Surface Area to Volume Ratio of a Cell

Please do NOT write on this sheet of paper

INTRODUCTION:

Cells come in a variety of sizes. Some red blood cells are only 8 µm in diameter. Nerve cells can reach lengths up to 1 meter. Most living cells, however, are between 2 and 200 µm in diameter. The research question for this activity is "Why can't organisms be just one giant cell?" We will be examining this in this laboratory activity.

Bromothymol Blue (BTB) is an indicator that turns yellow in the presence of an acid.

FORMULAS:

1. Surface Area = length of a side X width of a side X number of sides = (**length X width) X 6 sides**
2. volume = **length X width X height**
3. To calculate the ratio just divide surface area by volume - **ratio = (surface area) / (volume)**

MATERIALS:

3 beakers	vinegar	BTB Agar	triple beam balance	plastic knifes	ruler
spatular	ice tray	glass baking sheet	white paper	weighing boat	

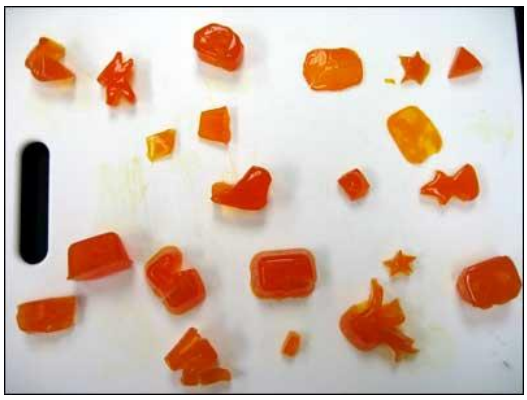
PROCEDURES:

Part 1

1. Before starting the lab calculate volume, surface area, and SA:V ratio of e ach of the three sizes of agar blocks that you will be working with. Enter the data in table 1.
2. From the baking dish of Bromothymol Blue agar cut blocks of specific sizes using a ruler and a plastic knife:
   1cm x 1cm x 1cm **2cm x 2cm x 2cm** **1cm x 1cm x 8cm**
3. Fill each beaker 3/4 full with vinegar
4. Ready your timer.
5. Immerse each block in common household white vinegar in small beakers.
6. Time until blue completely disappears. Helps to put beakers on white paper as a background.

Part 2 - The contest - Day 2

1. Take an ice cube block of the Bromothymol Blue agar.
2. Design a cell that maximizes volume & mass, but minimizes diffusion time.
3. Sketch your design (or take a picture) and include it with your data.
4. Take the mass of your "cell" using a triple beam balance. (remember to zero your balance using a the weighing boat)
5. Fill each beaker 3/4 full with vinegar
6. Ready your timer.
7. Wait until all teams are ready as we will be doing the race as a class.
8. Immerse each block in common household white vinegar in small beakers.
9. Time until blue completely disappears. Helps to put beakers on white paper as a background.
10. The winning team will win NQA passes for every member of the team



RULES: No donut-like holes through the agar cell, no poking, prodding, touching beaker containing agar cell in vinegar. Mrs. Robson will determine when 100% diffusion takes place. Students must mass agar at conclusion of race. The cell must not break when handled. Disqualification if cell breaks upon massing. Winner = highest ratio of mass divided by time.

DATA:

Table 1 - Copy this table into your lab notebook. Use the formulas in the introduction to fill out the first three columns of data table 1.

Cell Size (cm)	Surface Area (cm^2)	Volume (cm^3)	Ratio (Surface Area : Volume)	Time for Complete Diffusion
1 x 1 x 1				
2 x 2 x 2				
1 x 1 x 8				

Table 2 1 - Copy this table into your lab notebook

Custom Designed Cell	Mass	Time	Mass / Time
Team 1			
Team 2			
Team 3			
Team 4			
Team 5			
Team 6			

Sketch or include a photograph of your cell AND each team's cell before the race begins.

Analysis Questions - Please answer in your lab notebook after completion of the lab.

1. Describe the results from the comparative diffusion trials in Table 1. You must compare each block to the others in your description.
2. Explain the results from the comparative diffusion trials in Table 1. You must compare each block to the others in your explanation.
3. In general, what is the relationship between cell volume and diffusion time?
4. In general, what is the relationship between surface area and diffusion time?
5. Explain why cells can't get very, very big.
6. Explain how cell shape can be modified so that diffusion can support life processes.
7. Which team's cell won the race? Offer an explanation as to why.
8. Which team's cell came in last? Offer an explanation as to why.
9. Are there any sources of error for this lab?
10. What suggestions do you have for future experiments that can expand your knowledge of this topic?

Teacher Notes

Cell Races

This lab let's students explore the relationship between surface area, volume, and diffusion time. And quickly allows them to see that a large cell will starve or poison itself since material can't diffuse in or out fast enough. I make bromothymol blue agar (see recipe below), but you just need something safe that wil change color as it changes pH. I mold them in ice cube trays and use a spatula to remove the gelatinous cubes. Students cut various sizes of cells and place them in vinegar to watch -- and time -- the movement of color change as the vinegar diffuses in turning the blue to yellow.

Recipe to make Bromothymol Blue Agar for Cell Races

1. Mix 15g agar in 1 liter water.
2. Boil slowly in microwave or hot water bath until agar is melted (granules will disappear). Watch for and avoid boil-over.
3. Remove from heat. Add 0.1 g bromothymol blue solid or several drops of bromothymol blue solution and mix. If the mixture is not deep blue, then add more bromothymol blue. If the mixture is green or yellow, you will need to stir in dilute NaOH until it turns blue. Wear safety goggles and gloves when handling NaOH.
4. Pour the agar into ice cube trays -- enough for one ice cube per student group. Also pour into a large pyrex baking dish (13" x 9") -- enough to be 2cm deep. Let agar harden at room temperature or in refrigerator. Can be made several days in advance. This was enough for 50 students working in pairs. (Store in refrigerator, otherwise it will grow mold quickly)
5. From the baking dish students cut blocks of specific sizes:
   1cm x 1cm x 1cm
   2cm x 2cm x 2cm
   1cm x 1cm x 8cm
6. Students have to calculate volume, surface area, and SA:V ratio.
7. Students then immerse each block in common household white vinegar in small beakers. Agar turns yellow in acid. You can easily see the blue core disappear as diffusion takes place. Students time until blue completely disappears. Helps to put beakers on white paper as a background.
   You'll notice that 2x2x2 and 1x1x8 have same volume, but different surface area... so students see the comparative effects. You'll be amazed at how long 2x2x2 takes (45-60 minutes)!

And now for the Competitive Cell Races!

Then (usually next day) students are given an ice cube block of the agar and they must design their own cell to maximize volume & mass, but minimize diffusion time. This process allows students to confront a lot of misconceptions of cell design.

RULES: No donut-like holes through the agar cell, no poking, prodding, touching beaker containing agar cell in vinegar. Teacher determines when 100% diffusion takes place. Students mass agar at conclusion of race...cell must not break when handled. Disqualification if cell breaks upon massing. Winner = highest ratio of mass divided by time.

We sometimes run a second race after a trial run, so students can improve designs. I make a lot of agar just in case. It's a fun learning day!