

Bio Olympiad Syllabus for HSC/A-level

Biological Molecules:

Water: understand its dipolar nature; understand formation of hydrogen bonds; understand the importance of water as a solvent; understand other roles of water related to its high latent heat of vaporization, specific heat capacity, density and surface tension.

Proteins: understand the nature of amino acids as monomers in the formation of polypeptides and proteins; recall the general formula and general structure of amino acids; understand that amino acids are linked by peptide bonds to form polypeptides; understand the meaning of the terms primary, secondary, tertiary and quaternary structure.

Carbohydrates: understand the origin of monosaccharides, recall the structure and understand the roles of the monosaccharides and glucose, ribose and deoxyribose; understand the roles of fructose and galactose; understand that disaccharides and polysaccharides are composed of monomers joined by glycosidic bonds; know the monomers of and understand the roles of the disaccharide sucrose, maltose and lactose; recall the structure and understand the roles of the polysaccharide starch (amylose and amylopectin), cellulose and glycogen; relate structure to function of these polysaccharides.

Lipid: understand the general nature of lipids as fats, oils and waxes; recall the general structure of a triglyceride synthesized from glycerol and fatty acids; understand the formation of ester bonds; understand the nature of saturated and unsaturated fatty acids.

Nucleic Acid: understand that ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) are composed of mononucleotides; recall the basic structure of a mononucleotide; thymine, uracil and cytosine as pyrimidines; adenine and guanine as purines; understand the roles of messenger and transfer RNA; recall the structure of DNA; understand base pairing; understand the double helix; understand the mechanism of replication of DNA (semi conservative); understand the nature of the genetic code; understand that a gene is a sequence of bases on the DNA molecule which codes for a sequence of amino acids in a polypeptide chain; understand the processes of transcription and translation in the synthesis of proteins; understand that amino acid sequences are specified by DNA, understand codons and anticodons in relation to messenger and transfer RNA.

Enzymes: understand the structure of enzymes, and the concept of the active site and specificity; understand that enzymes are catalysts which reduce activation energy; understand how enzyme activity is affected by temperature, pH, substrate and enzyme concentrations.

Cell:

Prokaryotic cell: understand the main characteristic of prokaryotic cells, describe the structure of a bacterial cell and its inclusions as illustrated by *Escherichia coli*; understand the roles of the cell wall, bacterial chromosomes, plasmids, recognize and identify structures in electron micrographs of bacterial cells.

Eukaryotic cell: understand the organization of eukaryotic cells; recognize and identify the structure of these cells as revealed by light and electron microscopy; describe the structure and understand the

roles of the nucleus, nucleolus, rough and smooth endoplasmic reticulum, Golgi apparatus, lysosomes, chloroplasts, mitochondria, ribosomes, centrioles and microtubules, the cellulose cell wall; describe the structure and understand the properties and roles of the cell surface (plasma) membrane.

Tissue: understand that tissues are aggregations of cells of common origin, structure and function, Classification of tissues, as illustrated by the tissues of a mesophytic leaf; understand that the leaf and the liver are organs and composed of aggregations of tissues.

Cell division: describe different kind of cell division, understand the sequence of division of a nucleus following the replication of DNA during interphase; understand mitosis & meiosis.

Mitosis: recall the structure of a chromosome; understand the behavior of chromosomes during the stages of the mitotic cell cycle; describe the events of prophase, metaphase, anaphase and telophase; understand the significance of mitosis in growth and replacement; understand the significance of daughter nuclei with chromosomes identical in number and type; understand that the production of new individuals involves the transfer of genetic information from parent to offspring; understand the significance of mitosis in achieving this; understand the nature of natural and artificial cloning in plants and animals.

Transport & Exchange of molecules:

Transport across membrane: understand how molecules and ions move into and out of cells; understand the principles of osmosis in terms of the diffusion of water molecules from a higher to lower water potential through a partially permeable membrane; understand the factors which affect water

potential; understand the principles involved in active transport; endocytosis and exocytosis.

Exchanges with the environment: appreciate that materials exchanged with the environment include respiratory gases, nutrients and excretory products. the structure of the breathing system and the mechanism of ventilation; understand the effects of physical activity and increase in carbon dioxide concentration on breathing rate and volume. Describe the characteristics of alveoli as surfaces involved in gas exchange; describe the effects of smoking on ventilation and gas exchange; understand the effects of smoking in relation to pregnancy; describe the causes and effects of carbon monoxide; explain the origin of carbon monoxide from car exhausts and tobacco smoke.

Digestion and absorption: describe the structure of the alimentary canal in relation to digestion and absorption; describe mastication and movement of food along the gut; describe the histology of the ileum wall; understand the sources and effects of secretions concerned with the digestion of carbohydrates.

Transport of materials

Circulation: understand the functions of the circulatory system for the transport of respiratory gases, metabolites, metabolic wastes and hormones.

The circulatory system: describe the structure of the human heart and coronary circulation; understand the cardiac cycle; understand how the cardiac cycle is coordinated; describe a normal ECG and understand the role of artificial pacemakers; describe the structure and roles of arteries, veins and capillaries.

Blood and body fluids: describe the composition of blood as plasma and blood cells, to include erythrocytes and leukocytes (neutrophils, eosinophils,

monocytes and lymphocytes); describe the structure of erythrocytes and understand their role in transport; understand the roles of leucocytes in phagocytosis and secretion of antibodies; understand the transport of oxygen and carbon dioxide; describe the roles of respiratory pigments (haemoglobin, fetal haemoglobin and myoglobin); describe the interchange of materials between capillaries and tissue fluid, including the formation and reabsorption of tissue fluid and the formation of lymph.

Human Reproduction & Development:

Reproduction: describe the structures and functions of the male and female reproductive systems; recall that gamete formation involves a reduction division (meiosis) and understand its significance as the division of a diploid nucleus to give haploid nuclei; describe the production of gametes in oogenesis and spermatogenesis; describe and understand the events in the menstrual cycle; understand the roles of luteinizing hormone, follicle-stimulating hormone, estrogen and progesterone; describe the transfer of male gametes leading to fertilization; describe implantation; understand the functions of the placenta in relation to the development of the fetus; understand the role of the placenta; describe the stages of birth and understand the control by fetal and maternal hormones; understand the control of milk production by prolactin and oxytocin; understand the importance of colostrums.

Development: interpret human growth curves, including changes in the proportions of body parts from birth to maturity.

Energy & the Environment:

Energy: related laws, exothermic & endothermic reactions, How they direct biological reactions, entropy, energy change in reaction.

Ecosystems: recall the terms biosphere, ecosystem, habitat, producers, consumers and decomposers, trophic levels, food chains and food webs.

Energy flow: recall that carbon dioxide and water are converted to glucose and oxygen, using energy from sunlight in photosynthesis and that light energy is absorbed by chlorophyll; understand the role of producers, consumers and decomposers in food chains and food webs; describe food chains quantitatively, using pyramids of numbers, biomass and energy; understand how energy is transferred through food chains and food webs and why energy is lost between trophic levels; understand the terms productivity, gross primary production and net primary production.

Energy resources: understand how energy resources can be managed in a sustainable manner; describe the use of fossil fuels as illustrated by coal and oil; describe the use of renewable energy sources, as illustrated by fast-growing biomass, gasohol from sugar, biogas from domestic and agricultural wastes.

Respiration:

Cellular respiration describe the conversion of monosaccharides to pyruvate during glycolysis; the phosphorylation of hexose molecules; breakdown to glycerate 3-phosphate (GP); production of reduced coenzyme (NADH + H⁺) and ATP.

Aerobic respiration understand that during the complete oxidation of pyruvate the events of the Krebs cycle result in the production of carbon dioxide, more

reduced coenzyme (NADH + H⁺) and ATP; understand the role of the electron-transport chain in generating ATP (oxidative phosphorylation); understand the role of molecular oxygen as a hydrogen acceptor forming water; describe and understand the role of mitochondria as the site of Krebs cycle and electron-transport chain; understand the location of enzymes and electron carriers; understand the role of oxidoreductases.

Anaerobic respiration: understand the situations in which the pyruvate formed in glycolysis may not undergo complete oxidation; formation of lactic acid in muscle; formation of ethanol in yeast; compare and explain the differences in the yields of ATP from the complete oxidation of glucose and from the fermentation of glucose to lactic acid or ethanol.

Coordination:

Metabolic pathways: understand the concept of a metabolic pathway as a sequence of enzyme-controlled reactions; appreciate the roles of enzymes in the control of such pathways, illustrated by oxidoreductases and hydrolases; anabolism and catabolism; understand the significance of ATP in metabolism as the immediate supply of energy for biological processes.

Mammalian kidney: understand the role of the mammalian kidney in osmoregulation and nitrogenous excretion; describe the structure of the mammalian kidney; describe and understand the function of the nephrons; describe the process of ultrafiltration; understand the selective reabsorption of water and solutes; understand how the control of the water and solute content of the blood is achieved; the role of osmoreceptors in the hypothalamus; the pituitary

gland; the action of antidiuretic hormone; the principle of negative feedback.

Nervous coordination in mammals: describe the structure and functions of sensory, relay and effector neurones; the role of Schwann cells and myelination; understand the nature of the nerve impulse; describe the propagation of action potentials in terms of changes in the permeability of the membrane to sodium ions, resulting in a wave of depolarization, propagating an action potential; describe the structure and functions of a synapse; understand the role of acetylcholine as a transmitter substance; post-synaptic potentials; understand the effects of drugs on synaptic transmission, as illustrated by nicotine.

The central nervous system: describe the gross structure of the brain and spinal cord; describe the location and functions of the medulla, cerebellum, hypothalamus and cerebral hemispheres; describe the functioning of a spinal reflex arc and the types of neurone involved; understand the value of such reflexes in response to changes in the external environment.

Regulation of the internal environment: understand the concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium; understand that homeostasis allows organisms to be independent of the external environment; understand the concept and roles of feedback mechanisms.

Regulation of blood glucose: understand the factors which lead to variation in blood glucose levels; the roles of insulin, glucagon and adrenaline in the control of blood glucose levels; the role of the liver in glucose-glycogen metabolism.

Genetics:

Genes and alleles understand gene expression and the environmental influences on gene expression; recall monohybrid inheritance; understand the terms genotype and phenotype, homozygotes and heterozygotes, dominance and codominance; Mendel's law & his assumptions, some difference from that law.

Gene technology describe and understand the roles of reverse transcriptase, endonucleases and DNA ligase in the manipulation of DNA; describe the insertion of DNA into a host cell and the multiplication of the host cell; appreciate the use of marker genes to indicate that new genes have been incorporated into host cells; understand how protein synthesis is switched on and the synthesis of new product by the host cell as illustrated by the production of new genes into plants using the bacterium *Agrobacterium tumefaciens*; discuss the potential of genetically modified organisms; understand how the polymerase chain reaction (PCR) amplifies genetic material; describe genetic fingerprinting as a diagnostic tool; recognize the potential for gene therapy; discuss social, ethical and legal implications, Human Genome Project and its implications, Gene chips.

Adaptation:

understand the effects of extremes of environmental temperature and of life at high altitude.

Extremes of temperature: recall normal body temperature and appreciate diurnal variation; understand the structural, physiological and behavioral mechanisms of temperature regulation, including the structure and roles of the skin, and the roles of thermo receptors and the hypothalamus; understand the

causes and effects of heat stress, including salt loss, heat cramp, moderate and severe dehydration.

High altitude describe the environmental conditions in high mountains, including low atmospheric pressure, low temperature, low humidity, high winds and increased solar radiation; describe the physiological effects of high altitude including hypoxia, hyperventilation, changes in lung volume and pulmonary diffusing capacity, increased red cells and hemoglobin concentration, initial increase in cardiac output; describe the effects of high altitude stress, including the general symptoms of mountain sickness, increased secretion of antidiuretic hormone, redistribution of body fluids.

Microbiology & Biotechnology:

Diversity of microorganisms: describe the general characteristics of representatives of the following groups of microorganisms, illustrated by the examples named in each group.

Bacteria recall the structure of a bacterial cell and its inclusions, as illustrated by *Escherichia coli*; understand that cell structure is a mean of classifying bacteria; describe and understand the use of Gram staining in identifying bacteria; understand that bacteria are agents of infection.

Fungi (yeasts and moulds): describe the general characteristics of fungi; identify the differences in structure between yeasts and moulds as illustrated by *Saccharomyces* and *Penicillium*.

Viruses understand that the classification is based on virus structure and nucleic acid types as illustrated by tobacco mosaic virus (RNA) and human immunodeficiency virus (RNA retrovirus); understand that viruses are agents of infection; the nature of host cell specificity; describe the cell infection cycle and

latency as illustrated by human immunodeficiency virus (HIV).

Use of microorganisms in biotechnology

Food and drink describe and understand the processes involved in lactic acid fermentation leading to the production of alcohol; describe the processes involved in fermentation by yeast in brewing; understand the metabolic processes involved.

Medical applications describe the production of antibiotics, illustrated by penicillin from *Penicillium*; understand the effects of antibiotics (penicillin) on bacterial growth; understand antibiotic resistance and the reasons for its spread.

Fermentations explain the changes in pH in relation to storage; explain the role of yeast in bread making; understand the effect of ascorbic acid on the rising of dough; describe and understand the role of yeast in wine making.

Food science:

Balanced diet recall the sources and roles of nutrients required in a balanced diet, including carbohydrates, fats, proteins, vitamins, mineral ions, dietary fiber and water; understand the nutritional requirements with reference to energy, total fat, polyunsaturated and saturated fat, dietary fiber, sodium and sugars.

Under-nutrition recall the effects of lack of protein, iron, calcium and vitamin C (ascorbic acid); describe the effects of lack of vitamin A (retinol); explain the molecular basis of scurvy in terms of the hydroxylation of collagen.

Human Health:

Human disorders describe the causes and understand the treatment of the cardiovascular disorders of hypertension and coronary heart disease; describe the causes and understand the treatment of the pulmonary disorders of bronchitis, TB, pneumoconiosis and lung cancer; describe the causes and understand the treatment of arthritis.

Evolution & Biodiversity:

Human populations: World trends in population size: understand the factors affecting the growth and size of human populations; birth and death rates; Population structure understand growth curves and population pyramids in countries with stable, increasing and declining populations; describe the implications of world population trends.

Human influences on the environment: discuss the causes and effects of deforestation and desertification, with particular emphasis on communities, biodiversity and sustainable management; describe the ecological impact of human activity on the environment, to include atmospheric pollution (acid rain and greenhouse effect) and water pollution.

Biodiversity Distribution of plants and animals: understand the effects of a biotic and abiotic factors on the distribution of organisms in a terrestrial and an aquatic habitat; freshwater or marine littoral habitat.

Succession: understand that ecosystems are dynamic and subject to change over time, as illustrated by the change from grassland or abandoned farmland to woodland.

Conservation: describe the management of grassland and woodland habitats to maintain or

increase biodiversity, as illustrated by mowing, grazing, scrub clearance, use of fire and coppicing; discuss how intensive food production may affect wildlife.

Classification:

Classification of plant & animal kingdom; virus, protocista, monera, fungi, plantae, angiosperms; characteristic and examples of the 10 phylum of animal kingdom.

Malarial parasite: habitat, structure, life cycle, reproduction, control of malaria.

Cockroach: structure, habitat, digestive system, blood circulatory system, respiratory system, excretory system, nervous system, sense organs, reproductive system, metamorphosis.

Human body: skeletal system, digestive system, excretory system, nervous system, sensory organs and glands of human body.