

Fairfield Public Schools Science Curriculum

Draft Units

Biology



Biology: Description

Students in high school develop understanding of key concepts that will help them make sense of life science. The ideas are built upon students' science understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts from earlier grades. There are four life science disciplinary core ideas in high school: 1) From Molecules to Organisms: Structures and Processes, 2) Ecosystems: Interactions, Energy, and Dynamics, 3) Heredity: Inheritance and Variation of Traits, 4) Biological Evolution: Unity and Diversity. The performance expectations for high school life science blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge that can be applied across the science disciplines. While the performance expectations in high school life science couple particular practices with specific disciplinary core ideas, instructional decisions include use of many practices underlying the performance expectations.

Standards for this course are taken from the *Next Generation Science Standards* and are of three types:

Disciplinary Core Ideas (DCIs): Shown as content objectives, these standards define what students should know about the most essential ideas in the major science disciplines. The focus is on a limited number of core ideas in science and engineering both within and across the disciplines to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.

Science and Engineering Practices (SEP): These standards enable students to apply the content in the DCI's and the skills of practicing scientists and engineers to explain phenomena and solve real world problems. Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science.

Crosscutting Concepts: These standards provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. These broad concepts tie together the influence of engineering, technology, and science on society and the natural world.

<http://www.nextgenscience.org/next-generation-science-standards>

CROSS CUTTING CONCEPTS

Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Biology

Course Essential Questions

- What evidence shows that different species are related?
- How do organisms live and grow?
- How and why do organisms interact with their environment, and what are the effects of these interactions?
- What are the effects of interactions of organisms and their environment?
- How are characteristics of one generation passed to the next?
- How can individuals of the same species and even siblings have different characteristics?

Course: Year-at-a Glance

Unit	Title		Unit Essential Questions
1	Biological Evolution: Unity and Diversity	Evidence of Common Ancestry and Diversity	What evidence do we have that organisms are related and have changed over time? How do organisms with advantageous traits increase in proportion over time? How does natural selection lead to an increase in the population of some species, emergence of new species or the extinction of a species?
		Natural Selection	
		Adaptation and Biodiversity	
2	From Molecules to Organisms: Structures and Processes	Structure and Function	How does the structure and function of cells determine how organisms live and grow? What mechanisms do organisms need to grow and develop? Why is photosynthesis and respiration important in the cycling of matter and flow of energy?
		Growth and Development of Organisms	
		Organization for Matter and Energy Flow in Organisms	
3	Heredity: Inheritance and Variation of Traits	Inheritance of Traits	What is the role of DNA in determining the traits passed from parents to offspring? How does genetic variation arise and how does it get distributed in a population?
		Variation of Traits	
4	Ecosystems: Interactions, Energy, and Dynamics	Interdependent relationships in Ecosystems	What factors affect carrying capacity and biodiversity in ecosystems of different scales? How does the cycling of matter and flow of energy (including anaerobic and aerobic respiration) impact the biosphere, atmosphere, hydrosphere and geosphere? How do stable conditions and changing conditions (including human activities) affect an ecosystem? What is the effect of behavior on an individual or species chance of survival?
		Cycles of Matter and Energy Transfer in Ecosystems	
		Ecosystems Dynamics, Functioning and Resilience	
		Social Interactions and Behavior	

Monitoring Student Progress

Students' progress in relation to the content and skill standards will be measured with teacher-generated, as well as district-wide, formative and summative assessments in the following areas:

1. Determine the central ideas or information of scientific content and process; provide an accurate synthesis that makes clear the relationships among the key details and ideas

Unit 1 Natural Selection and Evolution

Overview

Evolution is the unifying theme of biology. Natural selection incorporates how species and populations change and adapt over time depending on changes in environmental conditions. There are multiple lines of scientific evidence that can be evaluated to support the processes of natural selection including the role of genetic variation in evolution.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
- Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment .
- Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
- Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Unit Essential Questions

- What evidence do we have that organisms are related and have changed over time?
- How do organisms with advantageous traits increase in proportion over time?
- How does natural selection lead to an increase in the population of some species, emergence of new species or the extinction of a species?

Crosscutting Concepts

- Patterns
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Cause and Effect

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

LS4.A : Evidence of Common Ancestry and Diversity

- Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent 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. (HS-LS4-1)

LS4.B: Natural Selection

- Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)
- The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

LS4.C: Adaptation

- Evolution is a consequence of the interaction 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. (HS-LS4-2)
- 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. (HS-LS4-3),(HS-LS4-4)
- Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) 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. (HS-LS4-5),(HS-LS4-6)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Using Mathematical and Computational Thinking
- Analyzing and Interpreting Data
- Obtaining, Evaluating, and Communicating Information
- Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

Corresponding CT Core Standards:

ELA/Literacy –

RST .11-12.1, WHST .9-12.2, WHST .9-12.9, SL.11-12.4, RST .11-12.8, WHST .9-12.5

Mathematics –

MP.2 , MP.4

Unit 2 From Molecules to Organisms: Structures and Processes

Overview

Identifying the the relationships between the structure and function of molecules, cells and organisms is key to understanding how organisms perform essential functions of life. Organisms are complex, organized, and built on a hierarchical structure, with each level providing the foundation for the next. Cellular division, including mitosis and meiosis, and differentiation produce and maintain complex organisms. Photosynthesis and cellular respiration provide most of the energy for life processes. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

Unit Content Objectives

- **At the conclusion of this unit, students will be able to:**
- **Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.**
- **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.**
- **Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.**
- **Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.**
- **Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.**
- **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.**
- **Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**

Unit Essential Questions

- How does the structure and function of cells determine how organisms live and grow?
- Why are the structures of DNA and proteins essential to carrying out the functions of living things?
- What mechanisms do organisms need to grow and develop?
- Why is photosynthesis and respiration important in the cycling of matter and flow of energy?
- How the matter and energy flow through different organizational levels of living systems result in chemical elements recombining in different ways to form different products?
- How is energy transferred from one system of interacting molecules to another as a result of chemical reactions?

Crosscutting Concepts

- Systems and System Models
- Energy and Matter
- Structure and Function
- Stability and Change

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)
- 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. (HS-LS1-2)
- 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. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. 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.

LS1.C: Organization for Matter and Energy Flow in Organisms

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5) 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. (HS-LS1-6)
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. 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. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Developing and Using Models
- Constructing Explanations and Designing Solutions
- Planning and Carrying out Investigations

Corresponding CT Core Standards:

ELA/Literacy –

RST .11-12.1, WHST .9-12.2, WHST .9-12.7, WHST .11-12.8, WHST .9-12.9, SL.11-12.5, WHST.9-12.5

Mathematics –

MP.4 , HSF-IF.C.7, HSF-BF.A.1

Unit 3 Heredity: Inheritance and Variation of Traits

Overview

Scientists have observed that individuals of the same species can vary in how they look, function, and behave. Mutations, the driver of these changes, can be caused by factors like inheritance of genes and the environment. Applying mathematical concepts, genetic variation can be predicted and quantified.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors
- Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Unit Essential Questions

- What is the role of DNA in determining the traits passed from parents to offspring?
- How does genetic variation arise and how does it get distributed in a population?

Crosscutting Concepts

- Cause and Effect
- Scale, Proportion, and Quantity
- Science is a Human Endeavor

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

LS3.A : Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA . The instructions for forming species' characteristics are carried in DNA . All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1)

LS3.B: Variation of Traits

- 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. 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. (HS-LS3-2)
- 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 depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Engaging in Argument from Evidence
- Analyzing and Interpreting Data
- Asking Questions and Defining Problems

Corresponding CT Core Standards:**ELA/Literacy –**

RST .11-12.1, RST .11-12.9, WHST .9-12.1

Mathematics –

MP.2

Unit 4 Ecosystems: Interactions, Energy, and Dynamics

Overview

The Earth is an ever changing system. Many factors within the system affect biodiversity and populations of species. Populations are affected by available energy, cycling of nutrients, populations of other species, and human activities. The biodiversity of an ecosystems is dependent upon an organism's ability to adapt and survive changes in the environment.

Unit Content Objectives

At the conclusion of this unit, students will be able to:

- Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales
- Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
- Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Unit Essential Questions

- What factors affect carrying capacity and biodiversity in ecosystems of different scales?
- How does the cycling of matter and flow of energy (including anaerobic and aerobic respiration) impact the biosphere, atmosphere, hydrosphere and geosphere?
- How do stable conditions and changing conditions (including human activities) affect an ecosystem?
- What is the effect of behavior on an individual or species chance of survival?

Crosscutting Concepts

- Scale, Proportion, and Quantity
- Energy and Matter
- Systems and System Models
- Stability and Change
- Cause and Effect

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

LS2.A: Interdependent Relationships in Ecosystems

- 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 such 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. (HS-LS2-1),(HS-LS2-2)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
- 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. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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. (HS-LS2-2),(HS-LS2-6)
- 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. (HS-LS2-7)

LS2.D: Social Interactions and Group Behavior

- Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HLSL2-8)

SCIENCE AND ENGINEERING PRACTICES (SEP):

- Engaging in Argument from Evidence
- Constructing Explanations and Designing Solutions
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Using Mathematical and Computational Thinking
- Developing and Using Models

Corresponding CT Core Standards:

ELA/Literacy –

RST.11-12.1, WHST.9-12.2, WHST.9-12.5, SL.11-12.5, RST.9-10.8, RST.11-12.7, RST.11-12.8, WHST.9-12.7

Mathematics –

MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSS-ID.A.1, HSS-IC.A.1, HSS-IC.B.6, MP.4, HSN-Q.A.1, HSN-Q.A.3