TEACHER PREPARATION GUIDE.

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Same Volume, Different Shapes

Biology | TEACHER GUIDE

Planning notes for teachers: materials, setup, expected results, and what to watch for.

Not yet classroom-tested. This is a new lab design that has not been tested in a classroom yet. Expected results, times and costs are estimates, not measured values. Run the full lab yourself before you use it with students or grade it, and adjust amounts to match your materials.

Item	Details
Unit and lessons	Unit 6: Cells and Homeostasis. Lessons: Surface Area to Volume Ratio, Passive Transport
Class time	One 50-minute period (10-minute soak), with gelatin set the day before
Groups	3 to 4 students
Cost	About $1 per group
Standards	HS-LS1-2. SEP: Using Mathematics and Computational Thinking; Developing and Using Models. CCC: Scale, Proportion, and Quantity; Structure and Function.

Big Idea

Keeping volume constant and changing only shape removes the most common misconception from the classic agar cube lab: that bigger surface area alone is the goal. Students see that diffusion depth is the same in every shape and that the SA:V ratio decides how much of the cell is reached.

Materials for 8 Groups

Item	Amount	Notes
Unflavored gelatin	6 packets	Or agar powder, which is firmer and easier to cut.
Red cabbage	1/4 head	Boil chopped leaves 10 minutes in 500 mL water and strain.
Baking soda	1/4 teaspoon	Turns the juice blue-green.
White vinegar	About 1.5 L	
Three flat pans or lids	3	To set gelatin 2 cm, 1 cm, and 0.5 cm deep.
Plastic knives, spoons, rulers, dishes	8 each	

Advance Preparation

1. Make cabbage juice and stir in baking soda a pinch at a time until it is blue-green.
2. Dissolve gelatin at double strength in the hot juice (about 3 packets per 360 mL). Pour into three pans so it sets 2 cm, 1 cm, and 0.5 cm deep. Refrigerate overnight.
3. Cut cubes (2 × 2 × 2 cm) from the 2 cm pan, rods (8 × 1 × 1 cm) from the 1 cm pan, and slabs (4 × 4 × 0.5 cm) from the 0.5 cm pan. Keep them cold.
4. Pilot one set. If the pink layer is less than 1 mm after 10 minutes, soak for 15 minutes.

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Expected Results

The pink depth should be about the same in all three shapes. The key uses a sample depth of 0.2 cm, which gives about 49% (cube), 66% (rod), and 84% (slab) colored. Real depths depend on your gelatin strength and temperature. At the same diffusion speed, the slab would be fully pink in about 16 minutes, the rod in about an hour, and the cube in about 4 hours.

What Can Go Wrong

- Warm gelatin melts and tears. Keep blocks in the refrigerator until the last minute.
- Uneven cuts. Precut blocks with a ruler and a long knife.
- Pink edges that blur. Cut the blocks and measure right away.

Misconceptions to Listen For

- "The largest surface area wins." Here, the volume is the same, so the ratio is what changes.
- "Vinegar moves faster into some shapes." The depth is the same; geometry does the rest.

Differentiation and Extensions

- Support: give a worked example of surface area for the cube. Sentence frame: "The ___ had the highest SA:V ratio, so ___% of it turned pink."
- Honors extension: diffusion depth grows with the square root of time. Use 0.2 cm in 10 minutes to predict the time for each shape to turn fully pink.
- Extension: give students 8 cm^3 of gelatin and challenge them to design the shape that colors fastest.

Safety and Disposal

- Goggles for vinegar. No eating.
- Vinegar down the drain with water; gelatin in the trash.

Standards

This lab builds toward these NGSS performance expectations:

- **HS-LS1-2:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Disciplinary core ideas: LS1.A Structure and Function

Science and engineering practices: Using Mathematics and Computational Thinking; Developing and Using Models

Crosscutting concepts: Scale, Proportion, and Quantity; Structure and Function

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