Science Objectives

- Students will learn that when isotopes of different atoms change chemically (in a decomposition reaction) and emit radioactivity in the process.
- Students will learn how the known rate at which isotopes decompose is used to estimate the age of a fossil.
- Students will discover that Carbon-14 is more useful for dating younger fossils and Uranium-238 is more useful older fossils.
- Students will learn that younger fossils are located in the upper layers under Earth's surface and older fossils in lower layers.

Vocabulary

- isotopes
- decompose
- Carbon–14
- Uranium–238
- radioactivity
- radioactive dating
- half-life
- archeological site

About the Lesson

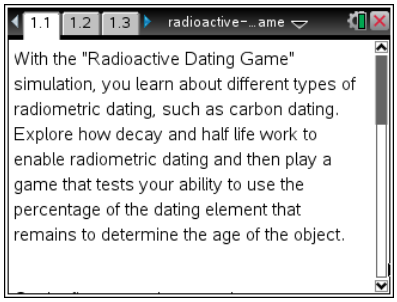
- This lesson involves students using TI-Nspire technology to simulate radioactive dating at an archeological site.
- As a result, students will:
  - Reinforce understanding of the atom and its parts.
  - Learn how the amount of radioactive emissions given off by certain isotopes as they decompose can help determine the age of fossils.
  - The decomposition rate of Carbon-14 is more useful for dating younger fossils and the decomposition rate of Uranium–238 is more useful for dating older fossils.
  - Recognize that younger fossils are in the upper layers under Earth's surface and older fossils are found in lower layers.

TI-Nspire™ Navigator™

- Send out the *Radioactive_Dating_Game.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to allow students to show how they manipulate variables that effect results.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software



Tech Tips:

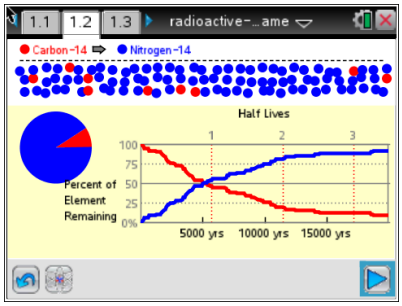
- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:
Student Activity

- Radioactive_Dating_Student_MG.doc
- Radioactive_Dating_Student_MG.pdf
- Radioactive_Dating_Game.tns

Discussion Points and Possible Answers

Move to page 1.2.



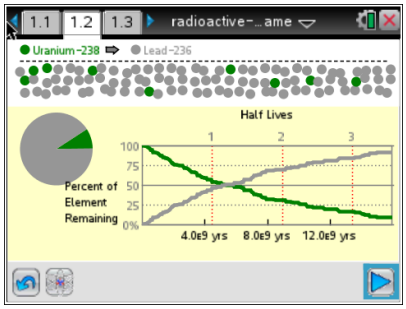
1. On this page students run the simulation for Carbon-14. They should observe how long it takes for the isotopes Carbon-14 and Uranium-238 to decompose and then analyze the patterns they see.

Q1. How are the divisions of half-life along the top of the horizontal axis of the graph determined? What is the pattern in the placement of the vertical lines named Half Lives?

Answer: The time it takes for each isotope to decompose is divided into approximately four equal parts. The last half-life is not shown in its entirety because the few atoms that decompose at the very end are not significant.

Q2. What do you notice about the rate at which Carbon-14 and Uranium-238 decompose in the beginning of the process? What do you notice about this rate of decomposition as time progresses?

Answer: The isotopes decompose quickly at the beginning of the aging process and then more slowly as time progresses.



2. Students select  to change from Carbon-14 to Uranium-238 and run the simulation again.

Q3. Why do you think the intersecting line for the decomposition of Uranium–238 is not exactly at the 1st half-life line?

Answer: When dividing Uranium into four parts to mark each half-life, Uranium-238 is much more of an approximation than Carbon-14. This is because Uranium-238 decomposes so much more slowly and its range is much less spread out.

Q4. What do you notice about the difference in decomposition rates between Carbon-14 and Uranium-238?

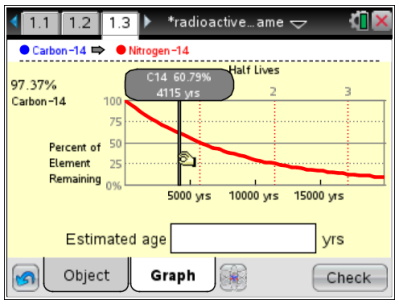
Answer: The decomposition rate of Carbon-14 is much faster than that of Uranium-238.

Q5. In what cases might Carbon-14 be more useful than Uranium-238 in determining the age of substances? In other instances, why might Uranium–238 be more useful than Carbon-14?

Answer: Because the range of Carbon-14 is less spread out than Uranium-238, Carbon-14 might be more useful for younger fossils. Uranium-14 might be more useful for older fossils.

Move to page 1.3 and select Graph.

3. Students should now look at a graph that shows the percent of Carbon-14 and Uranium-238 remaining after a given number of years.
4. Students can grab the gray bar and drag it to see how the percent remaining changes as the age increases from left to right.



Tech Tip: Students can select to grab the bar and drag it from left to right. They will eventually need to move this tool slowly to get as close as possible to the age value for each fossil shown on the **Game** page.

Tech Tip: Students should tap to grab and drag the bar to the left or right across the screen. It is best to grab the bar at its base so they do not obstruct the data above it.

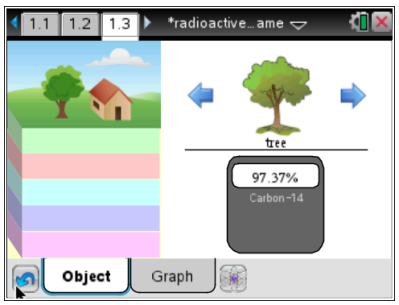
Q6. How does the age of Carbon-14 differ from the age of Uranium-238 after they have both decomposed about 50% (the first half-life)? 50% of the first 50% (the second half-life) and 50% of the previous 50% (the third half-life)?

Answer: 1st half-life Carbon-14: 5,500 years and Uranium-238: 4.43 billion years;
2nd half-life Carbon-14: 11,500 years and Uranium-238: 9 billion years;
3rd half-life Carbon-14: 17,000 years and Uranium-238 13.4 billion years

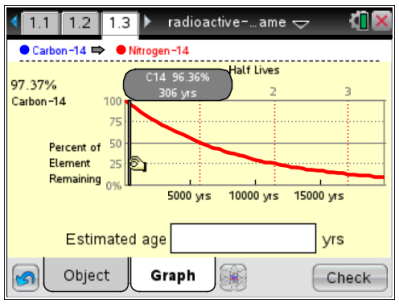
Q7. What is similar about the decomposition of both elements? What is different?

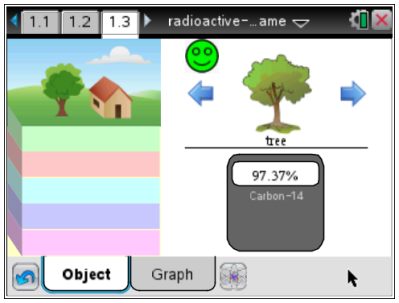
Answer: Carbon-14 and Uranium-238 decompose at approximately the same 50% rate for each half-life. Carbon-14 decomposes more quickly than Uranium-238.

On page 1.3, select Object.



5. Students should play the Radioactive Dating game by first selecting each of the different layers on and below Earth's surface. Students should view objects and where they can be found. Or they can use the arrows and to move up and down the layers on and under Earth's surface. (Note: Two objects are found at each level.) Point out to students that the depths and thicknesses of the layers are equally spaced for the purposes of this game and do not represent the same number of years. Students should then use the following directions to predict the age of each object using radioactive dating.
6. Students should first decide whether it is more useful to use Carbon-14 or Uranium-238. Then select to change from one isotope to the other.
7. Students should record the percentage of the isotope remaining the object. Then they select **Graph**.
8. Students should move the gray bar in both directions until the number in the oval is as close as possible the percentage they recorded in step 6. They should write down the corresponding age of the object.
9. Enter the estimated age in the box provided. (Note: When entering ages in billions, you must write the number in numerals without commas, for example 240000000 for 240 billion years.)
10. When students select Check they will know whether or not their answer is correct by the appearance of the green (correct) or red (incorrect) face.





Tech Tip: To enter the estimated age, students should tap inside the box next to Estimated age. Then they can select the button **".?123"** to the left or right of the space bar to enter a numerical quantity. After they have entered the value, they can select "return" and select Check to check their answer.

Analysis Questions

Q8. Where do you suppose the younger layers of Earth's surface are located? Where are older layers?

Answer: The younger layers of Earth's surface are the uppermost, while the older layers are the lowermost.

Q9. In which layers would the younger fossils be found? The older fossils be found?

Answer: The younger fossils are found in the uppermost layers and the older in the lowermost layers. This is because the lower layers were laid down first and the upper layers were laid down more recently.

Q10. Which isotope was more useful in analyzing younger fossils? Analyzing older fossils?

Answer: Carbon–14 is more useful in analyzing younger fossils and Uranium–238 is more useful for older fossils.

Q11. Did the percent remaining seem to make a difference when choosing Carbon-14 or Uranium-238? If so, when was this the case?

Answer: When analyzing older objects with Carbon-14, there was 0% of the isotope remaining. Therefore, using Uranium-238 was preferable to Carbon-14. For younger objects, Carbon-14 was preferable to Uranium–238 because the percentage remaining less than 100% and still showed a range.

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate how to move the slider to show how percentage of decomposition is related to the age of a fossil. They should also demonstrate the steps to playing the game.

Wrap Up

When students are finished with the activity, collect students' worksheets.

Assessment

- Formative assessment will consist of questions embedded in the student worksheet. Analyze questions in the student worksheet with the students. Teacher can also collect scores that students earned in the game.
- Summative assessment will consist of questions/problems on the chapter test.