About the Lesson

In this activity, students 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 and sketch a picture demonstrating your understanding of cell function.

Vocabulary

- cells
- sphere
- cube
- surface area
- volume

Teacher Preparation and Notes

- Students should know how to calculate volume and surface area of cubes and spheres and input data into lists on the TI-84 Plus family of calculators.

Activity Materials

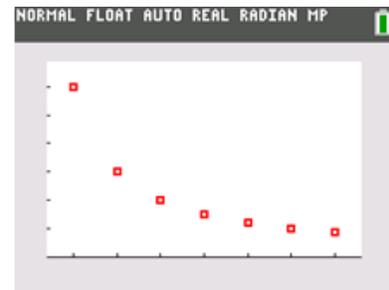- Compatible TI Technologies:

  TI-84 Plus*
  TI-84 Plus Silver Edition*
  🌑TI-84 Plus C Silver Edition
  🌑TI-84 Plus CE

* with the latest operating system (2.55MP) featuring MathPrint™ functionality.

Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

- The_Bigger_the_Better_Student.pdf
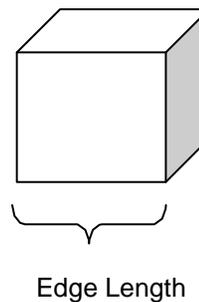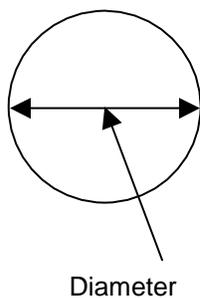- The_Bigger_the_Better_Student.doc

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.

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

Diameter

Edge Length

Entering the Data

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-84 Plus CE 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-84 Plus CE 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-84 Plus CE? 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].

    c. What are the units of measure for the data in **L2**? Describe the trend in the data. ([π] is above the [^] key.)

    Sample Response: 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. Press ▶ ▲ to highlight **L3**. Type in the formula for the volume of a sphere, again using the data in **L1**. Press **4** ÷ 2nd π 2nd L1 ∧ **3** enter.

a. What are the units of measure for the data in **L3**? Describe the trend in the data.

Sample Response: 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.

b. Compare this trend with the trend in the surface area data in **L2**.

Sample Response: Comparing this trend with the trend in the surface area data in **L2**, the volume increases at a greater rate than the surface area.

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-84 Plus CE into the table below:

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

9. Now, you will 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-84 Plus CE as shown at the right.
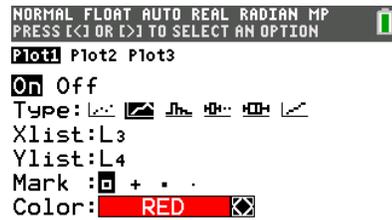
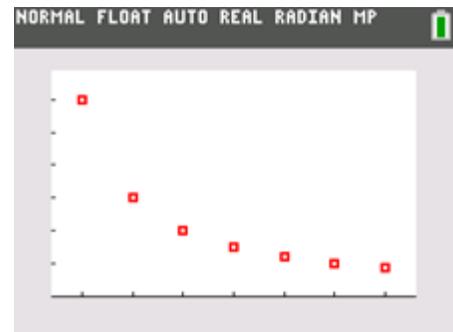10. Press [window]. Set your window as shown at the right.
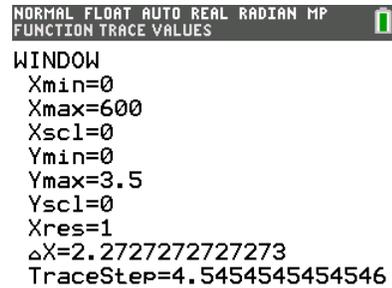
11. Press [graph].

Draw your graph here. Be sure to label the axis and include a title for the graph.

    Sample Response: The graph should look similar to the one at the right. An appropriate title may be: Surface Area/Volume Ratio vs. Volume.

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-84 Plus CE 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-84 Plus CE.

    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.

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 x edge length, or length x 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 here:

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

18. Describe the trend you see in the data in **L4**.
    Sample Response:

    Column **L4** in the data table verifies the answer to #4, because this is the Surface Area/Volume (SA/V) ratio.
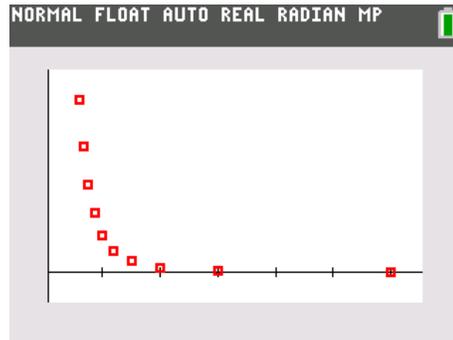
19. Press window. Set your TI-84 Plus CE as shown at the right.

20. Press graph.

```
NORMAL FLOAT AUTO REAL RADIAN MP
FUNCTION TRACE VALUES
WINDOW
 Xmin=-100
 Xmax=1200
 Xscl=0
 Ymin=0
 Ymax=7
 Yscl=0
 Xres=1
 ∆X=4.9242424242424
 TraceStep=▪.8484848484848
```

Draw your graph here. Be sure to label the axes and include a title.

Sample Response: Surface Area/Volume Ratio vs. Volume.

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NORMAL FLOAT AUTO REAL RADIAN MP
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Looking at the Results

1. In the original data table provided, the cell measurements were given in units of millimeters.

   a. What would be the unit of measure for the calculated surface area values?
      Sample Response: The units of measure for the calculated surface area values are mm^2.

   b. What would be the unit of measure for the volumes?
      Sample Response: The units of measure for the volumes are mm^3.

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

   Sample Response: Spherical and cube-shaped cells were used in this activity because spherical represents animal cells and cube-shaped represents plant cells.

3. 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.

   Sample Response: The volume increases at a faster rate than the surface area.

4. Complete this statement: As the volume of the cell increased, the SA/V ratio **decreased** and gets closer and closer **to zero.**

5. 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?

   Student answers will vary.

   Sample Response: If a cell gets too large, it may not be able to bring in materials or get rid of waste fast enough.

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

   Sample Response:
   Cells stay small by dividing when they get too large.

Going Further

1. 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.

   Student answers will vary.

   Sample Response: 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.

2. 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

   Student answers will vary.