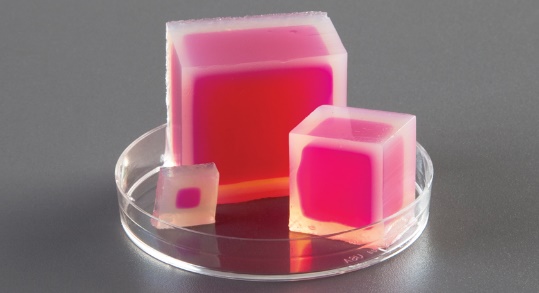
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**Investigation: Why Are Cells So Small?**

**Essential Question: How does the size and shape of a cell influence the speed at which materials can move into and out of the cell?**

Process: Create cell models using agar molds to compare rates of diffusion. 

Materials:

Agar Mold with BTB (made in advance)

Tweezers, Scalpel (or plastic knife)

Ruler, Beaker with white vinegar

## **Procedure**

1. You will receive a small tray filled with an agar mold. *\*See below for directions\** Avoid handling the agar with your bare hands and use a scalpel and tweezers to cut three agar cubes with the following approximate dimensions. Save your agar, you will need it later!

1 cm x 1 cm x 1 cm (small)

2 cm x 2 cm x 2 cm (medium)

1 cm x 1 cm x 8 cm (large)

2. Measure your cubes (the actual dimensions may not be perfect, depending on how you cut it) and determine the surface area, the volume, and the SA:V ratio. Record on data table.

3. Drop each block into a separate beaker (or container) of vinegar and immediately start timer. The agar has been infused with a chemical called bromothymol blue (BTB). The blue will turn to a yellow in the presence of acid. You will be able to observe this change with your cubes. Record the time it takes for the blue to completely disappear.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Actual Dimensions  L, W, H | Surface Area  In cm2  2 (LW + HL + HW) | Volume  In cm3  (LxWxH) | Surface Area / Volume | Time (Blue to Yellow) |
| Small Cube |  |  |  |  |  |
| Medium Cube |  |  |  |  |  |
| Large Cube |  |  |  |  |  |

## **Analysis**

## What is the independent variable in this experiment? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is the dependent Variable in this experiment?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which of the initial cubes had the fastest diffusion time? Which had the slowest?

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1. Which of the three variables you tested seemed to have the biggest impact on the rate of diffusion? Use **CER** (Claim Evidence Reasoning) to explain how you know this.

**Claim:** The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ has the biggest impact on the rate of diffusion.

The **Evidence** for this was \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The scientific **Reasoning** for this was: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **EVALUATE:** How does the agar cube model a cell and its cell membrane? What are the limitations of this model? (How is NOT like a real cell?)

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1. What are some adaptations in real life that larger volume cells use to optimize their Surface Area to volume ratio?

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**Part 2: How Does Shape Influence Rates of Diffusion?**

With what remains of your agar, **design a cell that maximizes volume and mass, but minimizes diffusion time**. Your "cell" will compete with other cells in the class to see which one has the fastest diffusion time.

**Rules:**

* No donut-like holes through the agar cell - cell membranes cannot sustain this shape
* No poking or agitating the beaker when the cell is submerged
* Instructor determines when 100% diffusion has occurred
* Agar cell will be massed at the end of the race
* Winner = highest ratio of mass divided by time

Sketch your design below.

* 4. What designs (Part 2) seemed to have the fastest diffusion rate?
* **Agar Recipe:**

15 g of agar in 1 liter water (or follow directions on packaging). You do want the agar to be thick so that it can be handled, so reduce water amounts. Agar is boiled in DI water and then allowed to cool. Knox gelatin can also be subsituted, but you may need to play around with the measurements.

While it is cooling, add .1 g of bromothymol blue (or about 10 ml aqueous solution, you just need to ensure that the agar turns a dark blue.) If the mixture is green/yellow, then add NaOH until it turns blue.

Pour agar into trays for students. You can be creative with the trays (ziploc tupperware containers should work, or even metal dissecting trays.) The molds must be at least 2 cm deep. Molds can be covered and refrigerated.

These are the molds I created using specimen containers and the lids from a box of micropipettes. You can be creative!

Alternatively, you can add phenolphthalein to the agar and then submerge cubes in sodium hydroxide. <-- this tends to be more expensive than white vinegar, and NaOH is dangerous to handle.

Image below shows saturation of agar by vinegar. The yellow area started as blue. A ruler placed under the flask can be used as another way to measure the rate of diffusion.