

**Main Criteria:** Next Generation Science Standards (NGSS)

**Secondary Criteria:** JoVE Core Biology

**Subject:** Life Science

**Grade:** 9-12

**Adopted:** 2013

STRAND	NGSS.HS-LS.	LIFE SCIENCE
TITLE	HS-LS1.	From Molecules to Organisms: Structures and Processes
		Students who demonstrate understanding can:
PERFORMANCE EXPECTATION	HS-LS1-1.	<p>Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.</p> <p><u>JoVE Biology</u></p> <p>02.13: Van der Waals Interactions            03.01: What are Proteins?            03.02: Protein Organization            03.03: Protein Folding            03.08: What are Nucleic Acids?            03.09: Phosphodiester Linkages            03.12: Biology: 3D-PAGE of Protein and Ribonucleoprotein Complexes            04.01: What are Cells?            04.05: The Nucleus            04.06: Ribosomes            04.14: Developmental Biology: Structure-function Studies in Mouse Embryonic Stem Cells            06.01: Bacterial Signaling            06.02: Yeast Signaling            06.14: Immunology and Infection: Real-time Live Imaging of T-cell Signaling Complex Formation            07.01: What is Metabolism?            10.02: Genomic DNA and Prokaryotes            10.03: Binary Fission            10.10: Live Cell Imaging            10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells            10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry            10.13: Genetics: Studying Cell Cycle-regulated Gene Expression            11.07: Chromatin Spread Preparations            11.08: Using FISH to Monitor Chromosome Segregation            11.09: Immunofluorescence Staining During Meiosis            12.01: Genetic Lingo            12.12: Genetic Screens            12.13: SNP Genotyping            12.14: High-throughput Isolation of Temperature-sensitive Lethal Mutants            12.15: Optogenetic Random Mutagenesis            12.16: Mosaic Zebrafish Transgenesis            13.01: The DNA Helix            13.02: DNA Packaging            13.03: Organization of Genes            13.04: Chromosomal Banding            13.05: Replication in Prokaryotes            13.06: Replication in Eukaryotes            13.07: Proofreading            13.08: Mismatch Repair            13.09: Nucleotide Excision Repair</p>

		<p>13.10: Mutations  13.11: Transcription  13.12: Translation  13.14: DNA Microarrays  13.15: Fluorescence in situ Hybridization (FISH)  13.17: Bioengineering: Folding and Characterization of a Bio-responsive Robot from DNA Origami  13.18: Genetics: Targeted in Situ Mutagenesis of Histone Genes in Budding Yeast  13.19: Biology: The ChIP-exo Method and Identifying Progein-DNA Interactions with Near Base-Pair Precision  14.01: What is Gene Expression?  14.02: The Central Dogma  14.03: RNA Structure  14.04: Types of RNA  14.05: MicroRNAs  14.06: RNA Splicing  14.07: Epigenetic Regulation  14.08: RNA Interference  14.09: RNA-seq  14.10: Genetics: Expression of Dietary Restriction  14.11: Genetics: Single-cell Profiling  14.12: Biology: Affinity-based Isolation of Tagged Nuclei  15.06: Embryonic Stem Cells  15.07: Induces Pluripotent Stem Cells  15.08: In-vitro Mutagenesis  15.09: DNA Isolation  15.10: Gene Therapy  15.11: Reproductive Cloning  15.12: CRISPR  15.13: Complementary DNA  15.14: PCR  15.15: Gel Electrophoresis  15.16: Biology: Alternative Cultures for Human Pluripotent Stem Cell Production, Maintenance, and Genetic Analysis  15.17: Genetics: Targeted Next-generation Sequencing and Bioinformatics Pipeline  15.19: Genetics: CRISPR Guide RNA Cloning for Mammalian Systems  16.07: Viral Mutations  16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues  21.07: Biology: A chemical Screening Procedure for Glucocorticoid Signaling with a Zebrafish Larva Luciferase Reporter System  21.08: Neuroscience: Preparation of Single-cohort Colonies and Hormone Treatment of Worker Honeybees  24.13: Developmental Biology: Live Imaging of Innate Immune and Preneoplastic Cell Interactions  25.08: Determination  25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes  30.05: Environment: Collection and Extraction of Occupational Air Samples for Analysis of Fungal DNA  30.06: Biology: A Comparative Analysis of Recombinant Protein Expression in Different Biofactories  30.07: Genetics: Exploring the Root Microbiome  33.06: Immunology and Infection: Forward Genetics Screens  33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
<b>PERFORMANCE EXPECTATION</b>	<b>HS-LS1-2.</b>	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

**JoVE Biology**

01.02: Levels of Organization  
01.10: Endocrine Disruption  
01.11: Muscle Physiology in Crabs  
04.09: The Extracellular Matrix  
04.10: Tissues  
04.12: Biology: Studying Mitochondria in Drosophila Ovaries  
05.01: The Fluid Mosaic Model  
05.05: Tonicity in Animals  
05.15: Immunology and Infection: Molecular Diffusion in Plasma Membranes  
05.16: Biology: Endocytosis and Recycling of Plasma Membrane Proteins  
05.17: Neuroscience: Examination of Synaptic Vesicle Recycling  
06.03: Contact-dependent Signaling  
06.04: Paracrine Signaling  
06.05: Synaptic Signaling  
06.06: G-protein Coupled Receptors  
06.07: Endocrine Signaling  
06.08: What are Second Messengers?  
06.09: Intracellular Signaling Cascades  
06.10: Ion Channels  
06.11: Enzyme-linked Receptors  
06.13: Medicine: Screening Bioactive Nanoparticles  
06.14: Immunology and Infection: Real-time Live Imaging of T-cell Signaling Complex Formation  
06.15: Biology: Identification of Intracellular Signaling Events  
07.14: Immunology and Infection : A Simple Flow Cytometric Method to Measure Glucose Uptake and Glucose Transporter Expression  
10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells  
10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry  
10.13: Genetics: Studying Cell Cycle-regulated Gene Expression  
14.11: Genetics: Single-cell Profiling  
14.12: Biology: Affinity-based Isolation of Tagged Nuclei  
15.16: Biology: Alternative Cultures for Human Pluripotent Stem Cell Production, Maintenance, and Genetic Analysis  
15.18: Bioengineering: The Multi-organ Chip  
15.19: Genetics: CRISPR Guide RNA Cloning for Mammalian Systems  
16.10: Immunology and Infection: Influenza A Virus Studies  
17.01: What is Monogastric Digestion?  
17.02: Anatomy of the Intestines  
17.03: Accessory Organs  
17.04: Lipid Digestion  
17.05: Protein Digestion  
17.06: Carbohydrate Digestion  
17.07: Neural Regulation  
17.08: Hormonal Regulation  
17.10: Neuroscience: Measuring Oral Fatty Acid Thresholds, Fat Perception, Fatty Food Liking, and Papillae Density in Humans  
17.11: Medicine: Scanning Skeletal Remains for Bone Mineral Density in Forensic Contexts  
17.12: Bioengineering: Treatment of Ligament Constructs with Exercise-conditioned Serum  
18.01: What is a Nervous System?  
18.02: The Parasympathetic Nervous System  
18.03: The Sympathetic Nervous System  
18.04: The Blood-brain Barrier  
18.05: Neuron Structure  
18.06: Glial Cells  
18.07: Action Potentials  
18.08: The Resting Membrane Potential

18.09: Long-term Potentiation  
18.10: Long-term Depression  
18.11: Optogenetics  
18.13: Developmental Biology: Immunostaining to Visualize Murine Enteric Nervous System Development  
18.14: Bioengineering: Three-dimensional Tissue Engineered Aligned Astrocyte Networks  
19.01: What is a Sensory System?  
19.02: The Tongue and Taste Buds  
19.03: Gustation  
19.04: Olfaction  
19.05: Hearing  
19.06: Hair Cells  
19.07: The Cochlea  
19.08: The Vestibular System  
19.09: The Retina  
19.10: Vision  
19.11: Somatosensation  
19.12: Thermosensation  
19.15: Neuroscience: Gustatory Coding  
20.01: What is the Skeletal System?  
20.02: Bone Structure  
20.03: Joints  
20.04: Bone Remodeling  
20.05: Skeletal Muscle Anatomy  
20.06: Classification of Skeletal Muscle Fibers  
20.07: Muscle Contraction  
20.08: Cross-bridge Cycle  
20.09: Motor Units  
20.10: The Spinal Cord  
20.11: Nociception  
20.12: Examining the Shoulder  
20.15: Biology: Subcellular Compartments of Muscle in *C. elegans*  
21.01: What is the Endocrine System?  
21.02: Intracellular Hormone Receptors  
21.03: Cell-surface Signaling  
21.04: Feedback Loops  
21.05: Hypothalamic-Pituitary Axis  
21.06: Receptor-targeted Nuclear Imaging  
21.07: Biology: A chemical Screening Procedure for Glucocorticoid Signaling with a Zebrafish Larva Luciferase Reporter System  
21.08: Neuroscience: Preparation of Single-cohort Colonies and Hormone Treatment of Worker Honeybees  
21.09: Developmental Biology: Assessment of the Effects of Endocrine Disrupting Compounds on the Developmental of Vertebrate Neural Network Function  
22.01: The Respiratory System  
22.02: Breathing  
22.03: Lung Capacity  
22.04: Gas Exchange and Transport  
22.05: Anatomy of the Circulatory System  
22.06: Anatomy of the Heart  
22.07: The Cardiac Cycle  
22.08: Blood Flow  
22.09: Blood Pressure  
22.11: Medicine: Increasing Pulmonary Artery Pulsatile Flow Improves Hypoxic Pulmonary Hypertension in Piglets  
22.12: Developmental Biology: Fetal Mouse Cardiovascular Imaging Using a High-frequency Ultrasound System  
22.13: Cancer: Right Ventricular Systolic Pressure Measurements in Combination with Harvest of Lung and Immune Tissue Samples in Mice  
23.01: Kidney Structure  
23.03: Filtration  
23.04: Hormonal Regulation

		<p>23.05: Dialysis  23.06: Biology: Physiology Lab Demonstration of Glomerular Filtration Rate in a Rat  23.07: Medicine: Non-invasive Imaging of Acute Allograft Rejection after Rat Renal Transplantation  23.08: Chemistry: Integration of Miniaturized Solid Phase Extraction and LC-MS/MS Detection of 2-Nitrotyrosine in Human Urine  23.09: Urea Cycle  24.01: What is the Immune System  24.02: Cell-mediated Immune Responses  24.03: Humoral Immune Responses  24.04: Antibody Structure  24.05: Affinity and Avidity  24.06: Cross-reactivity  24.07: Allergic Reactions  24.08: Inflammation  24.09: Vaccinations  24.10: Enzyme-linked Immunosorbent Assay (ELISA)  24.11: Medicine: Orthotopic Implantation and Peripheral Immune Cell Monitoring in the II-45 Syngeneic Rat Mesothelioma Model  24.12: Immunology and Infection: Determining Immune System Suppression versus CNS Protection for Pharmacological Interventions in Autoimmune Demyelination  24.13: Developmental Biology: Live Imaging of Innate Immune and Preneoplastic Cell Interactions  25.01: Spermatogenesis  25.02: Oogenesis  25.03: Fertilization  25.04: Cleavage  25.05: Gastrulation  25.06: Neurulation  25.07: Cell Migration  25.08: Determination  25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes  26.13: Behavior: Using a Virtual Store and a Research Tool to Investigate Consumer In-store Behavior  26.15: Neuroscience: Tracking Drosophila Larval Behavior  30.07: Genetics: Exploring the Root Microbiome  30.13: Bioengineering: Bone Strain During Dynamic Motion  33.06: Immunology and Infection: Forward Genetics Screens 33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
<p>PERFORMANCE EXPECTATION</p>	<p>HS-LS1-3.</p>	<p>Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.</p> <p><u>JoVE Biology</u>  01.01: What is Biology?  01.10: Endocrine Disruption  02.21: Vaporization  02.23: Medicine: Differential Effects of Lipid-lowering Drugs  02.24: Medicine: Efflux Assays  02.25: Biology: Biochemical and High Throughput Microscopic Assessment of Fat Mass  04.01: What are Cells?  04.02: Cell Size  04.03: Eukaryotic Compartmentalization  04.04: Prokaryotic Cells  04.13: Chemistry: From Constructs to Crystals  05.01: The Fluid Mosaic Model  05.02: What is an Electrochemical Gradient  05.03: Diffusion  05.04: Osmosis  05.05: Tonicity in Animals</p>

05.06: Tonicity in Plants  
05.07: Facilitated Transport  
05.08: Primary Active Transport  
05.09: Secondary Active Transport  
05.10: Receptor-mediated Endocytosis  
05.11: Pinocytosis  
05.12: Phagocytosis  
05.13: Exocytosis  
05.14: Cell-surface Biotinylation Assay  
05.15: Immunology and Infection: Molecular Diffusion in Plasma Membranes  
05.16: Biology: Endocytosis and Recycling of Plasma Membrane Proteins  
05.17: Neuroscience: Examination of Synaptic Vesicle Recycling  
06.04: Paracrine Signaling  
06.13: Medicine: Screening Bioactive Nanoparticles  
06.14: Immunology and Infection: Real-time Live Imaging of T-cell Signaling Complex Formation  
06.15: Biology: Identification of Intracellular Signaling Events  
07.01: What is Metabolism?  
07.13: Medicine: Study of In Vivo Glucose Metabolism  
07.14: Immunology and Infection : A Simple Flow Cytometric Method to Measure Glucose Uptake and Glucose Transporter Expression  
07.15: Biology: Glucose Uptake Measurement and Response to Insulin Stimulation  
09.07: C4 Pathway and CAM  
10.08: Positive Regular Molecules  
10.09: Negative Regulator Molecules  
10.10: Live Cell Imaging  
10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells  
10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry  
10.13: Genetics: Studying Cell Cycle-regulated Gene Expression  
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17.02: Anatomy of the Intestines  
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 22.11: Medicine: Increasing Pulmonary Artery Pulsatile Flow Improves Hypoxic Pulmonary Hypertension in Piglets  
 22.13: Cancer: Right Ventricular Systolic Pressure Measurements in Combination with Harvest of Lung and Immune Tissue Samples in Mice  
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 23.07: Medicine: Non-invasive Imaging of Acute Allograft Rejection after Rat Renal Transplantation  
 23.08: Chemistry: Integration of Miniaturized Solid Phase Extraction and LC-MS/MS Detection of 2-Nitrotyrosine in Human Urine  
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 24.06: Cross-reactivity  
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 24.09: Vaccinations  
 24.11: Medicine: Orthotopic Implantation and Peripheral Immune Cell Monitoring in the Il-45 Syngeneic Rat Mesothelioma Model  
 24.12: Immunology and Infection: Determining Immune System Suppression versus CNS Protection for Pharmacological Interventions in Autoimmune Demyelination  
 24.13: Developmental Biology: Live Imaging of Innate Immune and Preneoplastic Cell Interactions  
 25.01: Spermatogenesis  
 25.02: Oogenesis  
 25.03: Fertilization

		<p>25.04: Cleavage  25.05: Gastrulation  25.06: Neurulation  25.07: Cell Migration  25.08: Determination  26.11: Social Stress  27.04: Production Efficiency  29.07: Environment: Semi-High Throughput Screening for Potential Drought-tolerance in Lettuce  33.06: Immunology and Infection: Forward Genetics Screens 33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
<p>PERFORMANCE EXPECTATION</p>	<p>HS-LS1-4.</p>	<p>Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.</p> <p><u>JoVE Biology</u>  01.12: Teaching Core Biology Concepts  04.10: Tissues  04.12: Biology: Studying Mitochondria in Drosophila Ovaries 04.14: Developmental Biology: Structure-function Studies in Mouse Embryonic Stem Cells  06.13: Medicine: Screening Bioactive Nanoparticles  10.01: What is the Cell Cycle?  10.02: Genomic DNA and Prokaryotes  10.03: Binary Fission  10.05: Interphase  10.06: Mitosis and Cytokinesis  10.08: Positive Regular Molecules  10.09: Negative Regulator Molecules  10.10: Live Cell Imaging  10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells  10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry  10.13: Genetics: Studying Cell Cycle-regulated Gene Expression  11.06: Tetrad Analysis in Yeast  11.07: Chromatin Spread Preparations  11.08: Using FISH to Monitor Chromosome Segregation  11.09: Immunofluorescence Staining During Meiosis  12.09: Epistasis  12.12: Genetic Screens  12.16: Mosaic Zebrafish Transgenesis  13.11: Transcription  13.15: Fluorescence in situ Hybridization (FISH)  15.05: Adult Stem Cells  15.06: Embryonic Stem Cells  15.07: Induces Pluripotent Stem Cells  15.08: In-vitro Mutagenesis  15.16: Biology: Alternative Cultures for Human Pluripotent Stem Cell Production, Maintenance, and Genetic Analysis  16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues  18.13: Developmental Biology: Immunostaining to Visualize Murine Enteric Nervous System Development  18.14: Bioengineering: Three-dimensional Tissue Engineered Aligned Astrocyte Networks  25.01: Spermatogenesis  25.02: Oogenesis  25.04: Cleavage  25.05: Gastrulation  25.06: Neurulation  25.08: Determination  25.09: Fate Mapping  25.10: Biology: Microscopy of Fission Yeast Sexual Life Cycle</p>



		<p>25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes</p> <p>33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
PERFORMANCE EXPECTATION	HS-LS1-5.	<p>Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.</p> <p><u>JoVE Biology</u></p> <p>04.01: What are Cells?</p> <p>09.01: What is Photosynthesis?</p> <p>09.02: Light as Energy</p> <p>09.03: Anatomy of Chloroplasts</p> <p>09.04: Photosystem II</p> <p>09.05: Photosystem I</p> <p>09.06: The Calvin Cycle</p> <p>09.07: C4 Pathway and CAM</p> <p>09.08: Spectrophotometry</p> <p>09.10: Chemistry: Assembling Water-soluble Chlorophyll-binding Proteins</p> <p>09.12: Biology: Supramolecular Organization of Photosynthetic Membranes using SEM</p> <p>27.03: Primary Production</p>
PERFORMANCE EXPECTATION	HS-LS1-6.	<p>Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.</p> <p><u>JoVE Biology</u></p> <p>02.01: The Periodic Table and Organismal Elements</p> <p>02.13: Van der Waals Interactions</p> <p>02.23: Medicine: Differential Effects of Lipid-lowering Drugs</p> <p>02.24: Medicine: Efflux Assays</p> <p>02.25: Biology: Biochemical and High Throughput Microscopic Assessment of Fat Mass</p> <p>03.01: What are Proteins?</p> <p>03.02: Protein Organization</p> <p>03.03: Protein Folding</p> <p>03.04: What are Carbohydrates?</p> <p>03.05: Dehydration Synthesis</p> <p>03.06: Hydrolysis</p> <p>03.07: What are Lipids?</p> <p>03.08: What are Nucleic Acids?</p> <p>03.09: Phosphodiester Linkages</p> <p>03.11: Bioengineering: Small and Wide Angle X-Ray Scattering Studies</p> <p>03.12: Biology: 3D-PAGE of Protein and Ribonucleoprotein Complexes</p> <p>03.13: Biochemistry: Methods to Visualize and Analyze Membrane Interacting Proteins</p> <p>04.01: What are Cells?</p> <p>04.05: The Nucleus</p> <p>04.06: Ribosomes</p> <p>04.08: Mitochondria</p> <p>04.09: The Extracellular Matrix</p> <p>04.13: Chemistry: From Constructs to Crystals</p> <p>04.14: Developmental Biology: Structure-function Studies in Mouse Embryonic Stem Cells</p> <p>05.01: The Fluid Mosaic Model</p> <p>05.07: Facilitated Transport</p> <p>05.14: Cell-surface Biotinylation Assay</p> <p>05.15: Immunology and Infection: Molecular Diffusion in Plasma Membranes</p> <p>05.16: Biology: Endocytosis and Recycling of Plasma Membrane</p>

**Proteins**  
06.01: Bacterial Signaling  
06.02: Yeast Signaling  
06.03: Contact-dependent Signaling  
06.04: Paracrine Signaling  
06.05: Synaptic Signaling  
06.06: G-protein Coupled Receptors  
06.07: Endocrine Signaling  
06.08: What are Second Messengers?  
06.09: Intracellular Signaling Cascades  
06.11: Enzyme-linked Receptors  
06.14: Immunology and Infection: Real-time Live Imaging of T-cell Signaling Complex Formation  
06.15: Biology: Identification of Intracellular Signaling Events  
07.01: What is Metabolism?  
07.05: Potential Energy  
07.07: Activation Energy  
07.08: Hydrolysis of ATP  
07.09: Phosphorylation  
07.10: Induced-fit Model  
07.11: Feedback Inhibition  
07.12: Colorimetric Enzyme Assay  
07.13: Medicine: Study of In Vivo Glucose Metabolism  
07.14: Immunology and Infection : A Simple Flow Cytometric Method to Measure Glucose Uptake and Glucose Transporter Expression  
07.15: Biology: Glucose Uptake Measurement and Response to Insulin Stimulation  
08.01: What is Glycolysis?  
08.02: Energy-requiring Steps of Glycolysis  
08.03: Energy-releasing Steps of Glycolysis  
08.04: Pyruvate Oxidation  
08.08: Electron Carriers  
08.10: Dietary Connections  
08.11: ATP Bioluminescence  
09.10: Chemistry: Assembling Water-soluble Chlorophyll-binding Proteins  
09.11: Engineering: Printing Fabrication and Morphology Characterization of Solar Cells  
09.12: Biology: Supramolecular Organization of Photosynthetic Membranes using SEM  
10.02: Genomic DNA and Prokaryotes  
10.03: Binary Fission  
10.04: Genomic DNA in Eukaryotes  
10.10: Live Cell Imaging  
10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells  
10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry  
10.13: Genetics: Studying Cell Cycle-regulated Gene Expression  
11.07: Chromatin Spread Preparations  
11.08: Using FISH to Monitor Chromosome Segregation  
11.09: Immunofluorescence Staining During Meiosis  
12.01: Genetic Lingo  
12.12: Genetic Screens  
12.13: SNP Genotyping  
12.14: High-throughput Isolation of Temperature-sensitive Lethal Mutants  
12.15: Optogenetic Random Mutagenesis  
12.16: Mosaic Zebrafish Transgenesis  
13.01: The DNA Helix  
13.02: DNA Packaging  
13.03: Organization of Genes  
13.04: Chromosomal Banding  
13.05: Replication in Prokaryotes

13.06: Replication in Eukaryotes  
13.07: Proofreading  
13.08: Mismatch Repair  
13.09: Nucleotide Excision Repair  
13.10: Mutations  
13.11: Transcription  
13.12: Translation  
13.14: DNA Microarrays  
13.15: Fluorescence in situ Hybridization (FISH)  
13.17: Bioengineering: Folding and Characterization of a Bio-responsive Robot from DNA Origami  
13.18: Genetics: Targeted in Situ Mutagenesis of Histone Genes in Budding Yeast  
13.19: Biology: The ChIP-exo Method and Identifying Protein-DNA Interactions with Near Base-Pair Precision  
14.01: What is Gene Expression?  
14.02: The Central Dogma  
14.03: RNA Structure  
14.04: Types of RNA  
14.05: MicroRNAs  
14.06: RNA Splicing  
14.07: Epigenetic Regulation  
14.08: RNA Interference  
14.09: RNA-seq  
14.10: Genetics: Expression of Dietary Restriction  
14.11: Genetics: Single-cell Profiling  
14.12: Biology: Affinity-based Isolation of Tagged Nuclei  
15.06: Embryonic Stem Cells  
15.07: Induces Pluripotent Stem Cells  
15.08: In-vitro Mutagenesis  
15.09: DNA Isolation  
15.10: Gene Therapy  
15.11: Reproductive Cloning  
15.12: CRISPR  
15.13: Complementary DNA  
15.14: PCR  
15.15: Gel Electrophoresis  
15.16: Biology: Alternative Cultures for Human Pluripotent Stem Cell Production, Maintenance, and Genetic Analysis  
15.17: Genetics: Targeted Next-generation Sequencing and Bioinformatics Pipeline  
15.19: Genetics: CRISPR Guide RNA Cloning for Mammalian Systems  
16.07: Viral Mutations  
16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues  
17.04: Lipid Digestion  
17.05: Protein Digestion  
17.06: Carbohydrate Digestion  
17.08: Hormonal Regulation  
18.05: Neuron Structure  
18.11: Optogenetics  
20.15: Biology: Subcellular Compartments of Muscle in *C. elegans*  
21.07: Biology: A chemical Screening Procedure for Glucocorticoid Signaling with a Zebrafish Larva Luciferase Reporter System  
21.08: Neuroscience: Preparation of Single-cohort Colonies and Hormone Treatment of Worker Honeybees  
24.04: Antibody Structure  
24.05: Affinity and Avidity  
24.06: Cross-reactivity  
24.07: Allergic Reactions  
24.10: Enzyme-linked Immunosorbent Assay (ELISA)  
24.13: Developmental Biology: Live Imaging of Innate Immune and Preneoplastic Cell Interactions

		<p>25.08: Determination  25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes  27.13: Elemental Analysis  27.14: Environment: Understanding Dissolved Organic Matter Biogeochemistry Through In Situ Nutrient Manipulations in Stream Ecosystems  29.04: Biomarker Analysis for Paleoclimatology  30.05: Environment: Collection and Extraction of Occupational Air Samples for Analysis of Fungal DNA  30.06: Biology: A Comparative Analysis of Recombinant Protein Expression in Different Biofactories  30.07: Genetics: Exploring the Root Microbiome  32.05: Genetics: Testing the Role of Multi-copy Plasmids in the Evolution of Antibiotic Resistance  32.06: Immunology and Infection: A New Screening Method for the Directed Evolution of Thermostable Bacteriolytic Enzymes  33.06: Immunology and Infection: Forward Genetics Screens 33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
<p><b>PERFORMANCE EXPECTATION</b></p>	<p><b>HS-LS1-7.</b></p>	<p>Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.</p> <p><u>JoVE Biology</u>  03.04: What are Carbohydrates?  04.03: Eukaryotic Compartmentalization  04.08: Mitochondria  04.12: Biology: Studying Mitochondria in Drosophila Ovaries 07.01: What is Metabolism?  07.05: Potential Energy  07.06: Free Energy  07.07: Activation Energy  07.08: Hydrolysis of ATP  07.09: Phosphorylation  07.10: Induced-fit Model  07.11: Feedback Inhibition  07.12: Colorimetric Enzyme Assay  07.13: Medicine: Study of In Vivo Glucose Metabolism  07.14: Immunology and Infection : A Simple Flow Cytometric Method to Measure Glucose Uptake and Glucose Transporter Expression  07.15: Biology: Glucose Uptake Measurement and Response to Insulin Stimulation  08.01: What is Glycolysis?  08.02: Energy-requiring Steps of Glycolysis  08.03: Energy-releasing Steps of Glycolysis  08.04: Pyruvate Oxidation  08.05: The Citric Acid Cycle  08.06: Electron Transport Chains  08.07: Chemiosmosis  08.08: Electron Carriers  08.09: Fermentation  08.10: Dietary Connections  08.11: ATP Bioluminescence  08.12: Biology: High-resolution Respirometry to Assess Mitochondrial Function  08.13: Immunology and Infection: An Optimized Protocol to Analyze Glycolysis and Mitochondrial Respiration  08.14: Medicine: Boosting Mitochondrial Function  22.04: Gas Exchange and Transport  32.07: Bioengineering: Techniques for Evolution of Robust</p>

		Pentose-fermenting Yeast for Bioconversion of Lignocellulose to Ethanol
<b>STRAND</b>	<b>NGSS.HS-LS.</b>	<b>LIFE SCIENCE</b>
<b>TITLE</b>	<b>HS-LS2.</b>	<b>Ecosystems: Interactions, Energy, and Dynamics</b>
		Students who demonstrate understanding can:
<b>PERFORMANCE EXPECTATION</b>	<b>HS-LS2-1.</b>	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.  <u>JoVE Biology</u> 27.03: Primary Production 28.05: Population Growth 31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films
<b>PERFORMANCE EXPECTATION</b>	<b>HS-LS2-2.</b>	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.  <u>JoVE Biology</u> 06.01: Bacterial Signaling 10.03: Binary Fission 11.06: Tetrad Analysis in Yeast 27.01: What is an Ecosystem? 27.03: Primary Production 27.06: What are Biogeochemical Cycles? 27.08: The Carbon Cycle 27.09: The Nitrogen Cycle 27.10: The Phosphorous Cycle 27.11: The Sulfur Cycle 27.12: Bioremediation 27.16: Bioengineering: A Toolkit to Enable Hydrocarbon Conversion in Aqueous Environments 28.02: Distribution and Dispersion 28.05: Population Growth 28.07: Tree Surveying 28.08: Environment: Manipulating Plant-induced Soil Heterogeneity 28.09: Bioengineering: Assembly and Tracking of Microbial Community Development within a Microwell Array Platform 28.10: Environment: Empirical, Metagenomic, and Computational Techniques Illuminate the Mechanisms by which Fungicides Compromise Bee Health 29.03: Global Climate Change 29.05: Environment: Continuous Instream Monitoring of Nutrients and Sediment in Agricultural Watersheds 29.06: Engineering: Design and Use of a Full Flowing Sampling System (FFS) for the Quantification of Methane Emissions 30.01: What is Biodiversity? 30.02: Threats to Biodiversity 30.03: Benefits of Biodiversity 30.04: GIS and Urban Forestry 30.05: Environment: Collection and Extraction of Occupational Air Samples for Analysis of Fungal DNA 30.06: Biology: A Comparative Analysis of Recombinant Protein Expression in Different Biofactories 30.07: Genetics: Exploring the Root Microbiome 30.13: Bioengineering: Bone Strain During Dynamic Motion 31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films 33.04: Surveying Genetic Variation in Populations
<b>PERFORMANCE EXPECTATION</b>	<b>HS-LS2-3.</b>	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

		<p><u>JoVE Biology</u>  02.14: States of Water  04.04: Prokaryotic Cells  07.02: First Law of Thermodynamics  07.03: Second Law of Thermodynamics  07.04: Kinetic Energy  07.05: Potential Energy  07.06: Free Energy  08.07: Chemiosmosis  09.01: What is Photosynthesis?  09.04: Photosystem II  09.05: Photosystem I  09.06: The Calvin Cycle  09.07: C4 Pathway and CAM  09.10: Chemistry: Assembling Water-soluble Chlorophyll-binding Proteins  27.02: Trophic Levels  27.03: Primary Production  27.04: Production Efficiency  27.05: Trophic Efficiency  27.06: What are Biogeochemical Cycles?  27.07: The Water Cycle  27.08: The Carbon Cycle  27.09: The Nitrogen Cycle  27.10: The Phosphorous Cycle  27.11: The Sulfur Cycle  27.13: Elemental Analysis  27.14: Environment: Understanding Dissolved Organic Matter Biogeochemistry Through In Situ Nutrient Manipulations in Stream Ecosystems  27.16: Bioengineering: A Toolkit to Enable Hydrocarbon Conversion in Aqueous Environments  28.04: Energy Budgets  28.09: Bioengineering: Assembly and Tracking of Microbial Community Development within a Microwell Array Platform  30.04: GIS and Urban Forestry  31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films  31.07: Environment: Soil Lysimeter Excavation for Coupled Hydrological, Geochemical, and Microbiological Investigations</p>
<p><b>PERFORMANCE EXPECTATION</b></p>	<p><b>HS-LS2-4.</b></p>	<p>Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.</p> <p><u>JoVE Biology</u>  02.14: States of Water  02.21: Vaporization  07.02: First Law of Thermodynamics  07.03: Second Law of Thermodynamics  07.04: Kinetic Energy  07.05: Potential Energy  07.06: Free Energy  09.01: What is Photosynthesis?  09.04: Photosystem II  09.05: Photosystem I  09.06: The Calvin Cycle  09.07: C4 Pathway and CAM  09.10: Chemistry: Assembling Water-soluble Chlorophyll-binding Proteins  27.02: Trophic Levels  27.03: Primary Production  27.04: Production Efficiency  27.05: Trophic Efficiency  27.06: What are Biogeochemical Cycles?  27.07: The Water Cycle  27.08: The Carbon Cycle</p>

		<p>27.09: The Nitrogen Cycle  27.10: The Phosphorous Cycle  27.11: The Sulfur Cycle  27.13: Elemental Analysis  27.14: Environment: Understanding Dissolved Organic Matter Biogeochemistry Through In Situ Nutrient Manipulations in Stream Ecosystems  27.16: Bioengineering: A Toolkit to Enable Hydrocarbon Conversion in Aqueous Environments  28.04: Energy Budgets  28.09: Bioengineering: Assembly and Tracking of Microbial Community Development within a Microwell Array Platform  30.04: GIS and Urban Forestry  31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films  31.07: Environment: Soil Lysimeter Excavation for Coupled Hydrological, Geochemical, and Microbiological Investigations</p>
<p>PERFORMANCE EXPECTATION</p>	<p>HS-LS2-5.</p>	<p>Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.</p> <p><u>JoVE Biology</u>  03.04: What are Carbohydrates?  04.03: Eukaryotic Compartmentalization  04.08: Mitochondria  04.12: Biology: Studying Mitochondria in Drosophila Ovaries  07.01: What is Metabolism?  07.05: Potential Energy  07.06: Free Energy  07.07: Activation Energy  07.08: Hydrolysis of ATP  07.09: Phosphorylation  07.10: Induced-fit Model  07.11: Feedback Inhibition  07.12: Colorimetric Enzyme Assay  07.13: Medicine: Study of In Vivo Glucose Metabolism  07.14: Immunology and Infection : A Simple Flow Cytometric Method to Measure Glucose Uptake and Glucose Transporter Expression  07.15: Biology: Glucose Uptake Measurement and Response to Insulin Stimulation  08.01: What is Glycolysis?  08.02: Energy-requiring Steps of Glycolysis  08.03: Energy-releasing Steps of Glycolysis  08.04: Pyruvate Oxidation  08.05: The Citric Acid Cycle  08.06: Electron Transport Chains  08.07: Chemiosmosis  08.08: Electron Carriers  08.09: Fermentation  08.10: Dietary Connections  08.11: ATP Bioluminescence  08.12: Biology: High-resolution Respirometry to Assess Mitochondrial Function  08.13: Immunology and Infection: An Optimized Protocol to Analyze Glycolysis and Mitochondrial Respiration  08.14: Medicine: Boosting Mitochondrial Function  09.01: What is Photosynthesis?  09.03: Anatomy of Chloroplasts  09.04: Photosystem II  09.05: Photosystem I  09.06: The Calvin Cycle  09.07: C4 Pathway and CAM  09.10: Chemistry: Assembling Water-soluble Chlorophyll-binding Proteins</p>

		09.12: Biology: Supramolecular Organization of Photosynthetic Membranes using SEM 22.04: Gas Exchange and Transport 27.03: Primary Production 32.07: Bioengineering: Techniques for Evolution of Robust Pentose-fermenting Yeast for Bioconversion of Lignocellulose to Ethanol
PERFORMANCE EXPECTATION	HS-LS2-6.	Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.  <u>JoVE Biology</u> 27.05: Trophic Efficiency 27.10: The Phosphorous Cycle 28.05: Population Growth 28.08: Environment: Manipulating Plant-induced Soil Heterogeneity 28.09: Bioengineering: Assembly and Tracking of Microbial Community Development within a Microwell Array Platform
PERFORMANCE EXPECTATION	HS-LS2-7.	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.  <u>JoVE Biology</u> 27.08: The Carbon Cycle 28.08: Environment: Manipulating Plant-induced Soil Heterogeneity 28.10: Environment: Empirical, Metagenomic, and Computational Techniques Illuminate the Mechanisms by which Fungicides Compromise Bee Health 29.06: Engineering: Design and Use of a Full Flowing Sampling System (FFS) for the Quantification of Methane Emissions 30.02: Threats to Biodiversity 30.04: GIS and Urban Forestry
PERFORMANCE EXPECTATION	HS-LS2-8.	Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.  <u>JoVE Biology</u> 21.08: Neuroscience: Preparation of Single-cohort Colonies and Hormone Treatment of Worker Honeybees 26.01: What is Behavior? 26.02: Communication 26.02: Imprinting 26.04: Migration 26.09: Altruism 26.10: Inclusive Fitness 26.11: Social Stress
<b>STRAND</b>	<b>NGSS.HS-LS.</b>	<b>LIFE SCIENCE</b>
<b>TITLE</b>	<b>HS-LS3.</b>	<b>Heredity: Inheritance and Variation of Traits</b>
		Students who demonstrate understanding can:
PERFORMANCE EXPECTATION	HS-LS3-1.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.  <u>JoVE Biology</u> 02.13: Van der Waals Interactions 03.08: What are Nucleic Acids? 03.09: Phosphodiester Linkages 03.12: Biology: 3D-PAGE of Protein and Ribonucleoprotein Complexes 04.01: What are Cells? 04.03: Eukaryotic Compartmentalization 04.05: The Nucleus 04.14: Developmental Biology: Structure-function Studies in Mouse Embryonic Stem Cells



10.02: Genomic DNA and Prokaryotes  
10.03: Binary Fission  
10.04: Genomic DNA in Eukaryotes  
10.10: Live Cell Imaging  
10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells  
10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry  
10.13: Genetics: Studying Cell Cycle-regulated Gene Expression  
11.01: What is Meiosis?  
11.02: Meiosis I  
11.03: Meiosis II  
11.04: Crossing Over  
11.05 Human Life Cycle  
11.07: Chromatin Spread Preparations  
11.08: Using FISH to Monitor Chromosome Segregation  
11.09: Immunofluorescence Staining During Meiosis  
12.01: Genetic Lingo  
12.12: Genetic Screens  
12.13: SNP Genotyping  
12.14: High-throughput Isolation of Temperature-sensitive Lethal Mutants  
12.15: Optogenetic Random Mutagenesis  
12.16: Mosaic Zebrafish Transgenesis  
13.01: The DNA Helix  
13.02: DNA Packaging  
13.03: Organization of Genes  
13.04: Chromosomal Banding  
13.05: Replication in Prokaryotes  
13.06: Replication in Eukaryotes  
13.07: Proofreading  
13.08: Mismatch Repair  
13.09: Nucleotide Excision Repair  
13.10: Mutations  
13.11: Transcription  
13.12: Translation  
13.14: DNA Microarrays  
13.15: Fluorescence in situ Hybridization (FISH)  
13.17: Bioengineering: Folding and Characterization of a Bio-responsive Robot from DNA Origami  
13.18: Genetics: Targeted in Situ Mutagenesis of Histone Genes in Budding Yeast  
13.19: Biology: The ChIP-exo Method and Identifying Progein-DNA Interactions with Near Base-Pair Precision  
14.01: What is Gene Expression?  
14.02: The Central Dogma  
14.07: Epigenetic Regulation  
14.10: Genetics: Expression of Dietary Restriction  
14.11: Genetics: Single-cell Profiling  
14.12: Biology: Affinity-based Isolation of Tagged Nuclei  
15.06: Embryonic Stem Cells  
15.07: Induces Pluripotent Stem Cells  
15.08: In-vitro Mutagenesis  
15.09: DNA Isolation  
15.10: Gene Therapy  
15.11: Reproductive Cloning  
15.12: CRISPR  
15.13: Complementary DNA  
15.14: PCR  
15.15: Gel Electrophoresis  
15.16: Biology: Alternative Cultures for Human Pluripotent Stem Cell Production, Maintenance, and Genetic Analysis  
15.17: Genetics: Targeted Next-generation Sequencing and Bioinformatics Pipeline  
15.19: Genetics: CRISPR Guide RNA Cloning for Mammalian

		<p>Systems</p> <p>16.07: Viral Mutations</p> <p>16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues</p> <p>21.07: Biology: A chemical Screening Procedure for Glucocorticoid Signaling with a Zebrafish Larva Luciferase Reporter System</p> <p>21.08: Neuroscience: Preparation of Single-cohort Colonies and Hormone Treatment of Worker Honeybees</p> <p>24.13: Developmental Biology: Live Imaging of Innate Immune and Preneoplastic Cell Interactions</p> <p>25.01: Spermatogenesis</p> <p>25.02: Oogenesis</p> <p>25.08: Determination</p> <p>25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes</p> <p>30.05: Environment: Collection and Extraction of Occupational Air Samples for Analysis of Fungal DNA</p> <p>30.06: Biology: A Comparative Analysis of Recombinant Protein Expression in Different Biofactories</p> <p>30.07: Genetics: Exploring the Root Microbiome</p> <p>31.04: Karyotyping</p> <p>33.06: Immunology and Infection: Forward Genetics Screens</p> <p>33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
<p>PERFORMANCE EXPECTATION</p>	<p>HS-LS3-2.</p>	<p>Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.</p> <p><u>JoVE Biology</u></p> <p>10.11: Neuroscience: Assessing Cell Cycle Progression of Neural Stem and Progenitor Cells</p> <p>10.12: Biology: Temporal Tracking of Cell Cycle Progression Using Flow Cytometry</p> <p>10.13: Genetics: Studying Cell Cycle-regulated Gene Expression</p> <p>11.01: What is Meiosis?</p> <p>11.02: Meiosis I</p> <p>11.03: Meiosis II</p> <p>11.04: Crossing Over</p> <p>11.05 Human Life Cycle</p> <p>11.07: Chromatin Spread Preparations</p> <p>11.08: Using FISH to Monitor Chromosome Segregation</p> <p>11.09: Immunofluorescence Staining During Meiosis</p> <p>12.07: Multiple Allele Traits</p> <p>12.08: Polygenic Traits</p> <p>12.11: Nature and Nurture</p> <p>12.12: Genetic Screens</p> <p>12.13: SNP Genotyping</p> <p>12.14: High-throughput Isolation of Temperature-sensitive Lethal Mutants</p> <p>12.15: Optogenetic Random Mutagenesis</p> <p>12.16: Mosaic Zebrafish Transgenesis</p> <p>13.10: Mutations</p> <p>13.12: Translation</p> <p>13.15: Fluorescence in situ Hybridization (FISH)</p> <p>13.18: Genetics: Targeted in Situ Mutagenesis of Histone Genes in Budding Yeast</p> <p>13.19: Biology: The ChIP-exo Method and Identifying Progenitor-DNA Interactions with Near Base-Pair Precision</p> <p>14.10: Genetics: Expression of Dietary Restriction</p> <p>14.11: Genetics: Single-cell Profiling</p> <p>14.12: Biology: Affinity-based Isolation of Tagged Nuclei</p> <p>15.08: In-vitro Mutagenesis</p>

		<p>15.17: Genetics: Targeted Next-generation Sequencing and Bioinformatics Pipeline</p> <p>16.07: Viral Mutations</p> <p>16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues</p> <p>21.09: Developmental Biology: Assessment of the Effects of Endocrine Disrupting Compounds on the Developmental of Vertebrate Neural Network Function</p> <p>22.12: Developmental Biology: Fetal Mouse Cardiovascular Imaging Using a High-frequency Ultrasound System</p> <p>25.01: Spermatogenesis</p> <p>25.02: Oogenesis</p> <p>25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes</p> <p>26.10: Inclusive Fitness</p> <p>30.01: What is Biodiversity?</p> <p>32.01: What is Natural Selection?</p> <p>32.03: Frequency-dependent Selection</p> <p>32.04: Artificial Selection on Trichome Number</p> <p>32.05: Genetics: Testing the Role of Multi-copy Plasmids in the Evolution of Antibiotic Resistance</p> <p>32.06: Immunology and Infection: A New Screening Method for the Directed Evolution of Thermostable Bacteriolytic Enzymes</p> <p>33.01: What is Population Genetics?</p> <p>33.02: Generation of Genetic Variation</p> <p>33.02: Hardy-Weinberg Principle</p> <p>33.04: Surveying Genetic Variation in Populations</p> <p>33.07: Immunology and Infection: Identifying DNA Mutations in Purified Hematopoietic Stem/Progenitor Cells</p>
PERFORMANCE EXPECTATION	HS-LS3-3.	<p>Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.</p> <p><u>JoVE Biology</u></p> <p>11.06: Tetrad Analysis in Yeast</p> <p>11.07: Chromatin Spread Preparations</p> <p>11.08: Using FISH to Monitor Chromosome Segregation</p> <p>11.09: Immunofluorescence Staining During Meiosis</p> <p>12.01: Genetic Lingo</p> <p>12.02: Punnett Squares</p> <p>12.03: Monohybrid Crosses</p> <p>12.04: Dihybrid Crosses</p> <p>12.05: Pedigree Analysis</p> <p>12.07: Multiple Allele Traits</p> <p>12.08: Polygenic Traits</p> <p>12.09: Epistasis</p> <p>12.12: Genetic Screens</p> <p>12.13: SNP Genotyping</p> <p>13.15: Fluorescence in situ Hybridization (FISH)</p> <p>16.12: Biology: Fluorescence in situ Hybridizations (FISH) for the Localization of Viruses and Endosymbiotic Bacteria in Plant and Insect Tissues</p> <p>25.11: Developmental Biology: Analysis of Chromosome Segregation, Histone Acetylation, and Spindle Morphology in Horse Oocytes</p> <p>33.02: Hardy-Weinberg Principle</p>
STRAND	NGSS.HS-LS.	LIFE SCIENCE
TITLE	HS-LS4.	Biological Evolution: Unity and Diversity
		Students who demonstrate understanding can:
PERFORMANCE EXPECTATION	HS-LS4-1.	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

		<p><u>JoVE Biology</u> 16.07: Viral Mutations</p>
PERFORMANCE EXPECTATION	HS-LS4-2.	<p>Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.</p> <p><u>JoVE Biology</u> 16.07: Viral Mutations 26.05: Mate Choice 26.10: Inclusive Fitness 30.01: What is Biodiversity? 31.01: What is a Species? 31.02: Formation of Species 31.03: Speciation Rates 31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films 31.06: Biology: A Multi-detection Assay for Malaria Transmitting Mosquitoes 32.01: What is Natural Selection? 32.02: Types of Selection 32.03: Frequency-dependent Selection 32.04: Artificial Selection on Trichome Number 32.05: Genetics: Testing the Role of Multi-copy Plasmids in the Evolution of Antibiotic Resistance 32.06: Immunology and Infection: A New Screening Method for the Directed Evolution of Thermostable Bacteriolytic Enzymes 33.01: What is Population Genetics? 33.02: Generation of Genetic Variation 33.02: Hardy-Weinberg Principle 33.04: Surveying Genetic Variation in Populations 33.05: Environment: Protocol for Assessing the Relative Effects of Environment and Genetics on Antler and Body Growth for a Long-lived Cervid</p>
PERFORMANCE EXPECTATION	HS-LS4-3.	<p>Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.</p> <p><u>JoVE Biology</u> 33.02: Hardy-Weinberg Principle</p>
PERFORMANCE EXPECTATION	HS-LS4-4.	<p>Construct an explanation based on evidence for how natural selection leads to adaptation of populations.</p> <p><u>JoVE Biology</u> 26.05: Mate Choice 26.10: Inclusive Fitness 30.01: What is Biodiversity? 31.02: Formation of Species 31.03: Speciation Rates 31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films 31.06: Biology: A Multi-detection Assay for Malaria Transmitting Mosquitoes 32.01: What is Natural Selection? 32.02: Types of Selection 32.03: Frequency-dependent Selection 32.04: Artificial Selection on Trichome Number 32.05: Genetics: Testing the Role of Multi-copy Plasmids in the Evolution of Antibiotic Resistance 32.06: Immunology and Infection: A New Screening Method for the</p>

		<p>Directed Evolution of Thermostable Bacteriolytic Enzymes 33.01: What is Population Genetics?  33.02: Generation of Genetic Variation  33.02: Hardy-Weinberg Principle  33.04: Surveying Genetic Variation in Populations  33.05: Environment: Protocol for Assessing the Relative Effects of Environment and Genetics on Antler and Body Growth for a Long-lived Cervid</p>
PERFORMANCE EXPECTATION	HS-LS4-5.	<p>Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.</p> <p><u>JoVE Biology</u>  06.01: Bacterial Signaling  10.03: Binary Fission  11.06: Tetrad Analysis in Yeast  28.05: Population Growth  28.09: Bioengineering: Assembly and Tracking of Microbial Community Development within a Microwell Array Platform  28.10: Environment: Empirical, Metagenomic, and Computational Techniques Illuminate the Mechanisms by which Fungicides Compromise Bee Health  30.02: Threats to Biodiversity  31.02: Formation of Species  31.03: Speciation Rates  31.05: Engineering: Speciation and Bioavailability Measurements of Environmental Plutonium Using Diffusion in Thin Films  31.06: Biology: A Multi-detection Assay for Malaria Transmitting Mosquitoes  32.01: What is Natural Selection?  32.02: Types of Selection  32.03: Frequency-dependent Selection  32.04: Artificial Selection on Trichome Number  32.05: Genetics: Testing the Role of Multi-copy Plasmids in the Evolution of Antibiotic Resistance  32.06: Immunology and Infection: A New Screening Method for the Directed Evolution of Thermostable Bacteriolytic Enzymes  33.02: Generation of Genetic Variation  33.02: Hardy-Weinberg Principle  33.04: Surveying Genetic Variation in Populations</p>
PERFORMANCE EXPECTATION	HS-LS4-6.	<p>Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.</p> <p><u>JoVE Biology</u>  28.08: Environment: Manipulating Plant-induced Soil Heterogeneity  28.10: Environment: Empirical, Metagenomic, and Computational Techniques Illuminate the Mechanisms by which Fungicides Compromise Bee Health  29.06: Engineering: Design and Use of a Full Flowing Sampling System (FFS) for the Quantification of Methane Emissions  30.02: Threats to Biodiversity  30.04: GIS and Urban Forestry</p>