MINI- LAB: MODELING LIMITS TO CELL SIZE

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Complete the following lab in your lab-book.

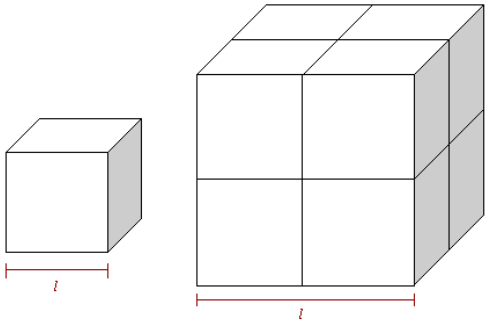
Why can't cells continue to grow larger and larger to become giant cells? Why are most cells, whether from an elephant or an earthworm, microscopic in size? What happens when a cell grows larger and what causes it to divide into two smaller cells rather than growing infinitely larger? This investigation will provide you with a 'hands-on' activity that simulates the changing relationship of surface area-to-volume for a growing cell.

Importance: Changes in the surface area to volume ratio have important implications for limits or constraints on organism size, and help explain some of the modifications seen in larger-bodied organisms.

We'll begin with a reminder of some basic geometric formulae. The surface area and volume of a cube can be found with the following equations:

$$SA = 6l^2 \qquad V = l^3$$

SA	*surface area (units squared)*
V	*volume (units cubed)*
l	*length (units)*



Purpose (*write the purpose in your lab book*): to determine the relationship between a cells size and its surface area to volume ratio.

Data collection and processing: Use the plastic blocks to create cubes of various sizes. Build at least 5 different sizes of cubes. Measure and record the side lengths of the cubes you build. Process your data by calculating the surface area, the volume, and the surface area to volume ratio for each cube you built. The surface area to volume ratio is calculated by dividing the surface area by the volume (please do the division calculation, don't leave it as a ratio or fraction).

- Show at least one worked example for each calculation.
- Create a data table to record the data (with title and labels).

CUBE SIDE LENGTH (cm)	SURFACE AREA (cm^2)	VOLUME (cm^3)	SURFACE AREA: VOLUME RATIO (cm^{-1})

EXAMPLE

Data presentation: Present your data in a line graph. Plot cube side length (l) on the X axis and the surface area to volume ratio on the Y axis. Add a smooth curve between data points.

Analysis:
Answer the following questions in complete sentences

1. Which cube has the largest surface area? Which cube has the largest volume? Which cube has the largest surface area to volume ratio?

2. Describe the meaning of your graph in words. "As the cube side length increases, the surface area to volume ratio _____. This means that…"

3. Why are cubes used in this mini-lab rather than cells? Does this affect the validity of the results? Why or why not?

4. To maintain life, materials must be able to move into and out of a cell. What might be the advantage of having a large surface area?

5. What might be the disadvantage of having a large volume?

6. Cells are generally very small. Propose an explanation for why large organisms are made of more cells rather than larger cells.

Why SA:V ratio matters to cells:

- The rate of exchange of substances into and out of the cell through the cell membrane depends on the organism's surface area that is in contact with the surroundings. The surface area of a cell is its plasma membrane.
- The volume of a cell determines how many nutrients it needs (bigger = more) and how much waste it produces (bigger=more).
- As a cell get bigger, its volume and surface area both get bigger, but not by the same amount. The volume increases as the cube but the area of the surface only increases by the square.
- As a cell gets bigger, it has more demand for nutrients and makes more waste. However in a bigger cell there is relatively less surface area of the membrane for taking in the nutrients or getting rid of the waste.

Example: gas exchange of oxygen for respiration.

- A cell needs oxygen for cell respiration. A big cell needs more oxygen than a little cell.
- Oxygen is obtained from the surrounding environment such as water or blood (depends on the cell). Oxygen diffuses across the cell membrane into the cell. Big cells need to have more oxygen diffusion across the cell membrane than a little cell.
- But the big cell has relatively small surface area compared to its volume i.e. the surface area: volume ratio is small.
- Cells must not get too big because they cannot obtain sufficient oxygen to satisfy the demands of the cell.