<https://www.youtube.com/watch?v=xuG4ZZ1GbzI>

SEE THIS SURFACE AREA TO VOLUME RATIO VIDEO!

# Why?

**Cell Size**

What determines the size of a cell?

Sometimes bigger is better—tall basketball players, more closet space, and savings accounts may come to mind. What about cells? Does having big cells make an organism bigger or better? Would having larger cells be an advantage to an organism? If so, why do cells divide rather than continue growing? Maybe there is an advantage to being small.

# Model 1 – Investigating Cell Size

CELL MEMBRANE

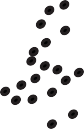
CYTOPLASM🡪

🡨RIBOSOMES

MITOCHONDRIA

🡨VACUOLE/VESSICLE

NUCLEUS



**Cell A Cell B**

1. Are the cells shown in Model 1 plant or animal cells? Explain your answer.

ANIMAL – NO CELL WALL, CHLOROPLAST, LARGE CENTRAL VACUOLE

1. Label Cell B in Model 1 with the following structures.

cell membrane cytoplasm nucleus

ribosomes vacuole mitochondria

1. Compare the smaller cell in Model 1 to the larger cell in Model 1.
   1. Which cell has a larger surface area (more cell membrane surface)?

CELL B (LARGER CELL) HAS A LARGER SURFACE AREA THAN CELL A.

* 1. Which cell has more channels in its cell membrane that can transport molecules (nutrients, oxygen, and waste products) in and out of the cell?

CELL B (LARGER CELL) HAS MORE CELL MEMBRANE CHANNELS THAN CELL A.

1. Compare the smaller cell to the larger cell in Model 1.
   1. Which cell has more mitochondria?

CELL B (LARGER CELL) HAS MORE MITOCHONDRIA THAN CELL A.

* 1. Propose an explanation for why the cell in part *a* would need more mitochondria for proper functioning of the cell.

SINCE THE CELL IS LARGER, IT WILL NEED MORE ATP TO RUN CELL PROCESSES.

1. What would be the consequences for a cell if the cell membrane was not large enough to have adequate channels for bringing in nutrients and removing waste?

- WOULD NOT BE ABLE TO MAINTAIN HOMEOSTASIS OR CARRY OUT ITS FUNCTION

- WOULD STARVE WITHOUT NUTRIENTS

- WOULD BE UNABLE TO PRODUCE ATP’s WITHOUT OXYGEN

- UNABLE TO MAKE PROTEINS WITHOUT AMINO ACIDS

- WOULD BE POISONED BY WASTE BUILD-UP

1. Compare the smaller cell to the larger cell in Model 1.
   1. Which cell has a larger volume?

CELL B

* 1. Imagine a glucose molecule entering the cell membrane. Would that molecule be able to reach the mitochondria faster if the cell had a smaller volume or a larger volume? Explain.

THE TRANSPORT OF A MOLECULE FROM THE CELL MEMBRANE TO THE MITOCHONDRIA WOULD BE FASTER IN A CELL WITH A SMALLER VOLUME BECAUSE THERE WOULD BE LESS DISTANCE TO TRAVEL.

* 1. As the mitochondria metabolize the glucose, they produce carbon dioxide waste. Would the CO2 molecules be able to leave the cell faster if the cell had a smaller volume or larger volume? Explain.

THE CO2 WOULD BE ABLE TO LEAVE A CELL WITH A SMALLER VOLUME FASTER BECAUSE THERE IS LESS DISTANCE TO TRAVEL.

1. Consider your answers to the previous questions. Is bigger always better for a cell? Explain.

BIGGER IS NOT ALWAYS BETTER. A LARGE SURFACE AREA IS BETTER FOR TRANSPORTING MOLECULES ACROSS THE CELL MEMBRANE, BUT A SMALL VOLUME IS BETTER IN TERMS OF EFFICIENCY OF TRANSPORTING MOLECULES THROUGHOUT THE CELL.

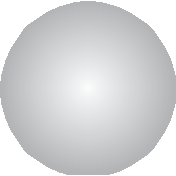
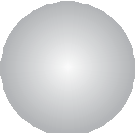


# Model 2 – Comparing Shapes

CUBES

|  |  |  |  |
| --- | --- | --- | --- |
| **Side** | 1 cm | 2 cm | 4 cm |
| **Surface area** | 6 cm2 | 24 cm2 | 96 cm2 |
| **Volume** | 1 cm3 | 8 cm3 | 64 cm3 |
| **Surface Area-to- Volume Ratio** | 6 : 1 | 3 : 1 | 96:64 =  1.5:1 |

SPHERES



|  |  |  |  |
| --- | --- | --- | --- |
| **Diameter** | 1 cm | 2 cm | 4 cm |
| **Surface area** | 3 cm2 | 13 cm2 | 50 cm2 |
| **Volume** | 0.5 cm3 | 4.2 cm3 | 34 cm3 |
| **Surface Area-to- Volume Ratio** | 6 : 1 | 3 : 1 | 1.5 : 1 |

CYLINDERS

|  |  |  |  |
| --- | --- | --- | --- |
| **Diameter × Height** | 1 cm × 1 cm | 1 cm × 2 cm | 1 cm × 4 cm |
| **Surface area** | 4.7 cm2 | 7.9 cm2 | 14 cm2 |
| **Volume** | 0.8 cm3 | 1.6 cm3 | 3.1 cm3 |
| **Surface Area-to- Volume Ratio** | 6 : 1 | 5 : 1 | 4.5 : 1 |

1. Label the sets of shapes in Model 2 with each of the following: cubes, spheres, cylinders.
2. Calculate the surface area and volume values that are missing in Model 2. Divide the work among the members of your group and check each other’s work.

10. Consider the data in Model 2.

* 1. Describe the change in the surface area of the cube when the length of the side doubles.

SURFACE AREA IS 4 X LARGER

* 1. Describe the change in the volume of the cube when the length of the side doubles.

VOLUME IS 8 X LARGER

* 1. When a shape gets larger, which increases at a faster rate, surface area or volume?

VOLUME INCREASES AT A FASTER RATE

1. Calculate the surface area-to-volume ratio for each shape in Model 2. One example is given in Model 1 for this calculation.
2. For all three of the shape sets, describe the change in the surface area-to-volume ratio as the size of the shape increases.

FOR ALL THREE SHAPES, THE SUFACE AREA TO VOLUME RATIO DECREASES AS THE SHAPE SIZE INCREASES.

1. Considering your answer to Question 7, is it more desirable for a cell to have a small surface area-to-volume ratio or a large surface area-to-volume ratio? Explain your answer in terms of the functions of a cell.

IT IS BEST FOR A CELL TO HAVE A LARGE SURFACE AREA AND A SMALL VOLUME. THEREFORE, A LARGE SURFACE AREA TO VOLUME RATIO IS MORE DESIRABLE.

1. Circle two ﬁgures in Model 2 that have a similar surface area (within 1 cm2 of each other).
   1. Do the two ﬁgures have the same volume?

NO, SPHERE HAS A LARGER VOLUME, DESPITE ITS SLIGHTLY SMALLER SURFACE AREA

* 1. Which shape has a more desirable surface area-to-volume ratio?

CYLINDER HAS A LARGER SURFACE AREA TO VOLUME RATIO.

1. In multicellular organisms some cells need to be large because of the functions they perform (*i.e.* nerve cells, muscle cells). What shape would be most desirable for these larger cells?

A LONG, CYLINDRICAL SHAPE.



# Extension Questions

1. Propose, by means of a sketch, geometrical shapes of cells that would allow a balance of function and materials movement for each of the following situations. (*Hint:* Think about which aspect of shape would help the cell best carry out its given function.)
   1. Long-distance communication.

LONG, THIN CYLINDERS (LARGE SURFACE AREA WITH SMALL DIAMETER)

\*nerve cells

* 1. Stretching.

LONG, THIN CYLINDERS (LARGE SURFACE AREA WITH SMALL DIAMETER)

\*muscle cells

* 1. Storage.

SPHERICAL, FOR MAXIMUM VOLUME

\*vacuoles, vesicles

* 1. Covering and protecting.

SHEET-LIKE SHAPE WITH LARGE SURFACE AREA

\*skin cells (epithelium—think of those thin, thin cheek cells that occur in layers…)

* 1. Importing large quantities of material for transfer to other cells.

ANY OF THE SMALL, SYMMETRICAL SHAPES FOR MAXIMUM SURFACE AREA TO VOLUME RATIO

1. Among unicellular eukaryotes, cell sizes differ greatly. *Amoeba* and *Paramecium* organisms are animal-like protists that are heterotrophic, have no cell wall, and are several times larger than most human cells. What might be some reasons why these unicellular organisms have larger cells than cells with similar traits (heterotrophic, lacking cell walls) that are found in multicellular organisms?

THESE UNICELLULAR ORGANISMS ARE NOT SPECIALIZED, BUT HAVE TO CARRY OUT ALL SURVIVAL FUNCTIONS—OBTAINING FOOD, REPRODUCING, MOVEMENT, DEFENSE, ETC.



