BIOLOGY 12 NAME: KEY

SURFACE AREA to VOLUME RATIO

SURFACE AREA (S.A.) = The outer surface of a cell: is the **area of material that it would take to completely cover an object.** It is important because this is where the exchange between the cell and its environment takes place.

VOLUME (V) = The amount of materials inside a cell. The volume of the cell determines the amount of nutrients that will have to be absorbed (brought into the cell) and the quantity of waste products that must be excreted (removed from the cell)

- The chemicals inside a cell that are required to keep the cell alive must enter and leave the cell through its surface. Therefore, the cell must have a sufficiently large surface area to keep the living material inside the cell supplied with materials brought in. In addition, the surface of the cell must be large enough to permit the waste materials that result from the cell's metabolism to leave before they "pollute" the cell.

  - The problem of maintaining adequate surface area arises because as the volume of a cell is doubled, its surface area also increases, ***but not proportionately!***

= Volume increases with the cube (x^3) of the cell's diameter, whereas its surface area only increases with the square (x^2).

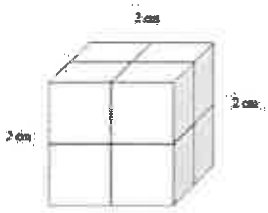
Consider, for example, the box-shaped cells shown below: (real cells have complex shapes, but the same principles apply)

SURFACE AREA = width x length x 6 sides

VOLUME = width x length x height

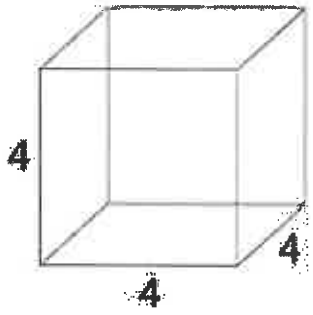
S.A. = $2 \times 2 \times 6 = 24 cm^2$

Vol = $2 \times 2 \times 2 = 8 cm^3$



Surface Area = $4 \times 4 \times 6 = 96 cm^2$

Volume = $4 \times 4 \times 4 = 64 cm^3$



$\frac{96}{24} = 4$

$\frac{64}{8} = 8$

Doubling the size of the cell increases the **volume** 8 times; the **surface area,** however, increases only 4 times.

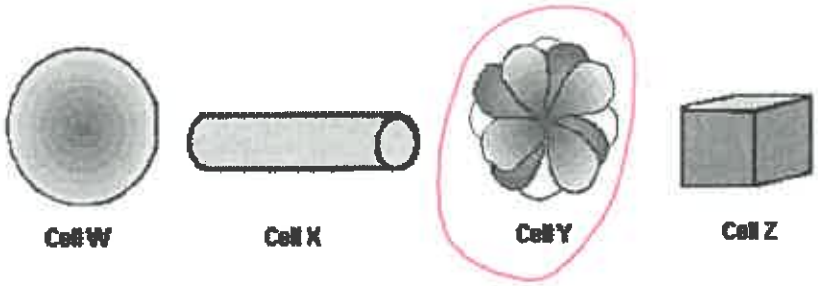
This comparison illustrates the dilemma that cells face and the constraint it imposes:

= As a cell size increases, its volume increases faster than its surface area.

Therefore, cells cannot grow so large that their surface areas become too small to supply materials to the inner parts of the cell and to get rid of wastes.

Note: An ostrich egg, like a hen's egg, is a large cell that contains mostly yolk. Yolk is food for the active parts of the cell. Yolk does not use energy, it supplies energy to the developing embryo, which at its early stages is a small point on the surface of the yolk. Since food materials are already stored inside the egg cell, an ostrich egg can remain alive even with a low surface area to volume ratio.

Which one of the cells below has the greatest surface area to volume ratio?



1. Calculate the volume, surface area, and the ratio of surface area to volume for each of the four cubes (the first one is done for you). Show all work for calculations.

(this ratio can be reduced to smaller numbers similar to the way that fractions can be reduced. It is customary to reduce SA:V ratios so that V is equal to 1. This can be done by dividing the SA by V and V by V as below)

(Let students try, go over first example)

Cube Size	Surface Area	Volume	Surface Area : Volume
2 cm cube	$2 \times 2 \times 6 = 24\ cm^2$ (2cm x 2cm x 6 sides)	$2 \times 2 \times 2 = 8\ cm^3$ (l x w x h)	24 : 8 = 3 : 1
3 cm cube	$54\ cm^2$	$27\ cm^3$	2:1
4 cm cube	$96\ cm^2$	$64\ cm^3$	$1.5:1 \times 2 = 3:2$ OR
5 cm cube	$150\ cm^2$	$125\ cm^3$	$1.2:1 \times 5 = 6:5$ OR

➢ **SUMMARY OF WHAT YOU SHOULD KNOW ABOUT THE IMPORTANCE OF THE SURFACE AREA TO VOLUME RATIO AS A FACTOR LIMITING CELL SIZE:**

SIGNIFICANCE OF SURFACE AREA TO VOLUME RATIO:
determines the rate at which materials are exchanged across a cell.

= Cell size is limited to allow efficient metabolism and transport of materials into and out of cells.

HOW DOES THE SA : V RATIO AFFECT METABOLISM OF A CELL:
A high SA:V ratio increases metabolism, as a cell grows and its SA:V ratio decreases, metabolism slows.

HOW DOES THE SA : V RATIO AFFECT THE RATE OF EXCHANGE OF MATERIALS AND ENERGY (HEAT) INTO AND OUT OF A CELL:
Not efficient when SA:V ratio is low.
Rate decreases as cell size increases

As the SA : V ratio decreases, cellular metabolism becomes less efficient. What can cells do about it?
Cells can:

- divide
- slow down metabolism
- *change shape to increase the surface area (e.g. get long and thin or flat, or develop many folds in the cell membrane to increase SA and therefore SA:V ratio.*