# Cell Size

*Learning objective 2.2.A Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.*

Name: Date: Period:

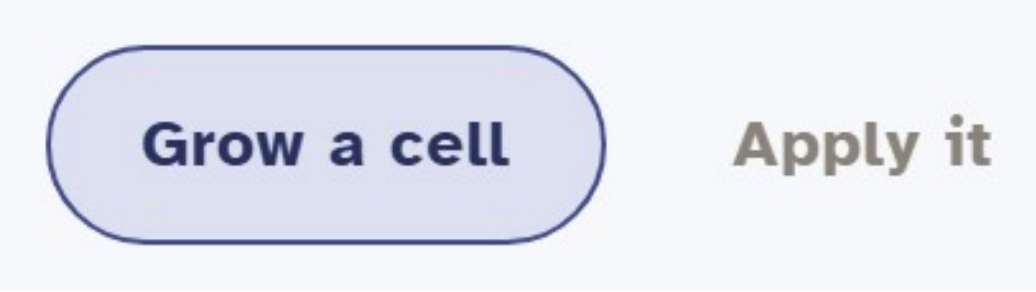
Use the tool **The Surface Area Problem**. Work on the Grow a cell tab for Parts 1 to 5, then switch to Apply it at the end of Part 5. The formulas you need are given in Part 1.

*switch tab* *scroll down* *work it on paper*

*record from the tool* *score yourself*

*The purple bar in the margin names the AP science practice a question uses.*

## Part 1 · Calculate before you slide




Use the **Grow a cell** tab. It is the one showing when the tool opens.

Keep the shape on **Cube** and the folding slider at **none**. Work these out on paper first using SA = $6s^2$ and V = $s^3$, then move the size slider to check. Show your work for at least two rows.

| Side length | Surface area | Volume | SA : V ratio |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 8 | | | |
| 10 | | | |

## Part 2 · Name the pattern

Stay on the **Grow a cell** tab.

Use the Part 1 table to answer questions 1 to 4.

SP 4 · REPRESENTING AND DESCRIBING DATA

**1. Describe the effect of increasing the side length of a cube on its SA : V ratio.**

**2. The side length of a cube increases from 1 to 5.**
**(a) Calculate the factor by which the surface area increases.**

**(b) Calculate the factor by which the volume increases.**

SP 1 · CONCEPT EXPLANATION

**3. Explain why the surface area and the volume in question 2 increase by different factors. In your answer, refer to squares and cubes.**

**4. (a) Determine a formula for the SA : V ratio of a cube in terms of its side length, s, only.**

**(b) Using your formula, calculate the SA : V ratio for s = 4. Compare your answer with the value in the Part 1 table.**

## Part 3 · When supply cannot reach the middle

Stay on the **Grow a cell** tab and scroll down to **the Can supply reach the middle? readout**.

Watch the **Can supply reach the middle?** readout as you move the size slider from 1 up to 10.

**5. Identify the smallest side length at which the tool reports that the core is unsupplied.**

**6. The tool keeps the supply depth constant and changes only the size of the cell. Explain why keeping the supply depth constant makes this a valid test of the effect of cell size.**

**7. Identify four exchanges that a cell makes across its surface that become less efficient as the SA : V ratio decreases.**

## Part 4 · Two ways out

Stay on the **Grow a cell** tab and scroll down to **the folding slider and the Shape matters too panel**.

First set the size to 6. Record the cube with no folding, then move the Membrane folding slider to the first moderate setting, and then all the way to the right (extreme). Then set folding back to none and use the **Shape matters too** panel.

| Setting | Surface area | Volume | SA : V ratio |
|---|---|---|---|
| Cube, size 6, no folding | | | |
| Cube, size 6, moderate folding | | | |
| Cube, size 6, extreme folding | | | |



**8. (a) Describe the effect of membrane folding on the surface area of the cell.**

**(b) Describe the effect of membrane folding on the volume of the cell.**

**9. In the equal-volume panel of Shape matters too, all four shapes have the same volume.**
**(a) List the four shapes in order from the least surface area to the most.**

**(b) Identify the shape that is least efficient at exchange. Provide reasoning to justify your identification.**

**10. A sphere with a diameter of 4 and a cube with a side length of 4 have the same SA : V ratio. Explain why shapes must be compared at equal volume, not at equal size, to determine which shape is more efficient at exchange.**

## Part 5 · Scale it up to organisms

Stay on the **Grow a cell** tab and scroll down to **the It scales up to whole organisms panel at the bottom**.

Open It scales up to whole organisms and answer questions 11 to 13 in complete sentences.




After question 13, click the Apply it tab at the top of the tool and work the cards there.

**11. Describe the effect of increasing body mass on the surface area-to-volume ratio of an animal.**

**12. (a) Predict whether a shrew or an elephant loses heat faster relative to its body mass.**

**(b) Justify your prediction using the SA : V ratios in the tool.**

**13. Describe the relationship between body size and metabolic rate per unit of body mass.**

**14. A student claims that a cell could grow to any size, as long as it continued to fold its membrane. Evaluate the student's claim.**

## Part 6 · Learning check self-report

Scroll down to the **Learning check** at the bottom of the tool. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

| Question | Points possible | Points I earned | Missed opportunities (what the rubric wanted that I left out) |
|---|---|---|---|
| 1 | 3 | | |
| 2 | 2 | | |
| 3 | 2 | | |
| 4 | 2 | | |
| **Total** | **9** | | |

## What the model simplifies

The cell is drawn as a two-dimensional cross-section, but every surface area and volume is calculated from the CED's real three-dimensional formulas, so the numbers are correct even though the picture is flat.

The shaded rim uses one fixed supply depth for every cell size, so that size is the only variable. Real diffusion depth depends on the substance, the concentration difference and how quickly the cell consumes it.

Membrane folding is modeled as a plain multiplier on surface area. Real folds have a shape and occupy some volume themselves.

In the tool the 'size' of a sphere is its diameter and the 'size' of a cylinder is its diameter, with the height set at twice that. The equal-volume panel is the comparison to use when shapes are being judged against each other.

Organism ratios treat each animal as a sphere of the same density. That is enough to show the direction of the relationship the CED asks for; it is not a body measurement.