It's a Date
Activity Facilitation Guide

NATIONAL MUSEUM *of* NATURAL HISTORY
Smithsonian

Cart or Table Activity

Materials and Set-Up

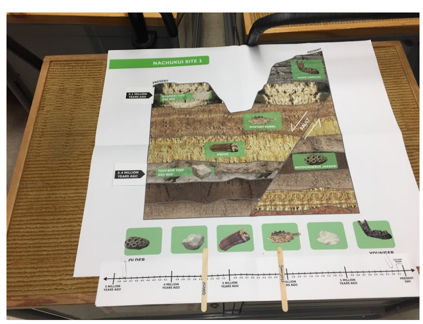
MATERIALS:

- Hillside gameboard
- 4 fossils (*Notochoerus jaegeri, Equus, Homo erectus, Homotherium*, 2 rocks from ash beds)
- 2 date cards
- 2 magnets
- Fault slice
- Timeline
- Index fossil sheet

SET-UP:

Place the fossils on the cart or table or on edge of board if you want more of an "attract".

Have other materials at hand ready to bring out as described in the Activity Flow below.



It's a Date Activity Overview

Activity Goal	Visitors use relative and absolute dating techniques to estimate the age of a mystery fossil.
Activity Summary	Visitors are presented with a collection of fossils from the Turkana Basin in Kenya and asked to determine the age of a mystery fossil. They then see a hillside with stratigraphic layers where the fossils were found. With this reference, they arrange the fossils in relative order from youngest to oldest. They are then given absolute dates of ash layers that bracket the mystery fossil, so they are able to provide an age range. Finally, they are shown evidence from other hillsides in the area that show the earliest date for a fossil--*Equus*, an index fossil in Africa--that is found in a layer below the mystery fossil, enabling the visitor to narrow the age range even more.

Learning Objective: What visitors think, feel and do during the activity	Visitors will: • Understand how layers of rock form so that fossils found in lower layers are older than those found in higher layers • Understand that volcanic ash layers contain specific elements that can be analyzed to get absolute dates • Order fossils and rocks from different stratigraphic layers on a horizontal timeline from youngest to oldest • Use absolute dates and index fossils from layers surrounding a mystery fossil to narrow in on a date range for that fossil • Feel like they're doing science.
Learning Outcomes: New understandings or changes in perspective that result from activity	We anticipate visitors who participate in this activity are more likely to: • Begin to understand how scientists understand the history of the Earth, and how they estimate the age of rocks, fossils and the planet • Apply their experience when they see how old other rocks and fossils are throughout the museum and beyond. • Feel more comfortable and confident engaging with science, independently and as a group or family.
Target Audience	Families with children 8-12, but adaptable for all.

Activity Flow

What to say	What to do
HOOK ***[INSERT YOUR OWN HERE]***	⟹ Differentiate according to audience
INTRODUCTION *We found these fossils in the Turkana Basin in Africa. I'm especially interested in figuring out how old this fossil is.* *Do you have any ideas about how old these are just looking at them?*	⟹ Have fossils (not the rocks) on the table in front of the visitor. Have them along the edge of the board if you want more of an "attract". Point to the homotherium (early cat) fossil. (You can explain these are just small copies of the original fossils). 

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How do you think I might figure it out?

What if we know where they were found? Could that help?

Yeah. Let's take a look at the hillside in Africa where these were found and learn how paleontologists figure out the ages of fossils.

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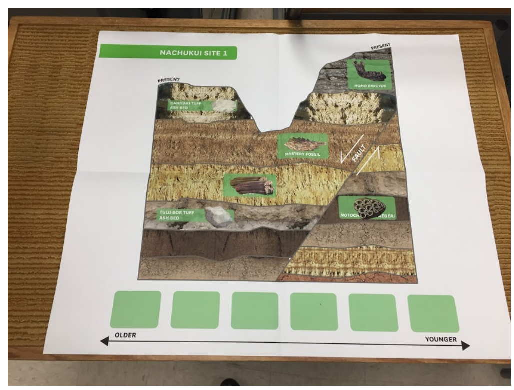
⟹ **IF they try to guess** you can say: *What information did you use to make that guess? Sometimes color and erosion can be deceptive.*

⟹ If they say dating, explain that most fossils don't contain the specific elements we can use to date other kinds of rocks.

⟹ Bring out/reveal the board with a picture of the hillside on it.



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GUIDED PARTICIPATION

PART 1. Relative Dating

Looking at this hillside, what do you notice?

You can see this is the present day, and the layers go back in time.

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⟹ Give visitors time to take in the hillside.

⟹ Respond, then walk them through as you place the fossils

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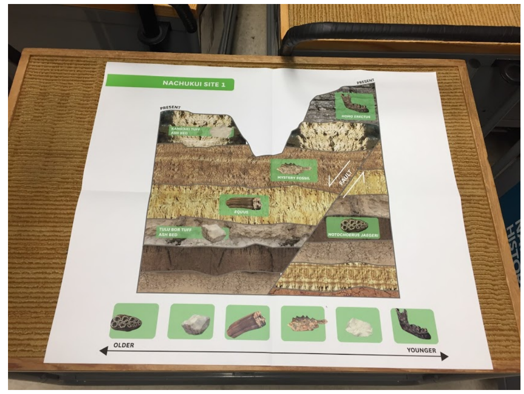
So, let's place these fossils in their layers. We have a horse tooth, this is a jaw of an early human, we have a pig tooth and we have a skull of an early cat. *Here is a rock from an ash layer and another rock from a different ash layer.* *The first thing we do as paleontologists if we want to date something is look at the rock layers and see if that can help us work out how old it is.* *Can you tell me which of these layers are oldest and which are most recent?* ***[VISITOR ACTION]***	and the two rocks in their layers, naming them as you go. ⇒ **IF they are STUCK** figuring out oldest vs. most recent layers, say something like this: If you pretend this is a hillside, this is the present day. If a layer is at the bottom, do you think it got put down before or after a layer on the top? Right, a long, long time ago, this was the top layer. Then a flood happened or loads of sand was blown in over thousands of years, and this layer built up. Then there was a volcano and all the ash from that volcano created this layer. Etc. . .

Now that you know that, can you work together to put these rocks and fossils in order from oldest to youngest?

[VISITOR ACTION]

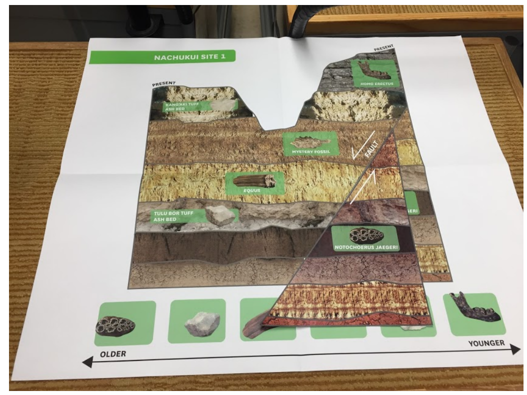
So you did the right thing, if it's older it's lower in the stratigraphy, in an older rock layer.

⇒ Guide them to use the green timeline at the bottom of the board to place the rocks and fossils.



⇒ **IF they get STUCK on FAULTS:** If they get the ash layer and pig tooth backwards, you can say something like: There's a trick in this hillside. You see this fault? It means that some force, like an earthquake, deep in the earth caused a fracture that made this earth move up and all this earth move down.

⇒ You can use the extra hillside slice to show them the physical movement and ask: Where do the layers match up?



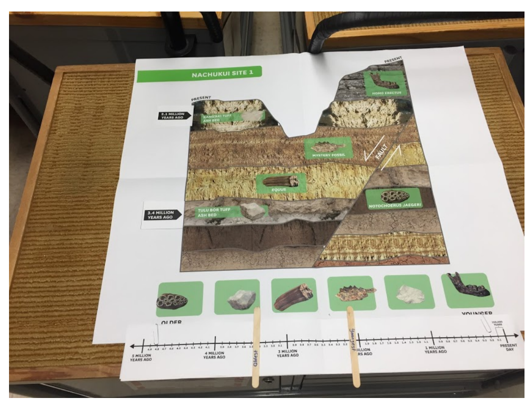
PART 2. Absolute Dating

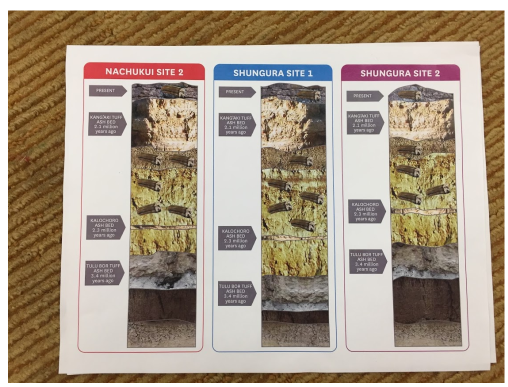
So, you've put the fossils in relative age order, but we still don't what they age they are. And remember, we're still trying to figure out the actual age of this mystery fossil.

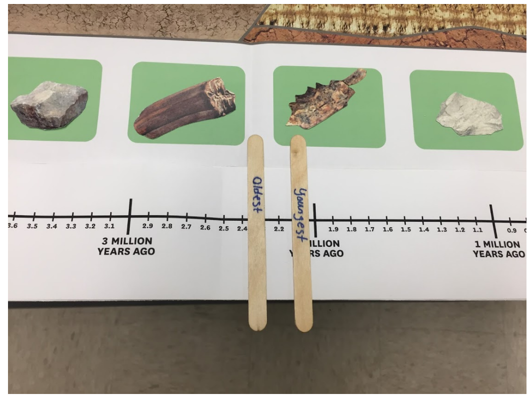
Paleontologists have learned that some layers are really useful for getting absolute, or real dates.

Here and here we have two layers of ash that got laid down when a volcano erupted. And we love ash layers because they have elements in them that we can use to get absolute dates. We use a special analysis,

⇒ Place the time cards for the ash layers and give the visitors the time scale.



called radiometric dating, to find out exactly how old it is. *So, looking at the mystery fossil in relation to the ash beds, what's the oldest the mystery fossil could be and what's the youngest? How would you show that on the timeline?* ***[VISITOR ACTION]*** *Great! So we're narrowing in a bit. If you look at the hill, is there anything that you see that might be able to help you narrow it more? If you got more information about it?* *If you knew more about Equus, how would it help you?* *Yes, Equus is actually a special fossil, called an index fossil, for telling us about time. This is just one hillside in the Turkana Basin. But we have other hillsides, and they have some of the same layers. Do you see any extra information in here that helps you narrow it down?* ***[VISITOR ACTION]*** *Can you talk to me why you chose to move it up to 2.3 million years?* *If you're looking for the horse fossils, you're right that they are all above that bed. These*	⟹ Give them the Index Fossil reference sheet. 

places are all real places in the Turkana Basin in Africa. And these are all volcanic tuff layers. And we know that the first places horses lived in Africa was 2.3 million years ago. So if we find anything above Equus, the index fossil, we know it can't be older than 2.3 million years.	
WRAP UP/RELEASE: *This is a fossil called homotherium, a type of cat, and when scientists at the museum found it, they did the same things you did to date it. Now you've done just what paleontologists do.* ***[INSERT YOUR OWN HERE]***	⇒ Identify the science skills the visitor used in the activity. ⇒ Tie it into what they may see out in the world like rock layers in road cuts along highways. ⇒ Direct them to other parts of the museum for related content.

Background Information: It's a Date

People generally understand that paleontologists work on fossils of organisms that lived long ago. But how are paleontologists able to figure out the age of a particular fossil? For that, we need to look not only at the fossils themselves, but also the rock layers that they were discovered in. To find approximate ages, we use **relative dating**, which involves studying the orientation of layers of rocks and the fossils found within them. To find more precise ages, we use **absolute dating**, which involves **radiometric dating** using the radioactive elements that can be found within rocks.

Relative Dating

To figure out the relative ages of rocks and fossils, we first need to understand how rock layers are deposited. If you have ever looked at exposed walls of rock, you may have noticed that you can often see layers within these walls. Layers of rock are known as **strata**, and the study of these rock layers is called **stratigraphy**. A man named Nicolas Steno, who is considered one of the founders of modern geology, is known for developing many of the core principles of stratigraphy such as the **law of superposition** and the **principle of original horizontality**.

The law of superposition states that, assuming the strata have not been deformed, the oldest layers will be at the bottom. All rocks are constantly being weathered and eroded into smaller pieces of sediment and, eventually, these sediments settle and are deposited in layers through a process known as **sedimentation**. An older layer must exist in order for a new layer to be deposited on top of it, so in a series of undisturbed strata, the layers will be stacked from oldest to youngest going from the bottom to the top. The principle of original horizontality states that, due to gravity, when sediment is first deposited, it does so in horizontal layers. There are of course some exceptions to this rule, such as sand dunes, but generally this principle is still widely applicable.

These basic rules are very important to remember when attempting to interpret the ages of rock layers, but it is even more important to remember that these rules are only true if the layers have not been deformed. More often than not, rock layers have gone through significant modification since the time when they were originally deposited. This is because our Earth's surface is made up of several tectonic plates that are constantly shifting relative to one another. At the boundaries between plates, they can collide into one another, diverge away from each other, or slide past each other. The motion of these plates can create **folds** and **faults** (fractures) in the rock that can tilt the layers or even move older layers on top of younger ones. This is why we so rarely see a stack of perfectly straight and horizontal layers of rock, and why we need to be careful when trying to interpret the relative ages of rock layers. Looks can be deceiving!

Index Fossils

As you can see, understanding stratigraphy is vital to relative dating, but the fossils found at a site can be incredibly useful for this purpose as well. **Index fossils** are fossils of organisms that lived during specific, relatively short spans of geologic time. As a result, they are very useful for relative dating, especially if the organism covered a wide geographic span so rocks from different areas can be matched as well. If you find an index fossil at a particular site, you know the age of that site is limited to the timespan during which that organism would have been alive. Having a variety of index fossils at a site often results in greater accuracy as you can restrict the age of the site to only times when all of those organisms would have coexisted.

Invertebrates are frequently useful as index fossils as many have distinctive shells that are well preserved and plentiful within the fossil record. **Foraminifera** (single-celled, shelled marine organisms) are often ideal index fossils because their morphology has evolved rapidly through time. Several species of foraminifera lasted no more than 1 million years, making such fossils particularly precise when trying to pinpoint the age of a layer. Other invertebrates such as ammonites, trilobites, and crinoids are also useful as index fossils as they are very common, widespread, and can relatively easily be identified at the species level.

Absolute Dating

Up to this point we have covered ways of identifying the relative age of rock layers, but what if we want to find a more specific numerical age? For these instances, we want to use absolute dating, which most frequently is accomplished through radiometric dating. When a rock forms, sometimes certain radioactive elements are incorporated into the rock. Over time, these unstable radioactive isotopes decay into more stable forms. We are able to estimate the rate at which these isotopes decay, and this is the key to figuring out the age of a rock. A half-life is the amount of time it takes for 50% of the original radioactive “parent” atoms contained within a sample to decay into more stable “daughter” atoms. By comparing the proportion of the parent atoms remaining in a rock sample to the amount that have already decayed into daughter atoms, we can determine how many half-lives have passed since the rock’s formation and thus figure out the age of the rock.

You may already be familiar with carbon dating and how it can be used in this way to find a rock’s age. People often think of radiometric dating and carbon dating as synonymous terms, but this isn’t so. Carbon dating is actually just one of many forms of radiometric dating. Radiometric dating can be done with a variety of different elements such as uranium, potassium and rubidium. All of these elements have different half-lives, meaning they decay at different rates. As a result, their usefulness in dating will vary depending on the age of the rock. For example, carbon-14 has a half-life of 5,730 years, meaning that every 5,730 years, half of the carbon-14 contained within a sample will have decayed to nitrogen-14. Remember that radiometric dating is dependent on our ability to examine the ratio of radioactive parent atoms to the stable daughter atoms in a given sample. Once all of the parent atoms have decayed into daughter atoms, the element is no longer useful in determining the age of the sample. Since carbon-14 has such a relatively short half-life, it is only useful for dating samples up to about 50,000 years old. For this reason, **carbon dating is used more frequently for finding the age of archaeological sites rather than paleontological ones.** For older specimens, we must turn to other elements with much longer half-lives.

Uranium-lead dating is useful in dating rocks ranging anywhere from 10,000 to about 4.5 billion years old. This is because uranium-235 has a half-life of 710 million years and uranium-238 has a half-life of 4.47 billion years. Potassium-argon dating involves potassium-40 decaying into argon-40 with a half-life of 1.25 billion years, whereas rubidium-strontium dating involves rubidium-87 decaying into strontium-87 with a half-life of an incredible 50 billion years. The particularly long half-life of rubidium has even allowed it to be used for dating rocks from the moon! If a mineral or rock is found to bear any of these elements and falls within the appropriate age range, one of these methods can be used to date the sample. However, **many of these radioactive elements can only be found in igneous rocks or volcanic ash**. Fossils are found in sedimentary rock rather than igneous rock, thus paleontologists will often search for ash layers above and below the fossil-bearing layer so they may date these layers and develop an approximate age-range for the fossiliferous layer.