HANDS-ON LAB

Modeling Cell Surface Area-to-Volume Ratio

Cells must transport materials across their membranes in order to maintain homeostasis. In this lab, you will use model cells to investigate the relationship between cell size and homeostasis. Your model cells will consist of agar cubes of different sizes. Agar is a gel-like material used as a growth medium for bacteria. The agar has been soaked in an indicator that turns pink when exposed to a basic solution. The indicator will allow you to measure how quickly materials diffuse across the model cell's membrane.

MATERIALS

- beaker, 250 mL
- graduated cylinder, 100 mL
- knife, plastic
- metric ruler
- paper towel
- phenolphthalein agar
- sodium hydroxide solution (1.0 M HCl), 100 mL
- spoon, plastic
- timer

SAFETY

Sodium hydroxide is corrosive. Phenolphthalein is irritating to body tissue. Wear goggles and gloves, and dispose of chemicals as instructed by your teacher.

PROBLEM

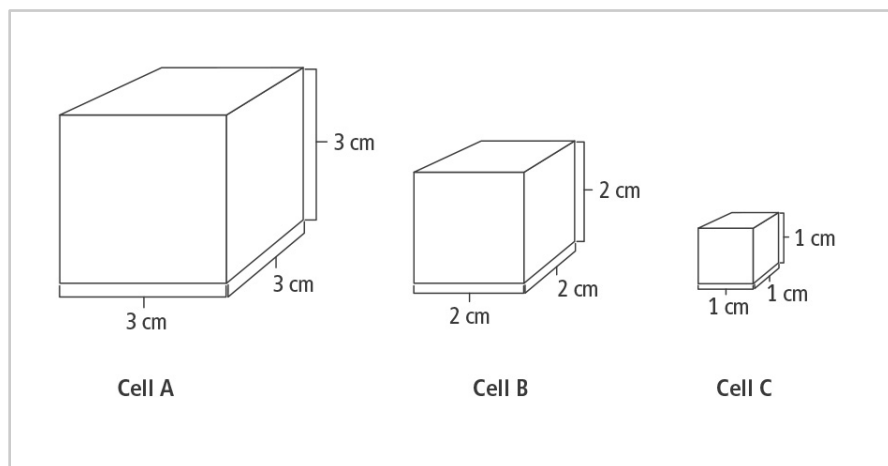How does a cell's size affect its ability to maintain homeostasis?

PREDICT

Make a prediction for how the diffusion of materials into the cell will change as your model cell gets larger. Explain your reasoning.

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PROCEDURE

1. Make three model cells by using the knife to cut three cubes from the phenolphthalein agar. Cell A should be 3 cm on each side, Cell B should be 2 cm on each side, and Cell C should be 1 cm on each side. Use the ruler to make exact measurements.

   The cube-shaped cells model what happens to the volume as the surface area increases.

Cell A   Cell B   Cell C

2. Calculate the total surface area of each cell. Record your data.

surface area of a cube = length $\times$ width $\times$ number of sides

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3. Calculate the volume of each cell. Record your data.

volume of a cube = length $\times$ width $\times$ height

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4. Calculate the surface area-to-volume ratio for each cell. For example, if the surface area was 27 cm^2 and the volume was 9 cm^3, the surface area-to-volume ratio would be 3:1. Record your data.

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5. Put the model cells in the beaker. Carefully cover them with sodium hydroxide solution, which turns the agar pink.

6. Soak the cells in solution for four minutes. Use the spoon to turn the cells repeatedly throughout that time.

7. Remove the cells from the solution and gently dry them on the paper towel.

8. Use the knife to cut each cube in half. Measure the distance (in cm) from the edge of the cell to the inner edge of the pink line. This shows how far the sodium hydroxide diffused. Record your data.

ANALYZE

1. How does the surface area-to-volume ratio change as cell size increases?

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2. Identify which cell turned pink in the greatest proportion, and explain how this relates to cell size and diffusion.

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EXPLAIN

Write an explanation that addresses each of the points below.

Claim How is a cell's size related to its ability to maintain homeostasis by transporting materials across the membrane? Was your prediction correct?

Evidence What evidence from your data supports your claim?

Reasoning Explain how the evidence you cited supports your claim.

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REFINE

Evaluate the model used in this investigation.

Precision and accuracy Did the model provide the level of precision needed to make a valid conclusion? Explain your answer. Did the model provide an adequate level of accuracy? Explain your answer.

Propose changes What changes would you make to this model if you were to carry out this investigation again? Why would you make these changes?

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