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# SCIENCE

## Academic Standards
## Three Dimensions of Science Learning
## Learning Goals

June 2020

# HIGH SCHOOL
# BIOLOGY & HONORS BIOLOGY

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# CATALINA FOOTHILLS SCHOOL DISTRICT

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY OVERVIEW

High School Biology and Honors Biology focus on the patterns, processes, and relationships of living organisms. At the high school level, students apply concepts learned in earlier grades to real-world situations and investigations using the science and engineering practices to fully explore phenomena and to develop solutions to societal problems related to food, energy, health, and environment. The field of life science is rapidly advancing and new technology and information related to the study of life processes is being developed daily. Students should have access to up-to-date information in the field while simultaneously gaining understanding of the historical developments which shaped today's understandings within the field. The standards for Biology & Honors Biology encompass the areas of cells and organisms; ecosystems, interactions, energy and dynamics; heredity; and biological diversity.

The "essential" and "plus" standards for High School Biology and Honors Biology are grouped into four main topics. In addition, two topics from standards in the Earth and Space Sciences, have been integrated into the course. This is to ensure that students have been taught the full set of "essential" science standards by their third year of high school (see "coding standards" below). Because students have some flexibility in the pathway they select to meet the graduation requirements for science, specific "essential" standards were integrated into some of the science courses to meet this Arizona State Board of Education requirement.

The list of high school Biology and Honors Biology topics below does not indicate the instructional sequence or how the standards will be organized for instruction. Educators will make decisions about instructional sequence and how standards will be grouped by units for classroom instruction and assessment to best meet student needs.

**High School Biology & Honors Biology Topics:**

- Ecosystems
- Cells and Organisms
- Genetics
- Evolution
- Role of Water in Earth's Surface Processes
- Earth and Human Activity

High school students continue the pattern from previous years by engaging in the science and engineering practices to apply their knowledge of core ideas to understand how scientists continue to build an understanding of phenomena and see how people are impacted by natural phenomena or to construct solutions. The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds.

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# Navigating the Science Standards: Abbreviated Version

The standards serve as the basis for the design of instruction and assessment of the district's science curriculum.

- **Standards** are what a student needs to know, understand, and be able to do by the end of each grade or course. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels.
- **Curriculum** refers to the resources used for teaching and learning the standards (units, lessons, texts, materials, tech apps, assessments, etc.).
- **Instruction** refers to the methods or methodologies used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of students in their classes to help them progress through the curriculum to achieve the standards.

**Grade Level or Course** and **Topic Area** for standard.

**Life Science** Description of what students will learn for the area of science under study (K-8 only).

**Standard – What is Assessed** Describes what students should be able to do at the end of instruction to show what they have learned. Combines Science and Engineering Practices, Core Ideas, and Crosscutting Concepts.

**Learning Goals** Indicators or evidence of learning at the end of a lesson or unit as aligned to the standard.

**Core Ideas for Knowing and Using Science** "Understandings" or big ideas for physical, earth and space, and life sciences that build in complexity across grade levels and students develop over time. **Background Information (Content)** is provided under each Core Idea.

**Science and Engineering Practices** Skills and knowledge that scientists and engineers engage in to either understand the world or solve a problem.

**Three Dimensions (3-D) of Science:** The Practices, Core Ideas, and Crosscutting Concepts that were used to create the standards.

**Crosscutting Concepts** Concepts that cut across all disciplines and help students deepen their understanding of core ideas.

## KINDERGARTEN

### LIFE SCIENCE: LIVING AND NON-LIVING THINGS

**Students develop an understanding that the world is comprised of living and non-living things. They investigate the relationship between structure and function in living things; plants and animals use specialized parts to help them meet their needs and survive.**

**Science Standard: K.L2U1.8 Observe, ask questions, and explain the differences between the characteristics of living and non-living things.**

**Learning Goals**

I can:

- Based on prior experiences, ask questions about living and non-living things.
- Make direct or indirect observations about living and non-living things:
  - Identify traits of living and non-living things.
  - Record observations (*e.g., through pictures and/or words*).
  - Make inferences about the characteristics of living and non-living things.
- List the characteristics of living things (*i.e., move, reproduce, react to stimuli*).
- Use evidence to explain how the characteristics of living things differ from the characteristics of non-living things.

**Core Ideas**

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- There is a wide variety of living things (organisms), including plants and animals. They are distinguished from non-living things by their ability to move, reproduce, and react to certain stimuli.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students ask questions to frame their exploration of living and non-living things.
- Students make observations about living and non-living things.
- Students use the evidence from their observations to make inferences about the characteristics of living and non-living things.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Problems**<br>• Ask questions based on observations of the natural and/or designed world.<br>**Constructing Explanations and Designing Solutions**<br>• Use information from direct or indirect observations to construct explanations.<br>• Distinguish between opinions and evidence in one's own explanations. | **Patterns**<br>• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.<br>**Structure and Function**<br>• The shape and stability of structures of natural and designed objects are related to their function(s).<br>**Systems and System Models**<br>• Objects and organisms can be described in terms of their parts. |

# ECOSYSTEMS

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### ECOSYSTEMS

**Science Standard: Essential HS.L2U3.18 Obtain, evaluate, and communicate about the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.**

**Learning Goals**

I can:

- Obtain information about the positive and negative ethical, social, economic and political implications of human activity on the biodiversity of an ecosystem:
  - Ask questions about human activity and biodiversity within ecosystems to frame the collection of information.
  - Gather information from a variety of sources *(e.g., texts, investigations, media, data sets, models*) in response to the investigative questions.
- Evaluate information about the positive and negative ethical, social, economic and political implications of human activity on the biodiversity of an ecosystem:
  - Determine the central ideas or conclusions of a scientific text.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the implications of human activity on biodiversity.
  - Evaluate data on the human effects on the environment including climate change, habitat destruction, invasive species, and pollution.
  - Verify data across texts.
- Communicate about the positive and negative ethical, social economic, and political implications of human activity on the biodiversity of an ecosystem:
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively)* in order to address positive and negative implications of human activity on the biodiversity of an ecosystem.
  - Explain ways that biodiversity enhances life on earth.
  - Explain interdependencies among components of an ecosystem.
  - Analyze connections between human activities and environmental disruptions.
  - Analyze the relationship between environments, resources, and species abundance.
  - Produce scientific/technical writing and/or oral presentations *(e.g., blog post, newspaper column, position paper, Socratic Seminar*) that communicate the human effects on the environment including climate change, habitat destruction, invasive species, overexploitation, and pollution.

## Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms

- Anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.

**Using Science**

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students explore the positive and negative ethical, social, economic, and political implications of human activity on the biodiversity of an ecosystem.
- When examining various perspectives of controversial issues, it is important to evaluate evidence to determine its scientific validity.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem. | **Cause and Effect: Mechanism and Prediction**<br>• Systems can be designed to cause a desired effect.<br>• Changes in systems may have various causes that may not have equal effects.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable. |

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| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY | |
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| LIFE SCIENCE | |

## ECOSYSTEMS

**Science Standard Plus HS+B.L2U1.1 Develop a model showing the relationship between limiting factors and carrying capacity, and use the model to make predictions on how environmental changes impact biodiversity.**

**Learning Goals**

I can:

- Develop a model showing the relationship between limiting factors and carrying capacity:
  - Use design criteria to develop a diagram, drawing, physical replica, mathematical representation, analogy, and/or computer simulation that represents the relationship between limiting factors and carrying capacity.
  - Use multiple types of models to represent limiting factors and carrying capacity.
  - Design a test of a model to ascertain its reliability.
  - Revise models based on results of tests and design criteria to more appropriately represent relationships between limiting factors and carrying capacity.
- Use a model to make predictions on how environmental changes impact biodiversity:
  - Identify, describe and relate components in mathematical and/or computational representations *(e.g., trends, averages, histograms, graphs, spreadsheets)* that are relevant to supporting given explanations of factors that affect carrying capacities of ecosystems.
  - Use a model to show how the factors affecting carrying capacity are interrelated.
  - Use a model to generate data to predict the impact of environmental changes on biodiversity.
  - Explain why some factors have larger effects than do other factors.

### Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students use models to explain environmental phenomena in terms of relationships between limiting factors and carrying capacity. Models are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Developing and Using Models**<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems. | **Cause and Effect: Mechanism and Prediction**<br>• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. |

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| • Design a test of a model to ascertain its reliability.<br><br>**Using Mathematics and Computational Thinking**<br>• Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations.<br>• Create a simple computational model or simulation of a designed device, process, or system. | • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.<br>• Changes in systems may have various causes that may not have equal effects.<br><br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br><br>**Scale, Proportion, and Quantity**<br>• Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.<br>• Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### ECOSYSTEMS

**Science Standard: Plus HS+B.L4U1.2 Engage in argument from evidence that changes in environmental conditions or human interventions may change species diversity in an ecosystem.**

Learning Goals

I can:

- Evaluate arguments about the role of environmental conditions and/or human intervention in changing species diversity in an ecosystem:
  - Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
- Construct, use, and present oral and written arguments to support how overpopulation, overexploitation, habitat destruction, pollution, introduction to invasive species and climate change cause changes in diversity in ecosystems:
  - Make and defend a claim about the role of environmental conditions and/or human intervention in changing species diversity in an ecosystem.
  - Use scientific evidence to develop and support the claim.

### Core Ideas

**Knowing Science**

L4: The unity and diversity of organisms, living and extinct, is the result of evolution.

- Biological extinction, being irreversible, is a critical factor in reducing the planet's natural capital. Humans depend on the living world for the resources and other benefits provided by biodiversity.

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem.
- Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Moreover, anthropogenic changes (induced by human activity) in the environment —including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students evaluate, develop, and defend arguments using scientific evidence from texts, observations, and investigations. As they weigh evidence regarding biodiversity, students will refine their understanding of ecosystems and the role of environmental conditions and human interventions.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Engaging in Argument from Evidence**<br>• Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. | **Cause and Effect: Mechanism and Prediction**<br>• Changes in systems may have various causes that may not have equal effects.<br>**Stability and Change** |

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| • Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.<br>• Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.<br>• Construct a counter-argument that is based on data and evidence that challenges another proposed argument. | • Much of science deals with constructing explanations of how things change and how they remain stable. |

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**Science Standard: Essential HS.L2U1.19 Develop and use models that show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment.**

**Learning Goals**

I can:

- Develop models that represent how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment:
  - Use design criteria to develop a diagram, drawing, physical replica, mathematical representation, analogy, and/or computer simulation that represents the role of transfer of matter and energy within an ecosystem.
  - Use multiple types of models to represent the effects of changes in transfer of matter and energy within an ecosystem.
  - Evaluate the merits and limitations of model types *(e.g., food chain vs. food web)* in order to select or revise a model that best fits the evidence or design criteria.
  - Revise models based on results of tests and design criteria to more appropriately represent connections between energy transfer within an ecosystem and photosynthesis and cellular respiration (including anaerobic processes).
- Use models to show how changes in the transfer of matter and energy within an ecosystem and interactions between species may affect organisms and their environment:
  - Analyze the conservation of matter and energy transfer in an ecosystem (*i.e., some matter reacts to release energy for life functions, some is stored in newly made structures, and much is discarded*).
  - Show the movement of the chemical elements that make up the molecules of organisms through living and nonliving components of the ecosystem (include soil, atmosphere, water, plants, etc.)
  - Demonstrate the movement of energy and matter through food webs.
  - Show how chemical elements are combined and recombined in different ways.
  - Show limitations to the number of organisms an ecosystem can sustain.
  - Convey the role of matter and energy in competition among species.
  - Analyze patterns emerging from changes in an ecosystem *(e.g., removal of a predator).*
  - Relate reactants and products of photosynthesis and cellular respiration.

## Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil and are combined and recombined in different ways.
- At each link in an ecosystem, matter and energy are conserved; some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. Competition among species is ultimately competition for the matter and energy needed for life.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students engage with models to better understand relationships among parts of an ecosystem. Models are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or design criteria.<br>• Design a test of a model to ascertain its reliability. | **Energy and Matter: Flows, Cycles, and Conservation**<br>• The total amount of energy and matter in closed systems is conserved.<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br>**Systems and System Models**<br>• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. |

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**Science Standard: Plus HS+B.L2U1.3 Use mathematics and computational thinking to support claims for the cycling of matter and flow of energy through trophic levels in an ecosystem.**

Learning Goals

I can:

- Use mathematical or computational representations to support a claim about the inefficiency in energy transfer results in fewer organisms at the higher trophic levels.
- Create a computational representation that shows why only 10% of energy is transferred to the next trophic level given examples of a complex food web.
- Use mathematical concepts to support claims about how matter (water, carbon, and nitrogen) is conserved and passes through the ecosystem in different forms.
- Use mathematical or computational thinking to make a claim about where energy originates (photosynthesis) and how it is used (cellular respiration).
- Construct explanations for how most energy is released as heat at each trophic level.

## Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- Matter and energy are conserved in each change. This is true of all biological systems, from individual cells to ecosystems. Energy is transferred from one system of interacting molecules to another.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Mathematics and computational thinking help students develop their understanding of the cycling of matter and the flow of energy within the ecosystem. Students also use mathematical explanations to create and support reasonable arguments.

## Science and Engineering Practices

**Using Mathematics and Computational Thinking**

- Create a simple computational model or simulation of a designed device, process, or system.
- Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations.

## Crosscutting Concepts

**Energy and Matter: Flows, Cycles, and Conservation**

- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.

**Patterns**

- Mathematical representations are needed to identify some pattern.

# CELLS AND ORGANISMS

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Essential HS.L1U1.20 Ask questions and/or make predictions based on observations and evidence to demonstrate how cellular organization, structure, and function allow organisms to maintain homeostasis.**

**Learning Goals**

I can:

- Ask questions that require relevant empirical evidence to answer.
- Base questions on careful observation of phenomena, models, or theories.
- Ask questions and describe ways that various parts of an organism (organ systems, organs and their component tissues) interact to provide specific functions *(e.g., maintenance of pH, temperature, transfer of fluids, response to stimuli)*.
- Ask questions and make predictions about the relationships between internal and external conditions of the cell *(e.g., pH conditions, temperature, transfer of fluids, response to stimuli).*
- Ask questions about factors at multiple levels of biological organization -- cells, tissues, organs, and organisms -- that respond to conditions and work together to maintain homeostasis at the organism level.
- Ask questions to determine how changes in the environment/organism might be measured or identified.
- Use observations and evidence to make predictions involving positive and negative feedback systems to maintain homeostasis.
- Ask questions to challenge the interpretation of a data set (or to assess accuracy and precision of data).

### Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Outside that range (e.g., at a too high or too low external temperature, with too little food or water available), the organism cannot survive. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students come to understand cellular organization and relationships between structure and function by making observations, asking evidence-based questions, and formulating predictions.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Problems**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer. | **Patterns**<br>• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.<br>• Empirical evidence is needed to identify patterns. |

| | |
|---|---|
| • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. | **Structure and Function**<br>• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. |

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Plus HS+B.L1U1.4 Develop and use models to explain the interdependency and interactions between cellular organelles.**

**Learning Goals**

I can:

- Develop models that represent the interdependency and interactions among cellular organelles in carrying out cellular functions:
    - Use design criteria to develop a diagram, drawing, physical replica, mathematical representation, analogy, and/or computer simulation that represents the interdependency and interactions among cellular organelles.
    - Use multiple types of models to represent the interdependency and interactions among cellular organelles.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability.
- Use models to explain how cellular organelles function as a system within the cell:
    - Use models to describe how organelles work interdependently to maintain homeostasis.
    - Use models to describe the role of enzymes in regulating cellular activity.
    - Use models to describe how a protein is made (at the ribosome) and transferred out of the cell (rough endoplasmic reticulum, ribosome, golgi apparatus, vesicle and cell membrane).

## Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Within cells there are many molecules of different kinds which interact in carrying out the functions of the cell. In multicellular organisms cells communicate with each other by passing substances to nearby cells to coordinate activity. A membrane around each cell plays an important part in regulating what can enter or leave a cell.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Because organelles are too small to be observed directly, modeling helps students make sense of cellular phenomena in terms of relationships between parts of the system. In developing models, students use an iterative process of comparing what they predict with what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Design a test of a model to ascertain its reliability. | **Systems and System Models**<br>• Models (e.g., physical mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.<br><br>**Structure and Function** |

| | |
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| | • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. |

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# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Plus HS+B.L1U1.5 Analyze and interpret data that demonstrates the relationship between cellular function and the diversity of protein functions.**

Learning Goals

I can:

- Use tools, technologies, and models to analyze and interpret data (*e.g., from investigations, demonstrations, texts, data sets, simulations)* that demonstrates the relationship between cellular function and the diversity of protein functions:
    - Ask questions to frame data analysis and interpretation.
    - Identify and describe patterns in data.
    - Use provided models to gather data on the shape of different proteins in the cell (transport proteins, DNA polymerase, amylase, actin and myosin, insulin, collagen, antibodies) and how it relates to their specific role in the cell.
    - Analyze data that show body tissues are a system of specialized cells with similar structures and functions, with each function mainly carried out by the proteins they produce.
    - Compare and contrast various data sets that relate proper functioning of proteins to proper functioning of cells.

## Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Systems of specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules, such as water, proteins, carbohydrates, lipids, and nucleic acids.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Because cellular function is too small to be observed directly, data analysis and interpretation help students make sense of relationships at the cellular level.

## Science and Engineering Practices

**Asking Questions and Defining Solutions**

- Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.
- Ask questions that require relevant empirical evidence to answer.
- Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

**Analyzing and Interpreting Data**

- Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution.
- Consider limitations (e.g., measurement error, sample selection) when analyzing and

## Crosscutting Concepts

**Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

**Structure and Function**

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

**Systems and System Models**

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| interpreting data.<br>• Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. | • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. |

| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY |
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| LIFE SCIENCE |
| CELLS AND ORGANISMS |

**Science Standard: Plus HS+B.L1U1.6 Develop and use models to show how transport mechanisms function in cells.**

**Learning Goals**

I can:

- Develop models that represent the functions of transport mechanisms in cells:
  - Use design criteria to develop a diagram, drawing, physical replica, mathematical representation, analogy, and/or computer simulation that represents the functions of transport mechanisms in cells.
  - Use multiple types of models to represent the functions of transport mechanisms in cells.
  - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
  - Design a test of a model to ascertain its reliability.
- Use models to show how transport mechanisms function in cells:
  - Use models to explain how water, proteins, carbohydrates, and lipids are transported to the cell membrane via different organelles.
  - Use models to explain how water, proteins, carbohydrates, lipids, and ions pass through the cell membrane based on their size, charge, and concentration.
  - Use models to describe how transport mechanisms help maintain homeostasis for the cell, tissue, organs, organ systems.
  - Use models to describe how the conditions surrounding the cell can create a concentration gradient and change the movement of certain molecules and atoms in or out of the cell.

## Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Within cells there are many molecules of different kinds which interact in carrying out the functions of the cell.
- In multicellular organisms cells communicate with each other by passing substances to nearby cells to coordinate activity. A membrane around each cell plays an important part in regulating what can enter or leave a cell. Activity within different types of cells is regulated by enzymes.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students make sense of cellular phenomena by making typically unseen structures “visible” through models.
- Models provide ways of explaining phenomena in terms of relationships between parts of a system. They are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Design a test of a model to ascertain its reliability.<br>• Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence of design criteria. | **Structure and Function**<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.<br>**Systems and System Models**<br>• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.<br>• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Plus HS+B.L1U1.7 Develop and use models to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms (plant and animal).**

Learning Goals

I can:

- Develop models that represent the hierarchical organization of interacting systems that provide specific functions within multicellular organisms:
    - Use design criteria to develop diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations that represent the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
    - Use multiple types of models to represent the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability.
    - Make a distinction between the accuracy of the model and actual body systems and functions it represents.
- Use models to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms:
    - Use a model to illustrate how the interaction between systems provides specific functions in multicellular organisms.
    - Model the functions of major body systems in terms of their contributions to the overall function of an organism.

### Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. Activity within different types of cells is regulated by enzymes.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students make sense of cellular phenomena by making typically unseen structures and functions “visible” through models.
- Models provide ways of explaining phenomena in terms of relationships between parts of a system. They are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Design a test of a model to ascertain its reliability. | **Systems and System Models**<br>• Models (e.g., physical mathematical, computer models) can be used to simulate systems and interactions - including energy, matter, and information flows - within and between systems at different scales.<br><br>**Structure and Function** |

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| • Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence of design criteria. | • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Essential HS.L2U1.21 Obtain, evaluate, and communicate data showing the relationship of photosynthesis and cellular respiration; flow of energy and cycling of matter.**

**Learning Goals**

I can:

- Obtain data about the relationships between photosynthesis and cellular respiration and between the flow of energy and cycling of matter:
  - Ask questions to frame the collection of data.
  - Gather data (*e.g., texts, investigations, media, data sets, models)* in response to the investigative question.
  - Determine the central ideas or conclusions of a scientific text.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
- Evaluate information about the relationship between photosynthesis and cellular respiration and between the flow of energy and cycling of matter:
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the relationship between photosynthesis and cellular respiration and between the flow of energy and cycling of matter.
  - Evaluate data that show the changes in energy of molecules involved in photosynthesis and cellular respiration.
  - Verify data across texts.
- Communicate data showing the relationship between photosynthesis and cellular respiration and between the flow of energy and cycling of matter
  - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that communicate data showing the relationship between photosynthesis and cellular respiration and between the flow of energy and cycling of matter.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) in order to share data about relationships between photosynthesis and cellular respiration and between the flow of energy and cycling of matter.
  - Diagram the flow of energy and matter from non-living systems (sunlight, gas, water) into a biological molecule (glucose) for living things.
  - Trace the transfer of elements from sugars made in photosynthesis to other biological molecules such as ATP, nucleic acids, and proteins.
  - Explain that cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed.
  - Explain that the energy released when breaking bonds in cellular respiration can drive chemical reactions between sugars and other substances, and the products of those reactions can be complex carbon-based molecules to build the body.

## Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- For example, aerobic (in the presence of oxygen) cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Anaerobic (without oxygen) cellular respiration follows a different and less efficient chemical pathway to provide energy in cells. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy loss to the surrounding environment.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students explore data to better understand relationships among cellular processes pertaining to the flow of energy and cycling of matter.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem. | **Energy and Matter: Flows, Cycles, and Conservation**<br>• The total amount of energy and matter in closed systems is conserved.<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.<br>**Scale, Proportion, and Quantity**<br>• Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. |

| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY |
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| LIFE SCIENCE |
| CELLS AND ORGANISMS |

**Science Standard: Plus HS+B.L2U1.8 Develop and use models to develop a scientific explanation that illustrates how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes.**

Learning Goals

I can:

- Develop models that represent how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes:
    - Use design criteria to develop diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations that represent how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes.
    - Use multiple types of models to represent how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability.
    - Revise models based on results of tests and design criteria to more appropriately represent how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes.
    - Represent the inputs and outputs of glycolysis, Kreb's cycle, and electron transport chain.
    - Represent how energy powers cell and body system processes.
- Use models to develop a scientific explanation of how photosynthesis transforms light energy into stored chemical energy and how cellular respiration breaks down macromolecules for use in metabolic processes:
    - Use evidence from models to explain how photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide and water into glucose and released oxygen.
    - Use evidence from models to explain how the energy stored in sugar gets broken down and used by cells during cellular respiration through aerobic and anaerobic processes.
    - Construct and revise explanations based on evidence obtained from models.
    - Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

## Core Ideas

**Knowing Science**

L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- Aerobic (in the presence of oxygen) cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Anaerobic (without oxygen) cellular respiration follows a different and less efficient chemical pathway to provide energy in cells. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy loss to the surrounding environment.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Models help students make meaning of cellular processes that are too small to observe directly. Students use evidence from models to construct explanations of photosynthesis and cellular respiration. Models are developed through an iterative process as students refine their representation of phenomena.

| Science and Engineering Practices | Crosscutting Concepts |
| --- | --- |
| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations.<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.<br>• Design a test of a model to ascertain its reliability.<br>**Constructing Explanations and Designing Solutions**<br>• Construct explanations for either qualitative or quantitative relationships between variables.<br>• Apply scientific reasoning to show why the data are adequate for the explanation or conclusion.<br>• Base explanations on evidence obtained from sources (including their own experiments) and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.<br>• Apply scientific knowledge and evidence to explain real-world phenomena, examples, or events.<br>• Construct explanations from models or representations. | **Systems and System Models**<br>• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.<br>• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.<br>**Energy and Matter: Flows, Cycles, and Conservation**<br>• The total amount of energy and matter in closed systems is conserved.<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.<br>• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.<br>• Energy drives the cycling of matter within and between systems. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Essential HS.L1U1.22 Construct an explanation for how cellular division (mitosis) is the process by which organisms grow and maintain complex, interconnected systems.**

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources (*e.g., scientific principles, models, theories, simulations*):
  - Explain why organisms need to undergo cell division (*e.g., growth, repair, development*) and be able to distinguish these reasons.
  - Apply scientific knowledge and evidence to describe how cell differentiation occurs and results in complex multicellular organisms composed of tissues and organs that work together to meet the needs of the whole organism.
  - Explain how chromosomes change throughout the cell cycle based on evidence obtained from multiple sources.
  - Apply models to describe the relationships between the series of cellular events that must happen for mitosis to occur correctly.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

### Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine evidence from texts, models, investigations, and simulations to develop explanations of cellular systems within organisms. Because cellular systems are so intricate and because they cannot be observed directly, students will need to rely on evidence from models, scientific texts, and/or investigations.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Constructing Explanations and Designing Solutions**<br>• Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.<br>• Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. | **Patterns**<br>• Empirical evidence is needed to identify patterns.<br>**Structure and Function**<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.<br>• Cause and Effect: Mechanism and Prediction<br>• Changes in systems may have various causes that may not have equal effects. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

### LIFE SCIENCE

### CELLS AND ORGANISMS

**Science Standard: Essential HS.L1U3.23 Obtain, evaluate, and communicate the ethical, social, economic and/or political implications of the detection and treatment of abnormal cell function.**

**Learning Goals**

I can:

- Obtain information about the implications of the detection and treatment of abnormal cell function:
  - Ask questions to frame the collection of information.
  - Gather information from a variety of sources (*e.g., texts, investigations, media, data sets, models)* in response to the investigative questions.
  - Record information about how cell cultures help cells grow in situ.
- Evaluate information about the ethical, social, economic, and/or political implications of the detection and treatment of abnormal cell function (*e.g., effects of suntanning beds, environmental disasters such as nuclear explosion, toxic waste sites, HeLa Cells):*
  - Determine the central ideas or conclusions of a scientific text.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports on the ethical, social, economic, and/or political implications of the detection and treatment of abnormal cell function.
  - Verify data across texts.
- Communicate the ethical, social, economic, and/or political implications of the detection and treatment of abnormal cell function:
  - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that communicate the ethical, social, economic, and/or political implications of the detection and treatment of abnormal cell function.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively*) in order to communicate the ethical, social, economic, and/or political implications of the detection and treatment of abnormal cell function.
  - Use multiple sources of information to describe the cellular processes that relate to abnormal cell function and division, including the interactions between cellular organelles that contribute to this process.
  - Explain how cells become abnormal and how abnormal cells can be detected (*i.e., invading microorganisms, environmental conditions or defective cell programming*).

### Core Ideas

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- Given a suitable medium, cells from a variety of organisms can be grown in situ, that is, outside the organism. These cell cultures are used by scientists to investigate cell functions and have medical implications such as the production of vaccines, screening of drugs, and in vitro fertilization.
- Diseases, which may be caused by invading microorganisms, environmental conditions, or defective cell programming, generally result in disturbed cell function.

**Using Science**

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students explore various perspectives of the detection and treatment of abnormal cell functions. It is important to consider the ethical values and political and economic realities in addition to science and technology.

- Scientific understanding can help to identify implications of applications, but decisions about whether certain actions should be taken to detect and treat abnormal cell function will require ethical and moral judgments.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.<br>• Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible.<br>• Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system. | **Structure and Function**<br>• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.<br>**Cause and Effect: Mechanism and Prediction**<br>• Changes in systems may have various causes that may not have equal effects. |

**HIGH SCHOOL BIOLOGY & HONORS BIOLOGY**

**LIFE SCIENCE**

**CELLS AND ORGANISMS**

**Science Standard: Essential HS+B.L1U1.9 Develop and use a model to communicate how a cell copies genetic information to make new cells during asexual reproduction (mitosis).**

Learning Goals

I can:

- Develop models that represent how a cell copies genetic information to make new cells during asexual reproduction (mitosis):
  - Use design criteria to develop diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations that represent how a cell copies genetic information to make new cells during asexual reproduction (mitosis).
  - Use multiple types of models to represent how a cell copies genetic information to make new cells during asexual reproduction (mitosis).
  - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
  - Design a test of a model to ascertain its reliability.
  - Revise models based on results of tests and design criteria to more appropriately represent how a cell copies genetic information to make new cells during asexual reproduction (mitosis).
- Use models to communicate how a cell copies genetic information to make new cells during asexual reproduction (mitosis):
  - Use evidence from models to explain DNA replication and formation of sister chromatids.
  - Use evidence from models to explain a cell's need to copy itself.
  - Use evidence from models to explain the various stages and checkpoints of the cell cycle.
  - Use evidence from models to explain asexual reproduction.

**Core Ideas**

**Knowing Science**

L1: Organisms are organized on a cellular basis and have a finite life span.

- In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Models help students make sense of relationships within cellular systems that are too small to observe directly. Models are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Developing and Using Models**<br>• Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations. | **Systems and System Models**<br>• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. |

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| • Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Design a test of a model to ascertain its reliability.<br>• Evaluate merits and limitations of two different models of the same proposed tool, process, or system in order to select or revise a model that best fits the evidence or design criteria. | • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. |

# GENETICS

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### GENETICS

**Science Standard: Essential HS.L3U1.24 Construct an explanation of how the process of sexual reproduction contributes to genetic variation.**

**Learning Goals**

I can:

- Construct an explanation based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations):*
    - Apply scientific reasoning to explain how meiosis occurs and results in the formation of gametes or spores that contain only one chromosome from each pair.
    - Apply a provided model to explain how an organism gets a complete set of chromosomes.
    - Use a provided model to show how chromosomes swap sections during meiosis thereby creating new genetic combinations.
    - Predict effects of chromosome abnormalities on the resulting zygote.
    - Explain that DNA tells part of the story, but that environment *(e.g., nutrients, chemicals, learning)* influences how those genes are expressed *(e.g., pH and hydrangeas, temperature and Himalayan rabbits).*

### Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- In sexual reproduction, a specialized type of cell division called meiosis occurs and results in the production of sex cells, such as gametes (sperm and eggs) or spores, which contain only one member from each chromosome pair in the parent cell.
- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine evidence from varied sources and apply scientific theories to construct well-supported explanations about cause and effect relationships between sexual reproduction and genetic variation.

### Science and Engineering Practices

**Constructing Explanations and Designing Solutions**

- Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.

### Crosscutting Concepts

**Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.
- Empirical evidence is needed to identify patterns.

**Cause and Effect: Mechanism and Prediction**

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### GENETICS

**Science Standard: Essential HS.L3U1.25 Obtain, evaluate, and communicate information about the causes and implications of DNA mutation.**

**Learning Goals**

I can:

- Obtain information about the causes and implications of DNA mutation:
  - Ask questions to frame the search for information.
  - Gather information from a variety of sources (*e.g., texts, investigations, media, data sets, models*) in response to the investigative questions.
  - Determine the central ideas or conclusions of a scientific text.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
- Evaluate information about the causes and implications of DNA mutation:
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the causes and implications of DNA mutation.
  - Evaluate evidence that describes possible effects of genetic mutation on an individual and population.
  - Evaluate evidence of how mutations lead to genetic diversity.
- Communicate information about the causes and implications of DNA mutation:
  - Use evidence to explain the possible effects of genetic mutation on an individual and a population.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively)* in order to share evidence that describes how different types of mutations impact formation of proteins.
  - Use evidence to explain how mutations that result in genetic variation can occur during replication and/or environmental factors.
  - Use evidence to explain how genetic variation that occurs as a result of meiosis will be passed to offspring.

### Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.
- Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine evidence from various sources to develop an understanding of cause and effect relationships surrounding DNA mutation. They synthesize evidence in order to communicate information to various audiences for various purposes.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Asking Questions and Defining Solutions** | **Cause and Effect: Mechanism and Prediction** |

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| • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br><br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem. | • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br>• Changes in systems may have various causes that may not have equal effects.<br><br>**Structure and Function**<br>• Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. |

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### GENETICS

**Science Standard: Essential HS.L3U3.26 Engage in argument from evidence regarding the ethical, social, economic, and/or political implications of a current genetic technology.**

Learning Goals

I can:

- Evaluate arguments regarding the ethical, social, economic, and/or political implications of a current genetic technology:
  - Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
  - Critique and evaluate competing arguments about genetic technology in light of evidence, limitations (trade-offs), constraints and ethical issues.
- Construct, use, and present oral and written arguments regarding the ethical, social, economic, and/or political implications of a current genetic technology:
  - Make and defend a claim about the ethical, social, economic, and/or political implications of a current genetic technology *(e.g., genomes, gene therapy, gene mapping, curing diseases).*
  - Use scientific evidence to develop and support the claim.
  - Use scientific evidence to explain the implications of a current genetic technology that manipulates the genome.

## Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- The overall sequence of genes of an organism is known as its genome. More is being learned all the time about genetic information by mapping the genomes of different kinds of organisms.
- When sequences of genes are known, genetic material can be artificially changed to give organisms certain features.
- In gene therapy special techniques are used to deliver into human cells genes that are beginning to help in curing disease.

**Using Science**

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students evaluate arguments and construct their own arguments about genetic technologies. Sound arguments must be based on scientific evidence and reasoning, and they must take into consideration the ethical, social, economic, and/or political implications of the use of genetic technology.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Engaging in Argument from Evidence**<br>• Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.<br>• Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.<br>• Construct a counter-argument that is based on data and evidence that challenges another proposed argument. | **Cause and Effect: Mechanism and Prediction**<br>• Changes in systems may have various causes that may not have equal effects.<br>• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable. |

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| • Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. | |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

### LIFE SCIENCE

### GENETICS

**Science Standard: Plus HS+B.L3U1.10 Use mathematics and computational thinking to explain the variation that occurs through meiosis and calculate the distribution of expressed traits in a population.**

**Learning Goals**

I can:

- Organize given data by the frequency, distribution and variation of expressed traits in a population.
- Perform and use appropriate statistical analyses of data, including probability measures, to determine the relationship between a trait's occurrence within a population and environmental factors.
- Analyze and interpret data to recognize and use patterns that predict changes in trait distribution within a population if the environment changes.
- Analyze and interpret data to describe if the expression of a chosen trait, and its variations, are causative or correlative to an environmental factor based on reliable evidence.

### Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- The information passed from parents to offspring is coded in the DNA molecules that form the chromosomes. In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation.
- Environmental factors can cause mutations in genes, and viable mutations are inherited.
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depend on both genetic and environmental factors.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students use mathematics to explore gene expression in populations to better understand relationships between genetic and environmental factors that affect variation and distribution of traits.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Using Mathematics and Computational Thinking**<br>• Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations.<br>• Apply techniques of algebra and functions to represent and solve scientific and engineering problems.<br>• Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. | **Patterns**<br>• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.<br>• Mathematical representations are needed to identify some patterns.<br>• Empirical evidence is needed to identify patterns. |

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### GENETICS

**Science Standard: Plus HS+B.L3U1.11 Construct an explanation for how the structure of DNA and RNA determine the structure of proteins that perform essential life functions.**

Learning Goals

I can:

- Construct an explanation based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations):*
    - Explain the relationship between the non-protein coding sections of DNA and their functions *(e.g., regulatory functions)* in an organism.
    - Apply scientific knowledge and evidence to describe the cause and effect relationships between DNA, the proteins it codes for, and resulting traits observed in an organism.
    - Explain the relationship among DNA, RNA, and proteins.
    - Revise explanations based on evidence obtained from a variety of sources and peer review.

## Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- The information passed from parents to offspring is coded in the DNA molecules that form the chromosomes.
- Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students develop scientific explanations by examining evidence from a variety of sources. Because DNA, RNA, and proteins cannot be directly observed, much of the evidence will come from models, simulations, and scientific texts.

## Science and Engineering Practices

**Constructing Explanations and Designing Solutions**

- Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.
- Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.

## Crosscutting Concepts

**Structure and Function**

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

**Cause and Effect: Mechanism and Prediction**

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY |
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| LIFE SCIENCE |
| GENETICS |

**Science Standard: Plus HS+B.L3U1.12 Analyze and interpret data on how mutations can lead to increased genetic variation in a population.**

**Learning Goals**

I can:

- Use tools, technologies, and models to analyze and interpret data (*e.g., from investigations, demonstrations, texts, data sets, simulations)* on how mutations can lead to increased genetic variation in a population:
  - Ask questions to frame data analysis and interpretation.
  - Identify and describe patterns in data.
  - Evaluate limitations (e.g., measurement error, sample selection) when analyzing and interpreting data.
  - Compare and contrast various types of data sets to (e.g. self-generated, archival) to examine observations about effects of genetic variation in populations.
  - Use data to make valid scientific claims about how mutations lead to increased genetic variation in a population.

## Core Ideas

**Knowing Science**

L3: Genetic information is passed down from one generation of organisms to another.

- Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation.
- Environmental factors can cause mutations in genes, and viable mutations are inherited.
- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- In order to understand how mutations affect genetic variation in a population, students must examine a range of data and evidence. Exploration of data requires careful analysis to identify patterns and skillful interpretation to make meaning of them.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Analyzing and Interpreting Data**<br>• Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. | **Patterns**<br>• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.<br>• Mathematical representations are needed to identify some patterns.<br>• Empirical evidence is needed to identify patterns.<br>**Cause and Effect: Mechanism and Prediction**<br>• Changes in systems may have various causes that may not have equal effects. |

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| • Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data.<br>• Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. | |

# EVOLUTION

ENVISION 21
DEEP LEARNING • CFSD

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### EVOLUTION

**Science Standard: Essential HS.L4U1.27 Obtain, evaluate, and communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.**

**Learning Goals**

I can:

- Obtain evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity:
  - Ask questions to frame the collection of evidence.
  - Gather evidence from a variety of sources (*e.g., texts, investigations, media, data sets, models*) in response to the investigative question.
  - Determine the central ideas or conclusions of a scientific text.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
- Evaluate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity:
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the relationship between changes in frequency of inherited traits and biological diversity within a population.
  - Evaluate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.
  - Evaluate evidence of how mutations and sexual reproduction in a population lead to genetic diversity.
  - Verify data across texts.
- Communicate evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.
  - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that communicate evidence describing the relationship between changes in frequency of inherited traits and biological diversity in a population.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats (*e.g., visually, quantitatively*) in order to share evidence that describes how changes in frequency of inherited traits in a population can lead to biological diversity.
  - Use evidence to explain how certain adaptations are more likely to be reproduced.

## Core Ideas

**Knowing Science**

L4: The unity and diversity of organisms, living and extinct, is the result of evolution.

- The differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. The traits that positively affect survival are more likely to be reproduced and thus are more common in the population. The distribution of traits in a population can change when conditions change.
- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. Species become extinct because they can no longer survive and reproduce in their altered environment.
- If members cannot adjust to change that is too fast or too drastic, the opportunity for the species' evolution is lost.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students gather evidence from a variety of sources to develop an understanding of biological diversity. This evidence then supports their explanations of phenomena.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem. | **Cause and Effect: Mechanism and Prediction**<br>• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br>• Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.<br>• Changes in systems may have various causes that may not have equal effects.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br>• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. |

| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY | |
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| LIFE SCIENCE | |
| **EVOLUTION** | |
| **Science Standard: Essential HS.L4U1.28 Gather, evaluate, and communicate multiple lines of empirical evidence to explain the mechanisms of biological evolution.**<br><br>Learning Goals<br>I can:<br>• Gather empirical evidence to explain the mechanisms of biological evolution:<br>  ○ Ask questions about biological evolution to frame the collection of evidence.<br>  ○ Gather empirical evidence (*e.g., texts, investigations, media, data sets, models*) in response to the investigative questions.<br>• Evaluate multiple lines of empirical evidence to explain the mechanisms of biological evolution:<br>  ○ Critically read scientific literature adapted for classroom use to determine central ideas about a change in environmental conditions that resulted in changes in allele frequencies in populations.<br>  ○ Determine the main idea of a scientific text about various mechanisms of evolution, and explaining how it is supported by key ideas.<br>  ○ Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.<br>  ○ Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the mechanisms of biological evolution.<br>  ○ Determine effects between environmental changes and the changes in the number of individuals in each species, and/or the number of individuals in each species (including emergence or extinction of species).<br>  ○ Verify data across texts.<br>• Communicate multiple lines of empirical evidence to explain the mechanisms of biological evolution:<br>  ○ Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively)* in order to explain the mechanisms of biological evolution.<br>  ○ Communicate logical arguments that identify links between the environmental changes and speciation based on the ability of individuals in a species to survive and reproduce. | |
| Core Ideas | |
| **Knowing Science**<br>L4: The unity and diversity of organisms, living and extinct, is the result of evolution.<br>• Natural selection is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.<br><br>**Using Science**<br>U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.<br>• Biological evolution is a complex concept that is best understood through the examination of multiple lines of empirical evidence. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the sources they explore. | |
| **Science and Engineering Practices** | **Crosscutting Concepts** |
| **Asking Questions and Defining Solutions** | **Patterns** |

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| • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br><br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem. | • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.<br>• Empirical evidence is needed to identify patterns.<br><br>**Cause and Effect: Mechanism and Prediction**<br>• Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.<br>• Changes in systems may have various causes that may not have equal effects. |

| HIGH SCHOOL BIOLOGY & HONORS BIOLOGY |
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| LIFE SCIENCE |
| EVOLUTION |

**Science Standard: Plus HS+B.L4U1.13 Obtain, evaluate, and communicate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations.**

**Learning Goals**

I can:

- Obtain empirical evidence to explain the change in genetic composition of a population over successive generations:
  - Ask questions to frame the collection of evidence.
  - Gather empirical evidence from a variety of sources (*e.g., texts, investigations, media, data sets, models*) in response to the investigative question.
  - Determine the main idea of a scientific text about the change in genetic composition of a population over successive generations.
  - Summarize and paraphrase complex concepts, processes, or information presented in simpler, but still accurate terms.
- Evaluate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations:
  - Evaluate the validity and reliability of claims, methods, and designs in scientific and technical texts or media reports regarding the change in genetic composition of a population over successive generations.
  - Verify data across texts.
  - Determine effects between environmental changes and the changes in the number of individuals in each species, and/or the number of individuals in each species (including emergence or extinction of species).
  - Analyze patterns of amino acid sequences to determine ancestry.
  - Analyze patterns in the fossil record, anatomy, and embryology to determine ancestry.
- Communicate multiple lines of empirical evidence to explain the change in genetic composition of a population over successive generations:
  - Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar*) that communicate evidence to explain the change in genetic composition of a population over successive generations.
  - Compare, integrate, and evaluate multiple sources of information presented in different media or formats (*e.g., visually, quantitatively*) in order to explain the change in genetic composition of a population over successive generations.
  - Explain how common ancestry and biological evolution are supported by multiple lines of empirical evidence.
  - Use evidence from DNA sequences (using BLAST, for example) to help determine ancestry.

## Core Ideas

**Knowing Science**

L4: The unity and diversity of organisms, living and extinct, is the result of evolution.

- Genetic information, like the fossil record, also provides evidence of evolution.
- DNA sequences vary among species, but there are many overlaps; in fact the ongoing branching that produces multiple lines of descents can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.
- The differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- When studying genetic changes in populations over time, it is important to examine multiple lines of empirical evidence. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the sources they explore.

| Science and Engineering Practices | Crosscutting Concepts |
|---|---|
| **Asking Questions and Defining Solutions**<br>• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.<br>• Ask questions that require relevant empirical evidence to answer.<br>**Obtaining, Evaluating, and Communicating Information**<br>• Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.<br>• Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible.<br>• Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.<br>• Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system. | **Patterns**<br>• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.<br>• Mathematical representations are needed to identify some patterns.<br>• Empirical evidence is needed to identify patterns.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br>• Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. |

# HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## LIFE SCIENCE

### EVOLUTION

**Science Standard: Essential HS+B.L4U1.14 Construct an explanation based on scientific evidence that the process of natural selection can lead to adaptation.**

**Learning Goals**

I can:

- Construct an explanation based on scientific evidence that the process of natural selection can lead to adaptation:
    - Apply scientific reasoning to explain how an advantageous heritable trait allows individuals to survive and reproduce resulting in natural selection over time in a population.
    - Use evidence to explain the cause and effect relationship between natural selection and adaptation.
    - Make qualitative and quantitative claims based on evidence from multiple sources that explain how individuals with competitive advantages can survive and reproduce at higher rates than individuals without the traits because of the competition for limited resources.
    - Revise explanations based on evidence obtained from a variety of sources and peer review.
    - Revise explanations of adaptations to account for changes in the distribution of traits when environmental conditions change.

## Core Ideas

**Knowing Science**

L4: The unity and diversity of organisms, living and extinct, is the result of evolution.

- Natural selection leads to adaptation —that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
- Adaptation also means that the distribution of traits in a population can change when conditions change.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students come to understand the relationship between natural selection and adaptation by examining multiple sources of evidence. That evidence is then used to construct a scientific explanation.

## Science and Engineering Practices

**Constructing Explanations and Designing Solutions**

- Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.

## Crosscutting Concepts

**Cause and Effect: Mechanism and Prediction**

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

**Stability and Change**

- Much of science deals with constructing explanations of how things change and how they remain stable.

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| | • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. |

# EARTH AND SPACE SCIENCES

## Role of Water in Earth's Surface Processes
## Earth and Human Activity

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## EARTH AND SPACE SCIENCES

### ROLE OF WATER IN EARTH'S SURFACE PROCESSES

**Science Standard: Essential HS.E1U1.12 Develop and use models of the Earth that explains the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere).**

Learning Goals

I can:

- Develop models of the Earth that explain the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere):
    - Use design criteria to develop diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations that represent the role of energy and matter in Earth's constantly changing internal and external systems.
    - Use multiple types of models to represent the role of energy and matter in Earth's constantly changing internal and external systems.
    - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
    - Design a test of a model to ascertain its reliability.
    - Develop a model of a dynamic Earth that demonstrates feedback systems between various spheres *(e.g., tectonic plates/geosphere and hydrosphere/biosphere/atmosphere).*
    - Revise models based on results of tests and design criteria to more appropriately represent the role of energy and matter in Earth's constantly changing internal and external systems.
- Use models of the Earth that explain the role of energy and matter in Earth's constantly changing internal and external systems (geosphere, hydrosphere, atmosphere, biosphere):
    - Use evidence from models to explain how energy arrives and is stored on Earth.
    - Use evidence from models to explain how all matter is recycled on Earth over time, including how matter is recycled due to the outward flow of energy from the Earth's interior and the gravitational movement of denser materials toward its interior.
    - Use evidence from models to demonstrate and predict changes in global and regional climate that can be caused by the sun's energy output and the Earth's orbit, tectonic events, ocean circulation, human activities, etc.
    - Use evidence from models to explain fast and slow changes in Earth's history *(e.g., ice ages throughout time, volcanoes, Pangea).*

## Core Ideas

**Knowing Science**

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- A model of Earth has a hot but solid inner core, a liquid outer core, a solid mantle and crust. The top part of the mantle, along with the crust, forms structures known as tectonic plates. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.
- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.
- Beneath the Earth's solid crust is a hot layer called the mantle. The mantle is solid when under pressure but melts (and is called magma) when the pressure is reduced. In some places there are cracks (or thin regions) in the crust which can allow magma to come to the surface, for example in volcanic eruptions.
- The Earth's crust consists of a number of solid plates which move relative to each other, carried along by movements of the mantle. Where plates collide, mountain ranges are formed and there is a fault line along the plate boundary where earthquakes are likely to occur and there may also be volcanic activity.

**Using Science**

U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Interactions among Earth's systems are incredibly complex. Models help students make sense of the relationships within these interrelated spheres. Models are developed through an iterative process of comparing what they predict and what is found in the real world.

| Science and Engineering Practices | Crosscutting Concepts |
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| **Developing and Using Models**<br>• Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.<br>• Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.<br>• Design a test of a model to ascertain its reliability. | **Systems and System Models**<br>• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.<br>• Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.<br>**Energy and Matter: Flows, Cycles, and Conservation**<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.<br>• Energy drives the cycling of matter within and between systems.<br>**Stability and Change**<br>• Feedback (negative or positive) can stabilize or destabilize a system.<br>**Cause and Effect: Mechanism and Prediction**<br>• Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. |

## HIGH SCHOOL BIOLOGY & HONORS BIOLOGY

## EARTH AND SPACE SCIENCES

### EARTH AND HUMAN ACTIVITY

**Science Standard: Essential HS.E1U3.14 Engage in argument from evidence about the availability of natural resources, occurrence of nature hazards, changes in climate, and human activity and how they influence each other.**

**Learning Goals**

I can:

- Evaluate arguments regarding the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other:
  - Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
  - Critique and evaluate competing arguments in light of evidence, limitations (trade-offs), constraints and ethical issues.
- Construct, use, and present oral and written arguments regarding the availability of natural resources, occurrence of natural hazards, changes in climate, and human activity and how they influence each other:
  - Make and defend a claim about the distribution of natural resources *(e.g., air, water, soil, minerals, metal, plants, animals)* and the need for sharing limited natural resources in ways that do not damage the planet *(e.g., renewable resources, trade, shipping, use of technology).*
  - Construct and defend an argument about ways in which population growth affects outcomes of natural hazards and climate change *(e.g., higher temperatures intensify hurricane storms which cause increased flooding).*
  - Make and defend a claim about the interrelationships among resource availability, natural hazards, climate change, and human activity over time.
  - Construct a counter-argument that is based on data and evidence that challenges another proposed argument.
  - Use scientific evidence to develop and support the claim.

### Core Ideas

**Knowing Science**

E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate.

- Historically, humans have populated regions that are climatically, hydrologically, and geologically advantageous for fresh water availability, food production via agriculture, commerce, and other aspects of civilization.
- Resource availability affects geopolitical relationships and can limit development.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.
- Though the magnitudes of humans' impacts are greater than they have ever been, so too are humans' abilities to model, predict, and manage current and future impacts. Materials important to modern technological societies are not uniformly distributed across the planet (e.g., oil in the Middle East, gold in California). Most elements exist in Earth's crust at concentrations too low to be extracted, but in some locations—where geological processes have concentrated them—extraction is economically viable.
- Most energy production today comes from nonrenewable sources, such as coal and oil. However, advances in related science and technology are reducing the cost of energy from renewable resources, such as sunlight. As a result, future energy supplies are likely to come from a much wider range of sources. As a result, future energy supplies are likely to come from a much wider range of sources.

**Using Science**

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students explore arguments about climate change, human activity, and natural hazards from various perspectives. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the arguments they examine.

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| • Effective arguments also consider various ethical, social, economic, and/or political implications. | |
| **Science and Engineering Practices** | **Crosscutting Concepts** |
| **Engaging in Argument from Evidence**<br>• Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.<br>• Construct a counter-argument that is based on data and evidence that challenges another proposed argument.<br>• Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. | **Cause and Effect: Mechanism and Prediction**<br>• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br>• Changes in systems may have various causes that may not have equal effects.<br>**Stability and Change**<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br>• Feedback (negative or positive) can stabilize or destabilize a system. |