Tiny Cells and Agar Gels (A Supplement to “Why Cells Aren’t Big”)

The procedure, analysis and evaluation, and student sheets for this lab are available as “Why Cells Aren’t Big” from NeoSci.

Overview
Dyed agar blocks representing different sizes of cells help demonstrate why cells are so small.

Introduction
Cells are very small. A human body, for example, has about 1 trillion cells. In order to view cells, we have to use compound light microscopes. But why are they so small?

The key to understanding why living things are not made of fewer, bigger cells lies in studying relationship between surface area and volume. A cell is surrounded by a plasma membrane that must regulate the substances going in and out of the cell. The materials a cell needs in order to grow and thrive must be able to enter the cell and reach all parts of the interior.

Consider a very big square model of a cell with sides 4mm across.

- The volume of the cell is $64\text{mm}^3$.
- But the cell only has $96\text{mm}^2$ of surface area in contact with the outside environment to exchange materials in and out of the cell.
- The surface-to-volume ratio of this cell is 3:2.

This cell could not allow substances to travel in and out of the cell quickly enough to meet the cell’s needs. In addition, there is a big distance to travel to get to the center of such a cell.

By contrast, consider a much smaller model of a cell with 1mm sides.

- It would have a volume of $1\text{mm}^3$ and
- a surface area of $6\text{mm}^2$,
- resulting in a 6:1 surface-to-volume ratio.

If one were to fill the same area with these smaller cells as was occupied by our large example, the volume covered would remain the same, but the total surface area provided by many smaller cells would be much increased, allowing for more efficient exchange. Put another way, a group of smaller cells has a greater ratio of plasma membrane area to cell volume than one large cell.

Motivation
One of the reasons we may not think about our own cells is that they are so small. But you, personally, are made up of about a trillion cells, so it may be worth it to give them some thought once in a while. Why do we have so many cells, and why do they have to be so small? Why couldn’t we be made of, say, a million cells or even 100,000 cells?

Objectives
At the completion of this laboratory, students should be able to
1. Explain the role of the cell membrane.
2. Make a case for smaller versus larger cells.
3. Explain the need for larger surface-to-volume ratios in cells.
Associated California State Biology Standards
1a. Students know cells are enclosed within semipermeable membranes that regulate their interaction with their surroundings.

Extension Activity
Handout the associated handout “Using Math to Talk About Cells,” which looks a bit closer at the optimal size and shape of a cell and analyzes alternatives.

Test Preparation
1. When the volume of a cell increases, its surface area
   (A) increases at the same rate.
   (B) remains the same.
   (C) increases at a faster rate.
   (D) increases at a slower rate.

2. Surface area is an important factor in limiting cell growth because
   (A) the cell can burst if the membrane becomes too large.
   (B) materials cannot enter the cell if it is too large.
   (C) the cell may become too large to take in enough food and to remove enough waste.
   (D) waste products cannot leave the cell if it is too small.

3. The size to which a cell can grow is limited by its
   (A) location.
   (B) structure.
   (C) function.
   (D) surface area.

4. As cell size increases, the surface-to-volume ratio
   (A) decreases.
   (B) increases.
   (C) increases then decreases.
   (D) remains the same.