MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

V.N. Karazin Kharkiv National University

Approved

Vice-rector for scientific and pedagogical work

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_____ February 2024

Program
for the attestation exam **in BIOLOGY**
for applicants of higher education in specialty 091**"Biology"**
educational and professional program **"Biology"**
(second (master's) level of higher education,
full-time and part-time education)

Approved at a meeting of the academic council
School of Biology
protocol No. 2 of "24" January 2024

Kharkiv - 2024

The program was compiled following OP Biology (second, master's, level of higher education) and is intended for self-preparation for the exam. The program consists of theoretical questions in 3 sections corresponding to the following mandatory educational components from the cycles of general and professional training:

Section 1. Methodology and organization of scientific research

Section 2. Teaching methods in higher education

Section 3. Systems biology, modern problems of biology, methods of evolutionary biology

The exam complements the attestation of education seekers by defending master's qualification papers. The defense checks the practical achievement by the applicants of the learning outcomes planned in the OP. The purpose of the exam is to check the theoretical foundations necessary for the applicants to achieve the learning outcomes planned in the OP:

PR1. Be able to communicate in a dialog mode with colleagues and the target audience.

PR2. Use libraries, information databases, and Internet resources to find the necessary information.

PR3. Find ways to quickly and effectively solve the task, and generate ideas, using the acquired knowledge and skills.

PR4. To present the results of scientific work in writing (in the form of a report, scientific publications, etc.) and orally (in the form of reports and defense of the report) using modern technologies, correctly conduct a discussion.

PR5. Determine your contribution to the case, and carry out coordinated work on the result, taking into account public, state, and industrial interests.

PR6. Know the basic rules of biological ethics, biosafety, protection, and basic approaches to risk assessment under the conditions of application of the latest biological, biotechnological, and medical-biological methods and technologies.

PR7. To adhere to the norms of academic integrity during training and conducting scientific activities to ensure trust in the results of scientific work, to know the main legal categories and features of using the results of intellectual activity.

PR8. Be able to identify potentially dangerous production processes that can create a threat of emergencies and observe the rules of life safety.

PR9. To know the peculiarities of the development of modern biological science, the main methodological principles of scientific research, and the methodological and methodical tools for conducting scientific research by specialization.

PR10. Model the main research processes, choose research methods, and hardware, or create new methods.

PR11. To be able to carry out statistical processing, analysis, and generalization of obtained experimental data using software tools and modern information technologies used in the field of biology.

PR12. To know and analyze the principles of structural and functional organization, mechanisms of regulation, and adaptation of organisms.

PR13. Demonstrate and use knowledge about the basic formation patterns, quantitative assessment, and strategies for preserving biological diversity, and increasing the productivity and sustainability of agrocenoses and natural ecosystems.

PR14. Use innovative approaches to solve specific biological problems.

PR15. Know the main requirements of the current legislation of Ukraine regarding the use of biological resources. Use regulatory and legal acts and regulatory and technical documentation in the field of scientific activity.

PR16. To know the principles of algorithm development and conducting research activities according to specialization.

PR17. Apply the acquired knowledge by specialization to solve specific practical tasks.

PR18. Apply pedagogical technologies at a level sufficient for the implementation of developed programs of educational disciplines by specialization in higher educational institutions.

PR19. Model objects and processes in living organisms and their components using information technologies.

PR20. Demonstrate and use integral modern ideas about the principles of the structural and functional organization of biological systems of different systematic affiliation, their phylogeny, and ontogeny.

PR21. To have methods of laboratory and field studies of biological objects using appropriate equipment; methods of observation, description, identification, analysis, classification, and cultivation of biological objects; methods of mathematical and statistical processing of biological research results.

PR22. Be able to provide professional advice in the field of biology.

PR23. Be able to popularize biological knowledge and defend a scientific worldview.

PR24. Understand the basic principles of the functioning of the international scientific community: principles of reviewing manuscripts of publications, measurement of scientometric indices, organization of international cooperation, submission of tender applications for grants, and principles of their selection.

PR25. Be able to independently and responsibly make decisions in complex and unpredictable conditions that require forecasting, based on analysis and synthesis, taking into account critical comments and based on a creative approach.

A brief wording of the questions is given in bold. After the colon, the meaning of the question is revealed, i.e., what exactly you need to know to successfully pass the exam. At the end of each chapter, there is a list of literature for the preparation

Section 1. METHODOLOGY AND ORGANIZATION OF SCIENTIFIC RESEARCH

1. **Research planning:** scientific problem and topic; the purpose and objectives of the research; object and subject of research; scientific and statistical hypotheses; research power.

2. **Types of scientific research:** fundamental and applied research; observation and experiment; retrospective and prospective study; continuous and selective research; exploratory and pilot studies.

3. **Study designs:** cohort study; cross-sectional study; longitudinal study; "sample-control"; "case-control"; "before-after"; a combination of "sample-control" and "before-after"; research of complex objects; subject studies; between-subject and within-subject design; balanced research; complete and incomplete balanced design; Latin square; even Latin square; odd Latin square; Greek-Latin square; control groups.

4. **Populations under investigation:** general population; the first model of the general population; the second model of the general population; sample population; types of samples; representative sample; biased sampling; sample formation; random unrepeatable and repeated selection; serial selection; sample size; absolute sample size; relative sample size; methods of randomization; tables of random numbers; random number generator; draw; formation of unrelated and related groups.

5. **Research conditions:** objectification of research; countering tendency; open and blind study; simple blind study; double and triple-blind study; standardization of research conditions; research accuracy; accuracy of measurements; accuracy of calculations; statistical accuracy; ethical attitude to the object of research: laboratory animals, natural objects, man.

6. **Scientific documentation:** research protocol; research documentation; laboratory journal; questionnaires; collections; electronic database; scientific reports; storage of scientific documentation.

7. **Data preparation for statistical analysis:** processing of primary material; checking records; classification of signs; quality features; quantitative signs; rank signs; simple and compound signs; data structure; simple; components; incomplete data sets; statistical scales; nominal scale; ordinal scale; interval scale; relationship scale; absolute

scale; variables: independent, dependent, unrelated, related; distribution analysis: normal, free; analysis of attacks; data transformation: changing the statistical scale, numerical transformation, data standardization; series modification: normalization, P%-th truncation, Windsor transformation; working with incomplete data sets: exclusion, filling by the average, filling using the regression equation; checking series for homogeneity; series summation.

8. **Types of statistics:** descriptive statistics; output statistics; parametric statistics; non-parametric statistics; one-dimensional statistics; multivariate statistics.

9. **Statistical analysis:** statistical techniques; evaluation: point evaluations, interval evaluations; assessment: qualitative characteristics, quantitative characteristics, central characteristics (characteristics of position), indicators of diversity, indicators of the form of distribution, indicators of strength, directions, and forms of communication, rank characteristics; comparison: simple comparison, multiple comparisons, independent groups, dependent groups; comparison of signs: quantitative, qualitative, ordinal (rank), qualitative and quantitative; survival rate; odds ratio; compliance analysis; comparison of methods; equivalence test; equivalence test; multidimensional statistics; use of cluster, discriminant, factor analysis; regression analysis: multiple regression, binary regression, polynomial regression.

10. **Statistical and scientific inference:** statistical hypothesis testing; errors of the first and second kind; level of significance; statistical conclusion; scientific conclusion; effect and result.

11. **Scientific reports:** written report; description of statistical techniques and methods; description of statistical analysis results; tabular representation; graphic presentation; publication preparation; demonstration preparation; oral presentation; poster report.

12. **Research errors:** errors that can be found in scientific reports; description (text); description of statistical techniques; description of statistical analysis results; tabular presentation; graphic presentation; citation; conclusion; plagiarism; falsification, methods of creating a scientific likeness.

Literature for the section 1:

General ideas:
https://fphil.uniba.sk/fileadmin/fif/katedry_pracoviska/klmv/bielik/Bielik-Methodology_of_Science.pdf
Statistic Analysis:
https://dl.icdst.org/pdfs/files/2aac38c9530d5311929878fa48492d9f.pdf

Section 2. TEACHING METHODS IN HIGHER SCHOOL

1. **General characteristics of higher education and its components as a system and process:** subject, purpose, tasks of the teaching methodology course in higher education; categorical and conceptual apparatus of teaching methods in higher education; the place of teaching methods in higher education in the system of sciences; goals of higher education teaching methods; study of patterns of development, education, and training of students.

2. **The national system of higher education:** the modern system of higher education in Ukraine, its structure and legal regulation; the Law of Ukraine "On Higher Education", "Regulations on the Organization of the Educational Process in Higher Educational Institutions" and other normative acts regulating the activities of higher educational institutions; system of state standards of higher education in Ukraine; licensing of educational activities and it's main standards; accreditation of areas, specialties, and higher educational institutions, its criteria and levels; general norms of activity of higher educational institutions; educational and qualification levels; the content and main tasks of the educational process in higher educational institutions; regulatory and legal basis of the educational process in a higher educational institution; material-technical, scientific-methodical and information support of the educational process in higher education.

3. **Principles of learning in a higher educational institution:** principles of learning activity, visibility, systematization of knowledge in higher education; conditions of the teacher's innovative activity; psychological and pedagogical foundations of knowledge acquisition in the process of studying in higher education; modern personal qualities of a teacher of higher education; the teacher as a subject of the pedagogical process; personal and professional self-development of a teacher of higher education; psychological characteristics of the personal qualities of a modern teacher; readiness for innovative activity as an important professional quality of a higher education teacher; development of innovative behavior of a teacher of higher education; studentship as a subject of the educational process in higher education; higher school - as a factor of socialization of the student's personality as a specialist; student adaptation to higher education.

4. **Methods, forms, and methods of learning in higher education:** teaching methods: methods of updating basic knowledge, stimulating and motivating educational and cognitive activities; methods of organization and implementation of educational and cognitive activities; methods of control and self-control for the effectiveness of educational and cognitive activities; peculiarities of the organization of the educational process in higher education; organization of educational work in higher education;

pedagogical technologies; learning methods depending on the type of cognitive activity: information-receptive, reproductive, problem-based, partially search (heuristic), search (experimental), etc.

5. **Patterns, principles, and types of teaching biology in higher education:** the role and place of biology in the life of modern society, solving global world problems; the current state of higher biological education; inseparability of biological and humanitarian education; solution to the problem of solid and conscious assimilation of biological knowledge in higher education.

6. **Didactic requirements for organizing and holding lectures:**didactic requirements for building a lecture course; requirements for the structure of the lecture course; types of lectures (introductory, thematic, overview, final, etc.); didactic purpose of the lecture; the main functions of the lecture: informative, indicative, explanatory, summarizing, concluding, etc.; the main stages of the lecture: actualization of basic knowledge, motivation for learning new material, learning new things, conclusions; the unity of educational and educational tasks in the lecture course; possibilities and limitations of the lecture form of presentation of educational material; peculiarities of the methodology of reading lectures on professionally oriented biological disciplines; dialogue between the lecturer and the audience as the main condition for achieving the goal of the lecture; substantive and methodical means of ensuring dialogue; methodical foundations of the use of technical teaching aids in lectures.

7. **Didactic requirements for the organization and conduct of seminars, laboratory (practical), individual classes:**types of seminar, practical (laboratory) classes; the structure of a seminar, practical (laboratory) lesson; peculiarities of planning a seminar, practical (laboratory) lesson; the main functions of seminar classes: deepening, concretization, systematization of knowledge obtained at lectures and during independent work; the main functions of practical (laboratory) classes: development of independent practical work skills, formation of specific practical work skills, encouragement of scientific and research activities; a method of training a scientific and pedagogical worker for a seminar, practical (laboratory) session; drawing up a plan-prospectus for seminar, practical (laboratory) classes; methodical bases of seminar, practical (laboratory) classes; peculiarities of the methodology and forms of conducting seminar, practical (laboratory) classes in professionally oriented biological disciplines; the basics of the technique of using technical teaching aids in seminar classes.

8. **Didactic requirements for the organization of individual and independent educational work of students:**methodical bases of preparation and conduct of individual training classes with students; individualization of education as one of the main principles of education in higher education; material and technical and educational

and methodological provision of individual training classes; methodical bases for training a scientific and pedagogical worker to conduct an individual study session with a student; the basics of the methodology of conducting individual training sessions with students; taking into account the specifics of the direction, specialty, academic discipline and topic when conducting individual classes; the use of remote forms of communication with students when organizing and conducting individual training sessions; purpose and forms of independent work; the method of organizing extracurricular (independent) educational activities of students extracurricular (independent) work in the general structure of educational activities of students in a higher educational institution; general methodical bases of preparation and formulation of individual tasks for students' independent work; taking into account the specifics of the direction, specialty, academic discipline and topic (block of topics); information provision of independent educational activities of students; methodical bases of organization of students' reporting on the performance of individual tasks of independent work; use of means of remote communication with students when organizing extracurricular (independent) educational activities; possibilities and limitations of independent work of students in higher education; specifics of organizing independent work; forms of activation of students' independent work; peculiarities of the advisory activity of a teacher of a higher school in the process of preparing scientific essays, term papers, diploma papers, term papers; the role of student scientific creativity in the activation of the educational process.

9. **Didactic requirements for the organization of the system of monitoring students' educational activities:** method of monitoring students' educational activities; functions of monitoring students' educational activities; types and forms of organization of checking students' educational activities (individual, group, frontal, self-monitoring, rating system, etc.); principles of organization, types and forms of control in terms of the credit-module system of organization of the educational process; basic forms of current control of students' knowledge; methodical bases and principles of implementing modular control of educational activities; semester exam in the conditions of the modular rating system of the organization of the educational process; methodical foundations of conducting semester exams; peculiarities of the method of assessing students' knowledge of professionally oriented biological disciplines of educational and professional programs of directions and specialties; assessment of students' knowledge according to the European scale of the ECTS credit-transfer system; semester credit in the conditions of the credit-module system of the organization of the educational process; methodical basis of the semester assessment; state certification, as a type of final control of students' educational activities, and its forms; purpose and essence of

state certification and regulatory requirements for it; general methodical bases of preparation and conduct of state exams and defense of theses.

10. **Didactic requirements for preparation of teaching-methodical and didactic materials:** typical types of teaching-methodical materials in higher education; general methodical bases for preparation of textbooks in specialized biological disciplines; electronic textbooks; methodological requirements for the preparation of teaching aids for specialized biological disciplines; the method of preparation of educational and work training programs in professional biological disciplines; preparation of methodical advice, test tasks and other teaching-methodical and didactic materials for specialized biological disciplines; general issues of the methodology of preparation of multimedia teaching and methodical materials from specialized biological disciplines for the organization of independent educational activities of students.

11. **Mastery of the professional and pedagogical activity of a higher school teacher:** the role of a higher school teacher in the quality training of future specialists of a certain specialty; the essence and specificity of the pedagogical activity of a teacher of a higher school; structural components of the pedagogical activity of a higher school teacher: a system of interconnected knowledge and skills (special, pedagogical, psychological, methodical); constructive, organizational-mobilizing, communicative-developmental, informational-orientational, research activity; pedagogical ethics and tact of a higher school teacher; the culture of verbal and non-verbal communication of a teacher of a higher school; peculiarities of pedagogical conflicts in a higher educational institution, ways of their resolution; peculiarities, methods and techniques of the educational influence of a teacher of a higher school on the behavior and activities of students; humanistic orientation of the teacher's personality; psychological means, methods, methods of increasing the effectiveness of professional and pedagogical communication with the student audience.

12. **The use of technologies for managing the educational and creative activities of students by a teacher of a higher school:** conceptual bases of management of educational and creative activity; technology for managing students' educational and creative activities; pedagogical influence on the development of a creative personality; the method of organizing and conducting didactic games in the management system of students' educational and creative activities; organization of educational and research work of students; use of problem-based learning, project method, interactive technologies, group work methods, etc.; development of critical and creative thinking of students, formation of a student team, a community based on joint research activities.

Literature for the section 2:

General approaches in relative field: http://www.wb-institute.org/meta-content/uploads/FINAL_E-HANDBOOK-EN.pdf
Distant education approaches: https://www.geocities.ws/mrteddy/bl4.pdf

Section 3. SYSTEMS BIOLOGY, MODERN PROBLEMS OF BIOLOGY, METHODS OF EVOLUTIONARY BIOLOGY

1. **Systems biology as a scientific paradigm:** justification of the need for a new paradigm in biology, prerequisites for its emergence; methodology of systems biology: "Top-down" and "Bottom-up" approaches; concepts of network analysis and dynamic modeling in biology; comparison of studies within the framework of the traditional paradigm and in the paradigm of systems biology; peculiarities of the scientific environment of systems biology; perspectives and problems of systems biology.

2. **Omics methods in modern biology:** features of modern laboratory equipment; genomics and transcriptomics: sequencing and hybridization methods; proteomics and metabolomics: electrophoresis, chromatography, mass spectrometry, nuclear magnetic resonance.

3. **Methods of bioinformatics in modern biology:** bioinformatics resources and their use for genomics, transcriptomics, proteomics, metabolomics data analysis.

4. **General characteristics of biological systems:** aggregates and systems: definitions, examples; principles of system description: morphological (elements, connections, structure, composition), functional, informational description; classification of systems by levels of complexity; properties of complex systems.

5. **The network as a static model of the system. Analysis of networks:** concept of network (graph), terminology of network analysis; tasks of network analysis; topological characteristics of networks: individual, global, local; basic models of network evolution; Pareto distribution in biology; network motifs.

6. **Dynamic properties of network motifs:** Boolean models and graphical analysis of dynamic properties of network motifs: simple activation, single-input module (activation, inhibition), autoregulation (positive, negative), circuit (activation, inhibition), coherent and incoherent feed-forward loops, feedback loops (positive, negative); limitations of Boolean models of networks; some general features of motifs of biological networks.

7. **Modeling as a way of studying biological systems:** cell cycle regulation as an example of a system with special dynamic properties; modeling as one of the methods of research in biology; classification of models; advantages of dynamic models; modeling algorithm; course of the in silico experiment.

8. **Molecular level: gene systems:** system description; levels of gene expression regulation: epigenomics, transcription factors, splicing of RNA, micro- and miRNA; reconstruction of gene expression regulation networks: bioinformatics methods and experimental methods; properties of pro- and eukaryotic expression regulation networks; approaches to dynamic modeling of transcription; modern fundamental and applied problems in the study of gene expression.

9. **Molecular level: protein systems:** system description: concept of interactome; reconstruction of protein-protein interaction networks: bioinformatics methods and experimental methods; properties of protein-protein interaction networks; approaches to dynamic modeling of protein-protein interactions; modern fundamental and applied problems in the study of protein interactions.

10. **Molecular level: metabolic systems:** description and reconstruction of metabolic networks: experimental methods and methods of bioinformatics; properties of metabolic networks; approaches to modeling metabolic networks: stoichiometric models, flow balance analysis (fluxomics), dynamic models; modern fundamental and applied problems in the study of metabolism.

11. **Molecular level: signaling systems:** description and reconstruction of signal systems: the dominance of experimental methods; properties of signal networks; approaches to modeling signal networks; modern fundamental and applied problems in the study of cell signaling.

12. **Physiological systems:** research of spatial organization and heterogeneity of cells, tissues, and organs: cytomics, tissomics; integration in the animal organism: secretomics and connectomics; properties of reconstructed connectomes; functional interaction of organ systems in the animal body: organomics, physiomics; perspectives of systemic medicine; peculiarities of the plant organism as a system; approaches to dynamic modeling of physiological processes; modern fundamental and applied problems in the study of physiological systems.

13. **Modern biology of development and aging:** systematic description of the process of embryogenesis; types of embryogenesis; mechanisms involved in embryogenesis; properties of embryogenesis systems; types of aging; hypotheses of aging mechanisms; properties of systems involved in aging processes.

14. **Populational level of life organization:** description of population systems; spatial structure of populations: reconstruction and analysis; social structure of populations: reconstruction and analysis; practical application of reconstruction of population networks: conservation of biodiversity, control of invasive species, systemic epidemiology; approaches to dynamic modeling of populations.

15. **Ecosystem level of living organization:** description of ecological systems; reconstruction of ecological networks: empirical methods and methods of bioinformatics; trophic, symbiotic, and networks of indirect interactions: degree of research and properties; approaches to dynamic modeling of ecosystems; modern fundamental and applied problems in the study of ecosystems.

16. **Modern evolutionary biology:** historical development of ideas about evolution: classical Darwinism, synthetic theory of evolution, the need for a new extended synthesis; evolutionary systems biology as the basis of a new extended synthesis: key concepts and directions of research; concepts of adaptive landscapes and networks of adaptive causal relationships; evolution of the ability to evolve: basic hypotheses.

17. **Globalization, its positive and negative consequences:** definition and origin of the concept; question history; positive and negative effects of globalization regarding the study and preservation of the environment; Ukraine in the context of globalization; anti-globalism; alterglobalism and other movements opposing globalization; ways to overcome the world's global problems.

18. **Climate changes and their biological consequences:** physical evidence and examples of climate change; historical and archaeological evidence; internal and external factors affecting the climate; the role of the anthropogenic factor; the impact of climate change on ecosystems; climate change and agriculture; Ukraine in the context of climate change.

19. **Global warming, threats to ecosystems and the existence of species:** temperature indicators of the climate of the last decades; the main factors of global warming; the role of the anthropogenic factor; consequences of global warming: melting of glaciers, rising sea level; consequences of global warming for ecosystems and threats to the existence of species; impact on agriculture; impact on human health; threats to Ukraine; ways to overcome problems related to global warming.

20. **Changes in ecosystems as a consequence of globalization and climate change:** the impact of globalization and climate change on the state of ecosystems; biotic changes as an indicator of the state of the environment and changes taking place; change in habitats of plant, animal and mushroom species; emergence and spread of invasive species and related biological threats.

21. **The problem of preserving biodiversity:** the concept of biodiversity; the importance of biodiversity; assessment of biological diversity; biodiversity research methods; DNA barcoding and taxonomy; digitization of life; dark taxa; threats to biodiversity; the problem of rare species; the Convention on the Protection of Biodiversity; biodiversity in Ukraine.

22. **Phenological changes in nature associated with climate changes:** seasonal phenomena in nature; main directions of phenological research; phenological changes

caused by climate change and global warming; applied aspects of phenological research for branches of farms with seasonal and cyclical production (agriculture, forestry, and forest park farms, fishing and hunting, fruit growing, horticulture and landscaping, etc.).

23. **Demographic explosion:** historical dynamics of the world population; modern demographic explosion, its causes, and features; overpopulation, its resource and ecological consequences; Malthusianism and neo-Malthusianism; measures to counter population growth.

24. **Demographic crisis:** the problem of reproduction of the population in Ukraine and in several developed countries of the world; the causes of the demographic crisis and the threats it causes; the dynamics of birth, migration, and mortality of the population; ways to overcome the demographic crisis; reproductive medicine and its role in solving the problem.

25. **Epidemics and pandemics:** history of pandemics: origin, causes and consequences; ways to prevent and overcome pandemics; the modern pandemic caused by the SARS-COVID-19 coronavirus, its causes, general statistics, methods of overcoming, the state of the problem in Ukraine.

26. **Biological emergencies:**epiphytotics; panphytotics; epizootics; ways of preventing and overcoming biological emergencies.

27. **The problem of providing the population with food:** world food problem according to FAO; achievements of genetic and cell engineering, their significance for solving the problem; genetically modified organisms; main areas of modification of agricultural plants and animals; classical and modern biotechnologies as a means of solving the food problem.

28. **Anthropogenic environmental factor:** modes of action in modern conditions; "man-made" impact on the biosphere; anthropogenic environmental factors; types of influence of society on nature; directions of harmful human influence on nature; depletion of the subsoil, pollution of the biosphere, man-made disasters; increasing anthropogenic load on ecosystems in modern conditions; modern approaches to minimizing the negative impact on the environment, conservation and rational use of biosphere resources.

29. **Paleogenomics:** modern views on the origin of man; species of the genus Homo; their distribution; a Denisovan person; Neanderthals; modern people Homo sapiens, history of the species; coexistence with other species of the genus Homo; hypotheses and theories about the origin of man; intraspecific polymorphism; ethnic groups.

30. **Genography:** research methods; settlement of intelligent human populations within the modern range; chronology of events; study of the gene pool of human populations; gene pool of Ukrainians; gene pool of Crimean Tatars.

31. **The latest advances in biology:** historical reference: the beginning of the tradition, facts, and figures; Nobel prizes in the field of physiology and medicine in recent years;

the latest biotechnologies in solving urgent problems of biology, agriculture, and medicine.

32. **Genetic diversity in populations:** genetic diversity; polymorphism; genetic diversity; nucleotide diversity; measurement of genetic diversity; parameter θ; Hardy-Weinberg equilibrium.

33. Factors affecting allele frequencies in the population: mutations; natural selection; directed selection; positive selection; negative selection; selection in favor of heterozygotes (overdominance); stabilizing selection; disruptive selection; selection in favor of homozygotes (under-dominance); frequency-dependent selection; gene drift; time and probability of fixation; changes in population size; bottleneck effect; founder effect; inbreeding; assortative mating; inbreeding coefficient; F-statistic, fixation index.

34. **Effective population size:** effective population size as an ideal population model; ratio of effective and real population size; factors affecting effective population size.

35. Speciation and criteria of species independence: species as the basic unit of diversity; speciation; population-genetic approach to species delimitation; Birky criterion; species delimitation methods.

36. **Neutral evolution:** the history of the emergence of the concept of neutral evolution; why neutral evolution is possible; neutral evolution as a basic hypothesis; neutrality tests; synonymous and non-synonymous substitutions; McDonald-Kreitman test; neutrality index; Tajima index; almost neutral evolution.

37. **Similarity, a compilation of a matrix of taxa and features, alignment:** homology and analogy; synapomorphy, autapomorphy, and plesiomorphy; homology and homoplasy; sign conflict and parsimony; monophyletic, polyphyletic and paraphyletic groups; pattern cladistics; types of signs; binary characters; signs with many states; transformations of states of signs; ordered and unordered features; additive binary coding; feature state trees; polarity of signs; working with the Mesquite package; compilation of matrices of taxa and features; obtaining nucleotide sequences from the genetic bank (GenBank); alignment of nucleotide sequences using ClustalX and MAFFT programs; determining the polarity of traits using out-group comparison.

38. **Methods of quantitative cladistics and finding the optimal tree:** unrooted and rooted cladograms; tree and data matching statistics: consistency index, residual index; optimization - methods of taking into account various models of evolutionary changes; finding the optimal tree; precise methods; heuristic methods: step-by-step addition and exchange of branches; methods of confidence assessment of tree clades: bootstrap and jack-knife; methods of constructing consensus trees; using the PAUP program to build phylogenetic trees according to the "parsimony" optimality criterion.

39. **Alternatives to parsimony: maximum likelihood, Bayesian analysis, distance methods:** phylogeny analysis as a statistical problem; maximum likelihood; plausibility of the phylogenetic hypothesis and its probability; calculation of the likelihood of a

phylogenetic tree; models of nucleotide substitution; using the IQ-TREE program to build phylogenetic trees according to the "maximum likelihood" optimality criterion; concepts of a priori and a posteriori probabilities; Bayesian statistics; application of Bayes theorem to determine the posterior probability of a phylogenetic tree; search for a tree with the maximum posterior probability; application of the MrBayes program to build phylogenetic trees; the concept of genetic distance; uncorrected and corrected genetic distance, nucleotide substitution models; calculation of genetic distances using the MEGA 11 program; cluster analysis (UPGMA); neighbor-joining (NJ) method; using PAUP and MEGA 11 programs to construct distance trees.

40. **Theoretical principles and methodology of phylogeography:** phylogeography – a methodology for determining patterns of geographical distribution of individuals and populations; application of phylogenetic methods in phylogeography; use of network diagrams (networks) and their interpretation; POPART program; phylogeography of the Pleistocene and the concept of refugium; methods of historical demography, use of neutrality indices and pairwise comparison of sequences for testing the model of population expansion; genetic differentiation of populations and isolation by distance.

41. **Molecular methods used in evolutionary analysis**: polymerase chain reaction; sequencing reaction; automatic sequencing; next generation sequencing; processing of molecular data, alignment, programs used to align nucleotide sequences; use of MEGA and MrBayes programs for phylogenetic analysis; main commands of the MrBayes program; performance of individual tasks; using FigTree program ver. 1.4.3 for processing the obtained phylogenetic trees.

42. **Problems of modern evolutionary biology; Kind problem:** the history of the development of the doctrine of the species; species concepts that have historical significance: typological and nominalistic concepts; modern species concepts: biological, Hennig, phylogenetic, and evolutionary concepts.

Literature for Section 3

1. Voit EO A first course in systems biology. - Garland Science, 2017. - 468 p.
2. Jobling M. et al. Human evolutionary genetics. - Garland Science, 2014. - 670.
3. Freeland JR Molecular Ecology. - Chichester: Wiley, 2005. - 388 p.
4. Page RDM, Holmes EC Molecular Evolution: A Phylogenetic Approach. - Oxford: Blackwell, 1998. - 346 pp.

STRUCTURE OF THE ATTESTATION EXAM AND AN EVALUATION SCHEME

The attestation exam is conducted in a test format.

The test consists of tasks with the choice of one correct answer. For each task, four answer options are provided, of which only one is correct.

The total number of test tasks is 63.

120 minutes are given to complete the test.

The answer to each question is counted as one test point if only one correct answer is indicated and not counted either an incorrect answer is indicated, more than one answer is indicated, or no answer is given.

The total number of scored test points is 63.

The test scores are converted into a 100-point grade using the table:

Table of conversion of test scores into the number of points on a 100-point scale

Scored test points	Assessment on a 100-point scale	Scored test points	Assessment on a 100-point scale
1	5	33	70
2	9	34	71
3	13	35	72
4	17	36	73
5	21	37	74
6	25	38	75
7	29	39	76
8	32	40	77
9	35	41	78
10	38	42	79
11	41	43	80
12	44	44	81
13	46	45	82
14	48	46	83
15	50	47	84
16	52	48	85
17	54	49	86
18	55	50	87
19	56	51	88
20	57	52	89
21	58	53	90

22	59
23	60
24	61
25	62
26	63
27	64
28	65
29	66
30	67
31	68
32	69

54	91
55	92
56	93
57	94
58	95
59	96
60	97
61	98
62	99
63	100

The correspondence between the rating on a 100-point scale and the rating on a four-level scale is determined as follows:

90-100 - "excellent"

70-89 - "good"

50-69 – "satisfactory"

0-49 – "unsatisfactory"