Small is Different: Activity 1

Surface Area

Over-Reacting

Lara and Anushua here! We were hard at work baking cookies at the Mill City Museum in Minneapolis and learned that this spot was actually the site of a huge flour dust explosion in the late 1800s. How can ordinary flour be explosive? We looked for answers at the **Science Museum of Minnesota** where we learned a little about something called surface area.

Our question:

How does surface area affect how things react?

We headed to the museum's Big Back Yard where we designed a geyser of an experiment to compare how surface area affects the reactivity of soda. It turns out surface area even plays a part in going "green." We caught a bus to the **University of Minnesota** to learn how scientists are developing more affordable solar cells with nanotechnology that increases their surface area and allows them to absorb more sunlight.

Nano Matters

Surface area to volume ratio is an important concept in nanotechnology because it helps explain why the same substance can behave differently when broken into nanosized pieces. Take a piece of aluminum, for instance. If you could grind it down into a superfine, nanosized powder, the volume would be fixed, but the amount of surface exposed would increase dramatically. This causes more of the substance to be in contact with oxygen in the air and is the reason researchers are even looking at nano-aluminum as a catalyst for rocket fuel! The increased reactivity of nanosized particles plays a huge role in research activities and allows scientists to use less material to achieve dramatic results.

Icebreaker

Learn volumes in the kitchen.

30 minutes plus baking time

DragonflyTV Skill: Experimenting

Guide your kids as they

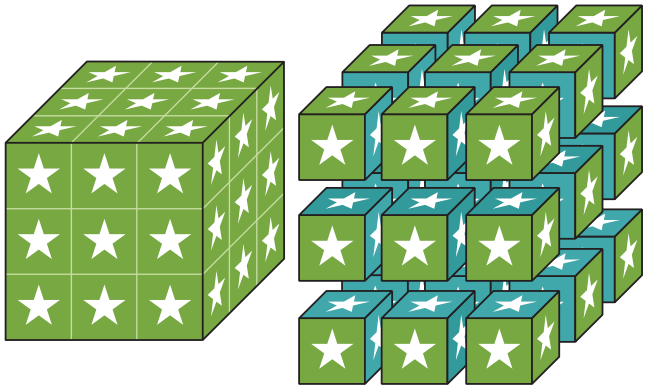
1) Set the scenario. You are in charge of bringing sugar cookies to a party and have already made the dough. You look in the cabinet and realize you only have 1 tablespoon of colored sugar left to coat the cookies! What should you do? What size and shape of cookie should you make to use the LEAST amount of colored sugar possible?
2) Now experiment! Find a sugar cookie recipe online or use premade dough.
3) Weigh the dough (or judge by eye) and split it into two equal parts.
4) Get rolling! Roll half the dough into one large ball. Roll the other half into 20–25 small balls.
5) Place 1 tablespoon of colored sugar onto a piece of wax paper and roll the large dough ball in the sugar until it is completely covered.
6) Repeat with a different color sugar for the smaller balls, making sure the cookies are completely covered. Which half used more sugar? Why?
7) Bake and enjoy! (Note: the larger cookie will take significantly longer to bake, depending on the oven.)

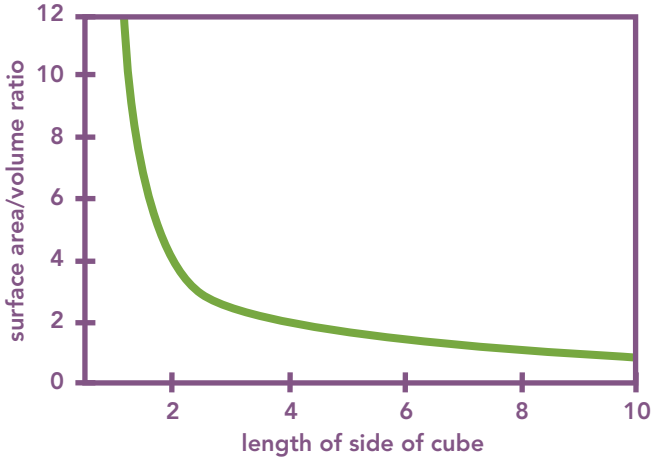
You'll need:

- sugar cookie dough
- 1 tablespoon red sugar (or color of your choosing)
- 1 tablespoon green sugar (or color of your choosing)
- wax paper
- measuring spoons
- oven
- cookie sheets

Are you a nano-bit curious?

Breaking a substance into smaller pieces increases the surface area to volume ratio. In other words, for the same VOLUME of material, there is an increased amount of SURFACE exposed. To help make the cookie experiment more clear, a demonstration similar to the one on our show can be performed. Take a block or piece of clay and first mark and then count the number of units of surface area. In the picture below, the large cube—representing the large cookie—has: 9 (units of area) x 6 (faces of the cube) = 54 total units of area. Now, break the block into its 27 individual pieces. 27 (cubes) x 1 (unit of area) x 6 (faces of each cube) = 162 total units of area. The small blocks—representing the small cookies—have much more exposed surface area even though the volume didn't change. That's why the small cookies required more sugar to coat! The graph shows how much the surface area to volume ratio increases as the size of the cube decreases.





Investigation

Aim high with this surface area activity.

2 hours

Guide your kids as they

1) Weigh out 25 g of each type of rock (rock, pea gravel and sand).
2) Put the pin into the geyser tube and top with a penny. Use a stick to level the penny. (This addition prevents the rocks from leaking out too early.)
3) Add the rocks to the tube and twist on the cap. Remove the cap from the 2 L bottle of soda and carefully screw on the geyser tube. (If you move too quickly, you risk moving the pin and starting the fun a bit early!)
4) Stand back and pull the pin. Measure (by counting bricks on a wall, for instance) how high the geyser surges.
5) Repeat this procedure for pea gravel and sand. Make sure the geyser tube is dry before the next round. Do 3 trials for each type of rock and average your results.

Adapted from an activity created by the National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT) at Northwestern University.

You'll need:

- 2 liter bottles of diet soda
- rocks, pea gravel and sand (For the most reliable results, get supplies from a local landscaping store and ask for the same type of rock.)
- geyser tube (Steve Spangler Science, Item# WGEY-500)
- penny
- thin stick or chopstick
- scale
- outdoor wall to measure against

DFTV Adult Tip

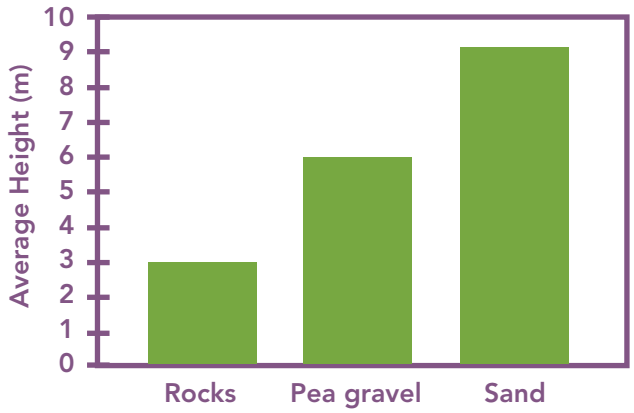
It may be advisable to have an adult screw the geyser tube on the soda bottle for each experiment. The tighter the cap is on, the better. If the soda is leaking out the sides versus out the top, you can help secure the connection with plumbing tape.

Are you a nano-bit curious?

The amount of exposed surface of a substance plays a large role in its reactivity. With increased surface area, more atoms are available to make contact with the surrounding material. Think about how fast a crushed piece of candy melts in your mouth as opposed to a whole piece. For most materials we use on a daily basis, the majority of atoms never come in contact with their surroundings. This is not the case for nanosized particles, which leads researchers to explore various nanoparticles as catalysts to speed up chemical reactions.

DFTV Kids Synthesize
Data and Analysis

	Trial 1	Trial 2	Trial 3	Average
Rocks	3 m	2 m	4 m	3 m
Pea gravel	6 m	5 m	7 m	6 m
Sand	9 m	8 m	10 m	9 m



Keep Exploring!

Other than surface area, what other factors influence reaction rate (e.g., temperature, pressure, concentration, addition of a catalyst)? Does the temperature of the soda make a difference? What about the chemical make-up of the soda (regular versus diet)? Does the amount of carbonation in the soda bottle make a difference (fresh soda versus flat soda)?

Even More to Explore!

Here's another way to have a reaction race on a slightly smaller scale.

Guide your kids as they

1) Place a whole antacid tablet into one of the dry drinking glasses. Crush the second tablet and place it in the other glass.
2) Fill the 2 additional cups with 1/2 cup water each. Add 1 drop of food coloring to each.
3) On the count of three, dump the colored water into each of the glasses with antacid.
4) Which one reacts faster? Why?

You'll need:

- 2 antacid tablets
- spoon or something you can use to crush a tablet
- 2 clear drinking glasses (tall with a small diameter works best)
- 2 additional cups (any type)
- water
- food coloring