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Department of Histology, Embryology, Cytology

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CYTOLOGY. EMBRYOLOGY

Textbook

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The textbook “Cytology. Embryology” is compiled taking into account the modern educational standard and curriculum in the discipline “Histology” for medical universities. It contains the main provisions of the subject, informational and didactic materials necessary for the successful development of the course of embryology and cytology.

The content of the lectures corresponds to the qualification characteristics of medical University graduates.

The material is intended for students of medical universities majoring in “Medicine”, “Pediatrics” and “Dentistry” in order to organize and improve the effectiveness of independent work in preparation for classes.

Published by the decision of the Department of Histology, Embryology, Cytology. Approved by the Ministry of Education and Science of the Kyrgyz Republic as a textbook for students of higher medical educational institutions.

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CONTENT

PREFACE

Dear colleagues!

Textbook “Cytology. Embryology” contains the basic information necessary for students to independently study cytology and embryology in practical classes. This manual is part of a course of lectures offered to students at the Department of Histology, Embryology, Cytology of the Medical Faculty of the Kyrgyz-Russian Slavic University named after the First President of the Russian Federation B.N. Yeltsin.

This textbook summarizes many years interesting experience of the staff of the department, especially since the methodological approaches at this department do not differ from those adopted in other medical universities of the Kyrgyz Republic. In the proposed textbook, all theoretical material is divided into topics given in a concise form, well-illustrated to facilitate understanding (including the author’s drawings). The authors hope that this textbook will serve students and young teachers well and their work will not be in vain.

The compilers express their gratitude to the leading specialist of the Department of Histology, Embryology, Cytology M.M. Yakubova for providing technical assistance in compiling the textbook. Head of the Department of Histology, Embryology, Cytology of the Medical Faculty of the Kyrgyz-Russian Slavic University named after the First President of the Russian Federation B.N. Yeltsin Candidate of Medical Sciences, Associate Professor Olga Petrovna Kalugina.

INTRODUCTION

It is well known that the tasks of general histology include the study of the structure, development, functioning and origin of tissues. Private histology is the study of the microscopic and ultramicroscopic structure of organs. It should be noted that the above division of histology into sections is artificial, since cells form tissues, tissues are part of organs, and organs form the body. Therefore, cells, tissues and organs are parts of the whole organism. Integrity is possessed only by the organism in its unity with the external environment, and cells, tissues and organs have subordinate significance.

We have to put up with the division of histology into sections, this is necessary, first of all, for the convenience of presenting the material. In addition, each of the sections is designed to solve a certain range of problems. And before you start studying histology, you need to get acquainted with cytology – the science of the cell – an elementary unit of the structure, functioning and origin of living matter.

Modern cytology studies the structure of cells, and their functioning as elementary living systems examines the functions of individual cellular components, the processes of cell reproduction, their adaptation to environmental conditions, and many other processes that allow us to judge the properties and functions common to all cells. It explains the features of specialized cells, the stages of formation of their special functions and the development of specific cellular structures.

Over the past half – century, cytology has turned from descriptive and morphological into an experimental science that sets itself the task of studying the physiology of the cell, its basic vital functions and properties, its biology. In other words, it is the physiology of the cell.

Everything living on earth has a cellular structure, and the value of cytology is also that it studies cells in all their diversity, cooperating with biology and botany, anatomy and physiology, biochemistry and biophysics, genetics and molecular biology, with histology, comprehending the structure of cells of individual tissues, with embryology – when studying the structure of germ cells. The data of cytological studies are widely used in medicine.

Taking into account the modern requirements of teaching the discipline "Histology, embryology, cytology", important issues of the section "Embryology" are such as the structure of germ cells, fertilization, embryonic development of birds and higher mammals, as well as the features of human embryogenesis. This information is set out in this manual. Before proceeding the study of human development as a representative of amniotes, it is necessary to master the following basic concepts of embryology: stages of embryogenesis (fertilization, cleavage, gastrulation, neurulation, organogenesis), the structure of eggs of various animals depending on the amount and distribution of yolk, cleavage (the relationship of the nature of cleavage – with the features of the structure of eggs), gastrulation (methods of gastrulation), germ disks and their derivatives.

As an element of comparative embryology, it is necessary to study the development of the lancet, amphibians, birds and humans, as well as to pay attention to the structure of the placenta and the assessment of critical periods in ontogenesis. Without knowledge of these basics, it is impossible to understand the pathological processes occurring in a developing and growing organism. In this regard, the importance of embryology in obstetrics and pediatrics is great. Thus, the study of cytology and embryology occupies an essential place in teaching at a medical university. Understanding of these sciences serves as a basis for further training in medical universities of pathological physiology, pathological anatomy and all clinical disciplines.

STAGES OF PREPARATION OF HISTOLOGICAL PREPARATION

Stages of preparation of histological preparation many cells in the human body differ in shape and type. They can always be distinguished, especially healthy from sick, and this is what cytology does. Specialists of pathological histology examine suspicious tissue cells. They examine, analyze and evaluate tissue cells using conventional and electron microscopes. After a few hours, the histologist can tell whether the tissue cells are healthy or not.

The main object of the study is a fixed and stained section of a tissue or organ, that is, a histological preparation, the preparation of which consists of several main stages.

1 – Taking the studied material.
2 – Fixation.
3 – Sealing of the material.
4 – Preparation of slices.
5 – Staining of slices.
6 – The conclusion of the slices in the balm.

Figure 1. Light microscope

Technique of making histological preparations

Histology, like any science, has its own objects and studying methods. The immediate objects of study are cells, fragments of tissues and organs, prepared in a special way for studying them under a light microscope (Figure 1).

Stage 1: Taking the material. The material for study any piece of organ taken from animals or corpses of deceased people can serve as a material for histological examination. In some cases, pieces of organs are excised in vivo (biopsies) or blood and bone marrow swabs are taken. In order not to damage the structure of the organ, pieces of 5x10mm in size are excised with eye scissors and placed in fixation fluids.

Stage 2: Fixing. Fixation prevents decomposition processes and thereby contributes to the preservation of the integrity of structures. The term "fixation" it means solid, unchanged, strong or fixing, preserving the structure of the organ as it had during life. The action of fixators is based on the rapid coagulation (coagulation) of proteins that are part of the living cytoplasm and protecting them from further changes, as a result of which the processes of vital activity stop, and the structures of the organ become dead, fixed. All fixation fluids are divided into simple and complex, depending on how many active components are included in the composition.

Simple fixators include formalin, ethyl alcohol, sulema, acetone.

Formalin (formol), which is a 35–40% formaldehyde solution, a liquid with a characteristic pungent odor, is a good fixing agent and pieces of organs can be preserved for years in a 10% formalin solution, mainly without losing the ability to stain during further processing. Formalin penetrates well into tissues and fixation of 0.5–1.0 cm pieces occurs within 24–48 hours.

Ethyl alcohol is used to fix the tissues of organs as absolute (100%) alcohol and 96-degree alcohol. Due to its pronounced coagulating effect, it deforms cellular elements less, but has less penetrating power than formalin.

Sulema is a good fixing agent, saturated solutions are used at the rate of 10 grams of sulema per 100 grams of distilled water. Fixa-

tion lasts 6–12 hours. When using it, you need to remember that it is a strong poison and spoils metal tools.

Acetone – penetrates quickly into tissues. Fixing pieces with a thickness of 2–3 mm.

Complex fixators include:

Carnois liquid – consists of six parts of absolute alcohol, three parts of chloroform and one part of cold acetic acid. Pieces with a thickness of 2–4 mm are fixed for 3–4 hours, after which they are transferred to 70° and 96° alcohols and poured into paraffin.

Liquid composition: absolute alcohol – 60 ml, chloroform – 30 ml, glacial acetic acid – 10 ml.

A very good retainer. It has special indications in cases when it is necessary to hurry with the study. Pieces, 2 to 4 mm thick, are fixed in it for 2 to 3–4 hours. It is impossible to hold objects in this liquid more than is necessary for their complete fixation, then they are transferred to 96° alcohol and poured.

Buena Liquid

When working with formalin solutions, care must be taken, because formalin vapors cause irritation of the mucous membranes of the eyes, nose, larynx and trachea.

Stage 3: Sealing of the material. The purpose of material sealing is to prepare a slice. Sealing is achieved by pouring into paraffin, celloidin, freezing in liquid nitrogen. Filling: place the samples in a mixture of xylene-paraffin and then in liquid paraffin for 1–2 hours at 52–56°C. Allow the paraffin, cooling, to harden; cut out of it a block with an enclosed sample and fix it on a wooden cube. They also use pouring into resins, gel30atin and freezing. After the final impregnation of the object, it is filled with molten paraffin, specially prepared for these purposes and stored in a thermostat (Figure 2).

Various devices are used as molds for pouring. L-shaped smooth squares are made of metal (brass, lead, steel). It is recommended to use squares, the long size of which is 8-10 cm, the short size is 3 cm, the height is 1.5-2 cm.

The squares are placed on a polished metal or glass plate and, by shifting the corners, create a mold of the desired size (Figure 3).

Figure 2. Filling of preparations

Figure 3. Cassettes, filling molds

Stage 4: Preparation of slices

The slices are prepared on a sledge microtome with a thickness of 5-30 microns. Placed in water for straightening. Then, for dewaxing, they are placed in xylene I, xylene II, where the paraffin dissolves. Then it is carried out on alcohols of descending concentration – 100°, 96°, 90°, 80°, 70°, 50° alcohol, and up to water. Everywhere it is necessary to keep the pieces for 5 minutes. This achieves dewaxing – the removal of paraffin (Figure 4).

Stage 5: Staining of slices

Classification of dyes:

The first group – the main dyes – hematoxylin, azur, methyl blue, methyl green, and toluidine blue.

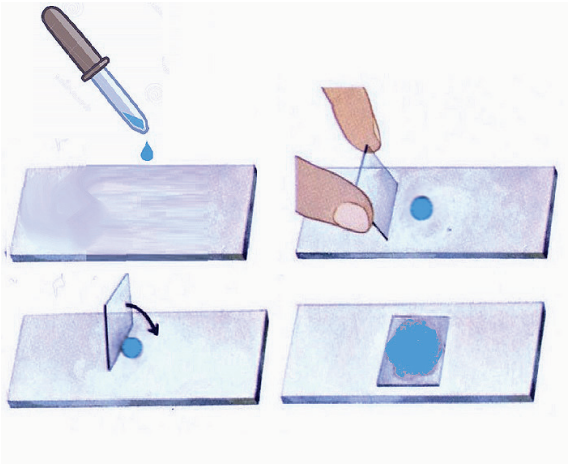


Figure 4. Preparation of preparations

The second group – acidic dyes – eosin, acid fuchsin.

The third group – neutral dyes – Romanovsky – Gimza paint (blood coloring).

The fourth group - interferent dyes – Sudan III, IV (fat staining).

In the usual pathoanatomical practice, the staining of sections with hematoxylin-eosin most often according to Van Gieson, Perls, Sudan III (Figure 5).

Figure 5. Dyes

Staining with hematoxylin-eosin. The slices are painted in small Petri dishes or on glasses. This method is used for staining slices prepared in any way. At the same time, the nuclei of cells acquire a violet-blue or deep blue color, and the cytoplasm and fibrous substance – light blue or pink-red. Fats and lipids are not stained.

Mammalian erythrocytes are stained only with eosin since they do not contain nuclei.

Painting by Van Gieson. In the sections painted according to Van Gieson, the connective tissue is painted bright red, the remaining tissues are yellow or grayish-yellow. The kernels are stained black or dark purple.

The staining is done as follows.

The sections are intensively stained with hematoxylin (Weigert's hematoxylin is better) and rinsed in water.

The solution immediately transferred to picrofuxin for 3–5 minutes (a mixture of a saturated aqueous solution of picric acid – 150.0 and a saturated aqueous solution of acid fuchsin – 3.0–5.0).

They are quickly washed in water (water extracts fuchsin from the cut).

Dehydrate with 95° alcohol for 1–2 minutes.

They are enlightened in carboxylate and enclosed in fir balsam, when stained with hematoxylin-eosin.

Painting by Sudan III. Sudan III – soluble in alcohol, acetone and fats, insoluble in water. Staining with Sudan III it is produced to determine fats and lipids in sections. The painting technique is as follows.

Frozen slices are transferred from water for 0.5–1 min to 50° alcohol.

The slices are placed in a freshly filtered Sudan solution for 10–20 minutes.

Rinse with 50° alcohol for 0.5–1 min.

Thoroughly washed with water for 10–15 minutes.

The sections are tinted with Ehrlich's or Boehmer's alum hematoxylin.

Rinse with water for 3–5 minutes. The sections repainted in hematoxylin are differentiated in a 1% aqueous solution of hydrochloric acid then they are rinsed with alkaline water and with clean water.

They are enclosed in glycerin or glycerin-gelatin.

Cover with a cover glass.

Stage 6: The conclusion of the slices in the balm.

The conclusion of stained sections in antireflective media, similar in refractive index to glass: Canadian and fir balsam, glycerin, gelatin.

Quality control

Histological preparation of any form must meet the following requirements:

1. To preserve the lifetime state of structures:

- Be quite thin and transparent. To study it under a microscope in transmitted light.
- Be contrasting. The studied structures should be clearly defined under the microscope.
- Preparations for light microscopy should be preserved for a long time and used for repeated examination.

These requirements are achieved with high-quality preparation of the drug. The main method of studying biological objects used in histology is microscopy (that is, the study of drugs under a microscope).

2. Possible errors

In order to get good histological sections, it is necessary to be able to recognize and eliminate the cause that degrades the quality of the section in a timely manner.

1. The slice crumbles. Reasons: Solid paraffin, low ambient temperature, slow cooling of paraffin, when pouring a large angle of inclination of the knife. Elimination: pour the material into a softer paraffin, after preliminary melting of the block in the thermostat, breathe on the surface of the block (warming) before each movement of the knife or adjust the electric plate next to the microtome, change the angle of the knife. 2. The poured material during the cutting process falls out of the surrounding mass of paraffin. Reasons: when transferring a piece to a mold for pouring, it is cooled down. Elimination: it is necessary to melt the block in the thermostat and pour it again, strictly observing the rules of pouring, after preliminary melting, the material is transferred to intermediate sections (to remove alcohol), then again it is impregnated and poured, the filling is made with cooled paraffin and insufficient alcohol removal before impregnation 2. The poured ma-

terial during the cutting process falls out of the surrounding mass of paraffin.

Reasons: when transferring a piece to a mold for pouring, it cooled down.

Elimination: it is necessary to melt the block in the thermostat and pour it again, strictly observing the rules of pouring, after preliminary melting, the material is transferred to intermediate sections (to remove alcohol), then again it is impregnated and poured, the filling is made with cooled paraffin and insufficient alcohol removal before impregnation (Figure 6).

Figure 6. Filled material in paraffin

3. The cutting plane is uneven, the material is poorly cut or is not cut at all, the knife jumps above the surface of the block.

Reason: overwork of the material during wiring and fixation.

Elimination: Impossible. It is only possible to soften the material somewhat if a layer of hot paraffin is applied to the cutting surface with a brush before each movement of the knife (allowing it to cool down later) or breathe on the surface of the block.

4. The slices twist, stick to the surface of the knife, crumple.

Reasons: small angle of the knife, soft paraffin, high ambient temperature.

Elimination: change the angle of inclination, pour the material into a harder paraffin and cool the block by placing it in the refrigerator before cutting (you can also put a piece of ice on the cutting surface) gluing, wrinkling or tearing of sections, especially when cut-

ting organs rich in bone, cartilage or dense connective tissue it may be a consequence of their electrification.

Place a drop of water on the blade (at the point of passage of the cut), breathe on the blade and block, rub the blade area and the adjacent part of the knife with a piece of solid paraffin.

5. The sections are torn or covered with furrows.

Reasons: notches on the knife blade, dirty paraffin (dense specks scratch the cut and spoil the blade), the material is poorly decalcified.

Elimination: point and edit the knife or move in the knife holder, refilling in pure paraffin (Figure 7).

Figure 7. Sledge microtome

Preparation of a series of paraffin slices

It is most convenient to use tapes from sections in the serial study of the material poured into paraffin. However, it is always easy to obtain such tapes. To achieve good results, the following basic conditions must be met:

1) The paraffin must be of good quality with a melting point of 48–52°C, sufficiently plastic, and the conclusion of the material in it is impeccable. It is impossible to get tapes with too dense and large objects.

2) The knife should be well sharpened and installed transversely.

3) The paraffin block is given a strictly rectangular shape, its length is installed parallel to the length of the microtome. At the same time, make sure that the narrow side of the block facing the knife

blade is also parallel to the latter. The cutting edge of the knife, being brought to the block, should be adjacent to its entire side.

4) The desired thickness of the slices is 7–8 microns. Too thin and thick slices are of little use. Cutting is carried out by jerky movements of the knife.

5) A temperature of about 18–220°C is desirable in the laboratory room. At a lower temperature, it is necessary to put an electric stove turned on near the microtome (near the unit). On the contrary, at too high a temperature, the paraffin becomes soft, the slices are easily crumpled, in which case the block is cooled with ice.

6) In the process of cutting, tears accumulate on the upper surface of the knife, as they accumulate, they are pushed up along the knife, hanging if necessary. Upon receipt of the tapes of the desired length, they are carefully removed using a dissecting needle and brush, and lowered into water. Then the slices are taken away and pasted on the glass.

7) Inscriptions on slides are made with a pen with a black ink pen.

Dewaxing

Before you start staining the slices, they are usually subjected to special pretreatment. Paraffin sections require the most complex preparation. Since paraffin does not have sufficient transparency and complicates the staining process (histological dyes are aqueous or alcoholic solutions that do not penetrate well into waxed tissues), it must be removed from the cut. To do this, the slice is subjected to dewaxing – the reverse process that is carried out when preparing the object for pouring paraffin, i. e. the slices are sequentially passed through a paraffin solvent, alcohols of descending concentration and placed in water. In practice, this is carried out as follows: label high cups, pour the appropriate solutions into them and install them in a certain sequence, ensuring that manipulations are carried out according to the following scheme:

Staining of histological sections with hematoxylin – eosin.

1. Xylene I, xylene II, alcohol 96°, alcohol 90°, alcohol 80°, alcohol 70°, alcohol 50°, water (keep everywhere for 5 minutes) – dewaxing.

2. Hematoxylin – 2–5 minutes.
3. Tap water – 5 minutes, then distilled water – 5 minutes.
4. Eosin – 1–3minutes.
5. Alcohol-96° – 1–2 minutes.
6. Alcohol-100° – 1–2 minutes.
7. Carbol – xylene – 5 minutes.
8. Xylene I – 5 minutes.
9. Xylene II – 5 minutes.

Conclusion in balsam – Canadian balsam is dripped on a slice and a cover glass is applied.

Thus, thanks to quality control, we can find out how well histological sections were performed. Since in the future, when the results are issued by the pathologist, the further treatment of the patient will depend. From all this it follows that a special place is occupied by the quality control of the slice, since it is important for histological examination and allows you to clarify the diagnosis.

CYTOLOGY

Histology is the science of the structure, development and vital activity of tissues of animal organisms.

The histology course includes:

1. Cytology – the study of the cell.
2. Embryology – the study of the embryo.
3. General histology – the study of tissues.
4. Private histology – the study of organs and systems of the body.

The main method of histology research is the method of micro coping cells, tissues and organs

Cytology is the study of the cell.

A cell is the smallest unit of a living organism.

Properties of a living organism:

1. Metabolism of substances, energy and information.
2. Irritability – the ability of the body to respond to stimuli.
3. Self-reproduction – the ability of a living organism, tissue, cell or cellular organoid to form its own kind.
4. Self-regulation – the ability to maintain structure.
5. Specificity (hemoglobin is present only in a living organism).
6. Memory – the ability to remember, record and reproduce information.
7. Movement.
8. Variability – the ability to change its characteristics and properties and pass them on to the next generation

Cellular theory is – a generalized idea of the structure of cells as living units, their reproduction and role in the formation of multicellular organisms (T. Schwann, 1838).

The main provisions of the cellular theory.

1. A cell is the smallest unit of a living being.
2. Similarity of cells of different organisms in structure.
3. Cell reproduction by dividing the original cell.
4. Cells as parts of a whole organism.

A cell is – a living system consisting of cytoplasm and nucleus, and is the basis for the development and vital activity of all animal organisms. There are non-nuclear cells that have lost their nuclei during development (red blood cells).

There are symplasts and syncytia in animals, except for individual cells.

SYMPLASTS – are large formations with many nuclei in the cytoplasm (skeletal muscle fibers).

SYNCYTIUM – are cells connected to each other by cytoplasmic bridges.

CYTOPLASM

The CYTOPLASM of the cell includes:

1) Cytolemma (plasmolemma, cell membrane).

2) Hyaloplasm – cytoplasm matrix (colloidal solution: proteins, polysaccharides, lipids, amino acids).

3) Organoids are constent components of a cell that perform certain functions.

4) Inclusions are provisional components of the cytoplasm, depending on the metabolic state of the cell (Figure 8).

Inclusions distinguish:

1. Trophic (stores of nutrients - protein, fat, carbohydrate).
2. Secretory products of the cells of the glands of internal and external secretion (secret).
3. Excretory metabolic products.
4. Pigment coloring substances (hemoglobin, hemosiderin, melanin, lipofuscin).

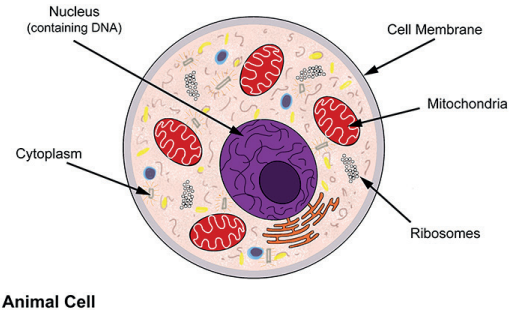


Figure 8. Structure of animal cell

CYTOLEMMA

The cytolemma (plasmolemma) is – a biomembrane – a surface peripheral structure, 6–10 nm thick, has a liquid mosaic structure. The main components of cell membranes are proteins (60 %), lipids (40 %), carbohydrates (5–10 %).

Carbohydrates cover the membrane from the outside in the form of long branching chains of polysaccharides associated with proteins (glycoproteins) and lipids (glycolipids), forming a glycocalyx.

The cytolemma consists of a double layer of lipids, which is permeated by protein molecules. Membrane lipids consist of two parts: 1- hydrophilic "heads" are directed to the membrane surface; 2-hydrophobic "tails" are directed inside the membrane (Figure 9).

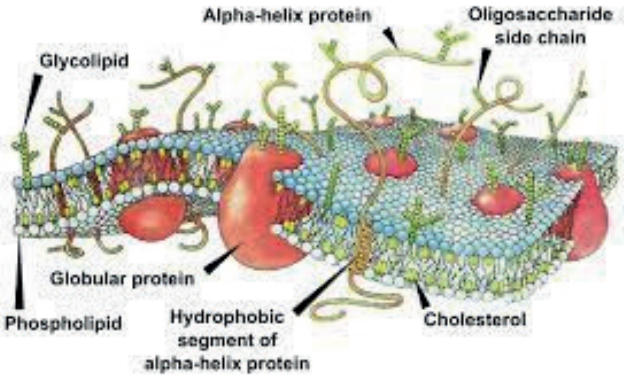


Figure 9. The cytolemma

Proteins in the membrane

1. Peripheral (with membrane).
2. Integral (through two layers of lipids).
3. Semi-integral proteins

Functions of the plasmolemma:

1. Transport-active and passive transport of substances, endocytosis: phagocytosis, pinocytosis, exocytosis – removal of substances from the cell.
2. Receptor – receptors.

3. Barrier, protective – a barrier between the external environment and the internal.

4. Intercellular interaction – formation of intercellular contacts.

Types of intercellular contacts:

1. A simple contact is the convergence of the plasmolemma of neighboring cells at a distance of 15–20 nm.

2. Slot contact (nexus) – 2–3 nm.

3. Dens contact - fusion of plasmolemmas.

4. By the type of "lock".

5. Desmosome (Figure 10).

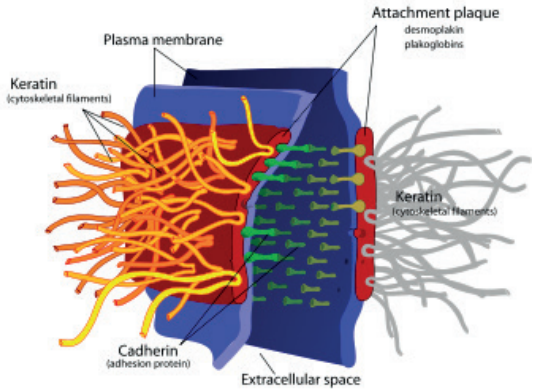


Figure 10. Types of intercellular contacts

6. Synaptic contact (Figure 11).

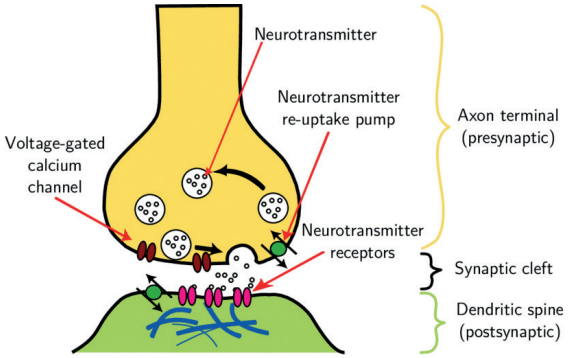


Figure 11. Synaptic contact

GENERAL (mandatory) organoids:
Membrane organoids:
Endoplasmic Network (EPS)
Golgi Complex
Lysosomes
Mitochondria

Non-membrane organoids:
Ribosomes
Microtubules
Centrosome (centrioli)

SPECIAL (optional):
Tonofibrils
Myofibrils
Neurofibrils
Synaptic vesicles
Microvilli
Cilia
Flagella

COMMON (mandatory) organoids, non-membrane

RIBOSOMES – consist of RNA (60 %) and protein (40 %) – complex ribonucleoproteins.

There are free and fixed ribosomes (on grAPS). Free ribosomes are polysomes in the form of chains, rings. The ribosome consists of large and small subunits (Figure 12). Function: protein synthesis.

CENTROSOME – consists of two centrioles: the mother and daughter, located at right angles to each other (Figure 13). The basis of the structure of centrioles are nine triplets of microtubules located around the circumference, forming a hollow cylinder. The formula of centrioles is (9×3) +0. There are no microtubules in the central part. The function is the formation of the division spindle.

MICROTUBULES are protein structures that do not have a membrane structure. They are straight, long hollow cylinders. The microtubule wall is constructed of 13 subunits of the protein – tubulin (Figure14).

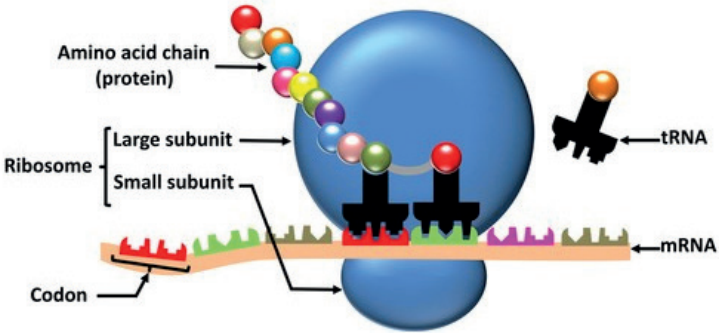


Figure 12. The ribosomes.

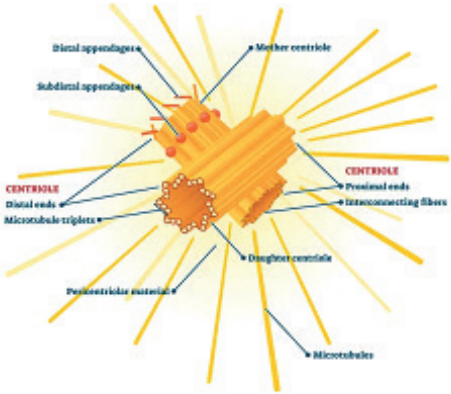


Figure 13. Centrosome

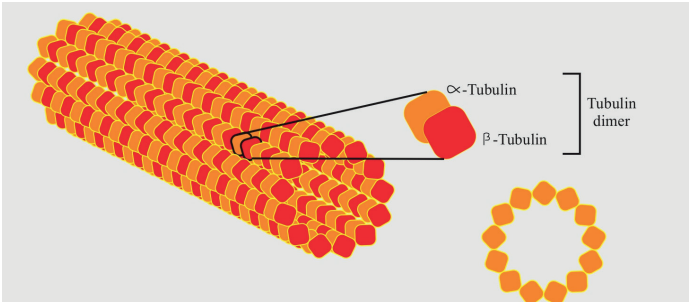


Figure 14. Microtubules

In living tissues, microtubules take part in the creation of:

1. the cytoskeleton necessary to maintain the shape of cells;
2. centriole – cell center;
3. division spindles;
4. cilia;
5. flagella.

GENERAL – (mandatory) organoids of the membrane structure.

ENDOPLASMIC NETWORK is an EPS, a closed structure that creates a network (reticulum) of membranes inside the cytoplasm, associated with the cytolemma and karyolemma. There are two types of EPS: granular and smooth.

Smooth EPS is represented by:

1. cylinders;
2. cisterns;
3. channels;
4. transport vesicles.

The functions of smooth EPS are synthesis, storage, transport of lipids and carbohydrates.

Granular EPS is represented by:

1. cylinders;
2. cisterns with ribosomes;
3. channels;
4. transport vesicles.

Ribosomes associated with GRES membranes are involved in the synthesis of proteins that are removed from the cell and go to the needs of the body. Gr.EPS, in which cylinders and tanks are located parallel to each other, is called ergastoplasm (Figure 15). It is characteristic of cells that actively synthesize secretory proteins. Functions – synthesis, depot and transport of proteins.

GOLGI COMPLEX (Golgi apparatus, plate complex)

Presented:

1. dictyosome-flattened cylinder;
2. vesicles;
3. vacuoles.

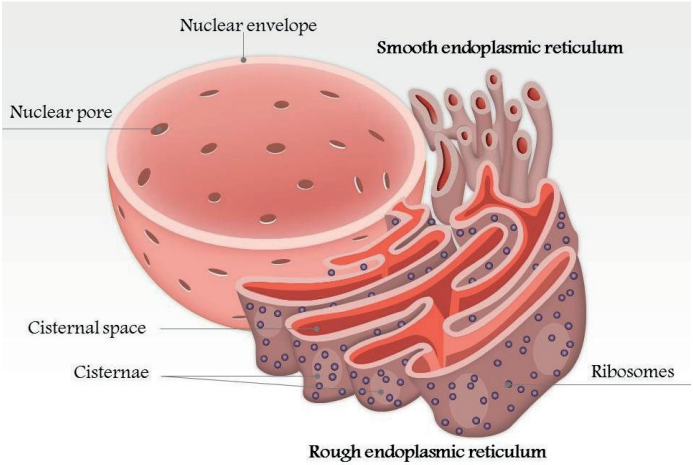


Figure 15. Endoplasmic reticulum

Participates in the synthesis of polysaccharides, their complexing with proteins, the processes of removing ready-made secretions outside the cell. Vacuoles of the lamellar complex give rise to lysosomes (Figure 16).

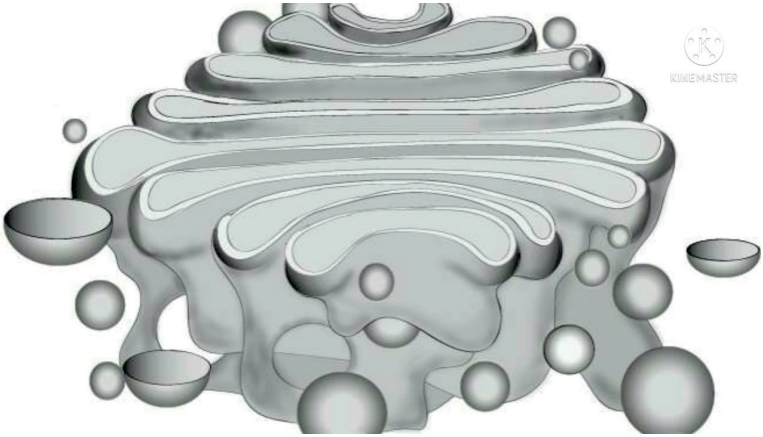


Figure 16. Golgi complex

LYSOSOMES

There are 4 types of lysosomes:

1. primary;
2. secondary;
3. telolysosomes (residual corpuscles);
4. autolysosomes.

Primary lysosomes are small membrane vesicles filled with 40 enzymes. The main enzyme is acid phosphatase. They participate in intracellular digestion.

Secondary lysosomes are formed from the fusion of primary lysosomes with phagocytic or pinocytic vacuoles. Substances trapped in this vacuole are split into monomers.

Telolysosomes are residual corpuscles that contain non-cleaved substances, which are then removed from the cell.

Autolysosomes perform the role of intracellular cleaners, destroying damaged, destroyed organoids (Figure 17).

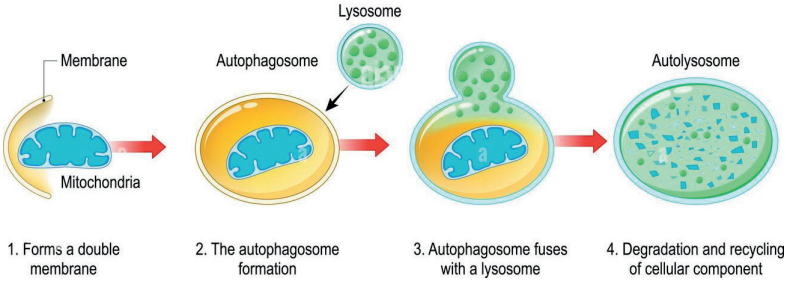


Figure 17. Lysosome

MITOCHONDRIA are the organelles of ATP synthesis. They are limited by two membranes: external and internal. The outer membrane is smooth, and the inner one forms numerous indentations – cristaes. The actual internal contents of the mitochondria are the matrix, in which small granules are found – mitochondrial ribosomes. These ribosomes are involved in the synthesis of mitochondrial proteins (Figure 18).

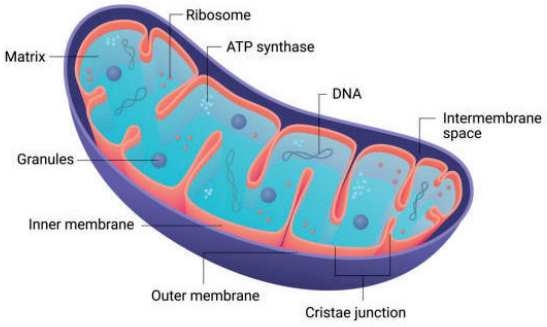


Figure 18. Mitochondria

The mitochondria is a self – replicating structure that has its own DNA, a ribosomal protein-synthesizing system. The number of cristaes depends on the intensity of redox processes in the tissues. The mitochondria is the energy station of the cell that ensures the oxidation of ADP into ATP.

SPECIAL ORGANOIDS

CILIA are the organoids of movement. They are cylindrical outgrowths of the cytoplasm. The axoneme is located inside the outgrowth, and at the base there are basal corpuscles, which are similar in structure to the centriole. Basal corpuscles consist of nine triplets of microtubules along the periphery **(9×3)+0**. They are located at the base of the cilia at right angles to each other. The axoneme in its composition has 9 microtubule duplets on the periphery and two in the center) – **(9×2)+2**.

The movement of the cilia can be undulating, pendulum-like. The cilia are located on the apical pole of the cell (Figure 19). They are found in the epithelium of the airways.

FLAGELLUM is an organoid of movement that occurs in the sperm. The flagellum is found in the tail of the sperm and consists of nine duplets of microtubules along the periphery and one pair of central microtubules – **(9×2)+2** (Figure 20). Thanks to the flagellum, spermatozoa move at a speed of 1–5 mm per minute.

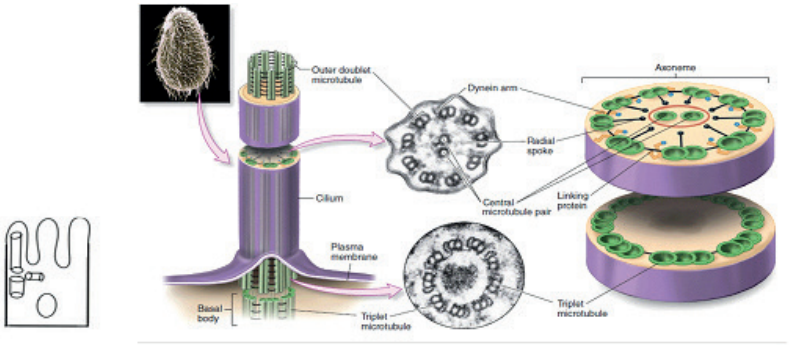


Figure 19. The cilia

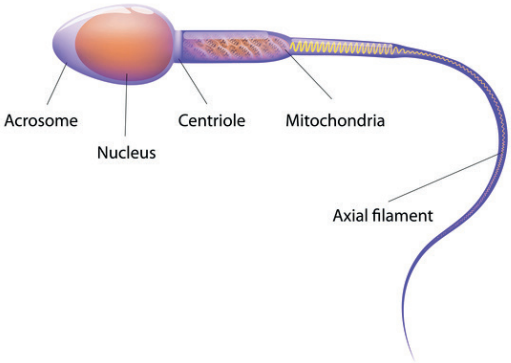


Figure 20. The flagellum

MICROVILLI are protrusions of the cytolemma at the apical pole of the cell (Figure 21). An increase in their number leads to a sharp increase in the area of the cell surface. This is especially important for the cells involved in absorption. So, in the intestinal epithelium on 1 mm2 of the surface in there are up to 2×108 microvilli. Microvilli have the shape of a cylinder with a rounded top.

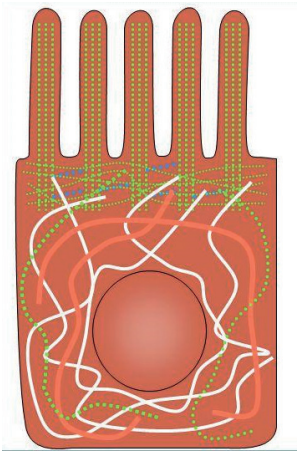


Figure 21. Microvilli

MYOFIBRILS are organoids of contraction. Two types of myofilaments are found in the composition of myofibrils – myosin (thick) and actin (thin). Actin and myosin filaments are involved in shortening cells during contraction (Figure 22). At the same time, a large number of short myosin filaments are embedded between actin filaments. Myofibrils are found in muscle tissues.

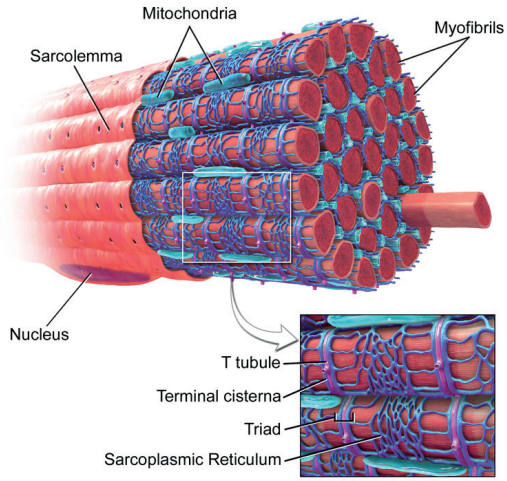


Figure 22. Myofibrils

TONOFIBRILS are supporting organoids. They are found in the cells of the multilayer squamous epithelium. Tonofibrils (bundles of tonofilaments) are well developed, in the basal and spiny layer and desmosomes are located between the cells, having the form of intercellular bridges (Figure 23).

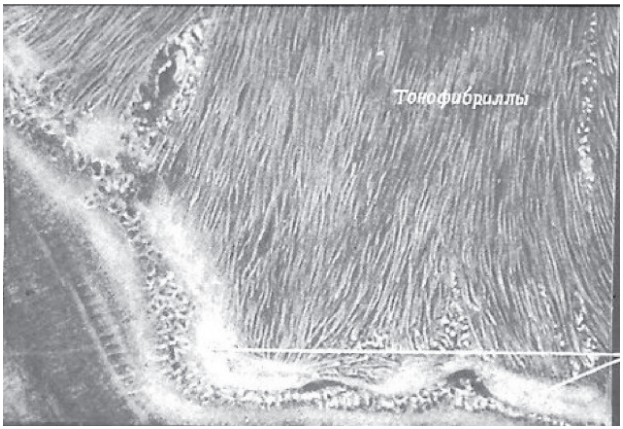


Figure 23. The tonofibrils

NEUROFIBRILS are supporting organoids. They form a network in the body of a neuron, and are located in parallel in the processes. Neurofibrils are involved in maintaining the shape of cells, the growth of processes and axonal transport (Figure 24).

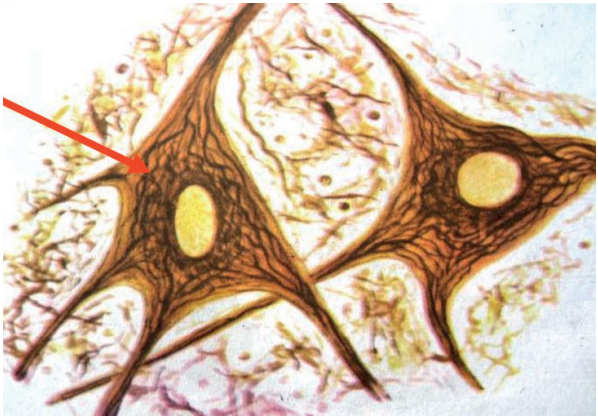


Figure 24. Neurofibrils

SYNAPTIC VESICLES are organoids of nerve impulse conduction.

They are located in the presynaptic part of the synapse. The shape and contents of synaptic vesicles are related to the function of the synapse. They contain mediators: acetylcholine, norepinephrine, dopamine, serotonin, glycine, gamma aminobutyric acid (GABA) (Figure 25).

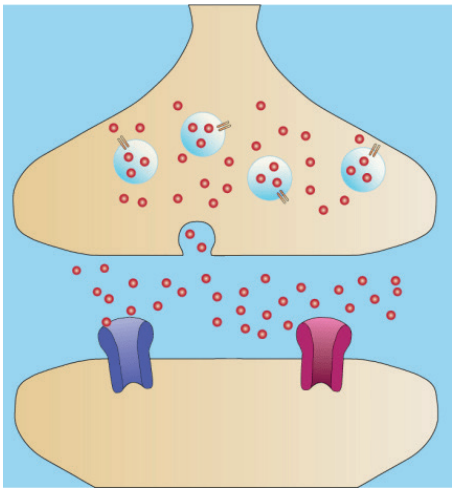


Figure 25. Synaptic vesicles

NUCLEUS

The cell nucleus is a permanent composite structure that provides genetic determination and regulation of protein synthesis.

The nucleus consists of:

1) karyolemma – nuclear shell;
2) karyoplasma – nuclear juice;
3) chromatin;
4) nucleoli.

The karyolemma (nuclear envelope) consists of outer and inner nuclear membranes separated by a perinuclear space. Due to the fusion of two nuclear membranes, nuclear pores are formed.

Numerous polyribosomes are located on the outer nuclear membrane from the hyaloplasm. The inner nuclear membrane is connected to the chromosomal material of the nucleus. Nuclear pores contain a complex, which is called the nuclear pore complex (Figure 26).

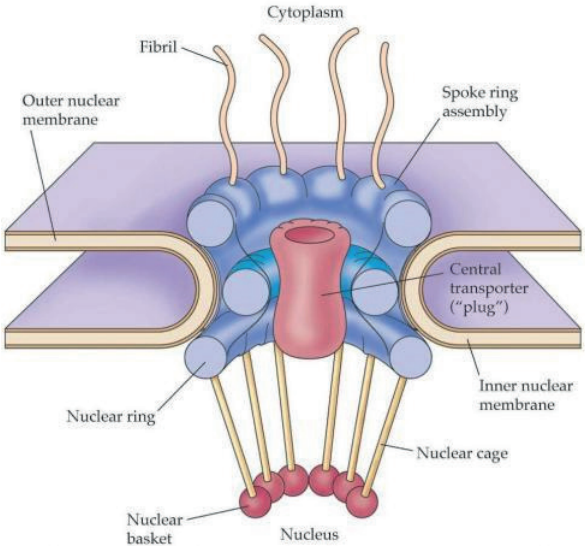


Figure 26. The nuclear pore

Along the border of the rounded hole in the nuclear shell there are three rows of granules of 8 in each: one row lies on the side of the nu-

cleus, the other on the side of the cytoplasm, the third is located in the central part of the pore, and in the center there is the central granule. The size of the granules is 25 nm.

There are 2 components in the nuclear pore: granular and fibrillary. The granular component is represented by the formula (3X8)+1=25.

Fibrillary processes, forming the fibrillary component of the pore, depart from the central granule.

CHROMOSOMES

Chromosomes can be in two structural and functional states:

1) in active, working, decondensed, when protein synthesis occurs with their participation in the interphase nucleus;

2) in inactive, condensed, when they perform the function of distributing and transferring genetic material to daughter cells.

The chromosome consists of two chromatids connected by a primary constriction – centromere. In one of the chromatids there is a secondary constriction – the nucleolar organizer. Chromatids are covered with histone proteins. The part of the chromatid behind the nucleolar organizer is called a satellite, which contains 4 chromosomes – DNA strands. Each chromatid contains two double chromonemes (2×2). There are primary (small) and secondary (large) whorls in the chromoneme (Figure 27).

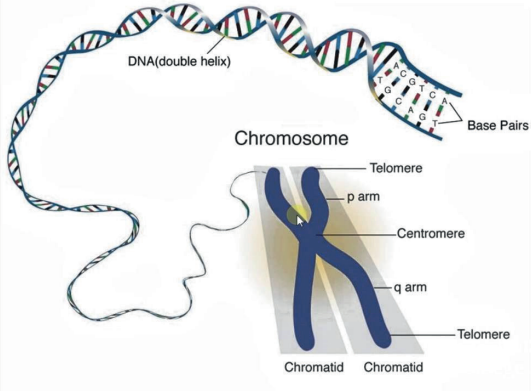


Figure 27. The chromosome

Chromonemes are attached to kinetochores located in the centromere. In the centromere and satellite, the chromonemes have only primary whorls, there are no secondary whorls. Chromomers – electron-dense corpuscles or chromocenters are located on the chromonems.

NUCLEOLUS – the densest structure of the nucleus – is a derivative of the chromosome in the zone of secondary constriction. It is not an independent structure. The nucleolus is the place of formation of ribosomal RNAs and ribosomes on which protein synthesis occurs.

Two main components are identified in the nucleolus: granular (on the periphery) and fibrillar (in the center) (Figure 28).

Granules are maturing ribosome subunits with a diameter of 15–20 mm. In the fibrillar zone, filamentous structures are distinguished – nucleolonems.

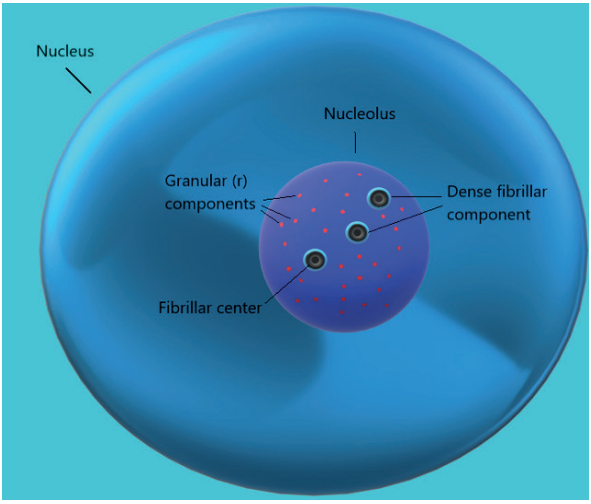


Figure 28. Nucleolus

CELL CYCLE

The **cell cycle** is the lifetime of a cell from division to division or from division to death.

The cell cycle consists of the interphase and the actual cell division (mitosis) (Figure 29).

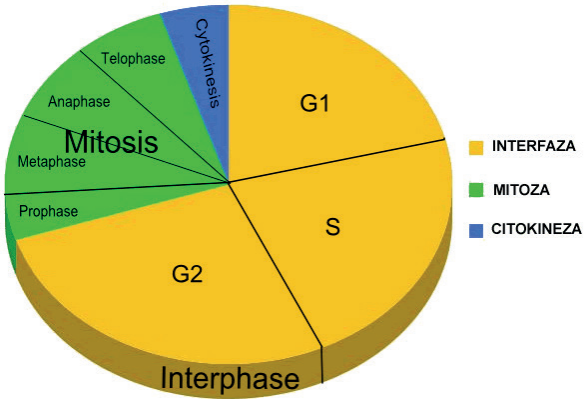


Figure 29. Cell cycle

The interphase takes 3/4 of the time and mitosis – 1/4. CC = I +M.

The interphase consists of three periods: I (I)= G1 + S + G2

1. presynthetic (G1),
2. synthetic (S),
3. post-synthetic (G2) periods.

G0 is the rest period, outside the cycle.

G1 – growth period, presynthetic, postmitotic period lasts 10-11 hours. During the G1 period, cell growth begins due to the accumulation of cellular proteins, which is due to an increase in the amount of RNA per cell. During this period, the preparation of the cell for DNA synthesis begins.

S – period, the synthetic period lasts 6-10 hours. In the S – period, the amount of DNA per nucleus doubles, and the number of chromosomes doubles accordingly.

G2 – energy period, post-synthetic, premitotic, lasts 4 hours. During this period, tubulin proteins (components) of the mitotic

spindle are synthesized. At the end of this period, RNA synthesis drops sharply.

G0 – are dormant cells that have stopped multiplying and do not enter the presynthetic period of interphase. These include stem cells, nerve cells, cardiomyocytes, liver cells, keratinized cells of the epidermis. Stem cells and liver cells retain the ability to divide, other cells lose it and remain in the G0 period until death.

CELL DIVISION

There are three ways of cell division: mitosis, amitosis, meiosis.

MITOSIS

Mitosis. Indirect cell division is a universal, widespread method of cell division. The process of indirect cell division is usually divided into several main phases: prophase, metaphase, anaphase, telophase.

Prophase – lasts 3–60 minutes, the longest phase of mitosis, has 5 processes:

1. Doubling of centrioles and their divergence to opposite poles of the cell.
2. Formation of the division spindle.
3. The disappearance of the nucleolus.
4. Destruction of the nuclear envelope.
5. Chromosomes become spiral and visible.

There are early and late prophase. Early prophase is called a dense tangle, because the boundary between the nucleus and the cytoplasm is still preserved due to the remnants of the karyolemma (Figure 30).

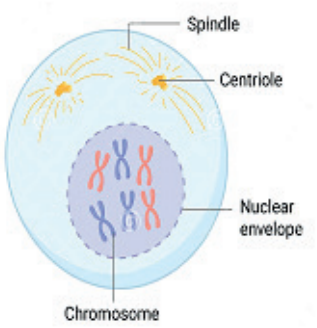


Figure 30. Prophase

The late prophase is called a loose tangle, because the boundary between the nucleus and the cytoplasm disappears due to the destruction of the karyolemma.

Metaphase – lasts 10–12 minutes. There are two processes going on at this time:

1. The division spindle is finally formed.
2. The threads of the division spindle are attached to the chromosomes.

There are early and late metaphases. The early one is called the mother star, because the chromosomes are arranged in the form of a star. The later one is called the metaphase plate, because the chromosomes line up in the equatorial plane of the spindle, forming a plate of chromosomes (Figure 31).

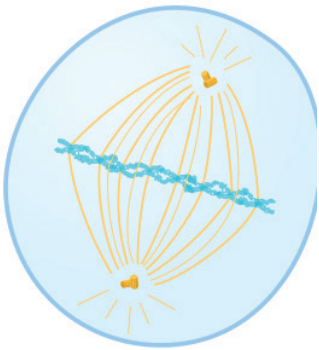


Figure 31. Metaphase

Anaphase is the shortest stage of mitosis. Duration 1–-3 minutes.

There is one process going on here – the divergence of chromosomes along the poles. The chromosomes simultaneously lose their connection with each other and synchronously begin to move away to opposite poles of the cell. The speed of chromosome movement is 0.2–05 microns/min (Figure 32).

Telophase is the final phase of mitosis, which lasts 12–20 minutes.

During the telophase, 5 processes occur:

1. The division spindle disappears.
2. The karyolemma is restored.
3. The nucleolus appears.

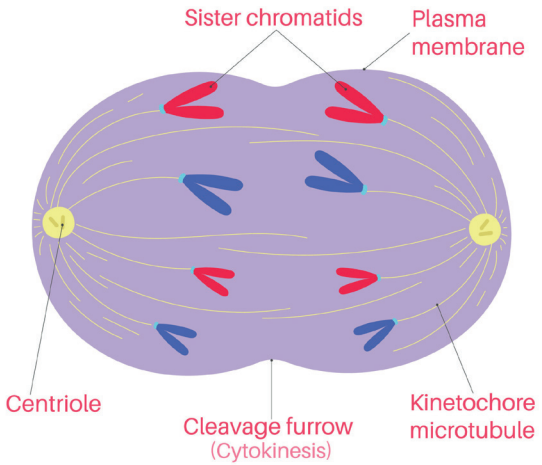


Figure 32. Anaphase

4. Chromosomes are despiralized.

5. Cytotomy (cytokinesis) – separation of the cytoplasm.

In the telophase, early and late telophase are distinguished. The early telophase is called a loose tangle due to the absence of a boundary between the nucleus and the cytoplasm. The late telophase is called a dense tangle as a result of the appearance of the boundary between the nucleus and the cytoplasm (Figure 33).

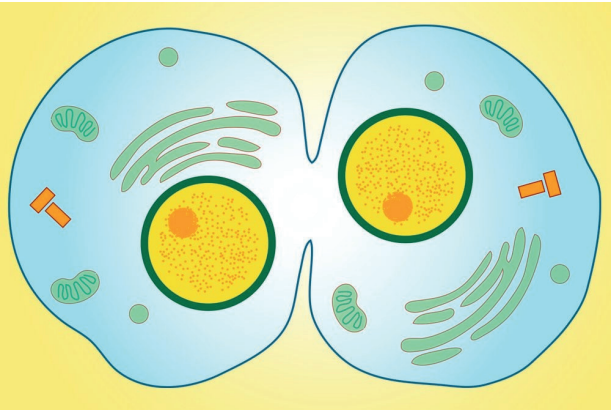


Figure 33. Cytokinesis

AMITOSIS

This is a direct division of a cell in which the nucleus is in an interphase state. In amitosis, a spindle of division is not formed and there is no condensation of chromosomes, there are no periods of interphase. There are 3 ways of amitosis: pulling, fragmentation, budding.

Pulling is the separation of the cytoplasm and the nucleus of the cell by tightening at the same time, as a result, two unequal cells are formed. The cell initially acquires a dumbbell shape (Figure 34).

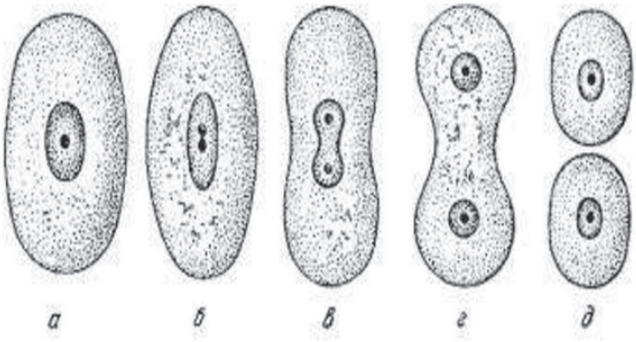


Figure 34. Amitosis

Fragmentation is the separation of the cell nucleus with the formation of multinucleated cells. Initially, an invagination is formed in the nucleus, a notch, which, going deeper inside, divides the nucleus into 2 parts. The most common is multiple division of the core, its fragmentation. At the same time, nuclei of unequal size are formed (Figure 35).

Budding is the cleavage of sections of the cytoplasm of the cell.

Frequently different forms of mitosis occur in various pathological processes (inflammation, regeneration, malignant growth), almost always in aging cells, doomed to death, degenerating. There are no reliable cases of changing the amitotic form of cell division to the mitotic one (Figure 36).

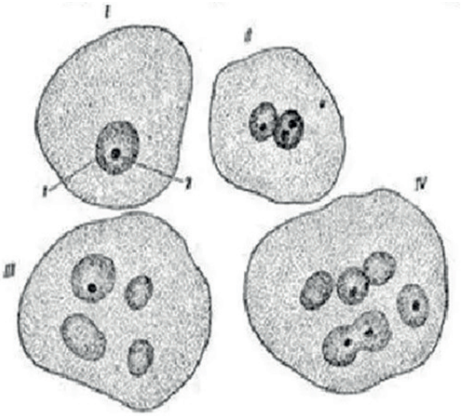


Figure 35. Fragmentation

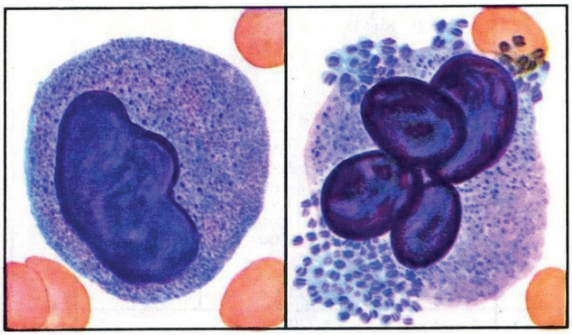


Figure 36. Budding

MEIOSIS

Meiosis is mitotic cell division, in which there is no synthetic interphase period. It occurs during the formation of gametes.

ENDOCYTOSIS

A feature of the plasma membrane of a cell is the ability to capture substances from the environment, immersing them inside the cell, where they are digested.

The process of substances entering the cell is called endocytosis. There are the following varieties of this process: phagocytosis – the arrival of solid particles, pinocytosis – the arrival of liquid particles. These varieties depend on the particle size. The capture and absorption by a cell of large particles, for example bacteria or even fragments of other cells is called phagocytosis (Figure 37).

The capture of individual molecules and macromolecular compounds is called pinocytosis.

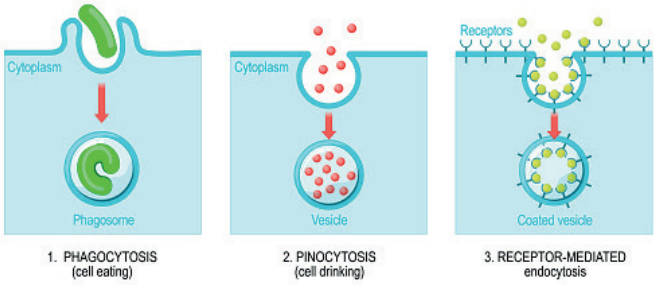


Figure 37. Endocytosis

First, the plasmolemma begins to form small indentations inside the cell. Then such local indentations are detached from the plasmolemma and are freely located under it in the form of bubbles. The bubbles contain absorbed substances. In the future, endocytic vesicles can merge with each other, grow. Hydrolytic enzymes (hydrolases) coming from lysosomes begin to be detected in their internal cavity. These enzymes break down biopolymers to monomers, which pass through the vesicle membrane into the hyaloplasm. Thus, the absorbed substances inside the endocytic vesicles undergo intracellular digestion.

EXOCYTOSIS

The plasmolemma participates in the removal of substances from the cell (proteins, mucopolysaccharides, lipoproteins, etc.) (Figure 38).

The isolation of macromolecules and structures from the cell is called exocytosis. Intracellular products enclosed in vesicles approach the plasmolemma. At the contact points, the plasmolemma and the bubble membrane merge. The contents of the bubble enter the environment.

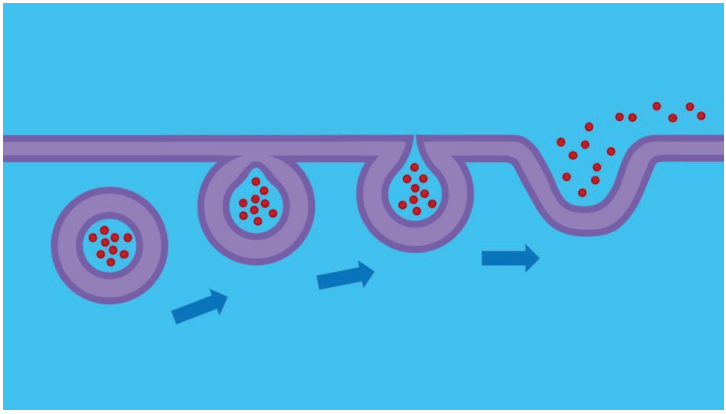


Figure 38. Exocytosis

ENDOREPRODUCTION

Endoreproduction is the formation of cells with an increased number of chromosome sets. Such polyploid cells appear as a result of the complete absence or incompleteness of individual stages of mitosis. Stopping can occur in prophase and metaphase, with cytotomy blockage. In this way, polyploid cells are formed in the liver, in the epithelium of the bladder, in the retinal pigment epithelium. Many substances that stop mitosis (colchicine, colcemide) prevent the formation of microtubules of the spindle of division, polymerization of tubulins (Figure 39).

Figure 39. Endoreproduction

CELL DEATH

When a cell dies, pyknosis occurs – chromatin aggregation, collecting it into coarse clots inside the nucleus, which often ends with the dissolution of the nucleus (karyolysis).

There are two forms of cell death - necrosis and apoptosis.

Necrosis is a sequential violation of cellular structures and functions, which ultimately leads to cell dissolution – lysis. Neurosis is caused by various external factors, chemical or physical, which affect the permeability of membranes, the synthesis of ATP, proteins stops, lysosomal enzymes are activated.

Apoptosis is the activation of cell self–destruction genes. These are the genes of a kind of programmed cell death. For example, after removal of the testes, prostate cells completely die, breast cells die during its involution. During apoptosis, membrane organelles do not change, protein synthesis does not decrease. The nuclei begin to fragment, then the cytoplasm also begins to fragment. Large fragments are detached from the cell and eventually lysed (Figure 40).

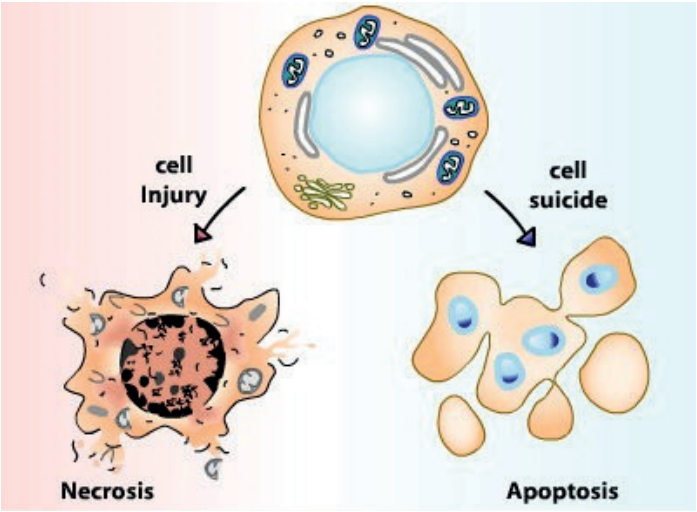


Figure 40. Necrosis and Apoptosis

CONTROL QUESTIONS ON CYTOLOGY

1. Stages of preparation of histological preparation.
2. The cell, its constituent components.
3. The essence and significance of cellular theory.
4. Cytoplasm, composition.
5. Cytolemma, its chemical composition, structure, functions, types of contacts.
6. Definition and classification of organoids
7. Organoids of general importance, their structure, functions.
8. Organoids of special significance, their structure and functions
9. Inclusion, their classification, role, methods of identification. The difference from organoids.
10. Interphase, nucleus, structure, chemical composition, functions.
11. Chromosomes, their structure and meaning.
12. Methods of substances entry into the cell. Phagocytosis and pinocytosis.
13. Methods of isolation of substances from the cell.
14. The life cycle of the cell. The role of cycle periods in cell life.
15. Methods of cell division.
16. Mitosis, its phases, the biological significance of mitosis.
17. Meiosis differences from mitosis. Amitosis.

SITUATIONAL TASKS IN CYTOLOGY

Task 1. In the micropreparation, a non-cellular structure is visible, containing many nuclei in the cytoplasm and limited by a common biological membrane. What is the name of such a structure?

Task 2. Under a large magnification of the microscope, a group of cells was found in the field of view, which after mitosis retain communication with each other in the form of the thinnest cytoplasmic bridges. What are these clusters of cells called? In which organs can they are located?

Task 3. Ultramicroscopic examination of the cell on one of its surfaces shows numerous outgrowths of the cytoplasm, limited by the plasmolemma and containing microtubules. What are these structural formations called? What is their functional significance?

Task 4. On the electronogram in the cytoplasm of the pancreocyte, cavity membrane formations in the form of tubules and cisterns are visible, on the surface of which numerous granular structures are found. What organelle of general significance can we talk about? What are the grains on its surface and what is their function?

Task 5. In the cytoplasm, during ultracytochemical studies, vacuolized corpuscles limited by the membrane were found. A high concentration of various hydrolases was detected in their contents. What structural formations are we talking about? What are their varieties (types) Do you know? What functions do they perform?

Task 6. The electronogram of the myosimplast shows elongated cavities bounded by two membranes, the inner of which forms protrusions into the cavities. Identify these structures. What functions do they perform?

Task 7. Under an electron microscope, numerous corpuscles up to 20–25 nm in size were detected in the cytoplasm of the glandulocyte of the parotid salivary gland, in which a sharply positive reaction to proteins and RNA was detected during cytochemical examination. What are these structural formations? What varieties of them do you know? What functions do they perform?

Task 8. It is known that some cells have high mobility. What formations of the cell surface does this process provide?

Task 9. When moving, the cell encountered a particle of organic matter. What is the possible mechanism of entry of this substance into the cell?

Task 10. By the method of electronic histochemistry, it was found that rosette-like structures containing glycogen can appear and disappear in the cytoplasm of liver cells during vital activity. What are the names of such cell structures?

Task 11. As a result of the action of ionizing radiation in some cells, the destruction of individual organelles takes place. How will their residues be disposed of?

Task 12. During the vital activity of the cell, the number of cisterns and tubules of the agranular endoplasmic network increases dramatically. Synthesis of which substances is activated in the cell?

Task 13. Using a micromanipulator, the centriole of the cell center was removed from the cell. How will this affect the further vital activity of the cell?

Task 14. The cells were affected by a drug that changes the structure of ribosomes. Which processes will be disrupted in the first place?

Task 15. Using a micromanipulator, the Golgi complex was removed from the cell. How will this affect its future life?

Task 16. The tissue culture was treated with a drug that blocks the function of the nucleoli. How will this affect the vital activity of cells?

CYTOLOGY TEST TASKS

1. What are the main chemical components of the cell membrane?

1) glycogen, proteins, polysaccharides;
2) phospholipids, proteins, polysaccharides;
3) phospholipids, acids, polysaccharides;
4) proteins, acids, polysaccharides.

2. What are the structural elements of the cytoplasm?

1) organoids, cytolemma, karyoplasm;
2) inclusions, nucleus, hyaloplasm;
3) organoids, inclusions, hyaloplasm;
4) cytolemma, nucleus, inclusions.

3. Which general-purpose organoids have a membrane structure?

1) endoplasmic network;
2) microtubules;
3) centrosome;
4) ribosomes.

4. Which general-purpose organoids have a non-membrane structure?

1) Golgi complex;
2) Mitochondria;
3) Ribosomes;
4) Lysosomes.

5. Identify a special purpose organoid:

1) Golgi complex;
2) microvilli;
3) microtubules;
4) mitochondria.

6. What general-purpose organoid is the energy source in the cell?

1) Mitochondria;
2) Microtubules;
3) Lysosomes;
4) Ribosomes.

7. Which general-purpose organoid consists of two membranes?

1) Lysosomes;
2) Golgi complex;
3) Mitochondria;
4) Eendoplasmic network.

8. What is the chemical composition of ribosomes?

1) 80 % protein, 20 % RNA;
2) 60 % protein, 40 % RNA;
3) 40 % protein, 60 % RNA;
4) 20 % protein, 80 % RNA.

9. What function do ribosomes perform in cells?

1) synthesis fat;
2) synthesis carbohydrate;
3) synthesis protein;
4) synthesis polysaccharide.

10. Determine the centriole formula

1) (9×3)+0;
2) (9×2)+2;
3) (8×3)+1;
4) (9×3)+1;

11. What is the structure of microtubules?

1) a cylinder whose wall is formed from 13 myosin protein molecules;
2) molecules a cylinder whose wall is formed from 13 actin protein molecules;

3) a cylinder whose wall is formed from 13 tubulin protein molecules;
4) a cylinder whose wall is formed from 13 eleidin protein molecules;

12. What elements of cells are called inclusions?

1) unstable accumulations of substances in the hyaloplasm;
2) hyaloplasm unstable accumulations of substances in the karyoplasm;
3) permanent accumulations of substances in the hyaloplasm;
4) permanent accumulations of substances in the karyoplasm.

13. What structural elements of the cell does protein synthesis provide?

1) Golgi complex, smooth endoplasmic network;
2) of mitochondria, microtubules;
3) of ribosomes, granular endoplasmic network;
4) of lysosomes, ribosomes.

14. Which cell organoids does the synthesis of carbohydrates and lipids provide?

1) Golgi complex, smooth endoplasmic network;
2) of mitochondria, microtubules;
3) of ribosomes, granular endoplasmic network;
4) of lysosomes, ribosomes.

15. Determine the formula of the axoneme of the cilia:

1) (9×2) + 2;
2) (9×3) +0;
3) (8×3) +1;
4) (8×3) + 0.

16. Determine the formula of the basal body of the cilia:

1) (9×2) +2;
2) (9×3) +0;
3) (8×3) +1;
4) (8×3) + 0.

17. Determine the flagellum formula

1) (9x×2) +2;
2) (9×3) + 0;
3) (8×3) + 1;
4) (8×3) + 0.

18. What cell organoid does the spindle of cell division forms?

1) Ribosome;
2) Mitochondria;
3) microtubules;
4) lysosome.

19. What cell organoid is called an intracellular cleaner?

1) Ribosome;
2) centrosome
3) lysosome;
4) microtubules.

20. Which cell organoid is a self-replicating structure that has its own DNA?

1) Ribosome;
2) Lysosome;
3) Microtubules;
4) mitochondria.

21. Which organoid of the cell is called the energy station of the cell?

1) Centrosome;
2) Ribosome;
3) Mitochondria;
4) of the lysosome.

22. Determine the source of lysosome development:

1) endoplasmic network;
2) Golgi complex;
3) cell center;
4) lysosome.

23. Determine the source of ribosome development:

1) endoplasmic network;
2) Golgi complex;
3) cell center;
4) nucleolus.

24. Determine the structural components of the Golgi complex:

1) cylinders, cisterns;
2) cisterns, tubules;
3) dictyosomes, vesicles;
4) tubules, vacuoles.

25. What is the chemical composition of the cytolemma?

1) 60 % protein, 40 % lipids;
2) 40 % protein, 60 % lipids;
3) 80 % protein, 20 % lipids;
4) 20 % protein, 80 % lipids.

26. What type of contacts does nexus belong to?

1) Simple;
2) Split;
3) Dense;
4) synaptic.

27. What organoid does the dictyosome contains?

1) Lysosome;
2) Ribosome;
3) Centrosome;
4) Golgi complex.

28. Determine the structural components of the endoplasmic network?

1) dictyosome, vesicles, vacuoles;
2) cylinders, cisterns, channels;
3) dictyosome, ribosome, tubules;
4) cylinders, vacuoles, tubules.

29. Determine the organoid of contraction:

1) microvilli;
2) microtubules;
3) myofibrils;
4) mitochondria.

30. Determine the organoid of the nerve impulse:

1) neurofibrils;
2) cilia;
3) microvilli;
4) synaptic vesicles.

31. In the cytoplasm of pancreatic cells, secretory granules appear and disappear in the apical part during the secretory cycle. What structural elements of the cell can these granules be attributed to?

1) Inclusions;
2) Ribosome;
3) Peroxisomes;
4) Lysosomes.

32. As a result of the action of ionizing radiation in some cells, the destruction of individual organelles takes place. How will their residues be disposed of by the cell?

1) primary lysosomes;
2) phagosome;
3) autolysosome;
4) peroxisome.

33. During the vital activity of the cell, the number of cisterns and tubules of the smooth endoplasmic network increases dramatically. Synthesis of which substances is activated in the cell?

1) Proteins;
2) Lipids;
3) Enzymes;
4) Inclusions.

34. The histological structure is determined on the preparation, limited by the cytoplasmic membrane, having a large amount of cytoplasm and many nuclei. What is it called?

1) Simplast;
2) Syncytium;
3) Cell;
4) Plate.

35. When moving, the cell met a lump of organic matter. What is the possible mechanism of entry of this substance into the cell?

1) endocytosis;
2) Exocytosis;
3) Mitosis;
4) Amitosis.

36. Pigment granules appear in the cytoplasm of pigment cells under the influence of sunlight. What structural elements of the cell can these granules be attributed to?

1) Ribosomes;
2) Peroxisomes;
3) Inclusion;
4) Lysosomes.

37. What is endocytosis?

1) removal of substances from the cell;
2) entry of substances into the cell;
3) intracellular digestion;
4) energy accumulation.

38. What is the structure of lysosomes?

1) membrane bubbles containing proteins;
2) membrane bubbles containing polysaccharides;
3) membrane bubbles containing lipids;
4) membrane bubbles containing hydrolytic enzymes.

39. What is autophagocytosis?

1) digestion in secondary lysosomes of proteins;
2) digestion in secondary lysosomes of polysaccharides;
3) digestion in secondary lysosomes of lipids;
4) digestion in secondary lysosomes of intracellular structures.

40. The cells were affected by a drug that changes the structure of ribosomes. Which processes will be disrupted in the first place?

1) synthesis lipid;
2) synthesis polysaccharide;
3) synthesis protein;
4) synthesis phagocytosis.

41. Using a micromanipulator, the Golgi complex was removed from the cell. Which processes will be disrupted in the first place?

1) synthesis lipid;
2) synthesis polysaccharide;
3) synthesis protein;
4) synthesis phagocytosis.

42. What structural elements form the nucleus:

1) hyaloplasm, organoids, cytoplasm;
2) karyoplasm, chromatin, karyolemma;
3) organoids, nucleolus, inclusions;
4) chromatin, hyaloplasm, karyolemma.

43. Determine the formula of the nuclear pores:

1) (9×3)+0;
2) (9×2)+2;
3) (8×3)+1;
4) (8×3)+0.

44. Specify the components of the nuclear pores:

1) supporting, granular;
2) fibrillar, granular;
3) trophic, granular;
4) membrane, granular.

45. What process leads to the formation of two cells with an equal diploid set of chromosomes?

1) Meiosis;
2) Mitosis;
3) Amitosis;
4) Phagocytosis.

46. How do old, damaged cells divide?

1) Mitosis;
2) Amitosis;
3) Meiosis;
4) Phagocytosis.

47. What is the cell cycle?

1) prophase, interphase;
2) metaphase, interphase;
3) mitosis, interphase;
4) amitosis, interphase.

48. What method of division leads to the formation of two cells of unequal size?

1) Mitosis;
2) Meiosis;
3) Amitosis;
4) Phagocytosis.

49. How are multinucleated cells formed?

1) Pulling;
2) Fragmentation;
3) Budding;
4) Pinocytosis.

50. What phase of mitosis does the despiralization of chromosomes occur?

1) Prophase;
2) Metaphase;
3) Anaphase;
4) Telophase.

51. What phase of mitosis do the centrioles double and diverge along the poles?

1) Prophase;
2) Metaphase;
3) Anaphase;
4) Telophase.

52. Determine the duration of the mitosis telophase:

1) 2 minutes;
2) 10 minutes;
3) 20 minutes;
4) 60 minutes.

53. What phase of mitosis does the formation of the division spindle end?

1) prophase;
2) metaphase;
3) anaphase;
4) telophase.

54. What phase of mitosis does cytotomy (cytokinesis) occur?

1) prophase;
2) metaphase;
3) anaphase;
4) telophase.

55. Determine the longest phase of mitosis

1) Prophase;
2) Metaphase;
3) Anaphase;
4) Telophase.

56. Determine the shortest phase of mitosis:

1) Prophase;
2) Metaphase;
3) Anaphase;
4) Telophase.

57. What period of mitosis do chromosomes spiral and become visible?

1) Prophase;
2) Metaphase;
3) Anaphase;
4) Telophase.

58. Determine which interphase period is the longest in time:

1) G1;
2) S;
3) G2;
4) G0.

59. Determine which interphase period is the shortest in time:

1) G1;
2) S;
3) G2;
4) G0.

60. In what period of interphase does the number of chromosomes double?

1) G1;
2) S;
3) G2;
4) G0.

61. How do germ cells divide?

1) Mitosis;
2) Amitosis;
3) Meiosis;
4) Phagocytosis.

62. Determine the method of cell division in which there is no synthetic interphase period:

1) Mitosis;
2) Amitosis;
3) Meiosis;
4) Phagocytosis.

63. Determine the method of cell division in which there are no periods of interphase:

1) Mitosis;
2) Amitosis;
3) Meiosis;
4) Phagocytosis.

64. What is the interphase period called the growth period?

1) G1;
2) S;
3) G2;
4) G0.

65. What is the interphase period called the energy period?

1) G1
2) S;
3) G2;
4) G0.

66. Determine the duration of the energy period of the interphase:

1) 4 hours;
2) 6 hours;
3) 10 hours;
4) 20 hours.

67. In what period of the cell cycle are dormant cells that have stopped multiplying?

1) G0;
2) G1;
3) G2;
4) S.

68. In the growing tissues of animals there are always cells that are "out of the cycle". What are these cells called?

1) cells S-period;
2) cells G0-period;
3) cells G-period;
4) cells G2-period.

69. Determine the process by which large particles are captured and absorbed by the cell:

1) exocytosis;
2) pinocytosis;
3) phagocytosis;
4) mitosis.

70. Determine the process by which small particles are captured and absorbed by the cell:

1) exocytosis;
2) pinocytosis;
3) phagocytosis;
4) amitosis.

71. Determine the process by which substances are excreted from the cell:

1) exocytosis;
2) pinocytosis;
3) phagocytosis;
4) mitosis.

72. The cell was treated with a drug that blocks the function of the nucleolus. Which processes will be disrupted in the first place?

1) lipid synthesis;
2) polysaccharide synthesis;
3) protein synthesis;
4) Phagocytosis.

73. The cell nucleus was treated with preparations that destroy histone proteins. Which structure will suffer in the first place?

1) Karyolemma;
2) Chromatin;
3) Nucleolus;
4) Karyoplasm.

74. On the preparations, a decrease in the size of cell nuclei, their compaction, and wrinkling were observed. What is the name of this phenomenon?

1) Mitosis;
2) Amitosis;
3) Phagocytosis;
4) Pyknosis.

75. What processes take place in the cell during prophase?

1) chromosome spiralization, nucleolus decay, karyolemma lysis;
2) chromosome despiralization, nucleolus assembly, karyolemma lysis;
3) chromosome spiralization, nucleolus assembly, karyolemma lysis ;
4) lysis chromosome despiralization, nucleolus decay, karyolemma lysis.

76. What happens during metaphase?

1) the spindle of division begins to form, the threads of the spindle of division are attached to the chromosomes;

2) the final formation of the spindle of division, the threads of the spindle of division are attached to the chromosomes;
3) the chromosomes diverge along the poles;
4) despiralization of chromosomes.

77. What happens during anaphase?

1) Cytotomy;
2) chromosome spiralization;
3) chromosome despiralization;
4) chromosome divergence to the poles of the cell.

78. What happens in the cell during telophase?

1) chromosome spiralization, nucleolus disintegration;
2) disintegration, chromosome despiralization, nucleolus formation;
3) chromosome divergence to the poles of the cell;
4) location of chromosomes along the equator of the cell.

79. What is the mitotic cycle?

1) Exocytosis;
2) Endocytosis;
3) interphase, mitosis;
4) prophase, metaphase, anaphase, telophase.

80. Determine the phase of mitosis, if a spindle of division is formed in the cell, the chromosomes are located in the equatorial plane of the spindle:

1) metaphase;
2) anaphase;
3) telophase.

81. Mitosis is a:

1) cell division in which there is no process of chromosome reduplication;
2) direct cell division;
3) indirect cell division;
4) formation of daughter cells with a haploid set of chromosomes.

82. Meiosis is a:

1) cell division in which there is no process of chromosome re-duplication;
2) direct cell division;
3) indirect cell division;
4) somatic cell division.

EMBRYOLOGY

Embryology – the science of embryo development

Embryonic development (embryogenesis) – the period from the moment of fertilization to birth (for viviparous animals), hatching from an egg (for oviparous).

Includes 3 stages.

Stage 1. Preembryonic development – progenesis:

1) Spermatogenesis;
2) Ovogenesis.

Stage 2. Embryogenesis – embryonic development:

1) Fertilization;
2) Cleavage;
3) Gastrulation;
4) Histogenesis;
5) Organogenesis.

Stage 3. Postembryonic development – development after birth.

Modern embryology as a science includes the development and structure of germ cells – progenesis. Embryology also studies the causes of disruption of normal embryogenesis. Medical embryology studies the patterns of human embryo development, the causes of deformities and other abnormalities, possible ways and methods of influencing embryogenesis. Abnormalities in embryonic development constitute a significant group of congenital diseases.

1. Embryonic development (embryogenesis) includes 5 main stages:
2. Fertilization and zygote formation
3. Cleavage and formation of blastula
4. Gastrulation – formation of germ leaves (ectoderm, endoderm, mesoderm)
5. Histogenesis – tissue formation
6. Organogenesis – the formation of organs

PROGENESIS

Embryogenesis is closely related to progenesis. Progenesis is the development and maturation of germ cells – eggs and spermatozoa. As a result of progenesis, a haploid set of chromosomes appears in mature germ cells, structures are formed that ensure their ability to fertilize and develop a new organism

Spermatogenesis

The process of development and maturation of male germ cells is called spermatogenesis. There are 4 periods of spermatogenesis (Figure 41):

1 – the period of reproduction;
2 – growth period;
3 – the period of maturation;
4 – the period of formation.

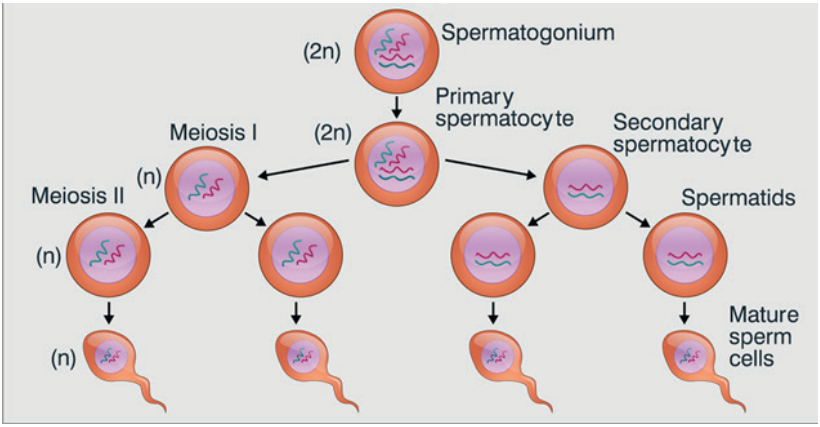


Figure 41. Spermatogenesis.

1. The period of reproduction of male germ cells – spermatogonia – in humans goes on throughout life and gradually fades to old age. Spermatogonia reproduce by mitosis. These are small rounded cells with a very small amount of cytoplasm. Part of the spermatogonia, ceasing to multiply, move into the next period of development – the period of growth.

2. Growth period

Spermatogonia turn into spermatocytes of the 1st order, the size of which increases by ≈ 4 times. There are 4 stages in the growth period: leptonema, zygonema, pachinema and diplonema.

At the stage of **leptonema**, chromosomes spiral, become visible (prophase). The number of chromosomal strands at this stage is diploid (46 chromosomes in humans).

The stage of **zygonema** is characterized by pairwise and longitudinal connection of homologous chromosomes.

At the **pachinema** stage, the chromosomes shorten, thicken, and cross, i. e., homologous chromatid or crossover sites are exchanged.

At the stage of **diplonema**, homologous chromosomes begin to move away from each other. The set of chromosomes becomes tetraploid (92 chromosomes in humans).

3. Maturation period

The maturation period is characterized by the onset of 2 rapidly successive meiotic divisions of spermatocytes of the 1st order, as a result, 2 spermatocytes of the 2nd order are formed first (a diploid set of 46 chromosomes), and then 4 spermatids.

In spermatids, the number of chromosomes is haploid, i. e. 23 chromosomes in humans. Spermatids are twice as small as spermatocytes of the second order.

Thus, as a result of two meiotic divisions, 4 spermatids with a haploid set of chromosomes are formed from a spermatocyte of the 1st order. After the formation of spermatids, the maturation period ends and the last period of development of male germ cells begins – the period of formation.

4. Formation period

The essence of the formation period is that spermatids turn into spermatozoa. The process of sperm formation from spermatids in humans and mammals is called spermiogenesis. The nucleus of the spermatid is strongly compacted and decreases in size, forming the head of the sperm.

The cytoplasm is preserved as a thin layer around the nucleus of the sperm.

At the anterior end of the sperm head there is a cover with a pointed end – an acrosome, which contains modified elements of the Golgi complex and participates in the production of enzymes (hyaluronidase). The centrosome is involved in the formation of the neck, as well as the axial thread of the tail of the sperm. The tail of the sperm is a motor apparatus that provides active mobility of the male germ cell (Figure 42).

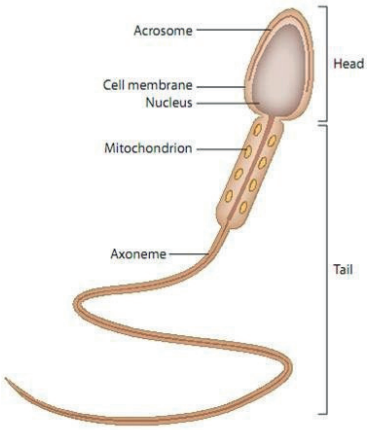


Figure 42. The structure of the sperm

The sperm (mature male germ cell) consists of a head, neck and tail.

Almost the entire head consists of a core. The anterior half of the sperm nucleus is covered with an acrosome and a "cover", which are derivatives of the Golgi complex. The proximal centriole and half of the distal centriole are located in the neck under the nucleus. The second half of the distal centriole, in the form of a ring, lies caudal. ((from lat. Cauda tail)-anatomical term meaning the location of a body part closer to the tail (pelvic) end of the body.) Mitochondria are located in the neck in the form of a spiral. The tail is represented by a flagellum consisting of microtubules according to the formula (9×2) + 2.

Spermatozoa are small in size 20–50 microns, but their size does not depend on the size of the animal. Spermatozoa have the ability to actively move. The shape of male germ cells can be very diverse. In

vertebrates, spermatozoa have a flagellar shape. The spermatozoa of animals differ from each other in the shape of the head.

In amphibians, the sperm head is long, pointed, in birds – corkscrew-shaped, in mammals - somewhat flattened. The life span and fertilizing ability of spermatozoa are not the same in different animals. The acrosome contains hyaluronidase, capable of dissolving the membranes covering the egg. In mammals, the life expectancy and fertilizing ability varies from several hours to several days. In an acidic environment, spermatozoa lose their ability to move, stick together.

Thus, the sperm is a specialized cell equipped with all the necessary functional and morphological devices that ensure fertilization, i. e. its fusion with the egg.

OVOGENESIS

The development of female germ cells is ovogenesis.

There are 3 periods in oogenesis: reproduction, growth and maturation (Figure 43).

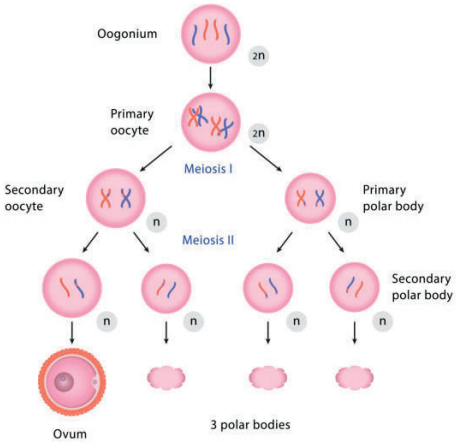


Figure 43. Ovogenesis

1 Period-reproduction of female germ cells in humans is observed only in embryogenesis. Female oogonia germ cells divide by

mitosis. Their number increases until the 5th month of intrauterine development (in humans).

2 Period-growth period during oogenesis is divided into a period of "small growth" and a period of "large growth". Oogonia cease to divide and differentiate into oocytes of the first order.

The period of small growth lasts until puberty. With the onset of puberty of the organism, oocytes of the 1st order enter a period of "great growth".

3 Period-maturation of female germ cells is characterized by two meiotic divisions. After the first meiotic division of an oocyte of the 1st order, 2 cells of different sizes arise: an oocyte of the second order and the first reduction body. An oocyte of the second order is a large cell into which the entire yolk and almost the entire cytoplasm passes. The first reduction body is a small cell containing a nucleus and a small amount of cytoplasm. The second-order oocyte and the first reduction body after the first meiotic division have a diploid set of chromosomes. In the second meiotic division, the second-order oocyte divides into two unequal cells, forming a mature egg and a second reduction body. At the same time, the first reduction body is divided into two bodies. Both in a mature egg and in three reduction bodies after the second meiotic division, there are 23 chromosomes, i. e. a haploid set of chromosomes. Reduction (directional, polar) corpuscles degenerate and dissolve. During the second meiotic division, the centrosome of the II-order oocyte begins to move to the equatorial zone, decreases in size and disappears. Thus, as a result of two meiotic divisions of the I-order oocyte, 4 cells with a haploid set of chromosomes are formed: one mature egg and 3 reduction corpuscles.

The formation of reduction bodies makes it possible for the egg to get rid of extra chromosomes and, at the same time, preserve almost all the cytoplasm and yolk necessary for the development of the organism. The human egg and reduction corpuscles contain identical sex chromosomes XX.

STRUCTURE AND TYPES OF EGGS

The egg has a spherical shape, in which there is no centrosome. The hyaloplasm contains trophic inclusions – yolk granules. Depending on the number of yolk granules, eggs are classified into isolecital and telolecital. Isolecital eggs contain few yolk granules, which are distributed evenly in the hyaloplasm, the nucleus in the center.

There are 2 types of isolecital eggs:

Primary isolecital – found in the lancet, the development period of which is 7 days

Secondary isolecital – found in humans and mammals

In placental mammals, due to intrauterine development and nutrition at the expense of the maternal organism, there is no need to create significant reserves of yolk in the egg. Therefore, isolecital eggs appeared a second time in evolution. The egg is surrounded by a shiny shell (transparent zone) and a layer of follicular cells (radiant crown) that take part in its nutrition. The structure of eggs is characterized by polarity, which is expressed the more strongly, the more yolk in the cell.

The amount of yolk in the cytoplasm is directly dependent on the conditions of the animal's development (in the external or internal environment) and the duration of development.

Telolecital eggs are classified into moderately and sharply telolecital.

Moderately telolecital (mesolecital) eggs contain more yolk granules, which are distributed unevenly. The pole of the egg cell, on which there are fewer yolk granules, is called animal, and on which there are more-vegetative. The nucleus shifts to the animalic pole and is located eccentrically.

Moderately telolecital eggs are found in a frog whose development period is 14 days.

With an increase in the amount of yolk in the cytoplasm, the size of the egg also increases. Terrestrial development has led to the emergence of secondary and tertiary shells that protect the egg from the damaging effects of mechanical, temperature and other environmental factors (birds, reptiles) (Figure 44).

The primary shell is the cytolemma.
The secondary shell is muco-protein.
Tertiary – shell, subcortical.

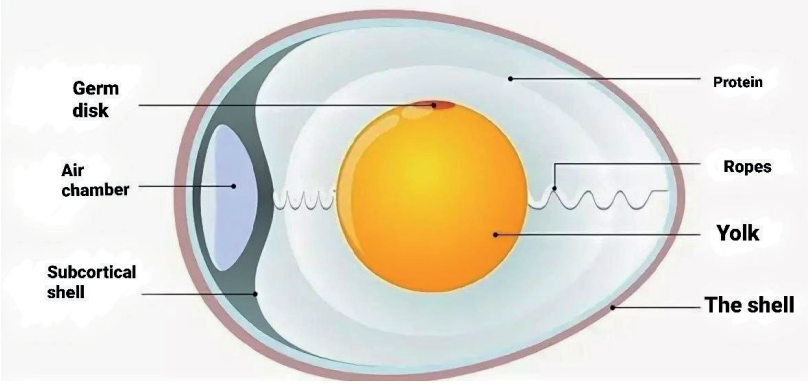


Figure 44. The structure of a sharply telolecital egg.

Sharply telolecital eggs are found in birds whose development period is 21 days. In connection with the landfall, the eggs are covered with fibrous and shell shells. The nucleus of the egg cell is located sharply eccentrically, at the animalic pole, and the vegetative pole of the egg cell contains a significant number of large-sized yolk granules (Figure 45).

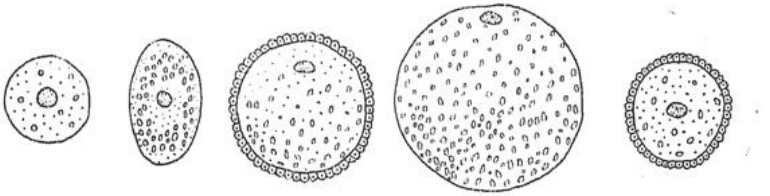


Figure 45. Types egg

FERTILIZATION

This is the first period of embryogenesis. Fertilization is the fusion of male and female germ cells, as a result of which a diploid set of chromosomes is restored, and a qualitatively new cell – a zygote (a unicellular embryo) arises. At the same time, the mass of the nucleus is doubled, and the volume of the cytoplasm remains the same.

In the process of fertilization, there are three phases: convergence, penetration, fusion (syncarion).

Among animals, there are external and internal fertilization. External fertilization usually takes place in an aquatic environment, and internal fertilization takes place in the genital tract of animals. The ability to fertilize a human egg and sperm remains 24-36 hours. Fertilization is one of the most complex phenomena (Figure 46).

The first phase is rapprochement (distant interaction). The convergence of germ cells is facilitated by:

1. The potential difference – spermatozoa have a positive electric charge, and the egg is negative.
2. Rheotaxis is the ability of mammalian spermatozoa to move against the fluid flow.
3. Chemotaxis – spermatozoa in a slightly alkaline environment move very quickly towards the egg.

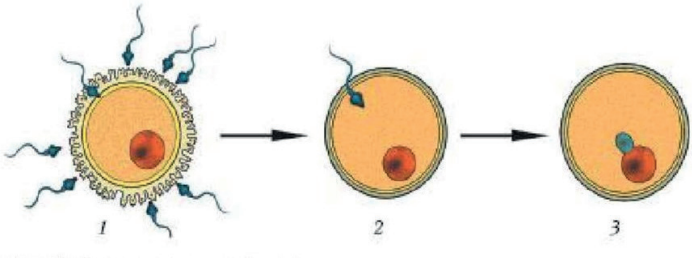


Figure 46. Stages of fertilization

The second stage is penetration (contact interaction). Penetration of one sperm into egg is called monospermia. This phenomenon is characteristic of vertebrates (Earth-modelled, man). In vertebrates, which have teloletal egg, in fertilization in egg penetrates many spermatozoids. This phenomenon is called polispermia.

Contact interaction of gamet (sexual cells) comes when spermatozoid gets closer to the egg.

Spermatozoids of various types of invertebrates and vertebrates contain substances capable of causing dissolving primary and secondary shells of egg. These substances (trypsin) are localized in spermatozoid acrosome. In the place of touch of spermatozoid to cytolemme egg is formed by the bulging – the tubercule of perception.

In this place in egg penetrate head and neck spermatozoid, and the tail remains outside. Typically, spermatozoids of one species of animals are not attached to the eggs of animals of other species and do not penetrate them. Fertilization comes only when penetrating spermatozoid of the same species of animals as egg.

After finding the head and cervix of spermatozoid on periphery cytoplasm egg is seal of cytoplasm and formed a shell of fertilization by thickness of 50 Nm. The shell of fertilization prevents penetration into the egg of several spermatozoids. Sperm penetration significantly increases the metabolic activity of egg-protein synthesis.

The third phase – Fusion of nuclei (sincarion) (Figure 47). In this phase, the nucleus of egg is called female pronucleus, and the nucleus of sperm-male pronucleus. Centrioli, made by spermatozoid, diverge to opposite poles and begins to form a belief division. Karyolemma dissolves. Chromosomes of both nuclei merge in late prophase or early metaphase – "mother star". The fusion of nuclear material ends with the process of fertilization. A zygote is formed with a diploid (doubled) set of chromosomes.

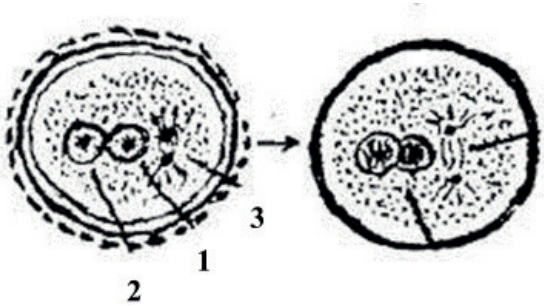


Figure 47. The stage of fertilization is the syncarion

The zygote is a unicellular embryo that enters the second period of embryonic development – the period of cleavage.

CLEAVAGE

Cleavage is a sequential mitotic division in which blastomeres do not grow and do not diverge, there is no G1 – growth period (Figure 48).

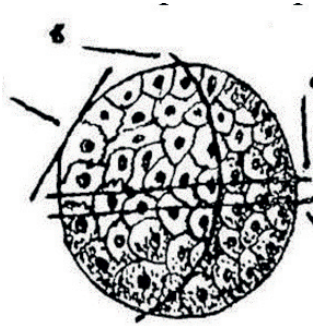


Figure 48. Schematic representation of cleavage furrows

The type of cleavage depends on the type of egg. There are 4 types of cleavage (Figure 49):

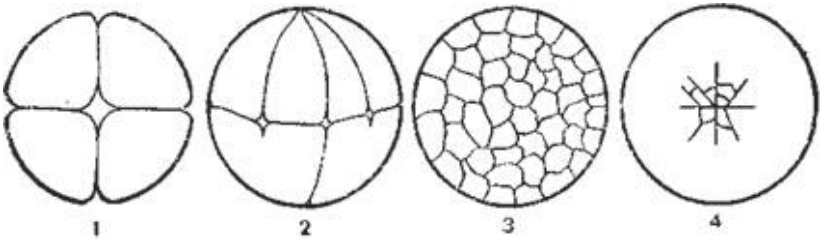


Figure 49. Types of egg cleavage. 1 – complete even; 2 – complete uneven; 3 – incomplete surface; 4 – partial discoidal.

1. Complete even cleavage, if the egg is primary isolecital. Cleavage is carried out by two furrows – latitudinal (equatorial) and meridian. Complete – the whole zygote is cleavage, even – the blastomeres are the same (Figure 50).

2. Complete uneven cleavage of a moderately telolecital egg (frog). Cleavage is also carried out by tangential furrows (there is no equatorial one). As a result, the entire zygote is cleavage, but the blastomeres are not the same in size - small and large. Cells containing more yolk are cleavage more slowly, so larger blastomeres are formed.

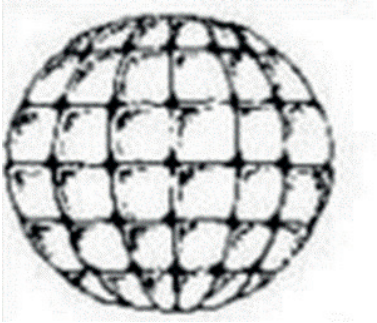


Figure 50. Complete even cleavage

3. Partial discoidal cleavage, if the egg is sharply telolecital (in birds). Cleavage occurs partially only at one pole. Where there is a lot of yolk in the cells, cleavage does not occur (Figure 51).

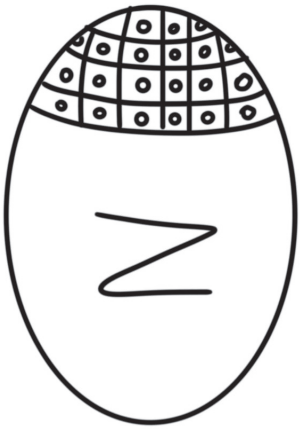


Figure 51. Partially discoidal cleavage

Complete uneven, asynchronous cleavage if the egg is secondary isolecital (in humans, mammals). The resulting blastula is the same size as the zygote (Figure 52, 53).

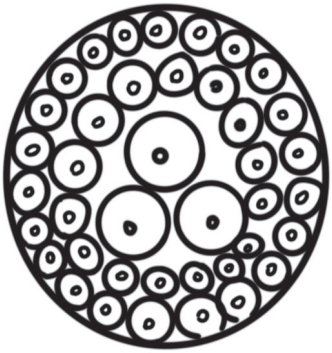


Figure 52. A secondary isolecital egg

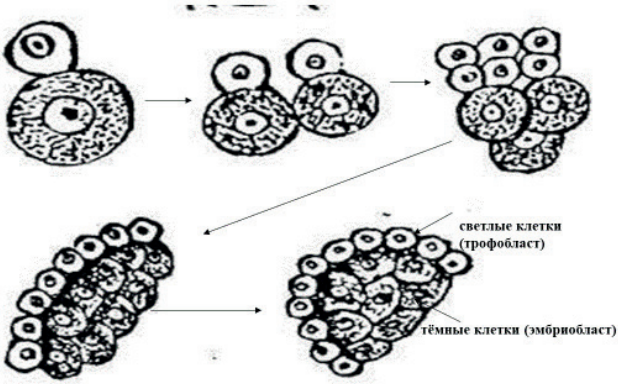


Figure 53. Formation of a human blastula.

TYPES OF BLASTULA

There are 4 types of blastula:

1. Coeloblastula is formed with complete even cleavage. The blastula is single-layered, the blastomeres are all the same size. There are roof (upper part), bottom (lower part) and edge zone (side part).

The cavity of the blastula is called the blastocele, which is located in the center (Figure 54).

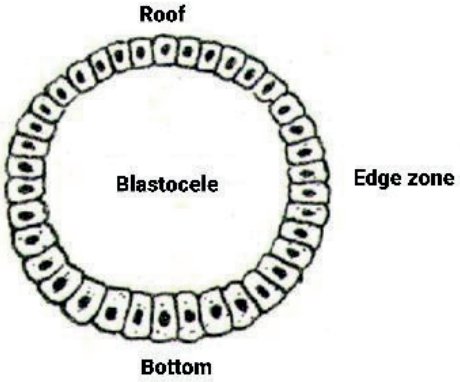


Figure 54. Coeloblastula

2. Amphiblastula – a multilayer blastula is formed with complete uneven cleavage. Distinguish the roof, bottom, edge zone. The blastocele is located eccentrically. In the bottom area, the blastomeres are large, since they contain a lot of yolk (Figure 55).

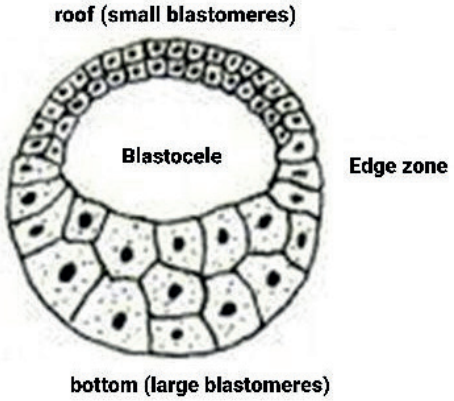


Figure 55. Amphiblastula

3. Discoblastula – formed with partial, discoidal cleavage in birds (Figure 56).

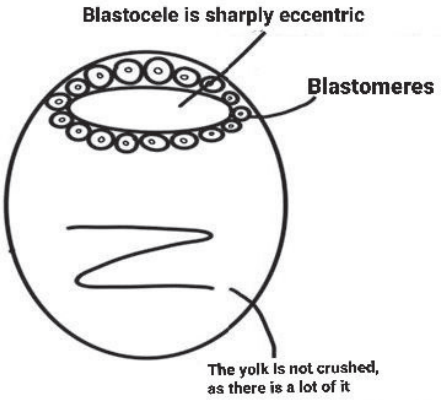


Figure 56. Discoblastula.

4. Blastocyst – formed with complete, asynchronous, uneven cleavage in humans (Figure. 57).

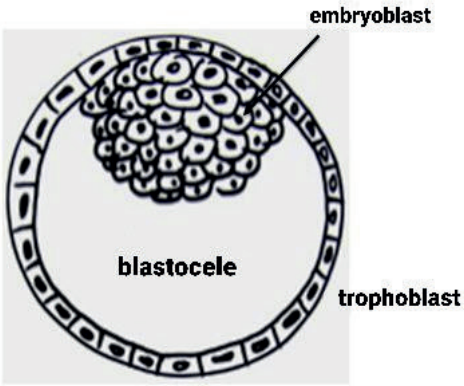


Figure 57. Blastocyst

GASTRULATION

The third stage of embryonic development is gastrulation – the process of formation of a two– and three-layer embryo.

There are 4 types of gastrulation.

Type 1 – **immigration** – displacement, cells move from the outer layer to the inside and form the inner layer (Figure 58).

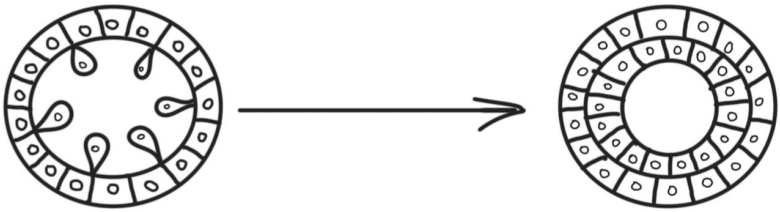


Figure 58. Immigration

Type 2 – **invagination** – ingestion the cells of the outer layer dig in, inside and separate, forming an inner layer. It occurs in the lancet (Figure 59).

Figure 59. Invagination

Type 3 – **delamination** – the cells of the outer layer divide and delaminate, forming an inner layer (Figure 60).

Type 4 – **epibolia** – fouling. Small cells grow into large cells. It occurs in amphibians (frogs) (Figure 61).

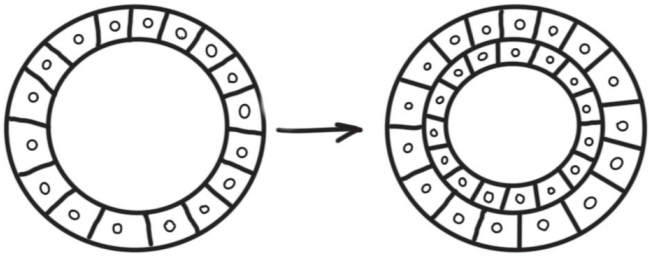


Figure 60. Delamination

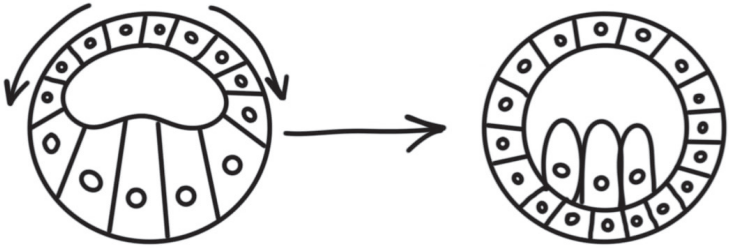


Figure 61. Epibolia

ORGANOGENESIS

Organogenesis is the formation of axial organs. After the formation of 2 embryonic leaves of the **ectoderm** (outer) and **endoderm** (inner), the formation of axial rudiments of organs begins and at the same time the formation of the third embryonic leaf – **mesoderm**. When differentiating the mesoderm, its dorsal part is first subdivided into somites, starting from the head end – *dermatome, myotome, sclerotome*. The ventral mesoderm is a *splanchnotome*, split into two leaves – parietal (closer to the ectoderm) and visceral (closer to the endoderm). Between the leaves there is a cavity – the *celom* (Figure 62).

1 - ectoderm;
2 - visceral
leaf of mesoderm (splanchnotoma);
3 - aortic arches;
4 - nephrotome;
5 - ectoderm;
6 -somitis:
7- neural tube and ganglion
plate;
8 - chord;
9 - parietal
leaf of mesoderm (splanchnotoma);
10 - overall;
11 - splankhnotom

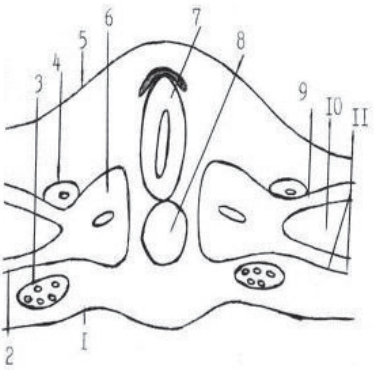


Figure 62. Formation of axial rudiments of organs

The process of the emergence of tissues from poorly differentiated cells of embryonic rudiments – stage 4 – **histogenesis**, stage 5 – **organogenesis**.

Germ leaves differentiate into tissues, and organs from them.

From the **ectoderm** are formed: the epidermis of the skin, partially sensory organs (cornea, auditory vesicles), appendages of the skin – hair, glands, neural tube.

From the **endoderm** are formed: digestive tube, digestive glands – liver and pancreas, respiratory system, thyroid gland, parathyroid gland, thymus.

From the **mesenchyme** are formed: connective tissue proper, cartilage tissue, smooth muscle tissue, hematopoiesis organs, cardiovascular system.

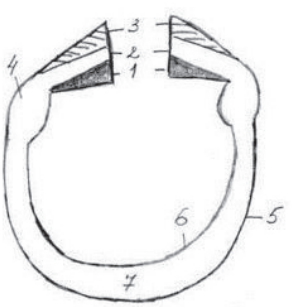
THE MESENCHYME is the germinal connective tissue from the evicting cells of the mesoderm, endoderm (Figure 63).

The **splanchnotome** forms the myocardium, the epicardium of the heart, the adrenal cortex, the serous membranes of the body cavities (abdominal cavity, pleural, cavity of the cardiac sac).

The genitourinary system develops from the **nephrotome** (segmental pedicle).

From the dorsal mesoderm are formed:

from the dermatome – the dermis of the skin,
from the myotome – skeletal muscle tissue,
from the sclerotome – bone tissue.



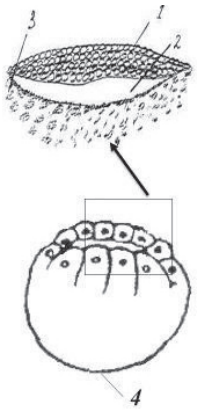
1 - sclerotomy;
2 - miotom;
3 - dermatome;
4 - nephrotome;
5 - parietal splanchnotome leaf;
6 - visceral splanchnotome leaf;
7 - overall.

Figure 63. Differentiation of the mesoderm

EMBRYOGENESIS OF BIRDS

Bird egg cells are richer in yolk than amphibian eggs. The accumulation of yolk in the eggs of birds is the result of changes in the living conditions under which the physiological development of these animal species took place, it causes obvious changes in their ontogenetic (individual) development. Abruptly, the telolecital eggs of birds can no longer be completely cleavage. The cleavage of the fertilized egg of birds is incomplete, partial, discoidal. The cleavage is partial, since the huge vegetative pole contains a very large amount of yolk. While the animal pole, in which the egg nucleus is located eccentrically, contains little yolk. Only a small (disc-shaped) field of the animal pole is subjected to cleavage.

The first furrow begins in the middle of the animal pole and goes meridionally, without going beyond the small circle. In the future, cleavage occurs completely unevenly and several layers of blastomeres appear, located one on top of the other. A cavity – a blastocele - forms between the yolk and the blastomeres (germ disk). The germ disk formed by the blastomeres corresponds to the roof, and the yolk corresponds to the bottom of the blastula. A blastula is called a discoblastula. The discoblastula of birds is a germ disk spread out on the yolk (Figure 64).



1 - blastomeres;
2 - the cavity;
3 - yolk;
4 - bottom.

In birds, a blastula is a layer of cells that has a disc-shaped shape and lies on an undivided yolk.

Figure 64. Discoblastula

As a result of discoidal cleavage, a discoblastula is formed, which later turns into a gastrula.

Gastrulation in birds is carried out in two ways – delamination and immigration. The first phase of gastrulation in birds is carried out by delamination, in which **ectoderm** and **endoderm** arise. Thus, as a result of delamination (splitting), a two–layer embryo - gastrula arises. (Figure 65).

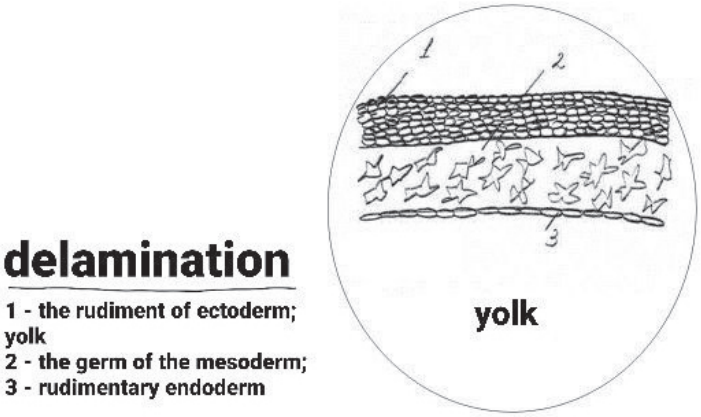


Figure 65. Delamination

The second phase of gastrulation is ***immigration***. The cell material of the ectoderm begins to move in two streams, to the right and left of the midline to the posterior end of the embryo. At the posterior end of the germ shield, the cell streams meet, turn and begin to move forward along the midline, forming at this point a thickened layer of cells called the primary strip. The anterior part of the primary strip forms an extension – called the primary or *Gensen nodule*.

In the primary nodule, a depression is formed by invagination, called the *primary fossa*. In the middle of the primary strip there is a longitudinal depression, called the primary groove or primary groove. Mesoderm formation in the second phase of gastrulation is carried out by invagination of ectoderm cell material in the area of the primary groove into the space between the outer and inner germ leaves (ectoderm and endoderm) (Figure 66).

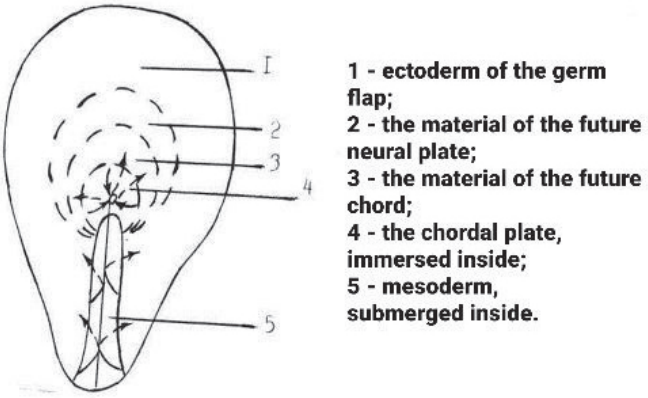


Figure 66. Immigration

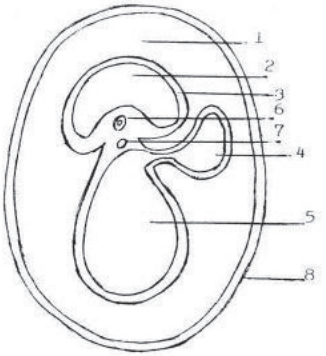
The cellular material located under the primary fossa forms a **neural plate**. The cellular material of the primary fossa, which invaginates deep, forms a chord. At the end of the second phase of gastrulation, the embryo of birds becomes three-layered.

The provisional (temporary, extra-embryonic) organs of birds include the ***yolk sac, allantois, amnion and serous membrane***. Birds have a trunk fold that separates the embryo from the extra-embryonic organs. The trunk fold lifts the embryo above the yolk. Therefore, the developing embryo does not sink into the yolk, but rises above it. Later, a second *amniotic fold* is formed, growing in the opposite direction. The amniotic fold rises above the embryo and fuses, forming an amnion and a serous membrane.

EXTRA-EMBRYONIC ORGANS

The yolk sac is formed by the extra-embryonic endoderm and the visceral leaf of the splanchnotome. Function: hematopoietic and trophic (Figure 67).

Allantois is formed by extra-embryonic endoderm and visceral splanchnotome leaf. A bulge is formed from the yolk sac. Function: excretory.



1 - serous cavity;
2 - amniotic cavity;
3 - amniotic membrane;
4 - allantois;
5 - yolk sac;
6 -neural tube;
7 - chord;
8 - serous membrane

Figure 67. Provisional organs

The amnion is formed by the extra-embryonic ectoderm and the parietal leaf of the splanchnotome. Function: protective (mechanical).

The serous membrane is formed by the extra-embryonic ectoderm and the parietal leaf of the splanchnotome. Function: gas exchange.

HUMAN EMBRYONIC DEVELOPMENT

Features:

1. Early development of extra–embryonic organs - amnion, chorion, yolk sac.
2. Later development of the embryo.

HUMAN DEVELOPMENT

I. Progenesis – Spermatogenesis, ovogenesis

II. Embryogenesis

1. Fertilization.
2. Cleavage.
3. Gastrulation.
4. Histogenesis.
5. Organogenesis.

III. Postembryonic development.

Stages of embryogenesis: 280 days.

1. Initial – 1st week
2. Germinal – 2–3 weeks
3. Fetal – 9 weeks and before birth

Critical periods of development:

1. Progenesis (ovogenesis, spermatogenesis);
2. Fertilization;
3. Implantation –-8 days (40 hours);
4. Organogenesis – 2–3 weeks;
5. Placentation and development of axial rudiments of organs – 5 weeks (from 3 to 8 weeks);
6. Stage of enhanced brain growth (15–20 weeks of development);
7. Differentiation of the sexual apparatus (20–24 weeks of development);
8. The second phase of brain differentiation and growth is 25 weeks.
9. Birth;
10. Newborn period (1 week, 40 days, up to 1 year);
11. Puberty (11–16 years old).

For the first time, the theory of critical periods of development was developed by the Soviet embryologist A.G. Svetlov (1960). The essence of the theory is that each stage of embryo development begins with a short stage of a qualitatively new restructuring. At this time, the embryo is most susceptible to the damaging effects of various factors.

PROGENESIS IS PREEMBRYONIC DEVELOPMENT

- **Spermatogenesis** lasts 72–76 days at a temperature of 34 C. The sperm is 60–70 microns in size.

The form is flagellated. The speed of movement is 30–50 microns/sec, 1–5 mm/min. The fertilizing ability persists for 1–2 days;

- **Ovogenesis** lasts 24–28 days – the egg (secondary, isolecital, fertilizing ability persists for 12–24 hours);
- Yolk granules;
- 3000–4000 follicular cells form a radiate crown;
- size – 130–150 microns;
- there is no centrosome.

Fertilization is the process of fusion of an egg and a sperm cell, a qualitatively new cell is formed – a zygote.

In humans, fertilization is internal, monospermal.

Stages:

1. Convergence stage.
2. Penetration.
3. Syncarion – fusion.

Fertilization lasts 12-24 hours in the ampullary part of the fallopian tube.

(Figure 68).

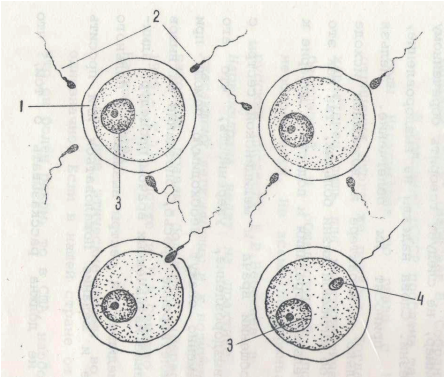


Figure 68. Stages of fertilization

FACTORS AFFECTING THE CONVERGENCE STAGE:

- pH of the medium (alkaline), in an acidic environment, spermatozoa lose mobility;
- the charge difference – the egg is negative, and the sperm is positive;
- chemotaxis – the egg secretes gynogamons that enhance sperm motility, spermatozoa – androgamons, reduce the speed of movement;
- rheotaxis – movement against the fluid flow;
- the number of spermatozoa – 350 million, 1 ml – 60 million;
- the size of the sperm is 60–70 microns, contains a Y chromosome, smaller in size, move fast, die faster; with the X chromosome, they move slowly, live longer;
- the speed of movement is 1–5 mm/min, after 30 minutes – in the uterus, after 1.5–2 hours – in the fallopian tube;
- maturity of spermatozoa, the number of abnormal spermatozoa increases with age.
- Damaging factors: medications, hypoxia, starvation, bad habits, X-rays.

STAGE 2 OF FERTILIZATION – PENETRATION

1. Capacitation – the activity of spermatozoa increases. The egg rotates in 4 revolutions per minute under the action of sperm flagella.

2. Acrosomal reaction – spermatozoa secrete hyaluronidase, which dissolves the shiny shell. The egg cell forms a perception tubercle through which only one sperm penetrates. After penetration, a fertilization shell is formed, which prevents polyspermia and persists until implantation.

3. Stage of fertilization is syncarion – fusion. The karyolemma dissolves, the chromosomes merge into an early stage of metaphase – the "mother star". A zygote containing 46 chromosomes is formed.

CLEAVAGE

Cleavage is complete, uneven, asynchronous. Occurs in the fallopian tube for 3–4 days.

As a result of cleavage, 2 types of blastomeres are formed: dark and light. The dark ones break up slowly and form an **embryoblast**. Light blastomeres are cleavage faster and form **trophoblast** – nutrient cells (Figure 69).

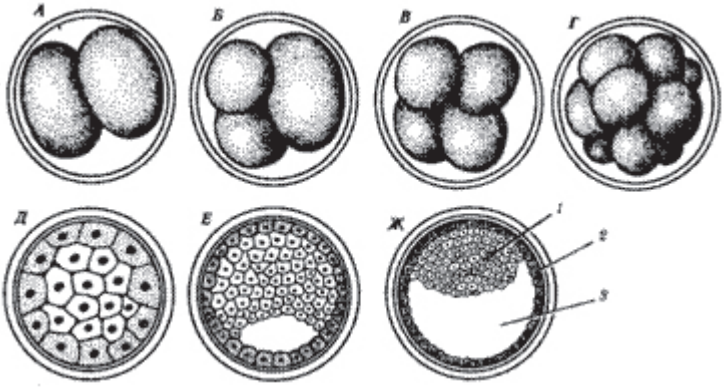


Figure 69. Cleavage

When passing through the oviduct, a cavity appears in the embryo and the embryo is called a blastocyst (Figure 70).

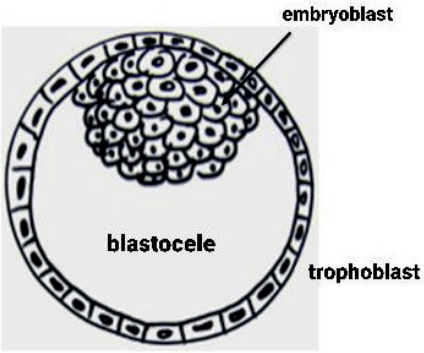


Figure 70. Blastocyst

On the 5th day after fertilization, the blastocyst enters the uterus. From the 5th to the 7th day, the blastula migrates through the uterus, absorbs the secret of the uterine glands and is implanted in the area of the uterine fundus. In the uterus, the embryo is cleavage to 107 cells and cleavage ends on the 7th day.

Thus, on the 7th day from the beginning of fertilization, the human embryo at the blastocyst stage approaches the uterine mucosa for attachment – implantation. The fertilization shell dissolves.

GASTRULATION

Gastrulation is the formation of germ leaves.
Phase 1 – delamination (7th day).
Phase 2 – immigration (14th day)
On the 7th day, implantation begins. It takes place in 2 stages:

1. Adhesion (adhesion)
2. Invasion (penetration)

Stage 1 – the trophoblast is differentiated into layers:
1) cytotrophoblast;
2) plasmodiotrophoblast.
Plasmodiotrophoblast adheres (adhesion) to the uterine mucosa.

Stage 2 – implantation is invasion.

Plasmodiotrophoblast synthesizes proteolytic enzymes (hyaluronidase) and destroys the lining of the uterus – epithelium, connective tissue, convoluted arteries, forming villi.

GASTRULATION BY DELAMINATION TYPE

The embryoblast splits into 2 leaves – outer and inner. The cells of the outer leaf close and form an amniotic vesicle. Implantation is a critical period, because there is a change of nutrition from histiotrophic (connective tissue) to hematotrophic (blood from destroyed convoluted arteries).

Implantation lasts 40 hours.

Day 11 – implantation is over. The epithelium of the uterine mucosa was restored. The extra-embryonic mesenchyme is evicted from the germ shield. 2 types of chorion are formed: smooth and villous (Figure 71).

The chorion consists of:

1. extra-germ mesenchyme;
2. plasmodiotrophoblast;
3. Cytotrophoblast.

Villous chorion >basal layer.

Smooth> uterine epithelium.

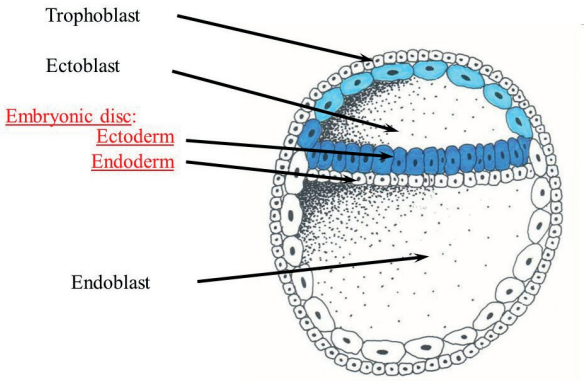


Figure 71. Delamination

Epithelium of the uterine mucosa.
The 2nd phase – gastrulation – 14 days (Figure 72)

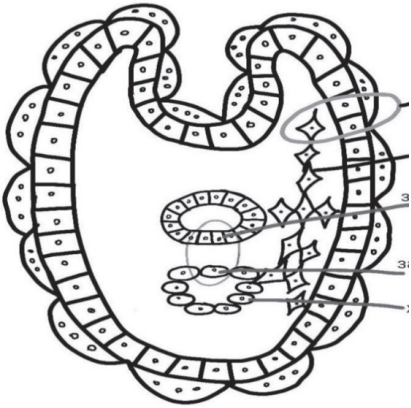


Figure 72. 14 days

1. The yolk sac (bubble) is formed by closing.
2. An amniotic or embryonic pedicle is formed from the extra-embryonic mesenchyme.
3. The yolk sac is attached to the chorion with the help of an amniotic pedicle, as well as an amniotic vesicle.
4. Immigration begins in the embryonic ectoderm.

Day 17 – 90° turn (Figure 73)

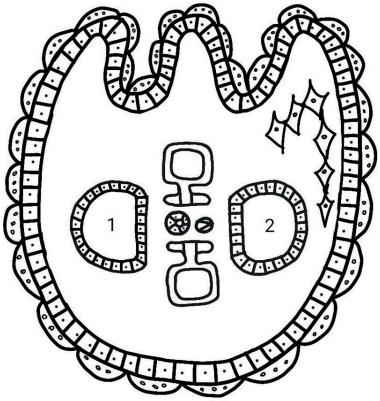


Figure 73. 17 days

Day 20 – the trunk fold separates the embryo from the extra-embryonic organs.

There is no amniotic fold (Figure 74).

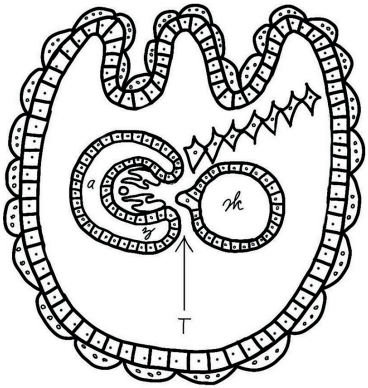


Figure 74. 20 days

24–25 days – another 90° turn (Figure 75)

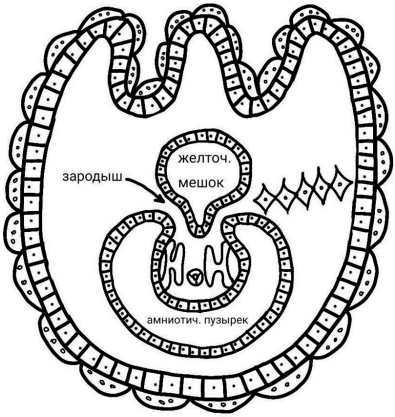


Figure 75. 24–25 days

Day 40 – allantois is formed as a result of protrusion from the yolk sac. The separation of the embryo from the extra-embryonic organs ends (Figure 76)

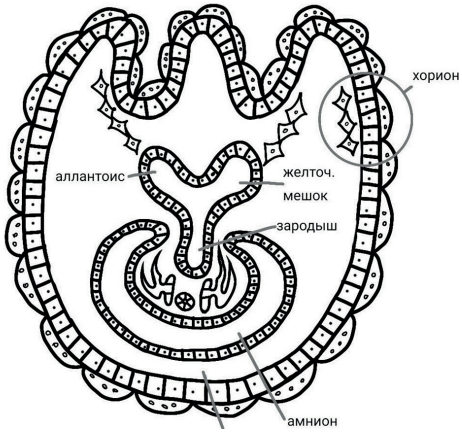


Figure 76. The 40th days

AMNION – consists of

1. The parietal leaf of the mesoderm.
2. Extra-embryonic ectoderm.

Function: protective, regulation of liquid volume.

YOLK SAC –

1. Visceral leaf of the mesoderm.
2. Extra-embryonic endoderm.

Function:

1) contains gonoblasts;
2) hematopoiesis is the source of vascular development;
3) At the 2nd month it is reduced and is part of the umbilical cord.

ALLANTOIS –

1. Visceral leaf of the mesoderm.
2. Extra-embryonic endoderm.

The function is excretory, at the end of the 2nd month it is reduced (Figure 77)

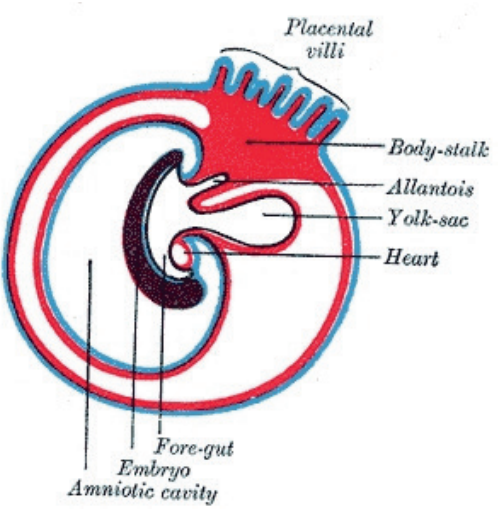


Figure 77. Allantois

CHORION – forms the future placenta (Figure 78)

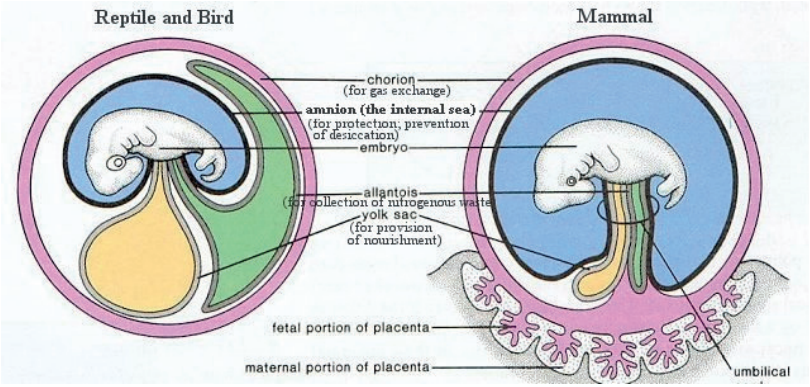


Figure 78. Human embryo with germ membranes

PLACENTA

Types of placentas.

The placenta is an extra–embryonic organ that provides a connection between the embryo and the mother (Figure 79).

Type 1. – epitheliochorial, diffuse.

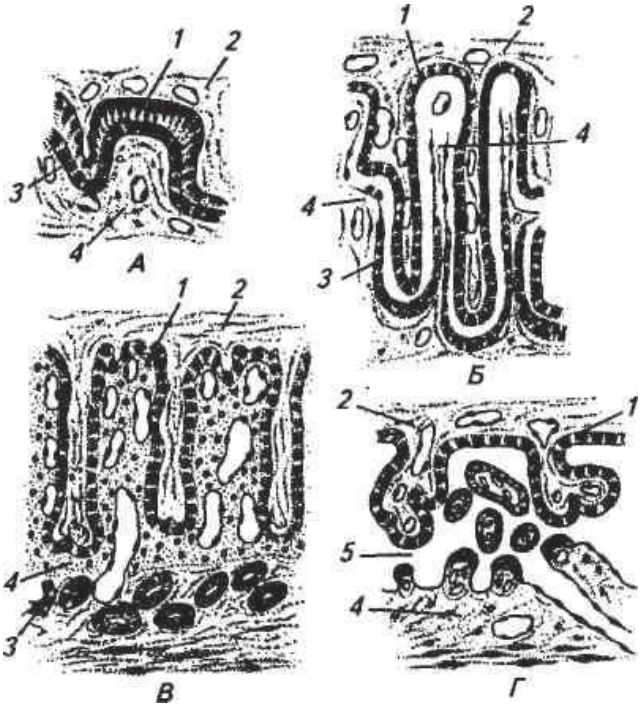


Figure 79. The relationship of embryonic and maternal tissues in placentas of various types: *A – epitheliochorial placenta (pig); B – desmochorial placenta (ruminants); C – endotheliochorial placenta (carnivorous); D – villous hemochorial placenta (primates); 1 – trophoblast; 2 – chorionic connective tissue with germ vessels; 3 – uterine epithelium; 4 – connective tissue of the uterine mucosa with maternal vessels; 5 – blood lacunae.*

Nutrition is diffuse due to the secretion of the uterine glands, there is no bleeding. The uterine mucosa is not damaged.

Type 2 – desmochorial type, multiple.

Uterine glands are partially destroyed, and decidual cells are nourished by connective tissue (Figure 80).

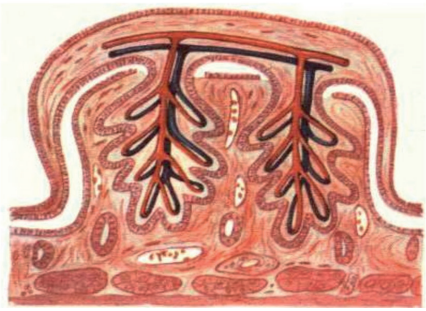


Figure 80. Desmochorial type

Type 3 – endotheliochorial type, cingulate.

The uterine glands, connective tissue are completely destroyed, the villi come into contact with the vascular endothelium without destroying them.

Type 4 – hemochorial type, discoidal (in humans).

The villi destroy blood vessels and are washed with maternal blood. The blood of the embryo mixes never with the blood of the mother, thanks to the barrier: endothelium – cytotrophoblast – plasmodiotrophoblast. This is a hematoplacental barrier – between the fetus and the mother, permeable to drugs, alcohol, viruses, nicotine, drugs.

The placenta begins to form from the 3rd week of intrauterine development, and ends at the 3rd month (Figure 81).

Functions of the placenta:

1. Trophic – the embryo feeds through the placenta.
2. Respiratory – oxygen is dissolved in the blood.
3. Excretory.
4. Hormonal – chorial gonadotropin is synthesized (8–10 weeks), progesterone, somatomammotropin.
5. Protective – protective against microorganisms.
6. Hematoplacental barrier.

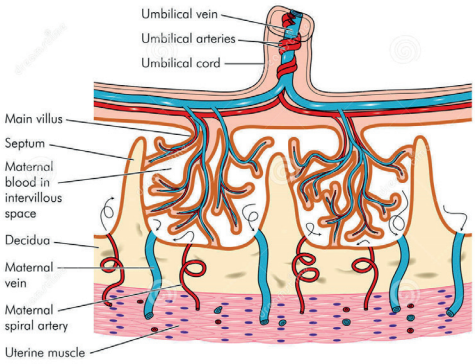


Figure 81. Hemochorial type

Human placenta:

1. The embryonic or fetal part.
2. The maternal or uterine part.

I. The embryonic part is the child part.

Villous chorion.

Chorial villi – anchor, stem.

1. Plasmodiotrophoblast or simplastotrophoblast.
2. Cytotrophoblast.
3. Choral plate – Loose connective tissue.
4. 2 umbilical arteries and 1 umbilical vein.
5. Amniotic membrane:

- amniotic epithelium
- Loose connective tissue.
- Loose connective tissue is a spongy layer.

The amniotic membrane is the organ in which the fetus is located.

Function – production of amniotic fluid, protects against penetration of harmful agents into the fetus, protects the fetus from mechanical damage.

II. The maternal or uterine part of the placenta.

1. The basal plate is the connective tissue of the uterine mucosa, contains decidual cells in which glycogen.

2. Septa – connective tissue septa – remnants of the functional layer of the endometrium.

3. Lacunae – filled with maternal blood. The blood in the lacunae is continuously renewed.

4. The remains of the uterine glands (Figure 82).

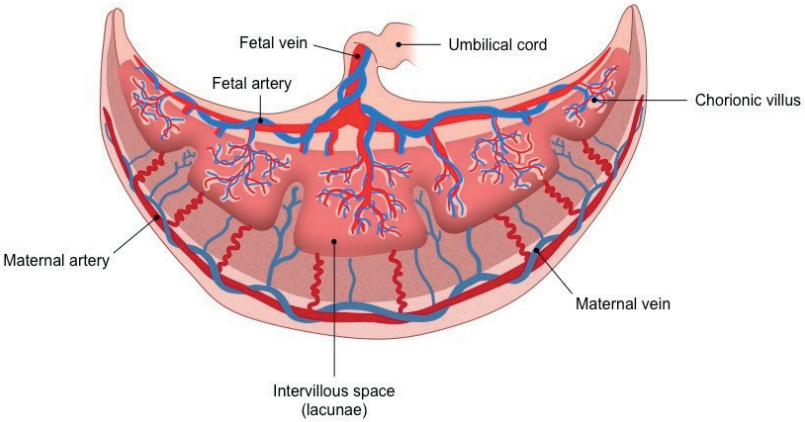


Figure 82. Placenta

CONTROL QUESTIONS ON EMBRYOLOGY

1. Progenesis – spermatogenesis, ovogenesis.
2. Sperm and egg types.
3. Stages of embryogenesis, their characteristics.
4. Fertilization, stages, types.
5.Types of cleavage and cleavage furrows.
6. Types of blastula, structure.
7. Methods of gastrulation.
8. Germ sheets.
9. Differentiation of the mesoderm.
10. Isolation of the embryo body by the trunk fold.
11. Extra-embryonic organs – yolk sac, allantois, amnion, serous membrane.
12. Distinctive features of human embryogenesis.
13. Critical periods in human embryogenesis.
14. Types of placentas.
15. The structure of the human placenta.

SITUATIONAL TASKS IN EMBRYOLOGY

1. A newborn has been diagnosed with a violation of the development of the ventricular myocardium. With in a violation of the development of which embryonic source is this pathology associated?

A. Ectoderm;
B. Endoderms;
C. Visceral splanchnoplevra;
D. Mesenchyma;
E. Parietal splanchnoplevra.

2. In Addison's disease, hyperpigmentation of the skin is observed. This is associated with the commonality of the sources of the development of melanocytes and the adrenal medulla. What is the source of their development?

A. Ectoderm;
B. Mesoderm;
C. Mesenchyma;
D. Neural crest;
E. Entoderma.

3. On the micro-preparation of a human embryo taken from an involuntary miscarriage, we see the embryonic shield in which two layers are recognized: – entoderm and ectoderm. At what stage of embryonic development was the embryo?

A. Formation of a blastula;
B. Histogenesis;
C. Progenesis;
D. Gastrulation;
E. Organogenesis.

4. In an experiment on a frog embryo, the external germ leaf – the ectoderm - was destroyed. Which of the following morphological structures will not develop in this embryo in the future?

A. Bone tissue;
B. Somites;
C. Nephrotome;
D. Splanchnotome;
E. Epidermis.

5. One of the critical periods of human embryogenesis is the introduction of the embryo into the uterine wall on the 7th day. The first phase of gastrulation occurs in the embryoblast during this period. How is this process carried out?

A. Epibolia;

B. Migration;

C. Delamination;

D. Invagination;

E. Neurulation.

6. During microscopic examination of the internal female genital organs, which were removed during the operation, an embryo was found built from two blastomeres. Name the place of its localization under the condition of normal development:

A. Ovary;

B. Fallopian tube, near the uterus;

C. Uterine cavity;

D. Abdominal cavity;

E. Ampoule part of the fallopian tube.

7. In the experiment, the rabbit embryo was destroyed by myote. Violation of the development of what structure will be observed in this embryo?

A. Serous membranes;

B. Axial skeleton;

C. Connective tissue of the skin;

D. Smooth muscles;

E. Skeletal muscles.

8. The histological preparation shows the chicken embryo at the stage of differentiation of the mesoderm into somites, segmental legs and splanchnotomes. From what material does the axial skeleton develop?

A. Myotome;

B. Dermatome;

C. Nephrotome;

D. Splanchnotome;

E. Sclerotome.

9. The process of cleavage the zygote ends with the formation of a blastula. What type of blastula is characteristic of humans?

A. Morula;

B. Celoblastula;

C. Discoblastula;

D. Amphiblastula;

E. Blastocyst.

10. Implantation of a human blastocyst begins. What is the name of the period of embryogenesis that begins simultaneously with implantation?

A. Histogenesis;

B. Invagination;

C. Differentiation;

D. Gastrulation;

E. Fragmentation.

11. A man was born in a shirt." What kind of "shirt" is this proverb talking about?

A. Amniotic;

B. Yolk;

C. Serous;

D. Chorial;

E. Trophoblastic.

12. In the experiment, the embryo of a bird was destroyed by sclerosis. Violation of the development of which structure will be caused by this manipulation?

A. Axial skeleton;

B. Connective tissue of the skin;

C. Stroma of internal organs;

D. Stroma of gonads;

E. Chords.

13. During gastrulation, the embryo passes from a histiotrophic to a hematotrophic method of nutrition. Which pharmacological organ provides this for the first time?

A. Amnion;

B. Trophoblast;

C. Yolk sac;

D. Chorion;

E. Allantois.

14. The antigen of tissue compatibility is inherited by the child from the father and mother. It is known that the expression parental antigens in embryogenesis begin too early. But the mother's immune system does not reject the embryo. Which pharmacological organ prevents the rejection of the embryo by the mother's body for the first time?

A. Amnion;

B. Chorion;

C. Allantois;

D. Yolk sac;

E. Umbilical cord.

15. A violation of endoderm differentiation was found in the embryonic material. Changes in the development of which organs can occur in this case?

A. Aorta;

B. Heart;

C. Kidneys;

D. Stomach;

E. Salivary glands.

16. During the formation of the human embryo, it is possible to observe the appearance of a cavity in its composition, light small blastomeres on the periphery and dark large blastomeres on one of the poles. What is the name of the embryo at this stage of development?

A. Morula;

B. Blastocyst;

C. Zygote;

D. Gastrula;

E. Germ disk.

17. During the forensic examination of a woman who died in a car accident, an embryo was found at the stage of early gastrula. Name the place of its localization under the condition of its normal development.

A. Ovary;

B. Ampoule part of the oviduct;
C. Uterine part of the oviduct;
D. Uterine wall;
E. Abdominal cavity.

18. In the period of early gastrulation of a person, ecto and endoderm are formed. By what mechanism are these sheets formed?

A. Delamination;
B. Invagination;
C. Epibolia;
D. Immigration;
E. Invagination, epibolia.

19. A human embryo was found in the uterine cavity, not attached to the endometrium. What stageof development is responsible for this placement of the embryo?

A. Zygotes;
B. Blastocysts;
C. Morula;
D. Gastrules;
E. Neurules.

20. In the first critical period in the fallopian tube, for an unknown reason, the fertilization shell dissolved in the embryo. What complication of pregnancy is possible in this case?

A. Death of the embryo;
B. Implantation of the embryo into the tube wall;
C. Invagination of the blastocyst wall;
D. Return of the blastocyst back to the ampullary zone of the tube;
E. Formation of two blastocysts;

21. Through the female genital tract, spermatozoa move towards the egg against the fluid (distant stage of fertilization). What is the name of this direction of movement?

A. Chemotaxis;
B. Thermotaxis;
C. Rheotaxis;
D. Capacitation;
E. Acrosomal reaction.

22. Implantation of the embryo into the uterine mucosa consists of two phases of adhesion and invasion. First phase is accompanied by:

A. Attachment of the blastocyst to the surface of the endometrium;

B. Destruction of connective tissue of the endometrium;

C. Destruction of epithelial cells of the mucous membrane (endometrium) of the uterus;

D. Activation of uterine gland secretion;

E. Suppression of uterine gland secretion.

23. In human embryogenesis, on the 20th day, the embryo body is separated from the pharmacological organs. What provides this process?

A. Overall;

B. Amniotic fold;

C. Trunk fold;

D. Yolk stalk;

E. Somites.

24. When examining the amniotic fluid obtained during amniocentesis (puncture of the amniotic membrane), cells were found whose nuclei contain sexual chromatin (Barr's body). What of the above can this indicate?

A. Polyploidy;

B. Male fetal development;

C. Genetic disorders in fetal development;

D. Trisomy;

E. Female fetal development.

25. In the preparation of a 10-day human embryo, 2 sacs are visible, which are in contact with each other (amniotic and yolk). What is the name of the structure that lies at the place of their contact?

A. Germ shield;

B. The bottom of the amniotic vesicle;

C. The roof of the yolk sac;

D. The amniotic pedicle;

E. Extra-embryonic mesoderm.

26. The preparation shows an ovocyte at the time of fertilization by its sperm. What is the main result of fertilization?

A. Cortical reaction;

B. Determination of the sex of the chil;

C. Completion of meiosis by ovocyte;

D. Penetration of ovolemma by sperm;

E. Zygote formation.

27. The histological preparation shows an extra-embryonic organ, which is abubble connected to the intestinal tube. Its wall is exiled from the inside by the epithelium, from the outside it is formed by connective tissue. In the early stages of embryogenesis, it performs the function of a hematopoietic organ. Name this organ.

A. Placenta;

B. Allantois;

C. Amnion;

D. Umbilical cord;

E. Yolk sac.

28. The implantation process takes place in two stages: adhesion and invasion. The morphological manifestation of the blastocyst adhesion process is:

A. Attachment of the blastocyst to the endometrium;

B. Destruction of the endometrial epithelium;

C. Destruction of endometrial connective tissue;

D. Destruction of endometrial vessels;

E. Formation of lacunae.

29. In the early stages of human embryo development, a finger-shaped outgrowth of the ventral wall of the primary intestine arises, which grows into the amniotic pedicle. What is the name of this pharmacological organ?

A. Placenta;

B. Yolk sac;

C. Amnion;

D. Allantoi;s

E. Umbilical cord.

30. The histological preparation shows a cross-section of the organ, the basis of which is formed by the mucous connective tissue, two arteries and a vein. What is this organ?

A. Umbilical cord;

B. Allantois;

C. Yolk sac;

D. Amnion;

E. Placenta.

31. A histological section of the human embryo shows a vesicle connected to the intestinal tube, which is one of the pharmacological organs. Primary germ cells and primary erythrocytes (megaloblasts) are located in its wall. Determine which is the pharmacological organ?

A. Umbilical cord;

B. Allantois;

C. Placenta;

D. Yolk sac;

E. Amnion.

32. In the process of embryogenesis, the formation of the anterior part of the primary intestine was damaged. Specify the possible localization of developmental abnormalities?

A. Liver;

B. Stomach;

C. Oral organs;

D. Pancreas;

E. Small intestine.

33. The woman had the flu and it turned out that it happened during the early phase of gastrulation. What consequences can be expected?

A. Violation of mesoderm formation;

B. Disruption of ecto- and endoderm formation;

C. Disruption of mesenchyma formation;

D. Violation of the epibolia process;

E. Violation of the invagination process.

TEST TASKS IN EMBRYOLOGY

Progenesis

1. What organoid is the egg devoid of?

1) endoplasmic reticulum;
2) centrosomes;
3) lysosomes;
4) ribosomes.

2. Which general-purpose organoid is modified in the sperm, if it is damaged, fertilization is impossible?

1) endoplasmic network;
2) mitochondria;
3) Golgi complex;
4) lysosomes.

3. What inclusions are contained in the egg?

1) trophi;
2) secretory;
3) excretory;
4) pigmented.

4. Which components of the egg cytoplasm provide the formation of different types of eggs?

1) organoids of the general value of the membrane structure;
2) special purpose organoids;
3) inclusions;
4) organoids of general significance of non-membrane structure.

5. Which components of the egg cytoplasm are yolk granules?

1) lysosomes;
2) peroxisomes;
3) ribosomes;
4) inclusions.

6. Which organoid of special significance does the sperm have?

1) microvilli;
2) myofibrils;
3) flagellum;
4) neurofibrils.

7. Determine the formula of the sperm flagellum?

1) (9×3)+0;
2) (9×2)+2;
3) (8×3)+1;
4) (8×3)+0.

8. Which general-purpose organoid does the sperm acrosome belong to?

1) peroxisome;
2) lysosome;
3) ribosome;
4) Golgi complex.

9. Determine the set of chromosomes in the sperm?

1) diploid;
2) haploid;
3) tetraploid;
4) multiploidy.

10. Determine how long a human egg spends its reserve of nutrients after ovulation, and then dies if there is no fertilization?

1) 12–24 minutes;
2) 12–24 hours;
3) 12–24 days;
4) 24–28 days.

11. Determine the type of amphibian egg (frog)?

1) primary isolecital;
2) secondary isolecital;

3) moderately telolecital;
4) sharply telolecital.

12. What type of egg do birds have?

1) primary isolecital;
2) secondary isolecital;
3) moderately telolecital;
4) sharply telolecital.

13. What type of egg does a person have?

1) primary isolecital;
2) secondary isolecital;
3) moderately telolecital;
4) sharply telolecital.

14. Determine the speed of movement of the human sperm?

1) 1–5 mm per minute;
2) 1–5 cm per minute;
3) 1–5 meters per minute;
4) 1–5 mm per second.

15. For how long do human spermatozoa retain their fertilizing ability?

1) 24–36 seconds;
2) 24–36 minutes;
3) 24–36 hours;
4) 4–6 days.

16. How long does the process of spermatogenesis in humans last?

1) 75 seconds;
2) 75 minutes;
3) 75 hours;
4) 75 days.

17. What period of spermatogenesis does spermiogenesis belong to?

1) breeding season;
2) growth period;
3) maturation period;
4) formation period.

18. At what stage of the growth period does a spermatocyte of the first order contain a tetraploid set of chromosomes?

1) leptogenic stage;
2) zygote stage;
3) pachinema stage;
4) diplonema stage.

19. What stage of gametogenesis is absent in ovogenesis?

1) reproduction;
2) growth;
3) maturation;
4) formation.

20. At what stage of gametogenesis are the reduction corpuscles formed?

1) reproduction;
2) growth;
3) maturation;
4) formation.

21. Determine the set of chromosomes in the zygote?

1) haploid;
2) diploid;
3) tetraploid;
4) multiploidy.

22. What is a zygote?

1) single-celled embryo;
2) two-cell embryo;

3) single-layer embryo;
4) two-layer embryo.

23. By the formation of which shell does the egg protect itself from the penetration of other spermatozoa?

1) serous membrane;
2) amniotic membrane;
3) fertilization shells;
4) follicular membrane.

24. Which sperm organoid contains enzymes (trypsin, hyaluronidase) that destroy egg shells?

1) centrosome;
2) acrosome;
3) lysosome;
4) ribosome.

25. Define what is a syncarion?

1) splitting;
2) epibolia;
3) prominence;
4) fusion.

26. Define what is penetration?

1) rotation;
2) splitting;
3) intrusion;
4) fusion.

27. Determine the duration of the first stage of embryogenesis – fertilization in humans?

1) 1-hour;
2) 10 hours;
3) 24 hours;
4) 36 hours.

28. What is formed in the egg in the area of attachment of the sperm?

1) primary tubercle;
2) the tubercle of perception;
3) the Gensen knot;
4) primary nodule.

29. Determine the isolecital egg?

1) the egg contains a lot of yolk in the center;
2) the egg has a lot of yolk on the vegetative pole;
3) the egg contains a lot of yolk on the animal pole;
4) the egg contains little yolk, evenly distributed throughout the cytoplasm.

30. Determine the telolecital egg?

1) the egg contains a lot of yolk in the center;
2) the egg contains a lot of yolk at the vegetative pole;
3) the egg contains a lot of yolk on the animal pole;
4) the egg contains little yolk, evenly distributed throughout the cytoplasm.

STAGES OF EMBRYOGENESIS

1. Determine the second stage of embryogenesis – cleavage and formation of a blastula?

1) A complex process of chemical and morphological changes, resulting in the formation of germ leaves.
2) Fusion of male and female germ cells, resulting in the formation of a zygote.
3) Multiple mitotic division of the zygote, in which there is no growth period.
4) Differentiation of embryonic rudiments with the formation of tissues and organs.

2. Determine the type of cleavage of the human zygote?

1) Complete even;
2) Complete uneven;
3) Incomplete discoidal;
4) Incomplete surface.

3. Determine the third type of embryogenesis – gastrulation?

1) A complex process of chemical and morphological changes, resulting in the formation of germ leaves;
2) Fusion of male and female germ cells, resulting in the formation of a zygot;.
3) Multiple mitotic division of the zygote, in which there is no growth period;
4) Differentiation of embryonic rudiments with the formation of tissues and organs.

4. As a result of what processes two – or three-layer embryos are formed?

1) Fertilization;
2) Cleavage;
3) Gastrulation;
4) Histogenesis.

5. An embryo consisting of an even number of blastomeres having the same size is visible on the preparations. Determine what type of cleavage is characteristic of this embryo?

1) Complete even;
2) Complete uneven;
3) Incomplete discoidal;
4) Incomplete surface.

6. In the embryo, fragmentation is noted only at the animal pole. What is the name of this type of cleavage?

1) Complete even;
2) Complete uneven;
3) Incomplete discoidal;
4) Full synchronous.

7. As a result of cleavage, micro – and macroblastomeres are formed in one embryo. Determine the type of cleavage?

1) Complete even;
2) Complete uneven;
3) Incomplete discoidal;
4) Incomplete surface.

8. On the preparation of a blastula with a multilayer blastoderm. The blastocele is located eccentrically. Determine the type of blastula?

1) Celoblastula;
2) Amphiblastula;
3) Discoblastula;
4) Blastocyst.

9. On the preparation of a blastula with a single-layer blastoderm. The blastocele is located in the center. Determine the type of blastula?

1) Celoblastula;
2) Amphiblastula;
3) Discoblastula;
4) Blastocyst.

10. On the preparation, a multilayer blastula is a germ disk spread out on the yolk. Determine the type of blastula?

1) Celoblastula;
2) Amphiblastula;
3) Discoblastula;
4) Blastocyst.

11. In the experiment, a substance blocking the movement of cells was introduced at the blastula stage. What stage of embryogenesis will be blocked?

1) Fertilization;
2) Cleavage;
3) Gastrulation;
4) Histogenesis.

12. Which of the listed representatives has gastrulation performed by epiboly (fouling)?

1) Lancet;
2) Amphibian;
3) Birds;
4) Person.

13. In the experiment, the process of cell movement through the primary strip was blocked in the embryo of a bird at the gastrula stage. The development of which germ leaf will be disrupted?

1) Ectoderm;
2) Endoderm;
3) Mesoderm;
4) Mesenchyme.

14. On the preparation of a blastula, in which a trophoblast and an embryoblast are distinguished. Determine the type of blastula?

1) Celoblastula;
2) Amphiblastula;

3) Discoblastula;
4) Blastocyst.

15. In the experiment, the embryo of a chicken disrupted the process of fusion of amniotic folds. The formation of which pharmacological body will be disrupted?

1) Yolk sac;
2) Allantois;
3) Amnion;
4) Chorion.

16. In an experiment, an extra-embryonic endoderm was damaged in a chicken embryo. The formation of which pharmacological body will be disrupted?

1) Yolk sac;
2) Amnion;
3) Serous membrane;
4) Chorion.

17. In an experiment, an extra-embryonic ectoderm was damaged in a chicken embryo. The formation of which pharmacological body will be disrupted?

1) Yolk sac;
2) Allantois;
3) Amnion;
4) Chorion.

18. During the development of the embryo, the pharmacological organ performing trophic and hematopoietic functions is damaged. What is the name of this organ?

1) Serous membrane;
2) Amnion;
3) Allantois;
4) Yolk sac.

19. During the development of the embryo, the pharmacological organ that performs the function of isolating metabolites is damaged. What is the name of this organ?

1) Serous membrane;
2) Amnion;
3) Allantois;
4) Yolk sac.

20. What is the name of the pharmacological respiratory organ?

1) Serous membrane;
2) Amnion;
3) Allantois;
4) Yolk sac.

21. During the development of the embryo, the pharmacological organ is damaged, which performs a protective function – the creation of an aquatic environment favorable for the free development of the embryo. What is the name of this organ?

1) Serous membrane;
2) Amnion;
3) Allantois;
4) Yolk sac.

22. On the preparation of the human embryo, the process of separating the embryo material from the emerging pharmacological organs is visible. With the help of what structure is this process going on?

1) equatorial furrow;
2) Tangential furrow;
3) Amniotic fold;
4) Bodies folds.

23. The experimenter destroyed myotome cells in the embryo. Which tissue development will be affected by this damage?

1) Epithelial;
2) Connecting;

3) Muscle;
4) Nervous.

24. The developing embryo was destroyed by a nephrotome. Which system's development will be disrupted?

1) Respiratory;
2) Endocrine;
3) Nervous;
4) Excretory.

25. The developing embryo was destroyed by sclerosis. On the development of which tissue will this affect in this body?

1) Epithelial;
2) Bone;
3) Muscle;
4) Nervous.

26. The developing embryo was destroyed by a dermatome. Which tissue development will be affected by this damage?

1) Epithelial;
2) Connecting;
3) Muscle;
4) Nervous.

27. The cell material of the primary nodule was destroyed in the developing embryo. Which tissue development will be affected by this damage?

1) Epithelial;
2) Connecting;
3) Muscle;
4) Nervous.

28. The developing embryo was destroyed by splanchnotome. What structures will be disrupted in this organism?

1) Skin;
2) Bone;

3) Pleura;
4) Trachea.

29. Violation of which stage of embryogenesis causes the birth of identical twins?

1) Fertilization;
2) Cleavage;
3) Gastrulation;
4) Histogenesis.

30. Which tissue develops from the mesenchyme?

1) Smooth muscle tissue;
2) Skeletal muscle tissue;
3) Cardiac muscle tissue;
4) Nerve tissue.

31. On a histological preparation, a human egg cell, in the cytoplasm of which there is a small number of yolk inclusions distributed evenly. What type of egg?

1) Primary isolecital;
2) Secondary isolecital;
3) Moderately telolecital;
4) Sharply telolecital.

32. A cavity forms in the human embryo and differentiation of blastomeres occurs. At what stage of development is the embryo?

1) Zygote;
2) Blastocyst;
3) Gastrula;
4) Neurula.

33. "A man was born in a shirt". What kind of "shirt" does the proverb say?

1) Fertilization shell;
2) Shiny shell;
3) Amniotic membrane;
4) Corona radiate.

34. The cellular material of the human embryo becomes two-layered. What is the stage of embryogenesis?

1) Fertilization;
2) Cleavage;
3) Gastrulation;
4) Histogenesis.

35. In the embryo of a person, the process of separating his body from the pharmacological organs is recorded. The formation of which structure leads to this?

1) Amniotic fold;
2) Bodies fold;
3) Fertilization shell;
4) Shiny shell.

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