

# **BIOLOGY**

## **PROGRAM OF ENTRANCE EXAMINATIONS IN BIOLOGY**

for applicants entering the 1st year of basic education programs and undergraduate education by programs of entrance examinations conducted by Kazan Federal University (Russia)

### **PROGRAM CONTENT**

#### **Biology as a Science**

Biology – the science of nature. The contribution of biology in the formation of the modern scientific view of the world and general cultural identity. The value of biological science for agriculture, industry, medicine and environmental protection. Methods of biology.

Levels of organization of life: a molecular, cellular, organismal, population, species, ecosystem, biosphere. The properties of living systems: the chemical composition, metabolism and energy, openness, growth, self-reproduction, heredity and variation, irritability, self-regulation; their occurrence in animals, plants, fungi and bacteria.

#### **The Cell: Structure and Functions**

The main provisions of the cell theory, its meaning in modern science. The cell – structural and functional unit of living things. The cellular structure of organisms as a reflection of the unity of nature.

The chemical composition of cells. The content of the chemical elements in the cell. Water, mineral salts and other inorganic substances, their role in life. Structure and function of organic substances: proteins, carbohydrates, lipids, nucleic acids, in connection with their functions. Structure and function of cell organelles; the relationship of these components as a basis for its integrity.

The variety of cells. Prokaryotic and eukaryotic cells. The structural features of cells of plants, animals and fungi. Viruses – acellular form. The role of viruses as causative agents of diseases and their prevention.

Cellular metabolism and its components – assimilation (anabolism) and dissimilation (catabolism). Plastic and energy metabolism. Enzymes, their properties and role in metabolism. The main stages of the plastic metabolism. DNA replication. Genes. The genetic code and its properties. Transcription. Translation. The role of the matrix processes in realization of genetic information. Autotrophic and heterotrophic organisms. Stages of photosynthesis and role of chlorophyll in this process. Biospheric importance of photosynthesis. Chemosynthesis. The main stages of energy metabolism. Fermentation and cell respiration, the metabolic role of oxygen. The role of ATP in energy and plastic

metabolism. The relationship of energy and plastic metabolism.

### **Reproduction and Individual Development of Organisms**

Cell division – the basis of growth, development and reproduction of organisms.

Mitosis and meiosis – the main methods of dividing of eukaryotic cells. Interphase.

The stages of mitosis and meiosis. The role of mitosis and meiosis.

Sexual and asexual reproduction, their role in nature. The methods of asexual reproduction in animals, plants and fungi. Development of the germ cells.

Fertilization in animals and plants. Double fertilization – a feature of flowering plants. The alternation of sexual and asexual generations (gametophyte and sporophyte) in plants.

The ontogenesis - the individual development of the organism, the main stages of ontogeny. Embryonic and postembryonic development. The main stages of embryo development (for example, animals). Direct development and development with metamorphosis (indirect). The concept of life cycle.

### **Genetics and Selection**

Genetics - the science of heredity and variation of organisms. The main methods of genetics. Hybridological analysis, mono-, di- and polyhybrid crossing. Basic concepts of genetics: gene, allele, character, homozygote and heterozygote, dominant and recessive, genotype, phenotype and the norm of reaction.

The laws of heredity established by G. Mendel, and the conditions for their implementation. Cytological foundations of laws of G. Mendel. Full and partial dominance.

The chromosomal theory of heredity. Linked inheritance and its cytological bases, debonding. Crossover (crossing of chromosomes) and its value. Genetic sex determination, sex chromosomes and autosomes, the inheritance of sex-linked characteristics.

Genotype as a historically holistic system. The concept of the interaction of genes and multiple activities. Role of genotype and environmental factors in the formation of the phenotype. Forms of variation in organisms: modification and genetic variation, mutation and combinative variability, their role in nature. Causes of mutations. The impact of the environment on the mutation process, mutagens. The main sources of combinative variability: independent behavior of homologous chromosomes during meiosis, crossing-over, fertilization.

The value of genetics for health care. Hereditary diseases and their precautions. Influence of radiation and chemical mutagens (including nicotine, alcohol and drugs) on human heredity.

Genetics – the theoretical basis for selection. Animal breeds and plant varieties.

The main methods of plant and animal selection: mutagenesis, polyploidy, hybridization, artificial selection.

Modern biotechnology: genetic and cellular engineering, microbial synthesis, their role in the development of health, industry, agriculture and environmental protection.

### **The Variety of Life**

Biological classification. The classification of organisms and role of C. Linnaeus as the founder of scientific taxonomy. Main systematic categories: species, genus, family, order, class, phylum, kingdom. Features of the structure and functioning of the representatives of the major kingdoms of nature: bacteria, plants, animals and fungi.

The kingdom of bacteria. The main features of the structure and activity of bacteria, their reproduction. Spores. The role of bacteria in the biosphere. Significance of bacteria for agriculture, industry and medicine. Pathogenic bacteria and their control.

The kingdom of fungi. Forms of vegetative body of fungi. Pileate mushrooms, their structure, nutrition, reproduction. Moulds. Yeast. Environmental groups of fungi. Mushrooms-parasites that cause diseases of plants, animals and humans. Mycorrhiza. The role of fungi in the biosphere and human value.

Lichens – symbiotic organisms composed of mushroom and cyanobacteria or green unicellular algae. The structure of the lichen. Ecological and morphological groups. Nutrition. Reproduction. The role of lichens in the biosphere and human value.

The kingdom of plants. General characteristics of the plants. The role of plants in the ecosystem structure and for humans. Classification of plants. Lower and higher plants. The life cycle of plants, alternation of generations (sporophyte and gametophyte). The evolution of life cycle of plants.

Lower plants (algae). Evolution and form of vegetative body. Main sections of algae – green, brown and red. Structure and activity of unicellular algae (chlamydomonas). Filamentous algae (ulothrix) and seaweeds. Reproduction and life cycles of algae. The role of algae in the biosphere and human value.

The plant invasion on land. The concept of the tissues and organs of the plants. Characteristics of psilophytes.

Moss plants. Green moss. The structure, reproduction and life cycle of common hair moss. Sphagnum moss, its structure. The formation of peat, its value.

Division Lycopside, Horsetails, Ferns: characteristics, key representatives, their structure and biology. Life cycle and reproduction of a fern.

Division Gymnosperms: characterization of the structure and reproduction. Distribution of conifers. The biological value of the seed. Gymnosperms role in the biosphere and human value.

Division Angiosperms (flowering plants). The structure of the flower. Ovule. Double fertilization. The formation of seeds and fruits. The role of the angiosperms in the biosphere and human value. The classification of angiosperms: classes dicotyledons and monocotyledons, their features. The features of the main families of plants; their biological characteristics (cruciferous, Rosaceae, beans, Solanaceae, Compositae, Liliaceae, Cereals).

The main groups of plant tissues (meristem, covering, strengthening, conductive, basic).

Vegetative organs of higher plants. Structure and function of roots, root types, types of root system modifications (metamorphoses). Bine. Buds. Stem. Branching of bine. Structure and function of stem modification shoots (rhizomes, tubers, bulb). Structure and function of leaf, leaf types, phyllotaxy, types of venation.

Generative organs of flowering plants. The structure of the flower due to the methods of pollination. Unisexual and bisexual flowers. The flower formula. Inflorescences and their biological significance. Structure and classification of seed (for example monocotyledonous and dicotyledonous plants), and fruits. Types of seed germination, seedling growth and nutrition. Propagation of fruits and seeds. Significance of flowers, fruits and seeds in nature and human life.

The origin of the plants. The main stages of evolution of the plant world: the emergence of photosynthesis, the occurrence of unicellular and multicellular algae, the invasion of plants on land (psilophytes), the appearance of spore and seed plants. Phylogenetic relationships in the plant world.

Animal Kingdom. Protozoans. General characteristics of the protozoans: the structure of cells, nutrition, respiration, excretion, movement, behavior and reproduction. Variety: common amoeba, green euglena and heterotrophic flagellates, paramecium and other ciliates. Differences of protozoans and multicellular animals. Their significance in nature and human life. Parasitic protozoa - pathogens of humans and animals.

Multicellular animals. The structural features of multicellular animals. The main tissues, organs and systems. The types of symmetry of the body of animals. Two- and three germ layered animals.

Phyla Coelenterates, Flatworms, Roundworms, Annelida. Characterization of the structure and the basic processes of life (external structure, the system of covers, movement and musculature, nutrition and digestive system, respiration, excretion and excretory system, the distribution of substances in the organism, body cavity, nervous system, behaviors, reproductive system and ways of reproduction). The life cycles of the most important representatives. Characteristics of the main classes. Role in the ecosystem and human life. Parasitic representatives of flatworms and roundworms, their significance for human health and agriculture. Prevention of parasitic diseases.

Phylum Arthropods. Characterization of the structure and the basic processes of life. Classes: Crustaceans, Arachnids, Insects. Features of arthropods in connection with the invasion to land-air environment. The main insect orders: Orthoptera, Coleoptera, Lepidoptera, Diptera, Hymenoptera. Insects with complete and incomplete metamorphosis. The variety of insects and their role in ecosystems and human life. Methods of controlling of insects - pests and disease vectors. Protection of insects.

Phylum Mollusks. Characterization of the structure and the basic processes of life, the main classes (Gastropods, Bivalves, Cephalopods). The role of mollusks in the aquatic and terrestrial ecosystems.

Phylum Chordates. General characteristics of the phylum. The main classes of chordates: lancelets, cartilaginous fishes, bony fishes, amphibians, reptiles, birds, mammals. Characterization of the structure and the basic processes of life in connection with the peculiarities of the environment and lifestyle. The origin and evolution of the main classes of vertebrates. Invasion of vertebrates on land and adaptation to land-air environment. Characteristics of the main groups. The role of various chordates in ecosystems and human life, protection and regulation of number. Major domestic and farm animals: origin, the biological basis of their content, feeding, breeding.

The evolution of the animal world. Origin of Protozoans and Multicellular animals. The origin of the main phyla of the animal kingdom. The increasing complexity of the structure and activity of animals in the process of evolution. The position of

man in the animal kingdom, systematic evidence of his identity.

### **Human and his Health**

An overview of the human body: the basic tissue and organ systems. The value of knowledge about the structure, functioning of the body and health to protect human health. Organs and systems of organs.

The integumentary system. Structure and function of the skin. Integumentary structures: hair and nails. The role of the skin in thermoregulation, hardening of the body. Skin hygiene, burns prevention and first aid, frostbite, and mechanical injuries.

Musculoskeletal system and movement. The main elements of the musculoskeletal system of human. Parts of the skeleton: the axial skeleton, the skeleton of the limbs and their girdles. Bone structure and function. The main types of bone and their compounds. Joints. Cartilage, tendons, ligaments. The structure of the muscles and their functions. The main muscle groups of human. First aid for bruises, sprains, fractures and dislocations.

Blood and blood circulation. The concept of the internal environment, the value of a constant internal environment. Blood, lymph and interstitial fluid. The composition of human blood: Blood plasma and various form elements, their structure and functions. Immunity and its types. Antigens and antibodies. Role of I. I. Mechnikov in the establishment of the doctrine of immunity. Infection diseases and their control. Vaccinations and their role in the prevention of infectious diseases. Blood groups. Transfusion of blood donation. Blood clotting. The structure of the circulatory system: heart and blood vessels (arteries, capillaries, veins). Systemic and lesser circulatory systems. Preventing of cardiovascular diseases. First aid for bleeding. The harmful effects of smoking, alcohol and drugs on the cardiovascular system.

Respiratory system and gas exchange. Main components of the respiratory system. The structure of the light, the mechanism of inhalation and exhalation, gas exchange. The value of breathing. Respiratory health. Respiratory diseases and their prevention. Preventing the spread of infectious diseases. Clean air as a factor of health. Methods of first aid for carbon monoxide poisoning and rescue of drowning.

Digestive system and nutrition. Structure and function of the digestive system. Digestive tract and their functions. The digestive gland. Role of enzymes in

digestion. Regulation of digestion, research of I.P. Pavlov. Food and nutritional substances: proteins, lipids, carbohydrates, minerals, water, vitamins. Health of the digestive organs, rational nutrition. The value of food and digestion. Metabolism and energy in the human body, prevention of metabolic disorders. The role of vitamins in the body, their content in foods. Prevention of food poisoning, intestinal infections and parasitic diseases.

Structure of the human urinary system. Organs of the urinary system and their function. Formation of primary and secondary urine. Prevention of diseases. A role of other systems of organs in allocation of metabolic products.

Men's and women's sexual system, their structure and function. Formation of gametes. Main stages of individual development of the human. Causes of infringement of individual development; hereditary diseases, their reasons and prevention. Sexually transmitted infections, their prevention.

Nervous and humoral regulation of processes of vital functions. The main endocrine glands and their value for growth, development and regulation of functions in the organism. Main hormones of the human. Structure of nervous system, its departments: central and peripheral nervous system. Structure and functions of the brain and spinal cord.

Somatic and vegetative nervous system. Sense organs, their structure and functions. Analyzers. Violations of analyzers functions and their prevention. Conditioned and unconditioned reflexes, reflex arches. Higher nervous activity, speech and thinking. Consciousness as function of the brain. Social and biological conditionality of human behavior. I. M. Sechenov' and I. P. Pavlov's role in creation of theory of higher nervous activity. Violations of nervous system activity and their prevention. Sleep, its value and hygiene. Interrelation of processes of nervous and humoral regulation.

### **Evolution of Organic World**

Proofs of nature evolution. History of evolution theory; K. Linneus, J. Cuvier, G.-B. Lamarck and their role in development of science. Main points of Ch. Darwin theory, its value.

Populations and their structure. Quantity of populations, their age and sexual structure, forms of coexistence between individuals. Variability in populations. Factors (driving forces) of evolution. Natural selection - the directing evolution factor. Forms of natural selection (moving, stabilizing, breaking off). Fight for

existence. The role of ecology in studying of mechanisms of evolutionary transformations. Fitness emergence, its relative character.

Species and its criteria. Mechanisms of species origin. Isolation and its types, role of geographical isolation.

Microevolution and macroevolution, ratio of their mechanisms. Role of studying of ontogenesis in understanding of mechanisms of evolution of the organic world. Biogenetic law. Biological progress and regress. Aromorphosis, idioadaptation, general degeneration; ratio of ways of evolution. Evolutionary parallelism and convergence, their reasons. Homologous and analogous organs.

Main stages of life evolution. Origin of life on the Earth. The most important aromorphoses in evolution of life.

Origin and evolution of the human. Proofs of the origin of humans from animals. Stages of human evolution. Driving forces of anthropogenesis. Origin of human races. Biological and social in human nature.

### **Organism and Environment. Ecosystems. Biosphere**

Ecology - science about relationship of organisms and environment, value of ecology.

Concepts of environment and ecological factors, classification of ecological factors. Action of ecological factors. The limiting factors. Concept of an ecological niche. Major abiotic factors: light, temperature, humidity, their role in life of organisms. The periodic phenomena in nature life: biological rhythms, photoperiodicity. Types of interspecific relationships: competition, predation, parasitism, symbiosis.

Variety of populations, their age and sexual structure. Dynamics of populations quantity and its reasons.

Biological communities - multispecific systems, interrelations of organisms in community. Ecosystem and biogeocenosis. Specific and spatial structure of ecosystems. A role of rare species in nature and measures for their protection. Trophic structure of ecosystems: producers, consumers, reducers. Rule of an ecological pyramid. Trophic chains and networks. Circulation of substances and transformation of energy in ecosystems.

Self-control of ecosystems. External and internal reasons of change in ecosystems, ecological succession.

Human influence on natural ecosystems, specifics of anthropogenic factors influence. Comparison of natural and artificial ecosystems. Agroecosystems and ecosystems of the cities. Value of biological diversity for normal functioning of natural ecosystems, preservation of biological diversity. Value of nature protection actions and rational environmental management.

Biosphere as a global ecosystem, its borders. Contribution of V. I. Vernadsky to



development of biosphere theory. Functions of live substance. Specifics of biomass distribution in the biosphere. Biological circulation. Evolution of the biosphere. Global changes in the biosphere and their reasons. Influence of human activity on evolution of the biosphere.

## **ENTRANCE EXAMINATIONS AND GRADING CRITERIA**

Entrance examinations are conducted in the written form. Examination' tasks content is settled according to the program of entrance examination based on State Federal educational standard for middle (full) general education, registered in Ministry of Science and Education of Russia at 17.05.2012 (number №413) and according to the State Federal educational standard for main general education, registered in Ministry of Science and Education of Russia at 17.12.2010 (number №1897).

Structure of examination' tasks fits to Specifications of control metric materials of the USE in biology for 2015 year.

During examination in biology, the applicant should show:

- knowledge of the basic concepts, theoretical points and patterns acting in wildlife;
- understanding of the principles of structure and functioning of live systems at various levels, knowledge of bases of organisms classification;
- ability to solve biological problems, including those in genetics;
- possession of the high level of biological thinking, understanding of integrity, coherence and community of the organic world, development of wildlife;
- ability to material generalization, ability to analyze it, to formulate and prove conclusions.