MINISTRY OF HEALTH CARE OF THE REPUBLIC OF BELARUS

GOMEL STATE MEDICAL UNIVERSITY

Chair of Medical Biology and Genetics

GUIDANCE OF MEDICAL BIOLOGY AND GENETICS. CYTOLOGY

Laboratory course of medical biology and genetics for foreign students in English medium

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Представлены методические рекомендации по медицинской биологии и генетике, раздел «Цитология», для проведения практических занятий со студентами факультета по подготовке специалистов для зарубежных стран, которые занимаются на английском языке. Изучение методик практических занятий, включенных в данные методические рекомендации, позволит закрепить полученные знания.

Утверждено и рекомендовано к изданию Центральным учебным научно-методическим советом учреждения образования «Гомельский государственный медицинский университет» 12 февраля 2008 г. протокол № 2

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INTRODUCTION

The practical guidance has been developed for practical classes of medical biology and genetics with students of the Department of General Medicine for Foreign Students, who study medicine in English. The content of the guidance meets the Program of Medical Biology and Genetics for students of higher medical schools № 08–14/5941, approved by Ministry of Health Care of the Republic of Belarus on September 3, 1997.

One of the difficulties in organization of educational process of medical biology and genetics with students of faculty on preparation of experts for the foreign countries (training in English) is absence of the educational and methodical literacomments upon this guidance, as it will be taken as a wish to help us in its impture adapted to the curriculum of medical biology and genetics. Therefore one of the major tasks facing to teachers of faculty is compiling and translation of the given methodical recommendations into English.

Authors will be grateful to everyone who will make any modification in case of reediting of the practical guidance

ВВЕДЕНИЕ

Методическое пособие предназначено для проведения практических занятий по медицинской биологии и генетике со студентами факультета по подготовке специалистов для зарубежных стран, обучающихся на английском языке. Материал пособия соответствует Программе по медицинской биологии и генетике для студентов высших медицинских учебных заведений № 08–14/5941, утвержденной Министерством здравоохранения Республики Беларусь от 3 сентября 1997 г.

При организации учебного процесса по медицинской биологии и генетике со студентами факультета по подготовке специалистов для зарубежных стран, обучающихся на английском языке, одной из трудностей является отсутствие учебно-методической литературы, адаптированной к учебной программе по медицинской биологии и генетике. Поэтому одной из важнейших задач, стоящих перед преподавателями кафедры, является составление и перевод на английский язык данных методических рекомендаций.

Авторы будут весьма благодарны всем, кто сочтет возможным высказать свои критические замечания в адрес предлагаемых методических рекомендаций, которые будут восприняты как выражение желания оказать помощь в его улучшении при последующем переиздании.

CELLULAR LEVEL OF LIFE ORGANIZATION

TOPIC 1. CELL IS AN ELEMENTARY UNIT OF LIFE. METHODS OF THE STUDYING OF CELL

The cell is an elementary structural, functional and genetic unit of life. It provides exchange processes, growth and development, duplication, heredity and homeostasis. Knowledge of the structural and functional organization of the cells of prokaryotes and eukaryotes, of the continuity and variety of living systems is necessary for representation about unity.

The received knowledge and skills are necessary for students studying histology, normal and pathological physiology, pathological anatomy, biochemistry, pharmacology, internal illnesses.

The purpose of the studies is to know:

- features of the structure of prokaryotic and eukaryotic cells;
- the basic methods of studying of cells;
- the variety of forms of cells and nucleus;
- substantive provisions and values of the modern cellular theory.

Control questions on the topic

1. The cytology as a science, its role in biology.
2. Cell theory, the basic stages (M. Shleiden, T. Shwann, R. Virchow). Contemporary statements.
3. Cell as an elementary, genetic, structural and functional biological unit.
4. Features of the structure of prokaryotic and eukaryotic cells.
5. Methods of studying of cells: histological, histochemical, microscopical ones (light, phase-contrast, dark-field illuminative, ultraviolet, electronic microcopies).
6. The structure of light microscope. Main rules during the work with the microscope.

Structure of a microscope

The microscope consists of 3 parts: mechanical, optical and lighting.

The mechanical part includes: a tube holder, a support, a tube, a revolver, a little objectve table, screws to move a little table and a preparation.

The optical part: sets of eyepieces which are inserted into a tube, and sets of objectives which are screwed into the jacks of the revolver.

The lighting part: a plano-concave mirror, an optical filter, a condenser and a diaphragm.

Rules of work with the microscope at small increase (an objective 8×)

1. Before the beginning of work to check up the accuracy of a microscope. It is forbidden to unscrew the eyepieces and objectives.
2. To place a microscope on a working place to the left from the edge of a table for the width of 10 cm.

3. To lift the condenser on a level of a subject table, to open the diaphragm.

4. To lead an objective of small increase (8×) to the cone up to the click by moving the revolver.

5. To place an objective on distance of 1 cm from the physical table.

6. To illuminate a field of vision by turning a mirror. Fingers should be placed on lateral sides of the mirror. Since that moment a microscope should be moved away.

7. To take a preparation from the box (to hold by lateral surfaces), to determine a face sheet, to consider a preparation on light and to find out the location of an object. To put a preparation on the physical table (a face sheet should be upwards), the object should be in the center of the physical table.

8. To lower an objective of small enlargement to the distance of 0.5 cm by observing from one side with the help of the screw.

9. To lift the cone by moving the macrometric screw and looking in an eyepiece till a clear-cut image appears.

10. To put in the center of a field of vision interesting parts of an object and to start studying and sketching it.

11. To lift an objective upwards on 2–3 cm upon termination of work, a preparation should be replaced to a box.

Practical part of employment

1. Studying the structure of a light microscope and rules of work on a big and small increase.

2. To study micro preparations (with a sketch).

— «The cell of a thin skin of an onions» (56×).

— «Blood of a frog» (280×).

— «Blood of the person» (630×).

3. Study micropreparations without a sketch.

— «Single-layered epithelium».

— «Nervous cells».

— «Ciliary epithelial cells».

TOPIC 2. THE BIOLOGY OF THE CELL

The cell is structure in which all the properties of living matter are supported, inherited and also transmitted in a number of generations. The cell is an elementary structural functional and genetic unit of all living forms. Knowledge of features of a structure of eukaryotic cells and basic functions of its organelles is necessary for students studying histology, normal and pathological physiology, pathological anatomy, at work of the doctor of general practice, the doctor-diagnostician.

The purpose: study structural components of eukaryotic cells, their structure and functions.

Control questions on the theme of employment

1. The structural elements of cell
2. The cytoplasm :

— the cell membrane , its structure and function;
— the hyaloplasm, its structure and properties;
— the organelles of general purpose, functional characteristic;
— the organelles of special purpose, functional characteristic;
— cytoplasmic inclusions, its classification and value.

3. The nucleus, its structure in the eukaryotic cell. Nucleus-cytoplasmic relationships as an index of functional state of the cell.
4. Morpho-functional traits of chromosomes. Types and rules of chromosomes.
5. Karyotype. Idiogram. Characteristics of the human karyotype. Denver and Paris classifications of the human chromosomes.

Practical part of employment

1. To study micro preparations (with a sketch).

— «Lamellar complex in nervous cells of a cat» (630×).
— «Mitochondria in cells of liver mammalia » (630×).
— «Centrosome in crushed ovum of ascarid » (630×).
— «Fatty inclusions in cells of a liver » (280×).

2. To lead karyotype a chromosomal complement of the person under the individual task.
3. To study of electrophotogrammes of the cell (without a sketch).

MOLECULAR–GENETIC LEVEL OF LIFE ORGANIZATION

TOPIC 3. THE ESSENCE OF LIFE. MOLECULAR–GENETIC LEVEL OF LIFE ORGANIZATION

Studying of life begins with a molecular-genetic level. Its structural unit is a code of the hereditary information, and the elementary phenomenon is a replication of codons and a transcription.

The purpose:

- to acquaint with a structure and functions of nucleic acids;
- to know a genetic code and its properties;
- to study levels of DNA packing in a chromosome.

Control questions on the theme of employment

1. The essence of life. Fundamental properties of life. Life organization levels.
2. Organization of genetic material in the non-cellular forms of life, prokaryotes and eukaryotes.

3. Structure of DNA. Chargaff rules. Watson's and Crick's postulates. Autoreproduction of DNA, its types.

4. Structure of RNA, types of RNA. RNA synthesis, its stages (primary transcript, processing, splicing).

5. Gene — a fragment of the genome nucleic acid. Spacers (transcribed and non-transcribed). Repeating sequences of nucleotides. Excessive genes.

6. Genetic code, its properties.

7. Molecular organisation of chromosomes. The value of histone, non-histone proteins, ions of metals. The structure of nucleosome.

8. Levels of DNA packing (fibril, chromonema, chromatid). Euchromatin. Heterochromatin (facultative, constitutive).

Practical part of employment

1. The solution of tasks on replication of DNA.

a. The sequence of nucleotides in one of the DNA strands is TGATTCAGAATACCA. What is the sequence in another strand?

b. The sequence of nucleotides in one of the DNA strands is AGGCATCATAGCCGA. What is the sequence in another strand?

2. The solution of tasks on a transcription.

a. If the sequence of nucleotides in the DNA molecule is ATTGCTCAA, what will be the sequence of nucleotides in the RNA?

b. What is the sequence of nucleotides in the RNA, if the fragment DNA is ATTCACAGATCCTAGGAGG.

3. The solution of tasks on Chargaff rules.

a. In the DNA the percentage of cytosine nucleotides is 18%. How many other nucleotides are there in this molecule?

b. In the fragment of DNA there are 950 cytosine nucleotides (20%). How many other nucleotides are there in this fragment?

Studying and sketching the micro preparations.

— «Polyten chromosomes of salivary gland of an insect» (280×).

TOPIC 4. A CELL AS AN OPEN SELF-REGULATING SYSTEM

The cell is an open automatically adjusted system, because there is a stream of substance, energy and information in it. These processes provide all vital signs of an organism. The stream of substance is provided by anabolism and catabolism. The major events are synthesis of fiber and ATP in the cell. The stream of energy is submitted by endocellular mechanisms of power supply — photo- and chemosynthesis, fermentation and breath. The internal information of the cell is written down in DNA and transferred during division to daughter cells.

Knowledge of these basic processes on a cellular level is necessary for developing the conception of functioning of systems of an organism normally and pathologically.

Received knowledge and skills are necessary for students in studying histology, normal and pathological physiology, pathological anatomy, biochemistry, pharmacology, internal illnesses.

The purpose:

- To master the conception of a cell as an open automatically adjusted system.
- To open the essence of streams of information and energy in the cell.

Control questions on the topic of employment

1. A cell as an open system. External and internal metabolism in the cell.
2. Membranous transport (active and passive). Osmosis. The effect of isotonic, hypotonic and hypertonic solutions on a plant and animal cells.
3. The organization of energy flow in a cell (photosynthesis, fermentation, cellular respiration). ATP as a common energy currency.
4. The external and internal informational flow in a cell. Coding of the genetic information in a cell.
5. The stream of substance . Protein synthesis, coding of proteins. Photosynthesis.

Practical part of employment

Studying micro preparations (without a sketch).

— «Accumulation of granules of paint in the cells» (630×).

Laboratory work.

1. To study the phenomenon of plasmolysis and deplasmolysis in the cells of a sheet plant (with a sketch).
2. To study influence of hypo- and hypertonic solutions on erythrocytes of a person's blood (with a sketch).

TOPIC 5. THE PHYSIOLOGY OF THE CELL

The knowledge of basic processes occurring in a cell in different stages of mitotic cycle helps to understand the reason of exact distribution of genetic material between daughter cells, and also the mechanism of occurrence of genome and chromosomal mutations. The knowledge of basic stages of meiosis is necessary for understanding the reasons for combinative variability of sexual duplication. It is important to know the basic types and kinds of cell fission in order to understand the ability of metaphytes to regenerate. Studying types of fabrics on ability to proliferate and heal after operative intervention is essential for the doctor, as he can forecast the restoration of a structure and function of the damaged body.

The purpose

- To master and fasten knowledge of basic periods of life cycle of a cell, ways of duplication of cells and their biological value, and also mechanisms of regulation of cell fission.

• To open the essence of a problem of cellular proliferation in medicine.

Control questions on the topic of employment

1. The life cycle of a cell, its periods and essence. Cytogenetic characteristics of a cell nucleus in the interphase.
2. Division of a cell, its types and kinds.
3. The mitosis. Phases, dynamics of distribution of genetic material, biological value.
4. The meiosis. Phases, cytological and cytogenetic characteristics, biological value.
5. The endomitosis and polyteny, mechanisms of occurring, biological value.
6. The amitosis, its types and forms, biological value.
7. The cell proliferation. The problem of cell proliferation in medicine.
8. Neuro-endocrine mechanisms of regulation of the cell division.

Practical part of employment

Studying micropreparations (with a sketch).

— «The mitosis in the onion cells» (280×).

— «The amitosis division in cells of a bladder of a mouse» (280×).

— «The mitosis in the animal cell» (280).

— «Crushing in the ascaris egg» (280×).

ONTOGENETIC LEVEL OF LIFE ORGANIZATION

TOPIC 6. THE REPRODUCTION OF ORGANISMS. HUMAN REPRODUCTION

Ability for self-reproduction is one of the basic features of living systems. The existence of an individual inheritance of attributes is supported by duplication. The knowledge of ways of duplication, evolution of forms, differentiations of sexual attributes, formation of sexual cells, features of fertilisation is necessary for the doctor at studying ontogenesis of the person, detection of the pathology, connected with chromosomal, genome mutations of zygotes.

The primary goal of modern reproductive strategy of a person is to remove the adverse factors interfering normal development of gametes.

The purpose

1. To know the evolution of forms of duplication, essence of asexual and sexual duplication, feature of sexual duplication at multicellular.
2. To familiarize with biological essence of regular and irregular types of sexual duplication.
3. To know biological features of reproduction of a person, formation of sexual dimorphism.

4. To learn and determine stages of gametogenesis (with the help of preparations).

Control questions on the topic of employment

1. Reproduction — one of the main features of life systems. Evolution of the types of reproduction.

2. The asexual reproduction, its types, biological value. Polyembryony as a type of asexual reproduction.

3. The sexual reproduction. Advantages of sexual reproduction over asexual reproduction. Forms of sexual reproduction in monocellular and multicellular organisms.

4. Features of sexual reproduction in multicellular organisms:

— meiosis as a specific process of gamete formation;

— ovo- and spermatogenesis of mammals;

— morphological and functional features of human gametes;

— insemination (external and internal). Enzymatic processes during insemination. Artificial insemination for mammals;

— fertilization, its phases and biological essence;

— monospermia and polyspermia.

5. The irregular types of sexual reproduction: parthenogenesis (artificial, natural), ginogenesis, androgenesis.

6. The formation of sexual dimorphism and bisexuality during evolution. Redefinition of sex.

7. The biological sex determination in a human. Sex dimorphism: genetic, gonad's. gametic, hormonal, morphological, social, behavioral.

8. The biological sexual differentiation. Significance of genes Tfm and H-Y in the formation of sex.

9. The hermaphroditism (true and false). Pathological forms of sexual consciousness. Transsexualism. Transvestism

10. The contemporary reproductive strategy of humankind (artificial insemination, in vitro fertilization, embryo placement to uterus, «substitutive motherhood»).

Practical part of employment

Studying micropreparations (with a sketch).

— «Fertilisation in the egg of Ascaris lumbricoides» (280×).

— «The ovicell of a frog» (56×).

— «The ovicell» (280×).

— «Spermatozoids of a mammal» (280×).

— «The ovicell of a mammal» (280×).

— «Testicle of a mammal» (56×).

TOPIC 7. THE BASIS OF CYTOGENETIC (FINAL CLASS).

CONTROL QUESTIONS ON THE TOPIC OF EMPLOYMENT

1. The essence of life. Fundamental properties of life. Levels of life organization.
2. Organization of genetic material in the non-cellular forms of life, prokaryotes and eukaryotes.
3. Structure of DNA. Chargaff rules. Watson's and Crick's postulates. Autoreproduction of DNA, its types.
4. Structure of RNA, types of RNA. RNA synthesis, its stages (primary transcript, processing, splicing).
5. Gene — a fragment of genome nucleic acid. Spacers. Repeating sequences of nucleotides. Excessive genes.
6. Genetic code, its properties.
7. Molecular structure of chromosomes. The value of histone, non-histone proteins, ions of metals. The structure of nucleosome.
8. Levels of DNA packing (fibril, chromonema, chromatid). Euchromatin. Heterochromatin (facultative, constitutive).
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12. Features of the structure of prokaryotic and eukaryotic cells.
13. Methods of studying cells: histological, histochemical, microscopy (light, phase-contrast, dark-field illumination, ultraviolet, electron microscope etc.).
14. The structure of light microscope. Main rules during work with the microscope.
15. The structural elements of a cell.
16. The cytoplasm:

— the cell membrane , its structure and function;

— the hyaloplasm, its structure and properties;

— the organelles of general purpose, functional characteristic;

— the organelles of special purpose, functional characteristic;

— cytoplasmic inclusions, their classification and value.

17. The nucleus, its structure in the eukaryotic cell. Nucleo- cytoplasmic relationships as significance of functional stage of cell.
18. Morpho-functional traits of chromosomes. Chromosome types and rules.
19. Karyotype. Idiogram. Characteristics of human karyotype. Denver and Paris classifications of human chromosomes.
20. A cell as an open system. External and internal substance exchange.

21. Membrane transport (active and passive). Osmosis. The effect of isotonic, hypotonic and hypertonic solutions on a plant and animal cell.

22. The organization of energy flow in a cell (photosynthesis, fermentation, cellular respiration). ATP as a common energy currency.

23. The external and internal information flow in a cell. Coding of genetic information in a cell.

24. The substance flow. Protein synthesis, coding of proteins. Photosynthesis.

25. The life cycle of a cell, its periods and essence. Cytogenetic characteristics of a nucleus in the interphase.

26. Division of a cell, its types and kinds.

27. The mitosis. Phases, dynamics of distribution of genetic material, biological value.

28. The meiosis. Phases, cytological and cytogenetic characteristics, biological value.

29. The endomitosis and polyteny, mechanisms of occurring, biological value.

30. The amitosis, its types and forms, biological value.

31. The cell proliferation. The problem of cell proliferation in medicine.

32. Neuro-endocrine mechanisms of regulation of the cell division.

33. Reproduction — one of the main features of life systems. Evolution of the types of reproduction.

34. The asexual reproduction, its types, biological value. Polyembryony as a type of asexual reproduction.

35. The sexual reproduction. Advantages of the sexual reproduction over asexual reproduction. Forms of sexual reproduction in monocellular and multicellular organisms.

36. Features of sexual reproduction in multicellular organisms:

— meiosis as a specific process of gamete formation;

— ovo- and spermatogenesis of mammals;

— morphological and functional features of human gametes;

— insemination (external and internal). Enzymatic processes at insemination. Artificial insemination of mammals;

— fertilization, its phases and biological essence;

— monospermia and polyspermia.

37. The irregular types of sexual reproduction: parthenogenesis (artifitial, natural), ginogenesis, androgenesis.

38. The formation of sex dimorphism and bisexuality during evolution. Redefinition of sex

39. Biological sex determination of a human. Sex dimorphism: genetic, gonade, gametic, hormonal, morphological, social, behavioral.

40. Biological sex differentiation. Significance of genes Tfm and H-Y in the formation of sex.

41. Features of human ovogenesis, its regulation by hormones.

42. Features of human spermatogenesis, its regulation by hormones.

43. The morpho-functional characteristic of mature gametes in human.

44. The human fertilization, the influence of seasonal rhythms, stresses, social factors.

45. The hermaphroditism (true and false). The pathological forms of sexual consciousness. Transsexualism. Transvestism.

46. The contemporary reproductive strategy of humankind (artificial insemination, in vitro fertilization, embryo placement to uterus, «substitutive motherhood»).

47. The ethical aspects of intervention in human reproduction, morphological and social sex, in hermaphroditism, transsexualism.

LITERATURE

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5. Лекционный материал.

CONTENTS

Учебное издание

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Практикум по медицинской биологии и генетике. Цитология: методическое пособие для лабораторных работ по медицинской биологии и генетике для иностранных студентов, обучающихся на английском языке (на английском языке)

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