CURRICULUM

FOR

ADVANCED PLACEMENT BIOLOGY

GRADES 11-12

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

ACKNOWLEDGMENTS

Dr. Susan Dube, Program Supervisor of Science/Technology Education

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

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Subject/Course Title:
AP Biology
Grades 11-12

Date of Board Adoptions:
September 17, 2019

RAHWAY PUBLIC SCHOOLS CURRICULUM

Advanced Placement Biology – Grades 11-12

PACING GUIDE

Unit	Title	Pacing
1	Statistical Analysis & Scientific Process	3 weeks
2	Cell Structures, Function, & Maintenance of Homeostasis	4 weeks
3	Cellular Energetics	5 weeks
4	Cell Communication & Cell Cycle	3 weeks
5	Heredity	4 weeks
6	Gene Expression & Regulation	5 weeks
7	Natural Selection	5 weeks
8	Ecology	5 weeks
9	Post Activities	6 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.
- Assign group research and presentations to teach the class.
- Assign/allow for leadership roles during collaborative work and in other learning activities.

ELL 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.
- 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.

ADVANCED PLACEMENT BIOLOGY CURRICULUM

UNIT ONE – STATISTICAL ANALYSIS AND SCIENTIFIC PROCESS

Content Area: Advanced Placement Biology

Unit Title: Statistical Analysis and Scientific Process

Target Course/Grade Level: 10-12th grade

Unit Summary: In this unit, students gain knowledge about the statistical formulas utilized throughout the AP Biology course and use practice problems and data sets to calculate mean, median, mode, standard deviation, standard error, and chi-square values. They learn how these calculations are relevant to the content of the course. Students learn how to add and properly interpret error bars on graphs. Students then review the process for planning and carrying out an investigation. They engage in an introductory lab experience to collect and analyze data. In the analysis of this lab, students will calculate and interpret standard error of the mean and chi square values. These values will be included in trifolds the students create to present their experimental process, results, and conclusions. Properly placed error bars will be included in the graphs constructed for and explained in the trifold presentation. The summer assignment will also be reviewed and assessed during this time period.

Approximate Length of Unit: 3 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations - Planning and carrying out in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost,	**LS1.A – Structure and Function –** Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	**Stability and Change** - Feedback (negative or positive) can stabilize or destabilize a system.

risk, time), and refine the design accordingly.		
Connections to Nature of Science Scientific Investigations Use a Variety of Methods - Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.		**Cause and Effect** - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER
9.3.ST.1.Apply engineering skills in a project that requires project management, process control and quality assurance.
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.STET.1. Use STEM concepts and processes to solve problems involving design and/or production.
9.3.STET.5. Apply the knowledge learned in STEM to solve problems.
9.3.STSM.2.Apply science and mathematics concepts to the development of plans, processes and projects that address real world 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.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Mathematics:

NJSLS Math – Statistics – ID – A.1-4. Summarize, represent, and interpret data on a single count or measurement variable
NJSLS Math – Statistics – IC - A.1 & 2. Understand and evaluate random processes underlying statistical experiment

Educational Technology:
8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:
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.11-12.6. 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.

Unit Understandings:
Students will understand that…

- Living systems are organized in a hierarchy of structural levels that interact.
- Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
- Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
- Transmission of information results in changes within and between biological systems.

Unit Essential Questions:

- What mathematical operations and formulas are significant to the study of Biology?
- How can mathematics be used to help solve scientific problems, analyze data, describe natural phenomena, make predictions, and describe processes symbolically?
- What mathematical routines are appropriate for describing natural phenomena?
- How can data from an experiment be analyzed to reject or fail to reject a null hypothesis and form a conclusion?

- What type of graph best supports various types of data collected during an experiment?
- What is the significance of error bars on a graph and how can they be evaluated?
- What procedures should be considered and followed when carrying out a scientific investigation?
- What elements should be included when presenting a scientific experiment and/or argument?
- How can statistical analysis be used to assess the validity of experimental data?

Knowledge and Skills:

Students will know…..

- The steps of calculating a mean for a data set.
- The steps for calculating standard error.
- The process for placing standard error bars on a graph following the 95% confidence interval.
- If error bars of two or more sample means overlap then the difference between the values is not statistically significant.
- The steps for calculating a chi square value for a given data set and determine the p-value for that data set.
- How to interpret a chi square value in order to draw conclusions about an experiment.
- The definition of a null hypothesis and an alternative hypothesis.
- The steps that should be followed when designing a controlled experiment.
- The correct orientation, labeling, units, scaling, plotting, type, and trend lines for a graph.
- The difference between a line graph, bar graph, histogram, pie chart, dual Y graph, and box and whisker plot.
- A claim answers the scientific question that was posed.
- Claims must be supported with evidence from experimentation or biological principles, concepts, and processes.
- The evidence for a claim must relate to biological theory and connect to biological principals.
- Scientists must share, present, explain, and argue their evidence for review by the greater scientific community.
- 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—
    a. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success.
    b. Animals use visual, audible, tactile, electrical, and chemical signals to indicate dominance, find food, establish territory, and ensure reproductive success.

Performance Expectations:

Students will be able to …

- Perform mathematical calculations including means, rates, ratios, percentages, and the mathematical equations in the *AP Biology Equations and Formulas* sheet.
- Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different.
- Perform chi-square hypothesis testing.
- Use data to evaluate a hypothesis (or prediction), including rejecting or failing to reject a null hypothesis and supporting or refuting alternative hypothesis.
- Identify or pose a testable question based on an observation, data, or model of a system.
- State the null and alternative hypotheses or predict the outcome of an experiment.
- Identify experimental procedures aligned to a question including identifying the independent and dependent variables, control group, and constants.

- Make observations and collect data from a laboratory set up.
- Propose a new or follow up investigation based on the evaluation of the results of an experiment or the design methods of an experiment.
- Construct an appropriate graph for a given data set.
- Describe data from a table or graph including specific data points, describing trends or patterns in data, and/or describing relationships between variables.
- Make a scientific claim and support it with experimental evidence and knowledge of biological principles and concepts.
- Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.
- Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?
Trifold Presentation: *AP Bio Lab Investigation 12: Animal Behavior*
Quiz: *Statistics Quiz*
CollegeBoard AP Classroom Personal Progress Checks for AP Biology
Summative Assessments (1): *Summer Project Assessment (relates to planning scientific investigations and data analysis)*

- Students will evaluate the procedure for a scientific investigation to identify variables, the control group, and constants. Students will analyze and evaluate a data set to create a graph and form a conclusion about the scientific investigation.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?
Introduction to AP Biology Statistics and Calculations ppt.
Bozeman Standard Deviation and Error Videos
AP Biology Statistics Practice Worksheets
Oreo Cookie Statistics Practice Lab
M&M Chi Square Lab
AP Bio Lab Investigation 12: Animal Behavior
Relevant Assignments from the Biozone AP Biology Student Workbooks
Free Response Friday
Read, Outline, and Self Quiz for Chapters 1 and sections of 49 related to Kinesis and Taxis in Animals

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, choice chambers, and calculators

UNIT TWO – CELL STRUCTURE, FUNCTION, AND MAINTENANCE OF HOMEOSTASIS

Content Area: Advanced Placement Biology

Unit Title: Cell Structure, Function, and Maintenance of Homeostasis

Target Course/Grade Level: 10-12th grade

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. Students will explore the chemical and cellular reactions related to the transport of materials that help to maintain homeostasis in cells and throughout entire organisms. Major focus will be given to the osmotic processes in cells and in organisms that allow a balance of water to be maintained and for cells and organisms to respond to changes in the environment. Students learn that water and the properties of water play a vital role in the survival of individuals and biological systems. Students will also discover the importance of the cell wall in plants and analyze and calculate water potential in plant cells.

Approximate Length of Unit: 4 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.A: Structure and Function** • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Connections to Nature of Science Scientific Investigations Use a Variety of Methods Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.		**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

21st Century Life and Career Skills:

CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER
9.3.12.AGPL.2:. Apply the principles of classification, plant anatomy and plant physiology to plant production and management.
HEALTH SCIENCE CAREER CLUSTER
9.3.HLBRD.4:.Demonstrate the principles of solution preparation, sterile techniques, contamination control, and measurement and calibration of instruments used in biotechnology research.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER
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- 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.2.Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
9.3.STSM.4.Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Mathematics:
GMD – A.3 - Explain volume formulas and use them to solve problems
MG – A.1-3 - Apply geometric concepts in modeling situations

Educational Technology:
8.1.12.A.5 - Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:
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.11-12.6. 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.

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:

- Why is carbon a critical element to living organisms and their survival?
- How do prokaryotic and eukaryotic cells differ in structure and function?
- How is the structure of an organelle related to its function?
- How do eukaryotic organelles interact?
- How do organelles provide evidence of the evolutionary relationships between cells and organisms?

- How does surface to volume ratio affect the survivability of a cell?
- How do the unique properties of water help to sustain all life on Earth?
- What processes do organisms use to exchange matter with the environment in order to grow, reproduce, and maintain organization?
- What chemical qualities allow the plasma membrane to be selectively permeable?
- How are growth and dynamic homeostasis maintained across the membranes of organisms?
- How do organisms use feedback mechanisms to maintain vital internal conditions and respond to external environmental changes?
- How do homeostatic mechanisms, such as osmoregulation, reflect both common ancestry and divergence due to adaptation in different environments?
- What internal and external factors might disrupt dynamic homeostasis in organisms?
- How does the structure and function of subcellular components, and their interactions, effect essential cellular processes that help to maintain homeostasis in cells?
- What is the significance of water potential especially in plant cells?

Knowledge and Skills:

Students will know…..

- Atoms and molecules from the environment are necessary to build new molecules –
    a. 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 organisms.
    b. Phosphorus is used to build certain lipids.
- 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—
    a. Rough ER compartmentalizes the cell.
    b. 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.
    b. Mitochondria have a double membrane. The outer membrane is smooth, but the inner membrane is highly convoluted, forming folds.
    c. Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes.
    d. A vacuole is a membrane-bound sac that plays many and differing roles. In plants, a specialized large vacuole serves multiple functions.
    e. 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—
    a. Endoplasmic reticulum provides mechanical support, carries out protein synthesis on membrane-bound ribosomes, and plays a role in intracellular transport.
    b. Mitochondrial double membrane provides compartments for different metabolic reactions.
    c. Lysosomes contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell's organic materials, and programmed cell death (apoptosis).
    d. Vacuoles have many roles, including storage and release of macromolecules and cellular waste products. In plants, it aids in retention of water for turgor pressure.
- 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

a. 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.
b. As cells increase in volume, the relative surface area decreases and the demand for internal resources increases.
c. More complex cellular structures (e.g., membrane folds) are necessary to adequately exchange materials with the environment.
d. As organisms increase in size, their surface area-to-volume ratio decreases, affecting properties like rate of heat exchange with the environment.

- Organisms have evolved highly efficient strategies to obtain nutrients and eliminate wastes. Cells and organisms use specialized exchange surfaces to obtain and release molecules from or into the surrounding environment.
- The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- Living systems depend on properties of water that result from its polarity and hydrogen bonding.
- The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.
- Structure and function of polymers are derived from the way monomers are assembled.
  a. Lipids are nonpolar molecules –
     i. Differences in saturation determine the structure and function of lipids.
     ii. Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions are often hydrophobic.
- 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 channel 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—
  a. In exocytosis, internal vesicles fuse with the plasma membrane and secrete large macromolecules out of the cell.
  b. 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—
    a. Large quantities of water pass through aquaporins.
    b. Charged ions, including Na^+ and K^+, require channel proteins to move through the membrane.
    c. Membranes may become polarized by movement of ions across the membrane.
- Membrane proteins are necessary for active transport.
- Metabolic energy (such as from ATP) is required for 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—
    a. 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.

Performance Expectations:

Students will be able to …

- Describe the composition of macromolecules required by living organisms.
- Describe the structure and/ or function of subcellular components and organelles.
- Explain how subcellular components and organelles contribute to the function of the cell.
- Describe the structural features of a cell that allow organisms to capture, store, and use energy.
- Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.
- Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment.
- Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell.
- Describe the Fluid Mosaic Model of cell membranes.
- Explain how the structure of biological membranes influences selective permeability.
- Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.
- Describe the role of the cell wall in maintaining cell structure and function.
- Describe the mechanisms that organisms use to maintain solute and water balance.
- Describe the mechanisms that organisms use to transport large molecules across the plasma membrane.
- Explain how the structure of a molecule affects its ability to pass through the plasma membrane.
- Explain how concentration gradients affect the movement of molecules across membranes.
- Explain how osmoregulatory mechanisms contribute to the health and survival of organisms.
- Describe the processes that allow ions and other molecules to move across membranes.
- Describe the membrane- bound structures of the eukaryotic cell.

- Explain how internal membranes and membrane- bound organelles contribute to compartmentalization of eukaryotic cell functions.
- Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells.
- Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts.

EVIDENCE OF LEARNING

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

Laboratory Reports, Trifold Presentations, or CER: *AP Bio Lab Investigations,* Osmosis and Diffusion *Laboratory (Original Lab Version)* or *Lab 4: Diffusion and Osmosis*
Student responses to *Cellular Transport Free Response Questions*
Quizzes: Subcellular Components and Organelles, Significance of Water, Cell Membrane Structure, Cell Size, Osmosis, Water Potential, Passive vs. Active Transport, Endosymbiosis
CollegeBoard AP Classroom Personal Progress Checks for AP Biology

Summative Assessments (2):
Cellular Components Exam:
- Students will identify cell structures, explain their functions, and describe organelle interactions. Students will differentiate between prokaryotic and eukaryotic cells and explain the evolutionary process leading to different cell types and the acquisition of organelles.

Cellular Transport Processes Exam:
- Students will identify the components of the plasma membrane and its chemical characteristics describing how this affects cell transport processes. Students will diagram and explain why cell size is limited. They will identify, explain, and differentiate between cell transport processes and mechanisms.

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

AP Bio Lab Investigation, Osmosis and Diffusion Laboratory (Original Lab Version) or Lab 4: Diffusion and Osmosis
Plasma Membrane and Cell Transport Questions wkst
Diffusion & Osmosis Challenge Activity
Fun with Water Potential Packet
Membrane Modeling Activity
Transpiration Lab Bench Activity. http://www.phschool.com/science/biology_place/labbench/lab9/intro.html
AP Bio Lab Investigation, Lab 11: Transpiration
Surface to Volume Ratio and Cell Size Limitations from a PowerPoint
Bozeman Osmoregulation Video Guide
Osmoregulation in Halobacteria and Paramecium Activity Packet
Graph and Switch – Properties of Water Penny Lab
Ask the Expert – Organelle Research Activity
Modeling the Cell Membrane Activity
Surface to Volume Ratio Lab – Agar Cubes
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

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, light source/lamps, goggles, 10 mL micropipettes, Celsius thermometer, microscopes, stereoscopes, and calculators

UNIT THREE – CELLULAR ENERGETICS

Content Area: Advanced Placement Biology

Unit Title: Cellular Energetics

Target Course/Grade Level: 10-12th grade

Unit Summary: In Unit 3, students build on knowledge gained in Unit 1 about the structure and function of cells, focusing on cellular energetics. Living systems are complex in their organization and require constant energy input. Students learn that living systems exist in a highly complex organization that requires input of energy and the exchange of macromolecules. This unit also introduces how and in what conformations molecules called *monomers* bond together to form polymers with specific focus on carbohydrates and proteins. Students begin to understand how the structure of monomers and polymers determines their function. 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 later in the course while studying how cells use energy to fuel life processes.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.		• Energy drives the cycling of matter within and between systems.
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**PS3.D: Energy in Chemical Processes** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.	
Scientific Knowledge is Open to Revision in Light of New Evidence • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.		

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER

9.3.12.AG.1.Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.

9.3.12.AG-FD.2.
Apply principles of nutrition, biology, microbiology, chemistry and human behavior to the development of food pro ducts.
9.3.12.AG-PL.2. Apply the principles of classification, plant anatomy and plant physiology to plant production and management.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER
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, engineerin g and mathematics (STEM) workplaces.
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.ST-SM.2.
Apply science and mathematics concepts to the development of plans, processes and projects that address real worl d problems.
9.3.ST-SM.4.
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summ arize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Mathematics:
Number and Quantity – N-Q – A.1-3 - Reason quantitatively and use units to solve problems.
Statistics – S-ID – A.1-4 Summarize, represent, and interpret data on a single count or measurement variable

Educational Technology:
8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

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.11-12.6. 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.

Unit Understandings:

Students will understand that…

- 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.
- The highly complex organization of living systems requires 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:

- Why is carbon a critical element to organisms and their survival?
- Why is structure critical to the function of an enzyme?
- What interactions can enzymes have with other molecules that will enhance or reduce their activity?
- What environmental conditions will enhance or reduce enzymatic activity?
- Why do all living systems require a constant input of energy?
- How and why do organisms capture and store free energy?
- For what biological processes is energy used?
- How and why do organisms exchange matter with the environment?
- What biotic and abiotic factors affect cell activities related to energy and matter capture and use?
- How are all biological systems from cells and organisms to populations, communities and ecosystems affected by complex biotic and abiotic interactions involving exchange of matter and free energy?
- How does the structure and function of the subcellular components involved in energy and matter transformations and their interactions provide essential cellular processes?

Knowledge and Skills:

Students will know…..

- Describe the properties of the monomers and types of bonds that connect the monomers in biological macromolecules.
- 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 –

a. Carbon is used to build biological molecules such as carbohydrates, proteins and lipids. Carbon is used in storage compounds and cell formation in organisms.

- Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.
- Structure and function of polymers are derived from the way their monomers are assembled –
    a. Complex carbohydrates comprise sugar monomers whose structure determine the properties and functions of the molecules.
    b. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched.
- 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—
    a. 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—
    a. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions.
    b. 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 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—
    a. Energy input must exceed energy loss to maintain order and to power cellular processes.
    b. Cellular processes that release energy may be coupled with cellular processes that require energy.
    c. 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—
    a. 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—
    a. Electron transport chain reactions occur in chloroplasts, mitochondria, and prokaryotic plasma membranes.
    b. In cellular respiration, electrons delivered by NADH and $FADH_2$ 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
    c. 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.
    d. 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.
    e. 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 a greater ability to survive and/or reproduce in different environments.

Performance Expectations:
Students will be able to …

- Describe the composition of macromolecules required by living organisms.
- Describe the properties of enzymes.
- Explain how enzymes affect the rate of biological reactions.
- Explain how changes to the structure of an enzyme may affect its function.
- Explain how the cellular environment affects enzyme activity.
- Describe the role of energy in living organisms.
- Describe the structural features of a cell that allow organisms to capture, store, and use energy.
- Describe the photosynthetic processes that allow organisms to capture and store energy.
- Explain how cells capture energy from light and transfer it to biological molecules for storage and use.
- Describe the processes that allow organisms to use energy stored in biological macromolecules.
- Explain how cells obtain energy from biological macromolecules in order to power cellular functions.
- 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.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Report, Trifold Presentation, or CER: *AP Bio Lab Investigations on Photosynthesis, Cellular Respiration, and/or Enzyme Activity or Catalysis*
Student responses to *Enzyme, Photosynthesis, and Cellular Respiration Free Response Questions*
Quizzes: Enzymes, Photosynthesis, and Cellular Respiration
CollegeBoard AP Classroom Personal Progress Checks for AP Biology
Summative Assessments (2):
Exam on Enzymes – Students will describe the function of enzymes and the importance of enzymes structure in lowering reaction rates. Students will define denaturing, identifying environmental factors that can affect enzyme shape and function. Students will elaborate on the interactions these factors have with enzymes that affect their structure and function. Students will analyze graphs related to enzyme function and calculate and compare reaction rates.
Cellular Energy Exam – Students will describe, compare, and contrast the processes of photosynthesis and cellular respiration. They will evaluate the significance of these processes in maintaining life on Earth.

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

The Importance of Enzymes PowerPoint
Toothpickase Activity
McGraw Hill Enzyme Animation: (**http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_enzymes_work.html**)
Biomolecules Dehydration Synthesis Modeling Activity for Carbohydrates
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 Investigations, Enzyme Catalysis Laboratory (Original Lab Version)
Photosynthesis PowerPoint

Concord Consortium: Leaf Photosynthesis Activity
C3, C4, and CAM Plants Overview Chart and Questions wkst
Cell Respiration PowerPoint
Pearson LabBench Cell Respiration Activity
Bozeman Science Fermentation Video and Questions
Yeast Fermentation Lab – Measuring CO_2 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, relevant sections of 29 and 30

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, goggles, beakers, burettes, burette clamps, ring stand, graduated dosing cups, hot water bath, spectrophotometer, calculators

UNIT FOUR – CELL COMMUNICATION AND THE CELL CYCLE

Content Area: Advanced Placement Biology

Unit Title: Cell Communication and Cell Cycle

Target Course/Grade Level: 10-12th grade

Unit Summary: In Unit 4, 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.

Approximate Length of Unit: 3 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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-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.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.A – Structure and Function –** Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Connections to Nature of Science Scientific Investigations Use a Variety of Methods	**LS1.B: Growth and Development of Organisms** In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system.

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER
9.3.12.AG- PL.2.
Apply the principles of classification, plant anatomy and plant physiology to plant production and management.

HEALTH SCIENCE CAREER CLUSTER
9.3.HL-BRD.2.
Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular bi ology, organic chemistry and statistics to conduct effective biotechnology research and development of products.

9.3.HL-BRD.3.
Demonstrate basic knowledge of recombinant DNA, genetic engineering, bioprocessing, monoclonal antibody prod uction, nanotechnology, bioinformatics, genomics, proteomics and transcriptomics to conduct biotechnology resear ch and development.
9.3.HL-BRD.5.
Determine processes for product design and production and how that work contributes to an understanding of the bi otechnology product development process.
9.3.HL-BRD.6.
Summarize and explain the larger ethical, moral and legal issues related to biotechnology research, product develop ment and use in society.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER

9.3.ST.1.
Apply engineering skills in a project that requires project management, process control and quality assurance.

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.5.Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
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.ST-SM.2.
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
9.3.ST-SM.4.
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Educational Technology:
8.1.8.F.1 Explore a local issue, by using digital tools to collect and analyze data to identify a solution and make an informed decision.

NJSLS Social Studies - History, Culture, and Perspectives –
6.3.12.D.1. Analyze the impact of current governmental practices and laws affecting national security and/or individual civil rights/ privacy.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

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.11-12.6. 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.

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:

- How do organisms use feedback mechanisms to survive in changing internal and external environments?
- What is the evolutionary significance of similarities and differences in the homeostatic mechanisms employed by various organisms?
- What are the biological implications for disruptions to dynamic homeostasis?
- How are the timing and coordination of physiological events regulated in various organisms in order to maintain homeostasis?
- What intercellular and intracellular signals mediate gene expression?
- How do cell communication processes reflect shared evolutionary history between organisms?
- How do cells communicate with each other when in direct contact, over short distances, and over long distance?
- What is the role of signal reception in cellular response?
- How do changes in signal transduction pathways alter cellular response?
- How do interactions between the various parts and systems of an organism allow for the development of complex biological properties?
- What events occur during mitosis that allow genetic information to be passed from one cellular generation to the next?

Knowledge and Skills:
Students will know…..

- Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling—
    a. 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—
    a. 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—
    a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship.
    b. 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—
    a. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.
    b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.
    c. 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—
    a. 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—
    a. The cell cycle consists of sequential stages of interphase (G_1, S, G_2), mitosis, and cytokinesis.
- A cell can enter a stage (G_0) 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—
    a. Mitosis plays a role in growth, tissue repair, and asexual reproduction.
    b. Mitosis alternates with interphase in the cell cycle.
    c. 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).

Performance Expectations:

Students will be able to …

- Describe the ways that cells can communicate with one another.
- Explain how cells communicate with one another over short and long distances.
- Describe the components of a signal transduction pathway.
- Describe the role of components of a signal transduction pathway in producing a cellular response.
- Describe the role of the environment in eliciting a cellular response.
- Describe the different types of cellular responses elicited by a signal transduction pathway.

- Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.
- Describe positive and/ or negative feedback mechanisms.
- Explain how negative feedback helps to maintain homeostasis.
- Explain how positive feedback affects homeostasis.
- Describe the events that occur in the cell cycle.
- Explain how mitosis results in the transmission of chromosomes from one generation to the next.
- Describe the role of checkpoints in regulating the cell cycle.
- Describe the effects of disruptions to the cell cycle on the cell or organism.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Report, Trifold presentation, or CER: *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
Student responses to a *Cell Communication, Endocrine System, and Feedback Loop Free Response Questions*
Quizzes: Cell Signaling, Hormones, Feedback Loops, Cell Cycle Regulation
CollegeBoard AP Classroom Personal Progress Checks for AP Biology
Summative Assessments (1):
Cell Signaling & The Cell Cycle Exam – Students will define the various types of cell communication and the basic steps of the cell signaling process. They will relate cell signaling to the process of cell division and describe how a failure in the cell signaling process and/or the cell cycle can lead to the development of cancer. Students will explain feedback mechanisms and how they help to maintain homeostasis through specific examples of positive and negative feedback mechanisms.

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
Cell Communication Web Quest Project
POGIL activities on Cellular Communication and Signal Transduction Pathways
Disease: Failures of Cell Communication Research Activity
Cell Signaling Case Study
Endocrine System PowerPoint
Modeling Blood Sugar Regulation Activity
Feedback Mechanisms POGIL
Fight or Flight Response Video and Play by Play wkst. (http://learn.genetics.utah.edu/content/cells/cellcom/)
"How Cells Communicate During Fight or Flight" (http://learn.genetics.utah.edu/content/cells/fight_flight/)
POGIL: Nervous System
Modeling Mitosis Activity
Regulation of Cell Division PowerPoint
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

RESOURCES

Teacher Resources:

Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, microscopes

UNIT FIVE – HEREDITY

Content Area: Advanced Placement Biology

Unit Title: Heredity

Target Course/Grade Level: 10-12th grade

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. 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 learning 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.

Approximate Length of Unit: 4 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own	**LS1.A: Structure and Function** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	**Structure and Function** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.		
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.	**LS3.A: Inheritance of Traits** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as yet known function.	**Patterns** Empirical evidence is needed to identify patterns.
Science is a Human Endeavor Technological advances have influenced the progress of science and science has influenced advances in technology.		**Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1 Review career goals and determine steps necessary for attainment.
9.2.12.C.2 Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3 Identify transferable career skills and design alternate career plans.
9.2.12.C.7 Examine the professional, legal, and ethical responsibilities for both employers and employees in the gl obal workplace.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER
9.3.12.AGFD.2 Apply principles of nutrition, biology, microbiology, chemistry and human behavior to the develo pment of food products.

HEALTH SCIENCE CAREER CLUSTER
9.3.HL.1 Determine academic subject matter, in addition to high school graduation requirements, necessary for pu rsuing a health science career.

9.3.HLBRD.1.Summarize the goals of biotechnology research and development within legal and ethical protocols.
9.3.HLBRD.2.Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular biology, organic chemistry and statistics to conduct effective biotechnology research and development of products.
9.3.HLBRD.3.Demonstrate basic knowledge of recombinant DNA, genetic engineering, bioprocessing, monoclonal antibody production, nanotechnology,
bioinformatics, genomics, proteomics and transcriptomics to conduct biotechnology research and development.
9.3.HLBRD.4 Demonstrate the principles of solution preparation, sterile techniques, contamination control, and measurement and calibration of instruments used in biotechnology research.
9.3.HLBRD.5 Determine processes for product design and production and how that work contributes to an understanding of the biotechnology product development process.
9.3.HLBRD.6 Summarize and explain the larger ethical, moral and legal issues related to biotechnology research, product development and use in society.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER
9.3.ST.1.Apply engineering skills in a project that requires project management, process control and quality assurance.
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.5.Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
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.2. Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
9.3.STSM.4.Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Mathematics:
SSE – A.1. Interpret the structure of expressions
REI – A.1. Understand solving equations as a process of reasoning and explain the reasoning

MD.A.1-4. Calculate expected values and use them to solve problems

Educational Technology –
8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.

Social Studies:
6.3.12.D.1. Analyze the impact of current governmental practices and laws affecting national security and/or individual civil rights/ privacy.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

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.11-12.6. 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.

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 does DNA or RNA act as the primary source of heritable information?
- What events occur during meiosis and fertilization that allow genetic information to be passed from one generation to the next?
- What pattern(s) exists for the transmission of genetic information from parent to offspring?
- What is Mendelian genetics?
- Why can’t all inheritance patterns be explained through Mendelian inheritance patterns?

- Why do changes in genotype result in changes to phenotype?
- What biological processes increase genetic variation in organisms?
- How do the timing and coordination of specific events effect the normal development of an organism?
- What variety of mechanisms exist in organisms that help to regulate the timing and coordination of events that allow for normal development to occur?

Knowledge and Skills:

Students will know…..

- Meiosis is a process that ensures the formation of haploid gamete cells in sexually reproducing diploid organisms—
    a. Meiosis results in daughter cells with half the number of chromosomes of the parent cell.
    b. 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.
- 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—
    a. Rules of probability can be applied to analyze passage of single-gene traits from parent to offspring.
    b. The pattern of inheritance (monohybrid, dihybrid, sex-linked, and genetically linked genes) can often be predicted from data, including pedigree, that give 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—

a. 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—
    a. 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.
    b. In animals, mitochondria are transmitted by the egg and not by sperm; as such, traits determined by the mitochondrial DNA are maternally inherited.
    c. 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.

Performance Expectations:
Students will be able to …

- Explain how meiosis results in the transmission of chromosomes from one generation to the next.
- Describe similarities and/ or differences between the phases and outcomes of mitosis and meiosis.
- Explain how the process of meiosis generates genetic diversity.
- Explain the inheritance of genes and traits as described by Mendel's laws.
- Explain deviations from Mendel's model of the inheritance of traits.
- Explain how the same genotype can result in multiple phenotypes under different environmental conditions.
- Explain how chromosomal inheritance generates genetic variation in sexual reproduction.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Report, Trifold Presentation, or CER: *Sections of AP Bio Lab Investigations Lab 7: Cell Division: Mitosis and Meiosis*
Student responses to *Genetics* and *Mitosis and Meiosis Free Response Questions*
Quizzes: Meiosis, Mendelian Genetics, Non-Mendelian Genetics
CollegeBoard AP Classroom Personal Progress Checks for AP Biology
Summative Assessments (1):
Meiosis and Genetics Exam*:*

- Students will describe the process of meiosis and explain how it leads to a reduction in chromosome number and genetic variation in gametes. Students will evaluate the effects of errors in the meiotic process. Students will compare and contrast mitosis and meiosis. Students will calculate expected outcomes for genotype and phenotype frequencies for a variety of Mendelian and non-Mendelian traits. Students will construct and analyze pedigrees.

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 wkst
Bozeman Science Linked Genes Video and worksheet
Corn Genetics Chi Square Activity
Non-Mendelian Genetics PowerPoint
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 1 and Biozone AP Biology 2 Student Workbooks
Free Response Fridays
Read, Outline, and Self Quizzes for Chapters 9 (revisit), 10, 11, 12

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology
Equipment Needed: computers, LCD projector, internet access, microscopes, calculators

UNIT SIX – GENE EXPRESSION AND REGULATION

Content Area: Advanced Placement Biology

Unit Title: Gene Expression and Regulation

Target Course/Grade Level: 10-12th grade

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. They 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 the *monomers* for RNA and DNA bond together to form the larger polymers critical to gene expression and regulation. 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.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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-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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence	**LS1.A: Structure and Function** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	**Structure and Function** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.		
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**LS3.A: Inheritance of Traits** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER
9.3.12.AG.1 Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Resources Career Cluster.

HEALTH SCIENCE CAREER CLUSTER
9.3.HLBRD.1. Summarize the goals of biotechnology research and development within legal and ethical protocols
9.3.HLBRD.2.Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular biology, organic chemistry and statistics to conduct effective biotechnology research and development of products.
9.3.HLBRD.3.Demonstrate basic knowledge of recombinant DNA, genetic engineering, bioprocessing, monoclonal antibody production, nanotechnology, bioinformatics, genomics, proteomics and transcriptomics to conduct biotechnology research and development.
9.3.HL-BRD.4.
Demonstrate the principles of solution preparation, sterile techniques, contamination control, and measurement and

calibration of instruments used in biotechnology research.

9.3.HL-BRD.5.

Determine processes for product design and production and how that work contributes to an understanding of the biotechnology product development process.

9.3.HL-BRD.6.

Summarize and explain the larger ethical, moral and legal issues related to biotechnology research, product development and use in society.

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER

9.3.ST.1. Apply engineering skills in a project that requires project management, process control and quality assurance.

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.5.Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.

9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

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

9.3.ST-ET.2. Display and communicate STEM information.

9.3.ST-ET.3. Apply processes and concepts for the use of technological tools in STEM.

9.3.ST-ET.4. Apply the elements of the design process.

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

9.3.ST-ET.6.

Apply the knowledge learned in the study of STEM to provide solutions to human and societal problems in an ethical and legal manner.

9.3.ST-SM.1.

Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

9.3.ST-SM.2.

Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

9.3.ST-SM.3. Analyze the impact that science and mathematics has on society.

21st Century Learning Standards:

Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

I**nterdisciplinary Connections and Standards:**

Educational Technology:

8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

Social Studies:
6.3.12.D.1. Analyze the impact of current governmental practices and laws affecting national security and/or individual civil rights/ privacy.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:
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.11-12.6. 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.

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.
- The processing of genetic information is imperfect and is a source of genetic variation.

Unit Essential Questions:

- Why is carbon a critical element to organisms and their survival?
- How does DNA or RNA act as the primary source of heritable information?
- What matter do organisms attain from the environment in order to build proteins?
- What is the function of the nucleus in eukaryotic cell?
- What are the subcomponents of DNA and RNA and how do these affect the properties of these biological molecules?
- How is DNA replicated in cells?
- How does variation in the nucleotides of DNA and RNA increase the range of functions within a cell?
- How does variation in the amino acid sequences increase the range of functions within a cell?
- What membrane bound organelles are involved in the synthesis of proteins and enzymes in eukaryotic cells?
- How does the process of protein synthesis differ in prokaryotic and eukaryotic cells?

- What role do DNA and RNA play in the synthesis of proteins?
- How can changes in genetic sequences impact the amino acid sequence in a protein and thereby affect its function?

Knowledge and Skills:

Students will know…..

- Atoms and molecules from the environment are necessary to build new molecules –
    a. Carbon is used to build biological molecules such as proteins and nucleic acids. Carbon is used in storage compounds and cell formation in organisms.
    b. Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids.
- Structure and function of polymers are derived from the way their monomers are assembled –
    a. 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).
    b. 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 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.
- Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.
- Directionality of the subcomponents influences structure and function of the polymer—
    a. 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.
    b. 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.
    c. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain.
    d. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the overall 3-D 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 the protein.
- 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.
    b. The basic structural differences between DNA and RNA include the following:
        i. DNA contains deoxyribose and RNA contains ribose.
        ii. RNA contains uracil and DNA contains thymine.
        iii. DNA is usually double stranded; RNA is usually single stranded.
        iv. The two DNA strands in double-stranded DNA are antiparallel in directionality.
- 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—
    a. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases RNA molecules.
    b. Prokaryotic organisms typically have circular chromosomes, while eukaryotic organisms typically have multiple linear chromosomes.
- Prokaryotes and eukaryotes can contain plasmids, which are small extrachromosomal, 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 continuity of hereditary information—
  a. DNA is synthesized in the 5' to 3' direction.
  b. Replication is a semiconservative process—that is, one strand of DNA serves as the template for a new strand of complementary DNA.
  c. Helicase unwinds the DNA strands.
  d. Topoisomerase relaxes supercoiling in front of the replication fork.
  e. DNA polymerase requires RNA primers to initiate DNA synthesis.
  f. DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand.
  g. 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—
  a. mRNA molecules carry information from DNA to the ribosome.
  b. 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.
  c. 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. 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—
  a. Addition of a poly-A tail.
  b. Addition of a GTP cap.
  c. Excision of introns and splicing and retention of exons.
  d. 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 salient features of translation include—
  a. Translation is initiated when the rRNA in the ribosome interacts with the mRNA at the start codon.
  b. The sequence of nucleotides on the mRNA is read in triplets called codons.
  c. 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.
  d. Nearly all living organisms use the same genetic code, which is evidence for the common ancestry of all living organisms.
  e. tRNA brings the correct amino acid to the correct place specified by the codon on the mRNA.
  f. The amino acid is transferred to the growing polypeptide chain.
  g. The process continues along the mRNA until a stop codon is reached.

    h. The process terminates by 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—
    a. Observable cell differentiation results from the expression of genes for tissue-specific proteins.
    b. Induction of transcription factors during development results in sequential gene expression.
- Both prokaryotes and eukaryotes have groups of genes that are coordinately regulated—
    a. In prokaryotes, groups of genes called operons are transcribed in a single mRNA molecule. The lac operon is an example of an inducible system.
    b. 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—
    a. The function and amount of gene products determine the phenotype of organisms.
        a. The normal function of the genes and gene products collectively comprises the normal function of organisms.
        b. 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—
        a. Whether a mutation is detrimental, beneficial, or neutral depends on the environmental context.
        b. Mutations are the primary source of genetic variation.
- Errors in mitosis or meiosis can result in changes in phenotype—
        a. Changes in Chromosome Number Often Result in new phenotypes, including sterility caused by triploidy, and increased vigor of other polyploids.
        b. 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—
        a. 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.
        b. Related viruses can combine/recombine genetic information if they infect the same host cell.
        c. 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—

a. Electrophoresis separates molecules according to size and charge.
b. During polymerase chain reaction (PCR), DNA fragments are amplified.
c. Bacterial transformation introduces DNA into bacterial cells.
d. DNA sequencing determines the order of nucleotides in a DNA molecule.

Performance Expectations:
Students will be able to …

- Describe the composition of macromolecules required by living organisms.
- Describe the structural similarities and differences between DNA and RNA.
- Describe the structures involved in passing hereditary information from one generation to the next.
- Describe the characteristics of DNA that allow it to be used as the hereditary material.
- Describe the properties of monomers and the types of bonds that connect the monomers in biological macromolecules.
- Describe the mechanisms by which genetic information is copied for transmission between generations.
- Describe the mechanisms by which genetic information flows from DNA to RNA to protein.
- Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.
- Describe how the phenotype of an organism is determined by its genotype.
- Describe the types of interactions that regulate gene expression.
- Explain how the location of regulatory sequences relates to their function.
- Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism.
- Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.
- Describe the various types of mutation.
- Explain how changes in genotype may result in changes in phenotype.
- Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.
- Explain the use of genetic engineering techniques in analyzing or manipulating DNA.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Report, Trifold Presentation, or CER: *Lab 8: Biotechnology: Bacterial Transformation* and *Lab 9: Biotechnology: Restriction Enzyme Analysis of DNA*
Student responses to *Gene Expression and Regulation Free Response Questions*
Quizzes: DNA Replication, Protein Synthesis, and Gene Regulation
CollegeBoard AP Classroom Personal Progress Checks for AP Biology

Summative Assessments (2):
DNA Replication and Protein Synthesis Exam

- Students will identify the structure of DNA and describe its "direction" and charge.
- Students will explain the steps and identify the enzymes required for the replication of DNA and the processes of transcription and translation.
- Students will explain how a change in a nucleotide sequence (a mutation) can lead to the production of a different protein, a non-functional protein, or no protein.
- Students will explain the physiological effects as well as the evolutionary significance of these changes.

Gene Regulation Exam

- Students will compare and contrast prokaryotic and eukaryotic gene regulation.
- Students will describe epigenetics and the factors that affect the epigenome.

- Students will explain various biotechnological advances and genetic engineering techniques.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?
DNA Structure PowerPoint
Biomolecules Dehydration Synthesis Modeling Activity for DNA
Directionality of DNA Animations
Gene to Protein PowerPoint
Transcription and Translation Modeling Activity
Protein Synthesis Skit
Biomolecules Dehydration Synthesis Modeling Activity for Proteins
Effects of Mutations on Protein Production Analysis Packet
HHMI Bacterial ID Lab BioInteractive Activity
DNA Replication PowerPoint
DNA Replication Modeling Activity
Replication of DNA Animation
Eukaryotic Gene Regulation Song Activity
Online Resources for Eukaryotic Gene Regulation:
The Epigenome at a Glance: http://learn.genetics.utah.edu/content/epigenetics/intro/
Gene Control: http://learn.genetics.utah.edu/content/epigenetics/control/
Lick Your Rats: http://learn.genetics.utah.edu/content/epigenetics/rats/
PHET simulation, Gene Machine: The Lac Operon
Lac Operon AP Biology Simulation Guide wkst
Prokaryotic and Eukaryotic Gene Regulation PowerPoint
HHMI - Modeling the Regulatory Switches of the Pitx1 Gene in Stickleback Fish Activity
Biotechnology PowerPoint
The E. coli Insulin Factory Activity
Food for the Masses activity
Pearson Lab Bench Activity for Molecular Biology.
http://www.phschool.com/science/biology_place/labbench/lab6/intro.html
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

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, test tubes, incubator, hot water bath, microcentrifuge tubes, thermometers, beakers, graduated cylinders, stop watch, sterile inoculation loops,

microcentrifuge tube holder/float, disposable plastic needle-nose transfer pipettes, gel electrophoresis chambers and power supplies, masking tape, microwave oven, calculators

UNIT SEVEN – NATURAL SELECTION

Content Area: Advanced Placement Biology

Unit Title: Natural Selection

Target Course/Grade Level: 10-12th grade

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.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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.

Science & Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions	**LS1.A: Structure and Function** All cells contain genetic information in the form of DNA molecules.	**Structure and Function** Investigating or designing new systems or structures

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.
Analyzing and Interpreting Data Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS4.A: Evidence of Common Ancestry and Diversity** **G**enetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	**Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.	**LS4.B: Natural Selection** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.
Using Mathematics and Computational Thinking	**LS4.C: Adaptation**	

Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	• Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. • Natural selection leads to adaptation that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. • Adaptation also means that the distribution of traits in a population can change when conditions change. • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.	

Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena -A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.		

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.
9.2.12.C.7.Examine the professional, legal, and ethical responsibilities for both employers and employees in the global workplace.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER

9.3.12.AG.1.
Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Re sources Career Cluster.
9.3.12.AG-ANI.4.
Apply principles of animal reproduction to achieve desired outcomes for performance, development and/or econom ic production.
9.3.12.AG-ANI.6.
Classify, evaluate and select animals based on anatomical and physiological characteristics.
9.3.12.AG-PL.2.
Apply the principles of classification, plant anatomy and plant physiology to plant production and management.
9.3.12.AG-PL.3.
Propagate, culture and harvest plants and plant products based on current industry standards.
9.3.12.AG-PL.4.
Apply principles of design in plant systems to enhance an environment (e.g., floral, forest, landscape and farm).

HEALTH SCIENCE CAREER CLUSTER

9.3.HL-BRD.2.
Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular bi ology, organic chemistry and statistics to conduct effective biotechnology research and development of products

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER
9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.

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.5. Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
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.ST-SM.2.
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
9.3.ST-SM.4.
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summarize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

I**nterdisciplinary Connections and Standards:**
Mathematics:
SSE – 1.a and b - Interpret the structure of expressions
REI – 1.a – Reasoning with Equations and Inequalities

Educational Technology:
8.1.12.A.3 Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.
8.2.12.E.3 Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).
Educational Technology
8.1.12.A.4 Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:
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.11-12.6. 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.

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:

- How does natural selection cause the evolution of species?
- How does natural selection effect phenotypic variation in a population?
- What other random processes influence the evolution of organisms?
- How is DNA (and in some cases RNA) key in the process of evolution by natural selection?
- What scientific evidence exists for evolution by natural selection?
- What core processes and features have evolved and are found throughout a wide variety of organisms today?
- What are phylogenic trees and cladograms and how can they be used by scientists?
- What is speciation? How and why does it occur?
- What is extinction? How and why does it occur?
- How do scientists know that organisms are still evolving?
- What hypotheses exist regarding the natural origin of life on Earth and what scientific evidence supports these ideas?
- What is the evolutionary significance of structural and functional differences in prokaryotic and eukaryotic cells?
- How do changes in genotype effect changes in phenotype and thereby influence the evolutionary process?
- How do environmental factors influence the process of evolution in organisms?
- What effects can variation in a population have on the dynamics of the population, its survival rate, and its evolution?

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 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—
    a. Mutation is a random process that contributes to evolution.
    b. Genetic drift is a nonselective process occurring in small populations—
        i. Bottlenecks.
        ii. Founder effect.
    c. Migration/gene flow can drive evolution
- Reduction of genetic variation within a given population can increase the differences between population.
- 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—
    a. Fossils can be dated by a variety of methods. These include:
        i. The age of the rocks where a fossil is found
        ii. The rate of decay of isotopes including carbon-14
        iii. Geographical data
    b. Morphological homologies, including vestigial structures, 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.
    a. DNA and RNA are carriers of genetic information.
    b. Ribosomes are found in all forms of life.
    c. Major features of the genetic code are shared by all modern living systems.
    d. Core metabolic pathways are conserved across all currently recognized domains.
- Structural evidence indicates common ancestry of all eukaryotes ---
    a. Membrane bound organelles
    b. Linear chromosomes

    c. 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—
    a. 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.
    b. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms—
        i. Shared characters are present in more than one lineage.
        ii. Shared, derived characters indicate common ancestry and are informative for the construction of phylogenetic trees and cladograms.
        iii. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram.
    c. 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—
    a. 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.
    b. Genetically diverse populations are more resilient to environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure.
    c. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures.

- Describe the scientific evidence that provides support for models of the origin of life on Earth.
- Several hypotheses about the origin of life on Earth are supported with scientific evidence—
    a. Geological evidence provides support for models of the origin of life on Earth.
        i. 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—
        ii. 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 (O_2).
        iii. Organic molecules could have been transported to Earth by a meteorite or other celestial event.
    c. Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life—
        i. Inorganic molecules/monomers served as building blocks for the formation of more complex molecules, including amino acids and nucleotides.
        ii. 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.

Performance Expectations:

Students will be able to …

- Describe the causes of natural selection.
- Explain how natural selection affects populations.
- Describe the importance of phenotypic variation in a population.
- Explain how humans can affect biodiversity within a population.
- Explain the relationship between changes in the environment and evolutionary changes in the population.
- Explain how random occurrences affect the genetic makeup of a population.
- Describe the role of random processes in the evolution of specific populations.
- Describe the change in the genetic makeup of a population over time.
- Describe the conditions under which allele and genotype frequencies will change in populations.
- Explain the impacts on the population if any conditions of Hardy-Weinberg are not met.
- Describe the types of data that provide evidence of evolution.
- Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.
- Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry.
- Explain how shared, conserved, fundamental processes and features support the concept of common ancestry for all organisms.
- Describe the structural and functional evidence on cellular and molecular levels that provide evidence for the common ancestry of all eukaryotes.
- Explain how evolution is an ongoing process in all living organisms.
- Describe the types of evidence that can be used to infer an evolutionary relationship.
- Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness.
- Describe the conditions under which new species may arise.
- Describe the rate of speciation under different ecological conditions.
- Explain the processes and mechanisms that drive speciation.
- Describe factors that lead to the extinction of a population.
- Explain how the risk of extinction is affected by changes in the environment.

- Explain species diversity in an ecosystem as a function of speciation and extinction rates.
- Explain how extinction can make new environments available for adaptive radiation.
- Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures.

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Reports or Trifold Lab Presentation:
AP Bio Lab Investigations -
1: Artificial Selection
2: Mathematical Modeling: Hardy-Weinberg,
3: Comparing DNA Sequences to Understand Evolutionary Relationships ‘
Student responses to a variety of *AP Biology Evolution Free Response Questions*
Quizzes on the following topics: Natural Selection and Evolution, Hardy-Weinberg Problems, Speciation, Origin of Life
CollegeBoard AP Classroom Personal Progress Checks for AP Biology
Summative Assessments (2):
Evolution and Natural Selection Exam –

- Students will explain the process of natural selection as the mechanism for evolution.
- Students will identify and describe the work of the scientists who made significant discoveries leading to the theory of natural selection.
- They will identify and describe the four evidences of evolution.
- Students will compare and contrast DNA sequences in order to identify relatedness between organisms on an evolutionary scale.

Evolutionary Ancestry, Speciation, & the Origin of Life Exam*:*

- Students will construct and evaluate cladograms describing evolutionary ancestry among organisms.
- They will explain the various mechanisms that can lead to speciation.
- Students will explain, analyze, and evaluate the scientific experiments and arguments supporting how life originated on Earth.

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
Quick Speciation Activity (http://www.indiana.edu/~ensiweb/lessons/quick.speciation.pdf)
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-scientific-evidence)
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

RESOURCES

Teacher Resources:

Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, Microsoft Excel or Google Sheets, planters, lights, soil, fast plant (or alternative species) seeds, calculators

UNIT EIGHT – ECOLOGY & EXAM PREPARATION

Content Area: Advanced Placement Biology

Unit Title: Ecology & Exam Preparation

Target Course/Grade Level: 10-12th grade

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. This unit includes 2 weeks of in class review in preparation for the AP Biology exam which is given in May.

Approximate Length of Unit: 5 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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-LS2-6. 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-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.	**LS2.A: Interdependent Relationships in Ecosystems** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

• Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.D: Social Interactions and Group Behavior** Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.
	LS4.D: Biodiversity and Humans • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).	

	• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.	

21st Century Life and Career Skills:

CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.
9.2.12.C.7 Examine the professional, legal, and ethical responsibilities for both employers and employees in the global workplace.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER

9.3.12.AG.1.
Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Re sources Career Cluster.
9.3.12.AG-ANI.4.
Apply principles of animal reproduction to achieve desired outcomes for performance, development and/or econom ic production.
9.3.12.AG-ANI.6. Classify, evaluate and select animals based on anatomical and physiological characteristics.
9.3.12.AG-ENV.1. Use analytical procedures and instruments to manage environmental service systems.
9.3.12.AG-ENV.2. Evaluate the impact of public policies and regulations on environmental service system operations.
9.3.12.AG-ENV.3. Develop proposed solutions to environmental issues, problems and applications using. scientific principles of meteorology, soil science, hydrology, microbiology, chemistry and ecology.
9.3.12.AG-ENV.4 Demonstrate the operation of environmental service systems (e.g., pollution control, water treatment, wastewater treatment, solid waste management and energy conservation).
9.3.12.AGNR.1 Plan and conduct natural resource management activities that apply logical, reasoned and scientifi cally based solutions to natural resource issues and goals.
9.3.12.AG-NR.2 Analyze the interrelationships between natural resources and humans.
9.3.12.AG-NR.3 Develop plans to ensure sustainable production and processing of natural resources.
9.3.12.AG-PL.2.
Apply the principles of classification, plant anatomy and plant physiology to plant production and management.

9.3.12.AG-PL.3. Propagate, culture and harvest plants and plant products based on current industry standards.
9.3.12.AG-PL.4.
Apply principles of design in plant systems to enhance an environment (e.g., floral, forest, landscape and farm).

HEALTH SCIENCE CAREER CLUSTER

9.3.HL-BRD.2.
Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular bi ology, organic chemistry and statistics to conduct effective biotechnology research and development of products

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER

9.3.ST.1.
Apply engineering skills in a project that requires project management, process control and quality assurance.
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, engineerin g and mathematics (STEM) workplaces.
9.3.ST.4.
Understand the nature and scope of the Science, Technology, Engineering & Mathematics Career Cluster and the ro le of STEM in society and the economy.
9.3.ST.5.
Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in each of the Science, Technology, Engineering & Mathematics Career Pathways.
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.ST-SM.2.
Apply science and mathematics concepts to the development of plans, processes and projects that address real worl d problems.
9.3.ST-SM.4.
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summ arize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:
Mathematics:
Algebra - SSE – A.1. Interpret the structure of expressions
Algebra - REI – A.1. Understand solving equations as a process of reasoning and explain the reasoning
Statistics – MD.A.1-4. Calculate expected values and use them to solve problems

Educational Technology - 8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

NJSLS Social Studies - History, Culture, and Perspectives - 6.3.12.D.2.Analyze a current foreign policy issue by considering current and historical perspectives, examining strategies, and presenting possible actions.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

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.11-12.6. 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.

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.
- Transmission of information results in changes within and between biological systems.
- 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 a change in the genetic make-up of a population over time and is supported by multiple lines of evidence.
- Competition and cooperation are important aspects of biological systems.

Unit Essential Questions:

- How do ecological communities interact and what is the significance of these interactions to the sustainment of life on Earth?
- How does the variation of species in an environment impact population dynamics?
- How does the diversity of species within an environment influence the health and stability of an ecosystem?
- How do organism interactions result in the movement of matter and energy throughout ecosystems?
- What behavioral and physical factors influence the patterns of species distribution and abundance between and within populations?
- Why does the distribution of local and global ecosystems change over time?
- What impacts do human activities have on local, regional and global ecosystems?

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—
    a. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success.
    b. 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—
    a. Natural selection favors innate and learned behaviors that increase survival and reproductive fitness.
    b. 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—
    a. Organisms use different strategies to regulate body temperature and metabolism.
        i. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures.
        ii. 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.
    b. Different organisms use various reproductive strategies in response to energy availability.
    c. 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.
    d. A net gain in energy results in energy storage or the growth of an organism.
    e. A net loss of energy results in 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. A change in energy resources such as sunlight can affect the number and size of the trophic levels.
    b. 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—
    a. Photosynthetic organisms capture energy present in sunlight.
    b. 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.
    a. 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—
    a. Population growth dynamics depend on a number of factors.
        i. 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—
    a. The introduction of new diseases can devastate native species.
    b. Habitat change can occur because of human activity.
- Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.

Performance Expectations:

Students will be able to …

- Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.
- Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.
- Describe the strategies organisms use to acquire and use energy.
- Explain how changes in energy availability affect populations and ecosystems.
- Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.
- Describe factors that influence growth dynamics of populations.
- Explain how the density of a population affects and is determined by resource availability in the environment.
- Describe the structure of a community according to its species composition and diversity.

- Explain how interactions within and among populations influence community structure.
- Explain how community structure is related to energy availability in the environment.
- Describe the relationship between ecosystem diversity and its resilience to changes in the environment.
- Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long- term structure.
- Explain the interaction between the environment and random or preexisting variations in poulations.
- Explain how invasive species affect ecosystem dynamics.
- Describe human activities that lead to changes in ecosystem structure and/ or dynamics.
- Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics.

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?
Laboratory Reports, Trifold Presentation, or CER: Investigation 10: Energy Dynamics
Student responses to *Ecology Free Response Questions*
Quizzes: Population Dynamics, Symbiotic Relationships, Limiting Factors and Species Competition, Human Impact and Climate Change

Summative Assessments (2):

Overview of Ecology Exam

- Students will describe ecological principles related to population dynamics, symbiotic relationships, limiting factors and species competition, and human impact on the environment.
- They will calculate population density and evaluate graphs of various populations to explain the effects of various factors on organisms and their environment.

Behavioral Ecology Exam

- Students will identify and describe interactions and factors in the environment that can affect the behavior of an organism.
- Students will explain how the behaviors of organisms can affect ecosystems.
- Students will describe how behaviors can increase or decrease the survivability of individual organisms and species in an ecosystem.

AP Biology Released Practice Exams
Student responses to *Practice Free Response Questions*
CollegeBoard AP Classroom Personal Progress Checks for AP Biology

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 PowerPoint

Population Dynamics Calculations Packet
Competition Among Species Activity
Human Impact on Ecosystems PowerPoint
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

RESOURCES

Teacher Resources:
Teacher User and Answer Guides: Biozone AP Biology workbook
Textbook: Biology: The Unity and Diversity of Life, 11th edition by C. Starr & R. Taggart, 2006
Manual: Biology Investigative Labs: An Inquiry-Based Approach
http://apcentral.collegeboard.com/apc/members/courses/teachers_corner/218954.html
CollegeBoard: AP Classroom Resources for AP Biology

Equipment Needed: computers, LCD projector, internet access, stereoscopes, calculators

POST AP BIOLOGY EXAM ACTIVITIES

Content Area: Advanced Placement Biology

Title: After Exam Activities

Target Course/Grade Level: 10-12th grade

Summary: The AP Biology Exam is given on the 2nd Monday of May. This leaves a 5 week period before final exams where students complete a variety of learning activities and labs to supplement the content that was taught throughout the year. The activities cover a wide range of topics; infectious disease, gene editing, climate change, embryology, women and minorities in science, and bioethics. The students also go on a field trip to the Turtle Back Zoo and complete a research project on one of the animals observed at the zoo. During this time, the free response questions for the exam are released by the CollegeBoard and the students work with each other and the teacher to determine what the acceptable answers would have been during the exam. The students also spend a week reviewing for the final exam for the course during this time period.

Approximate Length of Unit: 6 weeks

LEARNING TARGETS

NJ Student Learning Standards:
Science:
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-LS2-6. 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-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.	**LS1.A: Structure and Function** Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

• Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.		
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence.	**LS3.A: Inheritance of Traits** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.
Connections to Nature of Science **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also	**Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.

	aids humanity by preserving landscapes of recreational or inspirational value.	
Connections to Nature of Science **Science is a Human Endeavor** • Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.	**ETS1.B: Developing Possible Solutions** When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	**Structure and Function** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

21st Century Life and Career Skills:
CAREER AWARENESS, EXPLORATION, AND PREPARATION

9.2.12.C.1. Review career goals and determine steps necessary for attainment.
9.2.12.C.2. Modify Personalized Student Learning Plans to support declared career goals.
9.2.12.C.3. Identify transferable career skills and design alternate career plans.
9.2.12.C.7 Examine the professional, legal, and ethical responsibilities for both employers and employees in the gl obal workplace.

AGRICULTURE, FOOD & NATURAL RESOURCES CAREER CLUSTER

9.3.12.AG.1.
Analyze how issues, trends, technologies and public policies impact systems in the Agriculture, Food & Natural Re sources Career Cluster.
9.3.12.AG-ENV.2. Evaluate the impact of public policies and regulations on environmental service system operations.
9.3.12.AG-ENV.3. Develop proposed solutions to environmental issues, problems and applications using. scientific principles of meteorology, soil science, hydrology, microbiology, chemistry and ecology.
9.3.12.AG-NR.2 Analyze the interrelationships between natural resources and humans.
9.3.12.AG-NR.3 Develop plans to ensure sustainable production and processing of natural resources.

HEALTH SCIENCE CAREER CLUSTER

9.3.HL-BRD.2.
Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular bi ology, organic chemistry and statistics to conduct effective biotechnology research and development of products

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER

9.3.ST.2. Use technology to acquire, manipulate, analyze and report data.
9.3.ST.5.Demonstrate an understanding of the breadth of career opportunities and means to those opportunities in e ach of the Science, Technology, Engineering & Mathematics Career Pathways.
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.ST-SM.2.
Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.

9.3.ST-SM.4.
Apply critical thinking skills to review information, explain statistical analysis, and to translate, interpret and summ arize research and statistical data.

21st Century Learning Standards:
Career Ready Practices:

- **CRP1.** Act as a responsible and contributing citizen and employee.
- **CRP2.** Apply appropriate academic and technical skills.
- **CRP4.** Communicate clearly and effectively and with reason.
- **CRP5.** Consider the environmental, social and economic impacts of decisions.
- **CRP6.** Demonstrate creativity and innovation.
- **CRP7.** Employ valid and reliable research strategies.
- **CRP8.** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP9.** Model integrity, ethical leadership and effective management.
- **CRP11.** Use technology to enhance productivity.
- **CRP12.** Work productively in teams while using cultural global competence.

I**nterdisciplinary Connections and Standards:**
Mathematics:
S-ID – A.1-4 Summarize, represent, and interpret data on a single count or measurement variable

Educational Technology:
8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.

Social Studies:
6.3.12.D.2.Analyze a current foreign policy issue by considering current and historical perspectives, examining strategies, and presenting possible actions.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

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

EVIDENCE OF LEARNING

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

- Students will respond to multiple choice and free response questions that cover all of the content covered throughout the course.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?
Current Year AP Biology Free Response Questions Review and Analysis
"Cell"ection Organelle Poster Activity
Origami Embryo Modeling
Selected Lessons from Tufts University Infectious Disease Curriculum
Buffalo Case Study – Murder by HIV
"And the Band Played On" HBO Film and Analysis Activity
Climate Detectives Activity
"Chasing Ice" Documentary and Analysis Activity
Genome Editing and CRISPR Activity
"GATTACA" Movie and Analysis Questions
Annual Trip to the Turtle Back Zoo and Related Research Project
"Hidden Figures" Movie and Analysis Activity
Frog Dissection
Biology Escape Room Scavenger Hunt
Final Exam Review Packet

RESOURCES

Teacher Resources:

Teacher User and Answer Guides: *Buffalo Case Study – Murder by HIV Teacher's Guide, Climate Detectives Activity Answer Key, Genome Editing and CRISPR Activity Teacher's Guide, and Tufts University Infectious Disease Curriculum Answer Keys*

Equipment Needed: computers, LCD projector, internet access