

# Limitations on Cell Size: Surface Area to Volume

In order for cells to survive, they must constantly exchange ions, gases, nutrients, and wastes with their environment. These exchanges take place at the cell's surface. To perform this function efficiently, there must be an adequate ratio between the cell's volume and its surface area. As a cell's volume increases, its surface area increases, but at a decreased rate. If you continued to increase the cell's volume, it would soon be unable to efficiently exchange materials and the cell would die. This is the reason that the kidney cell of an elephant is the same general size as a mouse kidney cell.

In this lab activity, you will use agar cubes, which have a high salt content, as cell models. You will investigate how increasing a cell's surface area while maintaining an equal volume affects the rate of material exchange with the environment. When the agar cubes are placed in distilled water, they will begin to dissolve, releasing sodium and chloride ions. The solution's conductivity, measured by a Conductivity Probe, is proportional to the ion concentration in the solution.

## OBJECTIVES

In this experiment, you will

- Use agar cubes cut into various size blocks to simulate cells.
- Use a Conductivity Probe to measure the quantity of ions in a solution.
- Determine the relationship between the surface area and volume of a cell.

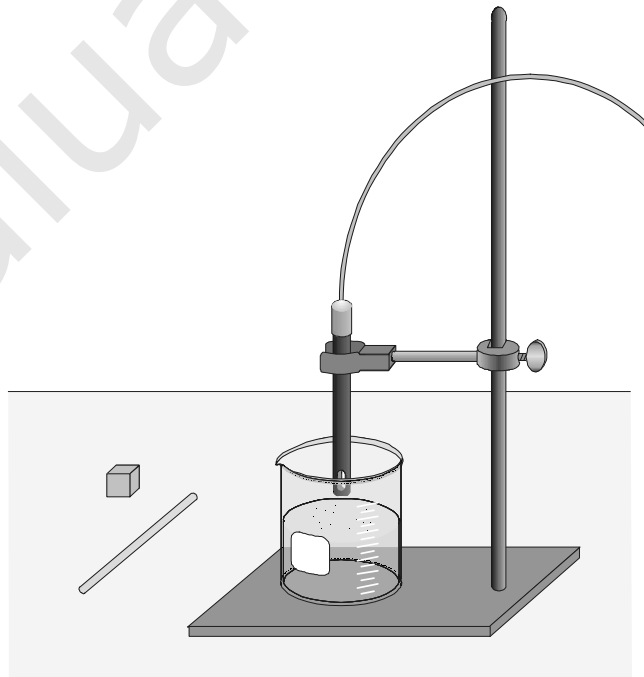


Figure 1

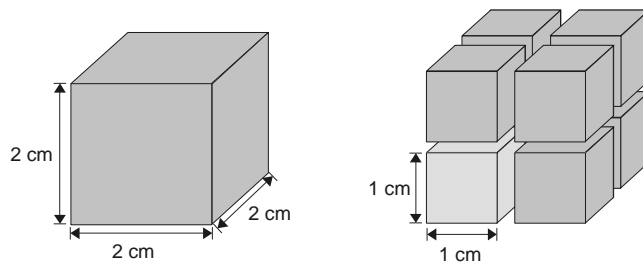
## MATERIALS

computer  
 Vernier computer interface  
 LoggerPro  
 Vernier Conductivity Probe  
 600 mL beaker  
 glass stirring rod  
 scalpel or razor blade (optional)

agar cubes  
 distilled water  
 ring stand  
 utility clamp  
 metric ruler  
 lined graph paper

## PRE-LAB ACTIVITY

1. Obtain three agar cubes.
2. Cut one agar cube into 8 equal cubes. Cut a second cube into 64 equal cubes. Leave the third cube whole.
3. Using a metric ruler, determine the total surface area and the total volume of each agar cube. Note: If the cube is cut into eight pieces, the surface area for that cube is the sum of the surface areas for each of the eight pieces.
4. Record the calculated surface areas and volumes in Table 1.
5. Use your answers from Step 4 to calculate the surface-to-volume ratio. Divide the surface area of each cube by its volume. Enter the results in Table 1. Use the example below to help you with your calculations.





Surface Area:	6 sides (2 cm X 2 cm) = 24 cm <sup>2</sup>	6 sides (1 cm X 1 cm) X 8 cubes = 48 cm <sup>2</sup>
Volume:	2 cm X 2 cm X 2 cm = 8 cm <sup>3</sup>	(1 cm X 1 cm X 1 cm) X 8 cubes = 8 cm <sup>3</sup>
Surface-to-volume ratio:	3 to 1	6 to 1

## PROCEDURE

1. Set up the utility clamp, Conductivity Probe, and ring stand as shown in Figure 1.
2. Connect the Conductivity Probe to the computer interface. Prepare the computer for data collection by opening the file “02 Limits on Cell Size” from the *Biology with Vernier* folder of LoggerPro.
3. Set the selector switch on the side of the Conductivity Probe to the 0–20000 μS/cm range.
4. Pour 300 mL of distilled water into the 600 mL beaker. Position the Conductivity Probe in the water so the tip is about 2 cm from the bottom of the beaker.

## Limitations on Cell Size: Surface Area to Volume

5. Place the solid agar cube sample in the beaker and begin data collection by clicking . Stir the water using the stirring rod. Data collection will automatically end after two minutes.
6. Determine the rate of ion exchange by performing a linear regression of the data:
  - a. Click the Linear Fit button, , to perform a linear regression. A floating box will appear with the formula for a best fit line.
  - b. Record the slope of the line,  $m$ , as the rate in Table 1.
7. Empty the water from the beaker and rinse it thoroughly. Rinse the probe with clean, distilled water. Blot the outside of the probe tip dry with a tissue or paper towel. It is *not* necessary to dry the *inside* of the hole near the probe end.
8. Move your data to a stored run. To do this, choose Store Latest Run from the Experiment menu.
9. Repeat Steps 4–8 for the sample of agar cut into 8 pieces.
10. Repeat Steps 4–8 for the sample of agar cut into 64 pieces.

### DATA AND CALCULATIONS

Table 1				
Pieces	Surface area (cm <sup>2</sup> )	Volume (cm <sup>3</sup> )	Surface-to-volume ratio	Rate (μS/cm s)
1				
8				
64				

### PROCESSING THE DATA

1. On Page 2 of this experiment file, plot the surface-to-volume ratio on the x-axis and rate on the y-axis.

### QUESTIONS

1. What is the relationship between rate of ion exchange and surface-to-volume ratio?
2. Why is it important for a cell to have a large surface-to-volume ratio?
3. Which is more efficient at exchanging materials, a small or a large cell? Explain.
4. Some cells in the body have adapted to the task of absorption and excretion of large amounts of materials. In what ways have these cells adapted to this task?

## *Computer 2*

---

5. How does cell growth affect the cell's surface-to-volume ratio?
6. In order for a cell to continue being efficient at exchanging materials, what must it do to maintain its surface-to-volume ratio as it grows larger?

# Vernier Lab Safety Instructions Disclaimer

**THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.**

**This copy does not include:**

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Biology with Vernier* lab manual includes 31 labs and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/bwv.html>



Vernier Software & Technology

Vernier Software & Technology  
13979 S.W. Millikan Way • Beaverton, OR 97005-2886  
Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440  
info@vernier.com • www.vernier.com