Card G · Two measures that answer different questions

Three hypothetical cube models have edges 2, 4 and 8 mm. At 4 minutes a supplied idealised penetrated layer is 0.5 mm deep from every face. Same material, temperature and surrounding conditions are assumed. For this supplied interval, the layer starts at depth d_start = 0 mm when t_start = 0 min. Average front speed = Δdepth/Δtime = (d_end − d_start)/(t_end − t_start). This is the model's interval average, not a constant future speed, intrinsic diffusion coefficient or molecular flux. The unpenetrated central cube has edge max(a − 2d, 0). Fraction penetrated = 1 − [max(a − 2d, 0)/a]³. This is a geometrical fraction, with no time unit. A layer is counted as penetrated; it is not a direct measure of molecule number or equal concentration throughout that layer.

Edge a	Depth d at 4 min	Central edge	Fraction penetrated
2 mm	0.5 mm	1 mm	0.875 = 87.5%
4 mm	0.5 mm	3 mm	0.578125 = 57.8125%
8 mm	0.5 mm	7 mm	0.330078125 = 33.0078125%

The average front speed over this interval is (0.5 − 0) mm ÷ (4 − 0) min = 0.125 mm/min for all three supplied models. Smaller cubes have a larger fraction penetrated at this time, despite the same stated depth and average front speed. Do not conclude that molecules intrinsically diffuse faster in the smaller cube. This imposed constant-depth example is not the physical claim that diffusion depth always increases linearly with time.

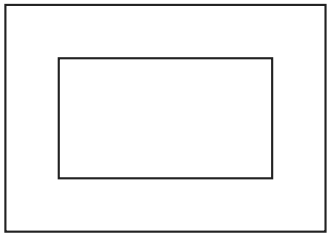
Slot 18 · How much has been reached?

Use Card G's geometric rule. A model cube has edge 6 mm and a layer 1 mm deep from every face at 5 minutes. For this supplied interval, the layer starts at depth d_start = 0 mm when t_start = 0 min. Average front speed = Δdepth/Δtime = (d_end − d_start)/(t_end − t_start). This is the model's interval average, not a constant future speed, intrinsic diffusion coefficient or molecular flux. Find the central edge and fraction penetrated. Separately calculate the

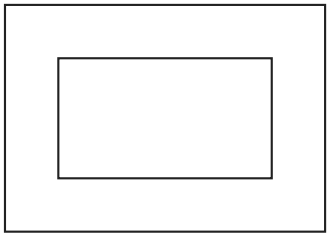
interval-average change in depth divided by elapsed time in mm/min. Explain why those two results answer different questions. Do not extend this one-time value into a constant speed for every later time.

Your explanation · words, directed marks or a sketch

Model 1 · not to scale



Model 2 · not to scale



Label dimensions, units and the question each measure answers.

Measure and evidence

Year 11 Biology · ordinary

Card H · Evidence worth asking for

Supplied plan H compares models with different edge sizes. It proposes measuring time to a defined centre endpoint while holding material, external concentration, temperature, stirring and measurement rule constant. Independent model samples would be repeated at each size; the plan does not say they have been tested. Holding conditions constant helps make a size comparison interpretable. Repeats can reveal variation but do not remove a consistent measurement bias.

Supplied invented repeat set: model A's endpoint times are 100, 104 and 108 seconds; model B's are 160, 164 and 168 seconds. Means are 104 s and 164 s; ranges are 8 s each. A's listed times are shorter, with no overlap in these small supplied sets. That supports a bounded comparison of the supplied numbers. It does not prove statistical significance, population behaviour, an exact cell-size law or that an actual investigation happened.

When evaluating a claim, name the measure, give the relevant numbers, state the conditions, and say what would improve the evidence. Avoid treating an unfamiliar value as an error merely because it disagrees with a prediction. Check the method and retain the value unless there are documented grounds for exclusion.

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Slot 19 · Improve a plan

Read Card H. Name the proposed independent variable, the dependent measure, and three conditions to keep constant. Calculate both supplied means and ranges. Give a conclusion about those numbers, one limitation, and a practical improvement to the proposed measurement or repeats. State whether a learner investigation has actually occurred.

Measure and evidence · continued

Year 11 Biology · ordinary

Your explanation · words, directed marks or a sketch

Variable / dependent measure
Constants / repeats
Numbers / limit / improvement