Big Idea 2: Biological Systems and Free Energy

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Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Big Idea 2

"Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis."

A.P. Biology

Belleville Board of Education

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Unit Overview

"Evolution is a change in the genetic makeup of a population over time, with natural selection its major driving mechanism. Darwin's theory, which is supported by evidence from many scientific disciplines, states that inheritable variations occur in individuals in a population. Due to competition for limited resources, individuals with more favorable variations or phenotypes are more likely to survive and produce more offspring, thus passing traits to future generations."

NGSS

SCI.HS-LS2-5	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. The basic modeling cycle is summarized in the diagram. It involves (1) identifying variables in the situation and selecting those that represent essential features, (2) formulating a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables, (3) analyzing and performing operations on these relationships to draw conclusions, (4) interpreting the results of the mathematics in terms of the original situation, (5) validating the conclusions by comparing them with the situation, and then either improving the model or, if it is acceptable, (6) reporting on the conclusions and the reasoning behind them. Choices, assumptions, and approximations are present throughout this cycle.
SCI.HS-LS2-4	Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
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-ESS1-2	Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
SCI.HS-ESS1-1	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
SCI.HS-LS2-3	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
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-LS1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
SCI.HS	Matter and Energy in Organisms and Ecosystems

Exit Skills

By the end of Big Idea 2, A.P. Biology Students should be able to:

- The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.
- The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.
- The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction.
- The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure.
- The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function.
- The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes.
- The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.
- The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products.
- The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction.
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Enduring Understanding

Enduring understanding 2.A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

Enduring understanding 2.B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal

environments that are different from their external environments.

Enduring understanding 2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.

Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

Enduring understanding 2.E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

Essential Questions

Essential knowledge 2.A.1: Do All living systems require constant input of free energy?

Essential knowledge 2.A.2: How Organisms capture and store free energy for use in biological processes?

Essential knowledge 2.A.3: Must Organisms exchange matter with the environment to grow, reproduce and maintain organization?

Essential knowledge 2.B.1: What makes Cell membranes selectively permeable?

Essential knowledge 2.B.2: How are Growth and dynamic homeostasis are maintained across membranes?

Essential knowledge 2.B.3: Why do Eukaryotic cells maintain internal membranes that partition the cell into specialized regions?

Essential knowledge 2.C.1: How can Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes?

Essential knowledge 2.C.2: In what ways do Organisms respond to changes in their external environments?

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions. What are they exchanging?

Essential knowledge 2.D.2: What equilibrium-like mechanism reflects both common ancestry and divergence due to adaptation in different environments?

Essential knowledge 2.D.3: In what ways are Biological systems are affected by disruptions to their dynamic homeostasis?

Essential knowledge 2.D.4: Name the Plants and animals that have a variety of chemical defenses against infections that affect dynamic homeostasis?

Essential knowledge 2.E.1: Timing and coordination of which events are necessary for the normal development of an organism, and how are these events regulated?

Essential knowledge 2.E.2: Timing and coordination of what type of events are regulated by multiple mechanisms?

Essential knowledge 2.E.3: Timing and coordination of behavior are regulated by various mechanisms, and what process are they essential to?

Learning Objectives

- The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow, and to reproduce.
- The student is able to justify a scientific claim that free energy is required for living systems to maintain organization, to grow, or to reproduce, but that multiple strategies for obtaining and using energy exist in different living systems.
- The student is able to predict how changes in free energy availability affect organisms, populations, and/or ecosystems.
- The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy.
- The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.
- The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.
- The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.
- Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination.
- The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products.
- The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction.
- The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure.
- The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function.
- The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. [See SP 1.4; Essential knowledge 2.B.2] Learning objective 2.13 The student is able to explain how internal membranes and organelles contribute to cell functions.
- The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells.
- The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered.
- The student is able to connect how organisms use negative feedback to maintain their internal environments.
- The student is able to evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms.
- The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments.
- The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy.
- The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.
- The student is able to evaluate data to show the relationship between photosynthesis and respiration in the flow of free energy through a system.
- The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.
- Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination.
- The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products.
- The student is able to explain how internal membranes and organelles contribute to cell functions.

- The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation.
- The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation.
- The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events.
- The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection.
- The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms.
- The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior

Interdisciplinary Connections

LA.11-12.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.
MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.4	Model with mathematics.
MA.9-12.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
TECH.8.1.12	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.
MA.9-12.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.9-12.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.11-12.WHST.11-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
LA.11-12.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.11-12.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.
LA.11-12.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
LA.11-12.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific

	procedures/ experiments, or technical processes.
HPE.2.1.12	All students will acquire health promotion concepts and skills to support a healthy, active lifestyle.
HPE.2.4.12	All students will acquire knowledge about the physical, emotional, and social aspects of human relationships and sexuality and apply these concepts to support a healthy, active lifestyle.

Alignment to 21st Century Skills & Technology

Key SUBJECTS AND 21st CENTURY THEMES

Mastery of key subjects and 21st century themes is essential for all students in the 21stcentury.

Key subjects include:

- English, reading or language arts
- World languages
- Arts
- Mathematics
- Economics
- Science
- Geography
- History
- Government and Civics

21st Century/Interdisciplinary Themes

- Environmental Literacy
- Global Awareness
- Health Literacy

21st Century Skills

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

Technology Infusion

- MS Powerpoint
- Google Drive
- Prezi
- Khan Academy
- Ted Talks
- Ted- ED
- Bozeman Science (Youtube)
- Windows Movie Maker
- Time Lapse
- Online Flow Chart maker
- MS Excel: graphs, charts, calculations, equations

Differentiation

As a Reminder:

The basis of good differentiation in a lesson lies in differentiating by content, process, and/or product.

Resources:

- NJDOE: Instructional Supports and Scaffolds for Success in Implementing the Common Core State Standards http://www.state.nj.us/education/modelcurriculum/success/math/k2/

Special Education

- assistive technology
- computer or electronic device utilizes
- multi-sensory presentation
- preferential seating

ELL

- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing students to correct errors (looking for understanding)
- providing study guides

Intervention Strategies

- allowing students to correct errors (looking for understanding)

- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- providing study guides
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using videos, illustrations, pictures, and drawings to explain or clarify

Evidence of Student Learning-CFU's

- Common benchmarks: Actual AP Test Questions, released by College Board
- Create a Multimedia Presentation
- Evaluation rubrics
- Outline
- Quizzes
- Self- assessments
- Socratic Seminar
- Study Guide
- Teacher Observation Checklist
- Top 10 List
- Unit tests

Primary Resources

Pearson: AP Biology, 8th ed.

Campbell, N.A. and Reece, J.B. - California - Pearson, San Francisco - 2008

Pearson: Test Prep Series for AP Biology

Holtzclaw, F.W. , Holtclaw, T.K. - New Jersey - Pearson, Upper Saddle River - 2014

College Board: AP Biology Investigative Labs: An inquiry based approach

The College Board, New York, N.Y. - 2012

Ancillary Resources

- PearsonEasyBridge.com worksheets for review
- Chrome Book Projects/ Research/ Analysis
- Google Classroom
- Barron's Review Flash Cards