Please DATE Me
Target Grade: Elementary/Middle School
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Brief Overview

This lesson aims to give the mentees an example of how scientific reasoning and techniques can be applied to various fields. In this case, mentees will learn about the evolution of animals by looking at variations in fossil remains over time. The mentees will also learn about the different types of geological dating, which provides insights into the order of historical events. Finally, mentees will be able to simulate piecing together the fossil remains as though they are at an archaeological site.

Teaching Goals

- **Fossils** are preserved remains, impressions, or traces of something that used to be alive.
- **Evolution** is the change in characteristics of a species over generations based on what traits are favorable for survival.
- How geologists, archaeologists, and other scientists create timelines of events:
    - **Relative Dating** is being able to figure out what order events happened.
    - **Absolute Dating** is estimating the age and time frame at which those events occurred.
- **Excavation:** the act or process of digging, especially when something specific is being removed from the ground.

Careers and Applications

Paleontology is the study of fossilized organisms. Within paleontology, there are multiple branches such as vertebrate, invertebrate, paleobotany, and micropaleontology that all focus on different types of organisms. From these fossils, paleontologists can begin to understand the relationship between modern-day organisms and their ancient ancestors. This information about the evolution of organisms is helpful to scientists, especially in the field of biology. Understanding the evolutionary history of organisms is useful in many ways, such as helping researchers to choose model organisms to experiment on or to provide more information about

hereditary illnesses and diseases. Without fossils, we would have no way of knowing what happened on earth billions of years ago, or how organisms such as us humans came to be.

Agenda

- Introduction (5 mins)
- Module 1: Are you my mother? (10 min)
- Module 2: Evolution (15 min)
- Module 3: Relative Dating (10 min)
- Module 4: I dig it! (15 min)
- Conclusion (5 mins)

Introduction

Begin by asking the mentees if they know any prehistoric animals (ie. dinosaurs, sabertooth lion, mammoth). Discuss with them how we know about these animals through fossil specimens. Explain how fossils are not just bones we find in the ground, but also traces of things such as imprints in fossilized mud or objects preserved in amber.

Module 1: Are You My Mother?

Introduction

Mentees will learn about how to identify animals based on what their fossils look like and also gain skills and intuition regarding the evolution of animals and how their bone structure changes. Mentees will also learn what defines and separates a species from another.

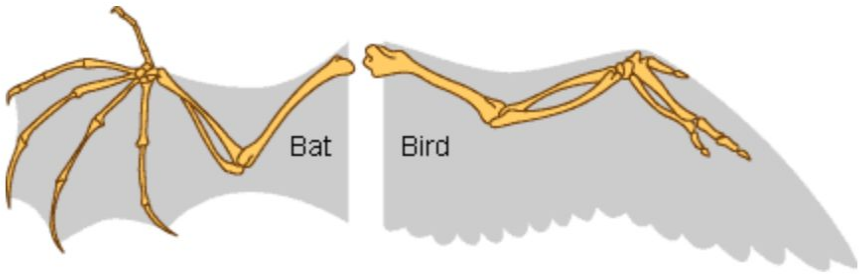
Teaching Goals

1. **Evolution:** The change in characteristics of a species over generations usually through natural selection
    a. We can understand how animals evolved by looking at their:
        i. **Skeleton:** The body part that forms the supporting structure of the organism. The structure can be internal or external. Fossils represent parts of the skeleton that allow us to understand how a certain organism was structured, how it walked, what it ate, and many more factors.
        ii. **Homologous structures:** similar structures (such as bones) found in organisms which indicate common ancestry
            1. Ex. forelimbs of mammals
        iii. **Analogous Structures:** similar structures found in organisms which are a result of similar environmental conditions rather than similar ancestry
            1. Ex. bird vs. insect wings

Background for Mentors

The current classification of fossils is based on how they are categorized into various species. In our lesson, we will be focusing on the definition of a species based on the **morphological species concept**, which states that similar structures may indicate two organisms belonging to the same species. This varies from the **biological species concept,** which states that organisms of the same species should be able to naturally interbreed and produce fertile offspring. The biological species concept, however, cannot be used for organisms/species that are no longer alive, as they cannot be observed breeding. The biological species concept also cannot be used for asexual organisms.

The morphological species concept, which we will be using, may have a shortcoming due to the presence of analogous structures. Analogous structures may look like an indication of the same species, but they are actually due to **convergent evolution**. An example of analogous structures include the wings of bats and birds, as they evolved independently from each other and do not signify common ancestry. Homologous structures, however, would be the arms of humans and the wings of bats, which do stem from common ancestry, as both are mammals.



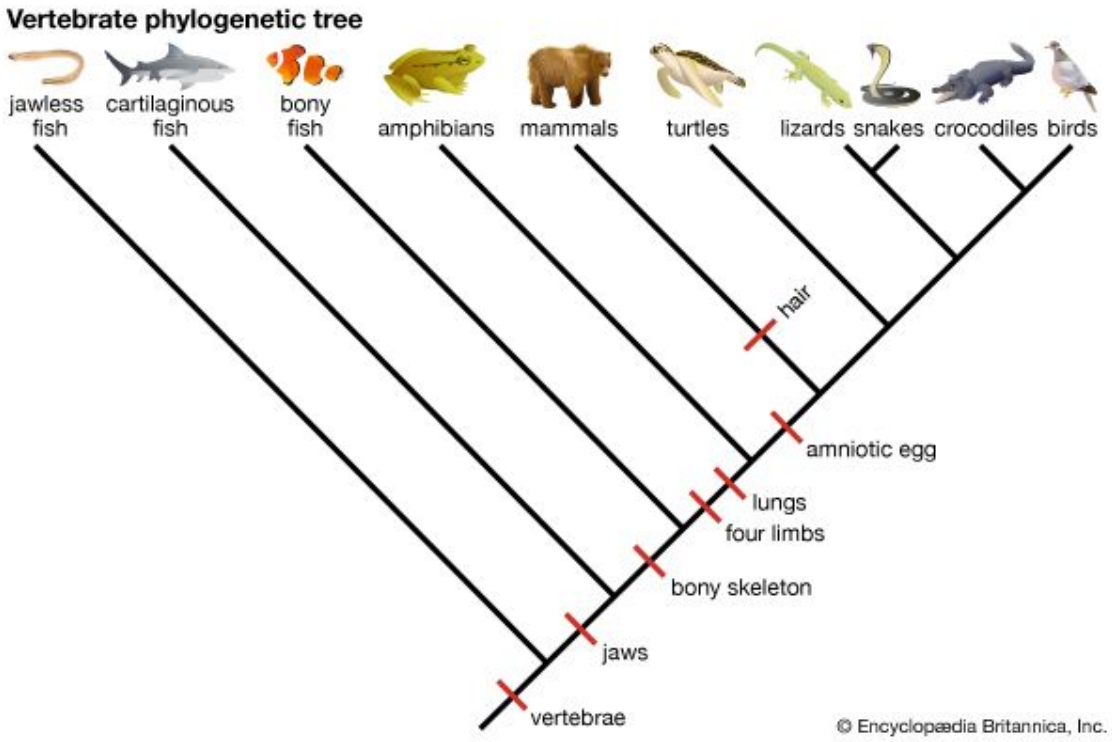
Analogous structure. While bats and birds have similar shaped wings, they are not related to each other; their respective species evolved independently

Materials

- 5 sets of photos of fossils (each set in a Ziploc bag)
- Strings (to connect fossils that evolved from each other)

Procedure

1. Have mentees get into groups of 4-5 and pass out the photos, strings, and tape.
2. Have mentees identify similar structures in the images
    a. Ask them if they know if the structures are homologous or analogous just based on the information that they have
3. Mentees should use string and tape to tape the photos to form an order of animals that evolved from each other.
    a. Older animals should be at the bottom, more recent animals should be at the top



Additional Notes for Mentors

The mentees most likely won't have background information about the organisms we use in the activity, so they'll have to rely on visual similarities. It is okay if their evolutionary history is not necessarily accurate, as long as they are able to justify with evidence why they believe certain animals are related.

<u>Module 2: Evolution</u>

Introduction:

This module is to show how natural selection can cause evolution. By creating their own beak that may or may not work to pick up the objects (representative of food), mentees will learn how selective pressures, such as lack of food, can cause certain animals to survive better than others.

Teaching Goals:

1. **Evolution:** Although already covered in the first module, it should be emphasized again to include the process of natural selection as the driving force of evolution. Evolution occurs when animals develop favorable adaptations over time.
    a. **Adaptations:** Traits an organism has that allow it to survive and produce offspring more successfully than other organisms, specific to its environmental demands

    b. **Natural selection:** The process by which organisms with favorable adaptations survive better and are able to pass down their traits to their offspring, while those who do not have these traits are unable to survive
2. **Engineering Design Process**: the process that engineers and scientists use as they test and improve methods to complete a task.

Background for Mentors:
Fossils are often a useful tool in better understanding the process of **evolution**, and the different ways that various organisms have changed over time. Evolution was defined by Darwin as "descent with modification," which highlights how small changes within species can lead to great changes over time in populations. The mechanism by which evolution functions through is called **natural selection**, which refers to the greater survival of organisms with favorable traits for the specific environment. Organisms are thus able to survive and reproduce, passing on these favorable heritable traits to their offspring, and ultimately promoting the trait throughout the species. The degree to which an organism is well suited and able to survive in its environment is called **fitness**.

In order for the process of natural selection, and ultimately evolution, to take place, several factors must be present. There must be genetic variation throughout the population, which may arise from sexual reproduction and gene exchange, or through mutation. Furthermore, there must be overproduction of offspring in order for the environment to put selective pressure on the population and some adaptations to become desirable over others. The beneficial traits must also be heritable, meaning that they exist in the genes of the individual, and can be passed onto offspring, in order to perpetuate the trait. Lastly, differential fitness, or varying ability to adapt to the environment must be present.

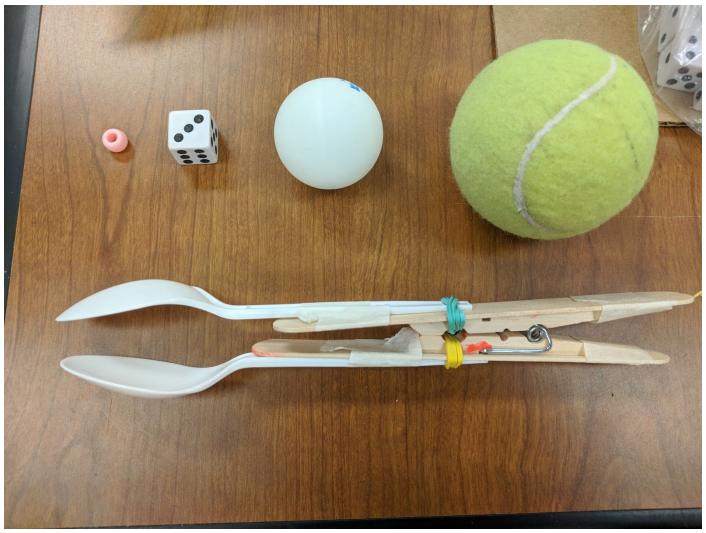
In this module, the differential fitness is represented by the shape of the beak which varies throughout individuals. The type of "food" present will represent the environmental pressure, which will induce natural selection for more favorable beaks. Throughout generations, a pattern of evolution will thus be seen for the more useful beak type, as long as the environmental pressures do not change, and the type of food remains the same. It is important to note that evolution takes place within populations and over time, not in individuals.

Materials:
- 1 clothespin per group
- 2 popsicle sticks per group
- 2 spoons per group
- 2 straws per group

- 2-4 rubber bands per group
- A set of 1 bead, 1 die, 1 ping pong ball, 1 tennis ball per site
- 2 rolls of tape

Procedure:

1. Explain how natural selection allows for certain traits to be passed on
    a. Explain the four conditions that need to be present in order for natural selection, and eventually evolutionary change, to occur
2. Demonstrate that the clothespin can pick up the bead, and show how it can't pick up the die or anything bigger than that
    a. Explain how this represents suitability to the environment
3. Pass out materials and allow students to use the engineering design process to try to create their own beak to pick up the bigger objects (dice, ping pong ball, tennis ball). The goal is to design something that can "eat" any given object, but students can also aim for designs targeted at single types of objects to start with.
4. Have students take turns coming up to the set of food in the front of their room to test their "beaks"



Beak Characteristics. As the type of "food" changes in the environment, birds need to adapt so that they can eat. Or else, they starve and die out due to natural selection.

Additional Notes for Mentors

You can also talk about Darwin's observation regarding finches and how their variation of beak sizes in different areas of the galapagos were evidence of natural selection. Also, make sure to warn the mentees beforehand to not injure themselves with the clothespin. Furthermore, mentees

may get frustrated being unable to pick something up, so make sure that no materials get broken in frustration.

Module 3: Relative Dating

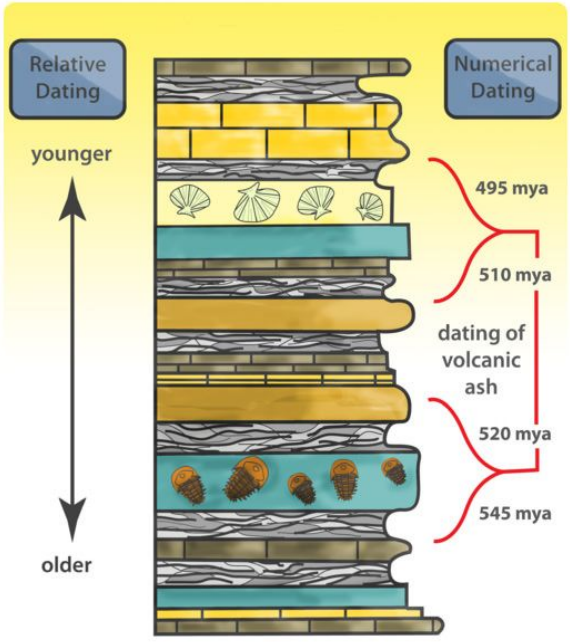
Introduction

Mentees will learn about relative and absolute dating, which are important methods for understanding the order in which events occurred.

Teaching Goals

1. **Absolute Dating**: The method for figuring out the exact age and chronological order of geological and archaeological events.
    a. Absolute dating is based on the physical, chemical, and biological properties of materials and objects at the site. The most common example is using the radioactive decay of carbon.
2. **Relative Dating:** The method for figuring out the order of events in respect to other events, without necessarily having an exact age.
    a. For advanced sites: When you are in an amorous engagement with another individual traveling at the speed of light.
    b. Relative dating can be performed by studying **stratigraphy:** the branch of geology concerned with the order and relative position of strata and their relationship to the geological time scale.
        i. **Strata:** A layer of sedimentary rock or soil, or igneous rock that was formed at the Earth's surface, with internally consistent characteristics that distinguish it from other layers.

Background for Mentors



Stratigraphy is an important field that allows paleontologists to determine the relative order of geological and archaeological events. Layers closer to the Earth's core are older than layers closer to the surface, which is how paleontologists can determine that the organisms in one layer came before the other.

Relative dating is not completely accurate sometimes, since natural events that alter Earth's geography such as landslides or earthquakes can

alter these strata, or layers, in a way that makes it hard to determine the true order of the fossils.

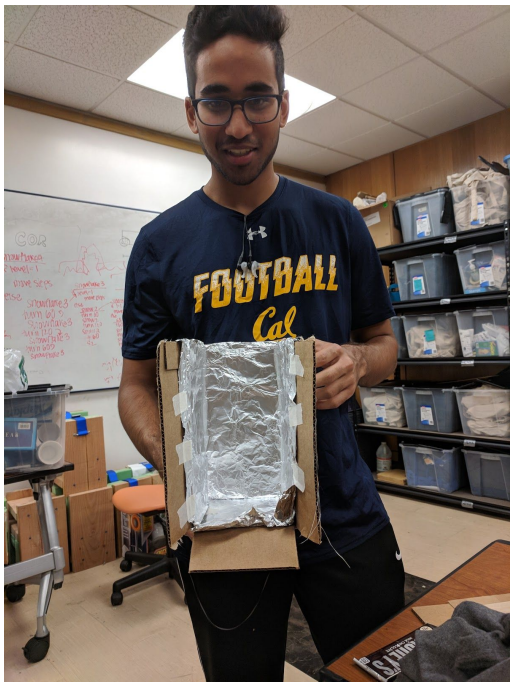
Here is a really interesting video that demonstrates how the layers can get messed up by natural disasters: GIF Stratigraphy speeded (excerpt from animation)

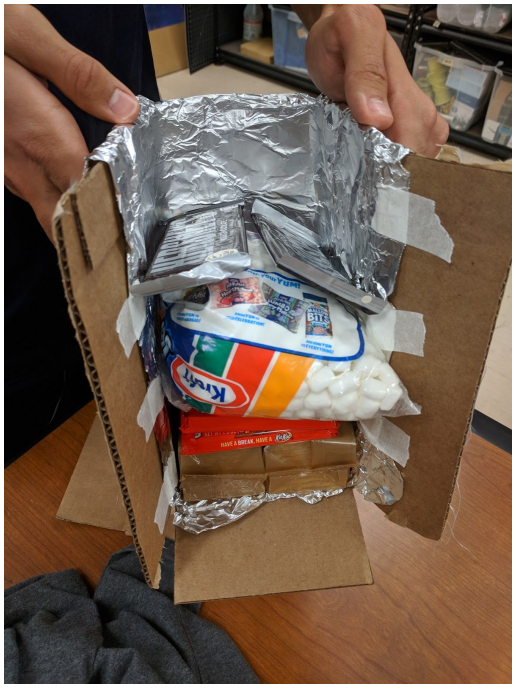
Materials

- 1 roll of tinfoil
- 2-3 pairs of sterile gloves (for mentors)
- 1 pack of Graham crackers
- 2 Cookies and Cream chocolate bar
- 2 Kit Kat
- 2 Hershey's milk chocolate bar
- Small paper cups or napkins, for passing out food

Procedure

1. Have a cardboard box with 4 sides that is lined with tin foil.
    a. The purpose of the walls is to hold the food in place but also make sure that the mentees can see what's going on as you make new layers.
2. Add the graham crackers into the tray and say that that is our initial layer of earth.
3. Add the rest of the chocolates in any random order, and make a story out of it.
    a. For example, you can say there was an ice age, and lots of sediments were brought in by a glacier - this would correspond to adding the cookies and cream bar.
    b. Another example - there was a volcanic eruption, so there was a layer of molten lava that became was deposited on top of the earth. Then add the Kit Kat.
    c. A third example - The ice age ended and plants started to grow again. Plants need soil to grow, so the corresponding layer would be the Hershey's bar.
4. At the end of the story, the food should be very distinct, so the mentees will be able to see how these are very similar to strata on Earth.
    a. Emphasize that the lower layers are the ones that were previously deposited, and relative dating allows us to know the order from oldest to youngest based on their positions.
5. Have one mentor cut up the candy and pass it out to the mentees.
6. At the end of the demonstration, if a board is available, draw out the layers of the Earth and add fossil remains in the layers. By using the fossil pictures from module 1, mentees will be able to see that relative dating and comparing structures both allows us to draw the same conclusion about evolutionary timelines.





Demo Setup: Handsome alpha male with school spirit holds up container that will be used to hold candy. The container is a 4-sided box lined with tin foil. The food is layered inside the box so that it is clear and obvious that each layer is distinct.

Additional Notes for Mentors

You can ask the mentees to name events that would result in a new layer being deposited, so that they can be engaged in developing the story. Emphasize that older layers are closer to the center of the Earth. Also make it very clear that if anyone is disrespectful while the demo is going on, no one will get to eat the candy at the end.

Module 4: I Dig It!

Introduction

Mentees will learn about the process of excavation and the difficulties in removing something fragile from the Earth.

Teaching Goals

1. **Fossils:** the remains or impression of a prehistoric organism preserved in petrified form or as a mold or cast in rock.
2. **Excavation:** the act or process of digging, especially when something specific is being removed from the ground.

Background for Mentors

The process of excavating a fossil is complex. To start, dinosaur fossils are usually found within **sedimentary rocks,** and so many paleontologists look for sedimentary rocks formed at a time when dinosaurs lived. As for the process of excavating itself, **field crews** usually have many tools. To break through the harder rock, they use shovels and even jackhammers. However, as they get closer to the bones they use smaller tools such as picks and rock hammers. Furthermore, they often discover fossils that are crumbling, and use special glues to help keep the pieces together.

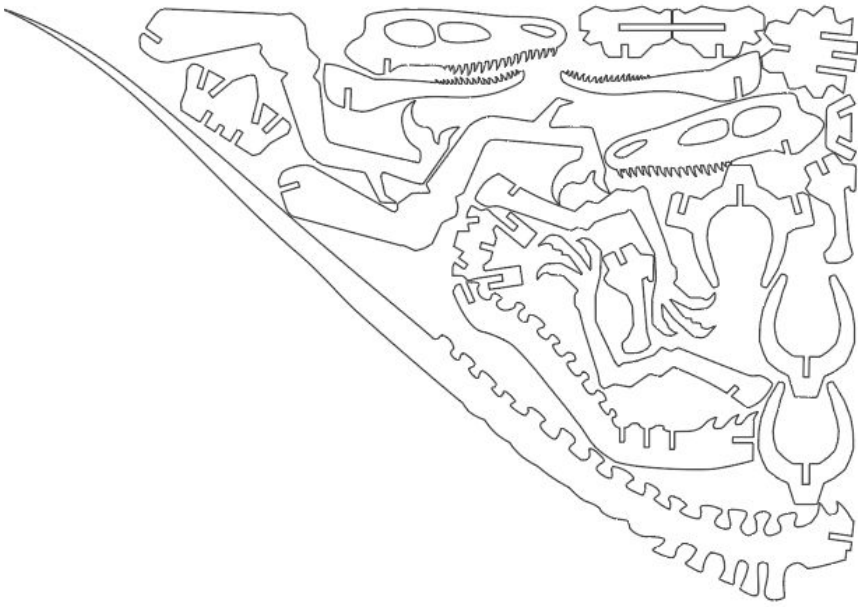
Essentially the process of excavating has many steps--all unique to the environment in which the fossil is found and the step of excavation that the crew is in. Because fossils are very old and delicate, field crews require many different types of tools, all specific to the situation to help them uncover what they're looking for.

Materials

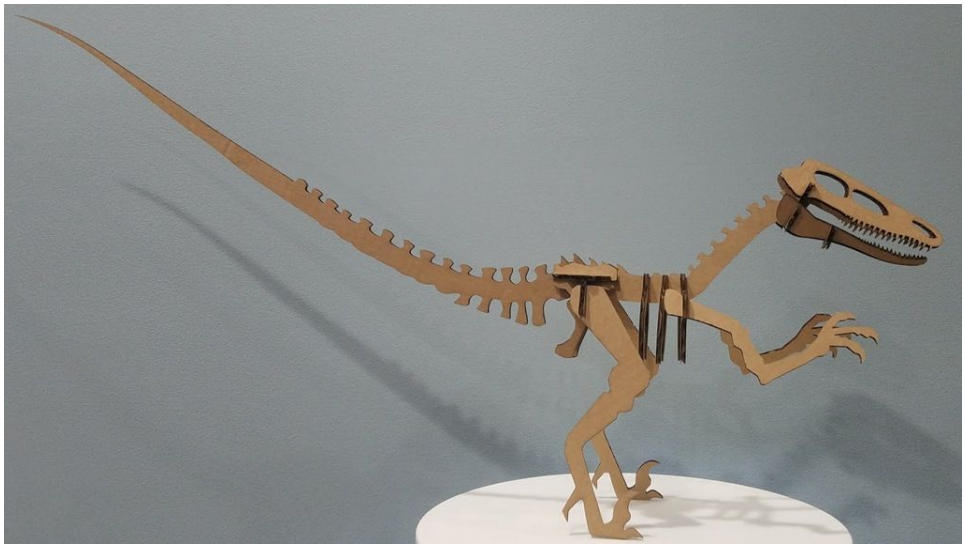
- 2 Containers of Play-doh per table
- 3-4 popsicle sticks per table
- 5 dinosaur piece sets (laser cut)
- 2-3 Toothpicks per table
- 2 spoons per table (plastic, metal)

Procedure

1. Provide premade excavation "plots" to each group of mentees
    a. Plots consist of play-doh with pieces of fossil puzzles buried inside
    b. Every group will receive the same puzzle, which is pretty fragile.
    c. The important part to emphasize here is how the tools must be used delicately in order to not damage the fossils. To vary the difficulty, leave 1 or 2 pieces missing per puzzle, to simulate real life

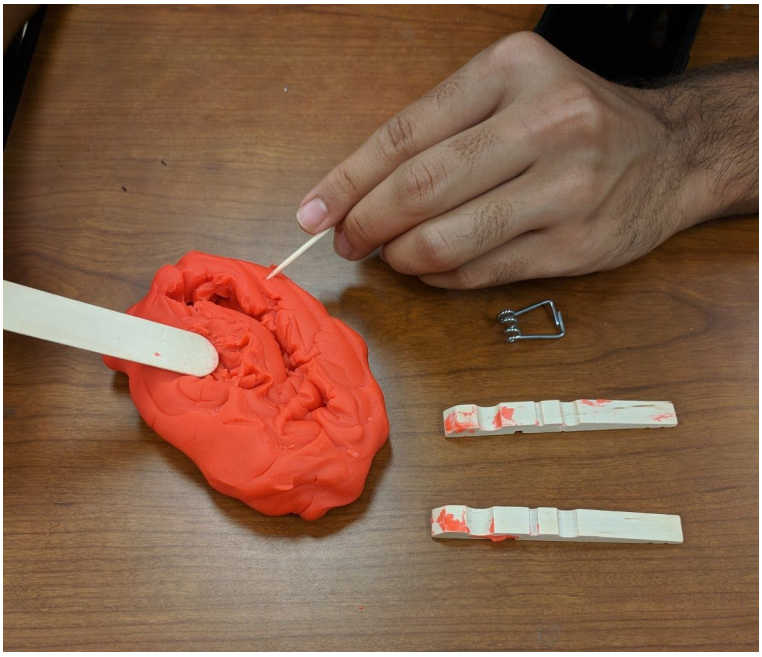


These are the puzzle pieces



They should assemble to look like this

2. Have mentees dig for and clean up pieces of fossils hidden inside the play-doh.
    a. Tell the mentees that their goal is to minimize damage to the land, since real life excavators do not want to damage local habitats and terrain.
    b. Emphasize again that the fossils are delicate, and they should be careful while uncovering them.
3. Once they find all the pieces, mentees should try to fit the pieces together and determine what type of fossil they dug up.



Excavation: The play doh is minimally damaged since we don't want to destroy the landscape during excavation. Only the toothpick and popsicle stick were used to pull out the pieces.

Additional Notes for Mentors

Have the kids think about what order they should use the tools in - you wouldn't start off with the toothpick and you wouldn't do the delicate excavation with a spoon. If they get stuck assembling the puzzle, have them think about the previous module and see how the pieces look like they would fit into that picture to identify what part of the dinosaur it is.

Conclusion

The field of paleontology, the study of fossilized organisms, can be very imprecise because of the lack of information paleontologists have. However, through tools like absolute and relative dating as well as utilizing evolutionary history of organisms, paleontologists can piece together all that data in order to gain a better understanding of the past. Scientists often have to use indirect ways to gain information about the things they want to learn.

References

- *Understanding Evolution*, UC Berkeley. https://evolution.berkeley.edu/evolibrary/article/side_0_0/biospecies_01
- *Paleontology,* National Geographic. https://www.nationalgeographic.org/encyclopedia/paleontology/

Summary Materials Table

Material	Amount per Group	Expected $$	Vendor (or online link)
Pictures of fossils	1 bag with 8ish pictures per table (4-6 students)		
String	One spool per site		Inventory
Tinfoil	One roll per site		Inventory
Sterile gloves	2-3 pairs per site		Inventory
Graham crackers	One box per site	$3	Amazon or Target
Hershey's Cookies and Cream chocolate bar	2 bars	$4	Bear Market/ Target
Hershey's milk chocolate bar	2 bars	$4	Bear Market/ Target
Kit Kat	2 bars	$4	Bear Market/ Target
Play doh	Two boxes per table (4 -6 students)		Inventory
Popsicle sticks	Two dozen		Inventory

Dinosaur puzzle pieces	1 dinosaur per table (5 total)		Jacobs Pass
Toothpicks	One box		Inventory
Spoons	10 plastic 10 metal		Cafe 3/ inventory