

## Biology

**Cytology: Basic characteristics of the cells.** Prokaryotic and eukaryotic cell - principal differences. Organic and inorganic components in the cell. **Carbohydrates** in the cell - basic structure and function. Proteins in the cell - basic structure and function. Enzymes and enzymatic reactions. Functional and substrate specificity of enzymes. **Nucleic acids in the cell** - structure and function. Types of nucleic acids. Differences in the structure and function between DNA and RNA. **Lipids** in the cell - their structural and storage function. **Biomembranes:** Composition, orientation of membrane macromolecules, characteristics of the cytoplasm membrane, transport of molecules across membranes by diffusion and osmosis, the role of transport proteins in the transfer of metabolites across cell membranes. Endocytosis and exocytosis - the process of phagocytosis and pinocytosis, the role of Golgi complex in exocytosis, the role of cytoskeleton in these processes. Osmosis - transport of the water across semipermeable membrane, hypertonic and hypotonic solutions, plant and animal cell in hypertonic and hypotonic environments. **Structure of the prokaryotic cell:** Organisation of DNA, membranous and non-membranous structures, composition of the cell wall, ribosome characteristics. **Structure of the eukaryotic cell:** Membranous structures of the cell - characteristics and function, one- and two-membranous organelles, non-membranous structures of the cell - characteristics and function, composition and function of the cytoskeleton, characteristics of the nucleus, chromatin - composition, nuclear chromosomes structure and shape, extra nuclear DNA in the cell - characteristics and function. **Metabolism:** Catabolic and anabolic processes, energy exchange in the cell, primary source of energy in the cell, aerobic and anaerobic metabolism, oxidative phosphorylation in the eukaryotic and prokaryotic cells, anaerobic glycolysis in eukaryotic and prokaryotic cells, the use of energy released by oxidative phosphorylation, the use of energy released during anaerobic glycolysis. The cell as an energetically autonomous unit. Autotrophy and its different types. Heterotrophy and its different types. **Genetic material and protein synthesis:** replication of DNA, transcription, translation, localisation of transcription and translation in prokaryotic and eukaryotic cells, The role of polymerases in replication and transcription, regulation of proteosynthesis. **Cell division:** haploid and diploid cells, the process of amitosis and mitosis, the origin and the role of the spindle and centromere of chromosomes. Cell cycle and its phases, processes occurring during individual phases of the cell cycle, regulation of the cell cycle, cells during the phase G<sub>0</sub>, cells with the failure in the main control point. **Multicellular organisms:** cell differentiation, tissue types, classification and characteristics of tissues, regulation of processes in organism. **Types of reproduction in multicellular organisms:** vegetative reproduction, sexual reproduction, the origin and types of gametes, isogamy and anisogamy. **Meiotic division:** characteristics of phase I. and II. of meiotic division, homologous chromosomes, synapsis, tetrad, crossing-over, genetic recombination, spermatogenesis, oogenesis, fertilization and origin of the zygote. **Viruses:** division of viruses depending on nucleic acids, characteristics of viruses depending on external coats, shape of virions, reproduction of viruses, (+) RNA viruses and retroviruses, provirus, the process of virogeny, viruses and diseases. **Bacteria:** the structure of bacterial cell, shape of bacteria, forms of autotrophic nutrition, bacterial plasmids, transformation, conjugation and transduction,. **Plants:** Plant cell and its cellular organelles, types of chlorophyles in plant cells, characteristics of plant tissues, the main characteristics of photosynthesis, saprophytism, semiparasitism and parasitism, mixotrophic nutrition. **Animals: Unicellulars:** general characteristics, taxonomic division, representatives of individual classes with respect to the diseases which they determine, their life cycle and type of reproduction.

**Multicellular animals:** Metabolism and energy flow in the organism: mechanisms of nutrition and processes of digestion. Phylogenesis of digestion system. Gas exchange between tissues and the environment. Phylogenesis of respiratory system. Types of body fluids in animals and in humans, composition and function. Systems of open and closed blood circulation, flow of the blood in blood vessels, blood groups and blood clotting. Phylogenesis of the circulatory system. Phylogenesis of the excretory system, structure and function of the nephron, secretion and composition of the urine. Hormonal regulations: mechanisms of direct and indirect effect of hormones, regulation of hormone level in body fluids. The structure and the function of the neurone. Transfer of neural signal by neurone and on synapses, action potential of neurite, phylogenesis of nervous system, central nervous system in vertebrates. Instincts, conditioned and unconditioned reflexes, origin and stability of conditioned reflexes, memory and memory traces, learning and thinking. Muscles: structure and function of muscle fibres, smooth muscle - its characteristics, striated muscle - its characteristics, characteristics of heart muscle and regulation of heart activity, classification of muscles according to the content of myoglobin, energy sources for muscle activity, muscle fatigue. Immune reactions of organism: antigens, non-specific and specific immunity, cellular and antibody immunity reaction, response of B and T lymphocytes to antigen, allergy, passive and active immunisation.

**Genetics:** Basic genetic terminology: codon, gene, allele, interrelationship between alleles, genotype, phenotype, homozygous and heterozygous individuals, autosomes and sex chromosomes, genome, karyotype, genofond. Regulatory genes, structural genes and genes for RNAs - their transcription and translation. Comparison of organisation of structural genes in prokaryotes and eukaryotes. Genetic information in prokaryotic and eukaryotic cell and its expression. **Autosomal heredity:** monohybrid and dihybrid crossing with complete and incomplete dominance, heredity of blood groups in human. **Gene linkage.** Genetic determination of sex: homogametic and heterogametic sex. **Gonosomal heredity** in human, human diseases caused by gonosomal genes and their heredity. **Mutations** and their classification, gene and genomic mutations in human and their heredity. **Heredity of quantitative and qualitative characteristics.** **Population genetics.** Definition of the population, autogamic and panmictic populations and their development, validity and limits of validity of the law of population equilibrium, practical application of this law. Methods used in human genetics, genetic diseases and dispositions, genetic counselling.

**Human biology:** **Bones:** structure, function, connection, skull, permanent and milk teeth, skeleton. **Muscles:** types of muscles, muscle systems, muscle innervation. **Blood:** composition, function, volume, blood cells - their origin, shape, function, sedimentation, types of haemoglobin, ABO system, Rh factor and its role, defence reactions of organism, blood transfusion. **Heart:** structure, activity, innervation, blood supply, minute volume of the heart, heart stroke, regulation of heart activity. **Arteries, veins, capillaries** - their structure and function, blood circulation, blood pressure, regulation of blood circulation, lymph production and function, hemostasis, emboly, trombosis. **Respiration:** airways, mechanism of inspiration and expiration, internal and external gase exchange, breathing regulation, respiratory defence reflexes and respiratory diseases. **Digestive system:** composition and function, glands of digestive secretion and their products, intestinal juice and its composition, metabolism and energy exchange, digestion of different foods, liver and its function, liver and gall-bladder diseases, defecation reflex, starvation, malnutrition and obesity. **Vitamins:** names, their role, deficiency effects, hypovitaminosis and avitaminosis. **Excretion:** kidneys - their structure and function, primary and secondary urine - composition and amount, regulation of kidney function. Role of the skin excretion. **Regulation of body functions:** neural and chemical regulation, their interrelationship. **Endocrine glands** and their hormones, regulation of hormone secretion into blood, most important effects of hormones. **Neural system:** neurone, synaptic junction, central nervous system. Brain - its parts and function,

spinal cord, spinal nerves, reflex circuit, spinal somatic reflexes, sympatic and parasympatic nervous system, higher nervous activity.

**Receptors:** stimulus, adaptation to stimuli, exteroceptors, interoceptors and proprioceptors, radioreceptors, chemoreceptors, mechanoreceptors and photoreceptors. **Reproductive system** of women and menstruation cycle, pregnancy, prenatal ontogenesis. Reproductive system in men.

## Chemistry

### General and inorganic chemistry

**Classification and properties of matter.** Physical versus chemical change. Elements, compounds, and mixtures. Unit conversion. Density. Temperature. Units of energy. Molecular weight. Relative weights. How many particles is in a mole? Moles of compounds. Gram-mole-particle conversions Atomic theory. Atomic number. Charged atoms - ions. Isotopes. Mass number. Relative atomic mass. Average atomic weight. Electronic versus nuclear changes. Radioactivity. Properties of radiation. Ionizing radiation. **Electron structure of atoms and bonds.** Electron configuration notation. Periodic table. Metals and nonmetals. Oxidation – reduction. Formulas for ionic compounds. Nomenclature. The nature of the ionic bond. Diatomic molecules. The nature of the covalent bond. Coordinate covalent bonds. Electronegativity and polarity. Recognizing ionic versus molecular compounds. Molecular shape. Molecular polarity..

**Chemical reactions and equations.** Balancing equations. Types of reactions. Oxidation-reduction reactions. Molar interpretation of the balanced equation. The mole ratio. Mole-mole, mole-gram, gram-gram conversions. Heat and chemical reactions. **Gases, liquids, solids.** Characteristics of gases. Intermolecular forces. Physical properties of liquids. Classes of crystalline solids. Properties of solids. Solution terminology. Factors influencing solubility. Electrolytes. Particles in solution. Concentration expressions. Colligative properties of solutions. Osmotic pressure of solutions. Colloids and suspensions. Active transport. Osmotic pressure and fluid transport. **Thermodynamics and equilibrium.** Principles of thermodynamics. The origin of heats of reaction (H). Entropy. Gibbs free energy. **Rate of reactions.** Activation energy. Factors influencing reaction rate. Reversible reactions. Equilibrium constant. **Acids and bases.** The Arrhenius definition. Brønsted-Lowry definition. Acid and base strength. Ionization of water, measurement of pH. Reactions of acids and bases. Acid-base indicators.

### Organic chemistry and biochemistry

**General properties of organic compounds.** Bonding in carbon compounds. Structural formulas for organic molecules. Condensed structural formulas. Functional-group concept. Homologous series. The R-group concept. Isomerism. Geometry around carbon atoms. Rotation about single bonds.

Nomenclature. Common nomenclature. Writing structures from names. Nomenclature and isomerism.

**Hydrocarbons.** Physical properties of hydrocarbons. Chemical properties of alkanes. Alkenes. Nomenclature of alkenes. Geometric isomerism. Bonding in alkenes - The double bond. Alkene reactions. Polymerization. Alkynes. Cyclic hydrocarbons. Aromatic hydrocarbons. Biologically significant hydrocarbons. Properties of the halogenated hydrocarbons.

**Alcohols.** The alcohol functional group. Hydrogen bonding in alcohols. Nomenclature of alcohols. Dehydration of alcohols. Oxidation of alcohols.

**Ethers, aldehydes and ketones.** The carbonyl group. Aldehyde and ketone nomenclature. Physical properties of aldehydes and ketones. Oxidation and reduction of aldehydes and ketones. Alcohol addition to aldehydes and ketones. Aldol addition of aldehydes and ketones. Reactions of aldehydes and ketones with nitrogen compounds. Phenols. Thiols.

**Saccharides.** Stereoisomerism. Stereoisomerism and glucose. Fischer projections. Multiple chiral centers. Classification: D-family versus L-family. Intramolecular hemiacetals and hemiketals.

Haworth projections. Mutarotation. Formation of di- and polysaccharides. Monosaccharides. Classification: Reducing and nonreducing sugars. Disaccharides. Polysaccharides.

**Amines.** Classification of amines. Nomenclature Physical properties of amines. Amine basicity.

**Carboxylic acids.** Nomenclature of carboxylic acids. Physical properties of carboxylic acids. Acidity and salt formation. Fatty acid salts as soap. Esterification. Esters from phosphoric acids. Thioesters. Hydrolysis of esters. Anhydrides of carboxylic acids. Amides. Amide formation.

**Lipids** - waxes, fats and oils. Hydrogenation of oils. Hydrolysis of simple lipids and digestion. Complex lipids. Phospholipids. The lipid bilayer of cell membranes. Steroids.

**Amino acids and proteins.** Structure of amino acids. Classification of amino acids. Stereoisomerism in amino acids. The peptide bond. Polypeptides. Primary structure of proteins. Secondary structure of proteins. Tertiary structure of proteins. Quaternary structure of proteins. Classification of proteins. Denaturation. Hydrolysis of proteins.

**Nucleic acids.** Chemical composition of DNA. The primary structure of DNA. The secondary structure of DNA. Ribonucleic acids. The genetic code. Protein biosynthesis I: Transcription. Protein biosynthesis II: Translation.

**Enzymes.** Enzyme composition, classification and nomenclature. Mechanism of enzyme activity. Substrate specificity and the enzyme-substrate complex. Factors affecting enzyme catalysis. Enzyme inhibition. Coenzymes and vitamins classification, relationship. The role of ATP.

**Hormones** - classification, target effects