**Goals**

- Recognize an exponential relationship from an equation
- Determine the growth factor and y-intercept based on an equation for an exponential relationship
- Solve problems involving exponents and exponential growth

In this activity, students explore the exponential growth of mold. An equation for the growth pattern is given. Students find the initial amount of mold and the growth factor from the equation, and use the equation to answer specific questions about the situation.

You might wish to have your class conduct an experiment in which they grow mold, collect data on the mold’s growth, and then analyze that data. See the directions below.

If the class begins the mold-growing experiment at the start of Problem 2.2, they should have enough data by the end of the unit to analyze the pattern of growth in the mold.

**Directions for Mold-Growing Experiment** Follow these steps to begin the experiment, or consult a science teacher in your building for advice on setting up the experiment.

- Cut a piece of transparent quarter-centimeter grid paper to fit the bottom of an 8- or 9-inch cake pan.
- Glue the paper to the bottom of the pan.
- Prepare a mixture of dry beef or chicken bouillon, gelatin, and water.
- Cover the bottom of the pan with a thin layer of the mixture.
- Put a very small amount of mold taken from bread or yogurt into the pan.
- Cover the pan with plastic wrap and secure it tightly with a rubber band.
- Place the pan in a dark place with a fairly uniform room temperature.

Beginning with day 1, have a group of students count the number of squares covered by mold each day. The amount of mold is equal to the area, or the number of squares, covered. Have students record the data in a table. When much of the pan is covered with mold, they can graph the data, determine an approximate growth factor, and write an equation.

**Launched 2.2**

Discuss with students the information in the student edition about moldy food. Having a piece of moldy bread or cheese on display makes a great attention grabber.

**Suggested Question** Ask:

- *How much mold is there at the end of day 1? At the end of day 2? At the end of day 3?*
- *Do you see any similarities between the pattern of change in this situation and the patterns of change in some of the problems in the last investigation and in Problem 2.1? Explain.* (The area covered by the mold increases by repeated multiplication. This is similar to the patterns seen in many of the reward plans from Investigation 1 and to the pattern of plant growth in Problem 2.1. It is also similar to Problem 2.1 in that both problems have an initial value greater than 1 and both involve an area being covered by something—either a plant or mold.)

Have students work on the problem in pairs.

**Explore 2.2**

This problem is similar to Problem 2.1, but it describes an exponential relationship with an equation, rather than with a verbal description.

When students evaluate the equation for a specific d value, make sure they raise only the base to the exponent, and not both the base and the initial value. For example, when computing $50(3^5)$, watch for students who find $50 \times 3$ and then raise the product, 150, to the exponent of 5.
This is not correct. Remind students to follow the order of operations: Evaluate exponents first and then multiply. Most graphing calculators use the correct order of operations. For example, if the expression 50 \[\times\] 3 \[\div\] 5 is entered, the calculator will give the correct result.

**Summarize 2.2**

**Suggested Questions** Ask questions such as the following to provoke discussion:

- How does the mold grow from one day to the next?
- Is the mold growth similar to other growth situations you have studied? Explain.
- What does each part of your equation tell you about the growth of the mold?
- Suppose you started with 25 mm\(^2\) of mold and it grew in the same way that it did in the problem. How would the equation change? How would the graph change?

Discuss the standard form for an exponential equation introduced in Question E: \(y = a(b^x)\). Help students see how this equation is similar to and different from the slope-intercept form of a linear equation.

- In the linear equation, \(y = mx + b\), which letter represents the y-intercept? \(b\)
- In the exponential equation, which letter represents the y-intercept? \(a\)

- Why do you think we add the y-intercept in a linear equation, but we multiply by it in an exponential equation? (You find the y-intercept by substituting 0 for \(x\). In a linear equation, \(y = mx + b\), you get \(y = m(0) + b = b\). So, you are left with the added term. Therefore, the added term must be the y-intercept. When you find the y-intercept for an exponential equation, \(y = a(b^x)\), you get \(y = a(b^0) = a(1) = a\). So, you are left with the term you multiply the power by. This term must be the y-intercept.
- In the linear equation, what tells us how quickly the dependent variable is changing as the value of the independent variable increases in increments of 1? (the slope, \(m\))
- In the exponential equation, what tells us how quickly the dependent variable is changing as the value of the independent variable increases in increments of 1? (the base, \(b\))
- What other similarities and differences do you notice between linear and exponential equations?

**Check for Understanding**

Repeat the last set of questions with specific examples such as these:

- \(y = -3x + 4\) \hspace{1cm} \(y = 1.5x\)
- \(y = 3^x\) \hspace{1cm} \(y = 10(5^x)\)
Mathematical Goals

- Recognize an exponential relationship from an equation
- Determine the growth factor and y-intercept based on an equation for an exponential relationship
- Solve problems involving exponents and exponential growth

Launch

Discuss with students the information in the student edition about moldy food.

- Do you see any similarities between the pattern of change in this situation and the patterns of change in some of the problems in the last investigation and in Problem 2.1? Explain.

Have students work on the problem in pairs.

Explore

When students evaluate the equation for a specific \( d \) value, make sure they raise only the base to the exponent. For example, when computing \( 50(3^5) \), watch for students who multiply \( 50 \times 3 \) and then raise the product, 150, to the exponent of 5. This is not correct. Remind students to follow the order of operations: Evaluate exponents first and then multiply.

Summarize

- How does the mold grow from one day to the next?
- Is the mold growth similar to other growth situations you have studied? Explain.
- What does each part of your equation tell you about the growth of the mold?
- Suppose you started with 25 mm\(^2\) of mold and it grew in the same way it did in the problem. How would the equation change?
- How would the graph change?

Discuss the standard form of an exponential equation: \( y = a(b^x) \). Help students see how this is similar to and different from the slope-intercept form of a linear equation.

- In the linear equation, \( y = mx + b \), which letter represents the y-intercept?
- In the exponential equation, which letter represents the y-intercept?
- Why do you think we add the y-intercept in a linear equation, but we multiply by it in an exponential equation?
Summarize (continued)

• In the linear equation, what tells us how quickly the dependent variable is changing as the value of the independent variable increases in increments of 1?

• In the exponential equation, what tells us how quickly the dependent variable is changing as the value of the independent variable increases in increments of 1?

• What other similarities and differences do you notice between linear and exponential equations?

Check for Understanding

Repeat the last set of questions with specific examples of linear and exponential equations, such as \( y = -3x + 4; y = 1.5x; \)
\( y = 3^x; \) and \( y = 10(5^x). \)

ACE Assignment Guide

for Problem 2.2

Core 5, 6, 8
Other Applications 7, Connections 22, 23; unassigned choices from previous problems

Adapted For suggestions about adapting ACE exercises, see the CMP Special Needs Handbook.

Connecting to Prior Units 22: Moving Straight Ahead; 23: Stretching and Shrinking

Answers to Problem 2.2

A. \( 50 \text{ mm}^2 \)
B. 3
C. \( 50(3)^5 = 12,150 \text{ mm}^2 \)
D. Between day 4 and day 5. On day 4, the area was 6,250 mm\(^2\), and on day 5, the area was 12,150 mm\(^2\).
E. 1. The value of \( b \) is 3. This represents the growth factor.
2. The value of \( a \) is 50. This represents the initial amount of mold.