

Lab 22. Biodiversity and the Fossil Record: How Has Biodiversity on Earth Changed Over Time?

Introduction

Biodiversity refers to the variation in life forms found on Earth. Biodiversity can be measured in two different ways. The first is richness, which refers to the total number of different life forms. The second is relative abundance, which is a measure of how common each type of life form is in a given area. In terms of richness, Earth is high in biodiversity—biologists have identified approximately 1.5 million different types of life forms, and some biologists think that the actual number of different life forms on Earth is at least 7 million.

To help organize and make sense of this biodiversity, biologists use a nested classification scheme. This system (see the figure to the right) starts with species as the foundational unit of classification. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring. Each species can then be placed into a larger group called a genus, based on similarities in traits. Each genus can then be placed into a larger group called a family. Families, in turn, can be grouped together to create an order; and so on.

There have been several different hypotheses offered to explain the source of all the biodiversity on Earth and the amount of biodiversity found on Earth over time. Here are three of these hypotheses:

1. All life on Earth appeared at the same time in Earth's history. As a result, biodiversity has remained the same throughout Earth's history.
2. Present-day forms of life arose from other forms of life over a considerable amount of time. As a result, biodiversity has increased throughout Earth's history.
3. All life on Earth appeared at the same time in Earth's history. However, current life forms are the survivors of one or more catastrophic events that wiped out many of the other life forms that once inhabited the Earth. As a result, biodiversity has decreased throughout Earth's history.

You can evaluate the merits of these three hypotheses by determining if they are consistent with what is found in the fossil record. Scientists, over many years, have collected data about the history of life on Earth. These data include the collection, classification, and dating of fossils. This information allows scientists to determine what the conditions were like on Earth in the past and when major events occurred in the history of life. It is important to note, however, that the fossil record provides only an incomplete picture of what life on Earth was like in the past. Although the fossil record is substantial, it is incomplete because life forms that are abundant, widespread, and have hard shells or skeletons are more likely to be preserved as fossils than are life forms that are rare, live in only specific locations, or have soft bodies. The fossil record, therefore, can only provide limited information about the history of life on Earth.

Your Task

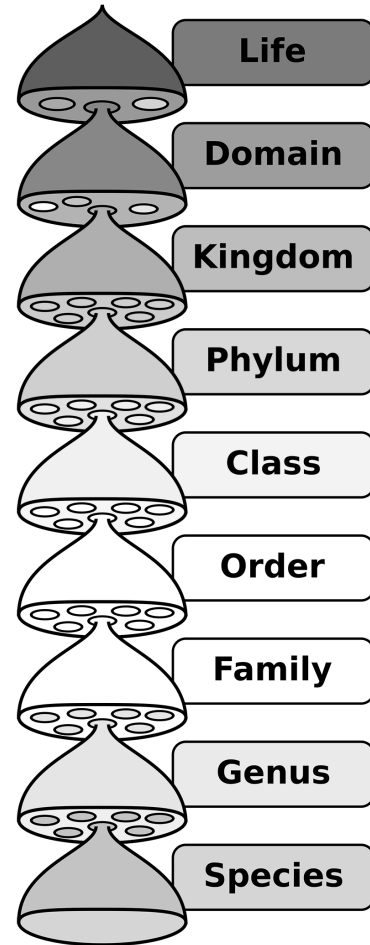
Determine if the fossil record supports any of the three hypotheses listed above.

The guiding question of this investigation is, **How has biodiversity on Earth changed over time?**

Materials

You will use an Excel file called "Diversity in the Fossil Record Data," which can be found at www.nsta.org/publications/press/extras/argument.aspx, in your investigation.

The biological classification scheme



Safety Precautions

1. Use caution when working with electrical equipment. Keep away from water sources in that they can cause shorts, fires and shock hazards. Use only GFI protected circuits.
2. Wash hands with soap and water after completing this lab.
3. Follow all normal lab safety rules.

Getting Started

The data file that you will use during this investigation comes from the Fossil Record website (www.fossilrecord.net). The Excel data file is a simplified version of the original Fossil Record 2 Excel file, which can be downloaded from the website. The Fossil Record 2 is a near-complete listing of the diversity of life through time, compiled at the level of the family by Mary Benton and originally published as a book in 1993. In biology, the term family refers to a taxonomic rank that falls between order and genus. The levels of classification include species, genus, family, order, class, phylum, and kingdom. For example, the Bonobo (*Pan paniscus*) is a part of the genus Pan, the family Hominidae, the order Primates, the class Mammalia, the phylum Chordata, and the kingdom Animalia. Many different species make up a particular family.

In the data file, there are tabs for 10 different classes of organisms (Mammalia, Reptilia, Amphibia, and so on). Each tab includes information about all the families within that class that have been found in the fossil record. The dates represent the midpoint of different geologic stages. For example, 0.001 mya is the midpoint of the Holocene stage and 0.8 mya is the midpoint of the Pleistocene stage. The number 1 in a cell indicates that a fossil belonging to that particular family has been found for that time period. A question mark (?) in a cell indicates that a fossil is likely to be found for a specific time period (because there are fossils from that family in earlier and later time periods) but has not been discovered yet. Cells that are blank indicate that there are no fossils from that family in that time period.

Investigation Proposal Required? Yes No

Connections to Crosscutting Concepts and to the Nature of Science and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- the importance of looking for patterns in nature,
- the importance of considering what is and what is not relevant at different scales of time,
- the difference between data and evidence in science, and
- the different types of methods that scientists use to answer questions.

Argumentation Session

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

- Why did you decide to focus on those data?
- What did you do to analyze your data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!