Curriculum for entrance exam (transfer)

BIOLOGY

1. Microscopic Structure of the Living Organism

A. The Cell and Its Functions:

prokaryotic and eukaryotic cells; cell membrane; mitochondrion; endoplasmic reticulum; Golgi apparatus; GERL; lysosomes; peroxysomes; cytoskeleton; plastids; cell wall in plants and bacteria; vacuoles; centrioles; ribosomes; nucleus: nuclear membrane, chromatin, nucleolus; B. Plant Tissues:

fundamental tissue system: epidermis - velamen, trichomes, lithocysts, stomatal complexes; parenchyma – chlorenchyma, aerenchyma, storage parenchyma; collenchyma – angular, tangenital, annular; sclerenchyma – sclereids and fibers; fascicular tissue system: xylem – tracheids and vessel members; phloem – sieve cells, sieve tubes and companion cells; vascular bundles; lateral meristems: vascular cambium and process of secondary growth of roots and stems; cork cambium; secretory/excretory systems: resin ducts and laticifers. C. Animal Tissues:

muscle tissue: skeletal muscles, cardiac muscle, smooth muscle; epithelial tissue: simple epithelium, stratified epithelium, glandular epithelium; connective tissues: classification and characterization of connective tissues, cells of the connective tissue, fibers of the connective tissue; nervous tissue: morphologic classification of neurons, neuroglia.

2. Cell biology

A. Cell Communication – signal transduction pathways, second messengers and the intracellular signal transduction; slow and rapid target cell adaptation/desensitization - drug/stimulant dependence

B. The Cell-Division Cycle - The mechanics of cell division (mitosis and cytokinesis), control of the cell-division cycle (cell-cycle checkpoints, cyclins and cyclin-dependent kinases); programmed cell death (apoptosis) – extrinsic and intrinsic pathways; necrosis

C. Basic Genetic Mechanisms - DNA replication, DNA repair, genetic recombination, genetic of bacteria and viruses (bacterial genomes, gene expression in bacteria, mutations in the bacteria genome, bacterial gene transfer, viral genomes). Transcription, post-transcriptional modifications, translation, post-translational modifications, the regulation of gene expression. **3. Biology of Development** A. Reproduction: asexual reproduction – definition, mechanisms, parthenogenesis; germ cells and fertilization - evolutionary aspects of the sexual reproduction; spermatogenesis, structure of the sperm cell; oogenesis; vitellogenesis; types of egg cells; egg membranes; the regulation of gonad functions; reproductive anatomy of human male and female, menstrual cycle of human female; menopause**,** fecundation; sperm penetration through the egg cell membranes; the acrosomal reaction; egg reaction to the contact with a sperm – the reception hillock, mechanism of the egg cell activation; blocks for polyspermy; parthenogenesis; incorrect fertilization. B. General embryology:

blastulation: patterns of cleavage; types of blastulas; embryo metabolism during blastulation; mechanisms of blastulation; evolution of blastulation; gastrulation: patterns of gastrulation; embryo metabolism during gastrulation; mechanisms of the embryonal development during gastrulation; evolution of gastrulation; early stages of organogenesis: neurulation and origin of primary axial organs, differentiation of somites and origin of the coeloma; ectodermal organs, mesodermal organs, endodermal organs, origin of primordial germ cells, mechanisms of organogenesis; prostome and deuterostome animals. C. Regeneration:

animals undergoing regeneration: *Hydra*, planarians, newts, salamanders; types of regeneration: by differentiation – urodeles, with the use of stem cells – flatworms, *Hydra*; human stem cells: embryonic and adult stem cells; stem cells as tools for repair of the human body – future of stem cells in medicine. D. Introduction to human embryology:

first stages of the zygote development: blastulation and implantation, embryo development from the epiblast, origin of the embryonic mesoderm; origin of the notochord; extraembryonic membranes and placenta, branchial splits, branchial arches; clinical aspects. E. Fetal and Neonatal Biology: prenatal age: post-menstrual interval, gestational age, assessment of prenatal age - early development (cleavage,

gastrulation) – 0 – 3 weeks, period of embryonic organogenesis – 4 - 8 weeks, fetal period – 9 – 38 - 42 weeks, short review of morphogenesis and dysmorphogenesis (reminder), fetal period and birth; growth and form of the fetus; fetal physiology: circulation, fetal lungs and respiratory system, fetal movements and sensations, fetal digestive tract, fetal kidney function, endocrine function in the fetus; parturition; adaptation to postnatal life: circulatory changes at birth, lung breathing in the perinatal period; categories of birth defects: category – isolated defect, multiple defects, mechanism – intrinsic, extrinsic, cause - etiology (multifactorial, mendelian, chromosomal). F. Biology of Aging:
what is aging? aging versus senescing; why do we age? how do we age? alterations in proteins and lipids, alterations in DNA: nuclear DNA – epigenetic events, mutational events, telomeric DNA, mitochondrial DNA – oxygen free radicals, germline mutations; progeroid syndromes of humans, death – morbidity and mortality due to genetic disease.

4. Animal Structure and Function

A. Nutrition: Functional Anatomy of the Alimentary System:
an outline of anatomy and physiology of the alimentary system; macroscopic and microscopic structure of selected organs of the alimentary system: salivary glands, stomach, small and large intestines, liver, pancreas; gastrointestinal disorders: prptic ulcer, disorders of the large intestine – constipation, diarrhoea.

B. Reproduction: Functional Anatomy of the Reproductive System: an outline of anatomy and physiology of the reproductive system; macroscopic and microscopic structure of selected organs of the reproductive system: testis, epididymis, vas deferens, prostate gland, penis, ovary and development of the graafian follicle, fallopian tube, uterus – with regard to a phase of the menstrual cycle; structure and function of the reproductive system in the light of comparative anatomy and physiology; pregnancy - mechanism of fertilization; transport of the fertilized ovum through the fallopian tube into the cavity of the uterus; development of the blastocyst and its implantation; anatomy and physiology of the placenta, with regard to its hormonal activity; development and functions of pregnancy membranes in the human embryo; metabolism of a pregnant woman; proturition and its mechanisms; microscopic structure of selected fetal organs: placenta, umbilical cord.

C. Water Balance and Waste Disposal: Functional Anatomy of the Excretory System: an outline of anatomy and physiology of the excretory system; macroscopic and microscopic structure of selected organs of the excretory system: kidney, urinary bladder, ureter; structure and function of the excretory system in the light of comparative anatomy and physiology – protonephridia, metanephridia, Malpighian tubules, gills as organs of nitrogen excretion and ionic regulation, evolution of the vertebrate kidney – *pronephros*, *mesonephros*, *metanephros*; kidney diseases: chronic and acute kidney failure.

D. Circulation: Functional Anatomy of the Cardio-Vasculatory System: an outline of anatomy and physiology of the cardio-vasculatory system; macroscopic and microscopic structure of selected organs of the cardio-vasculatory system: heart, arteries, veins, capillaries; structure and function of the cardio-vasculatory system in the light of comparative anatomy and physiology with special regard to the evolution of the heart; cardiac and coronary blood abnormalities (ischemic heart disease, hypertension).

E. Gas Exchange: Functional Anatomy of the Respiratory System:
an outline of anatomy and physiology of the respiratory system; macroscopic and microscopic structure of selected organs of the respiratory system: lung, trachea; structure and function of the respiratory system in the light of comparative anatomy and physiology – gills and external body surfaces, tracheal systems, lungs; pulmonary abnormalities: chronic pulmonary emphysema, pneumonia, asthma, tuberculosis.

F. Systems of Internal Communication and Regulation: Functional Anatomy Nervous and Hormonal Systems:
an outline of anatomy and physiology of the nervous system; macroscopic and microscopic structure of selected organs of the nervous system: spinal cord, brain, peripheral nerves, ganglia of the autonomic nervous system; comparative anatomy of the nervous system; an outline of anatomy and physiology of the hormonal system; macroscopic and microscopic structure of selected organs of the hormonal system:

hypophysis, thyroid gland, adrenal gland; structure and function of the hormonal system in the light of comparative anatomy and physiology; somatic sensations (headache), hormonal disorders (diabetes mellitus, Graves' disease, hypothyroidism, endemic goiter, tetany, Addison's disease, Cushing's syndrome, Conn's syndrome).

G. Sensory Mechanisms: Functional Anatomy of Sensory Organs:

an outline of anatomy and physiology of the major receptors; macroscopic and microscopic structure of selected receptors: the visual apparatus, the auditory apparatus, the olfactory apparatus; abnormalities in the eye optics, hearing abnormalities.

H. Introduction to Immunology the immune system and interactions in immune responses (antigens, lymphocytes, antibodies, specific and nonspecific reactions; organs of the immune system: primary organs – bone marrow and thymus, secondary organs – spleen and lymph node), molecules of the immune system (immunoglobulins, generation of antigen-binding diversity among immunoglobulins, antigen-antibody complexes, CD molecules, complement, monoclonal antibodies, the Major Histocompatibility Complex), lymphocytes (clones and subclones of lymphocytes, T-cell receptors, differentiation and maturation of stimulated cells, circulation of lymphocytes; nonspecific immunity, interferons, macrophages, granulocytes, monokines), presentation of antigens (antigen presenting cells, macrophages, B-lymphocytes, monocytes; cytokines; immunologic memory; anti-infectious immunity – immune responses against bacteriae and viruses), hypersensitivity (allergic reactions, mechanisms of allergy, allergenic factors, allergen nomenculature, allergic diseases), immunotherapy (is it effective? indications and contrindications for immunotherapy, possible modes of action, technique and safety).

5. Human biology:

A. Types of human tissues.
B. Structure and functions of the blood.
C. Types, structure and functions of muscles. Signal conductivity.
D. Endocrine system and hormones.
E. Structure and functions of the heart.
F. Functions of the cardiovascular system.
G. Functions of the respiratory system.
H. Functions of the urinary system.
I. Functions of the alimentary system.
J. Structure and functions of nervous system
K. Functions of sensory organs.

CHEMISTRY

1. Introduction to chemistry:
   A. some key terms – matter, atoms, molecules, composition, physical and chemical property, chemical reaction; classifying matter – element, compound, chemical symbol, homogeneous and heterogeneous mixture; measurement and the metric system; mass, volume, density, temperature
2. Atomic structure and the periodic table:
   A. the atomic theory, atomic weights, atomic structure - proton, neutron, electron, nucleus, atomic and mass number, isotopes
   B. the periodic table – Mendeleev's Periodic Table; The Modern Periodic Table; the periodic law; groups and periods; the representative elements (elements from main groups) and the transition elements; metals, nonmetals, metalloids (semimetals); noble gases
   C. quantum view of atomic structure – Bohr's hydrogen atom (a planetary model); ground states and excites states; quantum numbers (principal quantum number, orbital angular momentum quantum number, magnetic quantum number, electron spin quantum number); principal shells, subshells, valence shells, atomic orbitals, electron probabilities and the shapes of orbitals

D. electron configurations – *spdf* notation; orbital diagram; rules for electron configurations (the order in which subshells are filled with electrons, the Pauli exclusion principle, Hund's rule, maximum capacities of subshells and principal shells); electron configurations of main-group and transition elements; using the periodic table to write electron configurations; valence electrons and core electrons; electron configurations of ions

3. Introduction to chemical compounds:
   A. molecules and molecular compounds – a molecule, a molecular compound, an empirical formula, a molecular formula, a structural formula; writing formulas and names of binary molecular compounds
   B. ions and ionic compounds – ions (monoatomic ions and polyatomic ions), cations, anions; formulas and names of binary ionic compounds (the suffixes –ite and –ate; the prefixes hypo- and per-); the most important ions in the cells and fluids of human body – Na^+, K^+, Cl^-, Ca^{2+}, Mg^{2+}, $H_2PO_4^-$, HPO_4^{2-}, trace minerals (ions iron (II), chromium (III), copper (II), zinc, fluoride, iodide, bicarbonate), hydrates – recognition a hydrate formula, nonhydrated compounds
   C. acids, bases and salts – acid-base theories (acids and bases according to Arrhenius, acids and bases according to Brϕnsted and Lowry, Lewis acids and bases); acids and bases: strong versus weak; pH, a measure of acidity; pH and weak acids and bases; polyprotic acids; salts and hydrolysis; the neutralization reaction; formulas and names of acids, bases and salts
4. Chemical calculations:
   A. stoichiometry of chemical compounds – molecular masses and formula masses; the mole and Avogadro's Number; the mole and molar mass; mass percent composition; chemical formulas from mass percent composition (determining empirical formulas, relating molecular formulas to empirical formulas)
   B. stoichiometry of chemical reactions – writing and balancing chemical equations (reactans, products, stoichiometric coefficients) ; limiting reactans; solutions and solution stoichiometry (the solute, the solvent; molar concentration, molarity; dilution of solutions; percent concentration; solubility; pollution; productivity)
5. Organic compounds:
   A. introduction to organic chemistry – molecular and structural formulas; families of organic compounds, functional groups
   B. saturated hydrocarbons – alkanes and cycloalkanes, the general formula, writing structural formulas, structural isomerism in alkanes, nomenclature of alkanes and cycloalkanes (alkyl group, IUPAC nomenclature, others names), chemical reactions (a substitution reaction, Würtz reaction, burning reaction)
   C. unsaturated hydrocarbons – alkenes and cycloalkenes, the general formula, the carboncarbon double bond, structural isomerism in alkenes, nomenclature of alkenes and cycloalkenes, chemical reactions (addition, mechanism of addition reactions, dehydrogenation, dehalogenation, dehydrohalogenation, burning reaction, polymerization, oxidation, Markovnikov's rule); alkadience; alkynes and cycloalkynes general formula, the carbon-carbon triple bond, structural isomerism in alkynes, nomenclature of alkynes and cycloalkynes, chemical reactions (addition, dehydrogenation, dehalogenation, dehydrohalogenation, burning reaction); alkadiyne; aromatic hydrocarbons, the general formula, nomenclature of aromatic compounds, reactions of benzene (synthesis of benzene, nitrification, substitution, addition), isomerism in aromatic hydrocarbons (ortho-, meta-, para-), reactions of toluene (synthesis of toluene, addition, substitution)), aniline, phenole
   D. alcohols, phenols and ethers – alcohols (primary, secondary and tertiary alcohols), the general formula, structural isomerism in alcohols, nomenclature of alcohols, chemical reactions of alcohols (synthesis, dehydration, oxidation of a primary and secondary alcohols, reactions with metal from the first and second group of periodic table, reaction

with oxide); phenols, chemical reactions (synthesis, reactions with metal from the first and second group of periodic table, substitution, addition, nitrification); ethers, nomenclature of ethers (common and IUPAC names)

E. aldehydes and ketones – structure of aldehydes and ketones, structural isomerism in aldehydes and ketones, nomenclature of aldehydes and ketones, chemical reactions (Tollens reaction, Trommer reaction, reaction with alcohols)
F. carboxylic acids and esters – structure of carboxylic acids, fatty acids, nomenclature of carboxylic acids, acidity of carboxylic acids, soap and detergents, chemical reactions (synthesis, reactions with metal from the first and second group of periodic table, reaction with base), conversion of carboxylic acids to esters, nomenclature of esters, chemical reactions of esters (synthesis, hydrolysis, saponification)
G. amines and amides – aliphatic and aromatic amines, structural isomerism in amines, nomenclature of amines, chemical reactions, conversion of amines to amides, primary, secondary and tertiary amides, nomenclature of amides, chemical reaction

6. Bioorganic chemistry:
   A. Optical isomerism – chiral center, enantiomers, D and L forms, examples of chiral substances, importance in biochemistry.
   B. Amino acids – structure, function, isoelectric point. Proteinogenic and non-proteinogenic amino acids. Essential amino acids.
   C. Biogenic amines – structure, examples, function, deamination of amino acids.
   D. Polypeptides – structure and peptide bonds to form polypeptide chains
   E. Proteins – primary, secondary, tertiary and quaternary chemical structure. Type of bonds stabilizing each structure. Hydrolysis of proteins.
   F. Enzymes: Their kinetics mechanism of action, and regulation. Major classes of enzymes according to EC. Regulation of enzyme activity. Inhibitors.
   G. Nucleotides and nucleic acids - kinds of bases linked to a sugar-phosphate backbone; chemical structure of DNA and RNA. The function of DNA and RNA.
   H. ATP – structure and function. Formation of ATP by substrate level phosphorylation and oxidative phosphorylation.
   I. Lipids – classification and nomenclature. Hydrolysable and non-hydrolysable lipids. Fatty acids, triglycerides, phospholipids. Saturated and unsaturated fatty acids. Hydrolysis of lipids. Lipids as a source of energy – oxidation of fatty acids. Biosynthesis of fatty acids.
   J. Carbohydrates – classification and structure. Monosaccharides, disaccharides, and polysaccharides. Reactions of the monosaccharides – reduction, oxidation and formation of glycosides. Hydrolysis of di- and polysaccharides. Comparison of starch, cellulose and glycogen.
   K. Carbohydrate metabolism - glycolysis and the catabolism of hexoses
   L. Chemistry of the Citric Acid Cycle as an example of an amphibolic pathway. Its substrates and products.

PHYSICS

1. HISTORY AND BASIC CONCEPTS IN MECHANICS short history of mechanics; basic definitions (speed and velocity, acceleration, force, pressure, mass, weight, linear momentum, Newton's laws of motion, radian, angular velocity, angular acceleration, relations between angular and linear motion, moment of inertia, torque, Newton's laws of angular motion, angular momentum, work, energy, heat, power); units and conversions
2. DESCRIPTION AND CAUSES OF MOTION velocity and acceleration; acceleration of gravity; motion units; constant acceleration; graphical description of motion; Newton's laws; forces as vectors; force of gravity; mass; weight; density; phenomenon of weightless, equilibrium and torques, circular motion

3. WORK AND ENERGY work; energy; conservation of energy; power; principles of machines
4. BIOMECHANICS (PART I): STATIC FORCES, FRICTION, TRANSLATIONAL MOTION equilibrium and stability; equilibrium considerations for human body; stability of human body under action of an external force; skeletal muscles; levers; elbow and hip joint; spine; standing tip-toe on one foot; dynamic; aspects of posture; friction at hip joint, vertical jump; effect of gravity on vertical jump; running high jump; motion through air; energy consumed in physical activity
5. BIOMECHANICS (PART II): ANGULAR MOTION, ELASTICITY AND STRENGHT OF MATERIALS, INSECT FLIGHT forces on curved path; pendulum; walking; physical pendulum; speed and energy of walking; longitudinal stretch and compression; bone fracture (energy considerations); impulsive forces; fracture due to a fall (impulsive force considerations); whiplash injury; hovering flight; wing muscles; power required for hovering; kinetic energy of wing; elasticity of wings
6. PROPERTIES OF LIQUIDS AND GASES liquid state; pressure in liquids, Pascal's principle; Buoyant force and Archimedes principle; nature and laws of ideal gas; Boyle's law; Charles law; constant volume processes
7. THE MOTION OF FLUIDS IN BIOLOGY AND MEDICINE: PRESSURE AND CIRCULATORY SYSTEM Bernoulii's equation; viscosity and Poiseulle's law; turbulent flow; circulation of blood; blood pressure; control of blood flow; energetics of blood flow; types of pumps; heart as force pump; power produced by heart; blood pressure measurement techniques
8. KINETIC THEORY AND MOLECULAR PHENOMENA RELATED TO BIOLOGICAL PROCESSES kinetic theory of matter; molecules; diffusion; osmosis; dialysis; transport across living membranes; laws of gas transport; cohesion and adhesion; surface tension; capillary action; viscosity; adsorption and absorption; respiratory system
9. HEAT heat and laws of thermodynamics; methods for temperature measurement; internal energy; effects of heat; energy requirement of people; thermoregulation; heat transfer; convection; radiation; evaporation; heat application in medicine
10. THERMODYNAMICS first law of thermodynamics, second law of thermodynamics, thermal engines

1.HISTORY AND BASIC CONCEPTS IN ELECTRICITY AND MAGNETICS short history of electricity and magnetism; basic definitions (electric charge, electric field, voltage, electric current, resistor, capacitor, inductor)
2. ELECTRICITY electrical nature of matter; behavior of electric charges; flow of electric charge; electric fields and voltages; magnets and magnetic fields; electromagnets; interaction between electricity and magnetism
3. BASICS OF MAGNETISM magnetic field strength, magnetic induction, hysteresis

4. ACOUSTICS: WAVES AND SOUND elasticity; properties of sound; reflection and refraction; interference; diffrectation; piezoelectric effect; physics of hearing; decibel scale
5. SOUNDS IN BIOLOGY AND MEDICINE hearing testing – audiometry; bats and echoes; sounds produced by animals; clinical uses of sound
6. HISTORY AND BASIC CONCEPTS OF OPTICS short history of optics; basic definitions (geometric optics, Snell's law, converging lenses, diverging lenses, lens immersed in material medium)
7. OPTICS physics of vision; nature of light; refraction and lenses; image formation by eye; common vision defects; optical instruments; color vision; electromagnetic spectrum of light; quantum theory of light; interaction of electromagnetic waves with matter
8. LASERS characteristics of lasers; types of lasers; biological effects of laser irradiation , clinical application in surgery, dermatology, gynaecology, orthopaedics, rheumatology, biostimulation 9. ATOMIC AND NUCLEAR PHYSICS scale mode of atom; nature of nucleus; spectroscopy; quantum mechanics; types of radioactivity; X-rays; radiation therapy; isotopic tracers; atomic theory and life