

# **IB Biology HL**

**Optional Summer Enrichment**

2022

# Instructions

Each slide contains one topic from the Standard Level (SL) curriculum for IB Biology. All of these topics are generally taught at some level in the 9th grade Biology courses. Your objective throughout this optional activity is to answer the questions on each slide as accurately and completely as possible, knowing that you might not remember details from your previous Biology class. However, you are encouraged to use resources to help you. Some suggested resources include:

- [Bozeman Science YouTube Playlist](#)
- [Alex Lee YouTube Channel](#)
- [Crash Course YouTube Playlist](#)
- [Khan Academy](#)
- [BioNinja](#)

# Topic 1.1 – Introduction to Cells

*The evolution of multicellular organisms allowed cell specialization and cell replacement*

What are the parts and functions of the light microscope?

How are structures seen under the microscope measured accurately?

What is the cell theory?

How does the surface area to volume ratio affect cell size?

What is cell differentiation? What is cell specialization?

What are stem cells?

## **Topic 1.2 – Ultrastructure of Cells**

*Eukaryotes have a much more complex cell structure than prokaryotes*

How do prokaryotic cells differ from eukaryotic?

What are electron microscopes?

What are the functions of the parts of both prokaryotic and eukaryotic cells?

## **Topic 1.3 – Membrane Structure**

*The structure of biological membranes makes them fluid and dynamic*

What are phospholipids?

What are the types of membrane proteins?

How do phospholipids and proteins help to build biological membranes?

How does cholesterol contribute to the biological membranes of animals?

What is the fluid mosaic model?

What are the differences between the Davson-Danielli and the Singer-Nicolson models of the cell membrane?

# Topic 1.4 – Membrane Transport

*Membranes control the composition of cells by active and passive transport*

What is the difference between passive and active transport?

What is simple diffusion? Facilitated diffusion? Osmosis? Endocytosis? Exocytosis?

What are sodium-potassium pumps?

What is osmolarity?

What are hypotonic and hypertonic solutions?

## **Topic 1.5 – Origin of Cells**

*There is an unbroken chain of life from the first cells on Earth to all cells in organisms alive today*

How did we learn that cells can only be formed from the division of pre-existing cells?

From where did the first cells arise?

What is the endosymbiotic theory?

What were Louis Pasteur's experiments and how did they contribute to our understanding of the current cell theory?

# Topic 1.6 – Cell Division

*Cell division is essential but must be controlled*

What is mitosis? What is mitotic index and how can it be determined?

What is the difference between chromatin and chromosomes?

What is supercoiling of chromosomes?

What is interphase?

What is cytokinesis and how does it differ between plant and animal cells?

What is the cell cycle and how is it regulated by cyclins?

What are mutagens, oncogenes, and metastasis?

How is smoking correlated to the incidence of cancer?

## **Topic 2.1 – Molecules to Metabolism**

*Living organisms control their composition by a complex web of chemical reactions*

How does carbon form covalent bonds?

What are carbohydrates? Lipids? Proteins? Nucleic acids?

What is metabolism? Anabolism? Catabolism?

What is urea and how is it naturally made? How is it artificially made?

Draw molecular diagrams of glucose, ribose, saturated fatty acid chain, and amino acid.

## **Topic 2.2 – Water**

### ***Water is the medium of life***

**Why are water molecules polar?**

**How do water molecules form hydrogen bonds?**

**What is the difference between hydrophobic and hydrophilic substances?**

**How do the thermal properties of water compare to methane?**

**How does water act as a coolant?**

**How are the following molecules transported in blood: glucose, amino acids, cholesterol, fats, oxygen, and sodium chloride?**

## Topic 2.3 – Carbohydrates & Lipids

*Compounds of carbon, hydrogen, and oxygen are used to supply and store energy*

How do condensation reactions form di- and polysaccharides from monosaccharides, and triglycerides from fatty acids and glycerol?

Compare and contrast saturated, unsaturated, polyunsaturated, and *trans* fats.

Compare and contrast *cis* and *trans* isomers of unsaturated fats.

Compare and contrast the structure and function of cellulose, starch, and glycogen.

Why are lipids more suitable for long-term energy storage compared to carbohydrates?

How is body mass index (BMI) calculated?

## **Topic 2.4 – Proteins**

***Proteins have a very wide range of functions in living organisms***

How do condensation reactions form polypeptides from amino acids? Draw a molecular diagram of this reaction occurring between 2 amino acids and the formation of the peptide bond.

How many amino acids exist?

Why is the sequence of amino acids used to build a polypeptide important?

What is the difference between a polypeptide and a protein?

What is a proteome?

What are the functions of the following proteins: rubisco, insulin, immunoglobulins, rhodopsin, collagen, and spider silk?

What is denaturation and when does it occur?

## **Topic 2.5 – Enzymes**

*Enzymes control the metabolism of the cell*

What is the significance of an enzyme's active site?

How does molecular motion of substrates lead to enzyme catalysis?

How do temperature, pH, and substrate concentration affect enzyme activity?

How are enzymes denatured?

What are immobilized enzymes and what is their significance?

How is lactose-free milk produced?

How can experiments be designed to test the effects of temperature, pH, and substrate concentration on enzyme activity?

## **Topic 2.6 – Structure of DNA & RNA**

*The structure of DNA allows efficient storage of genetic information*

What are nucleotides and how are they used to create the polymers DNA and RNA?

Compare and contrast DNA and RNA with respect to the number of strands present, the base composition, and the type of pentose sugar.

Why are the DNA strands anti-parallel?

What is complementary base pairing and how does it play a role in the structure of DNA?

What was James Watson and Francis Crick's role in discovering the structure of DNA?

Draw a diagram of DNA and RNA nucleotides using circles to represent the phosphate group, pentagons to represent the sugar, and rectangles to represent the nitrogenous bases.

## **Topic 2.7 – DNA Replication, Transcription & Translation**

***Genetic information in DNA can be accurately copied and can be translated to make the proteins needed by the cell***

Why is DNA replication semi-conservative? How did Meselson and Stahl determine the theory of semi-conservative replication?

How do the following enzymes work to replicate DNA: Helicase and DNA polymerase?

Compare and contrast transcription and translation.

How is the code of mRNA used to build polypeptides?

How is the the codon chart used to determine which amino acid is coded for by each codon?

How does the polymerase chain reaction (PCR) work?

How can we create human insulin using gene transfer techniques in bacteria?

## **Topic 2.8 – Cell Respiration**

*Cell respiration supplies energy for the functions of life*

What is cell respiration?

How is ATP used by cells?

Compare and contrast aerobic cell respiration and anaerobic cell respiration with respect to the need for oxygen and ATP yield.

How is anaerobic cell respiration used in yeast to produce ethanol and carbon dioxide?

How do humans produce lactic acid?

How can respiration rates in germinating seeds or invertebrates be measured using a respirometer?

# Topic 2.9 – Photosynthesis

*Photosynthesis uses the energy in sunlight to produce the chemical energy needed for life*

What is photosynthesis?

What is the visible light spectrum?

Which wavelengths (and corresponding colors) of light are absorbed best by chlorophyll?

What is photolysis?

How are carbohydrates and other carbon compounds produced from carbon dioxide?

How do temperature, light intensity, and carbon dioxide concentration affect rates of photosynthesis? How could an experiment be designed to test these factors?

How does photosynthesis cause changes to Earth's atmosphere, oceans, and rock deposition?

Compare and contrast the absorption spectrum for chlorophyll and the action spectrum for photosynthesis.

How are photosynthetic pigments separated by chromatography?

## **Topic 3.1 – Genes**

*Every living organism inherits a blueprint for life from its parents*

What is a gene?

What are alleles?

How are new alleles formed?

What is the genome and what was the significance of the Human Genome Project?

How does sickle cell anemia occur?

How does the number of genes in humans compare to other species?

# Topic 3.2 – Chromosomes

***Chromosomes carry genes in a linear sequence that is shared by members of a species***

Compare and contrast prokaryotic and eukaryotic DNA.

What are plasmids?

What are homologous chromosomes?

What is the difference between a diploid nucleus and a haploid nucleus?

What is a karyogram? How is it used to deduce sex and diagnose Down syndrome in humans?

How is biological sex determined using chromosomes?

What is the difference between autosomes and sex chromosomes?

What technique did Cairns use to measure the length of DNA molecules?

What is the difference in genome size of the following species: *T2 phage*, *E.coli*, *D.melanogaster*, *H.sapiens*, and *P.japonica*?

What is the difference in chromosome number of the following species: *H.sapiens*, *P.troglodytes*, *C.familiaris*, *O.sativa*, and *P.equorum*?

## Topic 3.3 – Meiosis

*Alleles segregate during meiosis allowing new combinations to be formed by the fusion of gametes*

What is meiosis?

Compare and contrast the first division of meiosis with the second division.

When and why does DNA replication occur?

What is crossing over?

Why is the orientation of homologous chromosome pairs random?

How does crossing over, random orientation, and fusion of gametes promote genetic variation of the species?

What is non-disjunction and what does it cause? How does parental age affect the chances of non-disjunction?

Compare and contrast chorionic villus sampling (CVS) and amniocentesis.

Draw diagrams of the stages of meiosis.

# Topic 3.4 – Inheritance

## *The inheritance of genes follows patterns*

Who was Gregor Mendel and what are his principles of inheritance?

Why are gametes haploid?

Define the following terms: homozygous, heterozygous, genotype, phenotype, dominant, and recessive.

How is co-dominance different from complete dominance?

How do sex-linked diseases such as color blindness and hemophilia get inherited?

How does cystic fibrosis and Huntington's disease get inherited?

How do ABO blood groups get inherited?

What are the effects of radiation and mutagenic chemicals, as seen in Hiroshima and Chernobyl?

## **Topic 3.5 – Genetic Modification & Biotechnology**

***Scientists have developed techniques for artificial manipulation of DNA, cells, and organisms***

What are the benefits of the following technologies: PCR, gel electrophoresis, DNA profiling, gene transfer, and cloning?

How and why are DNA profiles analyzed?

How are restriction enzymes and DNA ligase used in gene transfer techniques?

What are the risks and benefits of crop genetic modification? What are the risks to monarch butterflies due to Bt crops?

What are some natural methods of cloning in plants and animals?

How is somatic cell nuclear transfer (SCNT) used to produce cloned embryos?

How are adult animals cloned using differentiated cells?

How can different factors affecting the rooting of stem cuttings be investigated?

# **Topic 4.1 – Species, Communities, and Ecosystems**

*The continued survival of living organisms including humans depends on sustainable communities*

Define the following terms: species, population, community, and ecosystem.

How does reproductive isolation lead to speciation?

Compare and contrast autotrophic and heterotrophic metabolism.

What are the differences between types of consumers: herbivores, carnivores, omnivores, detritivores, and saprotrophs?

What is the importance of nutrient cycling within ecosystems?

How do sealed mesocosms demonstrate ecosystem sustainability?

How can we test for associations between two species using a chi-square test and quadrat sampling techniques? How could we then determine statistical significance of the results?

## **Topic 4.2 – Energy Flow**

***Ecosystems require a continuous supply of energy to fuel life processes and to replace energy lost as heat***

What is the initial source of energy for most ecosystems?

How is light energy converted into chemical energy? How does this chemical energy flow through food chains? How is this chemical energy released and used by organisms?

Can living organisms convert heat energy into other forms of energy?

Can heat energy be lost?

Why is the length of food chains and the biomass of higher trophic levels restricted?

How do pyramids of energy quantitatively represent energy flow?

# Topic 4.3 – Carbon Cycling

*Continued availability of carbon in ecosystems depends on carbon cycling*

What is the role of carbon dioxide in the carbon cycle?

How is carbon represented in aquatic ecosystems?

How does the process of diffusion aid the movement of carbon within ecosystems?

What is methane and how is it produced? What is it converted to in the atmosphere?

How does peat form and what is its role in the carbon cycle?

How do fossil fuels form and what do they release when combustion occurs?

What role do corals and mollusks play in the carbon cycle with respect to their incorporation of calcium carbonate?

How are carbon fluxes estimated? How is data from air monitoring stations used to explain annual fluctuations?

Draw a diagram of the carbon cycle.

# Topic 4.4 – Climate Change

## *Concentrations of gases in the atmosphere affect climates experienced at the Earth's surface*

What are the two most significant greenhouse gases and why?

Why do methane and nitrogen oxides have less impact?

What determines the impact a greenhouse gas has on climate change?

Explain why global temperatures and climate patterns are influenced by concentrations of greenhouse gases.

Explain why there is a correlation between rising atmospheric concentrations of carbon dioxide from 200 years ago and average global temperatures.

Explain why the recent increases in atmospheric carbon dioxide are largely attributed to the increases in the combustion of fossil fuels.

What are some of the claims people give that indicate that human activities are not responsible for climate change?

How are the levels of dissolved carbon dioxide threatening coral reefs?

# Topic 5.1 – Evidence for Evolution

*There is overwhelming evidence for the evolution of life on Earth*

What is evolution?

How does the fossil record provide evidence for evolution?

How does the selective breeding of animals show that artificial selection can cause evolution?

How does the evolution of homologous structures by adaptive radiation explain similarities in structure when there are differences in function?

Compare and contrast the pentadactyl limb of mammals, birds, amphibians, and reptiles with different methods of locomotion.

How can populations of a species gradually diverge into separate species due to evolution?

How does continuous variation across the geographic range of related populations match the concept of gradual divergence?

How does the Peppered Moth demonstrate evolution?

# **Topic 5.2 – Natural Selection**

*The diversity of life has evolved and continues to evolve by natural selection*

What is natural selection?

Why is variation a key factor in natural selection? What processes increase variation?

What are adaptations?

Why do species tend to produce more offspring than the environment can support?

Why do individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring?

How do the changes in the beaks of finches on Daphne Major of the Galapagos Islands demonstrate evolution by natural selection?

How does the evolution of antibiotic resistance in bacteria explain natural selection?

# Topic 5.3 – Classification of Biodiversity

*Species are named and classified using an internationally agreed system*

Why is the binomial system of names for species used? What are the rules of the binomial system?

What are the 3 domains of life?

What is the hierarchy of taxa?

Compare and contrast natural and artificial classification.

Why would taxonomists reclassify groups of species?

What are the features of the following plant divisions: bryophyta, filicinophyta, coniferophyta, and angiospermophyta?

What are the features of the following animal phyla: porifera, cnidaria, platyhelmintha, annelida, mollusca, arthropoda, and chordata?

What are the features of the following animal classes: birds, mammals, amphibians, reptiles, and fish?

How are dichotomous keys constructed and used in identifying specimens?

## **Topic 5.4 – Cladistics**

*The ancestry of groups of species can be deduced by comparing their base or amino acid sequences*

What is a cladogram? What is a clade?

How is the evidence for which species are part of a clade obtained?

Why is there a positive correlation between the number of differences between two species and the time since they diverged from a common ancestor?

What are analogous traits? What are homologous traits?

How does evidence from cladistics show that classification of some groups based on structure did not correspond with the evolutionary origins of a group or species?

How and why was the reclassification of the figwort family completed?

How can cladograms be analyzed to determine evolutionary relationships?