LECTURE COMPLEX

Discipline: Structural organization of human physiological processes

Discipline code: SOFPCh 1203

Title of EP: 6B10115 “Medicine”

Volume of teaching hours/credits: 30 hours (1 credits)

Course – I**, semester of study** -I

Lecture length: 2 hours

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Lecture №1

1. Topic: General microbiology and virology. Morphology of bacteria and viruses.

2. Purpose: To familiarize students with the morphology, structure of bacterial cells and viruses and their role in human pathology.

3. Lecture abstracts.

Microorganisms are the most ancient form of organization of life on Earth; they appeared long before the emergence of plants and animals - approximately 3-4 billion years ago. Currently, microorganisms represent the most significant and most diverse part of the organisms inhabiting the Earth's biosphere. This served as the basis for the division of all microorganisms into 4 large kingdoms: bacteria, fungi, protozoa and viruses. Each of them is the object of study of separate sections of microbiology, independent disciplines - bacteriology, virology, mycology, protozoology and allergology.

Morphology and systematics of microorganisms. The morphology of microorganisms studies their appearance, shape and structural features, ability to move, spore formation, and methods of reproduction. Morphological characteristics play an important role in the recognition and classification of microorganisms. Since ancient times, the living world has been divided into two kingdoms: the plant kingdom and the animal kingdom. When the world of microorganisms was discovered, they were separated into a separate kingdom. Thus, until the 19th century, the entire world of living organisms was divided into three kingdoms. At first, the classification of microorganisms was based on morphological characteristics, since people knew nothing more about them. By the end of the 19th century, many species had been described; Various scientists, mostly botanists, divided microorganisms into groups adopted for the classification of plants. In 1897, physiological characteristics began to be used, along with morphological ones, for the taxonomy of microbes. As it turned out later, for a scientifically based classification, any signs alone are not enough. Therefore, a set of signs is used:

-morphological (cell shape, size, motility, reproduction, sporulation, Gram stain);

- cultural (nature of growth on liquid and solid nutrient media);

-physiological-biochemical (nature of accumulated products);

- genotypic (physico-chemical properties of DNA).

Genosystematics allows us to determine the type of microorganisms not by similarity, but by relatedness. It has been established that the nucleotide composition of total DNA does not change during the development of microorganisms under different conditions. The S- and R-forms are identical in DNA composition. Microorganisms have also been discovered that have a similar nucleotide composition

of DNA, although they belong to different systematic groups: Escherichia coli and some corynebacteria. This indicates that when systematically (taxonomy) of microbes, different characteristics should be taken into account.

Until recently, all living beings with a cellular structure, depending on the relationship of the nucleus and organelles with the cytoplasm, the composition of the cell wall and other characteristics, were divided into two groups (kingdoms):

1.1 Prokaryotes-prenuclear (classified as organisms that do not have a clearly defined nucleus, represented by a ring-shaped DNA molecule; the cell wall includes peptidoglycan (murein) and teichoic acids; ribosomes have sedimentation constants of 70; the energy centers of the cell are located in mesosomes and there are no organelles).

1.2 Nuclear eukaryotes (with a clearly defined nucleus separated from the cytoplasm by a membrane; the cell wall lacks peptidoglycan and teichoic acids; the ribosomes of the cytoplasm are larger; sedimentation constant is 80; energy processes are carried out in mitochondria; organelles contain the Golgi complex, etc.).

Later it turned out that among microorganisms there are also non-cellular forms - viruses, and therefore a third group (kingdom) was identified - vira.

The basic (lowest) taxonomic unit is the species. Species are united into genera, genera into families, families into orders, orders into classes, classes into divisions, divisions into kingdoms.

A species is a collection of individuals of the same genotype with clearly expressed phenotypic similarity.

Culture – microorganisms obtained from an animal, human, plant or environmental substrate and grown on a nutrient medium. Pure cultures consist of individuals of one species (offspring obtained from one cell - a clone).

Strain is a culture of the same species, isolated from different habitats and characterized by minor changes in properties. For example, E. coli isolated from the human body, cattle, water bodies, and soil can be of different strains.

Prokaryotes (bacteria and actinomycetes). Bacteria (prokaryotes) are a large group of microorganisms (about 1600 species), most of which are unicellular. Shape and size of bacteria. The main forms of bacteria are spherical, rod-shaped and convoluted. Globular bacteria - cocci have the usual spherical shape; they are also flattened, oval or bean-shaped. Cocci can be in the form of single cells - monococci (micrococci) or connected in various combinations: in pairs - diplococci, four cells - tetracocci, in the form of more or less long chains - streptococci, and also in the form of cubic-shaped clusters (in the form of bags) of eight cells located in two tiers one above the other - sarcins. There are irregularly shaped clusters resembling bunches of grapes - staphylococci. Rod-shaped bacteria can be single or connected in pairs - diplobacteria, in chains of three to four or more cells - streptobacteria. The relationship between the length and thickness of the sticks can be very different. Crinkled, or

curved, bacteria vary in length, thickness, and degree of curvature. Rods slightly curved in the shape of a comma are called vibrios, rods with one or more corkscrew-shaped curls are called spirilla, and thin rods with numerous curls are called spirochetes. Thanks to the use of an electron microscope to study microorganisms in natural substrates, bacteria were discovered that have a special cell shape: closed or open ring (toroids); with outgrowths (prosteks); worm-shaped - long with curved very thin ends; and also in the form of a hexagonal star.

The sizes of bacteria are very small: from tenths of a micrometer (μm) to several micrometers. On average, the body size of most bacteria is 0.5-1 microns, and the average length of rod-shaped bacteria is 2-5 microns. There are bacteria whose sizes significantly exceed the average size, and some are on the verge of visibility in conventional optical microscopes. The body shape of bacteria, as well as their size, can change depending on age and growth conditions. However, under certain, relatively stable conditions, bacteria retain their characteristic size and shape. The mass of a bacterial cell is very small, approximately $4\text{-}10^{-13}$ g.

The structure of a bacterial cell. The cell of prokaryotic organisms, which include bacteria, has fundamental ultrastructural features. The cell wall (shell) is an important structural element of most bacteria. The cell wall accounts for 5 to 20% of cell dry matter. It has elasticity, serves as a mechanical barrier between the protoplast and the environment, and gives the cell a certain shape. The composition of the cell wall includes a heteropolymer compound specific for prokaryotic cells - peptidoglycan (murein), which is absent in the cell walls of eukaryotic organisms. According to the staining method proposed by the Danish physicist H. Gram (1884), bacteria are divided into two groups: gram-positive and gram-negative. Gram-positive cells retain dye, while gram-negative cells do not, due to differences in the chemical composition and ultrastructure of their cell walls. Gram-positive bacteria have thicker, amorphous cell walls, they contain a large amount of murein (from 50 to 90% of the dry mass of the cell wall) and teichoic acids. The cell walls of gram-negative bacteria are thinner, layered, contain a lot of lipids, little murein (5-10%) and lack teichoic acids.

The cell wall of bacteria is often covered with mucus. The mucous layer can be thin, barely visible, but it can also be significant and can form a capsule. Often the capsule is much larger in size than the bacterial cell. The sliming of cell walls is sometimes so strong that the capsules of individual cells merge into mucous masses (zoogels), in which bacterial cells are embedded. The mucous substances produced by some bacteria are not retained as a compact mass around the cell wall, but diffuse into the environment. When rapidly multiplying in liquid substrates, mucus-forming bacteria can turn them into a continuous mucous mass. This phenomenon is sometimes observed in sugary extracts from beets during sugar production. In a short time, sugar syrup can turn into a viscous mucous mass. Meat, sausages, and cottage cheese are

subject to mucus; The viscousness of milk, pickles, pickled vegetables, beer, and wine is observed. The intensity of mucus formation and the chemical composition of mucus depend on the type of bacteria and cultivation conditions. The capsule has beneficial properties, mucus protects cells from unfavorable conditions - in many bacteria, mucus formation increases in such conditions. The capsule protects the cell from mechanical damage and drying out, creates an additional osmotic barrier, serves as an obstacle to the penetration of phages and antibodies, and sometimes it is a source of reserve nutrients. The cytoplasmic membrane separates the cell contents from the cell wall. This is an essential structure of any cell. When the integrity of the cytoplasmic membrane is violated, the cell loses its viability. The cytoplasmic membrane accounts for 8-15% of the dry matter of the cell. The membrane contains up to 70-90% of cell lipids, its thickness is 7-10 nm1. On sections of cells in an electron microscope, it is visible in the form of a three-layer structure - one lipid layer and two protein layers adjacent to it on both sides. The cytoplasmic membrane is invaginated into the cell in places, forming all kinds of membrane structures. It contains various enzymes; it is semi-permeable and plays an important role in the metabolism between the cell and the environment. The cytoplasm of a bacterial cell is a semi-liquid, viscous, colloidal system. In places it is permeated with membrane structures - mesosomes, which originated from the cytoplasmic membrane and have retained contact with it. Mesosomes perform various functions; they and the associated cytoplasmic membrane contain enzymes involved in energy processes - in supplying the cell with energy. Well-developed mesosomes are found only in gram-positive bacteria; in gram-negative bacteria they are poorly developed and have a simpler structure. The cytoplasm contains ribosomes, the nuclear apparatus and various inclusions. Ribosomes are scattered in the cytoplasm in the form of granules 20-30 nm in size; ribosomes are composed of approximately 60% ribonucleic acid (RNA) and 40% protein. Ribosomes are responsible for the synthesis of cell proteins. A bacterial cell, depending on its age and living conditions, may have 5-50 thousand ribosomes. The nuclear apparatus of bacteria is called a nucleoid. Electron microscopy of ultrathin sections of bacterial cells has revealed that the carrier of the cell's genetic information is a deoxyribonucleic acid (DNA) molecule. DNA has the form of a double helical strand closed in a ring; it is also called the “bacterial chromosome”. It is located in a certain area of the cytoplasm, but is not separated from it by its own membrane.

The cytoplasmic inclusions of a bacterial cell are diverse, mainly these are reserve nutrients that are deposited in cells when they develop in conditions of excess nutrients in the environment, and are consumed when the cells are starved. Polysaccharides are deposited in bacterial cells: glycogen, starch-like substance granulosa, which are used as a source of carbon and energy. Lipids are found in cells in the form of granules and droplets. Fat serves as a good source of carbon and energy. Many bacteria accumulate polyphosphates; they are contained in volutin granules and

are used by cells as a source of phosphorus and energy. Molecular sulfur is deposited in the cells of sulfur bacteria.

Motility of bacteria. Spherical bacteria are usually nonmotile. Rod-shaped bacteria are either motile or immobile. Curved and spiral-shaped bacteria are motile. Some bacteria move by sliding. The movement of most bacteria is carried out using flagella. Flagella are thin, spirally twisted filaments of a protein nature that can perform rotational movements. The length of the flagella varies, and the thickness is so small (10-20 nm) that they can be seen in a light microscope only after special treatment of the cell. The presence, number and location of flagella are constant characteristics for the species and have diagnostic value. Bacteria with one flagellum at the end of the cell are called monotrichous; with a tuft of flagella - lophotrichous; with a tuft of flagella at both ends of the cell - amphitrichous; Bacteria in which flagella are located on the entire surface of the cell are called peritrichous. The speed of movement of bacteria is high: in a second, a cell with flagella can cover a distance 20-50 times greater than the length of its body. Under unfavorable living conditions, with cell aging, and mechanical stress, mobility may be lost. In addition to flagella, on the surface of some bacteria there are a large number of thread-like formations, much thinner and shorter than fimbriae (or pili).

Reproduction of bacteria. Prokaryotic cells are characterized by simple cell division in two. Cell division begins, as a rule, some time after the division of the nucleoid. Rod-shaped bacteria are divided crosswise, spherical in different planes. Depending on the orientation of the division plane and their number, various forms arise: single cocci, paired, chains, in the form of packets, clusters. A feature of bacterial growth is the speed of the process. The rate of division depends on the type of bacteria and cultivation conditions: some species divide every 15-20 minutes, others - every 5-10 hours. With this division, the number of bacterial cells per day reaches a huge number. This is often observed in food products: rapid souring of milk due to the development of lactic acid bacteria, rapid spoilage of meat and fish due to the development of putrefactive bacteria, etc.

Sporulation. Spores in bacteria are usually formed under unfavorable development conditions: with a lack of nutrients, changes in temperature, pH, and with the accumulation of metabolic products above a certain level. Mostly rod-shaped bacteria have the ability to form spores. Each cell produces only one spore (endospore).

Sporulation is a complex process; several stages are distinguished in it: first, a restructuring of the genetic apparatus of the cell is observed, and the morphology of the nucleoid changes. DNA synthesis stops in the cell. Nuclear DNA is pulled out into a strand, which then splits; part of it is concentrated at one of the poles of the cell. This part of the cell is called the sporogenic zone. In the sporogenic zone, the cytoplasm is compacted, then this area is separated from the rest of the cellular contents by a

septum. The cut-off area is covered with the membrane of the mother cell, and a so-called prospore is formed. A prospore is a structure located inside the mother cell, from which it is separated by two membranes: outer and inner. A cortical layer (cortex) is formed between the membranes, similar in chemical composition to the cell wall of a vegetative cell. In addition to peptidoglycan, the cortex contains dipicolinic acid (C7H8O4Mg), which is absent in vegetative cells. Subsequently, a spore shell is formed on top of the prospore, consisting of several layers. The number, thickness and structure of layers vary among different types of bacteria. The surface of the outer shell can be smooth or with projections of different lengths and shapes. On top of the spore shell, a thin cover is often formed, surrounding the spore in the form of a sheath - an exosporium.

The spores are usually round or oval in shape. The diameter of the spores of some bacteria exceeds the width of the cell, as a result of which the shape of the spore-bearing cells changes. The cell takes on a spindle shape (clostridium) if the spore is located in its center, or a drumstick shape (plectridium) when the spore is close to the end of the cell.

After the spore matures, the mother cell dies, its shell is destroyed, and the spore is released. The process of spore formation occurs over several hours.

The presence of a dense, impenetrable shell in bacterial spores, a low water content in it, a large amount of lipids, as well as the presence of calcium and dipicolinic acid determine the high resistance of spores to environmental factors. Spores can remain viable for hundreds or even thousands of years. For example, viable spores have been isolated from the corpses of mammoths and Egyptian mummies, which are thousands of years old. The spores are resistant to high temperatures: in a dry state they die after heating at 165-170°C for 1.5-2 hours, and with superheated steam (in an autoclave) - at 121°C for 15-30 minutes.

Under favorable conditions, the spore germinates into a vegetative cell; this process usually lasts several hours.

The germinating spore begins to actively absorb water, its enzymes are activated, and the biochemical processes leading to growth are enhanced. During spore germination, the cortex turns into the cell wall of a young vegetative cell; Dipicolinic acid and calcium are released into the external environment. The outer shell of the spore breaks, and through the breaks a “sprout” of a new cell comes out, from which a vegetative bacterial cell is then formed.

Fundamentals of bacterial taxonomy. Modern bacterial classification systems are essentially artificial; they combine bacteria into certain groups based on their similarity in a set of morphological, physiological, biochemical and genotypic characteristics. For these purposes, Bergey's guide to identifying bacteria (1974, 8th edition and 1984, 9th edition) is used. According to the 8th edition, all prokaryotes are divided into two divisions - cyanobacteria and bacteria. The first section -

cyanobacteria (blue-green algae) - are phototrophic microorganisms. The second section is bacteria. This department is divided into 19 groups. The 17th group includes actinomycetes. According to the 9th edition, the kingdom of prokaryotes is divided into four divisions depending on the presence or absence of a cell wall and its chemical composition: the first division - thin-skinned, includes groups of bacteria, gram-negative, phototrophic and cyanobacteria; the 2nd section includes hard-skinned bacteria, including groups of bacteria that are positive for Gram staining; the third section includes mycoplasmas - bacteria that do not have a cell wall; The fourth section includes methane-forming and archaebacteria (a special group of bacteria that lives in extreme environmental conditions and is one of the oldest forms of life).

CLASSIFICATION OF MICROORGANISMS

Non-cellular forms	Cellular forms		
	Prokaryotes	Eukaryotes	
Viruses can exist in two forms: extracellular (virion) and intracellular (virus). Size: from 15-18 to 300-400 nm. 1nm = 10^{-3}mcm	Bacteria are single-celled microorganisms of plant origin, lacking chlorophyll and lacking a nucleus. Size: from 0.3 to 5-10 mcm. 1mcm = 10^{-3} mm	Protozoa are single-celled animal organisms. Size: from 2 to 50 mcm.	Fungi - unicellular and multicellular	microorganisms of plant origin, lacking chlorophyll, but having the features of an animal cell. Size: from 0.2 to 100 mcm.

4. Illustrative material: multimedia projector (presentation)

5. Literature:

Appendix No. 1

6. Security questions:

1. Name the principles of classification of microorganisms.
2. Name the general properties of microorganisms.
3. What are the distinctive properties of prokaryotic and eukaryotic cells.
4. What 4 kingdoms are living beings divided into?
5. Name the specific features of microorganisms that are used for their taxonomy and classification.
6. Principles of systematization of bacteria in Bergey's determinant.
7. Name the distinctive features of viruses.

8. List viral proteins.
9. Define the concepts of pathogenicity and virulence.

Lecture №2

1. Topic: Physiology and biochemistry of bacteria and viruses.
2. Purpose: To familiarize students with the physiology and biochemistry of bacteria and viruses.
3. Lecture abstracts.

The physiological and biochemical characteristics of microorganisms form the basis of their taxonomy. They are important for studying the mechanisms of pathogenic action, cultivating, differentiation and identification of individual microorganisms, as well as for developing biotechnologies for the production of vaccines, antibiotics and other biologically active products.

Bacteria, like all other organisms, require constant exchange of substances with the environment to exist and reproduce their own kind, and substances obtained from the environment undergo a number of changes inside the cell. All reactions that occur under the influence of enzymes and provide the cell with necessary substances constitute metabolism or metabolism. Intermediate or final substances formed in the corresponding sequence of enzymatic reactions are called metabolites.

As you know, metabolism is a combination of two opposite but interrelated processes - catabolism, or energy metabolism, and anabolism, or plastic (constructive) metabolism. In prokaryotes, just like in eukaryotes, in the process of enzymatic catabolic reactions, energy is released, which is accumulated in ATP molecules. In the process of enzymatic anabolic reactions, this energy is spent on the synthesis of numerous macromolecules of organic compounds, from which biopolymers are ultimately assembled - components of the microbial cell. The relationship between anabolism and catabolism is also expressed in the fact that at certain stages of metabolism the same intermediate products (amphibolites) are formed, which are used in both processes.

Classification of bacteria by food type:

1. Autotrophs
2. Heterotrophs
A. Parasites
B. Saprophytes

The most important chemical element needed by a cell is carbon. Depending on the source of its production, bacteria are divided into two types - autotrophs and heterotrophs.

Autotrophs are able to absorb it from carbon dioxide. The synthesis of proteins, fats and carbohydrates occurs on the basis of inorganic elements. This group, in particular,

includes many soil microbes and cyanobacteria. Autotrophs are the primary producers of organic matter, and they are the initial link in many food chains.

Heterotrophs obtain carbon from ready-made organic compounds. Among them are parasites and saprophytes.

Parasites feed on organic matter produced by other living things.

Saprophytes are rotting microbes that decompose dead organic matter. Most of them belong to soil bacteria.

Classification of bacteria by type of respiration:

1. Obligate aerobes (pathogens of tuberculosis, plague, cholera) are microorganisms that require oxygen for optimal growth.

2. Obligate anaerobes (causative agents of tetanus, botulism, gas anaerobic infections, bacteroides, fusobacteria) - bacteria that grow in the absence oxygen due to fermentation processes. They get oxygen from organic matter compounds during their metabolism. Some of them can't even stand a small amount of free oxygen.

3. Facultative anaerobes (staphylococci, Escherichia, Salmonella, Shigel and others) - can grow and reproduce both in the presence of oxygen and without it..

4. Microaerophiles (lactic acid, nitrogen-fixing bacteria) are a special group of microbes for which the oxygen concentration during cultivation can be reduced to 2%. Higher concentrations can inhibit growth.

5. Capneic (the causative agent of bovine brucellosis) - microorganisms that In addition to oxygen, they also require up to 10% carbon dioxide.

Genetics of bacteria.

Genetics (from the Greek genos - birth) is the science that studies heredity and variability. Microorganisms have the ability to change their main characteristics: morphological (structure); cultural (growth on nutrient media); biochemical or enzymatic signs (the addition of certain substances to the nutrient medium can cause activation of an enzyme that was previously in a latent state); biological properties - the degree of pathogenicity may change, methods for preparing live vaccines are based on this. For example, during 12-14 days of cultivating the anthrax pathogen at a temperature of 42-43°C, the microbes lost the ability to cause disease in animals, but retained their immunogenic properties .

BCG (Bacillus Calmette-Guerin) reduced the pathogenicity of the bovine species of Mycobacterium tuberculosis through long-term passages on a potato medium with bile and glycerin at a temperature of 38°C. Subcultures every 14 days received a weakened strain of Mycobacterium tuberculosis, which is called the BCG “vaccine” used to prevent tuberculosis.

Heredity is the ability of organisms to retain certain characteristics over many generations.

Variability is the acquisition of characteristics under the influence of various factors that distinguish them from previous generations.

Genetic information in bacterial cells is contained in DNA (in some viruses, RNA). The DNA molecule consists of two strands, each of which is spirally twisted relative to the other. When a cell divides, the helix doubles. And again a double-stranded DNA molecule is formed. The DNA molecule contains 4 nitrogenous bases - adenine, guanine, cytosine, thymine. The order of arrangement in the chain in different organisms determines their hereditary information encoded in DNA.

Forms of manifestation of variability

Non-hereditary phenotypic variability, or modification, of microorganisms arises as a cell's response to unfavorable conditions of its existence. This adaptive response to external stimuli is not accompanied by a change in genotype and therefore is not inherited. The morphology (lengthens), cultural properties (staphylococci without pigment with a lack of oxygen), biochemical or enzymatic properties may change, adaptive E. coli enzymes are produced, the lactase enzyme is produced on a medium with lactose.

Heritable genetic variation results from mutations and genetic recombinations. Variability of microorganisms

▪Phenotypic variability (non-heritable modification)

▪Genotypic variability is heritable

Mutations (from the Latin mutatio - to change) are inherited structural changes in genes. Mutations change sections of genomes (i.e., the hereditary apparatus).

Bacterial mutations can be spontaneous (spontaneous) and induced (directed), i.e., they appear as a result of the treatment of microorganisms with special mutagens (chemicals, temperature, radiation, etc.).

As a result of bacterial mutations, the following may occur:

* change in morphological properties; change in cultural properties; the emergence of drug resistance in microorganisms;

* weakening of pathogenic properties, etc.

Genetic recombinations include recombinations of genes that occur as a result of transformation, from a donor, transduction and conjugation.

Transformation is the transfer of genetic material to a recipient using isolated DNA from another cell. Cells that can perceive the DNA of another cell are called competent.

The state of competence often coincides with the logarithmic phase of growth. For transformation it is necessary to create special conditions, for example, by adding inorganic phosphates, the frequency of transformation increases.

Transduction is the transfer of hereditary material from a donor bacterium to a recipient bacterium, which is carried out by a phage. For example, with the help of

phage it is possible to reproduce flagella transduction, enzymatic properties, antibiotic resistance, toxigenicity and other characteristics.

Bacterial conjugation is the transfer of genetic material from one cell to another through direct contact. Moreover, a one-way transfer of genetic material occurs - from the donor to the recipient. A necessary condition for conjugation is the presence of a specific fertility factor F in the donor. Sexual F-hairs are found in gram-negative bacteria, through which genetic material is transferred. Cells that play the role of donor are designated F+, and recipient cells are designated F.

The F factor is located in the cytoplasm of cells, and it is not alone. During conjugation, only DNA is transferred without RNA and protein.

Practical significance of variability: using genetic methods, special cultures of yeast and other microbes are obtained, used in food manufacturing technology, production of toxoids, vaccines, antibiotics, vitamins;

* genetic engineering is of great scientific and practical importance, the methods of which make it possible to change the structure of genes and include in the chromosome of bacteria the genes of other organisms responsible for the synthesis of important and necessary substances that are very difficult to obtain chemically - insulin, interferon, etc.;

* using mutagenic factors (UV rays, X-rays, y-rays, diethyl sulfate, etc.) mutants were obtained - antibiotic producers that are 100-1000 times more active than the original ones.

4. Illustrative material: multimedia projector (presentation)

5. Literature:

Appendix No. 1

6. Security questions:

1. Name bacteria based on their nutritional types.
2. Define heredity and variability.
3. What are mutations.
4. What is transduction.
5. Methods for cultivating viruses.

Appendix No. 1

Recommended literature

Basic literature

1. Murray P. R., Rosenthal K. S., Pfaller M. A.Medical Microbiology. - Mosby, 2015
2. W. Levinson McGraw-Hill. Review of Medical Microbiology and Immunology, 2014

Additional literature

1. Saparbekova A.A. Microbiology and virology : educ. manual. - Second Edition. - Almaty : ЭСПИ, 2023. - 188 с
2. Gladwin Mark T. Clinical microbiology made ridiculously simple / Mark T. Gladwin, William Trattler, Scott C. Mahan . - 7th ed. - Miami :MedMaster, Ins, 2016. - 413 p.
3. Usmle Step 1. Immunology and microbiology : Lecturer notes / Alley Tiffany L. [et. al.]. - New York, 2019. - 511 p. - (Kaplan Medical)

Electronic textbooks

1. B. T. Seytkhanova, Sh. Zh. Kurmanbekova, Sh.T. Polatbekova, Sh.Zh. Gabdrakhmanova, A.N. Tolegen. CAUSATIVE AGENTS OF ACUTE RESPIRATORY VIRAL INFECTIOUS DISEASES (influenza virus, adenovirus, coronavirus) (I part) http://lib.ukma.kz/wp-content/uploads/2022/10/Illustrated-teach.-material-eng-2.pdf

2. B.T. Seytkhanova, Sh. Zh. Kurmanbekova, Sh.T. Polatbekova, Sh.Zh. Gabdrakhmanova, A.N. Tolegen. Pathogens of children's viral infections (measles, rubella, chickenpox and mumps virus) (Part II) http://lib.ukma.kz/wp-content/uploads/2022/10/illustrated-textbook.pdf

3. B.T. Seytkhanova, A.A. Abdramanova, A.N. Tolegen, P. Vinoth kumar Lecture compolex on the subject "Microbiology and immunology " (General Microbiology) http://lib.ukma.kz/wp-content/uploads/2022/10/Lecture-complex-General-Microbiology-2022.pdf

4. B.T. Seytkhanova, A.A. Abdramanova, A.N. Tolegen, P. Vinoth kumar LECTURE COMPLEX ON THE SUBJECT "MICROBIOLOGY AND IMMUNOLOGY"(Private Microbiology) http://lib.ukma.kz/wp-content/uploads/2022/10/Lecture-complex-Private-Microbiology-2022.pdf

Electronic base

№	Name	Link
1	Electronic library SKMA	http://lib.ukma.kz/repository
2	Republican interuniversity electronic library	https://online.zakon.kz/Medicine
3	«Aknurpress» Digital library	https://www.aknurpress.kz/
4	«Epigraph» Electronic library	http://www.elib.kz/
5	Epigraph - portal of multimedia textbooks	https://mbook.kz/ru/index/
6	ABS IPR SMART	https://www.iprbookshop.ru/auth
7	"Law" base of normative legal acts	https://zan.kz/ru
8	Cochrane Library	https://www.cochranelibrary.com/