

Species Across Time and Terrain

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Overview

In this set of activities, students figure out why fossil marine shells are found on land and why they vary from place to place. The activity uses as an example a set of species found in the fossil record in the Tamiami formation in southern Florida. Using data from the fossil record, they examine the spread of those species across the southeastern United States 3 million years ago, and the existence or extinction of those species over time. Students are asked to examine similarities and differences among the species, use information about the species to figure out past environments where the shells were found, and make data tables, bar graphs, line graphs, and pictures to organize and analyze the data.

This set of activities address MS-LS4-1 in the Next Generation Science Standards.

- 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.

NGSS Evidence Statements

Students are asked to engage in the following observable actions during the activities (specific activity in parentheses):

Online:

https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/MS%20LS4%20Evidence%20Statements%20June%202015%20asterisks.pdf

Observable features of the student performance by the end of the course:

- 1) Organizing data
 - a) Students organize the given data (e.g., using tables, graphs, charts, images), including the appearance of specific types of fossilized organisms in the fossil record as a function of time, as determined by their locations in the sedimentary layers or the ages of rocks. **(Part 2, Part 3)**
 - b) Students organize the data in a way that allows for the identification, analysis, and interpretation of similarities and differences in the data. **(Part 1, 2, 3)**
- 2) Identifying relationships
 - a) Students identify:
 - i) Patterns between any given set of sedimentary layers and the relative ages of those layers. **(Part 3)**
 - ii) The time period(s) during which a given fossil organism is present in the fossil record. **(Part 3)**
 - iii) Periods of time for which changes in the presence or absence of large numbers of organisms or specific types of organisms can be observed in the fossil record (e.g., a fossil layer with very few organisms immediately next to a fossil layer with many types of organisms). **(Part 3)**
 - iv) *Patterns of changes in the level of complexity of anatomical structures in organisms in the fossil record, as a function of time.*
- 3) Interpreting data

- a) Students analyze and interpret the data to determine evidence for the existence, diversity, extinction, and change in life forms throughout the history of Earth, using the assumption that natural laws operate today as they would have in the past. Students use similarities and differences in the observed patterns to provide evidence for:
- i) When mass extinctions occurred. *(Though mass extinctions are not covered directly by this activity, the concept of extinct is covered, which can be used to introduce the idea that we can use fossil data to learn about times of mass extinction.) (Part 3)*
 - ii) When organisms or types of organisms emerged, went extinct, or evolved. **(Part 3)**
 - iii) The long-term increase in the diversity and complexity of organisms on Earth. *(Though long-term increases in diversity and complexity are not covered directly, this data is representative of the kind of data that is compiled for different geologic intervals to learn about these long-term patterns.) (Part 3)*

Part 1: Ancient life

Overview:

In this activity, students try to figure out how the shapes and locations of fossils can be used to learn about ancient environments where those animals lived. The students use, as an example, 12 species that were found in the Tamiami formation, a formation in southern Florida that is about 3 million years old. Students are first given brief background information about the formation and the fossils. Next, they examine the fossil images and descriptions to identify characteristics of the fossils and their environment. They integrate this information by drawing a representation of what the environment might have been like when these species were alive.

The goals of this activity are to:

- introduce students to the set of species that will be examined in the activity
- examine the species
- identify environmental features based on information about the species

Students will be able to:

- analyze data in the fossil record for evidence about ancient environments
- construct a visual representation of an environment based on fossil data
- examine evidence in the fossil record that documents existence of and biodiversity within ancient marine invertebrates.

Total time: 40 min

Big question: What and how can we learn about ancient life?

Time	Activity	Materials
5 min	Think-pair-share: What was life like before there were people? How can we know? Has the area where we live always looked like this?	
5 min	Tell students that one way to know about Earth's history and ancient life is to examine the rock and fossil record. Tell students that they are going to examine fossils and see what they can learn from them. Share brief background information with students: These are fossils that were found in the Tamiami formation in southern Florida. A few helpful images are in the background information powerpoint.	Background info powerpoint, projector
10 min	Tell students that they are going to look at data on 12 species that were found in the Tamiami formation. Tell students there are a lot more species in the formation, but they're just going to look at 12 that were chosen to represent a variety of common patterns found in the fossil record. Hand out species info cards (images and text). Have students work in groups to examine the species and identify characteristics. Looking at both the images and text,	Species info cards, Board or poster paper

	<p>have students make lists of similarities and difference among the species. For example, students might conclude that they all lived in the ocean, some could move and some could not, there were a variety of different types of creatures and shell shapes, etc.</p> <p>Discuss with the whole class and make a class list of students' observations.</p>	
10 min	<p>In groups, ask students to think about what the environment might have been like where these species lived, and what else must have been part of the environment. (For example, it must have been underwater, there must have been marine plants or tiny floating organisms that became food particles, or there must have been marine worms.)</p> <p>Share ideas with the whole class and make a class description of the environment.</p>	Board or poster paper
10 min	<p>Have students draw a picture showing what the environment might have been like, based on what they have determined so far. Tell students to include at least 6 of the species, and anything that goes with them (e.g., particular type of food) in their drawing.</p>	Blank paper, colored pencils.

Part 2: Locations

Overview

In this activity, students figure out why different marine fossils are found in different places and what that means about ancient marine environments, using as an example the fossil record of the 12 species across four regions in the southeastern United States during a single time period. This activity consists of two sections. In Part 2a students use maps of the four locations to create a composite map showing locations where marine species lived 3 million years ago and the potential coastline in the region. In Part 2b students create data tables and bar graphs to examine and compare the presence or absence of species in the four locations. Students are asked to speculate about potential reasons for differences in species among the four locations.

The goals of this activity are to:

- examine where these species have been found in the region
- use location data to make a map of the potential ancient coastline
- create data tables and bar graphs to support examining data
- identify similarities and differences between the numbers of species at the locations
- think about potential causes of the differences, and what else they would need to know to support a claim

Students will be able to:

- analyze data in the fossil record for evidence of ancient environments
- analyze data in the fossil record to compare ancient and modern day geography (coastline)
- construct a visual representation of fossil data (composite map) to support analysis of geography data
- identify patterns in the fossil record that document existence and biodiversity among ancient marine invertebrates.
- construct data tables and bar graphs
- use mathematical representations (bar graphs) to support data analysis
- construct an argument based on evidence to support a claim about ancient environments

Big question: Were all oceans the same? Are they the same as today?

Total time: 75 minutes (3 parts)

Time	Activity	Materials
5 min	Think-write-pair-share: Ask students: Are all ocean environments the same? Were all ancient oceans the same? Why or why not? How do you know?	
	Tell students they are going to look at data showing fossil finds for the same set of species in Part 1 from different locations.	
5 min	Part 2a: Maps and coastlines. Hand out Location maps. Tell students that the dots show fossils that were found in different formations that are all roughly 3 million years old. Think-pair-share—Ask students to look at the maps and write down three things they observe. Then talk in groups, and make a list with the class. If it does not come up, remind students that	Location maps

	<p>all of the species are marine creatures that live in salt water. Possible observations may include:</p> <ul style="list-style-type: none"> • There are more dots in some spots than others. • The dots are in different states. • The dots are on land. • There aren't any dots in the ocean. • There are a lot of places without any dots. 	
10 min	Using all four maps, have students make a "composite map" and draw a potential coastline on a blank map. Tell students to put the dots from all four maps on their blank map, then color places that must have been underwater (because of the marine species) in blue (or shade it in with pencils), then connect them to show the potential coastline.	Blank map (one per student). Blue pencils or markers
5 min	Discuss with the whole class. Ask students: <ul style="list-style-type: none"> ○ What do you observe about this map? ○ How could we make a more accurate map? 	
	Part 2b: Life in the ocean	
5 min	Think-pair-share: Ask students: So we know that these places were underwater. Do you think they were all the same or were there different ecosystems? How can we know about this?	
3 min	<p>Tell students we're going to look at data showing fossil finds for each of the 12 species from the different locations in the maps. The data show the number of each species found at each location.</p> <p>Hand out Locations Data. Give students a minute to look at the data, then ask them for any initial observations about the data. Share with the class.</p>	Locations Data
10 min	<p>Tell students that organizing data into tables and graphs can help them identify patterns.</p> <p>Have students make a data table for the data. Depending on the students' experience with data, have them make it in notebooks or give them the starter table.</p>	Locations Data Table Starter
15 min	<p>Have students make bar graphs for the data.</p> <ul style="list-style-type: none"> • The horizontal axis should show the location, with a bar for each species present in the location, and the vertical axis should show the number found for each species. • If useful, have students use a different color (marker, colored pencil) for each species. • Alternative: have students work in groups to graph a single location, and then compare the graphs for different locations between groups. • Depending on the students' experience with bar graphs, have students make the graph in a notebook or give 	Locations Data Starter Graph

	<p>them the starter graph.</p> <ul style="list-style-type: none"> • Additionally, discuss as appropriate why a bar graph is a good way to examine this data (multiple unrelated data points (different species) for several categories (different locations)). 	
10 min	<p>Think-pair-share: Ask students: What do you notice about the data?</p> <p>Discuss their observations with the class: Observation and discussion prompts:</p> <ul style="list-style-type: none"> • Are the four locations the same? How are they similar and different? (For example, all have more than one species, some have a lot more). • Look at the locations on the map. What geographic features might contribute to the differences in species? (latitude and temperature, physical barrier of Florida peninsula separating Jackson Bluff from the others.) • Look back at the information about the different species. What might the environments have been like in the different locations? What do we know about the environments based on the species that are found there? 	
	<p>Extension Argumentation: Have students write evidence and reasoning related to the data in the activity to support the claim that the coastline in the southeast United States was different 3 million years ago that it is today.</p>	

Part 3: Species over Time

Overview

In this activity students figure out how we can study environmental change through time using as an example the number of fossils found for the 12 species in the same region of southern Florida at four points in time, ranging in age from 3 million to 50,000 years old. Students make a data table from raw data sheets, and a line graph from the data table. Most of the species decrease in number over time, with one species that spikes in the middle of the time interval and then decreases. Students are asked to notice patterns in the data, graph and analyze the data, and speculate about the reasons the numbers decreased. Interestingly, there is not a definitive answer to this question, and students can debate the various possibilities. Possible answers include changes in the environment (climate), changes in the ecosystem (species), changes in which species were preserved in the fossil record, changes in which fossils have been collected, or a combination of these or other factors.

The goals of this activity are to:

- examine changes in the numbers of the 12 species in the fossil record over time
- create data tables and line graphs to support analyzing data
- discuss known and missing information
- discuss an open-ended question about change in the natural world that does not have a definitive scientific answer

Students will be able to:

- analyze data to identify patterns in the fossil record that document existence, biodiversity, and extinction among ancient marine invertebrates.
- speculate and hypothesize on the causes of changes in the fossil record
- construct data tables and line graphs
- use mathematical representations (line graphs) to support data analysis

Big question: What happened to these species over time?

Total time: 50 min

Time	Activity	Materials
5 min	Think-pair-share: Show students a picture of a rock face/fossil pit with multiple layers. Ask them to describe what they see, and what they might be able to learn from it. After sharing, show an annotated image with different layers and ages labeled. If useful, ask again, what might we be able to learn from this?	Layered rock image, annotated image
5 min	Tell students they are going to look at data showing fossil finds in the same locations over multiple time periods. Hand out Time Data Sheet and Time Maps. Turn and talk, then share with class: what do students notice about the data and maps?	Time Data Sheet, Time Maps
	Remind students that organizing data into tables and graphs can help them identify patterns.	

10 min	<p>Have students make a data table from the data sheet, either in a notebook or using the starter table.</p> <p>Ask: do you see any patterns in the data? Discuss briefly with class.</p>	Time Data Starter Table
15 min	<p>Have students make a line graph of the data.</p> <ul style="list-style-type: none"> • The x axis should include the times (oldest to newest), and the y axis should show the number of each species found. Each species should have a separate line on the graph. • If useful, have students use a different color (marker, colored pencil) for each species. • Alternative: If graphing 12 species will take too long, have groups of students graph a subset, and compare graphs between groups to see the complete data set. • Depending on the students' experience with graphing, have students make the graph in their notebooks or use the starter graph. • If useful, discuss why a line graph is an appropriate way to examine this data (data show change over time for multiple factors (species). Line graphs allow examination of patterns within and among species, and comparisons of patterns between species). 	Time Graph Starter
15 min	<p>Think-pair-share: Ask students: What do you notice about the data? What happens over time?</p> <p>Discuss with the class: What might have caused these changes? Brainstorm with the class to come up with some ideas, additional information you might need to know, and open questions about the data.</p> <p>Have students work in groups to organize their ideas into: 1) evidence (things we know* based on the currently available time and location data sets); 2) external evidence (things we know based on books, other data, other science units; 3) hypotheses and speculation (ideas about what might have caused change); and 4) open questions and missing information (what we don't know).</p> <p>* We have more confidence in some things we "know" than other things. Discuss the level of certainty and how durable this knowledge is.</p> <p>Potential observations about the data and discussion points include the following:</p> <ul style="list-style-type: none"> • Overall, the number of each species found decreased over time. • The numbers for different species did not decrease at the same rates, and some increased in the middle time 	Organization worksheet

periods.

- Some species were not found at all in the later time periods.
- Some possible reasons for this include:
 - The species went extinct everywhere.
 - The species died out in that area but continued to live elsewhere.
 - The species existed but did not make it in to the fossil record.
 - The species exists in the fossil record for that area but we haven't found them yet.
- Scientists are still trying to figure out why the changes occurred. (Want to help? Become a paleontologist!)

Share with the whole class. Help students notice:

- there are things they know from the data available for this activity versus other information sources
- there are multiple reasonable explanations
- there are open questions about the natural world that scientists don't yet know the answers to
- we may be able to answer questions with more confidence if we can collect additional data
- some questions, however, may never be answerable with confidence if data is unavailable (e.g., fossils from a certain time and place were not preserved)

For helpful information on useful discussions about science, see [the Ambitious Science Teaching Project's Discourse Primer for Science Teachers](#).

See also the [Understanding Science](#) website from the University of California at Berkeley