LESSON PLAN
Ever-Evolving Evolution

Context
Evolution is the process by which life progresses from one form into another. The basic idea of biological evolution is that the Earth's present-day species are descended from earlier, distinctly different species. Life on Earth is thought to have begun about four billion years ago as simple one-celled organisms, which over a billion years became increasingly complex multi-cellular organisms. Examining DNA sequences can help determine how closely organisms or species are related. This sequence often closely matches their classification based on anatomical similarities.

Essential Questions
- What information can be learned from patterns in fossil records?
- What evolutionary relationships exist among organisms and fossil organisms?
- What does the evidence supporting changes in environmental conditions result in?

Enduring Understandings
- Evolution is the process by which life progresses from one form into another.
- Life on Earth is thought to have begun about four billion years ago as simple one-celled organisms, which over a billion years became increasingly complex multi-cellular organisms.
- Examining DNA sequences can help determine how closely organisms or species are related.

Time
These activities can be completed in 1–2 class periods of approximately 50 minutes.

Grade Level
Grades 6–12. Activities can easily be adapted to fit grade and ability levels.

Differentiation
These inquiry activities can be completed as a class guided by the teacher, in groups, pairs, or individually based on students’ abilities.

Materials
- Rosen Digital's Core Concepts: Biology database
- Computers
- Smart Board, iPad, or other computer projection presentation device (optional if Teacher/Librarian wants to demonstrate worksheets and/or have one group worksheet)
- Appropriate Assistive Technology for students with special needs (if applicable)
- Supplement 1 - Stone Age Diagrams
- Supplement 2 - Half of a Half-Life Worksheet
- Supplement 3 - Common Ancestor Pair Note Sheet
- Ring stand
- Rings
- Funnels
Lesson Plan (Cont.)

Ever-Evolving Evolution

- 100 mL graduated cylinders
- Ice cubes
- Research materials (access to books and the Internet)
- Supplies to make a display (poster board, markers, paper, glue, scissors) or access to computers to make posters using online resources
- Paper/pencils

Student Learning Objectives

- Students will be able to examine the history of life on Earth by analyzing and interpreting data from patterns in fossil records.
- Students will be able to infer evolutionary relationships by examining anatomical similarities and differences among organisms and fossil organisms.
- Students will be able to research to find evidence that changes in environmental conditions result from increases in the number of individuals of some species, the emergence of new species over time, and the extinction of other species.

Next Generation Science Standards Addressed

| MS-LS4-1. | Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.] |
| MS-LS4-2. | Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.] |
| MS-LS4-3. | Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.] |
| **MS-LS4-4.** | Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.] |
| **MS-LS4-6.** | Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.] |
| **HS-LS4-1.** | Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.] |
| **HS-LS4-2.** | 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. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.] |
| **HS-LS4-3.** | 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. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.] |
| **HS-LS4-4.** | Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] |
HS-LS4-5. 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. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

**NGSS Science and Engineering Practices Addressed**
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Develop and use a model to describe phenomena
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**NGSS Crosscutting Concepts Addressed**
- Patterns. Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data. 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.
- Cause and effect. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

**Common Core ELA Standards**

**CCSS.ELA-Literacy.RST.6-8.1, 9-10.1, 11-12.1**  
Cite specific textual evidence to support analysis of science and technical texts.

**CCSS.ELA-Literacy.RST.6-8.2, 9-10.2, 11-12.2**  
Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

**CCSS.ELA-Literacy.RST.6-8.4, 9-10.4, 11.12.4**  
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8, grades 9-10, or grades 11-12 texts and topics.

**CCSS.ELA-Literacy.RST.6-8.7, 9-10.7, 11-12.7**  
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
Activity 1: Stone Age

Introduction
Fossils are the remains or traces of long-dead organisms preserved in rock. They have been collected and puzzled over for hundreds of years. By the early 1800s biologists had begun to realize that many fossilized creatures no longer existed on Earth. They also noticed that some fossils were similar to, but not the same as, living creatures. This evidence suggested that they were distant ancestors of living animals. Geologists realized that the rocks in which fossils were found were sometimes millions of years old.

Signs in the rocks also tell scientists what the environment was like—for example, whether it was hot or cold, wet or dry. So, they can see from the fossils how living organisms have changed over time in response to major changes in the environment. Sedimentary rocks such as limestone are formed by layers of sediment called strata. Geologists showed that younger strata always lay above older strata, except when they have been buckled and folded later. This discovery allowed biologists to follow changes in fossil groups over time.

Materials
- Supplement 1 - Stone Age Diagrams

Teacher Tip!
Introduce students to this activity by showing them the trilobite fossil video or paleontologist video in the Beginnings of Life on Earth and Evolution Defined articles respectively.

Procedure
Project Supplement 1 (Stone Age Diagrams) on a whiteboard or overhead projector. As a group study the diagrams reviewing each layer. Students should discuss together how to determine the relative age of each of the rock units in the block diagram.

Teacher Tip!
For images of fossils, visit the Beginnings of Life on Earth and Evolution Defined articles.

Activity 2: Half of a Half-Life

Introduction
Students will develop the idea that carbon dating is based on gathering evidence in the present and extrapolating it to the past. Students will use a simple graph to extrapolate data to its starting point.

Chemical elements can have several isotopes. Isotopes contain the same number of protons as all other atoms of that element, but a different number of neutrons. This means different isotopes each have a different half-life. A half-life is the amount of time required for half of the radioactive atoms in a sample to decay to another form.

In carbon dating, scientists look at the amount of an isotope, such as carbon-14, present in an organism to determine how long ago it died. Carbon-14’s half-life is 5,730 years, so if a fossil is older than 5,730 years, half of it’s carbon-14 atoms will have decayed.
In this activity, students will work backwards to solve a puzzle, much like scientists work backwards to find the time that an organism died.

**Materials (for each group)**
- Supplement 2 - Half of a Half-Life Worksheet
- Ring stand
- Ring clamp
- Funnel
- 100 mL graduated cylinder
- Ice

**Procedure**
1. Set-up ring stands, rings, cylinders, and funnels. Fill the funnels with ice about ten minutes before the students arrive in the classroom. Put about four ice cubes in each set-up. Divide the class into six groups. Explain to students that by measuring how much carbon is left in a sample as well as its radioactivity, we can calculate when the organism died. It's a way of working backwards to solve a puzzle.

2. Using Supplement 2 (Half of a Half-Life Worksheet), immediately record the volume of the melted ice remains (water) in your graduated cylinder and note the time on the clock. Make a data table and, at regular intervals (you decide how long), record the time on the clock and the volume of water in the graduated cylinder.

3. During the intervals explain how carbon dating works.

4. Stop after about thirty minutes, unless the ice has completely melted earlier. Have students answer the questions from the worksheet based on their graphs and the data they collected.

**Activity 3: Distant Relatives**

**Introduction**
Evolution is also supported by studies of DNA that shed light on the common ancestry of different organisms. In different parts of the world there are animals that are similar to each other but are not identical. For example, jaguars live in South America, lions in Africa, and tigers in Asia. All are big cats, but each has a different coat and forms a separate species. Evolving from a common ancestor, each big cat adapted to its environment over millions of years. A similar pattern is found in many other creatures.

Explain that the class will work together in small groups to investigate how organisms with common ancestors adapt and evolve.

**Materials**
- Supplement 3 - Common Ancestor Pair Note Sheet
- Research materials (access to books and the Internet)
- Supplies to make a display (poster board, markers, paper, glue, scissors) or access to computers to make posters using online resources
- Pencils/paper

**Procedure**
1. Divide class into six to eight groups and give each group a Common Ancestor Pair. Suggested pairs: sea gull and...
pelican, horse and zebra, deer and moose, bat and squirrels, elephant and hyrax, dolphin and wolf, bear and raccoon, human and tunicate.

2. Have students groups investigate the Common Ancestor Pair to find out how they are related. They should specifically identify the lineage of each animal, how the organisms adapted and evolved, classification, and anatomical similarities.

3. Each group should explain how the adaptation benefits the species and include photographs and the evolutionary tree of the species.

Teacher Tip!
Distribute Supplement 3 (Common Ancestor Pair Note Sheet) to each group or student to help with research, citing sources, and organizing information.

Teacher Tip!
Students can also create multimedia slideshows or presentations using online resources such as Animoto, Glogster, or Prezi.

4. After groups have completed their research, they should create a poster or visual to display their findings and share with the class.

Assessment Evidence

Ongoing Assessment
- Supplement 1 - Stone Age Diagrams guided discussion
- Half of a Half-Life lab (Activity 2)

Summative Assessment
- Supplement 2 - Half of a Half-Life Worksheet Analysis
- Common Ancestor Pair posters or presentations (Activity 3)