

WEATHERING CUBES (1 Hour)

In this activity, students will model the weathering of rocks by shaking sugar cubes in a container. They will make observations and draw conclusions about the relationship between surface area, volume, and weathering.

OVERVIEW

Topic: Weathering, surface area to volume relationship

Real World Science Topics

- An exploration of the process of weathering on different-sized particles
- An exploration of the relationship between surface area, volume, and weathering

Objective

Students will gain an understanding of how rock weathering occurs, and they will understand how rock surface area and volume can affect weathering rates.

Materials Needed for Teacher Demonstration

- large rock
- very small rock

Materials Needed for Student Teams

- ruler
- sugar cubes (about 20 per team)
- plastic container with lid
- glue
- gravel (approximately 20 rocks)
- topsoil (enough to fill plastic container halfway)

STEPS FOR *WEATHERING CUBES*

- 1. Warm-Up Activity:** Display one large and one small rock to the class. Ask students to identify any relationship between the two rocks. Then prompt students to think about how one of the rocks could turn into the other. Again, accept student answers. Use their answers as a way to gauge their knowledge about rock processes such as weathering. Explain to students that weathering is when rocks are broken down by wind, water, or other weather. As very tiny pieces break off of the rock, it becomes smaller. Tell students that in the activity they will use sugar cubes to model the process of weathering.
- 2.** Divide students into small teams and hand out the materials as well as the Student Handouts. The materials are shown below:



- 3.** Instruct students to create sugar-cube “rocks” of different sizes. To do this, they will use the glue to attach sugar cubes to each other. Each group should make four “rocks” that are different shapes, but each “rock” should contain the same number of sugar cubes. For example, one rock might be a large cube consisting of 8 sugar cubes, while another might be a longer, plank-like rock also consisting of 8 sugar cubes. The image below shows a few ways sugar cubes can be glued together.



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Remind students that they can make oddly shaped rocks (L's, T's, or rocks in long straight lines). Instruct students to leave one sugar cube unglued. They will be measuring parts of that cube.

4. Hold up a sugar cube and explain that a “square” is one side of the sugar cube. The square has a length and a height. Have the class measure and record the length and height of a single sugar-cube square on their Student Handouts.

Explain that the area of a square is the length of the square multiplied by the height of the square. Have students calculate the area of the squares on their Student Handouts. Have students share their measurements and calculations with the class.

5. Hold up a sugar cube again and explain that cubes are three-dimensional squares. They have a length and a height, and they also have a width. Point to the width of the sugar cube. Then have students measure and record the width of the sugar cube on their Student Handouts.

Explain that the volume of a cube is calculated by multiplying the length, height, and width of the cube. Have students calculate the volume of the cube on their Student Handouts.

6. Now, have a student volunteer bring a sugar-cube “rock” to the front of the classroom. Explain that all sugar-cube rocks have surface area and volume. The surface area is the part of the rock you can see when you look at it. To calculate the surface area of the rock, you need to count up how many squares you can see on the surface of the rock. Then you multiply that number by the area of one square. (Remind students that this was the number they calculated in Question 2 on the Student Handout.)

Perform a sample calculation in front of the class using the rock from the student volunteer. Write the following formula on the board:

$$\text{Rock Surface Area} = (\text{Number of Squares}) \times (\text{Square Area})$$

Ask students to identify the number of squares they see on the rock. (You may need to pass the rock around so students can observe it more closely.) Write this number on the board. Then ask students to provide the “Square Area” value. (They should look to Question 2 on their Student Handouts.) Write this number on the board. Then perform the calculation to determine the rock surface area.

Next, explain that all sugar-cube rocks have a volume. The volume is the amount of space the

STEPS FOR *WEATHERING CUBES*

whole rock takes up. Volume includes the surface area and also the parts of the rock you can't see. To calculate the volume, you need to count up the number of cubes that make up the rock. Then you multiply that number by the volume of one cube.

Perform a sample calculation of the rock volume. Write the following equation on the board:

$$\text{Rock Volume} = (\text{Number of Cubes}) \times (\text{Sugar Cube Volume})$$

Have students identify the number of cubes that make up the rock and write this number on the board. Then have students provide the value of the "Sugar Cube Volume." (Remind students that this was the value they calculated in Question 4 on the Student Handout.) Write this number on the board and perform the calculation of the rock volume.

Then instruct students to compute the surface area and volume of each cluster of sugar cubes. They should record their answers in the first two columns of the chart in Question 5 of the Student Handout. Circulate around the classroom as students perform the calculations to aid any struggling students.

7. Have students draw a sketch of each rock in the chart on their Student Handouts. Then instruct students to place their gravel and soil in the plastic container, along with the first sugar-cube rock. They should secure the lid on the container and shake the container vigorously for one minute. After shaking, students should use their fingers to find the sugar-cube rock and remove it from the plastic tub. Because the tubs are only half-full, students should not need to dump out the contents of the tub to locate the rock.
8. Repeat Step 7 for the remaining three sugar-cube rocks. After shaking the plastic tub for a minute, students should remove and inspect the sugar cubes. They should write qualitative descriptions of how the rock changed. They should note if the shape of the rock changed—Did some cubes fall off?—and they should observe how much of sugar cube broke off of the rock. Have students record their observations in the chart on the Student Handout.
9. **Wrap-up Activity:** Have students share their results from this activity. Ask them several questions to get them thinking about weathering rate, surface area, and volume. Sample questions include:
 - In this activity, what objects were used to model rocks? What was used to model the natural weathering forces?
 - Which rock changed the most in size?
 - Why do you think some rocks weathered more than others?

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Ask students if they noticed a relationship between the surface area of a rock and how much it weathered. Students should find that rocks with a greater surface area weathered more than others, even though all of the rocks had the same volume. Ask students to think about why this might be the case. Remind them that the surface area is the part of an object that can touch other objects. Explain that when an object has more surface area, it is exposed to more things that can touch it or break away parts of it. This means rocks with more surface area will weather faster than rocks with less surface area, even if the rocks are the same volume.

Weathering Rocks Extension Activity

Challenge students to brainstorm other variables that might affect the rate at which the sugar cubes weather. For example, groups could test how the sugar cubes weather in different materials, including sand, soil only, or gravel only. Other groups could measure the rate of weathering on materials other than sugar cubes, like tortilla chips or ice cubes. Have students create a plan to test the effects of these variables, and then allow them to carry out their investigations.

What is weathering?

Weathering is the natural process that slowly breaks down rocks. Weathering can be mechanical or chemical. This activity focuses on mechanical weathering. Mechanical weathering is the breakdown of material caused by movement. Many things can cause mechanical weathering. Water in rivers carries rocks downstream, causing pieces of rock to break off. The force of water on rocks can also cause small pieces of rock to break off over time, causing the rocks to become smooth. Freeze/thaw cycles can cause rocks to move apart and break. Roots of plants can also break apart rocks. Gravity can carry rocks down mountains, causing other rock pieces to break off.

Chemical weathering is the breakdown of material caused by chemical processes. Chemical processes include oxidation, which is when the elements within a rock change when exposed to oxygen. For example, rocks with iron in them can oxidize and lose some of their iron. Another type of chemical weathering is caused by acidification. Acidic water or soil can cause rocks to break down over time.

In general, if a rock has a greater amount of surface area, it will become weathered more quickly than a rock with less surface area. For this reason, rocks that are spread out over a larger area tend to break down faster than smaller, more condensed rocks of the same material. When discussing weathering, it's important to remember that different material can weather at different rates. A sandstone rock will likely weather more quickly than a harder granite rock.

What is surface area and how do we compute it?

Surface area, like the name suggests, is the area of an object that is located on the surface of that object. You can think of surface area as the area of an extremely thin sheet of paper that is needed to completely cover an object. There are different methods for calculating the surface area of various geometric objects.

In this activity, students build larger objects using small sugar cubes. Each small sugar cube has six square sides. To determine the surface area of the small sugar cube, you can simply find the area of one square side and multiply it by 6. The area of a square is calculated by multiplying the length and height of the square. For typical sugar cubes, the length and height of each side is approximately 0.5 inch. This means the surface area of one sugar cube side is $(0.5 \text{ inch}) \times (0.5 \text{ inch}) = 0.25 \text{ in}^2$. The total surface area of a sugar cube is thus $(6) \times (0.25 \text{ in}^2) = 1.5 \text{ in}^2$. You can determine the surface area of any complex arrangement of sugar cubes by counting up the number of square faces that are exposed on that object and then multiplying that number by the area of one square (which is 0.25 in^2). For example, if students build a cube with four square faces on each side, then there are 24 squares total on the surface of the object. This means the surface area of that object would be $(24) \times (0.25 \text{ in}^2) = 6 \text{ in}^2$.

It is very important that your students pay careful attention to the units of measurement. Surface area is expressed (in this activity) as square inches.

What is volume and how do we compute it?

Volume is the amount of space an object takes up. Like surface area, there are different ways of calculating volume for different geometric objects. For a cube, volume is calculated by multiplying the length, width, and height of the cube. For a sugar cube, the volume is $(0.5 \text{ inch}) \times (0.5 \text{ inch}) \times (0.5 \text{ inch}) = 0.125 \text{ in}^3$. To determine the volume of an object created using multiple sugar cubes, simply multiply the number of sugar cubes by the volume of one sugar cube. If an object is made using eight sugar cubes, the volume would be $(8) \times (0.125 \text{ in}^3) = 1 \text{ in}^3$. Note that volume is expressed in cubic inches (or in^3).

Key Vocabulary

weathering: the gradual process of material wearing away from an object

surface area: the total amount of area that is exposed on the surface of an object

volume: the total amount of space that an object takes up

WEATHERING CUBES TEACHER HANDOUT

1. Measure the length and height of one sugar-cube “square.” Record your measurements below:

length: [Sample answer: 0.5 in]

height: [Sample answer: 0.5 in]

2. Calculate the area of the sugar-cube square using the following equation:

Square Area = (Length) x (Height)

[Sample answer: (0.5 in) x (0.5 in) = 0.25 in²]

3. Measure and record the width of one sugar cube.

width: [Sample answer: 0.5 in]

4. Calculate the volume of one sugar cube using the following equation:

Sugar Cube Volume = (Length) x (Height) x (Width)

[Sample answer: (0.5 in) x (0.5 in) x (0.5 in) = 0.125 in³]

5. Examine the sugar-cube rocks you formed. Calculate the surface area and volume of each rock using the following formulas:

Rock Surface Area = (Number of Squares) x (Square Area)

Rock Volume = (Number of Cubes) x (Sugar Cube Volume)

Record your calculations in the first two columns of the chart below:

[Sample data are shown in the chart.]

ROCK SKETCH	ROCK SURFACE AREA	ROCK VOLUME	OBSERVATIONS AFTER WEATHERING
Rock 1 [Sample: 4 x 4 cube]	6 in ²	1 in ³	[The rock wore away a little at the corners.]
Rock 2 [Sample: 4 x 2 flat rock]	7 in ²	1 in ³	[The rock wore down a little on all sides.]

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Rock 3 [Sample: straight line rock]	8 in ²	1 in ³	[A few pieces broke off of the ends of the rock. It wore down a little on all sides.]
Rock 4 [Sample: T-shaped rock]	8.5 in ²	1 in ³	[The rock wore down a lot on all sides. Some pieces broke off.]

6. Make a prediction about what will happen to each rock when it is tumbled in the plastic tub in a mixture of gravel and soil.

[Sample answer:

Rock 1: This rock has the least surface area, so I think it will almost completely disappear.

Rock 2: I think this rock will be half-sized.

Rock 3: This rock is made of six cubes. I think it will also be half-sized.

Rock 4: This rock is made of eight cubes. I think it will be less than half-size.]

7. After shaking each sugar rock, observe what happened to the rock. Write your observations in the chart above.

[Sample answers for this question appear in the chart above.]

8. Were your predictions correct? If not, write down what actually happened during the experiment.

[Sample answer: My prediction was wrong. The large, cube-shaped rock wore down the least, and the other rocks wore down much more.]

9. Which sugar-cube rock weathered the most? Why do you think this was the case?

[Sample answer: Rock 4 weathered the most. I think this was because it had the most surface area, and so there was more area for it to be weathered away.]

10. Do you think this experiment accurately shows how rocks weather?

[Sample answer: I think this experiment gives a good overall idea about how rocks weather, but it may not be accurate. For example, actual rocks might weather much differently than sugar cubes.]

WEATHERING CUBES STUDENT HANDOUT

Name:

Date:

1. Measure the length and height of one sugar-cube “square.” Record your measurements below:

length: _____ inch

height: _____ inch

2. Calculate the area of the sugar-cube square using the following equation:

Square Area = (Length) x (Height)

Square Area = _____ square inch

3. Measure and record the width of one sugar cube: _____ inch

4. Calculate the volume of one sugar cube using the following equation:

Sugar Cube Volume = (Length) x (Height) x (Width)

Sugar Cube Volume = _____ cubic inch

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5. Examine the sugar-cube rocks that you formed. Calculate the surface area and volume of each rock using the following formulas:

$$\text{Rock Surface Area} = (\text{Number of Squares}) \times (\text{Square Area})$$

$$\text{Rock Volume} = (\text{Number of Cubes}) \times (\text{Sugar Cube Volume})$$

Record your calculations in the first two columns of the chart below:

Rock Sketch	Rock Surface Area	Rock Volume	Observations after Weathering
Rock 1			
Rock 2			
Rock 3			
Rock 4			

6. Make a prediction about what will happen to each rock when it is tumbled in the plastic tub in a mixture of gravel and soil.

