Stratigraphy Cake
A hands-on investigation into making sense of the fossil record

Introduction
How do evolutionary biologists tell a story about change over time using the fossil record? How do they know when biological events took place? In this activity, students will take on the role of evolutionary biologists and use absolute and relative dating to paint a picture of how species and environment changed over time. They will take part in a fossil dig, use radiometric data to determine the absolute age of an ash and intrusion layer, create a timeline based on evidence from their own dig and their peers’ data, and create and argue an evolutionary story based on evidence.

NGSS Science and Engineering Practices
● Developing and using models.
● Analyzing and interpreting data
● Constructing Explanations and Designing
● Engaging in Argument from Evidence
Materials Needed (see Resource Section for purchase links)

For Class Activity (per group)
1 cross section of cake (see below)
toothpicks or popsicle sticks
small brushes
2m strip of register tape (or poster paper)
markers
plain white paper

Cake (makes enough for 6 groups)
Loaf pan
Small shells and/or other “fossils” (a few varieties)
Double recipe of salt dough (or Play Doh)
Food Coloring
Rolling pin
Sand
Sharp, non-serrated knife
Plastic wrap

Preparing the Cake
1. Prepare double batch of salt dough or obtain neutral colored Play Doh (enough to fill the loaf pan)
2. Use sand and food coloring to create three distinct balls of dough. These will become the sedimentary layers, and should be visually distinguishable from one another).
3. Create two smaller balls of dough using food coloring to create two distinct colors. Here we have used green and yellow.
4. Decide on the placement of the shells or fossils within the layers. The fossils you choose will depend on the evidence you want your students to gather. For example, you might choose a mix of shells in each layer with new shells appearing in the second layer, and one group disappearing in the end, allowing students to focus on the evolutionary relationships and possible extinction events. Or, you might choose to have some layers with fossils representing a marine environment and other layers representing a land environment.
5. Layer the pan with plastic wrap. This will make the cake easy to remove when you are ready.
6. Place the bottom sedimentary layer in the pan and gently press it down. It should be about 1 inch thick.
7. Sprinkle the shells on top of the layer so that they appear randomly mixed. Gently press them into the dough. Add enough dough of the same color to cover them.
8. Now, use one of the colored balls of dough to create a thin volcanic ash layer. Roll it out and place it on top of the first sedimentary layer. Trim the excess with a knife.
9. Create a second sedimentary layer. Again add the selected fossils, gently press them in, and cover them with dough that matches that layer.
10. Remove the cake from the pan and create a diagonal cut lengthwise in the cake. Split the cake in two.

11. Roll the second ball of colored dough thin and place it along the split. This will represent the igneous intrusion. Place the layers together gently. Remove the excess from the edges and place the cake back in the pan.

12. Create the final sedimentary layer, again adding the fossils and covering them with matching dough. Refrigerate until ready to begin the activity.
13. When ready, remove the cake from the pan carefully and slice horizontally into 5-6 pieces (depending on how many groups you have) and wrap individual slices in plastic wrap.

Preparing the Activity
1. Gather materials students will need to create a timeline of their findings. Include markers, copy paper, timelines (see below)

2. Using register tape or strips of poster paper, create a 2-meter timeline for each student. Students can also determine how to create these themselves based on a 500 million year section of time. Be sure to check for accuracy during the process so that timelines are comparable in the end.

3. Decide how you will give students the dates of the ash layer and intrusion layer. If the students have practiced looking at ratios of radioactive and daughter isotopes, you can provide them with ratios and the half-life of the material so that they can determine the date. See Radiometric Dating Activity sheets for more information.

**To Do and Notice**

1. Distribute a slice of cake, timeline, and papers for drawing to each group of students.

2. Before students begin digging into the layers, have them look carefully at the layers, sketch a diagram of their slice, and address the following questions on their paper:
   - Which layer is the oldest? How do you know? Can you be sure from the information you have?
   - Which layer is the youngest? How do you know? Can you be sure from the information you have?
   - How do you think each layer might have been formed? What order do you think they formed in?

3. When students are finished, provide radiometric dating data for the ash layer and igneous intrusion layer. (We used an age of 251 million years for the ash layer and 192 million years for the intrusion.)
   - What is the absolute date of the ash layer? What information does this provide about the surrounding layers?
   - What is the absolute date of the igneous intrusion layer? What information does this provide about the surrounding layers?
   - Note on the diagram the age (relative or absolute) of each layer.

4. Next, students will excavate the site and remove the fossils. For each layer, they should 1) sketch the type of fossil and 2) record the number found. Next, they will then place them on the timeline using the ages they have determined for each layer.

5. Have students create a story of how the species and environment at this site changed over time. They may use the following questions:
   - What patterns do you notice in the species present over time?
   - What possible explanations are there for changes in the species present over time?
   - Do you think there is an evolutionary relationship between the species?
   - What can you infer about the environment at this site? Do you think it changed over time?
   - What evidence do you have to support your ideas?
6. Finally, have all groups put up their timelines together. Does more data change the stories?

What’s Going On?
Even with the advent of DNA analysis to study relatedness, the fossil record provides a powerful line of evidence for evolutionary change throughout earth’s history. By the principal of superposition, we know that streambeds are formed particle by particle, deposited from the bottom up, so that lower layers are older than higher layers. Absolute dating can be used to determine the ages of igneous rocks, and thus the age of the sedimentary layers obtained relatively. As information is gathered from various excavation sites that encompass different time periods, a more defined understanding of evolution of organisms over time can be determined. A major point to consider in this activity is that only a small area has been excavated for fossils. Also, fossil formation is extremely rare. Because a layer does not have a particular fossil, or it does not appear after a certain layer, may only mean that the organism did not fossilize or has not been found.

Students’ stories of the evolution of the species and changes in the environment will differ. This mimics the process of science – finding alternate explanations for evidence. Students gain experience at developing explanations that are supported by evidence, and at seeing that these explanations are debated among scientists and modified as new evidence is uncovered.

Going Further
As an extension or an alternative, it is possible to create different cakes that represent different dig sites. There may be layers that overlap in terms of geologic time. This is a good way to have students rely more on one another’s data and to understand how fossil distribution may differ in different geographic regions. It is also a great way to introduce the idea of an index fossil, a fossil for which we are able to obtain an absolute date based its wide geographic distribution.

Background Information
How fossils form
Fossilization is a rare event that requires a complex set of circumstances. Usually, an organism simply decays with no remains preserved over long periods of time. Fossilization of an organism is actually extraordinarily rare. For a cast fossil to form, the organism must be buried by sediment, a mold of the bones turned to rock by the pressure, and the space filled with minerals when the bone dissolves. In this activity, we are using shelled animals. While the hard parts may dissolve over time, the mold left by the impression can be filled with minerals forming rocks over time.

Radiocarbon dating
For fossils 50,000 years old and younger, scientists can date the fossils themselves using radiocarbon dating. Living organisms contain three types of carbon in a fixed ratio with radioactive carbon, C14, being the least abundant. In living organisms,
because the organism is constantly exchanging carbon with its surroundings, the level of radioactive carbon is constant reflecting the fixed ratio in the atmosphere and hydrosphere. When an organism dies, that exchange stops and the radioactive carbon present in the organism begins to decay. Because C14 decays at a set rate with a half-life (the time it takes for half of the radioactive element to decay) by comparing the naturally occurring percentage of C14 to the percentage of C14 in the organism’s remains, scientists can determine when the organism died. After 50,000 years or so, there is not enough C14 still present in most samples to determine the age. In using radioactive materials to date fossils, we are able to determine the absolute age.

Clocks in Rocks
If a fossil is more than 50,000 years old, scientists must instead turn to surrounding rocks to determine dates. The difficulty lies in the fact that while fossils are embedded in sedimentary rocks, sedimentary rocks cannot be dated. Like fossils, rocks also contain minerals with radioactive isotopes. However, because sedimentary rocks are composed of a jumble of minerals from various places and times, chemical analysis of the radioactive isotopes would not provide an accurate date. In this case, there are two other methods scientists use. The first is called relative dating. Scientists can use the horizontal order of the layers to determine which is the oldest – the oldest layers forming first and comprising the bottom, and the youngest creating the top. Sometimes the layers are folded changing the order, but generally geologists can determine the original order based on surrounding information.

Scientists can also determine the ages of igneous rocks or ash. Unlike in radiocarbon dating where scientists look at the ratios of naturally occurring carbon, when minerals crystalize in igneous events, one form of the isotope is generally present. By comparing amounts of the original isotope with a known half-life to the amount of the daughter isotope (what it decays into), scientists can determine how long ago the event took place. For example, Uranium 235 (U235) decays into Lead-207 (Pb207) with a half-life of 704 million years.

This activity addresses two ways that information in igneous rocks can be applied to fossil dating. The first is volcanic ash. If ash is present (represented by the green layer in the instructions above) we know that all of the layers beneath it are older than the ash. The minerals here can give us an absolute age for the ash layer and a relative age for the layers beneath. The other event included in the activity is an igneous intrusion. These may be vertical creating dikes or may run horizontally along the sedimentary layers forming sills. Like the ash, the age of these can also be determined using radiometric dating. Because these originate below the earth’s crust, sedimentary layers that do not contain the intrusion must have formed after the intrusion.

Recommended Resources

Play Dough Recipe - Triple this recipe to make one fossil loaf of the thickness we used. Any kind of food coloring will do.
For fossils, we used a selection of shells from this assortment, and these leaf charms. You could also cut leaf fossils from a plastic folder.

*Half Life of Pennyium* – Classic activity to demonstrate radioactive decay
[http://bccp.berkeley.edu/o/Academy/pdfs/Penny_HalfLife.pdf](http://bccp.berkeley.edu/o/Academy/pdfs/Penny_HalfLife.pdf)

*Radiometric Dating* (content) – This description for teachers describes how radiocarbon dating and radiometric dating of rocks is used to determine ages of fossils. Interactive quizzes help make sure you have the concepts as you move through the information.

*Radiometric Dating (simulation)* – This PhET simulation for students allows them to tackle ideas of radioactive decay and half-lives.

*Sedimentary layer dating* – Use the thickness of shale layers to determine the age of the layers based on what we know about the time it takes for individual layers to form.
[http://www.indiana.edu/~ensiweb/lessons/varves.html](http://www.indiana.edu/~ensiweb/lessons/varves.html)