

Name _____

Why Cells are Small: Surface Area to Volume Ratios

Today's lab is about the size of cells. To understand this, we first have to understand surface area to volume ratios.

Let's start with surface area. Get a box of sugar cubes. The surface area of the cube is calculated by finding the area (length x width) of one side. But we want to know the *whole* surface. On a cube, there are 6 sides, so we multiply that area x 6. So

$$\text{Surface area of a cube} = \text{length} \times \text{width} \times 6$$

Volume is another simple calculation – we just multiply length x width x height. Build the following four structures from your sugar cubes, and fill out the table below.

The one we're most interested in, though is the surface area to volume ratio, which is just

$$\text{Surface area} \div \text{volume}$$

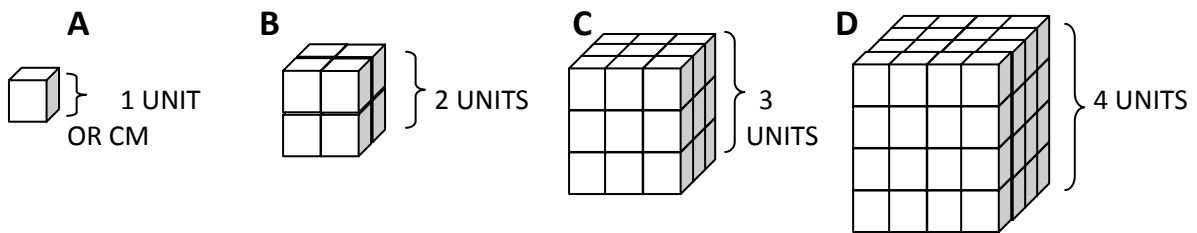


Figure	Total number of Cubes	Surface area of figure (=6 x length x width)	Volume of figure (= length x width x height)	Surface area to Volume Ratio (= SA / V)	Total surface of individual cubes* (= 6 * # cubes)
A	1	6	1	6	1
B	8	24	8	3	48
C	27	54	27	2	162
D	64	96	64	1.5	384 *because surface area of one cube is 6

Surface Area to Volume Lab Questions

1. What happened to the surface area as the size increased?

It increased.

2. What happened to the volume as the size increased?

It also increased, but not as quickly.

3. What happened to the surface area to volume ratio as the size increased?

It decreased.

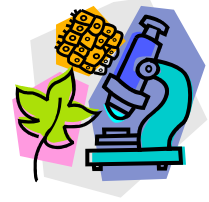
4. Now imagine you're looking at a very large cell. Next to it is a very small cell. Which one has a larger surface area to volume ratio?

The small one.

Surface Area to Volume Lab Part II: Hot Potato – Inquiry

Now you are going to apply what you just learned about surface area to volume ratios. Your job is to figure out how this whole thing applies to biology.

The cells you've looked at in biology have all been with the use of a microscope: they've all been very, very small. But some cells are not – they are much bigger, and you can even see them without any help from magnifying glasses or anything - for example, a human ovum (egg cell). Other gigantoid cells include the nerve cell of the giant squid (over a meter long and a millimeter thick!). But...most cells are tiny.



Why?

You've learned about osmosis and diffusion. This is how cells get almost everything they need: nutrients, ions, water, etc, and how they get rid of wastes. Will diffusion and osmosis be enough to support just any cell?

Questions

1. Do you think large cells and small cells carry out diffusion and osmosis at the same rate? Why or why not?

Let student make predictions

2. If a cell has a high concentration of something, say, waste, that it wants to get rid of, which do you predict will be able to get rid of the waste sooner – a smaller cell or a large one?

Smaller cell

Now, design an experiment to test your hypothesis from question #2.

We have large and small potatoes to model cells. They are hot. Just like in cellular processes, heat diffuses out of areas of high concentration to areas of low concentration, which makes it a great demonstration for testing questions like this, since cells are very hard to work with.

We will apply the hypothesis from question two to the potatoes. If you have a large hot potato and a small hot potato, and two thermometers (and using anything else around the room you can think of if you want), how can you test your hypothesis that one potato (whichever you predicted above) will lose heat faster than the other? What will you measure and how will you measure it? Describe your experiment briefly below, using 1-2 complete sentences.

Make sure students have a testable hypothesis and sound experimental design here. What will they test? What will they measure? I generally guided them to measuring temperature inside the potato – but where? They have two different sized potatoes they are measuring. The center of each is a good

place, but as long as they are systematic, it is fine. Will they measure temperature at intervals (every 3 min? 5 min?) or at a beginning and end point? Regardless, what is the end point?

It works well if they make a hole in the potato with a pencil first and then insert thermometers. Once the thermometers are in, it is best to have them put the potatoes on their sides so the thermometers are lying flat and are less likely to tip and break.

Once you have come up with an experiment, bring your paper to your teacher to approve your experiment and to get your two hot potatoes and begin.

Potatoes should be hot – I found it best precook at home, bring them in hot, and use a toaster oven through the day to keep them hot. The experiment will not work if they are not hot.

Data

Make sure students are recording the data. I avoid a data table here to encourage them to think about how they want to set up their experiment and not assume they have to conform to a specific protocol, but encourage them to set up a table themselves once they have their protocol.

Graph your data below. Make sure to label your x and y axis. Use a different color line for your different potatoes.



Questions

3. Which potato cooled off faster?

Should be the small one.

4. If the potato was a cell, and the heat was waste the cell was trying to get rid of, which cell do you think would have an advantage?

The small one.

5. How might surface area to volume ratios help decide the size of cells?

Big cells may have a hard time getting rid of wastes or getting enough nutrients to the center of the cells because they are larger – the increased volume makes it difficult to get things diffused into and out of the center of the cell.

6. Based on what you have learned today, in what way may multicellular organisms have an advantage over single-celled ones?

The largest structure (4x4) had a surface area to volume ratio of 1.5. But when you look at the individual cubes, the SA:V was 384. This means that large organisms can get large but not lose the benefits of being small, sort of the best of both worlds!

7. Consider a mouse and an elephant. If both were left in the cold overnight, which would be in more danger of freezing to death? Why?

The mouse, because it has the larger surface area to volume ratio – so it can lose more heat. The elephant would actually be able to use its large size to its advantage here, and retain the heat in the large volume of its body. The mouse has a much larger SA:V ratio, so, all physiological adaptations to their environments aside, the mouse would be in danger of freezing to death much quicker than the elephant should temperatures plummet.