Randolph Township Schools
Randolph High School

AP Biology Curriculum

"Nothing in biology makes sense except in the light of evolution."
- Theodosius Dobszhansky

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Science, Technology, Engineering, and Math
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Board APPROVAL
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Randolph Township Schools
Department of Science, Technology, Engineering, and Math

AP Biology

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Randolph Township Schools

Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Randolph Township Schools
Affirmative Action Statement

Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

RANDOLPH TOWNSHIP BOARD OF EDUCATION
EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

Randolph Township Schools
Department of Science, Technology, Engineering, and Math

Advanced Placement Biology

AP Biology is an elective course in the STEM department for sophomores, juniors, and seniors who have completed first year Biology and have taken or are taking Chemistry concurrently. The course builds on the skills and concepts acquired in Honors Biology, and prepares students to:

- Successfully perform on the College Board AP Biology exam
- Build and develop a foundation of knowledge about how the living world operates from the molecular level through ecosystems
- Design, conduct, and interpret experiments that test biological phenomena, and to interpret the results of others
- Apply valid and current scientific information to decisions related to biological phenomena such as medical care, personal and social health, biotechnology, environmental and ecological impacts of human choices
- Succeed at the college level in biology-related coursework intended for science majors

Approximately 1/3 of the course time is devoted to the conduct of laboratory exercises, which include both predesigned and self-designed experiments, research, and model-building exercises. Students will gain skills necessary to produce, analyze, model, graph and draw conclusions from data. Students are expected to demonstrate an accurate and comprehensive knowledge of biology by using and applying biological knowledge to form and present supported scientific arguments both orally and in writing.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Curriculum Pacing Chart
AP Biology

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
3 weeks	I	Science as a Process, Chemistry of Life, Cellular Functions
4 weeks	II	Cellular Metabolism
8 weeks	III	Organismal and Molecular Genetics
6 weeks	IV	Mechanisms of Evolution and the Development of Biological Diversity
6 weeks	V	Plant and Animal Form and Function
4 weeks	VI	Ecology
5 weeks	VII	Applications of Biology

36 weeks is the average

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT I: Science as a Process, Chemistry of Life, and Cell Functioning

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
<tr><td rowspan="5">AP Biology Big Idea 1: The process of evolution drives the diversity and unit of life. (Essential Knowledge: 1A.4, 1B.1, 1D.2)

AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2A.3, 2B.1, 2B.2, 2B.3, 2C.2, 2D.3)

AP Biology Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. (Essential Knowledge: 4A.1, 4A.2, 4A.4, 4B.1, 4C.1)</td><td>Interactions within biological systems lead to complex properties.</td><td>• Is there an “essence of life”?</td></tr>
<tr><td>Growth, reproduction and maintenance of the organization of living systems require free energy and matter.</td><td>• How do you design an investigation?</td></tr>
<tr><td>Growth, reproduction, and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.</td><td>• How do organisms maintain homeostasis?</td></tr>
<tr><td>Growth and dynamic homeostasis of a biological system are influenced by changes in the system’s environment.</td><td>• Which comes first, structure or function?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

Organisms must exchange matter with the environment to grow, reproduce and maintain organization.</td><td>Students will be able to:

Use calculated surface area-to-volume ratios to predict which cell(s) might eliminate wastes or procure nutrients faster by diffusion.

Explain how cell size and shape affect the overall rate of nutrient intake and the rate of waste elimination.

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.</td></tr>
</table>

		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.
	Cell membranes are selectively permeable due to their structure.	Use representations and models to pose scientific questions about the properties of cell membranes and selective permeability based on molecular structure. Construct models that connect the movement of molecules across membranes with membrane structure and function.
	Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	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.
	Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	Explain how internal membranes and organelles contribute to cell functions. Use representations and models to describe differences in prokaryotic and eukaryotic cells.
	Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.	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. Design an experiment to demonstrate how negative feedback loops maintain homeostasis.

		Evaluate data that show the effect(s) of changes in concentrations of key molecules on negative feedback mechanisms. Make predictions about how negative feedback mechanisms are used to maintain an internal environment. Make predictions about how positive feedback mechanisms amplify activities and processes in organisms based on scientific theories and models. Justify that positive feedback mechanisms amplify responses in organisms.
	The subcomponents of biological molecules and their sequence determine the properties of that molecule.	Explain the connection between the sequence and the subcomponents of a biological polymer and its properties. Refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer. Use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.
	The structure and function of subcellular components, and their interactions, provide essential cellular processes.	Make a prediction about the interactions of subcellular organelles. Construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. Use representations and models to analyze situations qualitatively to describe how

	KEY TERMS: Covalent bonding, molecule, organic, polymer, metabolism, carbohydrate, protein, lipid, nucleic acid, membrane, enzyme, osmosis, diffusion	interactions of subcellular structures, which possess specialized functions, provide essential functions.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Calculating the significance of experimental data using the Chi-Square goodness of fit test.
- Designing an investigation to determine the effect of various factors on the rate of an enzymatic reaction.
- Constructing graphs and charts of experimental data.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab: Choice Chamber- Fruit Fly Behavior
- Lab: Diffusion and Osmosis- Measurement of Water Potential
- Lab: Catalase Enzyme Kinetics
- Lab: Properties of Water with Statistical Analysis

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT I: Science as a Process, Chemistry of Life, and Cell Functioning

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
3 weeks *Note: summer assignment covers Chapters 1-7 and is a review of first-year biology.*	Unit I: Science as a Process, Chemistry of Life, and Cell Functioning • Ch. 1 Themes in the Study of Life • Ch. 2 The Chemical Context of Life • Ch. 3 Water and Life • Ch. 4 Carbon and the Molecular Diversity of Life • Ch. 5 The Structure and Function of Large Biological Molecules • Ch. 6 A Tour of the Cell • Ch. 7 Membrane Structure and Function	Activity: M&Ms and Chi Squared Virtual Lab: Testing for Organic Molecules Virtual Lab: Enzyme-Controlled Reaction McGraw Hill Animations Concord Consortium Simulations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT II: Cellular Metabolism

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
<tr><td rowspan="5">AP Biology Big Idea 1: The process of evolution drives the diversity and unit of life. (Essential Knowledge: 1A.4, 1B.1, 1D.2)

AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2A.1, 2A.2, 2A.3, 2B.2, 2B.3, 2C.2, 2D.3, 2D.4, 2E.1, 2E.2, 2E.3)

AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Essential Knowledge: 3B.2, 3D.1, 3D.2, 3D.3, 3D.4, 3E.1)

AP Biology Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. (Essential Knowledge: 4A.1, 4A.2, 4A.4, 4B.1, 4B.2, 4C.1)</td><td>Growth, reproduction and maintenance of the organization of living systems require free energy and matter.</td><td>• How do cells use and create energy?</td></tr>
<tr><td>Continued life requires that cells create and maintain internal environments that are different from their external environments.</td><td>• How do cells maintain a constant internal environment?</td></tr>
<tr><td>Cells and organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.</td><td>• What are specific feedback mechanisms?
• How do cells and organisms interpret and respond to feedback?</td></tr>
<tr><td>Cells communicate by generating, transmitting, and receiving chemical signals.</td><td>• How and why do cells communicate?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

All living systems require constant input of free energy.</td><td>Students will be 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.

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.</td></tr>
</table>

		Predict how changes in free energy availability affect organisms, populations and ecosystems.
	Organisms capture and store free energy for use in biological processes.	Use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy. Construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy.
	Cell communication processes share common features that reflect a shared evolutionary history.	Describe basic chemical processes for cell communication shared across evolutionary lines of descent. Generate scientific questions involving cell communication as it relates to the process of evolution. Use representation(s) and appropriate models to describe features of a cell signaling pathway.
	Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	Construct explanations of cell communication through cell-to-cell direct contact or through chemical signaling. Create representation(s) that depict how cell-to-cell communication occurs by direct contact or from a distance through chemical signaling.
	Signal transduction pathways link signal reception with cellular response.	Describe a model that expresses the key elements of signal transduction pathways by which a signal is converted to a cellular response.

	Changes in signal transduction pathways can alter cellular response. **KEY TERMS:** Aerobic, respiration, fermentation, light reactions, Calvin cycle, citric acid cycle, glycolysis, carbon cycle, hormone, competitive inhibition, ATP, exergonic, endergonic, catabolic, anabolic, energy, coupling, cofactors, coenzymes, ATP synthase, oxidative phosphorylation, chemiosmosis, photophosphorylation, photosystems, pigments	Justify claims based on scientific evidence that changes in signal transduction pathways can alter cellular response. Describe a model that expresses key elements to show how change in signal transduction can alter cellular response. Construct an explanation of how certain drugs affect signal reception and, consequently, signal transduction pathways.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Designing an investigation to determine factors that influence the rate of cellular respiration.
- Modeling the processes of cellular respiration and photosynthesis.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab: Cellular Respiration in yeast or peas

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT II: Cellular Metabolism

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 weeks	Unit II: Cellular Metabolism • Ch. 8 An Introduction of Metabolism • Ch. 9 Cellular Respiration and Fermentation • Ch. 10 Photosynthesis • Ch. 11 Cell to Cell Communications	Demonstration: Leaf Disc Lab Virtual Lab: Photosynthesis One Virtual Lab: Photosynthesis Two Concord Consortium Simulations – Cellular Respiration Online Game: BioManBio - Photosynthesis McGraw Hill Animations Concord Consortium Simulations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT III: Organismal and Molecular Genetics

STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. *(Essential Knowledge: 3A.1, 3A.2, 3A.3, 3A.4, 3B.1, 3B.2, 3C.1, 3C.2, 3C.3)* **AP Biology Big Idea 4:** Biological systems interact, and these systems and their interactions possess complex properties. *(Essential Knowledge: 4A.1, 4C.1, 4C.2)*	Heritable information provides for continuity of life.	• How and why do living things store information?
	Expression of genetic information involves cellular and molecular mechanisms.	• How is information used during life?
	Transmission of information results in changes within and between biological systems.	• How are living things like, and not like, their ancestors and descendants?
	KNOWLEDGE	**SKILLS**
	Students will know: DNA, and in some cases RNA, is the primary source of heritable information. In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization. The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.	**Students will be able to:** Use models to demonstrate how information transfers from DNA to RNA to polypeptides. Compare the function of DNA and RNA in daily cell functioning. Make predictions about natural phenomena occurring during the cell cycle. Describe the events that occur in the cell cycle. Construct a representation that connects the process of meiosis to the passage of traits from parent to offspring.

		Pose questions about ethical, social or medical issues surrounding human genetic disorders. Apply mathematical routines to determine Mendelian patterns of inheritance provided by data sets.
	The inheritance pattern of many traits cannot be explained by simple Mendelian genetics	Explain deviations from Mendel's model of the inheritance of traits. Explain how the inheritance patterns of many traits cannot be accounted for by Mendelian genetics. Describe representations of an appropriate example of inheritance patterns that cannot be explained by Mendel's model of the inheritance of traits.
	Gene regulation results in differential gene expression, leading to cell specialization.	Describe the connection between the regulation of gene expression and observed differences between different kinds of organisms. Describe the connection between the regulation of gene expression and observed differences between individuals in a population.
	A variety of intercellular and intracellular signal transmissions mediate gene expression.	Explain how the regulation of gene expression is essential for the processes and structures that support efficient cell function. Use representations to describe how gene regulation influences cell products and function. Explain how signal pathways mediate gene expression, including how this process can affect protein production.

		Use representations to describe mechanisms of the regulation of gene expression.
	Changes in genotype can result in changes in phenotype.	Predict how a change in genotype, when expressed as a phenotype, provides a variation that can be subject to natural selection. Create a visual representation to illustrate how changes in a DNA nucleotide sequence can result in a change in the polypeptide produced. Explain the connection between genetic variations in organisms and phenotypic variations in populations.
	Biological systems have multiple processes that increase genetic variation.	Compare and contrast processes by which genetic variation is produced and maintained in organisms from multiple domains. Construct an explanation of the multiple processes that increase variation within a population.
	Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	Construct an explanation of how viruses introduce genetic variation in host organisms. Use representations and appropriate models to describe how viral replication introduces genetic variation in the viral population.
	The subcomponents of biological molecules and their sequence determine the properties of that molecule.	Explain the connection between the sequence and the subcomponents of a biological polymer and its properties. Refine representations and models to explain how the subcomponents of a biological polymer and their sequence determine the properties of that polymer.

		Use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule. Make a prediction about the interactions of subcellular organelles. Construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions.
	The structure and function of subcellular components and their interactions provide essential cellular processes.	Use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions.
	Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	Refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.
	KEY TERMS: Gene, chromosome, mutation, mitosis, binary fission, differentiation, replication, clone, tissue, organ, cancer, oncogene, cell cycle, gene expression, protein dose, germ line, dominant, recessive, codominant, allele, meiosis, crossing over, gamete, sexual reproduction, zygote, embryo, messenger RNA, ribosome, triplets, codons, transfer RNA, transgenic, intron, exon, base pairing, nucleotides, amino acids, X-linked, genome	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Calculating the probability of genotype and/or phenotype of future generations based on parental genotype and/or phenotype.
- Modeling how genetic information undergoes transcription and translation to create proteins, and how factors can regulate this process.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab and Virtual Lab: Cell Division: Mitosis and Meiosis
- Lab: Biotechnology: Bacterial Transformation
- Lab: Biotechnology: Restriction Enzyme Analysis

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT III: Organismal and Molecular Genetics

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
8 weeks	Unit III: Organismal and Molecular Genetics • Ch. 13 Meiosis and Sexual Life Cycles • Ch. 14 Mendel and the Gene Idea • Ch. 15 Chromosomal Basis of Inheritance • Ch. 16 Molecular Basis of Inheritance- Structure, Function and History and DNA • Ch. 17 From Gene to Protein • Ch. 18 Regulation of Gene Expression • Ch. 19 Viruses • Ch. 20 Biotechnology • Ch. 21 Genomes and their Evolution	Demo: Cell Differentiation Virtual Lab: Drosophila Genetics Virtual Lab: DNA Replication Virtual Lab: PCR Activity: PCR Paper Lab Virtual Lab: Gel Electrophoresis Virtual Lab: Bacterial Transformation Activity: Bacterial Transformation Paper Lab Movie: Ghost in Your Genes McGraw Hill Animations Concord Consortium Simulations Biotechnology Research Reports DNA-RNA-Protein Model Building

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT IV: Mechanisms of Evolution and the Development of Biological Diversity

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
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AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2A.2, 2C.2, 2D.1, 2D.2)

AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Essential Knowledge: 3A.1, 3A.2, 3A.3, 3C.1, 3C.2)

AP Biology Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. (Essential Knowledge: 4A.4, 4A.6, 4B.3, 4C.2, 4C.3, 4C.4)</td><td>Organisms are linked by lines of descent from common ancestry.</td><td>• What is a species?</td></tr>
<tr><td>Life continues to evolve within a changing environment.</td><td>• Why is diversity valuable?</td></tr>
<tr><td>The origin of living systems is explained by natural processes.</td><td>• Where did life come from?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

Natural selection is a major mechanism of evolution.</td><td>Students will be 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.

Evaluate evidence provided by data to qualitatively and quantitatively investigate the role of natural selection in evolution.

Apply mathematical methods to data from a real or simulated population to predict what will happen to the population in the future.</td></tr>
</table>

	Natural selection acts on phenotypic variations in populations.	Evaluate data-based evidence that describes evolutionary changes in the genetic makeup of a population over time. Connect evolutionary changes in a population over time to a change in the environment.
	Evolutionary change is also driven by random processes.	Use data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and effects of selection in the evolution of specific populations. Justify data from mathematical models based on the Hardy-Weinberg equilibrium to analyze genetic drift and the effects of selection in the evolution of specific populations. Make predictions about the effects of genetic drift, migration and artificial selection on the genetic makeup of a population.
	Biological evolution is supported by scientific evidence from many disciplines, including mathematics.	Evaluate evidence provided by data from many scientific disciplines that support biological evolution. Refine evidence based on data from many scientific disciplines that support biological evolution. Design a plan to answer scientific questions regarding how organisms have changed over time using information from morphology, biochemistry and geology. Synthesize scientific evidence from many scientific disciplines to support the modern concept of evolution.

		Construct and/or justify mathematical models, diagrams or simulations that represent processes of biological evolution.
	Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.	Pose scientific questions that correctly identify essential properties of shared, core life processes that provide insights into the history of life on Earth. 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. Justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
	Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	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. Evaluate evidence provided by a data set in conjunction with a phylogenetic tree or a simple cladogram to determine evolutionary history and speciation. Create a phylogenetic tree or simple cladogram that correctly represents evolutionary history and speciation from a provided data set.

	Speciation and extinction have occurred throughout the Earth's history.	Analyze data related to questions of speciation and extinction throughout the Earth's history. Design a plan for collecting data to investigate the scientific claim that speciation and extinction have occurred throughout the Earth's history
	Speciation may occur when two populations become reproductively isolated from each other.	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. Justify the selection of data that address questions related to reproductive isolation and speciation. Describe speciation in an isolated population and connect it to change in gene frequency, change in environment, natural selection and/or genetic drift.
	Populations of organisms continue to evolve.	Describe a model that represents evolution within a population. Evaluate given data sets that illustrate evolution as ongoing process.
	There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.	Describe a scientific hypothesis about the origin of life on Earth. Evaluate scientific questions based on hypotheses about the origin of life on Earth. Describe the reasons for revisions of scientific hypotheses of the origin of life on Earth.

	Scientific evidence from many different disciplines supports models of the origin of life. **KEY TERMS:** Population, adaptation, natural selection, artificial selection, sexual selection, fitness, genotype, phenotype, adaptive radiation, phylogeny, species, gene pool, extinction, genetic drift, reproductive isolation, biodiversity, Hardy-Weinberg equilibrium	Evaluate scientific hypotheses about the origin of life on Earth. Evaluate the accuracy and legitimacy of data to answer scientific questions about the origin of life on Earth. Justify the selection of geological, physical, and chemical data that reveal early Earth conditions.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Modeling natural selection as a mechanism of evolution.
- Calculating the allele frequencies of a population in Hardy-Weinberg equilibrium.
- Predicting the relatedness of species based on evolutionary data.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab: Mathematical Modeling: Hardy-Weinberg
- Lab: Cladistics and Phylogeny
- Lab: Comparing DNA Sequences to Understand

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT IV: Mechanisms of Evolution and the Development of Biological Diversity

SUGGESTED TIME ALLOTMENT	CONTENT – UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
6 weeks	Unit IV: Mechanisms of Evolution and the Development of Biological Diversity • Ch. 22 Descent with Modification • Ch. 23 The Evolution of Populations • Ch. 24 Origin of Species • Ch. 25 History of Life on Earth • Ch. 26 Phylogeny and the Tree of Life • Ch. 27 Bacteria and Archaea	HHMI Evolutionary Lessons Hardy-Weinberg Interactive Virtual Lab: Artificial Selection Activity: Candy Cladistics Evolutionary Relationships with BLAST Movie: What Darwin Never Knew McGraw Hill Animations Concord Consortium Simulations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT V: Plant and Animal Form and Function

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
<tr><td rowspan="8">AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2.A.1, 2A.2, 2A.3, 2B.1, 2B.2, 2B.3, 2C.1, 2C.2, 2D.1, 2D.2, 2.D.3, 2D.4, 2E.1, 2E.2, 2E.3)

AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Essential Knowledge: 3D.1, 3D.2, 3D.3, 3D.4, 3E.1, 3E.2)

AP Biology Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. (Essential Knowledge: 4A.4, 4B.2, 4C.1)</td><td>The diversity of species within an ecosystem may influence the stability of the ecosystem.</td><td>• How can a more complex system be stronger than a simple one?</td></tr>
<tr><td>Biological systems are affected by disruptions to their dynamic homeostasis.</td><td>• How much natural or manmade change can an ecosystem absorb before it fails?</td></tr>
<tr><td>Communities are composed of populations that interact in complex ways.</td><td>• Is every species equally important in nature?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.</td><td>Students will be able to:

Refine representations to illustrate how interactions between external stimuli and gene expression result in specialization of cells, tissues and organs.</td></tr>
<tr><td>Organisms exhibit complex properties due to interactions between their constituent parts.</td><td>Evaluate scientific questions concerning organisms that exhibit complex properties due to the interaction of their constituent parts.

Refine representations and models to illustrate biocomplexity due to interactions of the constituent parts.</td></tr>
<tr><td>Cooperative interactions within organisms promote efficiency in the use of energy and matter.</td><td>Use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter.</td></tr>
</table>

	Biological systems are affected by disruptions to their dynamic homeostasis.	Use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. Predict the effects of a change in a component(s) of a biological system on the functionality of an organism(s).
	Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.	Create representations and models to describe immune responses. Create representations or models to describe nonspecific immune defenses in plants and animals.
	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.	Describe the role of programmed cell death in development and differentiation, the reuse of molecules, and the maintenance of dynamic homeostasis. Design a plan for collecting data to support the scientific claim that the timing and coordination of physiological events involve regulation. Connect concepts that describe mechanisms that regulate the timing and coordination of physiological events. 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.

	Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.	Justify scientific claims, using evidence, to describe how timing and coordination of behavioral events in organisms are regulated by several mechanisms.
	Individuals can act on information and communicate it to others.	Analyze data to support the claim that responses to information and communication of information affect natural selection. Analyze data that indicate how organisms exchange information in response to internal changes and external cues, and which can change behavior. 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. Describe how organisms exchange information in response to internal changes or environmental cues.
	Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses	Connect concepts in and across domain(s) to predict how environmental factors affect responses to information and change behavior. 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. Describe how nervous systems detect external and internal signals. Describe how nervous systems transmit information.

	KEY TERMS: Stems, leaves, xylem, phloem, meristem, stomata, water potential, aquaporin, pollination, reception, transduction, response, tropism, auxins, organs, endocrine system, nervous system, immune system, homeostasis, feedback system	Describe how the vertebrate brain integrates information to produce a response. Create a visual representation to describe how nervous systems detect external and internal signals. Construct a visual representation to describe how nervous systems transmit information. Design a visual representation to describe how the vertebrate brain integrates information to produce a response.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Designing an investigation to determine factors that affect the rate of transpiration of a plant.
- Modeling how systems respond to stimuli and signals.
- Designing an investigation to analyze the ability of an organism to maintain homeostasis under stress.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab: Transpiration
- Lab: Comparative Anatomy
- Lab: Homeostasis self-designed physiology investigations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT V: Plant and Animal Form and Function

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
6 Weeks	Unit V: Plant and Animal Form and Function • Ch. 29 and 30: Plant Diversity • Ch. 35 Plant Structure, Growth, and Development • Ch. 36: Resource Acquisition in Plants • Ch. 39: Plant Responses to Internal and External Signals • Ch. 32, 33, and 34: Animal Diversity • Ch. 40 Basic Principles of Animal Form and Function • Ch. 48 Neurons • Ch. 49 Nervous Systems • Ch. 43 The Immune System • Ch. 45 The Endocrine System • Ch. 50 Sensory and Motor Mechanisms • Ch. 51 Animal Behavior	Activity: Plant Dissection Demo: Action Potential Immune System Model Building Nervous System Model Building Simulation: Mouse Party Neurotransmitters McGraw Hill Animations Concord Consortium Simulations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT VI: Ecology

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
<tr><td rowspan="6">AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2A.1, 2A.2, 2A.3, 2D.1, 2D.3)

AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Essential Knowledge: 3E.1)

AP Biology Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties. (Essential Knowledge: 4A.5, 4A.6, 4B.2, 4B.3, 4B.4, 4C.2, 4C.3, 4C.4)</td><td>The diversity of species within an ecosystem may influence the stability of the ecosystem.</td><td>• How can a more complex system be stronger than a simple one?</td></tr>
<tr><td>Biological systems are affected by disruptions to their dynamic homeostasis.</td><td>• How much natural or manmade change can an ecosystem absorb before it fails?</td></tr>
<tr><td>Communities are composed of populations that interact in complex ways.</td><td>• Is every species equally important in nature?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

All living systems require constant input of free energy.</td><td>Students will be 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.

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.

Predict how changes in free energy availability affect organisms, populations and ecosystems.</td></tr>
</table>

	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.	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. Analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system (cells, organisms, populations, communities or ecosystems).
	Biological systems are affected by disruptions to their dynamic homeostasis.	Use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems.
	Communities are composed of populations of organisms that interact in complex ways.	Justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities. Apply mathematical routines to quantities that describe communities composed of populations of organisms that interact in complex ways. Predict the effects of a change in the community's populations on the community.
	Interactions among living systems and with their environment result in the movement of matter and energy.	Apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy.

	Interactions between and within populations influence patterns of species distribution and abundance. Distribution of local and global ecosystems changes over time. The diversity of species within an ecosystem may influence the stability of the ecosystem. **KEY TERMS:** Ecosystem, community, trophic level, niche, food chain, food web, nitrogen cycle, carbon cycle, detritus, scavenger, predator, prey, parasite, symbiosis, commensalism, coevolution, hydrothermal vents, territoriality, inclusive fitness, reciprocity	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. Predict the effects of a change of matter or energy availability on communities. Use data analysis to refine observations and measurements regarding the effect of population interactions on patterns of species distribution and abundance. Explain how the distribution of ecosystems changes over time by identifying large-scale events that have resulted in these changes in the past. 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.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Predicting how changes in matter or energy will affect ecosystems.
- Analyzing consequences of human actions on both local and global ecosystems.

KEY LEARNING EVENTS AND INSTRUCTION:

- Lab: Energy dynamics in a living ecosystem

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT VI: Ecology

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 Weeks	Unit VI: Ecology • Ch. 52 Introduction to the Biosphere • Ch. 53 Population Ecology • Ch. 54 Community Ecology • Ch. 55 Ecosystems and Restoration Ecology • Ch. 56 Conservation Biology and Global Change	Simulation: Modeling Ecosystems Virtual Lab: Abiotic Factor Homeostasis Ecological Succession Studies Organism Distribution and Abundance Studies McGraw Hill Animations Concord Consortium Simulations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT VII: Applications of Biology

<table>
<tr><th>STANDARDS / GOALS:</th><th>ENDURING UNDERSTANDINGS</th><th>ESSENTIAL QUESTIONS</th></tr>
<tr><td rowspan="6">AP Biology Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, reproduce, and to maintain dynamic homeostasis. (Essential Knowledge: 2C.1, 2E.1)

AP Biology Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes. (Essential Knowledge: 3D.2, 3E.1)</td><td>Science is a human endeavor that inevitably involves a mixture of objectivity and bias.</td><td>• How do we know what we know?</td></tr>
<tr><td>Control and change of natural systems result in complex, and often unintended consequences.</td><td>• Where does science end and values begin?</td></tr>
<tr><td>Science provides a method for continuous improvement in human knowledge and control of the natural world and of ourselves.</td><td>• What questions should biological science focus on in the immediate future?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:
The purpose of biological content knowledge is to allow for understanding, prediction, and control of living systems.

The living world is a nonverbal system, requiring translation for human understanding.

Correctly designed and conducted investigations generate numerical data which answer questions.</td><td>Students will be able to:
Apply specific content knowledge to current practical issues of society.

Use representations and models to communicate scientific phenomena and solve scientific problems.

Use mathematics appropriately, including selection of suitable techniques to use.

Plan and implement data collection strategies appropriate to a particular scientific question.</td></tr>
</table>

	Interpretation of scientific data requires a mixture of many analytic techniques.	Perform data analysis and evaluation of evidence.
	A scientific theory is a verbal model of how major phenomena work and are related to each other; theories both generate good investigative ideas and explain the results but are always subject to revision based on evidence.	Work with scientific explanations and theories to inform and critique particular investigations.
	Practical application of biological knowledge requires us to move up and down the hierarchy of levels of analysis, from the atomic to the ecosystem level.	Connect and relate knowledge across various scales, concepts and representations in and across domains.
	A valid test of a hypothesis requires rigorous control of independent and extraneous variable; many strategies exist for this.	Evaluate research in terms of its importance, internal validity, and external validity.
	Science is inevitably driven by human needs, interests, and values, including the selection of questions to investigate and the development of technologies to implement new knowledge.	Distinguish appropriately between matters of empirical knowledge, opinion, and values.
	Change to one part of an incompletely understood system can result if major changes to other parts of the system.	Discover and discuss examples of the law of unintended consequences.
	Investigation of biological phenomena often involve historical data or the comparison of naturally occurring conditions rather than laboratory experiments.	Design and critique natural experiment techniques such as analysis of the fossil record, comparison of ecosystems, or epidemiological studies of disease.
	KEY TERMS: Will vary	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Conducting research on a current and relevant topic in biology.

KEY LEARNING EVENTS AND INSTRUCTION:

- Individual Research Project

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology
UNIT VII: Applications of Biology

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
5 Weeks	Unit VII: Applications of Biology Students will research and present a topic in biology from a list of options. Some possible topics/ investigations: 1. emerging infectious disease and public health issues 2. issues in conservation biology, ecosystem preservation and restoration 3. impacts of biotechnology in medicine and food supply Use of computational biology techniques in revising the proposed evolutionary history of vertebrates	Students will conduct both primary and secondary research in support of their chosen topics of study. Sources will include the textbook, internet databases, email contact with scientists, possible field trips, and original experiments.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology

APPENDIX A

RESOURCES:

Textbook:

Campbell Biology 9th Edition
Reece, Urry, Cain, Wasserman, Minorsky, and Jackson
Pearson Publishing 2011

Technology:

- Pearson Mastering Biology for tutorials and basic homework/review assignments
- Vernier probe system
- Various websites including Protein Data Bank
- Assorted laboratory equipment including electrophoresis boxes, centrifuges, incubators, autoclave, etc.
- Daily use of devices for access to internet images, tutorials, etc.

Supplemental readings and media taken from sources such as

Scientific American
Science
Nature
New York Times Science section
Science Daily
BBC Science
PBS
NPR
Howard Hughes Medical Institute

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology

APPENDIX B

Opportunities exist for interdisciplinary units with courses such as Animal Behavior, Marine Biology, Anatomy and Physiology, and other science electives. Discussions/papers on issues related to biotechnology, for example assisted fertility treatments, genetically modified food organisms, etc., might be done jointly with English or Social Studies classes.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
AP Biology

APPENDIX C

AP Essential Knowledge Standards and New Jersey Student Learning Standards for Science Crosswalk
Adapted from:
Next Generation Science Standards Website

AP Essential Knowledge Standards	NGSS Performance Expectations
1.A.1 Natural selection is a major mechanism of evolution.	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-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. 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.

AP Essential Knowledge Standards	NGSS Performance Expectations
1.A. 2 Natural selection acts on phenotypic variations in populations.	HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. 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. 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-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.	HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

AP Essential Knowledge Standards	NGSS Performance Expectations
1.C.1 Speciation and extinction have occurred throughout the Earth's history.	HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. 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.
1.C.2 Speciation may occur when two populations become reproductively isolated from each other.	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.
1.C.3 Populations of organisms continue to evolve.	HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. 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.
1.D.2 Scientific evidence from many different disciplines supports models of the origin of life.	HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history.

AP Essential Knowledge Standards	NGSS Performance Expectations
2.A.1 All living systems require constant input of free energy.	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-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
2.A.2 Organisms capture and store free energy for use in biological processes.	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-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

AP Essential Knowledge Standards	NGSS Performance Expectations
2.A.3 Organisms must exchange the matter with the environment to grow, reproduce and maintain organization.	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-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
2.B.1 Cell membranes are selectively permeable due to their structure.	HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
2.B.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	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.
2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.	HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
2.C.2 Organisms respond to changes in their external environments.	HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

AP Essential Knowledge Standards	NGSS Performance Expectations
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.	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-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. 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.
2.D.3 Biological systems are affected by disruptions to their dynamic homeostasis.	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.
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.	HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 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.
2.E.2	HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

AP Essential Knowledge Standards	NGSS Performance Expectations
2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.	HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. 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.
3.A.1 DNA, and in some cases RNA, is the primary source of heritable information.	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.
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.	HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 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.
3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.	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.
3.A.4	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

AP Essential Knowledge Standards	NGSS Performance Expectations
3.B.1 Gene regulation results in differential gene expression, leading to cell specialization.	HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 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.
3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
3.C.1 Changes in genotype can result in changes in phenotype.	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-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.
3.C.2 Biological systems have multiple processes that increase genetic variation.	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.
3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
3.E.1 Individuals can act on information and communicate it to others.	HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. 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.
3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

AP Essential Knowledge Standards	NGSS Performance Expectations
4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule.	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. HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes.	HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
4.A.3 Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	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-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 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-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
4.A.4 Organisms exhibit complex properties due to interactions between their constituent parts.	HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

AP Essential Knowledge Standards	NGSS Performance Expectations
4.A.5 Communities are composed of populations of organisms that interact in complex ways.	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. HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

AP Essential Knowledge Standards	NGSS Performance Expectations
4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy.	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-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-LS2-7 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. HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
4.B.1 Interactions between molecules affect their structure and function.	HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter.	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-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

AP Essential Knowledge Standards	NGSS Performance Expectations
4.B.3 Interactions between and within populations influence patterns of species distribution and abundance.	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-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
4.B.4 Distribution of local and global ecosystems changes over time.	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. HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
4.C.1 Variation in molecular unites provides cells with a wider range of functions.	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.

AP Essential Knowledge Standards	NGSS Performance Expectations
4.C.2 Environmental factors influence the expression of the genotype in an organism.	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
4.C.3 The level of variation in a population affects population dynamics.	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. 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.
4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem.	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-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.