



The program is designed for self-preparation for the exam. It consists of twenty sections. A brief formulation of the basic disciplines underlying the section is given in **bold**. For each section, the content of the questions is disclosed, i.e., what exactly you need to know to pass the exam. At the end of each section, there is a list of literature for preparation. At the end of the program, the structure of the exam and the evaluation criteria are described.

## **I. HUMAN ANATOMY**

The importance of studying human anatomy for the biologist's worldview. Musculoskeletal system. Bones: skeletal system, bone development, growth and restructuring, bone connections. Muscular system. Structure, development, work of muscles. Nervous system: central and peripheral. Sensory organs: smell, taste, hearing, balance, vision. Endocrine glands: development, structure, topography and functions. Digestive system. Departments of the digestive tract. structure, functions, age-related features. Respiratory system: departments, structure, functions and age-related features. Urinary and genital apparatus. Structure and topography of male and female genital organs. Cardiovascular system. Heart: structure, topography, blood supply, innervation, conduction system. Blood vessels: structure, innervation. Vessels of small, large and cardiac circulation. Lymphatic system. Organs of hematopoiesis and immune system. Lymphoid organs: classification, topography, structure, functions.

### **Literature**

1. Human anatomy: 3 vol./ed. By Koveshnikov V.G. – Lugansk, 2019. – ISBN 966-8526-54-6.

## **II. PLANT ANATOMY**

Plant cell. Membrane structures. Plastid system: types of plastids, general structure, chemical composition, functions, genetic relationship. Vacuole - formation, functions, chemical composition of cell sap. Osmotic properties of a plant cell. Cell membrane: structure, chemical composition, functions, biogenesis, physical and chemical modifications. Storage nutrients. Plant tissues - concepts, types, classifications. Meristems. Epidermis as a multifunctional tissue. Periderm, crust. Mechanical tissues: collenchyma and sclerenchyma. Systems of absorbing, assimilating, storing tissues. Xylem and phloem as complex tissues. Exo- and endogenous excretory structures. Vascular fiber (conductive) bundles - tissue complexes. Primary structure of the stem. Types of stem structure of dicotyledonous plants: bunch, non-bunch and transitional. Secondary structure of stems of woody plants. Modifications (metamorphosis) of stems. Anatomy of the leaf. Ecological plasticity of the anatomical structure of the leaf blade. Leaf blade. Zones of the root. General plan of the primary structure of the root. Endodermis of the root and Caspian girdles. Secondary structure of the root of dicots. Modifications (metamorphosis) of roots.

### **Literature**

1. Evert P.F. Esau's Plant Anatomy. Evert, K. Esau. - J. Wiley & Sons, Inc. Publication, 2006. - 612 pp.

### **III. BIOLOGY OF INDIVIDUAL DEVELOPMENT**

Subject, model objects and methods of modern developmental biology. Scientists who have made a significant contribution to the study of the development of organisms. The concept of ontogeny and life cycle. The cytological basis of growth. The sexual process and its biological significance. Gamete structure and gametogenesis: characteristics and subtle mechanisms of fertilization. Parthenogenesis: characteristics and diversity of stages of embryonic development of multicellular animals (crushing, gastrulation, organogenesis). Embryonic membranes of vertebrates. Human embryonic development. Features of plant development (in comparison with animals). Determination and differentiation of cells. Induction and competence. General ideas about the genetic basis of the development of organisms. Determination of sex in ontogeny. Postembryonic development. Metamorphosis. Reparative and physiological regeneration. Aging.

#### **Literature**

1. Gilbert S. Developmental biology (10th edition) - Sinauer Associates, 2013 - 719 pp.

### **IV. BIOTECHNOLOGY**

Objects of biotechnology; viruses and viroids, prokaryotes, cyanobacteria, microalgae and fungi. Limitations and possibilities of using higher plants and animals as objects of biotechnology. Methods of modern biotechnology: methods of fundamental research of mechanisms of functioning of biological systems; methods of molecular biotechnology; methods of industrial biotechnology. Principles of functioning of biological systems: principles of intermolecular interactions; concept of metabolism. Cultures of plant cells in biotechnology: cell production, methods of cultivation; clonal reproduction, methods of obtaining virus-free material. Cultures of animal cells in biotechnology; obtaining, use. Lymphoid hybridomas; obtaining, selection, use of monoclonal antibodies. Recombinant DNA technology of bacterial cells; isolation of individual genes, vector construction, translation and selection of clones. Recombinant DNA technology of plant cells and transgenic plants: general scheme of transgene transfer. The problem of GMOs. Obtaining clones and transgenic animals; characterization of clones and methods of their production, obtaining chimeras and mosaics. Transgenesis, prospects and problems. Engineering enzymology; methods of immobilization and practical application. Characterization and design of biosensors, areas of application. General characteristics of biotechnological production.

#### **Literature**

1. Clark D., Pazdernik N. Biotechnology. 2nd Edition. Academic Cell, 2015. 835 p.

### **V. BIOPHYSICS**

Biothermodynamics. Principles of equilibrium thermodynamics, concepts of

dissipation function and dissipative structures, Prigogin's theorem for stationary states of open systems.

Molecular biophysics. Structural principles and basic types of physical interactions of the organization of proteins and nucleic acids. Properties of water and its special function in the life of the organism. Biophysics of the cell. Organization and dynamic properties of membrane components, generalized membrane potential and its moving forces, classification of ion transport processes in the cell. Electrodiffusion theory of ion transport.

Photo and radio biophysics. Physiological and destructive effects of photons on the biological system, the primary mechanism of radiation injury, direct and indirect effects of radiation on the body.

### **Literature**

1. William C. Parke Biophysics: A Student's Guide to the Physics of the Life Sciences and Medicine. - Springer Cham, <https://doi.org/10.1007/978-3-030-44146-3>

## **VI. BIOCHEMISTRY**

Chemical composition of living organisms. Types of biomolecules: proteins, nucleic acids, carbohydrates, lipids. Interrelation of structure and function of biomolecules. Enzymes: structure, properties, classification, mechanism of action. Regulation of the rate of enzymatic reactions. Cofactors and coenzymes. Vitamins as precursors in the biosynthesis of coenzymes. Enzymopathies. Metabolism: anabolism, catabolism. The cycle of tricarboxylic acids and its role in metabolism. Energy of living systems. High-energy biomolecules. Biological oxidation. Structure of the respiratory chain of mitochondria. Chemiosmotic theory of conjugation of oxidation and phosphorylation. Biological membranes and their functions. Transfer of substances across membranes. Carbohydrate metabolism. Biosynthesis and breakdown of glycogen. Anaerobic and aerobic oxidation of glucose. Gluconeogenesis. Pentose phosphate cycle of glucose oxidation. Lipid metabolism.  $\beta$ -Oxidation of fatty acids in mitochondria, its energy efficiency. Fatty acid biosynthesis, phospholipid biosynthesis, cholesterol biosynthesis. Eicosanoids. Metabolism of proteins and amino acids. Reactions of transamination, desamination and decarboxylation of amino acids. Transformation of the carbon skeleton of amino acids. Ways of ammonia formation. The cycle of urea formation. Metabolism of nucleic acids and nucleotides. Molecular mechanisms of storage, transmission and realization of genetic information. DNA replication. Molecular mechanisms of mutations. DNA repair. Transcription. RNA processing. Structure and function of ribosomes. Genetic code. Main stages and mechanisms of translation. Regulation of gene expression in pro- and eukaryotes. Genetic engineering. Recombinant DNA. Hormones, their chemical nature, classification. Receptors. Secondary messengers. Molecular mechanisms of action of hormones on target cells: molecular and cellular mechanisms of action of peptide hormones and biogenic amines, molecular and cellular mechanisms of action of steroid and thyroid hormones. Integration and regulation of metabolism. Biochemical functions of hepatocytes, biotransformation of xenobiotics and endogenous

toxins. Biochemistry and pathobiochemistry of blood: biochemistry and pathobiochemistry of hemoglobin, biochemical composition of blood in normal and pathological conditions. Biochemical parameters of blood in patients with *acute respiratory disease COVID-19 caused by coronavirus SARS-CoV-2*. Biochemistry of immune processes: cellular and biochemical organization of the immune system, immunoglobulins (structure and biological functions), mediators and hormones of the immune system, biochemical components of the complement system, biochemical mechanisms of immunodeficiency states. Features of immune-dependent manifestations in *COVID-19 caused by SARS-CoV-2 coronavirus*. Features of the chemical composition and metabolism of the nervous system, neurotransmitters, receptors for neurotransmitters and physiologically active compounds, neurochemical mechanisms of action of psychotropic drugs (neuroleptics, antidepressants and anxiolytics).

### Literature

1. Nelson D.L., Cox M.M., Lehninger Principles of biochemistry. – New York : W.H. Freeman and Company, 2012. – 1119 p.
2. Lieberman M. A., Ricer R. Biochemistry, molecular biology, and genetics. 6th ed. – Philadelphia: Wolters Kluwer; Baltimore; New York: Lippincott Williams & Wilkins, 2014. – IX, 449 p.

### VII. BOTANY

Systematics of plants. Types of plant reproduction. Types of life cycles in plants. Algae: origin, phylogeny, systematics, characteristics of divisions, ecology, distribution, types of nutrition, importance in bioindication and self-purification of water bodies. Myxomycetes: structure and way of life, developmental cycles, ecology, distribution, importance in nature. Fungi: place in the system of the organic world, phylogeny, importance in nature. Variety of types of reproduction. Fungi. Characteristics of departments, classes and orders. Lichens. Dualistic nature of lichen melt. The place of lichens in the system of the organic world. Morphology, anatomical structure, physiology and biochemistry of lichens. Reproduction of lichens. The place and role of lichens in nature and human activity. Higher plants: spore, vascular, archegonial, seed, flowering plants. Ecological groups and life forms of plants. Plant communities, their functional structure, classification and ecology. Fundamentals of plant geography. Patterns of distribution of plants and plant communities on the Earth's surface. Higher spore and naked-seeded plants: life form, morphological structure, reproduction, life cycle, ecology, distribution, practical importance. Generative organs of flowering plants. Ancestral group, time and place of origin of flowering plants. The main phylogenetic systems of flowering plants.

### Literature

1. Plant Systematics: A Phylogenetic Approach. Walter S. Judd, C. S. Campbell, E. A. Kellogg, P. F. Stevens. – Sinauer Associated, Inc. Publishers Sunderland, Massachusetts, USA. – 1999.

## **VIII. VIROLOGY**

The nature of viruses. Morphology and structure of viral particles. Types of virion symmetry. Packaging of the genome. Chemical composition of viral particles. Classification of viruses. Replication of viruses. Attachment and penetration into the cell. "Undressing" the genome. Features of plant cell infection. Replication of viral nucleic acid. Replication of viroids. Expression of viral genes: transcription and translation. Morphogenesis of virions and their exit from the cell. Defective viral particles. Features of replication of satellite viruses. Spread of viruses. Basic principles of virus transmission by vectors. Permissive and non-permissive cells. The consequence of infection with a host virus. Factors that affect the outcome of viral infection. Innate and adaptive human immunity. Unproductive infection. Productive infection. Features of the interaction of bacteriophages with bacteria. Lysogeny. The main families of viruses that cause diseases in humans and animals. Viral carcinogenesis. Mechanisms of malignant tumors under the influence of viruses. Means of combating viral infections. Viral vaccines. Antiviral drugs. Pathogenesis of diseases caused by prions. The main hypotheses of the origin of viruses. Genetics of viruses. Composition and organization of the virus genome. Ways to increase the coding capacity of the genome. The main processes that control the heredity and variability of viruses. Genetic and non-genetic interactions between viruses. Evolution of viruses. The main methods of research and identification of viruses.

### **Literature**

1. Knipe D.M., Howley P.M. Fields Virology, 5th Edition, 2007.
2. Cann A.J. Principles of molecular virology: 4th ed. - Amsterdam: Elsevier Academic Press.- 2005. - 315 pp.
3. Carter J., Saunders V. Virology: principles and applications. - Chichester, England, John Wiley & Sons Ltd., 2007.- 358 pp.

## **IX. GENETICS**

Chromosomal theory of heredity. The structure of chromosomes depending on the functional state of the cell. Chromosomal and other types of sex determination. Gene linkage and crossover. Allelic and non-allelic interactions. Inheritance of nuclear and cytoplasmic, autosomal and sex-linked, monogenic and polygenic (including quantitative) traits. The structure of nucleic acids and their role in the preservation and realization of hereditary information. Structural organization of DNA in cells. DNA replication. Homologous recombination of DNA. Gene expression. The genetic code. Protein synthesis (transcription, splicing, alternative splicing, translation). Reverse transcription. The importance of RNA for the realization of hereditary information. Variability of genetic material. Types of mutations. Molecular mechanisms of mutational variability. Mechanisms of DNA repair. Modification variability. Genome organization in viruses, prokaryotes, eukaryotes. Cytoplasmic heredity: genetics of mitochondria and chloroplasts. Gene structure in prokaryotes and eukaryotes.

Regulation of gene activity in prokaryotes and eukaryotes. Levels of regulation of gene activity: replication, transcription, and translation. Horizontal transfer of genetic information, its role in evolution. The human genome. Compilation of pedigrees. Determination of types of inheritance in humans. Hereditary monogenic and multifactorial human diseases. Modern technologies of genetic research. Polymerase chain reaction, its types, application. Application of genetic markers in forensics, breeding, anthropology, medicine. Sanger DNA sequencing, NGS technology, third generation sequencing technology. Genome-wide association studies (GWAS). CRISPR technology. Genetic engineering. Achievements of genetic engineering of microorganisms, plants, animals, their use in industry, agriculture, pharmacology, medicine. Gene therapy. Genome editing using CRISPR technology. Structure of ideal and real populations. Factors of population dynamics.

### **Literature**

1. Lieberman M. A., Ricer R. Biochemistry, molecular biology, and genetics. 6th ed. – Philadelphia: Wolters Kluwer; Baltimore; New York: Lippincott Williams & Wilkins, 2014. – IX, 449 p.

## **X. HISTOLOGY**

Methods of histological research. Preparation of histological specimens. Organization of tissues. Stem cells. Histogenesis. Epithelial layer. Structure, origin and function of the basement membrane. Structure and classification of glands. Types of secretion, age-related changes in epithelial tissues. Embryonic hemocytopoiesis. Hematopoiesis in the postembryonic period. Characterization of lymph. Fibrous connective tissue: structure, types, functional significance. Connective tissue cells. Loose fibrous connective tissue. The structure of dense organized fibrous connective tissue (for example, tendon). Connective tissue with special properties (reticular, adipose, pigment, mucous). Cartilage tissue: classification, structure and functions. Cartilage, its importance in cartilage nutrition and growth. Cartilage development and age-related changes. Structure and functions of bone tissue. Direct and indirect osteogenesis. Bone as an organ. Periosteum, its role in the structure, nutrition, growth of bone. Sources of muscle tissue development and its morphological and functional characteristics. Unstriated and striated muscle tissue. Histogenesis, structure and age-related changes in muscle tissue. Structure of muscle fiber. Myosatellite cells. Muscle as an organ. Myon. Endomysium, perimysium, epimysium. Morphological and functional characteristics of nervous tissue: classification, structure, age-related changes, regeneration. Nerve fibers. Reflex arcs. Cell death: induction and inhibition.

### **Literature**

1. Michael H. Ross and Wojciech Pawlina Histology: A Text and Atlas: With Correlated Cell and Molecular Biology 7th Edition. -

## **XI. ECOLOGY**

Structural levels of biosystems. Regulation, positive and negative feedback. Regulation and stability of biosystems. Hydrological cycle. Sedimentary cycle. Cycles of nitrogen, carbon, phosphorus, sulfur and other elements. Mechanisms of regulation of biogeochemical cycles. Biological classification of ecosystems. The cycle of substances and energy flow in ecosystems. Ecosystem productivity, its methods of assessment and measures. Succession and its causes. Trophic networks and levels. Ecological pyramids and ecological efficiencies. Populations, their static and dynamic characteristics. Models of population growth. The Lotka-Voltaire model. Mathematical models in ecology, the limits of their applicability. Ecological strategies. Types of interaction between species. Ecological niche. Gause's principle of competitive exclusion. Life forms. Environment, environmental factors. Conditions and resources. Liebig's law of minimum. Shelford's rule of tolerance. Size classes of organisms. Solar radiation: spectral composition, absorption by the atmosphere, biological effects, adaptation of organisms. Photoperiodism. Temperature and its effect on organisms. Thermobiological types of organisms. Bergman, Allen, Gloger rules. The concept of effective temperatures. The main habitats. Features of man as a species. Regulation of the number of human populations. The main stages of development of human relations with the environment. The main problems of our time. Renewable and non-renewable resources. Biospheric thinking, eco-conversion. Possible ways to overcome the environmental crisis of our time.

### **Literature**

1. Begon M., Townsend C.R., Harper J.L. Ecology. From individuals to ecosystems. - Malden - Oxford - Victoria, Blackwell Publishing, 2006. - 738 pp.
2. Moles M.C. Ecology: concepts and applications. McGraw-Hill Education, 2016. - 592 p.

## **XII. ZOOLOGY**

Invertebrates. Type Sarcomastigophora. Phylogenetic relationships of unicellular. Protozoa are pathogens of humans and domestic animals. Free-living sarcoderma and flagellates. Type Apicomplexa - pathogens of humans and domestic animals. Type Ciliate or Infusoria. Theories of the origin of multicellularity. Type of plate. Type Sponges. Type Gastropoda. Type Ribworms. Change of symmetry type, appearance of organs and tissues. Type Flatworms. Features of symmetry and structure. Parasitic flatworms. Type Primary cavity worms. Parasitic roundworms. Type Ringworms - biodiversity, structural features and evolutionary significance. Type Arthropoda: subtypes Gastropoda, Trachea, Helicera, Trilobita. Type Arthropoda: Chytons, Gastropods, Bivalves, Cephalopods - change of general organization. Types Mosses and Arthropods. Supertype of the Secondary Arthropoda. Type Pogonophora. Type Needle-skinned. Zoology of vertebrates. The role of vertebrates in modern ecosystems. Zoological systematics, its principles and importance, features. Chordates. Stages of chordate evolution. Subtypes of



Chordates. Subtype Cnidarians, classes Ascidiaceae, Sorberacea, Salps, Appendicularia. Subtype Cephalopoda. Subtype Vertebrata. Origin of the main features of the subtype. Transition from active swimming filtration to predatory feeding. Jawless vertebrates. Evolution and systematics of the superclass Pisces. The main features of fish anatomy and their physiological characteristics. Ichthyofauna of Ukraine, its importance and problems of protection. Evolution and systematics of the superclass Quadrupeds. Landfall of vertebrates. Evolution and systematics of vermin, their anatomy and physiological features. Batrachofauna and herpetofauna of Ukraine, their importance and problems of protection. Evolution and origin of birds. The main features of bird anatomy, their physiological characteristics, systematics, ethology. Avifauna of Ukraine, its importance and problems of protection. Evolution and systematics of the class Mammalia. The main features of mammalian anatomy and their physiological characteristics, systematics, ethology.

#### **Literature**

1. Kardong K.V. Vertebrates. Comparative anatomy, function, evolution. - New York: McGraw-Hill, 2012. - 794 pp.

### **XIII. IMMUNOLOGY**

Defense systems of the animal body. Natural, acquired, innate immunity. Adaptation and protective phenomenon of inflammation. The complement system. Structural and functional organization of the immune system, its anatomical, morphological and molecular elements. Functions of the immune system. The relationship of the immune system with other regulatory (nervous and endocrine) systems. Antigens, types, structure, properties. Antigens of the major histocompatibility complex, features of structure, localization, biological role. Genesis of immunocompetent cells: T-, B-lymphocytes, macrophages. Immunoglobulins, structure, heterogeneity, peculiarities of synthesis, functions. Mechanisms of specific interaction of antigens and antibodies, formation of immune complexes. The main forms of realization of the specific reaction of AG-AT. Regulatory effects of cytokines. Humoral immune response to thymus-independent and thymus-dependent antigens, stages, effects, factors and mechanisms. Cellular immune response, stages, effects, factors, mechanisms. Characterization of transplantation, antiviral, antitumor immunity. The system of immunobiological surveillance of the body. Control and regulation of the immune response, mechanisms of induction and inhibition. Immune memory, its positive and negative forms. Normal and atypical variants of the secondary immune response. Immune tolerance, mechanisms of formation of natural and artificial forms. Fundamentals of immunopathology: hypersensitivity reactions, autoimmune phenomena, immunodeficiency states. Principles of immunodiagnostics and immunoprophylaxis. Age-related features of human immune status. Fundamentals of ecoimmunology. Phytoimmunology. Immunity as a general biological phenomenon. The concepts of "immunity", "resistance", "susceptibility" and "tolerance". Features of plant defense reactions and categories of plant immunity. Features of phytopathogenic organisms (ecological, trophic, types of specialization). Distinctive features of the

pathological process caused by phytopathogenic viruses, bacteria, oomycetes and fungi. Pathogenesis of *Agrobacterium tumefaciens*. Plant resistance to phytopathogenic organisms. Factors of passive immunity. Active defense reactions of plants. Hypersensitivity reaction as a form of apoptosis. Systemic acquired resistance. Molecular genetic basis of plant-pathogen interaction. Resistance genes, avirulence genes and proteins encoded by them.

#### **Literature**

1. Agrios G.N. Plant pathology (5th ed.). - London: Elsevier Academic Press, 2005.- 948 p.
2. Dickinson M. Molecular plant pathology.- London, New York: BIOS Scientific Publishers, 2003, 273 pp.
3. Abbas A., Lichtman A.H., Pillai Sh. Basic Immunology.- Elsevier , 2019.- 336 p.
4. Abbas A., Lichtman A.H., Pillai Sh. Cellular and Molecular Immunology.- Elsevier, 2018.- 579 p.

### **XIV. MICROBIOLOGY**

History, directions of development of microbiology. The place of microorganisms in the system of living organisms. Rules for working with microorganisms and safety in the microbiological laboratory. methods of sterilization and disinfection. Asepsis and antisepsis. Basic morphological types of prokaryotes. Morphology and cytology of prokaryotes. Differences in the structure of pro- and eukaryotes. Features of prokaryotic systematics. Traditional and phylogenetic classification of prokaryotes. Archaea, their place in the system of the organic world. Types of prokaryotic nutrition. Fermentation and its pathogens. L-forms, mycoplasmas, rickettsia, chlamydia. Actinobacteria. Groups of phototrophic and chemotrophic bacteria. Fixation of molecular nitrogen by microorganisms. Variability of microorganisms: transformation, transduction, conjugation. Features of the ecology of microorganisms. The role of microorganisms in the cycle of substances in nature. Commensalism, metabolism, symbiosis, predation, parasitism, antagonism in microorganisms. Possibilities of using microorganisms in various sectors of the economy.

#### **Literature**

1. Animal Microbiology / HU Jianhe, HANG Bolin, XU Yanzhao, SUN Yawei / - Science Press and Narosa Publishing House Pvt. Ltd. 2020, 439 p.

### **XV. MOLECULAR BIOLOGY**

The main tasks of modern molecular biology, its subject and prospects. Methods of molecular biological experiment in solving general biological and practical problems. Study of the principles of functioning of molecular biological systems. The concept of intermolecular interactions and characterization of weak interactions (Van der Waals forces, hydrogen bonding, hydrophobic and electrostatic interactions). The principle of complementarity on the example of DNA structure, transcription and translation mechanisms. Enzyme-substrate interactions and the central dogma of molecular biology. The principle of

cooperativity as a mechanism of membrane biogenesis and enzyme activity reception. Cytoskeleton and regulation of genome expression. The principle of self-assembly on the example of chromatin and ribosome biogenesis. The principle of hierarchy in the structural organization of chromatin, ribosomes and membranes. The principle of structural and functional organization in biology on the example of regulation of genome expression and enzyme activity.

#### **Literature**

1. Lewin's genes / Jocelyn E Krebs; Elliott S Goldstein; Stephen T Kilpatrick Burlington, MA : Jones & Bartlett Learning, ©2018
2. Molecular Biology of the Cell, 4th edition / Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter/ New York: Garland Science; 2002.
3. Epigenetics / Allis, Caparros, Jenuwein, Reinberg/ / 2015. Cold Spring Harbor Laboratory Press: Cold Spring Harbor, NY.
4. Molecular Biotechnology: Principles & Applications of Recombinant DNA 2nd Edition / Bernard R. Glick, Jack J. Pasternak / American Society Microbiology; 2nd edition (March 1, 2003) / 708 p.
5. Lehninger Principles of Biochemistry 4th Edition / David L. Nelson, Michael M. Cox / W. H. Freeman; 4th edition (April 23, 2004) / 1100 p.

### **XVI. RADIOBIOLOGY**

History of development, subject and sections of radiobiology. Physical basis of radiobiology. Characterization of ionizing radiation and its interaction with matter. Physical parameters of radiobiological processes. Instrumental methods of dosimetry. Natural and artificial sources of human and biota exposure to ionizing radiation. Types of radiation cell death and quantification of survival. Radioresistance of multicellular organisms. Theoretical concepts in radiobiology. Principles of hit and target theory, structural and metabolic theory. Fundamentals of molecular radiobiology. Effect of radiation on water and organic molecules. Radiation-chemical transformations of carbohydrates, lipids, proteins and nucleic acids. Biochemical processes in irradiated organisms. Radiation mutagenesis and repair processes of DNA and other molecules in cells. Radiobiology of animals and humans. Radiation syndromes in mammals and humans. Radiosensitivity and radioresistance of living organisms. Criteria for radiosensitivity. Causes of different radiosensitivity of mammals. Modification of radiobiological effects. Radiosensitization and radiomimetic effects in radiobiology, synergistic phenomena in radiobiology. Long-term effects of radiation. Biological mechanisms of late effects of radiation. Biological significance of natural radioactivity in the environment. Natural radioactivity and evolution of species.

#### **Literature**

1. Radiobiology Textbook  
<https://library.oapen.org/handle/20.500.12657/76707>

### **XVII. THEORIES OF EVOLUTION**

The subject and object of evolutionary biology; methods of studying the

evolutionary process; links of evolutionary biology with other sciences. Classification of levels of structural organization of living things (molecular genetic, ontogenetic, population-species, biogeocenotic). Creationism, transformism and evolutionism - explanation of biodiversity and adaptation of organisms within these approaches. Basic concepts of the historical development of living organisms from the pre-Darwinian period to the present. The evolutionary theory of Charles Darwin. Provisions of the synthetic theory of evolution and their further development. Formation of the doctrine of microevolution and its importance for evolutionary theory. Hereditary variability as a material of the evolutionary process. Factors of evolution. Organic evolution as an objective phenomenon of nature. Evidence of evolution. Problems of molecular evolution, neutral theory of molecular evolution. Problems of evolutionary biology of development. Problems of macroevolution. Species formation. Reconstruction of phylogeny. The main stages of anthropogenesis, its driving forces and distinctive features. Prerequisites and stages of life on Earth. Evolution of types of nutrition. Evolution of the cell. The main stages and ways of plant evolution. The main stages and ways of evolution of animals. Evolution of ecosystems and differentiation of the biosphere. Concepts of genetic and cultural coevolution.

### **Literature**

1. Ridley M. Evolution. 3rd ed. Malden: Blackwell Publishing, 2004. - 786 p.
2. Futuyma D. J., Kirkpatrick M. Evolution. 4th ed. Sunderland: Sinauer Associates, 2017. - 724 p.
3. Herron J. C., Freeman S. Evolutionary Analysis. 5th edition. Harlow: Pearson Education, 2015. - 865 p.
4. Jobling M. et al. Human evolutionary genetics. - Garland Science, 2014. - 690 p.

## **XVIII. PHYSIOLOGY AND BIOCHEMISTRY OF PLANTS**

Structural components of a plant cell. Functional relationship of organelles. Photosynthesis. Pigment system of higher plants. Primary processes of photosynthesis. Ways of fixation of CO<sub>2</sub> (dark phase of photosynthesis) - Calvin cycle, Hatch-Sack cycle, SAM photosynthesis, glycolate cycle (photorespiration). Transport of assimilates in the plant. Ecology of photosynthesis. Global photosynthesis. Cellular respiration and its role. Ways of oxidation of the respiratory substrate. Cyanide-resistant respiration. Ecological and ontogenetic control of plant respiration. General characteristics of plant water metabolism. Mechanism of water entry - the gentle end engine (weeping, gutting). Intracellular, short-range and long-range transport of water in plants. The upper end of the water transport is transpiration. Mechanism of stomatal movements. Regulation of water exchange. Plant nutrition. Patterns of substance absorption. Physiological role of macro- and microelements. Release of substances by roots. The concept of growth and development, their relationship. Phytohormones: auxins, cytokinins, gibberellins, ABA, ethylene, non-classical phytohormones. Plant movements. Photoreception and photo-morphogenesis. Stages of plant ontogeny. Photoperiodism, vernalization. Reproduction of plants.

Aging of plants. Plant biotechnology. General concepts - resistance, adaptation, stress. Drought resistance, heat resistance, cold resistance, frost resistance, winter hardiness, salt resistance, anoxia and hypoxia, gas resistance, radio resistance, resistance to heavy metals. Features of plant biochemistry. Carbohydrates, their functions in plants, chemical properties, classification, characteristics of individual representatives. Metabolism of carbohydrates in plants. Proteinogenic and non-proteinogenic amino acids. Classification and importance of plant proteins. Metabolism of amino acids and proteins in plants. Lipids. Composition of vegetable oils, their physical and chemical properties and importance. Characterization of plant lipoids. Lipid metabolism in the plant. Substances of secondary origin (organic acids of aliphatic series, phenolic compounds, glycosides, terpenes and terpenoids, alkaloids). Their chemical properties, distribution in plants, characteristics of individual representatives, importance, metabolism.

#### **Literature**

1. Hans-Walter Heldt, Fiona Heldt. Plant Biochemistry Third edition.- Elsevier Academic Press, - 2005. - 630 p.
2. Plant Physiology /Edited By Philip Stewart, Sabine Globig.- Published by Apple Academic Press, - 2021. - 298 p.

### **XIX. HUMAN AND ANIMAL PHYSIOLOGY**

Structural and functional organization and regulation of vital activity of an animal organism. Properties of excitable cells (tissues). Nature of membrane potentials: resting potential and action potential. Features of the structure, innervation, mechanisms of contraction of striated skeletal and smooth muscles. Reflex activity of the nervous system. Synaptic processes. Nerve centers and their properties. The relationship between excitatory and inhibitory processes. Principles of coordination of reflex activity. Structural and functional characteristics of the central nervous system. Principles of structure, functioning, interaction of sensory systems. Physiology of higher nervous activity. Unconditional and conditioned reflexes, their classification, properties, biological significance. Stages and mechanisms of formation and inhibition of conditioned reflexes. Types of higher nervous activity. Features of the human GNI. Autonomic nervous system, features of the structure and regulatory influence of its departments. Structural and functional organization of the endocrine system. Characteristics of synthesis, secretion, metabolism, mechanism of action, effects of various hormones. Physiological basis of reproduction. Structural and functional organization, humoral and nervous mechanisms of regulation of visceral systems: blood, circulation, respiration, excretion, digestion. Regulation of metabolism and energy; thermoregulation. General adaptation syndrome. P. K. Anokhin's theory of functional systems.

#### **Literature**

1. Ravikumar Patil H.S., Makari H.K., Gurumurthy H. A Textbook of Human Physiology. Paperback .- Dreamtech Press , 2020.-224 p

### **XX. CYTOLOGY**

The study of prokaryotic and eukaryotic cells and their general structure. Unity of structure and function of the cell, its organoids and other structural elements. General characteristics of the cell. Cells of prokaryotes and eukaryotes. Size and shape of cells. Methods of cell research. Surface apparatus of the cell. Structure and function of the plasma membrane (chemical composition and molecular organization of the plasma membrane), supramembrane and submembrane structures. Formation of intercellular contacts, their types and functional significance. Simple contact, "lock", desmosomes, tight contact, septal contact. Communication contacts - tight, plasmodesmata. Adhesive properties of the cell apparatus. Functions of the cell surface apparatus: permeability and different types of transport. Vacuolar system of the cell, its composition, structure and functions. Morphological and functional unity of the components of the vacuolar system, their phylogeny. Organoids of energy metabolism, structure and function. Biogenesis and phylogeny of mitochondria and chloroplasts. Similar structure of mitochondria and plastids, functional unity. Structures of the cytoskeleton, structure, chemical composition and functions. Cellular inclusions, their localization, chemical composition and functional significance. Structural components of the nucleus and the life cycle of the cell. Types of cell reproduction. Cell differentiation. The role of the nucleus and cytoplasm in cell differentiation.

#### **Literature**

1. Molecular biology of the cell\ by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Rafi Keith Roberts, and Peter Walter.-5<sup>th</sup> ed. Garland Science, Taylor & Francis Group, 2008.-1601 pp.
2. Karp G. Cell and Molecular Biology. 7th edition. Wiley, 2013. – 864 p.

## **STRUCTURE OF THE TASK AND EVALUATION CRITERIA FOR THE ADMISSION EXAM TO THE POSTGRADUATE PROGRAM**

If the exam is held **offline**, it is conducted in a mixed form: a written part and an oral examination. The applicant receives a task with three theoretical questions from different sections of the program. For a written answer to each question, an applicant can receive 25 points (75 points in total).

### **CRITERIA FOR ASSESSING THE KNOWLEDGE OF APPLICANTS (written response)**

Score in points	Explanation
20-25	The applicant demonstrates a deep understanding and fluency in theoretical material, familiarity with the literature, can give examples and explain the meaning of concepts and results, the presentation is competent, logical and comprehensive.
15-19	The applicant demonstrates an understanding of a significant part of the theoretical material, can give examples and explain the meaning of concepts and results, the presentation is competent and logical with minor inaccuracies.
10-14	The applicant is generally aware of the theoretical material, can give examples and explain the meaning of some concepts and results, the presentation is incomplete, contains inaccuracies.
5-9	The applicant is poorly oriented in a significant part of the theoretical material, makes significant mistakes that he or she corrects, and does not clearly explain the meaning of concepts and results.
1-4	The applicant does not understand a significant part of the theoretical material, makes significant mistakes, and cannot explain the meaning of concepts and results.
0	The applicant did not complete the assignment.

During the oral examination, the Commission asks the applicant five additional questions. For a correct answer to each of the five oral questions, an applicant can receive five points, for a total of 25 points.

The applicant's answer to each question is evaluated by each examiner according to the following criteria:

**CRITERIA FOR ASSESSING THE KNOWLEDGE OF APPLICANTS**  
(oral survey)

Score in points	Explanation
5	The applicant demonstrates a deep understanding and fluency in theoretical material, familiarity with the literature, can give examples and explain the meaning of concepts and results, the presentation is competent, logical and comprehensive.
4	The applicant demonstrates an understanding of a significant part of the theoretical material, can give examples and explain the meaning of concepts and results, the presentation is competent and logical with minor inaccuracies.
3	The applicant is generally aware of the theoretical material, can give examples and explain the meaning of some concepts and results, the presentation is incomplete, contains inaccuracies.
2	The applicant is poorly oriented in a significant part of the theoretical material, makes significant mistakes that he or she corrects, and does not clearly explain the meaning of concepts and results.
1	The applicant does not understand a significant part of the theoretical material, makes significant mistakes, and cannot explain the meaning of concepts and results.
0	The applicant did not complete the assignment.

The total maximum number of points is 100.

If the exam is held **online**, it is conducted in writing. The applicant receives a task with three theoretical questions from different sections of the program. An applicant can get 34 points for answering the first question and 33 points for answering the second and third questions each one (100 points in total).

In this case the applicant's answer to each question is evaluated by each examiner according to the following criteria:

**CRITERIA FOR ASSESSING THE KNOWLEDGE OF APPLICANTS**  
(online examination)

Score in points	Explanation
30-33(34)	The applicant demonstrates a deep understanding and fluency in the theoretical material , familiarity with the literature, can give examples and explain the meaning of concepts and results, the presentation is competent, logical and comprehensive.
20-29	The applicant demonstrates an understanding of a significant part of



	<b>the theoretical material, can give examples and explain the meaning of concepts and results, the presentation is competent and logical with minor inaccuracies.</b>
<b>10-19</b>	<b>The applicant is generally aware of the theoretical material, can give examples and explain the meaning of some concepts and results, the presentation is incomplete, contains inaccuracies.</b>
<b>1-9</b>	<b>The applicant does not understand a significant part of the theoretical material, makes significant mistakes, and cannot explain the meaning of concepts and results.</b>
<b>0</b>	<b>The applicant did not complete the assignment.</b>

The total amount of points for the answers is calculated as the arithmetic mean of the sum of the points received from each examiner and rounded to the nearest whole number.

The average number of points assigned by the examiners is converted to a scale of 100-200 in accordance with the following table:

<b>The average score from examiners</b>	<b>ratings. dung score</b>	<b>The average score from examiners</b>	<b>rating- dung score</b>	<b>The average score from examiners</b>	<b>rating- dung score</b>
1	1	35	74	69	138
2	3	36	76	70	140
3	6	37	78	71	142
4	10	38	80	72	144
5	12	39	82	73	146
6	14	40	84	74	148
7	18	41	86	75	150
8	20	42	88	76	152
9	22	43	90	77	154
10	24	44	92	78	156
11	26	45	94	79	158
12	28	46	96	80	160
13	30	47	97	81	162
14	32	48	98	82	164
15	34	49	99	83	166
16	36	50	100	84	168
17	38	51	102	85	170
18	40	52	104	86	172
19	42	53	106	87	174
20	44	54	108	88	176
21	46	55	110	89	178
22	48	56	112	90	180
23	50	57	114	91	182
24	52	58	116	92	184
25	54	59	118	93	186
26	56	60	120	94	188
27	58	61	122	95	190
28	60	62	124	96	192
29	62	63	126	97	194

30	64	64	128	98	196
31	66	65	130	99	198
32	68	66	132	100	200
33	70	67	134		
34	72	68	136		

### **Interpretation of the final rating score**

<b>Rating score</b>	<b>Rating on a four-level scale</b>
179-200	excellent
139-178	good
100-138	satisfactorily
<100 points	unsatisfactorily

When calculating the competition score, the rating score is used.

### **Chairman of the subject committee**

\_\_\_\_\_ **Lyubov ATRAMENTOVA**

Approved at the meeting of the Admissions Committee  
 Kharkiv National University  
 V.N. Karazin National University  
 Protocol No. 2 dated April 15, 2024.

### **Executive Secretary of the admission committee**

\_\_\_\_\_ **Sergiy YELTSOV**