# Spontaneous and Exponential Decay

**Learning goal:** Students will understand some key aspects of spontaneous decay of radioactive nuclei and how to model them.

**Learning objective**

Science content objective:

- Students will understand how chance and randomness enter into some natural processes, and the conditions that lead to exponential decay (and growth).

Science model/computation objectives:

- Students will learn how to develop a simple model of the system that includes chance.
- Students will understand the difference between mathematics that can predict a probability and a computer simulation that predicts simulated, probablistic data.
- Students will learn how to relate a probabilistic model and a computer simulation.
- Students will understand that computer models can be used to explore and develop scientific concepts by using a computer as a simulated laboratory.

Scientific skills objective:

- Students will practice the following scientific skills:
    - Graphing (visualizing) data.
    - Describing trends revealed by data.
    - Proportional reasoning and its limits.
    - Interpreting the contextual meaning of graphs.
    - Testing (confirm, modify or reject) hypothesis using simulated data.

**Activities**

In this lesson, students will:

- Identify key objects or components within models and their relationships.
- Make statements that describe characteristics of the system.
- Make concept maps that incorporate components and relationships.
- Create mathematical equations that describe the relationships that exist within the system.
- Understand the use of iteration to relate solution at present time to that at future times.
- Create or modify computer simulations of a model and analyze their predictions compared to observed natural phenomena.

**Products**

At the end of this module students will produce and evaluate 1) a list of system statements, 2) concept maps, 3) mathematical equations and 4) a mathematical model implemented as computational simulation. Each product is a different view of the data and phenomenon.

**Where's Computational Scientific Thinking and Intuition Development**

In this lesson students will construct a model and then a computer program that simulates the natural process of spontaneous, radioactive decay. A mathematical model can predict the probability of observing a specific number of particles, or the average number of particles observed, but it cannot predict exactly what number will be observed for each measurement. In contrast, the computer program provides an actual *simulation* of the natural process, so that it is possible to observe the type of fluctuations that occur with natural data. In numerous ways the simulation is like doing an experiment on a computer.

After some discussion and experimentation, the students should come to realize that the computer simulation can be a more accurate description of nature than is the mathematical expression, the exponential function. A strong developmental understanding of the value of simulations is provided by hearing that the results of the simulation sound like an actual Geiger counter.