COURSE OUTLINES – BIOLOGY – SL + HL – 2023/2024 (DP1)

Level of organisation	Theme	Topic	Content	Allocated time		
				IB hours (60 minutes)	SL – 4 lessons per week	HL – 6 lessons per week
1. Molecules	**A. Unity and Diversity**	A1.1 Water	A1.1.1—Water as the medium for life A1.1.2—Hydrogen bonds as a consequence of the polar covalent bonds within water molecules A1.1.3—Cohesion of water molecules due to hydrogen bonding and consequences for organisms A1.1.4—Adhesion of water to materials that are polar or charged and impacts for organisms A1.1.5—Solvent properties of water linked to its role as a medium for metabolism and for transport in plants and animals A1.1.6—Physical properties of water and the consequences for animals in aquatic habitats A1.1.7—Extraplanetary origin of water on Earth and reasons for its retention A1.1.8—Relationship between the search for extraterrestrial life and the presence of water	2+1	3	4

		A1.2 Nucleic acids	A1.2.1—DNA as the genetic material of all living organisms A1.2.2—Components of a nucleotide A1.2.3—Sugar–phosphate bonding and the sugar–phosphate “backbone” of DNA and RNA A1.2.4—Bases in each nucleic acid that form the basis of a code A1.2.5—RNA as a polymer formed by condensation of nucleotide monomers A1.2.6—DNA as a double helix made of two antiparallel strands of nucleotides with two strands linked by hydrogen bonding between complementary base pairs A1.2.7—Differences between DNA and RNA A1.2.8—Role of complementary base pairing in allowing genetic information to be replicated and expressed A1.2.9—Diversity of possible DNA base sequences and the limitless capacity of DNA for storing information A1.2.10—Conservation of the genetic code across all life forms as evidence of universal common ancestry A1.2.11—Directionality of RNA and DNA A1.2.12—Purine-to-pyrimidine bonding as a component of DNA helix stability A1.2.13—Structure of a nucleosome A1.2.14—Evidence from the Hershey–Chase experiment for DNA as the genetic material A1.2.15—Chargaff’s data on the relative amounts of pyrimidine and purine bases across diverse life forms	3+2	4	7
	B. Form and function	B1.1 Carbohydrates and lipids	B1.1.1—Chemical properties of a carbon atom allowing for the formation	4	5	5

			of diverse compounds upon which life is based B1.1.2—Production of macromolecules by condensation reactions that link monomers to form a polymer B1.1.3—Digestion of polymers into monomers by hydrolysis reactions B1.1.4—Form and function of monosaccharides B1.1.5—Polysaccharides as energy storage compounds B1.1.6—Structure of cellulose related to its function as a structural polysaccharide in plants B1.1.7—Role of glycoproteins in cell–cell recognition B1.1.8—Hydrophobic properties of lipids B1.1.9—Formation of triglycerides and phospholipids by condensation reactions B1.1.10—Difference between saturated, monounsaturated and polyunsaturated fatty acids B1.1.11—Triglycerides in adipose tissues for energy storage and thermal insulation B1.1.12—Formation of phospholipid bilayers as a consequence of the hydrophobic and hydrophilic regions B1.1.13—Ability of non-polar steroids to pass through the phospholipid bilayer			
		B1.2 Proteins	B1.2.1—Generalized structure of an amino acid B1.2.2—Condensation reactions forming dipeptides and longer chains of amino acids B1.2.3—Dietary requirements for amino acids B1.2.4—Infinite variety of possible peptide chains	2+2	3	6

			B1.2.5—Effect of pH and temperature on protein structure B1.2.6—Chemical diversity in the R-groups of amino acids as a basis for the immense diversity in protein form and function B1.2.7—Impact of primary structure on the conformation of proteins B1.2.8—Pleating and coiling of secondary structure of proteins B1.2.9—Dependence of tertiary structure on hydrogen bonds, ionic bonds, disulfide covalent bonds and hydrophobic interactions B1.2.10—Effect of polar and non-polar amino acids on tertiary structure of proteins B1.2.11—Quaternary structure of non-conjugated and conjugated proteins B1.2.12—Relationship of form and function in globular and fibrous proteins			
	C. Interaction and interdependence	C1.1Enzymes and metabolism	C1.1.1—Enzymes as catalysts C1.1.2—Role of enzymes in metabolism C1.1.3—Anabolic and catabolic reactions C1.1.4—Enzymes as globular proteins with an active site for catalysis C1.1.5—Interactions between substrate and active site to allow induced-fit binding C1.1.6—Role of molecular motion and substrate-active site collisions in enzyme catalysis C1.1.7—Relationships between the structure of the active site, enzyme–substrate specificity and denaturation C1.1.8—Effects of temperature, pH and substrate concentration on the rate of enzyme activity	3+2	4	7

			C1.1.9—Measurements in enzyme-catalysed reactions C1.1.10—Effect of enzymes on activation energy C1.1.11—Intracellular and extracellular enzyme-catalysed reactions C1.1.12—Generation of heat energy by the reactions of metabolism C1.1.13—Cyclical and linear pathways in metabolism C1.1.14—Allosteric sites and non-competitive inhibition C1.1.15—Competitive inhibition as a consequence of an inhibitor binding reversibly to an active site C1.1.16—Regulation of metabolic pathways by feedback inhibition C1.1.17—Mechanism-based inhibition as a consequence of chemical changes to the active site caused by the irreversible binding of an inhibitor			
		C1.2 Cell respiration	C1.2.1—ATP as the molecule that distributes energy within cells C1.2.2—Life processes within cells that ATP supplies with energy C1.2.3—Energy transfers during interconversions between ATP and ADP C1.2.4—Cell respiration as a system for producing ATP within the cell using energy released from carbon compounds C1.2.5—Differences between anaerobic and aerobic cell respiration in humans C1.2.6—Variables affecting the rate of cell respiration C1.2.7—Role of NAD as a carrier of hydrogen and oxidation by removal of hydrogen during cell respiration C1.2.8—Conversion of glucose to pyruvate by stepwise reactions in glycolysis with a net yield of ATP and reduced NAD	2+3	3	7

			C1.2.9—Conversion of pyruvate to lactate as a means of regenerating NAD in anaerobic cell respiration C1.2.10—Anaerobic cell respiration in yeast and its use in brewing and baking C1.2.11—Oxidation and decarboxylation of pyruvate as a link reaction in aerobic cell respiration C1.2.12—Oxidation and decarboxylation of acetyl groups in the Krebs cycle with a yield of ATP and reduced NAD C1.2.13—Transfer of energy by reduced NAD to the electron transport chain in the mitochondrion C1.2.14—Generation of a proton gradient by flow of electrons along the electron transport chain C1.2.15—Chemiosmosis and the synthesis of ATP in the mitochondrion C1.2.16—Role of oxygen as terminal electron acceptor in aerobic cell respiration C.1.2.17—Differences between lipids and carbohydrates as respiratory substrates			
		C1.3 Photosynthesis	C1.3.1—Transformation of light energy to chemical energy when carbon compounds are produced in photosynthesis C1.3.2—Conversion of carbon dioxide to glucose in photosynthesis using hydrogen obtained by splitting water C1.3.3—Oxygen as a by-product of photosynthesis in plants, algae and cyanobacteria C1.3.4—Separation and identification of photosynthetic pigments by chromatography	3+3	4	8

			C1.3.5—Absorption of specific wavelengths of light by photosynthetic pigments C1.3.6—Similarities and differences of absorption and action spectra C1.3.7—Techniques for varying concentrations of carbon dioxide, light intensity or temperature experimentally to investigate the effects of limiting factors on the rate of photosynthesis C1.3.8—Carbon dioxide enrichment experiments as a means of predicting future rates of photosynthesis and plant growth C1.3.9—Photosystems as arrays of pigment molecules that can generate and emit excited electrons C1.3.10—Advantages of the structured array of different types of pigment molecules in a photosystem C1.3.11—Generation of oxygen by the photolysis of water in photosystem II C1.3.12—ATP production by chemiosmosis in thylakoids C1.3.13—Reduction of NADP by photosystem I C1.3.14—Thylakoids as systems for performing the light-dependent reactions of photosynthesis C1.3.15—Carbon fixation by Rubisco C1.3.16—Synthesis of triose phosphate using reduced NADP and ATP C1.3.17—Regeneration of RuBP in the Calvin cycle using ATP C1.3.18—Synthesis of carbohydrates, amino acids and other carbon compounds using the products of the Calvin cycle and mineral nutrients C1.3.19—Interdependence of the light-dependent and light-independent reactions			

	D. Continuity and change	D1.1 DNA replication	D1.1.1—DNA replication as production of exact copies of DNA with identical base sequences D1.1.2—Semi-conservative nature of DNA replication and role of complementary base pairing D1.1.3—Role of helicase and DNA polymerase in DNA replication D1.1.4—Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA D1.1.5—Applications of polymerase chain reaction and gel electrophoresis D1.1.6—Directionality of DNA polymerases D1.1.7—Differences between replication on the leading strand and the lagging strand D1.1.8—Functions of DNA primase, DNA polymerase I, DNA polymerase III and DNA ligase in replication D1.1.9—DNA proofreading	2+2	3	6
		D1.2 Protein synthesis	D1.2.1—Transcription as the synthesis of RNA using a DNA template D1.2.2—Role of hydrogen bonding and complementary base pairing in transcription D1.2.3—Stability of DNA templates D1.2.4—Transcription as a process required for the expression of genes D1.2.5—Translation as the synthesis of polypeptides from mRNA D1.2.6—Roles of mRNA, ribosomes and tRNA in translation D1.2.7—Complementary base pairing between tRNA and mRNA D1.2.8—Features of the genetic code D1.2.9—Using the genetic code expressed as a table of mRNA codons D1.2.10—Stepwise movement of the ribosome along mRNA and linkage of	3+3	4	8

			amino acids by peptide bonding to the growing polypeptide chain D1.2.11—Mutations that change protein structure D1.2.12—Directionality of transcription and translation D1.2.13—Initiation of transcription at the promoter D1.2.14—Non-coding sequences in DNA do not code for polypeptides D1.2.15—Post-transcriptional modification in eukaryotic cells D1.2.16—Alternative splicing of exons to produce variants of a protein from a single gene D1.2.17—Initiation of translation D1.2.18—Modification of polypeptides into their functional state D1.2.19—Recycling of amino acids by proteasomes			
		D1.3 Mutations and gene editing	D1.3.1—Gene mutations as structural changes to genes at the molecular level D1.3.2—Consequences of base substitutions D1.3.3—Consequences of insertions and deletions D1.3.4—Causes of gene mutation D1.3.5—Randomness in mutation D1.3.6—Consequences of mutation in germ cells and somatic cells D1.3.7—Mutation as a source of genetic variation D1.3.8—Gene knockout as a technique for investigating the function of a gene by changing it to make it inoperative D1.3.9—Use of the CRISPR sequences and the enzyme Cas9 in gene editing D1.3.10—Hypotheses to account for conserved or highly conserved sequences in genes	3+2	4	7

Practical work				12+12	16	31
2. Cells	**A. Unity and Diversity**	A2.1 Origins of cells (HL only)	A2.1.1—Conditions on early Earth and the pre-biotic formation of carbon compounds A2.1.2—Cells as the smallest units of self-sustaining life A2.1.3—Challenge of explaining the spontaneous origin of cells A2.1.4—Evidence for the origin of carbon compounds A2.1.5—Spontaneous formation of vesicles by coalescence of fatty acids into spherical bilayers A2.1.6—RNA as a presumed first genetic material A2.1.7—Evidence for a last universal common ancestor A2.1.8—Approaches used to estimate dates of the first living cells and the last universal common ancestor A2.1.9—Evidence for the evolution of the last universal common ancestor in the vicinity of hydrothermal vents	2		3
		A2.2 Cell structure	A2.2.1—Cells as the basic structural unit of all living organisms A2.2.2—Microscopy skills A2.2.3—Developments in microscopy A2.2.4—Structures common to cells in all living organisms A2.2.5—Prokaryote cell structure A2.2.6—Eukaryote cell structure A2.2.7—Processes of life in unicellular organisms A2.2.8—Differences in eukaryotic cell structure between animals, fungi and plants A2.2.9—Atypical cell structure in eukaryotes	4+1	5	7

			A2.2.10—Cell types and cell structures viewed in light and electron micrographs A2.2.11—Drawing and annotation based on electron micrographs A2.2.12—Origin of eukaryotic cells by endosymbiosis A2.2.13—Cell differentiation as the process for developing specialized tissues in multicellular organisms A2.2.14—Evolution of multicellularity			
		A2.3 Viruses (HL only)	A2.3.1—Structural features common to viruses A2.3.2—Diversity of structure in viruses A2.3.3—Lytic cycle of a virus A.2.3.4—Lysogenic cycle of a virus A2.3.5—Evidence for several origins of viruses from other organisms A2.3.6—Rapid evolution in viruses	2		3
	B. Form and function	B2.1Membranes and membrane transport	B2.1.1—Lipid bilayers as the basis of cell membranes B2.1.2—Lipid bilayers as barriers B2.1.3—Simple diffusion across membranes B2.1.4—Integral and peripheral proteins in membranes B2.1.5—Movement of water molecules across membranes by osmosis and the role of aquaporins B2.1.6—Channel proteins for facilitated diffusion B2.1.7—Pump proteins for active transport B2.1.8—Selectivity in membrane permeability B.2.1.9—Structure and function of glycoproteins and glycolipids B2.1.10—Fluid mosaic model of membrane structure	4+2	5	8

			B2.1.11—Relationships between fatty acid composition of lipid bilayers and their fluidity B2.1.12—Cholesterol and membrane fluidity in animal cells B2.1.13—Membrane fluidity and the fusion and formation of vesicles B2.1.14—Gated ion channels in neurons B2.1.15—Sodium–potassium pumps as an example of exchange transporters B2.1.16—Sodium-dependent glucose cotransporters as an example of indirect active transport B2.1.17—Adhesion of cells to form tissues			
		B2.2 Organelles and compartmentaliza-tion	B2.2.1—Organelles as discrete subunits of cells that are adapted to perform specific functions B2.2.2—Advantage of the separation of the nucleus and cytoplasm into separate compartments B2.2.3—Advantages of compartmentalization in the cytoplasm of cells B2.2.4—Adaptations of the mitochondrion for production of ATP by aerobic cell respiration B2.2.5—Adaptations of the chloroplast for photosynthesis B2.2.6—Functional benefits of the double membrane of the nucleus B2.2.7—Structure and function of free ribosomes and of the rough endoplasmic reticulum B2.2.8—Structure and function of the Golgi apparatus B2.2.9—Structure and function of vesicles in cells	1+2	1	3
		B2.3Cell specialization	B2.3.1—Production of unspecialized cells following fertilization and their	2+1	3	4

			development into specialized cells by differentiation B2.3.2—Properties of stem cells B2.3.3—Location and function of stem cell niches in adult humans B2.3.4—Differences between totipotent, pluripotent and multipotent stem cells B2.3.5—Cell size as an aspect of specialization B2.3.6—Surface area-to-volume ratios and constraints on cell size B2.3.7—Adaptations to increase surface area-to-volume ratios of cells B2.3.8—Adaptations of type I and type II pneumocytes in alveoli B2.3.9—Adaptations of cardiac muscle cells and striated muscle fibres B2.3.10—Adaptations of sperm and egg cells			
	C. Interaction and interdependence	C2.1 Chemical signalling (HL only)	C2.1.1—Receptors as proteins with binding sites for specific signalling chemicals C.2.1.2—Cell signalling by bacteria in quorum sensing C2.1.3—Hormones, neurotransmitters, cytokines and calcium ions as examples of functional categories of signalling chemicals in animals C2.1.4—Chemical diversity of hormones and neurotransmitters C2.1.5—Localized and distant effects of signalling molecules C2.1.6—Differences between transmembrane receptors in a plasma membrane and intracellular receptors in the cytoplasm or nucleus C2.1.7—Initiation of signal transduction pathways by receptors C2.1.8—Transmembrane receptors for neurotransmitters and changes to membrane potential	4		5

			C2.1.9—Transmembrane receptors that activate G proteins C2.1.10—Mechanism of action of epinephrine (adrenaline) receptors C2.1.11—Transmembrane receptors with tyrosine kinase activity C2.1.12—Intracellular receptors that affect gene expression C2.1.13—Effects of the hormones oestradiol and progesterone on target cells C2.1.14—Regulation of cell signalling pathways by positive and negative feedback			
		C2.2Neural signalling	C2.2.1—Neurons as cells within the nervous system that carry electrical impulses C2.2.2—Generation of the resting potential by pumping to establish and maintain concentration gradients of sodium and potassium ions C2.2.3—Nerve impulses as action potentials that are propagated along nerve fibres C2.2.4—Variation in the speed of nerve impulses C2.2.5—Synapses as junctions between neurons and between neurons and effector cells C2.2.6—Release of neurotransmitters from a presynaptic membrane C2.2.7—Generation of an excitatory postsynaptic potential C2.2.8—Depolarization and repolarization during action potentials C2.2.9—Propagation of an action potential along a nerve fibre/axon as a result of local currents C2.2.10—Oscilloscope traces showing resting potentials and action potentials	3+3	4	8

			C2.2.11—Saltatory conduction in myelinated fibres to achieve faster impulses C2.2.12—Effects of exogenous chemicals on synaptic transmission C2.2.13—Inhibitory neurotransmitters and generation of inhibitory postsynaptic potentials C2.2.14—Summation of the effects of excitatory and inhibitory neurotransmitters in a postsynaptic neuron C2.2.15—Perception of pain by neurons with free nerve endings in the skin C2.2.16—Consciousness as a property that emerges from the interaction of individual neurons in the brain			
	D. Continuity and change	D2.1 Cell and nuclear division	D2.1.1—Generation of new cells in living organisms by cell division D2.1.2—Cytokinesis as splitting of cytoplasm in a parent cell between daughter cells D2.1.3—Equal and unequal cytokinesis D2.1.4—Roles of mitosis and meiosis in eukaryotes D2.1.5—DNA replication as a prerequisite for both mitosis and meiosis D2.1.6—Condensation and movement of chromosomes as shared features of mitosis and meiosis D2.1.7—Phases of mitosis D2.1.8—Identification of phases of mitosis D2.1.9—Meiosis as a reduction division D2.1.10—Down syndrome and non-disjunction D2.1.11—Meiosis as a source of variation D2.1.12—Cell proliferation for growth, cell replacement and tissue repair D2.1.13—Phases of the cell cycle	3+1	4	7

			D2.1.14—Cell growth during interphase D2.1.15—Control of the cell cycle using cyclins D2.1.16—Consequences of mutations in genes that control the cell cycle D2.1.17—Differences between tumours in rates of cell division and growth and in the capacity for metastasis and invasion of neighbouring tissue			
		D2.2 Gene expression (HL only)	D2.2.1—Gene expression as the mechanism by which information in genes has effects on the phenotype D2.2.2—Regulation of transcription by proteins that bind to specific base sequences in DNA D2.2.3—Control of the degradation of mRNA as a means of regulating translation D2.2.4—Epigenesis as the development of patterns of differentiation in the cells of a multicellular organism D2.2.5—Differences between the genome, transcriptome and proteome of individual cells D2.2.6—Methylation of the promoter and histones in nucleosomes as examples of epigenetic tags D2.2.7—Epigenetic inheritance through heritable changes to gene expression D2.2.8—Examples of environmental effects on gene expression in cells and organisms D2.2.9—Consequences of removal of most but not all epigenetic tags from the ovum and sperm D2.2.10—Monozygotic twin studies D2.2.11—External factors impacting the pattern of gene expression	3		4
		D2.3Water potential	D2.3.1—Solvation with water as the solvent	2+2	3	6

			D2.3.2—Water movement from less concentrated to more concentrated solutions D2.3.3—Water movement by osmosis into or out of cells D2.3.4—Changes due to water movement in plant tissue bathed in hypotonic and those bathed in hypertonic solutions D2.3.5—Effects of water movement on cells that lack a cell wall D2.3.6—Effects of water movement on cells with a cell wall D2.3.7—Medical applications of isotonic solutions D2.3.8—Water potential as the potential energy of water per unit volume D2.3.9—Movement of water from higher to lower water potential D2.3.10—Contributions of solute potential and pressure potential to the water potential of cells with walls D2.3.11—Water potential and water movements in plant tissue			
Collaborative Sciences Project				10	13	13
3. Organisms	**A. Unity and Diversity**	A3.1 Diversity of organisms	A3.1.1—Variation between organisms as a defining feature of life A3.1.2—Species as groups of organisms with shared traits A3.1.3—Binomial system for naming organisms A3.1.4—Biological species concept A3.1.5—Difficulties distinguishing between populations and species due to divergence of non-interbreeding populations during speciation A3.1.6—Diversity in chromosome numbers of plant and animal species A3.1.7—Karyotyping and karyograms	3+2	4	7

			A3.1.8—Unity and diversity of genomes within species A3.1.9—Diversity of eukaryote genomes A3.1.10—Comparison of genome sizes A3.1.11—Current and potential future uses of whole genome sequencing A3.1.12—Difficulties applying the biological species concept to asexually reproducing species and to bacteria that have horizontal gene transfer A3.1.13—Chromosome number as a shared trait within a species A3.1.14—Engagement with local plant or animal species to develop a dichotomous key A3.1.15—Identification of species from environmental DNA in a habitat using barcodes			
		A3.2Classification and cladistics (HL only)	A3.2.1—Need for classification of organisms A3.2.2—Difficulties classifying organisms into the traditional hierarchy of taxa A3.2.3—Advantages of classification corresponding to evolutionary relationships A3.2.4—Clades as groups of organisms with common ancestry and shared characteristics A3.2.5—Gradual accumulation of sequence differences as the basis for estimates of when clades diverged from a common ancestor A3.2.6—Base sequences of genes or amino acid sequences of proteins as the basis for constructing cladograms A3.2.7—Analysing cladograms A3.2.8—Using cladistics to investigate whether the classification of groups	3		4

			corresponds to evolutionary relationships A3.2.9—Classification of all organisms into three domains using evidence from rRNA base sequences			
	B. Form and function	B3.1Gas exchange	B3.1.1—Gas exchange as a vital function in all organisms B3.1.2—Properties of gas-exchange surfaces B3.1.3—Maintenance of concentration gradients at exchange surfaces in animals B3.1.4—Adaptations of mammalian lungs for gas exchange B3.1.5—Ventilation of the lungs B3.1.6—Measurement of lung volumes B3.1.7—Adaptations for gas exchange in leaves B3.1.8—Distribution of tissues in a leaf B3.1.9—Transpiration as a consequence of gas exchange in a leaf B3.1.10—Stomatal density B3.1.11—Adaptations of foetal and adult haemoglobin for the transport of oxygen B3.1.12—Bohr shift B3.1.13—Oxygen dissociation curves as a means of representing the affinity of haemoglobin for oxygen at different oxygen concentrations	3+1	4	5
		B3.2 Transport	B3.2.1—Adaptations of capillaries for exchange of materials between blood and the internal or external environment B3.2.2—Structure of arteries and veins B3.2.3—Adaptations of arteries for the transport of blood away from the heart B3.2.4—Measurement of pulse rates B3.2.5—Adaptations of veins for the return of blood to the heart	3+2	4	7

			B3.2.6—Causes and consequences of occlusion of the coronary arteries B3.2.7—Transport of water from roots to leaves during transpiration B3.2.8—Adaptations of xylem vessels for transport of water B3.2.9—Distribution of tissues in a transverse section of the stem of a dicotyledonous plant B3.2.10—Distribution of tissues in a transverse section of the root of a dicotyledonous plant B3.2.11—Release and reuptake of tissue fluid in capillaries B3.2.12—Exchange of substances between tissue fluid and cells in tissues B3.2.13—Drainage of excess tissue fluid into lymph ducts B3.2.14—Differences between the single circulation of bony fish and the double circulation of mammals B3.2.15—Adaptations of the mammalian heart for delivering pressurized blood to the arteries B3.2.16—Stages in the cardiac cycle B3.2.17—Generation of root pressure in xylem vessels by active transport of mineral ions B3.2.18—Adaptations of phloem sieve tubes and companion cells for translocation of sap			
		B3.3Muscle and motility (HL only)	B3.3.1—Adaptations for movement as a universal feature of living organisms B3.3.2—Sliding filament model of muscle contraction B3.3.3—Role of the protein titin and antagonistic muscles in muscle relaxation B3.3.4—Structure and function of motor units in skeletal muscle	3		4

			B3.3.5—Roles of skeletons as anchorage for muscles and as levers B3.3.6—Movement at a synovial joint B3.3.7—Range of motion of a joint B3.3.8—Internal and external intercostal muscles as an example of antagonistic muscle action to facilitate internal body movements B3.3.9—Reasons for locomotion B3.3.10—Adaptations for swimming in marine mammals			
Total				**76 hours SL/ 140 hours HL**	**101 lessons**	**186 lessons**

COURSE OUTLINES – BIOLOGY – SL + HL – 2024/2025 (DP2)

Level of organisation	Theme	Topic	Content	Allocated time		
				IB hours (60 minutes)	SL – 4 lessons per week	HL – 4 lessons per week
3. Organisms	**C. Interaction and interdependence**	C3.1 Integration of body systems	C3.1.1—System integration C3.1.2—Cells, tissues, organs and body systems as a hierarchy of subsystems that are integrated in a multicellular living organism C3.1.3—Integration of organs in animal bodies by hormonal and nervous signalling and by transport of materials and energy C3.1.4—The brain as a central information integration organ C3.1.5—The spinal cord as an integrating centre for unconscious processes C3.1.6—Input to the spinal cord and cerebral hemispheres through sensory neurons C3.1.7—Output from the cerebral hemispheres to muscles through motor neurons C3.1.8—Nerves as bundles of nerve fibres of both sensory and motor neurons C3.1.9—Pain reflex arcs as an example of involuntary responses with skeletal muscle as the effector C3.1.10—Role of the cerebellum in coordinating skeletal muscle contraction and balance C3.1.11—Modulation of sleep patterns by melatonin secretion as a part of circadian rhythms	5+2	7	9

			C3.1.12—Epinephrine (adrenaline) secretion by the adrenal glands to prepare the body for vigorous activity C3.1.13—Control of the endocrine system by the hypothalamus and pituitary gland C3.1.14—Feedback control of heart rate following sensory input from baroreceptors and chemoreceptors C3.1.15—Feedback control of ventilation rate following sensory input from chemoreceptors C3.1.16—Control of peristalsis in the digestive system by the central nervous system and enteric nervous system C3.1.17—Observations of tropic responses in seedlings C3.1.18—Positive phototropism as a directional growth response to lateral light in plant shoots C3.1.19—Phytohormones as signalling chemicals controlling growth, development and response to stimuli in plants C3.1.20—Auxin efflux carriers as an example of maintaining concentration gradients of phytohormones C3.1.21—Promotion of cell growth by auxin C3.1.22—Interactions between auxin and cytokinin as a means of regulating root and shoot growth C3.1.23—Positive feedback in fruit ripening and ethylene production			

		C3.2 Defence against disease	C3.2.1—Pathogens as the cause of infectious diseases C3.2.2—Skin and mucous membranes as a primary defence C3.2.3—Sealing of cuts in skin by blood clotting C3.2.4—Differences between the innate immune system and the adaptive immune system C3.2.5—Infection control by phagocytes C3.2.6—Lymphocytes as cells in the adaptive immune system that cooperate to produce antibodies C3.2.7—Antigens as recognition molecules that trigger antibody production C3.2.8—Activation of B-lymphocytes by helper T-lymphocytes C3.2.9—Multiplication of activated B-lymphocytes to form clones of antibody-secreting plasma cells C3.2.10—Immunity as a consequence of retaining memory cells C3.2.11—Transmission of HIV in body fluids C3.2.12—Infection of lymphocytes by HIV with AIDS as a consequence C3.2.13—Antibiotics as chemicals that block processes occurring in bacteria but not in eukaryotic cells C3.2.14—Evolution of resistance to several antibiotics in strains of pathogenic bacteria C3.2.15—Zoonoses as infectious diseases that can transfer from other species to humans C3.2.16—Vaccines and immunization C3.2.17—Herd immunity and the prevention of epidemics	5	7	7

			C3.2.18—Evaluation of data related to the COVID-19 pandemic			
	D. Continuity and change	D3.1Reproduction	D3.1.1—Differences between sexual and asexual reproduction D3.1.2—Role of meiosis and fusion of gametes in the sexual life cycle D3.1.3—Differences between male and female sexes in sexual reproduction D3.1.4—Anatomy of the human male and female reproductive systems D3.1.5—Changes during the ovarian and uterine cycles and their hormonal regulation D3.1.6—Fertilization in humans D3.1.7—Use of hormones in in vitro fertilization (IVF) treatment D3.1.8—Sexual reproduction in flowering plants D3.1.9—Features of an insect-pollinated flower D3.1.10—Methods of promoting cross-pollination	5+3	7	10

			D3.1.11—Self-incompatibility mechanisms to increase genetic variation within a species D3.1.12—Dispersal and germination of seeds D3.1.13—Control of the developmental changes of puberty by gonadotropin-releasing hormone and steroid sex hormones D3.1.14—Spermatogenesis and oogenesis in humans D3.1.15—Mechanisms to prevent polyspermy D3.1.16—Development of a blastocyst and implantation in the endometrium D3.1.17—Pregnancy testing by detection of human chorionic gonadotropin secretion D3.1.18—Role of the placenta in foetal development inside the uterus D3.1.19—Hormonal control of pregnancy and childbirth D3.1.20—Hormone replacement therapy and the risk of coronary heart disease			

		D3.2Inheritance	D3.2.1—Production of haploid gametes in parents and their fusion to form a diploid zygote as the means of inheritance D3.2.2—Methods for conducting genetic crosses in flowering plants D3.2.3—Genotype as the combination of alleles inherited by an organism D3.2.4—Phenotype as the observable traits of an organism resulting from genotype and environmental factors D3.2.5—Effects of dominant and recessive alleles on phenotype D3.2.6—Phenotypic plasticity as the capacity to develop traits suited to the environment experienced by an organism, by varying patterns of gene expression D3.2.7—Phenylketonuria as an example of a human disease due to a recessive allele D3.2.8—Single-nucleotide polymorphisms and multiple alleles in gene pools D3.2.9—ABO blood groups as an example of multiple alleles D3.2.10—Incomplete dominance and codominance	5+3	7	10

			D3.2.11—Sex determination in humans and inheritance of genes on sex chromosomes D3.2.12—Haemophilia as an example of a sex-linked genetic disorder D3.2.13—Pedigree charts to deduce patterns of inheritance of genetic disorders D3.2.14—Continuous variation due to polygenic inheritance and/or environmental factors D3.2.15—Box-and-whisker plots to represent data for a continuous variable such as student height D3.2.16—Segregation and independent assortment of unlinked genes in meiosis D3.2.17—Punnett grids for predicting genotypic and phenotypic ratios in dihybrid crosses involving pairs of unlinked autosomal genes D3.2.18—Loci of human genes and their polypeptide products D3.2.19—Autosomal gene linkage D3.2.20—Recombinants in crosses involving two linked or unlinked genes D3.2.21—Use of a chi-squared test on data from dihybrid crosses			
		D3.3Homeostasis	D3.3.1—Homeostasis as maintenance of the internal environment of an organism D3.3.2—Negative feedback loops in homeostasis D3.3.3—Regulation of blood glucose as an example of the role of hormones in homeostasis D3.3.4—Physiological changes that form the basis of type 1 and type 2 diabetes D3.3.5—Thermoregulation as an example of negative feedback control	2+2	3	6

			D3.3.6—Thermoregulation mechanisms in humans D3.3.7—Role of the kidney in osmoregulation and excretion D3.3.8—Role of the glomerulus, Bowman's capsule and proximal convoluted tubule in excretion D3.3.9—Role of the loop of Henle D3.3.10—Osmoregulation by water reabsorption in the collecting ducts D3.3.11—Changes in blood supply to organs in response to changes in activity			
Practical work				8+8	10	21
4. Ecosytems	**A. Unity and Diversity**	A4.1 Evolution and speciation	A4.1.1—Evolution as change in the heritable characteristics of a population A4.1.2—Evidence for evolution from base sequences in DNA or RNA and amino acid sequences in proteins A4.1.3—Evidence for evolution from selective breeding of domesticated animals and crop plants A4.1.4—Evidence for evolution from homologous structures A4.1.5—Convergent evolution as the origin of analogous structures A4.1.6—Speciation by splitting of pre-existing species A4.1.7—Roles of reproductive isolation and differential selection in speciation A4.1.8—Differences and similarities between sympatric and allopatric speciation A4.1.9—Adaptive radiation as a source of biodiversity A4.1.10—Barriers to hybridization and sterility of interspecific hybrids as mechanisms for of preventing the mixing of alleles between species	4+1	5	7

			A4.1.11—Abrupt speciation in plants by hybridization and polyploidy			
		A4.2 Conservation of biodiversity	A4.2.1—Biodiversity as the variety of life in all its forms, levels and combinations A4.2.2—Comparisons between current number of species on Earth and past levels of biodiversity A4.2.3—Causes of anthropogenic species extinction A4.2.4—Causes of ecosystem loss A4.2.5—Evidence for a biodiversity crisis A4.2.6—Causes of the current biodiversity crisis A4.2.7—Need for several approaches to conservation of biodiversity A4.2.8—Selection of evolutionarily distinct and globally endangered species for conservation prioritization in the EDGE of Existence programme	3	4	4
	B. Form and function	B4.1 Adaptation to environment	B4.1.1—Habitat as the place in which a community, species, population or organism lives B4.1.2—Adaptations of organisms to the abiotic environment of their habitat B4.1.3—Abiotic variables affecting species distribution B4.1.4—Range of tolerance of a limiting factor B4.1.5—Conditions required for coral reef formation B4.1.6—Abiotic factors as the determinants of terrestrial biome distribution B4.1.7—Biomes as groups of ecosystems with similar communities due to similar abiotic conditions and convergent evolution	3	4	4

			B4.1.8—Adaptations to life in hot deserts and tropical rainforest			
		B4.2 Ecological niches	B4.2.1—Ecological niche as the role of a species in an ecosystem B4.2.2—Differences between organisms that are obligate anaerobes, facultative anaerobes and obligate aerobes B4.2.3—Photosynthesis as the mode of nutrition in plants, algae and several groups of photosynthetic prokaryotes B4.2.4—Holozoic nutrition in animals B4.2.5—Mixotrophic nutrition in some protists B4.2.6—Saprotrophic nutrition in some fungi and bacteria B4.2.7—Diversity of nutrition in archaea B4.2.8—Relationship between dentition and the diet of omnivorous and herbivorous representative members of the family Hominidae B4.2.9—Adaptations of herbivores for feeding on plants and of plants for resisting herbivory B4.2.10—Adaptations of predators for finding, catching and killing prey and of prey animals for resisting predation B4.2.11—Adaptations of plant form for harvesting light B4.2.12—Fundamental and realized niches B4.2.13—Competitive exclusion and the uniqueness of ecological niches	4	5	5
	C. Interaction and interdependence	C4.1 Populations and communities	C4.1.1—Populations as interacting groups of organisms of the same species living in an area C4.1.2—Estimation of population size by random sampling	5	7	7

			C4.1.3—Random quadrat sampling to estimate population size for sessile organisms C4.1.4—Capture–mark–release–recapture and the Lincoln index to estimate population size for motile organisms C4.1.5—Carrying capacity and competition for limited resources C4.1.6—Negative feedback control of population size by density-dependent factors C4.1.7—Population growth curves C4.1.8—Modelling of the sigmoid population growth curve C4.1.9—Competition versus cooperation in intraspecific relationships C4.1.10—A community as all of the interacting organisms in an ecosystem C4.1.11—Herbivory, predation, interspecific competition, mutualism, parasitism and pathogenicity as categories of interspecific relationship within communities C4.1.12—Mutualism as an interspecific relationship that benefits both species C4.1.13—Resource competition between endemic and invasive species C4.1.14—Tests for interspecific competition C4.1.15—Use of the chi-squared test for association between two species C4.1.16—Predator–prey relationships as an example of density-dependent control of animal populations C4.1.17—Top-down and bottom-up control of populations in communities C4.1.18—Allelopathy and secretion of antibiotics			

		C4.2Transfers of energy and matter	C4.2.1—Ecosystems as open systems in which both energy and matter can enter and exit C4.2.2—Sunlight as the principal source of energy that sustains most ecosystems C4.2.3—Flow of chemical energy through food chains C4.2.4—Construction of food chains and food webs to represent feeding relationships in a community C4.2.5—Supply of energy to decomposers as carbon compounds in organic matter coming from dead organisms C4.2.6—Autotrophs as organisms that use external energy sources to synthesize carbon compounds from simple inorganic substances C4.2.7—Use of light as the external energy source in photoautotrophs and oxidation reactions as the energy source in chemoautotrophs C4.2.8—Heterotrophs as organisms that use carbon compounds obtained from other organisms to synthesize the carbon compounds that they require C4.2.9—Release of energy in both autotrophs and heterotrophs by oxidation of carbon compounds in cell respiration C4.2.10—Classification of organisms into trophic levels C4.2.11—Construction of energy pyramids C4.2.12—Reductions in energy availability at each successive stage in food chains due to large energy losses between trophic levels C4.2.13—Heat loss to the environment in both autotrophs and heterotrophs due	5	7	7

			to conversion of chemical energy to heat in cell respiration C4.2.14—Restrictions on the number of trophic levels in ecosystems due to energy losses C4.2.15—Primary production as accumulation of carbon compounds in biomass by autotrophs C4.2.16—Secondary production as accumulation of carbon compounds in biomass by heterotrophs C4.2.17—Constructing carbon cycle diagrams C4.2.18—Ecosystems as carbon sinks and carbon sources C4.2.19—Release of carbon dioxide into the atmosphere during combustion of biomass, peat, coal, oil and natural gas C4.2.20—Analysis of the Keeling Curve in terms of photosynthesis, respiration and combustion C4.2.21—Dependence of aerobic respiration on atmospheric oxygen produced by photosynthesis, and of photosynthesis on atmospheric carbon dioxide produced by respiration C4.2.22—Recycling of all chemical elements required by living organisms in ecosystems			
	D. Continuity and change	D4.1Natural selection	D4.1.1—Natural selection as the mechanism driving evolutionary change D4.1.2—Roles of mutation and sexual reproduction in generating the variation on which natural selection acts D4.1.3—Overproduction of offspring and competition for resources as factors that promote natural selection D4.1.4—Abiotic factors as selection pressures	2+2	3	6

			D4.1.5—Differences between individuals in adaptation, survival and reproduction as the basis for natural selection D4.1.6—Requirement that traits are heritable for evolutionary change to occur D4.1.7—Sexual selection as a selection pressure in animal species D4.1.8—Modelling of sexual and natural selection based on experimental control of selection pressures D4.1.9—Concept of the gene pool D4.1.10—Allele frequencies of geographically isolated populations D4.1.11—Changes in allele frequency in the gene pool as a consequence of natural selection between individuals according to differences in their heritable traits D4.1.12—Differences between directional, disruptive and stabilizing selection D4.1.13—Hardy–Weinberg equation and calculations of allele or genotype frequencies D4.1.14—Hardy–Weinberg conditions that must be maintained for a population to be in genetic equilibrium D4.1.15—Artificial selection by deliberate choice of traits			
		D4.2Stability and change	D4.2.1—Stability as a property of natural ecosystems D4.2.2—Requirements for stability in ecosystems D4.2.3—Deforestation of Amazon rainforest as an example of a possible tipping point in ecosystem stability D4.2.4—Use of a model to investigate the effect of variables on ecosystem stability	4+2	5	8

			D4.2.5—Role of keystone species in the stability of ecosystems D4.2.6—Assessing sustainability of resource harvesting from natural ecosystems D4.2.7—Factors affecting the sustainability of agriculture D4.2.8—Eutrophication of aquatic and marine ecosystems due to leaching D4.2.9—Biomagnification of pollutants in natural ecosystems D4.2.10—Effects of microplastic and macroplastic pollution of the oceans D4.2.11—Restoration of natural processes in ecosystems by rewilding D4.2.12—Ecological succession and its causes D4.2.13—Changes occurring during primary succession D4.2.14—Cyclical succession in ecosystems D4.2.15—Climax communities and arrested succession			
		D4.3Climate change	D4.3.1—Anthropogenic causes of climate change D4.3.2—Positive feedback cycles in global warming D4.3.3—Change from net carbon accumulation to net loss in boreal forests as an example of a tipping point D4.3.4—Melting of landfast ice and sea ice as examples of polar habitat change D4.3.5—Changes in ocean currents altering the timing and extent of nutrient upwelling D4.3.6—Poleward and upslope range shifts of temperate species D4.3.7—Threats to coral reefs as an example of potential ecosystem collapse D4.3.8—Afforestation, forest regeneration and restoration of peat-	3+1	4	5

			forming wetlands as approaches to carbon sequestration D4.3.9—Phenology as research into the timing of biological events D4.3.10—Disruption to the synchrony of phenological events by climate change D4.3.11—Increases to the number of insect life cycles within a year due to climate change D4.3.12—Evolution as a consequence of climate change			
Scientific Investigation				10	13	13
Total				**76 hours SL/ 100 hours HL**	**98 lessons**	**129 lessons**