IB SL Biology Y1 Unit 3: Metabolism

Teacher(s)	IB Biology Y1 - Trotter PLC Logue/Trotter	**Subject group and course**	Group 4/IB Biology Y1 SL MHS Y1 SGO		
Course part and topic	Unit 3: Metabolism SL **C1.1**.1-1.1.10, **C1.2**.1-1.2.6, **C1.3**.1-1.3.8, **D1.1**.1-1.1.5, **D1.2**.1-1.1.11	**SL or HL/Year 1 or 2**	SL Y1	**Dates**	8 weeks

Unit description and texts	**DP assessment(s) for unit**
Molecular biology explains living processes in terms of chemical reactions and substances involved. Enzymes help control metabolism by speeding up chemical reactions by lowering the activation energy of reactions. Photosynthesis and Cellular Respiration are processes by which organisms create energy by converting one form of energy to another or by the breakdown of materials. Protein synthesis provides the materials needed to build organisms Sickle Cell Theme throughout the course New IB Biology Guide First Assessment 2025	● Unit Formative and Summative assessment(s) ● *Will test on separate processes not on one Unit Assessment ● Applications of Skills: ● Practicum: Investigation of a factor affecting enzyme activity – interpret graphs (C1.1) ● Determine reaction rates through experimentation and secondary data for enzyme catalyzed reactions. (C1.1) ● Interpret graphs showing the energy required to make and break bonds with substrates (C1.1) ● Measure the rate of cellular respiration – what affects cellular respiration rate? (C1.2) ● Thin layer or paper Chromatography- pigmentation of spinach leaves – calculate Rf values – identify pigments by color and value (C1.3) ● Determine the rate of photosynthesis from data for oxygen production and carbon dioxide consumption for varying wavelengths – plot data to make an action spectrum (C1.3) ● Rates of Photosynthesis Lab – limiting factors (C1.3)

Topic Abbreviations:

Themes: A = Unity & Diversity, B = Form & Function, C = Interaction & Interdependence, D = Continuity & Change

Level of Organization: 1 = Molecules, 2 = Cells, 3 = Organisms, 4 = Ecosystems

INQUIRY: Establishing the purpose of the unit

Statement of Inquiry:
Research is continuously being conducted to find novel applications for enzymes that will promote human health and wellness.

Phenomenon:
The beta globin protein is one of the subunits of hemoglobin, a protein necessary for the oxygen-carrying function of red blood cells. People with the sickle cell mutation in both copies of the HBB gene produce proteins that clump together and lead to changes in the shape and behavior of red blood cells.

Crosscutting Concepts
- Stability and Change
- Systems & System Models
- Cause and Effect
- Patterns

SEP:
- Carrying out Investigations
- Developing & Using Models
- Constructing Explanations
- Engage in Argument from Evidence

CORE IDEAS
- Enzymes
- Cellular Energy: Respiration/Fermentation/Photosynthesis
- DNA Replication
- Protein Synthesis

ACTION: teaching and learning through inquiry

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Content/skills/concepts—essential understandings

Themes: A = Unity & Diversity, B = Form & Function, C = Interaction & Interdependence, D = Continuity & Change

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GQ - Guiding Questions

NOS - Nature of Science

AOS - Application of Skills

LQ - Linking Question

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Learning process

Check the boxes for any pedagogical approaches used during the unit. Aim for a variety of approaches to help facilitate learning.

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C1.1, C1.2, C1.3, D1.1, D1.2

Students will know the following content/Students will grasp the following concepts:

C1.1 Enzymes and Metabolism (Interactions and Interdependence - Molecules)

GQ -

- **What are the relative advantages of specificity and versatility?**
- **For each form of nutrition, what are the unique inputs, processes, and outputs?**

Guidance:
C1.1.1—Enzymes as catalysts
Students should understand the benefit of increasing rates of reaction in cells.

C1.1.2—Role of enzymes in metabolism
Students should understand that metabolism is the complex network of interdependent and interacting chemical reactions occurring in living organisms. Because of enzyme specificity, many different enzymes are required by living organisms, and control over metabolism can be exerted through these enzymes.

C1.1.3—Anabolic and catabolic reactions
Examples of anabolism should include the formation of macromolecules from monomers by condensation reactions including protein synthesis, glycogen formation and photosynthesis. Examples of catabolism should include hydrolysis of macromolecules into monomers in digestion and oxidation of substrates in respiration.

C1.1.4—Enzymes as globular proteins with an active site for catalysis
Include that the active site is composed of a few amino acids only, but interactions between amino acids

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Learning experiences and strategies/planning for self-supporting learning:

Lecture
Socratic Seminar
Small Group/Pair Work
PowerPoint Lecture Notes
Individual Presentations
Group Presentations
Student Lecture/Leading the class
Interdisciplinary Learning
-

Details: Modeling, Think/Pair/Share, CER, Writing Prompts, Videos, etc.

Accommodations:

- *SWD/504 – Accommodations Provided*
- *ELL – Reading & Vocabulary Support*
- *Intervention Support*
- *Extensions – Enrichment Tasks and Project*

Guidance:

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within the overall three-dimensional structure of the enzyme ensure that the active site has the necessary properties for catalysis. **C1.1.5—Interactions between substrate and active site to allow induced-fit binding** Students should recognize that both substrate and enzymes change shape when binding occurs. **C1.1.6—Role of molecular motion and substrate-active site collisions in enzyme catalysis** Movement is needed for a substrate molecule and an active site to come together. Sometimes large substrate molecules are immobilized while sometimes enzymes can be immobilized by being embedded in membranes. **C1.1.7—Relationships between the structure of the active site, enzyme–substrate specificity and denaturation** Students should be able to explain these relationships. **C1.1.8—Effects of temperature, pH and substrate concentration on the rate of enzyme activity** The effects should be explained with reference to collision theory and denaturation. **AOS: Students should be able to interpret graphs showing the effects.** **NOS: Students should be able to describe the relationship between variables as shown in graphs. They should recognize that generalized sketches of relationships are examples of models in biology. Models in the form of sketch graphs can be evaluated using results from enzyme experiments.** **C1.1.9—Measurements in enzyme-catalyzed reactions** **AOS: Students should determine reaction rates through experimentation and using secondary data.** **C1.1.10—Effect of enzymes on activation energy** **AOS: Students should appreciate that energy is required to break bonds within the substrate and that there is an energy yield when bonds are made to form the products of an enzyme catalysed reaction. Students should be able to interpret graphs showing this effect.** **LQ -** ● **What are examples of structure-function relationships in biological macromolecules?** ● **What biological processes depend on differences or changes in concentration?** **C1.2 Cell Respiration (Interaction and Interdependence - Molecules)**	❖ Lactase can be immobilized in alginate beads and experiments can then be carried out in which the lactose in milk is hydrolyzed. ❖ Students should be able to sketch graphs to show the expected effects of temperature, pH, and substrate concentration on the activity of enzymes. They should be able to explain the patterns or trends apparent in these graphs. ❖ In diagrams of DNA structure, the helical shape does not need to be shown, but the two strands should be shown antiparallel. Adenine should be shown paired with thymine and guanine with cytosine, but the relative lengths of the purine and pyrimidine bases do not need to be recalled, nor the numbers of hydrogen bonds between the base pairs. ❖ The different types of DNA polymerase do not need to be distinguished. ❖ Details of the metabolic pathways of cell respiration are not needed but the substrates and final waste products should be known. ❖ There are many simple respirometers which could be used. Students are expected to know that an alkali is used to absorb CO_2, so reductions in volume are due to oxygen use. Temperature should be kept constant to avoid volume changes due to temperature fluctuations. ❖ Students should know that visible light has

GQ - ● **What are the roles of hydrogen and oxygen in the release of energy in cells?** ● **How is energy distributed and used inside cells?** **Guidance:** **C1.2.1—ATP as the molecule that distributes energy within cells** Include the full name of ATP (adenosine triphosphate) and that it is a nucleotide. Students should appreciate the properties of ATP that make it suitable for use as the energy currency within cells. **C1.2.2—Life processes within cells that ATP supplies with energy** Include active transport across membranes, synthesis of macromolecules (anabolism), movement of the whole cell or cell components such as chromosomes. **C1.2.3—Energy transfers during interconversions between ATP and ADP** Students should know that energy is released by hydrolysis of ATP (adenosine triphosphate) to ADP (adenosine diphosphate) and phosphate, but energy is required to synthesize ATP from ADP and phosphate. Students are not required to know the quantity of energy in kilojoules, but students should appreciate that it is sufficient for many tasks in the cell. **C1.2.4—Cell respiration as a system for producing ATP within the cell using energy released from carbon compounds** Students should appreciate that glucose and fatty acids are the principal substrates for cell respiration but that a wide range of carbon/organic compounds can be used. Students should be able to distinguish between the processes of cell respiration and gas exchange. **C1.2.5—Differences between anaerobic and aerobic cell respiration in humans** Include which respiratory substrates can be used, whether oxygen is required, relative yields of ATP, types of waste product and where the reactions occur in a cell. Students should be able to write simple word equations for both types of respiration, with glucose as the substrate. Students should appreciate that mitochondria are required for aerobic, but not anaerobic, respiration. **C1.2.6—Variables affecting the rate of cell respiration** **AOS: Students should make measurements allowing for the determination of the rate of cell respiration. Students should also be able to calculate the rate** **LQ -** ● **In what forms is energy stored in living organisms?** ● **What are the consequences of respiration for ecosystems?** **C1.3 Photosynthesis (Interaction and Interdependence - Molecules)**	wavelengths between 400 and 700 nanometers, but they are not expected to recall the wavelengths of specific colors of light. ❖ Water free of dissolved carbon dioxide for photosynthesis experiments can be produced by boiling and cooling water. ❖ Paper chromatography can be used to separate photosynthetic pigments, but thin layer chromatography gives better results. **Assessment Objectives:** The assessment objectives for biology reflect those parts of the aims that will be formally assessed either internally or externally. It is the intention of this course that students can fulfill the following assessment objectives. 1. Demonstrate knowledge of: A. terminology, facts, and concepts B. skills, techniques, and methodologies. 2. Understand and apply knowledge of: A. terminology and concepts B. skills, techniques, and methodologies. 3. Analyze, evaluate, and synthesize: A. experimental procedures B. primary and secondary data C. trends, patterns, and predictions. 4. Demonstrate the application of skills necessary to carry out insightful and ethical investigations

GQ - ● **How is energy from sunlight absorbed and used in photosynthesis?** ● **How do abiotic factors interact with photosynthesis?** **Guidance:** **C1.3.1—Transformation of light energy to chemical energy when carbon compounds are produced in photosynthesis** This energy transformation supplies most of the chemical energy needed for life processes in ecosystems. **C1.3.2—Conversion of carbon dioxide to glucose in photosynthesis using hydrogen obtained by splitting water** Students should be able to write a simple word equation for photosynthesis, with glucose as the product. **C1.3.3—Oxygen as a by-product of photosynthesis in plants, algae, and cyanobacteria** Students should know the simple word equation for photosynthesis. They should know that the oxygen produced by photosynthesis comes from the splitting of water. **C1.3.4—Separation and identification of photosynthetic pigments by chromatography** **AOS: Students should be able to calculate Rf values from the results of chromatographic separation of photosynthetic pigments and identify them by color and by values. Thin-layer chromatography or paper chromatography can be used.** **C1.3.5—Absorption of specific wavelengths of light by photosynthetic pigments** Include excitation of electrons within a pigment molecule, transformation of light energy to chemical energy and the reason that only some wavelengths are absorbed. Students should be familiar with absorption spectra. Include both wavelengths and colors of light in the horizontal axis of absorption spectra. **C1.3.6—Similarities and differences of absorption and action spectra** **AOS: Students should be able to determine rates of photosynthesis from data for oxygen production and carbon dioxide consumption for varying wavelengths. They should also be able to plot this data to make an action spectrum.** **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** **AOS: Students should be able to suggest hypotheses for the effects of these limiting factors and to test these through experimentation.**	

NOS: Hypotheses are provisional explanations that require repeated testing. During scientific research, hypotheses can either be based on theories and then tested in an experiment or be based on evidence from an experiment already carried out. Students can decide in this case whether to suggest hypotheses for the effects of limiting factors on photosynthesis before or after performing their experiments. Students should be able to identify the dependent and independent variable in an experiment.

C1.3.8—Carbon dioxide enrichment experiments as a means of predicting future rates of photosynthesis and plant growth
Include enclosed greenhouse experiments and free-air carbon dioxide enrichment experiments (FACE).

NOS: Finding methods for careful control of variables is part of experimental design. This may be easier in the laboratory but some experiments can only be done in the field. Field experiments include those performed in natural ecosystems. Students should be able to identify a controlled variable in an experiment.

LQ -
- **What are the consequences of photosynthesis for ecosystems?**
- **What are the functions of pigments in living organisms?**

D1.1 DNA Replication (Continuity and Change - Molecules)

GQ -
- **How is new DNA produced?**
- **How has knowledge of DNA replication enabled applications in biotechnology?**

Guidance:
D1.1.1—DNA replication as production of exact copies of DNA with identical base sequences
Students should appreciate that DNA replication is required for reproduction and for growth and tissue replacement in multicellular organisms**.**

D1.1.2—Semi-conservative nature of DNA replication and role of complementary base pairing
Students should understand how these processes allow a high degree of accuracy in copying base sequences.

D1.1.3—Role of helicase and DNA polymerase in DNA replication
Limit to the role of helicase in unwinding and breaking hydrogen bonds between DNA strands and the general role of DNA polymerase.

D1.1.4—Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA
Students should understand the use of primers, temperature changes and Taq polymerase in the polymerase chain reaction (PCR) and the basis of separation of DNA fragments in gel electrophoresis.

D1.1.5—Applications of polymerase chain reaction and gel electrophoresis Students should appreciate the broad range of applications, including DNA profiling for paternity and forensic investigations. **NOS: Reliability is enhanced by increasing the number of measurements in an experiment or test. In DNA profiling, increasing the number of markers used reduces the probability of a false match.** **LQ -** ● **How is genetic continuity ensured between generations?** ● **What biological mechanisms rely on directionality?** **D1.2 Protein Synthesis (Continuity and Change - Molecules)** **GQ -** ● **How does a cell produce a sequence of amino acids from a sequence of DNA bases?** ● **How is the reliability of protein synthesis ensured?** **Guidance:** **D1.2.1—Transcription as the synthesis of RNA using a DNA template** Students should understand the roles of RNA polymerase in this process. **D1.2.2—Role of hydrogen bonding and complementary base pairing in transcription** Include the pairing of adenine (A) on the DNA template strand with uracil (U) on the RNA strand. **D1.2.3—Stability of DNA templates** Single DNA strands can be used as a template for transcribing a base sequence, without the DNA base sequence changing. In somatic cells that do not divide, such sequences must be conserved throughout the life of a cell. **D1.2.4—Transcription as a process required for the expression of genes** Limit to understanding that not all genes in a cell are expressed at any given time and that transcription, being the first stage of gene expression, is a key stage at which expression of a gene can be switched on and off. **D1.2.5—Translation as the synthesis of polypeptides from mRNA** The base sequence of mRNA is translated into the amino acid sequence of a polypeptide. **D1.2.6—Roles of mRNA, ribosomes and tRNA in translation** Students should know that mRNA binds to the small subunit of the ribosome and that two tRNAs can bind simultaneously to the large subunit.	

D1.2.7—Complementary base pairing between tRNA and mRNA Include the terms “codon” and “anticodon”. **D1.2.8—Features of the genetic code** Students should understand the reasons for a triplet code. Students should use and understand the terms “degeneracy” and “universality”. **D1.2.9—Using the genetic code expressed as a table of mRNA codons** Students should be able to deduce the sequence of amino acids coded by an mRNA strand. **D1.2.10—Stepwise movement of the ribosome along mRNA and linkage of amino acids by peptide bonding to the growing polypeptide chain** Focus on elongation of the polypeptide, rather than on initiation and termination. **D1.2.11—Mutations that change protein structure** Include an example of a point mutation affecting protein structure. **LQ -** ● **How does the diversity of proteins produced contribute to the functioning of a cell?** ● **What biological processes depend on hydrogen bonding?**	
Students will be assessed on classwork, discussions, group work, lab work and reflections using a variety of formats with a focus on the applications and skills provided in the syllabus.	**Formative assessment:** Quiz/Test Project/Model CER/Reflection Essay/Writing Assignment Lab Experiments

Students will be assessed per subtopic and then at the end of the unit (Topic) to ensure understanding using IB exam style questions, modeling, reflection, lab reports, and writing prompts	**Summative assessment:** Quiz/Test Project/Model CER/Reflection Essay/Writing Assignment Labs
Students may be aware of many of the concepts within this unit, so building on prior knowledge using scaffolding techniques to aid students in a deeper understanding and extending learning to ensure that students can meet the goals set by the unit.	Differentiation: Affirm Identity - build self-esteem Value Prior Knowledge Scaffold Learning Extend Learning Details: Many concepts may be familiar to the students and others will need more scaffolding and extension.

Approaches to learning (ATL) *Check the boxes for any explicit approaches to learning connections made during the unit. For more information on ATL, please see the guide.*
Thinking - Asking questions and defining problems Social Communication- Constructing Explanations/Engaging in Argument from Evidence Self-management - Carrying out Investigations Research- Developing and using models

Language and learning *Check the boxes for any explicit language and learning connections made during the unit. For more information on the IB's approach to language and learning, please see the guide.*	TOK connections *Check the boxes for any explicit TOK connections made during the unit*	CAS connections *Check the boxes for any explicit CAS connections. If you check any of the boxes, provide a brief note in the "details" section explaining how students engaged in CAS for this unit.*
Activating Background Knowledge Scaffolding for new learning Acquisition of new learning through practice Demonstrating proficiency	Personal and Shared Knowledge Ways of Knowing Areas of Knowledge The Knowledge Framework Details: Development of some techniques benefits human populations more than others. For example, the development of lactose-free milk available in Europe and North America would have greater benefit in Africa/ Asia where lactose intolerance is more prevalent. The development of techniques requires financial investment. Should knowledge be shared when techniques developed in one part of the world are more applicable in another?	Creativity Activity Service Details: Modeling and active participation in the learning process. Creating materials to aid their fellow classmates in understanding a particular concept through peer interaction and team/group activities.

International Mindedness/Aims:
International Mindedness: (Research/Reflections/Writing) Enzymes are extensively used in industry to produce items from fruit juice to washing powder. **Aims: (Labs/Activities/Student Reflections/CER Activities)** **The course enables students, through the overarching theme of the NOS, to:** **1. develop conceptual understanding that allows connections to be made between different areas of the subject, and to other DP sciences subjects** **2. acquire and apply a body of knowledge, methods, tools, and techniques that characterize science** **3. develop the ability to analyze, evaluate and synthesize scientific information and claims** **4. develop the ability to approach unfamiliar situations with creativity and resilience**

5. design and model solutions to local and global problems in a scientific context **6. develop an appreciation of the possibilities and limitations of science** **7. develop technology skills in a scientific context** **8. develop the ability to communicate and collaborate effectively** **9. develop awareness of the ethical, environmental, economic, cultural, and social impact of science.**

Resources
● Textbook TBD – evaluation of resources ● IB Biology Guide First Assessment 2025 ● Van de Lagemaat, R. www.inthinking.net: Andorra la Vella, Andorra, 2019. ● IB Biology Schoology Course ● Discovery Education Biology and Chemistry Resources Additional Resources: Old Syllabus ● Damon, A.; McGonegal, R.; Tosto, P.; Ward, W. *Standard level biology*; Pearson Education Limited: Harlow, Essex, 2014. ● Greenwood, T.; Pryor, K.; Bainbridge-Smith, L.; Allan, R. Environmental science: student workbook; Biozone International: Hamilton, New Zealand, 2013. ● Hodder Study and Revision Guide for the IB Diploma Hodder IA Internal Assessment for Biology

Stage 3: Reflection—considering the planning, process and impact of the inquiry

What worked well	**What didn't work well**	**Notes/changes/suggestions:**
List the portions of the unit (content, assessment, planning) that were successful	*List the portions of the unit (content, assessment, planning) that were not as successful as hoped*	*List any notes, suggestions, or considerations for the future teaching of this unit*