EXPLORATIONS

Activity 2

The Bigger, the Better?

Objectives

- To calculate the surface area and volume of cubes and spheres of different sizes
- To calculate the surface area/volume ratio of cubes and spheres
- To understand the relationship between the surface area and the volume of a cell
- To demonstrate an understanding of why cells need to be small

In this activity you will

- calculate the surface area of different shaped cell models.
- calculate the volume of different shaped cell models.
- understand the differences in cells, and their functions.
- sketch a picture demonstrating your understanding of cell function.

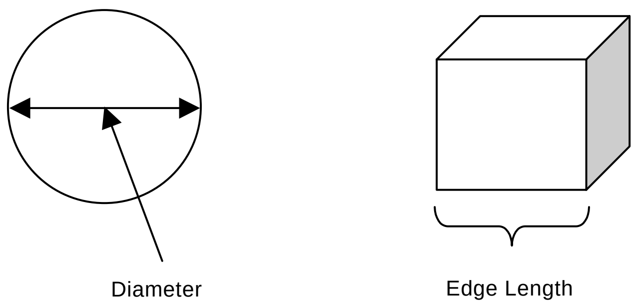
Introduction

Take a look at your hand. Take a really close look at your hand. How many cells can you see? What do you mean you can't see any cells? Why not? Apparently because they are too small for us to see. A typical human being has hundreds of trillions of cells in his or her body. Have you ever stopped to wonder why we have trillions of tiny cells, rather than having millions of bigger ones? This activity will help you understand why cells are usually very small.

Problem

Imagine that you have several cells in front of you. Some of the cells are spherical (round) and some are cubic (square). The sizes of the cells are given in the data table on the next page. Your job is to calculate the surface area and the volume of each cell, and then determine the ratio of the surface area to the volume of each. In order to do this, you need to know the mathematical formulas for calculating the surface areas and the volumes of spheres and cubes. (These formulas will be provided for you later in this activity.)

Spherical Cell Diameter (in mm)	Cube-Shaped Cell Edge Length (in mm)
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10



Procedure

1. Before entering data in the lists, clear any existing data from the lists.

a. Press [2nd] [MEM].

b. Highlight **4:ClrAllLists**, and then press [ENTER].

c. This takes you to the Home screen, and you will see **4:ClrAllLists** with a blinking cursor following it. Press [ENTER], and the TI-83 Plus displays **Done**. Your lists are now cleared.

2. Press [STAT]. Press [ENTER] to choose **1:Edit**.

3. Make sure you are in the first data line in **L1**, and enter the spherical cell diameter values from the data table above. Press either [ENTER] or [▼] after you enter each number.

Think about how you will calculate the surface areas and volumes for the different sized cells you entered into **L1**.

The formula for calculating the surface area of a sphere is $4\pi r^2$.

The formula for calculating the volume of a sphere is $4/3\pi r^3$.

You can use the lists on the TI-83 Plus to calculate these values for you. Before you do that, however, look at the data table again. What measurements are being shown? What measurement of the sphere do you need in order to calculate the surface area and the volume? How can you do this with the TI-83 Plus? Think about it, and then follow the instructions below.

4. Press [▲] to go to the very top of **L1**. Be sure to highlight the heading **L1**, not just the first line in **L1**. How can you change these diameters to radii?

5. Press [2nd] [L1] [÷] **2**, and then press [ENTER]. **L1** now contains the radii of each of the spherical cells.

6. From the data in **L1**, calculate the surface area and the volume of each cell.

a. Press [▶] [▲] to highlight **L2**.

b. Type in the formula for the surface area of a sphere using the data in **L1**. Press **4** [2nd] [π] [2nd] [L1] [^] **2** [ENTER]. What are the units of measure for the data in **L2**? Describe the trend in the data. ([π] is above the [^] key.)

7. Press [▶] [▲] to highlight **L3**. Type in the formula for the volume of a sphere, again using the data in **L1**. Press **4** [÷] **3** [2nd] [π] [2nd] [L1] [^] **3** [ENTER]. What are the units of measure for the data in **L3**? Describe the trend in the data. Compare this trend with the trend in the surface area data in **L2**.

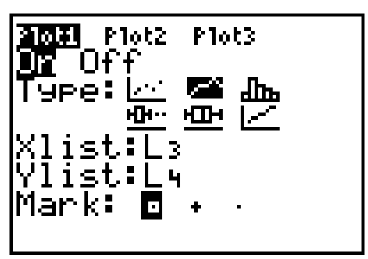
8. Press [▶] [▲] to highlight **L4**. Type in the formula for the ratio between surface area and volume. Press [2nd] [L2] [÷] [2nd] [L3] [ENTER]..

✏ *Enter the data from your TI-83 Plus into the table on the Data Collection and Analysis page.*

9. Make a graph comparing the volume of your cells with the surface area/volume ratio of those same cells.

a. Press [2nd] [STAT PLOT] to access the STAT PLOTS menu.

b. Press [ENTER] to select **1:Plot1.** Set your TI-83 Plus as shown at the right.



10. Press [WINDOW]. Set your window as shown at the right.

```
WINDOW
 Xmin=0
 Xmax=600
 Xscl=0
 Ymin=0
 Ymax=3.5
 Yscl=0
 Xres=1
```

11. Press [GRAPH].

Draw your graph under question 11 on the Data Collection and Analysis page.

12. Press [TRACE] and then press [◄] and [►] to move the cursor from point to point on the graph. Make note of the trend you see in the data, because you will be answering questions about this graph later.

13. Clear the data from the TI-83 Plus lists. Press [2nd] [MEM], choose **4:ClrAllLists**, and then press [ENTER]. This clears the data from all of your lists.

14. Go back and look at the cube-shaped cells. Enter the edge length measurements in your TI-83 Plus.

a. Press [STAT]. Press [ENTER] to select **1:Edit.**

b. In **L1**, enter the edge length data for the cube-shaped cells from the table on page 14.

15. Calculate the surface areas of the different sized cube-shaped cells. The surface area of a cube can be calculated by taking the area of one face of the cube (edge length times edge length, or length times width) and multiplying it by 6 (the number of sides in a cube).

a. Highlight **L2**. Be sure to highlight the heading **L2**, not just the first line in **L2**.

b. Press **6** [×] [2nd] [L1] [x^2] and then press [ENTER].

16. Calculate the volumes of the cells. The formula for determining the volume of a cube is length times width times height. In this case, you can simply take the edge length and raise it to the 3rd power.

a. Highlight **L3**.

b. Press [2nd] [L1] [MATH]. Highlight **3:^{3}** and then press [ENTER] [ENTER].

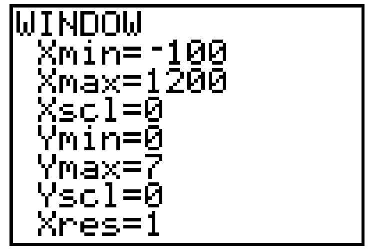
17. Calculate the ratio of surface area to volume of the cubic cells.

a. Highlight **L4**.

b. Press [2nd] [L2] [÷] [2nd] [L3] and then press [ENTER].

Enter your calculated data in the table under question 12 on the Data Collection and Analysis page.

18. Press [WINDOW]. Set your TI-83 Plus as shown at the right.



19. Press [GRAPH].

Draw your graph under question 13 on the Data Collection and Analysis page.

Data Collection and Analysis

Name ____________________

Activity 2: The Bigger, the Better?

Date ____________________

Data Collection

Enter the data from *Procedure* step #8 in the table below.

L1 (Radius)	L2 (Surface Area)	L3 (Volume)	L4 (SA/V Ratio)

Describe the trend you see in the data in **L4**.

Data Analysis

1. In the original data table, the cell measurements were given in units of millimeters. What would be the unit of measure for the calculated surface area values?

2. What would be the unit of measure for the volumes?

3. Why were spherical and cube-shaped cells used in this activity? What were these two shapes intended to model?

4. Obviously, as the cells got larger, both the surface area and the volume increased. Describe the rates of increase of the surface area compared to the volume.

5. Which column in your data table verifies your answer to #4? Explain.

6. Complete this statement: As the volume of the cell increased, the SA/V ratio ________________, and gets closer and closer to what value? _____________

7. The cell membrane is the regulatory passageway between the inside and the outside of the cell. A cell must take in materials such as oxygen and food, and must rid itself of waste products. According to your data, if a cell gets too large, what challenges might it face?

8. What is one way that cells solve the problem of getting too large? Explain.

9. Surface area and volume are not only important factors to consider at the cellular level, but at the organism level, as well. Mammals that live in cold environments tend to have a round, thick shape with short, thick extremities. On the other hand, mammals that live in warmer environments are more likely to have thinner bodies with longer, thinner extremities. Explain why.

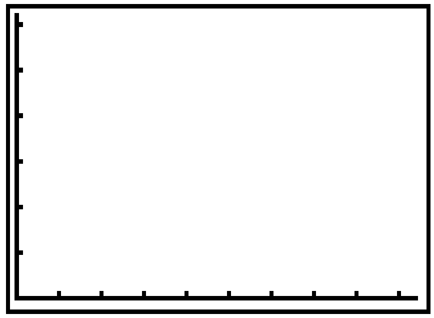
10. In the space below, sketch a picture of an arctic fox and a desert fox, then explain why you drew them the way you did.

Arctic Fox **Desert Fox**

Explanation:

11. Draw your graph here. Be sure to label your axes.

Graph Title: ________________

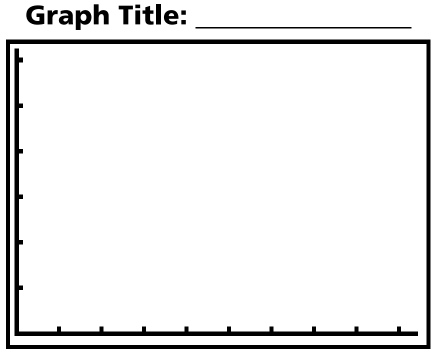


12. Enter your calculated data in this table.

L1 (Edge Length)	L2 (Surface Area)	L3 (Volume)	L4 (SA/V Ratio)

13. Draw your graph here. Be sure to label your axes.

Graph Title: ________________



Teacher Notes

Activity 2

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Concepts

- Surface area to volume ratios
- Cell size

Procedure

3. The measurements being shown are diameters. The measurement needed to calculate the surface area and the volume of the sphere is the radius. (Students must calculate this in step 4.)

4. You can change these diameters to radii by dividing the diameter by 2.

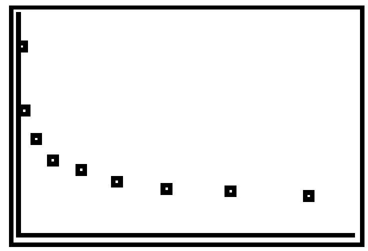
6. The units of measure for the data in **L2** are mm^2. The trend in the data in **L2** can be described as increasing, but not at a constant rate.

7. The units of measure for the data in **L3** are mm^3. The trend in the data can be described as increasing, but not at a constant rate. Comparing this trend with the trend in the surface area data in **L2**, the volume increases at a greater rate than the surface area.

Data Analysis – Answer Key

1. In the original data table, the cell measurements were given in units of millimeters. The units of measure for the calculated surface area values are mm^2.
2. The units of measure for the volumes are mm^3.
3. Spherical and cube-shaped cells were used in this activity because spherical represents animal cells and cube-shaped represents plant cells.
4. The volume increases at a faster rate than the surface area.
5. Column **L4** in the data table verifies the answer to #4, because this is the Surface Area/Volume (SA/V) ratio.
6. As the volume of the cell increased, the SA / V ratio decreased, and gets closer and closer to zero.

7. If a cell gets too large, it may not be able to bring in materials or get rid of waste fast enough.
8. Cells stay small by dividing when they get too large.
9. Round, thick shaped animals have a smaller surface area to volume ratio, so heat escapes them more slowly. Longer, thinner bodies allow heat to escape much faster due to the high SA/V ratio.
10. Drawings and explanations will vary.
11. Graph title suggestion:
    Surface Area/Volume Ratio versus Volume.
    The graph should look similar to the one at the right.



12. The calculated data is in the table below.

L1 (Radius)	L2 (Surface Area)	L3 (Volume)	L4 (SA/V Ratio)
1	6	1	6
2	24	8	3
3	54	27	2
4	96	64	1.5
5	150	125	1.2
6	216	216	1
7	294	343	0.86
8	384	512	0.75
9	486	729	0.67
10	600	1000	0.6

13. Graph title suggestion:
    Surface Area/Volume Ratio versus Volume.
    The graph should look similar to the one at the right.