Surface Area to Volume Ratio

Cells need to exchange materials with their environment in order to survive. Diffusion is one important process by which substances enter and leave cells. The size (or volume) of a cell is an important factor in determining the amount of exchange that needs to take place – with larger cells generally needing more nutrients and producing more waste.

Phenolphthalein, an acid/base indicator that turns pink in the presence of a base such as NaOH, has been added to agar cubes.

1. [SP 6] Predict what will happen to the agar cubes as soon as they are placed in NaOH and over the next several minutes. Provide reasoning for your prediction.

Procedure:

1. Each group will cut three agar cubes: a 3cm cube, a 2cm cube, and a 1cm cube. Cut the cubes as accurately as possible.

2. Complete the first three columns of Table 1.

Q2. [SP 6] Predict which cube will be most pink.

3. Pour 200mL of 0.1M sodium hydroxide solution into your 400mL beaker. Note the time and immerse the three blocks in the sodium hydroxide solution. Let them soak for 10 minutes with periodic gentle stirring and turning.

4. After 10 minutes, use a spoon or tongs to remove the cubes from the sodium hydroxide solution. Blot the with a paper towel.

5. Promptly cut each cube in half and measure the depth to which the pink color has penetrated. Sketch each block's cross-section.

6. Complete the rest of Table 1.

Table 1: Data collected for three cubes

Cube	Surface area (cm^2)	Volume (cm^3)	Surface area to volume ratio	Diffusion Depth (mm)	Volume that was not pink* (cm^3)	Volume of the diffused cube (total volume – volume that was not pink)	Percent Diffusion**	Diffusion Rate (mm/min)
1cm								
2cm								
3cm								

* *i.e.*, the volume of the small portion of the cube that did not turn pink

** % diffusion = Volume diffused /total volume x 100

3. [SP 2] Describe what happens to the surface area and volume as a cube gets larger.

4. [SP 2, SP 5] Identify the cube in which diffusion was most efficient and explain why that cube was the most efficient.

5. [SP 4] This investigation had no control group. Propose an appropriate control that could be included and describe its value.

6. [SP 1] Identify what the cubes in this investigation are meant to model.

7. [SP 7] Anything that comes into a cell (such as oxygen and food) or goes out of it (such as waste) must travel across the cell membrane. The amount of membrane surface area available for this exchange determines how quickly it can happen. If the surface area is too small, the cell will be unable to exchange materials with its environment at a sufficient rate. Considering that a large surface area is favorable to a small surface area, provide a reason that nearly all cells are quite small.

8. [SP 6, SP 7] Imagine three cubes, A, B, and C, with surface area to volume ratios of 3:1, 4:1 and 5:2, respectively. Predict in which of these cubes diffusion would be most efficient. Provide reasoning for your prediction.

9. [SP 7] Provide a reason to explain why large organisms are multicellular.

10. [SP 7] Describe some adaptations that large, multicellular organisms have to increase the exchange of materials with the environment.