Unit 2 - Molecular Biology

Content Area: **Science**
Course(s): **IB Biology, SL**
Time Period: **First Marking Period**
Length: **4 Weeks**
Status: **Published**

Unit Overview

Sudents will learn about the chemical priniples that are needed for the investigations of life. Students will also have an understanding of the molecular understanding of how their bodies work.

STAGE 1- DESIRED RESULTS

2.1 Falsification of theories—the artificial synthesis of urea helped to falsify vitalism.

2.2 Use theories to explain natural phenomena—the theory that hydrogen bonds form between water molecules explains the properties of water.

2.3 Evaluating claims—health claims made about lipids in diets need to be assessed.

2.4 Looking for patterns, trends and discrepancies—most but not all organisms assemble proteins from the same amino acids.

2.5 Experimental design—accurate, quantitative measurements in enzyme experiments require replicates to ensure reliability.

2.6 Using models as representation of the real world—Crick and Watson used model making to discover the structure of DNA.

2.7 Obtaining evidence for scientific theories—Meselson and Stahl obtained evidence for the semi-conservative replication of DNA.

2.8 Assessing the ethics of scientific research—the use of invertebrates in respirometer experiments has ethical implications.

2.9 Experimental design—controlling relevant variables in photosynthesis experiments is essential.

Standards

2020 New Jersey Student Learning Standards- Science

Science and Engineering Practices

- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Using Mathematics and Computational Thinking

Cross Cutting Concepts

- Cause and Effect
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Functions

Disciplinary Core Ideas

Life Sciences

- LS1A: Structure and Functions
- LS1B: Growth and Development of Organisms
- LS1C: Organization for Matter and Energy Flow in Organisms
- LS1D: Information Processing
- LS2B: Cycles of Matter and Energy Transfer in Ecosystems

Engineering. Technology. and Applications of Science

- ETS1A: Defining and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutioins

Essential Questions

2.1 How do living organisms control their composition by a complex web of chemical reactions?

2.2 Why is water the medium of life?

2.3 How are compounds of carbon, hydrogen and oxygen used to supply and store energy?

2.4 How do proteins have a very wide range of functions in living organisms?

2.5 How do enzymes control the metabolism of the cell?

2.6 How is the structure of DNA an efficient storage of genetic information?

2.7 How is genetic information in DNA accurately copied and can be translated to make the proteins needed by the cell?

2.8 How does cell respiration supplies energy for the functions of life?

2.9 How does photosynthesis use the energy in sunlight to produce the chemical energy needed for life?

Enduring Understanding

Students will investigate how the microscope structures of their bodies, from atoms to complex molecules, function as whole units to establish life.

Students will draw connections to the basis of life between kingdoms.

Students will know...

2.1

Understandings:

- Molecular biology explains living processes in terms of the chemical substances involved.
- Carbon atoms can form four covalent bonds allowing a diversity of stable compounds to exist.
- Life is based on carbon compounds including carbohydrates, lipids, proteins and nucleic acids.
- Metabolism is the web of all the enzyme-catalysed reactions in a cell or organism.
- Anabolism is the synthesis of complex molecules from simpler molecules including the formation of macromolecules from monomers by condensation reactions.
- Catabolism is the breakdown of complex molecules into simpler molecules including the hydrolysis of macromolecules into monomers.

2.2

Understandings:

- Water molecules are polar and hydrogen bonds form between them.
- Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water.
- Substances can be hydrophilic or hydrophobic.

2.3

Understandings:

- Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers.
- Fatty acids can be saturated, monounsaturated or polyunsaturated.
- Unsaturated fatty acids can be cis or trans isomers.
- Triglycerides are formed by condensation from three fatty acids and one glycerol.

2.4

Understandings:

- Amino acids are linked together by condensation to form polypeptides.
- There are 20 different amino acids in polypeptides synthesized on ribosomes.
- Amino acids can be linked together in any sequence giving a huge range of possible polypeptides.
- The amino acid sequence of polypeptides is coded for by genes.
- A protein may consist of a single polypeptide or more than one polypeptide linked together.
- The amino acid sequence determines the three-dimensional conformation of a protein.
- Living organisms synthesize many different proteins with a wide range of functions.
- Every individual has a unique proteome.

2.5

Understandings:

- Enzymes have an active site to which specific substrates bind.
- Enzyme catalysis involves molecular motion and the collision of substrates with the active site.
- Temperature, pH and substrate concentration affect the rate of activity of enzymes.
- Enzymes can be denatured.
- Immobilized enzymes are widely used in industry.

2.6

Understandings:

- The nucleic acids DNA and RNA are polymers of nucleotides.
- DNA differs from RNA in the number of strands present, the base composition and the type of pentose.
- DNA is a double helix made of two antiparallel strands of nucleotides linked by hydrogen bonding

between complementary base pairs.

2.7

Understandings:

- The replication of DNA is semi-conservative and depends on complementary base pairing.
- Helicase unwinds the double helix and separates the two strands by breaking hydrogen bonds.
- DNA polymerase links nucleotides together to form a new strand, using the pre-existing strand as a template.
- Transcription is the synthesis of mRNA copied from the DNA base sequences by RNA polymerase.
- Translation is the synthesis of polypeptides on ribosomes.
- The amino acid sequence of polypeptides is determined by mRNA according to the genetic code.
- Codons of three bases on mRNA correspond to one amino acid in a polypeptide.
- Translation depends on complementary base pairing between codons on mRNA and anticodons on tRNA.

2.8

Understandings:

- Cell respiration is the controlled release of energy from organic compounds to produce ATP.
- ATP from cell respiration is immediately available as a source of energy in the cell.
- Anaerobic cell respiration gives a small yield of ATP from glucose.
- Aerobic cell respiration requires oxygen and gives a large yield of ATP from glucose.

2.9

Understandings:

- Photosynthesis is the production of carbon compounds in cells using light energy.
- Visible light has a range of wavelengths with violet the shortest wavelength and red the longest.
- Chlorophyll absorbs red and blue light most effectively and reflects green light more than other colours.
- Oxygen is produced in photosynthesis from the photolysis of water.
- Energy is needed to produce carbohydrates and other carbon compounds from carbon dioxide.
- Temperature, light intensity and carbon dioxide concentration are possible limiting factors on the rate of photosynthesis.

Students will be able to...

2.1

- Hypothesize how urea as an example of a compound that is produced by living organisms, but can also be artificially synthesized.

2.2

- Compare the thermal properties of water with those of methane.
- Analyze the use of water as a coolant in sweat.
- Critique the modes of transport of glucose, amino acids, cholesterol, fats, oxygen and sodium chloride in blood in relation to their solubility in water.

2.3

- Explain the structure and function of cellulose and starch in plants and glycogen in humans.
- Cite the scientific evidence for health risks of trans fats and saturated fatty acids.
- Compare lipids are more suitable for long-term energy storage in humans than carbohydrates.
- Evaluate the evidence and the methods used to obtain the evidence for health claims made about lipids.

2.4

- Recall that rubisco, insulin, immunoglobulins, rhodopsin, collagen and spider silk as examples of the range of protein functions.
- **Application: Denaturation of proteins by heat or by deviation of pH from the optimum. (Lab Practical)**

2.5

- **Application: Methods of production of lactose-free milk and its advantages. (Lab Practical)**

2.6

- Assess Crick and Watson's elucidation of the structure of DNA using model making.

2.7

- Analyze the use of Taq DNA polymerase to produce multiple copies of DNA rapidly by the polymerase chain reaction (PCR).
- Explain the production of human insulin in bacteria as an example of the universality of the genetic code allowing gene transfer between species.

2.8

- Explain the use of anaerobic cell respiration in yeasts to produce ethanol and carbon dioxide in baking.
- Investigate lactate production in humans when anaerobic respiration is used to maximize the power of muscle contractions.

2.9

- Infer changes to the Earth's atmosphere, oceans and rock deposition due to photosynthesis.

STAGE 2- EVIDENCE OF LEARNING

Formative Assessment

- 3- Minute Pause
- Debriefing
- Exit Card / Ticket
- Index Card Summaries
- Journal Entry
- Observation
- One Word Summary
- Questions & Answers
- Quiz
- Think-Pair-Share
- Web or Concept Map

Authentic Assessments

2.1

- Skills: Drawing molecular diagrams of glucose, ribose, a saturated fatty acid and a generalized amino acid.
- Skill: Identification of biochemicals such as sugars, lipids or amino acids from molecular diagrams.

2.3

- Skill: Use of molecular visualization software to compare cellulose, starch and glycogen.
- Skill: Determination of body mass index by calculation or use of a nomogram.

2.4

- Skill: Drawing molecular diagrams to show the formation of a peptide bond.

2.5

- Skill: Design of experiments to test the effect of temperature, pH and substrate concentration on the activity of enzymes.
- Skill: Experimental investigation of a factor affecting enzyme activity.

2.6

- Skill: Drawing simple diagrams of the structure of single nucleotides of DNA and RNA, using circles, pentagons and rectangles to represent phosphates, pentoses and bases.

2.7

- Skill: Use a table of the genetic code to deduce which codon(s) corresponds to which amino acid.
- Skill: Analysis of Meselson and Stahl's results to obtain support for the theory of semi-conservative replication of DNA.
- Skill: Use a table of mRNA codons and their corresponding amino acids to deduce the sequence of amino acids coded by a short mRNA strand of known base sequence.
- Skill: Deducing the DNA base sequence for the mRNA strand.

2.8

- Skill: Analysis of results from experiments involving measurement of respiration rates in germinating seeds or invertebrates using a respirometer.

2.9

- Skill: Drawing an absorption spectrum for chlorophyll and an action spectrum for photosynthesis.
- Skill: Design of experiments to investigate the effect of limiting factors on photosynthesis.
- Skill: Separation of photosynthetic pigments by chromatograph.

Laboratories will be used for assessment

Quizzes will be given.

Benchmark Assessments

Chapter tests will be given.

STAGE 3- LEARNING PLAN

Instructional Map

Helpful guidance for implementing IB Biology Curriculum

2.1

- Only the ring forms of D-ribose, alpha–D-glucose and beta-D-glucose are expected in drawings.
- Sugars include monosaccharides and disaccharides.
- Only one saturated fat is expected and its specific name is not necessary.
- The variable radical of amino acids can be shown as R. The structure of individual R-groups does not need to be memorized.
- Students should be able to recognize from molecular diagrams that triglycerides, phospholipids and steroids are lipids. Drawings of steroids are not expected.
- Proteins or parts of polypeptides should be recognized from molecular diagrams showing amino acids linked by peptide bonds.

2.2

- Students should know at least one example of a benefit to living organisms of each property of water.
- Transparency of water and maximum density at 4°C do not need to be included.
- Comparison of the thermal properties of water and methane assists in the understanding of the significance of hydrogen bonding in water.

2.3

- The structure of starch should include amylose and amylopectin.
- Named examples of fatty acids are not required.
- Sucrose, lactose and maltose should be included as examples of disaccharides produced by combining monosaccharides.

2.4

- The detailed structure of the six proteins selected to illustrate the functions of proteins is not needed.
- Egg white or albumin solutions can be used in denaturation experiments.
- Students should know that most organisms use the same 20 amino acids in the same genetic code although there are some exceptions. Specific examples could be used for illustration.

2.5

- Lactase can be immobilized in alginate beads and experiments can then be carried out in which the lactose in milk is hydrolysed.
- 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.

2.6

- 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.

2.7

- The different types of DNA polymerase do not need to be distinguished.

2.8

- 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 CO2, so reductions in volume are due to oxygen use. Temperature should be kept constant to avoid volume changes due to temperature fluctuations.

2.9

- Students should know that visible light has wavelengths between 400 and 700 nanometres, but they are not expected to recall the wavelengths of specific colours 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.

Modification/Differentiation of Instruction

Differentiation Strategies for Special Education Students

- Remove unnecessary material, words, etc., that can distract from the content
- Use of off-grade level materials
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Time allowed
- Level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Varied homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary

- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Ability to work at their own pace
- Present ideas using auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment
- Differentiated checklists and rubrics, if available and appropriate

Differentiation Strategies for Gifted and Talented Students

- Increase the level of complexity
- Decrease scaffolding
- Variety of finished products
- Allow for greater independence
- Learning stations, interest groups
- Varied texts and supplementary materials
- Use of technology
- Flexibility in assignments
- Varied questioning strategies
- Encourage research
- Strategy and flexible groups based on formative assessment or student choice
- Acceleration within a unit of study
- Exposure to more advanced or complex concepts, abstractions, and materials
- Encourage students to move through content areas at their own pace
- After mastery of a unit, provide students with more advanced learning activities, not more of the same activity
- Present information using a thematic, broad-based, and integrative content, rather than just single-subject areas

Differentiated Strategies for ELL Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials, including visuals
- Use technology, if available and appropriate
- Differentiate homework and products

- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Allow students to work at their own pace
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Role play
- Provide graphic organizers, highlighted materials
- Strategy and flexible groups based on formative assessment

Differentiation Strategies for At Risk Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in "chunks"
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment

504 Plans

Students can qualify for 504 plans if they have physical or mental impairments that affect or limit any of their abilities to:

- walk, breathe, eat, or sleep
- communicate, see, hear, or speak
- read, concentrate, think, or learn
- stand, bend, lift, or work

Examples of accommodations in 504 plans include:

- preferential seating
- extended time on tests and assignments
- reduced homework or classwork
- verbal, visual, or technology aids
- modified textbooks or audio-video materials
- behavior management support
- adjusted class schedules or grading
- verbal testing
- excused lateness, absence, or missed classwork
- pre-approved nurse's office visits and accompaniment to visits
- occupational or physical therapy

Modification Strategies

- Cooperative Grouping
- Highlighted Text
- Interactive Notebook
- Oral Directions
- Peer Tutoring
- Preferential Seating
- Teacher Notes
- Use of Additional Reference Materials

Differentiation Strategies

High Preparation

- Alternative Assessments
- Games and Tournaments
- Independent Research / Project
- Multiple Intelligence Options
- Multiple Texts
- Varying Graphic Organizers

Low Preparation

- Flexible Grouping
- Open-ended Activities
- Use of Collaboration
- Varied Journal Prompts
- Work Alone / Together

Horizontal Intergration- Interdisciplinary Connections

See Appendix

Vertical Integration- Discipline Mapping

Previous courses

6th grade – Diversity of life

7th grade – Populations and Ecosystems

8th grade – Human Systems Interactions and Heredity and Adaptations

9th grade – Honors Biology

10th grade – Honors Chemistry

Possible next courses

Honors Physics

Anatomy & Physiology

IB Physics

Zoology

Forensics

Additional Materials

Videos used through McGraw Hill, Crash Course and Howard Hughes Medical Institute.

Current Research articles supplied through Newsela.