Verona Public School District
Curriculum Overview

AP Biology

Curriculum Committee Members:
Casey Harris

Supervisor:
Glen Stevenson

Curriculum Developed:
Summer 2017

Board Approval Date:
August 29, 2017

Verona Public Schools
121 Fairview Ave., Verona, NJ 07044
www.veronaschools.org

Verona Public Schools Mission Statement:

The mission of the Verona Public Schools, the center of an engaged and supportive community, is to empower students to achieve their potential as active learners and productive citizens through rigorous curricula and meaningful, enriching experiences.

Course Description:

Advanced Placement Biology is a course designed to be the equivalent of a two-semester college introductory biology course which is usually taken by biology majors during their first year in college. A major goal is to provide the students with the conceptual framework, factual knowledge, critical thinking skills, analytical skills, and laboratory experience that will enhance their understanding of biological principles. AP students must possess an extraordinary work ethic and solid performance in the comprehension of scientific reading material such as published articles, text, and laboratory protocols. The course given at VHS follows the syllabus of the AP Biology Committee of the College Board.

Prerequisite(s):

Biology Honors or Teacher Recommendation

Standard 8: Technology Standards	
8.1: Educational Technology: *All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.*	**8.2: Technology Education, Engineering, Design, and Computational Thinking - Programming:** *All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.*
A. Technology Operations and Concepts **X** B. Creativity and Innovation **X** C. Communication and Collaboration D. Digital Citizenship E. Research and Information Fluency **X** F. Critical thinking, problem solving, and decision making	**X** A. The Nature of Technology: Creativity and Innovation **X** B. Technology and Society C. Design **X** D. Abilities for a Technological World E. Computational Thinking: Programming

SEL Competencies and Career Ready Practices	
Social and Emotional Learning Core Competencies: *These competencies are identified as five interrelated sets of cognitive, affective, and behavioral capabilities*	**Career Ready Practices:** *These practices outline the skills that all individuals need to have to truly be adaptable, reflective, and proactive in life and careers. These are researched practices that are essential to career readiness.*
Self-awareness: The ability to accurately recognize one's emotions and thoughts and their influence on behavior. This includes accurately assessing one's strengths and limitations and possessing a well-grounded sense of confidence and optimism.	**X** CRP2. Apply appropriate academic and technical skills. CRP9. Model integrity, ethical leadership, and effective management. CRP10. Plan education and career paths aligned to personal goals.
Self-management: The ability to regulate one's emotions, thoughts, and behaviors effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working toward achieving personal and academic goals.	CRP3. Attend to personal health and financial well-being. CRP6. Demonstrate creativity and innovation. **X** CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP11. Use technology to enhance productivity.
Social awareness: The ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behavior, and to recognize family, school, and community resources and supports.	CRP1. Act as a responsible and contributing citizen and employee. CRP9. Model integrity, ethical leadership, and effective management.
Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. This includes communicating clearly, listening actively, cooperating, resisting inappropriate social pressure, negotiating conflict constructively, and seeking and offering help when needed.	**X** CRP4. Communicate clearly and effectively and with reason. CRP9. Model integrity, ethical leadership, and effective management. CRP12. Work productively in teams while using cultural global competence.
Responsible decision making: The ability to make constructive and respectful choices about personal behavior and social interactions based on consideration of ethical standards, safety concerns, social norms, the realistic evaluation of consequences of various actions, and the well-being of self and others.	**X** CRP5. Consider the environmental, social, and economic impact of decisions. **X** CRP7. Employ valid and reliable research strategies. **X** CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP9. Model integrity, ethical leadership, and effective management.

Standard 9: 21st Century Life and Careers		
9.1: Personal Financial Literacy: *This standard outlines the important fiscal knowledge, habits, and skills that must be mastered in order for students to make informed decisions about personal finance. Financial literacy is an integral component of a student's college and career readiness, enabling students to achieve fulfilling, financially-secure, and successful careers.*	**9.2: Career Awareness, Exploration & Preparation:** *This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.*	**9.3: Career and Technical Education:** *This standard outlines what students should know and be able to do upon completion of a CTE Program of Study.*
A. Income and Careers B. Money Management C. Credit and Debt Management D. Planning, Saving, and Investing **X** E. Becoming a Critical Consumer F. Civic Financial Responsibility G. Insuring and Protecting	A. Career Awareness (K-4) B. Career Exploration (5-8) **X** C. Career Preparation (9-12)	A. Agriculture, Food & Natural Res. B. Architecture & Construction C. Arts, A/V Technology & Comm. D. Business Management & Admin. E. Education & Training F. Finance G. Government & Public Admin. H. Health Science I. Hospital & Tourism J. Human Services K. Information Technology L. Law, Public, Safety, Corrections & Security M. Manufacturing N. Marketing **X** O. Science, Technology, Engineering & Math P. Transportation, Distribution & Log.

Course Materials	
Core Instructional Materials: *These are the board adopted and approved materials to support the curriculum, instruction, and assessment of this course.*	**Differentiated Resources**: *These are teacher and department found materials, and also approved support materials that facilitate differentiation of curriculum, instruction, and assessment of this course.*
● Principles of Life (2nd Edition) by Hillis, Sadava, Hill and Price	● Albert.io assessment tools ● Review books from Barron's and Pearson ● College Board Secure and Released Exams

AP Biology

Big Idea 1: The process of evolution drives the diversity and unity of life. (Units 1 & 2 focus on this big idea)
Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis. (Units 2 & 3 focus on this big idea)
Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Units 2 & 6 focus on this big idea)
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties (Units 3 & 4 focus on this big idea)

Unit 1: Unity & Diversity

Unit Duration: 4 weeks (September)

Stage 1: Desired Results

Established Goals: College Board Learning Objectives

2.14 The student is able to use representations and models to describe differences in prokaryotic and eukaryotic cells. [See SP 1.4]
1.14 The student is able to pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth. [See SP 3.1]
1.15 The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. [See SP 7.2]
1.16 The student is able to justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. [See SP 6.1]
1.17 The student is able to pose scientific questions about a group of organisms whose relatedness is described by a phylogenetic tree or cladogram in order to (1) identify shared characteristics, (2) make inferences about the evolutionary history of the group, and (3) identify character data that could extend or improve the phylogenetic tree. [See SP 3.1]
1.18 The student is able to evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation. [See SP 5.3]
1.19 The student is able create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set. [See SP 1.1]
1.25 The student is able to describe a model that represents evolution within a population. [See SP 1.2]
1.26 The student is able to evaluate given data sets that illustrate evolution as an ongoing process. [See SP 5.3]
1.27 The student is able to describe a scientific hypothesis about the origin of life on Earth. [See SP 1.2]
1.28 The student is able to evaluate scientific questions based on hypotheses about the origin of life on Earth. [See SP 3.3]
1.29 The student is able to describe the reasons for revisions of scientific hypotheses of the origin of life on Earth. [See SP 6.3]
1.30 The student is able to evaluate scientific hypotheses about the origin of life on Earth. [See SP 6.5]
1.31 The student is able to evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. [See SP 4.4]
1.32 The student is able to justify the selection of geological, physical, and chemical data that reveal early Earth conditions. [See SP 4.1]
3.27 The student is able to compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. [See SP 7.2]
3.28 The student is able to construct an explanation of the multiple processes that increase variation within a population.
3.29 The student is able to construct an explanation of how viruses introduce genetic variation in host organisms. [See SP 6.2]
3.30 The student is able to use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population. [See SP 1.4]
4.1 The student is able to explain the connection between the sequence and the subcomponents of a biological polymer and its properties. [See SP 7.1]
4.2 The student is able to refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer. [See SP 1.3]
4.3 The student is able to use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule. [See SP 6.1, 6.4]
4.17 The student is able to analyze data to identify how molecular interactions affect structure and function. [See SP 5.1]

Transfer Goal: Students will be able to <u>independently</u> use their learning to demonstrate how scientists collect data about natural selection in populations.

Students will understand that:

- Observations of cell structures allow us to identify and classify life's diversity
- Some cell structures were once their own free living organisms
- Organisms maintain stable internal environments
- Organic macromolecules make up and perform the work of cells
- Darwin's Theory of Natural Selection to explains the similarities and differences between organisms.
- A wide range of evidence supports evolution.

College Board Enduring Understandings
1.A: Change in the genetic makeup of a population over time is evolution.
1.B: Organisms are linked by lines of descent from common ancestry.
1.C: Life continues to evolve within a changing environment.
1.D: The origin of living systems is explained by natural selection
4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment

Central question: How can a natural mechanism simultaneously produce all of life's similarities and differences?

Essential Questions:

- How did Long Horned Cattle develop their horns?
- Why would a bird have a tail that inhibited its ability to fly?
- How did seashells get onto mountaintops?
- Why do eukaryotes occupy such a small branch on the tree of life?
- Are viruses alive?
- Why are two identical frogs considered separate species?
- Should we be concerned about overusing antibiotics?
- Can the accuracy of phylogenetic methods be tested?

Students will know:

- The major characteristics of the three domains and four eukaryotic kingdoms, including characteristics of life
- How to analyze phylogenies and use cladograms
- The relationship between viruses and the domains of life
- The evidence for endosymbiotic theory
- The structures and functions of the organic macromolecules and other key biochemistry concepts, including Watson/Crick/Franklin lesson
- Darwin's theory of natural selection
- Reasons and evidence for speciation

College Board Essential knowledge

- 4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- 4.A.2: The structure and function of subcellular components, and their interactions, provide essential cellular processes.
- 4.B.1: Interactions between molecules affect their structure and function.
- 1.A.1: Natural selection is a major mechanism of evolution.
- 1.A.2: Natural selection acts on phenotypic variations in populations.
- 1.A.3: Evolutionary change is also driven by random processes.
- 1.A.4: Biological evolution is supported by scientific evidence from many disciplines, including mathematics.
- 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
- 1.B.2: Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
- 1.C.1: Speciation and extinction have occurred throughout the Earth's history.
- 1.C.2: Speciation may occur when two populations become reproductively isolated from each other.
- 1.C.3: Populations of organisms continue to evolve.
- 1.D.1: There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
- 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.
- 4.C.3: The level of variation in a population affects population dynamics.
- 3.C.2: Biological systems have multiple processes that increase genetic variation

Students will be able to:

- Differentiate between the three domains of life
- Justify the selection of chemical data that reveals Earth's early conditions.
- Evaluate hypotheses about the formation of life on Earth and provide reasons why early hypotheses were revised.
- Make a scaled timeline
- Justify the claim that organisms share many conserved core processes
- Use the theory of natural selection to explain life's unity and diversity
- Pose scientific questions that identify properties of shared, core life processes.
- Use data to support hypotheses about evolutionary relationships
- Evaluate evidence in order to create cladograms or other evolutionary trees and to pose questions and make inferences to improve cladograms.
- Construct an explanation of the multiple processes that increase variation within a population.

Stage 2: Acceptable Evidence

Transfer Task: To design an experiment that will provide evidence for evolution by natural selection.

Unit 2: Genes, Heredity, & Evolution | **Unit Duration:** 7 weeks (October, November)

Stage 1: Desired Results

Established Goals: **College Board Learning Objectives**

1.1 The student is able to convert a data set from a table of numbers that reflect a change in the genetic makeup of a population over time and to apply mathematical methods and conceptual understandings to investigate the cause(s) and effect(s) of this change. [See SP 1.5, 2.2]
1.2 The student is able to evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution. [See SP 2.2, 5.3]
1.3 The student is able to apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future. [See SP 2.2]
1.9 The student is able to evaluate evidence provided by data from many scientific disciplines that support biological evolution. [See SP 5.3]
1.10 The student is able to refine evidence based on data from many scientific disciplines that support biological evolution. [See SP 5.2]
1.11 The student is able to design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology. [See SP 4.2]
1.12 The student is able to connect scientific evidence from many scientific disciplines to support the modern concept of evolution. [See SP 7.1]
1.13 The student is able to construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution. [See SP 1.1, 2.1]
1.20 The student is able to analyze data related to questions of speciation and extinction throughout the Earth's history. [See SP 5.1]
1.21 The student is able to design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history. [See SP 4.2]
1.22 The student is able to use data from a real or simulated population(s), based on graphs or models of types of selection, to predict what will happen to the population in the future. [See SP 6.4]
1.23 The student is able to justify the selection of data that address questions related to reproductive isolation and speciation. [See SP 4.1]
1.24 The student is able to describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift. [See SP 7.2]
3.1 The student is able to construct scientific explanations that use the structures and mechanisms of DNA and RNA to support the claim that DNA and, in some cases, that RNA are the primary sources of heritable information. [See SP 6.5]
3.2 The student is able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information. [See SP 4.1]
3.3 The student is able to describe representations and models that illustrate how genetic information is copied for transmission between generations. [See SP 1.2]
3.4 The student is able to describe representations and models illustrating how genetic information is translated into polypeptides. [See SP 1.2]
3.7 The student can make predictions about natural phenomena occurring during the cell cycle. [See SP 6.4]
3.8 The student can describe the events that occur in the cell cycle. [See SP 1.2]
3.9 The student is able to construct an explanation, using visual representations or narratives, as to how DNA in chromosomes is transmitted to the next generation via mitosis, or meiosis followed by fertilization. [See SP 6.2]
3.10 The student is able to represent the connection between meiosis and increased genetic diversity necessary for evolution. [See SP 7.1]
3.11 The student is able to evaluate evidence provided by data sets to support the claim that heritable information is passed from one generation to another generation through mitosis, or meiosis followed by fertilization. [See SP 5.3]
3.12 The student is able to construct a representation that connects the process of meiosis to the passage of traits from parent to offspring. [See SP 1.1, 7.2]
3.14 The student is able to apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets. [See SP 2.2]
3.15 The student is able to explain deviations from Mendel's model of the inheritance of traits. [See SP 6.5]
3.16 The student is able to explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. [See SP 6.3]
3.17 The student is able to describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits. [See SP 1.2]
3.24 The student is able to predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection. [See SP 6.4, 7.2]
3.25 The student can create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. [See SP 1.1]
3.26 The student is able to explain the connection between genetic variations in organisms and phenotypic variations in populations. [See SP 7.2]
4.22 The student is able to construct explanations based on evidence of how variation in molecular units provides cells with a wider range of functions. [See SP 6.2]
4.23 The student is able to construct explanations of the influence of environmental factors on the phenotype of an organism. [See SP 6.2]
4.24 The student is able to predict the effects of a change in an environmental factor on the genotypic expression of the phenotype. [See SP 6.4]
4.25 The student is able to use evidence to justify a claim that a variety of phenotypic responses to a single environmental factor can result from different genotypes within the population. [See SP 6.1]
4.26 The student is able to use theories and models to make scientific claims and/or predictions about the effects of variation within populations on survival and fitness. [See SP 6.4]

Transfer Goal: Students will be able to independently use their learning to use multiple mathematical routines to determine patterns of inheritance and explain what these patterns tell us about the nature of the genes being investigated.

Students will understand that:
- Gregor Mendel's work allowed us to develop the concept of a gene helped complete our understanding of evolution by natural selection
- Genes are located on chromosomes and their precise location can be determined through experimentation and data analysis
- Punnett squares and pedigrees allow us to determine patterns of heredity
- Mutations are heritable changes in DNA
- The structure of DNA explains its functions
- Genes are expressed via transcription and translation.

College Board Enduring Understandings

3.A: Heritable information provides for continuity of life.
3.C: The processing of genetic information is imperfect and is a source of genetic variation.
This unit will also deepen two enduring understandings from unit 1:
1.B: Organisms are linked by lines of descent from common ancestry.
1.C: Life continues to evolve within a changing environment.

Central Question: What mechanism could possibly preserve traits without blending, and yet still allow for changes in populations over time?

Essential Questions:
- Can you predict the phenotype of the offspring when you know the phenotype of the parents?
- How can we explain patterns of inheritance that don't match Mendel's pea plant data?
- How can a non-living molecule store information, replicate, and give rise to physical traits?
- Why is the rate of sickle cell anemia far higher than average in parts of Africa?
- How do antibiotics target bacterial protein synthesis? Why do they sometimes stop working?
- Why do we age?
- Was John Hopkins hospital right to have used Henrietta Lack's cells without her permission?
- Do heterozygotes have a mating advantage?

Students will know:
- To use Chi square calculations to determine whether observed patterns are meeting expected ones.
- That microevolution is a change of allele frequency from one generation to the next
- How to use Hardy-Weinberg equations to tell whether or not a population is evolving
- Sexual life cycles
- Eukaryotic cells copy their nuclei by mitosis
- Chromosome number is maintained generation to generation by meiosis plus fertilization
- Cancer is unregulated mitosis
- Genomes are full sequences of an organism's DNA
- The processes of transcription, translation and RNA editing

College Board Essential Knowledge

3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.
3.A.2: In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.
3.A.3: The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
3.A.4: The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
3.C.1: Changes in genotype can result in changes in phenotype.
3.C.2: Biological systems have multiple processes that increase genetic variation.
3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
3.C.1: Changes in genotype can result in changes in phenotype.

Students will be able to:
- Use Punnett squares and pedigrees to determine patterns of inheritance and predict offspring phenotype.
- Identify chromosomal disorders using karyotypes
- Explain patterns of inheritance using processes that include the cell cycle and mitosis or meiosis plus fertilization.
- Use knowledge of Mendelian and non-mendelian inheritance patterns to predict the relative distance between two genes in the genome.
- Use the Hardy Weinberg equilibrium to mathematically determine if populations are changing over time and then to design investigations to determine how.
- Apply Chi Square analysis to data to determine whether experimental results are meeting predicted expectations.
- Justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information.
- Construct an explanation, through visual representation or narrative, of how genetic information is copied for transmission and then transmitted via mitosis and via meiosis plus fertilization.
- Determine DNA sequence from protein structure (reverse engineer the double helix)
- Describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift
- Make scientific claims about the effects of variation within populations on survival and fitness.
- Use genome sequences to explain differences in cell function between species and to create hypotheses about evolutionary relationships.

Stage 2: Acceptable Evidence

Transfer Task: Analyze data sets to determine when and explain why patterns of inheritance are non-Mendelian.

Unit 3: Cell Transport	**Unit Duration:** 2-3 weeks (December)

Stage 1: Desired Results

Established Goals: College Board Learning Objectives

2.6 The student is able to use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion. [See SP 2.2]
2.7 Students will be able to explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination. [See SP 6.2]
2.8 The student is able to justify the selection of data regarding the types of molecules that an animal, plant or bacterium will take up as necessary building blocks and excrete as waste products. [See SP 4.1]
2.9 The student is able to represent graphically or model quantitatively the exchange of molecules between an organism and its environment, and the subsequent use of these molecules to build new molecules that facilitate dynamic homeostasis, growth and reproduction. [See SP 1.1, 1.4]
2.10 The student is able to use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure. [See SP 1.4, 3.1]
2.11 The student is able to construct models that connect the movement of molecules across membranes with membrane structure and function. [See SP 1.1, 7.1, 7.2]
2.12 The student is able to use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes. [See SP 1.4]
2.13 The student is able to explain how internal membranes and organelles contribute to cell functions. [See SP 6.2]
2.27 The student is able to connect differences in the environment with the evolution of homeostatic mechanisms. [See SP 7.1]
4.4 The student is able to make a prediction about the interactions of subcellular organelles. [See SP 6.4]
4.5 The student is able to construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. [See SP 6.2]
4.6 The student is able to use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. [See SP 1.4]

Transfer Goal: Students will be able to independently use their learning to design methods to investigate the effect of changing environments on living cells and cell models.

Students will understand that:

- Cells use a variety of methods to transport molecules
- The hydrophobic nature of the cell membrane helps explain the selective permeability of membranes and internal membranes allow eukaryotic cells to increase efficiency and grow larger than prokaryotic cells
- ATP is the energy source for cells

College Board Enduring Understanding

2.B: Growth, reproduction, and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.

Central Question: How did cells develop the ability to create internal environments that are different from their outside environment?

Essential Questions:

- Why is the search for water important in the search for life in outer space?
- Why do marine and freshwater organisms possess strikingly different traits?
- Why do my fingers get pruney?
- Why are cells small and round?
- How are large, complex proteins allowed into or through cell membranes?

Students will know:

- How diffusion and osmosis affect cells
- Active transport moves molecules from low to high concentration
- The parts of the endomembrane system and how they work together to create specialized molecules.
- Water potential calculations
- How the sodium potassium pump creates electrochemical gradients
- That ATP is made by phosphorylating ADP in an ongoing cycle

College Board Essential Knowledge

2.A.3: Organisms must exchange matter with the environment to grow, reproduce, and maintain organization
2.B.1: Cell membranes are selectively permeable due to their structure.
2.B.2: Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
2.B.3: Eukaryotic cells maintain internal membranes that partition the cell into specialized regions
4.B.1: Interactions between molecules affect their structure and function.
4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.

Students will be able to:

- Use digital scales
- Predict which cell(s) will eliminate wastes or procure nutrients faster.
- Connect membrane structure to energy efficiency in cells.
- Use knowledge of the endomembrane system to model how various proteins are produced within cells.
- Pose and answer scientific questions about the properties of cell membranes and selective permeability based on molecular structure.
- To justify predictions about the permeability of cell membranes to certain molecules.
- Construct models to connect the movement of molecules across membranes with membrane structures and functions.
- Justify a prediction of the cellular pathway that the synthesis a particular molecule followed based on the properties of that molecule.
- To use water potential calculations to justify predictions about how cells will change in various solutions.
- To model how electrochemical gradients are established with the sodium potassium pump
- Use representations and models to analyze situations or solve problems qualitatively and quantitatively to investigate whether dynamic homeostasis is maintained by the active movement of molecules across membranes.
- Design the primary protein structure of ion channels and provide examples of how such channels help a cell maintain homeostasis.

Stage 2: Acceptable Evidence

Transfer Task: To design an experiment to calculate the water potential of a root vegetable.

AP Biology

Unit 4: Energy Dynamics	**Unit Duration:** 5 weeks (January - February)

Stage 1: Desired Results

Established Goals: College Board Learning Objectives

1.15 The student is able to describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. [See SP 7.2]
2.1 The student is able to explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce. [See SP 6.2]
2.2 The student is able to justify a scientific claim that free energy is required for living systems to maintain organization, to grow or to reproduce, but that multiple strategies exist in different living systems. [See SP 6.1]
2.3 The student is able to predict how changes in free energy availability affect organisms, populations and ecosystems. [See SP 6.4]
2.4 The student is able to use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy. [See SP 1.4, 3.1]
2.5 The student is able to construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy. [See SP 6.2]
2.22 The student is able to refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems. [See SP 1.3, 3.2]
2.23 The student is able to design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions. [See SP 4.2, 7.2]
2.24 The student is able to analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems). [See SP 5.1]
4.11 The student is able to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities. [See SP 1.4, 4.1]
4.12 The student is able to apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. [See SP 2.2]
4.13 The student is able to predict the effects of a change in the community's populations on the community. [See SP 6.4]
4.14 The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. [See SP 2.2]
4.15 The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [See SP 1.4]
4.16 The student is able to predict the effects of a change of matter or energy availability on communities.[See SP 6.4]
4.18 The student is able to use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter. [See SP 1.4]
4.19 The student is able to use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. [See SP 5.2]
4.20 The student is able to explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. [See SP 6.3]
4.21 The student is able to predict consequences of human actions on both local and global ecosystems. [See SP 6.4]
4.27 The student is able to make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability. [See SP 6.4]

Transfer Goal:
Students will be able to <u>independently</u> use their learning to collect data to support the idea that environmental factors affect metabolic rates.

Students will understand that:
- Energy isn't created or destroyed but simply changes form.
- The way organisms use energy helps us define what life is
- Photosynthesis and cell respiration are integral parts of the flow of carbon through ecosystems.
- Internal membranes have, in part, allowed eukaryotic cells to develop greater complexity than prokaryotes.
- The biological diversity within an ecosystem affects the stability of that ecosystem.

College Board Enduring Understandings
2.A: Growth, reproduction, and maintenance of the organization of living systems require free energy and matter.
4.A: Interactions within biological systems lead to complex properties.
4.B: Competition and cooperation are important aspects of biological systems.
4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Central Question: How can our bodies produce enough energy to run so many complex process?

Essential Questions:
- Do living things defy the laws of thermodynamics?
- How did eukaryotic cells get so big?
- Where does the weight of an oak tree come from?
- How do plants make complex organic molecules?
- How can plants grow in the desert?
- Why do some populations grow while others remain steady, shrink, or disappear?

Students will know:
- How to solve problems using Gibbs free energy calculations.
- The ADP/ATP
- The major steps of glycolysis, the krebs cycle and the electron transport chain
- The light and dark reactions of photosynthesis
- How CAM and C4 plants avoid photorespiration
- How respirometers can be used to measure metabolism
- How environmental conditions affect the metabolic rate of regulators and conformers differently
- Food web and material cycle dynamics, including using quantitative methods to investigate them.
- Types of symbiosis
- How different types of competition affect populations

College Board Essential Knowledge
2.A.1: All living systems require constant input of free energy.
2.A.2: Organisms capture and store free energy for use in biological processes.
2.A.3: Organisms must exchange matter with the environment to grow, reproduce, and maintain organization
4.A.5: Communities are composed of populations of organisms that interact in complex ways.
4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.
4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter.
4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem.

Students will be able to:
- Construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.
- Analyze and model the flow of energy and matter in ecosystems.
- Design and carry out an experiment to test the effect of changes in environmental conditions on regulators and conformers.
- Calculate how gibbs free energy changes in exergonic and endergonic reactions.
- Provide evidence for glycolysis being an ancient process.
- Refine scientific models and questions about the effect of complex biotic and abiotic interactions on all biological systems, from cells and organisms to populations, communities and ecosystems.
- Design a plan for collecting data to show that all biological systems (cells, organisms, populations, communities and ecosystems) are affected by complex biotic and abiotic interactions.
- Apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy.
- Mathematically model population changes using logistic growth calculations.
- Use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter.
- Predict consequences of human actions on both local and global ecosystems
- Make scientific claims and predictions about how species diversity within an ecosystem influences ecosystem stability.
- To explain how cooperative interactions affect ecosystem dynamics.

Stage 2: Acceptable Evidence

Transfer Task: To design an investigation to test the impact of environmental conditions on the metabolic rate of living organisms.

AP Biology

Unit 5: Homeostasis, Communication, and Behavior	**Unit Duration:** 5 weeks (February - March)

Stage 1: Desired Results

Established Goals: College Board Learning Objectives

2.15 The student can justify a claim made about the effect(s) on a biological system at the molecular, physiological or organismal level when given a scenario in which one or more components within a negative regulatory system is altered. [See SP 6.1]
2.16 The student is able to connect how organisms use negative feedback to maintain their internal environments. [See SP 7.2]
2.17 The student is able to evaluate data that show the effects of changes in concentrations of key molecules on negative feedback mechanisms. [See SP 5.3]
2.18 The student can make predictions about how organisms use negative feedback mechanisms to maintain their internal environments. [See SP 6.4]
2.19 The student is able to make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models. [See SP 6.4]
2.20 The student is able to justify that positive feedback mechanisms amplify responses in organisms. [See SP 6.1]
2.21 The student is able to justify the selection of the kind of data needed to answer scientific questions about the relevant mechanism that organisms use to respond to changes in their external environment. [See SP 4.1]
2.25 The student can construct explanations based on scientific evidence that homeostatic mechanisms reflect continuity due to common ancestry and/or divergence due to adaptation in different environments. [See SP 6.2]
2.26 The student is able to analyze data to identify phylogenetic patterns or relationships, showing that homeostatic mechanisms reflect both continuity due to common ancestry and change due to evolution in different environments. [See SP 5.1]
2.27 The student is able to connect differences in the environment with the evolution of homeostatic mechanisms. [See SP 7.1]
2.28 The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. [See SP 1.4]
2.29 The student can create representations and models to describe immune responses. [See SP 1.1, 1.2]
2.30 The student can create representations or models to describe nonspecific immune defenses in plants and animals.[See SP 1.1, 1.2]
2.35 The student is able to design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. [See SP 4.2]
2.36 The student is able to justify scientific claims with evidence to show how timing and coordination of physiological events involve regulation. [See SP 6.1]
2.37 The student is able to connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. [See SP 7.2]
2.38 The student is able to analyze data to support the claim that responses to information and communication of information affect natural selection. [See SP 5.1]
2.39 The student is able to justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms. [See SP 6.1]
2.40 The student is able to connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior. [See SP 7.2]
3.6 The student can predict how a change in a specific DNA or RNA sequence can result in changes in gene expression. [See SP 6.4]
3.18 The student is able to describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. [See SP 7.1]
3.19 The student is able to describe the connection between the regulation of gene expression and observed differences between individuals in a population. [See SP 7.1]
3.20 The student is able to explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. [See SP 6.2]
3.21 The student can use representations to describe how gene regulation influences cell products and function. [See SP 1.4]
3.23 The student can use representations to describe mechanisms of the regulation of gene expression. [See SP 1.4]
3.31 The student is able to describe basic chemical processes for cell communication shared across evolutionary lines of descent. [See SP 7.2]
3.32 The student is able to generate scientific questions involving cell communication as it relates to the process of evolution. [See SP 3.1]
3.33 The student is able to use representation(s) and appropriate models to describe features of a cell signaling pathway. [See SP 1.4]
3.34 The student is able to construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. [See SP 6.2]
3.35 The student is able to create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling. [See SP 1.1]
3.36 The student is able to describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response. [See SP 1.5]
3.37 The student is able to justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. [See SP 6.1]
3.38 The student is able to describe a model that expresses key elements to show how change in signal transduction can alter cellular response. [See SP 1.5]
3.39 The student is able to construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways. [See SP 6.2]
3.40 The student is able to analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. [See SP 5.1]
3.41 The student is able to create a representation that describes how organisms exchange information in response to internal changes and external cues, and which can result in changes in behavior. [See SP 1.1]
3.42 The student is able to describe how organisms exchange information in response to internal changes or environmental cues. [See SP 7.1]
3.43 The student is able to construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. [See SP 6.2, 7.1]
3.44 The student is able to describe how nervous systems detect external and internal signals. [See SP 1.2]
3.45 The student is able to describe how nervous systems transmit information. [See SP 1.2]
3.46 The student is able to describe how the vertebrate brain integrates information to produce a response. [See SP 1.2]
3.47 The student is able to create a visual representation of complex nervous systems to describe/explain how these systems detect external and internal signals, transmit and integrate information, and produce responses. [See SP 1.1]
3.48 The student is able to create a visual representation to describe how nervous systems detect external and internal signals. [See SP 1.1]
3.49 The student is able to create a visual representation to describe how nervous systems transmit information. [See SP 1.1]
3.50 The student is able to create a visual representation to describe how the vertebrate brain integrates information to produce a response. [See SP 1.1]
4.8 The student is able to evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts. [See SP 3.3]
4.9 The student is able to predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s). [See SP 6.4]
4.10 The student is able to refine representations and models to illustrate biocomplexity due to interactions of the constituent parts.[See SP 1.3]

Transfer Goal:
Students will be able to <u>independently</u> use their learning to be able to explain cancer as a cell signaling problem.

Students will understand that:

College Board Enduring Understandings

4.A: Interactions within biological systems lead to complex properties.
3.B: Expression of genetic information involves cellular and molecular mechanisms.
3.D: Cells communicate by generating, transmitting, and receiving chemical signals.
2.C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.
3.E: Transmission of information results in changes within and between biological systems.
2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
2.E: Many biological processes involved in growth, reproduction, and dynamic homeostasis include temporal regulation and coordination.

Central question: How do complex multicellular organisms coordinate the activities of trillions of cells?

Essential Questions:

- Why aren't we sick all the time?
- How do my muscles contract and relax?
- How can one molecule make chocolate taste terrible?
- How do mutations in genes for transcription factors affect cells?
- Can some forest fires be a good thing?
- How do signaling problems lead to cancer?

Students will know:	**Students will be able to:**
- That cell signaling pathways involve the steps of reception, transduction, and response - The importance of electrochemical gradients in nerve cell function - How neuromuscular pathways allow us to move - Systems of gene expression were first discovered in prokaryotes - The expression of eukaryotic genes is controlled by different mechanisms than prokaryotic genes. - Genes are negatively and positively regulated and this allows organisms to save energy College Board Essential Knowledge 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes. 2.C.2: Organisms respond to changes in their external environments. 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis. 2.D.1: All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments. 2.D.4: Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis. 2.E.3: Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection. 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization. 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression 3.D.1: Cell communication processes share common features that reflect a shared evolutionary history. 3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling. 3.D.3: Signal transduction pathways link signal reception with cellular response. 3.D.4: Changes in signal transduction pathways can alter cellular response. 3.E.1: Individuals can act on information and communicate it to others. 3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses. 4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.	● Model cell signaling pathways and construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling ● Construct an explanation, based on scientific theories and models, about how nervous systems detect external and internal signals, transmit and integrate information, and produce responses. ● Create representations of neuromuscular pathways in multicellular organisms ● Justify a claim made about the effect(s) on a biological system when given a scenario in which one or more components within a negative regulatory system is altered. ● Justify that positive feedback mechanisms amplify responses in organisms. ● Use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. ● To develop explanations of how specific and non-specific immune responses help different organisms maintain homeostasis. ● To create models and explanations that compare and contrast prokaryotic and eukaryotic gene expression ● Create models to demonstrate how changes in transduction pathways can lead to cancer. ● Design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. ● Justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms. ● Predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s) ● Use graphs and data tables to explain the effect of environment on plant and animal signaling and behavior. ● Create and explain models of operons in prokaryotes. ● Connect knowledge about chromatin structure to differential gene expression in eukaryotes.

Stage 2: Acceptable Evidence

Transfer Task: To create a detailed model of a cell signaling pathway of the students choice and demonstrate how the organism is affected from a change in one piece of the model.

AP Biology

Unit 6: Genomes, Genetic Engineering, and Development	**Unit Duration:** 5 weeks (March - April)

Stage 1: Desired Results

Established Goals: **College Board Learning Objectives**

2.31 The student can connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [See SP 7.2]
2.32 The student is able to use a graph or diagram to analyze situations or solve problems (quantitatively or qualitatively) that involve timing and coordination of events necessary for normal development in an organism. [See SP 1.4]
2.33 The student is able to justify scientific claims with scientific evidence to show that timing and coordination of several events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms. [See SP 6.1]
2.34 The student is able to describe the role of programmed cell death in development and differentiation, the reuse of molecules, and the maintenance of dynamic homeostasis. [See SP 7.1]
3.5 The student can justify the claim that humans can manipulate heritable information by identifying at least two commonly used technologies. [See SP 6.4]
3.13 The student is able to pose questions about ethical, social or medical issues surrounding human genetic disorders. [See SP 3.1]
3.22 The student is able to explain how signal pathways mediate gene expression, including how this process can affect protein production. [See SP 6.2]
4.7 The student is able to refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs. [See SP 1.3]

Transfer Goal:
Students will be able to independently use their learning to genetically engineer bacteria using plasmids.

Students will understand that:

- Computers are used to house genome data and to quickly compare DNA sequences to determine evolutionary relationships. This data is available to the public.
- The universal nature of DNA allows scientists to transfer any gene from one organism to another
- Fixing genetic disorders is possible, but because genes are expressed in complex ways this goal has been more difficult to achieve than it was first thought

College Board Enduring Understandings

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

3.B: Expression of genetic information involves cellular and molecular mechanisms.

3.C: The processing of genetic information is imperfect and is a source of genetic variation.

Central Question: Can we genetically engineer a human being?

Essential Questions:

- Whose DNA is this?
- What does genome sequencing reveal about organisms?
- What organisms are we most closely related to and how do we know?
- Can the secret to human origins be revealed by a computer?
- Can we cure cystic fibrosis?
- Can we limit our exposure to mutagens?
- How do animals grow into the right shape?
- How do you know if a cell has been successfully transformed?
- Why isn't the use of stem cells controversial anymore?

Students will know:

- How to use bioinformatics to analyze phylogenetic data
- That plasmids are used to introduce new traits into bacteria
- The proper development of an organisms requires timing and coordination
- The proper development of an organism requires gradients of specific molecules in the egg cell.
- Stem cells are undifferentiated cells of an early embryo
- Adult stem cells remain inside organisms to regenerate tissue.

College Board Essential Knowledge

2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.

4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues, and organs.

4.C.2: Environmental factors influence the expression of the genotype in an organism.

Students will be able to:

- Analyze evolutionary relationships using bioinformatics
- Conduct DNA comparisons using gel electrophoresis
- Connect concepts in and across domains to show that timing and coordination of specific events are necessary for normal development in an organism and that these events are regulated by multiple mechanisms.
- Illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.
- Pose questions about ethical, social or medical issues surrounding human genetic disorders.
- Use representations to describe how gene regulation influences cell products and function and leads to differences between individuals within and across species.
- Predict which of several mutations would be repaired most easily by cells.
- Make hypotheses about which level of eukaryotic gene expression is influencing changes in the phenotype of a population over time.
- To use knowledge of eukaryotic gene control to answer questions about evolution.
- Genetically engineer bacteria using plasmids

Stage 2: Acceptable Evidence

Transfer Task: To carry out an experiment to demonstrate that genes can be inserted into cells.