Surface Area to Volume Ratio

BACKGROUND INFO

Diffusion is the movement of a substance from an area of higher concentration to an area of lower concentration. While cells utilize a number of methods for transporting materials in and out of the cell (*eg* osmosis, facilitated diffusion, ion channels, and carrier proteins), diffusion requires no energy and no extra proteins or cell organelles. In other words, diffusion is a cheap (energy-wise) and efficient way for the cell to move stuff it has to move. Molecules like oxygen (O_2), carbon dioxide (CO_2), and glucose can diffuse through the cell membrane with no energy cost to the cell.

We'll be modeling the cell using cubes of agar (a gelatin-like substance from seaweed). The agar has been soaked in 1.0% phenolphthalein (a pH indicator that shows magenta if the pH is above 8.2). The cubes have been stored in 0.01% sodium hydroxide (a strong base) causing them to have a deep magenta color. We'll be using the diffusion of vinegar (an acidic solution which will turn the phenolphthalein, and therefore the agar, clear) into the agar to model the diffusion of oxygen into the agar "cells".

OBJECTIVE(S)

- to examine how the surface area to volume ratio affects the diffusion of substances in and out of cubes of varying sizes

EQUIPMENT

- 3 agar cubes (varying sizes) with phenolphthalein stored in a 0.01% sodium hydroxide solution
- white vinegar (apx. 200 mL)
- scalpel

PROCEDURE(S)

1. Using forceps, gently place 3 agar cubes of different sizes in a 600 mL beaker.
2. Pour just enough vinegar into the beaker to completely cover the three cubes.
3. At 10 minutes, use the forceps to remove the cubes from the vinegar onto a paper towel and blot the cubes dry on all sides.
4. Measure the cubes with a ruler and enter the data in the table in the data section.
5. Slice the cubes down the middle to get a more accurate measurement and measure how far the vinegar diffused into the cubes.
6. Complete the calculations for the rest of the table in the data section.
7. Clean up: the agar can be rolled up in the paper towels and disposed of in a trash can; the beakers and forceps can be thoroughly rinsed and placed in the drain rack. Be sure to wash your own hands when the lab is completed as well.

DATA

Block #	width (cm)	length (cm)	height (cm)	**Surface Area** (cm^2)	**Volume** (cm^3)	**SA:Vol ratio**	**Diffusion** (by vinegar) (cm)	**Diffusion rate** (cm/min)	**Volume** (magenta) (cm^3)	**% Vol. clear**

ANALYSIS/DISCUSSION

1. What do the agar blocks in this demonstration represent? What does the vinegar represent?
2. What happens to the surface area of the cubes as they get bigger?
3. What happens to the volume of the cubes as they get bigger?
4. What happens to the suface area:volume ratio as the cubes get bigger?
5. Sketch how each of the cubes looked after 10 minutes when you pulled them out of the vinegar.
6. Which sized cube had the fastest diffusion rate? Explain the relationship of the diffusion rates for the different sized cubes.
7. Which sized cube(s) had the greatest percentage of its volume diffused into by the vinegar during the time allotted?
8. Construct a graph showing the % diffusion as compared to some aspect of the cubes' dimensions.
9. Some actual cells in the body are about the size of 0.01 mm. Find the surface area to volume ratio for such a cell and compare it to the "cells" in this demonstration.
10. What might be an advantage for a single-celled organism to be larger than other single-celled organisms? What might be a disadvantage? How do animals like humans get around that disadvantage?