6-12 Fossil Gap Activity

South Carolina Aquarium

Overview

Focus Questions
What is a fossil? What are the different types of fossils? How do fossil records document the existence, diversity, extinction and change of life forms throughout history?

Activity Synopsis
Students will start by learning about the different types of fossils. They will organize a collection of fictitious animal "fossils" based on their approximate age and appearance into a geologic time scale then draw in what a missing "fossil" organism might look like within the fossil timeline. With this they will discover changes over time.

Objectives
The learner will be able to:

- Determine between fossil types
- Create a geologic timeline from fossil pictures
- Analyze and fill in gaps in the fossil record
- Identify changes over time within the fossil record

Time Frame
90 minutes

Student Key Terms
- fossil
- petrified fossils
- molds (fossils)
- casts (fossils)
- preserved remains (fossils)
- carbon film fossils
- trace fossils
- paleontology
- relative age
- absolute scale
- geologic time scale
- eon
- era
- period
- epoch
- index fossils

Teacher Key Terms
- evolution
- macroevolution
- microevolution
- phylogenetic tree

Standards

South Carolina College- and Career-Ready Science Standards 2021

6th Grade: 6-ESS1-4, 6-ESS2-1, 6-ESS2-2, 6-ESS2-3

7th Grade: 7-LS2-2, **7-LS2-4**
8th Grade: 8-LS1-5, **8-LS4-1**, 8-LS4-2, **8-LS4-4**, 8-LS4-6
Biology: B-LS4-1, **B-LS4-2**, B-LS4-3, B-LS4-4, B-LS4-5
Earth and Space Science: E-ESS2-7

***Bold standards are the main standards addressed in this activity**

Sixth Grade Performance Expectations

6-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
6-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
6-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
6-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Seventh Grade Performance Expectations

7-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
7-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Eighth Grade Performance Expectations

8-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
8-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 operated in the past as they do today.
8-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 their ancestral relationships.
8-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individual's probability of surviving and reproducing in a specific environment.
8-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.

Biology Performance Expectations

B-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
B-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.
B-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.
B-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
B-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.

Earth and Space Science Performance Expectations

E-ESS2-7 Communicate scientific information that illustrates how Earth's systems and life on Earth change and influence each other over time.

Cross Curricular Standards

6-12 Fossil Gap Activity

South Carolina Aquarium

South Carolina College and Career Standards for ELA
Inquiry (I) – 1.1, 2.1
Writing (W) – 2.1, 3.1
Communication (C) – 1.2, 2.1

Background

Key Points
Key Points will give you the main information you should know to teach the activity.

- **Paleontology** is the study of fossils and their histories. It involves the application of a number of disciplines associated with the natural sciences like zoology, botany, ecology, geology and biogeography.
- The term **fossil** is used to describe the remains of all plants and animal residues from the past, including all traces of their activities, which have survived up until present day thanks to a physiochemical process known as "fossilization."
- Different fossil types include **petrified fossils, molds and casts, carbon films, preserved remains and trace fossils**.
- **Geologic time scale** is a chronological representation used by geologists, paleontologist, and other earth scientists to describe the timing and relationships between events that have occurred throughout Earth's history.
- **Index fossils** are fossils that can be used to identify certain geologic periods. They are guide fossils to specific times in earth's history.
- Diversity of life or biodiversity relates to the variety of organisms which currently live or have lived on Earth in the past. This not only includes the variability within and between species but also within and between ecosystems.

Detailed Information
Detailed Information gives more in-depth background to increase your own knowledge, in case you want to expand upon the activity or you are asked detailed questions by students.

There is evidence that some ancient cultures used fossil shells as adornments. However up through the Middle Ages, fossils were mostly regarded as freaks of nature which formed spontaneously by some plastic force present in the primordial mud. By the 17th century, fossils began to be compared to their living counterparts. It was not until the 18th century that a correct interpretation of fossils became universally accepted and the foundations for geology and modern systematic zoology were laid, thus leading to the birth of modern paleontology. **Paleontology** is the study of what fossils tell us about the past.

From the moment an organism dies, the soft body tissue begins to decompose due to bacterial action and the current environmental conditions which results in their total destruction. However, though rarely, this process fails resulting in the more durable body parts like bones, teeth shells and woody plant parts enduring long enough to pass through physiochemical stages to form fossils. Generally, dead organisms deposited into aquatic environments are most likely to be fossilized than those stranded on land. They are generally found in sedimentary rocks, those rocks formed by an accumulation of debris collected from the breakdown of other pre-existing rocks (shale, sandstone, conglomerates) or by the chemical precipitation of minerals, as in carbonate rocks.

Fossils are the remains of living thing from the past which includes all traces of their activities (for example, body parts, burrows and tracks). Fossils survive time due to a process called fossilization. There are many types of fossils including petrified, molds and casts, carbon films, preserved remains and trace fossils.

The most widespread fossilization process is known as mineralization. The original tissue is completely replaced by a mineral substance, present in saturated form in the water which permeates the sediment. This process creates **petrified fossils**, **molds** and **casts**. The most common minerals involved are calcium carbonate ($CaCO_3$) and silica. The fossils preserved due to mineralization may be in the form of a petrified fossil (ex. a shell becomes filled with sediment and then dissolves), cast (ex. the original shell is replaced by a different mineral), or a mold (ex. a shell leaves its exterior shape impressed on sediment.) The most well-known replacements is that of wood by agate or opal as a result of the action of hot, silica-bearing waters forming petrified wood like that found in the Petrified Forest National Park in Arizona.

The fossilization process known as carbonization normally involves plant matter. It occurs as the result of bacteria action under anaerobic (without air) conditions on large accumulations of organic substances. This leads to the elimination of oxygen and nitrogen resulting in an increase in carbon and hydrogen. This chemical degradation along with pressure and heat lead a carbon film behind which results in **carbon film fossils**. The great deposits of coal (natural carbon), found mostly in marshy forests of the Carboniferous period, were created this way.

Sometimes the remains of organisms are completely preserved, meaning all of their soft body tissues are still intact. These fossils are called **preserved remains** and are rare. Even the most delicate body parts are preserved. Examples include bird feathers in limestone, worms in shale formations, mammoths in ice, and insects in amber. Natural mummification can also preserve delicate animal parts. One example is a particular genus of dinosaur that was first “mummified” and then “mineralized.”

Trace fossils are fascinating because they are evidence of an organism’s life (not the body) that was preserved. Examples of trace fossils are preserved footprints, burrows, holes, scat (animal feces) and stomach contents.

Fossils provide the most tangible evidence of the evolution of living organisms. **Evolution** is defined as the change in a population of organisms over a long period of time. Evolution accounts for the genetic and physical similarities among various groups of organisms as well as geographical distribution of different species. Changes over time can be clearly seen by examining the fossil record.

The fossil record is far from complete, however, it demonstrates, without doubt, that living species are not fixed immutables. Instead, they are the product of a very long series of changes whose history, via fossil remains, can now be reconstructed in outline and, in some cases, in detail. Fossils show that many thousands of plants and animals species, common in the past, no longer exist, and that most of those living today resemble strongly the fossil forms found in relatively recent rocks. The fossil record clearly shows the great diversity of life throughout Earth’s history.

Paleontological documentation has resulted in tracing the origins of some major taxa, for example vertebrate relationships between reptiles and birds and between reptiles and mammals. It is even possible, with sufficient fossil data, to gain more detailed information on lower taxa such as species. Evolution at the taxa level above species is known as **macroevolution**; at the species level, **microevolution**.

The study of rock strata in sedimentary rock allows paleontologists to reconstruct the sequence of physical and biological events that have characterized the history of the Earth and to subdivide it into smaller units called **epochs, periods, eras,** and **eons**. In this way a relative age can be ascribed to every event in the Earth’s history. Therefore, the **relative age** of a fossil can be determined based on the layer of rock in which the fossil is found. Older sedimentary layers are found deeper within the Earth than newer layers and contain older fossils. For example, the last of the dinosaurs became extinct in the Cretaceous period, at the end of the Maastrichtian epoch, which marks the close of the Mesozoid era.

To arrive at a fossil’s **absolute age** or date, expressed in millions of years, paleontologists use radiometric methods which measure the decay of radioactive elements like uranium, potassium, and strontium isotopes within the fossil. It is generally possible to find out the age of igneous rocks and, in special cases, that of sedimentary rocks in which fossils are usually found. **Index fossils** are commonly found fossils that can be used to identify specific time periods. They are well known fossils and serve as a “guide” to geologic time. Examples of index fossils include ammonites, brachiopods, graptolites and trilobites.

By combining the two types of chronology, absolute and relative, a geologic timeline or **geologic time scale**, can be constructed. Add to this the age and appearance of fossils, fossils can then be placed into groups and sequences within the timeline. A study of the fossils within the timeline often shows patterns of changes and emergence of new species that have occurred over time, thus documenting the diversity of life seen throughout Earth’s history. This kind of organization can be used to show how various species are related in an evolutionary tree or **phylogenetic tree**.

Based upon the supposition that natural phenomena occurred in the past in the same way as they occur today, it is possible to reconstruct the original environment in which a sequence of sediment was laid down. This also requires a study of the characteristics of the fossils contained within the sediment, along with the study of its geochemical and sedimentological characteristics. The study of fossils can provide information related to all the characteristic components of an environment like degree of temperature, salinity, etc. Corals are excellent indicators of climate changes. They require specific environmental conditions in order to develop, so if coral reefs of the past formed under similar conditions as present day reefs, an assumption can be made about the environment in which coral fossils are found.

One of the greatest causes of geographical change in our planet appears to have been the birth of the continents. According to the plate tectonics theory, the Earth's lithosphere (land mass) is divided into moving sections that include the continents, with the result that the continents' positions vary with the passing of geological time. Fossils can provide classic evidence of plate tectonics. The discovery of remains of the same organisms, either terrestrial or at least incapable of traveling for long distances across the sea, in continents today separated by oceans provide evidence of plate tectonics. For example, fossils of *Lystrosaurus*, a typically terrestrial mammal-like reptile of the Permian period, have been found in Antarctica, India, South America and southern Africa, thereby indicating that these land masses were once joined together at the end of the Paleozoic era.

Procedures

(A portion of this activity is modified from "Lab 13: Examination of the Fossil Record," Bio 101 Laboratory Manual, York Technical College, pp. 85-91, 2013.)

Materials

Part 1: Fossils

- Fossil Introduction PowerPoint
- Fossils (any you have access to)

Part 2: Fossil Gap

- Fossil Drawings (one per student)
- Fossil Gap Worksheet (one per student)
- Fossil Gap Answer Key (for teacher only)
- Scissors
- Glue or tape

Procedure

Part 1. Fossils

1. Use the Fossil Introduction PowerPoint to review the different types of fossils as well as the basics to the study of earth's history. Topics reviewed include:
    a. Fossil definition
    b. Types of fossils
    c. Paleontology
    d. Geologic Time Scale
    e. Relative age
    f. Absolute age
    g. Index fossils
2. If real fossils are available, have students study them. Ask them to identify the fossils by type.
3. Have students suggest reasons why some organisms or parts of organisms might not form fossils.
4. Discuss how paleontologists use fossils found in rock layers or strata to describe major climatic events that have occurred in Earth's history and how these events have changed the Earth's surface.
5. Discuss how the Earth's history timeline is divided into different groups - era, period and epoch, based upon major climatic changes and thus relative and absolute fossil ages.

Part 2. Fossil Gap

1. Let students know that they are going to use the information they learned during the Intro PowerPoint to create a geologic time scale of bivalves.
2. Give each student the Fossil Drawings and a Fossil Gap Worksheet. Have the students cut out each "fossil," making sure the time period is included with each fossil.
3. Next have them place each "fossil" on the timeline sheet next to the appropriate period from which the fossil came. NOTE: The term "upper" means more recent and the "fossil" should be placed at the top of the row. The term "lower" means an earlier time period and the "fossil" should be placed lower in the row, toward the older time periods. In each column, there may be several specimens from the main time period. However, there will not be a "fossil" for each time period, thus illustrating the incompleteness of fossil records.
4. Next have students arrange the "fossils" following these steps:
   a. Center the oldest fossil at the bottom of the fossil column (toward the oldest layer.)
   b. Place those fossils that appear to be similar in the same vertical line.
   c. When the fossils appear to have a significant difference in appearance, split the fossils into two branches, side-by-side within the appropriate time period. Two lineages have been created at this point.
   d. Continue the placement of the remaining fossils.
5. For each missing "fossil", have students sketch in a possible likeness of the missing "fossil." This can only be done if there is a "fossil" prior to and immediately following the missing "fossil." If the gap is too large (2 or more empty spaces, a fossil cannot be drawn.
6. Have students write a summary paragraph about what they observed during this activity. Have them include possible explanations why some "fossils" are missing from fossil records.
7. Have students discuss their summaries as a class.

Follow-up questions

1. During which time period did the organism differentiate into two branches or lineages?
2. Which of the two branches was more successful as a species? Explain how this decision was made.

At-home Learning and Virtual Modifications

At-home and Virtual Learning: Use the following Nearpod information to choose how to complete this activity. You could choose to have them do it independently (lesson is narrated to help them along) or with you leading. This interactive activity will cover what a fossil is, the different types of fossils, and how paleontologists can use fossils to fill in gaps in the record.

Nearpod Fossil Gap (without student interaction)

Nearpod Fossil Gap Lesson (with student interaction) - directions
1. Create a free nearpod account (https://nearpod.com/)
2. Ask Aquarium to send you the Fossil Gap nearpod link (email education@scaquarium.org)
3. After you receive Aquarium link, add lesson to your nearpod activities by clicking "Add to My Library"
4. Send to students using Live Participation
5. You'll be able to see their answers and interactions

Assessment

Assessment 1

Grade students on their Fossil Gap Worksheet.

Scoring rubric for out of 100 points

Correct time period placement of each fossil **30 points (3 pts each)**

Correct placement of fossils within the two branches	**20 points (5 pts each)**
Sketches of missing fossils	**25 points (5 pts each)**
Written summary	**25 points**

Assessment 2

Give Fossil Quiz. On a blank piece of paper, have students write the numbers 1-6 down the side of their paper. Show them one fossil picture at a time and have them write what fossil type for each. You can give them the list of fossil types or not (both versions are on PowerPoint). The last slide shows to fossils that are related but separated by time. Have students draw what the missing fossil could look like. Then have them explain why they fossil was missing from the fossil record.

Scoring rubric out of 100 points

Fossil Identification (6):	**60 points (10 points each)**
Fossil Drawing:	**20 points**
Missing Explanation:	**20 points**

Cross-Curricular Extensions

STEM Extension

Have students design and build two make believe organisms out of clay that share the same evolutionary path. One organism from the Triassic Period and one from the Cretaceous Period. Make sure they leave a fossil gap of an organism that would have lived in the Jurassic Period. Have them explain the difference in characteristics from the Triassic to Cretaceous Periods. This activity will require them to research what scientists think animals looked like from those periods as well as create something from their imagination.

Resources

Teacher Reference Books and Magazine Articles

Arduini, Paolo and Giorgio Teruzzi. *Simon & Schuster's Guide to Fossils*. U. S. Editor Sidney Horenstein American Museum of Natural History. Simon & Schuster, Inc., New York, 1986.
This field guide contains"280 full-color photographs of the most significant fossils from animal and plant groups, plus information on age, appearance, geographic distribution, environment, classification, and more."

McGill, John, Bruce Romein, Jennifer Morgan (and Mary L. Brown). *Bio 101 Laboratory Manual*. York Technical College, 2013.
This laboratory manual contains a lab upon which this activity was based.

"Rock(s) Around the Block" by Sidney Horenstein; SCHOLASTIC Science World. February 9, 1990 Vol. 46, No. 11 pg. 8-11; WWW.SCHOLASTIC.COM
This article covers not just rock types, but also fossils.

"Feathery Find" by Patricia Janes; SCHOLASTIC Science World. May 9, 2005 Vol. 61, No. 14 pg. 12-15; WWW.SCHOLASTIC.COM

Teacher Reference Websites

Fossils:
American Geosciences Institute
http://www.k5geosource.org/1content/1sc/fossils/pg11.html

Kentucky Geological Survey
http://www.uky.edu/KGS/fossils/fossilid.htm
Great site for identifying unknown fossils.

Fossil Mysteries
http://www.sdnhm.org/archive/exhibits/mystery/fieldguide.html
Field Guide, activities and resources.

Folly Beach: Ocean Treasures
http://www.follybeach.com/seashells.php
Folly Beach, SC Shells & Fossils

University of California Museum of Paleontology
http://www.ucmp.berkeley.edu/taxa/inverts/mollusca/bivalvia.php
Bivalve information

Evolutionary/Geologic Timelines:
BBC – Nature, Prehistoric Life
http://www.bbc.co.uk/nature/history_of_the_earth#timeline

The Talk Origins Archive
http://www.talkorigins.org/origins/geo_timeline.html

San Diego Natural History Museum
http://www.sdnhm.org/archive/exhibits/mystery/fg_timeline_print.html

New Scientist – Timeline: The Evolution of Life
http://www.newscientist.com/article/dn17453-timeline-the-evolution-of-life.html?full=true

About Education – A Beginner's Guide to Evolution
http://animals.about.com/od/evolution/u/evolution.htm#s3

Student Reference Books

Zim, Herbert S. and Paul R. Shaffer. *Rocks and Minerals A Guide to Familiar Minerals, Gems, Ores and Rocks.* Golden Press, New York, 1957.
This field guide is an introduction to rocks and minerals, and contains a section on fossils within the sedimentary rocks topic.

Field Trip Sites

Howe, Jerry T. and Andrew S. Howard. *Fossil Locations in South Carolina, Museum Bulletin No. 3 South Carolina State Museum.* Converse College, Spartanburg, S.C., 1976-1978.
Although very out-dated, this monograph was prepared to aid both the amateur and professional paleontologist in terms of directions to locating fossil sites throughout South Carolina.

Bob Campbell Museum, Clemson, SC
On the grounds of the South Carolina Botanical Gardens.

South Carolina State Museum, Columbia, SC
Many exhibits concerning geology and fossils of South Carolina.

Charleston Museum, Charleston, SC
A few exhibits designated for rocks and fossils.

College of Charleston Mace Brown Natural History Museum, Charleston, SC
Many local and international fossils, highlighting whales.