Diffusion Blues in Agar Cells

A Diffusion Demonstration

Introduction

Diffusion and osmosis are among the most commonly studied topics in biology. Virtually all living cells are, to varying degrees, dependent on these processes. This activity will enable students to explore the relationship between diffusion and cell size by experimenting with model "cells."

Concepts

- Cell size
- Diffusion

Materials (for each setup)

Agar powder, 20 g
Bromthymol blue, 0.4 g
Vinegar or acetic acid solution, 1 M, 3 L
Metric ruler
Plastic knife
Heat source
Tray for casting gel (see *Preparation* section)
Beaker, 400-mL
Spoon or tongs
Water, distilled or deionized, 1 L

Safety Precautions

Vinegar, 4–8% acetic acid, may be a body tissue irritant. Wear chemical splash goggles and chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

One liter of agar mixture is the minimum volume required for 15 lab groups. Mix 20 g of agar with one liter of distilled or deionized water. Heat almost to a boil, with frequent stirring, until solution clears. Remove from heat and while agar mixture cools add 0.4 g bromthymol blue and stir. The solution should be a deep green color. Pour into a shallow tray to a depth of 3 cm and allow it to set (overnight). A tray measuring 12 cm × 25 cm that is at least 3 cm deep will require about one liter of agar mixture. Volume adjustments may be necessary depending on the tray used. Prior to class, cut the agar into 3 × 3 × 5 cm blocks, one per lab group.

Procedure

1. Each group will cut the 3 × 3 × 5 cm block into three smaller agar cubes. A 3-cm cube, a 2-cm cube, and a 1-cm cube. Cut cubes as accurately as possible.
2. Pour 200 mL of vinegar into the 400-mL beaker. Note the time and immerse the three blocks in the vinegar. Try not to have the cubes touching one another. Let the cubes soak in vinegar for 5–7 minutes with periodic gentle stirring and turning.
3. After 5–7 minutes, use a spoon or tongs to remove the blocks and blot dry them with a paper towel.
4. Promptly cut each block in half and measure the depth to which the yellow color has penetrated. Sketch each block's cross section.

Publication No. 10636
091117

5. Set up and complete the following data table:

Cube	Surface Area (cm^2)	Volume (cm^3)	Surface-to-Volume Ratio	Diffusion Depth (mm)	Diffusion Rate (mm/min)
1-cm					
2-cm					
3-cm					

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Agar blocks can be disposed of in the trash according to Flinn Suggested Disposal Method #26a. Vinegar should be disposed of according to Flinn Suggested Disposal Method #26b.

Discussion

The primary objective of this lab is to demonstrate a potential limitation on cell size. Diffusion is a fairly slow process and a cell that relies primarily on diffusion to transport essential molecules into and throughout its interior—and to carry waste products out—could conceivably grow too large for this process to work efficiently.

Have the students fill out the first three columns of the table before running the experiment and use these numbers to predict the outcome. Some will assume that the "cell" with the largest surface area will be the most efficient at moving materials in and out.

When the blocks are cut, students will discover that the penetration depths and diffusion rates are equal for all three sizes. What is dramatically different is how much of the interior volume of each cube has been affected. Mathematically inclined students can calculate the percentage of each cell's interior volume that has turned yellow. This will give a fairly direct indication of which cell is most likely to "survive."

The key characteristic of the blocks is not total surface area, but their surface-to-volume ratio. The table shows that cube size and surface-to-volume ratio are inversely proportional and that the cube with the highest ratio is the most efficient. One obvious conclusion is that smaller cells are better able to move materials in and out. A cell could eventually reach a size at which materials could not diffuse in fast enough to meet requirements, and waste products could build up to toxic levels.

Two optional activities can easily be added to demonstrate the effect of temperature on diffusion rate, and the effect of concentration on diffusion rate. To study temperature effects, assign a few of the lab groups to heat or chill the vinegar 10 degrees above or below room temperature prior to immersing their agar cubes. To study concentration effects, assign a few lab groups to use a 0.5 M or 2 M acetic solution.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-LS1 From Molecules to Organisms: Structures and Processes
  - LS1.A: Structure and Function
  - LS1.C: Organization for Matter and Energy Flow in Organisms

Disciplinary Core Ideas: High School
- HS-LS1 From Molecules to Organisms: Structures and Processes
  - LS1.A: Structure and Function
  - LS1.C: Organization for Matter and Energy Flow in Organisms

Science and Engineering Practices
- Developing and using models
- Planning and carrying out investigations
- Constructing explanations and designing solutions

Crosscutting Concepts
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Stability and change

Materials required for *Diffusion in Agar Cells* are available from Flinn Scientific, Inc. This activity is also available as a Flinn Labortory Kit that contains all the materials to perform this activity.

Catalog No.	Description
A0012	Agar powder, 100 g
A0013	Agar powder, 500 g
A0095	Acetic acid solution, 1 M, 1 L
B0233	Bromthymol blue, lab grade, 5 g
FB1638	Cell Size and Diffusion Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.