# SCIENCE 3D

## SEA TURTLE 360

In this packet, sample student answers are provided in red and notes to teachers are in blue.

In this **Mission Research** activity, students will investigate how to date fossils using both radiometric decay and the concepts of index fossils and superposition. They will practice their skills by interpreting graphs and diagrams of rock layers.

The first turtles appear in the fossil record around 230 million years ago. The first known turtle with a shell appeared 220 million years ago. Then, the first sea turtles show up in the fossil record around 120 million years ago. How do we know? Paleontologists have used the fossil record and the rocks the fossils are found in to learn about when different species lived and when they went extinct. We can learn about the relative age of species by looking at their position relative to one another in layers of rocks. Younger rocks are formed on top of older ones as sediment is deposited over time. But this method doesn't tell us when each layer of rock was formed.

How old are the rocks that fossils are found in? There are two ways to find out. One is to use radiometric dating. This technique uses the known rate of decay of radioactive isotopes to figure out the age of rocks. Isotopes are variations of the same element. Each isotope has the same number of protons in the atom, but they have different numbers of neutrons in their nuclei. Isotopes of an element have the same properties but different atomic masses. For example, carbon-12 has 6 protons and 6 neutrons. Carbon-14 has 6 protons and 8 neutrons. Radioactive isotopes are unstable. Over time, they transform into more stable forms through a process called decay. Carbon-14, over time, decays into carbon-12. The decay of each isotope occurs at a known rate. By comparing the ratio of the undecayed material to the decayed material, you can calculate how long ago a rock was formed. You might have heard about "carbon dating." Carbon dating uses the ratio of undecayed carbon-14 to stable carbon-12 in a sample of material to determine its age. Basically, if you know what proportion of carbon-14 is left in a sample, you can determine the age.

## ACTIVITY I: USING CARBON-14 TO DATE SAMPLES

Let's practice radiometric dating!

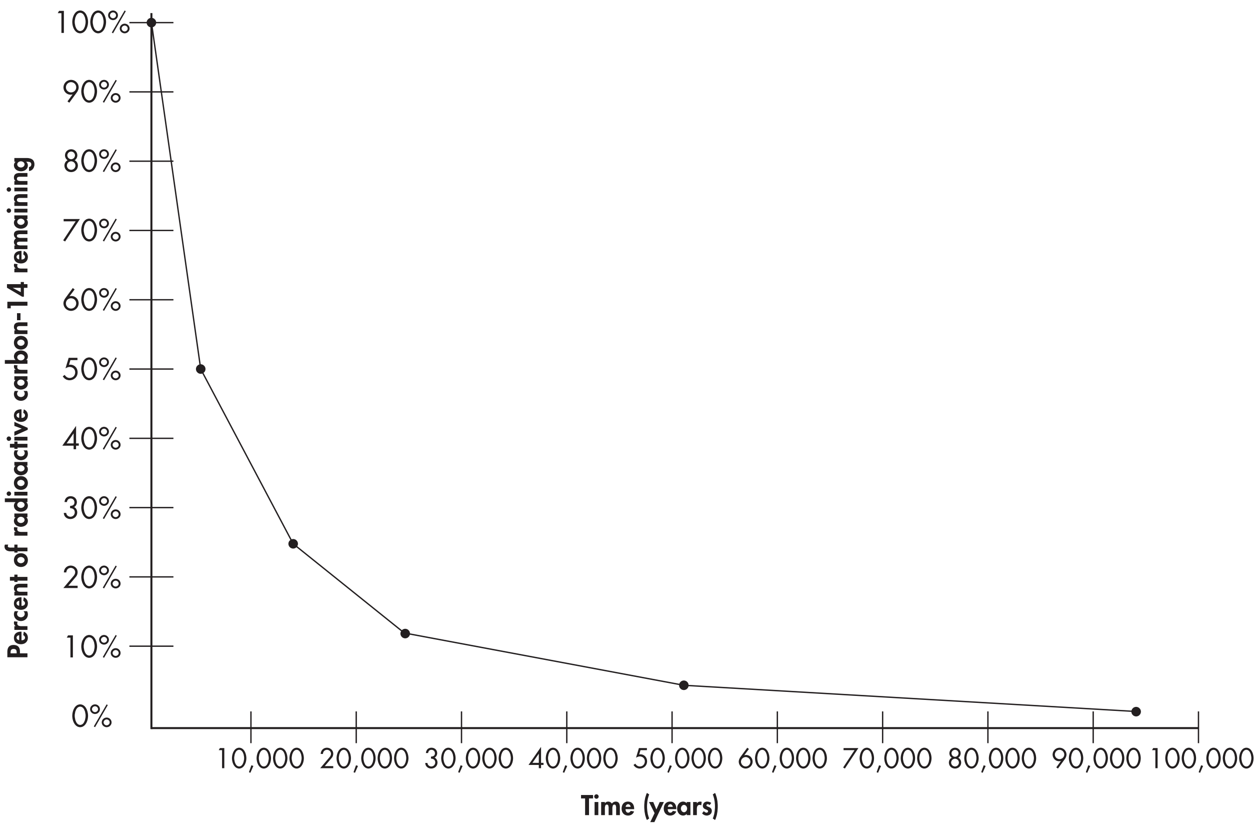



Figure 1. Decay of carbon-14

Help students understand how to use the curve to calculate ages. Students should select a percentage along the *y*-axis and then move horizontally until they hit the curve. From the curve, they should look straight down at the x-axis value to determine the age.

1. Scientists have found an ancient turtle shell and want to determine its age. They measure that it has 40% of its carbon-14 remaining. Use Figure 1 to **estimate** the age of the shell. **Describe** how you made this estimate.

I estimate that the shell is 10,000 years old. I used the graph. I found 40% on the *y*-axis and then found where that *y*-value intersects the curve. From that point, I dropped my finger down to the *x*-axis, which was at a value of 10,000.

2. Scientists have found a piece of a turtle's beak and want to determine its age. They measure that it has 20% of its carbon-14 remaining. Use Figure 1 to **estimate** the age of the beak. **Describe** how you made this estimate.

I estimate that the beak is 20,000 years old. I used the graph. I found 20% on the *y*-axis and then found where that *y*-value intersects the curve. From that point, I dropped my finger down to the *x*-axis, which was at about a value of 20,000. Estimates between 17,000 and 21,000 are acceptable.

3. Scientists have the fossilized remains of a huge turtle and want to determine its age. Based on other fossils in the area, they think it is at least 5 million years old. **Describe** whether or not they should use carbon-14 for dating the fossil. **Support** your argument with information from Figure 1.

They should not use carbon-14 because after 50,000 to 100,000 years, there isn't enough of it left to determine the age of the fossil. By looking at the x-axis, you can see the curve approaches 0% between 50,000 and 100,000 years.

Carbon-14 has a half-life of 5,700 years. That means that half of the carbon-14 sample will decay into carbon-12 every 5,700 years. So, carbon won't help date fossils that are millions of years old! However, isotopes of two other elements may help. The decay of potassium-40 into argon-40 has a half-life of 1.3 billion years. And the decay of half of a sample of uranium-238 into lead-206 takes 4.5 billion years! Figures 2 and 3 below, graph their decays.

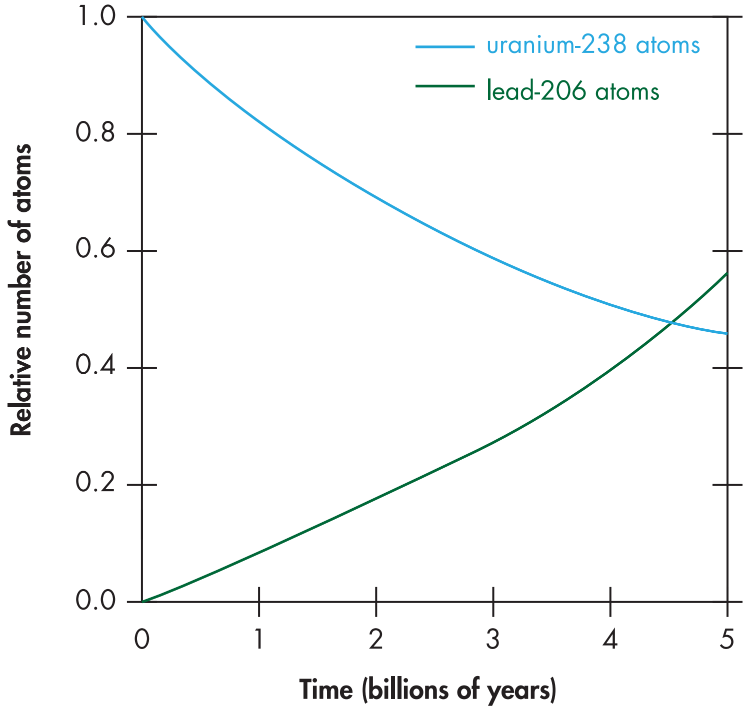



Figure 2. Proportion of uranium-238 and lead-206 in a sample over time

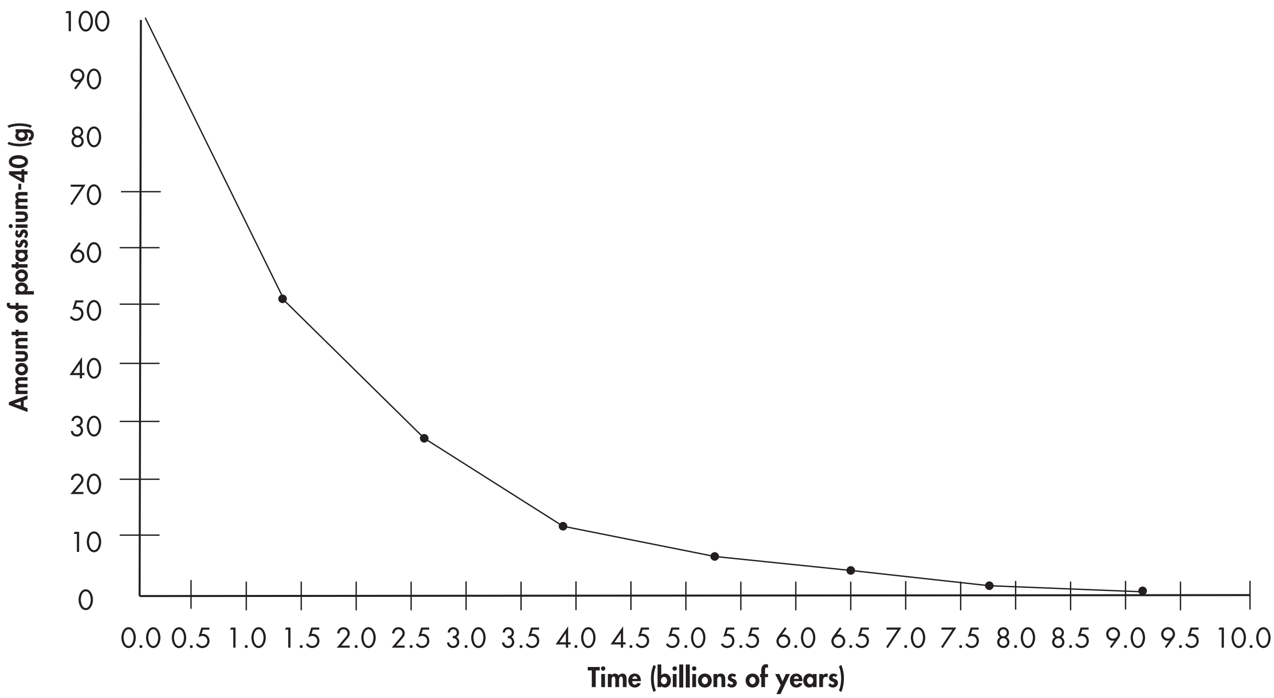



Figure 3. Amount of potassium-40 that would be left in a sample over time if the sample started with 100 g of potassium-40

4. **Describe** if you think potassium-40 and uranium-238 would be useful in investigating the ages of fossils from sea turtles and other extinct marine reptiles. Use evidence from Figures 2 and 3 in your answer.

Isotopes of these elements should be useful, because there will be plenty of uranium-238 or potassium-40 in a sample after tens or hundreds of millions of years. Figures 2 and 3 show that there is still half or more of the sample left after up to one billion years. Some students may say they won't work well because they take too long to decay. This is a reasonable answer based on the graphs. In this case, reinforce that scientists can measure even small decreases in the amount of these materials in a sample, so these isotopes do work.

**Extend the lesson:** To add more math practice, have students calculate the proportion of a sample left after one, two, and three half-lives. Then, have them look up the half-lives of different materials and compare.

## ACTIVITY 2: INDEX FOSSILS

Radiometric data can be expensive. Wouldn't it be useful if there was a less expensive way to estimate the age of fossils? There is! They are called index fossils. These are fossils of animals that help date the rocks in which they were found. If you have an index fossil and have used radiometric dating to know when they occurred, then when you see the index fossil in a rock layer, you know the other fossils in that rock layer are about the same age.

Not every species makes a good index fossil. To be a good fossil the species needs to have four attributes. It must be widespread, abundant, found over a limited geological time, and be distinctive from other fossils.

**Construct** arguments on why an index fossil should have each of these attributes. The following questions may work best as a class discussion. Have students think deeply about what purpose index fossils need to serve. Getting exactly accurate answers is less important than thinking logically about the challenge of using index fossils to date other fossils.

1. Index fossils must be widespread:

If a fossil is found over a large area, then it will be able to be used for dating other fossils in many areas. If it only is found in one or a few places, it won't be widely used.

2. Index fossils must be abundant:

If a fossil is abundant it is likely that it will occur in most rocks from that time period and the environment it lived in. If it is a species that was not abundant, it will be unlikely that it will be found in the same rocks as other fossils you want to age.

3. Index fossils must be limited in geological time:

If a species lived for many millions of years, then the fossil won't help with dating because you won't know what time period the fossil was from when you found it.

4. Index fossils must be distinctive:

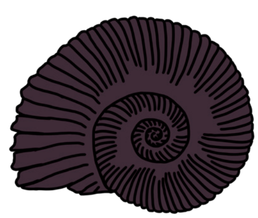
It a fossil is similar to other species that lived at different times, it won't be very useful because it can be confused with other fossils. This may lead to inaccurate dates.

Let's practice how to identify and use index fossils. The images below represent different fossils. Look for them in the six "rock layers" from areas around the world on the next page. The different shading of each layer represents a distinct rock layer from the same time period. Look at the fossils in the rock layers to see if you can identify candidates for index fossils!

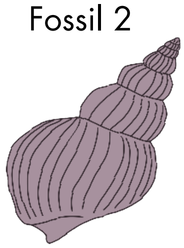
Fossil 1

Fossil 3

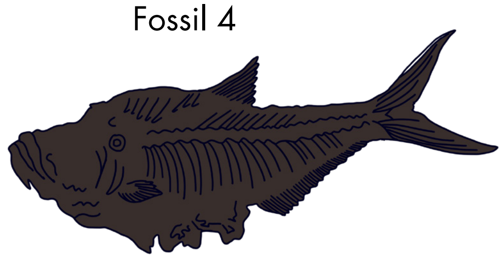
Fossil 5



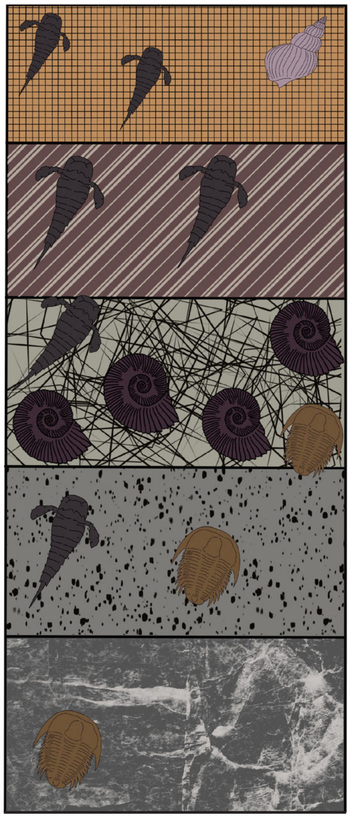
Fossil 2



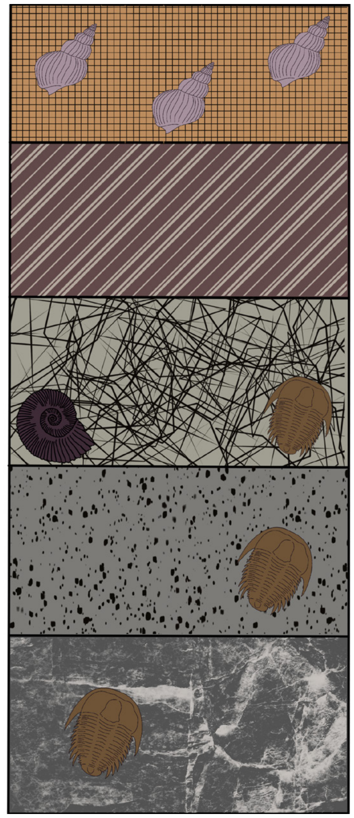
Fossil 4



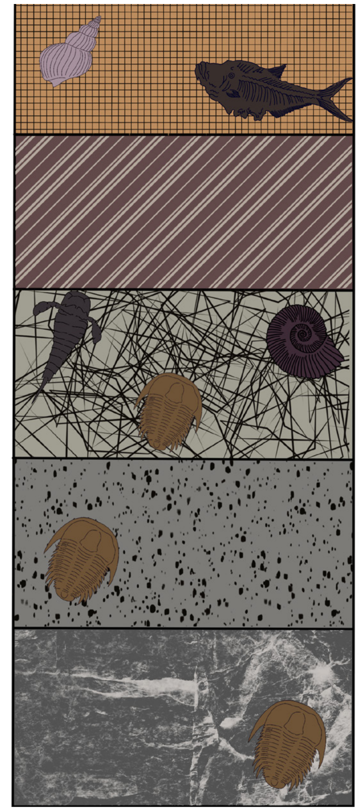
Location 1



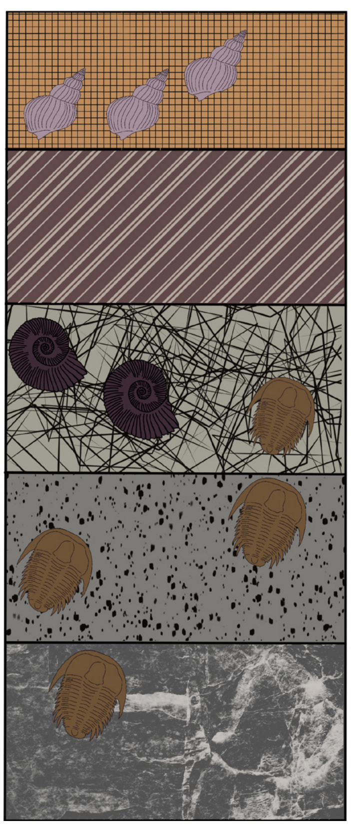
Location 2



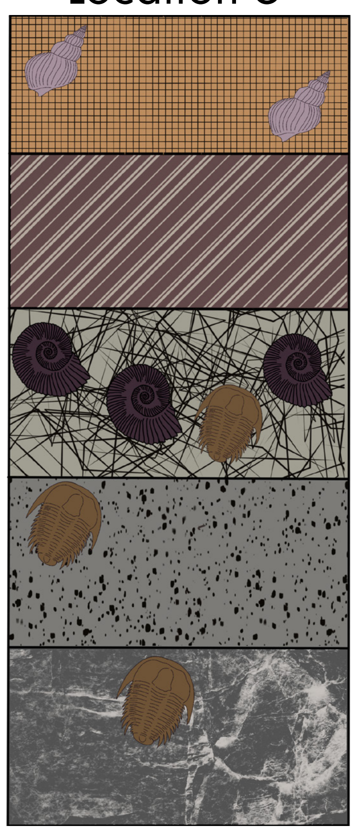
Location 3



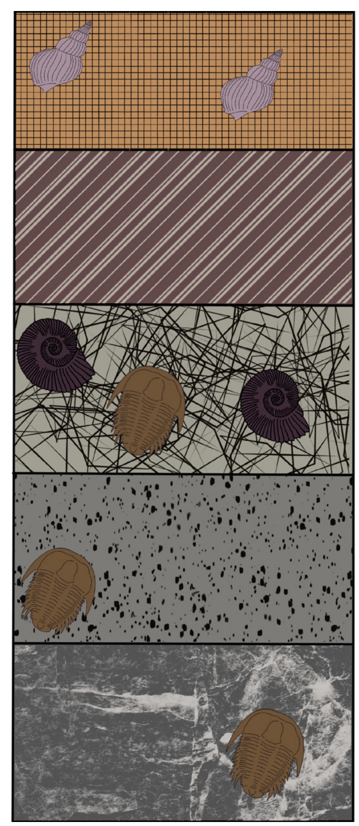
Location 4



Location 5

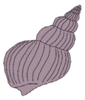
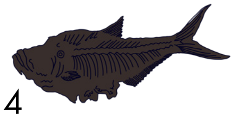


Location 6



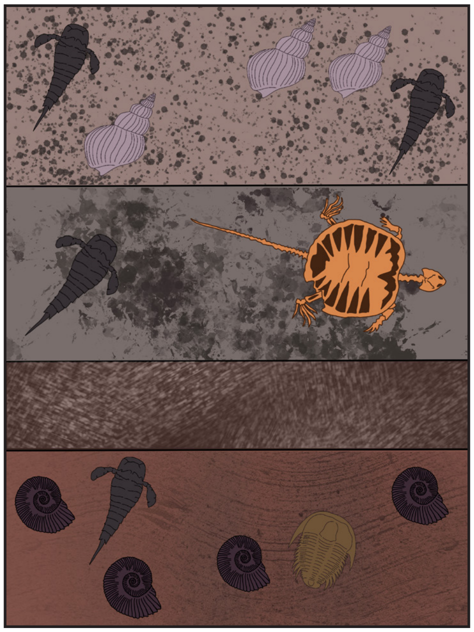
5. **Complete** Table 1 by filling in each column with **"yes"** or **"no"** to determine if each fossil might be a good index fossil.

**Table 1. Characteristics of fossils found in six locations around the world**

| Fossil | Widespread? | Distinctive? | Limited in time? | Abundant? | Good index fossil? |
|---|---|---|---|---|---|
| 1  | No | Yes | No | Yes [No is ok here too since it is never more than 2 per layer] | No |
| 2  | Yes | Yes | Yes | Yes | Yes |
| 3  | Yes | Yes | No | Yes [No is ok here too since it is never more than 1 per layer] | No |
| 4  | No | Yes | Yes | No | No |
| 5  | Yes | Yes | Yes | Yes | Yes |

Interpreting the fossil record can be tricky! One reason is that entire rock layers can disappear. Imagine if an area experiences erosion. Over the years, soil disappears, then the rock weathers and erodes. Eventually, conditions may change and deposition might occur again, causing new fossils to form. Millions of years later, paleontologists may encounter a fossil record with a whole span of time missing! Other events can make reading the record of rocks challenging. Magma may cut up through layers of rock, replacing sedimentary rocks that had formed with igneous rocks. So, not all layers or rock will look the same everywhere, but newer rocks will still be on top of older rocks.

The rock layer below is from a different place in the world than the ones shown before.



6. **Compare** and **contrast** the set of rock layers above with the set of six layers pictured earlier.

Students will notice that the same fossils are found in the same layers and that the basic order is the same. They may point out that the turtle is not in any of the other rock layers and, most importantly, that there is a new layer in this location.

A team of paleontologists did radiometric dating on two fossils from Location 1 in the first set of rock layers. They found rocks that were between 190 and 200 million years old where Fossil 5 fossils were found. The Fossil 2 fossils were dated to between 120 and 150 million years ago. And dates for Fossil 1 ranged from 90 to 210 million years ago!

7. Based on the information above, **estimate** the potential age range of the turtle fossil. Cite evidence to support your answer.

This fossil must be from between 150 and 190 million years ago. It has to be younger (more recent) than 190 million years ago because it is in a rock layer that is above the one with Fossil 1, which disappeared 190 million years ago. It has to be older than Fossil 2 because it is in a rock layer below them. This index fossil first appeared 150 million years ago.

**Extend the lesson:** Challenge students to design a demonstration that will model the erosion of sediment and deposition of different layers of rock. This could be a physical model, or they could draw a poster that demonstrates the process. For example, you could suggest they use glass bowls and different types of cereal.