A Cell So Small 41

1
40- to 50-minute session

MODELING

ACTIVITY OVERVIEW

Students model the relative size of cells to determine why cells are so small. This activity is used to reinforce the concept that multicellular organisms are made up of many cells.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Scientists create models to communicate scientific information. (Inquiry: 1)
2. Living systems at all levels of organization demonstrate the complementary nature of structure and function. (Life Science: 1)
3. All living things are composed of microscopic units called cells. (Life Science: 1)
4. Cells of all organisms have similar structures, such as the cell membrane. These structures function similarly in each organism. (Life Science: 1)

KEY VOCABULARY

cell

multicellular

MATERIALS AND ADVANCE PREPARATION

For the teacher

	1	Transparency 41.1, "The Model"
*	1	overhead projector
*	1	apple (optional)

For the class

*		Unifix cubes

MATERIALS AND ADVANCE PREPARATION

For each group of four students

1	bottle of blue food coloring
1	plastic cup, half-full of water
1	SEPUP tray
1	SEPUP filter funnel
2	pieces of filter paper
1	30-mL graduated cup
2	10-mL vials with caps
1	stir stick
2	pieces of carbon
	carbon powder
1	dropper (optional)
*	water

**Not supplied in kit*

TEACHING SUMMARY

Getting Started

1. The class discusses the relative size of cells.

Doing the Activity

2. Students model the relative size of cells.

Follow–Up

3. The class summarizes the results of the model.

BACKGROUND INFORMATION

Surface Area-to-Volume Ratio

While the need for nutrients and oxygen is proportional to volume (amount) of tissue, the movement of nutrients, oxygen, wastes, and heat must occur at surfaces. In order for an organism to get oxygen and food fast enough to maintain its tissues, it has to have plenty of surface area per unit volume. Similarly, movement of wastes out of cells also requires adequate surface area.

Adequate surface area can be achieved in two ways: by small size alone or by shapes that have a high surface area-to-volume ratio. Thus, individual cells are small. In addition, they often have non-spherical shapes, since a sphere has the lowest surface-to-volume ratio of any 3-dimensional shape. For example, the red blood cell is concave, which increases its surface to volume ratio. Increased surface area is observed at the level of organisms, organs, and tissues as well. For example, organs like the lungs and intestines have evolved to have shapes with folds or pockets that increase surface area.

TEACHING SUGGESTIONS

GETTING STARTED

1. The class discusses the relative size of cells.

Begin by discussing Activity 39, "Cells Alive!" in which students investigated the ability of yeast cells to respire. Review the idea that, in order for the cells to respire, nutrients had to enter the cells and that cellular respiration produces carbon dioxide wastes that have to leave the cell. Ask, ***Do you think it would be easier for gases to enter and leave one large cell or lots of small ones? Why?*** Have students discuss these questions in their groups of four and then write responses in their student notebooks. Many students may think that a larger cell provides more cell membrane for gases to cross.

Explain that students will model the ability of small vs. large cells to take up nutrients or oxygen. Have them read the Introduction and Challenge in the Student Book, which introduces the investigation of why cells are so small. Explain that powdered carbon will be used to model many small cells, while pieces of carbon will be used to model a few large cells. Display the food coloring: the blue color represents oxygen or nutrients that the cell needs to respire and stay alive. You can use Transparency 41.1, "The Model," to review these ideas.

At this point, you may wish to have students record a prediction about which size cell is more likely to absorb oxygen and nutrients quickly.

DOING THE ACTIVITY

2. Students model the relative size of cells.

Demonstrate how to fold the filter paper and set up the filtering apparatus (described in Steps 1 and 2 of the Procedure). Then have students perform the activity.

As students complete the activity, they can begin to respond to the Analysis Questions.

FOLLOW-UP

3. The class summarizes the results of the model.

Ask students what they observed and how they can explain the results. Some may realize that the powdered carbon has the same amount (mass) of material, but that it has much more surface available for the blue food coloring to be absorbed. If your students completed Unit B, "Body Works," in *Issues and Life Science*, you can remind them that in Activity 14, "Breakdown" they saw that a powdered antacid would react faster with vinegar. Similarly, they discovered that a chewed piece of candy dissolved faster than a whole one. Each of these phenomena also depends on surface area. The more you break something into smaller pieces, the more surface contact there will be between the pieces and their environment. Similarly, when the carbon is in very small pieces, more surface area is available for the blue food coloring to be absorbed.

You can further extend this concept by cutting up an apple, first in halves and then in quarters. As you continue cutting, you have the same total amount of apple, but the amount of surface area increases.

Extend this concept to cells. Many small cells have more surface area than one large cell. With smaller cells, more surface area is available for oxygen and nutrients to diffuse in and carbon dioxide to diffuse out of the cell. Thus many small cells can take up oxygen and nutrients and release carbon dioxide much more quickly than one large cell.

SUGGESTED ANSWERS TO QUESTIONS

1. *In this model, what did each of the following represent:*

   a. *carbon powder*

   The carbon powder represented many small cells.

   b. *carbon pieces*

   The carbon pieces represented a few large cells.

   c. *blue dye*

   The blue dye represented oxygen or nutrients that were absorbed by the cells.

2. *What happened to the blue dye in each vial? Explain.*

   In the vial with powdered carbon, the blue dye disappeared from the water. In the vial with pieces of carbon, the blue dye was unchanged or lighter, but did not disappear. This suggests that the powdered carbon removes or changes the blue dye better than the large pieces.

3. *According to the model, which cells—large or small—are most efficient at taking up oxygen and nutrients from the environment? Explain.*

   Small cells are most efficient at taking up oxygen and nutrients from the environment. (Note that they are also able to release waste carbon dioxide more efficiently.)

4. *What is one reason multicellular organisms, such as people, are made up of many small cells instead of one large cell?*

   Smaller cells have more surface area for oxygen and nutrients to diffuse into the cytoplasm. A number of small cells with a volume equivalent to that of one large cell would have a greater total surface area. One large cell, like the large pieces of carbon, would not be efficient at obtaining nutrients and oxygen from the environment.

   ■ **Teacher's Note:** In addition, in multicellular organisms, different cells can perform different functions; this specialization allows for more complex organisms.

The Model

Cells absorb oxygen and nutrients for respiration.

But why are cells so small?

	Represented By
Many small cells	**Carbon powder**
Few large cells	**Carbon pieces**
Oxygen and nutrients	**Blue dye**

©2009 The Regents of the University of California