Ministry of health Republic of Belarus
Establishment of education "Gomel state medical university"

Department of histology, cytology and embryology

MANUAL
for 1-st year students of faculty of foreign students on gynecology

Topic: 3:
GENERAL EMBRYOLOGY (GERM CELLS, FERTILIZATION, CLEAVAGE)

Duration 4 hours

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THE MOTIVATIONAL CHARACTERISTIC OF THE THEME

Embryology – the scientific base of many medical disciplines: obstetrics, pediatrics, gynecology. In medical high school embryology includes bases of the general, (comparative) embryology and bases embryology developments of mammals and the person.

The knowledge of the general embryology is necessary for understanding of the main laws of embryology developments, its specific features at various representatives of fauna in connection with various conditions of their life and duplication. Studying of bases эмбрионального developments is important for understanding of sources and mechanisms of becoming of tissues and organs, the adult person. Embryological knowledge is necessary to the future doctor for rational preventive maintenance of anomalies and defects. Developments of fetus, and also for the prevention of adverse influences. Factors of environment and life on current of pregnancy.

THE PURPOSE

To study a structure of male's and females sexual cells formation, fertilization, cleavage.

PROBLEMS

The student should know:

1) Features of development of male and female sexual cells.

2) Micro- ultramicroscopic structure of sperm, classification, micro-ultramicroscopic structure of ovum.

3) Stages of process of fertilization and cleavage of zygote.

4) Various types of cleavage of a zygote and various types blastocyte.

Should be able:

1) To define under a microscope sexual cells and their structural components.

2) To explain stages of development of germs layers and to their feature depending on a structure ovum.

REQUIREMENTS TO THE INITIAL LEVEL OF KNOWLEDGE

For full mastering a theme it is necessary for student to repeat from medical biology and genetics prognosis and early embryologenesiss.

CONTROL QUESTIONS FROM RELATED SUBJECTS

1) The Structure and development of sexual cells. Meiosis as process of formation of sexual cells.

2) Types of oocyte.

3) Fertilization, zygote.

4) Cleavage and its types.

CONTROL QUESTIONS ON THE THEME

1) Sexual cells. The morphological and functional characteristic. A role in transfer of the genetic information.

2) Spermatogenesis. Structure of sperm.

3) Oogenesis. Oocyte, structure and classification.

4) Fertilization, its biological essence. Zygote.
5) Cleavage. Types.

THE PRACTICAL PART

1) The Scheme and structure of sperm – to enter designations (Exercise № 1 in an album)
2) The Scheme of a structure ovum – to enter designations (Exercise № 2 in an album)
3) The Scheme of a stage of fertilization and the beginning of crushing – to enter designations (Exercise № 3 in an album)
4) In the table-scheme «The comparative characteristic embryogenesis to enter types of oocyte, cleavage. (Exercise № 4 in an album)
5) Studying diagrams

SLIDES

1. Sperme
2. Ovum
3. Cleavage
4. Blastocyst

QUESTIONS FOR SELF-CHECKING KNOWLEDGE

1) Write down in copybook the basic periods of development of a germ, briefly having noted essence of each of them.
2) Having studied process of cleavage, briefly formulate and write down than cleavage from mitosis divisions of a cell? From what the type of cleavage depends
3) Parts of blactocyst.
4) The features of cleavage and its characteristic.

GENERAL EMBRYOLOGY (GERM CELLS, FERTILIZATION, CLEAVAGE)

Embryology is the science about embryonic development of the individual.

Medical embryology studies human embryonic development, causes of its failures, influence of exogenic factors on embryogenesis and mechanisms of its regulation.

Embryogenesis , as part of ontogenesis, includes the time between fertilization and birth.

The process of embryo development involves many processes, namely cell *division, migration, growth, induction and differentiation,* which more or less depend upon each other.

Human embryogenesis is divided into three periods: initial period ($Г^1$ week), embryonic period (2^{nd}-8^{th} week), and fetal period (9^{th} week until birth) [1].

Basic Human Embryogenesis stages are similar to another vertebrates.

Early:

1. Fertilization, which results in zygote formation
2. Cleavage, which results in blastula formation.

3. Gastrulation, which results in formation of the germ layers.

4. Notogenesis, which results in formation axial buds complex

Late:

5 Histogenesis and organogenesis. During this stage the tissues, organs and organ systems are formed.

Many embryologists refer the formation of reproductive cells – progenesis -- to embryogenesis.

Gametogenesis is a process of sex cell formation. There are spermatogenesis (spermatozoa formation) and ovogenesis (ovicell formation). The development of sex cells in embryogenesis happens early in development. They appear at the end of *3′* week of embryogenesis in extraembryonic yolk entoderm and later migrate to the gonads. These cell are called gonoblasts.

Spermatogenesis

There are 4 phases of the spermatogenesis: mitotic phase, growth period, meiotic phase and spermiogenesis. Spermatogonia are the first cell of the spermatogenesis. They arise from gonoblast. During 1 phase diploid spermatogonia divide some times and are transformed into spermatocyte I. Then spermatocyte I enlarge their size up to 4 times (growth period).

Spermatocytes I enter meiotic phase, which consist of two following divisions (meiosis I and meiosis II),

Meiosis J is called reduction division, because it leads to chromosome number reduction and formation of haploid chromosome set. Spermatocytes II form.

Meiosis II is also called equation division. It is resemble ordinary mitosis. It results in spermatids formation. Spermatids, as spermatocytes II, have haploid chromosome set, each chromosome is presented by one chromatid.

Spermiogenesis is longest phase. It results in spermatozoa formation from spermatids. It lasts for about 50 days. The process begins from formation of acrosome, which contain enzymes to dissolve coats of the ovum. The centrosome moves on the opposite pole. The proximal centriole lies close to the nucleus, whereas a distal centriole divides on two parts. From one of them the flagella is formed. The second plays a role of basal body. The sperm cytoplasm is subject to reduction. The nucleus elongates and become more compact.

Ovogenesis

In general it similar spermatogenesis, but it has its particular features. Mitotic phase lasts

during early ontogenesis in the ovarium. At the end of embryonic development the number of oogonia is around 7 millions. After birth the division is terminated and all oogonia are transformed to oocytes I. These oocytes I are blocked on a stage of diplotene of first meiotic division.

Then oocytes I enter the long growth period. It is subdivided into period of small growth (from birth to sexual maturation) and period of large or rapid growth (it happens regulary during each month). Thus the growth period may last 12-50 years. The meiotic phase starts just before ovulation. The first meiotic division results in formation of oocyte II and reduction body. In it turn reduction body may split on two. Oocyte II is blocked in

metaphase of meiosis II. Further maturation is induced by fertilization. Oocyte II splits on ovicell and reduction body. As result of maturation we have three reduction body and one ovicell. Ovicell loses its centrioles. The reduction bodies are phagocyted by other cells [1, 2]

Spermatozoon (sperm).

The mature human sperm is a highly specialized cell. It consists of a head, a neck, a middle piece and a tail. This is a very small cell about 60 micrometers long. There is a big dense nucleus. The nucleus coat hasn't pores. The genetic material is haploid and contains 22 autosomes and 1 sex chromosome (X or Y). The cytoplasm is reduced.

The head is capped by the acrosomal cap. Acrosome is a derivate of coplex Golgi and has similar structure as lysosome.

The neck contains a proximal centriole. The acsonemm passes through middle piece and the tail. It consist of two central microtubules and nine outer doublet microtubules. The middle piece also contains mitochondrial sheath.

With help of the tail movements the spermatozoa are able to move with the speed 1-5 mm per second.

Ovum (egg, oocyte !!) is a big round haploid cell about 130 micrometers in diameter. It is surrounded by noncellular covering zona pellucida and by layer of follicular cells (corona radiate).

The cell has all organells but only one centriole. The cell gets another centriole from the sperm during fertilization.

There are many inclusions (pigment and yolk or lecithin). Type of the human ovum with the small amount of yolk inclusions distributed throughout the cytoplasm is called secondary *isolecithal* and *oligolecithal* type of an ovum.

Complex of ovicell membrane and cytoplasm layer just under it is called *cortical layer*. This layer contains granules with several enzymes, which can change properties of zona pellucida after fertilization .The ovicells have very good developed cytoskeleton [1, 2].

Fertilization

The development of organism begins from one cell, called **zygote.** The zygote appears as a result of the fusion of the mature gametes. This process is *called fertilization.*

The fertilization happens in the uterine tube, where the ovum enters from the ovary, and consists of two phases – distant phase and contact phase.

In time of *distant phase* sperms and ovum produce physiological active substances, which are necessary for distant interaction, for stimulation of the sperms moving and gametes meeting.

Note the following: the sperms get the ability to fertilize the ovum only after they have been in the female genital tract. This final step in their maturation is called *capacitation,*

The second phase of fertilization is *contact phase* when the sperm and the ovum fuse. To perform fertilization process it is nessesary to have at least 200 millions spermatozoa. If there are less than this amount ferilization can not be performed because of lack of proteolytic enzyme activity.

A few hundreds of the sperms from millions reach the ovum, but only one, which has maximum activity, goes across corona radiate, surrounding the ovum. Then sperm's acrosomal cap is shed and the enzymes are released from the acrosome. This process is called the *acrosomal reaction.* The enzymes make a local lysis in the follicular cells layer and zona pellucida, after that the sperm's head penetrates the ovum membrane and sinks into the cytoplasm. Only the head with nucleus and proximal centriole sink. The middle piece and the tail don't penetrate into ovum.

The membrane of the ovum overlying the region of the sperm head fuses. After that another sperms cannot penetrate the ovum. There are several mechanism of polyspermia blocking.

l.The cortical reaction in the ovicell that lead to liberation of cortical layer enzymes, which change zona pellucida making it unpermeable to spermatozoa and transform to *cover of fertilization.*

2. The enzymes also degrade ZP2 and ZP3 receptors and block acrosome reaction of spermatozoa.

3. Also after fertilization the charge of cytoplasm of ovicell is changed to negative. And negative charged spermatozoa are repulsed from it [2].

The condition of the fertilized ovum, when it has two pronuclei (nucleus of a sperm and nucleus of an ovum) is called *syncaryon.* Pronuclei draw together and fuse.

So, in summary, fertilization properly consists of the entry of the sperm's head into the ovum. This is followed by the fusion of the male and female pronuclei to restore the diploid number of chromosomes.

The process of fertilization leads to formation of the *zygote* and ends with the initiation of its cleavage.

Cleavage

Cleavage is the quickly mitotic segmentation of the zygote, resulting to formation of multicellular unilayer embryo.

The cell are divided very quickly because G_1 period absence and do not grow. So the total size of embryo is the same during cleavage (C*overor* membrane *of fertilization prevents it also),* but the cells become smaller and smaller. It change relationship between the volume of nuclear and cytoplasmic material. The correlation between the nucleus and cytoplasm of an ovum is one to ten, while each somatic cell has correlation one to three.

The type of cleavage depends upon amount of the yolk. That's why the human cleavage is complete (all zigote material is subject to division) , unequal (cells have different size) and asynchronic (cells divide at the different time).

The cells which appear during the cleavage are called *blastomeres.*

Embryo passes down the uterine tube. The stage of 12- 16 cells is called a *morula which* is similar to a mulberry. Soon morula appears in the uterus. Then the cavity forms between blastomers.

At 7-th day the morula is transformed into *blastula.* The human blastula is termed a *blastocyst.*

Blastocyst consist of:

– outer cells – *trophoblast,* which further differentiates to chorion and placenta, so provides the nutrition to the embryo.

– aggregation of the bigger, ducker blastomers at one pole – *embryoblast,* which serves for embryo body formation and the last extra embryonic organs.

– *blastocoele*- cavity of the blastocyst.

Eventually the membrane of fertilization disappears and the blastocyst becomes attached to the uterine wall. The trophoblast begins produce the enzymes to lysis of inner uterine membrane. In the result the embryo sinks into the substance of the uterine wall. This process is called the implantation and happened on the 6-7 days of embryogenesis [1, 2].

REFERENCES

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