AP Biology
Cell Size is Limited by Surface Area (Topic 2.3)

To maintain homeostasis, cells must have enough surface area to exchange materials. However, as cells grow the surface area to volume ratio changes. As a result, there is a limit to cell growth because if a cell becomes too large there is not enough surface area for the exchange of materials and homeostasis cannot be maintained. When a cell reaches a critical surface area to volume ratio, it stops growing and the cell dies or is signaled to divide. In this activity, you will establish the relationship between surface are and volume using the relevant AP equations show below.

RELEVANT EQUATIONS

Volume of a Sphere: $V = \frac{4}{3}\pi r^3$

Volume of a Cube: $V = s^2$

Volume of a Rectangular Solid: $V = lwh$

Volume of a Cylinder: $V = \pi r^2 h$

Surface Area of a Sphere: $SA = 4\pi r^2$

Surface Area of a Cube: $SA = 6s^2$

Surface Area of a Rectangular Solid: $SA = 2lh + 2lw + 2wh$

Surface Area of a Cylinder: $SA = 2\pi rh + 2\pi r^2$

r = radius
l = length
h = height
w = width
s = length of one side of a cube

For each cube below:

1. Calculate the surface area and volume.
2. Divide the surface area by the volume to calculate the surface area to volume ratio (SA/V).
3. Graph the length of the side (cm) versus the surface area to volume ratios. Note that the surface area to volume ratio does not have a unit since surface area is measured in cm^3 and volume is measured in mL (same as cm^3). Be sure to label your graph appropriately!

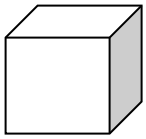
There are six cubes. Cube 6 is on the next page.

Cube 1

l = 1cm
w = 1 cm
h = 1 cm

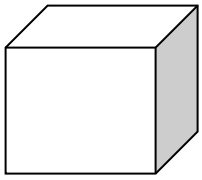
Cube 2

l = 2 cm
w = 2 cm
h = 2 cm



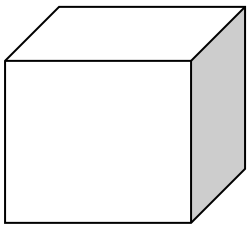
Cube 3

l = 3 cm
w = 3 cm
h = 3 cm



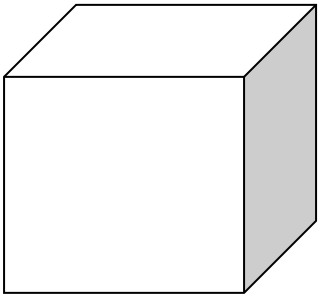
Cube 4

l = 4 cm
w = 4 cm
h = 4 cm



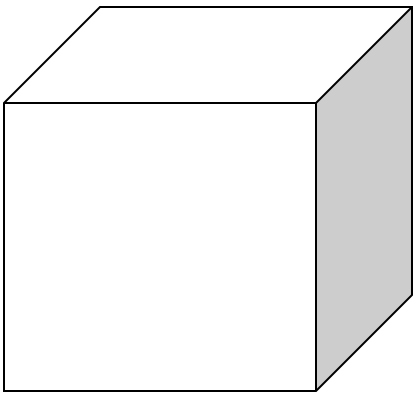
Cube 5

l = 5 cm
w = 5 cm
h = 5 cm



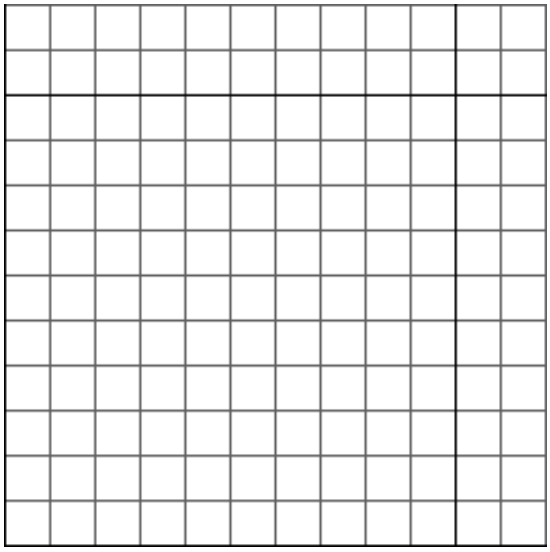
Cube 6

l = 6 cm
w = 6 cm
h = 6 cm



Data Analysis

Cube Number	Length of Cube Side (cm)	SA/V Ratio of Cube
1		
2		
3		
4		
5		
6		



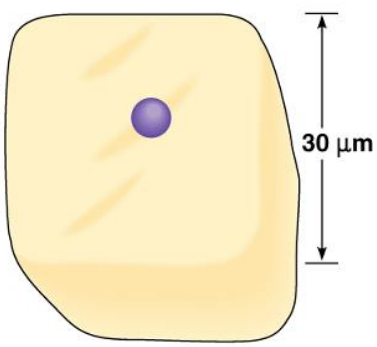
Conclusion

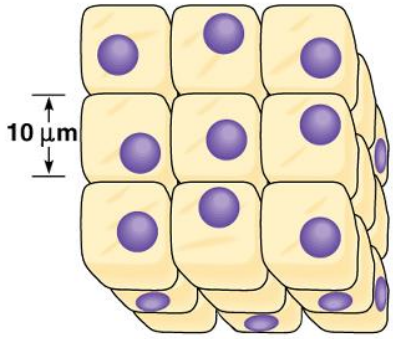
What is the relationship between size and surface area of a cube?

Problems

1. **Use the AP equations to calculate the following data values for the cells shown below.**

   - Surface area of the large cell _____
   - Surface area of a single small cell _____
   - Total surface area of all the small cells together _____
   - Surface area to volume ratio (SA/V) of the large cell _____
   - Surface area to volume ratio (SA/V) of one small cell _____

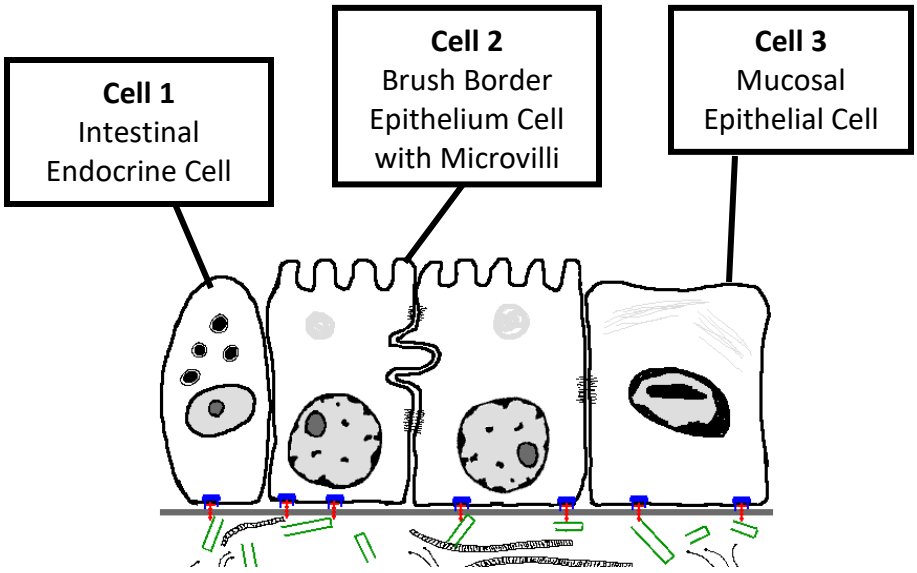




2. **Justify or refute the following statement based on the data values obtained for the cells above.**

"Numerous small cells are evolutionarily advantageous in regard to maintaining homeostasis in multi-cellular organisms"

3. **Which of the following cells has the greatest efficiency? Explain why.**



Section of a Villus – an extension of the small intestinal wall

4. The outer layer of a plant root may contain elongated cells called root hair cells. Explain why this is an evolutionary advantage or disadvantage in terms of maintaining cellular homeostasis. In doing so, discuss how surface area to volume differs in root hair cells verses normal epithelial cells.