2020 Unit 03: Cellular Energetics

Content Area: **Science**
Course(s): **Advanced Placement Biology**
Time Period: **November**
Length: **6 weeks**
Status: **Published**

Unit Overview

In Unit 3, students build on knowledge gained in Unit 2 about the structure and function of cells, focusing on cellular energetics. Living systems are complex in their organization and require constant energy input. This unit will provide students with the knowledge necessary to master the concepts of energy capture and use. Students work through enzyme structure and function, learning the ways in which the environment plays a role in how enzymes perform their function(s). Students gain a deeper understanding of the processes of photosynthesis and cellular respiration, knowledge they will use in Unit 6 while studying how cells use energy to fuel life processes.

Enduring Understandings

- All organisms transfer matter and convert energy from one form to another. Both matter and energy are necessary to build and maintain structures within the organism.
- Measurement and observation tools are used to categorize, represent and interpret the natural world.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
- The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.

Essential Questions

- How do organisms use energy or conserve energy to respond to environmental stimuli?
- How is energy captured and then used by a living system?

Standards / Indicators / Student Learning Objectives (SLOs)

- Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.] (HS-LS2-3)
- Describe the photosynthetic processes that allow organisms to capture and store energy
- Describe the properties of enzymes.
- Explain how cells obtain energy from biological macromolecules in order to power cellular functions.
- Explain how enzymes affect the rate of biological reactions.

- Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.] (HS-LS1-5)

SCI.HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
SCI.HS-LS1-7	Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
SCI.HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Science & Engineering Practices

9-12.HS-ETS1-1.1.1	Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
9-12.HS-ETS1-3.6.1	Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
9-12.HS-ETS1-2.6.1	Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

9-12.HS-LS1-1.LS1.A.1	Systems of specialized cells within organisms help them perform the essential functions of life.
9-12.HS-LS1-2.LS1.A.1	Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
9-12.HS-LS1-3.LS1.A.1	Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.
9-12.HS-LS1-5.LS1.C.1	The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
9-12.HS-LS1-6.LS1.C.1	The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
9-12.HS-LS1-7.LS1.C.1	As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
9-12.HS-LS1-6.LS1.C.2	As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
9-12.HS-LS1-7.LS1.C.2	As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy

	needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
9-12.HS-LS2-4.LS2.B.1	Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
9-12.HS-LS2-5.LS2.B.1	Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
9-12.HS-LS2-5.PS3.D.1	The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

Cross Cutting Concepts

9-12.HS-LS1-5.5.1	Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
9-12.HS-LS2-3.5.1	Energy drives the cycling of matter within and between systems.
9-12.HS-LS2-4.5.1	Energy cannot be created or destroyed— it only moves between one place and another place, between objects and/or fields, or between systems.
9-12.HS-LS1-7.5.1	Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.
9-12.HS-LS1-1.6.1	students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.
9-12.HS-LS1-3.7.1	Feedback (negative or positive) can stabilize or destabilize a system.

Lesson Titles

- cellular respiration
- chemosynthesis
- Environmental Impacts on Enzyme Function
- Enzyme Structure
- fermentation
- photosynthesis

21st Century Skills and Career Ready Practices

CRP.K-12.CRP1	Act as a responsible and contributing citizen and employee.

CRP.K-12.CRP2	Apply appropriate academic and technical skills.
CRP.K-12.CRP3	Attend to personal health and financial well-being.
CRP.K-12.CRP4	Communicate clearly and effectively and with reason.
CRP.K-12.CRP5	Consider the environmental, social and economic impacts of decisions.
CRP.K-12.CRP6	Demonstrate creativity and innovation.
CRP.K-12.CRP7	Employ valid and reliable research strategies.
CRP.K-12.CRP8	Utilize critical thinking to make sense of problems and persevere in solving them.
CRP.K-12.CRP9	Model integrity, ethical leadership and effective management.
CRP.K-12.CRP10	Plan education and career paths aligned to personal goals.
CRP.K-12.CRP11	Use technology to enhance productivity.
CRP.K-12.CRP12	Work productively in teams while using cultural global competence.

Interdisciplinary Connections:

LA.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, qualitatively, as well as in words) in order to address a question or solve a problem.
LA.RH.11-12.9	Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

LA.WHST.11-12.1	Write arguments focused on discipline-specific content.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.1.B	Develop claim(s) and counterclaims using sound reasoning and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
LA.WHST.11-12.1.C	Use transitions (e.g., words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
LA.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LA.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
TECH.8.1.12.A.CS1	Understand and use technology systems.
TECH.8.1.12.A.CS2	Select and use applications effectively and productively.
TECH.8.1.12.B.CS1	Apply existing knowledge to generate new ideas, products, or processes.
TECH.8.1.12.B.CS2	Create original works as a means of personal or group expression.
TECH.8.1.12.C.CS1	Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media.
TECH.8.1.12.C.CS4	Contribute to project teams to produce original works or solve problems.
TECH.8.1.12.D.CS2	Demonstrate personal responsibility for lifelong learning.
TECH.8.1.12.E.CS1	Plan strategies to guide inquiry.
TECH.8.1.12.E.CS2	Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
TECH.8.1.12.E.CS4	Process data and report results.
TECH.8.1.12.F.CS2	Plan and manage activities to develop a solution or complete a project.
TECH.8.1.12.F.CS3	Collect and analyze data to identify solutions and/or make informed decisions.

ELA/Literacy & Math Standards

- • Choose a level of accuracy appropriate to limitations on measurement when reporting quantities representing matter cycles and energy flows among organisms in ecosystems.
- • Cite specific textual evidence to support an explanation for the cycling of matter and flow of energy in aerobic and anaerobic conditions, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- • Define appropriate quantities to represent matter and energy for the purpose of descriptive modeling of their cycling and flow among organisms in ecosystems.
- • Develop and strengthen an explanation based on evidence for the cycling of matter and flow of

energy in aerobic and anaerobic conditions by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

- Develop and write an explanation, based on evidence, for the cycling of matter and flow of energy in aerobic and anaerobic conditions by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples.

- Represent the cycling of matter and flow of energy among organisms in an ecosystem symbolically and manipulate the representing symbols. Make sense of quantities of and relationships between matter and energy as they cycle and flow through an ecosystem.

- Use a mathematical model to describe the cycling of matter and flow of energy among organisms in an ecosystem. Identify important quantities in the cycling of matter and flow of energy among organisms in an ecosystem and map their relationships using tools. Analyze those relationships mathematically to draw conclusions, reflecting on the results and improving the model if it has not served its purpose.

- Use units as a way to understand the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret units consistently in formulas to determine the cycling of matter and flow of energy among organisms in an ecosystem. Choose and interpret the scale and the origin in graphs and data displays representing the cycling of matter and flow of energy among organisms in an ecosystem.

- English Language Arts/Literacy
- Mathematics

Instructional Strategies, Learning Activities, Levels of Blooms / DOK

- additional help during tutoring/Delsea One
- carbon transfer in Elodea lab
- chromatography lab
- class discussion
- class notes
- demonstration
- fermentation lab
- floating leaf disc lab
- photosynthesis poster project
- respiration poster project
- slide presentation
- TED talk
- video clip
- webquest
- worksheets

Modifications

ELL Modifications

- Focus on domain specific vocabulary and keywords
- Group students
- K-W-L charts (what I know - what I want to know - what I've learned)
- Provide ELL students with multiple literacy strategies
- Repeat, reword, clarify
- Tap prior knowledge
- Use graphic organizer
- Use real objects when possible

IEP & 504 Modifications

- Focus on domain specific vocabulary and keywords
- modeling and showing lots of examples
- non-verbal redirection of behaviors
- providing study guides that don't lead the student to study too much extraneous information (less unnecessary details)/scaffolded study guides
- rewording questions so that there are not higher level vocabulary within the question (you are testing for understanding of the content not the ability to understand the question)

Gifted and Talented Modifications

- Ask students' higher level questions that require students to look into causes, experiences, and facts to draw a conclusion or make connections to other areas of learning
- Determine where students' interests lie and capitalize on their inquisitiveness. (Is there a specific career they are interested in? How would this apply to their interest?)
- Encourage students to explore concepts in depth and encourage independent studies or investigations
- Evaluation of thesis statements
- Generating and testing hypotheses
- Graph analysis / interpretation
- Journal article analysis

At Risk Modifications

- additional help during tutoring/Delsea One/Academic Enrichment
- hands-on Instruction
- modeling and showing lots of examples
- review, restate, reword directions
- testing modifications
- visuals

Alternative Assessments

Performance tasks
Project-based assignments
Problem-based assignments
Presentations
Reflective pieces
Concept maps
Case-based scenarios
Portfolios

Benchmark Assessments

Skills-based assessment
Reading response
Writing prompt
Lab practical

Formative Assessment

- exit ticket
- google survey
- Kahoot
- KWL form
- lesson summary
- previous class review
- question of the day
- Think-pair-share

Summative Assessment

- alternative assessment
- cellular respiration lab
- cellular respiration project
- cellular respiration quiz
- cellular respiration test
- food chain project

- marking period assessment / benchmark assessment
- photosynthesis lab
- photosynthesis project
- photosynthesis quiz
- photosynthesis test

Resources and Materials

- AP Classroom
- Google Classroom
- Leaf Photosynthesis NetLogo Model: This Java-based NetLogo model allows students to investigate the chemical and energy inputs and outputs of photosynthesis through an interactive simulation. http://ngss.nsta.org/Resource.aspx?ResourceID=249
- Of Microbes and Men: Students will develop a model to show the relationships among nitrogen and the ecosystem including parts that are not observable but predict observable phenomena. They will then construct an explanation of the effects of the environmental and human factors on this cycle. http://www.science-live.org/teachers/NitrogenGame.html
- Surviving Winter in the Dust Bowl (Food Chains and Trophic Levels): This is one of 30 lessons from the NSTA Press book Scientific Argumentation in Biology. The lesson engages students in an argumentation cycle based on an engaging scenario in which their group is a farm family trying to survive a dust bowl winter with limited food and water resources. The family has a bull, a cow, and limited amounts of water and wheat. Students are presented with four options that include various combinations of eating or keeping the animals alive and eating the wheat. Within this scenario, the lesson provides data on nutritional requirements of cows and humans, along with nutritional contents of wheat, milk, and beef. Students then use this data to construct an argument for the best strategy to allow their family to survive. As they construct this argument, students build and apply knowledge of food chains, trophic levels, interdependence among organisms, and energy transfers within ecosystems. This lesson is intended for middle or high school students. Teachers are encouraged to refer to the preface, introduction, student assessment samples, and appendix provided in the full book for important background on the practice of argumentation and resources for classroom implementation. http://ngss.nsta.org/Resource.aspx?ResourceID=147
- textbook

Technology

- chromebooks
- http://www.glencoe.com/sites/common_assets/science/virtual_labs/LS12/LS12.html
- https://lhsblogs.typepad.com/files/cell-respiration-virtual-lab.pdf
- internet

TECH.8.1.12	Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.
TECH.8.1.12.B	Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.
TECH.8.1.12.C	Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.

TECH.8.1.12.E	Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.
TECH.8.1.12.F	Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
TECH.8.2.12.C	Design: The design process is a systematic approach to solving problems.