**IB HL Biology I – Junior Semester I**

**UNIT 1 – Cells**

**Topic 1.1: Introduction of Cells**

1. Outline the cell theory
2. Discuss the evidence for the cell theory
3. State that uni-cellular organisms carry out all the functions of life.
4. Compare the relative sizes of molecules, cell membrane thickness, viruses, bacteria, organelles and cells, using the appropriate SI unit.
5. Calculate the linear magnification of drawings and the actual size of specimens in images of known magnification
6. Explain the importance of the surface area to volume ratio as a factor limiting cell size.
7. State that multicellular organisms show emergent properties
8. Explain that cells in multicellular organisms differentiate to carry out specialized functions by expressing some of their genes but not others
9. State that stem cells retain the capacity to divide and have the ability to differentiate along different pathways.
10. Outline one therapeutic use of stem cells

**Topic 1.2: Prokaryotic and Eukaryotic Cells**

1. Draw and label a diagram of the ultrastructure of Escherichia coli (E. coli) as an example of a prokaryote
2. Annotate the diagram from 2.2.1 with the functions of each named structure.
3. Identify structures from 2.2.1 in electron micrographs of E. coli.
4. State that prokaryotic cells divide by binary fission.
5. Draw and label a diagram of the ultrastructure of a liver cell as an example of an animal cell.
6. Annotate the diagram from 2.3.1 with the functions of each named structure.
7. Identify structures from 2.3.1 in electron micrographs of liver cells.
8. Compare prokaryotic and eukaryotic cells
9. State three differences between plant and animal cells.
10. Outline two roles of extracellular components

**Topic 1.3 & 1.4: Membranes**

1. Draw and label a diagram to show the structure of membranes.
2. Explain how the hydrophobic and hydrophilic properties of phospholipids help to maintain the structure of cell membranes.
3. List the functions of membrane proteins.
4. Define diffusion and osmosis.
5. Explain passive transport across membranes by simple diffusion and facilitated diffusion.
6. Explain the role of protein pumps and ATP in active transport across membranes.
7. Explain how vesicles are used to transport materials within a cell between the rough endoplasmic reticulum, Golgi apparatus and plasma membrane
8. Describe how the fluidity of the membrane allows it to change shape, break and re-form during endocytosis and exocytosis.

**Topic 1.6 :– Cell Division**

1. Outline the stages in the cell cycle, including interphase (G1, S, G2), mitosis and cytokinesis
2. State that tumours (cancers) are the result of uncontrolled cell division and that these can occur in any organ or tissue.
3. State that interphase is an active period in the life of a cell when many metabolic reactions occur, including protein synthesis, DNA replication and an increase in the number of mitochondria and/or chloroplasts.
4. Describe the events that occur in the four phases of mitosis (prophase, metaphase, anaphase and telophase
5. Explain how mitosis produces two genetically identical nuclei.
6. State that growth, embryonic development, tissue repair and asexual reproduction involve mitosis

**Topic 10.1 : A – Meiosis**

1. Describe the behaviour of the chromosomes in the phases of meiosis.
2. Outline the formation of chiasmata in the process of crossing over.
3. Explain how meiosis results in an effectively infinite genetic variety in gametes through crossing over in prophase I and random orientation in metaphase I.

**IB HL Biology I – Junior Semester I**

**UNIT 2 - Molecular Biology**

**Topic 2.3: Carbohydrates and Lipids**

1. Distinguish between organic and inorganic compounds.
2. Identify amino acids, glucose, ribose and fatty acids from diagrams showing their structure
3. List three examples each of monosaccharides, disaccharides and polysaccharides.
4. State one function of glucose, lactose and glycogen in animals, and of fructose, sucrose and cellulose in plants.
5. Outline the role of condensation and hydrolysis in the relationships between monosaccharides, disaccharides and polysaccharides; between fatty acids, glycerol and triglycerides; and between amino acids and polypeptides.
6. Outline three functions of lipids.
7. Compare the use of carbohydrates and lipids in energy storage.

**Topic 2.4: Proteins**

1. Draw a general amino acid and describe how they are linked together.
2. Illustrate how three general amino acids are linked together by condensation.
3. Why is this known as a “polypeptide”?
4. What is the only difference between each of the 20 amino acids?
5. What is the difference between a polypeptide and a protein?
6. Why does every individual has a unique proteome? Connect this with the statement “the amino acid sequence of polypeptides is coded for by genes”.

**Topic 2.5: Enzymes**

1. Define enzyme and active site.
2. Explain enzyme–substrate specificity.
3. Explain the effects of temperature, pH and substrate concentration on enzyme activity.
4. Define denaturation.
5. Explain the use of lactase in the production of lactose-free milk.

**Topic 2.6: DNA and RNA**

1. Outline DNA nucleotide structure in terms of sugar (deoxyribose), base and phosphate
2. State the names of the four bases in DNA.
3. Outline how DNA nucleotides are linked together by covalent bonds into a single strand.
4. Explain how a DNA double helix is formed using complementary base pairing and hydrogen bonds.
5. Draw and label a simple diagram of the molecular structure of DNA.

**Topic 2.7: DNA Replication**

1. Explain DNA replication in terms of unwinding the double helix and separation of the strands by helicase, followed by formation of the new complementary strands by DNA polymerase.
2. Explain the significance of complementary base pairing in the conservation of the base sequence of DNA.
3. Outline that DNA replication is semi-conservative

**Topic 3: E – Transcription and Translation**

1. Compare the structure of RNA and DNA.
2. Outline DNA transcription in terms of the formation of an RNA strand complementary to the DNA strand by RNA polymerase.
3. Describe the genetic code in terms of codons composed of triplets of bases.
4. Explain the process of translation, leading to polypeptide formation.
5. Discuss the relationship between one gene and one polypeptide

**Topic 7.1: DNA Structure**

1. Outline the structure of nucleosomes
2. Describe that only a small proportion of the DNA in the nucleus constitutes genes and that the majority of DNA consists of repetitive sequences.
3. Describe the structure of DNA including the antiparallel strands, 3'-5' linkages and hydrogen bonding between purines and pyrimidines.

**Topic 7.2: DNA Replication**

1. Outine that DNA replication occurs in a 5’ to 3’ direction.
2. Explain the process of DNA replication in prokaryotes, including the role of enzymes (helicase, DNA polymerase, RNA primase and DNA ligase), Okazaki fragments and deoxynucleoside triphosphates.
3. State that DNA replication is initiated at many points in eukaryotic chromosomes.

**IB HL Biology I – Junior Semester I**

**UNIT 3 Genetics**

**Topic 7.2: Transcription**

* State that transcription is carried out in a 5’ to 3’ direction.
* Distinguish between the sense and antisense strands of DNA.
* Explain the process of transcription in prokaryotes, including the role of the promoter region, RNA polymerase, nucleoside triphosphates and the terminator.
* State that eukaryotic RNA needs the removal of introns to form mature mRNA.

**Topic 7.3: Translation**

* Explain that each tRNA molecule is recognized by a tRNA-activating enzyme that binds a specific amino acid to the tRNA, using ATP for energy.
* Outline the structure of ribosomes, including protein and RNA composition, large and small subunits, three tRNA binding sites and mRNA binding sites.
* State that translation consists of initiation, elongation, translocation and termination.
* State that translation occurs in a 5’ to 3’ direction.
* Draw and label a diagram showing the structure of a peptide bond between two amino acids.
* Explain the process of translation, including ribosomes, polysomes, start codons and stop codons.
* State that free ribosomes synthesize proteins for use primarily within the cell, and that bound ribosomes synthesize proteins primarily for secretion or for lysosomes.

**Topic 4 : Chromosomes, Genes, Alleles, Mutations**

* State that eukaryote chromosomes are made of DNA and proteins.
* Define gene, allele and genome
* Define gene mutation.
* Explain the consequence of a base substitution mutation in relation to the processes of transcription and translation, using the example of sickle-cell anemia.

**Topic 4 : Meiosis**

* State that meiosis is a reduction division of a diploid nucleus to form haploid nuclei.
* Define homologous chromosomes.
* Outline the process of meiosis, including pairing of homologous chromosomes and crossing over, followed by two divisions, which results in four haploid cells.
* Explain that non-disjunction can lead to changes in chromosome number, illustrated by reference to Down syndrome (trisomy 21).
* State that, in karyotyping, chromosomes are arranged in pairs according to their size and structure
* State that karyotyping is performed using cells collected by chorionic villus sampling or amniocentesis, for pre-natal diagnosis of chromosome abnormalities.
* Analyse a human karyotype to determine gender and whether non-disjunction has occurred

**Topic 4 : Theoretical Genetics**

* Define genotype, phenotype, dominant allele, recessive allele, codominant alleles, locus, homozygous, heterozygous, carrier and test cross.
* Determine the genotypes and phenotypes of the offspring of a monohybrid cross using a Punnett grid
* State that some genes have more than two alleles (multiple alleles).
* Describe ABO blood groups as an example of codominance and multiple alleles.
* Explain how the sex chromosomes control gender by referring to the inheritance of X and Y chromosomes in humans.
* State that some genes are present on the X chromosome and absent from the shorter Y chromosome in humans.
* Define sex linkage.
* Describe the inheritance of color blindness and hemophilia as examples of sex linkage.
* State that a human female can be homozygous or heterozygous with respect to sex-linked genes.
* Explain that female carriers are heterozygous for X-linked recessive alleles.
* Predict the genotypic and phenotypic ratios of offspring of monohybrid crosses involving any of the above patterns of inheritance.
* Deduce the genotypes and phenotypes of individuals in pedigree charts.

**Topic 4 : Genetic Engineering and Biotechnology**

* Outline the use of polymerase chain reaction (PCR) to copy and amplify minute quantities of DNA.
* State that, in gel electrophoresis, fragments of DNA move in an electric field and are separated according to their size.
* State that gel electrophoresis of DNA is used in DNA profiling.
* Describe the application of DNA profiling to determine paternity & also in forensic investigations
* Analyse DNA profiles to draw conclusions about paternity or forensic investigations.
* Outline three outcomes of the sequencing of the complete human genome.
* State that, when genes are transferred between species, the amino acid sequence of polypeptides translated from them is unchanged because the genetic code is universal.
* Outline a basic technique used for gene transfer involving plasmids, a host cell (bacterium, yeast or other cell), restriction enzymes (endonucleases) and DNA ligase.
* State two examples of the current uses of genetically modified crops or animals.
* Discuss the potential benefits and possible harmful effects of one example of genetic modification
* Define clone.
* Outline a technique for cloning using differentiated animal cells.
* Discuss the ethical issues of therapeutic cloning in humans.

**Topic 10 : Meiosis**

* Describe the behaviour of the chromosomes in the phases of meiosis.
* Outline the formation of chiasmata in the process of crossing over.
* Explain how meiosis results in an effectively infinite genetic variety in gametes through crossing over in prophase I and random orientation in metaphase I.
* State Mendel’s law of independent assortment
* Explain the relationship between Mendel’s law of independent assortment and meiosis.

**Topic 10 : Dihybrid crosses and Gene linkage**

* Calculate and predict the genotypic and phenotypic ratio of offspring of dihybrid crosses involving unlinked autosomal genes.
* Distinguish between autosomes and sex chromosomes.
* Explain how crossing over between non-sister chromatids of a homologous pair in prophase I can result in an exchange of alleles.
* Define linkage group.
* Explain an example of a cross between two linked genes.
* Identify which of the offspring are recombinants in a dihybrid cross involving linked genes.
* Define polygenic inheritance.
* Explain that polygenic inheritance can contribute to continuous variation using two examples, one of which must be human skin color.

**IB HL Biology I – Junior Semester II**

**UNIT 4 - Evolution**

**Topic 5: D –Evolution**

* Define evolution.
* Outline the evidence for evolution provided by the fossil record, selective breeding of domesticated animals and homologous structures.
* State that populations tend to produce more offspring than the environment can support.
* Explain that the consequence of the potential overproduction of offspring is a struggle for survival
* State that the members of a species show variation
* Explain how sexual reproduction promotes variation in a species.
* Explain how natural selection leads to evolution
* Explain two examples of evolution in response to environmental change; one must be antibiotic resistance in bacteria.

**Topic 5: E – Classification**

* Outline the binomial system of nomenclature.
* List seven levels in the hierarchy of taxa—kingdom, phylum, class, order, family, genus and species—using an example from two different kingdoms for each level.
* Distinguish between the following phyla of plants, using simple external recognition features: bryophyta, filicinophyta, coniferophyta and angiospermophyta.
* Distinguish between the following phyla of animals, using simple external recognition features: porifera, cnidaria, platyhelminthes, annelida, mollusca and arthropoda.
* Apply and design a key for a group of up to eight organisms

**Option D: A – Origin of Life**

* Describe four processes needed for the spontaneous origin of life on Earth.
* Outline the experiments of Miller and Urey into the origin of organic compounds.
* State that comets may have delivered organic compounds to Earth.
* Discuss possible locations where conditions would have allowed the synthesis of organic compounds.
* Outline two properties of RNA that would have allowed it to play a role in the origin of life.
* State that living cells may have been preceded by protobionts, with an internal chemical environment different from their surroundings.
* Outline the contribution of prokaryotes to the creation of an oxygen-rich atmosphere.
* Discuss the endosymbiotic theory for the origin of eukaryotes.

**Option D: B – Species and Speciation**

* Define allele frequency and gene pool.
* State that evolution involves a change in allele frequency in a population’s gene pool over a number of generations
* Discuss the definition of the term species.
* Describe three examples of barriers between gene pools.
* Explain how polyploidy can contribute to speciation
* Compare allopatric and sympatric speciation
* Outline the process of adaptive radiation.
* Compare convergent and divergent evolution.
* Discuss ideas on the pace of evolution, including gradualism and punctuated equilibrium.
* Describe one example of transient polymorphism.
* Describe sickle-cell anemia as an example of balanced polymorphism.

**Option D: C – Human Evolution**

* Outline the method for dating rocks and fossils using radioisotopes, with reference to 14C and 40K.
* Define half-life.
* Deduce the approximate age of materials based on a simple decay curve for a radioisotope.
* Describe the major anatomical features that define humans as primates.
* Outline the trends illustrated by the fossils of Ardipithecus ramidus, Australopithecus including A. afarensis and A. africanus, and Homo including H. habilis, H. erectus, H. neanderthalensis and H. sapiens.
* State that, at various stages in hominid evolution, several species may have coexisted.
* Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution.
* Discuss the correlation between the change in diet and increase in brain size during hominid evolution.
* Distinguish between genetic and cultural evolution.
* Discuss the relative importance of genetic and cultural evolution in the recent evolution of humans.

**Option D: D – The Hardy-Weinberg Principle**

* Explain how the Hardy–Weinberg equation is derived.
* Calculate allele, genotype and phenotype frequencies for two alleles of a gene, using the Hardy–Weinberg equation.
* State the assumptions made when the Hardy–Weinberg equation is used.

**Option D: Phylogeny and Systematics**

* Outline the value of classifying organisms
* Explain the biochemical evidence provided by the universality of DNA and protein structures for the common ancestry of living organisms.
* Explain how variations in specific molecules can indicate phylogeny.
* Discuss how biochemical variations can be used as an evolutionary clock.
* Define clade and cladistics.
* Distinguish, with examples, between analogous and homologous characteristics.
* Outline the methods used to construct cladograms and the conclusions that can be drawn from them.
* Construct a simple cladogram.
* Analyse cladograms in terms of phylogenetic relationships.
* Discuss the relationship between cladograms and the classification of living organisms.

**IB HL Biology I – Junior Semester II**

**UNIT 7 Ecology**

**Topic 5: A – Communities and Ecosystems**

* Describe what is meant by a food chain, giving three examples, each with at least three linkages (four organisms).
* Describe what is meant by a food web.
* Define trophic level.
* Deduce the trophic level of organisms in a food chain and a food web.
* Construct a food web containing up to 10 organisms, using appropriate information
* State that light is the initial energy source for almost all communities.
* Explain reasons for the shape of pyramids of energy.
* Explain that energy enters and leaves ecosystems, but nutrients must be recycled.
* State that saprotrophic bacteria and fungi (decomposers) recycle nutrients
* Define species, habitat, population, community, ecosystem and ecology
* Distinguish between autotroph and heterotroph
* Distinguish between consumers, detritivores and saprotrophs

**Topic 5: B – The Greenhouse Effect**

* Draw and label a diagram of the carbon cycle to show the processes involved.
* Analyse the changes in concentration of atmospheric carbon dioxide using historical records.
* Explain the relationship between rises in concentrations of atmospheric carbon dioxide, methane and oxides of nitrogen and the enhanced greenhouse effect
* Outline the precautionary principle
* Evaluate the precautionary principle as a justification for strong action in response to the threats posed by the enhanced greenhouse effect.
* Outline the consequences of a global temperature rise on arctic ecosystems.

**Topic 5: C – Polulations**

* Outline how population size is affected by natality, immigration, mortality and emigration.
* Draw and label a graph showing a sigmoid (S-shaped) population growth curve.
* Explain the reasons for the exponential growth phase, the plateau phase and the transitional phase between these two phases.
* List three factors that set limits to population increase