Pennies Radioactive Half Life Lab

(***Reference***: http://www.ncsu.edu/scivis/lessons/halflife/halflife2.html)

Topics

Scientific Visualization Objectives
Biology Objectives
Tools
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Evaluation Criteria

Purpose: To model the concept of radioactive half life.

Overview:

Students will model radioactive decay using pennies, collect data from their model, apply scientific visualization techniques to their data and create animated models explaining the concept of radioactive half-life. After completing this exercise students will have a better understanding of the method that scientists use for dating fossils, and given the half life of a substance be able to calculate what percent of a sample will be left after a given time.

Topics:

Scientific Visualization: Theoretical models, data driven visualization, concept model, 2D static, 3D animation.

Science: Earth Science and Biology -Radioactive Decay - Dating Fossils

NC Scientific and Technical Visualization Objectives:

Part I of this lesson is a level one project meant to be done as a class with teacher guidance and can be completed in one to two periods. Part II can be done as a level one or level two project depending on the amount of guidance given by the teacher. Depending on which techniques are chosen the level two objectives covered will be different.

Level I

5. Apply 2-D and 3D visualization techniques.
5.01 Design and evaluate a simple visualization
5.02 Produce computer based concept driven visualization projects.
5.03 Produce computer based data driven visualization projects.

Level II

2.01 Apply advanced principles and techniques of scientific visualization.
4.04 Apply advanced 3-D animation techniques.

NC Earth and Environmental Science Goals and Objectives:

7.5 Demonstrate knowledge of the history of the earth and its inhabitants.

Engage in activities, research, and discussion on geologic evidence of the earth's past including fossil types and their formation, evolution and the extinction of species, dating processes, the geologic time scale, and the theory of uniformitarianism.

NC Biology Goals and Objectives:

7.3 Demonstrate knowledge that organic variation is important and necessary for species survival.

Through activities, models, and research, describe and discuss current evolutionary theory in relation to genetic variation within populations including concepts such as mutation selection, migration, and genetic drift.

Note that although radiometric dating is not explicitly mentioned in the Biology goals and objectives it is included in the teaching of evolution so that students can gain an appreciation for the fossil evidence for evolution.

Tools:

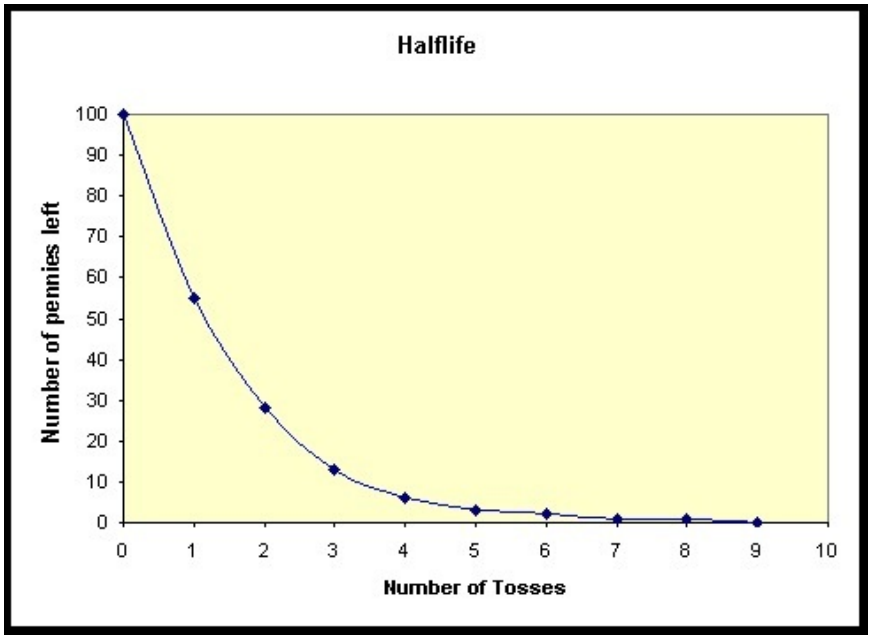
Microsoft Excel
TrueSpace

Teacher Instructions:

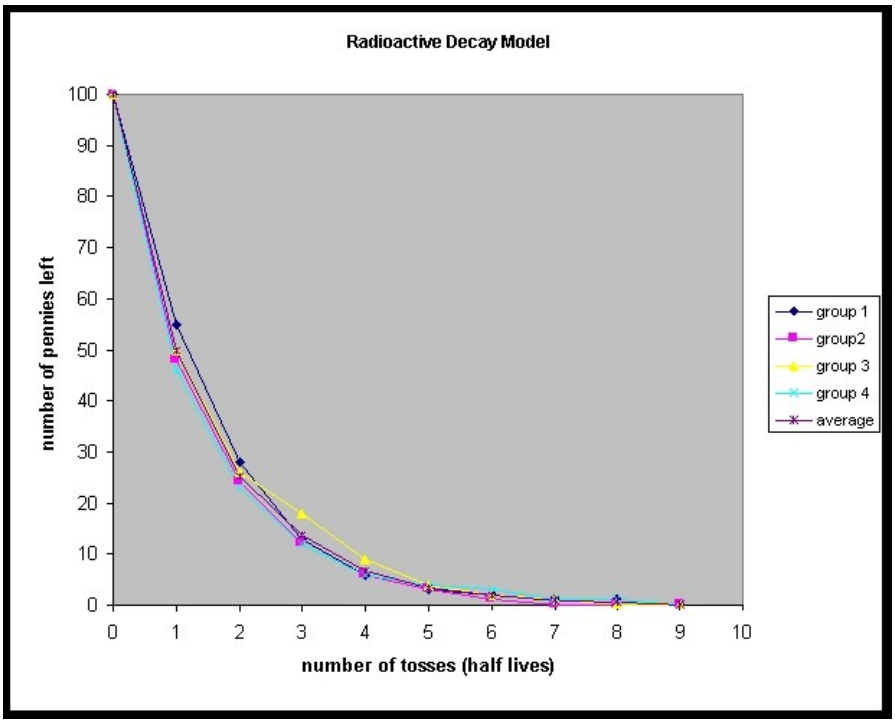
BACKGROUND INFORMATION: Scientists use several different methods of dating fossils. One of these is radiometric dating. This is also called radioactive dating. Atoms of radioactive elements can decay, giving off nuclear particles and becoming different, more stable elements. Although we don't know when any given atom will do this, radiometric dating depends on the fact that each radioactive element decays at a known rate. Many elements have several forms which differ in the number of neutrons in the nucleus. These different forms are called isotopes. The rate of radioactive decay is different for each radioactive isotope. The half life of an element is the amount of time it will take for half of any given sample to decay. By knowing the half life of an element, the amount of the radioactive element left and the amount that has decayed (the amount of the new element) we can figure out approximately how old some fossils and rock samples are.

In this activity students use pennies to model radioactive decay and then collect and graphically display data from their models. Pennies heads up represent the radioactive atoms. Each shaking of the box represents one half life. The penny flipping to tails represents the decay to a stable element. After a penny has flipped it is removed to indicate that a stable element won't change back to the radioactive form.

The directions are designed for students to work in pairs. Group size can be adjusted to meet your needs. After the students have completed the data collection and initial graph of the data, the teacher can discuss with the students which types of graphs will best represent this data. The initial graph for a single group might look like this:



The initial class graph might look like this:



Analysis:

Decay is usually graphed showing the decrease in the amount of radioactive material; however, the increase in the stable daughter element can also be shown. In a discussion students could compare the graphs and explain their relationship.

A bar graph for this data has several disadvantages compared to a line graph. A half life is represented by one box shaking. This is a weakness of the model which should be discussed with the students. In reality decay takes place over a long period of time not discrete steps. The bar graph shows the decay happening in steps. Because decay is a more continuous process and a half life may be millions of years long it is useful to interpolate. A line graph can be used to estimate in between data points better than a bar graph. A series of pie charts is also sometimes used to illustrate radioactive decay. This has the advantage of showing both the initial radioactive element and the stable daughter element. This illustrate a change in ratio - but can't be used for interpolation.

Links to Step by Step Instructions

Excel DeltaGraph

References

Texts:

Biology Prentice Hall. p274 - 277

Online: Georgia Geosciences Online -lecture notes on radiometric dating

Student Work Sheet **Name**_____

Radioactive Half Life Lab

Purpose: To model radioactive decay using pennies, and collect, display, and analyze data from the model.

Background: Scientists use several different methods of dating fossils. One of these is radiometric dating. This is also called radioactive dating. Each radioactive atom can decay, giving off nuclear particles and becoming a more stable element. Although we don't know when any given atom will do this, radiometric dating depends on the fact that each radioactive element decays at a known rate. This rate is different for each radioactive isotope. The half life of an element is the amount of time it will take for half of any given sample to decay. By knowing the half life of an element, the amount of the radioactive element left and the amount that has decayed (the amount of the new element) we can figure out approximately how old a fossil or a sample of rock is.

Materials:

Each group of students needs:

100 pennies

box with lid (shirt or shoe box works well)

Procedure:

1. Answer the pre lab questions.

2. Count to be sure you have 100 pennies to start with.

3. Put your pennies heads up in the box and shake.

4. Remove all the pennies that are now tails.

5. Count the remaining pennies and enter this data on your data table.

6. Repeat until you have no pennies left.

7. Enter your data into your spreadsheet and the class spreadsheet.

8. Copy the class data into your spreadsheet. (If your computer lab is networked the teacher may be able to do this automatically.)

9. Use your spreadsheet's formula function to find the class average of how many pennies left after 0 tosses (should be 100).

10. Copy this formula down to the rest of the class average column. Most spreadsheets including Excel and Deltagraph will adjust the formula as it is copied so the correct row numbers are used.

11. Format the average column to 0 decimal places which will round to the nearest whole.

12. Use the spreadsheet chart function to graph your data and the class data.
Put the # of pennies on the Y axis (vertical)
Put the # of shakes on the X axis (horizontal)

13. Graph the data for analysis questions 3-7.

14. Print your data table and graphs.

15. Answer the analysis questions.

16. Prepare a conclusion summarizing the lab and what you learned.

17. Hand in Pre lab questions, data, graphs, analysis questions, and conclusion.

ANALYSIS QUESTIONS:

Pre-Lab:

1. What is radiometric dating used for?

2. If you toss 100 pennies, on average, how many heads would you expect?

3. Do you know in advance which pennies will be heads?

Post Lab:

Science Questions:

1. How many shakes did it take you to get rid of all of your pennies? How did this compare to the other groups?

2. Why should you average your data with the data from other groups?

3. Sodium 24 (Na 24) has a half life of 15 hours. Fill in the following table showing the decay of a 100g sample.

grams of Na -24	hours passed
100	0
50	15
25	___
12.5	___
6.25	___
_____	75

4. Graph your data table from question #3 above.

5. How does this graph compare to the graph for your pennies?

6. Using your graph approximate how many hours have passed if you have 75 grams of your original sample of Na 24 left.

7. If 40 hours have passed how much of the original 100 gram sample should be left?

8. Carbon 14 has a half life of 5770 years. If you start out with 100 grams of carbon 14 in how many years will you only have 25 grams left?

10. In what way is the penny toss like the decay of a radioactive element?

11. Why isn't C14 dating used in dating dinosaur bones? How are dinosaur bones dated? *(C14 has half-life of 5,700 years- none left after 60,000 years-dinosaur bones are older, so other radioactive elements are used)*

12. What assumptions does Carbon 14 dating rely on?

Scientific and Technical Visualization Questions

1. How does it change the graph to graph the number of tails instead of heads?

   What advantage does a line graph have over a bar graph in this visualization?

2. Did you to choose to use a background grid? Why or why not?

3. ??? Suggestions ??

Part II

Design a presentation of radiometric dating methods. It should include a 3D visualization to illustrate the process of radioactive decay of a single atom of an assigned element and an animation to show the changing ratio of C14 to C12 in a fossil over time. You will need to research your element to find out how it decays - some radioactive elements go through a chain of unstable daughter elements before reaching a stable element. Your presentation should include a visualization of this process.

Students are to include their bibliography as Appendix A at the end of the design brief. Students are to include their sketches and drawings as Appendix B of the design brief.

You will give a presentation to a selected audience. Afterwards go through a self -evaluation process. Write several paragraphs reflecting upon the entire design and development process. Point out areas of particular difficulty, successes and failures as well as things you found particularly enjoyable. Point out things you would do differently in you were to go through this process again.

Due Date: _____

Team Members: _____

Audience: _____

Available Software: _____

Available Hardware: _____

Evaluation Criteria:

Success will be measured by the following criteria:

Chose an appropriate visualization method based on the data.
Accurately represent
Chose an appropriate design based on the output media.
Chose an appropriate design based on the audience.
Appropriate arrangement of illustrations on page/display with titling and text.
Appropriate appendices with bibliography and preliminary sketches.
Students Written Evaluation of the Design and Production Process

Plan of Work:

_____

_____