Surface area to volume ratio

Student activity • observation and reasoning

YEAR 10 / LESSON 17 / BIOLOGY + SCIENCE (DOUBLE AWARD)

The question

Why does increasing size make exchange more difficult?

Use the supplied examples, record your reasoning and correct it using evidence.

Equipment

- Student booklet, paper models, pencil and ruler

Paper, modelling and written reasoning only. No chemicals or biological samples are handled.

Course coverage: Shared Biology / Double Award: 2.15–2.16. Exchange and organism size.

Plan, model or apparatus sketch

Draw and label the apparatus or biological model; identify one limitation.

Method and reasoning

Read the whole sequence before starting

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1. Draw cubes of side 1, 2 and 3 cm. Calculate total surface area using $6l^2$ and volume using l^3; state the units.

2. Calculate surface area divided by volume for each cube. Also calculate the shortest distance from a face to the centre.

3. Compare the cubes: distinguish absolute surface area from surface area per unit volume. Do not claim that the larger cube has less total area.

4. Use a model penetration depth of 0.2 cm from every face to calculate unpenetrated core volume: $(l-0.4)^3$, provided l is at least 0.4 cm.

5. Calculate the fraction of each cube reached in the model as [1−core volume/total volume]×100. This is a geometric calculation, not a measured diffusion result.

6. Relate larger organisms to specialised exchange surfaces and transport systems; explain how a thin, folded surface can support exchange.

Cleanup

- Return models and keep the corrected work.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Cube formulae: area = $6l^2$; volume = l^3; area/volume = $6/l$. Model only: penetration depth 0.2 cm from each face leaves core sides 0.6, 1.6 and 2.6 cm for 1, 2 and 3 cm cubes. The model assumes equal depth at every surface and does not measure real rates.

Example / trial	Observation / evidence	Explanation / limit
1 cm cube: area / volume / fraction		
2 cm cube: area / volume / fraction		
3 cm cube: area / volume / fraction		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Calculate area, volume and area/volume for a 2 cm cube.

2. Which cube has the greatest absolute area?

3. Which has the greatest area per unit volume?

4. Calculate the percentage reached for the 1 cm cube.

5. Why is distance to the centre relevant?

6. How can an exchange surface increase exchange without greatly increasing body volume?