JoVE | SCIENCE EDUCATION

Main Criteria: AP Biology Course Description
Secondary Criteria: JoVE
Subject: Science
Grade: 9-12
Correlation Options: Show Correlated
Adopted: 2012

BIG IDEA	**AP.B.1.**	**Big Idea 1: The process of evolution drives the diversity and unity of life.**
ENDURING UNDERSTANDING	**1.A.**	**Change in the genetic makeup of a population over time is evolution.**
ESSENTIAL KNOWLEDGE	**1.A.1.**	**Natural selection is a major mechanism of evolution.**
LEARNING OBJECTIVE	**1.A.1.a.**	**According to Darwin's theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.** JoVE • **An Overview of Genetic Analysis**
LEARNING OBJECTIVE	**1.A.1.c.**	**Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.** JoVE • **An Overview of Genetic Analysis** • **C. elegans Development and Reproduction** • **SNP Genotyping** • **Yeast Reproduction** • **Zebrafish Maintenance and Husbandry**
LEARNING OBJECTIVE	**1.A.1.d.**	**Environments can be more or less stable or fluctuating, and this affects evolutionary rate and direction; different genetic variations can be selected in each generation.** JoVE • **An Overview of Genetic Analysis**
LEARNING OBJECTIVE	**1.A.1.e.**	**An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an**

		advantage to an organism in a particular environment. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Cognition • An Introduction to Drosophila melanogaster • An Introduction to Learning and Memory • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • Basic Chick Care and Maintenance • Basic Mouse Care and Maintenance • C. elegans Chemotaxis Assay • Development of the Chick • Drosophila Development and Reproduction • Drosophila Maintenance • Fear Conditioning • Positive Reinforcement Studies • Spatial Memory Testing Using Mazes • Yeast Maintenance
BIG IDEA	AP.B.1.	Big Idea 1: The process of evolution drives the diversity and unity of life.
ENDURING UNDERSTANDING	1.A.	Change in the genetic makeup of a population over time is evolution.
ESSENTIAL KNOWLEDGE	1.A.2.	Natural selection acts on phenotypic variations in populations.
LEARNING OBJECTIVE	1.A.2.a.	Environments change and act as selective mechanism on populations. JoVE • An Overview of Genetic Analysis
LEARNING OBJECTIVE	1.A.2.b.	Phenotypic variations are not directed by the environment but occur through random changes in the DNA and through new gene combinations. JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression

		• An Overview of Genetic Analysis • An Overview of Genetics and Disease • C. elegans Development and Reproduction • C. elegans Maintenance • Drosophila Development and Reproduction • Fundamentals of Breeding and Weaning • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Isolating Nucleic Acids from Yeast • Mouse Genotyping • Passaging Cells • RNAi in C. elegans • SNP Genotyping • The TUNEL Assay • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Reproduction and Development
LEARNING OBJECTIVE	**1.A.2.d.**	**Humans impact variation in other species.** JoVE • An Introduction to Aging and Regeneration • An Introduction to Drosophila melanogaster • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • An Overview of Genetic Engineering • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Development and Reproduction • Chick ex ovo Culture • DNA Ligation Reactions • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Fate Mapping • Fundamentals of Breeding and Weaning • Gene Silencing with Morpholinos • Genetic Engineering of Model Organisms • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification

		• Molecular Cloning • Mouse Genotyping • Plasmid Purification • RNAi in C. elegans • Restriction Enzyme Digests • Solid-Liquid Extraction • Testing For Genetically Modified Foods • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	**AP.B.1.**	**Big Idea 1: The process of evolution drives the diversity and unity of life.**
ENDURING UNDERSTANDING	**1.A.**	**Change in the genetic makeup of a population over time is evolution.**
ESSENTIAL KNOWLEDGE	**1.A.3.**	**Evolutionary change is also driven by random processes.**
LEARNING OBJECTIVE	**1.A.3.a.**	**Genetic drift is a nonselective process occurring in small populations.** JoVE • An Overview of Genetic Analysis
BIG IDEA	**AP.B.1.**	**Big Idea 1: The process of evolution drives the diversity and unity of life.**
ENDURING UNDERSTANDING	**1.A.**	**Change in the genetic makeup of a population over time is evolution.**
ESSENTIAL KNOWLEDGE	**1.A.4.**	**Biological evolution is supported by scientific evidence from many disciplines, including mathematics.**
LEARNING OBJECTIVE	**1.A.4.a.**	**Scientific evidence of biological evolution uses information from geographical, geological, physical, chemical and mathematical applications.** JoVE • An Overview of Genetic Analysis • High-Performance Liquid Chromatography (HPLC)
BIG IDEA	**AP.B.1.**	**Big Idea 1: The process of evolution drives the diversity and unity of life.**
ENDURING UNDERSTANDING	**1.A.**	**Change in the genetic makeup of a population over time is evolution.**
ESSENTIAL KNOWLEDGE	**1.A.4.**	**Biological evolution is supported by scientific evidence from many disciplines, including mathematics.**
LEARNING OBJECTIVE	**1.A.4.b.**	**Molecular, morphological and genetic information of existing and extinct organisms add to our understanding**

		of evolution. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	1.A.4.b.2.	Morphological homologies represent features shared by common ancestry. Vestigial structures are remnants of functional structures, which can be compared to fossils and provide evidence for evolution. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Drosophila melanogaster • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation
DEMONSTRATED UNDERSTANDING	1.A.4.b.3.	Biochemical and genetic similarities, in particular DNA nucleotide and protein sequences, provide evidence for evolution and ancestry. JoVE • An Overview of Genetic Analysis
DEMONSTRATED UNDERSTANDING	1.A.4.b.4.	Mathematical models and simulations can be used to illustrate and support evolutionary concepts. JoVE • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio
BIG IDEA	AP.B.1.	Big Idea 1: The process of evolution drives the diversity and unity of life.
ENDURING UNDERSTANDING	1.B.	Organisms are linked by lines of descent from common ancestry.
ESSENTIAL KNOWLEDGE	1.B.1.	Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.
LEARNING OBJECTIVE	1.B.1.a.	Structural and functional evidence supports the relatedness of all domains. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	1.B.1.a.1.	DNA and RNA are carriers of genetic information through transcription, translation and replication. [See also 3.A.1] JoVE • An Introduction to Cell Division • An Overview of Epigenetics • An Overview of Gene Expression • Cell Cycle Analysis • Chromatin Immunoprecipitation

		• DNA Ligation Reactions • DNA Methylation Analysis • Detecting Reactive Oxygen Species • Electrophoretic Mobility Shift Assay (EMSA) • Expression Profiling with Microarrays • Gene Silencing with Morpholinos • Genetic Screens • Genome Editing • Live Cell Imaging of Mitosis • Method of Standard Addition • Molecular Cloning • PCR: The Polymerase Chain Reaction • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • Restriction Enzyme Digests • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning
BIG IDEA	AP.B.1.	Big Idea 1: The process of evolution drives the diversity and unity of life.
ENDURING UNDERSTANDING	1.B.	Organisms are linked by lines of descent from common ancestry.
ESSENTIAL KNOWLEDGE	1.B.2.	Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.
LEARNING OBJECTIVE	1.B.2.a.	Phylogenetic trees and cladograms can represent traits that are either derived or lost due to evolution. JoVE • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio
LEARNING OBJECTIVE	1.B.2.b.	Phylogenetic trees and cladograms illustrate speciation that has occurred, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor. JoVE • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio
BIG IDEA	AP.B.1.	Big Idea 1: The process of evolution drives the diversity and unity of life.
ENDURING UNDERSTANDING	1.C.	Life continues to evolve within a changing environment.
ESSENTIAL KNOWLEDGE	1.C.3.	Populations of organisms continue to evolve.
LEARNING OBJECTIVE	1.C.3.a.	Scientific evidence supports the idea that evolution has occurred in all species.

		<u>JoVE</u> • An Introduction to the Chick: Gallus gallus domesticus • An Overview of Genetic Analysis
BIG IDEA	AP.B.1.	Big Idea 1: The process of evolution drives the diversity and unity of life.
ENDURING UNDERSTANDING	1.D.	The origin of living systems is explained by natural processes.
ESSENTIAL KNOWLEDGE	1.D.1.	There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.
LEARNING OBJECTIVE	1.D.1.a.	Scientific evidence supports the various models. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	1.D.1.a.1.	Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized due to the presence of available free energy and the absence of a significant quantity of oxygen. <u>JoVE</u> • High-Performance Liquid Chromatography (HPLC)
DEMONSTRATED UNDERSTANDING	1.D.1.a.2.	In turn, these molecules served as monomers or building blocks for the formation of more complex molecules, including amino acids and nucleotides. [See also 4.A.1] <u>JoVE</u> • An Overview of Gene Expression • Chromatin Immunoprecipitation • Ion-Exchange Chromatography • MALDI-TOF Mass Spectrometry • Photometric Protein Determination • Tandem Mass Spectrometry • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	1.D.1.a.4.	These complex reaction sets could have occurred in solution (organic soup model) or as reactions on solid reactive surfaces. [See also 2.B.1] <u>JoVE</u> • High-Performance Liquid Chromatography (HPLC)
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.1.	All living systems require constant input of free energy.
LEARNING OBJECTIVE	2.A.1.b.	Living systems do not violate the second law of thermodynamics, which states that entropy increases

		over time. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.1.b.3.	Energetically favorable exergonic reactions, such as ATP-->ADP, that have a negative change in free energy can be used to maintain or increase order in a system by being coupled with reactions that have a positive free energy change. <u>JoVE</u> • An Introduction to Cell Metabolism • An Introduction to Cell Motility and Migration • Detecting Reactive Oxygen Species • Invasion Assay Using 3D Matrices • The ATP Bioluminescence Assay • The Transwell Migration Assay
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.1.	All living systems require constant input of free energy.
LEARNING OBJECTIVE	2.A.1.d.	Organisms use free energy to maintain organization, grow and reproduce. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.1.d.1.	Organisms use various strategies to regulate body temperature and metabolism. <u>JoVE</u> • Basic Care Procedures
DEMONSTRATED UNDERSTANDING	2.A.1.d.2.	Reproduction and rearing of offspring require free energy beyond that used for maintenance and growth. Different organisms use various reproductive strategies in response to energy availability. <u>JoVE</u> • An Introduction to Caenorhabditis elegans • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio • C. elegans Development and Reproduction • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Fundamentals of Breeding and Weaning

		• Yeast Maintenance • Yeast Reproduction • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Reproduction and Development
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.a.	Autotrophs capture free energy from physical sources in the environment. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.2.a.1.	Photosynthetic organisms capture free energy present in sunlight. JoVE • An Introduction to Cell Metabolism
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.b.	Heterotrophs capture free energy present in carbon compounds produced by other organisms. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.2.b.1.	Heterotrophs may metabolize carbohydrates, lipids and proteins by hydrolysis as sources of free energy. JoVE • Biofuels: Producing Ethanol from Cellulosic Material
DEMONSTRATED UNDERSTANDING	2.A.2.b.2.	Fermentation produces organic molecules, including alcohol and lactic acid, and it occurs in the absence of oxygen. JoVE • An Introduction to Saccharomyces cerevisiae • Biofuels: Producing Ethanol from Cellulosic Material • Culturing and Enumerating Bacteria from Soil Samples

BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.d.	RE
DEMONSTRATED UNDERSTANDING	2.A.2.d.1.	During photosynthesis, chlorophylls absorb free energy from light, boosting electrons to a higher energy level in Photosystems I and II. JoVE • Reconstitution of Membrane Proteins
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.e.	Photosynthesis first evolved in prokaryotic organisms; scientific evidence supports that prokaryotic (bacterial) photosynthesis was responsible for the production of an oxygenated atmosphere; prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis. JoVE • An Overview of Alkenone Biomarker Analysis for Paleothermometry • An Overview of bGDGT Biomarker Analysis for Paleoclimatology • Conversion of Fatty Acid Methyl Esters by Saponification for Uk'37 Paleothermometry • Extraction of Biomarkers from Sediments - Accelerated Solvent Extraction • Removal of Branched and Cyclic Compounds by Urea Adduction for Uk'37 Paleothermometry • Sonication Extraction of Lipid Biomarkers from Sediment • Soxhlet Extraction of Lipid Biomarkers from Sediment
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.f.	Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that harvest free energy from simple carbohydrates. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.2.f.1.	Glycolysis rearranges the bonds in glucose molecules, releasing free energy to form ATP from ADP and inorganic phosphate, and resulting in the production of pyruvate. JoVE • An Introduction to Cell Metabolism • Detecting Reactive Oxygen Species • The ATP Bioluminescence Assay
DEMONSTRATED UNDERSTANDING	2.A.2.f.3.	In the Krebs cycle, carbon dioxide is released from organic intermediates ATP is synthesized from ADP and inorganic phosphate via substrate level phosphorylation and electrons are captured by coenzymes. JoVE • An Introduction to Cell Metabolism • Detecting Reactive Oxygen Species • The ATP Bioluminescence Assay
DEMONSTRATED UNDERSTANDING	2.A.2.f.4.	Electrons that are extracted in the series of Krebs cycle reactions are carried by NADH and FADH2 to the electron transport chain. JoVE • An Introduction to Cell Metabolism • Detecting Reactive Oxygen Species • The ATP Bioluminescence Assay
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.g.	The electron transport chain captures free energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes. Evidence of student learning is a demonstrated understanding of each of the following:

DEMONSTRATED UNDERSTANDING	2.A.2.g.2.	In cellular respiration, electrons delivered by NADH and FADH2 are passed to a series of electron acceptors as they move toward the terminal electron acceptor, oxygen. In photosynthesis, the terminal electron acceptor is NADP+. JoVE • An Introduction to Cell Metabolism • Biofuels: Producing Ethanol from Cellulosic Material • Detecting Reactive Oxygen Species • The ATP Bioluminescence Assay
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.2.	Organisms capture and store free energy for use in biological processes.
LEARNING OBJECTIVE	2.A.2.h.	Free energy becomes available for metabolism by the conversion of ATP-->ADP, which is coupled to many steps in metabolic pathways. JoVE • An Introduction to Cell Metabolism • An Introduction to Cell Motility and Migration • Detecting Reactive Oxygen Species • Invasion Assay Using 3D Matrices • The ATP Bioluminescence Assay • The Transwell Migration Assay
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.3.	Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
LEARNING OBJECTIVE	2.A.3.a.	Molecules and atoms from the environment are necessary to build new molecules. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.3.a.1.	Carbon moves from the environment to organisms where it is used to build carbohydrates, proteins, lipids or nucleic acids. Carbon is used in storage compounds and cell formation in all organisms. JoVE • An Overview of Alkenone Biomarker Analysis for

		Paleothermometry • An Overview of bGDGT Biomarker Analysis for Paleoclimatology • Carbon and Nitrogen Analysis of Environmental Samples • Conversion of Fatty Acid Methyl Esters by Saponification for Uk'37 Paleothermometry • Extraction of Biomarkers from Sediments - Accelerated Solvent Extraction • Metabolic Labeling • Purification of a Total Lipid Extract with Column Chromatography • Removal of Branched and Cyclic Compounds by Urea Adduction for Uk'37 Paleothermometry • Sonication Extraction of Lipid Biomarkers from Sediment • Soxhlet Extraction of Lipid Biomarkers from Sediment
DEMONSTRATED UNDERSTANDING	2.A.3.a.2.	Nitrogen moves from the environment to organisms where it is used in building proteins and nucleic acids. Phosphorus moves from the environment to organisms where it is used in nucleic acids and certain lipids. JoVE • Algae Enumeration via Culturable Methodology • Bacterial Growth Curve Analysis and its Environmental Applications • Carbon and Nitrogen Analysis of Environmental Samples • Culturing and Enumerating Bacteria from Soil Samples • Determination Of Nox in Automobile Exhaust Using UV-VIS Spectroscopy • Filamentous Fungi • Metabolic Labeling • Nutrients in Aquatic Ecosystems • Soil Nutrient Analysis: Nitrogen, Phosphorus, and Potassium
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.A.	Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
ESSENTIAL KNOWLEDGE	2.A.3.	Organisms must exchange matter with the environment to grow, reproduce and maintain organization.
LEARNING OBJECTIVE	2.A.3.b.	Surface area-to-volume ratios affect a biological system’s ability to obtain necessary resources or eliminate waste products. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.A.3.b.1.	As cells increase in volume, the relative surface area decreases and demand for material resources increases;

		more cellular structures are necessary to adequately exchange materials and energy with the environment. These limitations restrict cell size. <u>JoVE</u> • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cell Metabolism • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Molecular Developmental Biology • An Introduction to Stem Cell Biology • Annexin V and Propidium Iodide Labeling • C. elegans Development and Reproduction • Calcium Imaging in Neurons • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • Electro-encephalography (EEG) • Embryonic Stem Cell Culture and Differentiation • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Isolating Nucleic Acids from Yeast • Murine In Utero Electroporation • Patch Clamp Electrophysiology • Reconstitution of Membrane Proteins • The ATP Bioluminescence Assay • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Yeast Maintenance • Yeast Reproduction • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	2.A.3.b.2.	The surface area of the plasma membrane must be large enough to adequately exchange materials; smaller cells have a more favorable surface area-to-volume ratio for exchange of materials with the environment. <u>JoVE</u> • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method

		• Calcium Imaging in Neurons • Cell Cycle Analysis • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • Electro-encephalography (EEG) • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Live Cell Imaging of Mitosis • Murine In Utero Electroporation • Neuronal Transfection Methods • Patch Clamp Electrophysiology • Plasmid Purification • Primary Neuronal Cultures • Protein Crystallization • Reconstitution of Membrane Proteins • The TUNEL Assay • The Western Blot • Yeast Maintenance • Yeast Transformation and Cloning
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.A.**	**Growth, reproduction and maintenance of the organization of living systems require free energy and matter.**
ESSENTIAL KNOWLEDGE	**2.A.3.**	**Organisms must exchange matter with the environment to grow, reproduce and maintain organization.**
LEARNING OBJECTIVE	**LO 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]** JoVE • Dialysis: Diffusion Based Separation • Using Diffusion Tensor Imaging in Traumatic Brain Injury
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.B.**	**Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.**
ESSENTIAL KNOWLEDGE	**2.B.1.**	**Cell membranes are selectively permeable due to their structure.**
LEARNING OBJECTIVE	**2.B.1.a.**	**Cell membranes separate the internal environment of the cell from the external environment.**

		JoVE • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Calcium Imaging in Neurons • Cell Cycle Analysis • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • Electro-encephalography (EEG) • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Live Cell Imaging of Mitosis • Murine In Utero Electroporation • Neuronal Transfection Methods • Patch Clamp Electrophysiology • Plasmid Purification • Primary Neuronal Cultures • Protein Crystallization • Reconstitution of Membrane Proteins • The TUNEL Assay • The Western Blot • Yeast Maintenance • Yeast Transformation and Cloning
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.B.**	**Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.**
ESSENTIAL KNOWLEDGE	**2.B.1.**	**Cell membranes are selectively permeable due to their structure.**
LEARNING OBJECTIVE	**2.B.1.b.**	**Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model. [See also 4.A.1] Evidence of student learning is a demonstrated understanding of each of the following:**
DEMONSTRATED UNDERSTANDING	**2.B.1.b.1.**	**Cell membranes consist of a structural framework of phospholipid molecules, embedded proteins, cholesterol, glycoproteins and glycolipids.** JoVE • An Introduction to Cell Death

		• An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Calcium Imaging in Neurons • Cell Cycle Analysis • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • Electro-encephalography (EEG) • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Live Cell Imaging of Mitosis • Murine In Utero Electroporation • Neuronal Transfection Methods • Patch Clamp Electrophysiology • Plasmid Purification • Primary Neuronal Cultures • Protein Crystallization • Reconstitution of Membrane Proteins • The TUNEL Assay • The Western Blot • Yeast Maintenance • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	**2.B.1.b.2.**	**Phospholipids give the membrane both hydrophilic and hydrophobic properties. The hydrophilic phosphate portions of the phospholipids are oriented toward the aqueous external or internal environments, while the hydrophobic fatty acid portions face each other within the interior of the membrane itself.** **JoVE** • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Calcium Imaging in Neurons • Cell Cycle Analysis • Cell-surface Biotinylation Assay

		• Detecting Reactive Oxygen Species • Electro-encephalography (EEG) • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Live Cell Imaging of Mitosis • Murine In Utero Electroporation • Neuronal Transfection Methods • Patch Clamp Electrophysiology • Plasmid Purification • Primary Neuronal Cultures • Protein Crystallization • Reconstitution of Membrane Proteins • The TUNEL Assay • The Western Blot • Yeast Maintenance • Yeast Transformation and Cloning
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.B.**	**Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.**
ESSENTIAL KNOWLEDGE	**2.B.1.**	**Cell membranes are selectively permeable due to their structure.**
LEARNING OBJECTIVE	**2.B.1.c.**	**Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments. Evidence of student learning is a demonstrated understanding of each of the following:**
DEMONSTRATED UNDERSTANDING	**2.B.1.c.2.**	**Other examples are cell walls of prokaryotes and fungi.** **JoVE** • An Introduction to Cell Motility and Migration • An Introduction to Transfection • An Overview of Genetic Engineering • Bacterial Growth Curve Analysis and its Environmental Applications • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Culturing and Enumerating Bacteria from Soil Samples • Genetic Engineering of Model Organisms • Invasion Assay Using 3D Matrices • Molecular Cloning • Plasmid Purification • Recombineering and Gene Targeting • The Transwell Migration Assay
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**

ENDURING UNDERSTANDING	2.B.	Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
ESSENTIAL KNOWLEDGE	2.B.1.	Cell membranes are selectively permeable due to their structure.
LEARNING OBJECTIVE	LO 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] JoVE • Dialysis: Diffusion Based Separation
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.B.	Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
ESSENTIAL KNOWLEDGE	2.B.2.	Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
LEARNING OBJECTIVE	2.B.2.a.	Passive transport does not require the input of metabolic energy; the net movement of molecules is from high concentration to low concentration. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.B.2.a.1.	Passive transport plays a primary role in the import of resources and the export of wastes. JoVE • An Introduction to Endocytosis and Exocytosis • Cell-surface Biotinylation Assay • FM Dyes in Vesicle Recycling • In ovo Electroporation of Chicken Embryos • Reconstitution of Membrane Proteins • Using Diffusion Tensor Imaging in Traumatic Brain Injury • Yeast Transformation and Cloning
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.B.	Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
ESSENTIAL KNOWLEDGE	2.B.2.	Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.
LEARNING OBJECTIVE	2.B.2.b.	Active transport requires free energy to move molecules from regions of low concentration to regions of high concentration. Evidence of student learning is a demonstrated understanding of each of the following:

DEMONSTRATED UNDERSTANDING	2.B.2.b.1.	Active transport is a process where free energy (often provided by ATP) is used by proteins embedded in the membrane to “move” molecules and/or ions across the membrane and to establish and maintain concentration gradients. JoVE • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Calcium Imaging in Neurons • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • FM Dyes in Vesicle Recycling • Patch Clamp Electrophysiology • Reconstitution of Membrane Proteins • The TUNEL Assay • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	2.B.2.b.2.	Membrane proteins are necessary for active transport. JoVE • An Introduction to Endocytosis and Exocytosis • An Introduction to Neurophysiology • An Introduction to Transfection • Calcium Imaging in Neurons • Cell-surface Biotinylation Assay • Detecting Reactive Oxygen Species • FM Dyes in Vesicle Recycling • Patch Clamp Electrophysiology • Reconstitution of Membrane Proteins • The TUNEL Assay • Yeast Transformation and Cloning
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.B.	Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments.
ESSENTIAL KNOWLEDGE	2.B.3.	Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
LEARNING OBJECTIVE	2.B.3.b.	Membranes and membrane-bound organelles in eukaryotic cells localize (compartmentalize) intracellular metabolic processes and specific enzymatic reactions. [See also 4.A.2] JoVE • An Introduction to Aging and Regeneration • An Introduction to Cell Death • An Introduction to Cell Metabolism • Annexin V and Propidium Iodide Labeling

		• Density Gradient Ultracentrifugation • Detecting Reactive Oxygen Species • Metabolic Labeling • The ATP Bioluminescence Assay • The TUNEL Assay
LEARNING OBJECTIVE	2.B.3.c.	Archaea and Bacteria generally lack internal membranes and organelles and have a cell wall. JoVE • An Introduction to Cell Motility and Migration • An Introduction to Transfection • An Overview of Genetic Engineering • Bacterial Growth Curve Analysis and its Environmental Applications • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Culturing and Enumerating Bacteria from Soil Samples • Genetic Engineering of Model Organisms • Invasion Assay Using 3D Matrices • Molecular Cloning • Plasmid Purification • Recombineering and Gene Targeting • The Transwell Migration Assay
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.C.	Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.
ESSENTIAL KNOWLEDGE	2.C.1.	Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.
LEARNING OBJECTIVE	2.C.1.a.	Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point. JoVE • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cell Metabolism • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Molecular Developmental Biology • An Introduction to Stem Cell Biology • Anesthesia Induction and Maintenance • Annexin V and Propidium Iodide Labeling • Basic Care Procedures • Basic Mouse Care and Maintenance • Blood Withdrawal I

		• Blood Withdrawal II • C. elegans Development and Reproduction • Calcium Imaging in Neurons • Cell-surface Biotinylation Assay • Compound Administration I • Compound Administration II • Compound Administration III • Compound Administration IV • Considerations for Rodent Surgery • Detecting Reactive Oxygen Species • Diagnostic Necropsy and Tissue Harvest • Electro-encephalography (EEG) • Embryonic Stem Cell Culture and Differentiation • Explant Culture of Neural Tissue • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Isolating Nucleic Acids from Yeast • Murine In Utero Electroporation • Patch Clamp Electrophysiology • Reconstitution of Membrane Proteins • Sterile Tissue Harvest • The ATP Bioluminescence Assay • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Tree Identification: How To Use a Dichotomous Key • Yeast Maintenance • Yeast Reproduction • Yeast Transformation and Cloning • Zebrafish Maintenance and Husbandry
LEARNING OBJECTIVE	**2.C.1.c.**	**Alteration in the mechanisms of feedback often results in deleterious consequences.** **JoVE** • An Introduction to Behavioral Neuroscience • An Introduction to Caenorhabditis elegans • An Introduction to Cell Metabolism • An Introduction to Cognition • An Introduction to Developmental Neurobiology • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • Ankle Exam • Anterograde Amnesia • Anxiety Testing • Assessing Dexterity with Reaching Tasks • Balance and Coordination Testing • C. elegans Chemotaxis Assay • Chromatin Immunoprecipitation • Cranial Nerves Exam I (I-VI)

		• Cranial Nerves Exam II (VII-XII) • Crowding • Decision-making and the Iowa Gambling Task • Decoding Auditory Imagery with Multivoxel Pattern Analysis • Detecting Reactive Oxygen Species • Dichotic Listening • Ear Exam • Elbow Exam • Executive Function and the Dimensional Change Card Sort Task • Executive Function in Autism Spectrum Disorder • Eye Exam • Eye Tracking in Cognitive Experiments • Foot Exam • Genetic Screens • Hand and Wrist Exam • Hip Exam • Incidental Encoding • Knee Exam • Learning and Memory: The Remember-Know Task • Lower Back Exam • Measuring Grey Matter Differences with Voxel-based Morphometry: The Musical Brain • Measuring Verbal Working Memory Span • Modeling Social Stress • Motor Exam I • Motor Exam II • Motor Maps • Multiple Object Tracking • Neck Exam • Ophthalmoscopic Examination • Peripheral Vascular Exam • Peripheral Vascular Exam Using a Continuous Wave Doppler • Physiological Correlates of Emotion Recognition • Prospect Theory • Sensory Exam • Shoulder Exam I • Spatial Memory Testing Using Mazes • The ATP Bioluminescence Assay • The Inverted-face Effect • The Morris Water Maze • The Precision of Visual Working Memory with Delayed Estimation • The Split Brain • The Staircase Procedure for Finding a Perceptual Threshold • Tissue Regeneration with Somatic Stem Cells • Using Diffusion Tensor Imaging in Traumatic Brain Injury

		• Verbal Priming • Visual Search for Features and Conjunctions • fMRI: Functional Magnetic Resonance Imaging
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.C.	Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostasis.
ESSENTIAL KNOWLEDGE	2.C.2.	Organisms respond to changes in their external environments.
LEARNING OBJECTIVE	2.C.2.a.	Organisms respond to changes in their environment through behavioral and physiological mechanisms. JoVE • An Introduction to Behavioral Neuroscience • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cell Metabolism • An Introduction to Cell Motility and Migration • An Introduction to Developmental Neurobiology • An Introduction to Endocytosis and Exocytosis • An Introduction to Learning and Memory • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Molecular Developmental Biology • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Anesthesia Induction and Maintenance • Annexin V and Propidium Iodide Labeling • Anterograde Amnesia • Anxiety Testing • Approximate Number Sense Test • Are You Smart or Hardworking? How Praise Influences Children's Motivation • Basic Care Procedures • Basic Chick Care and Maintenance • Basic Mouse Care and Maintenance • C. elegans Chemotaxis Assay • C. elegans Development and Reproduction • C. elegans Maintenance • Calcium Imaging in Neurons • Chick ex ovo Culture • Color Afterimages • Considerations for Rodent Surgery • Crowding • Decision-making and the Iowa Gambling Task • Decoding Auditory Imagery with Multivoxel Pattern

		Analysis • Detecting Reactive Oxygen Species • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Diagnostic Necropsy and Tissue Harvest • Drosophila Development and Reproduction • Drosophila Larval IHC • Drosophila Maintenance • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electro-encephalography (EEG) • Event-related Potentials and the Oddball Task • Executive Function and the Dimensional Change Card Sort Task • Executive Function in Autism Spectrum Disorder • Explant Culture of Neural Tissue • Eye Tracking in Cognitive Experiments • Fear Conditioning • Finding Your Blind Spot and Perceptual Filling-in • Fundamentals of Breeding and Weaning • Habituation: Studying Infants Before They Can Talk • Histological Staining of Neural Tissue • How Children Solve Problems Using Causal Reasoning • In ovo Electroporation of Chicken Embryos • Inattentional Blindness • Incidental Encoding • Invasion Assay Using 3D Matrices • Invertebrate Lifespan Quantification • Isolating Nucleic Acids from Yeast • Just-noticeable Differences • Language: The N400 in Semantic Incongruity • Learning and Memory: The Remember-Know Task • Measuring Grey Matter Differences with Voxel-based Morphometry: The Musical Brain • Measuring Reaction Time and Donders' Method of Subtraction • Measuring Verbal Working Memory Span • Mental Rotation • Modeling Social Stress • Motion-induced Blindness • Motor Learning in Mirror Drawing • Multiple Object Tracking • Murine In Utero Electroporation • Neuronal Transfection Methods • Object Substitution Masking • Patch Clamp Electrophysiology • Physiological Correlates of Emotion Recognition • Positive Reinforcement Studies • Primary Neuronal Cultures • Prospect Theory • RNAi in C. elegans

		• Rodent Handling and Restraint Techniques • Rodent Stereotaxic Surgery • Self-administration Studies • Spatial Cueing • Spatial Memory Testing Using Mazes • Sterile Tissue Harvest • The ATP Bioluminescence Assay • The Ames Room • The Attentional Blink • The Inverted-face Effect • The McGurk Effect • The Morris Water Maze • The Multi-group Experiment • The Precision of Visual Working Memory with Delayed Estimation • The Rubber Hand Illusion • The Simple Experiment: Two-group Design • The Staircase Procedure for Finding a Perceptual Threshold • The TUNEL Assay • The Transwell Migration Assay • Using Diffusion Tensor Imaging in Traumatic Brain Injury • Using TMS to Measure Motor Excitability During Action Observation • Using Your Head: Measuring Infants' Rational Imitation of Actions • Verbal Priming • Visual Attention: fMRI Investigation of Object-based Attentional Control • Visual Search for Features and Conjunctions • Visual Statistical Learning • Within-subjects Repeated-measures Design • Yeast Maintenance • Yeast Reproduction • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Reproduction and Development • fMRI: Functional Magnetic Resonance Imaging
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.D.	Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
ESSENTIAL KNOWLEDGE	2.D.1.	All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
LEARNING OBJECTIVE	2.D.1.a.	Cell activities are affected by interactions with biotic and abiotic factors.

		<u>JoVE</u> • An Introduction to Cell Death • Biofuels: Producing Ethanol from Cellulosic Material • Co-Immunoprecipitation and Pull-Down Assays • DNA Ligation Reactions • Enzyme Assays and Kinetics • Introduction to Catalysis • Live Cell Imaging of Mitosis • Molecular Cloning • PCR: The Polymerase Chain Reaction • Restriction Enzyme Digests • The ELISA Method • The TUNEL Assay
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.D.**	**Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.**
ESSENTIAL KNOWLEDGE	**2.D.2.**	**Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.**
LEARNING OBJECTIVE	**2.D.2.b.**	**Organisms have various mechanisms for obtaining nutrients and eliminating wastes.** <u>JoVE</u> • Abdominal Exam I: Inspection and Auscultation • Abdominal Exam II: Percussion • Abdominal Exam III: Palpation • Abdominal Exam IV: Acute Abdominal Pain Assessment • C. elegans Development and Reproduction • Development and Reproduction of the Laboratory Mouse • Male Rectal Exam • Zebrafish Reproduction and Development
BIG IDEA	**AP.B.2.**	**Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.**
ENDURING UNDERSTANDING	**2.D.**	**Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.**
ESSENTIAL KNOWLEDGE	**2.D.3.**	**Biological systems are affected by disruptions to their dynamic homeostasis.**
LEARNING OBJECTIVE	**2.D.3.a.**	**Disruptions at the molecular and cellular levels affect the health of the organism.** <u>JoVE</u> • An Introduction to Drosophila melanogaster • An Overview of Genetics and Disease

		• Basic Care Procedures • Basic Mouse Care and Maintenance • Detection of Bacteriophages in Environmental Samples • Genetic Screens • Testing For Genetically Modified Foods • Using GIS to Investigate Urban Forestry
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.D.	Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
ESSENTIAL KNOWLEDGE	2.D.4.	Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
LEARNING OBJECTIVE	2.D.4.a.	Plants, invertebrates and vertebrates have multiple, nonspecific immune responses. JoVE • An Introduction to the Laboratory Mouse: Mus musculus • Basic Care Procedures • Co-Immunoprecipitation and Pull-Down Assays • Drosophila Larval IHC • Emergency Tube Thoracostomy (Chest Tube Placement) • Histological Staining of Neural Tissue • Intra-articular Shoulder Injection for Reduction Following Anterior Shoulder Dislocation • MALDI-TOF Mass Spectrometry • Needle Thoracostomy (needle Decompression) for Temporizing Tension Pneumothorax Treatment • The ELISA Method • The TUNEL Assay • The Western Blot
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.D.	Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
ESSENTIAL KNOWLEDGE	2.D.4.	Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.
LEARNING OBJECTIVE	2.D.4.b.	Mammals use specific immune responses triggered by natural or artificial agents that disrupt dynamic homeostasis. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.D.4.b.1.	The mammalian immune system includes two types of specific responses: cell mediated and humoral. JoVE • An Introduction to the Laboratory Mouse: Mus

		musculus • Basic Care Procedures • Co-Immunoprecipitation and Pull-Down Assays • Drosophila Larval IHC • Emergency Tube Thoracostomy (Chest Tube Placement) • Histological Staining of Neural Tissue • Intra-articular Shoulder Injection for Reduction Following Anterior Shoulder Dislocation • MALDI-TOF Mass Spectrometry • Needle Thoracostomy (needle Decompression) for Temporizing Tension Pneumothorax Treatment • The ELISA Method • The TUNEL Assay • The Western Blot
DEMONSTRATED UNDERSTANDING	**2.D.4.b.2.**	**In the cell-mediated response, cytotoxic T cells, a type of lymphocytic white blood cell, "target" intracellular pathogens when antigens are displayed on theoutside of the cells.** JoVE • An Introduction to the Laboratory Mouse: Mus musculus • Co-Immunoprecipitation and Pull-Down Assays • Histological Staining of Neural Tissue • The ELISA Method • The TUNEL Assay • The Western Blot
DEMONSTRATED UNDERSTANDING	**2.D.4.b.4.**	**Antigens are recognized by antibodies to the antigen.** JoVE • An Introduction to the Laboratory Mouse: Mus musculus • Co-Immunoprecipitation and Pull-Down Assays • Histological Staining of Neural Tissue • The ELISA Method • The TUNEL Assay • The Western Blot
DEMONSTRATED UNDERSTANDING	**2.D.4.b.5.**	**Antibodies are proteins produced by B cells, and each antibody is specific to a particular antigen.** JoVE • An Introduction to the Laboratory Mouse: Mus musculus • Co-Immunoprecipitation and Pull-Down Assays • Histological Staining of Neural Tissue • The ELISA Method • The TUNEL Assay • The Western Blot

BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.E.	Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.
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.
LEARNING OBJECTIVE	2.E.1.a.	Observable cell differentiation results from the expression of genes for tissue-specific proteins. JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Motility and Migration • An Introduction to Developmental Genetics • An Introduction to Developmental Neurobiology • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Overview of Epigenetics • An Overview of Gene Expression • C. elegans Development and Reproduction • DNA Methylation Analysis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Larval IHC • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Explant Culture of Neural Tissue • Expression Profiling with Microarrays • Fate Mapping • Gene Silencing with Morpholinos • Genetic Engineering of Model Organisms • Induced Pluripotency • Murine In Utero Electroporation • RNA-Seq • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Reproduction and Development
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.E.	Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

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.
LEARNING OBJECTIVE	2.E.1.b.	Induction of transcription factors during development results in sequential gene expression. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.E.1.b.4.	Genetic mutations can result in abnormal development. JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cell Metabolism • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to Endocytosis and Exocytosis • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Saccharomyces cerevisiae • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Chromatography-Based Biomolecule Purification Methods • Cytogenetics • Embryonic Stem Cell Culture and Differentiation • Fundamentals of Breeding and Weaning • Gene Silencing with Morpholinos • Genetic Engineering of Model Organisms • Genetic Screens • Isolating Nucleic Acids from Yeast • Passaging Cells • SNP Genotyping • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Whole-Mount In Situ Hybridization
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.E.	Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

ESSENTIAL KNOWLEDGE	2.E.3.	Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
LEARNING OBJECTIVE	2.E.3.a.	Individuals can act on information and communicate it to others. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.E.3.a.2.	Learning occurs through interactions with the environment and other organisms. JoVE • An Introduction to Learning and Memory • An Introduction to the Laboratory Mouse: Mus musculus • Assessing Dexterity with Reaching Tasks • Basic Mouse Care and Maintenance • C. elegans Chemotaxis Assay • Development and Reproduction of the Laboratory Mouse • Drosophila Maintenance • Fear Conditioning • Positive Reinforcement Studies • Spatial Memory Testing Using Mazes • The Morris Water Maze
BIG IDEA	AP.B.2.	Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.
ENDURING UNDERSTANDING	2.E.	Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.
ESSENTIAL KNOWLEDGE	2.E.3.	Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.
LEARNING OBJECTIVE	2.E.3.b.	Responses to information and communication of information are vital to natural selection. [See also 2.C.3] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	2.E.3.b.3.	Behaviors in animals are triggered by environmental cues and are vital to reproduction, natural selection and survival. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Learning and Memory • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Reward and Addiction • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio

		• Anesthesia Induction and Maintenance • Anxiety Testing • Assessing Dexterity with Reaching Tasks • Balance and Coordination Testing • Basic Care Procedures • Basic Chick Care and Maintenance • Basic Mouse Care and Maintenance • C. elegans Chemotaxis Assay • Considerations for Rodent Surgery • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Diagnostic Necropsy and Tissue Harvest • Drosophila Development and Reproduction • Drosophila Maintenance • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Fear Conditioning • Fundamentals of Breeding and Weaning • Modeling Social Stress • Positive Reinforcement Studies • RNAi in C. elegans • Rodent Handling and Restraint Techniques • Self-administration Studies • Spatial Memory Testing Using Mazes • Sterile Tissue Harvest • The Morris Water Maze • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Reproduction and Development
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.1.	DNA, and in some cases RNA, is the primary source of heritable information.
LEARNING OBJECTIVE	3.A.1.a.	Genetic information is transmitted from one generation to the next through DNA or RNA. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.1.a.1.	Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics

		• An Introduction to Molecular Developmental Biology • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Cell Cycle Analysis • Chromatin Immunoprecipitation • Community DNA Extraction from Bacterial Colonies • Cytogenetics • DNA Gel Electrophoresis • DNA Ligation Reactions • DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Development and Reproduction of the Laboratory Mouse • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electrophoretic Mobility Shift Assay (EMSA) • Embryonic Stem Cell Culture and Differentiation • Enzyme Assays and Kinetics • Explant Culture for Developmental Studies • Expression Profiling with Microarrays • Förster Resonance Energy Transfer (FRET) • Gel Purification • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Molecular Cloning • Mouse Genotyping • PCR: The Polymerase Chain Reaction • Photometric Protein Determination • Plasmid Purification • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • Recombineering and Gene Targeting

		• Restriction Enzyme Digests • SNP Genotyping • Testing For Genetically Modified Foods • The TUNEL Assay • Two-Dimensional Gel Electrophoresis • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling
DEMONSTRATED UNDERSTANDING	3.A.1.a.2.	Noneukaryotic organisms have circular chromosomes, while eukaryotic organisms have multiple linear chromosomes, although in biology there are exceptions to this rule. JoVE • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • C. elegans Development and Reproduction • Cell Cycle Analysis • Chromatin Immunoprecipitation • Cytogenetics • DNA Methylation Analysis • Electrophoretic Mobility Shift Assay (EMSA) • Expression Profiling with Microarrays • Genetic Crosses • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Plasmid Purification • RNA-Seq • SNP Genotyping
DEMONSTRATED UNDERSTANDING	3.A.1.a.4.	The proof that DNA is the carrier of genetic information involved a number of important historical experiments. These include: i) Contributions of Watson, Crick, Wilkins, and Franklin on the structure of DNA; ii) Avery-MacLeod-McCarty experiments; iii) Hershey-Chase experiment. JoVE • An Introduction to Developmental Genetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering
DEMONSTRATED UNDERSTANDING	3.A.1.a.5.	DNA replication ensures continuity of hereditary information: i) Replication is a semiconservative process; that is, one strand serves as the template for a new, complementary strand; ii) Replication requires DNA

		polymerase plus many other essential cellular enzymes, occurs bidirectionally, and differs in the production of the leading and lagging strands. JoVE • An Introduction to Cell Division • Cell Cycle Analysis • DNA Ligation Reactions • Genetic Screens • Live Cell Imaging of Mitosis • Method of Standard Addition • Molecular Cloning • PCR: The Polymerase Chain Reaction • Restriction Enzyme Digests • Yeast Maintenance • Yeast Transformation and Cloning
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.1.	DNA, and in some cases RNA, is the primary source of heritable information.
LEARNING OBJECTIVE	3.A.1.b.	DNA and RNA molecules have structural similarities and differences that define function. [See also 4.A.1] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.1.b.1.	Both have three components -- sugar, phosphate and a nitrogenous base -- which form nucleotide units that are connected by covalent bonds to form a linear molecule with 3' and 5' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics • An Introduction to Molecular Developmental Biology • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Maintenance

		• Cell Cycle Analysis • Chromatin Immunoprecipitation • Community DNA Extraction from Bacterial Colonies • Cytogenetics • DNA Gel Electrophoresis • DNA Ligation Reactions • DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electrophoretic Mobility Shift Assay (EMSA) • Embryonic Stem Cell Culture and Differentiation • Enzyme Assays and Kinetics • Explant Culture for Developmental Studies • Expression Profiling with Microarrays • Förster Resonance Energy Transfer (FRET) • Gel Purification • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Metabolic Labeling • Method of Standard Addition • Molecular Cloning • Mouse Genotyping • PCR: The Polymerase Chain Reaction • Photometric Protein Determination • Plasmid Purification • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • Rodent Stereotaxic Surgery • SNP Genotyping • Spectrophotometric Determination of an Equilibrium Constant

		• Testing For Genetically Modified Foods • The TUNEL Assay • Two-Dimensional Gel Electrophoresis • Ultraviolet-Visible (UV-Vis) Spectroscopy • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
DEMONSTRATED UNDERSTANDING	3.A.1.b.3.	Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G): i) Purines (G and A) have a double ring structure; ii) Pyrimidines (C, T and U) have a single ring structure. JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics • An Introduction to Molecular Developmental Biology • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Maintenance • Cell Cycle Analysis • Chromatin Immunoprecipitation • Community DNA Extraction from Bacterial Colonies • Cytogenetics • DNA Gel Electrophoresis • DNA Ligation Reactions • DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation

		• Electrophoretic Mobility Shift Assay (EMSA) • Embryonic Stem Cell Culture and Differentiation • Enzyme Assays and Kinetics • Explant Culture for Developmental Studies • Expression Profiling with Microarrays • Förster Resonance Energy Transfer (FRET) • Gel Purification • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Metabolic Labeling • Method of Standard Addition • Molecular Cloning • Mouse Genotyping • PCR: The Polymerase Chain Reaction • Photometric Protein Determination • Plasmid Purification • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • Rodent Stereotaxic Surgery • SNP Genotyping • Spectrophotometric Determination of an Equilibrium Constant • Testing For Genetically Modified Foods • The TUNEL Assay • Two-Dimensional Gel Electrophoresis • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
DEMONSTRATED UNDERSTANDING	3.A.1.b.4.	The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function: i) mRNA carries information from the DNA to the ribosome; ii) tRNA molecules bind specific amino acids and allow information in the mRNA to be translated to a linear peptide sequence; iii) rRNA molecules are

		functional building blocks of ribosomes; iv) The role of RNAi includes regulation of gene expression at the level of mRNA transcription. <u>JoVE</u> • An Introduction to Developmental Genetics • An Introduction to Molecular Developmental Biology • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • C. elegans Maintenance • Chromatin Immunoprecipitation • DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Detecting Reactive Oxygen Species • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electrophoretic Mobility Shift Assay (EMSA) • Expression Profiling with Microarrays • Gene Silencing with Morpholinos • Genome Editing • Invertebrate Lifespan Quantification • Metabolic Labeling • Method of Standard Addition • Molecular Cloning • PCR: The Polymerase Chain Reaction • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Rodent Stereotaxic Surgery • Spectrophotometric Determination of an Equilibrium Constant • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.1.	DNA, and in some cases RNA, is the primary source of heritable information.
LEARNING OBJECTIVE	3.A.1.c.	Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a

		protein. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.1.c.1.	The enzyme RNA-polymerase reads the DNA molecule in the 3' to 5' direction and synthesizes complementary mRNA molecules that determine the order of amino acids in the polypeptide. JoVE • An Overview of Epigenetics • An Overview of Gene Expression • Chromatin Immunoprecipitation • DNA Methylation Analysis • Detecting Reactive Oxygen Species • Electrophoretic Mobility Shift Assay (EMSA) • Expression Profiling with Microarrays • Gene Silencing with Morpholinos • Genome Editing • Molecular Cloning • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • Whole-Mount In Situ Hybridization
DEMONSTRATED UNDERSTANDING	3.A.1.c.3.	Translation of the mRNA occurs in the cytoplasm on the ribosome. JoVE • Chromatin Immunoprecipitation • Electrophoretic Mobility Shift Assay (EMSA)
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.1.	DNA, and in some cases RNA, is the primary source of heritable information.
LEARNING OBJECTIVE	3.A.1.e.	Genetic engineering techniques can manipulate the heritable information of DNA and, in special cases, RNA. JoVE • An Introduction to Aging and Regeneration • An Introduction to Molecular Developmental Biology • An Introduction to Neurophysiology • An Introduction to Organogenesis • An Introduction to Saccharomyces cerevisiae • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio

		• An Overview of Gene Expression • An Overview of Genetic Engineering • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Development and Reproduction • Chick ex ovo Culture • DNA Ligation Reactions • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Explant Culture of Neural Tissue • Fate Mapping • Fundamentals of Breeding and Weaning • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Molecular Cloning • Mouse Genotyping • Murine In Utero Electroporation • Neuronal Transfection Methods • Plasmid Purification • Primary Neuronal Cultures • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • Rodent Stereotaxic Surgery • Solid-Liquid Extraction • Testing For Genetically Modified Foods • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
LEARNING OBJECTIVE	3.A.1.f.	Illustrative examples of products of genetic engineering include: Genetically modified foods; Transgenic animals; Cloned animals; Pharmaceuticals, such as human insulin or factor X. JoVE • An Introduction to Aging and Regeneration

		• An Introduction to Drosophila melanogaster • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • An Overview of Genetic Engineering • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Development and Reproduction • Chick ex ovo Culture • DNA Ligation Reactions • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Fate Mapping • Fundamentals of Breeding and Weaning • Gene Silencing with Morpholinos • Genetic Engineering of Model Organisms • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Molecular Cloning • Mouse Genotyping • Plasmid Purification • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • Solid-Liquid Extraction • Testing For Genetically Modified Foods • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	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.

LEARNING OBJECTIVE	3.A.2.a.	The cell cycle is a complex set of stages that is highly regulated with checkpoints, which determine the ultimate fate of the cell. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.2.a.4.	Mitosis alternates with interphase in the cell cycle. JoVE • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • Cell Cycle Analysis • Live Cell Imaging of Mitosis • Yeast Reproduction • Yeast Transformation and Cloning
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	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.
LEARNING OBJECTIVE	3.A.2.b.	Mitosis passes a complete genome from the parent cell to daughter cells. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.2.b.1.	Mitosis occurs after DNA replication. JoVE • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • Cell Cycle Analysis • Live Cell Imaging of Mitosis • Yeast Reproduction • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	3.A.2.b.2.	Mitosis followed by cytokinesis produces two genetically identical daughter cells. JoVE • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • Cell Cycle Analysis • Live Cell Imaging of Mitosis • Yeast Reproduction • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	3.A.2.b.3.	Mitosis plays a role in growth, repair, and asexual reproduction JoVE • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • Cell Cycle Analysis

		• Live Cell Imaging of Mitosis • Yeast Reproduction • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	3.A.2.b.4.	Mitosis is a continuous process with observable structural features along the mitotic process. Evidence of student learning is demonstrated by knowing the order of the processes (replication, alignment, separation). JoVE • An Introduction to Cell Division • An Introduction to Saccharomyces cerevisiae • Cell Cycle Analysis • Live Cell Imaging of Mitosis • Yeast Reproduction • Yeast Transformation and Cloning
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	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.
LEARNING OBJECTIVE	3.A.2.c.	Meiosis, a reduction division, followed by fertilization ensures genetic diversity in sexually reproducing organisms. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.2.c.1.	Meiosis ensures that each gamete receives one complete haploid (1n) set of chromosomes. JoVE • An Introduction to Cell Division • Genetic Crosses • Recombineering and Gene Targeting • Yeast Reproduction
DEMONSTRATED UNDERSTANDING	3.A.2.c.2.	During meiosis, homologous chromosomes are paired, with one homologue originating from the maternal parent and the other from the paternal parent. Orientation of the chromosome pairs is random with respect to the cell poles. JoVE • An Introduction to Cell Division • Genetic Crosses • Recombineering and Gene Targeting • Yeast Reproduction
DEMONSTRATED UNDERSTANDING	3.A.2.c.3.	Separation of the homologous chromosomes ensures that each gamete receives a haploid (1n) set of chromosomes composed of both maternal and paternal chromosomes.

		<u>JoVE</u> • An Introduction to Cell Division • Genetic Crosses • Recombineering and Gene Targeting • Yeast Reproduction
DEMONSTRATED UNDERSTANDING	3.A.2.c.4.	During meiosis, homologous chromatids exchange genetic material via a process called "crossing over," which increases genetic variation in the resultant gametes. [See also 3.C.2] <u>JoVE</u> • An Overview of Genetic Analysis • Drosophila Development and Reproduction • Genetic Crosses
DEMONSTRATED UNDERSTANDING	3.A.2.c.5.	Fertilization involves the fusion of two gametes, increases genetic variation in populations by providing for new combinations of genetic information in the zygote, and restores the diploid number of chromosomes. <u>JoVE</u> • An Introduction to Caenorhabditis elegans • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio • C. elegans Development and Reproduction • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Genetic Crosses • Zebrafish Reproduction and Development
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.3.	The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
LEARNING OBJECTIVE	3.A.3.a.	Rules of probability can be applied to analyze passage of single gene traits from parent to offspring. <u>JoVE</u> • Fundamentals of Breeding and Weaning • Genetic Crosses
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.

ESSENTIAL KNOWLEDGE	3.A.3.	The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
LEARNING OBJECTIVE	3.A.3.b.	Segregation and independent assortment of chromosomes result in genetic variation. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.A.3.b.1.	Segregation and independent assortment can be applied to genes that are on different chromosomes. JoVE • Genetic Crosses
DEMONSTRATED UNDERSTANDING	3.A.3.b.2.	Genes that are adjacent and close to each other on the same chromosome tend to move as a unit; the probability that they will segregate as a unit is a function of the distance between them. JoVE • The ELISA Method
DEMONSTRATED UNDERSTANDING	3.A.3.b.3.	The pattern of inheritance (monohybrid, dihybrid, sex-linked, and genes linked on the same homologous chromosome) can often be predicted from data that gives the parent genotype/phenotype and/or the offspring phenotypes/genotypes. JoVE • Fundamentals of Breeding and Weaning • Genetic Crosses
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.3.	The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.
LEARNING OBJECTIVE	3.A.3.c.	Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction. JoVE • An Introduction to Aging and Regeneration • An Introduction to Cell Division • An Introduction to Endocytosis and Exocytosis • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Saccharomyces cerevisiae • An Introduction to Stem Cell Biology • An Overview of Gene Expression

		• An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Chromatography-Based Biomolecule Purification Methods • Cytogenetics • Embryonic Stem Cell Culture and Differentiation • Gene Silencing with Morpholinos • SNP Genotyping • Tissue Regeneration with Somatic Stem Cells • Whole-Mount In Situ Hybridization
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.4.	The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
LEARNING OBJECTIVE	3.A.4.a.	Many traits are the product of multiple genes and/or physiological processes. Evidence of student learning is a demonstrated understanding of the following:
DEMONSTRATED UNDERSTANDING	3.A.4.a.1.	Patterns of inheritance of many traits do not follow ratios predicted by Mendel's laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios. JoVE • An Overview of Epigenetics • An Overview of Genetic Analysis • An Overview of Genetics and Disease • DNA Methylation Analysis • Genetic Crosses
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.A.	Heritable information provides for continuity of life.
ESSENTIAL KNOWLEDGE	3.A.4.	The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.
LEARNING OBJECTIVE	3.A.4.b.	Some traits are determined by genes on sex chromosomes. JoVE • An Overview of Epigenetics • An Overview of Genetics and Disease • DNA Methylation Analysis
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.B.	Expression of genetic information involves cellular and molecular mechanisms.

ESSENTIAL KNOWLEDGE	**3.B.1.**	**Gene regulation results in differential gene expression, leading to cell specialization.**
LEARNING OBJECTIVE	**3.B.1.c.**	**In eukaryotes, gene expression is complex and control involves regulatory genes, regulatory elements and transcription factors that act in concert. Evidence of student learning is a demonstrated understanding of each of the following:**
DEMONSTRATED UNDERSTANDING	**3.B.1.c.3.**	**The combination of transcription factors binding to the regulatory regions at any one time determines how much, if any, of the gene product will be produced.** **JoVE** • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics • An Introduction to Developmental Neurobiology • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Chick ex ovo Culture • Chromatin Immunoprecipitation • DNA Methylation Analysis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Explant Culture of Neural Tissue • Expression Profiling with Microarrays • Fate Mapping • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Introduction to the Microplate Reader

		• Isolating Nucleic Acids from Yeast • Mouse Genotyping • Murine In Utero Electroporation • PCR: The Polymerase Chain Reaction • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Rodent Stereotaxic Surgery • Testing For Genetically Modified Foods • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	**AP.B.3.**	**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**
ENDURING UNDERSTANDING	**3.B.**	**Expression of genetic information involves cellular and molecular mechanisms.**
ESSENTIAL KNOWLEDGE	**3.B.1.**	**Gene regulation results in differential gene expression, leading to cell specialization.**
LEARNING OBJECTIVE	**3.B.1.d.**	**Gene regulation accounts for some of the phenotypic differences between organisms with similar genes.** **JoVE** • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics • An Introduction to Developmental Neurobiology • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Chick ex ovo Culture • Chromatin Immunoprecipitation

		• DNA Methylation Analysis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Explant Culture of Neural Tissue • Expression Profiling with Microarrays • Fate Mapping • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Histological Staining of Neural Tissue • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Introduction to the Microplate Reader • Isolating Nucleic Acids from Yeast • Mouse Genotyping • Murine In Utero Electroporation • PCR: The Polymerase Chain Reaction • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Rodent Stereotaxic Surgery • Testing For Genetically Modified Foods • The TUNEL Assay • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.B.	Expression of genetic information involves cellular and molecular mechanisms.
ESSENTIAL KNOWLEDGE	3.B.2.	A variety of intercellular and intracellular signal transmissions mediate gene expression.
LEARNING OBJECTIVE	3.B.2.b.	Signal transmission within and between cells mediates cell function.

		<u>JoVE</u> • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Reward and Addiction • Development and Reproduction of the Laboratory Mouse • Self-administration Studies
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.
ESSENTIAL KNOWLEDGE	3.C.1.	Changes in genotype can result in changes in phenotype.
LEARNING OBJECTIVE	3.C.1.a.	Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype. [See also 3.A.1] Evidence of student learning is a demonstrated understanding of the following:
DEMONSTRATED UNDERSTANDING	3.C.1.a.1.	DNA mutations can be positive, negative or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein. <u>JoVE</u> • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetics and Disease • Genetic Engineering of Model Organisms • Genetic Screens • Isolating Nucleic Acids from Yeast • Passaging Cells • The TUNEL Assay
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.

ESSENTIAL KNOWLEDGE	3.C.1.	Changes in genotype can result in changes in phenotype.
LEARNING OBJECTIVE	3.C.1.b.	Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random changes, e.g., mutations in the DNA. Evidence of student learning is a demonstrated understanding of the following:
DEMONSTRATED UNDERSTANDING	3.C.1.b.1.	Whether or not a mutation is detrimental, beneficial or neutral depends on the environmental context. Mutations are the primary source of genetic variation. JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetics and Disease • Genetic Engineering of Model Organisms • Genetic Screens • Isolating Nucleic Acids from Yeast • Passaging Cells • The TUNEL Assay
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.
ESSENTIAL KNOWLEDGE	3.C.1.	Changes in genotype can result in changes in phenotype.
LEARNING OBJECTIVE	3.C.1.d.	Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected by environmental conditions. [See also 1.A.2, 1.C.3] Evidence of student learning is a demonstrated understanding of the following:
DEMONSTRATED UNDERSTANDING	3.C.1.d.1.	Selection results in evolutionary change. JoVE • An Overview of Genetic Analysis

BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.
ESSENTIAL KNOWLEDGE	3.C.2.	Biological systems have multiple processes that increase genetic variation.
LEARNING OBJECTIVE	3.C.2.c.	Sexual reproduction in eukaryotes involving gamete formation, including crossing-over during meiosis and the random assortment of chromosomes during meiosis, and fertilization serve to increase variation. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms. [See also 1.B.1, 3.A.2, 4.C.2, 4.C3] JoVE • An Overview of Genetic Analysis • Drosophila Development and Reproduction • Genetic Crosses
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.
ESSENTIAL KNOWLEDGE	3.C.3.	Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
LEARNING OBJECTIVE	3.C.3.a.	Viral replication differs from other reproductive strategies and generates genetic variation via various mechanisms. [See also 1.B.3] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.C.3.a.1.	Viruses have highly efficient replicative capabilities that allow for rapid evolution and acquisition of new phenotypes. JoVE • Detection of Bacteriophages in Environmental Samples
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.C.	The processing of genetic information is imperfect and is a source of genetic variation.
ESSENTIAL KNOWLEDGE	3.C.3.	Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.
LEARNING OBJECTIVE	3.C.3.b.	The reproductive cycles of viruses facilitate transfer of genetic information. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.C.3.b.1.	Viruses transmit DNA or RNA when they infect a host cell. [See also 1.B.3] JoVE

		• An Introduction to the Laboratory Mouse: Mus musculus • An Overview of Genetic Engineering • Co-Immunoprecipitation and Pull-Down Assays • Detection of Bacteriophages in Environmental Samples • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR
BIG IDEA	**AP.B.3.**	**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**
ENDURING UNDERSTANDING	**3.D.**	**Cells communicate by generating, transmitting and receiving chemical signals.**
ESSENTIAL KNOWLEDGE	**3.D.1.**	**Cell communication processes share common features that reflect a shared evolutionary history.**
LEARNING OBJECTIVE	**3.D.1.a.**	**Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment. [See also 1.B.1]** **JoVE** • An Introduction to Developmental Neurobiology • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Calcium Imaging in Neurons • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • Motor Exam I • Motor Exam II • Patch Clamp Electrophysiology • Rodent Stereotaxic Surgery • Self-administration Studies
LEARNING OBJECTIVE	**3.D.1.d.**	**In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.** **JoVE** • An Introduction to Cell Death • An Introduction to Motor Control • Biofuels: Producing Ethanol from Cellulosic Material • Co-Immunoprecipitation and Pull-Down Assays • DNA Ligation Reactions • Enzyme Assays and Kinetics • Introduction to Catalysis • Live Cell Imaging of Mitosis • Molecular Cloning • Motor Exam I • Motor Exam II • PCR: The Polymerase Chain Reaction

		• Restriction Enzyme Digests • The ELISA Method • The TUNEL Assay
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.D.	Cells communicate by generating, transmitting and receiving chemical signals.
ESSENTIAL KNOWLEDGE	3.D.2.	Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
LEARNING OBJECTIVE	3.D.2.b.	Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell. Evidence of student learning is a demonstrated understanding of the following:
DEMONSTRATED UNDERSTANDING	3.D.2.b.1.	Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body. JoVE • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Reward and Addiction • Anxiety Testing • Development and Reproduction of the Laboratory Mouse • Modeling Social Stress • Self-administration Studies • Thyroid Exam
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.D.	Cells communicate by generating, transmitting and receiving chemical signals.
ESSENTIAL KNOWLEDGE	3.D.3.	Signal transduction pathways link signal reception with cellular response.
LEARNING OBJECTIVE	3.D.3.a.	Signaling begins with the recognition of a chemical messenger, a ligand, by a receptor protein. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.D.3.a.1.	Different receptors recognize different chemical messengers, which can be peptides, small chemicals or proteins, in a specific one-to-one relationship. JoVE • An Introduction to Cell Death • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Modeling Behavioral Disorders and Stress

		• An Introduction to Reward and Addiction • Biofuels: Producing Ethanol from Cellulosic Material • Co-Immunoprecipitation and Pull-Down Assays • DNA Ligation Reactions • Development and Reproduction of the Laboratory Mouse • Enzyme Assays and Kinetics • Introduction to Catalysis • Live Cell Imaging of Mitosis • Molecular Cloning • PCR: The Polymerase Chain Reaction • Restriction Enzyme Digests • Self-administration Studies • The ELISA Method • The TUNEL Assay
BIG IDEA	**AP.B.3.**	**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**
ENDURING UNDERSTANDING	**3.D.**	**Cells communicate by generating, transmitting and receiving chemical signals.**
ESSENTIAL KNOWLEDGE	**3.D.4.**	**Changes in signal transduction pathways can alter cellular response.**
LEARNING OBJECTIVE	**3.D.4.a.**	**Conditions where signal transduction is blocked or defective can be deleterious, preventative or prophylactic.** **JoVE** • An Introduction to Cell Metabolism • Detecting Reactive Oxygen Species • Eye Exam • Introducing Experimental Agents into the Mouse • Ophthalmoscopic Examination • Peripheral Vascular Exam • Peripheral Vascular Exam Using a Continuous Wave Doppler • The ATP Bioluminescence Assay
BIG IDEA	**AP.B.3.**	**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**
ENDURING UNDERSTANDING	**3.E.**	**Transmission of information results in changes within and between biological systems.**
ESSENTIAL KNOWLEDGE	**3.E.1.**	**Individuals can act on information and communicate it to others.**
LEARNING OBJECTIVE	**3.E.1.c.**	**Responses to information and communication of information are vital to natural selection and evolution. [See also 1.A.2] Evidence of student learning is a demonstrated understanding of the following:**
DEMONSTRATED UNDERSTANDING	**3.E.1.c.1.**	**Natural selection favors innate and learned behaviors that increase survival and reproductive fitness.**

		<u>JoVE</u> • An Overview of Genetic Analysis
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.E.	Transmission of information results in changes within and between biological systems.
ESSENTIAL KNOWLEDGE	3.E.2.	Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
LEARNING OBJECTIVE	3.E.2.a.	The neuron is the basic structure of the nervous system that reflects function. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.E.2.a.1.	A typical neuron has a cell body, axon and dendrites. Many axons have a myelin sheath that acts as an electrical insulator. <u>JoVE</u> • An Introduction to Behavioral Neuroscience • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Cognition • An Introduction to Developmental Neurobiology • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Ankle Exam • Anterograde Amnesia • Balance and Coordination Testing • Calcium Imaging in Neurons • Color Afterimages • Cranial Nerves Exam I (I-VI) • Cranial Nerves Exam II (VII-XII) • Crowding • Detecting Reactive Oxygen Species • Ear Exam • Elbow Exam • Electro-encephalography (EEG) • Embryonic Stem Cell Culture and Differentiation • Emergent Lateral Canthotomy and Inferior Catholysis • Event-related Potentials and the Oddball Task • Explant Culture of Neural Tissue • Eye Exam • FM Dyes in Vesicle Recycling • Finding Your Blind Spot and Perceptual Filling-in • Foot Exam • Hand and Wrist Exam • Hip Exam • Histological Staining of Neural Tissue

		• Inattentional Blindness • Just-noticeable Differences • Knee Exam • Lower Back Exam • Measuring Grey Matter Differences with Voxel-based Morphometry: The Musical Brain • Motion-induced Blindness • Motor Exam I • Motor Exam II • Murine In Utero Electroporation • Neck Exam • Neuronal Transfection Methods • Object Substitution Masking • Ophthalmoscopic Examination • Patch Clamp Electrophysiology • Physiological Correlates of Emotion Recognition • Primary Neuronal Cultures • Rodent Stereotaxic Surgery • Self-administration Studies • Sensory Exam • Shoulder Exam I • Shoulder Exam II • Spatial Cueing • The Ames Room • The Attentional Blink • The Inverted-face Effect • The McGurk Effect • The Rubber Hand Illusion • The Split Brain • The Staircase Procedure for Finding a Perceptual Threshold • Using Diffusion Tensor Imaging in Traumatic Brain Injury • Using TMS to Measure Motor Excitability During Action Observation • fMRI: Functional Magnetic Resonance Imaging
DEMONSTRATED UNDERSTANDING	**3.E.2.a.2.**	**The structure of the neuron allows for the detection, generation, transmission and integration of signal information.** JoVE • An Introduction to Behavioral Neuroscience • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Cognition • An Introduction to Developmental Neurobiology • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction

		• Ankle Exam • Anterograde Amnesia • Balance and Coordination Testing • Calcium Imaging in Neurons • Color Afterimages • Cranial Nerves Exam I (I-VI) • Cranial Nerves Exam II (VII-XII) • Crowding • Detecting Reactive Oxygen Species • Ear Exam • Elbow Exam • Electro-encephalography (EEG) • Embryonic Stem Cell Culture and Differentiation • Emergent Lateral Canthotomy and Inferior Catholysis • Event-related Potentials and the Oddball Task • Explant Culture of Neural Tissue • Eye Exam • FM Dyes in Vesicle Recycling • Finding Your Blind Spot and Perceptual Filling-in • Foot Exam • Hand and Wrist Exam • Hip Exam • Histological Staining of Neural Tissue • Inattentional Blindness • Just-noticeable Differences • Knee Exam • Lower Back Exam • Measuring Grey Matter Differences with Voxel-based Morphometry: The Musical Brain • Motion-induced Blindness • Motor Exam I • Motor Exam II • Murine In Utero Electroporation • Neck Exam • Neuronal Transfection Methods • Object Substitution Masking • Ophthalmoscopic Examination • Patch Clamp Electrophysiology • Physiological Correlates of Emotion Recognition • Primary Neuronal Cultures • Rodent Stereotaxic Surgery • Self-administration Studies • Sensory Exam • Shoulder Exam I • Shoulder Exam II • Spatial Cueing • The Ames Room • The Attentional Blink • The Inverted-face Effect • The McGurk Effect • The Rubber Hand Illusion

		• The Split Brain • The Staircase Procedure for Finding a Perceptual Threshold • Using Diffusion Tensor Imaging in Traumatic Brain Injury • Using TMS to Measure Motor Excitability During Action Observation • fMRI: Functional Magnetic Resonance Imaging
BIG IDEA	AP.B.3.	Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.
ENDURING UNDERSTANDING	3.E.	Transmission of information results in changes within and between biological systems.
ESSENTIAL KNOWLEDGE	3.E.2.	Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.
LEARNING OBJECTIVE	3.E.2.c.	Transmission of information between neurons occurs across synapses. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	3.E.2.c.1.	In most animals, transmission across synapses involves chemical messengers called neurotransmitters. JoVE • An Introduction to Developmental Neurobiology • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Calcium Imaging in Neurons • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • Patch Clamp Electrophysiology • Rodent Stereotaxic Surgery • Self-administration Studies
DEMONSTRATED UNDERSTANDING	3.E.2.c.2.	Transmission of information along neurons and synapses results in a response. JoVE • An Introduction to Developmental Neurobiology • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Calcium Imaging in Neurons • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • Patch Clamp Electrophysiology • Rodent Stereotaxic Surgery • Self-administration Studies
DEMONSTRATED UNDERSTANDING	3.E.2.c.3.	The response can be stimulatory or inhibitory. JoVE

		• An Introduction to Developmental Neurobiology • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Calcium Imaging in Neurons • FM Dyes in Vesicle Recycling • Histological Staining of Neural Tissue • Patch Clamp Electrophysiology • Rodent Stereotaxic Surgery • Self-administration Studies
BIG IDEA	**AP.B.3.**	**Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.**
ENDURING UNDERSTANDING	**3.E.**	**Transmission of information results in changes within and between biological systems.**
ESSENTIAL KNOWLEDGE	**3.E.2.**	**Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.**
LEARNING OBJECTIVE	**3.E.2.d.**	**Different regions of the vertebrate brain have different functions.** **JoVE** • An Introduction to Behavioral Neuroscience • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Cognition • An Introduction to Developmental Neurobiology • An Introduction to Learning and Memory • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • An Introduction to Reward and Addiction • Anterograde Amnesia • Anxiety Testing • Assessing Dexterity with Reaching Tasks • Balance and Coordination Testing • Binocular Rivalry • Color Afterimages • Cranial Nerves Exam I (I-VI) • Cranial Nerves Exam II (VII-XII) • Crowding • Decision-making and the Iowa Gambling Task • Decoding Auditory Imagery with Multivoxel Pattern Analysis • Dichotic Listening • Electro-encephalography (EEG) • Event-related Potentials and the Oddball Task • Executive Function and the Dimensional Change Card Sort Task • Executive Function in Autism Spectrum Disorder

		• Explant Culture of Neural Tissue • Eye Tracking in Cognitive Experiments • Fear Conditioning • Finding Your Blind Spot and Perceptual Filling-in • Histological Staining of Neural Tissue • Inattentional Blindness • Incidental Encoding • Just-noticeable Differences • Language: The N400 in Semantic Incongruity • Learning and Memory: The Remember-Know Task • Measuring Grey Matter Differences with Voxel-based Morphometry: The Musical Brain • Mental Rotation • Modeling Social Stress • Motion-induced Blindness • Motor Exam I • Motor Exam II • Motor Learning in Mirror Drawing • Motor Maps • Murine In Utero Electroporation • Mutual Exclusivity: How Children Learn the Meanings of Words • Neuronal Transfection Methods • Object Substitution Masking • Physiological Correlates of Emotion Recognition • Primary Neuronal Cultures • Prospect Theory • Rodent Stereotaxic Surgery • Self-administration Studies • Sensory Exam • Spatial Cueing • Spatial Memory Testing Using Mazes • The Ames Room • The Attentional Blink • The Inverted-face Effect • The McGurk Effect • The Morris Water Maze • The Rubber Hand Illusion • The Split Brain • The Staircase Procedure for Finding a Perceptual Threshold • Using Diffusion Tensor Imaging in Traumatic Brain Injury • Using TMS to Measure Motor Excitability During Action Observation • Verbal Priming • Visual Attention: fMRI Investigation of Object-based Attentional Control • Visual Search for Features and Conjunctions • Visual Statistical Learning • Within-subjects Repeated-measures Design • fMRI: Functional Magnetic Resonance Imaging

BIG IDEA	**AP.B.4.**	**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**
ENDURING UNDERSTANDING	**4.A.**	**Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.**
ESSENTIAL KNOWLEDGE	**4.A.1.**	**The subcomponents of biological molecules and their sequence determine the properties of that molecule.**
LEARNING OBJECTIVE	**4.A.1.a.**	**Structure and function of polymers are derived from the way their monomers are assembled. Evidence of student learning is a demonstrated understanding of each of the following:**
DEMONSTRATED UNDERSTANDING	**4.A.1.a.1.**	**In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate and a nitrogen base (adenine, thymine, guanine, cytosine or uracil). DNA and RNA differ in function and differ slightly in structure, and these structural differences account for the differing functions. [See also 1.D.1, 2.A.3, 3.A.1]** **JoVE** • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Molecular Developmental Biology • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Maintenance • Cell Cycle Analysis • Chromatin Immunoprecipitation • Community DNA Extraction from Bacterial Colonies • Cytogenetics • DNA Gel Electrophoresis • DNA Ligation Reactions • DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Development and Reproduction of the Laboratory Mouse • Development of the Chick

		• Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electrophoretic Mobility Shift Assay (EMSA) • Embryonic Stem Cell Culture and Differentiation • Enzyme Assays and Kinetics • Explant Culture for Developmental Studies • Expression Profiling with Microarrays • Förster Resonance Energy Transfer (FRET) • Gel Purification • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Metabolic Labeling • Molecular Cloning • Mouse Genotyping • PCR: The Polymerase Chain Reaction • Photometric Protein Determination • Plasmid Purification • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • SNP Genotyping • Spectrophotometric Determination of an Equilibrium Constant • Testing For Genetically Modified Foods • The TUNEL Assay • Ultraviolet-Visible (UV-Vis) Spectroscopy • Whole-Mount In Situ Hybridization • Yeast Maintenance • Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
DEMONSTRATED UNDERSTANDING	4.A.1.a.2.	In proteins, the specific order of amino acids in a polypeptide (primary structure) interacts with the environment to determine the overall shape of the protein, which also involves secondary tertiary and quaternary structure and, thus, its function. The R group of an amino acid can be categorized by chemical

		properties (hydrophobic, hydrophilic and ionic), and the interactions of these R groups determine structure and function of that region of the protein. [See also 1.D.1, 2.A.3, 2.B.1] <u>JoVE</u> • An Introduction to Cell Motility and Migration • An Introduction to Saccharomyces cerevisiae • An Overview of Epigenetics • An Overview of Gene Expression • Cell-surface Biotinylation Assay • Chromatin Immunoprecipitation • Co-Immunoprecipitation and Pull-Down Assays • Density Gradient Ultracentrifugation • Dialysis: Diffusion Based Separation • Drosophila Larval IHC • Electrophoretic Mobility Shift Assay (EMSA) • Enzyme Assays and Kinetics • FM Dyes in Vesicle Recycling • Förster Resonance Energy Transfer (FRET) • Genetic Engineering of Model Organisms • Introduction to Catalysis • Introduction to Mass Spectrometry • Invasion Assay Using 3D Matrices • Ion-Exchange Chromatography • MALDI-TOF Mass Spectrometry • Metabolic Labeling • Photometric Protein Determination • Protein Crystallization • Reconstitution of Membrane Proteins • Separating Protein with SDS-PAGE • Separation of Mixtures via Precipitation • Surface Plasmon Resonance (SPR) • Tandem Mass Spectrometry • The ELISA Method • The Transwell Migration Assay • The Western Blot • Two-Dimensional Gel Electrophoresis • Yeast Transformation and Cloning
DEMONSTRATED UNDERSTANDING	4.A.1.a.4.	Carbohydrates are composed of sugar monomers whose structures and bonding with each other by dehydration synthesis determine the properties and functions of the molecules. Illustrative examples include: cellulose versus starch. <u>JoVE</u> • An Overview of Alkenone Biomarker Analysis for Paleothermometry • An Overview of bGDGT Biomarker Analysis for Paleoclimatology • Conversion of Fatty Acid Methyl Esters by

		Saponification for Uk'37 Paleothermometry • Extraction of Biomarkers from Sediments - Accelerated Solvent Extraction • Purification of a Total Lipid Extract with Column Chromatography • Removal of Branched and Cyclic Compounds by Urea Adduction for Uk'37 Paleothermometry • Sonication Extraction of Lipid Biomarkers from Sediment • Soxhlet Extraction of Lipid Biomarkers from Sediment
BIG IDEA	**AP.B.4.**	**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**
ENDURING UNDERSTANDING	**4.A.**	**Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.**
ESSENTIAL KNOWLEDGE	**4.A.1.**	**The subcomponents of biological molecules and their sequence determine the properties of that molecule.**
LEARNING OBJECTIVE	**4.A.1.b.**	**Directionality influences structure and function of the polymer. Evidence of student learning is a demonstrated understanding of each of the following:**
DEMONSTRATED UNDERSTANDING	4.A.1.b.1.	Nucleic acids have ends, defined by the 3' and 5' carbons of the sugar in the nucleotide, that determine the direction in which complementary nucleotides are added during DNA synthesis and the direction in which transcription occurs (from 5' to 3'). [See also 3.A.1] <u>JoVE</u> • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Genetics • An Introduction to Molecular Developmental Biology • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetic Engineering • An Overview of Genetics and Disease • Annexin V and Propidium Iodide Labeling • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • C. elegans Maintenance • Cell Cycle Analysis • Chromatin Immunoprecipitation • Community DNA Extraction from Bacterial Colonies • Cytogenetics • DNA Gel Electrophoresis • DNA Ligation Reactions

		• DNA Methylation Analysis • Density Gradient Ultracentrifugation • Detecting Environmental Microorganisms with the Polymerase Chain Reaction and Gel Electrophoresis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Electrophoretic Mobility Shift Assay (EMSA) • Embryonic Stem Cell Culture and Differentiation • Enzyme Assays and Kinetics • Explant Culture for Developmental Studies • Expression Profiling with Microarrays • Förster Resonance Energy Transfer (FRET) • Gel Purification • Gene Silencing with Morpholinos • Genetic Crosses • Genetic Engineering of Model Organisms • Genetic Screens • Genome Editing • In ovo Electroporation of Chicken Embryos • Induced Pluripotency • Invertebrate Lifespan Quantification • Isolating Nucleic Acids from Yeast • Live Cell Imaging of Mitosis • Metabolic Labeling • Method of Standard Addition • Molecular Cloning • Mouse Genotyping • PCR: The Polymerase Chain Reaction • Photometric Protein Determination • Plasmid Purification • Protein Crystallization • Quantifying Environmental Microorganisms and Viruses Using qPCR • RNA Analysis of Environmental Samples Using RT-PCR • RNA-Seq • RNAi in C. elegans • Recombineering and Gene Targeting • Restriction Enzyme Digests • Rodent Stereotaxic Surgery • SNP Genotyping • Spectrophotometric Determination of an Equilibrium Constant • Testing For Genetically Modified Foods • The TUNEL Assay • Two-Dimensional Gel Electrophoresis • Ultraviolet-Visible (UV-Vis) Spectroscopy • Whole-Mount In Situ Hybridization • Yeast Maintenance

		• Yeast Transformation and Cloning • Zebrafish Breeding and Embryo Handling • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
DEMONSTRATED UNDERSTANDING	4.A.1.b.2.	Proteins have an amino (NH2) end and a carboxyl (COOH) end, and consist of a linear sequence of amino acids connected by the formation of peptide bonds by dehydration synthesis between the amino and carboxyl groups of adjacent monomers. JoVE • An Introduction to Cell Motility and Migration • An Introduction to Saccharomyces cerevisiae • An Overview of Epigenetics • An Overview of Gene Expression • Cell-surface Biotinylation Assay • Chromatin Immunoprecipitation • Co-Immunoprecipitation and Pull-Down Assays • Density Gradient Ultracentrifugation • Dialysis: Diffusion Based Separation • Drosophila Larval IHC • Electrophoretic Mobility Shift Assay (EMSA) • Enzyme Assays and Kinetics • FM Dyes in Vesicle Recycling • Förster Resonance Energy Transfer (FRET) • Genetic Engineering of Model Organisms • Introduction to Catalysis • Introduction to Mass Spectrometry • Invasion Assay Using 3D Matrices • Ion-Exchange Chromatography • MALDI-TOF Mass Spectrometry • Metabolic Labeling • Photometric Protein Determination • Protein Crystallization • Reconstitution of Membrane Proteins • Separating Protein with SDS-PAGE • Separation of Mixtures via Precipitation • Surface Plasmon Resonance (SPR) • Tandem Mass Spectrometry • The ELISA Method • The Transwell Migration Assay • The Western Blot • Two-Dimensional Gel Electrophoresis • Yeast Transformation and Cloning
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.

ESSENTIAL KNOWLEDGE	4.A.2.	The structure and function of subcellular components, and their interactions, provide essential cellular processes.
LEARNING OBJECTIVE	4.A.2.d.	Mitochondria specialize in energy capture and transformation. [See also 2.A.2, 2.B.3] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.A.2.d.1.	Mitochondria have a double membrane that allows compartmentalization within the mitochondria and is important to its function. JoVE • An Introduction to Aging and Regeneration • An Introduction to Cell Metabolism • Density Gradient Ultracentrifugation • Detecting Reactive Oxygen Species • The ATP Bioluminescence Assay
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.2.	The structure and function of subcellular components, and their interactions, provide essential cellular processes.
LEARNING OBJECTIVE	4.A.2.g.	Chloroplasts are specialized organelles found in algae and higher plants that capture energy through photosynthesis. [See also 2.A.2, 2.B.3] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.A.2.g.2.	Chloroplasts contain chlorophylls, which are responsible for the green color of a plant and are the key light-trapping molecules in photosynthesis. There are several types of chlorophyll, but the predominant form in plants is chlorophyll a. JoVE • Reconstitution of Membrane Proteins
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.3.	Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.
LEARNING OBJECTIVE	4.A.3.b.	Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type. [See also 3.B.1, 3.B.2]

		JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Motility and Migration • An Introduction to Developmental Genetics • An Introduction to Developmental Neurobiology • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • An Introduction to Stem Cell Biology • An Overview of Epigenetics • An Overview of Gene Expression • C. elegans Development and Reproduction • DNA Methylation Analysis • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Drosophila Larval IHC • Embryonic Stem Cell Culture and Differentiation • Explant Culture for Developmental Studies • Explant Culture of Neural Tissue • Expression Profiling with Microarrays • Fate Mapping • Gene Silencing with Morpholinos • Genetic Engineering of Model Organisms • Induced Pluripotency • Murine In Utero Electroporation • RNA-Seq • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Zebrafish Breeding and Embryo Handling • Zebrafish Reproduction and Development
LEARNING OBJECTIVE	**4.A.3.c.**	**Environmental stimuli can affect gene expression in a mature cell. [See also 3.B.1, 3.B.2]** JoVE • An Introduction to the Chick: Gallus gallus domesticus • An Overview of Genetic Analysis • An Overview of Genetics and Disease • Basic Chick Care and Maintenance • C. elegans Maintenance • DNA Methylation Analysis • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Invertebrate Lifespan Quantification • RNAi in C. elegans • Yeast Maintenance • Yeast Reproduction

		• Zebrafish Maintenance and Husbandry • Zebrafish Reproduction and Development
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.4.	Organisms exhibit complex properties due to interactions between their constituent parts.
LEARNING OBJECTIVE	4.A.4.a.	Interactions and coordination between organs provide essential biological activities. JoVE • An Introduction to Behavioral Neuroscience • An Introduction to Caenorhabditis elegans • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Developmental Neurobiology • An Introduction to Learning and Memory • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Motor Control • An Introduction to Reward and Addiction • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Zebrafish: Danio rerio • Anesthesia Induction and Maintenance • Anxiety Testing • Approximate Number Sense Test • Assessing Dexterity with Reaching Tasks • Balance and Coordination Testing • Basic Care Procedures • Binocular Rivalry • Blood Withdrawal I • Blood Withdrawal II • C. elegans Chemotaxis Assay • C. elegans Development and Reproduction • C. elegans Maintenance • Co-Immunoprecipitation and Pull-Down Assays • Color Afterimages • Compound Administration I • Compound Administration II • Compound Administration III • Compound Administration IV • Considerations for Rodent Surgery • Crowding • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Diagnostic Necropsy and Tissue Harvest • Dichotic Listening • Drosophila Larval IHC

		• Explant Culture of Neural Tissue • Finding Your Blind Spot and Perceptual Filling-in • Fundamentals of Breeding and Weaning • Habituation: Studying Infants Before They Can Talk • Histological Staining of Neural Tissue • Inattentional Blindness • Incidental Encoding • Just-noticeable Differences • Measuring Reaction Time and Donders' Method of Subtraction • Measuring Verbal Working Memory Span • Mental Rotation • Modeling Social Stress • Motion-induced Blindness • Motor Learning in Mirror Drawing • Multiple Object Tracking • Murine In Utero Electroporation • Neuronal Transfection Methods • Object Substitution Masking • Physiological Correlates of Emotion Recognition • Primary Neuronal Cultures • Prospect Theory • Rodent Stereotaxic Surgery • Self-administration Studies • Spatial Cueing • Sterile Tissue Harvest • The Ames Room • The Attentional Blink • The Inverted-face Effect • The McGurk Effect • The Precision of Visual Working Memory with Delayed Estimation • The Rubber Hand Illusion • The Staircase Procedure for Finding a Perceptual Threshold • Verbal Priming • Visual Search for Features and Conjunctions • Visual Statistical Learning • Zebrafish Reproduction and Development • fMRI: Functional Magnetic Resonance Imaging
LEARNING OBJECTIVE	4.A.4.b.	Interactions and coordination between systems provide essential biological activities. JoVE • An Introduction to Behavioral Neuroscience • An Introduction to Cellular and Molecular Neuroscience • An Introduction to Learning and Memory • An Introduction to Motor Control • An Introduction to Neuroanatomy • An Introduction to Neurophysiology • Anterograde Amnesia

		• Anxiety Testing • Calcium Imaging in Neurons • Decoding Auditory Imagery with Multivoxel Pattern Analysis • Histological Staining of Neural Tissue • Learning and Memory: The Remember-Know Task • Modeling Social Stress • Motor Learning in Mirror Drawing • Motor Maps • Patch Clamp Electrophysiology • Physiological Correlates of Emotion Recognition • Rodent Stereotaxic Surgery • The Split Brain • fMRI: Functional Magnetic Resonance Imaging
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.5.	Communities are composed of populations of organisms that interact in complex ways.
LEARNING OBJECTIVE	4.A.5.a.	The structure of a community is measured and described in terms of species composition and species diversity. JoVE • Analysis of Earthworm Populations in Soil
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.5.	Communities are composed of populations of organisms that interact in complex ways.
LEARNING OBJECTIVE	4.A.5.c.	Mathematical models and graphical representations are used to illustrate population growth patterns and interactions. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.A.5.c.2.	A population can produce a density of individuals that exceeds the system's resource availability. JoVE • Nutrients in Aquatic Ecosystems
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.

ESSENTIAL KNOWLEDGE	4.A.6.	Interactions among living systems and with their environment result in the movement of matter and energy.
LEARNING OBJECTIVE	4.A.6.a.	Energy flows, but matter is recycled. [See also 2.A.1] JoVE • Algae Enumeration via Culturable Methodology • Analysis of Earthworm Populations in Soil • Bacterial Growth Curve Analysis and its Environmental Applications • Carbon and Nitrogen Analysis of Environmental Samples • Determination Of Nox in Automobile Exhaust Using UV-VIS Spectroscopy • Dissolved Oxygen in Surface Water • Filamentous Fungi • Fundamentals of Breeding and Weaning • Nutrients in Aquatic Ecosystems • Soil Nutrient Analysis: Nitrogen, Phosphorus, and Potassium • Using GIS to Investigate Urban Forestry
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.6.	Interactions among living systems and with their environment result in the movement of matter and energy.
LEARNING OBJECTIVE	4.A.6.e.	Models allow the prediction of the impact of change in biotic and abiotic factors. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.A.6.e.1.	Competition for resources and other factors limits growth and can be described by the logistic model. JoVE • Analysis of Earthworm Populations in Soil • Dissolved Oxygen in Surface Water • Tree Survey: Point-Centered Quarter Sampling Method • Visualizing Soil Microorganisms via the Contact Slide Assay and Microscopy
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.6.	Interactions among living systems and with their environment result in the movement of matter and energy.

LEARNING OBJECTIVE	4.A.6.f.	Human activities impact ecosystems on local, regional and global scales. [See also 2.D.3] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.A.6.f.1.	As human populations have increased in numbers, their impact on habitats for other species have been magnified. JoVE • Nutrients in Aquatic Ecosystems
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.A.	Interactions within biological systems lead to complex properties and their sequence determine the properties of that molecule.
ESSENTIAL KNOWLEDGE	4.A.6.	Interactions among living systems and with their environment result in the movement of matter and energy.
LEARNING OBJECTIVE	4.A.6.g.	Many adaptations of organisms are related to obtaining and using energy and matter in a particular environment. [See also 2.A.1, 2.A.2] JoVE • An Introduction to Caenorhabditis elegans • An Introduction to Cognition • An Introduction to Drosophila melanogaster • An Introduction to Learning and Memory • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • Basic Chick Care and Maintenance • Basic Mouse Care and Maintenance • C. elegans Chemotaxis Assay • Development of the Chick • Drosophila Development and Reproduction • Drosophila Maintenance • Fear Conditioning • Positive Reinforcement Studies • Spatial Memory Testing Using Mazes • Yeast Maintenance • Zebrafish Breeding and Embryo Handling • Zebrafish Maintenance and Husbandry • Zebrafish Microinjection Techniques • Zebrafish Reproduction and Development
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.B.	Competition and cooperation are important aspects of biological systems.

ESSENTIAL KNOWLEDGE	4.B.1.	Interactions between molecules affect their structure and function.
LEARNING OBJECTIVE	4.B.1.a.	Change in the structure of a molecular system may result in a change of the function of the system. [See also 3.D.3] JoVE • An Introduction to Aging and Regeneration • An Introduction to Caenorhabditis elegans • An Introduction to Cell Death • An Introduction to Cell Division • An Introduction to Developmental Genetics • An Introduction to Drosophila melanogaster • An Introduction to Modeling Behavioral Disorders and Stress • An Introduction to Saccharomyces cerevisiae • An Introduction to Transfection • An Introduction to the Zebrafish: Danio rerio • An Overview of Epigenetics • An Overview of Gene Expression • An Overview of Genetic Analysis • An Overview of Genetics and Disease • Genetic Engineering of Model Organisms • Genetic Screens • Isolating Nucleic Acids from Yeast • Passaging Cells • The TUNEL Assay
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.B.	Competition and cooperation are important aspects of biological systems.
ESSENTIAL KNOWLEDGE	4.B.1.	Interactions between molecules affect their structure and function.
LEARNING OBJECTIVE	4.B.1.b.	The shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.B.1.b.1.	For an enzyme-mediated chemical reaction to occur, the substrate must be complementary to the surface properties (shape and charge) of the active site. In other words, the substrate must fit into the enzyme's active site. JoVE • An Introduction to Cell Death • Biofuels: Producing Ethanol from Cellulosic Material • Co-Immunoprecipitation and Pull-Down Assays • DNA Ligation Reactions • Enzyme Assays and Kinetics • Introduction to Catalysis • Live Cell Imaging of Mitosis

		• Molecular Cloning • PCR: The Polymerase Chain Reaction • Restriction Enzyme Digests • The ELISA Method • The TUNEL Assay
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.B.	Competition and cooperation are important aspects of biological systems.
ESSENTIAL KNOWLEDGE	4.B.2.	Cooperative interactions within organisms promote efficiency in the use of energy and matter.
LEARNING OBJECTIVE	4.B.2.a.	Organisms have areas or compartments that perform a subset of functions related to energy and matter, and these parts contribute to the whole. [See also 2.A.2, 4.A.2] Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.B.2.a.2.	Within multicellular organisms, specialization of organs contributes to the overall functioning of the organism. JoVE • An Introduction to Aging and Regeneration • An Introduction to Developmental Genetics • An Introduction to Learning and Memory • An Introduction to Molecular Developmental Biology • An Introduction to Organogenesis • C. elegans Development and Reproduction • Development and Reproduction of the Laboratory Mouse • Development of the Chick • Explant Culture for Developmental Studies • Fate Mapping • Genetic Engineering of Model Organisms • Tissue Regeneration with Somatic Stem Cells • Transplantation Studies • Whole-Mount In Situ Hybridization • Zebrafish Reproduction and Development
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.B.	Competition and cooperation are important aspects of biological systems.
ESSENTIAL KNOWLEDGE	4.B.3.	Interactions between and within populations influence patterns of species distribution and abundance.
LEARNING OBJECTIVE	4.B.3.a.	Interactions between populations affect the distributions and abundance of populations. Evidence of student learning is a demonstrated understanding of each of the following:
DEMONSTRATED UNDERSTANDING	4.B.3.a.1.	Competition, parasitism, predation, mutualism and commensalism can affect population dynamics.

		<u>JoVE</u> • Analysis of Earthworm Populations in Soil • C. elegans Development and Reproduction • Dissolved Oxygen in Surface Water • Genetic Crosses • Recombineering and Gene Targeting • Tree Survey: Point-Centered Quarter Sampling Method • Visualizing Soil Microorganisms via the Contact Slide Assay and Microscopy
DEMONSTRATED UNDERSTANDING	**4.B.3.a.2.**	**Relationships among interacting populations can be characterized by positive and negative effects, and can be modeled mathematically (predator/prey, epidemiological models, invasive species).** <u>JoVE</u> • Analysis of Earthworm Populations in Soil • C. elegans Development and Reproduction • Genetic Crosses • Recombineering and Gene Targeting • Tree Survey: Point-Centered Quarter Sampling Method • Visualizing Soil Microorganisms via the Contact Slide Assay and Microscopy
DEMONSTRATED UNDERSTANDING	**4.B.3.a.3.**	**Many complex symbiotic relationships exist in an ecosystem, and feedback control systems play a role in the functioning of these ecosystems.** <u>JoVE</u> • C. elegans Development and Reproduction • Genetic Crosses • Recombineering and Gene Targeting • Visualizing Soil Microorganisms via the Contact Slide Assay and Microscopy
BIG IDEA	**AP.B.4.**	**Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.**
ENDURING UNDERSTANDING	**4.B.**	**Competition and cooperation are important aspects of biological systems.**
ESSENTIAL KNOWLEDGE	**4.B.3.**	**Interactions between and within populations influence patterns of species distribution and abundance.**
LEARNING OBJECTIVE	**4.B.3.b.**	**A population of organisms has properties that are different from those of the individuals that make up the population. The cooperation and competition between individuals contributes to these different properties.** <u>JoVE</u> • Algae Enumeration via Culturable Methodology • An Introduction to the Chick: Gallus gallus domesticus • An Introduction to the Laboratory Mouse: Mus musculus • An Introduction to the Zebrafish: Danio rerio • Analysis of Earthworm Populations in Soil

		• Aseptic Technique in Environmental Science • Bacterial Growth Curve Analysis and its Environmental Applications • Bacterial Transformation: Electroporation • Bacterial Transformation: The Heat Shock Method • Basic Mouse Care and Maintenance • C. elegans Maintenance • Culturing and Enumerating Bacteria from Soil Samples • Detection of Bacteriophages in Environmental Samples • Dissolved Oxygen in Surface Water • Drosophila Maintenance • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Filamentous Fungi • Isolation of Fecal Bacteria from Water Samples by Filtration • Passaging Cells • Plasmid Purification • Quantifying Environmental Microorganisms and Viruses Using qPCR • Tree Identification: How To Use a Dichotomous Key • Tree Survey: Point-Centered Quarter Sampling Method • Yeast Maintenance • Yeast Reproduction
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.B.	Competition and cooperation are important aspects of biological systems.
ESSENTIAL KNOWLEDGE	4.B.4.	Distribution of local and global ecosystems changes over time.
LEARNING OBJECTIVE	4.B.4.a.	Human impact accelerates change at local and global levels. [See also 1.A.2] JoVE • Biofuels: Producing Ethanol from Cellulosic Material • Determination Of Nox in Automobile Exhaust Using UV-VIS Spectroscopy • Dissolved Oxygen in Surface Water • Lead Analysis of Soil Using Atomic Absorption Spectroscopy • Measuring Tropospheric Ozone • Nutrients in Aquatic Ecosystems • Tree Identification: How To Use a Dichotomous Key • Tree Survey: Point-Centered Quarter Sampling Method • Turbidity and Total Solids in Surface Water • Water Quality Analysis via Indicator Organisms
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

ENDURING UNDERSTANDING	4.C.	Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
ESSENTIAL KNOWLEDGE	4.C.2.	Environmental factors influence the expression of the genotype in an organism.
LEARNING OBJECTIVE	4.C.2.a.	Environmental factors influence many traits both directly and indirectly. [See also 3.B.2, 3.C.1] JoVE • An Introduction to Drosophila melanogaster • An Introduction to the Chick: Gallus gallus domesticus • An Overview of Genetic Analysis • An Overview of Genetics and Disease • Basic Chick Care and Maintenance • C. elegans Maintenance • DNA Methylation Analysis • Drosophila Development and Reproduction • Drosophila melanogaster Embryo and Larva Harvesting and Preparation • Invertebrate Lifespan Quantification • RNAi in C. elegans • Yeast Maintenance • Yeast Reproduction • Zebrafish Maintenance and Husbandry • Zebrafish Reproduction and Development
BIG IDEA	AP.B.4.	Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.
ENDURING UNDERSTANDING	4.C.	Naturally occurring diversity among and between components within biological systems affects interactions with the environment.
ESSENTIAL KNOWLEDGE	4.C.3.	The level of variation in a population affects population dynamics.
LEARNING OBJECTIVE	4.C.3.b.	Genetic diversity allows individuals in a population to respond differently to the same changes in environmental conditions. JoVE • An Overview of Genetic Analysis