**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Partner:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Why Do Cells Divide?**

**Background:** Many cells grow until they reach a certain size and then divide. Why don’t cells grow indefinitely, until they become the size of basketballs? What problems arise when a cell grows larger? Why does a cell divide into 2 smaller cells when it reaches a certain size? These are all questions that scientists have attempted to resolve.

Cell division is a necessary part of the life of any multicellular organism and allows for growth, repair, and formation of cells for reproduction. Growth of an organism occurs mainly by an increase in the number of cells rather than by the enlargement of individual cells. This process seems to be controlled by simple physical laws.

For living things to survive, they must be able to take in nutrients and eliminate wastes. Nutrients *diffuse* into the cell, and wastes diffuse out of the cell through the *cell membrane*. During diffusion, substances move from and area of high concentration to an area of low concentration until there is no *concentration gradient*, or unequal distribution of particles.

In this lab, you will create enlarged cell models of various sizes using a substance called ***agar***. This gelatinous material is used in laboratories as a medium to support the growth of various organisms. It is actually a form of gelatin made from seaweed. The agar that you will use in this lab has been prepared with ***phenolphthalein***, an acid-base indicator. Phenolphthalein is a colorless substance that turns pink in the presence of a base, such as sodium hydroxide (NaOH).

**Learning Objectives:**

* Make a hypothesis that describes the relationship among surface area, volume, and diffusion of a cell.
* Determine the relationship between surface area and volume of a model cell.
* Determine the relationship between surface area and mass of a model cell.
* Apply these mathematical relationships to living cells.

**Procedure:**

1. Place the agar that your teacher has prepared and distributed to you in your cardboard tray. Using the plastic knife, **CAREFULLY** cut the agar into a 1-cm, a 2-cm, and a 4-cm cube. Make sure to measure each side of the agar (length, width, and height) to ensure that each cube is accurate.

Which of the 3 “cells” do you think has the best chance of survival? Why? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Examine Table 1. Next to the row marked **“Formulas”**, write in the mathematical formulas that can be used to calculate the value described in the heading of each column. **Use *s* as the length of one side** of your model. Once you have written in the formulas, let your teacher check them before you continue the investigation.
2. Use your formulas to complete Table 1. **Be sure to simplify, or reduce, any ratios. Don’t forget to place a unit after each measurement!!!**  **Data Table 1 –**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measurements of Cell Models** | | | | |
| **Formulas** |  |  |  |  |
| Cell Size (length of 1 side) | Area of One Face | Total Surface Area of Cell | Volume of Cell | SA:V ratio |
| 1 cm |  |  |  |  |
| 2 cm |  |  |  |  |
| 4 cm |  |  |  |  |

1. Which of the above measurements represents the cell membrane? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which of the above measurements represents the amount of cytoplasm in a cell? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How many 1-cm cubes would be needed to make an 8 cm cube? Use the data you calculated in Table 1 to explain your answer. Show your work.
4. Do the surface area and volume of a cell increase at the same rate? Explain your answer.
5. List the cubes in order of their surface area to volume ratio, from largest to smallest.
6. What happens to the surface area to volume ratio as a cell increases in size?
7. Do you think molecules will more easily pass in and out of a cell with a large surface area to volume ratio or a small surface area to volume ratio? Explain your answer.
8. Formulate a hypothesis that describes how diffusion is affected by the cell’s size (using SA:V ratios). Remember one variable is measurable and the other variable is manipulated in the experiment, then predict how the manipulated (independent) variable affects the dependent variable.
9. Place your 3 cubes into the cup. Try to position them so that they are touching each other as little as possible. Record the appropriate times in Table 2. Pour 100mL of 0.1M sodium hydroxide (NaOH) solution into the beaker until the cubes are completely covered with the solution. **Note the time in the data table below.**

**Data Table 2 – Diffusion Times**

|  |  |
| --- | --- |
| Time cubes placed in NaOH |  |
| Time for diffusion | +10 minutes |
| Time cubes are to be removed from NaOH |  |

1. What happened to the cubes as you poured the NaOH into the cup? Why did this change take place?
2. After 10 minutes, remove the cubes from the NaOH solution with the plastic spoon. Place the cubes on your cardboard tray and carefully blot them with a paper towel.
3. **Carefully** cut each block in half and measure the pale yellow/white area in the center. ( It should be the same measurement for length, width and height.) Calculate the volume of this yellow/white region by cubing the length of the white/yellow side. Complete Table 3. Don’t forget the units!!!

**Data Table 3 – Diffusion Measurements**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Cell Model** | **Volume of cube**  (from table 1) | **Length of yellow/white side** | **Width of diffusion** | **Volume of yellow/white region of cube** | **Volume of pink region of cube**  (vol. of cube-vol. of yellow/white left) | **Percentage of cube that is pink**  (vol. pink/vol. cube x 100) |
| 1 cm |  |  |  |  |  |  |
| 2 cm |  |  |  |  |  |  |
| 4 cm |  |  |  |  |  |  |

1. On the grid below, use a pink colored pencil to draw a cross section of each of the cubes. Assume each block is 1cm x 1cm. Draw your 3 cubes to scale and color the correct color.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

1. Construct a graph on Excel using the percentages for each cell (1 graph for your whole group. Print it out). Using your graph, what would be the % of pink in a 3cm cube? \_\_\_\_\_\_\_\_\_\_\_\_ A 1.5 cm cube? \_\_\_\_\_\_\_\_\_\_\_
2. Do the percentages that you calculated for Table 3 change your mind about your answer to #1? Explain.
3. What is indicated by the width of the pink area of each cube?
4. What did you notice when you measured the width of the pink area of each cube? Why do you think this is so?
5. For cellular respiration to occur, oxygen must diffuse into a cell and carbon dioxide must diffuse out. Which cube accurately represents an efficiently respiring cell? Use the data that you have calculated in this activity to support your choice.
6. If small cells are better and bigger SA:V ratios are better, then explain why an egg cell is usually very large?
7. What do cells do to increase their surface area to volume ratios?
8. The size of some human cells is 0.01mm. Using the formulas in this activity, calculate the surface area to volume ratio of such a cell (assume the cell is a 0.01mm cube). **SHOW ALL YOUR WORK** below. Then describe the extent and rate of diffusion into this living cell as compared to the smallest agar cube. Explain.
9. Explain the diffusion that occurred in this experiment in terms diffusion. What moved where and why?

Extra credit: research articles, successively pairing with *surface-to-volume* the terms *biology, microbiology, biomechanics,*

*dung beetles, birds, bees, nematodes, worms, toads, elephants, whales, corn, roots, seeds, fish, sponges, proteins, cancer, watersheds,*

*bats,* and so on. From the tens of thousands of articles available, pick one that interests you and present it to the class. Write a summary in your own words and attach a copy of your article. Surface-to-volume reasoning, as you will prove , plays essential roles in nearly all fields of science, especially biology.