Standard 15 : Diversity and Evolution of Living Organisms

A. The scientific theory of evolution is the fundamental concept underlying all of biology.

B. The scientific theory of evolution is supported by multiple forms of scientific evidence.

C. Organisms are classified based on their evolutionary history.

D. Natural selection is a primary mechanism leading to evolutionary change.

Number: SC.912.L.15

Title: Diversity and Evolution of Living Organisms

Type: Standard

Subject: Science

Grade: 912

Body of Knowledge: Life Science

Related Benchmarks

Code	Description
SC.912.L.15.1	Explain how the scientific theory of evolution is supported by the fossil record, comparative anatomy, comparative embryology, biogeography, molecular biology, and observed evolutionary change. **Remarks/Examples:** Annually Assessed on Biology EOC. Also assesses SC.912.L.15.10; SC.912.N.1.3; SC.912.N.1.4; SC.912.N.1.6; SC.912.N.2.1; SC.912.N.3.1; and SC.912.N.3.4.
SC.912.L.15.2	Discuss the use of molecular clocks to estimate how long ago various groups of organisms diverged evolutionarily from one another.
SC.912.L.15.3	Describe how biological diversity is increased by the origin of new species and how it is decreased by the natural process of extinction.
SC.912.L.15.4	Describe how and why organisms are hierarchically classified and based on evolutionary relationships.
SC.912.L.15.5	Explain the reasons for changes in how organisms are classified.
SC.912.L.15.6	Discuss distinguishing characteristics of the domains and kingdoms of living organisms. **Remarks/Examples:** Annually Assessed on Biology EOC. Also assesses SC.912.L.15.4; SC.912.L.15.5; SC.912.N.1.3; and SC.912.N.1.6.
SC.912.L.15.7	Discuss distinguishing characteristics of vertebrate and representative invertebrate phyla, and chordate classes using typical examples.
SC.912.L.15.8	Describe the scientific explanations of the origin of life on Earth. **Remarks/Examples:** Annually assessed on Biology EOC. Also assesses SC.912.N.1.3, SC.912.N.1.4, and SC.912.N.2.1.
SC.912.L.15.9	Explain the role of reproductive isolation in the process of speciation.
SC.912.L.15.10	Identify basic trends in hominid evolution from early ancestors six million years ago to modern humans, including brain size, jaw size, language, and manufacture of tools.
SC.912.L.15.11	Discuss specific fossil hominids and what they show about human evolution.
SC.912.L.15.12	List the conditions for Hardy-Weinberg equilibrium in a population and why these conditions are not likely to appear in nature. Use the Hardy-Weinberg equation to predict genotypes in a population from observed phenotypes.
SC.912.L.15.13	Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success. **Remarks/Examples:** Annually assessed on Biology EOC. Also assesses SC.912.L.15.14, SC.912.L.15.15, and SC.912.N.1.3.
SC.912.L.15.14	Discuss mechanisms of evolutionary change other than natural selection such as genetic drift and gene flow.
SC.912.L.15.15	Describe how mutation and genetic recombination increase genetic variation.

Related Access Points

Independent

Access Point Number	Access Point Title
SC.912.L.15.In.1:	Identify that prehistoric plants and animals changed over time (evolved) or became extinct.
SC.912.L.15.In.2:	Classify living organisms into their kingdoms.
SC.912.L.15.In.3:	Identify that there are scientific explanations of the origin of life on Earth.
SC.912.L.15.In.4:	Recognize ways that the appearance of humans, their language, and their tools have changed over time.
SC.912.L.15.In.5:	Recognize that some living things produce very large numbers of offspring to ensure that enough survive to continue the species (a condition for natural selection).
SC.912.L.15.In.1:	Identify that prehistoric plants and animals changed over time (evolved) or became extinct.
SC.912.L.15.In.6:	Recognize that changes in the genes of a species can affect the characteristics of their offspring.

Supported

Access Point Number	Access Point Title
SC.912.L.15.Su.1:	Match fossils to related species.
SC.912.L.15.Su.2:	Match organisms to the animal, plant, and fungus kingdoms.
SC.912.L.15.Su.3:	Recognize that there are scientific explanations of how life began.
SC.912.L.15.Su.4:	Recognize that humans have changed in appearance over a very long period of time.
SC.912.L.15.Su.5:	Recognize that some living things, such as fish and turtles, produce very large numbers of offspring because most will die as a result of dangers in the environment before they grow up.
SC.912.L.15.Su.6:	Recognize that characteristics of the offspring of living things are sometimes different from their parents.

Participatory

Access Point Number	Access Point Title
SC.912.L.15.Pa.1:	Recognize that plants and animals change as they age.
SC.912.L.15.Pa.2:	Sort common living things into plant and animal kingdoms.
SC.912.L.15.Pa.3:	Recognize that animals produce offspring.
SC.912.L.15.Pa.4:	Recognize differences in physical characteristics within a species of animals, such as different types of dogs.

Related Resources

Text Resource

Name	Description
"The Riddle of the Human Species," a New York Times Opinionator blog by biologist E. O. Wilson :	This informational text resource is intended to support reading in the content area. This *New York Times* Opinionator blog by one of the world's leading biologists is an explanation of the important role that "eusociality" has played in human evolution.
400,000-Year-Old Human DNA Adds New Tangle to our Origin Story :	Modern DNA extraction methods have shed light on two extinct human cousin species. Scientists are finding new ways to study fossil mitochondrial DNA which have led to rethinking how groups of early humans should be divided evolutionarily.
A Living Fossil:	This informational text resource is intended to support reading in the content area. In 1996, a team of scientists discovered a species of rodent in Laos that was new to science. In a recent study, DNA analysis places the rodent in a mammal family that was previously thought to have gone extinct over 10 million years ago. Therefore, the rodent is a "living fossil."
Against the Tide: Fish Quickly Adapt to Lethal Levels of Pollution:	This informational text resource is designed to support reading in the content area. The article describes the evolution of a type of fish who can survive in a human-altered, toxic environment. The text discusses possible reasons for this successful evolution and what the implications are for other species, including humans.
Analysis of Fossilized Antarctic Bird's 'Voice Box' Suggests Dinosaurs Couldn't Sing:	This informational text resource is intended to support reading in the content area. Scientists have presented new findings on the fossilized voice box called a syrinx -- and its apparent absence in non-avian dinosaur fossils of the same age. This may indicate that other non-avian dinosaurs were not able to make noises similar to the bird calls we hear today.
Arctic Fox and Other Polar Predators May Have Originated in the Himalayas:	This informational text resource is intended to support reading in the content area. This article discusses the possibility that the modern Arctic fox and other "hypercarnivorous" polar predators may have their origins in the Tibetan Plateau. The study uses fossil evidence, comparative anatomy, and biogeography to trace the evolutionary origins of the Arctic fox to the Himalayas.
Bacteria Learn New Trick:	This informational text resource is intended to support reading in the content area. This article shows how, through experimentation, bacteria evolve over a short period of time. The E.coli bacteria show the ability to eat a new food, citrate, after 13,000 generations of gene mutation.
Caribbean Bat Species Need 8 Million Years to Recover from Recent Extinction Waves:	This informational text resource is intended to support reading in the content area. The article discusses how Caribbean bat species are ideal for understanding the implications of extinction and its effects on species. The article suggests that the geographic isolation of these species helps scientists to understand the causes of extinction and how long species may need to recover from natural and human impact.
Could Common Earthly Organisms Thrive on Mars?:	This informational text resource is intended to support reading in the content area. This article asks the question: could life exist on Mars? The research depicted specifically applies to a simple, single-celled organism called a methanogen, which is in the kingdom Archaea. So far, studies have shown that these types of organisms are able to survive in manipulated environments similar to the harsh conditions on Mars.

Evolution Made Ridiculous Flightless Birds Over and Over:	This informational text resource is intended to support reading in the content area. This article focuses on the evolution of ratites—large, flightless birds like the ostrich—and how they evolved to become flightless birds. New research shows that ratites evolved from common flying ancestors and that the evolutionary process occurred over and over again.
Extinct Relative Helps to Reclassify the World's Remaining Two Species of Monk Seal:	This informational text resource is intended to support reading in the content area. Scientists used DNA and morphological analysis to classify the extinct Caribbean monk seal. In doing so, they grouped it with the critically endangered Hawaiian monk seal into a new genus, *Neomonachus*. The also critically endangered Mediterranean monk seal remains in its own genus, *Monachus*.
Finding the Origins of Life in a Drying Puddle:	This text resource is designed to support reading in the content area. The article describes how researchers at Georgia Tech have discovered that polypeptides, which are the main component of proteins, can be formed by mixing amino and hydroxyl acids, and then simply putting them through wet and dry cycles. This would be a more plausible way for early prebiotic molecules to form. Previously, the only way to produce polypeptides involved boiling temperatures, which are not conducive to life.
Genetic Solution to Cancer, Diabetes?:	This informational text resource is intended to support reading in the content area. The text describes a rare form of dwarfism called Laron's Syndrome, which is associated with an unusually low incidence of cancer and diabetes. This combination of characteristics allows scientists to speculate on the relationship between all three conditions. It appears that a mutation that causes dwarfism protects against the common diseases of cancer and diabetes.
How New Zealand's Glaciers Shaped the Origin of the Kiwi Bird:	This informational text resource is designed to support reading in the content area. The article discusses research conducted by scientists that proves there are more species and subspecies of kiwi birds than originally thought in New Zealand. The article discusses how scientists believe glaciers isolated populations and how new genetic lineages were discovered by analyzing the kiwi genome.
International Research Team Close Human Evolution Gap with Discovery of 1.4 Million-Year-Old Fossil :	This informational text resource is intended to support reading in the content area. Scientists discover a fossil which dates back 1.42 million years and shows the development of a bone not found in human fossils prior to this date.
Long-held Theory on Human Gestation Refuted:	This informational text resource is intended to support reading in the content area. This is a fine synopsis of a previously reported (and highly technical) study that shows the thought process behind challenging an existing theory. The subject is human evolution and the biology of childbirth. It encompasses basic anthropology concepts such as walking upright, as well as the biology of energy needs in pregnancy. Long-held views (that narrow birth canals are required for bipedalism) are debunked by careful analysis of how women with varying hip widths actually walk—and the authors found no difference.
Male Faces May Have Evolved to Be Punch-Resistant:	This informational text resource is intended to support reading in the content area. The article describes new research suggesting that human ancestors, particularly males, evolved stronger jaws that were resistant to punches. (Females, perhaps less prone to fighting, do not show this same adaptation). This contradicts earlier hypotheses, which suggested that larger jaws evolved to better consume food resources.
Meet the Oldest Member of the Human Family:	This informational text is intended to support reading in the content area. This article from *Scientific American* describes a fossil skull of a new genus and species of hominid thought to be 7 million years old, which was found in central Africa.
Meteorites May Have Sparked Life on Earth:	This informational text resource is intended to support reading in the content area. Scientists have formulated and tested another theory to explain how life began on Earth: meteorites crashing into the surface of the ancient planet brought with them the elements of life's building blocks. The results of the scientists' simulations are promising.
New Fossils Reveal Older Human Ancestor:	This informational text resource is intended to support reading in the content area. This text is about the finding of a hominid fossil that is 1.5 million years older than other hominid fossils found to date.
New Housecat-Size Feline Species Discovered:	This informational text is intended to support reading in the content area. The article discusses how scientists have discovered a species of Oncilla (little tiger cats) in Northeastern Brazil, which are a genetically different species than those in the rest of South America.
Newly Discovered Paddle Prints Show How Ancient Sea Reptiles Swam:	This informational text resource is intended to support reading in the content area. Scientists have found fossils in seabeds in China that are tracks left by nothosaurs, ancient sea reptiles. These tracks provide evidence that these reptiles moved by rowing their forelimbs in unison, answering a long-standing question about how they propelled themselves.
Polar Bear Evolution Was Fast and Furious:	This informational text resource is intended to support reading in the content area. New evidence shows that polar bears split off from their closest ancestors, brown bears, less than 500,000 years ago. This is a very short time for a large mammal to evolve. In that time, polar bears have evolved many adaptations to their specialized lifestyle, including the ability to process the large amount of fat in their seal-based diet. This is shown by their unique DNA sequence of genes related to fat processing and heart development.
Probing Question: What is a Molecular Clock?:	This informational text resource is intended to support reading in the content area. The article explains what molecular clocks are and how they are used to calculate evolutionary divergence and other evolutionary events.
Remote Sheep Population Resists Genetic Drift:	This informational text resource is intended to support reading in the content area. This article describes a mouflon population located on a remote island in the Indian Ocean. This population of sheep was transplanted to Haute Island over 50 years ago. Recent studies show that the population has maintained its genetic diversity. This finding challenges scientists' beliefs about the theories of genetic drift and shows the power of natural selection.
Scientists Discover Fossil of Bizarre Groundhog-Like Mammal on Madagascar:	This informational text resource is designed to support reading in the content area. This article describes a new research discovery of the fossil remains of a groundhog-like mammal found in Madagascar. The article details the methodology scientists employed to unearth the fossil skull and explains the insights it offers into early mammalian evolution in the Southern Hemisphere.

Seeing Double: New Study Explains Evolution of Duplicate Genes:	This informational text resource is intended to support reading in the content area. A new study explains that about half of our genes are copies, made by error during DNA replication, that have escaped elimination by natural selection through the addition of methyl groups. Usually these copies would be susceptible to developing mutations, but it is newly understood that they are evolving new functions instead.
Shedding Light on Millipede Evolution:	This informational text resource is designed to support reading in the content area. The author tells of his success in locating and reclassifying a species of millipedes known as ***Motyxia bistipita***. Until his rediscovery these millipedes were not known to show bioluminescence. Once he discovered this trait he was then also able to trace their evolutionary lineage and determine the reasons for the development of this ability in ***bipista's*** relatives. This article also discusses bioluminescence in other species and its important medical applications.
Skull Fossil Suggests Simpler Human Lineage:	This informational text resource is intended to support reading in the content area. This article discusses the discovery of "Skull 5" and the traits that have led scientists to the conclusion that early Homo was a more diverse genus than realized before.
The Mythology of Natural Selection:	This informational text resource is intended to support reading in the content area. The text describes how natural selection occurs when mutations occur in an individual's DNA sequence. Two different populations can have two different genetic mutations yet end up with a similar phenotype.
The Oldest Fish in the World Lived 500 Million Years Ago:	This informational text resource is intended to support reading in the content area. The article describes the discovery of an ancient fish that provides scientists with a "missing link" in the fossil record, helping them understand when and how organisms transitioned from boneless, jawless organisms into the fish that dominate the oceans today. The text details the adaptations these ancient fish had and draws connections to adaptations found in later species.
Tough Decisions on the Front Line of Nature Conservation:	This informational text resource is intended to support reading in the content area. This article expresses its author's opinion about *culling* animals in zoos, which is reducing a population by selective slaughter. The argument supports the idea of culling as a way to control inbreeding and to control the breeding of animals that will not help the species stay adaptable and immune to diseases.
What the New Superbug Means for the US:	This informational text resource is intended to support reading in the content area. The text describes how colistin-resistant bacteria have reached the United States, which is cause for great concern. There are currently some strains of bacteria that are resistant to all types of antibiotics. Scientists will have to develop new antibiotics if we are to continue our mostly successful fight against bacterial disease.
What We Learned about Human Origins in 2013:	This informational text is intended to support reading in the content area. The article summarizes the gains in the understanding of hominid evolution to include comparative archaeology and biology, DNA and tool analysis.
Why Did Penguins Stop Flying? The Answer Is Evolutionary:	This informational text is intended to support reading in the content area. This news article describes evidence from a recent study of seabirds that may help explain why penguins lost the ability to fly.

Lesson Plan

Name	Description
A Strange Fish Indeed-The Discovery of a Living Fossil:	Through a series of fictionalized diary entries, this case recounts the 1939 discovery by Marjorie Courtenay-Latimer (and identification by J.L.B. Smith) of a living coelacanth, a fish believed to be extinct for over 70 million years. Developed for use in a freshman biology course as an introduction to the nature and methods of scientific inquiry, the case could also be modified for use in a number of upper-level biology courses such as ichthyology, evolutionary biology, and conservation ecology.
Ancient DNA Gives Clues to Dog Evolution:	In this lesson, students will analyze an **informational text** that addresses the genetic analysis of a 4,800-year-old dog found in a tomb in Ireland and how this information gives rise to a new hypothesis that dogs may have been domesticated at least twice, once in East Asia and also in Europe. This lesson is designed to support reading in the content area. The lesson plan includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric.
Asthma Island :	In this activity, students simulate the founder effect on Tristan Da Cunha island. The island is located in the Southern Atlantic Ocean between South America and the southern part of Africa. It is the most isolated island on earth. The island's population is is 268 people and there are now 80 families that live in the island. Students will explore genetic drift (bottleneck and founder effect) and the importance of genetic variation in a population.
Becoming Whales:	Students will experience the historical discovery of fossils that increasingly link whales to earlier land-dwelling mammals. This experience reveals how scientists can make predictions about past events, based on the theory and evidence that whales evolved. This lesson also provides confirmation, with multiple independent lines of evidence, that there is a series of intermediate forms, showing gradual accumulation of changes, linking certain terrestrial mammal groups with modern whales.
Bioluminescent Millipedes Spark Bright Ideas!:	In this lesson, students will analyze an informational text by scientist Paul Marek, who re-charted the millipede *Motyxia Bistipida's* evolutionary tree based on new information about its bioluminescence. This informational text resource is intended to support reading in the content area. The lesson plan includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric. Numerous options to extend the lesson are also included.
Bird Brains - Evolutionary Relationships:	Students will compare the sequence of amino acids in a gene shared between humans and six other organisms and infer evolutionary relationships among the species.
Classification of Domains and Kingdoms:	This lesson is organized around the big idea Classification, Heredity, and Evolution for a high-school biology course. The design of the lesson is general, however, the 5E model can be easily incorporated. The lesson teaches students how to distinguish characteristics of living organisms belonging to the domains of Archaea, Bacteria, and Eukarya and the kingdoms of Protista, Fungi, Plantae, and Animalia.
ComBATing Extinction:	In this lesson, students will analyze an **informational text** intended to support reading in the content area. The article explains how Caribbean bat species are uniquely suited for studying the consequences of extinction. By reading this article, students will get a better understanding of geographic isolation and speciation, which are major themes when discussing the theory of evolution. In addition, students will gain an understanding of the devastating effects human impact can have on populations of species.

Cutting the Deck:	The lesson provides basic resources and tools to reinforce the mechanisms of speciation with emphasis on geographic isolation by using a common deck of playing cards to model events that could lead to speciation.
Discovering New Kiwis:	In this lesson plan, students will analyze an informational text resource intended to support reading in the content area. The article discusses research that proves there are more species and subspecies of kiwi birds than originally thought in New Zealand. The article discusses how scientists believe glaciers isolated kiwi populations. As a result, new genetic lineages were discovered by analyzing the kiwi genome.
Domains and Kingdoms:	This is a two day (45 min class period) lesson plan designed for high school classes. This lesson plan includes a video hook, a card sort of domains and kingdoms, a web map template (and answer key), a simile homework assignment, and a summative assessment in the form of a brace map (template and answer key provided). The objectives of the lesson plan is that students are able to list characteristics of organisms found in the domains/kingdoms, classify an organism into a domain or kingdom, and predict which form evolved first.
Evolution by Natural Selection:	Principles of natural selection are demonstrated by a simulation involving different color pompoms on different color and texture habitats and student feeders equipped with different types of feeding implement. Students learn how different adaptations contribute to differences in survival and reproductive success, which results in changing frequencies of genotypes in the populations.
Evolution of a Bead Population:	Students practice modeling the processes of genetic drift, gene flow, the founder effect and natural selection using a population of colored pony beads.
Fossil Evidence of Evolution on Earth:	This lesson will be used to teach about fossil evidence found in layers on the Earth and how it shows how life has evolved.
Hominid Cranium Comparison (The Skulls Lab):	Students describe, measure and compare cranial casts from contemporary apes (chimpanzees and gorillas, typically), modern humans and fossil "hominins" (erect and bipedal forms evolutionarily separated from apes). ("Hominid" is the new collective term for African apes and humans.) The purpose of the activity is for students to discover some of the similarities and differences that exist between these forms, and to see the pattern of the gradual accumulation of traits over time, leading to modern humans.
How to Make a Monkey Glow in the Dark:	This lesson focuses on mutations and genetic recombination and how they increases the diversity of a population. The concept is presented as a PowerPoint, computer activity, and literacy article. Glow in the dark monkeys, spider goats, and modern biotechnology are used as attention grabbers.
Humans vs. the Superbug:	In this lesson, students will analyze an informational text intended to support reading in the content area. The article addresses how the United States is addressing the discovery of *E.coli* that is resistant to colistin, an antibiotic used only as a last resort. The text describes steps to take now that this superbug has reached our country. Scientists from the Vanderbilt University School of Medicine explain why it is so easy for bacteria to share their "knowledge" about antibiotic resistance and discuss how concerned the U.S. citizens should be, as well as what we can do to slow the spread of superbugs.
Identifying Misconceptions on Natural Selection:	In this lesson, students will take a short inventory on Natural Selection where they will be asked to read short passages and answer questions based on the Theory of Natural Selection. By comparing answers the students gave, the teacher will be able to identify common misconceptions they have on the Theory of Evolution.
Introduction to Darwin and evolution:	This activity will introduce Darwin and his travels. A world map is used along with excerpts from his book to plot his voyage and discoveries.
Introduction to Natural Selection:	To develop an understanding of natural selection, specifically, how it unfolds from generation to generation.
Is Natural Selection Random?:	Students will use the real-world example of Hurricane Opal wiping out the beach mouse population from Shell Island in 1995. Students will identify the environmental pressures that led to the differentiation of the Choctawhatchee beach mouse from the mainland population (St. Andrew beach mouse) as natural selection. They will examine the beach mouse population on this island immediately following the hurricane as an example of genetic drift, and the re-population of the island as gene flow. Students will then track changes in the population from the initial re-population following the hurricane to the current population and relate this to natural selection.
Island Biogeography:	Students will study the concept of speciation and predict an island habitat"s biodiversity based on the island's size and distance from the mainland.
Killer Microbe:	A lesson about the important topic of antibiotic-resistant bacteria with student activities and A/V resources.
Link to Evolution:	In this lesson, students will analyze an informational text that presents the major discovery of a nearly-intact cranial fossil of an ancient mammal from the Southern Hemisphere. The article discusses the significance of the discovery of this previously unknown mammal, a mammal scientists have named *Vintana sertichi*. This lesson plan is designed to support reading in the content area. The lesson plan includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric.
Meet the Family: Investigating Primate Relationships:	In this lesson students will see the different types of evidence scientists use to understand evolutionary relationships among organisms. They will first practice by using shared physical characteristics to predict relationships among members of the cat family and then use this approach to predict primate relationships. They will compare their predictions to evidence provided by analyzing amino acid sequences and build a phylogenetic tree based on these sequences. Finally, they will look at the tree in the context of time in order to see divergence times.
MERMAID TAXONOMY:	This MEA is designed to educate students about the use of classification systems and the general characteristics of vertebrates.
MIT BLOSSOMS - Classifying Animals by Appearance vs DNA Sequence:	In this Blended Learning lesson, students will learn how to make phylogenetic trees based on both physical characteristics and on DNA sequence. The lesson model includes a video of a scientist who co-facilitates the lesson with the teacher, a teacher's guide, the handouts students will need, and a transcript. The Blended Learning model combines online learning with classroom instruction, where world-class experts, such as scientists and mathematicians from around the world use video to help teachers deliver lessons, while ensuring the students and teacher actively engage in the lesson through activities and discussion.

Name That Embryo:	This lesson introduces the concept of comparative embryology. Students will work in groups to observe similarities and differences in embryos from different organisms, and will make inferences to an evolutionary relationship between them.
Natural Selection on Beach Mice:	In this lesson, students simulate the process of natural selection and its effects on prey phenotype frequencies over multiple generations. Students are provided with four background patterns and many prey pieces in four corresponding patterns. In this way, each prey type is well-camouflaged for one corresponding background, but is less suited to the others in varying degrees. Following several rounds of natural selection simulation, students compare prey phenotype frequencies to those frequencies found using random selection.
Nemo's Distant Relatives:	This lesson introduces the concept of speciation through geographic isolation. It uses pictures, small groups, and a short reading article to reinforce the concepts with multiple learning styles.
Of Mice and Mutations: Natural Selection in Action:	This informational text resource is intended to support reading in the content area. In this lesson, students will analyze a text that addresses the issue of evolution by natural selection and mutation, using Florida "beach mice" as a case study. The lesson plan includes text-dependent questions, a writing prompt, answer keys, and a writing rubric. Ideas for extending the lesson are also included.
Origins of Life:	Students will develop a scientific explanation for the origin of life on Earth and present the information that they find to the class through song, rap, story-telling, play-acting, or another creative method approved by the instructor.
Pollution Evolution - A Solution?:	In this lesson, students will analyze an informational text intended to support reading in the content area. The article in this lesson describes how a species of fish has adapted to lethal levels of toxic pollutants due to their high level of genetic variation, which allows them to evolve quickly. Scientists hope to use studies of these fish to understand human reactions to environmental chemicals. This lesson includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric.
Searching for the Recipe: Polypeptides & the Origins of Life:	In this lesson, students will analyze an informational text that addresses a new method of producing polypeptides from only amino and hydroxy acids, with no biological catalysts necessary. Researchers at Georgia Tech have been able to produce polypeptides by subjecting amino and hydroxy acids through a wet and dry cycle. This allows for prebiotic molecules to be formed on land, without large amounts of water or extreme boiling temperatures. This method also allows for the breakdown and reassembly of organic materials to form random sequences that could lead to the variation needed for life. This lesson plan is intended to support reading in the content area; it includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric.
Selection Dance Party:	In this lesson, students will learn how sexual selection leads to the evolution of species by exploring how courtship rituals lead to the selection of traits in a population.
Selection, Naturally: A 5E Approach to Evolution by Natural Selection:	No need to search multiple lesson plans! The 5E (Engage, Explore, Explain, Elaborate, Evaluate) is a way to cover natural selection in a format that addresses misconceptions and allow learners to gather information through critical thinking over a series of activities.
Shelly Sells Dichotomous Keys by the Seashore:	Students will be create a dichotomous key to identify and group shells.
Simulating Natural Selection via Paperus discus:	This is a low cost, simple to setup lab that simulates factors involved in natural selection. Students become "predators" that, along with the background environment, put selective pressure on a population of prey (discs). Students will make predictions, manipulate materials, collect data, analyze that data, and write a conclusion. This lab is easily modified to accommodate lower grade levels or expanded for higher level courses.
T Rex Blood?:	A PBS Nova Podcast/Video with accompanying activities that introduce and explore paleontology and the geologic timescale through analysis of fossil bones.
The Evolutionary Processes of Population Change:	This is a lesson plan designed to explain three evolutionary processes: natural selection, genetic drift, and gene flow. The lesson plan consists of a brief review about mutations and DNA, a PowerPoint discussion about the three evolutionary processes, and a hands-on activity. The activity is designed to help the students understand how populations change over time due to different traits in individuals in a population, as well as how to identify the different evolutionary processes in a population.
The Times They Are A Changin':	Students will combine their knowledge of the effects of climate change on ecosystems with trends in hominid evolution to predict future changes in hominid evolution.
This Dinosaur Can't Sing:	In this lesson, students will analyze an **informational text** intended to support reading in the content area. The article presents new research that suggests dinosaurs were not able to vocalize or "sing" in a way similar to modern birds. The lesson plan includes a note-taking guide, text-dependent questions, a writing prompt, answer keys, and a writing rubric. Numerous options to extend the lesson are also included.
Walk This Way:	This lesson explores the topic of hominid evolution using pictures of fossils, short guided notes with a PowerPoint Presentation, an engaging video, website exploration, and a graphing exercise. While this topic can be difficult to teach, this lesson presents the topic in a straight-forward, non-controversial manner, focusing on conclusions scientists have made based on fossil evidence.
What is that Vertebrate?:	In this group-centered activity, students will be actively engaged in learning the characteristics that define the classes of vertebrates. Activities include a card sort, developing criteria for vertebrate classes, student teaching, and classifying a mystery animal.
	Richard Dawkins, an English ethologist, evolutionary biologist, and writer of the 21st century, has said, "You can't even begin to understand biology, you can't understand life, unless you understand what it's all there for, how it arose - and that means evolution." his quote emphasizes the importance of the comprehension of the theory of evolution in the discipline of biology. Living beings may seem diverse, but under the eyes of evolution, every living being comes from a common ancestor. Therefore, all species in the planet Earth are related. Thanks to the discovery of DNA and

What is the Evidence for Evolution? Finding Scientific Proof:	the technological advances being made in molecular genetics, we know that all organisms share the same four nitrogen bases which codifies within the same 20 amino acids: the difference is just the sequence. The evolutionary theory explains relationships between organisms by common ancestry. With all this knowledge, it's imperative to understand the foundation and what supports this theory. This lesson contains three learning activities to achieve the learning objective. The first activity is a bell work that consist of three questions to assess prior knowledge of the students in diversity and evolution. The second activity is a collaborative research for each category that supports evolution. The last activity is the completion of notes taken by each student to ensure understanding and comprehension for every piece of evidence.
Who Are My Relatives?:	This lesson will help students develop a cladogram to demonstrate the evolutionary relationships of diverse organisms.

Problem-Solving Task

Name	Description
Aggresion in Dogs: Evolution of a Species:	Scientists know all dogs descended from the gray wolf, but they don't know exactly how that happened. In this activity, students will engage in a card game simulation to learn how selective pressures can affect an organism's evolution.
Anolis Lizards of the Greater Antilles: Using phylogeny to test hypotheses :	Students "take a trip" to the Greater Antilles to figure out how the Anolis lizards on the islands might have evolved. They begin by observing the body structures and habitat of different species, then plot this data on a map of the islands to look for patterns in their distribution. From the patterns they observe, students develop alternative hypotheses about how these lizards colonized the islands and evolved. To test their hypotheses, they are given a phylogeny which they color code according to their previous data. By combining both types of data, students make a final hypothesis about how they think the lizards colonized the islands.

Teaching Idea

Name	Description
Animals in the News-SeaWorld Classroom Activity:	In this activity the student will identify various animals' biographical information and research various animals using the Internet and literature.
Butterfly Sort:	This is a teaching idea where students develop a classification scheme for butterflies and moths based on observable traits. Through the development and discussion of classification schemes, students begin to make inferences about evolutionary relationships. This activity was used in the BIOSCOPES Diversity and Ecology Institute.
Butterfly Sort: Classification Methods:	In this lesson, students will explore ways to classify organisms based on physical similarities by devising a system to classify moths and butterflies using characteristics shown on black and white pictures. In doing so, they will construct a tree using various traits that vary among the different butterfly species. They will then defend their organizational scheme based on observed traits.
Climbing The Tree of Life: Cladograms:	This is an activity where students create cladograms given a beginning point (species) and end point (species) using the Tree of Life website.
Primate Scavenger Hunt-SeaWorld Classroom Activity:	Students will conduct an investigation into conservation issues that concern modern day primates and will research various primates.
Simulating Evolutionary Processes with Poker Chips:	In this lesson, students use colored discs to simulate changes in population allele frequencies that occur due to evolutionary processes. They first show that allele frequencies do not change when only random mating occurs in a population. Then they demonstrate the effects of natural selection, genetic drift, gene flow, and mutation on population allele frequencies.
Tree of Life: A Web-Based Exploration:	In this lesson, students explore the diversity and relationships among life on Earth. Using the Tree of Life website (TOLweb.org), students will move up and down the Tree of Life, exploring many different branches as the search the tree for specific organisms and create their own trees that show evolutionary relationships among seemly unrelated species.

Tutorial

Name	Description
Bacteria:	This video from the Khan Academy introduces the symbiotic relationship between the many bacteria that live inside the human body. The basics of bacteria structure, reproduction, and bacterial infections are discussed.
Cytoplasmic Streaming in Cells:	This animation discusses how different organisms use cytoplasmic streaming. It further discusses the mechanism of cytoplasmic streaming in *Nitella*, a green alga.
Endosymbiosis:	The theory of endosymbiosis suggests that mitochondria and chloroplasts were once free-living, small prokaryotes that were taken up by larger prokaryotes. It also describes how a large host cell and ingested bacteria could easily become dependent on one another for survival, resulting in a permanent relationship. This tutorial will help the learners to understand the process of endosymbiosis.
Founder Effect:	In population genetics, the founder effect is the loss of genetic variation that occurs when a new population is established by a very small number of individuals from a larger population. This tutorial will help the learners understand this phenomenon via this interactive tutorial.
Hardy-Weinberg Principle:	This Khan Academy video discusses the conditions required for Hardy-Weinberg equilibrium and explains how to solve Hardy-Weinberg problems.
Molecular Clock:	Molecular clocks are models that use mutation rates to measure evolutionary time. Mutations tend to accumulate at a constant rate for related species. The rate of mutations is the ticking that powers a molecular clock. This tutorial will help the learners understand this concept in order to recognize how species diverge from a common ancestors.

Natural Selection:	Natural selection is a process through which a population can evolve for a specific environment. This tutorial will help the learner to understand how variation, heritability, adaptation, and selective pressure work together for natural selection to occur within a population.
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Variation in a Species:	This Khan Academy video explains how variation can be introduced into a species and the importance of sexual reproduction in this process.
Viruses:	This introduction to viruses by the Khan Academy addresses the question: Are viruses alive? How viruses enter cells and replicate is discussed in detail.
What Causes Antibiotic Resistance?:	This short video describes the process of antibiotic resistance. Right now, you are inhabited by trillions of micro organisms. Many of these bacteria are harmless (or even helpful!), but there are a few strains of 'super bacteria' that are pretty nasty -- and they're growing resistant to our antibiotics. Why is this happening? Kevin Wu details the evolution of this problem that presents a big challenge for the future of medicine.

Original Student Tutorial

Name	Description
Beyond Natural Selection: Mechanisms of Evolution :	Explore mechanisms of evolutionary change other than natural selection such as mutation, gene flow, and genetic drift in this interactive tutorial.
Classification of Living Organisms:	Explore the characteristics of domains and kingdoms used to classify living organisms with this interactive tutorial. You also will learn more about the reasons behind how and why this classification is done.
Classification using DNA:	Learn how to explain differences in genetic and non-genetic classification methods. You should also know why genetic evidence is very powerful for understanding evolutionary relationships among organisms.
Climbing Around the Hominin Family Tree:	Learn to identify basic trends in the evolutionary history of humans, including walking upright, brain size, jaw size, and tool use in "Climbing Around the Hominin Family Tree" online tutorial.
Conditions for Natural Selection:	Explore three conditions required for natural selection and see how these conditions lead to allele frequency shifts in a population.
Diagramming Diversity 1:	Learn how living organisms are classified according to their characteristics, which reflects their evolutionary history and relationships, as you complete this interactive tutorial.
Diagramming Diversity II:	Learn to explain how a phylogenetic tree, or cladogram, is used to classify living organisms based on inherited similarities, and how it relates to other methods of hierarchical classification.
Earliest Beginnings :	Learn how to identify and describe the leading scientific explanations of the origin of life on Earth.
Evolution: Examining the Evidence:	Learn how to identify explicit evidence and understand implicit meaning in a text. You should be able to explain how different types of scientific evidence support the theory of evolution, including direct observation, fossils, DNA, biogeography, and comparative anatomy and embryology.
Natural Selection:	Describe the conditions required for natural selection and tell how it can result in changes in species over time. In this interactive tutorial, follow Charles Darwin through a life of exploration, observation, and experimentation to see how he developed his ideas.
Plants Evolve:	Learn about how plants evolved in this interactive online tutorial.
Structure and Function of Fungi: Asexual and Sexual Reproduction (2 of 3):	Learn about asexual and sexual reproduction of fungi in this interactive tutorial. This is Part 2 of 3 in this series on the Structure and Function of Fungi. Click HERE to open Part 1, Basic Characteristics and Structures Click HERE to open Part 3, Nutrition and Mutualistic Relationships
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Perspectives Video: Teaching Idea

Name	Description

Debating Comparative Embryology as Evidence of Evolution:	Let this teacher tell you a tail tale about a comparative embryology idea.
Modeling Bird Beaks for Natural Selection:	Pick up a new idea about how to teach concepts related to natural selection in this video!
Teaching about Hierarchy with the Encyclopedia of Life:	Dr. Jeff Holmes from the Harvard University Museum of Comparative Zoology discusses the *Encyclopedia of Life* as a teaching resource for concepts regarding hierarchical relationships of organisms. This video was created in collaboration with the Okaloosa County SCIENCE Partnership including the Smithsonian Institution and Harvard University.

Project

Name	Description
Dichotomous Keys and Cladograms Performance Task:	Students will work in groups to select 5-10 organisms, create a dichotomous key that could identify them, and a cladogram to show their evolutionary relationships.

Lesson Study Resource Kit

Name	Description
Diversity and Evolution: An NGSSS-based biology toolkit for grades 9-12:	This toolkit supports the development of an instructional unit on diversity and evolution and aligns with Next Generation Sunshine State Standards for science as well as Florida standards for English language arts and mathematics for students in grades 9-12. The elements of this toolkit were assembled based upon their suitability for constructing a multi-day instructional unit on hominid evolution that corresponds with the 5E Learning Cycle of engage, explore, explain, elaborate, and evaluate. Your task as a lesson study team is to analyze the materials that are included in this toolkit and evaluate how they can be incorporated in a 5-E instructional unit plan that complies with the Next Generation Sunshine State Standards and Florida standards for English language arts and mathematics. As you study these resources it is important to make note of any deficiencies or gaps that will need to be addressed and make modifications in the lesson resources and activities where needed.
Exploring Diversity and Evolution: A Lesson Study Resource Kit for grades 9-12:	This lesson study resource kit is designed to support lesson study teams in developing a unit of instruction for students in grades 9-12 on the topic of diversity and evolution.

Educational Game

Name	Description
EvoDots - Software for Evolutionary Analysis:	The software application, which allows the students to simulate natural selection in a population of dots, goes along with a tutorial which is also at this site.

Assessment

Name	Description
Evolution Performance Task:	This resource will help students to understand the difference between a Venn diagram and a cladogram. After viewing this students are intended to create and analyze their own cladograms..
Summative Assessment Evolution:	This performance task will demonstrate students' understanding of natural selection at the end of a unit on the theory of evolution.

Video/Audio/Animation

Name	Description
Evolution's Continuing Creativity:	In this National Science Foundation video and reading selection, researchers describe the relationship between diverging color patterns in Heliconius butterflies and the long-term divergence of populations into new and distinct species.
Hardy-Weinberg Principle:	This video describes the Hardy-Weinberg Principle. It is fairly entertaining mostly due to the narration of the instructor.
Marine fossils in the Arctic landscape:	In this video, research is presented describing scientific studies of marine fossils found in Arctic regions.
Mechanisms of Evolution:	This TED Ed video explains the mechanisms of evolutionary change: change in population size, sexual selection, mutation, gene flow, and natural selection.
Pocket Mouse Evolution:	This simulation shows the spread of a favorable mutation through a population of pocket mice. Even a small selective advantage can lead to a rapid evolution of the population.
Variation in a Species:	The video describes how variation can be introduced into a species.
Variation Is Essential: How Does Variation Within a Population Affect the Survival of a Species?:	This is a lesson about phenotypical variation within populations and how these differences are essential for biological evolution. Students will use a model organism (in this case, kidney beans) to explore variation patterns and subsequently connect these differences to artificial & natural selection. The NGSS' CrossCutting Concepts and Science & Engineering Practices are embedded throughout the lesson. The main learning objectives are: • Using a model (kidney beans) to explore the natural variations within a population. • Measuring differences between individuals in a population (population of beans). • Describing how genetic/phenotypic variation is a key part of biological evolution because it is a prerequisite for natural selection. • Demonstrating in which ways genetic variation is advantageous to a population because it enables some individuals to adapt to the environment while maintaining the survival of the population.

	The NGSS Performance Expectations covered are HS-LS4-2. & HS-LS4-4.
Zebrafish Heart Regeneration:	This video presentation will help to understand the regeneration process in a zebrafish. When the zebrafish heart is damaged, the wound site is rapidly sealed with a fibrin clot that stems bleeding within seconds. Following clot formation, the tissue that surrounds the heart muscle, *the epicardium*, gradually covers the fibrin clot via migration and cell division. Over the next few months, new cardiac muscle is produced and replaces the clot.

Perspectives Video: Expert

Name	Description
Explaining Evolution through the Fossil Record:	Dr. Gregory Erickson explains the fossil record and how it supports the scientific theory of evolution.
Methods of Evolution in Animal Populations Big and Small:	Interested in how evolution happens? Drift into this video and go with the flow.
Mutations and Genetic Diversity:	Mutations don't just happen to comic book heroes and villains. Learn more about this natural biological phenomenon!
Physical Environment and Natural Selection:	This video is a natural selection for learning about evolution.
Tweeting - From Birds to Humans:	Frank Johnson discusses tweeting.
Using Mathematics to Optimize Wing Design:	Nick Moore discusses his research behind optimizing wing design using inspiration from animals and how they swim and fly.

Virtual Manipulative

Name	Description
Mechanisms of Evolution:	Evolution is the process by which modern organisms have descended from ancient ancestors. There are five processes that can lead to evolution within a population. These are Genetic drift, Gene flow, Mutation, Natural selection and Sexual selection. This tutorial will help the learners understand and visualize the way by which these processes affect evolution.
Mesquite - Phylogenetic Trees:	Students use software to create evolutionary trees by comparing and contrasting physical traits. This activity demonstrates the complexity of creating evolutionary trees when multiple traits are being analyzed. The use of the software simplifies the analysis without compromising the learning objectives.
Natural Selection:	Students will explore natural selection by controlling the environment and causing mutations in bunnies. This will demonstrate how natural selection works in nature. They will have the opportunity to throw in different variables to see what will make their species of rabbit survive.

Unit/Lesson Sequence

Name	Description
Modeling for Understanding Natural Selection:	This series of lessons introduces students to evolutionary reasoning and to the explanatory power of the Darwinian model of natural selection. Students read three evolutionary scientists' (Paley, Lamarck and Darwin) original work and compare their thinking, proposed mechanism of evolution, use of evidence, and explanatory power of their theory. They apply the three scientists thinking to another scenario to refine their understanding of the explanations.

Worksheet

Name	Description
The Biology Corner:	This resource for biology teachers includes a lesson plan section which contains classroom activities, labs and worksheets. The activity sheets are categorized by Science and Literacy, Anatomy, Scientific Method, Cells, Phyla, Evolution and Taxonomy, Genetics, Ecology, and Plants.

Educational Software / Tool

Name	Description
What Is It Like Where You Live?:	This site offers an abundance of information on Earth's biomes (rainforest, tundra, taiga, desert, temperate, and grasslands), as well as marine and freshwater ecosystems. The site features relevant facts, pictures, maps, indigenous plants and animals, additional links, and much more. This resource is a wonderful reference, not a lesson plan. Teachers will need to provide an objective and structure for student interaction with the website.

WebQuest

Name	Description
What is the Evidence for Evolution?:	This lesson on evolution consists of two activities. In the first, students will take on the role of a paleontologist who is investigating a particular period of time in Earth's history using the **Web Geological Time Machine** at the University of California, Berkeley Museum of Paleontology Web site to make a detailed journal entry with illustrations. In the second activity, Evolution WebQuest, students investigate a variety of types of evidence for evolution from different areas of science. Students divide into groups of six and each member of the group becomes a specialist in anatomy and physiology, paleontology or molecular biology. The anatomists study the structure, physiologists study function, molecular biologists study genetics, and the paleontologists study fossils to find examples of evidence for evolution.

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Meet the Family: Investigating Primate Relationships:	In this lesson students will see the different types of evidence scientists use to understand evolutionary relationships among organisms. They will first practice by using shared physical characteristics to predict relationships among members of the cat family and then use this approach to predict primate relationships. They will compare their predictions to evidence provided by analyzing amino acid sequences and build a phylogenetic tree based on these sequences. Finally, they will look at the tree in the context of time in order to see divergence times.
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