BIOLOGY

I. GENERAL AND CELL BIOLOGY

Prominent personalities in biology

William Harvey. Jan Evangelista Purkyně. Charles Darwin. Louis Pasteur. Johann Gregor Mendel. Alexander Fleming. Robert Koch. James Dewey Watson and Francis Harry Compton Crick. Andreas Vesalius. Marcello Malpighi. Antonie Philips van Leeuwenhoek. Robert Hooke. Matthias Jakob Schleiden. Thomas Hunt Morgan.

Classification hierarchy and evolution

Taxonomy. Biological species. Taxonomy of vertebrates. Human taxonomy. – Hierarchical structure of living systems. Acellular organisms. Unicellular organisms. Multicellular organisms: Characteristics, distinct features, classification. – Evolutionary theories, Darwin's concept of evolution Evolutionary factors: variability, mutation, selection, genetic drift, gene flow. – Origin of life, prebiotic evolution, evolution of cellular organisms. Evolution of Homo sapiens, its ancestors and related species.

The Cell

Cell theory. Size of cells. Structure, organization and functions of cells (prokaryotic, eukaryotic, plant, animal). Chemical composition of cells: organic and inorganic compounds. Proteins: structure and functions. Nucleic acids: DNA and RNA, localization, functions. Saccharides. Lipids. – Cell organelles: structure and function. Nucleus. Mitochondria. Endoplasmic reticulum. Golgi apparatus. Lysosomes. Ribosomes. Centrioles. Cytoskeletal system. Chloroplasts. Biomembranes. Transmembrane transport. Endocytosis, pinocytosis, phagocytosis. Diffusion and osmosis. Energetics of living systems: photosynthesis, cell respiration, glycolysis, oxidative phosphorylation. – Cell cycle: Phases, regulation. Mitosis, phases, regulation and errors. Meiosis. Significance of mitosis and meiosis. Similarities and differences between meiosis and mitosis.

II. GENETICS AND HEREDITY

Nucleus and chromatin: Human karyotype, structure and classification of chromosomes, gamete maturation, sex determination. Structure and function of nucleic acids, intra- and extranuclear DNA. RNA and its types, structure and function. DNA replication, transcription, translation and genetic code. Genome, chromosome, and gene structure. Regulation of gene expression. Mutations and their consequences. Genetics of eukaryotic and prokaryotic cell. – Genetics: Genotype and phenotype. Gene expression,

dominant and recessive alleles, homozygous, heterozygous, complete and incomplete dominance, codominance. Mendel laws and Mendelian and non-Mendelian modes of inheritance. Gene linkage and gene interactions. Medically important autosomal recessive, dominant, sex-linked and multifactorial traits. Medically important chromosomal abnormalities.

III. HUMAN BIOLOGY

Tissues of the human body: Epithelial tissues. Connective tissues. Muscular tissue. Nervous tissue. Ectoderm, endoderm, mesoderm, differentiation – Body fluids: Total body water. Extracellular and intracellular fluid. Blood plasma. Basic characteristic of volumes and chemical composition. – Blood: Blood constituents, plasma and cells. Red blood cells, white blood cells, platelets. Basic characteristic of functions and count. Volume of blood. – Blood groups: AB0 system. Agglutination. Agglutinogens. Agglutinins. Blood transfusion. Universal donor. Universal recipient. Rh system. – Musculoskeletal system: Axial skeleton. Appendicular skeleton. Structure and development of bones. Articulations. Structure of skeletal muscle. Motor units. Mechanism of muscle contraction. – Respiratory system: Functions of respiratory system. Conducting passages. Lungs. Ventilation. Transport of respiratory gases. External and internal respiration, gas exchange. – Heart: Location and general description. Chambers and valves. Circulatory routes. Conduction system of the heart. Heart rate. – Circulatory system: Major components and functions of circulatory system. Blood vessels: arteries, veins, capillaries. Blood pressure. Lymphatic system. Lymph nodes. Spleen. – Gastrointestinal system: Principal function of the digestive system. Organs of the gastrointestinal tract. Glands of digestive system. Liver. Bile. Basic nutrients, vitamins, their sources and importance. Digestion and absorption of carbohydrates, proteins and fats. – Excretory system: Functions of urinary system. Production and composition of urine. Kidneys – position and structure. Ureters. Urinary bladder. Urethra. – Nervous system: Organization and functions of the nervous system. Neurons and neuroglia. Peripheral nerves: somatic and autonomic. Brainstem: spinal cord, pons, midbrain. Cerebellum. Diencephalon. Cerebral hemispheres. Reflexes. Resting membrane and action potential, electrical and chemical synapses. – Sensory system: The olfaction. The taste. The skin perception. The sight, the eye, its structure and function. The vestibular apparatus. The men's hearing. – Endocrine system: Classification of glands. Hormones. Pituitary gland. Thyroid and parathyroid glands. Pancreas. Adrenal glands. Gonads.

IV: ECOLOGY

Scope and definition. Hierarchy: organisms, species, populations, communities, ecosystems, biomes, biosphere. Biodiversity. Habitat, biotope. Biotic and abiotic factors. Niche. Population, community, ecosystem ecology. Food web and food chain. Trophic levels, producers, consumers, decomposers. Atmosphere: terminology, composition.

CHEMISTRY

I. GENERAL AND INORGANIC CHEMISTRY

Atoms and molecules

Definition of atom. Atomic number. Mass number. Protons and neutrons. Electrons. Electron configurations. Isotopes. Isotones. Radioactivity. Radioactive decay. Atomic, molecular and molar mass. Relative atomic or molecular mass. Dalton. – Molar mass and amount of a substance. Avogadro´s constant. Units. – Chemical bonds: Strong bonds – covalent bond, ionic bond, metallic bond. Weak bonds – hydrogen bridges, Van der Waals Forces, hydrophobic interactions. Intermolecular forces in solids, liquids and gases.

The periodic table of elements

Arrangement. Rows. Columns. Electron configuration of elements. Symbols of elements. Periodic properties of elements. Stoichiometry. – Group I.A (1) elements. Hydrogen and alkali metals (lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs, francium (Fr)). Valence electrons. Isotopes of hydrogen. The role of sodium and potassium in the body fluids. – Group II.A (2) elements. The alkaline-earth metals. Beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), radium (Ra). Valence electrons. The role of magnesium and calcium in the human body. – Group III.A (13) elements. Boron (B), aluminium (Al), gallium (Ga), indium (In), thallium (Tl). Valence electrons. Occurrence of Al on earth. – Group IV.A (14) elements. Carbon (C), silicon (Si), germanium (Ge), tin (Sn), lead (Pb). Valence electrons. Importance of C for living organisms. Carbon oxides. – Group V.A (15) elements. Nitrogen family. Nitrogen (N), phosphorus (P), arsenic (As), antimony (Sb), bismuth (Bi). Valence electrons. Abundance of nitrogen in the atmosphere. Ammonia. Nitrogen oxides. – Group VI.A (16) elements. Chalcogens. Oxygen (O), sulphur (S), selenium (Se), tellurium (Te), polonium (Po). Valence electrons. Abundance of oxygen in the Earth's crust, in the atmosphere. Oxidation of nutrients to gain energy. Oxides. Water. Sulphides, sulfuric acid, sulphates. – Group VII.A (17) elements. Halogens. Fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). Valence electrons. Halide anions. Sodium chloride. Importance of

fluoride and iodide intake for health. – Group VIII.A (18) elements. Noble gases. Helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and the radioactive radon (Rn). Reactivity. Electron shell. Occurrence in air.

Nomenclature of inorganic compounds

Oxides. Hydroxides. Inorganic acids. Halides. Sulphides. Cyanides. Nitrates. Sulphates. Hydrogen carbonates. Phosphates. Hydrides. Stoichiometric calculations. Oxidation states.

Mixtures

Homogenous mixtures: solutions. Dissolved substance and solvent. Solubility. – Mass fraction, molarity, mass concentration, calculations. – Solutions of nonelectrolytes and electrolytes, dissociation, calculations. – Heterogeneous mixtures: suspensions, emulsions. Sedimentation. Stability. – Density, mass, volume: calculations, units.

Chemical reactions

Synthesis. Decomposition. Single replacement (displacement). Double replacement (partner-exchange). Condensation. Hydrolysis. Impact of temperature, concentration of reactants and presence of catalysts on the rate of chemical reaction. Equilibrium constant. – Oxidation and reduction. Transfer of electrons. Redox pair. Oxidizing and reducing agents. Balancing chemical equations. – Protolytic reactions. Acids, bases, amphoteric compounds. Concentration of hydrogen ions, pH concept. Strong and weak acids, pH calculation. Neutralization (titration), calculations. Dissociation constant.

II. ORGANIC CHEMISTRY AND BIOCHEMISTRY

General structure, nomenclature, molecular, empirical, structure formulas, and reactions of organic compounds. – Important terms in organic chemistry: Valence of C, H, O, N, halogens, saturated and unsaturated hydrocarbons, aliphatic and aromatic hydrocarbons, single and multiple bonds, isomers, common halogen derivatives. – Thiols, alcohols, phenols, aldehydes, ketones, and quinones. –Carboxylic acids: mono-, di- and tricarboxylic acids and their derivatives: salts, esters, amides, anhydrides, halides, and nitriles. Fatty acids. – Heterocyclic derivatives: furan, imidazole, indole, purine, pyridine, pyrimidine, pyran, pyrrole. – Amines: nomenclature, structure, classification: primary, secondary, tertiary amines, choline, epinephrine, norepinephrine, dopamine, serotonin, and histamine. – Amino acids: formulas, classification, properties, reactions. – Saccharides: structure, properties, D- and L- enantiomers, reactivity, the most important mono-, di- and polysaccharides. – Lipids: triacylglycerols, phospholipids, steroids. Cholesterol, lecithin, sphingomyelin. – Proteins: structure,

properties and function. Primary, secondary, tertiary, and quaternary structure. – Nucleic acids: structure, components, purine and pyrimidine bases, nucleosides, nucleotides, complementary base pairing, bonds in nucleic acids. DNA and RNA, types of RNA. – Vitamins.

PHYSICS

I. UNITS AND QUANTITIES

Systems of units: SI, CGS and MKS. Base and derived SI units. – Standard prefixes used to denote multiples of ten. Conversion of metrical units of length, surface and volume, density of water. – Expression of derived SI units in base SI units. Scalar and vector quantities.

II. MECHANICS

Uniform linear motion. Distance, time, velocity. Calculation. – Accelerated linear motion. Free fall. Acceleration. Gravitational acceleration, g. Particle position, velocity and acceleration calculations. – Newton's laws of motion. Force, momentum, impulse, weight, torque – definitions, equations, calculations. Uniform circular motion: frequency, angular frequency, centripetal acceleration equations and calculation. – Newton's law of universal gravitation. Gravitational force. Gravitational constant. Distance between the bodies (particles). – Work: definition, SI units, work and energy, calculations. Power: definition, SI units, calculations, mechanical efficiency. – Mechanical energy: definition, SI units, calculations. Kinetic energy. Potential energy. – Ideal liquid. Pressure. Definition, SI units, formula, calculations. Hydrostatic pressure. Pascal principle. Atmospheric pressure. – Archimedes' principle. Buoyant force. Formula. Calculation. – Volume, mass, density. Common units. Formula. Density of water. Density of air. – Flow. Fluid dynamics. Units. Equation of continuity. Bernoulli's law. Viscosity. Laminar and turbulent flow. – Surface tension. Formula. Unit. Effects of surface tension.

III. THERMODYNAMICS

Thermodynamic systems, states and processes. – Temperature, Celsius and absolute temperature scales. Absolute zero temperature. Normal body temperature. – The 1st and 2nd principles of thermodynamics. – Ideal gas law. Equation. Ideal gas. Universal gas constant. Isobaric, isothermic and isochoric processes. Boyle's law, Charles's law, Avogadro's law, and Gay-Lussac's law. –Thermal expansion and contraction of solids, heat, heat capacity, specific heat capacity. Calorimetric equation.

IV. ELECTRICITY AND MAGNETISM

Electric charge, SI unit. Electrostatic attraction or repulsion. Electron, proton. – Coulomb's law, electric field intensity, potential, potential difference. – Capacitance. Parallel plate capacitor. Unit. Capacitors in series and in parallel. – Electric current. Definition. SI unit. Formulas. Ohm's law. Current. Voltage Resistance. SI units. Calculations. Relation to electric current and voltage. Units. Resistor. Combination of resistors. – Electric power, equations, unit, calculation. – Faraday's law of electrolysis, Faraday's constant. – Magnetic force, magnetic permeability, magnetic flux and flux density, definitions, units. Magnetic field, Ampère's rule. – Electromagnetic induction, Faraday's law, Lenz's law, Fleming's rule. Alternating current, effective values of current and voltage, electric power of alternating current, impedance (capacitance, inductance), AC transformer.

V. OPTICS AND ACOUSTICS

Properties of light, speed, wavelengths, spectrum, frequency, visible light, ultraviolet and infrared light, photon energy. – Light reflection and refraction, refraction index, Snell's law, critical angle. – Convex and concave mirrors and lenses, refractive power, lens equation and magnification, imaging equation. – Interference of light, polarised light. – Luminous intensity, luminous flux, illumination, definitions, formulas, units. – Properties of human eye. – Acoustics: Production, control, transmission, reception, and effects of sound. – Frequency, wavelength, speed of sound. – Sound pressure, sound pressure level, intensity, intensity level, definitions, units. – Hearing. Noise, pitch, loudness, timbre, sonic texture and spatial location of sound. – Ultrasound. Infrasound.