Names: ____ LabQuest **2**

Limitations on Cell Size: Surface Area to Volume

50 Points

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 bouillon cubes, which have a high salt content, as cell models. You will observe how cells of equal volume perform reactions faster when their surface area is increased. When the bouillon 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.

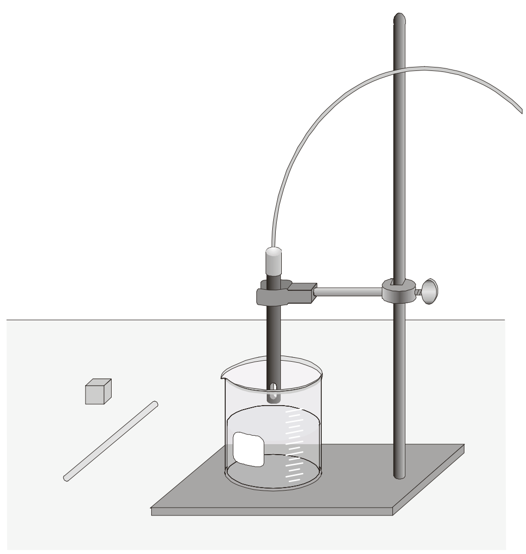


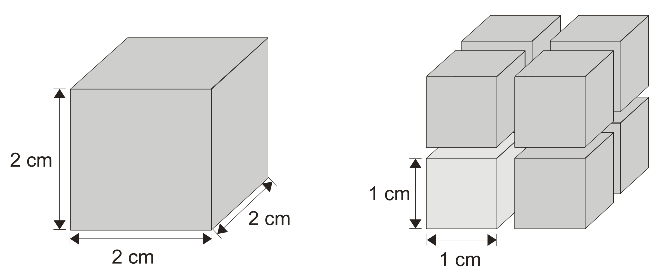
Figure 1

MATERIALS

LabQuest
LabQuest App
Vernier Conductivity Probe
400 mL beaker
glass stirring rod
ring stand
utility clamp
bouillon cubes
distilled water
metric ruler
lined graph paper
Logger *Pro*
scalpel or razor blade (optional)

PRE-LAB ACTIVITY

1. Set aside one whole bouillon cube.
2. Cut a bouillon cube into two equal pieces.
3. Cut a bouillon cube into four equal pieces.
4. Cut a bouillon cube into eight equal pieces.
5. Using a metric ruler, determine the total surface area and the total volume of each bouillon cube. **Note:** If the cube is cut into eight pieces, the total surface area for that cube is the sum of the surface areas for each of the eight pieces.
6. Record the calculated surface areas and volumes in Table 1.
7. Use your answers from Step 6 to calculate the surface-to-volume ratio. Divide the surface area of the 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^2	6 sides (1 cm X 1 cm) X 8 cubes = 48 cm^2
Volume:	2 cm X 2 cm X 2 cm = 8 cm^3	(1 cm X 1 cm X 1 cm) X 8 cubes = 8 cm^3
Surface-to-volume ratio:	3 to 1	6 to 1

Figure 2

PROCEDURE

1. Set up the utility clamp, Conductivity Probe, and ring stand as shown in Figure 1.
2. Set the selector switch on the side of the Conductivity Probe to the 0–20000 μS/cm range. Connect the Conductivity Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
3. On the Meter screen, tap Rate. Change the data-collection rate to 0.5 samples/second and the data-collection length to 80 seconds.

4. Pour 200 mL of distilled water into the 400 mL beaker. Position the Conductivity Probe in the water so the tip is about 3 cm from the bottom of the beaker.

5. Place the solid bouillon cube sample in the beaker and start data collection. Stir the water moderately with the stirring rod. Continue stirring the water during the entire data collection period. Avoid hitting the bouillon pieces with the stirring rod.

6. Data collection will stop after 80 seconds. Analyze the graph to determine the rate of ion exchange. To do this:
   a. Examine the graph and identify the most linear region.
   b. Tap and drag your stylus across the most linear region to select these data points.
   c. Choose Curve Fit from the Analyze menu. Select Linear as the Fit Equation.
   d. Record the slope, *m*, as the rate of ion exchange in (µS/s). Select OK.

7. Empty the water from the beaker. Rinse the beaker and Conductivity Probe thoroughly. Dry the beaker and blot the outside of the probe shaft dry using a paper towel. It is not necessary to dry the inside of the hole near the probe end.

8. Repeat Steps 4–7 for the sample of bouillon cut into 2 pieces.

9. Repeat Steps 4–7 for the sample of bouillon cut into 4 pieces.

10. Repeat Steps 4–7 for the sample of bouillon cut into 8 pieces.

DATA

Table 1				
Pieces	Surface area (cm^2)	Volume (cm^3)	Surface-to-volume ratio	Rate (µS/s)
1				
2				
4				
8				

PROCESSING THE DATA

1. Make a graph of rate *vs*. surface-to-volume ratio. Plot surface-to-volume on the x-axis and rate on the y-axis.

CONCLUSION (SUMMARY OF EXPERIMENT, ANALYSIS OF DATA, DISCUSSION OF ERROR)

QUESTIONS

1. What is the relationship between rate of ion exchange and surface-to-volume ratio?

2. What is the advantage of a cell that has 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?

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?