MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

V.N. Karazin Kharkiv National University

"APPROVED"

Deputy Head of the Admissions Committee, Vicerector for scientific and pedagogical work of V. N. Karazin Kharkiv National University

_____Oleksandr HOLOVKO

Program

of the professional exam in **BIOLOGY**

for admission to study

to obtain a **Master's** degree

in the specialty E1 Biology and biochemistry Educational and professional program **"BIOLOGY"**

Kharkiv - 2025

The program is designed for self-preparation for the exam. It consists of 149 theoretical questions in 18 sections. The short wording of the questions is given in bold. After the colon, the content of the question is revealed, i.e., what exactly you need to know to pass the exam. At the end of each section, you will find a list of references for preparation.

I. CELL BIOLOGY

1. **Cell surface apparatus**: chemical composition and molecular organization of the plasma membrane; supramembrane and submembrane structures of the cell surface apparatus; formation of intercellular contacts, their types and functional significance; types of transport through the cell membrane.
2. **The vacuolar system of the cell**: structure and functions of the smooth and granular endoplasmic reticulum; ribosomes, structure and chemical composition; Golgi apparatus - structure, functions; lysosomes - formation, classification, properties of lysosomal enzymes.
3. **Organoids of energy metabolism:** structure of mitochondria, chemical composition of outer mitochondrial membranes, cristae, matrix, their role in ATP synthesis in the cell; plastids - structure, chemical composition; DNA and ribosomes of mitochondria and chloroplasts.
4. **Cytoskeleton:** microfilaments - chemical composition, structure, localization, formation of pseudopodia, microvilli; actomyosin complexes of non-muscle and muscle cells; microtubules - chemical composition, structure, localization; structure of centrioles, their functions and reproduction; structure of axonemes, cell movement due to cilia and flagella.
5. **Nucleus:** nuclear membrane, nuclear lamina, nuclear pores, nuclear-cytoplasmic transport; chromatin, chemical characteristics, active (diffuse) and inactive (condensed) chromatin, heterochromatin, constitutive and optional; levels of chromatin organization, the role of histones and non-histone proteins; chromosomes of a dividing cell, chromosome structure, types of chromosomes; nucleus-forming regions of chromosomes, nucleus structure, granular and fibrillar components.
6. **Cell cycle:** pre-synthetic period, synthesis period, postsynthetic period and mitosis; resting period (G0 -phase); structural and biochemical changes of the cell in each interphase period; mitotic stages, their characteristics; structure of the division spindle; cytokinesis of animal and plant cells; polythene chromosomes, polyploid cells; stages of meiosis; lamp-brush chromosomes; cell death: apoptosis, necrosis.

1. *Karp G. Cell and Molecular Biology. 7th edition. Wiley, 2013. - 864 p.*

II. STRUCTURAL BOTANY: PLANT ANATOMY

7. **The plant cell:** general organization and diversity, cell components - membrane and envelope organelles, the concept of the endomembrane, the plastid system.
8. **Products of protoplast life:** cell membrane - structure, biochemical composition and biogenesis; vacuole - osmotic properties of a plant cell; reserve substances.
9. **Plant tissues:** classification, types, general features; meristematic, integumentary and mechanical tissues.
10. **Plant tissues:** structural and functional features; conducting (transport), absorbing, assimilating, secretory and storage tissues; vascular fiber bundles (VFB).
11. **Anatomy of vegetative organs:** stem - features of structure, function, development; theory of histogens; primary and secondary structure of the stem of monocotyledonous and dicotyledonous plants; stellar theory; modifications (metamorphosis) of stems.
12. **Structure and functions of the leaf and root:** connection of the leaf with the stem (evolutionary and structural-functional); anatomical plasticity of the leaf blade, leaf fall, root zones, primary and secondary structure, modifications (metamorphosis) of roots, mycorrhiza, nodules.

1. *Evert R.F. Esau's plant anatomy: meristems, cells, and tissues of the plant body - their structure, function, and development. 3rd edition. - New Jersey: Wiley-Interscience, 2006. -*

III. HUMAN ANATOMY AND HISTOLOGY

13. **General anatomy and general histology:** correct anatomical position of the human body (Kelliker's position / posture) and anatomical landmarks (planes, axes, lines), general anatomical terms; general principles of organization, development and classification of tissues; general, classification and morphofunctional characteristics, distinctive features, features of the structure of cells and intercellular substance, location in human organs, sources of development and regeneration: different types of epithelial tissue, different types of connective tissue, different types of connective tissue, different types of connective tissue.

14. **Functional anatomy and histology of the** musculoskeletal system**:** general, classification and morphofunctional characteristics of bones, departments, skeletal system; general, classification and morphofunctional characteristics of groups of bone joints (continuous, semi-articular, discontinuous joints), joint system; general, classification and morphofunctional characteristics of the muscular system.

15. **Anatomy and histology of the nervous system**: general, classification and morphofunctional characteristics of structural and functional units of the nervous system (neuron / reflex arc); classification and morphofunctional characteristics of glial cells, neurons, nerve fibers; general principles of structure and histological structure of the mixed nerve; general, classification, morphofunctional and comparative characteristics of the nervous system: somatic and autonomic nervous system, central and peripheral parts of the nervous system; zo

16. **Anatomy and histology of the sensory organs and the integumentary system:** morphofunctional characteristics and histological structure of the organ of smell, organ of taste, organ of hearing and balance, organ of vision; classification and morphofunctional characteristics of receptors, conducting pathways and cortical part of the system of skin sensitivity, olfactory and taste analyzers, hearing analyzer, statokinetic and visual analyzers; histological structure of the skin and its appendages (hair, nails), classification, morphofunctional characteristics and histological structure of the mammary gland, sweat and sebaceous glands of the skin.

17. **Anatomy and histology of endocrine glands and diffuse neuroendocrine system (*APUD-system)***: general, classification and morphological characteristics; external, internal and histological structure of the pineal gland, pituitary gland, thyroid gland, pineal gland, adrenal glands, paraganglia, pancreatic islets of Langerhans-Sobolev, endocrine part of the gonads.

18. **Anatomy and histology of digestive system organs**: general and morphofunctional characteristics of the digestive system, its departments and organs of these departments; abdominal and peritoneal cavities; histological structure of the peritoneum, derived structures of the peritoneum; classification, morphofunctional characteristics and histological structure of each individual organ of the digestive system according to the generally accepted plan: name *(Nomina latina*, Ukrainian equivalent of the Latin term), shape, number, size, weight, classification characteristics of the organ, functions, topography (skeletotopia, synthopia holotopia), how the peritoneum covers the organ; external, internal macroscopic and microscopic (histological) structure of the organ, its structural and functional unit; histological structure of the tubular organ wall; blood supply and innervation, lymphatic vessels of the organ.

19. **Anatomy and histology of respiratory system organs:** general and morphofunctional characteristics of the respiratory system; its departments and organs of these departments; mediastinum, departments, organs; classification, morphofunctional characteristics and histological structure of each individual organ of the respiratory system according to the generally accepted plan: name (*Nomina latina*, Ukrainian equivalent of the Latin term), shape, number, size, weight, classification characteristics of the organ, functions, topography (skeletotopy, synthopy. holotopia); external, internal macroscopic and microscopic (histological) structure of the organ, its structural and functional unit; histological structure of

the wall of a tubular (hollow) organ; blood supply and innervation, lymphatic vessels.
20. **Anatomy and histology of urinary system organs, male and female reproductive systems organs:** general and morphofunctional characteristics of the urinary system, male and female reproductive systems; their departments and organs of these departments; classification, morphofunctional characteristics and histological structure of each individual organ of the urinary system, male and female reproductive systems according to the generally accepted plan: name (*Nomina latina*, Ukrainian equivalent of the Latin term), shape, number, size, weight, classification characteristics of the organ, functions, topography (skeletotopy, synthopy holotopia), external, internal macroscopic and microscopic structure of the organ, its structural and functional unit, histological structure of the wall of the tubular (hollow) organ, blood supply and innervation of the organ.
21. **Anatomy and histology of organs of the cardiovascular system:** general and morphofunctional characteristics of the heart, circulatory system (blood vessels) and lymphatic system (lymphatic vessels, primary and secondary lymphoid organs); classification, morphofunctional characteristics and histological structure of the walls of blood and lymphatic vessels; types of arteries by the structure of their walls; types of veins by the structure of their walls; types of hemocapillaries by the structure of their walls, hemomicrocirculatory channel; general principles of blood supply to the human body; general characteristics of the large and small circulation, vessels of the large and small circulation; structure of the heart: size, weight, classification characteristics, functions, topography (skeletotopy, syntopy. holotopia), external structure; heart chambers, structure of the heart wall (endocardium, atrial myocardium, ventricular myocardium, cardiac stimulus complex, epicardium, core), valvular apparatus, soft skeleton, blood supply and innervation, lymphatic vessels of the heart; morphological signs of primary and secondary lymphoid organs, lymphoid formations in the walls of the digestive, respiratory and urinary systems, skin; classification, morphofunctional characteristics, topography and histological structure of lymphoid organs (red bone marrow, thymus, lymph nodes; tonsils, cricoid process, spleen) according to the generally accepted plan.

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

IV. VIROLOGY

22. **Nature of viruses:** principles of structural organization of viral particles, morphology and structure of viral particles, classification of viruses.
23. **Virus replication:** attachment and penetration into the cell, "undressing" of the genome, expression of viral genes: transcription and translation, replication of viral nucleic acid, viral particles morphogenesis and their exit from the cell.
24. **Spread of viruses, the consequence of infection with a host virus:** mechanisms of virus spread, the main principles of virus transmission by vectors, factors that affect the outcome of a viral infection, innate and adaptive human immunity, unproductive and productive infection.
25. **Viral carcinogenesis; pathogenesis of diseases caused by prions:** mechanisms of malignant tumors under the influence of viruses, nature of prions, prion diseases of animals and humans, prion strains.
26. **Origin and evolution of viruses:** main hypotheses of the origin of viruses, mechanisms of virus evolution, co-evolution of viruses and their hosts.

1. *Carter J., Saunders V. Virology: principles and applications. - Chichester, England: John Wiley & Sons Ltd., 2007. - 358 p.*

V. MICROBIOLOGY

27. **Peculiarities of prokaryotic cell organization:** structure of the genetic apparatus of prokaryotes, obligatory and optional intracellular components; intracellular structures derived from the cytoplasmic membrane and those surrounded by a protein membrane; peculiarities of

the structure of bacterial flagella.
28. **Differences in the structure of Gram-positive and Gram-negative bacteria:** structure and functions of peptidoglycan and outer membrane; functions of teichoic acids; organization of periplasmic compartment.
29. **Features of archaeal biology:** unusual cell morphology; differences in the structure of archaeal cells; physiological groups of archaea; ecological niches occupied by archaea.
30. **Sources of carbon and energy for prokaryotes:** use of CO and CO2, organic compounds by bacteria; peculiarities of bacterial photosynthesis, respiration; organic and inorganic electron donors.
31. **Fermentation as the simplest way for prokaryotes to produce energy:** the essence of fermentation, types of fermentation, intermediate and final products of fermentation.
32. **Bacteria with a parasitic mode of existence:** peculiarities of rickettsia biology; structure, metabolism and life cycle of chlamydia.
33. **Participation of microorganisms in the nitrogen cycle:** processes of nitrogen fixation, ammonification, nitrification and denitrification.
34. **Possibilities of using microorganisms in various fields:** microorganisms as a source of protein, use of prokaryotes to produce food, pigments, enzymes, vitamins, amino acids, bacterial fertilizers; use of bacteria for genetic engineering manipulations.

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

VI. BOTANY
35. **Photosynthetic pigments and products of algal assimilation:** chemical nature, distribution in taxonomic groups, evolutionary trends.
36. **Features of the structure of algal cells:** nucleus, chloroplasts, cell membranes - features in different taxonomic groups, evolutionary trends.
37. **Types of meltwater and morphological differentiation in algae:** definition, distribution in taxonomic groups, evolutionary trends.
38. **Reproduction of algae:** vegetative, asexual, types of sexual process - definition, biological significance, distribution by taxonomic groups, evolutionary trends.
39. **Types of algal life cycles:** alternation of nuclear phases, position of reductive fission, alternation of generations, distribution in taxonomic groups, evolutionary trends.
40. **The main taxonomic groups of algae:** distinctive features, ecology, distribution, importance in nature and economy.
41. **General characteristics of the life form Fungi:** diversity in origin, morphological structure, cytological and biochemical features, taxonomy.
42. **Features of the structure and functioning of the fungal cell:** fungal organelles, cell wall structure, features of fungal growth and nutrition, genetic features, life cycles.
43. **Vegetative body of fungi:** diversity of thallus types, evolution and functional modifications.
44. **Asexual reproduction of fungi:** diversity and evolution of reproductive structures, strategies of distribution.
45. **Sexual reproduction of fungi:** peculiarities of sex determination, diversity and evolution of reproductive structures, and propagation strategies.
46. **The role of fungi in nature and human life:** ecological and trophic groups of fungi and their functional role; fungi as model objects in biology and the discoveries made on them.
47. **Slugs:** structure, developmental cycles, ecology, division into taxa.
48. **Lichens:** phycobiont and mycobiont, anatomical and morphological structure, reproduction, ecology, division into taxa.
49. **Vegetative organs of higher plants:** shoot (stem, leaf, bud), root - morphological structure, functions, diversity.
50. **Metamorphosis of vegetative organs:** diversity in origin and function.

51. **Generative organs:** morphological structure, functions, diversity, essence and evolutionary significance of double fertilization.
52. **Higher spore plants:** division into taxa, distinctive features - structure, reproduction, life cycle, ecology.
53. **Holosperms:** structure, reproduction, life cycle, ecology, division into taxa.
54. **Flowering plants:** structure, reproduction, life cycle, ecology, division into taxa.

1. *Plant Systematics: A Phylogenic Approach. Walter S. Judd, C. S. Campbell, E. A. Kellogg, P. F. Sinauer Associated, Inc. Publishers Suderland, Massachusetts, USA. - 1999.*

VII. ZOOLOGY

55. **Zoology as a modern integral science of animals, origin of eukaryotes, diversity of protozoa:** methods of zoology; cladistics; modern concepts of geochronology; main stages of invertebrate evolution; the role of symbiosis in the evolution of protozoa - the origin of eukaryotes; levels of symbiont integration; evolution of views on the system of the organic world; phylogenetic relationships of macrotaxa; macrotaxonomy; phylum of the organic world; system of kingdoms; diversity of protozoa; parasitic protozoa.
56. **Origin of multicellular organisms, types Sponges and Platelets:** theories of the origin of multicellular organisms - celluorization, placules, planulae, gastrei, phagocytes; macro-taxonomy of multicellular organisms; choanoflagellates and their colonies; cell differentiation in colonies and the origin of sponges; morphology and cellular composition of sponges; features of embryogenesis; classification and diversity of sponges; type Platelets.
57. **Differentiation of tissues, types of Cnidarians and Ribworms:** origin of Cnidarians, tissue differentiation, beginning of organ systems formation; morphology and anatomy of Cnidarians, radial symmetry; systematics and life cycles; ecological and geological significance of Cnidarians; Ribworms - origin of mesoderm.
58. **Origin of three-layers and body cavities, diversity of worms:** transition to crawling on the substrate; change of symmetry type; morphological and anatomical consequences of ecological niche change - development of the skin-muscle sac, mesoderm and excretory system; systematics, morphology, anatomy of flatworms; parasitic forms and their life cycles; reasons for the formation of body cavities; morphology and embryogenesis of primary and secondary body cavities; connection with the development of new ecological niches; necrotic and circulatory systems; primary cavities - variety of types; secondary cavities, organ systems, circulatory and excretory systems; ringworms.
59. **Landfall of invertebrates, arthropods:** diversity of arthropods; arthropodization of primary cavities, molecular genetic data; tardigrades and onychophores; formation of the external skeleton and changes in organ systems; features of the structure of the muscular, circulatory, excretory and respiratory systems; structure of the body cavity; landfall; systematics, morphology and anatomy of arthropods; structure of the body, head, mouth appendages and limbs.
60. **Type Mollusca:** modern concepts of evolution and phylogeny of mollusks, molecular genetic data; systematics, morphology, anatomy of mollusks.
61. **Lophophora and secondary mouths:** phylogenetic relationships with secondary cavity and ringworms; bryozoans, brachiopods, foronids; changes in the method of crushing, mouth and secondary body cavity; branchiopods, chetonates, hemichordates; diversity and systematics of needleworms.
62. **Evolutionary strategies of invertebrates:** a general overview of invertebrate evolution; the main directions of phylogeny - analogies and homologies, complication of organ systems, arthropodization, formation of skeletal structures - from external to chordal.
63. **General characteristics of chordates**.
64. **Subtypes of Cephalopods, Coverflies:** general characteristics.
65. **Subtype Vertebrata, superclass (section) Jawless:** origin of the main features of vertebrates, transition from actively swimming filtration to predatory feeding, general characteristics of jawless.

66. **Superclass Pisces:** main features of anatomy, physiological features, evolution, systematics.
67. **Superclass Tetrapods, classes Amphibia, Reptilia:** evolution, systematics, landfall of vertebrates, main features of anatomy of amphibians and reptiles, physiological features, evolution, systematics.
68. **Class Birds:** main features of anatomy, physiological features, systematics, ethology.
69. **Class Mammalia:** main features of anatomy, physiological features, systematics, ethology.

1. *Kardong K.V. Vertebrates. Comparative anatomy, function, evolution. - 8th ed. New York: McGraw-Hill Education, 2019 - 796 p.*

VIII. BIOECOLOGY

70. **Ecology and biosystems:** levels of organization, sustainability and properties of biosystems, approaches to the study of biosystems.
71. **Biosphere:** the biosphere, biogeochemical cycles of water, carbon, nitrogen, sulfur, phosphorus, the emergence and stages of life on Earth.
72. **Biogeocenology and community ecology:** concepts of biogeocenosis, ecosystem, biome, structure, classification, productivity, succession, trophic relationships and levels, ecological efficiencies and pyramids.
73. **Population ecology:** characteristics and properties of populations, models of population growth, classification of relationships between populations, ecological strategies, regulation of population size, strategies of intrapopulation interaction.
74. **Autecology and basics of environmental science:** classification of environmental factors, Liebich's law of minimum, Shelford's rule of tolerance, size classes of organisms, biological effects of solar radiation and temperature, Bergman, Allen, Gloger rules, basic environments, life forms of organisms.
75. **Human ecology and nature conservation:** features of humans as a species, regulation of population size, main stages of development of humanity's relations with the environment, the environmental crisis of our time and possible ways to overcome it.

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

IX. BIOORGANIC CHEMISTRY

76. **Structure and functions of carbohydrates:** classification of carbohydrates; structure, chemical properties and biological role of monosaccharides (aldose, ketose, pentose, hexose); structure, properties and biological role of monosaccharide derivatives (O- and N-glycosides, aldonic and uronic acids, sucrose alcohols, aminosaccharides, sugar phosphates, deoxysaccharides); structure, properties and biological role of oligosaccharides; structure, properties and biological role of homopolysaccharides (starch, glycogen, cellulose, chitin) and heteropolysaccharides (for example, hyaluronic acid, heparin and chondroitin sulfate).
77. **Structure and functions of amino acids:** diversity of the structure of natural amino acids; stereoisomerism of protein amino acids; acid-base properties; classification of proteinogenic amino acids by polarity and charge of the radical (side chain); color reactions to amino acids (ninhydrin, xanthoprotein, Fol's).
78. **Structure and function of peptides and proteins:** peptide bond (formation, structure, biuretic reaction); levels of structural organization of proteins (primary, secondary, tertiary and quaternary structures); types of bonds between amino acid residues involved in the stabilization of each level of structural organization of proteins; physicochemical properties of proteins (solubility, isoelectric point); denaturation of proteins, factors contributing to protein denaturation, features of the structure and functions of globular and fibrillar proteins.
79. **Structure and function of nucleic acids: nitrogenous** bases of pyrimidine (uracil,

cytosine, thymine) and purine (adenine, guanine) series, which are part of natural nucleotides; structure and properties of DNA (nucleotide composition, Chargaff's rules, nature of internucleotide bonds, complementarity of nitrogenous bases); primary and spatial structures of DNA; DNA complexes with proteins; levels of structural organization of chromatin; structure, properties and biological functions of RNA; basic types of RNA (mRNA, tRNA, rRNA); features of the structure of different types of RNA.

80. **Structure and function of lipids and biomembranes:** classification of lipids; structure and properties of fatty acids (saturated, monounsaturated, polyunsaturated); chemical structure, properties and biological role of saponifiable lipids (triacylglycerols, glycerophospholipids, sphingophospholipids, sphingoglycolipids); structure of isoprene derivatives (steroids, terpenes), molecular composition of biological membranes (lipid composition, types of membrane proteins), liquid mosaic model of membrane structure, basic properties and functions of biological membranes.

81. **Biologically active substances:** water-soluble vitamins (thiamine, riboflavin, folic acid, pantothenic acid, pyridoxal, nicotinamide, B12, biotin, ascorbic acid) and their coenzyme functions, fat-soluble vitamins (A, E, K and D) and their regulatory role, quinones and metalloporphyrins and their role in redox processes, biological pigments (chlorophyll, carotenoids, melanins, flavonoids, bilins), bioregulators (examples of phytohormones, animal hormones and intracellular regulators), diversity of structure and mechanisms of antibiotic action (examples: beta-lactams, tetracyclines, non-polyene macrolides and aminoglycosides).

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.*

X. BIOCHEMISTRY

82. **Enzymatic catalysis:** chemical nature and basic properties of enzymes; features of the structure of the active center of the enzyme; catalytic and substrate specificity of enzymes; main stages and mechanisms of enzymatic catalysis; classification and nomenclature of enzymes; brief description of enzyme classes; determination of enzyme activity; units of enzyme activity.

83. **Cofactors and coenzymes:** structure of complex enzymes (concepts of apoenzyme, cofactor, holoenzyme); role of apoenzymes and cofactors in biocatalysis; vitamins as precursors in coenzyme biosynthesis; vitamins: definition, classification (water-soluble, fat-soluble, vitamin-like compounds) and their functions.

84. **General pathway of catabolism:** oxidative decarboxylation of pyruvate; tricarboxylic acid cycle (localization in the cell, enzymatic reactions, regulation, energy balance of the cycle, importance in metabolism); organization of the mitochondrial respiratory chain, mechanism of coupling of oxidation and phosphorylation.

85. **Carbohydrate metabolism and its regulation:** anaerobic and aerobic breakdown of glucose (stages, regulatory reactions, substrate phosphorylation reactions, energy balance, biological role); glucose biosynthesis - gluconeogenesis - (substrates, "bypass stages", biological role); glycogen biosynthesis and breakdown (stages, regulatory enzymes, hormonal regulation of processes, biological role).

86. **Lipid metabolism and its regulation:** β-oxidation of fatty acids (activation of fatty acids, role of carnitine in the transport of fatty acids into mitochondria, main stages, energy balance); biosynthesis of higher saturated fatty acids on the example of palmitate (sources of acetyl groups, transfer of acetyl groups from mitochondria to cytoplasm, formation of malonyl-CoA, main stages catalyzed by fatty acid synthase, sources of NADPH, regulation).

87. **Intracellular metabolism of amino acids:** reactions of transamination of amino acids and their biological significance; direct and indirect deamination of free L-amino acids in tissues; glutamate dehydrogenase and its role in amino acid metabolism; reactions of

decarboxylation of L-amino acids and physiological significance of products formed in these reactions.

88. **Molecular mechanisms of transmission and realization of genetic information:** DNA replication in prokaryotic cells (mechanism, stages, replicative fork, main enzymes and proteins involved in replication); transcription in bacterial cells (structure of gene promoters, RNA polymerase, main stages of RNA synthesis, ρ-dependent and ρ-independent termination); Protein biosynthesis - translation - (genetic code and its properties, components of the ribosomal protein synthesizing system, transporting tRNAs and amino acid activation, main stages of translation).

89. **Basic systems of metabolic regulation and intercellular communication:** systems of metabolic regulation; interaction of the nervous and endocrine systems of the body; general characteristics of hormones and approaches to their classification; hormone receptors; role of hormones in the regulation of metabolism and functions.

1. *Nelson D.L., Cox M.M., Lehninger Principles of biochemistry: W.H. Freeman and Company, 2012. - 1119 p.*

XI. MOLECULAR BIOLOGY

90. **Structure and function of nucleic acids:** biological information and informational biopolymers; central dogma of molecular biology; main stages of realization of genetic information in cells; role of weak interactions in the structure of informational biopolymers and in molecular recognition; evidence of genetic role of nucleic acids; primary structure of nucleic acids (nucleotide composition, internucleotide bonds); Watson and Crick model of DNA; conformational forms of DNA; ring DNA molecules; DNA supercoiling; topoisomerases, their types and mechanism of action; physical and chemical properties of DNA; structure and functions of RNA; bacterial genome; structure of prokaryotic genes; eukaryotic genome: nucleotide sequences of the eukaryotic genome; structure of eukaryotic genes; general characteristics of histones; levels of eukaryotic DNA compactification; genome instability; mobile elements.

91. **Structure and functions of proteins:** proteinogenic amino acids: structure, classification; levels of structural organization of protein molecules; types of bonds that stabilize the corresponding protein structures; factors affecting the spatial structure of the protein; protein folding; chaperones; basic biological functions of proteins.

92. **DNA replication and repair:** DNA replication in prokaryotes: E. coli replication origins, structure and function; enzymatic apparatus and replication auxiliary proteins; modern scheme of E. coli DNA replication (initiation, elongation, termination); DNA replication in eukaryotes: DNA polymerases; replication origins in eukaryotes; ORC complex and replication initiation; telomeres and telomerase; variety of repair systems: direct repair, excision repair, repair of non-complementary base pairs (mismatches), SOS repair, post-replication repair, double-strand break repair.

93. **Gene expression:** transcription in prokaryotes: structure of promoters, structure of bacterial RNA polymerase, stages of transcription, ro-dependent and ro-independent transcriptional termination; transcription in eukaryotes: RNA polymerases, types of genes transcribed by eukaryotic RNA polymerases, basal transcription factors; processing of primary rRNA and tRNA transcripts in prokaryotes; exon-intron structure of eukaryotic genes; constitutive and alternative splicing; processing of primary transcripts of mRNA (capping of the 5'-end and polyadenylation of the 3'-end of the transcript), rRNA and tRNA in eukaryotes; RNA editing; organization of ribosomes; genetic code; principles of codon-anticodon interaction; ambiguity of the genetic code; activation of amino acids; aminoacyl-tRNA synthetase; translation in pro- and eukaryotes: stages and main factors of translation; post-translational modification of proteins.

94. **Regulation of protein activity and gene expression:** regulation of protein activity as a basis for the regulation of cellular processes; urgent regulation; long-term regulation; protein lifespan and its regulation; regulation of gene expression in prokaryotes on the example of the

lactose operon; peculiarities of gene expression regulation in eukaryotic cells.
95. **Mechanisms of intercellular communication, signaling:** basic parameters of signal transduction; diversity of receptors and signaling molecules; mechanisms of signaling at the cellular level; secondary messengers; signaling in prokaryotes; features of signaling processes in eukaryotes. The role of proteins in the regulation of the transition between the phases of the mitotic cycle and differentiation of eukaryotic cells; mechanisms of apoptosis, abnormal cell proliferation and mechanisms of oncogenesis; formation of oncogenes from proto-oncogenes; tumor suppressor proteins.
96. **Practical aspects of molecular biology:** genetic engineering methods in molecular biology research; cell transformation; vectors, gene knockout and knockdown, cell mutagenesis.

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.*

XII. GENETICS
97. **Cytological bases of heredity:** structure and types of chromosomes, chromosome structure depending on the functional state of the cell, types of chromosome coloration, criteria of cytoplasmic heredity, heredity caused by DNA of cell organoids, structure and expression of mitochondrial and plastid genomes, infectious heredity, cytoplasmic pretermutation, prions.
98. **Patterns of trait inheritance:** inheritance of monogenic autosomal traits with full penetrance, interaction of non-allelic genes, complementarity, epistasis, polymeric interaction of non-allelic genes, peculiarities of inheritance of quantitative traits, pleiotropic effect of the gene, penetrance, expressivity.
99. **Sex and sex-linked inheritance:** types of sex determination, sex chromosomes, gene dose compensation, peculiarities of inheritance of sex-linked traits; inheritance of traits in case of non-existence of X chromosomes, inheritance of holandry, hologenic and partially sex-linked traits; inheritance of sex-dependent and sex-limited traits, genetic theories of sex determination, balance theory of sex determination (K. Bridges).
100. **Gene linkage and crossover:** mapping of genes in linkage groups, multiple crossover and interference, coincidence rate, genetic and cytological chromosome maps, structure of genetic chromosome maps, determination of distance between genes, cytological evidence of crossover.
101. **Molecular mechanisms of recombination:** molecular mechanisms of homologous recombination by Holliday and Melson-Redding, conversion phenomenon, internal and external factors affecting the frequency of crossover, mitotic crossover, unequal crossover, processes leading to genetic recombination in prokaryotes, mechanisms of site-specific recombination.
102. **Structure of genes, organization of genomes, regulation of gene activity:** evidence for the genetic role of nucleic acids, central dogma of molecular biology, structure and function of DNA and RNA, replication, transcription, processing in eukaryotes, translation, properties of the genetic code, criteria of allelicism, cis-trans test for allelicism, the phenomenon of step allelicism, organization of genomes of viruses and prokaryotes, features of the organization of the eukaryotic genome, chemical and enzymatic artificial synthesis of genes, isolation of genes using restriction enzymes, the concept of vector, creation of gene banks of different organisms, modern methods of analyzing the structure and function of genes, the main trends in the evolution of genes, pseudogenes, levels of regulation of gene activity, operon structure and types of regulation of operon function, peculiarities of gene regulation in eukaryotes, promoter structure, specific and non-specific regulation, regulation at different levels of organization of genetic material, transposition mechanisms, evolution of

regulatory systems.
103. **Variability and stability of genetic material:** types of variability and their characteristics, gene rearrangement in ontogeny, epigenetic heredity and variability, modification variability, reaction rate, combinational variability, mutational variability, classification of mutations, law of homologous series of hereditary variability (M. I. Vavilov), types of polyploidy and their importance in breeding and evolution, spontaneous and induced mutagenesis, radiation mutagenesis, features of chemical mutagenesis, cell cycle checkpoints, repair mechanisms.
104. **Genetics of populations:** basic genetic characteristics of a population, genetic processes in autogamous and allogamous populations, Hardy-Weinberg's law, panmictic populations, adaptability of organisms and the rate of evolution, genetic heterogeneity of a population.
105. **Genetic bases of breeding:** main directions of breeding work, the doctrine of variety and source material in plant breeding, the doctrine of breed, sources of variability for selection, methods of selection and evaluation of breeding material in plants, selection and selection of parental pairs in animal breeding, modern methods of breeding.

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.*

XIII. BIOLOGY OF INDIVIDUAL DEVELOPMENT
106. **Germ cells (gametes) and fertilization:** morphology of germ cells, gametogenesis, gamete interactions during fertilization, parthenogenesis.
107. **Crushing and blastification:** general characteristics and mechanisms of crushing, types (methods) of crushing, types of blastules.
108. **Gastrulation and laying of axial organs:** general characteristics and mechanisms of gastrulation; germ sheets (ecto-, meso- and endoderm) and their derivatives; types (methods) of gastrulation; primary and secondary mouth animals; chordal laying, neurulation and folding (folding of the embryo) in vertebrates.
109. **Organogenesis:** general characteristics of organogenesis; provisional organs of vertebrate embryos: yolk sac, amnion, chorion (and placenta), allantois (and umbilical cord).
110. **Comparative embryology:** development of model objects (from chordates): lanceolate, danio rerio fish, spurred frog, chicken, mouse.
111. **Individual human development:** early embryogenesis: from fertilization to implantation; differentiation and interaction of cells in development; formation of organs and systems from germinal leaves.

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

XIV. HUMAN AND ANIMAL PHYSIOLOGY
112. **Electrophysiological characteristics of excitable objects:** types and main systems of ion transport across the cell membrane; basic properties of excitable tissues; excitability, arousal; membrane potentials: resting membrane potential (RMP), action potential (AP), local response (LR), electrotonic potentials; mechanisms of RMP occurrence, mechanisms of development, properties and conditions of AP and LR occurrence; changes in cell excitability during AP development; nerve fibers: types, classification and morpho-functional characteristics, properties; impulse conduction by nerve and muscle fibers: mechanism of excitation conduction; factors determining the speed of nerve impulse conduction.
113. **General physiology of the nervous system, physiology of individual parts of the central nervous system:** general physiology of the central nervous system - structural and functional organization of the nervous system, modern concept of neurogenesis, synaptogenesis, synaptic processes, characteristics of the main neurotransmitter systems, reflex principle of the nervous system, excitation and inhibition - the main processes of reflex activity; physiology of individual parts of the central nervous system - sensory, motor,

conductive, reflex functions of the spinal cord, medulla oblongata

114. **Nervous and hormonal regulation of visceral functions and metabolism. Physiology of the autonomic (autonomous, visceral) nervous system (ANS):** structural and functional characteristics of the ANS, its divisions (sympathetic nervous system-SNS, parasympathetic nervous system-PNS, metasympathetic nervous system-MNS), neurotransmitter supply of autonomic synapses, influence of ANS divisions on effector organs, interactions between the ANS compartments, types of visceral reflexes, biological role of hormones of the peripheral elements of the human endocrine system - thyroid, parathyroid, adrenal, gonads, and Langerhans cells.

115. **Physiology of higher nervous activity (HNA):** forms of HNA; innate forms of behavior - unconditioned reflexes and instincts; comparative characteristics of unconditioned and conditioned reflexes, conditioned reflexes, their classification, properties, biological role, physiological basis, conditions and rules for the formation of conditioned reflexes, stages and mechanisms of formation and localization of temporary connection, cortical-subcortical interaction in the formation and existence of conditioned reflexes, inhibition of conditioned reflexes: external and internal, types of VND, their physiological characteristics.

116. **Physiology of sensory systems**: functions of sensory systems; general characteristics of the organization and functions of the peripheral (role and classification of sensory receptors), conductive, cortical parts of the sensory system; thresholds of sensitivity (absolute and differential), Weber-Fechner law; adaptation of sensory systems; characteristics of the structural organization, functioning of sensory systems: visual, auditory, vestibular, motor, somatosensory, taste, olfactory.

117. **Physiology of the blood system:** structural and functional organization of the physiological and functional blood systems, functions of the blood system, modern theory of hematopoiesis, blood cells (red blood cells, white blood cells, platelets), their structure, life cycle, metabolism, properties, functions, physicochemical properties and biochemical composition of blood plasma, regulation of blood aggregation, blood groups.

118. **Indicators of hemodynamics, local and central mechanisms of its regulation in the systemic circulation:** functional types of vessels; blood depots; hemodynamic parameters: blood pressure, volumetric and linear blood velocity in different parts of the vascular bed, total peripheral vascular resistance (TPR), blood viscosity; local mechanisms of hemodynamic regulation; central nervous regulation of hemodynamics; hormonal regulation of hemodynamics.

119. **Physiology of the respiratory (respiratory) system**: respiration as a somato-visceral function, types and stages of respiration, external (pulmonary) respiration: processes of inspiration (inspiration) and exhalation (expiration), effects, factors and mechanisms of pulmonary gas exchange, respiratory volumes and capacities; principle of spirometry, centers of regulation of the respiratory system.

120. **Secretory function of the human digestive system:** composition of digestive secretions (saliva, gastric, pancreatic, intestinal juices, bile), the role of their components in digestion.

121. **Physiology of the excretory system:** general morphological and functional characteristics of the excretory system; renal physiology: functions; participation of the kidneys in the excretory processes; mechanisms of urine formation, osmotic concentration and dilution of urine; mechanisms of regulation of renal function; renal parietal apparatus, renin-angiotensin-aldosterone system; participation of the kidneys in maintaining the constancy of the physicochemical properties of the internal environment of the body.

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

XV. IMMUNOLOGY

122. **The innate immunity system (IIS):** cellular and humoral components of the IIS, phagocytosis: objects of phagocytosis, types of pathogenicity patterns, effectors (microphages and macrophages), stages, mechanisms, cytotoxic effect of natural killer cells, protective

phenomenon of inflammation, main humoral factors of innate immunity (complement system, proteins of the acute phase of inflammation, cytokines, interferons).
123. **Structural and functional organization of the immune system (IS):** anatomical, morphological and molecular elements of the IS, central and peripheral organs and tissues of the mammalian immune system, including genesis of the main immunocompetent cells (ICC) - lymphocytes, macrophages in prenatal and postnatal periods of ontogeny; antigen-independent and antigen-dependent stages of T- and B-genesis, functional classification of ICC, main molecules of the immune system.
124. **Characterization of antigens (AGs):** types of AGs, their structure, properties (foreignness, specificity, antigenicity, immunogenicity), factors that determine them; valence, classification of AGs: by epitope structure (protein-peptide, oligosaccharide, haptens); thymus-dependent and thymus-independent; functional classification; by the relationship between donor and recipient antigens, antigens of the major histocompatibility complex, features of structure, synthesis, localization, biological role.
125. **Immunoglobulins (Ig):** structure, heterogeneity, features of synthesis, properties (avidity, affinity), functions, immunoglobulins - B-cell receptors (BCR) and immunoglobulins - antibodies (AT), mechanisms of specific interaction of antigens and antibodies, formation of immune complexes (IC:AG-AT), the main forms of realization of the specific reaction of AG-AT, general and specific properties and functions of immunoglobulins of different classes (IgM, IgG, IgA, IgD, IgE).
126. **Immunoreactivity:** types of immune response: humoral and cellular, comparative characteristics of humoral and cellular immune responses: objects of action, stages, effectors, factors, mechanisms, importance of the immune synapse, forms of immunoreactivity (characteristics of immune reactions in which the T- or B-link of the immune system predominates), immune memory, primary and secondary immune responses, immune tolerance, hypersensitivity reactions, control and regulation of the immune response (antigens, antigen-presenting cells, regulatory cells;. anti-idiotypic regulation; cytokine network; neurohumoral regulation).
127. **Plant immunity**: components of nonspecific and specific resistance in plants, peculiarities of the course of protective **immunity** in plants.

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.- Elsivier , 2019.- 336 p.*
4. *Abbas A., Lichtman A.H., Pillai Sh. Cellular and Molecular Immunology.- Elsivier, 2018.- 579 p.*

XVI. PLANT PHYSIOLOGY AND BIOCHEMISTRY

128. **Specific features of the plant cell:** structural features in relation to biological functions.
129. **Pigment systems of photosynthetic organisms**: chlorophylls, carotenoids, phycobilins, their classification, absorption spectra, main representatives, functions.
130. **Primary processes of photosynthesis:** characterization of the electron transport chain; cyclic, noncyclic and pseudocyclic electron flows; photophosphorylation.
131. **Ways of CO fixation :2** C-3 pathway of photosynthesis, Hatch-Sack cycle, SAM-type of photosynthesis; photorespiration and its physiological significance.
132. **Ways of oxidation of respiratory substrates in a plant cell:** glycolysis, fermentation, Krebs cycle, direct oxidation of glucose, pentose phosphate shunt, glyoxylate cycle; specificity of plant cellular respiration.
133. **Water metabolism in a plant:** concepts of water activity, water potential and components of water potential; short and long distance transport of water through the plant; transpiration.
134. **Mineral nutrition of plants:** passive and active transport of ions through the plasma

membrane; ion absorption by the root; intracellular, short- and long-range transport of ions.
135. **Growth and development of plants, factors of their regulation: the** concepts of "growth" and "development"; classical phytohormones and their regulatory role; factors that determine the transition to flowering; stages of flowering, classical theories of plant flowering.
136. **Phenomena of photoperiodism and vernalization in plants:** perception and transmission of photoperiodic signal; regulatory role of phytochrome system.
137. **Plant resistance to stressors: the** concepts of "stress", "adaptation", "resistance"; the triad of stress (according to Selye); drought resistance, heat resistance, frost resistance, salt resistance.

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.*

XVII. THEORIES OF EVOLUTION

138. **Evolutionary ideas in biology:** history of formation and significance.
139. **Organic evolution as an objective phenomenon of nature:** evidence and methods of study.
140. **The main theories of evolution: the** position, factors and essence of the evolutionary process.
141. **Microevolution:** modern ideas about the role of microevolutionary processes, the problem of species and speciation, the role of genetic processes in the evolution of populations, the problem of organic expediency.
142. **Macroevolution:** modern ideas about the role of macroevolutionary processes, the main directions or pathways of organic evolution.
143. **History of life on Earth:** evolution of ecosystems, anthropogenesis.

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

XVIII. BIOTECHNOLOGY

144. **Biotechnology as a science: the** subject and objectives of biotechnology, the stages of formation of biotechnology as a science, and the main directions of development. "Color classification of biotechnology products. The importance of biotechnology in solving global problems of humanity.
145. **Objects and methods of modern biotechnology:** characteristics of biotechnology objects, basic requirements for their use. Classification of biotechnological methods. Modern scientific biotechnological methods - methods of cellular and genetic engineering. Stages of biotechnological production and general scheme of the biotechnological process. Main characteristics of the target product, requirements for its quality. GLP and GMP standards, TU and DSTU standards. Methods of utilization of by-products and waste.
146. **Industrial microbiology:** industrial microbiological processes: synthesis and transformation technologies. Objects and products of microbiological synthesis. Classification of types of fermenters and bioreactors. Requirements, features of biology, characteristics, methods of selection of microorganisms-producers. Microbial synthesis of low molecular weight compounds: amino acids, vitamins, organic acids, β-carotene. Technologies for the production of enzymes and enzyme preparations of microbial origin. Application of

immobilized enzymes in biotechnology. Examples of food biotechnology.

147. **Phytobiotechnology:** Totipotency is a unique property of a plant cell. Characteristics of the main in vitro cultures: callus culture, suspension culture, culture of isolated protoplasts. Biotechnologies based on the culture of cells, tissues and organs of higher plants: microclonal reproduction, plant material recovery, production of valuable biologically active substances (BAS), cryopreservation of cell and meristem cultures, plant transgenesis.

148. **Animal biotechnology:** Features, types and conditions of animal cell cultivation. Somatic hybridization. Preparation of monoclonal antibodies. The concept of multi-uni-, pluri- and totipotency. Stem cells - main characteristics and areas of use in medicine. Cryopreservation and embryo transplantation. Cloning of animals. Transgenic animal organisms. Problems of bioethics and biosafety in biotechnological research.

149. **Environmental biotechnology:** biotechnology of water purification. Biodegradation of xenobiotics. Phytoremediation. Biodegradation and conversion of municipal and industrial waste. Biodegradation of oil pollution. Bioenergy. Production of biofuels and biogas.

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

STRUCTURE OF THE PROFESSIONAL ADMISSION EXAMINATION AND EVALUATION SCHEME

The examination is conducted in the form of an exam in a test format.

The content of the test is determined on the basis of this Program of Professional Examination in Biology for admission to study for a master's degree in specialty E1 Biology and Biochemistry, educational and professional program "Biology".

The Biology test consists of multiple-choice questions. Each task has four possible answers, of which only one is correct.

The total number of test items is 63.

The test takes 120 minutes to complete.

The answer to each task is counted as one test score if only one correct answer is given and is not counted if an incorrect answer is given, or more than one answer is given, or no answer is given.

The total number of test points gained is 63.

Converting test scores to a grade on a 200-point scale is done using a table:

Table of conversion of test scores to the number of points on a 200-point scale

Test scores gained	Score on a 200-point scale	Test scores gained	Score on a 200-point scale
1	5	33	150
2	15	34	152
3	25	35	154
4	35	36	156
5	45	37	158
6	55	38	160
7	65	39	162
8	70	40	164
9	75	41	166
10	80	42	168
11	85	43	170
12	90	44	172
13	95	45	174
14	100	46	176
15	110	47	178
16	120	48	180
17	130	49	182
18	134	50	184
19	135	51	186
20	136	52	188
21	137	53	190
22	138	54	191
23	139	55	192
24	140	56	193
25	141	57	194
26	142	58	195
27	143	59	196
28	144	60	197
29	145	61	198
30	146	62	199
31	147	63	200
32	148		

An applicant is admitted to participate in the competitive selection for enrollment if the score of the professional entrance test is at least 100 points.

Chairman of the professional attestation commission

_____Viktoriia KOMARYSTA

Approved at the meeting of the Admissions Committee
Kharkiv National University
V.N. Karazin National University
Protocol No. 2 dated March 20, 2025.

Executive Secretary
of the admission committee

_____ Hanna ZUBENKO