ESL
SCIENCE
BUSINESS
BILINGUAL
PRESCHOOL
MATHEMATICS
LIBRARY MEDIA
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WORLD LANGUAGES
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TECHNOLOGY EDUCATION
ENGLISH LANGUAGE ARTS
FINE & PERFORMING ARTS
FAMILY & CONSUMER SCIENCE
HEALTH & PHYSICAL EDUCATION

RAHWAY PUBLIC SCHOOLS

CURRICULUM & INSTRUCTION

Content Area: Science

Course: Advanced Placement Biology

Grade Level: 11-12

This curriculum is part of the Educational Program of Studies of the Rahway Public Schools.

ACKNOWLEDGMENTS

Jeffery Kurczeski,

Program Supervisor of 7-12 Math & Science and 9-12 Business & Technology Education

The Board acknowledges the following who contributed to the preparation of this curriculum.

Adrienne Savard, Science Teacher

Dr. Tiffany A. Beer, Director of Curriculum and Instruction

Dr. Aleya Shoieb, Superintendent of Schools

Subject/Course Title:
Advanced Placement Biology
Grades 11-12

Date of Board Adoption:
August 27, 2024

RAHWAY PUBLIC SCHOOLS CURRICULUM

Advanced Placement Biology: Grades 11-12

PACING GUIDE

Unit	Title	Pacing
1	Chemistry of Life	2 weeks
2	Cell Structure and Function	3 weeks
3	Cellular Energetics	4 weeks
4	Cell Communication and Cell Cycle	3 weeks
5	Heredity	4 weeks
6	Gene Expression and Regulation	5 weeks
7	Natural Selection	5 weeks
8	Ecology	4 weeks

ACCOMMODATIONS

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Provide extra visual and verbal cues and prompts.
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
- Provide study sheets and teacher outlines prior to assessments.
- Quiet corner or room to calm down and relax when anxious.
- Reduction of distractions.
- Permit answers to be dictated.
- Hands-on activities.
- Use of manipulatives.
- Assign preferential seating.
- No penalty for spelling errors or sloppy handwriting.
- Follow a routine/schedule.
- Provide student with rest breaks.
- Use verbal and visual cues regarding directions and staying on task.
- Assist in maintaining agenda book.

IEP Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Differentiate reading levels of texts (e.g., Newsela).
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide extra visual and verbal cues and prompts.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Provide students with additional information to supplement notes.
- Modify questioning techniques and provide a reduced number of questions or items on tests.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.

ML Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc…).
- Have student repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.

● Assign group research and presentations to teach the class. ● Assign/allow for leadership roles during collaborative work and in other learning activities.	● Allow student to listen to an audio version of the text. ● Give directions in small, distinct steps. ● Allow copying from paper/book. ● Give student a copy of the class notes. ● Provide written and oral instructions. ● Differentiate reading levels of texts (e.g., Newsela). ● Shorten assignments. ● Read directions aloud to student. ● Give oral clues or prompts. ● Record or type assignments. ● Adapt worksheets/packets. ● Create alternate assignments. ● Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted. ● Allow student to resubmit assignments. ● Use small group instruction. ● Simplify language. ● Provide scaffolded vocabulary and vocabulary lists. ● Demonstrate concepts possibly through the use of visuals. ● Use manipulatives. ● Emphasize critical information by highlighting it for the student. ● Use graphic organizers. ● Pre-teach or pre-view vocabulary. ● Provide student with a list of prompts or sentence starters that they can use when completing a written assignment. ● Provide audio versions of the textbooks. ● Highlight textbooks/study guides. ● Use supplementary materials. ● Give assistance in note taking ● Use adapted/modified textbooks. ● Allow use of computer/word processor. ● Allow student to answer orally, give extended time (time-and-a-half). ● Allow tests to be given in a separate location (with the ESL teacher). ● Allow additional time to complete assignments and/or assessments. ● Read question to student to clarify. ● Provide a definition or synonym for words on a test that do not impact the validity of the exam. ● Modify the format of assessments. ● Shorten test length or require only selected test items. ● Create alternative assessments. ● On an exam other than a spelling test, don’t take points off for spelling errors.

UNIT 1 OVERVIEW

Content Area: Science

Unit Title: Chemistry of Life

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: This first unit sets the foundation for students to understand the chemical basis of life, which is needed for mastery of future areas of focus and provides students with a survey of the elements necessary for carbon-based systems to function. Students learn that water and the properties of water play a vital role in the survival of individuals and biological systems. They also learn that living systems exist in a highly complex organization that requires input of energy and the exchange of macromolecules. This unit also addresses in detail how and in what conformations molecules called monomers bond together to form polymers. The structure of monomers and polymers determines their function. In the units that follow, students will need to understand and explain the interaction and bonding of atoms to form molecules.

Approximate Length of Unit: 2 weeks

LEARNING TARGETS

NJ Student Learning Standards:

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.

College Board Standards:

SYI-1.A Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.

ENE-1.A Describe the composition of macromolecules required by living organisms.

SYI-1.B Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.

SYI-1.C Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.

IST-1.A Describe the structural similarities and differences between DNA and RNA.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.

9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.
9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:
ELA
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.
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.
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.
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.
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.
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.
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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Living systems are organized in a hierarchy of structural levels that interact.
- The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- Living systems are organized in a hierarchy of structural levels that interact.
- Heritable information provides for continuity of life.

Unit Essential Questions:

- What is the role of energy in the making and breaking of polymers?
- How do living systems transmit information in order to ensure their survival?
- How would living systems function without the polarity of the water molecule?

Knowledge and Skills:
Students will know...

- The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- Living systems depend on the properties of water that result from its polarity and hydrogen bonding.
- The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.
- Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.
- Atoms and molecules from the environment are necessary to build new molecules.
- Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids.
- Carbon is used in storage compounds and cell formation in all organisms.
- Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.

- Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.
- The structure and function of polymers are derived from the way their monomers are assembled.
- In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate, and a nitrogen base (adenine, thymine, guanine, cytosine, or uracil). DNA and RNA differ in structure and function.
- In proteins, the specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. Amino acids have directionality, with an amino (NH_2) terminus and a carboxyl (COOH) terminus. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, or ionic), and the interactions of these R groups determine the structure and function of that region of the protein.
- Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules.
- The directionality of the subcomponents influences the structure and function of the polymer.
- Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3’ hydroxyl and 5’ phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3’ end of the growing strand, resulting in the formation of a covalent bond between nucleotides.
- DNA is structured as an antiparallel double helix, with each strand running in opposite 5’ to 3’ orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds.
- Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain.
- Proteins have a primary structure determined by the sequence order of their constituent amino acids, a secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, a tertiary structure that is the overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein.
- Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched.
- DNA and RNA molecules have structural similarities and differences related to their function—a. Both DNA and RNA have three components—sugar, a phosphate group, and a nitrogenous base—that form nucleotide units that are connected by covalent bonds to form a linear molecule with 5’ and 3’ ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.
- The basic structural differences between DNA and RNA include the following: DNA contains deoxyribose and RNA contains ribose, RNA contains uracil and DNA contains thymine, DNA is usually double-stranded; RNA is usually single-stranded, and the two DNA strands in double-stranded DNA are antiparallel in directionality.

Students will be able to...

- Describe characteristics of a biological concept, process, or model represented visually.
- Describe biological concepts and/ or processes.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Lab Report Analysis for Properties of Water Laboratory.
- Written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Chemical molecule and bonding model analysis.
- Biozone AP Bio Unit 1 Personal Progress Check
- Quizzes: Properties of Water, Elements of Life, and Macromolecules.
- AP Bio Unit 1 FRQ Progress Check
- AP Bio Unit 1 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Properties of Water Laboratory
- Construct Paper Models for modeling and analyzing dehydration synthesis reactions for carbohydrates, lipids, proteins, and nucleic acids.
- Graph and Switch - Students determine how many drops of water can fit onto a penny. Various substances (e.g., salt, sugar, vinegar) can be added to the water to determine how the surface tension of the water is affected. Students then graph their data and calculate descriptive statistics.
- Index Card Summaries/Questions - Students use diagrams (found online) of water drops, glucose, amino acids, nucleotides, glycerol, and fatty acids to learn how dehydration synthesis builds molecules.
- Think-Pair-Share - Students use cards containing pictures of biological molecules to find patterns in the molecules. Functional groups are identified and marked on each card, and then the cards are organized based on similarities in their structure. Students then learn about the properties of the molecules, and the students identify each of the molecules on the cards.
- Watch and review AP Daily Videos for each section of the unit.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.

- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Printer/Copier
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Scissors, glue, and colored copy paper (modeling chemical molecules and bonding).

UNIT 2 OVERVIEW

Content Area: Science

Unit Title: Cell Structure and Function

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: The cell is the basic unit of life. Cells contribute to the organization of life and provide the environment in which organelles function. Organelles in turn provide compartmentalization and organize cellular products for dispersal and waste for disposal. Cells have membranes that allow them to establish and maintain an internal environment. These membranes also control the exchange of material with the cell's external environment—an important, foundational concept. The maintenance of the internal and external conditions of a cell is called homeostasis. Student understanding of these concepts will be necessary for later units when the focus of instruction shifts to cellular products and by-products and when students learn why the cellular exchange of energy and materials matters.

Approximate Length of Unit: 3 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

College Board Standards:

SYI-1.D Describe the structure and/ or function of subcellular components and organelles.

SYI-1.E Explain how subcellular components and organelles contribute to the function of the cell.

SYI-1.F Describe the structural features of a cell that allow organisms to capture, store, and use energy.

ENE-1.B Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.

ENE-1.C Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment.

ENE-2.A Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell.

ENE-2.B Describe the Fluid Mosaic Model of cell membranes.

ENE-2.C Explain how the structure of biological membranes influences selective permeability.

ENE-2.D Describe the role of the cell wall in maintaining cell structure and function.

ENE-2.E Describe the mechanisms that organisms use to maintain solute and water balance.

ENE-2.F Describe the mechanisms that organisms use to transport large molecules across the plasma membrane.

ENE-2.G Explain how the structure of a molecule affects its ability to pass through the plasma membrane.
ENE-2.H Explain how concentration gradients affect the movement of molecules across membranes.
ENE-2.I Explain how osmoregulatory mechanisms contribute to the health and survival of organisms.
ENE-2.J Describe the processes that allow ions and other molecules to move across membranes.
ENE-2.K Describe the membrane bound structures of the eukaryotic cell.
ENE-2.L Explain how internal membranes and membrane bound organelles contribute to compartmentalization of eukaryotic cell functions.
EVO-1.A Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells.
EVO-1.B Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts.

Career Readiness, Life Literacies, and Key Skills:
9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
9.3.ST‑ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST‑ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
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9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

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.

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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.

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.

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.

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WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

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.

WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.

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.

WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

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.

F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:

Students will understand that…

- Living systems are organized in a hierarchy of structural levels that interact.
- The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.
- Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.

Unit Essential Questions:

- From where and how did eukaryotic cells evolve?
- How do the mechanisms for transport across membranes support energy conservation?
- What are the advantages and disadvantages of cellular compartmentalization?
- How are living systems affected by the presence or absence of subcellular components?

Knowledge and Skills:

Students will know...

- Ribosomes comprise ribosomal RNA (rRNA) and protein. Ribosomes synthesize protein according to mRNA sequence.
- Ribosomes are found in all forms of life, reflecting the common ancestry of all known life.
- Endoplasmic reticulum (ER) occurs in two forms—smooth and rough. Rough ER is associated with membrane-bound ribosomes— Rough ER compartmentalizes the cell. Smooth ER functions include detoxification and lipid synthesis.
- The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs— a. Functions of the Golgi include the correct folding and chemical modification of newly synthesized proteins and packaging for protein trafficking.
- Mitochondria have a double membrane. The outer membrane is smooth, but the inner membrane is highly convoluted, forming folds.
- Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes.
- A vacuole is a membrane-bound sac that plays many differing roles. In plants, a specialized large vacuole serves multiple functions.
- Chloroplasts are specialized organelles that are found in photosynthetic algae and plants. Chloroplasts have a double outer membrane.
- Organelles and subcellular structures, and the interactions among them, support cellular function— The endoplasmic reticulum provides mechanical support, carries out protein synthesis on membrane-bound ribosomes, and plays a role in intracellular transport. The mitochondrial double membrane provides compartments for different metabolic reactions. Lysosomes contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell's organic materials, and programmed cell death (apoptosis). Vacuoles have many roles, including the storage and release of macromolecules and cellular waste products. In plants, it aids in the retention of water for turgor pressure.
- The folding of the inner membrane increases the surface area, which allows for more ATP to be synthesized.
- Within the chloroplast are thylakoids and the stroma.
- The thylakoids are organized in stacks, called grana.
- Membranes contain chlorophyll pigments and electron transport proteins that comprise the photosystems.
- The light-dependent reactions of photosynthesis occur in the grana.
- The stroma is the fluid within the inner chloroplast membrane and outside of the thylakoid.
- The carbon fixation (Calvin-Benson cycle) reactions of photosynthesis occur in the stroma.
- The Krebs cycle (citric acid cycle) reactions occur in the matrix of the mitochondria.
- Electron transport and ATP synthesis occur on the inner mitochondrial membrane.
- Surface area-to-volume ratios affect the ability of a biological system to obtain necessary resources, eliminate waste products, acquire or dissipate thermal energy, and otherwise exchange chemicals and energy with the environment.

- The surface area of the plasma membrane must be large enough to adequately exchange materials— These limitations can restrict cell size and shape. Smaller cells typically have a higher surface area-to-volume ratio and more efficient exchange of materials with the environment. As cells increase in volume, the relative surface area decreases, and the demand for internal resources increases. More complex cellular structures (e.g., membrane folds) are necessary to adequately exchange materials with the environment. As organisms increase in size, their surface area-to-volume ratio decreases, affecting properties like rate o
- Organisms have evolved highly efficient strategies to obtain nutrients and eliminate waste. Cells and organisms use specialized exchange surfaces to obtain and release molecules from or into the surrounding environment.
- Phospholipids have both hydrophilic and hydrophobic regions. The hydrophilic phosphate regions of the phospholipids are oriented toward the aqueous external or internal environments, while the hydrophobic fatty acid regions face each other within the interior of the membrane.
- Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.
- Cell membranes consist of a structural framework of phospholipid molecules that is embedded with proteins, steroids (such as cholesterol in eukaryotes), glycoproteins, and glycolipids that can flow around the surface of the cell within the membrane.
- The structure of cell membranes results in selective permeability.
- Cell membranes separate the internal environment of the cell from the external environment.
- Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.
- Small nonpolar molecules, including N_2, O_2, and CO_2, freely pass across the membrane. Hydrophilic substances, such as large polar molecules and ions, move across the membrane through embedded channels and transport proteins.
- Polar uncharged molecules, including H_2O, pass through the membrane in small amounts.
- Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments.
- Cell walls of plants, prokaryotes, and fungi are composed of complex carbohydrates.
- Passive transport is the net movement of molecules from high concentration to low concentration without the direct input of metabolic energy.
- Passive transport plays a primary role in the import of materials and the export of wastes.
- Active transport requires the direct input of energy to move molecules from regions of low concentration to regions of high concentration.
- The selective permeability of membranes allows for the formation of concentration gradients of solutes across the membrane.
- The processes of endocytosis and exocytosis require energy to move large molecules into and out of cells. In exocytosis, internal vesicles fuse with the plasma membrane and secrete large macromolecules out of the cell. In endocytosis, the cell takes in macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.
- Membrane proteins are required for facilitated diffusion of charged and large polar molecules through a membrane. Large quantities of water pass through aquaporins. Charged ions, including Na+ and K+, require channel proteins to move through the membrane. Membranes may become polarized.
- Membrane proteins are necessary for active transport.
- Metabolic energy (such as from ATP) is required for the active transport of molecules and/ or ions across the membrane and to establish and maintain concentration gradients.

- The Na+/K+ ATPase contributes to the maintenance of the membrane potential.
- External environments can be hypotonic, hypertonic, or isotonic to internal environments of cells. Water moves by osmosis from areas of high water potential/low osmolarity/ low solute concentration to areas of low water potential/high osmolarity/high solute concentration.
- Growth and homeostasis are maintained by the constant movement of molecules across membranes.
- Osmoregulation maintains water balance and allows organisms to control their internal solute composition/water potential.
- A variety of processes allow for the movement of ions and other molecules across membranes, including passive and active transport, endocytosis, and exocytosis.
- Membranes and membrane-bound organelles in eukaryotic cells compartmentalize intracellular metabolic processes and specific enzymatic reactions.
- Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface areas where reactions can occur.
- Membrane-bound organelles evolved from once free-living prokaryotic cells via endosymbiosis.
- Prokaryotes generally lack internal membrane-bound organelles but have internal regions with specialized structures and functions.
- Eukaryotic cells maintain internal membranes that partition the cell into specialized regions
- Membrane-bound organelles evolved from previously free-living prokaryotic cells via endosymbiosis.

Students will be able to...

- Describe biological concepts and/or processes.
- Make a scientific claim.
- Represent relationships within biological models, including mathematical models.
- Perform mathematical calculations, including ratios.
- Describe characteristics of a biological concept, process, or model represented visually.
- Make observations or collect data from representations of laboratory setups or results.
- Use data to evaluate a hypothesis (or prediction), including supporting or refuting the alternative hypothesis.
- Propose a new/next investigation based on an evaluation of the design/methods.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.
- Construct a graph, plot, or chart.
- Explain biological concepts and/or processes.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.
- Support a claim with evidence from biological principles, concepts, processes, and/or data.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Laboratory Reports, Trifold Presentations, or CER: AP Bio Lab Investigations, Osmosis and Diffusion Laboratory (Original Lab Version) or Lab 4: Diffusion and Osmosis.
- Student written and oral responses to Cellular Function and Transport Free Response Questions.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 2 Personal Progress Check
- Quizzes: Subcellular Components and Organelles, Significance of Water, Cell Membrane Structure, Cell Size, Osmosis, Water Potential, Passive vs. Active Transport, and Endosymbiosis.
- AP Bio Unit 2 Progress Check FRQs
- AP Bio Unit 2 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Speed Dating for Lonely Organelles Activity
- AP Bio Lab Investigation: Osmosis and Diffusion Laboratory (Original Lab Version) or Lab 4: Diffusion and Osmosis.
- Diffusion & Osmosis Challenge Activity
- Fun with Water Potential Packet
- Membrane Modeling Activity
- AP Bio Lab Investigation, Lab 11: Transpiration
- Surface to Volume Ratio and Cell Size Limitations from a Google Slides Presentation.
- Bozeman Osmoregulation Video Guide
- Osmoregulation in Halobacteria and Paramecium Activity
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 2 (Section 5), 3 (Section 4), 4, (Section 1), 5, relevant sections of 21, 29, and 30.
- Surface-to-Volume Ratio Lab - Agar Cubes
- Minute to Win It - Before teaching the topic, students have 5 minutes to read a case study about osmosis and answer questions about the scenario. Students also draw what they think is occurring on the cellular level. After teaching the topic, students revisit their answers as well as their drawings.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Agar cubes
- Craft materials for transport models
- Light source/lamps
- Celsius thermometer
- Microscopes
- Stereoscopes

UNIT 3 OVERVIEW

Content Area: Science

Unit Title: Cellular Energetics

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: 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.

Approximate Length of Unit: 4 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

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.

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.

College Board Standards:

ENE-1.D Describe the properties of enzymes.

ENE-1.E Explain how enzymes affect the rate of biological reactions.

ENE-1.F Explain how changes to the structure of an enzyme may affect its function.

ENE-1.G Explain how the cellular environment affects enzyme activity.

ENE-1.H Describe the role of energy in living organisms.

ENE-1.I Describe the photosynthetic processes that allow organisms to capture and store energy.

ENE-1.J Explain how cells capture energy from light and transfer it to biological molecules for storage and use.

ENE-1.K Describe the processes that allow organisms to use energy stored in biological macromolecules.

ENE-1.L Explain how cells obtain energy from biological macromolecules in order to power cellular functions.

SYI-3.A Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.

9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.

9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

9.3.STSM.3 Analyze the impact that science and mathematics has on society.

9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.

9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.

9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.

9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.

9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).

9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.

9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.

9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.

9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

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.

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.

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.

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.

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.

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.

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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- The highly complex organization of living systems requires a constant input of energy and the exchange of macromolecules.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Unit Essential Questions:

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

Knowledge and Skills:
Students will know...

- The structure of enzymes includes the active site that specifically interacts with substrate molecules.
- For an enzyme-mediated chemical reaction to occur, the shape and charge of the substrate must be compatible with the active site of the enzyme.
- The structure and function of enzymes contribute to the regulation of biological processes. Enzymes are biological catalysts that facilitate chemical reactions in cells by lowering the activation energy.
- Change to the molecular structure of a component in an enzymatic system may result in a change of the function or efficiency of the system. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions. Environmental temperatures

and pH outside the optimal range for a given enzyme will cause changes to its structure, altering the efficiency with which it catalyzes reactions.

- In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity.
- Environmental pH can alter the efficiency of enzyme activity, including through the disruption of hydrogen bonds that provide enzyme structure.
- The relative concentrations of substrates and products determine how efficiently an enzymatic reaction proceeds.
- Higher environmental temperatures increase the speed of movement of molecules in a solution, increasing the frequency of collisions between enzymes and substrates and therefore increasing the rate of reaction.
- Competitive inhibitor molecules can bind reversibly or irreversibly to the active site of the enzyme. Noncompetitive inhibitors can bind allosteric sites, changing the activity of the enzyme.
- All living systems require constant input of energy.
- Life requires a highly ordered system and does not violate the second law of thermodynamics. Energy input must exceed energy loss to maintain order and to power cellular processes. Cellular processes that release energy may be coupled with cellular processes that require energy. Loss of order or energy flow results in death.
- Energy-related pathways in biological systems are sequential to allow for a more controlled and efficient transfer of energy. A product of a reaction in a metabolic pathway is generally the reactant for the subsequent step in the pathway.
- Organisms capture and store energy for use in biological processes. Photosynthesis captures energy from the sun and produces sugars. Photosynthesis first evolved in prokaryotic organisms. Scientific evidence supports the claim that prokaryotic (cyanobacterial) photosynthesis was responsible for the production of an oxygenated atmosphere. Prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.
- The light-dependent reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways that capture energy present in light to yield ATP and NADPH, which power the production of organic molecules.
- During photosynthesis, chlorophylls absorb energy from light, boosting electrons to a higher energy level in photosystems I and II.
- Photosystems I and II are embedded in the internal membranes of chloroplasts and are connected by the transfer of higher energy electrons through an electron transport chain (ETC).
- When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) is established across the internal membrane.
- The formation of the proton gradient is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase.
- The energy captured in the light reactions and transferred to ATP and NADPH powers the production of carbohydrates from carbon dioxide in the Calvin cycle, which occurs in the stroma of the chloroplast. Within the chloroplast are thylakoids and the stroma The thylakoids are organized in stacks called grana. Membranes contain chlorophyll pigments and electron transport proteins that comprise the photosystems. The light-dependent reactions of photosynthesis occur in the grana. The stroma is the fluid within the inner chloroplast membrane and outside of the thylakoid. The carbon fixation (Calvin-Benson cycle) reactions of photosynthesis occur in the stroma.
- Fermentation and cellular respiration use energy from biological macromolecules to produce ATP. Respiration and fermentation are characteristic of all forms of life.

- Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that capture energy from biological macromolecules.
- The electron transport chain transfers energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes. Electron transport chain reactions occur in chloroplasts, mitochondria, and prokaryotic plasma membranes. In cellular respiration, electrons delivered by NADH and FADH2 are passed to a series of electron acceptors as they move toward the terminal electron acceptor, oxygen. In photosynthesis, the terminal electron acceptor is NADP+. Aerobic prokaryotes use oxygen as a terminal electron acceptor, while anaerobic prokaryotes use other molecules. The transfer of electrons is accompanied by the formation of a proton gradient across the inner mitochondrial membrane or the internal membrane of chloroplasts, with the membrane(s) separating a region of high proton concentration from a region of low proton concentration. In prokaryotes, the passage of electrons is accompanied by the movement of protons across the plasma membrane. The flow of protons back through membrane-bound ATP synthase by chemiosmosis drives the formation of ATP from ADP and inorganic phosphate. This is known as oxidative phosphorylation in cellular respiration, and photophosphorylation in photosynthesis. In cellular respiration, decoupling oxidative phosphorylation from electron transport generates heat. This heat can be used by endothermic organisms to regulate body temperature.
- Glycolysis is a biochemical pathway that releases energy in glucose to form ATP from ADP and inorganic phosphate, NADH from NAD+, and pyruvate.
- Pyruvate is transported from the cytosol to the mitochondrion, where further oxidation occurs.
- In the Krebs cycle, carbon dioxide is released from organic intermediates, ATP is synthesized from ADP and inorganic phosphate, and electrons are transferred to the coenzymes NADH and $FADH_2$.
- Electrons extracted in glycolysis and Krebs cycle reactions are transferred by NADH and $FADH_2$ to the electron transport chain in the inner mitochondrial membrane.
- When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) across the inner mitochondrial membrane is established.
- Fermentation allows glycolysis to proceed in the absence of oxygen and produces organic molecules, including alcohol and lactic acid, as waste products.
- The conversion of ATP to ADP releases energy, which is used to power many metabolic processes.
- Variation at the molecular level provides organisms with the ability to respond to a variety of environmental stimuli.
- Variation in the number and types of molecules within cells provides organisms with a greater ability to survive and/or reproduce in different environments.

Students will be able to...

- Explain biological concepts and/ or processes.
- Identify experimental procedures that are aligned with the question, including identifying appropriate controls.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.
- Provide reasoning to justify a claim by connecting evidence to biological theories.
- Support a claim with evidence from biological principles, concepts, processes, and/or data.
- Construct a graph, plot, or chart.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Mini Laboratory Reports or CERProtocols for the Enzyme, Photosynthesis, Cell Respiration, and Fermentation Labs.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 3 Personal Progress Check
- Quizzes: Enzymes, Photosynthesis, Aerobic Respiration, and Anaerobic Respiration.
- AP Bio Unit 3 Progress Check FRQs
- AP Bio Unit 3 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- The Importance of Enzymes and their Function Google Slides Presentation.
- Toothpickase Lab Activity
- AP Bio Lab Investigations – 5: Photosynthesis 6: Cellular Respiration or AP Bio Lab Investigation Cellular Respiration Lab (Original Version), 13: Enzyme Activity or AP Bio Lab Investigation, Enzyme Catalysis Laboratory (Original Lab Version).
- Photosynthesis Google Slides Presentation
- Concord Consortium: Leaf Photosynthesis Activity
- C3, C4, and CAM Plants Overview Chart and Questions
- Cell Respiration Google Slides Presentation
- Bozeman Science Fermentation Video and Questions
- Yeast Fermentation Lab – Measuring CO2 Production
- Aerobic and Anaerobic Respiration Comparison Chart
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 3 (Sections 2 and 3), 4 (Sections 5-8), 6, 7, 8, and relevant sections of 29 and 30.
- Graph and Switch - Students perform a yeast fermentation lab using the sucrose solutions from the Diffusion and Osmosis Lab your students may have performed in Unit 2.
- Misconception Check - Students complete online research to learn about the work of Peter and Rosemary Grant. Using data from their work, students build their graphing and statistical analysis skills. Additionally, students practice explaining trends in data and supporting their claims with evidence.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Burettes
- Burette clamps
- Hot water bath
- Spectrophotometer
- Respirometers

UNIT 4 OVERVIEW

Content Area: Science

Unit Title: Cell Communication and the Cell Cycle

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: Students continue to learn about the role of cells, focusing on how cells use energy and information transmission to communicate and replicate. Through systems of complex transduction pathways, cells can communicate with one another. Cells can also generate and receive signals, coordinate mechanisms for growth, and respond to environmental cues. To maintain homeostasis, cells respond to their environment. They can also replicate and regulate replication as part of the cell cycle that provides for the continuity of life. In Unit 5, students will move on to learn about heredity.

Approximate Length of Unit: 3 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Hs-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

College Board Standards:

IST-3.A Describe the ways that cells can communicate with one another.

IST-3.B Explain how cells communicate with one another over short and long distances.

IST-3.C Describe the components of a signal transduction pathway.

IST-3.D Describe the role of components of a signal transduction pathway in producing a cellular response.

IST-3.E Describe the role of the environment in eliciting a cellular response.

IST-3.F Describe the different types of cellular responses elicited by a signal transduction pathway.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.

9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.

9.3.ST‑ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.
9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:
ELA
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.
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.
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.
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.
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.
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.
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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Cells communicate by generating, transmitting, receiving, and responding to chemical signals.
- Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
- Heritable information provides for continuity of life.

Unit Essential Questions:

- In what ways do cells use energy to communicate with one another?
- How does the cell cycle aid in the conservation of genetic information?
- Why and in what ways do cells communicate with one another?

Knowledge and Skills:
Students will know...

- Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling. Cells communicate by cell-to-cell contact.
- Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell.
- Signals released by one cell type can travel long distances to target cells of another cell type.
- Signal transduction pathways link signal reception with cellular responses.
- Many signal transduction pathways include protein modification and phosphorylation cascades.
- Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or a protein, in a specific one-to-one relationship. G protein-coupled receptors are an example of a receptor protein in eukaryotes.
- Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal. Second messengers (such as

cyclic AMP) are molecules that relay and amplify the intracellular signal. The binding of ligand-to-ligand-gated channels can cause the channel to open or close.

- Signal transduction pathways influence how the cell responds to its environment.
- Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis).
- Changes in signal transduction pathways can alter cellular response. Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal.
- Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway.
- Organisms use feedback mechanisms to maintain their internal environments and respond to internal and external environmental changes.
- Negative feedback mechanisms maintain homeostasis for a particular condition by regulating physiological processes. If a system is perturbed, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular and cellular levels.
- Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set point. Amplification occurs when the stimulus is further activated, which, in turn, initiates an additional response that produces system change.
- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes.
- The cell cycle is a highly regulated series of events for the growth and reproduction of cells. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis. A cell can enter a stage (G0) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Non-dividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
- Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells— Mitosis plays a role in growth, tissue repair, and asexual reproduction. Mitosis alternates with interphase in the cell cycle. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).
- A number of internal controls or checkpoints regulate progression through the cycle.
- Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).

Students will be able to...

- Explain biological concepts and/or processes.
- Describe biological concepts and/or processes.
- Provide reasoning to justify a claim by connecting evidence to biological theories.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.
- Describe data from a table or graph, including describing trends and/or patterns in the data.
- Perform mathematical calculations, including percentages.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Mini Laboratory Reports or CER Protocols for AP Bio Lab Investigations, Mitosis and Meiosis Laboratory (Original Lab Version) and/or AP Bio Lab Investigations Lab 7: Cell Division: Mitosis and Meiosis.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 4 Personal Progress Check
- Quizzes: Cell Signaling, Feedback Loops, and Cell Cycle Regulation.
- AP Bio Unit 4 Progress Check FRQs
- AP Bio Unit 4 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Cell Communication: Pathways with Friends Activity
- Cell Communication Sequencing Activity
- Video, "Cell Signals" from the DNA Learning Center website
- POGIL activities on Cellular Communication and Signal Transduction Pathways
- Disease: Failures of Cell Communication Research Activity
- Cell Signaling Case Study
- Modeling Blood Sugar Regulation Activity
- Feedback Mechanisms POGIL
- Fight or Flight Response Video and Play-by-Play Worksheet (http://learn.genetics.utah.edu/content/cells/cellcom/)
- "How Cells Communicate During Fight or Flight" (http://learn.genetics.utah.edu/content/cells/fight_flight/)
- Mitosis Modeling Activity
- Regulation of Cell Division Google Slides Presentation
- Sections of AP Bio Lab Investigations, Mitosis and Meiosis Laboratory (Original Lab Version)
- Sections of AP Bio Lab Investigations Lab 7: Cell Division: Mitosis and Meiosis
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 3 (Sections 4, 5), 9, 29 (Section 3), 34 (Sections 1-7), 36 (Sections 1- 10), 42, relevant sections of 49.
- One-Minute Essay - Students write a one-minute essay with a prompt that allows for formative assessment of their understanding, such as, "Describe an example of communication between two cells."

- Fishbowl - Students read a case study about cell signaling and then answer any questions that accompany the case study. Students complete a fishbowl to discuss their learnings from the case study and applications to real life.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Craft materials
- Microscopes

UNIT 5 OVERVIEW

Content Area: Science

Unit Title: Heredity

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: Unit 5 focuses on heredity and the biological concepts and processes involved in ensuring the continuity of life. Students learn that the storage and transmission of genetic information via chromosomes from one generation to the next occur through meiosis. The meiotic division ensures genetic diversity, which is crucial to the survival of a species. In this unit, students gain a deeper understanding of Mendelian genetics and learn how non-Mendelian genetics describes those patterns of inheritance that seem to violate Mendel's laws. This unit also teaches the role played by chromosomal inheritance, environmental factors, and nondisjunction on an individual's phenotype. In Unit 6, students move on to learn about gene expression and regulation

Approximate Length of Unit: 4 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

College Board Standards:

IST-1.F Explain how meiosis results in the transmission of chromosomes from one generation to the next.

IST-1.G Describe similarities and/ or differences between the phases and outcomes of mitosis and meiosis.

IST-1.H Explain how the process of meiosis generates genetic diversity.

EVO-2.A Explain how shared, conserved, fundamental processes and features support the concept of common ancestry for all organisms.

IST-1.I Explain the inheritance of genes and traits as described by Mendel's laws.

IST-1.J Explain deviations from Mendel's model of the inheritance of traits.

SYI-3.B Explain how the same genotype can result in multiple phenotypes under different environmental conditions.

SYI-3.C Explain how chromosomal inheritance generates genetic variation in sexual reproduction.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.
9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

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.
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.
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.
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.
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.

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.
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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Heritable information provides for continuity of life.
- Organisms are linked by lines of descent from common ancestry.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Unit Essential Questions:

- How is our understanding of evolution influenced by our knowledge of genetics?
- Why is it important that not all inherited characteristics get expressed in the next generation?
- How would Mendel's laws have been affected if he had studied a different type of plant?
- How does the diversity of a species affect inheritance?

Knowledge and Skills:
Students will know...

- Meiosis is a process that ensures the formation of haploid gamete cells in sexually reproducing diploid organisms. Meiosis results in daughter cells with half the number of chromosomes of the parent cell. Meiosis involves two rounds of a sequential series of steps (meiosis I and meiosis II).
- Mitosis and meiosis are similar in the way chromosomes segregate but differ in the number of cells produced and the genetic content of the daughter cells.

- Separation of the homologous chromosomes in meiosis I ensures that each gamete receives a haploid (1n) set of chromosomes that comprises both maternal and paternal chromosomes.
- During meiosis I, homologous chromatids exchange genetic material via a process called "crossing over" (recombination), which increases genetic diversity among the resultant gametes.
- Sexual reproduction in eukaryotes involving gamete formation—including crossing over, the random assortment of chromosomes during meiosis, and subsequent fertilization of gametes—serves to increase variation.
- DNA and RNA are carriers of genetic information.
- Ribosomes are found in all forms of life.
- Major features of the genetic code are shared by all modern living systems.
- Core metabolic pathways are conserved across all currently recognized domains.
- Mendel's laws of segregation and independent assortment can be applied to genes that are on different chromosomes.
- Fertilization involves the fusion of two haploid gametes, restoring the diploid number of chromosomes and increasing genetic variation in populations by creating new combinations of alleles in the zygote. Rules of probability can be applied to analyze the passage of single-gene traits from parent to offspring. The pattern of inheritance (monohybrid, dihybrid, sex-linked, and genetically linked genes) can often be predicted from data, including pedigree, that gives the parent genotype/phenotype and the offspring genotypes/phenotypes.
- Patterns of inheritance of many traits do not follow ratios predicted by Mendel's laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios. Genes that are adjacent and close to one another on the same chromosome may appear to be genetically linked; the probability that genetically linked genes will segregate as a unit can be used to calculate the map distance between them.
- Some traits are determined by genes on sex chromosomes and are known as sex-linked traits. The pattern of inheritance of sex-linked traits can often be predicted from data, including pedigree, indicating the parent genotype/phenotype and the offspring genotypes/phenotypes.
- Many traits are the product of multiple genes and/or physiological processes acting in combination; these traits therefore do not segregate in Mendelian patterns.
- Some traits result from non-nuclear inheritance. Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules. In animals, mitochondria are transmitted by the egg and not by sperm; as such, traits determined by the mitochondrial DNA are maternally inherited. In plants, mitochondria and chloroplasts are transmitted in the ovule and not in the pollen; as such, mitochondria-determined and chloroplast-determined traits are maternally inherited.
- Environmental factors influence gene expression and can lead to phenotypic plasticity. Phenotypic plasticity occurs when individuals with the same genotype exhibit different phenotypes in different environments.
- Segregation, independent assortment of chromosomes, and fertilization result in genetic variation in populations.
- The chromosomal basis of inheritance provides an understanding of the pattern of transmission of genes from parent to offspring.
- Certain human genetic disorders can be attributed to the inheritance of a single affected or mutated allele or specific chromosomal changes, such as nondisjunction.

Students will be able to...

- Explain biological concepts and/or processes.
- Identify or pose a testable question based on an observation, data, or a model.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.
- Perform mathematical calculations, including means.
- Select and perform appropriate statistical hypothesis testing.
- Explain biological concepts, processes, and/or models in applied contexts.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Mini Laboratory Reports or CER Protocols for Sections of AP Bio Lab Investigations Lab 7: Cell Division: Mitosis and Meiosis.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student written and oral responses to practice FRQs.
- Student self-assessment through group activities.
- Biozone AP Bio Unit 5 Personal Progress Check
- Quizzes: Meiosis, Mendelian Genetics, Non-Mendelian Genetics
- AP Bio Unit 5 Progress Check FRQs
- AP Bio Unit 5 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Meiosis Modeling Activity
- How Mistakes in Cell Division Can Result in Down Syndrome and Miscarriages Packet
- Sections of AP Bio Lab Investigations, Mitosis and Meiosis Laboratory (Original Lab Version) Sections of AP Bio Lab Investigations Lab 7: Cell Division: Mitosis and Meiosis.
- Chromosomes and Genes – A Simulation Activity
- Gene Linkage & Chromosome Maps Practice Problems
- Bozeman Science Linked Genes Video and Question
- Corn Genetics Chi Square Activity
- Non-Mendelian Genetics Google Slides Presentation
- National Center for Case Study Teaching in Science: More Than Meets the Eye Case Study
- AP Biology Pedigree Problems
- How the Flu Virus Infects the Body Video
- Relevant Assignments from the Biozone AP Biology Student Workbooks

- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 9 (revisit), 10, 11, 12.
- Think-Pair-Share - Students construct simulated chromosomes with pop beads or pipe cleaners and manipulate them through the stages of meiosis. As students are modeling the process, they can make a sketch or take a photograph of each stage.
- Debate - Students read a case study about the genetics and evolution of skin color, then answer any questions that accompany the case study. Instead of answering the questions independently, students work in groups to debate possible answers to some or all of the questions.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Craft materials

UNIT 6 OVERVIEW

C**ontent Area:** Science

Unit Title: Gene Expression and Regulation

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: Progressing from the continuity of life to gene expression, in Unit 6 students gain in-depth knowledge about nucleic acids and their role in gene expression. Students receive a finer focus on the comparison between the structures of DNA and RNA. This unit highlights how an individual's genotype is physically expressed through that individual's phenotype. Understanding protein synthesis (transcription and translation) is vital to answering essential questions about gene expression. Regulation of gene expression and cell specialization are instrumental in ensuring survival within an individual and across populations. Unit 7 moves on to cover natural selection.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

College Board Standards:

IST-1.K Describe the structures involved in passing hereditary information from one generation to the next.

IST-1.L Describe the characteristics of DNA that allow it to be used as the hereditary material.

IST-1.M Describe the mechanisms by which genetic information is copied for transmission between generations.

IST-1.N Describe the mechanisms by which genetic information flows from DNA to RNA to protein.

IST-1.O Explain how the phenotype of an organism is determined by its genotype.

IST-2.A Describe the types of interactions that regulate gene expression.

IST-2.B Explain how the location of regulatory sequences relates to their function.

IST-2.C Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism.

IST-2.D Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.
IST-2.E Describe the various types of mutation.
IST-4.A Explain how changes in genotype may result in changes in phenotype.
IST-4.B Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.
IST-1.P Explain the use of genetic engineering techniques in analyzing or manipulating DNA.

Career Readiness, Life Literacies, and Key Skills:
9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.
9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.
9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:
ELA
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.
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.
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.

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.
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.
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.
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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Heritable information provides for continuity of life.
- Differences in the expression of genes account for some of the phenotypic differences between organisms.

Unit Essential Questions:

- How does gene regulation relate to the continuity of life?
- How is a species' genetic information diversified from generation to generation?

Knowledge and Skills:
Students will know...

- DNA, and in some cases RNA, is the primary source of heritable information.
- Genetic information is transmitted from one generation to the next through DNA or RNA. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases RNA molecules. Prokaryotic organisms typically have circular chromosomes, while eukaryotic organisms typically have multiple linear chromosomes.

- Prokaryotes and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded, circular DNA molecules.
- DNA, and sometimes RNA, exhibits specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G)— a. Purines (G and A) have a double ring structure. b. Pyrimidines (C, T, and U) have a single-ring structure.
- DNA replication ensures the continuity of hereditary information. DNA is synthesized in the 5' to 3' direction. Replication is a semiconservative process—that is, one strand of DNA serves as the template for a new strand of complementary DNA. Helicase unwinds the DNA strands. Topoisomerase relaxes supercoiling in front of the replication fork. DNA polymerase requires RNA primers to initiate DNA synthesis. DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand. Ligase joins the fragments on the lagging strand.
- The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function. mRNA molecules carry information from DNA to the ribosome. Distinct tRNA molecules bind specific amino acids and have anti-codon sequences that base pair with the mRNA. tRNA is recruited to the ribosome during translation to generate the primary peptide sequence based on the mRNA sequence. rRNA molecules are functional building blocks of ribosomes.
- Genetic information flows from a sequence of nucleotides in DNA to a sequence of bases in an mRNA molecule to a sequence of amino acids in a protein.
- RNA polymerases use a single template strand of DNA to direct the inclusion of bases in the newly formed RNA molecule. This process is known as transcription.
- The DNA strand acting as the template strand is also referred to as the noncoding strand, minus strand, or antisense strand. The selection of which DNA strand serves as the template strand depends on the gene being transcribed.
- The enzyme RNA polymerase synthesizes mRNA molecules in the 5' to 3' direction by reading the template DNA strand in the 3' to 5' direction.
- In eukaryotic cells, the mRNA transcript undergoes a series of enzyme-regulated modifications. Addition of a poly-A tail. Addition of a GTP cap. Excision of introns and splicing and retention of exons. Excision of introns and splicing and retention of exons can generate different versions of the resulting mRNA molecule; this is known as alternative splicing.
- Translation of the mRNA to generate a polypeptide occurs on ribosomes that are present in the cytoplasm of both prokaryotic and eukaryotic cells and on the rough endoplasmic reticulum of eukaryotic cells.
- In prokaryotic organisms, translation of the mRNA molecule occurs while it is being transcribed.
- Translation involves energy and many sequential steps, including initiation, elongation, and termination.
- The following are the salient features of translation. Translation is initiated when the rRNA in the ribosome interacts with the mRNA at the start codon and the sequence of nucleotides on the mRNA is read in triplets called codons. Each codon encodes a specific amino acid, which can be deduced by using a genetic code chart. Many amino acids are encoded by more than one codon. Nearly all living organisms use the same genetic code, which is evidence of the common ancestry of all living organisms. tRNA brings the correct amino acid to the correct place specified by the codon on the mRNA. The amino acid is transferred to the growing polypeptide chain. The process continues along the mRNA until a stop codon is reached. The process terminates by the release of the newly synthesized polypeptide/protein.

- Genetic information in retroviruses is a special case and has an alternate flow of information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny.
- Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription.
- Epigenetic changes can affect gene expression through reversible modifications of DNA or histones.
- The phenotype of a cell or organism is determined by the combination of genes that are expressed and the levels at which they are expressed. Observable cell differentiation results from the expression of genes for tissue-specific proteins. Induction of transcription factors during development results in sequential gene expression.
- Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated. In prokaryotes, groups of genes called operons are transcribed in a single mRNA molecule. The lac operon is an example of an inducible system. In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression.
- Promoters are DNA sequences upstream of the transcription start site where RNA polymerase and transcription factors bind to initiate transcription.
- Negative regulatory molecules inhibit gene expression by binding to DNA and blocking transcription.
- Gene regulation results in differential gene expression and influences cell products and function.
- Certain small RNA molecules have roles in regulating gene expression.
- Changes in genotype can result in changes in phenotype. The function and amount of gene products determine the phenotype of organisms. The normal function of the genes and gene products collectively comprises the normal function of organisms. Disruptions in genes and gene products cause new phenotypes.
- Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype. DNA mutations can be positive, negative, or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein.
- Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random mutations in the DNA whether a mutation is detrimental, beneficial, or neutral depends on the environmental context. Mutations are the primary source of genetic variation.
- Errors in mitosis or meiosis can result in changes in phenotype. Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy, and increased vigor of other polyploids. Changes in chromosome number often result in human disorders with developmental limitations, including Down syndrome/ Trisomy 21 and Turner syndrome.
- Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected for by environmental conditions. The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer of DNA), and transposition (movement of DNA segments within and between DNA molecules) increase variation. Related viruses can combine/recombine genetic information if they infect the same host cell. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.

- Genetic engineering techniques can be used to analyze and manipulate DNA and RNA. Electrophoresis separates molecules according to size and charge. During polymerase chain reaction (PCR), DNA fragments are amplified. Bacterial transformation introduces DNA into bacterial cells. DNA sequencing determines the order of nucleotides in a DNA molecule.

Students will be able to…

- Explain biological concepts, processes, and/or models in applied contexts.
- Explain relationships between different characteristics of biological concepts, processes, or models represented visually in applied contexts.
- Represent relationships within biological models, including diagrams.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts.
- Make a scientific claim.
- Support a claim with evidence from biological principles, concepts, processes, and/or data.
- Explain how biological concepts or processes represented visually relate to larger biological principles, concepts, processes, or theories.
- Make observations or collect data from representations of laboratory setups or results.
- Explain the relationship between experimental results and larger biological concepts, processes, or theories.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Formal Laboratory Report, Mini Lab Report or CER Protocols for AP Bio Lab Investigations, Lab 8: Biotechnology: Bacterial Transformation and Lab 9: Biotechnology: Restriction Enzyme Analysis of DNA.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 6 Personal Progress Check
- Quizzes: DNA Structure, DNA Replication, Transcription, Translation, Genetic Mutations, Prokaryotic Gene Regulation, Eukaryotic Gene Regulation, and Biotechnology.
- AP Bio Unit 6 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.
- AP Bio Unit 6 Progress Check FRQs

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- DNA Structure Google Slides Presentation
- Directionality of DNA Animations
- Gene to Protein Google Slides Presentation

- Protein Synthesis: Transcription and Translation Modeling Activity
- Protein Synthesis Skit
- Effects of Mutations on Protein Production Analysis
- HHMI Bacterial ID Lab BioInteractive Activity
- DNA Replication Google Slides Presentation
- DNA Replication Modeling Activity
- Replication of DNA Animation
- Eukaryotic Gene Regulation Song Activity
- Online Resources for Eukaryotic Gene Regulation: The Epigenome at a Glance
- PHET simulation, Gene Machine: The Lac Operon
- Prokaryotic and Eukaryotic Gene Regulation Google Slides Presentation
- HHMI - Modeling the Regulatory Switches of the Pitx1 Gene in Stickleback Fish Activity
- Biotechnology Google Slides Presentation
- The E. coli Insulin Factory Activity
- Lab 8: Biotechnology: Bacterial Transformation
- Transformation Efficiency Practice Problems
- Lab 9: Biotechnology: Restriction Enzyme Analysis of DNA
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 6 (revisit), 13, 14, 15, 16.
- Think-Pair-Share - Students will build a model of transcription using pool noodles. Using everyday materials, such as tape, colored paper, yarn (or string), and markers, they identify the promoter region, TATA box, transcription start site, and terminal sequence. They describe the process of transcription from the initial binding of the transcription factors to the production of the transcript.
- Construct an Argument - Students develop a skit to demonstrate the process of translation. Once they have an understanding of the process, the challenge is to act out what might happen if there were a change in the DNA sequence or if one of the needed components was unavailable. Students debrief by explaining the rationale for the modifications made in their skit.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.

- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Craft materials
- Microscopes
- Test Tubes, incubator
- Hot Water Bath
- Microcentrifuge Tubes
- Thermometers
- Stopwatch
- Sterile Inoculation Loops
- Disposable Plastic Needle-nose Transfer Pipettes
- Gel Electrophoresis Chambers
- Microwave Oven

UNIT 7 OVERVIEW

Content Area: Science

Unit Title: Natural Selection

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: The concepts in Unit 7 build on foundational content from previous units as students discover natural selection, a mechanism of evolution—the theory that populations that are better adapted to their environment will survive and reproduce. Thus, the evolution of a species involves a change in its genetic makeup over time. In this unit, students study the evidence for and mechanisms of evolutionary change. Students also learn what happens when a species does not adapt to a changing or volatile environment and about the Hardy-Weinberg equilibrium as a model for describing and predicting allele frequencies in non-evolving populations. Students will learn to calculate and draw conclusions about the evolution, or lack thereof, of a population from data related to allele frequencies. Biological principles studied here and in previous units will culminate in Unit 8, which covers ecology.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

College Board Standards:

EVO-1.C Describe the causes of natural selection.
EVO-1.D Explain how natural selection affects populations.
EVO-1.E Describe the importance of phenotypic variation in a population.
EVO-1.F Explain how humans can affect diversity within a population.
EVO-1.G Explain the relationship between changes in the environment and evolutionary changes in the population.
EVO-1.H Explain how random occurrences affect the genetic makeup of a population.
EVO-1.I Describe the role of random processes in the evolution of specific populations.
EVO-1.J Describe the change in the genetic makeup of a population over time.
EVO-1.K Describe the conditions under which allele and genotype frequencies will change in populations.
EVO-1.L Explain the impacts on the population if any of the conditions of Hardy Weinberg are not met.
EVO-1.M Describe the types of data that provide evidence for evolution.
EVO-1.N Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.
EVO-2.B Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry.
EVO-2.C Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes.
EVO-3.A Explain how evolution is an ongoing process in all living organisms.
EVO-3.B Describe the types of evidence that can be used to infer an evolutionary relationship.
EVO-3.C Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness.
EVO-3.D Describe the conditions under which new species may arise.
EVO-3.E Describe the rate of evolution and speciation under different ecological conditions.
EVO-3.F Explain the processes and mechanisms that drive speciation.
EVO-3.G Describe factors that lead to the extinction of a population.
EVO-3.H Explain how the risk of extinction is affected by changes in the environment.
EVO-3.I Explain species diversity in an ecosystem as a function of speciation and extinction rates.
EVO-3.J Explain how extinction can make new environments available for adaptive radiation.
SYI-3.D Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.
SYI-3.E Describe the scientific evidence that provides support for models of the origin of life on Earth.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.
9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.
9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.
9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
9.3.STSM.3 Analyze the impact that science and mathematics has on society.
9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.
9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.
9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.
9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.
9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).
9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.
9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.
9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.
9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.
9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:
ELA
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.
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.
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.
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.
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.
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.
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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.

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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
- Organisms are linked by lines of descent from common ancestry.
- Life continues to evolve within a changing environment.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Unit Essential Questions:

- What conditions in a population make it more or less likely to evolve?
- How does species interaction encourage or slow changes in species?

Knowledge and Skills:
Students will know...

- Natural selection is a major mechanism of evolution.
- According to Darwin's theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.
- Evolutionary fitness is measured by reproductive success.
- Biotic and abiotic environments can be more or less stable/fluctuating, and this affects the rate and direction of evolution; different genetic variations can be selected in each generation.
- Natural selection acts on phenotypic variations in populations.
- Environments change and apply selective pressures to populations.
- Some phenotypic variations significantly increase or decrease the fitness of the organism in particular environments.
- Through artificial selection, humans affect variation in other species.
- Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species.
- Evolution is also driven by random occurrences. Mutation is a random process that contributes to evolution. Genetic drift is a nonselective process occurring in small populations. Bottlenecks, Founder effect, and Migration/gene flow can drive evolution.

- Reduction of genetic variation within a given population can increase the differences between populations.
- The mutation results in genetic variation, which provides phenotypes on which natural selection acts.
- Hardy-Weinberg is a model for describing and predicting allele frequencies in a nonevolving population. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are—(1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating, and (5) absence of selection. These conditions are seldom met, but they provide a valuable null hypothesis.
- Allele frequencies in a population can be calculated from genotype frequencies.
- Changes in allele frequencies provide evidence for the occurrence of evolution in a population.
- Small populations are more susceptible to random environmental impact than large populations.
- Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).
- Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution. Fossils can be dated by a variety of methods. These include: the age of the rocks where a fossil is found, the rate of decay of isotopes including carbon-14, geographical data, and Morphological homologies, including vestigial structures, which represent features shared by common ancestry.
- A comparison of DNA nucleotide sequences and/or protein amino acid sequences provides evidence for evolution and common ancestry.
- Many fundamental molecular and cellular features and processes are conserved across organisms.
- Structural and functional evidence supports the relatedness of organisms in all domains.
- Structural evidence indicates common ancestry of all eukaryotes; Membrane-bound organelles, linear chromosomes, and genes that contain introns.
- Populations of organisms continue to evolve.
- All species have evolved and continue to evolve— a. Genomic changes over time. b. Continuous change in the fossil record. c. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs. d. Pathogens evolve and cause emergent diseases.
- Phylogenetic trees and cladograms show evolutionary relationships among lineages.
- Phylogenetic trees and cladograms both show relationships between lineages, but phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms; Shared characters are present in more than one lineage and shared, derived characters indicate common ancestry and are informative for the construction of phylogenetic trees and cladograms. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.
- Phylogenetic trees and cladograms can be used to illustrate speciation that has occurred. The nodes on a tree represent the most recent common ancestor of any two groups or lineages.
- Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.
- Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.
- Speciation may occur when two populations become reproductively isolated from each other.

- The biological species concept provides a commonly used definition of species for sexually reproducing organisms. It states that species can be defined as a group capable of interbreeding and exchanging genetic information to produce viable, fertile offspring.
- Punctuated equilibrium is when evolution occurs rapidly after a long period of stasis. Gradualism is when evolution occurs slowly over hundreds of thousands or millions of years.
- Divergent evolution occurs when adaptation to new habitats results in phenotypic diversification. Speciation rates can be especially rapid during times of adaptive radiation as new habitats become available.
- Speciation results in diversity of life forms.
- Speciation may be sympatric or allopatric.
- Various prezygotic and postzygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations.
- Extinctions have occurred throughout Earth's history.
- Extinction rates can be rapid during times of ecological stress.
- Human activity can drive changes in ecosystems that cause extinctions.
- The amount of diversity in an ecosystem can be determined by the rate of speciation and the rate of extinction.
- Extinction provides newly available niches that can then be exploited by different species.
- The level of variation in a population affects population dynamics. Population ability to respond to changes in the environment is influenced by genetic diversity. Species and populations with little genetic diversity are at risk of decline or extinction. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures.
- Several hypotheses about the origin of life on Earth are supported with scientific evidence. Geological evidence provides support for models of the origin of life on Earth. Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until 3.9 bya, and the earliest fossil evidence for life dates to 3.5 bya. Taken together, this evidence provides a plausible range of dates when the origin of life could have occurred. b. There are several models about the origin of life on Earth. Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized because of the presence of available free energy and the absence of a significant quantity of atmospheric oxygen (O2). Organic molecules could have been transported to Earth by a meteorite or other celestial event. Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life. Inorganic molecules/monomers served as building blocks for the formation of more complex molecules, including amino acids and nucleotides. The joining of these monomers produced polymers with the ability to replicate, store, and transfer information.
- The RNA World Hypothesis proposes that RNA could have been the earliest genetic material.

Students will be able to...

- Describe characteristics of a biological concept, process, or model represented visually.
- Explain biological concepts and/or processes.
- Describe data from a table or graph, including describing relationships between variables.
- State the null hypothesis or predict the results of an experiment.
- Perform mathematical calculations, including mathematical equations in the curriculum.
- Explain biological concepts, processes, and/ or models in applied contexts.
- Describe data from a table or graph, including identifying specific data points.

- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.
- Propose a new/next investigation based on an evaluation of the evidence from an experiment.
- Represent relationships within biological models, including flowcharts.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.
- Explain relationships between different characteristics of biological concepts, processes, or models represented visually in theoretical contexts.
- Provide reasoning to justify a claim by connecting evidence to biological theories.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Mini Laboratory Reports or CER Protocols
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework.
- Student written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 7 Personal Progress Check
- Quizzes: Natural Selection, Population Genetics, Evidence of Evolution, Phylogeny, Speciation, and Origin of Life.
- AP Bio Unit 7 Progress Check FRQs
- AP Bio Unit 7 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Biology in Motion Evolution Simulation Lab
- HHMI: Pocket Mice Video and related activities
- Brine Shrimp Selection Lab
- AP Biology Lab Investigation 1: Artificial Selection
- Hardy Weinberg Selection Card Game
- Hardy Weinberg Practice Packet
- AP Biology Lab Investigation 2: Mathematical Modeling: Hardy-Weinberg
- Genetic Drift Internet Simulation Activity: http://www.biology.arizona.edu/evolution/act/drift/drift.html
- AP Biology Lab Investigation 3: Comparing DNA Sequences to Understand Evolutionary Relationships.
- "Need to Know": AP Biology, Origin of Life (https://www.biologycorner.com/APbiology/evolution/ch19_origin_of_life.html)

- Bozeman Science Origin of Life Video https://www.bozemanscience.com/011-the-origin-of-life-scientificevidence
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 4 (Sections 1, 3, 4), 17, 18, 19, 20, relevant sections of 21.
- Ask the Expert - Students view a cartoon of an isolating mechanism that leads to speciation. Students discuss what is happening in this cartoon and how it relates to speciation. Students complete research on other isolating mechanisms and draw their own cartoon to illustrate their learnings.

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.
- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Craft materials
- Brine Shrimp
- Planters
- Lights
- Soil
- Fast plant seeds
- Pill bugs
- Choice Chambers

UNIT 8 OVERVIEW

Content Area: Science

Unit Title: Ecology

Target Course/Grade Level: Advanced Placement Biology/Grades 11-12

Unit Summary: As a culmination of this course, Unit 8 brings together all other units to show how a system's interactions are directly related to the system's available energy and its ability to evolve and respond to changes in its environment. When highly complex living systems interact, communities and ecosystems will change based on those interactions. The more biodiversity present in a system, the more likely that system is to maintain its health and success in the face of disruption. Energy flows through systems; the rate of flow determines the success of the species within the systems. By this point in the curriculum, a student should be able to accurately determine what happens within biological systems when disruptions occur.

Approximate Length of Unit: 4 weeks

LEARNING TARGETS

NJ Student Learning Standards:

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

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.

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

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.

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Career Readiness, Life Literacies, and Key Skills:

9.3.ST.2 Use technology to acquire, manipulate, analyze and report data.

9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

9.3 ST.4 Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the role of STEM in society and the economy.

9.3.ST-ET.1 Use STEM concepts and processes to solve problems involving design and/or production.

9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

9.3.STSM.3 Analyze the impact that science and mathematics has on society.

9.3.STSM.4 Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

9.4.12.CI.1 Demonstrate the ability to reflect, analyze, and use creative skills and ideas.

9.4.12.CI.3 Investigate new challenges and opportunities for personal growth, advancement, and transition.

9.4.12.CT.1 Identify problem-solving strategies used in the development of an innovative product or practice.

9.4.12.CT.2 Explain the potential benefits of collaborating to enhance critical thinking and problem solving.

9.4.12.CT.3 Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that addresses a local or global issue (e.g., environmental justice).

9.4.12.CT.4 Participate in online strategy and planning sessions for course-based, school-based, or other project and determine the strategies that contribute to effective outcomes.

9.4.12.IML.2 Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of information, in media, data, or other resources.

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.

9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualizations for an intended audience.

9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change.

9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

9.4.12.TL.4: Collaborate in online learning communities or social networks or virtual worlds to analyze and propose a resolution to a real-world problem.

Interdisciplinary Connections and Standards:

ELA

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.

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.

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.

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.

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.

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.

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.
WHST.11-12.1 Write arguments focused on discipline-specific content.
WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.11-12.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
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.
WHST.11-12.6 Use technology, including the Internet, to produce, share, and update writing products in response to ongoing feedback, including new arguments or information.
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.
WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
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.
F.IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F.BF.A.1 Write a function that describes a relationship between two quantities.

Unit Understandings:
Students will understand that…

- Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
- The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
- Living systems are organized in a hierarchy of structural levels that interact.
- Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
- Evolution is characterized by changes in the genetic make-up of a population over time and is supported by multiple lines of evidence.

Unit Essential Questions:

- How does diversity among and between species in a biological system affect the evolution of species within the system?
- How does the acquisition of energy relate to the health of a biological system?
- How do communities and ecosystems change, for better or worse, due to biological disruption?
- How does a disruption of a biological system affect genetic information storage and transmission?
- How do species interactions affect the survival of an ecosystem?

Knowledge and Skills:

Students will know...

- Organisms respond to changes in their environment through behavioral and physiological mechanisms.
- Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.
- Individuals can act on information and communicate it to others.
- Communication occurs through various mechanisms. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success. Animals use visual, audible, tactile, electrical, and chemical signals to indicate dominance, find food, establish territory, and ensure reproductive success.
- Responses to information and communication of information are vital to natural selection and evolution. Natural selection favors innate and learned behaviors that increase survival and reproductive fitness. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.
- Organisms use energy to maintain organization, grow, and reproduce. Organisms use different strategies to regulate body temperature and metabolism. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures. Ectotherms lack efficient internal mechanisms for maintaining body temperature, though they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals. Different organisms use various reproductive strategies in response to energy availability. There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms—generally, the smaller the organism, the higher the metabolic rate. A net gain in energy results in energy storage or the growth of an organism. A net loss of energy results in a loss of mass and, ultimately, the death of an organism.
- Changes in energy availability can result in changes in population size.
- Changes in energy availability can result in disruptions to an ecosystem. A change in energy resources such as sunlight can affect the number and size of the trophic levels. A change in the producer level can affect the number and size of other trophic levels.
- Autotrophs capture energy from physical or chemical sources in the environment. Photosynthetic organisms capture energy present in sunlight. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, and this process can occur in the absence of oxygen.
- Heterotrophs capture energy present in carbon compounds produced by other organisms. Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.
- Populations comprise individual organisms that interact with one another and with the environment in complex ways.
- Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment. Population growth dynamics depend on a number of factors. Reproduction without constraints results in the exponential growth of a population.
- A population can produce a density of individuals that exceeds the system's resource availability.
- As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues.
- The structure of a community is measured and described in terms of species composition and species diversity.
- Communities change over time depending on interactions between populations.

- Interactions among populations determine how they access energy and matter within a community.
- Relationships among interacting populations can be characterized by positive and negative effects and can be modeled. Examples include predator/prey interactions, trophic cascades, and niche partitioning.
- Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics.
- Cooperation or coordination between organisms, populations, and species can result in enhanced movement of, or access to, matter and energy.
- Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.
- Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.
- The diversity of species within an ecosystem may influence the organization of the ecosystem.
- The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.
- An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.
- Mutations are random and are not directed by specific environmental pressures.
- The intentional or unintentional introduction of an invasive species can allow the species to exploit a new niche free of predators or competitors or to outcompete other organisms for resources.
- The availability of resources can result in uncontrolled population growth and ecological changes.
- The distribution of local and global ecosystems changes over time.
- Human impact accelerates change at local and global levels. The introduction of new diseases can devastate native species. Habitat change can occur because of human activity.
- Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.

Students will be able to...

- Identify experimental procedures that are aligned with the question, including identifying dependent and independent variables.
- Explain the relationship between experimental results and larger biological concepts, processes, or theories.
- Construct a graph, plot, or chart.
- Perform mathematical calculations, including rates.
- Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different.
- Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on data.
- Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject the null hypothesis.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- End of Unit Common Assessment - See folder for assessment links.
- Responses to conceptual problems from the Biozone AP Bio workbook assigned in class and for homework
- Student written and oral responses to practice FRQs.
- Student self-assessment through POGIL and group activities.
- Biozone AP Bio Unit 8 Personal Progress Check
- Quizzes: Responses to Environment, Energy Flow in Ecosystems, Population Ecology, Community Ecology, Biodiversity, and Ecosystem Disruptions.
- AP Bio Unit 8 MC Progress Check - Only available in an online format through the AP Classroom; cannot be downloaded/shared digitally.
- AP Bio Unit 8 Progress Check FRQs

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Traveling Through the Changing Biomes Essay
- Survivorship Curves Do Now
- Population Dispersal Pattern Do Now
- Prey-Predator Populations Computer Simulation
- Isle Royale: Moose and Wolves Populations Data Analysis Activity
- Hula Hoop Diversity Activity
- Population Dynamics Google Slides Presentation
- Population Dynamics Calculations Packet
- Competition Among Species Activity
- Human Impact on Ecosystems Google Slides Presentation
- Relevant Assignments from the Biozone AP Biology Student Workbooks
- Free Response Fridays
- Read, Outline, and Self Quizzes for Chapters 45-49.
- AP Biology Exam Review Packet and Materials

RESOURCES

Teacher Resources:

- Workbook: Greenwood, Tracey, et al. *Biozone AP Biology*. 3rd ed., Biozone International Ltd, 2021.
- Textbook: Evers, Christine A., and Cecie Starr. *Biology: The Unity and Diversity of Life*. 11th ed., Thomson Brooks/Cole, 2006.

- Manual: Biology Investigative Labs: An Inquiry-Based Approach. http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
- AP Biology Classroom, College Board Web Access.

Equipment Needed:

- Computer, display monitor, and Chromebook(s) for use with Google Slides presentations, video and animation presentations, and virtual demonstrations.
- Calculators
- Laboratory equipment and chemicals for demonstrations and labs.
- Hula Hoops
- Magnifying Glasses
- Stereoscopes