROSCOPE "BIOLAM P-11"

The aim of the lesson: to form a system of knowledge about a structure of the microscope "Biolam P-11" and rules of work with it.

Session objectives:

1. To study the structure of the light student microscope.
2. To learn the technique of microscopic examination.

SOFTWARE ISSUES:

1. The emergence and development of biology as a science.
2. Modern biology as a system of sciences about nature.
3. Biology in the medical school.
4. Device light microscope "Biolam P-11".
5. The technique of microscopic examination.

Equipment:

1. Microscope "Biolam P-11".
2. Slide: **Euglena** viridis.

Exircise1. The structure of the microscope "Biolam P-11"

1.1. Read the text, look at the main components of the microscope, find them in the figure 1.

The microscope is an essential tool in modern biology. It allows us to view structural details of organs, tissue, and cells not visible to the naked eye.

The main objective of our activities is to consider the main parts of the microscope: mechanical, optical and lighting parts (Fig. 1) and study of a light microscope.

The mechanical part includes a base, a mechanical stage with a round hole in the middle. The object is placed on a stage. The light beam, allowing us to consider the object in transmitted light, passes through the hole in the middle of the stage.

The coarse focus adjustment knob (7) is located on the sides of the base. The arm of the microscope during the rotation of this knob goes up and down to focus the image. The fine focus adjustment knob (8) is located on the base (1), the rotation moves the arm slightly and is used for precise focusing.

The optical part of the microscope presents eyepiece (6) and lens (5).

The eyepiece is at the top of the tube and facing the eye. The eyepiece is a lens system enclosed in a metal tube. The numerals on the upper surface of the eyepiece mean its magnification (x7, x10, x15).

A rotating plate, or a revolver (4), in which there are four sockets for lenses, is situated on the opposite side. The objective lenses is a lens system enclosed in a common metal frame. The lens is screwed into the socket of the revolver. The magnification of the lens is written on the side surface.

There are small lens magnification (x8), lens high magnification (x40) and the immersion lens used for the study of the smallest objects (x100).

The total magnification of the microscope is equal to the magnification of the eyepiece times the magnification of the lens.

The lighting part of the microscope consists of a mirror or special lighting lamps (not shown), the condenser and diaphragm.

The mirror is located on a base, it can be rotated in any direction.

The condenser (10) is subject under the stage; it consists of two or three lenses, entered into a joint frame. Changing the position of the condenser (above, below), you can modify the intensity of light. The condenser adjustment (9) located anterior to the coarse focus is to move the condenser.

When lowering the condenser the lighting is reduced, when raising the condenser the lighting is increased.

The diaphragm (11) is used to regulate lighting. With a special lever on the right side of the condenser, it is possible to change the position of the diaphragm plate relative to each other and reduce or expand the hole in the diaphragm. This allows you to adjust the intensity of the light and make the image more contrast.

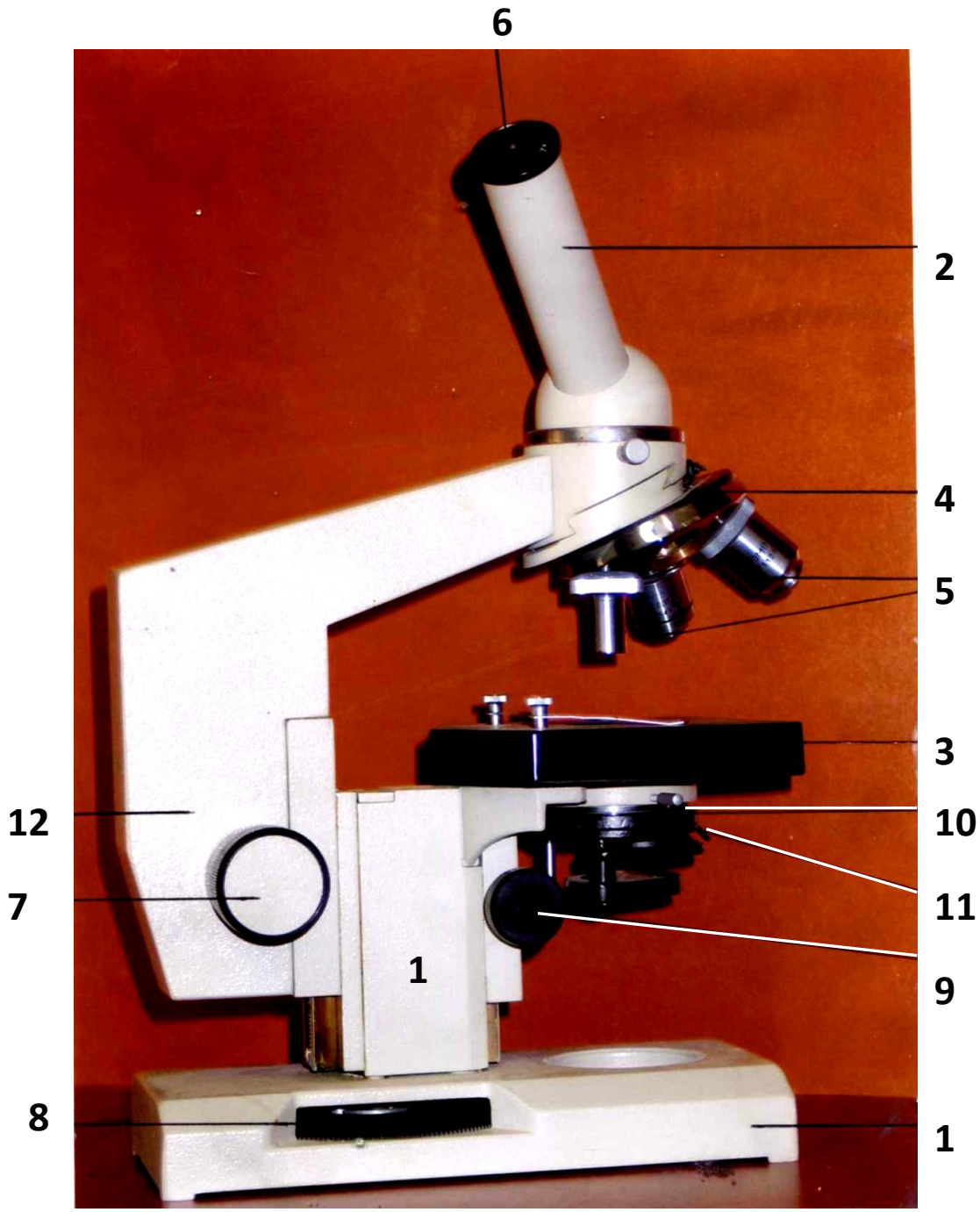


Figure 1. Microscope "Biolam P-11": 1-base; 2-tube; 3-mechanical stage; 4-revolver (revolving nosepiece); 5-objective lenses; 6-eyepiece; 7-coarse focus adjustment knob ; 8-fine focus adjustment knob; 9-condenser adjustment knob; 10-diaphragm; 11- lever on the right side of the condenser; 12-arm.

Exircise2. **Rules of work with the microscope "Biolam P-11"**

2.1. Read the text. Learn the rules of working with the microscope.

How to view an object under the microscope?

1. Clean the eyepiece, lens and slides with using a swipe.
2. Use the coarse focus adjustment knob to maximize the working distance (the distance between the stage and the objective lens).
3. Rotate the revolver into position with the scanning power (x8) objective lens in the viewing position. Turn the revolver until you hear a slight click and the lens is fixed.
4. Using coarse focus adjustment knob lift the lens above the stage to a height of approximately 0,5 cm. **Remember that the study of any object starts with a small magnification.**
5. Open the diaphragm and slightly lift the condenser. Looking into the eyepiece of its left eye, rotate the mirror in different directions until the field of view is illuminated brightly and evenly.
6. Place the slide on the stage so that the object was in the center of its hole.
7. Look into the eyepiece. At the same time slowly rotating a coarse focus adjustment knob on yourself lift the objective lens up until an image of the object is shown in the field of view (**remember that the focal length for a small magnification of approximately 0,7 cm**).
8. For consideration of the object at high magnification of the microscope, place it in the center of the field of view. Adjust the sharpness of the image using a fine focus adjustment knob.
9. Rotating the revolver, put in the working position of the lens at high magnification. **Remember that when focusing on an object at high magnification is necessary to work only with fine focus adjustment knob.**
10. Rotate the fine focus adjustment knob in one direction or another to achieve a crisp image of the object.
11. If the image of the object is missing, repeat the operations specified in paragraphs 6-9.
12. Draw the object.

2.2. Consider under a microscope slide Euglena viridis at low and high magnification. Draw the object in the album, make notations. Use sample design of laboratory work.

Sample design of laboratory work

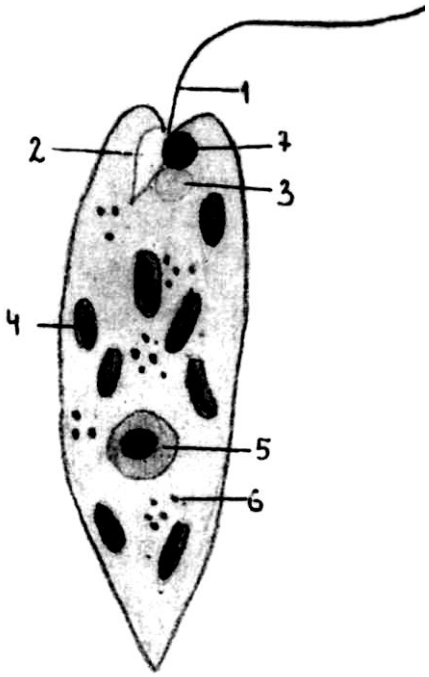
Date:

Lesson topic:

Title microscopic slide: **Euglena** viridis

The microscopic drawing (color, size 7x9 cm).

On one page should be no more than two drawings.



Legend:

1 - flagellum; 2 - channel contractile vacuoles; 3 - contractile vacuole; 4 - the chromatophores; 5 - nucleus; 6 - grain starch; 7 - light-sensitive eyes.

Control questions

1. List the elements of the mechanical part of the microscope.
2. List the elements of the optical part of the microscope.
3. List the elements of lighting part of the microscope.
4. How through the condenser and aperture you can increase the intensity of illumination of the object?
5. Name the small and high lenses magnification.
6. What eyepieces have the microscope?
7. What is the function of the revolver of the microscope?

Topic: Biological manifestations and levels of the life organization.

The aim of the lesson: to form a system of knowledge about the biological foundations of general regularities of the organism.

Session objectives:

1. To study the biological manifestations and levels of life organization.
2. To study structural types and variety of cells.
3. To study the morphology of plant, animal and bacterial cells.
4. To develop skills definitions on slides various types of cells and structures

SOFTWARE ISSUES:

1. The definition of "life". The development of the concept "life" at the present stage.
2. Fundamental properties of the living. The biological manifestation of life.
3. The levels of structurally functional organization of life. The concept of basic unit of the structural-functional level.

Equipment:

1. Microscope "Biolam P-11".
2. Slides: plant cell, red blood cells of the frog, spinal cord of the dog, simplest - cross-striated skeletal muscle fiber, syncytium - reticular tissue of bone marrow, spinal ganglion of the dog, bacterial cell, intercellular substance of loose fibrous connective tissue.

Exercise 1.

1.1. Read the text

Properties of Life

Biology is the science of life. Biologists study life in many different ways. What characteristics do define life? All living organisms have five basic characteristics:

1. Order.

All organisms consist of one or more cells with highly ordered structures: atoms make up molecules, which construct cellular organelles, which are contained within cells. This hierarchical organization continues at higher levels in multicellular organisms and among organisms.

2. Sensitivity.

All organisms respond to stimuli. Plants grow toward a source of light, and your pupils dilate when you walk into a dark room.

3. Growth, development, and reproduction.

All organisms are capable of growing and reproducing, and they all possess hereditary molecules that are passed to their offspring, ensuring that the offsprings are of the same species. Although crystals also "grow," their growth does not involve hereditary molecules.

4. Regulation.

All organisms have regulatory mechanisms that coordinate the organism's internal functions. These functions include supplying cells with nutrients, transporting substances through the organism, and many others.

5. Homeostasis.

All organisms maintain relatively constant internal conditions, different from their environment, a process called homeostasis.

All living things share certain key characteristics: order, sensitivity, growth, development and reproduction, regulation, and homeostasis.

1.2. Fill in the gaps in sentences

_____ is ability to maintain relatively constant internal conditions, different from their environment.

_____ - the process of increasing the weight or volume of the structure of the organism, which is accompanied by quantitative changes. For example, increasing the number of cells.

_____- the process of transition from one state to another, more perfect, the transition from an old qualitative state to a new qualitative state, from simple to complex, from lower to higher.

_____is the ability to reproduce itself.

_____ - the ability to coordinate the internal functions of the body.

_____ is the body's ability to respond to stimuli of the internal and external environment.

Exercise 2.

2.1. Read the text

The levels of life organization

In unicellular (single-celled) organisms, the single cell performs all life functions. It functions independently. However, multicellular (many celled) organisms have various levels of organization within them. Individual cells may perform specific functions and also work together for the good of the entire organism. The cells become dependent on one another.

Molecular level

At this level some of the properties have a living DNA molecule. They are able to store hereditary information and to reproduce by replication.

The cellular level of life organization

Cells are the basic unit of structure and function in living things. They may serve a specific function within the organism.

Cell is an open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.

Examples - blood cells, nerve cells, bone cells, etc.

Tissue level of organization of life

Tissue is a group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity.

- muscle tissue
- nervous tissue
- epithelial tissue
- connective tissue

Organ level of organization of life

Organ is a constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function.

System-organ level of organization of life

Organ system is a group of organs that together perform a common activity.

For example, the nervous system, endocrine system, circulatory system, etc.

Organismal level of organization of life

The organism - an open system consisting of interconnected organs and organ systems which have the ability to self-regulation and have new features which are not in individual organ systems.

Usually made up of organ systems, but an organism may be made up of only one cell such as bacteria or protist.

Population-species level of organization of life

Species - a group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.

Population - group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding.

Community level of organization of life

Community - a group of interdependent organisms of different species growing or living together in a specified habitat.

The ecosystem level of organization of life

Ecosystem - a biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.

Biosphere level of organization of life

Biosphere - the totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere.

2.2. Fill in the gaps in sentences

_____is group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding.

_____ is a constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function.

_____is a biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.

_____is an open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.

_____is a group of organs that together perform a common activity.

_____is a group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.

_____is a group of interdependent organisms of different species growing or living together in a specified habitat.

_____is the totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere.

_____ is a group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity.

_____ is an open system consisting of interconnected organs and organ systems, and have the ability to self-regulation and has new features which are not in individual organ systems.

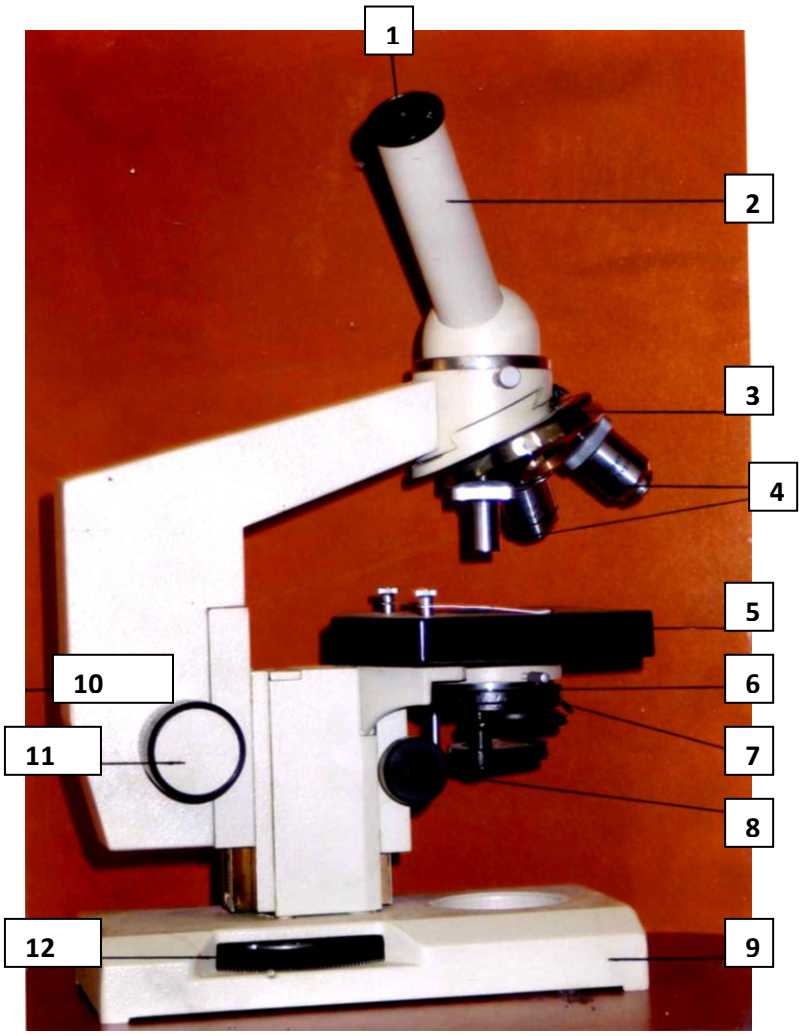
2.3. Fill the table

Specify the levels of structurally functional organization of life. Bring an elementary unit for each level.

No	The level of structural and functional organization of life	The basic unit level and its characteristics	Example	The name of the science that studies this level.

Exercise 3. The structure of the microscope "Biolam P-11"

3.1. Designate the components of the microscope in the figure



3.2. Answer the tests. Circle the one correct answer.

1. The mechanical part includes:
   a) an eyepiece
   b) a base
   c) a mirror
   d) a condenser
2. The optical part includes:
   a) a stage
   b) a lens
   c) a mirror
   d) a condenser
3. The lighting part includes:
   a) a stage
   b) a lens
   c) an eyepiece
   d) a condenser
4. There are four sockets for lenses in
   a) a stage
   b) a revolver
   c) a mirror
   d) a condenser
5. It is used for precise focusing
   a) a coarse focus adjustment knob
   b) a revolver
   c) a fine focus adjustment knob
   d) a condenser
6. Changing its the position (above, below), you can modify the intensity of light
   a) a coarse focus adjustment knob
   b) a revolver
   c) a fine focus adjustment knob
   d) a condenser
7. It is used to adjust the intensity of the light and make the image more contrast
   a) a coarse focus adjustment knob
   b) a revolver
   c) a stage
   d) a diaphragm
8. The study of any object starts with
   a) a small magnification
   b) a high magnification
   c) a rotation the fine focus adjustment knob
   d) a rotation the diaphragm

9. The focal length for a small magnification of approximately
   a) 10 cm
   b) 0,7 cm
   c) 2 cm
   d) 5 cm
10. When focusing on an object at high magnification is necessary to work only with
   a) a coarse focus adjustment knob
   b) a revolver
   c) a fine focus adjustment knob
   d) a diaphragm
11. Rotating it in different directions you make the field of view illuminated brightly and evenly
   a) a stage
   b) a lens
   c) a mirror
   d) a condenser

3.3. Answer the questions.

1. List the elements of the mechanical part of the microscope.
2. List the elements of the optical part microscope.
3. List the elements of lighting part of a microscope.
4. How through the condenser and aperture can you increase the intensity of illumination of the object?
5. Name the small lenses and high magnification.
6. To what extent does the microscope have eyepieces?
7. What is the function of the revolve
r of a microscope?

3.4. Give a detailed answer

1. The microscope is mounted opposite the source of artificial light, however, the field of view in the eyepiece is dark. What should be done and in what sequence, so that the field of view would appear lit?

2. At high magnification, the object is blurred in all positions of micrometrical screw. Explain the sequence of your actions on the way out of this situation.

3. A foreign body is visible in the field of view. How can we determine its localization (microscopic glass, objective lens, eyepiece lens) and improve the image quality?

4. The microscope is mounted opposite the source of artificial lighting. The field of view is illuminated unevenly. There is decomposition of light (diffraction). What is a way out from this situation?

5. A high-quality image of the object is obtained at low magnification of the microscope. During the transition to the examination of the object at high magnification of the microscope the objective lens rests on the coverslip and cannot take up the normal position. Explain the cause of the defect and the steps on the way out of this situation.

Exercise 4. Study the slides under the microscope

4.1. Draw the diagram and mark the cell structures

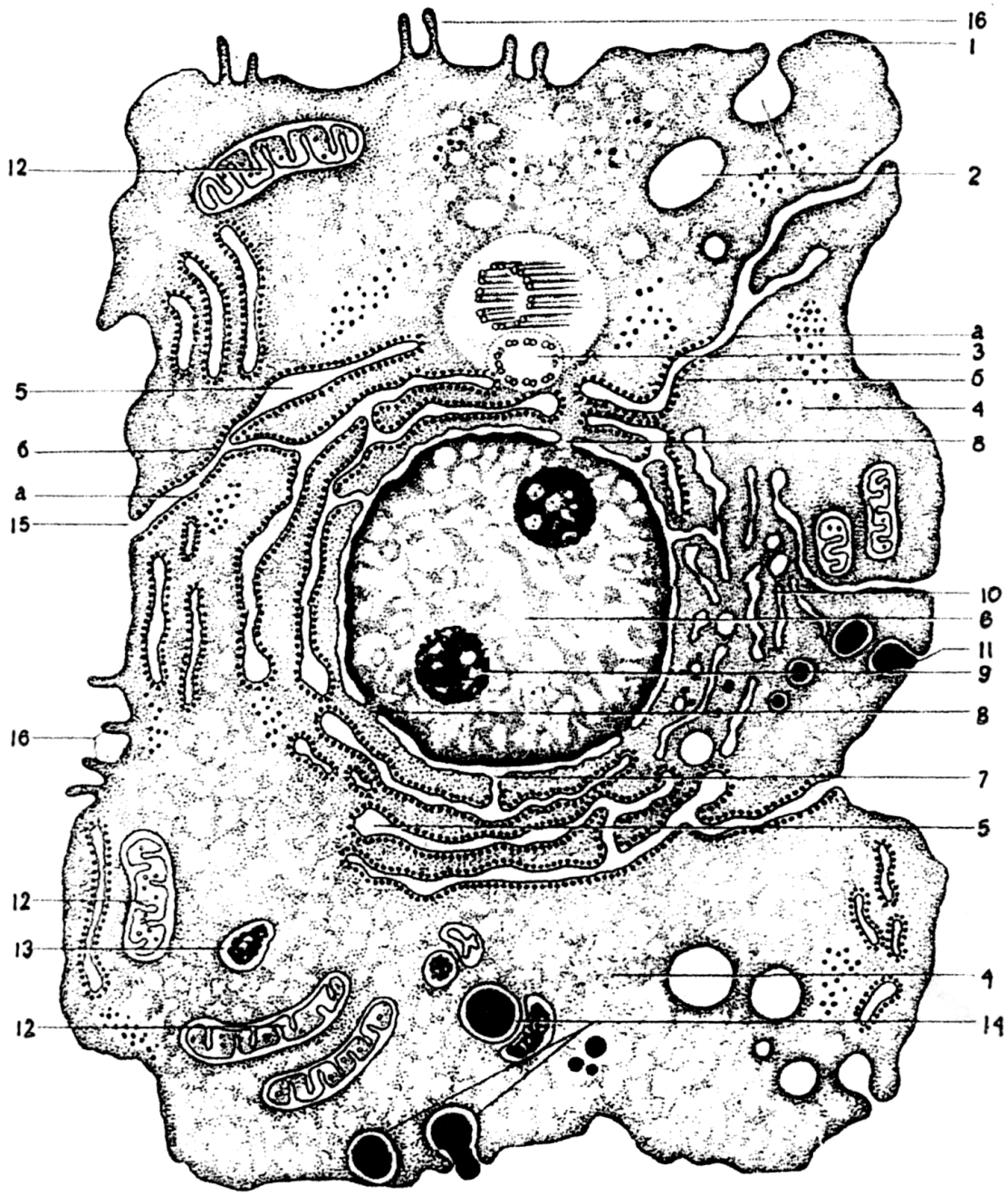
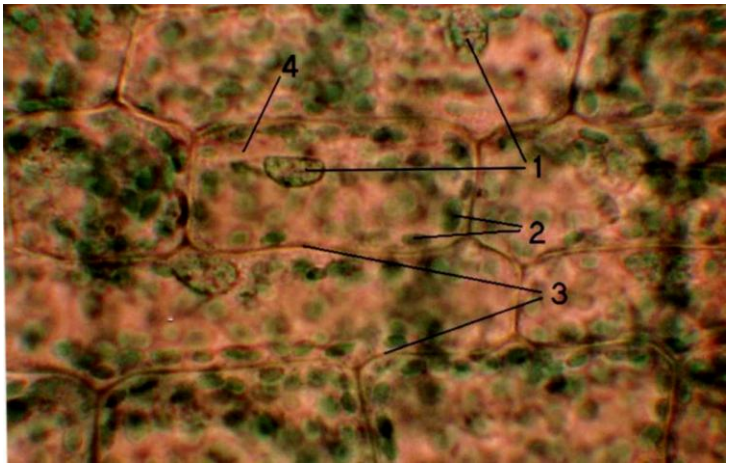


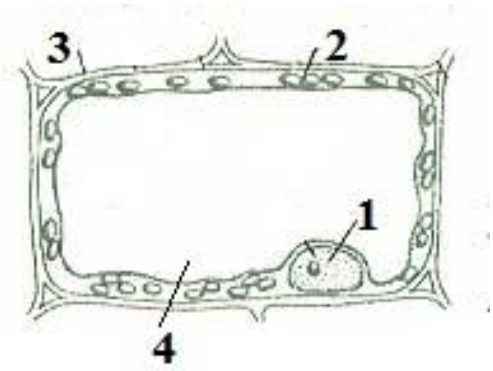
Diagram of the microscopic structure of the cell. 1 - plazmolemma; 2 - endocytosis bubbles; 3 - centrosome; 4 - hyaloplasm; 5 - granular endoplasmic network (a - elementary biological membrane, b - ribosomes); 6 - core; 7 - communications perinuclear space and channels of granular endoplasmic reticulum; 8 - nuclear pores; 9 - the nucleolus; 10 - Golgi apparatus; 11 - secretory vesicles; 12 - mitochondria; 13 - lysosomes; 14 - stage of phagocytosis; 15 - communication plasmalemma and channels of granular endoplasmic reticulum; 16 – microvilli.

4.2. Draw the slides and mark the cell structures

4.2.1. Plant cell

At low magnification of the microscope look painted green cut leaf blades of eelgrass plants. Will consider it at a high magnification microscope. Note the rectangular shape of the cells and the border between the cells. Rotating the micrometer screw and changing, thus, the focusing lens, consider a cell with the surface and at some depth (in optical section). The center of the cell is a vacuole that most of the bright green color and uniformity of structure. Near the cell walls are the core (dark) and the chloroplast - dark green oval or rounded structures.
Draw a section cut from a few cells.



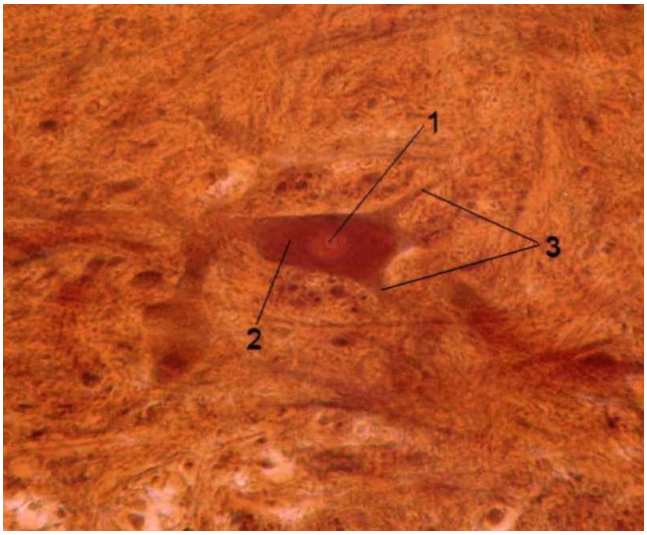


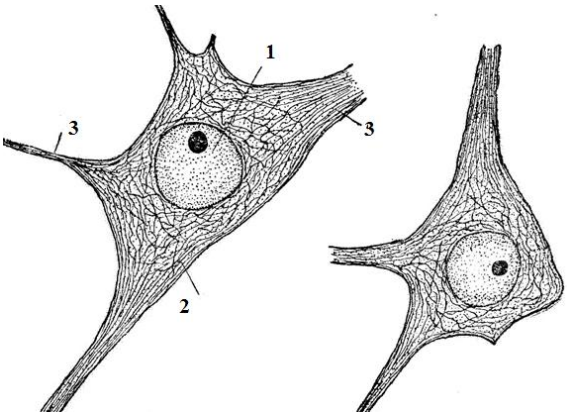
Indicate in the figure: 1) core; 2) chloroplasts; 3) cell boundaries; 4) vacuole.

4.2.2. The spinal cord of the dog

At low magnification of the microscope, locate the gray matter of the spinal cord. Note the variety of forms and the number of outgrowths, the dark coloration of the cytoplasm and light-colored vesicular nucleus.

Draw the plot of the slide that includes several nerve cells.

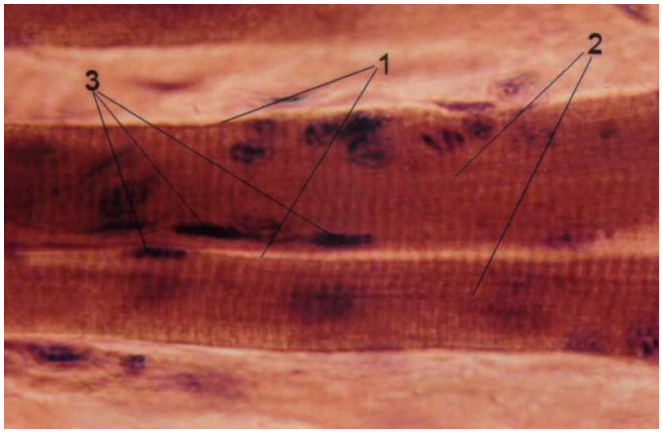


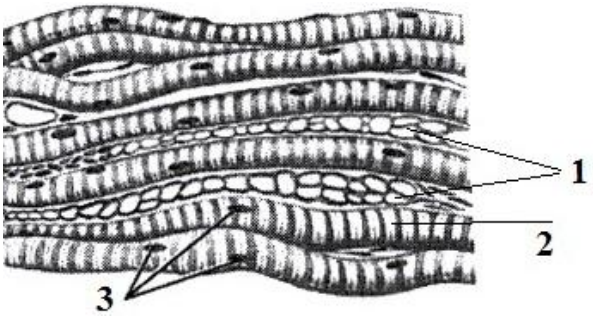


Indicate in the figure: 1) the core of the nerve cells; 2) cytoplasm; (3) the spikes of the neuron.

4.2.3. Simplast - cross-striated skeletal muscle fiber

Consider slide muscle fibers. Note the numerous elongated nuclei within the muscle fibers. Fiber is multinucleated (simplast) structure with a single (undifferentiated cells) cytoplasm. The fiber cytoplasm (sarcoplasm) is characterized by transverse striations.

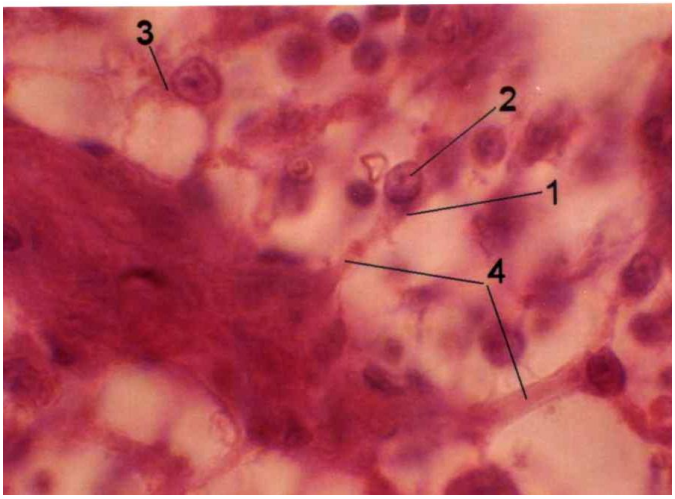


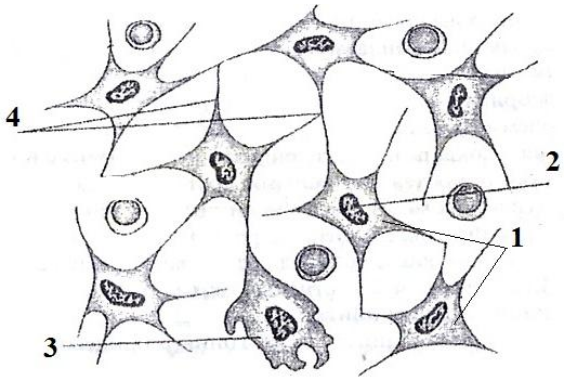


Refer figure: 1) the external boundaries of the fiber; 2) cytoplasm (sarcoplasm); 3) nucleus.

4.2.4. The syncytium - reticular tissue of bone marrow

Consider colored red reticular cells of the syncytium. Nucleus reticular cells have a round or oval shape and slightly colored. Around the nucleus is in the form of a thin strip of cytoplasm, into cellular processes. Through the last reticular cells are connected to each other, forming a reticular structure - the syncytium. In loops of syncytium are lymphocytes with nuclei, painted in dark blue color.

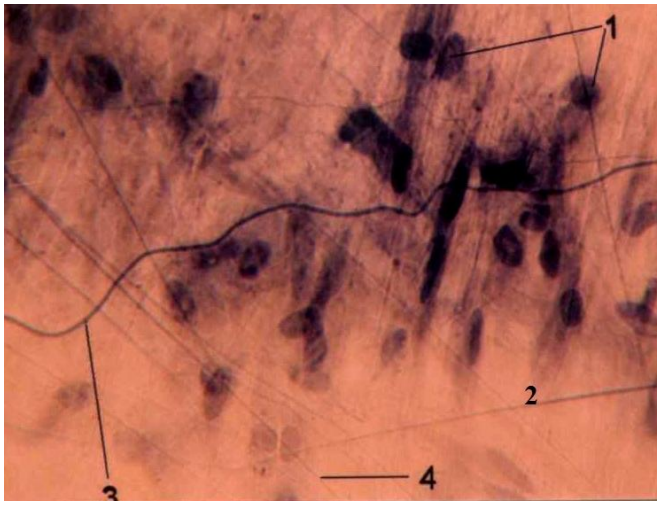


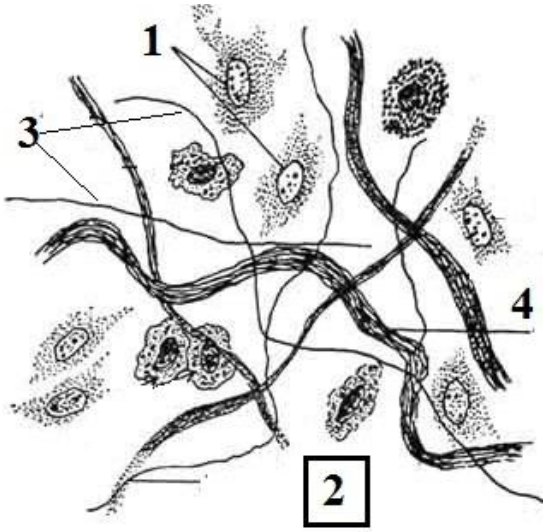


Refer figure: 1) reticular cells of the syncytium; 2) the core of reticular cells; 3) the cytoplasm of reticular cells; 4) processes of reticular cells.

4.2.5. Intercellular substance of loose fibrous connective tissue

Consider the micrograph. The tissue formed by cells and intercellular substance. Intercellular substance is represented by fibers oriented in different directions, and amorphous substance. Last transparent and homogeneous. There are cells and fibers: thick, slightly sinuous collagen fibers, and thin, straight, elastic fibers.



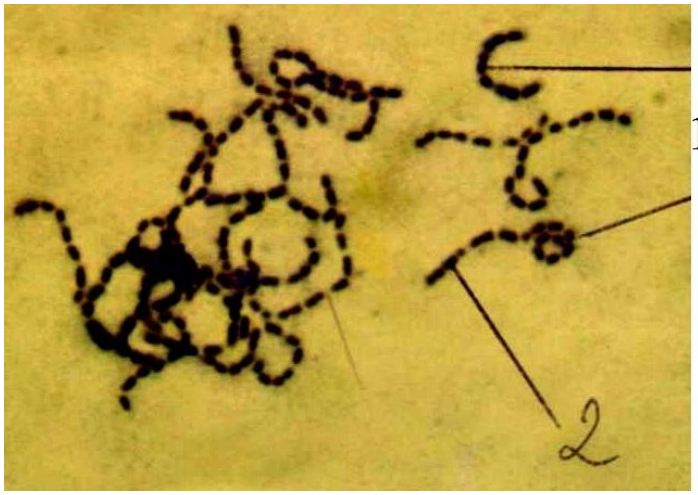


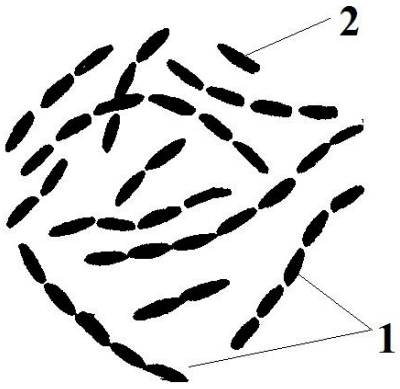
Refer figure: 1) cell unformed loose fibrous connective tissue; 2) amorphous substance; 3) collagen fibers; 4) elastic fibers.

4.2.6. Bacterial cell

At high magnification of the microscope will consider clusters of rod-shaped bacteria form. The cytoplasm of bacterial cells are colored blue-violet color. Individual bacteria are commonly connected to each other in chains of greater or lesser length. Note the absence in the bacterial cell nucleus. Cell wall of bacterial cells using a microscope "Biolam P-11" not detected and appear in the form of transparent space between cells, forming a chain.

Draw a plot of the chain, including several bacterial cells.



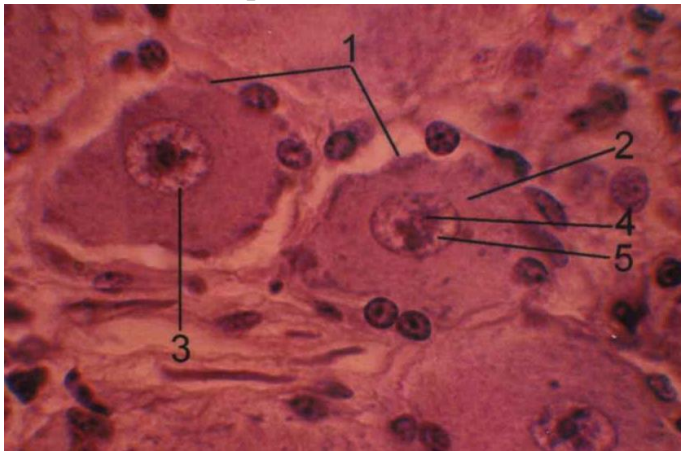


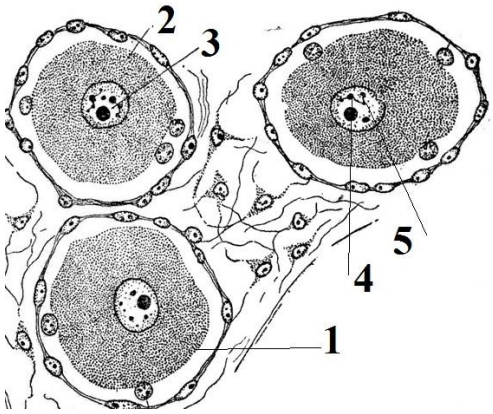
Indicate in the figure: 1) the chain of bacterial cells; 2) the bacterium is rod-shaped.

4.2.7. Spinal ganglion of the dog

At low magnification of the microscope, locate clusters of large cells with pale nuclei (neurons). Look at them under a microscope. Note the vesicular nucleus and a dark rounded nucleolus.

Draw the plot of the slice that includes several nerve cells.



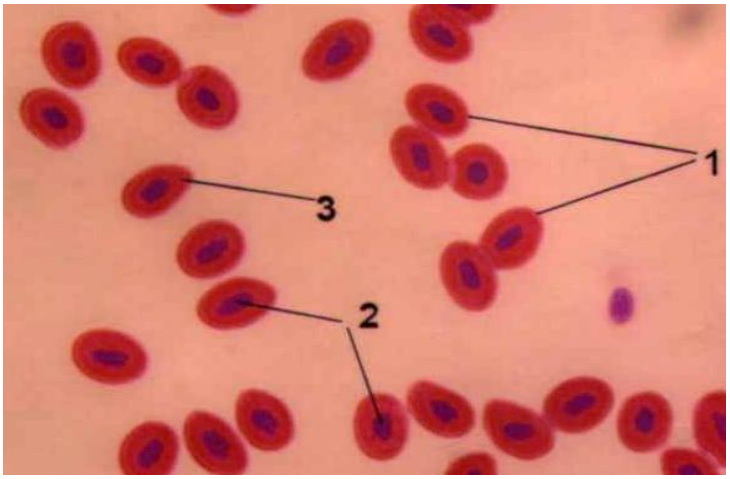


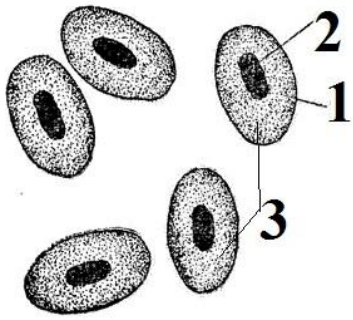
Indicate in the figure: 1) the cell boundaries; 2) the cytoplasm of nerve cells; 3) the core; 4) heterochromatin; 5) euchromatin.

4.2.8. Blood frogs

Note the numerous large cells - erythrocytes. They are oval in shape, the cytoplasm is colored in pink. In the center of the erythrocyte is a dark oval nucleus.

Draw a few cells.





Indicate in the figure: 1) red blood cells; 2) the nucleus; 3) the cytoplasm.

Topic: Structure and function of the cell membrane. Transport of substances through the membrane.

The aim of the lesson: to form a system of knowledge about the characteristics of the structure and functions of cell membranes.

Session objectives:
To examine the structural and functional features of basic biological membrane and plasmalemma of the cell.

SOFTWARE ISSUES:
1. The concept of elementary biological membrane as a structural basis of cell metabolism.
2. Surface unit cells: glycocalyx, plasma membrane and submembrane complex, their structure and properties.
3. Transport of substances through the membrane.

Equipment:
1. Microscope "Biolam P-11".

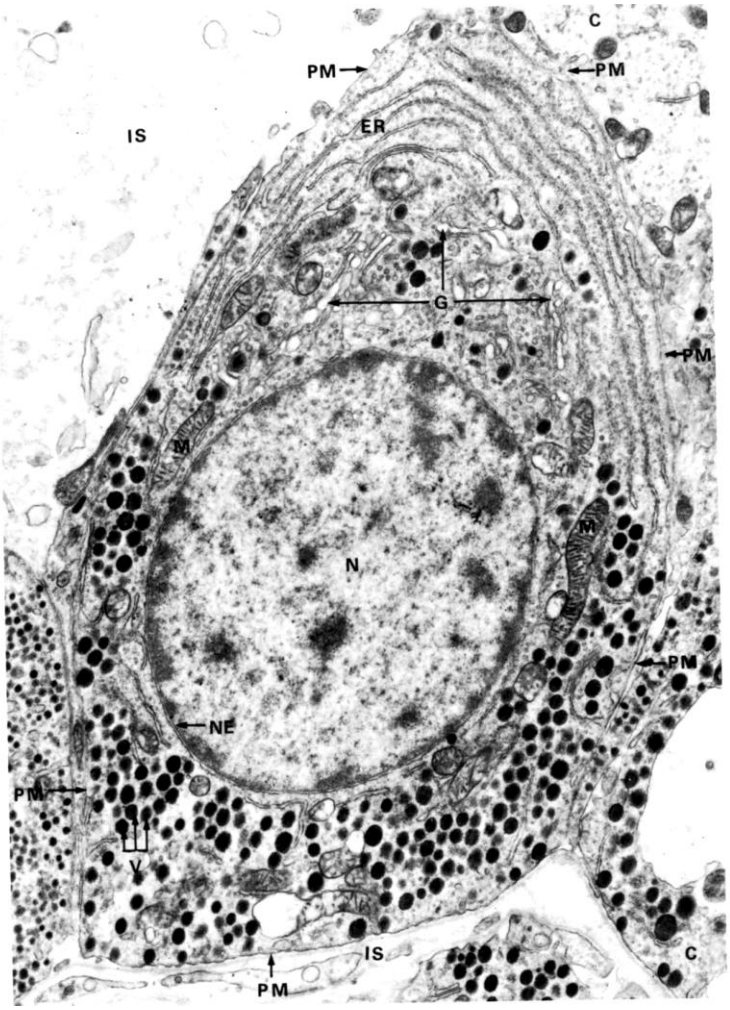
Exercise 1. **The study of electron micrographs**

To understand an electron micrograph, the first step is to identify individual cells (or parts thereof). The nucleus (if included in the plane of section) provides a good starting point and is a useful reference with respect to the size of other organelles. The plasma membrane is then identified and traced out, thus defining the limits of the cell. At times the membrane may appear to fade out; this is usually the product of an oblique plane of section which renders the membrane less easy to see. Other organelles such as mitochondria are then identified before more detailed examination is made of other organelles. From the relative proportions of organelles, much can then be deduced about the function of cells and thus the identity of the tissue.

1.1. The overall plan the structure of cells.

1.1.1. Read the text:

General view of cells under an electron microscope



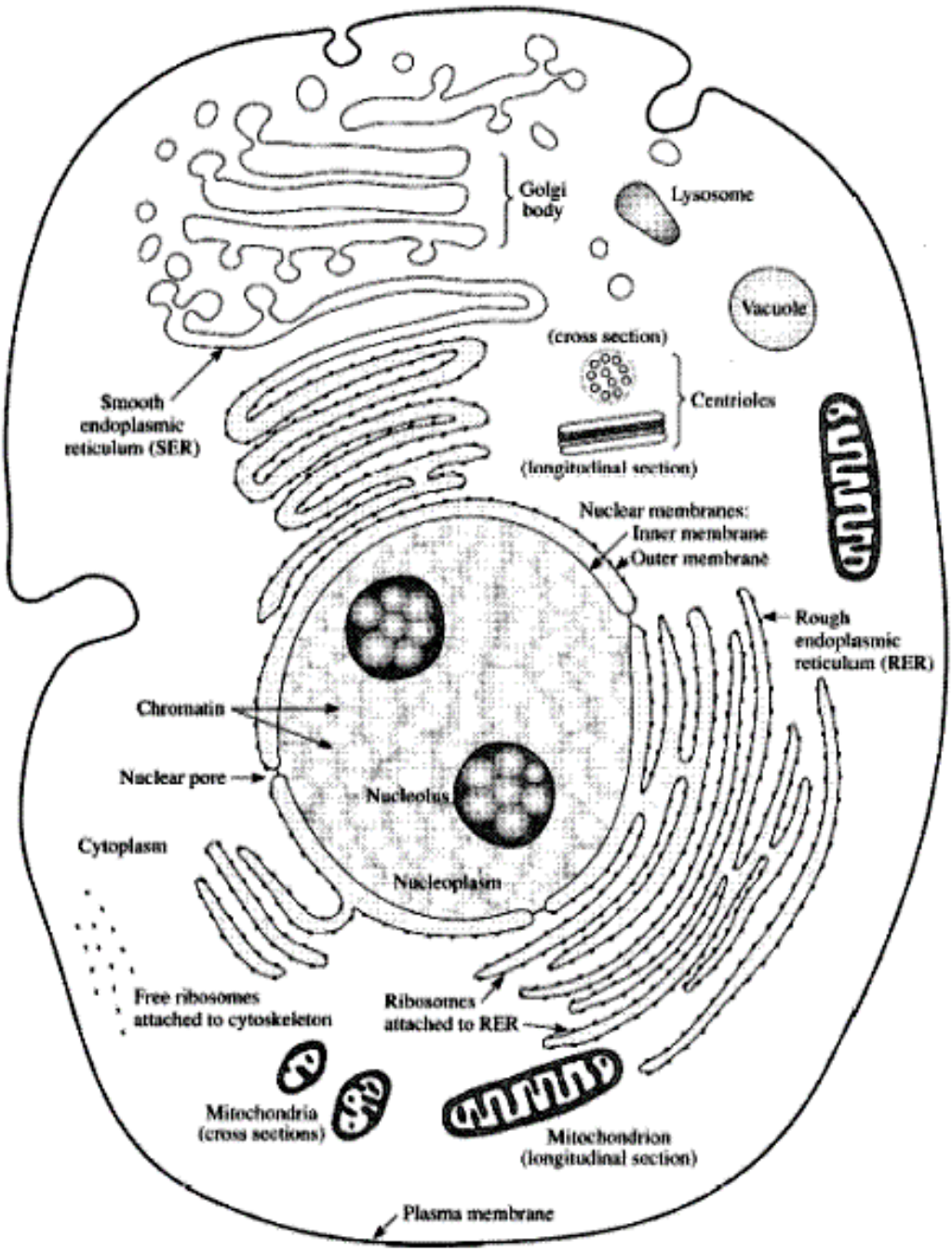
The basic structural features common to all cells are illustrated in this electron micrograph of a hormone-secreting cell from the pituitary gland. All cells are bounded by an external limiting membrane called the plasma membrane or plasmalemma PM which serves as a dynamic interface between the internal environment of the cell and its various external environments. In this particular example, the cell interacts with two types of external environment, adjacent cells C and intercellular spaces IS. Such interactions depend on the specialised function of the cell and include transfer of nutrients and metabolites, attachment of the cell to adjacent cells and other structures and intercellular communications.

The nucleus **N** is the largest organelle and its substance, often referred to as the nucleoplasm, is bounded by a membrane system called the nuclear envelope **NE**. The cytoplasm contains a variety of organelles most of which are also bounded by membranes. An extensive system of membrane-bound tubules, saccules and flattened cisterns, collectively known as the endoplasmic reticulum **ER**, is widely distributed throughout the cytoplasm. A more distended system of membrane-bound saccules, the Golgi apparatus **G**, is typically located close to the nucleus. Scattered free in the cytoplasm are a number of relatively large, elongated organelles called mitochondria **M** which have a smooth outer membrane and a convoluted inner membrane system. In addition to these major organelles, the cell contains a variety of other membrane-bound structures, an example of which are the numerous, electron-dense secretory vacuoles **V** (in this case containing hormone) seen in this micrograph.

Thus the cell is divided into a number of membrane-bound compartments each of which has its own particular biochemical environment. Membranes therefore serve to isolate incompatible processes. In addition, membranes incorporate enzyme systems and are themselves the site of many specific biochemical reactions.

The cytoplasmic organelles are suspended in a fluid medium called the cytosol in which much of the intermediary metabolism of the cell takes place. Within the cytosol, there is a network of minute tubules and filaments collectively known as the cytoskeleton which provides structural support for the cell and its organelles as well as providing a mechanism for cellular and intracellular movement; elements of the cytoskeleton are only visible with very high magnification.

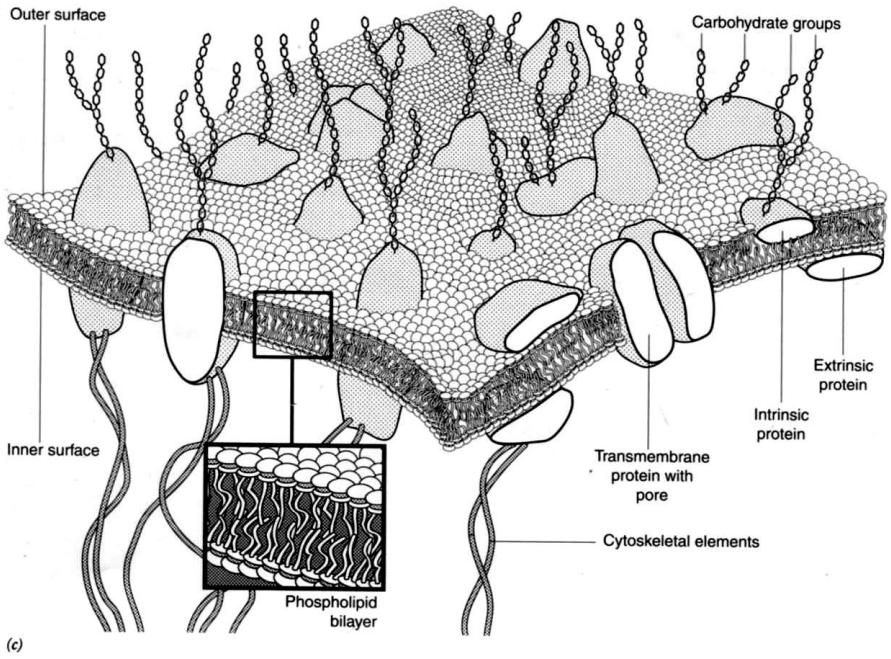
1.1.2. Draw the scheme of the structure of the cell.



1.2. Model of the structure of the outer membrane of the cell

1.2.1. Read the text, consider an electron micrograph of the cell membrane.

Despite intensive investigation, the structure of cell membranes is still not known with certainty; however, a theoretical model has been progressively developed which satisfactorily incorporates much of the currently available biochemical and histological evidence.



Towards the end of the last century, it was observed that lipids rapidly gain entry into cells, and it was postulated that the 'cell boundary' was composed of lipid. In the 1920s, it was found that by measuring the minimum area that could be occupied by a monolayer of lipids extracted from a defined number of red blood cells, there was enough lipid present in the monolayer to cover each cell twice. From this it was concluded that cells were bounded by a double layer of lipid.

Later, it was proposed that cell membranes are symmetrical structures consisting of a bilayer of phospholipid molecules sandwiched between two layers of protein. This model, however, failed to explain the selective permeability of most cell membranes to molecules which are not lipid-soluble such as glucose, sodium ions and potassium ions. These theoretical difficulties were overcome by postulating the existence of 'pores' composed of protein through which hydrophilic molecules could be transported by passive or active mechanisms.

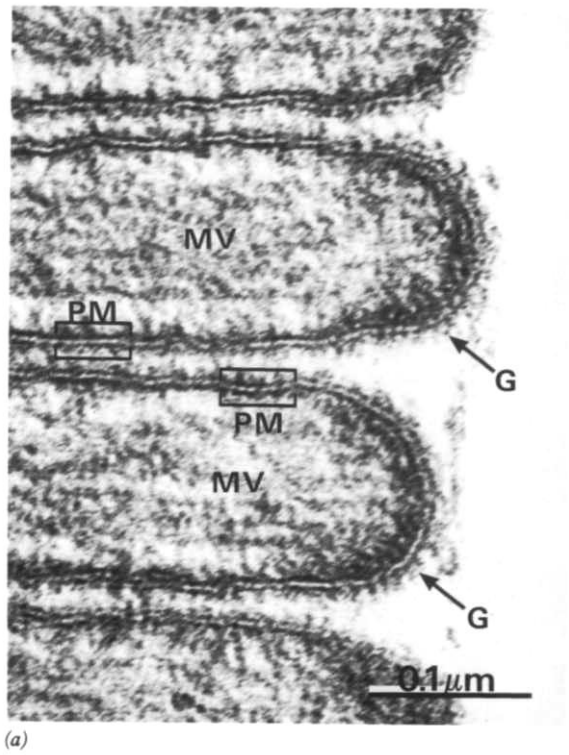
Electron microscopic studies in the 1950s revealed that all membranes have a three-layer (trilaminate) structure and this led to the concept of the unit membrane in which it was proposed that all cell membranes have a similar structure.

Fluid mosaic model of membrane structure

The current concepts of membrane structure derive from the work of Singer and Nicholson in the early 1970s. In this model, cell membranes consist basically of phospholipid molecules arranged as a bilayer.

Phospholipid molecules are amphipathic, i.e. they consist of a polar, hydrophilic (water-loving) head and a non-polar, hydrophobic (water-hating) tail. The polar heads are mainly derived from glycerol conjugated to a nitrogenous compound such as choline, ethanolamine or serine via a phosphate bridge as shown in diagram (b). The phosphate group is negatively charged whereas the nitrogenous group is positively charged. The non-polar tail of the phospholipid molecule consists of two long-chain fatty acids each covalently linked to the glycerol component of the polar head.

Phospholipids in aqueous solution will spontaneously form a bilayer with the hydrophilic (polar) heads directed outwards and the hydrophobic tails forced together inwards. The weak intermolecular forces which hold the bilayer together allow individual phospholipid molecules to move relatively freely within each layer and sometimes to 'flip' between layers.



(a)

Membrane structure (illustrations opposite)
(a) EM x 210 000
(c) Fluid mosaic model of membrane structure

Cholesterol molecules are also present in the bilayer in an almost one-to¬one ratio with phospholipids. Cholesterol molecules can regulate the fluidity and can stabilise the phospholipid bilayer.

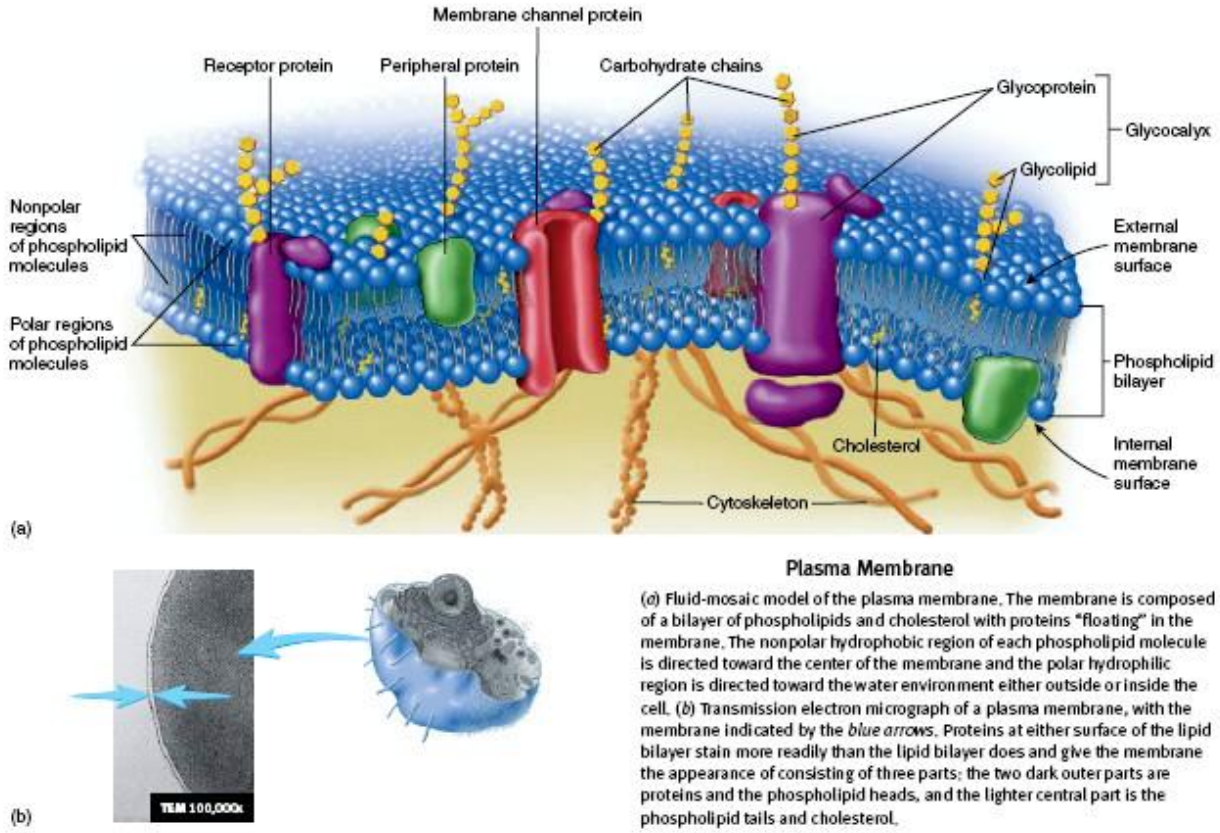
Associated with the bilayer are a variety of protein molecules which make up almost half of the total mass of the membrane. Some proteins are incorporated within the membrane (intrinsic or integral proteins) whereas others are held to the inner or outer surface by weaker electrostatic forces (extrinsic or peripheral proteins). Some intrinsic proteins span the entire thickness of the membrane (transmembrane proteins) to be exposed to each surface, some functioning as 'pores' through which hydrophilic molecules are actively or passively transported across the membrane. Many proteins are not fixed but rather 'float' within the membrane such that they are freely mobile within the plane of the phospholipid bilayer. This has led to the use of the term fluid mosaic model of membrane structure. Whilst the lipid component of the membrane principally determines its mechanical properties, the dynamic functions of the membrane as an interface between biological compartments is a function of the membrane proteins. Other integral proteins may be fixed by attachment to elements of the cytoskeleton.

On the external surface of the plasma membranes of animal cells, many of the membrane proteins and some of the membrane lipids are conjugated with short chains of polysaccharide; these glycoproteins and glycolipids respectively project from the surface of the bilayer forming an outer coating which may be analogous to the cell walls of plants, bacteria and fungi. This polysaccharide layer has been termed the glycocalyx and appears to vary in thickness in different cell types; a similar layer is often also present on membrane surfaces within the cell which are not exposed to the cytosol (e.g. luminal aspects of membrane systems). The glycocalyx appears to be involved in cell recognition phenomena, in the formation of intercellular adhesions and in the adsorption of molecules to the cell surface; in some situations the glycocalyx also provides mechanical and chemical protection for the plasma membrane.

The electron micrograph in (a) provides a high magnification view of a plasma membrane **PM**, in this case of minute surface projections (microvilli) **MV** of a lining cell from the small intestine. The characteristic trilaminate appearance comprises two electron-dense layers separated by an electron-lucent layer. The outer dense layers are thought to correspond to the hydrophilic 'heads' of phospholipid molecules whilst the electron-lucent layer is thought to represent the intermediate hydrophobic layer mainly consisting of fatty acids and cholesterol. On

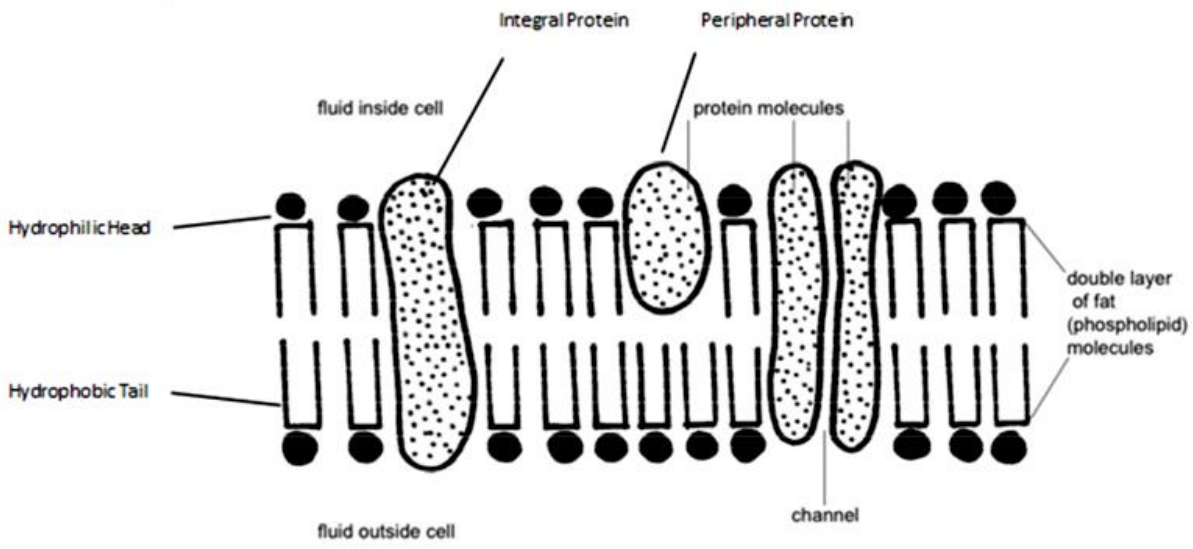
the external surface of the plasma membrane is a fibrillar coat, called the 'fuzzy coat', representing the glycocalyx **G**. This is an unusually prominent feature of small intestinal lining cells where it incorporates a variety of digestive enzymes.

1.2.2. Consider drawing and scheme structure of the membrane. Draw the scheme of the structure of the cell membrane. Make notations.



Plasma Membrane

(*a*) Fluid-mosaic model of the plasma membrane. The membrane is composed of a bilayer of phospholipids and cholesterol with proteins "floating" in the membrane. The nonpolar hydrophobic region of each phospholipid molecule is directed toward the center of the membrane and the polar hydrophilic region is directed toward the water environment either outside or inside the cell. (*b*) Transmission electron micrograph of a plasma membrane, with the membrane indicated by the *blue arrows*. Proteins at either surface of the lipid bilayer stain more readily than the lipid bilayer does and give the membrane the appearance of consisting of three parts: the two dark outer parts are proteins and the phospholipid heads, and the lighter central part is the phospholipid tails and cholesterol.



1.3. Transport across plasma membranes

1.3.1. Read the text:

Transport across plasma membranes

Plasma membranes mediate the exchange of molecules between the internal and external environments of the cell in four principal ways enabling the cell to control the quality of its internal environment with a high degree of specificity.

• **Passive diffusion.** This type of transport is entirely dependent on the presence of a concentration gradient across the plasma membrane. Lipids and lipid-soluble metabolites such as ethanol pass freely through plasma membranes which also offer little barrier to the diffusion of gases such as oxygen and carbon dioxide. The plasma membrane is, in general, impermeable to hydrophilic molecules. Nevertheless some small molecules including water and urea, and inorganic ions such as bicarbonate, are able to pass down osmotic and electrochemical gradients through the membrane via hydrophilic regions, the nature of which remains obscure.

• **Facilitated diffusion.** This type of transport is also concentration-dependent and involves the transport of larger hydrophilic metabolites such as glucose and amino acids. This process is strictly passive but requires the presence of so-called 'carriers' to which the metabolites bind specifically, but reversibly, in a manner analogous to the binding of substrate with enzyme.

• **Active transport.** This mode of transport is not only independent of concentration gradients but also often operates against extreme concentration gradients. The classic example of this form of transport is the continuous transport of sodium out of the cell by the 'sodium pump'; this process requires the expenditure of energy provided in the form of ATP. Active transport is mediated by 'dynamic pores' consisting of transmembrane protein systems. Both active and passive transport processes are enhanced if the area of the plasma membrane is increased by folds or projections of the cell surface as exemplified by the absorptive cells lining the small intestine.

• **Bulk transport.** This involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound *vacuoles (vesicles)* within the cytoplasm. When the process involves the creation of small vacuoles it is known as *pinocytosis,* and when large vacuoles are formed it is called *phagocytosis.*

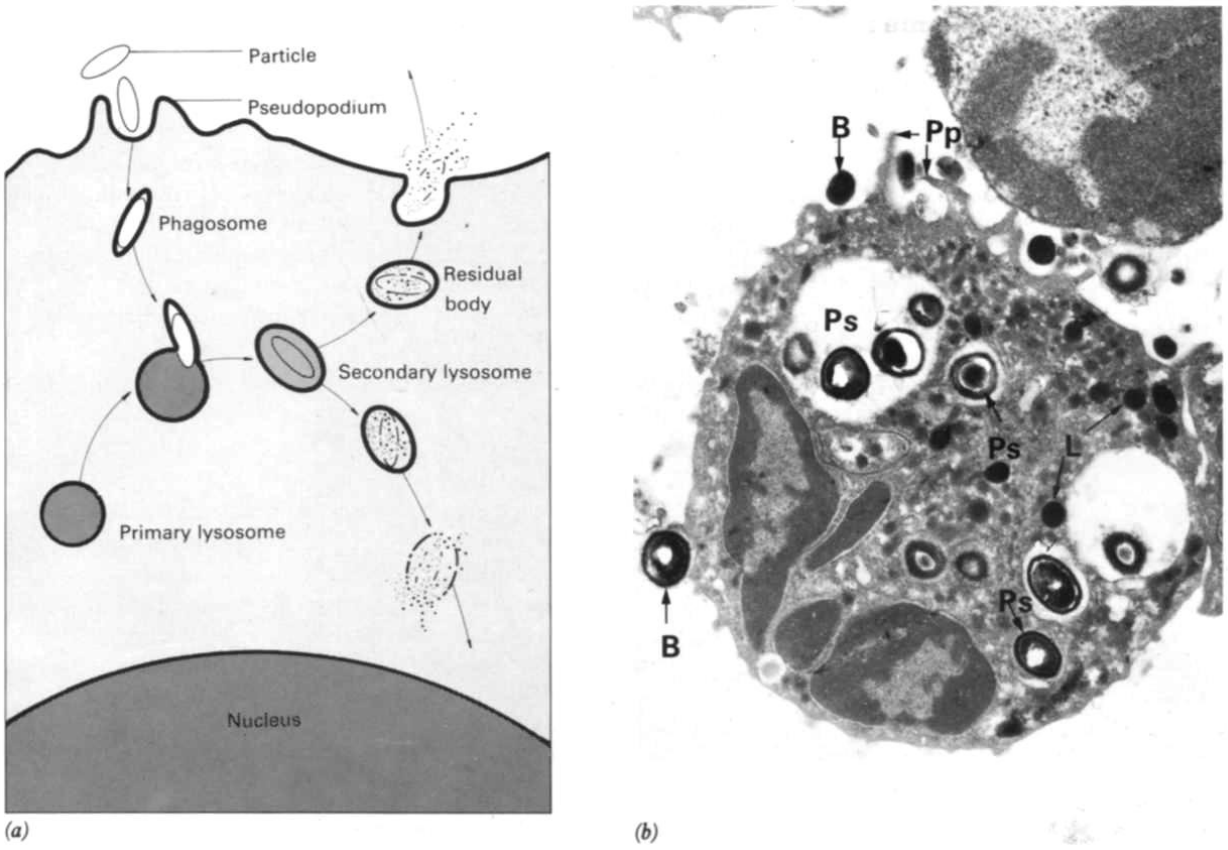
• The term *endocytosis*, encompassing both processes, is probably a more appropriate term for inwardly directed bulk transport. Endocytotic vesicles either discharge their contents directly into the cytoplasm or fuse with membrane-bound organelles called *lysosomes* which contain a variety'of enzymes which are capable of degrading carbohydrates, lipids, proteins, nucleic acids and other organic molecules. Lysosomal enzymes digest engulfed material which is then made available for metabolic processes. In many secretory processes, bulk transport occurs in the opposite direction when it is termed *exocytosis.* In some tissues where cells form a barrier between two extracellular environments, bulk transport involving pinocytotic vesicles is used to transport large molecules from one side of the cell to the other without the involvement of lysosomes; this is described as *transcytosis.*

Histologically, the passive and active processes of transport can only be observed indirectly; for example, cells suspended in hypotonic solutions swell due to passive uptake of water whereas cells placed in hypertonic solutions tend to shrink due to outflow of waterBulk transport, however, is readily observable by microscopy.

The diagram summarises the main steps in endocytosis of particulate matter.

The first stage of phagocytosis involves recognition of the matter to be ingested. This then becomes enveloped by plasma membrane which may involve the formation of cytoplasmic extensions called *pseudopodia.* When the particle is completely surrounded, the encompassing plasma membranes fuse and the membrane surrounding the engulfed particle forms a vesicle, known as a *phagosome* or *endocytotic vesicle*, which detaches from the plasma membrane to float freely within the cytoplasm. The phagosome is then in some way recognised by one or more lysosomes *(primary lysosomes)* which fuse with the phagosome to form a *secondary*

lysosome. This exposes the engulfed material to a battery of lysosomal enzymes. When digestion is complete, the lysosomal membrane may rupture, discharging its contents into the cytoplasm.



Endocytosis *(a) Schematic diagram (b) EMx11 750*

Undigested material may remain within membrane-bound vesicles called *residual bodies,* the contents of which may be later discharged at the cell surface by exocytosis; alternatively residual bodies may accumulate in the cytoplasm. Membrane-bound organelles containing multiple small vesicles called *multivesicular bodies,* are also found in some cells and are thought to represent a form of secondary lysosome or residual body containing multiple pinocytotic vesicles or their remnants.

Micrograph (b) illustrates a highly phagocytic white blood cell, a neutrophil, in the process of engulfing and destroying bacteria **B.** Note the manner in which pseudopodia **Pp**

embrace the bacteria before engulfment. Note also phagosomes **Ps** containing bacteria in various stages of degradation. Several primary lysosomes **L** are also visible.

Receptor-mediated endocytosis

Whilst some bulk transport may be relatively non-selective and driven by concentration gradients, much endocytosis is highly selective and mediated by specific receptors incorporated in the plasma membrane. The term *ligand* (ligare = to bind) is used to describe molecules taken up by such *receptor-mediated endocytosis.* The receptors are either located in small invaginations of the membrane called *coated pits* or drift laterally within the membrane to become localised within pits. Coated pits are so named for a coating on the inner (cytoplasmic) aspect of the membrane by a protein called *clathrin;* this mediates the engulfment process by formation of a curved lattice structure which governs the shape of the developing membranous vesicle. The *coated vesicles* so formed then lose this clathrin coating which is returned to the inner aspect of the surface membrane and reused in the formation of more coated pits.

Lysosomes are also involved in the degradation of cellular organelles, many of which have only a finite lifespan and are therefore replaced continuously; this lysosomal function is

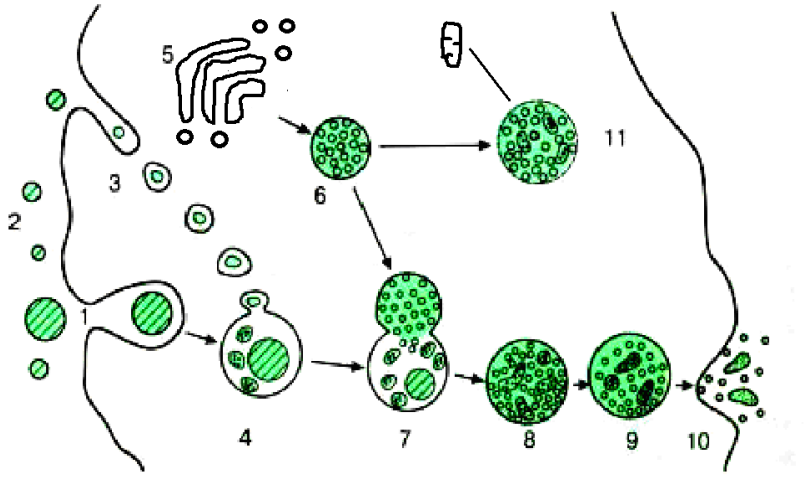
termed *autophagy*. Most autophagocytic degradation products accumulate and become indistinguishable from the residual bodies of endocytosis. With advancing age, residual bodies accumulate in the cells of some tissues and appear as brown *lipofuscingranules.*

1.3.2. Fill in the table using the text of section 1.3.

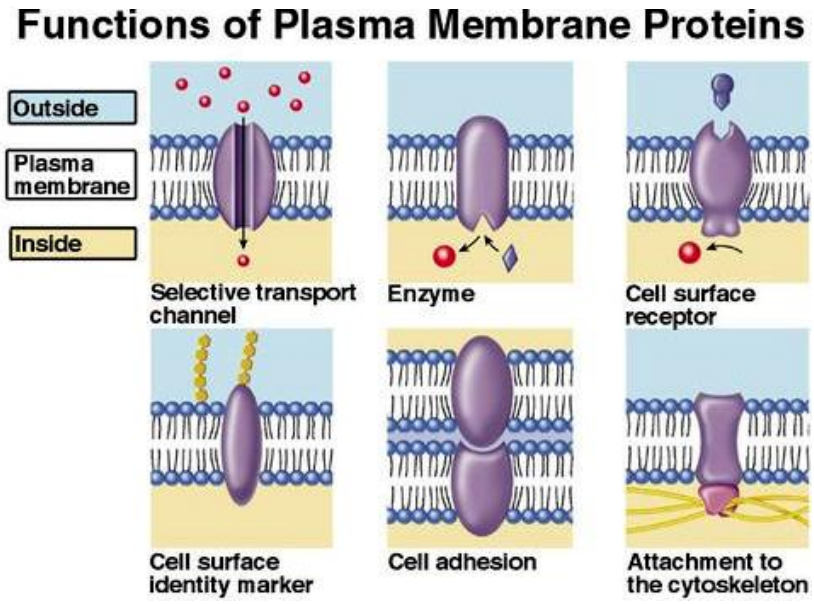
Transport across plasma membranes

Type of transport	**Dependence from concentration gradients**	**Examples of transported materials**	**Structures of membranes involved in the transport of substances**
Passive diffusion			
Facilitated diffusion			
Active transport			
Bulk transport			

1.3.3. Draw the scheme of endocytosis, using the text from the section 1.3. Make designations.

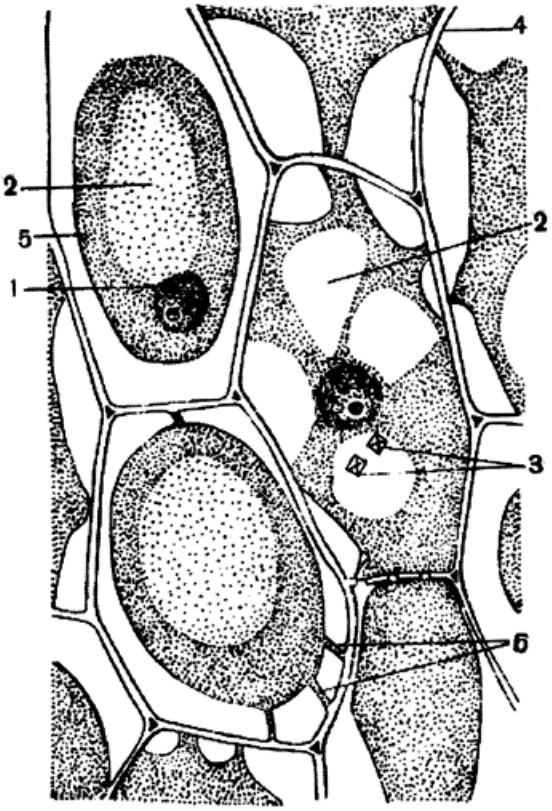


1.4. Consider drawing. Write down the function of the plasma membrane proteins.



Lab №1.

Plasmolysis cells in the skin scales of onion



Osmosis of the plant cells can be seen by placing the plant tissue in a hypertonic solution. This will be a plasmolysis - separation of the cytoplasm from the cell walls. Consider the phenomenon of plasmolysis, using the skin covering the inner onion scales. If the cell is placed in a hypertonic solution, the water will come out of the vacuole and the cytoplasm through the sheath outwardly. Plasmalemma and tonoplast having elasticity, are reduced, plasmalemma departs from the cell walls - plasmolysis occurs. In many cells plasmolysis is concave. In some places, protoplast associates thin cytoplasmic threads with cell walls. Some of them with time breaks. Cells after plasmolysis can be returned to its original state. To do this, place the cell in water. In this case the concentration of substances in the vacuole would be higher than in the surrounding medium. The water will actively flow into the cell. The volume of vacuoles will increase . The cytoplasm will be connected with cell walls - deplasmolysis occurs. It is best to observe the plasmolysis in the cells of purple onion scales. Onion painted due to the presence in the cell sap water-soluble pigment - anthocyanin. When the water comes out of the vacuoles the concentration of pigment increases and color of the cell sap becomes more intense.

Materials and equipment: bulb blue bow 1M KNO_3 (can replace weak solutions of NaCl, Ca $(NO_3)_2$, glucose, sucrose, glycerol), scalpel or razor blade, a dissecting needle slides and cover glasses, microscopes, glass with tap water, filter paper, glass rods.

Progress. Prepare a temporary slide of onion scales. Remove the skin from the convex side of the succulent onion scales containing anthocyanin. Put slides in the drop of water and covere it by cover glass. Consider the slide at low and high magnification. Replace the water in the solution of KNO_3. Watch a microscope for changes in the cells. Draw the cells of the epidermis inner bulb scales of onion: a common look and cells after plasmolysis. Describe the sequential steps of plasmolysis: angled, concave, convex (rounded). Replace the solution under a cover glass to water. Consider the cell where deplasmolis occurred.

Figure: Plasmolysis cells of onion scales

Indicate in: 1 - the nucleus; 2 - vacuoles; 3 - calcium oxalate crystals; 4 - sheath cells; 5 - plasmalemma; 6 - threads Hecht.

Topic: The organelles of the cell .

The aim of the lesson: to form a system of knowledge about the characteristics of the structure, location and functions of cell organelles.

Session objectives:
1. To examine the structural and functional characteristics of organelles general purpose.
2. To examine the structural and functional features of the organelles of a special purpose.

SOFTWARE ISSUES:
1. Organelles (organelles) General purpose. Ribosomes, their structure, chemical composition, role in protein biosynthesis.
2. Endoplasmic network: types, structure, functions.
3. Lamellar complex (Golgi complex): structure and meaning in the metabolism.
4. Lysosomes: classification, ultrastructure and functions.
5. The structure and composition of the peroxisome.
6. Mitochondria: structure, functional role.
7. Structure and biological role of microfilaments and microtubules.
8. The centrosome.
9. Special organelles: ciliated cilia, flagella, and microvilli.
10. Neurofibrils and myofibrils.

Equipment:
1. Microscope "Biolam P-11".
2. Main slides: chondriosomes (mitochondria) in the epithelial cells of the intestine roundworm.
3. PowerPoint: the Golgi complex.

***Exircise* 1. The structure of the cell membrane organelles**

1.1. Read the text, consider an electron micrograph of lysosome and peroxisomes:

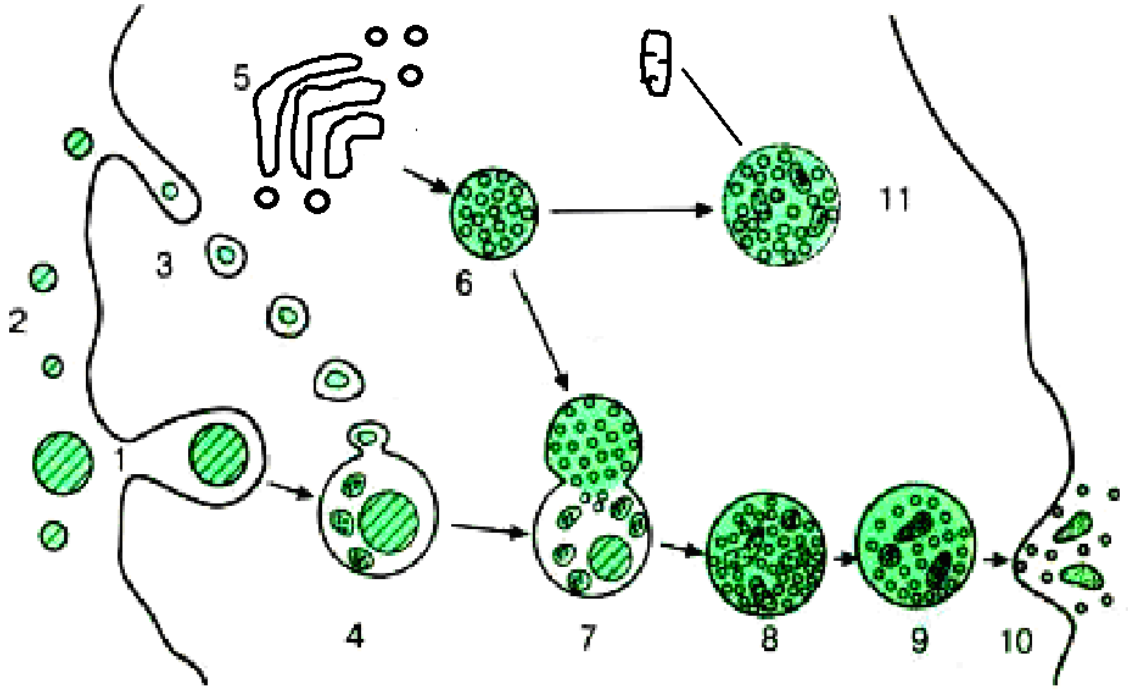
These micrographs show the typical features of lysosomes and residual bodies. Micrograph (a) shows part of the cytoplasm of a liver cell. Primary lysosomes **Ly,** vary greatly in size and appearance but they are recognised as membrane-bound organelles containing an amorphous granular material. Secondary lysosomes **Ly_2** are even more variable in appearance but are recognisable by their diverse particulate content some of which is extremely electron-dense. The distinction between residual bodies and secondary lysosomes is often difficult but one distinctive type of residual body, the multivesicular body **MB,** is seen in this micrograph. Note the size of lysosomes relative to mitochondria **M.**

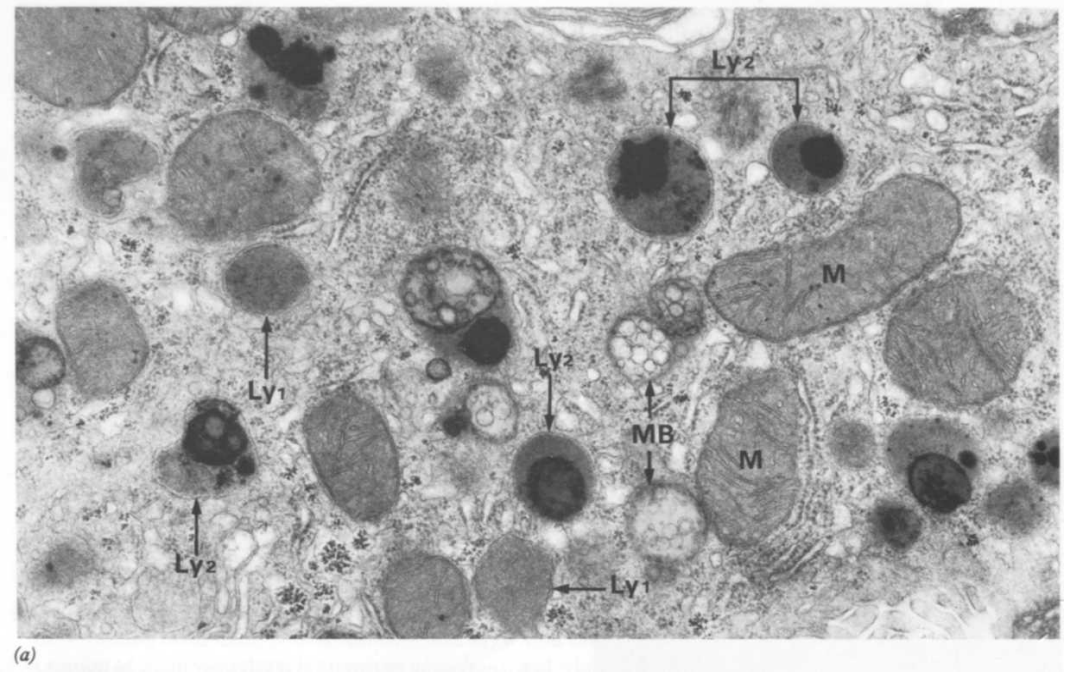
Micrograph (b) shows two secondary lysosomes or residual bodies at higher magnification, allowing the limiting membrane to be visualised. Both contain electron dense particulate material and amorphous granular material.

The lysosomal enzymes comprise more than 40 different acid hydrolases which are optimally active at a pH of about 5.0. This may be a protective mechanism for the cell should lysosomal enzymes escape into the cytosol where they would be less active at the higher pH.

Histochemical methods can be used to demonstrate sites of enzyme activity within cells and thus act as markers for organelles which contain these enzymes. Such a method has been used in micrograph (c) to demonstrate the presence of *acid phosphatase,* a typical lysosomal enzyme; enzyme activity is represented by a very dense deposit within a lysosome **L.** Other organelles remain unstained but the outline of a mitochondrion **M** and saccules of endoplasmic reticulum **ER** can nevertheless be identified.

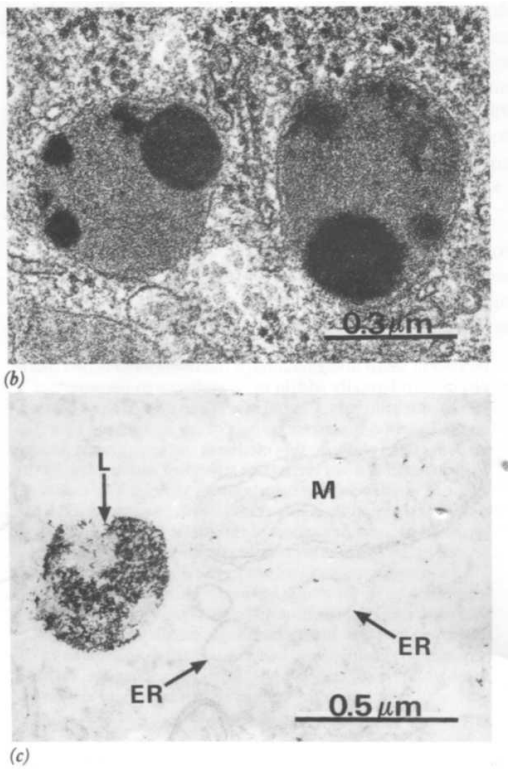
Draw the and indicate different types of lysosomes

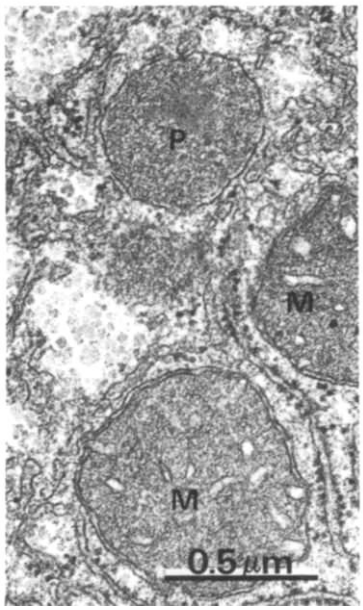




Lysosomes

a) EM x 27 000 (b) EM x 60 000
(c) Histochemical method for acid phosphatase: EM x 50 *000*





Peroxisomes *(EMx40000)*

1

Peroxisomes are small, spherical, membrane-bound organelles (also known as *microbodies)* which closely resemble lysosomes in size and electron microscopic appearance. They are, however, distinguished from lysosomes by their content of an entirely different set of enzymes which can be demonstrated by histochemical techniques.

Peroxisomes contain oxidases involved in certain catabolic pathways (e.g. beta oxidation of long chain fatty acids) utilising molecular oxygen and resulting in the formation of hydrogen peroxide, a potentially cytotoxic byproduct. Hydrogen peroxide is nevertheless utilised by certain phagocytic cells of the defence system to kill ingested microorganisms and also has a role in certain metabolic pathways. Peroxisomes also contain *catalase* which regulates hydrogen

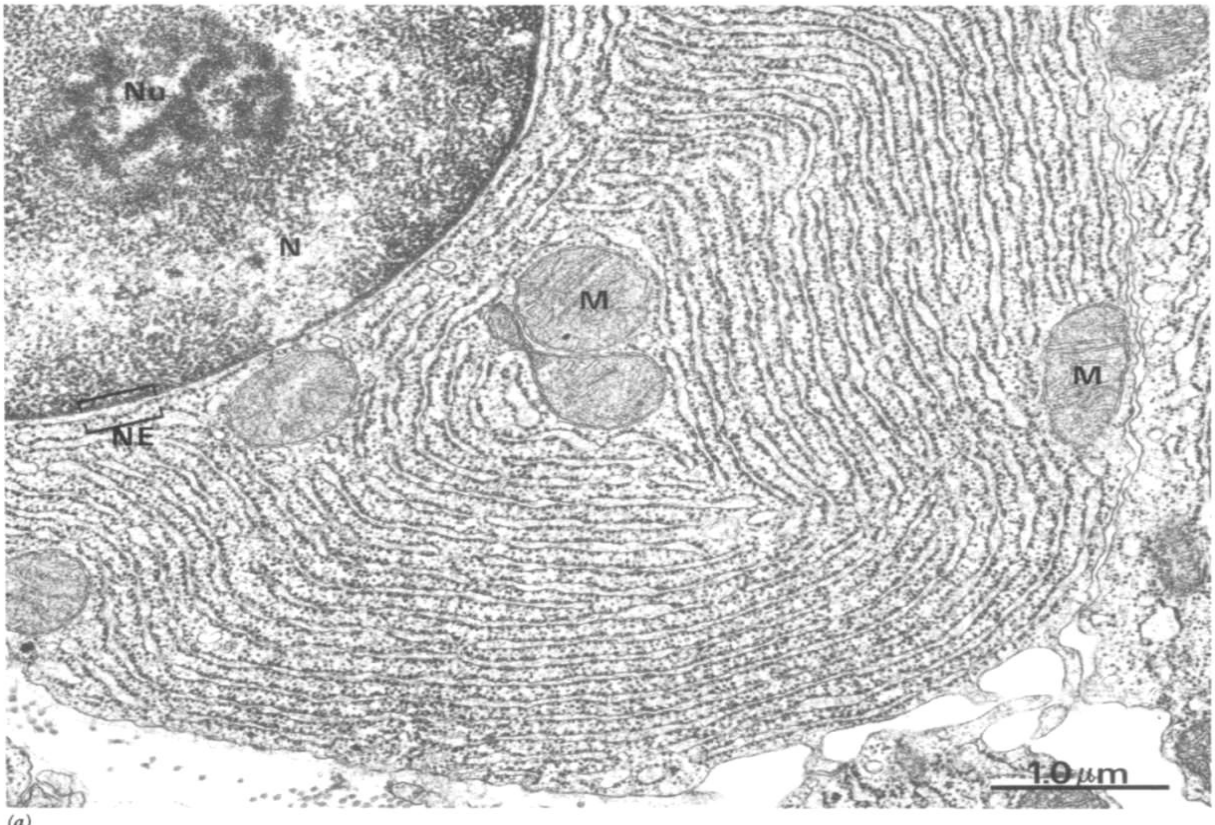
peroxidase concentration, utilising it in the oxidation of a variety of potentially toxic metabolites and ingested substances including phenols and alcohol.

The peroxisomes of many species have a central crystalloid structure called a *nucleoid* which contains the enzyme *urate oxidase.* This is not present in humans which thus lack the ability to metabolise urates. The peroxisomes of the liver and kidney are particularly large and abundant reflecting the functions of these organs in lipid metabolism and management of metabolic waste products.

In this micrograph, note the fine granular electron-dense contents of a peroxisome **P,** the size of which can be compared to that of adjacent mitochondria **M.**

1.2. Read the text, consider an electron micrograph the endoplasmic reticulum

The endoplasmic reticulum consists of an interconnecting network of membranous tubules, vesicles and flattened sacs *(cisternae)* which ramifies throughout the cytoplasm. Much of its surface is studded with ribosomes giving a rough or granular appearance leading to the name *rough* or *granular endoplasmic reticulum* (rER or gER). Proteins are synthesised by the ribosomes on the external surface of the rER and are then passed into the reticular lumen. Protein synthesised by rER is destined either for secretion or for incorporation in lysosomes; integral membrane proteins are also synthesised on rER. In contrast, proteins synthesised on free ribosomes areutilised within the cytosol.



Rough endoplasmic reticulum
a) EM x 23 000 (b)EMx 50 000

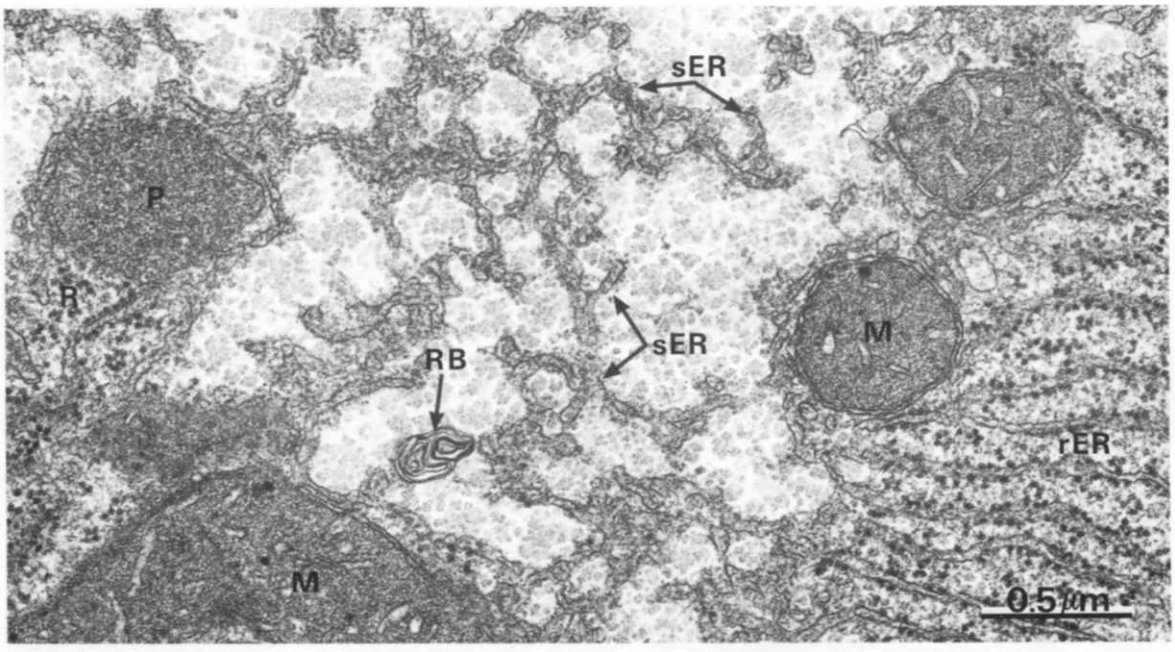
These micrographs illustrate rough endoplasmic reticulum in a cell which is specialised for the synthesis and secretion of protein; in such cells rough endoplasmic reticulum tends to be profuse and to form closely packed parallel laminae of flattened c^sternae.

In micrograph (a), the dimensions of the rER can be compared with that of mitochondria **M** and the nucleus **N.** The nucleus typically contains a prominent nucleolus **Nu.** Note the close association of the rER with the nuclear envelope **NE** with which it is in continuity. The chromatin in the nucleus is mainly dispersed (euchromatin) consistent with this great biosynthetic activity.

Micrograph (b) shows part of the rER at high magnification. Numerous ribosomes stud the surface of the membrane system and numerous other ribosomes lie free in the intervening cytosol.

Smooth endoplasmic reticulum (sER) consists of an irregular network of membranous tubules and vesicles devoid of ribosomes in contrast to the flattened ribosome-studded cisternae of rough endoplasmic reticulum. It forms part of the intracellular membrane system being continuous with the rough endoplasmic reticulum and Golgi apparatus (see Fig. 1.9). The principal functions of smooth endoplasmic reticulum are lipid biosynthesis and intracellular transport; in liver cells, smooth endoplasmic reticulum also plays a major role in the metabolism of glycogen and detoxification of various noxious metabolic byproducts, drugs and alcohol. In highly contractile cells (muscle), sER is involved in storage and release of calcium ions which activates the contractile mechanism (see Ch. 6). One particular enzyme, cytochrome P450, is present in large amounts in the smooth endoplasmic reticulum of liver; this enzyme hydroxylates water-insoluble hydrocarbons which become dissolved in the lipid bilayer of the membranous vesicles.

In general, most cells do not have a prominent system of smooth endoplasmic reticulum but, rather, scattered elements can be seen amongst the other organelles. The notable exceptions are the liver and those cells specialised for lipid biosynthesis such as the steroid hormone-secreting cells of the adrenal glands and the gonads. In this micrograph from the liver, most of the membranous elements are smooth endoplasmic reticulum **sER;** however, for comparison, rough endoplasmic reticulum **rER** is included in the lower right of the field. Note the continuity of the two forms of ER. This field also includes several mitochondria **M,** a peroxisome **P,** free ribosomes and polyribosomes **R** and a whorl of membrane in a residual body **RB.**



Smooth endoplasmic reticulum *(EM* x *40 000)*

Lipid biosynthesis

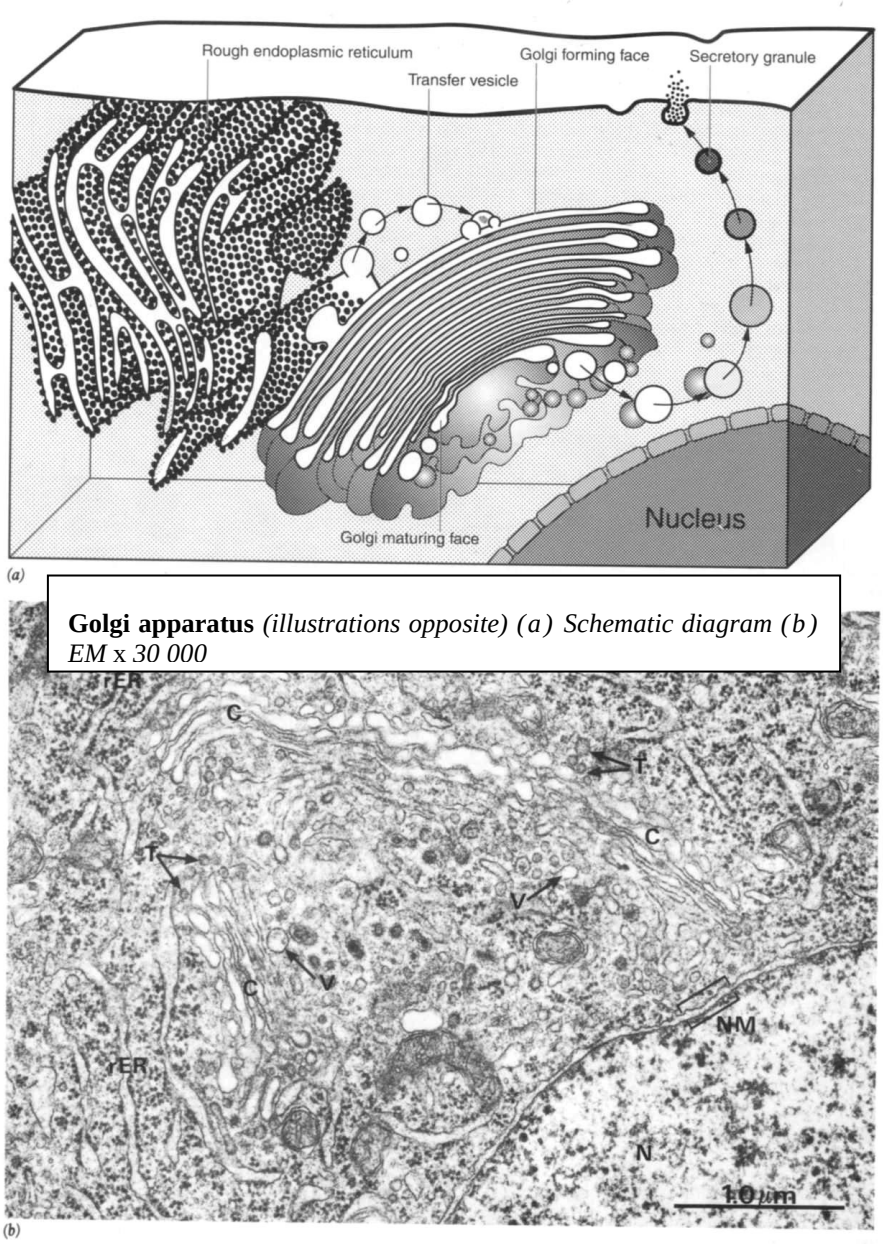
Lipids are synthesised by all cells in order to repair and replace damaged or worn membranes. Cells may also synthesise lipid as a means of storing excess energy (as cytoplasmic droplets), for lipid transport (e.g. chylomicron production by cells of the small intestine) and in the form of steroid hormones. The precursor molecules (fatty acids, triglycerides and cholesterol) are available to the cell from dietary sources, mobilisation of lipid stored in other cells or can be synthesised by most cells using simple sources of carbon such as acetyl-CoA and other

intermediates of glucose catabolism. Fatty acids and triglycerides are mostly synthesised within the cytosol, whereas cholesterol and phospholipids are synthesised in areas of endoplasmic reticulum devoid of ribosomes called *smooth endoplasmic reticulum (sER).*

1.3. Read the text, consider an electron micrograph Golgi apparatus

Secretion

The export from cells of excretory (waste) products or secretory products involves the four principal mechanisms outlined earlier for the transport of materials into cells across the plasma membrane. Excretion or secretion of small molecular weight compounds or lipid-soluble materials rarely involves bulk transport, whereas secretion of proteins and protein complexes almost always involves this mode of transfer. Prior to release from the cell, proteins and other secretory products are packaged within membrane-bound vesicles. These then fuse with the surface plasma membrane thus releasing their contents by the process of exocytosis. The Golgi apparatus (also called Golgi body or Golgi complex) is the organelle primarily responsible for the packaging process. By a similar process, the Golgi is also responsible for lysosome formation.



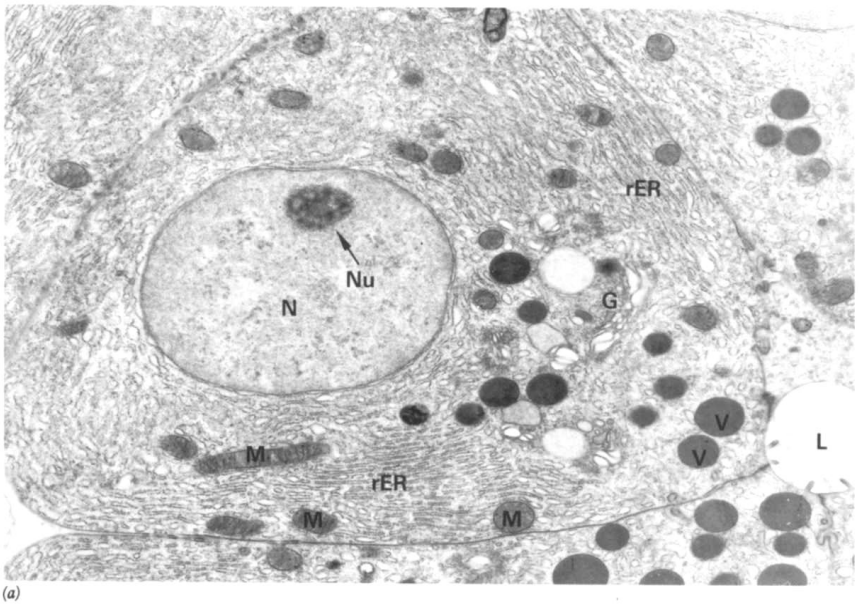
Golgi apparatus *(illustrations opposite) (a) Schematic diagram (b) EM x 30 000*

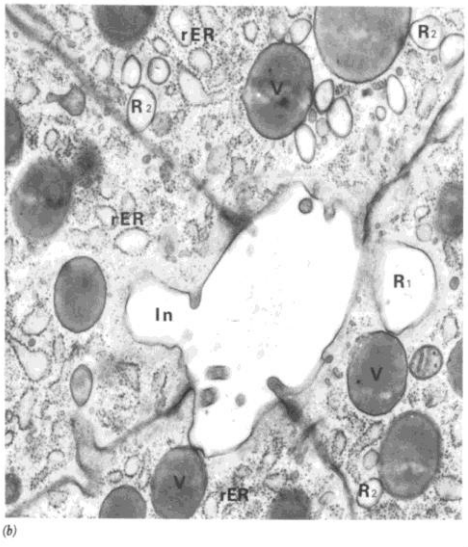
The Golgi apparatus is also involved in modification of certain proteins and contains the enzymes required for the synthesis of glycoproteins; these include plasma membrane glycoproteins forming the glycocalyx. Like wise, the Golgi is also responsible for the elaboration of membrane glycolipids.

During the secretory process, large amounts of intracellular membrane become incorporated into the plasma membrane and the Golgi system recycles excess plasma membrane, returning it to an internal 'pool' of membrane. The Golgi apparatus also elaborates new membrane necessary for cell growth and formation of membrane-bound organelles such as lysosomes, as well as replacing membrane lost or damaged during normal metabolic activities.

The diagram (a) illustrates the main structural features of the Golgi apparatus and summarises the mechanism by which secretory products are packaged within membrane-bound vesicles.

The Golgi apparatus consists of a system of stacked, saucer-shaped cisternae with the concave surface facing the nucleus. Proteins, synthesised on ribosomes of the rough l endoplasmic reticulum, are transported within the endoplasmic reticulum to the vicinity of the Golgi apparatus. Small membrane-bound vesicles containing protein, known as *transfer vesicles,* bud off from the endoplasmic reticulum and then coalesce with the convex surface of the Golgi apparatus, an area of the Golgi apparatus known as *the forming face.* By a mechanism still unresolved, secretory product is passed towards the concave surface, the *maturing face,* where new vesicles containing secretory product are formed; these *secretory vesicles* are of much greater dimensions than the transfer vesicles seen at the Golgi forming face. After release from the maturing face, the contents of secretory vesicles become increasingly condensed to form mature secretory vesicles, often termed *secretory granules,* which are then liberated at the cell surface by exocytosis.





Exocytosis

a) EM x 14000 (b) EM

The micrograph (b) illustrates a particularly well developed Golgi apparatus; transfer vesicles **T** and elements of the rough endoplasmic reticulum **rER** are seen adjacent to the forming face. A variety of larger vesicles **V** can be seen in the concavity of the maturing face, some of which appear to be budding from the Golgi cisternae **C;** such vesicles represent both potential secretory granules and lysosomes. Note the proximity of the Golgi apparatus to the nucleus **N;** the nuclear membrane **NM** is particularly well demonstrated in this micrograph.

Micrograph (a) illustrates a typical protein-secreting cell, in this case from the pancreatic gland which produces a secretion rich in digestive enzymes. In the nucleus **N,** the chromatin is

The Golgi apparatus is a dynamically changing structure, the appearance of which varies according to the functional state of the cell; for this reason the 'classic' appearance of the Golgi apparatus is, in practice, rarely seen. Moreover, a cell may contain as many as 100 Golgi stacks or even more, all being linked by an anastomosing membrane network.

typically dispersed, and there is a prominent nucleolus **Nu.** The cytoplasm is packed with rough endoplasmic reticulum rER, there is a prominent Golgi apparatus G and scattered mitochondria **M.** Secretory vesicles V become increasingly electron-dense as they are concentrated towards the glandular lumen **L.**

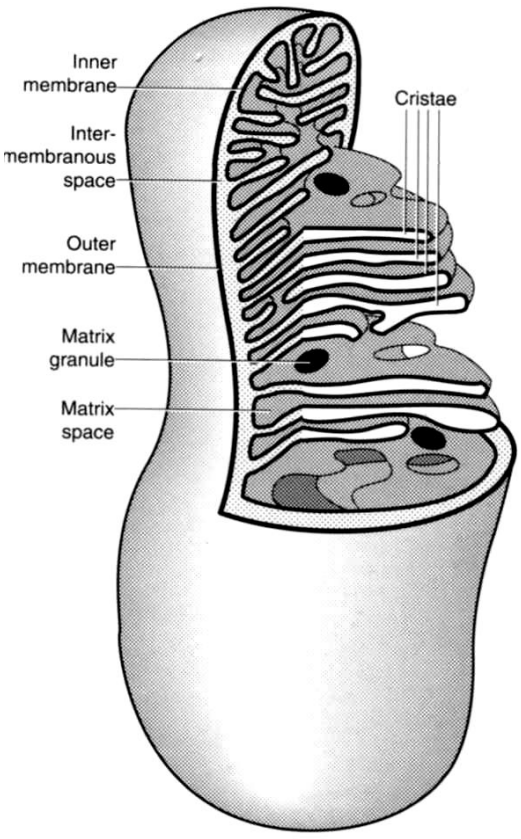
Micrograph (b) shows the apical regions of four pancreatic secretory cells converging on a tiny central excretory duct. Large secretory vesicles V are seen approaching the lumen, one of which appears to be fusing with the surface plasma membrane. A deep invagination **In** in one of the plasma membranes probably represents a secretory vesicle which has just discharged its contents. A large vesicle R,, and numerous smaller, apparently empty vesicles R_2 may represent vesicle membrane in the process of being recycled.

1.4. Read the text, consider an electron micrograph mitochondria

Energy production and storage

All cellular functions are dependent on a continuous supply of energy which is derived from the sequential breakdown of organic molecules during the process of *cellular respiration.* The energy released during this process is ultimately stored in the form of ATP molecules. In actively respiring cells, ATP forms a pool of readily available energy for all the metabolic functions of the cell. The main substrates for cellular respiration are simple sugars and lipids, particularly glucose and fatty acids. Cellular respiration of glucose (glycolysis) begins in the cytosol where it is partially degraded to form pyruvic acid, yielding a small amount of ATP. Pyruvic acid then diffuses into specialised membranous organelles called *mitochrondria* where, in the presence of oxygen, it is degraded to carbon dioxide and water; this process yields a large quantity of ATP. In contrast, fatty acids pass directly into mitochondria where they are also degraded to carbon dioxide and water; this also generates a large amount of ATP. Glycolysis may occur in the absence of oxygen and is therefore termed *anaerobic respiration,* whereas mitochondrial respiration is dependent on a continuous supply of oxygen and is therefore termed *aerobic respiration.* Mitochondria are the principal organelles involved in cellular respiration in mammals and are found in large numbers in metabolically active cells such as those in the liver and skeletal muscle.

Under favourable nutritional conditions, most cells generate and store excess glucose and fatty acids in the relatively insoluble and non-toxic forms, glycogen and triglyceride respectively. Cells vary greatly in their content of stored carbohydrate and lipid; extreme examples are nerve cells, which contain almost no intracellular glycogen or triglyceride, and fat cells, the cytoplasm of which is almost entirely filled with stored lipid.

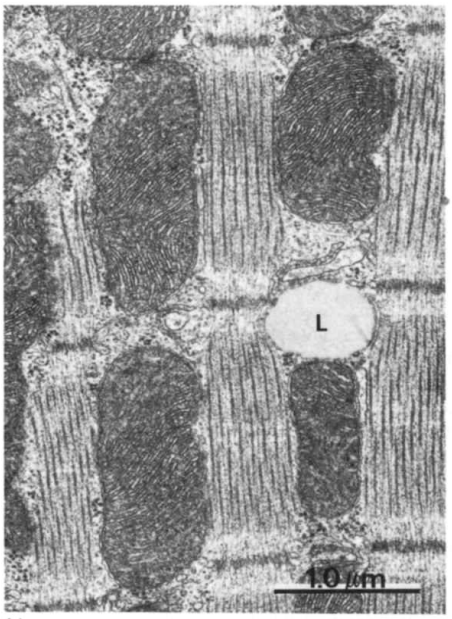


Mitochondria

Mitochondria vary considerably in size and shape but are most often elongated, cigar-shaped organelles. They are motile and tend to localise at intracellular sites of maximum energy requirement. The number of mitochondria in cells is highly variable; liver cells contain as many as 2000 mitochondria whereas inactive cells contain very few.

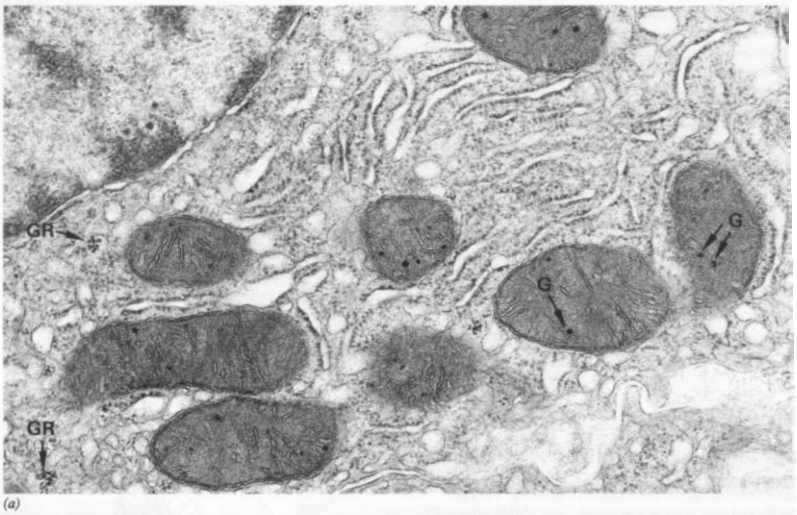
Each mitochondrion consists of two layers

of membrane. The outer membrane is relatively permeable and contains enzymes that convert certain lipid substrates into forms that can be metabolised within the mitochondrion. The inner membrane is thrown into folds called *aristae* projecting into the inner cavity which is filled with an amorphous substance called *matrix.* The matrix contains a number of dense *matrix granules,* the nature and function of which are unclear. The inner mitochondrial membrane is closely applied to the outer membrane leaving a narrow *intermembranous space* which extends into each crista. Aerobic respiration takes place within the matrix and inner mitochondrial membranes and this process is enhanced by the large surface area provided by the cristae.

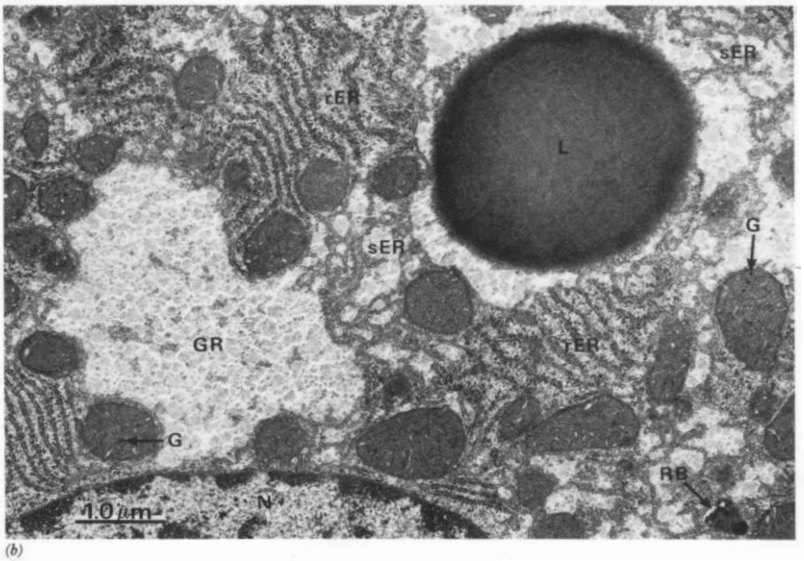


(c)

Mitochondria, lipid droplets and glycogen *(illustrations (a) and (b) opposite) (a) EM* x *42 000 (b) EM x 17 000 (c)EMx 25 000 (d) EM* x *32 400 (e) EM*



(a)



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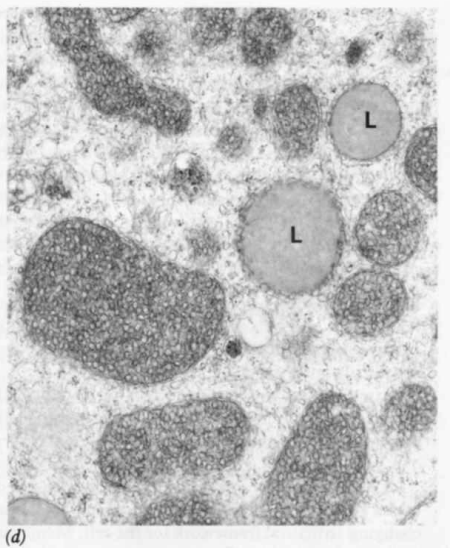
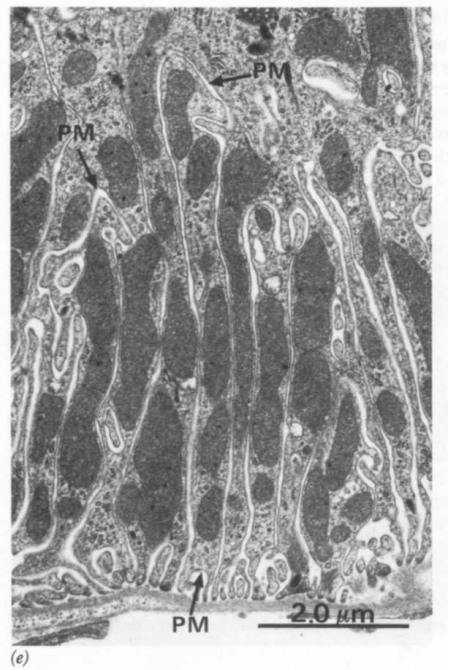


(d)



(e)

The matrix contains most of the enzymes involved in oxidation of fatty acids and the Krebs cycle. The inner membrane contains the cytochromes, the carrier molecules of the electron transport chain, and the enzymes involved in ATP production.

As organelles, mitochondria have several most unusual features. The mitochondrial matrix contains a strand of DNA arranged as a circle in a manner analogous to the chromosomes of bacteria. The matrix also contains ribosomes which have a similar structure to bacterial ribosomes.

Mitochondria synthesise at least some of their own constituent proteins, others being synthesised by the cell in which they reside. In addition, mitochondria under-go self-replication in a manner similar to bacterial cell division. It has thus been proposed that mitochondria are semi-autonomous organelles which arose during evolution as bacterial intracellular parasites of larger, more advanced cells.

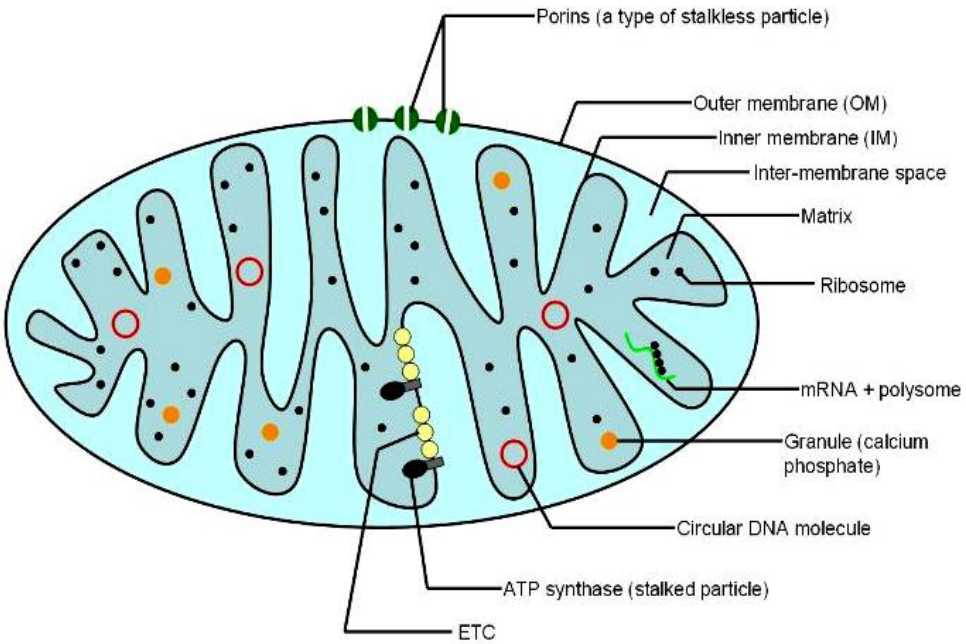
All mitochondria conform to the same general structure but vary greatly in size, shape and arrangement of cristae; these variations often reflect the metabolic status of the cell type in which the mitochondria are found. Mitochondria move freely within the cytosol and tend to aggregate in intracellular sites with high energy demands where their shape often conforms to the available space.

Micrographs (a) and (b), both of liver cell cytoplasm, show the typical appearance of mitochondria when cut in different planes of section; note their relatively dense matrix containing a few matrix granules **G.** Glycogen is well demonstrated in micrographs (a) and (b), appearing either as irregular granules (called a *particles)* or as aggregations termed *glycogen rosettes* **GR** (also called *particles).* As seen in micrograph (b), lipid droplets **L** are not bounded by a membrane; their size and electron density varies considerably. Note also rough and smooth endoplasmic reticulum **(rER** and **sER),** nuclei **N** and a residual body **RB.**

Mitochondria from heart muscle and steroid-secreting cells can be seen in micrographs (c) and (d) respectively. In each, the cristae are densely packed, reflecting the metabolic activity of the cell. The cristae have a characteristic shape, those of heart muscle being laminar whereas those of steroid-secreting cells are tubular. Note lipid droplets **L** in both fields.

Micrograph (e) shows the base of an absorptive cell from a kidney tubule where there is intense active transport of ions. The basal plasma membrane **PM** is deeply infolded so as to greatly increase its surface area, and elongated mitochondria are packed into the intervening spaces.

Draw the scheme structure of mitochondria, make notations



REMEMBER

ENDOPLASMIC RETICULUM is a system of cavities, channels and vesicles bounded by a membrane from the cytoplasm.

There are 2 types:

1. **The granular (roughened EPS) has the ribosome on the surface. Its main function is protein synthesis.**
2. **Agranular (smooth) EPS has not ribosomes on the surface, its main function is the synthesis of carbohydrates and lipids.**

EPS also performs the functions of:

3. Collects products synthesis of substances.
4. Convert substances (sulfation of proteins performs in EPS channels).
5. Transports synthesis products to the Golgi complex.
6. Shares the cell into separate compartaments.
7. Participates in the formation of the nuclear membrane (rough EPS).

Specific functions:

8. In muscle cells EPS deposits of calcium needed for muscle contraction.
9. EPS liver cells involved in the detoxification of substances.

GOLGI APPARATUS is a system of cavities (tanks), channels vacuoles bounded by cytoplasmic membrane. Flattened cavity usually located in a pile forming dictyosomes.

The convex surface facing the core surface is called cis-surface and concave surface is called trans-surface. Bubbles with primary secret formed in EPS, pouring into the tank of the side of the Golgi complex cis-surface. Membrane vesicles with prepared secret separated from the trans-surface.

Functions of the Golgi complex:

1. The accumulation of substances.
2. Sorting of substances.
3. Formation of more complex substances from the primary products of the synthesis. For example, the formation of lipoproteins from lipids and proteins.
4. Identification of the substance (accession of the receptor).
5. Packing of synthesis products into membrane vesicles and transport them out of the cell by exocytosis.
6. The formation of lysosomes.
7. Detoxification of substances

LYSOSOMES are the organelles having a circular shape bounded by a membrane and containing hydrolytic (digestive) enzymes.

There are 4 types:

1. The primary lysosomes - are formed in the Golgi apparatus and also contain inactive enzymes.
2. The secondary lysosomes (phagolysosome) - formed after the merger of the primary lysosomes and endosomes (or phagosome, or pinosomy). They digest substances under the action of digestive enzymes to useful products enter the cytoplasm and undigested substainces remain inside.
3. The tertiary lysosomes (telolizosomy) are lysosomes containing undigested residues. They either accumulate in the cytoplasm, or removed by exocytosis.
4. Aytolysosome - a kind of secondary lysosomes, provide the digestion of intracellular structures that have lost their meaning. Also provides a process of apoptosis and metamorphosis.

<u>The functions of lysosomes</u>:
1. Digestion substances (trophic).
2. The protective function (destroying old structures of cells, involved in the process of metamorphosis and apoptosis)

PEROXISOMES - organelles rounded, limited by membrane and containing a set of enzymes that neutralize hydrogen peroxide.

MITOCHONDRIA is an organelle mainly oval, delimited from cytoplasm by two membranes. The outer membrane is smooth, and the internal membrane forms numerous protrusions, called Christie. The liquid contents of mitochondria is called matrix. It is a colloidal solution. The matrix has its own circular double-stranded DNA (like bacteria), 70S ribosomes (like bacteria), all kinds of RNA.

Oxygen step of energy metabolism passes in mitochondria: in a matrix - the Krebs cycle, on the inside of the membrane - the processes of oxidative phosphorylation, leading to the synthesis of ATP.

<u>The main functions of mitochondria</u>:
1. Synthesis of ATP.
2. Synthesis of its own proteins.
3. Storage of hereditary information (cytoplasmic inheritance, maternal effect).

There is a symbiotic hypothesis of the origin of mitochondria. It is believed that mitochondria were previously aerobic bacteria that have penetrated into the cell and left there for rights of symbionts: they give energy in the form of ATP to the cell, and a cell give them substrate for oxidation.

<u>Evidence</u>: 1) the inner membrane of mitochondria by amino acid composition is close to the membrane of bacteria; 2) circular DNA and ribosomes 70S are like bacteria; 3) the ability to divide by 2, independently from cell division.

PLASTID is organelles of plant cells.
There are 3 types:
1. Chloroplasts - the green plastids contain the pigment chlorophyll, the function - photosynthesis.
2. Chromoplasts - yellow-orange color contain carotenoids, the function - coloring autumn leaves and fruit.
3. Leucoplasts - colorless plastids the function - the supply of nutrients (starch).

CHLOROPLASTS are oval-shaped organelles, bounded from the cytoplasm by two membranes. The outer membrane is smooth, and the internal forms numerous protrusions in the form of one-membrane cavities called thylakoids. The cavities are stacked into piles called granum. Membranes connecting granum, called the stroma thylakoids or lamellae. Photosynthetic pigments are in the thylakoid membrane. They take part in the process of photosynthesis. The liquid contents of the chloroplast is called stroma, it take part in dark phase of photosynthesis. The stroma has an own circular double-stranded DNA (such as bacteria), their own ribosomes 70S (like bacteria), all kinds of RNA.

<u>The functions of chloroplasts:</u>
1. **Photosynthesis.**
2. **The synthesis of its own proteins.**
3. **Storage of hereditary information (cytoplasmic inheritance, maternal effect).**

Exircise 2. Organelles that do not have a membrane structure

2.1. The cytoskeleton and cell movement

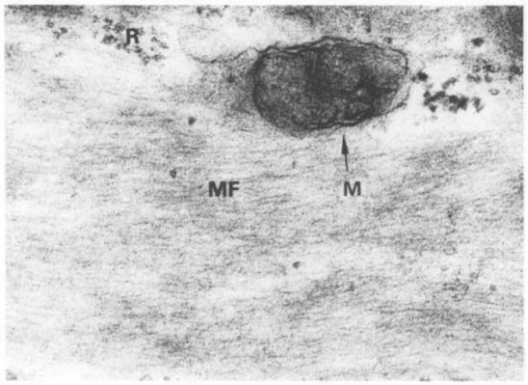
Read the text, consider an electron micrograph microfilaments and microtubules

In order to maintain structural stability, there is within every cell a supporting framework of minute filaments and tubules known as the *cytoskeleton.* Nevertheless, the cell membrane and intracellular organelles are not rigid or static structures but are in a constant state of movement to accommodate processes such as endocytosis, phagocytosis and secretion. Some cells (e.g. white blood cells) propel themselves about by amoeboid movement, other cells have actively motile membrane specialisations such as cilia and flagella (see Ch. 5), whilst other cells (e.g. muscle cells) are highly specialised for contractility. In addition, cell division is a process which involves extensive reorganisation of cellular constituents. The cytoskeleton thus incorporates features which accommodate all these dynamic functions.

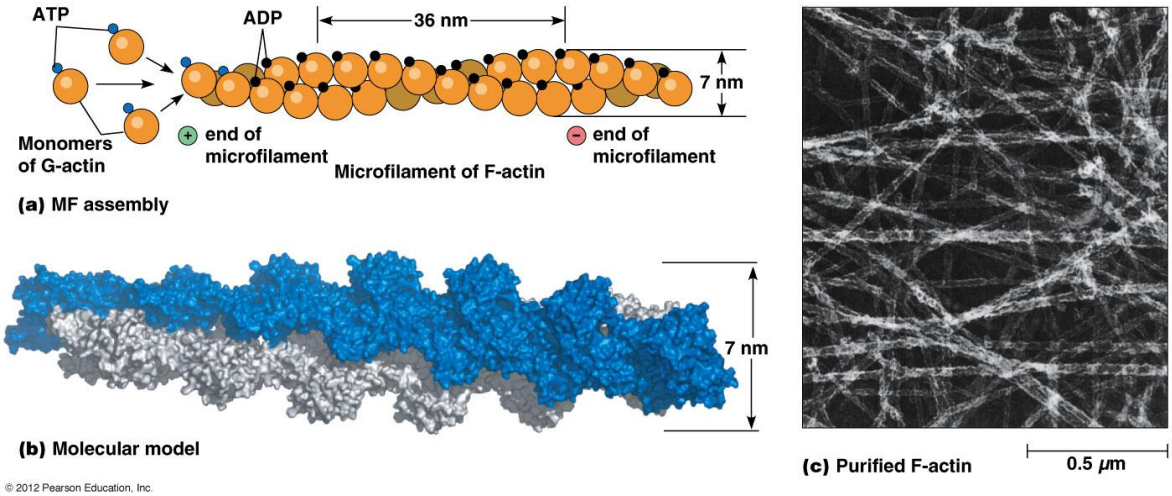
The cytoskeleton of each cell contains structural elements of three main types, *microfilaments, microtubules* and *intermediate filaments* as well as many accessory proteins responsible for linking these structures to one another, to the plasma membrane and to the membranes of the intracellular organelles.

• **Microfilaments.** Microfilaments are extremely fine strands (5 nm in diameter) of a protein known as *actin.* Each actin filament consists of two strings of bead-like subunits twisted together like a rope. The globular subunits are stabilised by calcium ions and associated with ATP molecules which provide energy for contractile processes.

Actin filaments are best demonstrated histologically in skeletal muscle cells where they are arranged in bundles with another type of filamentous protein called *myosin.* Contraction occurs when the actin and myosin filaments slide relative to one another due to the rearrangement of intermolecular bonds fuelled by the release of energy from associated ATP molecules.



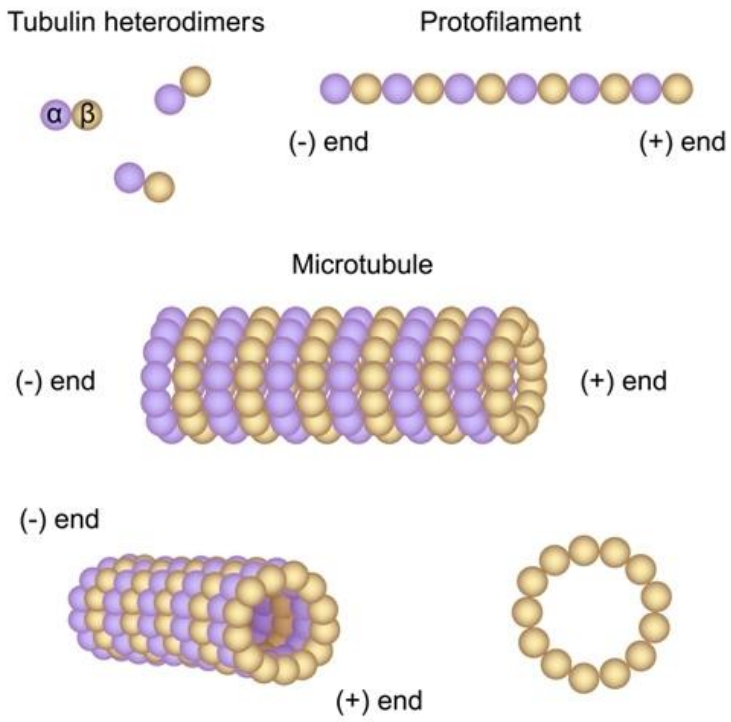
Microfilaments *(EM x 76 500)*
In general, individual microfilaments are difficult to demonstrate because of their small diameter and diffuse arrangement amongst other cytoplasmic components. In this example from a smooth muscle cell, a cell type in which cytoplasmic filaments are a predominant feature, parallel arrays of microfilaments **MF** are readily seen. The diameter of microfilaments may be compared with the diameter of a mitochondrion **M** and ribosomes **R.**



Cells not considered to be overtly contractile also contain the globular subunits of various subtypes of actin which appear to assemble readily into microfilaments and then dissociate, thereby providing a dynamically changing structural framework for the cell. Membrane specialisations such as microvilli (see Fig. 5.16) also contain a skeleton of actin filaments which not only provide structural support but also cause the microvilli to shorten and elongate.

Beneath the plasma membrane, actin in association with various transmembrane and linking proteins (predominantly *filamin)* forms a robust supporting mesh work called the *cell cortex* which protects against deformation yet can be rearranged to accommodate change in cell morphology.

• **Microtubules.** Microtubules (25 nm in diameter) are much larger than microfilaments but, like them, are made up of globular protein subunits which can readily be assembled and disassembled to provide for alterations in cell shape and position of organelles. The microtubule subunits are of two types, *alpha* and *beta tubulin,* which polymerise to form a hollow tubule; when seen in cross-section, 13 tubulin molecules make up a circle. Microtubules grow out from a specialised *microtubule organising centre* called the *centrosome* (see below) and in most cells, movement appears to be effected by the addition or subtraction of tubulin subunits from the microtubules causing them to become either lengthened or shortened. *Microtubule-associated proteins* (MAPs) stabilise the tubular structure and including *capping proteins* which stabilise the growing ends of the tubules. Two *attachment proteins, dynein* and *kinesin* (which can move along the tubules towards and away from the cell centre respectively), may become attached to membranous organelles (e.g. mitochondria, vesicles) providing a means by which they can be moved about within the cytoplasm. The function of the spindle during cell division is a classic example of this process on a large scale. In cilia, nine pairs of microtubules are disposed in a cylindrical structure, and movement occurs by rearrangement of chemical bonds between adjacent microtubule pairs.

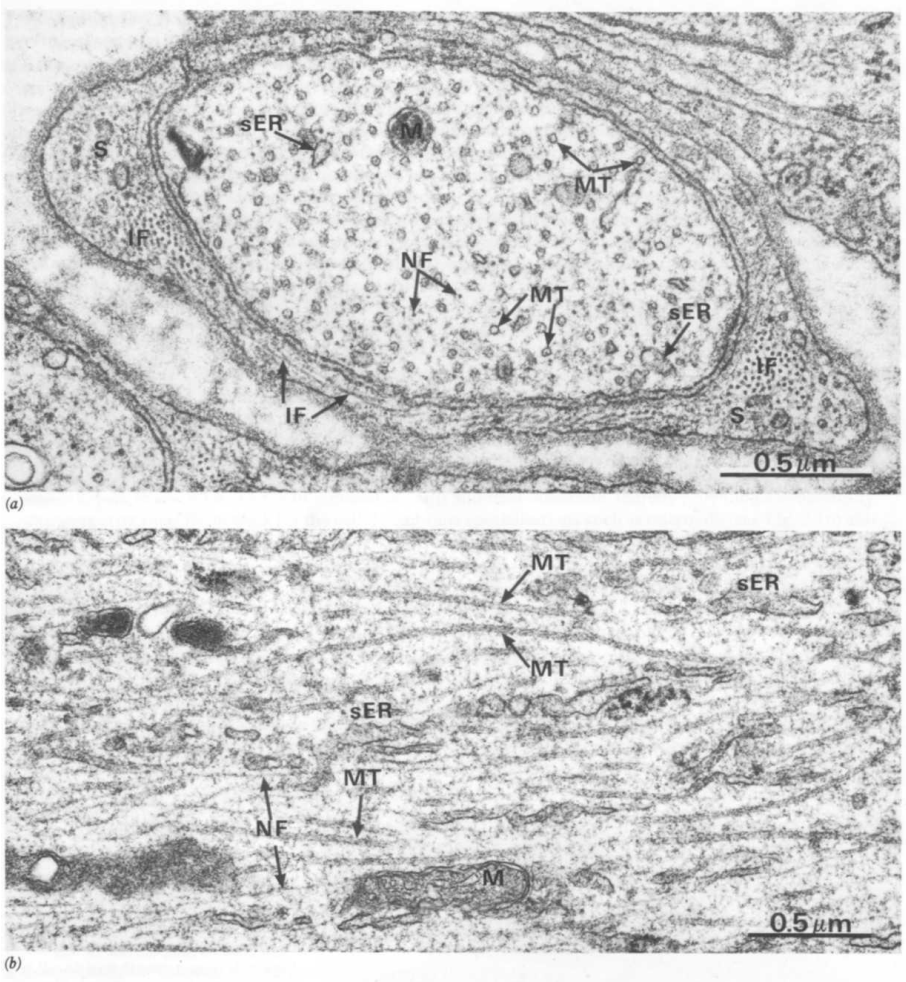


• **Intermediate filaments.** Intermediate filaments (10-12 nm in diameter) are, as their name implies, intermediate in size between microfilaments and microtubules. However, in contrast, intermediate filaments have a stable fibrous structure made up of a variety of different irregular molecular strands which appear to be specific to particular cell types. For example, in epithelial cells, the intermediate filaments are composed of the protein *cytokeratin* and are known as *tonofibrils;* the filaments form a tough supporting meshwork within the cytoplasm and are anchored to the plasma membrane at strong intracellular junctions with the adjacent epithelial cells. Other tissue specific intermediate filament proteins include *vimentin* (cells of mesodermal origin), *desmin* (muscle) and *neurofilament protein* (nerve cells).

The organising centre for the cytoskeleton appears to be located near the nucleus in an area called the *centrosome* (cell centre) which contains a pair of *centrioles.* Each centriole consists of nine triplets of microtubules arranged in a cylindrical manner, the pair of centrioles being disposed at right angles to one another. The centrosome appears to act as a nucleation centre for microtubules which radiate from here towards the cell periphery. Centrioles appear to be

necessary for microtubular function. For example, prior to cell division the pair of centrioles is duplicated, the pairs migrating towards opposite ends of the cell. Here they act as organising centres for the microtubules of the spindle which controls distribution of chromosomes to the daughter cells. Likewise a pair of centrioles, known as a *basal body,* is found at the base of the microtubules of cilia.

The distribution of microfilaments and intermediate filaments tends to be complementary to that of the microtubules and there is experimental evidence that, at least in some situations, microtubules may form a temporary framework around which more permanent cytoskeletal structures can be built up. The elements of the cytoskeleton are attached to one another and to the plasma membrane and the membranes of cytoplasmic organelles by a variety of linking proteins. In addition, some of the metabolic enzyme systems of the cytosol appear to be bound to various elements of the cytoskeleton.



Intermediate filaments and microtubules *(EM (a) TS* x *53000 (b) LSx 40 000J*

Intermediate filaments and microtubules. These micrographs are taken from nervous tissue; nerve cells contain both intermediate filaments and microtubules, allowing comparison of size and morphology. Each nerve cell has an elongated cytoplasmic extension called an axon which in the peripheral nervous system is ensheathed by a supporting Schwann cell. Micrograph (a) shows an axon in transverse section ensheathed by the cytoplasm of a Schwann cell **S.**

Micrograph (b) shows part of an axon in longitudinal section. The axonal microtubules provide structural support and direct intra-axonal transport. In longitudinal section, microtubules **MT** appear as straight, unbranched structures and in transverse section appear hollow. Their diameter can be compared with small mitochondria **M** and smooth endoplasmic reticulum **sER.**

Intermediate filaments (known as neurofilaments in nervous tissue) are a prominent feature of nerve cells, providing internal support for the cell by cross linkage with microtubules and other organelles. The microtubules but are much smaller in diameter and not hollow in cross-section. Intermediate filaments **IF** are also seen in the Schwann cell cytoplasm in micrograph (a).

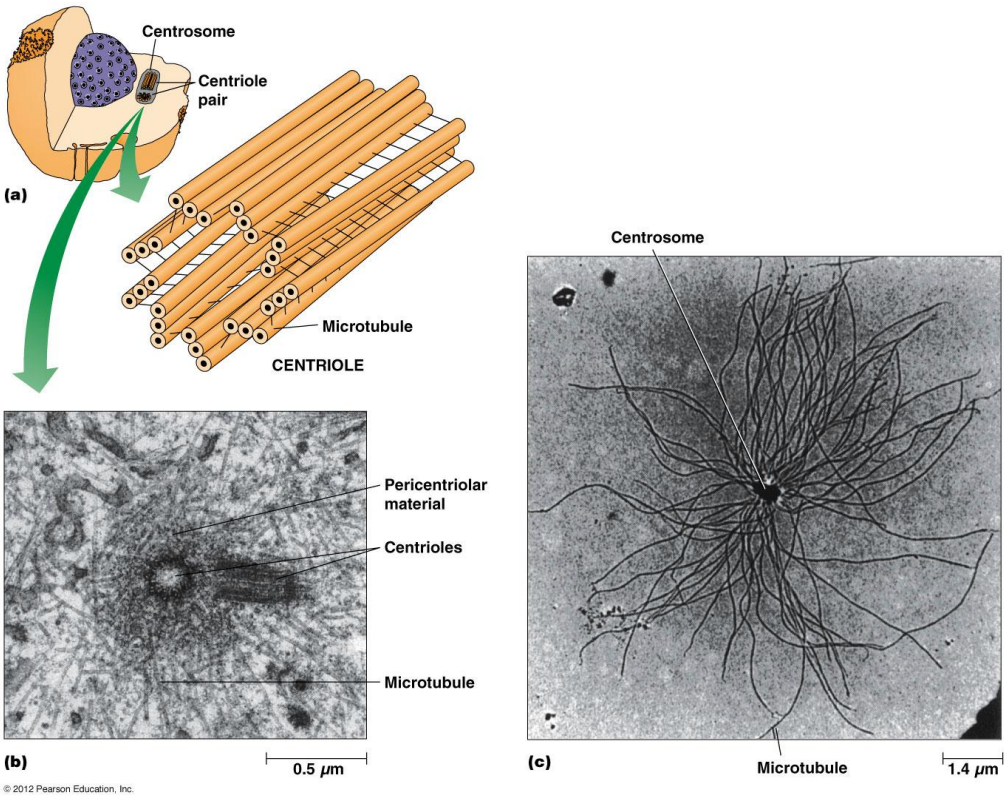
Moreover, the cytoskeleton appears to provide a mechanism whereby some molecules can be transported within the cell; such molecules are bound to microfilaments and microtubules and as these elongate and shorten, the molecules are moved from one site to another. The cytoskeletal elements may then disassemble leaving the transported molecules in new positions.

In summary, the cytoskeleton consists of three main structural elements. The microfilaments and the microtubules are relatively labile and dynamically changing structures (except where they perform highly specialised functions such as in muscle and cilia respectively), whereas the intermediate filaments serve a more static supporting function. The functions of the cytoskeleton are fourfold. Firstly, it provides the structural support for the plasma membrane, cellular organelles and some cytosol enzyme systems. Secondly, it provides the means for movement of intracellular organelles, the plasma membrane and other cytosol constituents necessary for the routine function of all cells. Thirdly, the cytoskeleton provides the locomotor mechanism for amoeboid movements and specialised motile structures such as cilia and flagella. Finally, the cytoskeleton is responsible for the property of contractility in the cells of specialised tissues such as muscle.

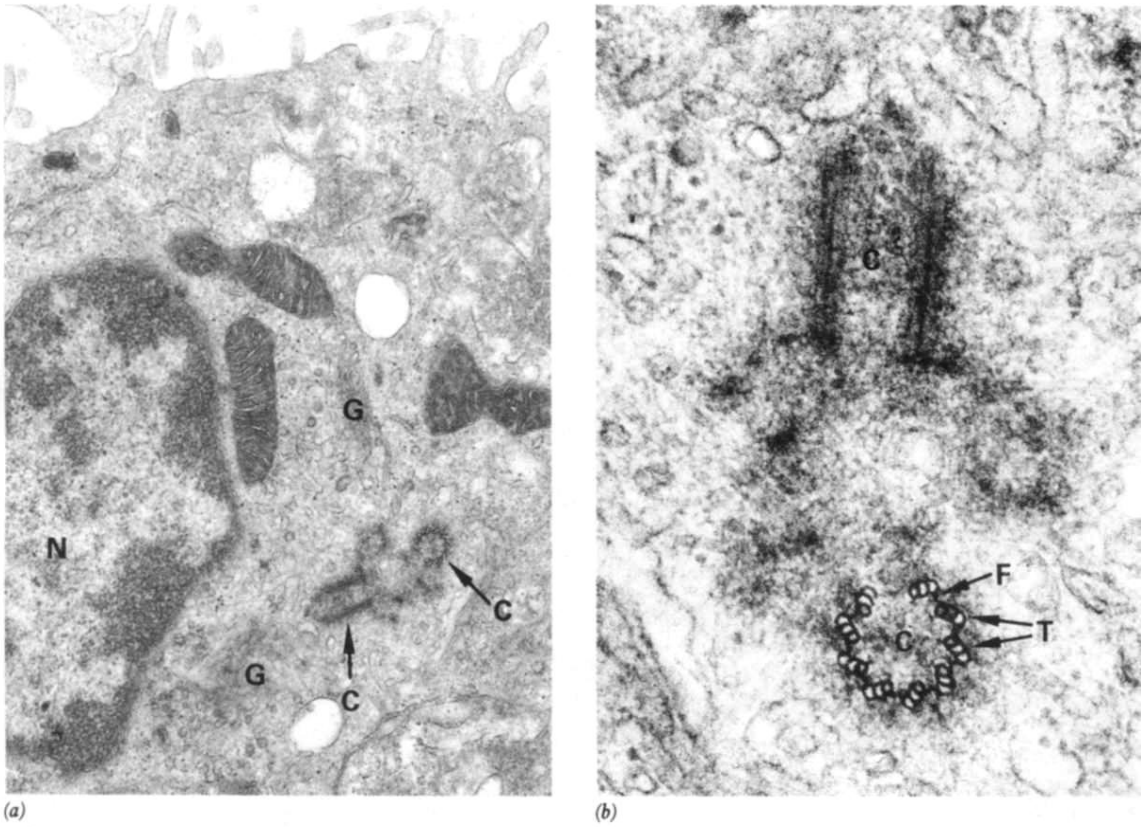
2.2. Read the text, consider an electron micrograph centrosome

The centrosome is a zone of cytoplasm usually centrally located in the cell adjacent to the nucleus **N** and often surrounded by the Golgi apparatus **G**. The centrosome, the *cell centre*, contains a pair of *centrioles* **C** together known as a *diplosome* and the surrounding cytoplasm is of increased electron density.

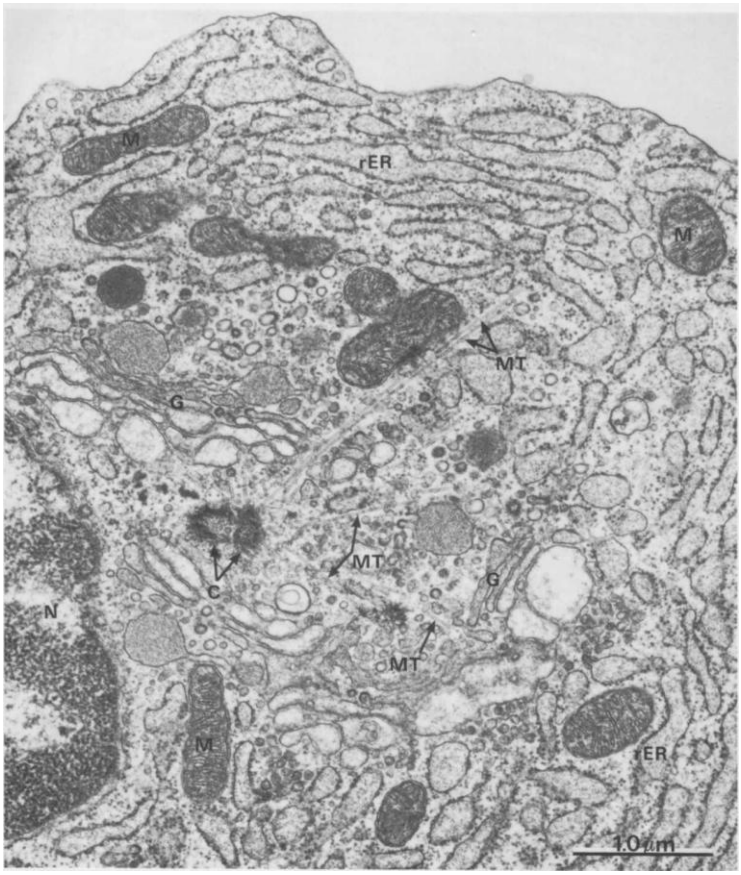
Centrioles are highly specialised microtubular structures and the centrosome in some way acts as the organising centre for the growth of microtubules of the cytoskeleton which radiates outwards in a star-like arrangement called an *aster*.



Each centriole is cylindrical in form, closed at one end, and consisting of nine triplets of parallel microtubules. In transverse section as seen in the lower half of micrograph (b), each triplet **T** is seen to consist of an inner microtubule which is circular in cross-section and two further microtubules which are C-shaped in cross-section. Each of the inner microtubules is connected to the outermost microtubule of the adjacent triplet by fine filaments **F,** thus forming a cylinder. The two centrioles of each diplosome are arranged with their long axes at right angles to each other as can be seen in these micrographs; the significance of this arrangement is obscure.



Centrosome *(a) EM x 9200 (b) EM x 48000*

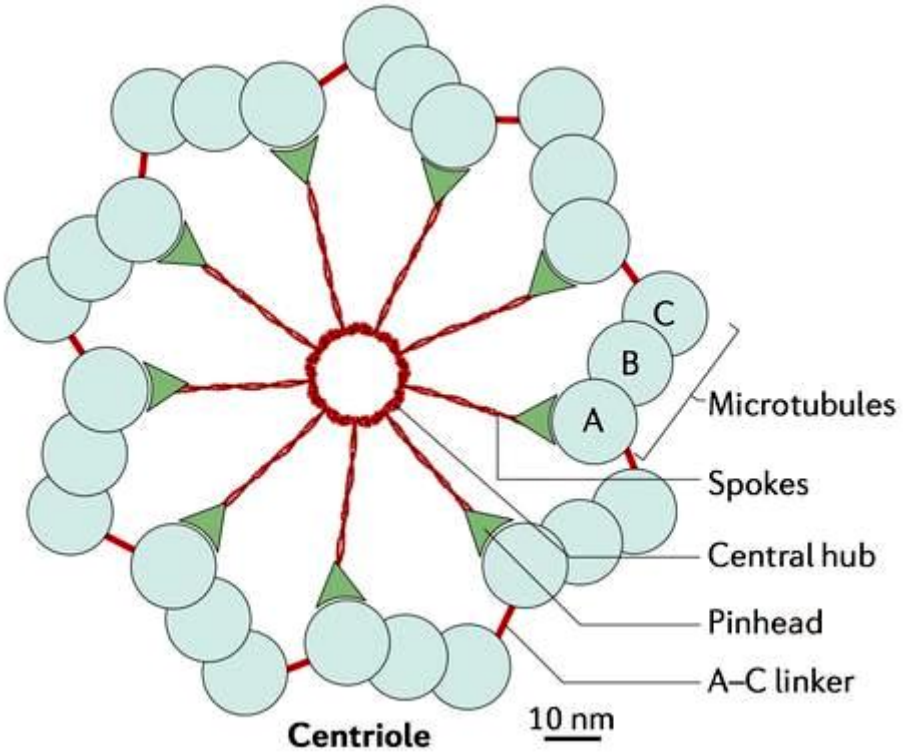


Centrosome and microtubules *(EMx30000)*

This micrograph shows the centrosome acting as organising centre for the microtubules of the cytoskeleton. The centrosome consists of two centrioles C (both cut somewhat obliquely in this specimen) typically located at the centre of the cell close to the nucleus **N.** Several microtubules **MT** are seen radiating from the centrosome towards the cell periphery.
Other features of this micrograph, which is from an antibody secreting plasma cell, include profuse rough endoplasmic reticulum **rER** distended with secretory product, several saccular profiles of an extensive Golgi complex G and scattered mitochondria **M**

Structures apparently identical to centrioles form the basal bodies of cilia and flagella. Cilia are a cell surface specialisation, each cilium comprising a minute hair-like cytoplasmic extension containing microtubules. Cilia move in a wave-like fashion for the purpose of moving secretions across a tissue surface. Flagella are the long tails responsible for the motility of sperm but also are found in modified form at other unusual sites; microtubules also provide their means of locomotion.

Draw the scheme structure of centriole



REMEMBER

RIBOSOMES are organelles consisting of two subunits - large and small. The large subunit has the shape of the bucket, it is composed of proteins and 3 molecules of rRNA in eukaryotes, and 2 molecules of rRNA in prokaryotes. The small subunit has the shape of the handset, it is composed of proteins and one molecule of rRNA. During protein synthesis mRNA connects with the small subunit, so that in the active site of the ribosome is two codon (triplet) mRNA. The large subunit participate in the formation of a peptide bond between amino acids. The function of ribosomes: protein synthesis.

CELLULAR CENTER is formed centrioles and system of microtubules radiating from centrioles.

Centrioles look like 2 cylinders arranged perpendicular to each other. The wall of each cylinder is formed by nine triplets of microtubules. There are not microtubules in the center of centriole. The formula, which reflects the structure of centrioles: 9x3 +0.

Options centrioles:

1. Education Center microtubules. Therefore centrioles refers to elements of the cytoskeleton of the cell.
2. Form a basal bodies of cilia and flagella.
3. Form a thread spindle during cell division.

MICROTUBULES are tubes of small diameter, the wall of which is formed by globular protein – tubulin. It can be polymerized. Microtubules are polar opposites: one end is increasing, with the other broken.

Microtubule function:

1. Provide support and shape of cells (cytoskeleton).
2. Transport of substances and organelles of a cell.
3. Form the centrioles, cilia, flagella.
4. Are the thread spindle.

MICROFILAMENTS is thin filaments formed mainly actin protein capable of polymerization. Actin microfilament are located mainly under plasmolemma of cell, where they form a dense network, also they are located the cytoplasm.

Functions of microfilaments:

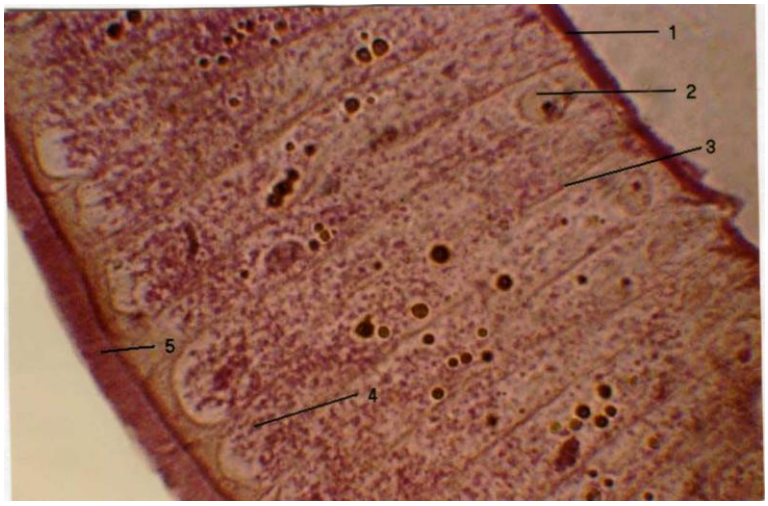
1. Provide support and shape of the cells.
2. Provide the transport of substances. For example, a membrane package (endocytosis and exocytosis).
3. They form the inner frame of the microvilli.
4. Microfilament are part of myofibrils muscle cells and fibers.

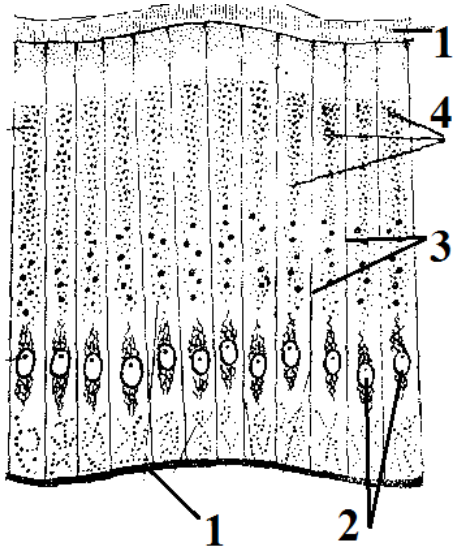
3. BASIC MICROSCOPE SLIDE

3.1. Chondriosomes (mitochondria) in the epithelial cells of the intestinal roundworm (dyed by iron haematoxylin)

At low magnification of the microscope, select the area of the wall of the intestine roundworm with more visible grain in the cytoplasm of cells and place it in sight. Consider at high magnification. The nuclei are located on the same level in the basal part of the cells. In the cytoplasm are many rod-shaped, filamentous, or curved mitochondria. Transversely cut the mitochondria have the appearance of grains.

Draw the plot of the slice with multiple cells.





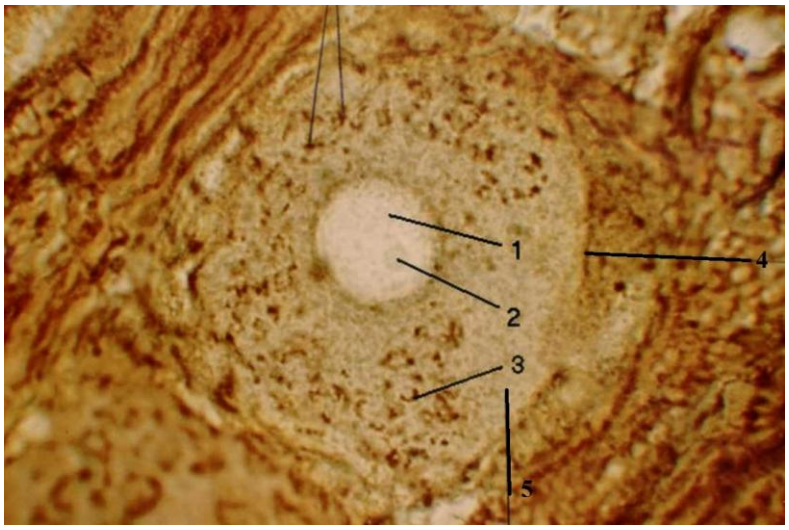
Indicate in the figure: 1) basal membrane; 2) the core; 3) plasmalemma; 4) mitochondria; 5) brush border (microvilli).

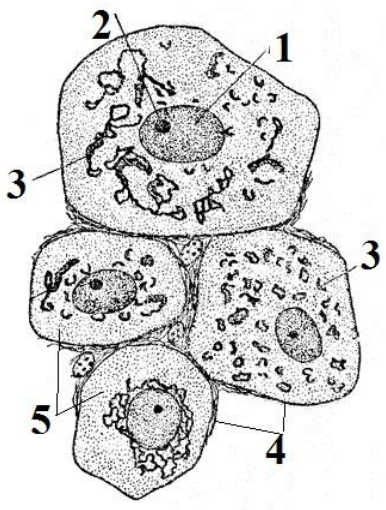
DEMONSTRATION SLIDES

3.2. The Golgi complex (by impregnation with silver salts)

At low magnification find a large square round shape with pale vesicular nucleus, in the cytoplasm which are clearly visible convoluted dark thread. Place it in the center of the field of view and set the lens at high magnification. Consider a large bright nucleus with a dark nucleolus, cytoplasm and surrounding the nucleus in the form of a coil (baskets), dark thread of the Golgi complex. Sometimes the threads are scattered throughout the cytoplasm.

Draw the plot of the slice with one or more cells.





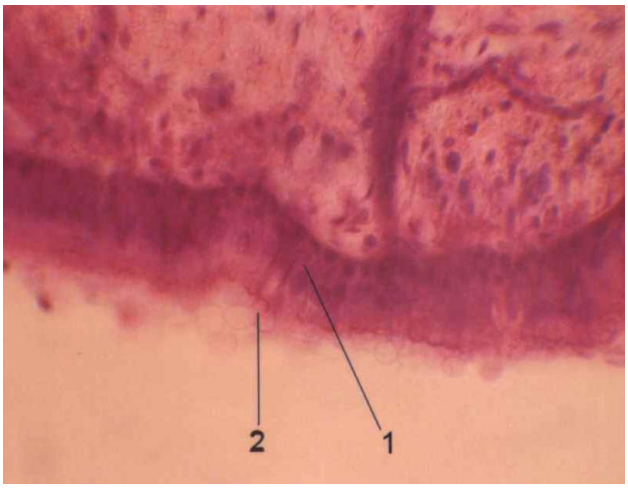
Indicate in the figure: 1) nucleus; 2) the nucleolus; 3) the Golgi complex; 4) the cell boundaries; 5) the cytoplasm.

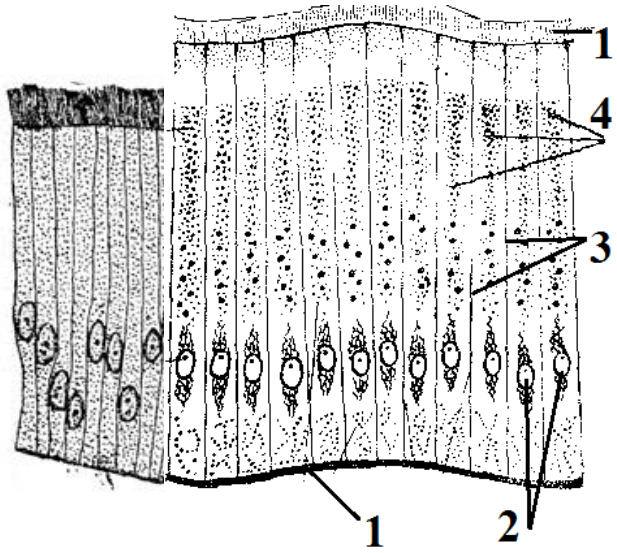
DEMO MICROGRAPH

3.3. Ciliated cilia of epithelial cells of the trachea (coloring with hematoxylin-eosin)

Note edging apical end of epithelial cells formed cilia.

Draw the plot of the slice with multiple cells.



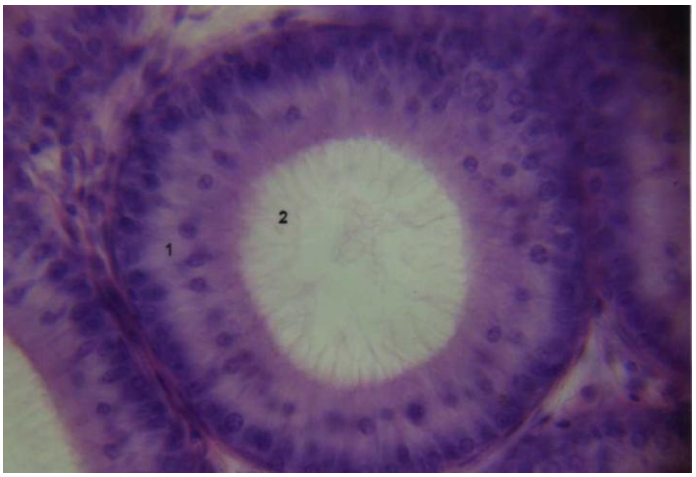


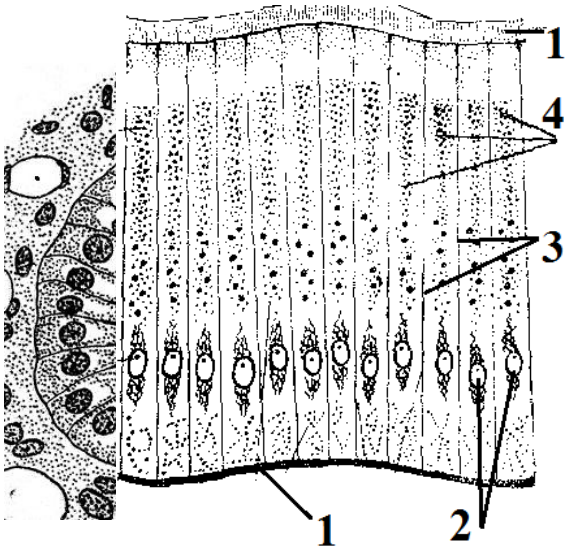
Refer figure: 1) epithelial cell: 2) cilia.

3.4. Ciliated cilia of epithelial cells of the canal of the epididymis testicles (dyed with hematoxylin-eosin).

Note edging apical end of epithelial cells formed cilia.

Draw the plot of the slice with multiple cells.



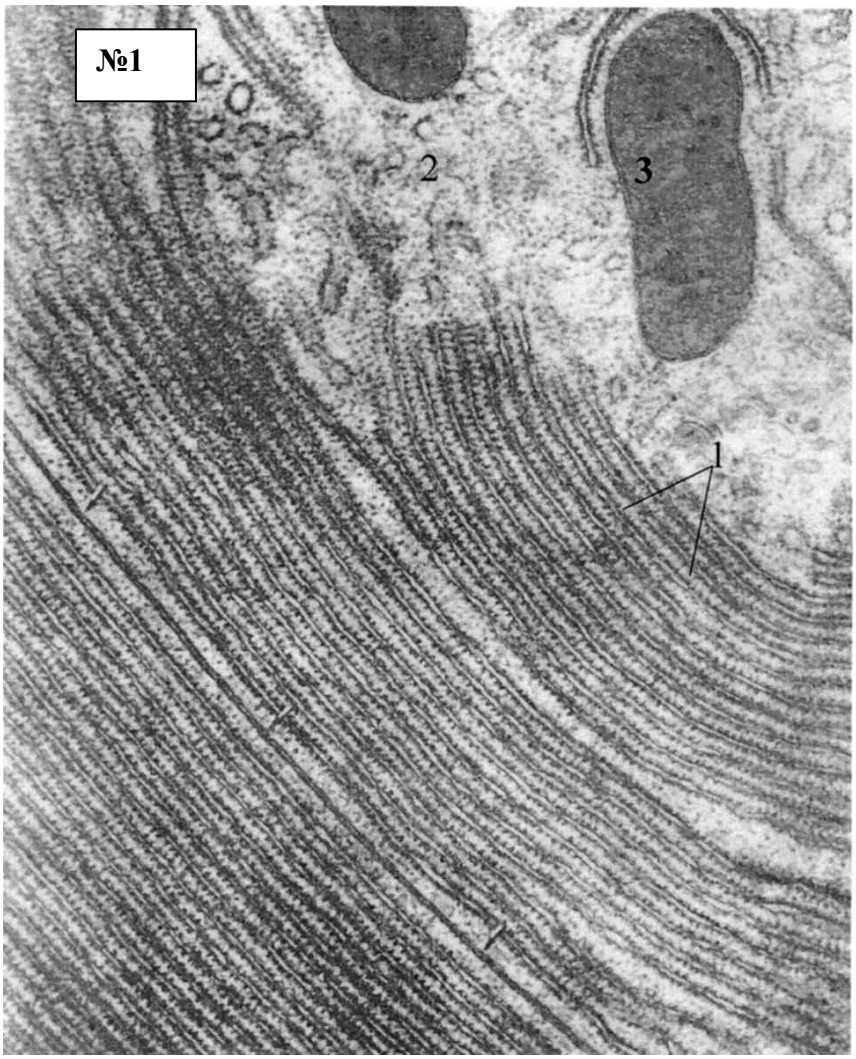


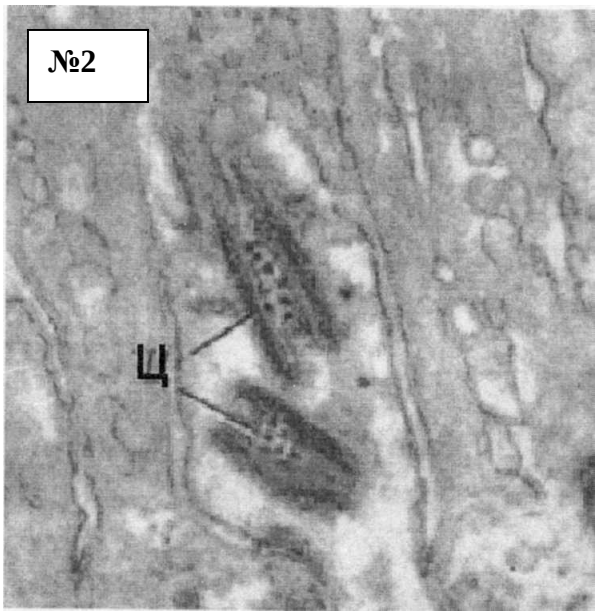
Refer figure: 1) epithelial cell; 2) cilia.

4**. ELECTRONIC MICROGRAPH**

Consider electronic micrographs of cell organelles. Pay attention to the features of their ultramicroscopic structure.

Describe the structures that you see in electron micrographs





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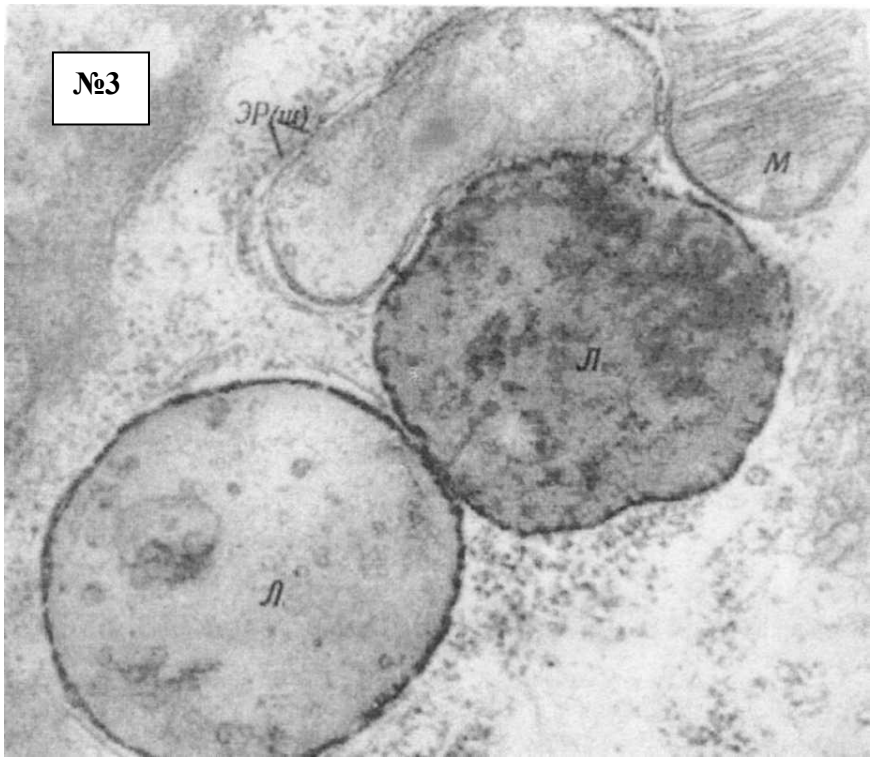

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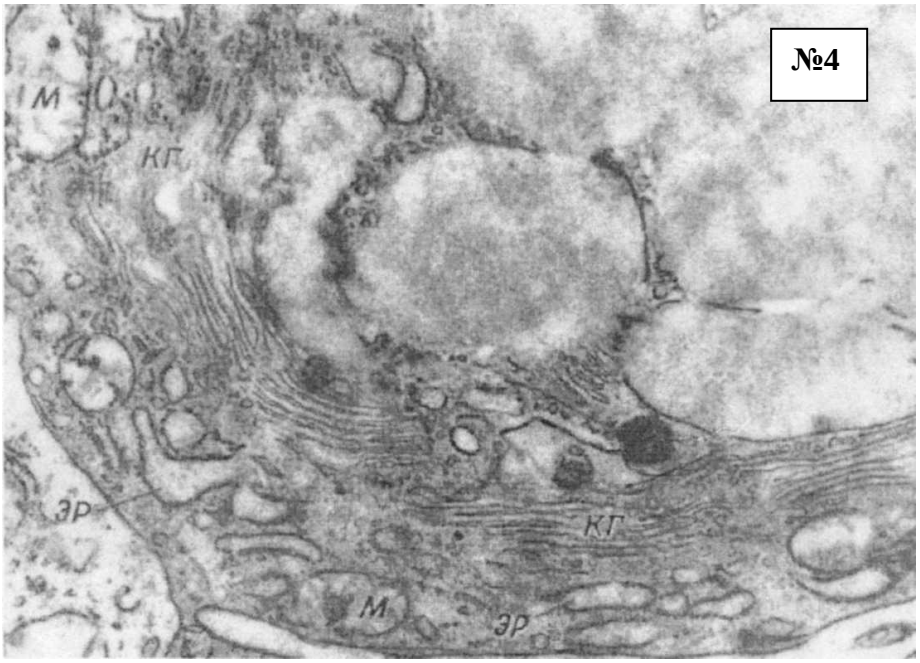

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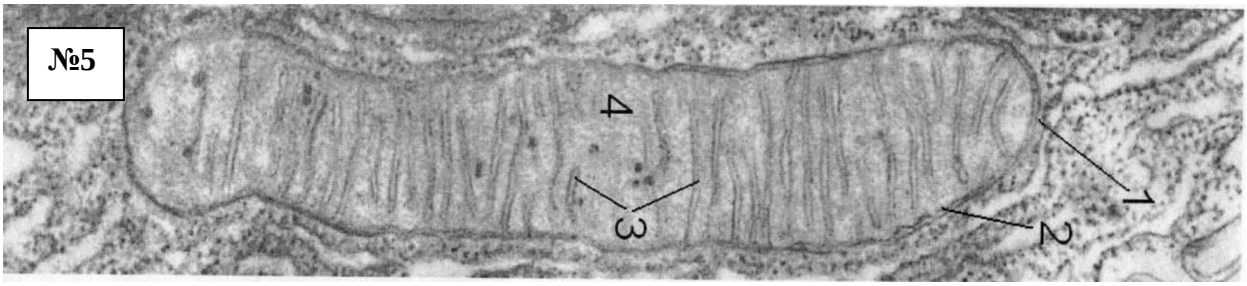


Tests «Cell organelles»

1. The composition of the outer membrane of the cell includes:
a) proteins and lipids
b) carbohydrates and RNA
c) DNA and RNA
d) carbohydrates and DNA

2. The cell membrane organelles include
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

3. The function of ATP synthesis in the cell is performed
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

4. Protein synthesis was carried out in a cell
a) ribosomes
b) cell center
c) peroxisomes
d) microtubules

5. The two membranes are limited
a) ribosomes
b) cell center
c) mitochondria
d) microtubules

6. Synthesis of complex substances in the cell provides a simple
a) Golgi complex
b) cell center
c) microtubules
d) granular EPS

7. Dictyosome part of the
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS

8. Have their own DNA
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS

9. A stack of flat tank called the Golgi complex
a) dictyosome
b) matrix
c) chromatin
d) cristae

10. The liquid contents of mitochondria is called
a) dictyosome
b) matrix
c) chromatin
d) cristae

11. The function of storing genetic information in the cell is performed
a) ribosomes
b) microfilaments
c) peroxisomes
d) nucleus
12. The transport function of the membrane is provided
a) lipids
b) surface proteins
c) carbohydrates
d) integral proteins
13. rRNA and proteins are part of
a) ribosomes
b) microfilaments
c) mitochondria
d) core
14. The structures formed by the mitochondrial inner membrane, called
a) thylakoids
b) crista
c) grana
d) stroma
15. The pigment chlorophyll contained in
a) chloroplasts
b) chromoplasts
c) lekoplastah
d) leukocytes
16. The function of photosynthesis performed
a) chloroplasts
b) chromoplasts
c) lekoplasty
d) leukocytes

Tests for self-control 2
1. The _____ is composed of DNA and protein.
A. chromatin
B. ribosome
C. flagellum
D. centriole
E. mitochondrion
2. Ribosomal subunits are manufactured in the _____.
A. peroxisome
B. lysosome
C. smooth endoplasmic reticulum
D. rough endoplasmic reticulum
E. nucleolus
3. _____ are the sites of protein synthesis.
A. Peroxisomes
B. Ribosomes
C. Golgi apparatuses
D. Mitochondria
E. Microfilaments

4. The _____ is a selective barrier, regulating the passage of material into and out of the cell.
A. plasma membrane
B. lysosome
C. nuclear envelope
D. chloroplast
E. nucleus
5. Where is calcium stored?
A. centrioles
B. mitochondria
C. smooth endoplasmic reticulum
D. microtubules
E. rough endoplasmic reticulum
6. Which of these are hollow rods that shape and support the cell?
A. plasma membrane
B. peroxisomes
C. microtubules
D. microfilaments
E. chloroplasts
7._____ is/are identical in structure to centrioles.
A. Chromatin
B. Mitochondria
C. Basal bodies
D. Nuclear envelopes
E. Microfilaments
8. Which of these cannot rapidly pass directly through the phospholipids of the plasma membrane?
A. Water, glucose and hydrogen ion
B. Water
C. Hydrogen ion
D. Lipid soluble molecule
E. Glucose
9. What name is given to the process by which water crosses a selectively permeable membrane?
A. passive transport
B. phagocytosis
C. pinocytosis
D. osmosis
E. diffusion
10. Which of these organelles carries out cellular respiration?
A. smooth endoplasmic reticulum
B. mitochondrion
C. chromatin
D. ribosomes
E. nucleolus

THEME 4. THE NUCLEUS OF THE CELL.

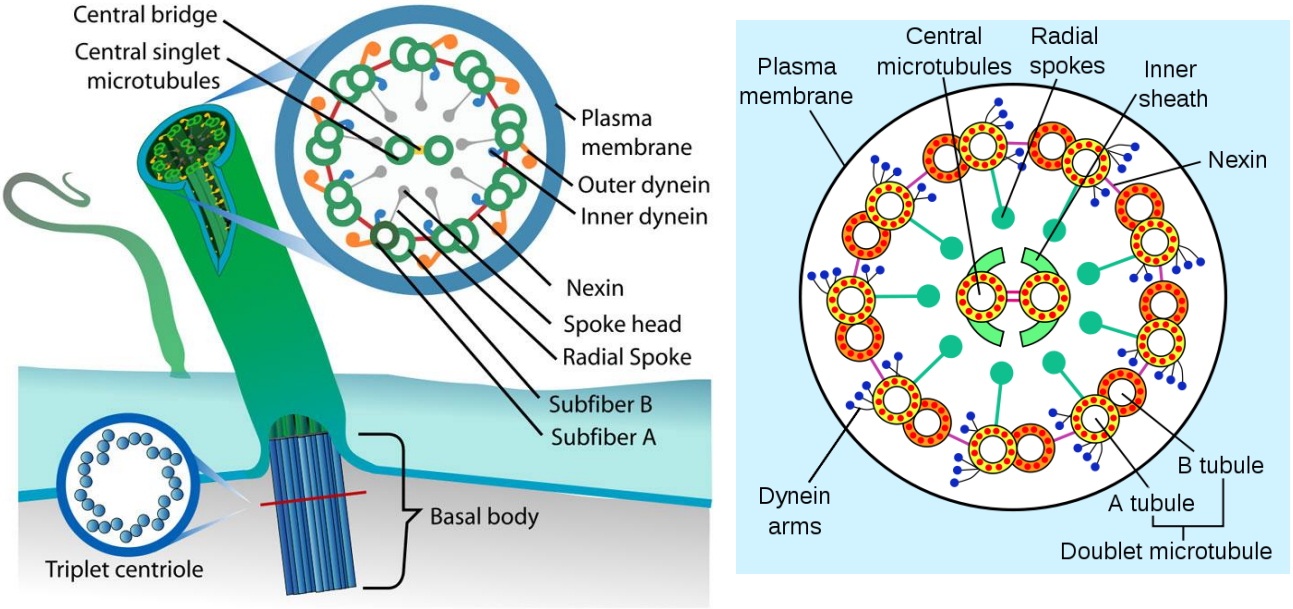
The aim of the lesson: to develop knowledge of the microscopic structure of the nucleus, types of intracellular inclusions.

Session objectives:
1. To study the microscopic structure of the cell nucleus.
2. To study the structure of the DNA molecule, the levels of its packaging in eukaryotes.
3. To study the structure and citatory inclusions in cells of different morphological types.
4. To develop skills to determine the drugs inclusions in various cell types.

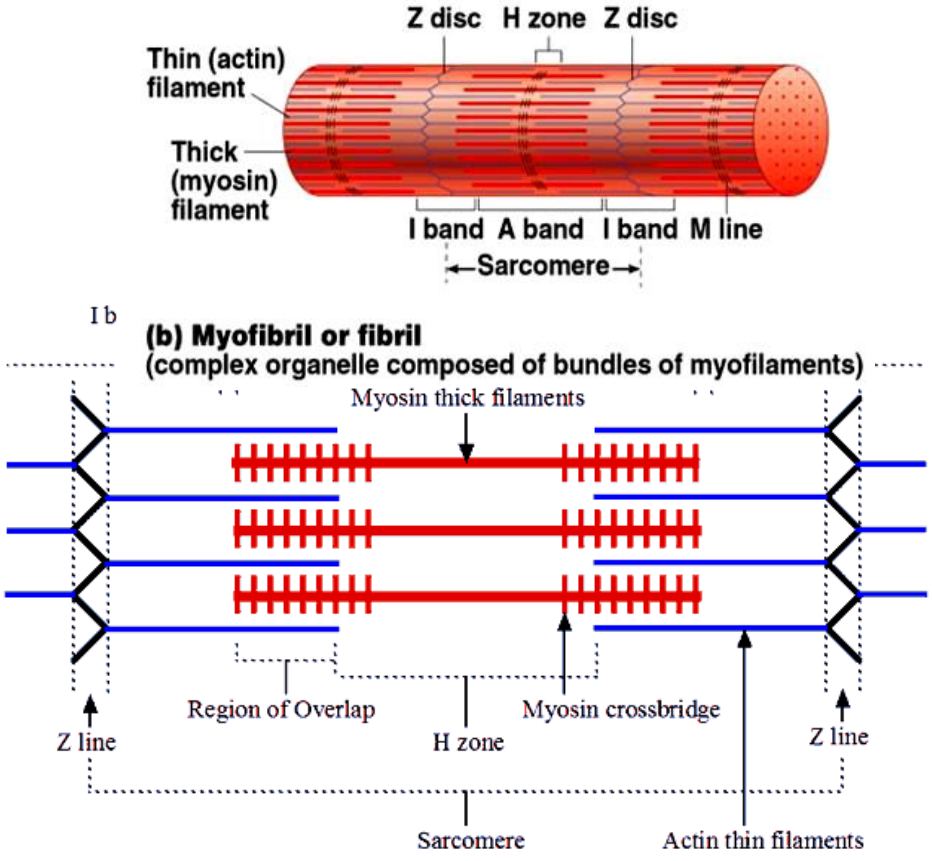
SOFTWARE ISSUES:
1. Microscopic, ultramicroscopic structure, chemical characteristics and functions of the cell nucleus (kariolemmoj, karyoplasm lying, chromatin, nucleolus).
2. Varieties of chromatin, features of its structure and localization.
3. The levels of DNA packaging in eukaryotes.
4. The structure and chemical composition of chromosomes.
5. Intracellular inclusions: classification and importance in vital activities of cells.

Equipment:
1. Microscope "Biolam P-11".
2. Main slides: inclusion of fat in the liver cells of amphibians; inclusion pigment in the skin cells of a tadpole; the inclusion of glycogen in the liver cells of amphibians; the inclusion of protein in the egg bezzubki.

Exercise 1. Consider the scheme and draw the structure of cilia.



Exercise 2. Consider the scheme and draw the structure of myofibril



Exercise 3. Consider the electron micrograph of the cell nucleus, the structure of the nucleus.

Micrograph (a) illustrates the typical nucleus of a highly active, protein-secreting cell, in this case a plasma cell responsible for secretion of antibody. Typical of such cells, the cytoplasm contains numerous profiles of ribosome-studded endoplasmic reticulum **ER** and considerable numbers of mitochondria **M** responsible for production of the energy required for such a metabolically active cell.

Constituents of the nucleus

The nucleus not only contains DNA, which comprises less man *20°*$_o$ of its mass, but also contains a large quantity of ^^tein called *nucleoprotein* and some RNA. Most of the nucleoprotein is closely associated with DNA, these DNA-binding proteins being of two major types, *histones* and *nonhistones.* Histones, which comprise the bulk of DNA-associated protein, are relatively low molecular weight proteins with a high content of positively charged amino acids which bind them readily to the negatively charged DNA strands. Histones may be involved in the folding of DNA strands and the regulation of DNA activity. The nonhistone DNA-associated proteins are a heterogeneous group which may also be involved in the regulation of gene activity. The remaining nucleoproteins include enzymes responsible for DNA and RNA synthesis. All nucleoproteins are synthesised in the cytoplasm and imported into the nucleus. The nuclear RNA represents newly synthesised messenger, transfer and ribosomal RNA which has not yet passed into the cytoplasm.

Except during cell division, the chromosomes, each comprising a discrete length of the DNA complement, exist as tangled strands which extend throughout the nucleus and cannot be visualised individually by direct electron microscopy. Nuclei appear as heterogeneous structures with electron-dense and electron-lucent areas. The dense areas, called *heterochromatin,* represent that portion of the DNA complement and its associated nucleoprotein which is not active in RNA synthesis. Heterochromatin **H** tends to be clumped around the periphery of the nucleus but also forms irregular clumps throughout the nucleus. In females, the quiescent X-chromosome (equivalent to the Y-chromosome of the male) forms a small discrete mass known as a *Barr body;* Barr bodies are seen at the edge of the nucleus in a small proportion of female cells when cut in a favourable plane of section. The electron-lucent nuclear material, called *euchromatin* **E,** represents that part of the DNA which is active in RNA synthesis. Collectively, heterochromatin and euchromatin are known as *chromatin,* a name derived from the strongly coloured appearance of nuclei when stained for light microscopy.

Nucleoli

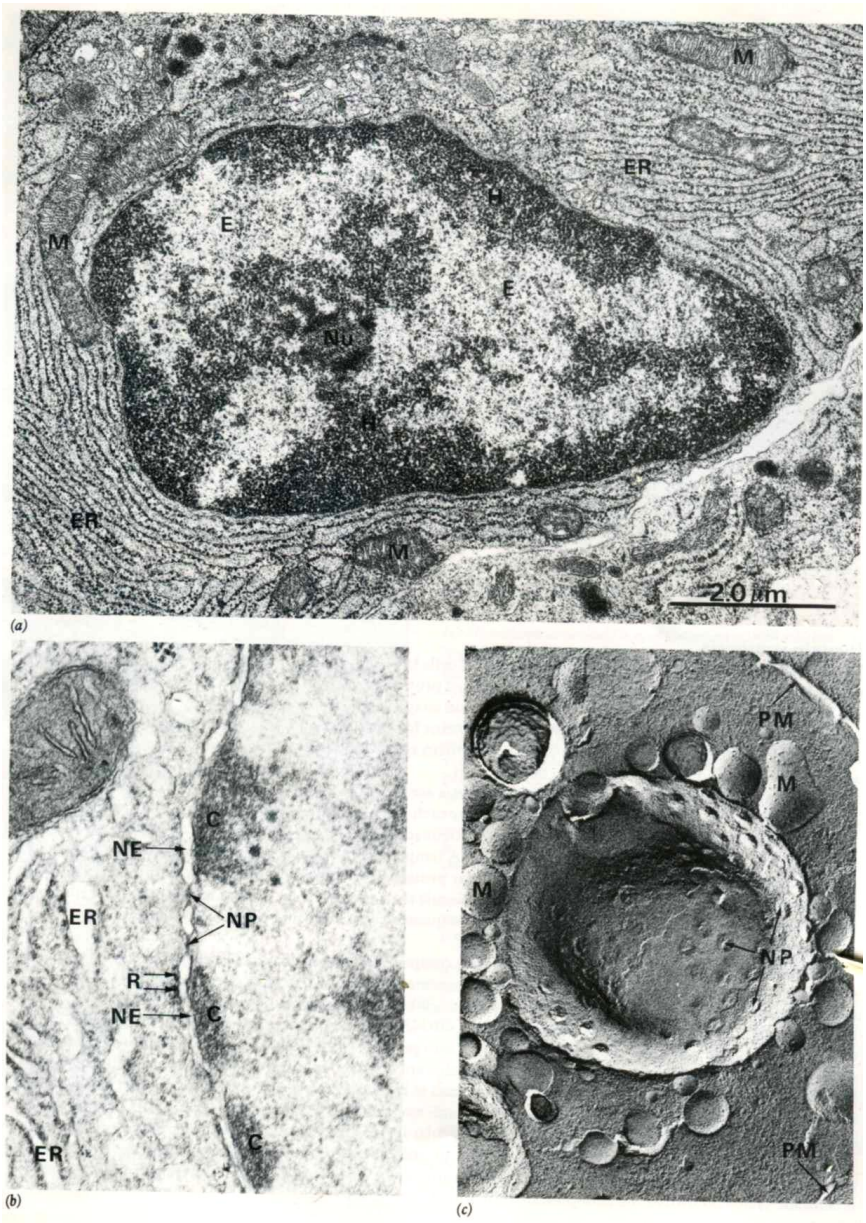
Many nuclei, especially those of cells highly active in protein synthesis, contain one or more dense structures called *nucleoli* **Nu** which are the sites of ribosomal RNA synthesis and ribosome assembly. The many different ribosomal proteins are imported from the cytoplasm and conjugated with ribosomal RNA to form the ribosomal subunits which then pass into the cytoplasm before being assembled into fully active ribosomes. Nucleoli are heterogeneous structures, the paler areas being the sites of DNA coding for ribosomal RNA and the dark areas being the sites of partially assembled ribosomes.

Each cell type has a characteristic nuclear morphology and, in general, the degree of activity of any cell may be judged by the ultrastructural appearance of its nucleus. Relatively inactive cells have small nuclei in which the chromatin is predominantly in the condensed form (heterochromatin) and in which the nucleolus is small or aosent. In highly active cells, the nuclear material is dispersed (euchromatin) and nucleoli are a prominent feature.

Nuclear envelope

The nuclear envelope **NE** which encloses the nucleus is illustrated in micrograph (b). It consists of two layers of membrane (each layer of standard phospholipid bilayer structure) which represent a specialised part of the endoplasmic reticulum. The intermembranous (perinuclear) space is continuous with that of the endoplasmic reticulum **ER** and like much of the endoplasmic reticulum, the outer surface of the nuclear envelope is studded with ribosomes **R.** On the inner

aspect of the nuclear envelope there is an electron-dense fibrillar layer, the nuclear lamina, consisting of polypeptides bound to membrane proteins and linked with condensed peripheral chromatin **C.** To the nuclear lamina is attached a network of filamentous proteins which provide internal support for the nuclear contents and nucleoli and thus represent the nuclear cytoskeleton.



Nucleus / *illustrations opposite) (a) EM* x 75 *000 (b) EM* x 67500
(c) Freeze-etched preparation x *34 000*

Nuclear pores

The nuclear envelope contains numerous *nuclear pores* **NP** at the margins of which the inner and outer membranes become continuous. Each pore contains an electron-dense structure known as a *nuclear pore complex* which consists of a ring of proteins with a central channel, the whole complex being secured to and stabilised by the nuclear lamina. Nuclear pores permit and regulate the exchange of metabolites, macromolecules and ribosomal subunits between nucleus and cytoplasm.

Micrograph (c) shows an example of a technique called *freeze-etching.* Briefly, this method involves the rapid cooling of cells to subzero temperatures; the frozen cells are then fractured. Internal surfaces of the cell are thus exposed (in a somewhat random manner), the fracture lines tending to follow natural planes of weakness. Surface detail is obtained by 'etching' or subliming excess water molecules from the specimen at low temperature. A thin carbon impression is then made of the surface and this mirror image is viewed by conventional electron microscopy. Freeze-etching provides a valuable tool for studying internal cell surfaces at high resolution.

In this preparation, the plane of cleavage has included part of the nuclear envelope in which nuclear pores **NP** are clearly demonstrated. Note also the outline of the plasma membrane **PM** and mitochrondria **M.**

Exercise 4. Consider the structure of the nuclear pore, make a drawing.

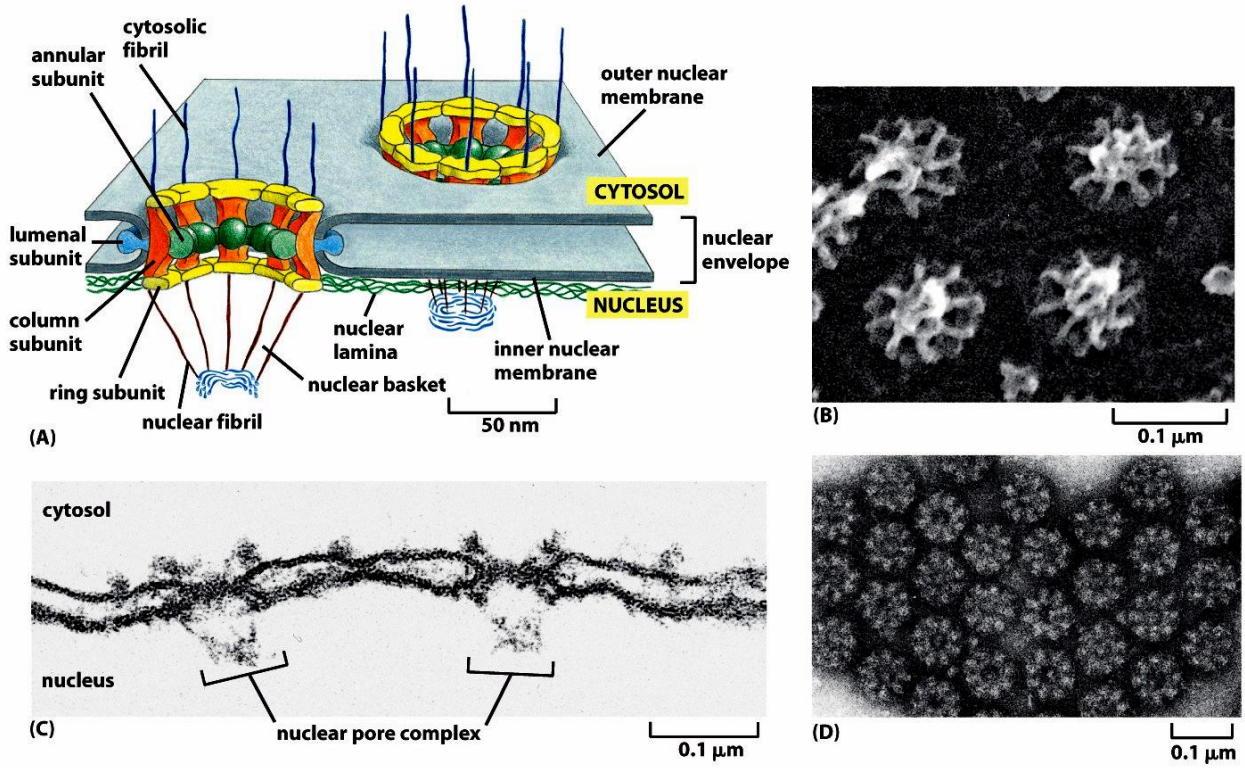
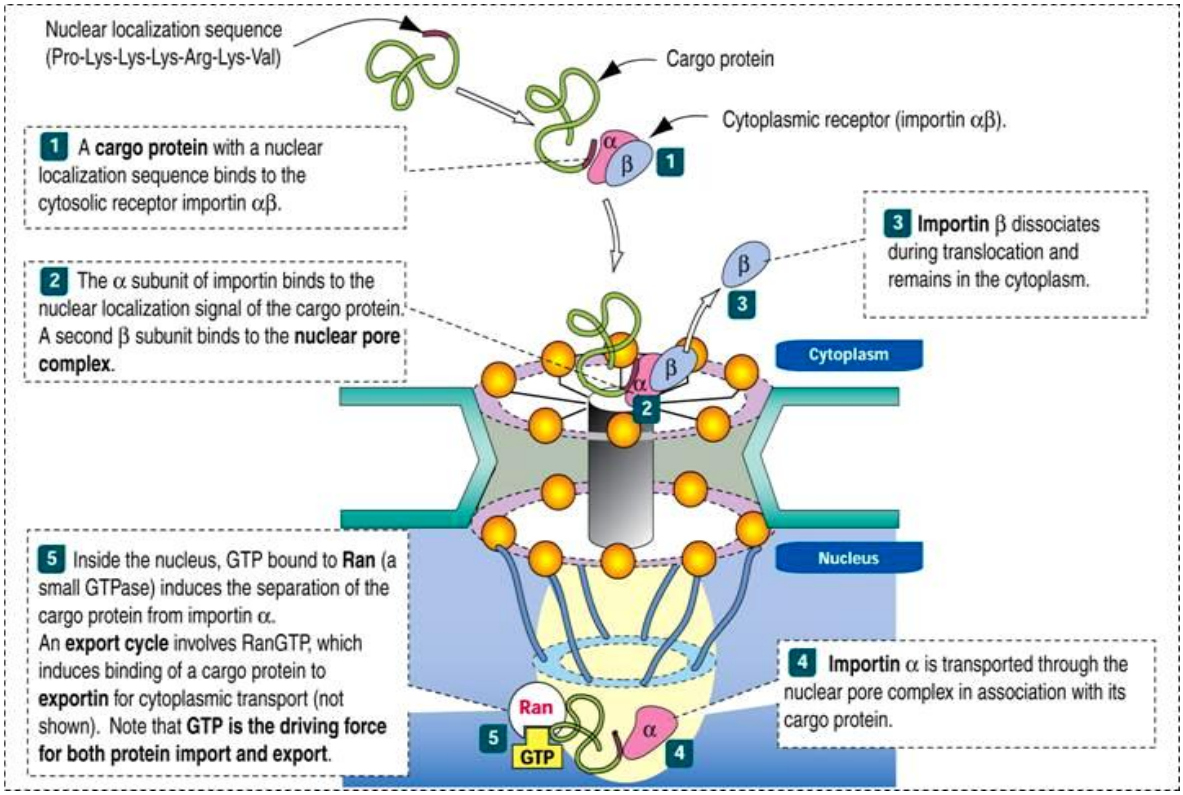
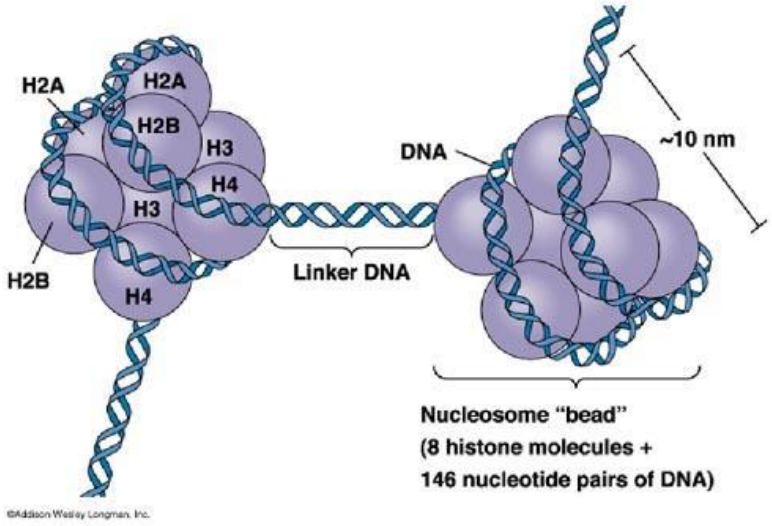


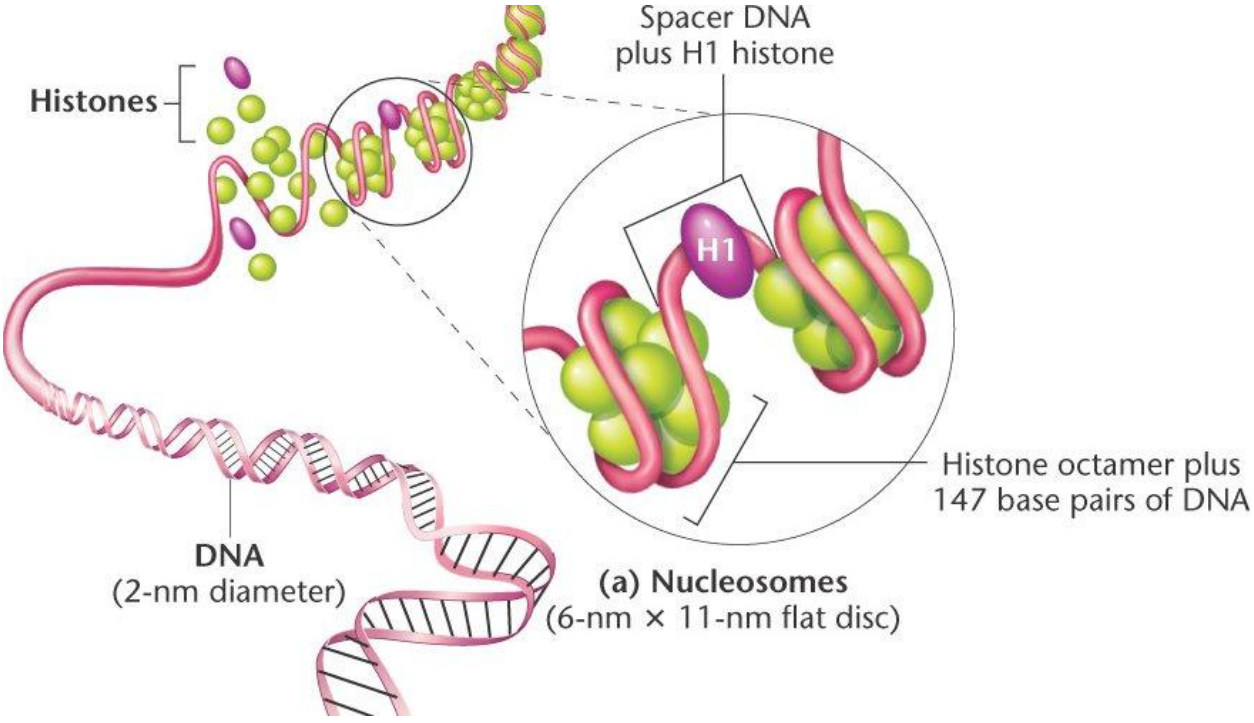
Figure 12-9 Molecular Biology of the Cell 5/e (© Garland Science 2008)



Exercise 5. Chromatin.

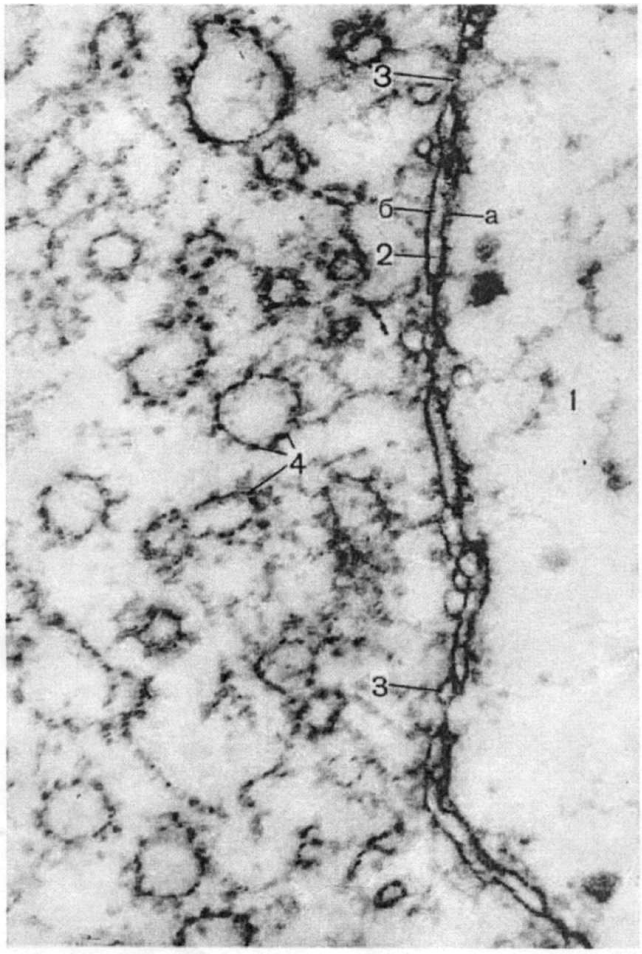


Chromatin is the complex of DNA with proteins-gistonami (there are 9 of histone proteins: 4 twin-H2A, H2B, H3, H4, 1 unpaired - H1). 8 proteins form a globular structure - octamer. Around each octamer almost twice the DNA helix is wound, forming a nucleosome. DNA between nucleosomes enters the complex from the 9th protein histone H1. It contributes to the further rapprochement of nucleosomes and DNA packaging. This level of DNA packaging is called a nucleosome.
There are euchromatin and heterochromatin.
Euchromatin - in the light microscope is almost not visible and contains functionally active DNA (from it can read information).
Heterochromatin - out. Microscope has the form of grains and clumps, contains functionally inactive DNA (reading of information does not occur).



Draw the scheme of formation of nucleosomes.

Exercise 6. Consider electron micrograph, sketch him, make notations

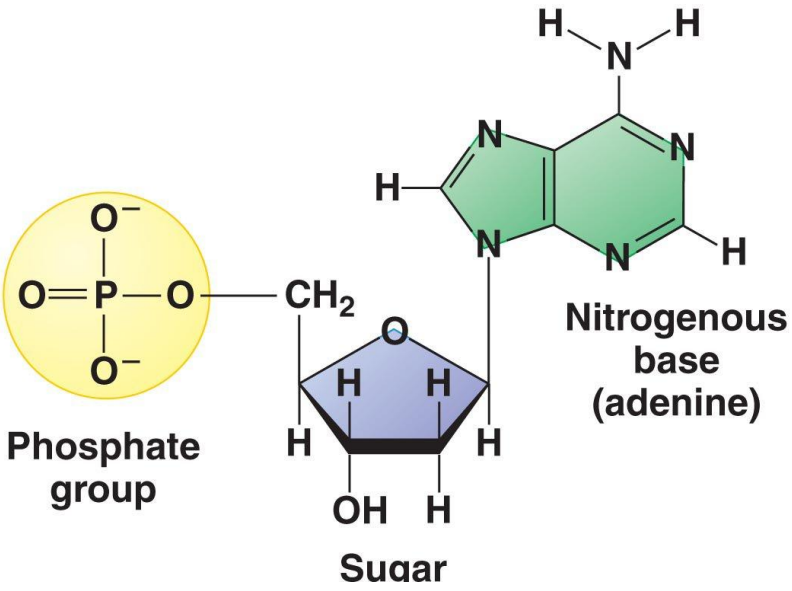


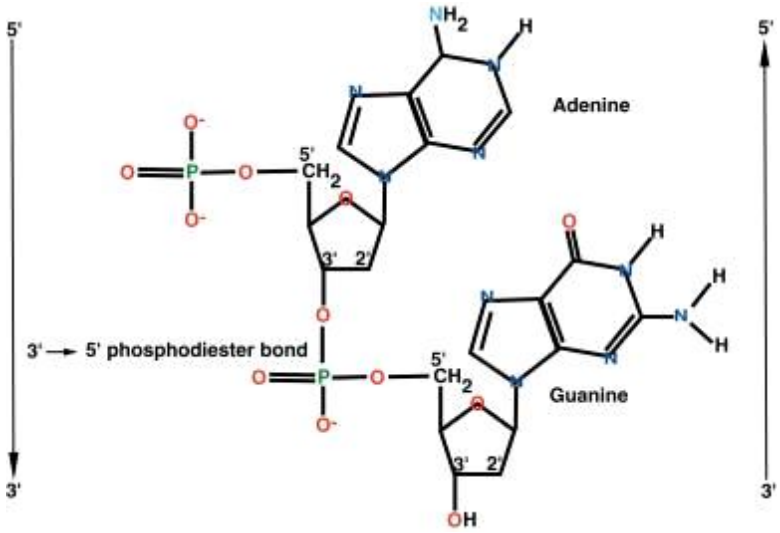
The karyolemma. Consider an electron micrograph of part of the giant cells of the salivary gland of the mosquito.

Indicate in the figure: 1 - nucleus; 2 - nuclear membrane (kariolemma): a-inner nuclear membrane; b - outer nuclear membrane; 3 - nuclear pores; 4 - granular ndoplasmic network; 5 - perinuclear space

Exercise 7. The structure of DNA.

Consider the structure of the nucleotide, draw its structural formula.



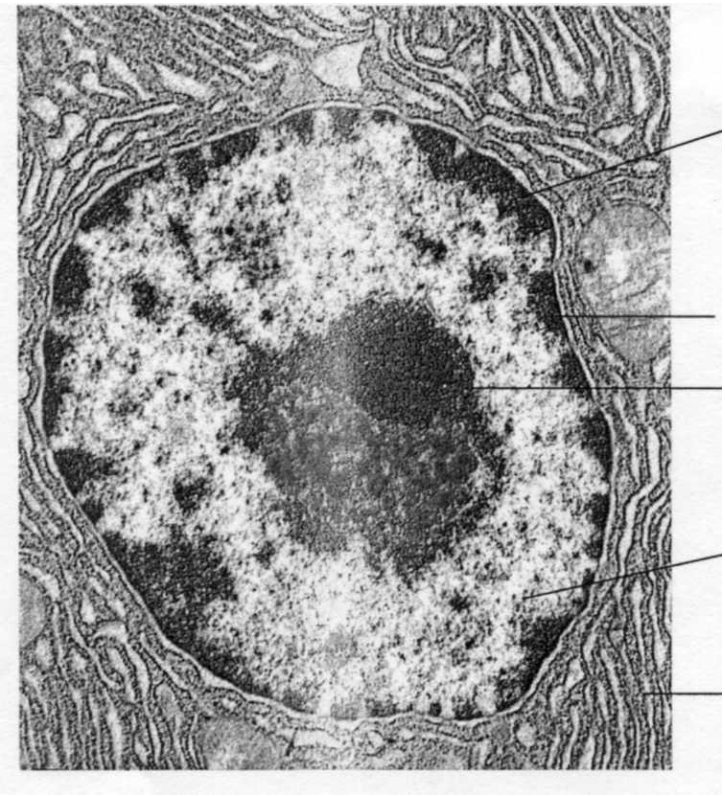


Consider the circuit fragment of the DNA molecule. Answer the questions:

1. It represents the skeleton of the DNA molecule?
2. What connections are connected nucleotides in a polynucleotide chain?
3. What connections are interconnected chains of DNA?
4. What does the entry "5'-end and 3'-end"?
5. What is the meaning of the assertion that the chain of DNA antiparallel?

Exercise 8. Consider an electron micrograph of the nucleus.

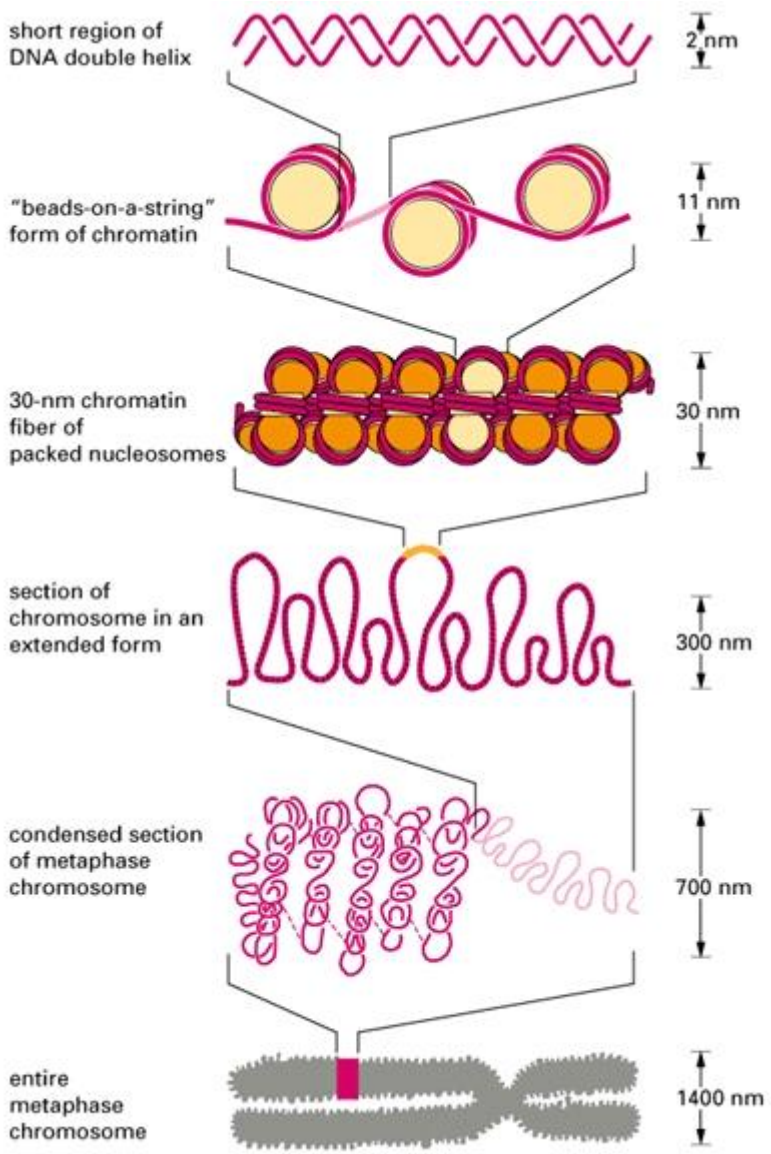
Draw the micrograph. Mark the corresponding figures the following structures: the nuclear envelope (1), heterochromatin, occupying a peripheral position (2), euchromatin (4), the nucleolus (3), tanks EPS (5). Describe the main differences between heterochromatin from euchromatin.

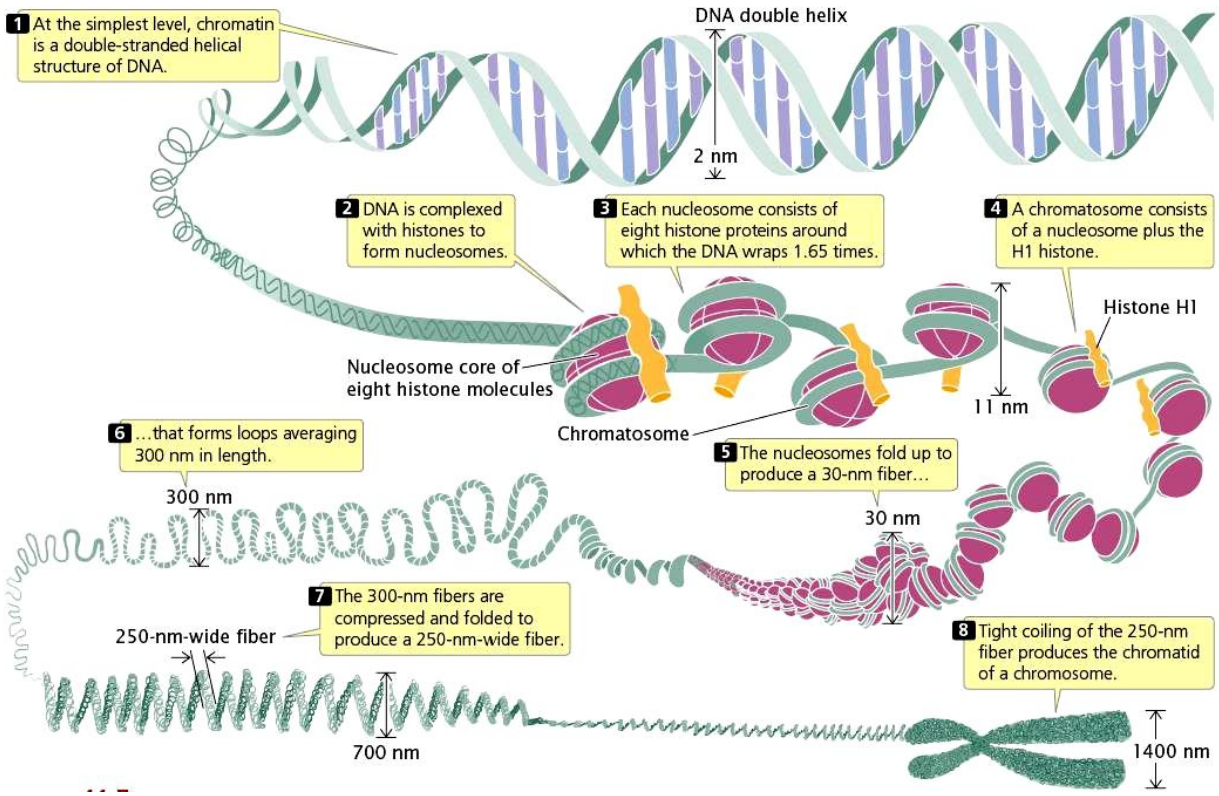


Exercise 9. Levels of packaging of chromatin in the cell nucleus.

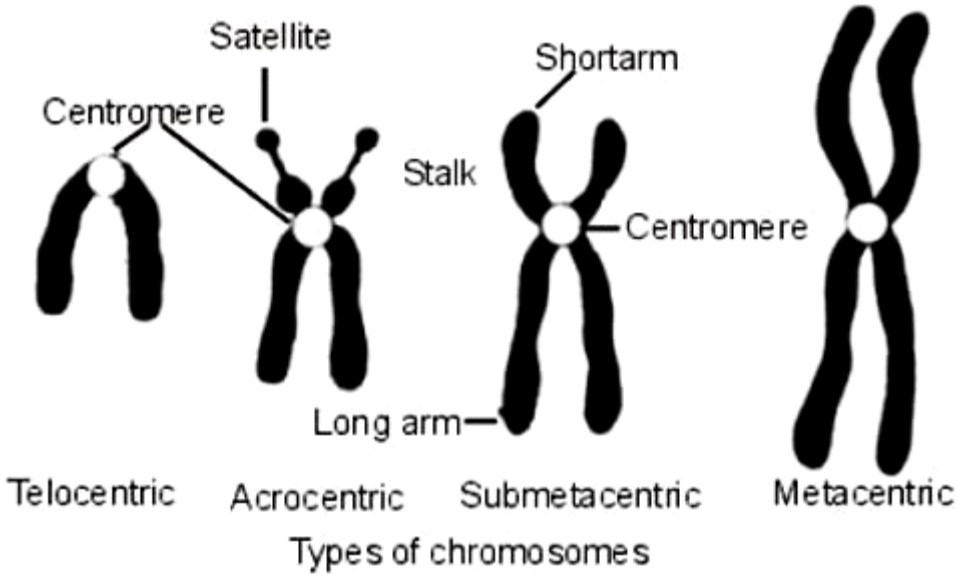
The DNA double helix forms a filament diameter of 2 nm. It is screwed onto octamer and forms nucleosomes. Nucleosomes are part of the nucleosomal filament, with a diameter of 11 nm. Nucleosomal filament is twisted and forms the chromatin fiber, with a diameter of 30 nm. Chromatin the fiber forms looped domains (neskondensirovannyh chromatin) with a diameter of 300 nm. More tightly Packed form loop domains of the condensed sections of the chromosome, with a diameter of 700 nm. They are part of a metaphase chromosome, having a diameter of 1400 nm.

Draw levels of DNA packaging, make a notation.





Exercise 10. Classification of chromosomes.
Consider the main types of chromosomes, draw them.



REMEMBER

FLAGELLUM (cilium) - a protrusion of the outer membrane of the cell. Axoneme passes in the center of the flagellum which ends in cytoplasm by basal body (structure like centrioles (9x3 + 0)). Axoneme formed nine doublets microtubules arranged circumferentially and two unpaired microtubules are in the center (formula – 9x2 + 2).

MYOFIBRILS are contractile organelles of muscle cells and fibers. They are formed thick - myosin microfilaments and thin - actin microfilaments. Protein Z-line are located in the center of actin filaments. Plot myofibrils between the two Z-lines is called a sarcomere. Sarcomere is a structural and functional unit of myofibrils. Actin filaments are located between the myosin. With the reduction of myofibrils actin filaments as if entering between the myosin myofibril and myofibril are shortened.

On the myofibril are:

I-band: consists of actin filaments;

H-band: it consists only of myosin filaments;

A-band: determined by the length of the filaments of myosin, myosin filaments, and includes the ends of actin filaments.

NUCLEUS is an essential organelle typical for eukaryotes.

Nucleus functions:

1. Storage of genetic information;

2. The regulation of all vital processes in the cell.

The nucleus consists of:

1) nuclear envelope

2) nucleoplasma

3) chromatin

4) nucleoli

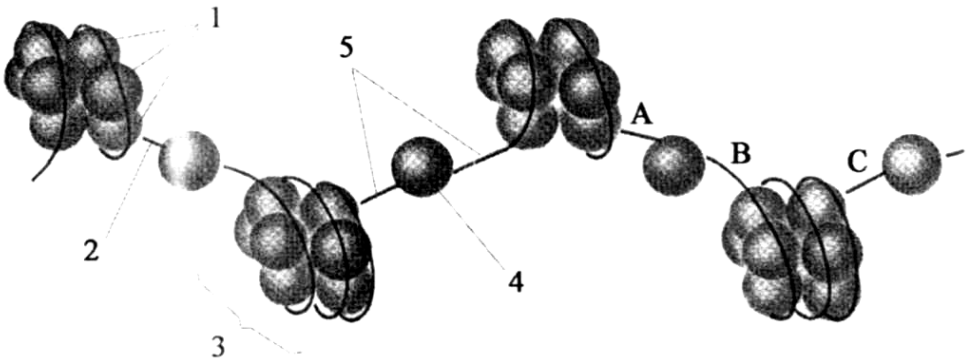
***Nuclear envelope* - formed by 2 membranes: outer membrane is often a continuation of the granular EPS and bears on the surface of the ribosome; inner membrane - smooth, it enters into a complex with the internal structure called lamina (involved in maintaining the shape of the nucleus, in the packing of chromatin). The nuclear envelope contains numerous nuclear pores. Each pore consists of a ring of proteins with a central channel, the whole complex being secured to and stabilised by the nuclear lamina. Nuclear pores regulate the exchange of metabolites, macromolecules and ribosomal subunits between nucleus and cytoplasm.**

***Chromatin* is the complex of DNA with histone proteins (there are 9 of histone proteins: 4 paired H2A, H2B, H3, H4, 1 unpaired - H1). 8 proteins form a globular structure - octamer. Around each octamer almost twice the DNA helix is wound, forming a nucleosome. DNA between nucleosomes enters the complex with the 9th protein histone H1. H1 take part to the further DNA packaging. This level of DNA packaging is called a nucleosomal level. There are euchromatin and heterochromatin. Euchromatin is almost not visible in the light microscope and contains functionally active DNA (from it can read information). Heterochromatin has the form of grains and clumps in the light microscope , contains functionally inactive DNA (reading of information does not occur).**

***Nucleolus* is an electron-dense body, is a place where accumulate a large number of organic materials (copies of rRNA, ribosomal proteins), large and small subunits of the ribosomes around the fragment of DNA encoding rRNA. The function of the nucleolus is the formation of ribosomes.**

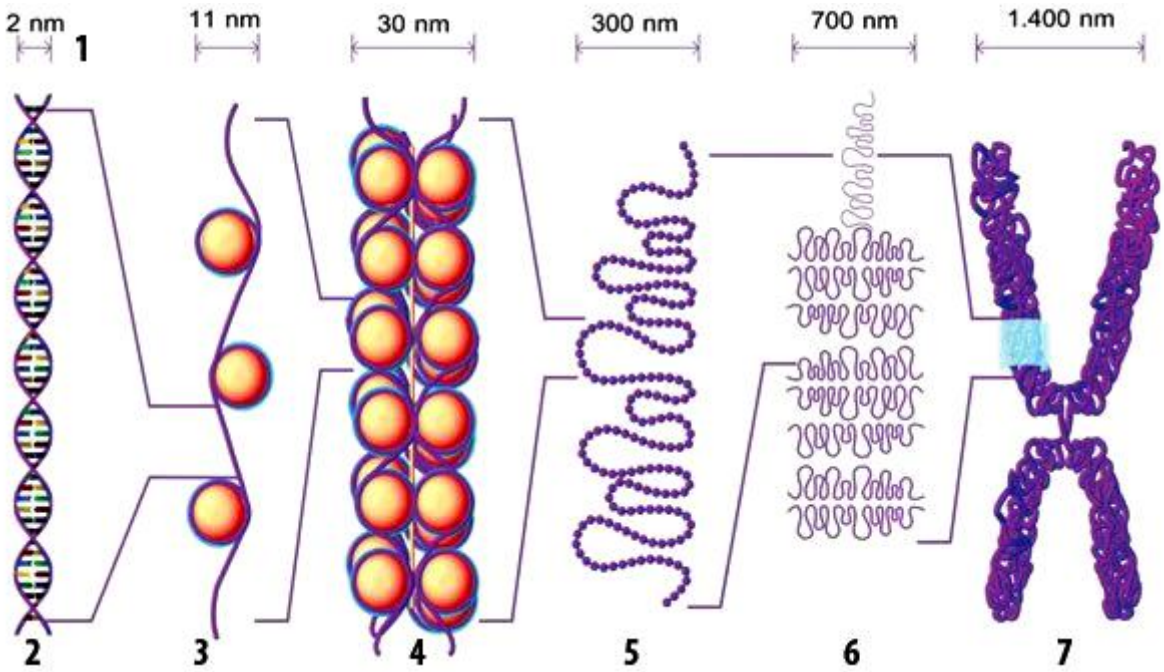
ASSIGNMENTS FOR SELF-CONTROL

Task 1. The figure shows the scheme of the nucleosomal filament. What is shown under the numbers 1, 2, 3, 4, 5?

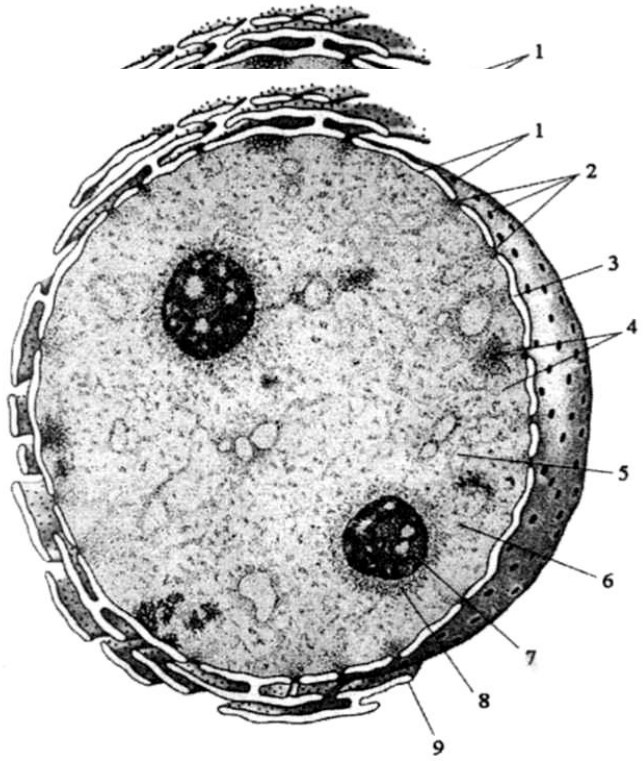


Task 2. The diagram shows the levels of DNA packaging.

What level are numbered 1-7? Describe it.

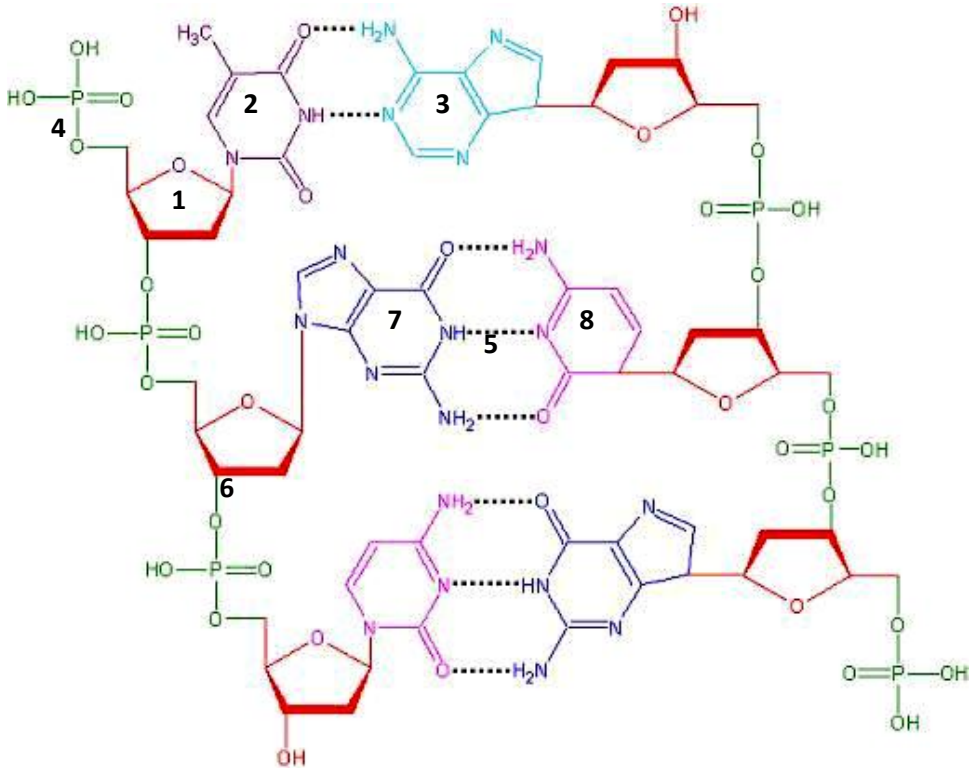


Task 3. The figure shows the scheme of the ultramicroscopic structure of the nucleus.



Task 4. Consider the schematic structure of the DNA molecule.

What structures in the figure marked with numbers 1-6, in the figure B numbers 1-8?



CONTROL QUESTIONS

1. What structure is the nucleus of the cell and what functions it performs?
2. What is pore complex?
3. The chemical composition is karyolymph?
4. What is the relationship between DNA, chromatin and chromosome?
5. What structure is the DNA molecule?
6. What is the role of histone and nonhistone proteins?
7. What is the chemical composition of chromatin has? Name its types.

TOPIC: CELL LIFE CYCLE.

The aim of the lesson: to form knowledge about the periods of the life cycle of the cell.

Session objectives:
1. To form the concept of life cycle of the cell.
2. To study the main stages of DNA replication.
3. To study the main methods of cell division: mitosis, amicos, meiosis.

SOFTWARE ISSUES:
1. Temporal organization of the cell.
2. The concept of life (cell) cycle.
3. Periods of the life cycle of the cell.
4. The interphase.
5. DNA replication.
6. Methods of cell division: mitosis, amicos, meiosis.
7. Phase of mitosis and its biological significance.
8. Phase of meiosis and its biological significance.
9. Cell cycle regulation and mitotic activity of cells.

Equipment:
1. Microscope "Biolam-11".
2. Main slides: plant cell mitosis onion root
3. Demonstration slides: mitosis in the cells of the boundary zone of the liver.

Exercise 1. MITOSIS AND ITS BIOLOGICAL SIGNIFICANCE

1.1. Read the text, remember, what happens in each phase of mitosis

MITOSIS - indirect cell division in which one parent cell 2 is formed a subsidiary, in which the genetic material is the same as in the parent cells.

Includes 4 phases:

Prophase

DNA spiralized, and chromosomes become visible. The nuclear envelope breaks down, the nucleolus disappears, the centriole go to different poles. Between them begin to form filaments of the mitotic spindle. In the cell 2n4c.

Metaphase

In this phase the chromosomes are most clearly visible. Each chromosome consists of two chromatids that are connected in the region of the centromere.

Dwukrotnie chromosomes line up in the equator, forming the parent star. To centromeres chromosomes attach to the spindle fibers division. In the cell 2n4c.

Anaphase

There is a separation of the centromere of the chromosome. Each chromosome splits into 2 chromatids, which become independent of sister chromosomes. Chromatids (sister chromosome) diverge to different poles of the cell. At the poles becomes 2n2c, and in General in the cage 4n4c.

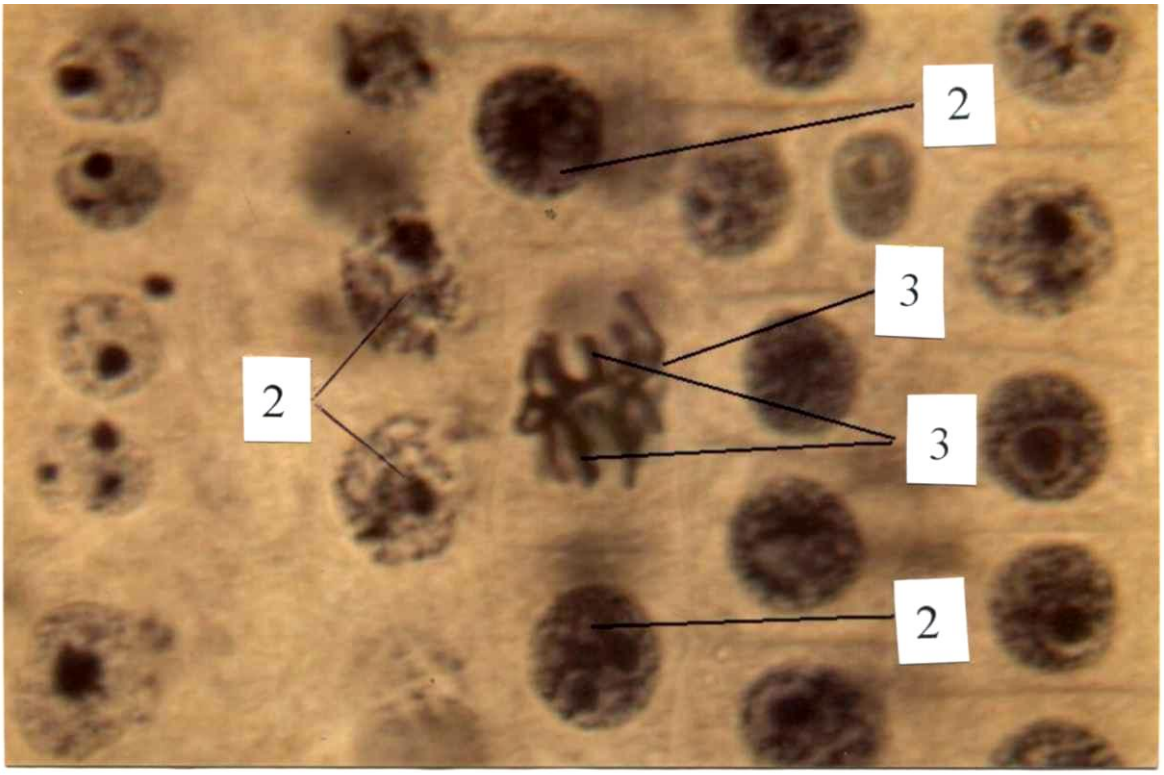
Telophase

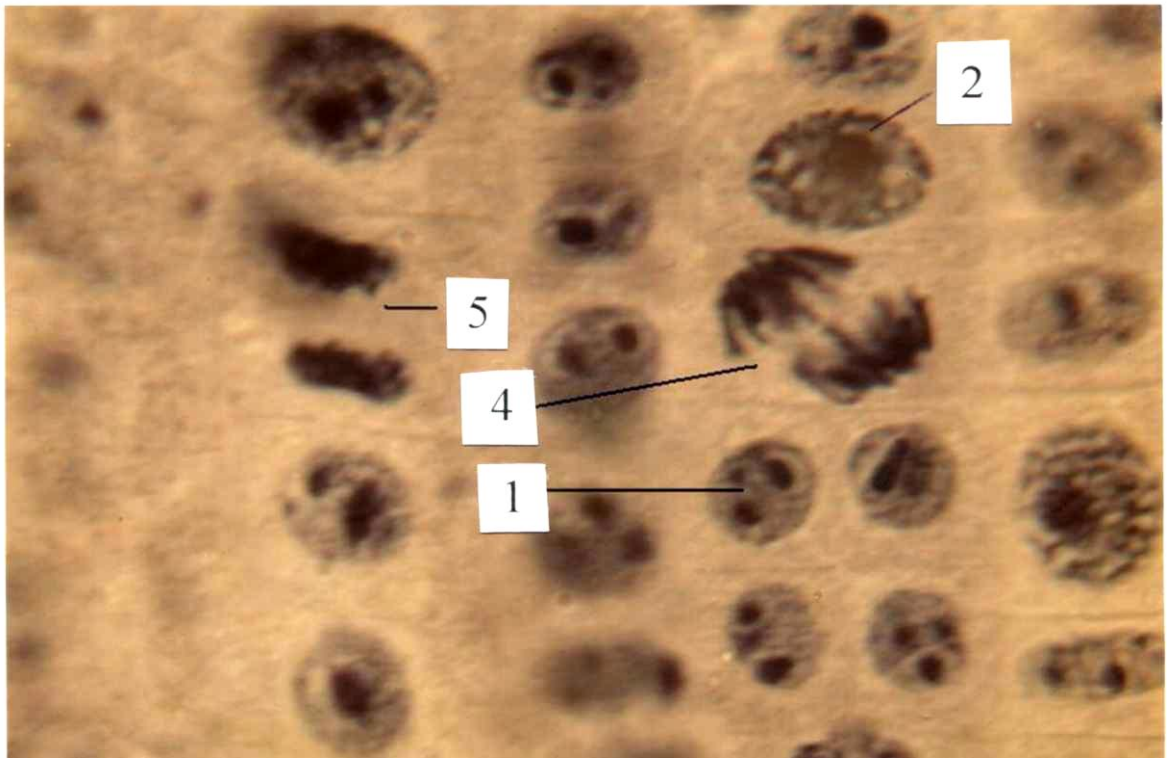
DNA deserialized. Chromosomes are not visible. Formed nuclear envelope, inside the nucleus the nucleolus is formed. Then cytokinesis occurs (catatonia) – division of cytoplasm, and forms 2 daughter cells with a set PS.

Significance of mitosis:

1. Ensures genetic stability, as the daughter cells are exact genetic copy of the parent cells.
2. Ensures the growth of organisms.
3. Provides embryonic development of organisms.
4. Provides for the recovery of organisms.
5. Is the basis of asexual reproduction.

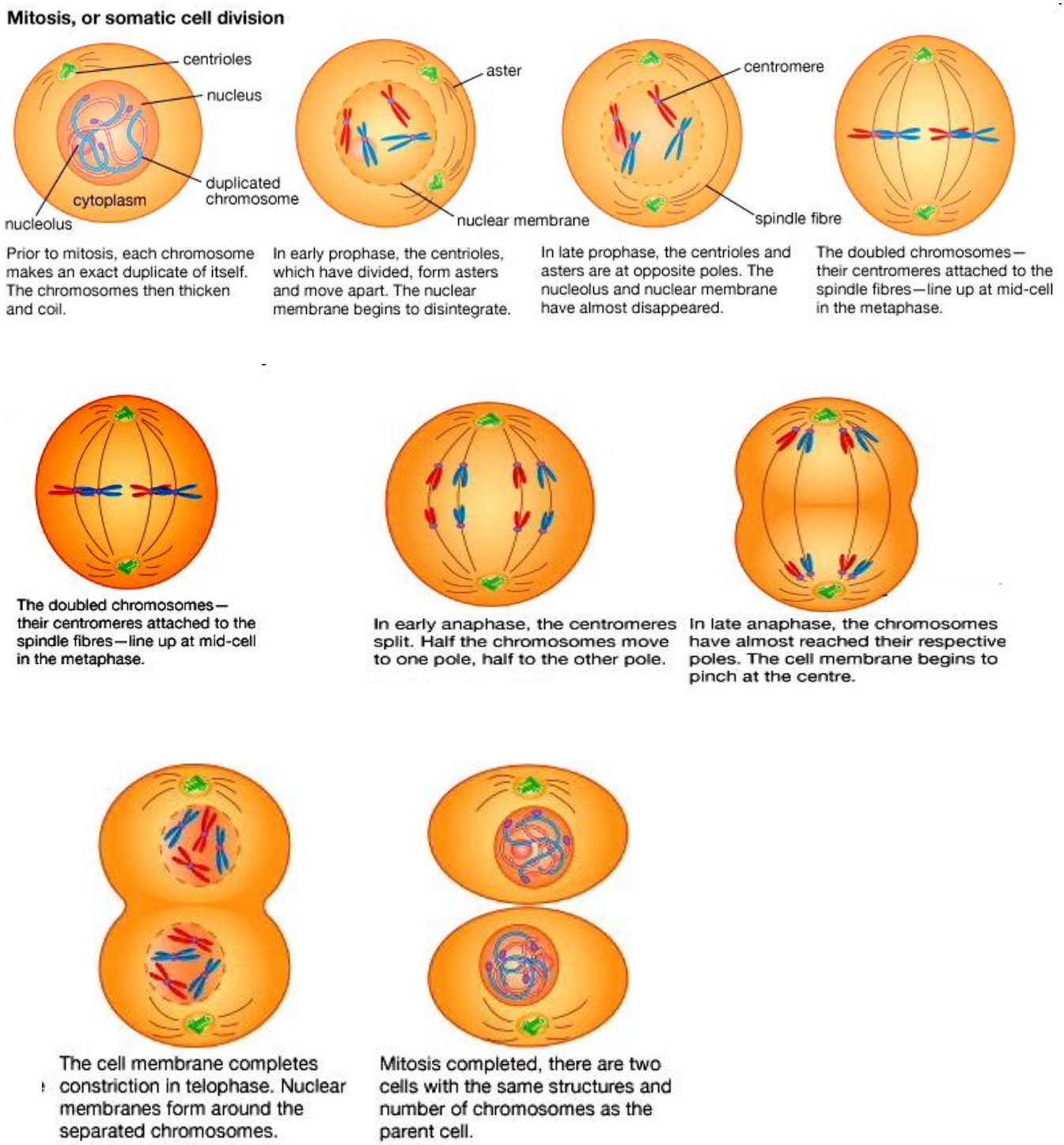
1.2. Consider slide on low and high magnification, locate the main phases of mitosis





Refer figure: 1) interphase; 2) prophase 3) metaphase; 4) anaphase; 5) telophase

1.3. Draw the phase of mitosis



Exercise 2. MEIOSIS AND ITS BIOLOGICAL SIGNIFICANCE

1.1. Read the text, remember, what happens in each phase of meiosis

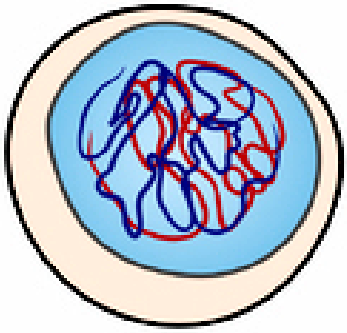
Meiosis is an indirect cell division in which one diploid mother cell forms 4 haploid daughter cells, the genetic material of which is different from the genetic material of the parent cell.

Consists of 2 divisions:

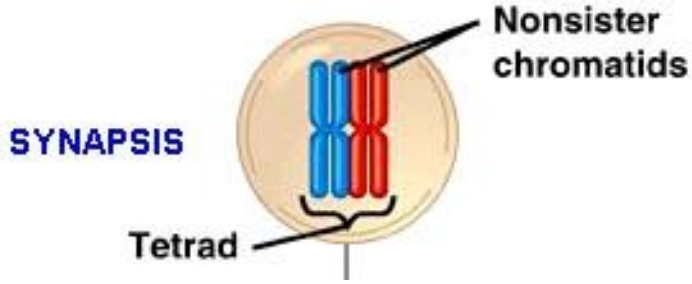
1. Reduction (2n4c→1n2c) – halves the number of chromosomes.
2. Equatione (1n2c→1n1c) – the number of chromosomes is equalized with the number of DNA (chromatids).

REDUCTION DIVISION includes 4 phases:
The Prophase I includes 5 stages:

Leptotene
DNA spiralized and chromosomes become visible in the form of thin fibers.

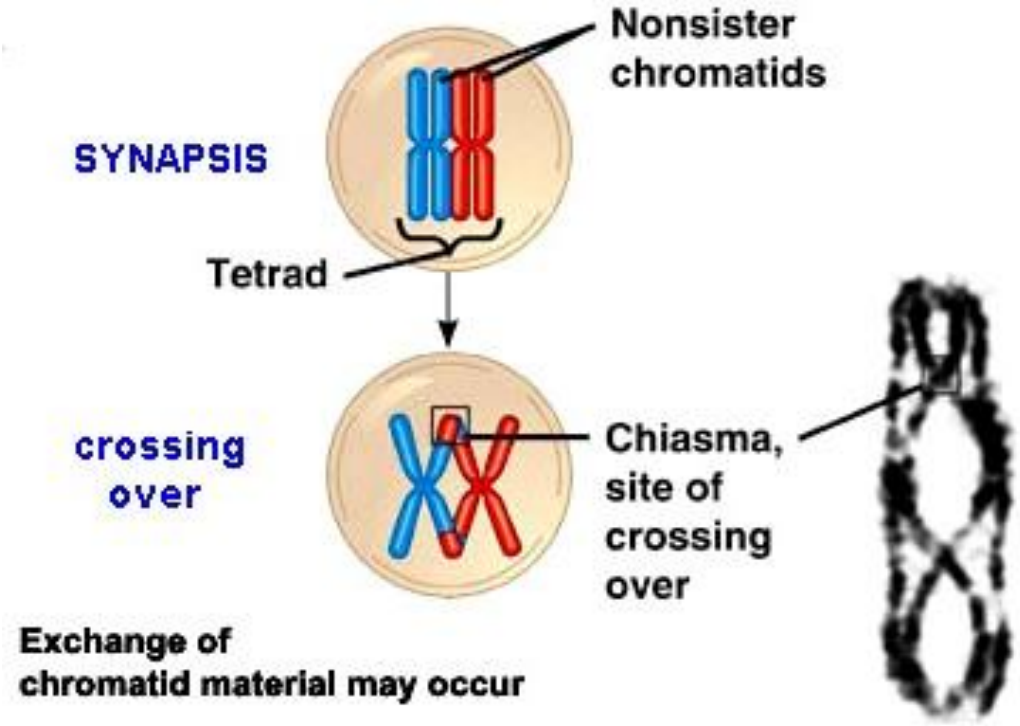


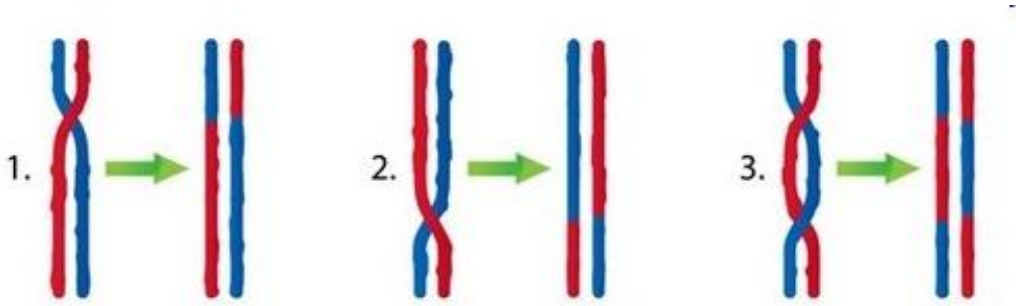
Zygotene
Conjugate is convergence and connection of homologous chromosomes (homologous chromosomes are chromosomes similar in shape, dimensions and location of genes). The result is formation of bivalent (tetrad). Each bivalent consists of 2 homologous chromosomes (4 chromatids (DNA)).



Pachytene

Crossing over occurs – the exchange of parts between homologous chromosomes.





Diplotene

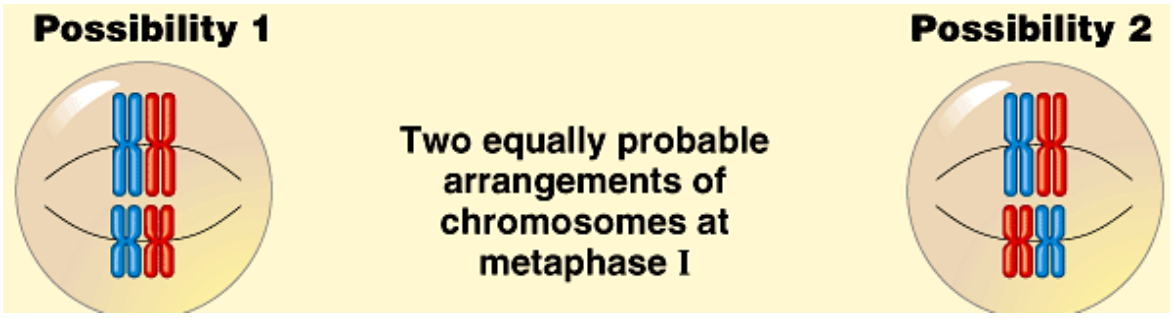
Chromosome in bivalent slightly repel each other. Become visible places chiasm – chiasmata.

Diakines

Chromosomes remain in bivalents, but completely isolated from each other. The nuclear envelope breaks down, the nucleolus disappears, the centriole go to different poles. Filaments of the mitotic spindle begin to form between them. In the cell 2n4c.

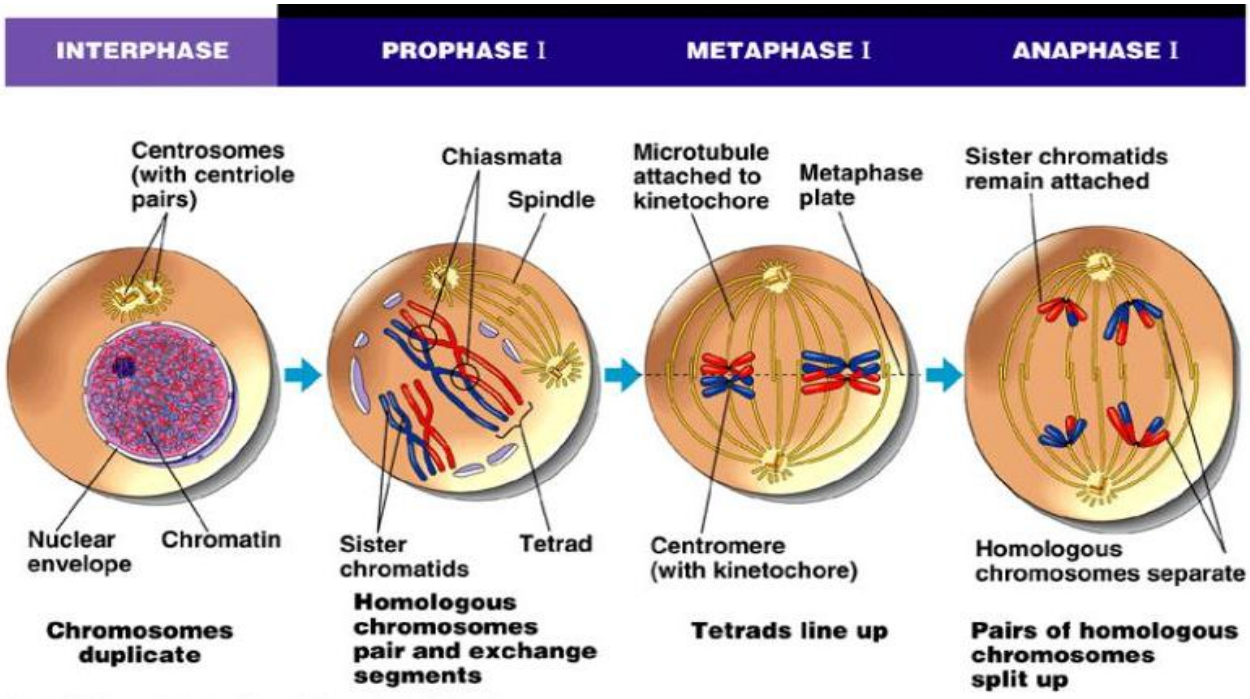
Metaphase I

Bivalency line up on the equator of the cell. The spindle fibers division attach to centromeres chromosomes. In the cell 2n4c.



Anaphase I

In anaphase I, the microtubules of the spindle fibers begin to shorten. As they shorten, they break the chiasmata and pull the centromeres toward the poles, dragging the chromosomes along with them. Because the microtubules are attached to kinetochores on only one side of each centromere, the individual centromeres are not pulled apart to form two daughter centromeres, as

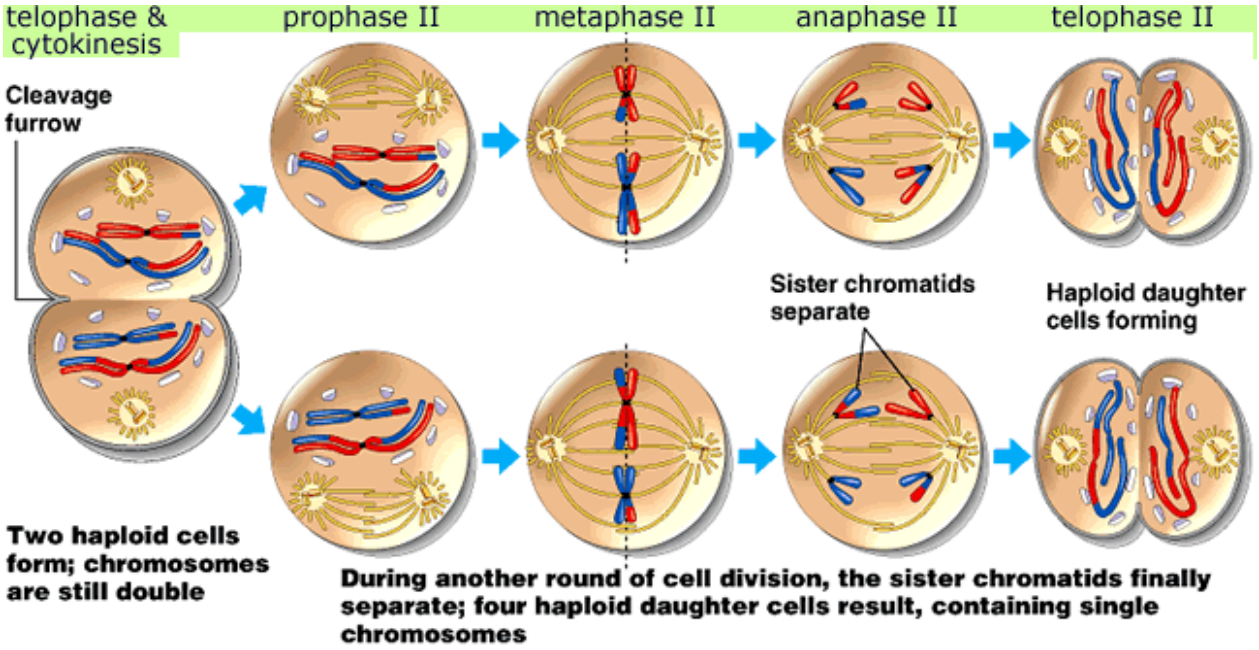


they are in mitosis. Instead, the entire centromere moves to one pole, taking both sister chromatids with it. When the spindle fibers have fully contracted, each pole has a complete haploid set of chromosomes consisting of one member of each homologous pair. Because of the random orientation of homologous chromosomes on the metaphase plate, a pole may receive either the maternal or the paternal homologue from each chromosome pair. As a result, the genes on different chromosomes assort independently; that is, meiosis I results in the independent assortment of maternal and paternal chromosomes into the gametes.

Chiasmata created by crossing over have a key impact on how chromosomes align in metaphase I. In the first meiotic division, the chiasmata hold one sister chromatid to the other sister chromatid; consequently, the spindle microtubules can bind to only one side of each centromere, and the homologous chromosomes are drawn to opposite poles. In mitosis, microtubules attach to both sides of each centromere; when the microtubules shorten, the sister chromatids are split and drawn to opposite poles

Telophase I

By the beginning of telophase I, the chromosomes have segregated into two clusters, one at each pole of the cell. Now the nuclear membrane reforms around each daughter nucleus. As each chromosome replicated before meiosis I began, each chromosome now contains two sister chromatids attached by a common centromere. Importantly, *the sister chromatids are no longer identical*, because of the crossing over that occurred in prophase I. Cytokinesis may or may not occur after telophase I. The second meiotic division, meiosis II, occurs after an interval of variable length.



Between 1 and 2 divisions of meiosis may be a slight period of rest – interlines. However during it is no doubling of the DNA, since each chromosome still consists of 2 chromatids.

EQUAZIONE DIVISION (essentially, mitosis)

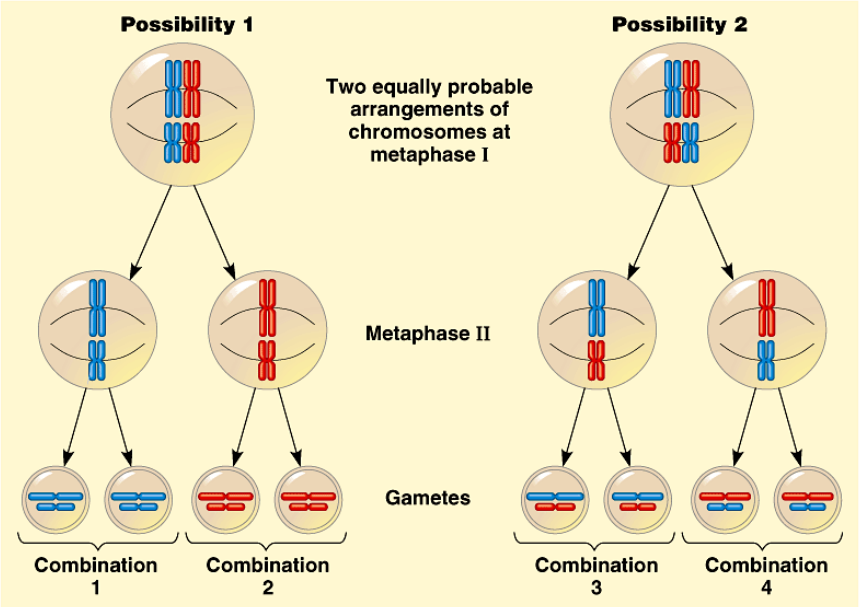
Includes 4 phases:

The prophase II At the two poles of the cell the clusters of chromosomes enter a brief prophase II, each nuclear envelope breaking down as a new spindle forms.

Metaphase II. In metaphase II, spindle fibers bind to both sides of the centromeres.

Anaphase II. The spindle fibers contract, splitting the centromeres and moving the sister chromatids to opposite poles.

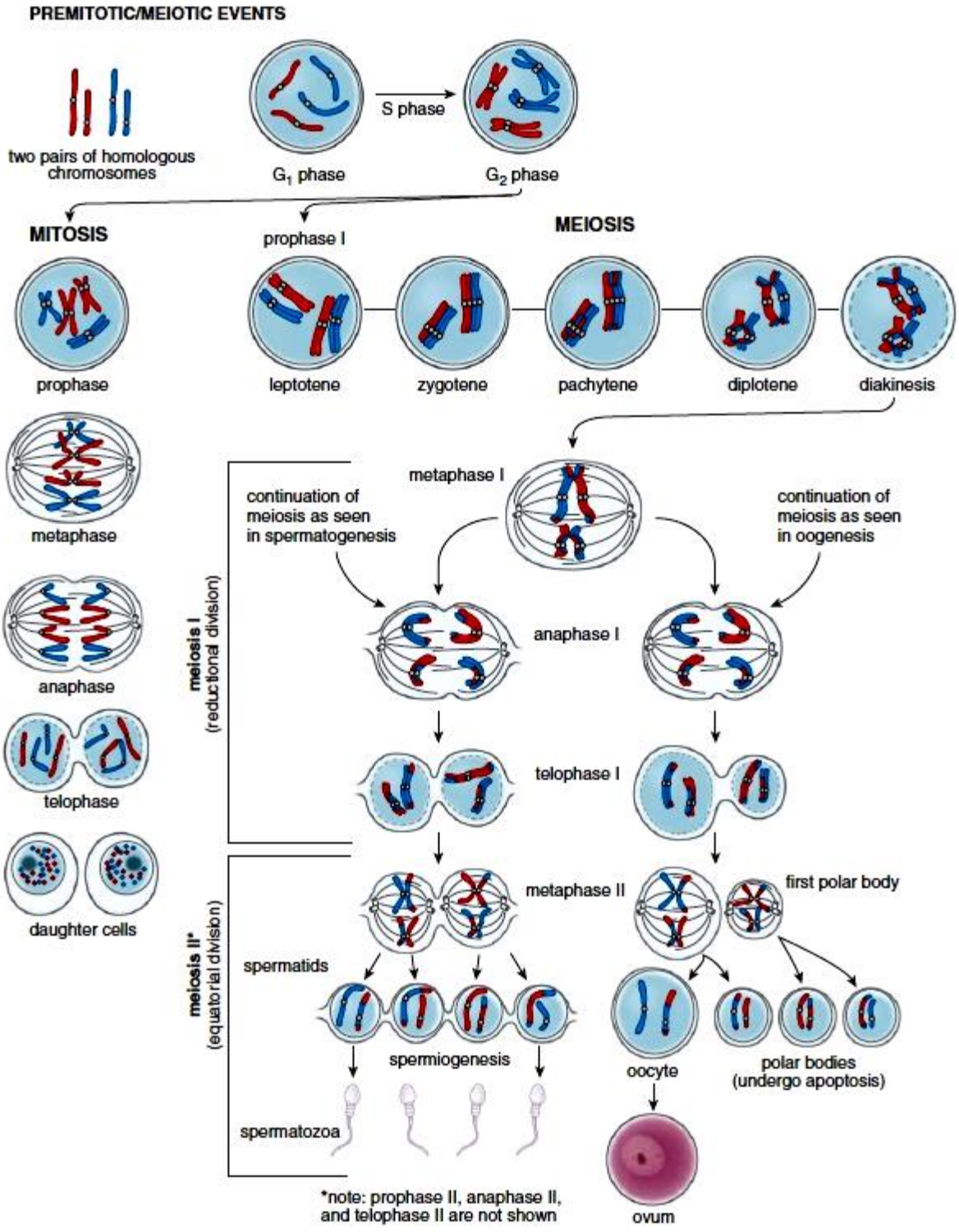
Telophase II. Finally, the nuclear envelope reforms around the four sets of daughter chromosomes. The final result of this division is four cells containing

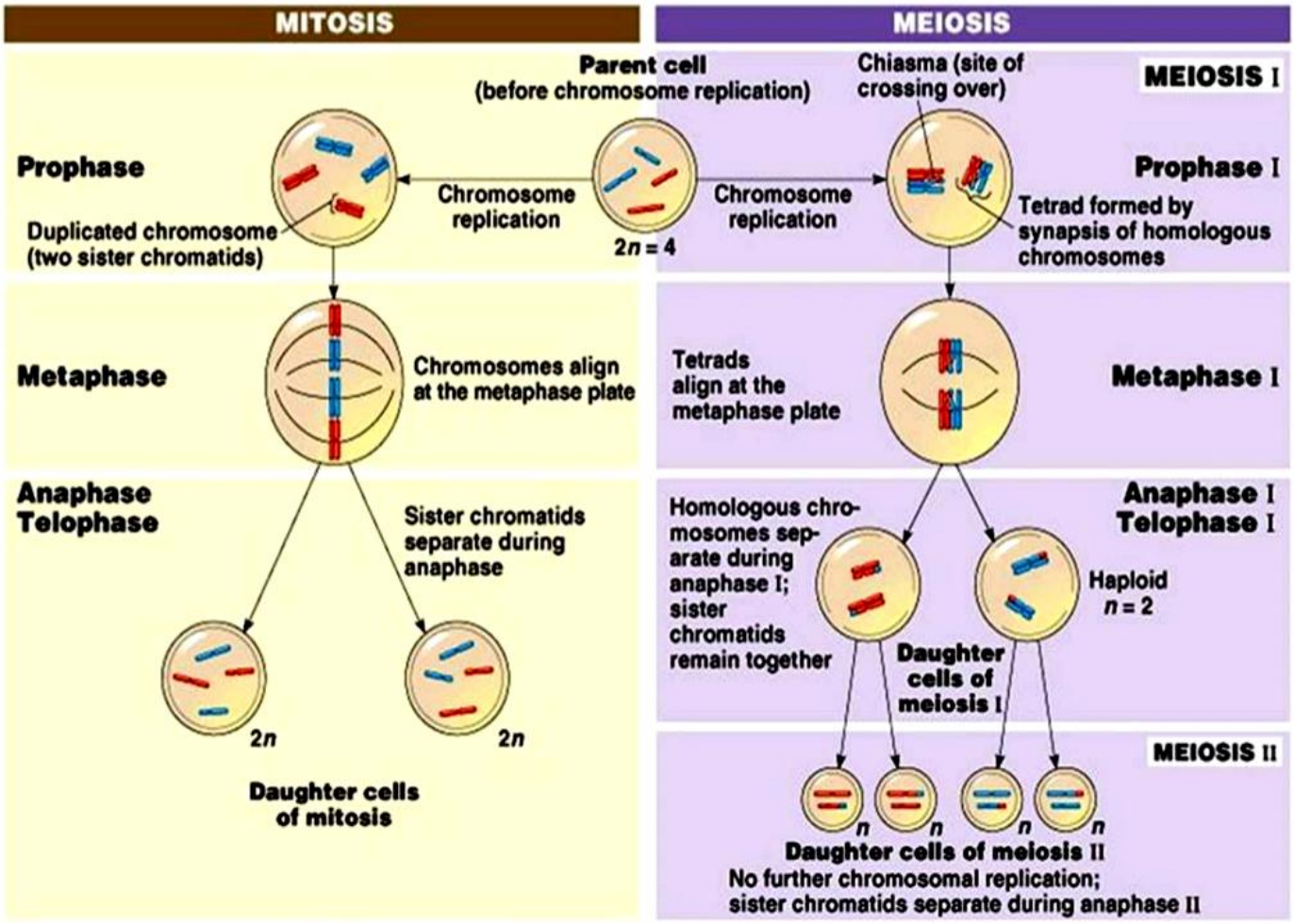


haploid sets of chromosomes. No two are alike, because of the crossing over in prophase I. Nuclear envelopes then form around each haploid set of chromosomes. The cells that contain these haploid nuclei may develop directly into gametes, as they do in animals.

1.2. Draw the main stages of meiosis on the album.

1.3 Compare mitosis and meiosis schemes. Write down the main differences from mitosis meiosis.




MITOSIS
MEIOSIS
Parent cell
(before chromosome replication)
Chiasma (site of crossing over)
MEIOSIS I
Prophase
Chromosome replication
Chromosome replication
Prophase I
Duplicated chromosome (two sister chromatids)
2n = 4
Tetrad formed by synapsis of homologous chromosomes
Metaphase
Chromosomes align at the metaphase plate
Tetrads align at the metaphase plate
Metaphase I
Anaphase Telophase
Sister chromatids separate during anaphase
Homologous chromosomes separate during anaphase I; sister chromatids remain together
Anaphase I Telophase I
Haploid n = 2
Daughter cells of meiosis I
2n
2n
Daughter cells of mitosis
MEIOSIS II
n n n n
Daughter cells of meiosis II
No further chromosomal replication; sister chromatids separate during anaphase II

The control tests to the topic: "Levels of organization of life. The device of the light microscope".

1. A group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding
   a) population
   b) species
   c) ecosystem
   d) Biosphere
2. The optical part includes:
   a) a stage
   b) a lens
   c) a mirror
   d) a condenser
3. A constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function
   a) organ
   b) cell
   c) organelle
   d) organ system
4. A biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.
   a) population
   b) species
   c) ecosystem
   d) Biosphere
5. The mechanical part includes:
   a) an eyepiece
   b) a base
   c) a mirror
   d) a condenser
6. An open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.
   a) organ
   b) cell
   c) organelle
   d) organ system
7. A group of organs that together perform a common activity.
   a) community
   b) cell
   c) organelle
   d) organ system
8. A group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.
   a) population
   b) species
   c) ecosystem
   d) Biosphere
9. There are four sockets for lenses in
   a) a stage
   b) a revolver
   c) a mirror
   d) a condenser
10. The study of any object starts with
   a) a small magnification
   b) a high magnification
   c) a rotation the fine focus adjustment knob
   d) a rotation the diaphragm
11. A group of interdependent organisms of different species growing or living together in a specified habitat
   a) population
   b) community
   c) ecosystem
   d) Biosphere

12. The focal length for a small magnification of approximately
    a) 10 cm
    b) 0,7 cm
    c) 2 cm
    d) 5 cm
13. A totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere
    a) population
    b) community
    c) ecosystem
    d) Biosphere
14. Changing its the position (above, below), you can modify the intensity of light
    a) a coarse focus adjustment knob
    b) a revolver
    c) a fine focus adjustment knob
    d) a condenser
15. A group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity
    a) organ
    b) tissue
    c) organelle
    d) organ system
16. Rrotating it in different directions you made the field of view is illuminated brightly and evenly
    a) a stage
    b) a lens
    c) a mirror
    d) a condenser
17. When focusing of an object at high magnification is necessary to work only with
    a) a coarse focus adjustment knob
    b) a revolver
    c) a fine focus adjustment knob
    d) a diaphragm
18. An open system consisting of interconnected organs and organ systems, and have the ability to self-regulation and has new features which are not in individual organ systems
    a) population
    b) community
    c) ecosystem
    d) organism
19. The lighting part includes:
    a) a stage
    b) a lens
    c) an eyepiece
    d) a condenser
20. It is used for precise focusing
    a) a coarse focus adjustment knob
    b) a revolver
    c) a fine focus adjustment knob
    d) a condenser
21. It is used to adjust the intensity of the light and make the image more contrast
    a) a coarse focus adjustment knob
    b) a revolver
    c) a stage
    d) a diaphragm

The control tests to the topic: "Chemical composition of cells"

1. Protein – heteropolymer, the monomers of which are
a) nucleotides
b) amino acids
c) phospholipids
d) nitrogenous bases
2. In the protein amino acids are connected by
a) hydrogen bond
b) ionic bond
c) metallic bond
d) peptide bond.
3. Peptide bond is formed between the carboxyl group of one amino acid and
a) carboxyl group of another amino acid
b) amino group of another amino acid
c) phosphate group of another amino acid
d) hydroxyl group of another amino acid
4. Peptide bond is
a) covalent polar bond.
b) covalent nonpolar bond.
c) hydrogen bond
d) ionic bond
5. Primary structure of the protein
a) chain of amino acids connected by hydrogen bonds
b) chain of amino acids connected by peptide bonds
c) chain of nucleotides connected by peptide bonds
d) chain of amino acids connected by covalent nonpolar bonds
6. Secondary structure of the protein
a) helix
b) globule
c) chain
d) two chain
7. Helix is folded in the form of globules by
a) formation of disulfide bridges between the radicals of amino acids
b) metallic bond
c) peptide bonds
d) covalent nonpolar bonds
8. The enzymes are
a) structural proteins
b) regulatory proteins
c) protective molecules
d) biological catalysts
9. The function of antibodies
a) transport
b) defense
c) catalysis
d) regulation
10. The protein which transports oxygen in the blood
a) insulin
b) hemoglobin
c) myosin
d) tubulin

11. Monomers of DNA are
a) nucleotides
b) amino acids
c) phospholipids
d) nitrogenous bases
12. Each nucleotide is composed of three parts:
a) phosphate, pentose sugar - ribose, nitrogenous base
b) carbonate, pentose sugar - deoxyribose, nitrogenous base
c) phosphate, pentose sugar - deoxyribose, nitrogenous base
d) phosphate, pentose sugar - deoxyribose, glucose.
13. DNA consists of 4 types of nitrogenous bases
a) adenine, uracil, thymine, cytosine
b) adenine, guanine, uracil, cytosine
c) adenine, guanine, thymine, cytosine
d) adenine, guanine, thymine, uracil
14. Nucleotides of DNA are linked by
a) covalent polar bond
b) covalent nonpolar bond
c) hydrogen bond
d) ionic bond
15. Covalent polar bond is formed between
a) phosphate grope of one nucleotide and nitrogenous base of the second nucleotide
b) nitrogenous base of one nucleotide and sugar of the second nucleotide
c) nitrogenous base of one nucleotide and nitrogenous base of the second nucleotide
d) phosphate grope of one nucleotide and sugar of the second nucleotide
16. DNA chains are interconnected by
a) covalent polar bond.
b) covalent nonpolar bond.
c) hydrogen bond
d) ionic bond
17. In the DNA double helix:
a) adenine is complementary to thymine
b) adenine is complementary to guanine
c) uracil is complementary to thymine
d) cytosine is complementary to thymine
18. The structure of RNA nucleotides, unlike the DNA includes
a) sugar - ribose and the nitrogenous base adenine
b) sugar - deoxyribose and the nitrogenous base cytosine
c) sugar - deoxyribose and the nitrogenous base uracil
d) sugar - ribose and the nitrogenous base uracil
19. Transfer RNA
a) carries amino acids to the ribosomes during protein synthesis
b) is a part of the ribosome
c) carries genetic information from DNA to the ribosomes
d) brings amino acids to the ribosome
20. Messenger RNA
a) carries amino acids to the ribosomes during protein synthesis
b) is a part of the ribosome
c) carries genetic information from DNA to the ribosomes
d) brings amino acids to the ribosome

The control test on the topic "Structure and function of the cell membrane. Transport substances through the membrane"

1. The basis of the cell membrane is formed
a) by two layers of proteins
b) fatty acids
c) by two layers of nitrogenous compounds
d) by two layers of lipids
2. Each phospholipid has
a) hydrophilic (polar) head and three hydrophobic (nonpolar) tails.
b) hydrophilic (polar) head and two hydrophobic (nonpolar) tails
c) hydrophobic (nonpolar) head and two hydrophilic (polar) tails
d) hydrophilic (polar) tail and two hydrophobic (nonpolar) heads
3. The non-polar tails of the phospholipid molecule consist of
a) two long-chain glycerol
b) two long-chain choline
c) two long-chain fatty acids
d) three long-chain fatty acids
4. The polar heads of phospholipids in the bilipid layer
a) are located on its outer side
b) are located inside
c) are arranged randomly
d) are located both outside and inside
5. Model of membrane structure is
a) sandwich model
b) fluid mosaic model
c) lipid-electron model
d) mathematical model
6. Transmembrane proteins are
a) extrinsic proteins
b) peripheral proteins
c) integral proteins
d) hormones
7. The term fluid mosaic model of membrane structure. is used because
a) many proteins are not fixed but 'float' within the membrane so they are freely mobile within the plane of the phospholipid bilayer
b) proteins form a continuous layer on the surface of lipids
c) lipids form a continuous layer on the surface of proteins
d) many proteins are firmly fixed in the lipid bilayer
8. Polysaccharide layer on the external surface of the plasma membranes of animal cells has been termed
a) glycocalyx
b) cell wall
c) acrosome
d) dictyosome
9. The glycocalyx takes part
a) in cell division
b) in energy metabolism
c) in the formation of intercellular adhesions
d) to the enzymatic cleavage substances
10. Passive diffusion
a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.

b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

11. Facilitated diffusion

a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

12. Active transport

a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

13. Bulk transport

a) is entirely dependent on the presence of a concentration gradient across the plasma membrane.
b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

14. Passive transport of substances through the membrane include

a) osmosis
b) exocytosis
c) endocytosis
d) pinocytosys

15. Active transport of substances through the membrane include

a) osmosis
b) diffusion
c) endocytosis
d) facilitated diffusion

16. If the cells placed in a hypotonic solution

a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell shrinks
d) the cell does not change

17. If the cells placed in hypertonic solution

a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell ruptures
d) the cell does not change

18. Phagocytosis

a) the process of penetration into the cell liquid droplets
b) the process of penetration of solid particles into the cell
c) the process of penetration of water into the cell
d) the process of penetration ions into the cell

19. Pinocytosis

a) the process of penetration into the cell liquid droplets
b) the process of penetration of solid particles into the cell
c) the process of penetration of water into the cell
d) the process of penetration ions into the cell

20. Cholesterol molecules of membrane can
a) play the role of enzymes
b) stabilise the phospholipid bilayer
c) participate in the process of osmosis
d) participate in the formation of cell-cell contacts

The control test on the topic «Cell organelles»

1. The composition of the outer membrane of the cell includes:
a) proteins and lipids
b) carbohydrates and RNA
c) DNA and RNA
d) carbohydrates and DNA
2. The cell membrane organelles include
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
3. The function of ATP synthesis in the cell is performed
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
4. Protein synthesis was carried out in a cell
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
5. The two membranes are limited
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
6. Synthesis of complex substances in the cell provides a simple
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
7. Dictyosome part of the
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
8. Have their own DNA
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
9. A stack of flat tank called the Golgi complex
a) dictyosome
b) matrix
c) chromatin

d) cristae

10. The liquid contents of mitochondria is called

a) dictyosome
b) matrix
c) chromatin
d) cristae

11. The function of storing genetic information in the cell is performed

a) ribosomes
b) microfilaments
c) mitochondria
d) core

12. The transport function of the membrane is provided

a) lipids
b) surface proteins
c) carbohydrates
d) integral proteins

13. rRNA and proteins are part of

a) ribosomes
b) microfilaments
c) mitochondria
d) core

14. The structures formed by the mitochondrial inner membrane, called

a) thylakoids
b) crista
c) grana
d) stroma

15. The pigment chlorophyll contained in

a) chloroplasts
b) chromoplasts
c) lekoplastah
d) leukocytes

16. The function of photosynthesis performed

a) chloroplasts
b) chromoplasts
c) lekoplasty
d) leukocytes

Insert the missing word

1. The _____ is composed of DNA and protein.

A. chromatin
B. ribosome
C. flagellum
D. centriole
E. mitochondrion

2. Ribosomal subunits are manufactured by the _____.

A. peroxisome
B. lysosome
C. smooth endoplasmic reticulum
D. rough endoplasmic reticulum
E. nucleolus

3. _____ are the sites of protein synthesis.
A. Peroxisomes
B. Ribosomes
C. Golgi apparatuses
D. Mitochondria
E. Microfilaments
4. Which of these manufactures cellular membranes by adding membrane proteins and phospholipids to its own membrane?
A. ribosomes
B. nucleolus
C. Golgi apparatus
D. rough endoplasmic reticulum
E. lysosomes
5. The _____ is a selective barrier, regulating the passage of material into and out of the cell.
A. plasma membrane
B. lysosome
C. nuclear envelope
D. chloroplast
E. nucleus
6. Where is calcium stored?
A. centrioles
B. mitochondria
C. smooth endoplasmic reticulum
D. microtubules
E. rough endoplasmic reticulum
7. Which of these are hollow rods that shape and support the cell?
A. plasma membrane
B. peroxisomes
C. microtubules
D. microfilaments
E. chloroplasts
8._____ is/are identical in structure to centrioles.
A. Chromatin
B. Mitochondria
C. Basal bodies
D. Nuclear envelopes
E. Microfilaments
9. Which of these cannot rapidly pass directly through the phospholipids of the plasma membrane?
A. Water, glucose and hydrogen ion
B. Water
C. Hydrogen ion
D. Lipid soluble molecule
E. Glucose
10. What name is given to the process by which water crosses a selectively permeable membrane?
A. passive transport
B. phagocytosis
C. pinocytosis
D. osmosis
E. diffusion

11. Which of these organelles carries out cellular respiration?
A. smooth endoplasmic reticulum
B. mitochondrion
C. chromatin
D. ribosomes
E. nucleolus

Final test on the topic "Structure and function of the cell"

1. The basis of the cell membrane is formed
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c) by two layers of nitrogenous compounds
d) by two layers of lipids

2. Each phospholipid has
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b) hydrophilic (polar) head and two hydrophobic (nonpolar) tails
c) hydrophobic (nonpolar) head and two hydrophilic (polar) tails
d) hydrophilic (polar) tail and two hydrophobic (nonpolar) heads

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a) are located on its outer side
b) are located inside
c) are arranged randomly
d) are located both outside and inside

4. Model of membrane structure is
a) sandwich model
b) fluid mosaic model
c) lipid-electron model
d) mathematical model

5. The glycocalyx takes part
a) in cell division
b) in energy metabolism
c) in the formation of intercellular adhesions
d) to the enzymatic cleavage substances

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b) involves the transport of larger hydrophilic metabolites such as glucose and amino acids.
c) often operates against extreme concentration gradients
d) involves large molecules or small particles being engulfed by the plasma membrane, thus forming membrane-bound vacuoles (vesicles) within the cytoplasm.

7. If the cells placed in a hypotonic solution
a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell shrinks
d) the cell does not change

8. If the cells placed in hypertonic solution
a) the water will penetrate from the cell to the outside
b) the water will penetrate in cell
c) cell ruptures
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9. Phagocytosis

a) the process of penetration into the cell liquid droplets
b) the process of penetration of solid particles into the cell
c) the process of penetration of water into the cell
d) the process of penetration ions into the cell

10. Cholesterol molecules of membrane can

a) play the role of enzymes
b) stabilise the phospholipid bilayer
c) participate in the process of osmosis
d) participate in the formation of cell-cell contacts

11. A group of individuals of one species living in isolation from similar groups of individuals of this species and is characterized by higher levels of interbreeding

a) population
b) species
c) ecosystem
d) Biosphere

12. A constant structure of the body, consisting of several tissues that have a particular shape, size, and performs a specific function

a) organ
b) cell
c) organelle
d) organ system

13. A biological community of living organisms of different species, closely interacting with each other and with their environment, having the ability to self-replicate and self-regulation.

a) population
b) species
c) ecosystem
d) Biosphere

14. An open system, bounded from the environment by a membrane and containing within the cytoplasm with organelles and a nucleus.

a) organ
b) cell
c) organelle
d) organ system

15. A group of organs that together perform a common activity.

a) community
b) cell
c) organelle
d) organ system

16. A group of individuals similar in morphological, physiological, biochemical and other characteristics, occupying a certain territory, having panmixia and giving fertile offspring.

a) population
b) species
c) ecosystem
d) Biosphere

17. A group of interdependent organisms of different species growing or living together in a specified habitat

a) population
b) community
c) ecosystem
d) Biosphere

18. A totality of the planet's living organisms that inhabit certain areas of the atmosphere, hydrosphere and lithosphere
a) population
b) community
c) ecosystem
d) Biosphere
19. A group of cells and their derivatives, having a common origin, similar structure and functions grouped together to perform a specific activity
a) organ
b) tissue
c) organelle
d) organ system
20. An open system consisting of interconnected organs and organ systems, and have the ability to self-regulation and has new features which are not in individual organ systems
a) population
b) community
c) ecosystem
d) organism
21. Protein – heteropolymer, the monomers of which are
a) nucleotides
b) amino acids
c) phospholipids
d) nitrogenous bases
22. In the protein amino acids are connected by
a) hydrogen bond
b) ionic bond
c) metallic bond
d) peptide bond.
23. Peptide bond is formed between the carboxyl group of one amino acid and
a) carboxyl group of another amino acid
b) amino group of another amino acid
c) phosphate group of another amino acid
d) hydroxyl group of another amino acid
24. Peptide bond is
a) covalent polar bond.
b) covalent nonpolar bond.
c) hydrogen bond
d) ionic bond
25. Primary structure of the protein
a) chain of amino acids connected by hydrogen bonds
b) chain of amino acids connected by peptide bonds
c) chain of nucleotides connected by peptide bonds
d) chain of amino acids connected by covalent nonpolar bonds
26. Secondary structure of the protein
a) helix
b) globule
c) chain
d) two chain
27. Helix is folded in the form of globules by
a) formation of disulfide bridges between the radicals of amino acids
b) metallic bond
c) peptide bonds

d) covalent nonpolar bonds

28. The enzymes are

a) structural proteins
b) regulatory proteins
c) protective molecules
d) biological catalysts

29. The function of antibodies

a) transport
b) defense
c) catalysis
d) regulation

30. The protein which transports oxygen in the blood

a) insulin
b) hemoglobin
c) myosin
d) tubulin

31. Monomers of DNA are

a) nucleotides
b) amino acids
c) phospholipids
d) nitrogenous bases

32. Each nucleotide is composed of three parts:

a) phosphate, pentose sugar - ribose, nitrogenous base
b) carbonate, pentose sugar - deoxyribose, nitrogenous base
c) phosphate, pentose sugar - deoxyribose, nitrogenous base
d) phosphate, pentose sugar - deoxyribose, glucose.

33. DNA consists of 4 types of nitrogenous bases

a) adenine, uracil, thymine, cytosine
b) adenine, guanine, uracil, cytosine
c) adenine, guanine, thymine, cytosine
d) adenine, guanine, thymine, uracil

34. Nucleotides of DNA are linked by

a) covalent polar bond
b) covalent nonpolar bond
c) hydrogen bond
d) ionic bond

35. Covalent polar bond is formed between

a) phosphate grope of one nucleotide and nitrogenous base of the second nucleotide
b) nitrogenous base of one nucleotide and sugar of the second nucleotide
c) nitrogenous base of one nucleotide and nitrogenous base of the second nucleotide
d) phosphate grope of one nucleotide and sugar of the second nucleotide

36. DNA chains are interconnected by

a) covalent polar bond.
b) covalent nonpolar bond.
c) hydrogen bond
d) ionic bond

37. In the DNA double helix:

a) adenine is complementary to thymine
b) adenine is complementary to guanine
c) uracil is complementary to thymine
d) cytosine is complementary to thymine

38. The structure of RNA nucleotides, unlike the DNA includes
a) sugar - ribose and the nitrogenous base adenine
b) sugar - deoxyribose and the nitrogenous base cytosine
c) sugar - deoxyribose and the nitrogenous base uracil
d) sugar - ribose and the nitrogenous base uracil
39. The cell membrane organelles include
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
40. The function of ATP synthesis in the cell is performed
a) ribosomes
b) cell center
c) Golgi complex
d) microtubules
41. The two membranes are limited
a) ribosomes
b) cell center
c) mitochondria
d) microtubules
42. Synthesis of complex substances in the cell provides a simple
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
43. Dictyosome part of the
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
44. Have their own DNA
a) Golgi complex
b) cell center
c) mitochondria
d) granular EPS
45. The liquid contents of mitochondria is called
a) dictyosome
b) matrix
c) chromatin
d) cristae
46. The function of storing genetic information in the cell is performed
a) ribosomes
b) microfilaments
c) dictyosome
d) nucleus
47. rRNA and proteins are part of
a) ribosomes
b) microfilaments
c) mitochondria
d) nucleus
48. The mitochondrial inner membrane formes
a) thylakoids

b) crista
c) grana
d) stroma

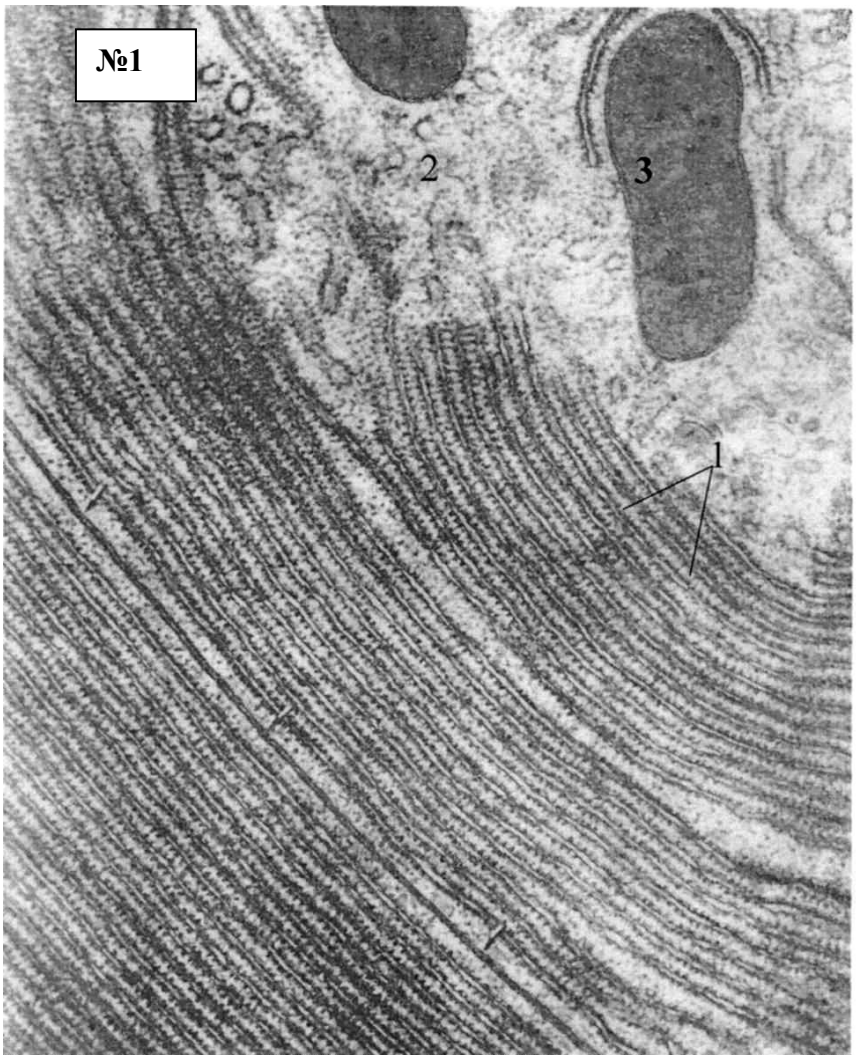
49. The pigment chlorophyll contained in

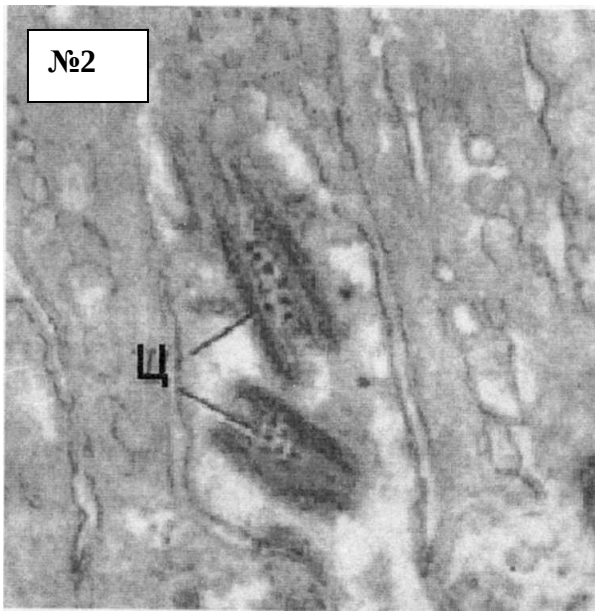
a) chloroplasts
b) chromoplasts
c) lekoplastah
d) leukocytes

50 Organelles of cell which take part in cellular respiration

A. smooth endoplasmic reticulum
B. mitochondria
C. chromatin
D. ribosomes
E. nucleolus

Describe the electron micrographs, what structures you can see what functions they perform in the cell.





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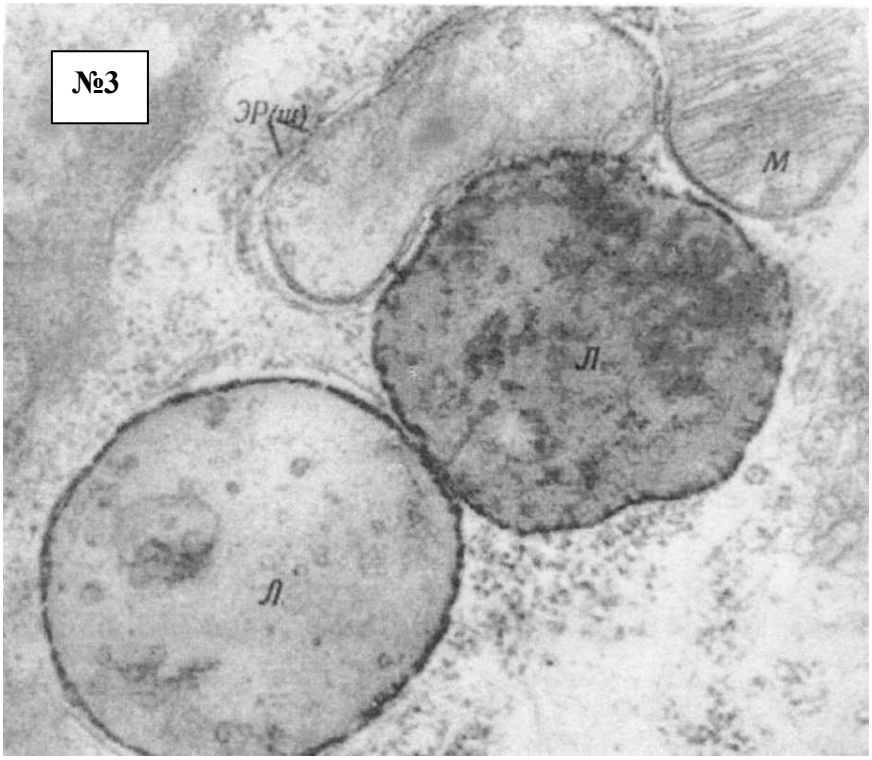

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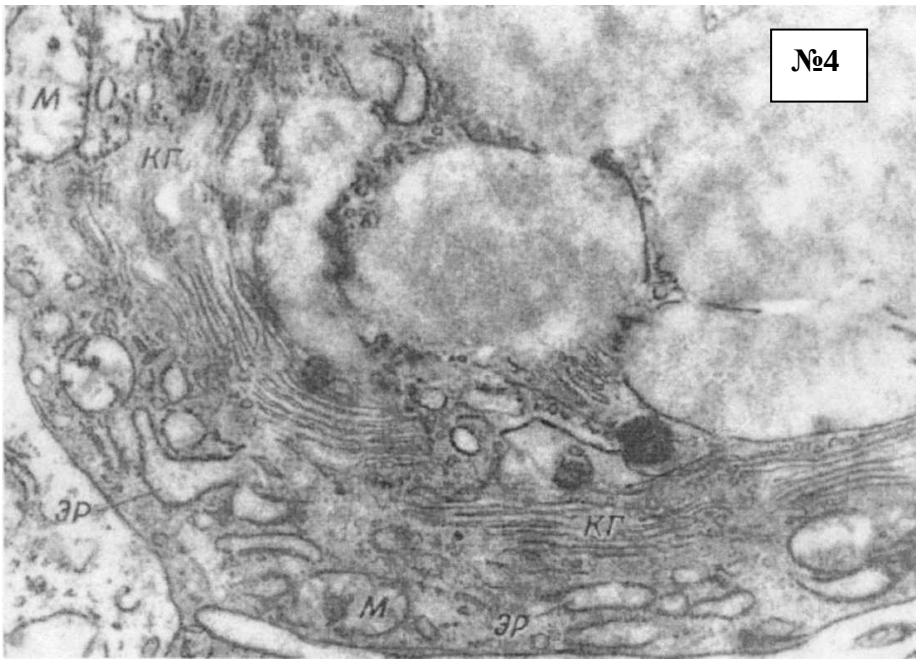

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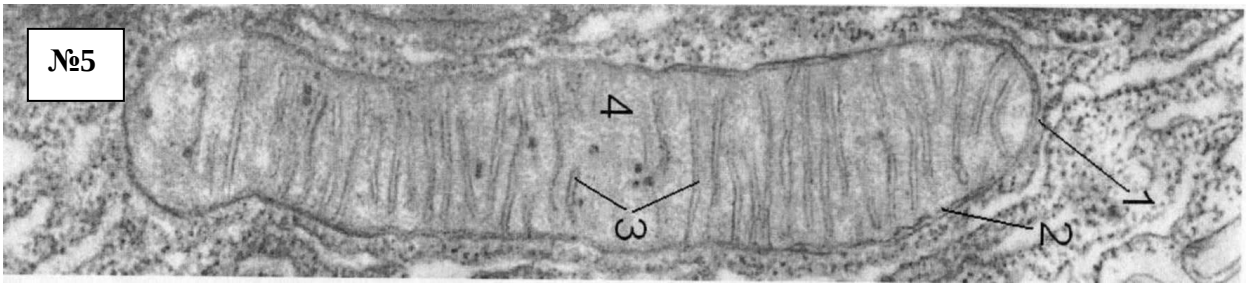

RECOMMENDED READING

Campbell biology. -- 9th ed. p. cm. Rev. ed. of: Biology / Neil A. Campbell, Jane B. Reece. 8th ed. c.2009.