

## GRADE 12 ADVANCED BIOLOGY LEVEL 2 - IB BIOLOGY YEAR 2 FRAMEWORK

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### NATURE OF SCIENCE, SCIENTIFIC METHODOLOGY AND ENQUIRY

Throughout grade 12 Biology students are expected to:

- Develop a testable hypothesis, design and conduct an investigation identifying ethical and safety implications of the research.
- Identify variables, organize and present quantitative and qualitative results, looking for trends and discrepancies.
- Apply error measurements and calculation as well as basic statistical analysis and mathematical correlations.
- Discuss data from multiple perspectives, critically concluding and evaluating the results and future applications of experimental results.
- Explore the use of technology in order to reduce uncertainty and infer about validity of data.

## **THEMES AND CONTENT**

### **Evolution and Biodiversity**

- Evidence for evolution
- Natural selection
- Classification of biodiversity
- Cladistics

### **Human Physiology**

- Digestion and absorption
- The blood system
- Defense against infectious disease
- Gas exchange
- Neurons and synapses
- Hormones, homeostasis and reproduction

Additional higher level (HL) and Advanced Study Bio Students also cover:

### **Nucleic acids**

- DNA structure and replication
- Transcription and gene expression
- Translation

### **Metabolism, cell respiration and photosynthesis**

- Metabolism
- Cell respiration
- Photosynthesis

**Plant biology**

- Transport in the xylem of plants
- Transport in the phloem of plants
- Growth in plants
- Reproduction in plants

**Genetics and evolution**

- Meiosis
- Inheritance
- Gene pools and speciation

**Animal physiology**

- Antibody production and vaccination
- Movement
- The kidney and osmoregulation
- Sexual reproduction

Students pursuing the IB Diploma will additionally choose between one of four study options while in the second semester of the second year of the program, in order to further study and better support section B of the Paper 3 on the final exam. The options will be:

- Neurobiology and Behavior
- Biotechnology and Bioinformatics
- Ecology and Conservation
- Human Physiology

## **OTHER SKILLS AND EXPECTATIONS**

### **MATHEMATICAL SKILLS**

- Perform the basic arithmetic functions: addition, subtraction, multiplication and division.
- Carry out calculations involving means, decimals, fractions, percentages and ratios.
- Represent and interpret frequency data in the form of bar charts, graphs and histograms, including direct and inverse proportion.
- Plot graphs (with suitable scales and axes) involving two variables that show linear or non-linear relationships.
- Plot and interpret scattergraphs to identify a correlation between two variables and appreciate that the existence of a correlation does not establish a causal relationship.
- Determine the mode and median of a set of data, calculate and analyze standard deviation.
- Select statistical tests appropriate for the analysis of particular data and interpret the results.

### **SCIENCE NOTEBOOK**

- Notebooks are an independent responsibility of the student.
- Students are expected to keep an organized notebook with notes from class, work done at home and data collected during labs.

### **SCIENTIFIC WRITING**

- Students will write Laboratory Reports about experiments conducted in class, related to the subject content, which will include (but not limited to) the following requirements:
  - Conduct independent background research to sustain their findings.
  - Include in-text citations for research.
  - Use reliable sources, correctly cited in MLA format or APA style.
  - Provide a bibliography.
  - Submit personal investigation/Internal Assessment via Turnitin.

(Additional information about research parameters is available on the CAISL website).

## **INFORMATION TECHNOLOGY**

- Students are expected to use digital measurement tools (probes) in order to collect data and make appropriate use of data collection and analysis software (Logger Pro).
- Students are expected to master the use of Excel to manipulate and interpret collected data.

## **SCIENCE LABORATORY SAFETY EXPECTATIONS**

- Students will be expected to continue to follow the expectations for safe and appropriate practices during laboratory activity, as learned in 11<sup>th</sup> grade and shown on the “Science Laboratory Safety” document.

## **ASSESSMENT**

For students to receive a credit towards their High School Diploma and successfully conclude Y2 of the IB program, they must demonstrate proficiency on:

- Summative Tests
- Formative worksheets
- Lab Reporting
- Data based questions
- Virtual (on-line/Digital) lab work
- Personal Investigation – Following their end of Y1/11<sup>th</sup> grade plan, students will develop their proposed topic of research, research question and procedure by organizing individual hands-on scientific experiments, from which processed data will be analyzed and a discussion, conclusion and evaluation generated.
- Final exam

**Students who are pursuing the IB Diploma in addition to the High School Diploma must complete both years of the program. During the second year they must also demonstrate proficiency on:**

- Internal Assessment - Following their end of Y1/11<sup>th</sup> grade plan, students will develop their proposed topic of research, research question and procedure by organizing individual hands-on scientific experiments, from which processed data will be analyzed and a discussion, conclusion and evaluation generated, to produce a report to be sent to the external evaluation. The work demands for a minimum commitment of 10 hours of work.
- Final exam comprised of three independent papers (P1 – Multiple choice questions; P2- Data Analysis- Part A, and student-chosen questions – Part B; P3- Curricular experiments and data analysis - Part A and “Option” – Part B). The weight of each one of the above on the final grade is distributed in the following way:

20% Final IA submitted to external evaluation

20% P1 (45min SL exam /1h HL exam)

40% P2 (1h 15min SL exam / 2h 15min HL exam)

20% P3 (1h SL exam / 1h 15min HL exam)

## **PERFORMANCE INDICATORS**

### **Evolution and Biodiversity**

Analyze the overwhelming evidence for the evolution of life on Earth and look for patterns, trends and discrepancies.

Understand that evolution occurs when heritable characteristics of a species change and the fossil record provides evidence for that change.

Understand homologous structures, adaptive radiation and the way populations of a species can gradually diverge into separate species by evolution.

Recognize that the diversity of life has evolved and continues to evolve by natural selection, in which the theory of evolution is supported, and can explain the development of antibiotic resistance in bacteria.

Realize that natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species, showing examples.

Use and understand the purpose of scientific nomenclature and the binomial system to identify a species rather than the many different local names.

Classify species using a hierarchy of taxa.

Recognize features of bryophyta, filicinophyta, coniferophyta and angiospermophyta as well as porifera, cnidaria, platylhelmintha, annelida, mollusca, arthropoda and chordata.

Construct a dichotomous key for use in identifying specimens.

Understand that the ancestry of groups of species can be deduced by comparing their base or amino acid sequences.

Analyze evidences that classify species as part of a clade obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein.

Analyze cladograms to deduce evolutionary relationships.

### Human Physiology and the Blood System

Understand that the structure of the wall of the small intestine allows it to move, digest and absorb food

Understand the relation between the digestive system different organs and their function.

Recognize that enzymes digest most macromolecules in food into monomers in the small intestine.

Develop the use of dialysis tubing to model absorption of digested food in the intestine.

Produce an annotated diagram of the digestive system and identify tissue layers in transverse sections of the small intestine viewed with a microscope or in a micrograph.

Recognize that the blood system continuously transports substances to cells and simultaneously collects waste products.

Identify the function and structure of arteries, veins and capillaries as well as the way elastic fibers assist in maintaining blood pressure between pump cycles.

Explain how the sinoatrial node acts as a pacemaker and sends out an electrical signal that stimulates contraction as it is propagated through the walls of the atria and then the walls of the ventricles.

Discuss how the heart rate can be increased or decreased by impulses brought to the heart through nerves from the medulla / brain understanding that epinephrine increases the heart rate to prepare for vigorous physical activity.

Understand William Harvey's discovery of the circulation of the blood with the heart acting as the pump and the cardiac cycle.

### Human Physiology and Defense against infectious disease

Recognize on the human body structures and processes that resist the continuous threat of invasion by pathogens and understand their action.

Understand that some risks associated with scientific research (e.g. Florey and Chain's tests on the safety of penicillin) would not be compliant with current protocol on testing.

Identify the cascade process as a result of the rapid conversion of fibrinogen to fibrin by thrombin.

Comprehend specific and non-specific immunity to diseases as well as the fact that the production of antibodies by lymphocytes in response to particular pathogens gives specific immunity.

Understand the function of antibiotics, alternatives and that viruses lack a metabolism and cannot therefore be treated with antibiotics.

Recognize that some bacteria have evolved with genes that confer resistance to antibiotics and some strains of bacteria have multiple resistance.

Discuss the effects of HIV on the immune system and methods of transmission.

### Human Physiology and Gas Exchange

Discuss how the lungs are actively ventilated to ensure that gas exchange can occur passively.

Understand that ventilation maintains concentration gradients of oxygen and carbon dioxide between air in alveoli and blood flowing in adjacent capillaries.

Draw and label the respiratory.

Discuss causes and consequences of lung cancer and emphysema.

Reference external and internal intercostal muscles and diaphragm and abdominal muscles as examples of antagonistic muscle action.

Monitor ventilation in humans at rest and after mild and vigorous exercise.

Draw a diagram to show the structure of an alveolus and an adjacent capillary.

### Human Physiology and the Nervous System, Hormones, Homeostasis and Reproduction

Recognize that as neurons transmit the message in the form of electrical impulses, synapses modulate the message.

Understand saltatory conduction, the importance of sodium and potassium movement of ions across the neuronal membranes to generate a resting potential and depolarization and repolarization of the neuron.

Discuss the importance of synapses as junctions between neurons and between neurons and receptor or effector cells.

Discuss the secretion and reabsorption of acetylcholine by neurons at synapses.

Analyze oscilloscope traces showing resting potentials and action potentials.

Consider how hormones are used when signals need to be widely distributed.

Recognize that Insulin and glucagon are secreted by  $\beta$  and  $\alpha$  cells of the pancreas respectively to control blood glucose concentration, Thyroxine is secreted by the thyroid gland to regulate the metabolic rate and help control body temperature, Leptin is secreted by cells in adipose tissue and acts on the hypothalamus of the brain to inhibit appetite and Melatonin is secreted by the pineal gland to control circadian rhythms.

Identify the SRY gene on the Y chromosome and its influence on embryonic gonads to develop as testes and secrete testosterone, which will then influence the development of male genitalia and both sperm production and male secondary sexual characteristics during puberty.

Recognize Estrogen and progesterone as cause of pre-natal development of female reproductive organs and female secondary sexual characteristics during puberty.

Analyze how the menstrual cycle is controlled by negative and positive feedback mechanisms involving ovarian and pituitary hormones.



Discuss causes and treatment of Type I and Type II diabetes.

Understand the use in IVF of drugs to suspend the normal secretion of hormones, followed by the use of artificial doses of hormones to induce superovulation and establish a pregnancy.

Annotate diagrams of the male and female reproductive system to show names of structures and their functions.

Analyze how William Harvey failed to solve the mystery of sexual reproduction because effective microscopes were not available when he was working, so fusion of gametes and subsequent embryo development remained undiscovered.

*For students wishing to pursue Advance Study in Biology or IB Biology HL, the following topics will be studies in addition.*

### *Nucleic acids*

Recognize that nucleosomes help to supercoil the DNA and that it's structure suggests a mechanism for DNA replication.

Associate DNA polymerases with the addition of nucleotides to the 3' end of a primer and understand that DNA replication is continuous on the leading strand and discontinuous on the lagging strand as well as the influence of a complex system of enzymes on the process.

Discuss how some regions of DNA do not code for proteins but have other important functions.

Understand the implications of Rosalind Franklin's and Maurice Wilkins' investigation of DNA structure by X-ray diffraction.

Analyze results of the Hershey and Chase experiment providing evidence that DNA is the genetic material and use a molecular visualization software to analyze the association between protein and DNA within a nucleosome.

Understand that transcription occurs in a 5' to 3' direction, nucleosomes help to regulate transcription in eukaryotes and eukaryotic cells modify mRNA after transcription.

Highlight the importance of splicing of mRNA as it increases the number of different proteins an organism can produce, that gene expression is regulated by proteins that bind to specific base sequences in DNA and that the environment of a cell and of an organism has an impact on gene expression.

Understand the promoter as an example of non-coding DNA with a function and analyze changes in the DNA methylation patterns.

Recognize that the synthesis of the polypeptide involves a repeated cycle of events, that free ribosomes synthesize proteins for use primarily within the cell and bound ribosomes synthesize proteins primarily for secretion or for use in lysosomes.

Know that translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane and Initiation of translation involves assembly of the components that carry out the process.

Identify the repeated cycle of events the synthesis of a polypeptide involves and recognize that the disassembly of the components follows termination of translation.

Know that free ribosomes synthesize proteins for use primarily within the cell but bound ribosomes synthesize proteins primarily for secretion or for use in lysosomes.

Recognize that the sequence and number of amino acids in the polypeptide is the primary structure, that in the secondary structure the formation of alpha helices and beta pleated sheets are stabilized by hydrogen bonding, the tertiary structure is the further folding of the polypeptide stabilized by interactions between R groups and the quaternary structure exists in proteins with more than one polypeptide chain.

Understand that tRNA-activating enzymes illustrate enzyme–substrate specificity, the role of phosphorylation and that translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane.

Identify polysomes in electron micrographs of prokaryotes and eukaryotes.

Name some of the tRNA binding sites as well as their roles, recognize that polar and non-polar amino acids are relevant to the bonds formed between R groups and that quaternary structure may involve the binding of a prosthetic group to form a conjugated protein.

#### Metabolism, cell respiration and photosynthesis HL

Recognize that metabolic pathways consist of chains and cycles of enzyme-catalyzed reactions and that enzymes lower the activation energy of the chemical reactions that they catalyze.

Recall that enzyme inhibitors can be competitive or non-competitive and metabolic pathways can be controlled by end-product inhibition.

Use databases to identify potential new anti-malarial drugs.

Calculate and plot rates of reaction from raw experimental results.

Distinguishing different types of inhibition from graphs at specified substrate concentration Cell respiration involves the oxidation and reduction of electron carriers.

Understand that the Phosphorylation of molecules makes them less stable.

Recognize that In glycolysis, glucose is converted to pyruvate in the cytoplasm and that it gives a small net gain of ATP without the use of oxygen.

Recognize that in aerobic cell respiration pyruvate is decarboxylated, oxidized and converted into acetyl compound and attached to coenzyme A to form acetyl coenzyme A in the link reaction. In the Krebs cycle, the oxidation of acetyl groups is coupled to the reduction of hydrogen carriers, liberating carbon dioxide.

Annotate a diagram of a mitochondrion to indicate the adaptations to its function.

Understand how in chemiosmosis protons diffuse through ATP synthase to generate ATP and that oxygen is needed to bind with the free protons to maintain the hydrogen gradient, resulting in the formation of water.

Explain how the structure of the mitochondrion is adapted to the function it performs.

Elucidate how light-dependent reactions take place in the thylakoid membranes and the space inside them and light-independent reactions take place in the stroma.

Understand that reduced NADP and ATP are produced in the light-dependent reactions and the absorption of light by photosystems generates excited electrons.

Recognize that photolysis of water generates electrons for use in the light-dependent reactions and that the transfer of excited electrons occurs between carriers in thylakoid membranes.

Comprehend that excited electrons from Photosystem II are used to contribute to generate a proton gradient, ATP synthase in thylakoids generates ATP using the proton gradient and that excited electrons from Photosystem I are used to reduce NADP.

Know that in the light-independent reactions a carboxylase catalyzes the carboxylation of ribulose biphosphate.

Explain how the structure of the chloroplast is adapted to its function in photosynthesis.

Analyze diagrams of the pathways of aerobic respiration to deduce where decarboxylation and oxidation reactions occur.

Recognize that energy released by oxidation reactions is carried to the cristae of the mitochondria by reduced NAD and FAD and that the transfer of electrons between carriers in the electron transport chain in the membrane of the cristae is coupled to proton pumping.

Know that glycerate 3-phosphate is reduced to triose phosphate using reduced NADP and ATP as well as that triose phosphate is used to regenerate RuBP and produce carbohydrates.

Recognize that ribulose biphosphate is reformed using ATP.

Understand Calvin's experiment to elucidate the carboxylation of RuBP.

Annotate a diagram to indicate the adaptations of a chloroplast to its function.

### Plant biology

Recognize that transpiration is the inevitable consequence of gas exchange in the leaf and that plants transport water from the roots to the leaves to replace losses from transpiration.

Understand the cohesive property of water and how the structure of the xylem vessels allow transport under tension as well as how the adhesive property of water and evaporation generate tension forces in leaf cell walls.

Explain how active uptake of mineral ions in the roots causes absorption of water by osmosis.

Draw the structure of primary xylem vessels in sections of stems based on microscope images.

Measure transpiration rates using potometers and design an experiment to test hypotheses about the effect of temperature or humidity on transpiration rates.

Identify how plants transport organic compounds from sources to sinks.

Recognize that the incompressibility of water allows transport along hydrostatic pressure gradients and that active transport is used to load organic compounds into phloem sieve tubes at the source where high concentrations of solutes in the phloem lead to water uptake by osmosis.

Understand that raised hydrostatic pressure causes the contents of the phloem to flow towards sinks.

Recognize that undifferentiated cells in the meristems of plants allow indeterminate growth and that mitosis and cell division in the shoot apex provide cells needed for extension of the stem and development of leaves.

Know that plant hormones control growth in the shoot apex and that plant shoots respond to the environment by tropisms.

Highlight the importance of auxin as a powerful plant hormone.

Know that flowering involves a change in gene expression in the shoot apex and that the switch to flowering is a response to the length of light and dark periods in many plants.

Accept that success in plant reproduction depends on pollination, fertilization and seed dispersal.

Agree that most flowering plants use mutualistic relationships with pollinators in sexual reproduction.

Understand adaptations of plants in deserts and in saline soils for water conservation.

Develop models of water transport in xylem using simple apparatus including blotting or filter paper, porous pots and capillary tubing.

Identify structure–function relationships of phloem sieve tubes and xylem and phloem in microscope images of stem and root.

Analyze data from experiments measuring phloem transport rates using aphid stylets and radioactively labelled carbon dioxide.

Explain how auxin efflux pumps can set up concentration gradients of auxin in plant tissue and the hormone influences cell growth rates by changing the pattern of gene expression.

Produce micropropagation of plants using tissue from the shoot apex, nutrient agar gels and growth hormones.

Recognize the present rapid bulking up of new varieties, production of virus-free strains of existing varieties and propagation of orchids and other rare species.

Study methods used to induce short-day plants to flower out of season.

Draw the internal structure of seeds and half-views of animal-pollinated flowers.

Design experiments to test hypotheses about factors affecting germination.

### Genetics and evolution HL

Understand that chromosomes replicate in interphase before meiosis, that crossing over is the exchange of DNA material between non-sister homologous chromatids and that it produces new combinations of alleles on the chromosomes of the haploid cells.

Recognize that chiasmata formation between non-sister chromatids can result in an exchange of alleles, that homologous chromosomes separate in meiosis I, sister chromatids separate in meiosis II and that the independent assortment of genes is due to the random orientation of pairs of homologous chromosomes in meiosis I.

Draw diagrams to show chiasmata formed by crossing over.

Know that gene loci are said to be linked if on the same chromosome, unlinked genes segregate independently because of meiosis and that variation can be discrete or continuous.

Understand that the phenotypes of polygenic characteristics tend to show continuous variation.

Recognize that a gene pool consists of all the genes and their different alleles, present in an interbreeding population and that evolution requires that allele frequencies change with time in populations.

Know that reproductive isolation of populations can be temporal, behavioral or geographic, that speciation due to divergence of isolated populations can be gradual but it can also occur abruptly.

Identify examples of directional, stabilizing and disruptive selection.

Analyze speciation in the genus *Allium* by polyploidy and compare allele frequencies of geographically isolated populations

Use chi-squared tests to determine whether the difference between an observed and expected frequency distribution is statistically significant.

Recognize Morgan's discovery of non-Mendelian ratios in *Drosophila*.

Produce and analyze Punnett squares for dihybrid traits.

Recognize that polygenic traits such as human height may also be influenced by environmental factors.

Calculate the predicted genotypic and phenotypic ratio of offspring of dihybrid crosses involving unlinked autosomal genes.

Identify recombinants in crosses involving two linked genes and use a chi-squared test on data from dihybrid crosses

### Animal physiology

Recognize that every organism has unique molecules on the surface of its cells and that pathogens can be species-specific although others can cross species barriers.

Understand that B lymphocytes are activated by T lymphocytes in mammals and that activated B cells multiply to form clones of plasma cells (which secrete antibodies) and memory cells.

Accept that antibodies aid the destruction of pathogens

Know that white cells release histamine in response to allergens and histamines cause allergic symptoms.

Recognize that Immunity depends upon the persistence of memory cells.

Comprehend that vaccines contain antigens that trigger immunity but do not cause the disease.

Recognize that the fusion of a tumor cell with an antibody-producing plasma cell creates a hybridoma cell.

Know that smallpox was the first infectious disease of humans to have been eradicated by vaccination.

Recognize that bones and exoskeletons provide anchorage for muscles and act as levers and that synovial joints allow certain movements but not others.

Know that the movement of the body requires muscles to work in antagonistic pairs.

Understand that skeletal muscle fibers are multinucleate and contain specialized endoplasmic Reticulum, that muscle fibers contain many myofibrils and that each myofibril is made up of contractile sarcomeres. The contraction of the skeletal muscle is achieved by the sliding of actin and myosin filaments.

Be aware that ATP hydrolysis and cross bridge formation are necessary for the filaments to slide and calcium ions and the proteins tropomyosin and troponin control muscle contractions.

Know that animals are either osmoregulators or osmoconformers and that Malpighian tubule system in insects and the kidney carry out osmoregulation and removal of nitrogenous wastes.

Recognize that the composition of blood in the renal artery is different from that in the renal vein, that the ultrastructure of the glomerulus and Bowman's capsule facilitate ultrafiltration, the proximal convoluted tubule selectively reabsorbs useful substances by active transport and the loop of Henle maintains hypertonic conditions in the medulla.

Identify how ADH controls reabsorption of water in the collecting duct and know that the length of the loop of Henle is positively correlated with the need for water conservation in animals.

Understand how the type of nitrogenous waste in animals is correlated with evolutionary history and habitat.

Explain some consequences of dehydration and overhydration and the need for treatment of kidney failure by hemodialysis or kidney transplant.

Draw and label a diagram of the human kidney and annotate diagrams of the nephron Spermatogenesis and oogenesis both involve mitosis, cell growth, two divisions of meiosis and differentiation.

Understand how processes in spermatogenesis and oogenesis result in different numbers of gametes with different amounts of cytoplasm.

Recognize that fertilization in animals can be internal or external and it involves mechanisms that prevent polyspermy.

Comprehend that the implantation of the blastocyst in the endometrium is essential for the continuation of pregnancy and HCG stimulates the ovary to secrete progesterone during early pregnancy.

Explain how the placenta facilitates the exchange of materials between the mother and fetus and that estrogen and progesterone are secreted by the placenta once it has formed.

Know that birth is mediated by positive feedback involving estrogen and oxytocin.

Recognize how the average 38-week pregnancy in humans can be positioned on a graph showing the correlation between animal size and the development of the young at birth for other mammals.

Understand that monoclonal antibodies are produced by hybridoma cells.

Know that monoclonal antibodies to HCG are used in pregnancy test kits.

Recognize that antigens on the surface of red blood cells stimulate antibody production in a person with a different blood group.

Analyze epidemiological data related to vaccination programs.

Identify antagonistic pairs of muscles in an insect leg.

Annotate a diagram of the human elbow.

Draw labelled diagrams of the structure of a sarcomere.

Analyze electron micrographs to find the state of contraction of muscle fibers.

Understand how blood cells, glucose, proteins and drugs are detected in urinary tests.

Annotate diagrams of seminiferous tubule and ovary to show the stages of gametogenesis and diagrams of mature sperm and egg to indicate functions.

Students pursuing the IB Diploma will further choose one of the following four study options while in the second semester of the second year of the program, in order to further study and better support section B of the Paper 3 on the final exam. The options will be:

- Neurobiology and Behavior
- Biotechnology and Bioinformatics
- Ecology and Conservation
- Human Physiology