

## **Introduction Activities: Species Diversity and Classification**

By Dr. Amie Patchen

Last updated June 29, 2018.

### **Overview**

In this set of activities, students observe images of fossil shells, ask questions about those fossils, and sort the fossils into categories based on their physical characteristics. Parts 1 and 2 introduce students to the fossils, encourage careful observation, and focus on the scientific practices related to asking testable questions. Parts 3 and 4 address content related to 3<sup>rd</sup> grade NGSS DCI, as well as the crosscutting concept of patterns. While the content is most closely aligned to the 3<sup>rd</sup> grade standards, the practices related to asking questions and identifying patterns to categorize data could be useful for a variety of grades. The particular practices, concepts, standards, and related evidence statements for each activity are outlined below.

### **Part 1. Asking questions**

#### **Overview:**

In this lesson, students begin to explore fossils from the Neogene Atlas by examining images and thinking of questions about them. Students first work in groups to ask as many questions as possible based on just the images. After sharing their initial questions with the group, students are given a little bit of information about the fossils and then challenged to write more questions. Finally, students are asked to reflect on what they have learned about the fossils through observing the images and developing questions. The goals of this activity are to:

- introduce students to the fossils in an engaging way
- foster curiosity about the fossils
- foster close and careful observation of the fossil images
- develop knowledge based on observations
- develop students' abilities to ask questions about the natural world
- help students reflect on the value of asking questions

#### **SWBAT:**

- Ask questions about fossils
- Observe images to learn about the natural world
- Describe information learned through observation and asking questions

#### **NGSS Practice: Asking questions**

##### **K-2**

- Ask questions based on observations to find more information about the natural and/or designed world(s).

##### **6-8**

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information

##### **9-12**

- Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.

**Total time: 45 min**

**Lesson outline:**

Time	Activity	Supplies
10 min	Give each pair/group of students a set of 10 fossil cards. Without telling them anything about the images, have them write as many questions about the images as they can in 10 minutes.	Fossil cards (10/group) Paper, pencils
10 min	Group brainstorm: have each group of students share their questions with the whole class and make a list of their questions on the board. There will be a lot of overlap—start with one group and have them read out their questions, and have other groups raise hands if they also wrote that question. Put check marks next to the question for each group that asked it. One option to make it more interactive-- assign points: each question is worth one point, and each question no one else thought of is worth two. See which group earned the most points.	Board/poster paper
5 min	Give students a little bit of information about the images: <ul style="list-style-type: none"><li>• These are fossils</li><li>• They were found in the southeastern United States</li><li>• They are from roughly 3 million years ago</li><li>• They are all marine animals (they live in the ocean)</li><li>• Some of the species are extinct, but some are still alive today</li></ul>	Information about the images
5 min	Challenge students to write 10 more questions, now that they know more about the images.	Paper, pencils
5 min	Share and record new questions with the class.	Board/poster paper
10 min	Reflection and wrap up: Thinking of questions is a good way to encourage students to make close observations of something. Help students see that asking questions about these images also helped them notice and learn things about them.  Ask students: What do we know about the things in these images so far? Make a class list of their answers. Students may start by listing the facts they were given about the fossils—record these first and then encourage them to tell you more things they know.	Board/poster paper. Save the class list for the next activity!

## Part 2. Testable questions (and what do paleontologists do?)

### Overview:

In this lesson, students consider which of the questions they wrote in Part 1 are testable in a scientific manner. While all questions are good questions, science builds knowledge by asking questions that can be tested through an investigation using data, and then testing them. Students are asked to consider what makes a question “testable”, which of the questions they asked about the fossil images are testable, and what data would be needed to test them.

The goals of this lesson are to:

- foster deeper thought about the fossils in the images
- foster thought about the fossils’ environments and other relevant factors
- develop students’ abilities to identify testable questions
- develop students’ abilities to plan investigations

### SWBAT:

- Identify testable and non-testable questions
- Determine whether a given question is testable
- Outline the information needed to answer a testable question
- Design an experiment to test a testable question
- Outline known and unknown information related to fossils

### NGSS Practices: Asking questions

#### K-2

- Ask questions based on observations to find more information about the natural and/or designed world(s).
- Ask and/or identify questions that can be answered by an investigation.
- Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.

#### 3-5

- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships
- Evaluate appropriate methods and/or tools for collecting data.

#### 6-8

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

#### 9-12

- Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- Evaluate a question to determine if it is testable and relevant.
- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
- Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation’s design to ensure variables are controlled.

**Total time: 55 min**

**Lesson Outline:**

Time	Activity	Supplies
5 min	Think-Pair-Share: What does it mean for a question to be testable? What does it mean to answer a question based on data?	
5 min	With the whole class, look at the question list from Part 1. Pick a couple of the questions from the list that are testable and a couple that are not. Ask students if they think they are testable, and why or why not. Discuss briefly.	Class questions from Part 1
10 min	Have students work with their groups from Part 1 to decide whether they questions they came up with are testable or not.	Group question lists from Part 1
10 min	Discuss students’ questions with the whole class. Have each group share a couple of their questions that are testable and a couple that are not, and their reasoning about which are which. After a group shares their reasoning, ask the rest of the class if anyone had a similar question, if everyone agrees with the reasoning, or if anyone has other thoughts or questions about the question or reasoning.	
10 min	In groups, have students pick three of their testable questions and think about what sort of data they would need in order to test and answer it. How might they get that data?  The goals of this part are to 1) get students to start thinking more broadly about what can be learned from fossils, and 2) give students a topic for thinking about experimental design. If one or both of these are very new ideas, help students get started by talking through one example with the whole class first.  Possible extensions: <ul style="list-style-type: none"> <li>• Have students write a more detailed plan for testing</li> </ul>	

	<p>one question.</p> <ul style="list-style-type: none"> <li>• Give students more information about the location and era, or examples of ways that paleontologists study fossils (see background information section), to help them think of possibilities.</li> </ul>	
5 min	Share one idea from each group with the whole class. Talk about what paleontologists do, how they study fossils, what they can learn from fossils	Information about what paleontologists do (in background info section)
10 min	<p>Reflection and wrap up:</p> <ul style="list-style-type: none"> <li>• In Part 1 students made a class list of things they knew about the fossils at the end of the activity. Ask students to add to that list by making a column of “missing data”-- specific things they do <i>not</i> know about the fossils.</li> <li>• To get the discussion started, ask students to think about the data they said they needed to investigate their testable questions.</li> <li>• If students suggest additional things they do know, add those to the list from Part 1.</li> <li>• The goals of this reflection are to help students recognize what they have learned, and help them see that asking questions and thinking about how to answer them are a good way to learn about the natural world, even before conducting any investigations.</li> </ul>	

## Part 3. Making categories

### Overview

In this lesson students examine a variety of fossil images and sort them into categories. Working in groups, students are asked to create three different categorization systems for the images and then share their systems with the class. Students are then given information about the way scientists have categorized these fossils and asked to think about how scientists determined their system and whether it makes sense based on the images alone. Finally, students reflect on the purpose of categorization and what they learned from the activity.

The goals of this lesson are to:

- introduce students to a range of fossils from the Neogene Atlas
- foster careful observation of the fossil images
- identify physical traits of different fossils
- develop students' abilities to see similarities and differences in data
- develop students' abilities to sort and categorize data
- help students see categorization as a tool for organizing and analyzing data

### SWBAT:

- Sort fossil images based on observations of characteristics
- Describe physical characteristics of fossils
- Identify similarities and differences between different fossils
- Create categories based on physical characteristics
- Describe the characteristics of the specimens in a category
- Describe information learned through the process of categorization

### NGSS DCI:

- 3-LS3-1: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
- 3-LS4-1: Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

### Evidence statements

This activity best addresses the following evidence statements for the performance expectations:

- 3-LS3-1
  - 2-a-iii: Students identify and describe patterns in the data, including differences in traits in a group of similar organisms.
- 3-LS4-1
  - 2-a: Students identify and describe relationships in the data, including:
    - i. That fossils represent plants and animals that lived long ago.
    - ii. The relationships between the fossils of organisms and the environments in which they lived (e.g., marine organisms, like fish, must have lived in water environments).
    - iv. That some fossils represent organisms that lived long ago and have no modern counterparts.

- v. The relationships between fossils of organisms that lived long ago and their modern counterparts.
  - 3-a: Students describe that:
    - Fossils provide evidence of organisms that lived long ago but have become extinct (e.g., dinosaurs, mammoths, other organisms that have no clear modern counterpart).
    - Features of fossils provide evidence of organisms that lived long ago and of what types of environments those organisms must have lived in (e.g., fossilized seashells indicate shelled organisms that lived in aquatic environments).

**NGSS Crosscutting concept: Patterns**

**3-5**

- students identify similarities and differences in order to sort and classify natural objects

**Total time: 45 min**

**Lesson Outline:**

Time	Activity	Supplies
15-20 min	<p>Give each group of students a set of the 26 variety cards. Working in groups, have students come up with 3 different ways to categorize the cards into at least three categories each time, and with no categories with just one card. For each system, have students “name” each of the groups in the system based on the characteristics of the group. For example, group names could be “small rounds,” “wavy ridges,” or “pointy.”</p> <p>Extensions: have students write the criteria (inclusion, exclusion) for each group.</p>	<p>Set of cards for each group. Paper, pencils.</p>
10 min	<p>With the whole class, have each group share their categorization systems. Make a list of the different systems. Discuss similarities and differences between systems.</p>	<p>Board/poster paper</p>
10 min	<p>Tell students the groupings scientists use:</p> <ul style="list-style-type: none"> <li>• CORALS- Cards P, W, L, Q, J</li> <li>• ECHINODERMS- Cards F, C, D</li> <li>• MOLLUSCS- BIVALVES- Cards A, O, M, B, K, S</li> <li>• MOLLUSCS- GASTROPODS- Cards G, H, R, U, X, E, T, V, I, N</li> </ul> <p>In groups, have students look at the system and talk about what characteristics scientists used to make their categories. Ask students to answer these questions with their group. One option could be to have each group of students look at one group of species, and then share with the class.</p>	<p>Fossil information</p>

	<ul style="list-style-type: none"> <li>• What do the species in each group have in common that sets them apart from the other groups? (What are the unique group characteristics?)</li> <li>• What are some differences among the different species in the same group?</li> <li>• Do the categories make sense based on the information you can see in the images?</li> </ul>	
5 min	Give students the descriptions of the species. Have them examine and discuss similarities and differences in the species' behaviors among and within the groups.	Fossil information sheets
5 min	<p>Reflection and wrap up: Talk about categorization as a useful tool:</p> <p>Think-Write-Pair-Share: Ask: why might scientists want to categorize things? What can you learn by making categories? What can categorization help you do?</p> <p>Ex:</p> <ul style="list-style-type: none"> <li>• Organize a lot of data</li> <li>• Look really carefully at the data (observation)</li> <li>• Notice patterns</li> <li>• See connections between individual animals, related groups of animals.</li> <li>• See things that don't fit</li> </ul>	
	Extension: Refer back to Part 1. Can students think of more questions to ask about the fossils after making different categorization systems?	Question lists from Part 1



## Part 4. Cone snail categorization

### Overview:

In this lesson, students look more closely at one family of fossils, the Conidae, or cone snails. Similar to Part 3, students will examine a set of images and develop categories based on physical characteristics. As these fossils are all from the same family, they are more similar than the set of images in Part 3 and will require students to look closely at the physical traits. Working in groups, students will develop categories, name and describe their categories, and compare categories with other groups. They will then examine scientists' classifications of the species and discuss traits, inheritance, and phylogeny related to the fossils.

The goals of this lesson are to:

- foster careful observation of the physical traits of the fossils
- develop students' abilities to sort and categorize based on species' physical traits
- discuss group similarities and differences in traits
- discuss inheritance of traits and phylogeny related to the fossils

### SWBAT:

- Sort fossil images based on observations of characteristics
- Describe physical characteristics of fossils
- Identify similarities and differences between different fossils
- Identify similarities and differences between closely related species
- Describe how individuals of the same species have physical characteristics in common, but there is variation among those characteristics
- Create categories based on physical characteristics
- Describe the characteristics of the specimens in a category

### NGSS DCI:

- 3-LS3-1: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
- 3-LS4-1: Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

### Evidence statements

This activity best addresses the following evidence statements for the performance expectations:

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  - 2-a-iii: Students identify and describe patterns in the data, including differences in traits in a group of similar organisms.
- 3-LS4-1
  - 2-a: Students identify and describe relationships in the data, including:
    - i. That fossils represent plants and animals that lived long ago.
    - ii. The relationships between the fossils of organisms and the environments in which they lived (e.g., marine organisms, like fish, must have lived in water environments).
    - iv. That some fossils represent organisms that lived long ago and have no modern counterparts.

- v. The relationships between fossils of organisms that lived long ago and their modern counterparts.
  - 3-a: Students describe that:
    - Fossils provide evidence of organisms that lived long ago but have become extinct (e.g., dinosaurs, mammoths, other organisms that have no clear modern counterpart).
    - Features of fossils provide evidence of organisms that lived long ago and of what types of environments those organisms must have lived in (e.g., fossilized seashells indicate shelled organisms that lived in aquatic environments).

**NGSS Crosscutting concept: Patterns**

**3-5**

- students identify similarities and differences in order to sort and classify natural objects

**Total time: 70 min**

**Lesson Outline:**

Time	Activity	Supplies
5 min	<p>Tell students they will look more closely at one “group” of the organisms from the first set of cards.</p> <p>Tell students these are cone snails, and are related to modern day species. Share basic information and watch a youtube video of cone snails eating fish:</p> <ul style="list-style-type: none"> <li>• Cone snails are a group of marine invertebrate animals (they don’t have a backbone)</li> <li>• They live in tropical marine habitats around the world--especially coral reefs.</li> <li>• There are over 700 living species.</li> <li>• All cone snails are venomous predators that use neurotoxins to paralyze their prey.</li> <li>• Most species hunt worms, but some hunt other snails or even fish!</li> <li>• At least one fish-eating species has venoms that are so powerful that they have killed people.</li> <li>• Cone snails sting their prey with a harpoon-like tooth, then inject their venom into the prey. Once paralyzed, the prey is pulled into the shell, where it is consumed by the animal inside.</li> </ul> <p>Watch! Videos about cone snail hunting techniques and their venom:</p> <p>The Nature of Science: How killer cone snails kill:</p>	<p>Information about cone snails, video clip/link, projector to show video</p>

	<p><a href="https://www.youtube.com/watch?v=4wihKnARrAw">https://www.youtube.com/watch?v=4wihKnARrAw</a></p> <p>National Geographic Wild: Killer Cone Snail: <a href="https://www.youtube.com/watch?v=zcBmMPJrrKk">https://www.youtube.com/watch?v=zcBmMPJrrKk</a></p> <p>PBS Deep Look: Watch these cunning snails stab and swallow fish whole: <a href="https://www.youtube.com/watch?v=jYMjLgPFSso">https://www.youtube.com/watch?v=jYMjLgPFSso</a></p>	
15 min	<p>Give each group of students a set of the cone snail cards. Tell students that these are fossil cone snail shells from the Plio-Pleistocene fossil record of the southeastern United States. Most of the specimens lived between 2-3 million years ago.</p> <p>Tell students that there are images of several different species. Their goal is to sort the images into species based on the physical characteristics. To start, tell students there is more than one image for each species. If they get stuck, you can offer additional hints: there are at least three images for each species, there are seven different species, some species have young (smaller) and old (larger) individuals</p> <p>Have the students sort the cards into groups. Have students name each of the groups based on the characteristics, and write a description of the characteristics that make a fossil a member of that group. Encourage students to include conditions for both inclusion and exclusion. Have students write the group names and characteristics on index cards, and arrange the card groups on their table.</p>	<p>Cone snail cards Index cards</p>
10 min	<p>Gallery walk- once students are done making categories, have students walk around the room and look at how other groups categorized the images. Tell students to look at both the groupings and the descriptions, and record similarities and differences to their own categories for each table.</p>	<p>Paper, pencils</p>
10 min	<p>With the whole class, discuss the activity—did all the groups make the same categories? Did they all have the same criteria? What were the similarities and differences?</p>	
10 min	<p>Show students how scientists’ classified the images.</p> <p>Turn and talk: have each group briefly discuss how scientists’ system compared to their own, then discuss with the whole class. Where their systems similar? What matched and what didn’t?</p>	<p>Classification information (Cone Snail Handout)</p>

	Optional: Have students look at the 3D images and information about the species on the Neogene Atlas.	
20 min	<p>Discuss taxonomy: Think-write-pair-share: Ask students: What does it mean for a classification system to be “accurate”? How do you know if a given system is accurate or not?</p> <p>Discuss students thoughts with the class. Some ideas might include:</p> <ul style="list-style-type: none"> <li>• All the individuals in a group are similar</li> <li>• There aren’t overlaps between groups (individuals that could be in both)</li> <li>• Groups are “actual” groups (based on the idea that there are definitive answers in nature)</li> <li>• Individuals in a group are related</li> </ul> <p>Prompts to encourage deeper thinking— Ask students:</p> <ul style="list-style-type: none"> <li>• What does it mean for individuals to be similar?</li> <li>• How similar do they need to be?</li> <li>• How big of a difference is too big?</li> <li>• Are all similarities or differences equal? (for example, is being the same size as important as being the same shape?)</li> <li>• What does it mean for individuals to be related?</li> <li>• Are groups always distinct from other groups, or can there be overlap?</li> </ul> <p>Tell students that they are talking about a process called <i>taxonomy</i>. Share some information. Have students read the text on the Philosophy of Taxonomy, or share the major points with the class.</p> <p>Major points:</p> <ul style="list-style-type: none"> <li>• Classifying individual organisms into species groups is called <i>taxonomy</i>.</li> <li>• There is not a single “correct” answer.</li> <li>• Scientists disagree (repeatedly and continuously!) about what should be considered a species and what species an individual belongs to.</li> <li>• Classifications are considered hypotheses that are tested and revised as new information becomes available.</li> </ul> <p>Have students discuss or write answers to the follow up</p>	Philosophy of Taxonomy text (Cone Snail Handout)

	<p>questions:</p> <ol style="list-style-type: none"><li>1. What is taxonomy?</li><li>2. How do scientists decide which individuals belong to which species?</li><li>3. Do scientists always agree on classification? Why or why not?</li><li>4. Why might a scientist change their classification system?</li><li>5. Is there a “right” answer? Why or why not?</li></ol>	
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