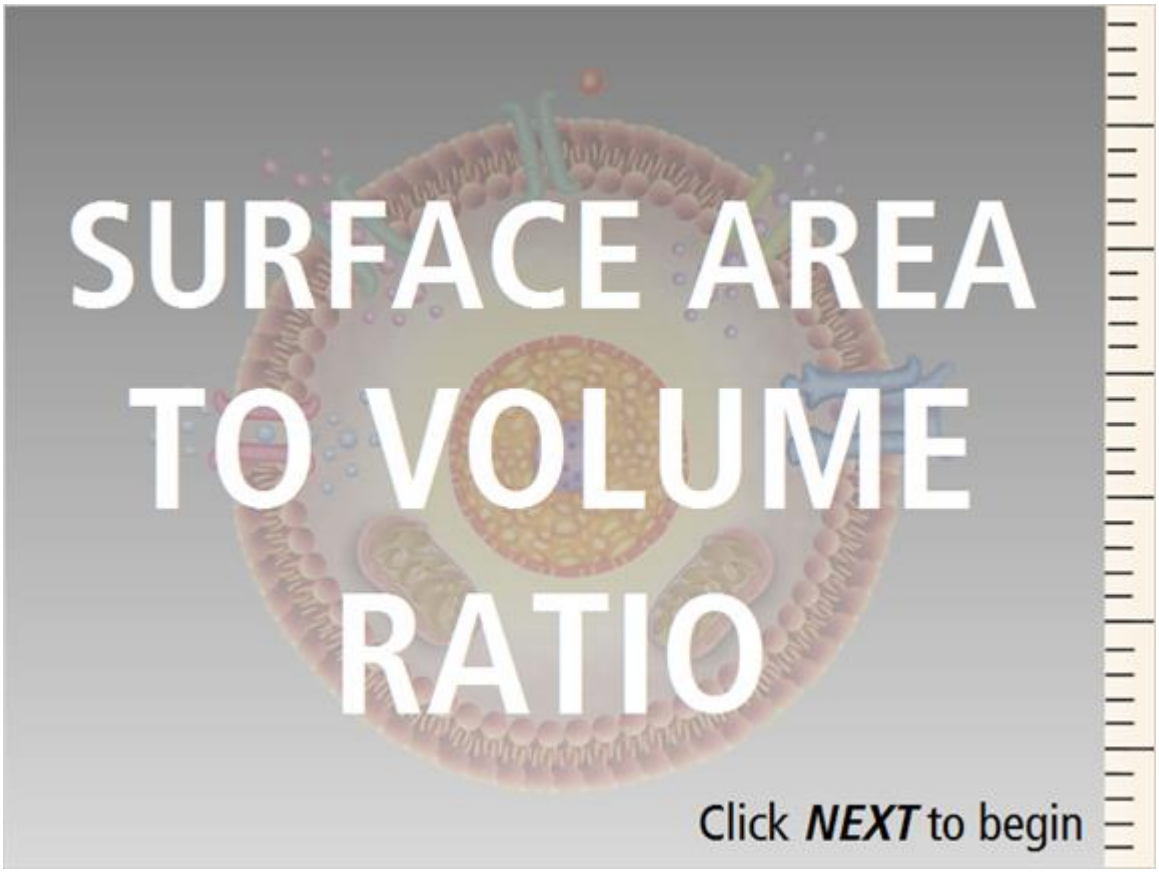
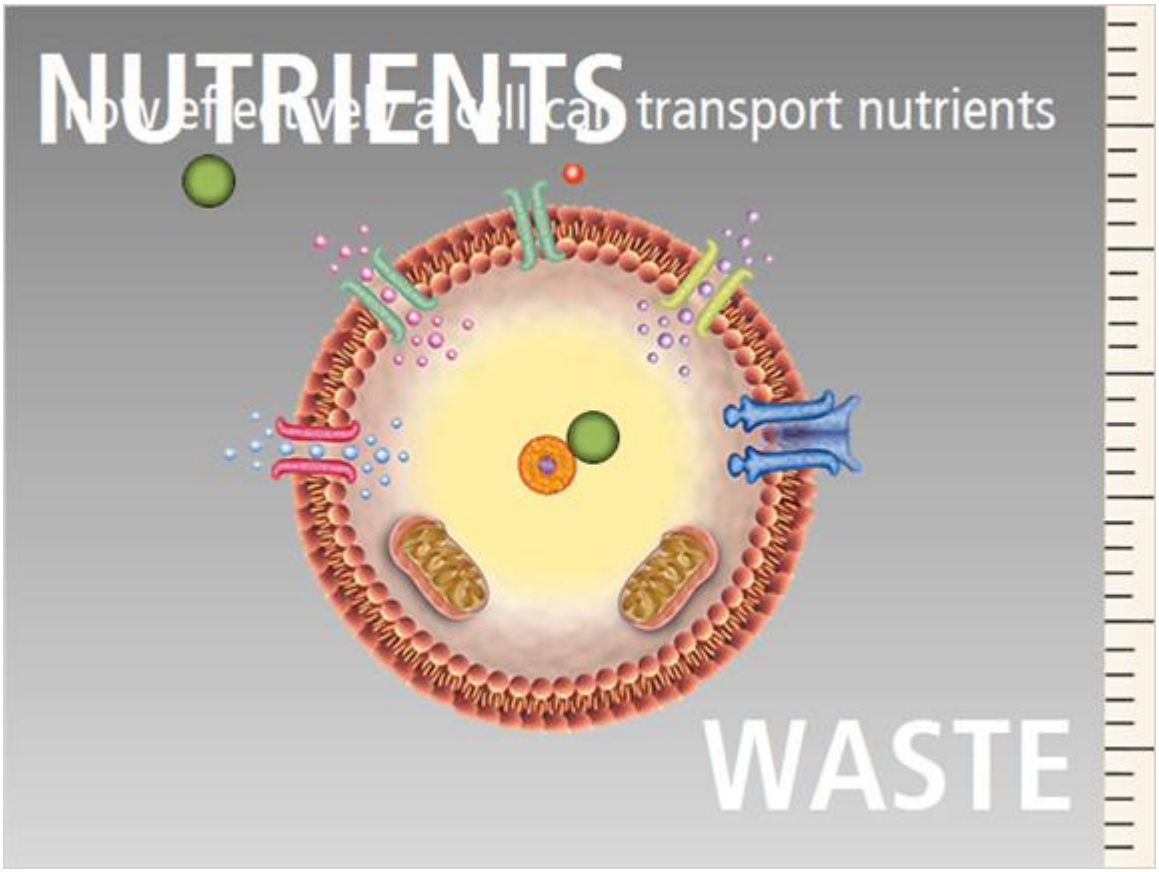
Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



Surface Area to Volume Ratio

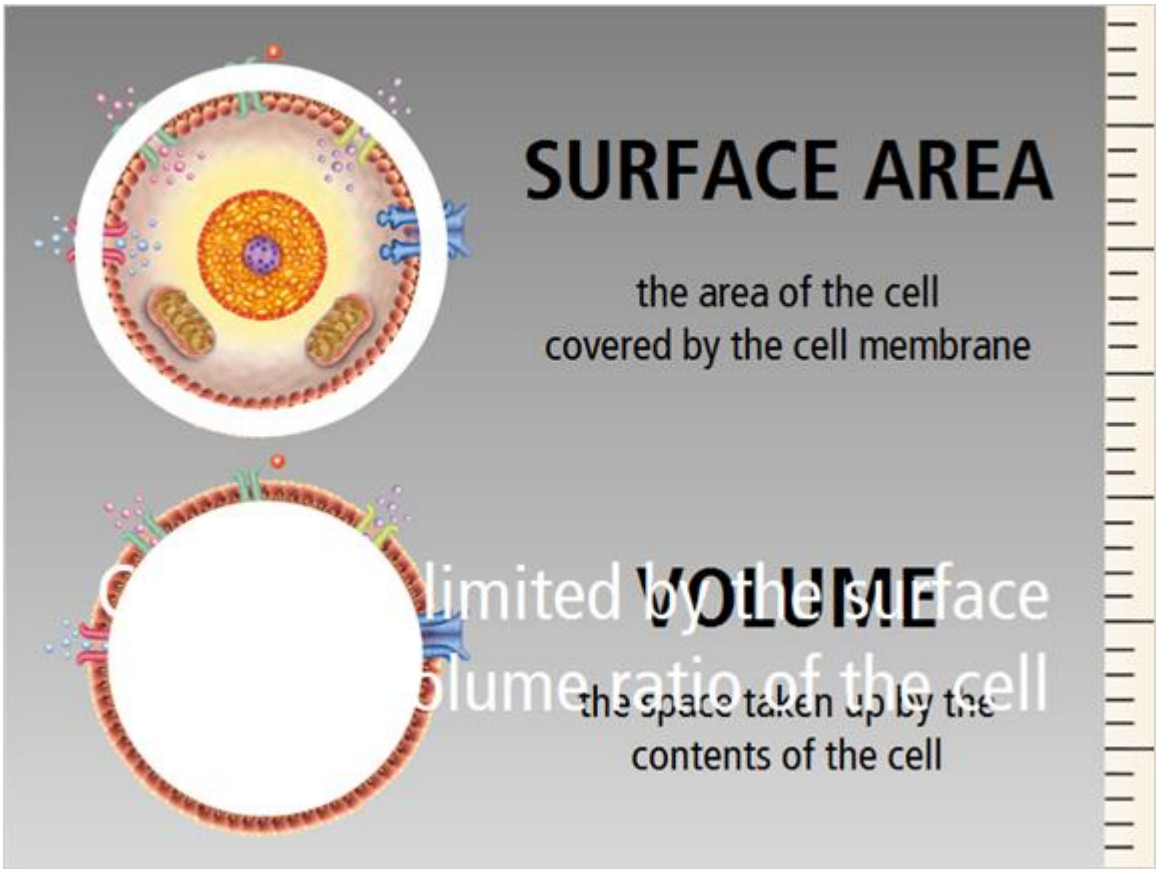
Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



The surface area to volume ratio is extremely important in determining how effectively a cell can transport nutrients. Cells take in nutrients and expel waste. If a cell's surface area to volume ratio is too small, the cell cannot effectively transport nutrients. In this interactivity, learn about the important of a cell's surface to volume ratio. Click ***NEXT*** to continue.

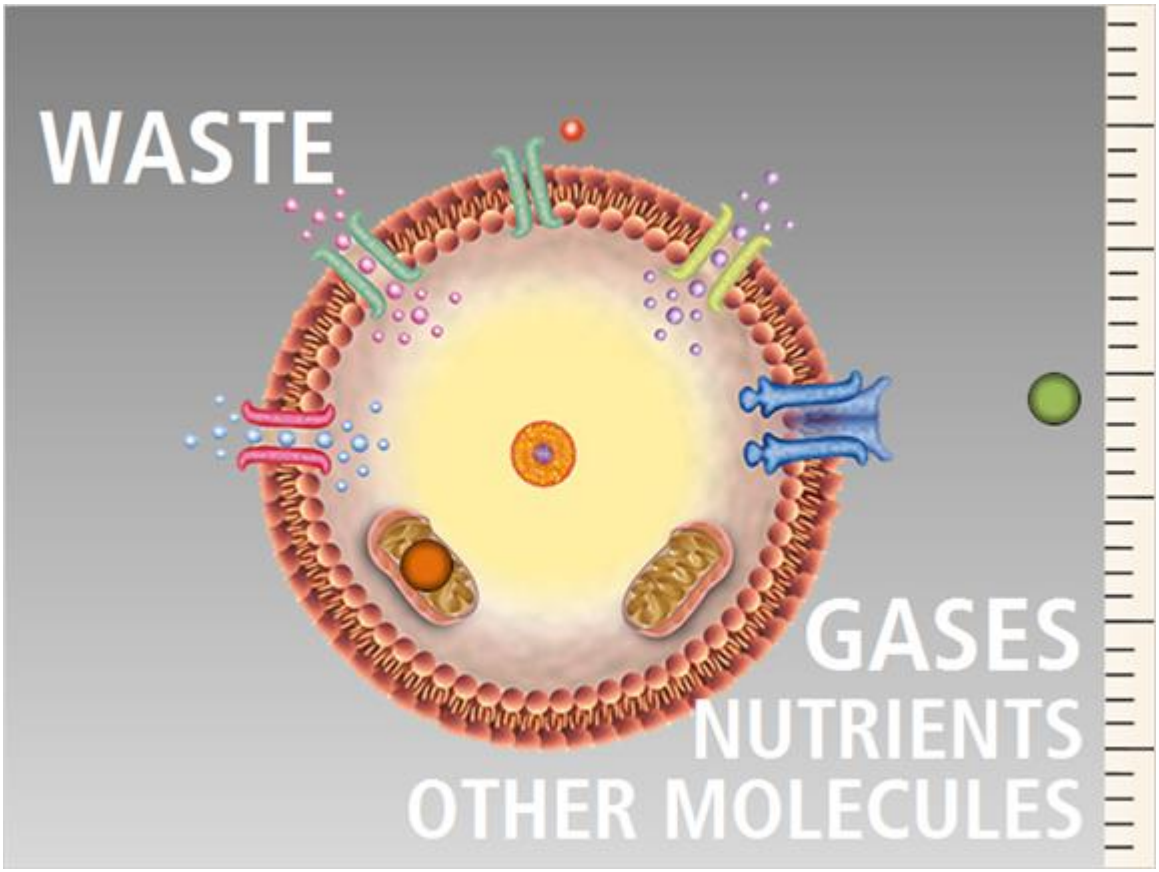
Module 3: Cell Biology - Structure and Function

Topic 4 Content: Surface Area to Volume Ratio Notes



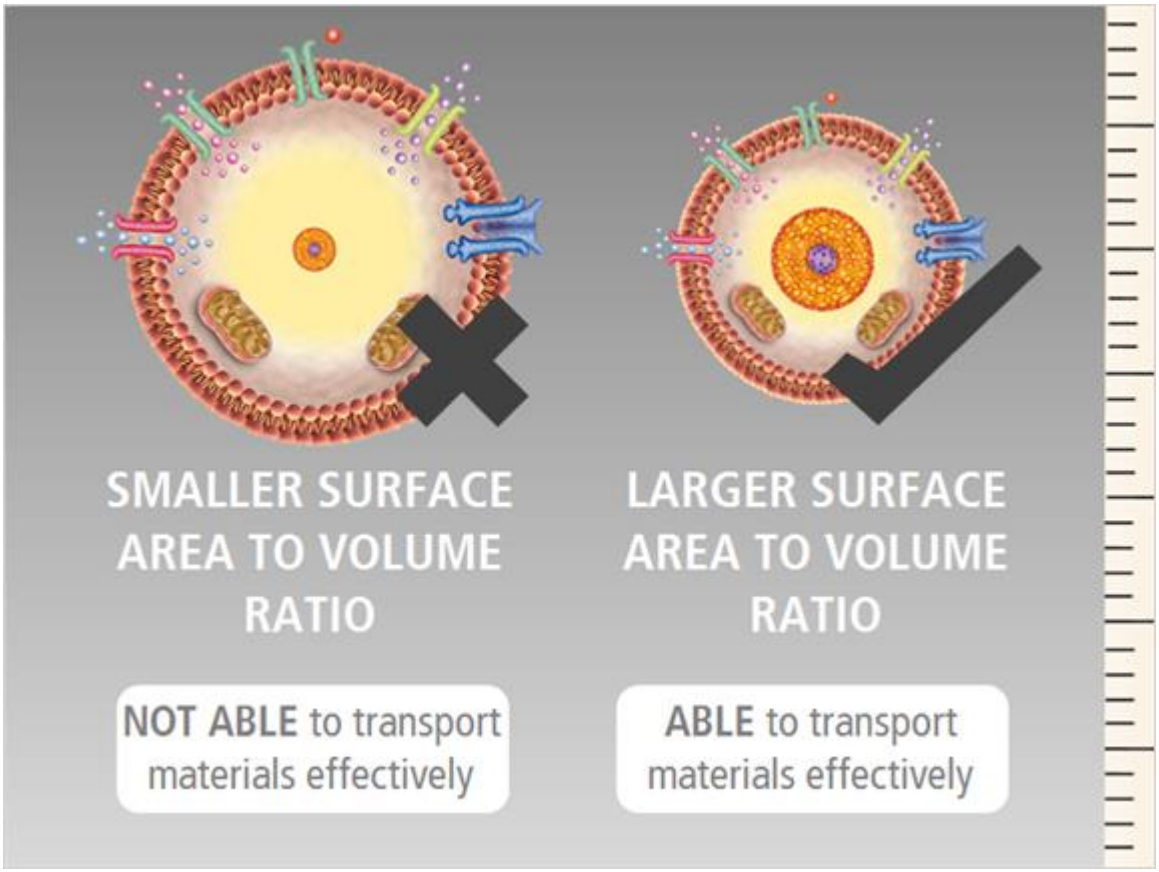
Why are cells so small? Cell size is limited by the surface area to volume ratio of the cell. The area of the cell covered by the cell membrane is the surface area. The volume of the cell is the space taken up by the contents of the cell, including the cytoplasm, organelles, and the nucleus. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



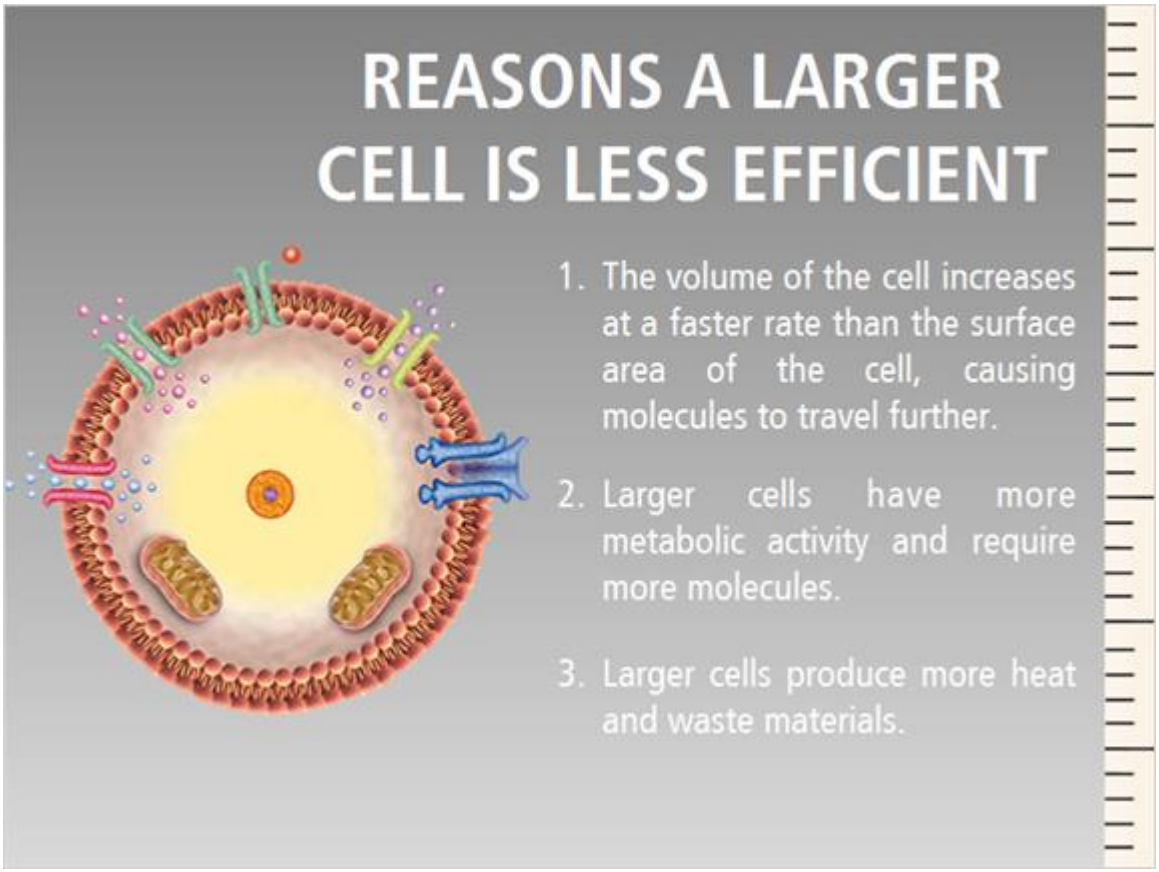
Everything a cell needs, such as gases, nutrients, and other important molecules must enter through the cell membrane and travel through the cell to the target organelle. Also, any waste materials produced must travel out of the cell, through the cell membrane. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



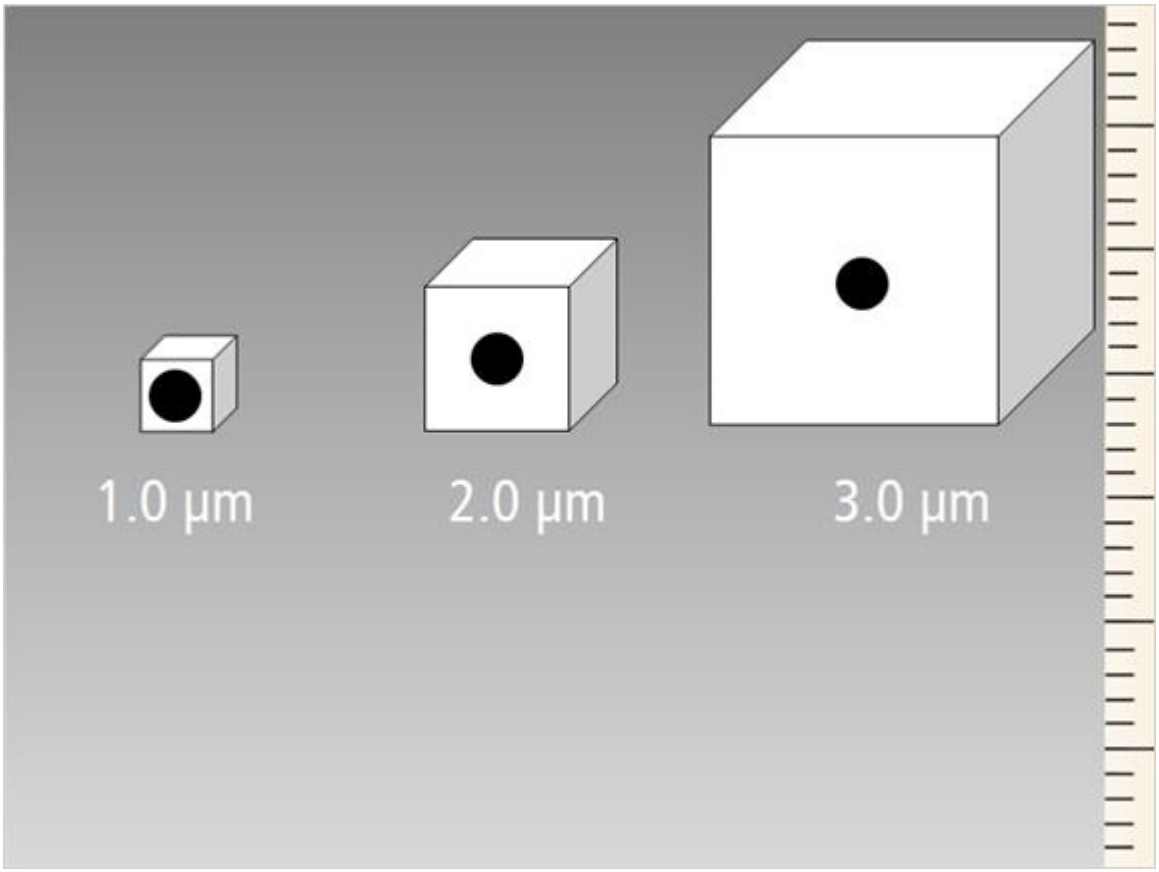
Look at the two cells that are shown here. You can easily observe that the cell on the left is larger than the cell on the right. Which of the cells have the ability to transport materials more efficiently? If you chose the cell on the right, you are correct. This cell has a larger surface to volume ratio and can transport materials more efficiently. When the surface area to volume ratio is too small, the cell cannot transport materials efficiently. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



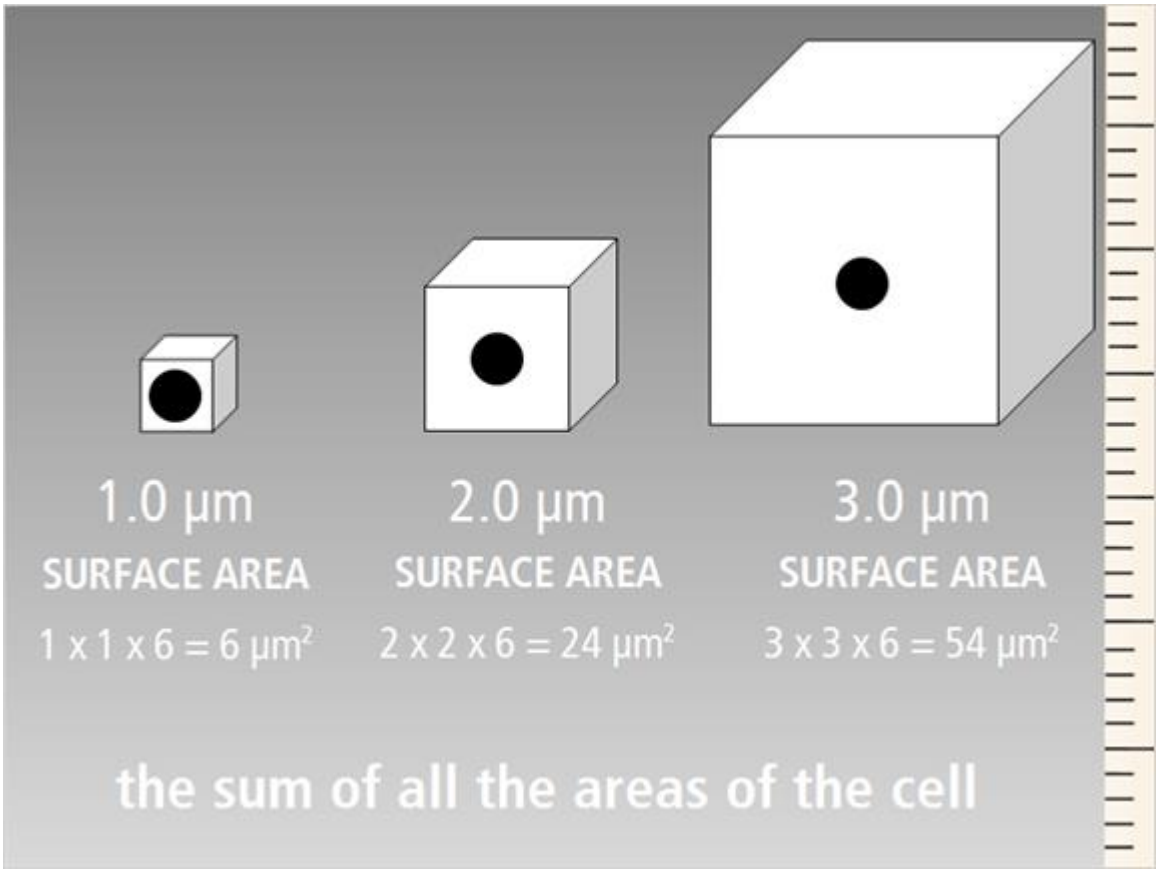
Why are larger cells less efficient than smaller cells? As the size of a cell increases, the volume of the cell increases at a faster rate than the surface area of the cell. This causes molecules to travel further on their way to the organelles. Larger cells have more metabolic activity. This requires more molecules to fuel the chemical reactions. Larger cells produce more heat and waste materials. If a cell's surface to volume ratio becomes too small, it would not be able to function. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



For a cell function efficiently, it needs a large surface area and a small volume. As a cell increases in size, the volume of the cell increases at a faster rate than the surface area, causing the ratio of surface area to volume to decrease. To demonstrate this principle, pretend that these cubes represent cells of different sizes and the black dots represent the nucleus of the cells. The smallest cell is 1.0 µm, the medium-sized cell is 2.0 µm, and the largest cell is 3.0 µm. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
Topic 4 Content: Surface Area to Volume Ratio Notes



Surface area is the sum of all the areas of the cell. In this example, you calculate the area by multiplying the length by the width of each side. Then, the area of each side is determined by multiplying 1 µm by 1 µm. Since there are six sides to the cube, you multiply 1 µm by 6 sides. The surface area of the smallest cell is 6 μm^2.

The surface area of the medium-sized cell is determined by multiplying 2 µm by 2 µm by 6 sides. The medium-sized cell has a surface area of 24 μm^2.

The largest cell is determined by multiplying 3 µm by 3 µm by 6 sides. The largest cell has a surface of 54 μm^2. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
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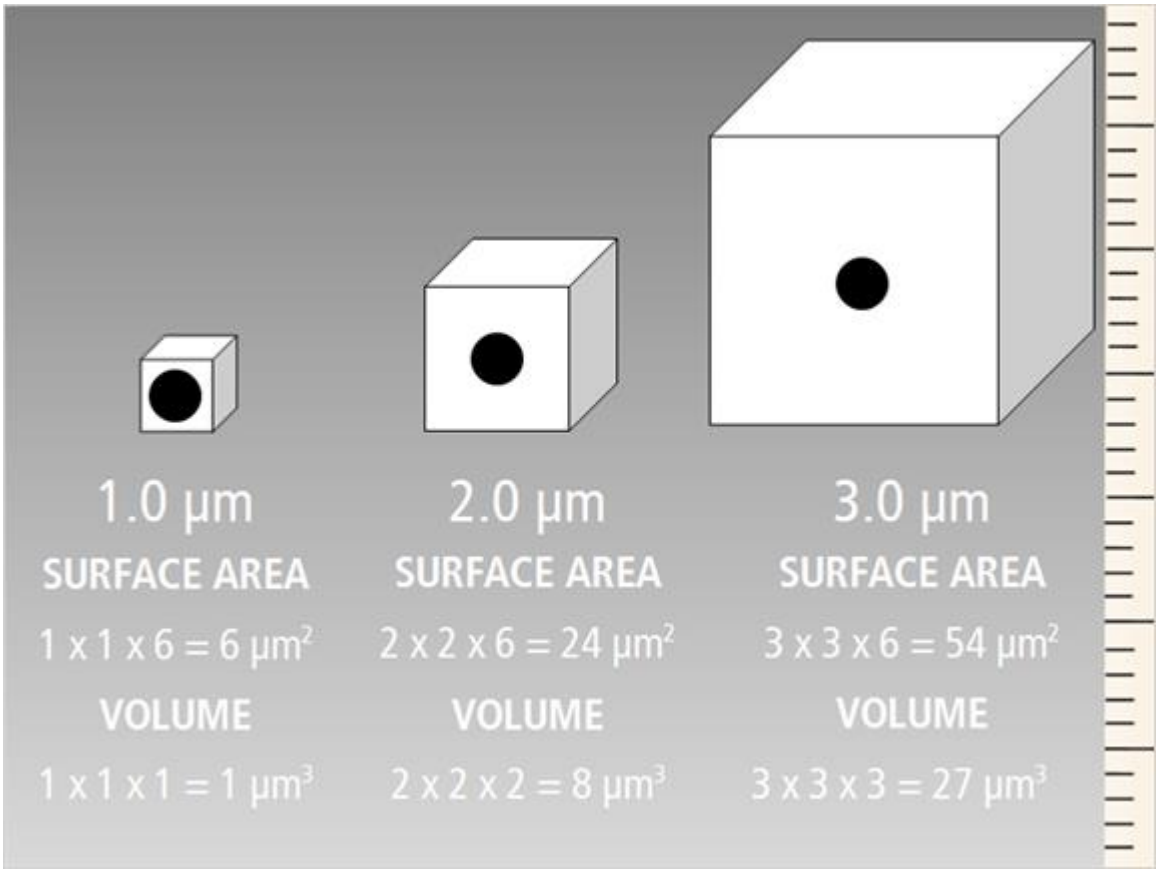

In order to compare the surface area to the volume of a cell, you must calculate the volume. In order to calculate volume, you multiply the length by width by height. In the smallest cell, the volume is found by multiplying 1 µm by 1 µm by 1 µm. The volume of the smallest cell is 1 μm^3.

The volume of the medium-sized cell is 8 μm^3. This is found by multiplying 2 µm by 2 µm by 2 µm.

The volume of the largest cell is 27 μm^3. This is found by multiplying 3 µm by 3 µm by 3 µm. Click ***NEXT*** to continue.

Module 3: Cell Biology - Structure and Function
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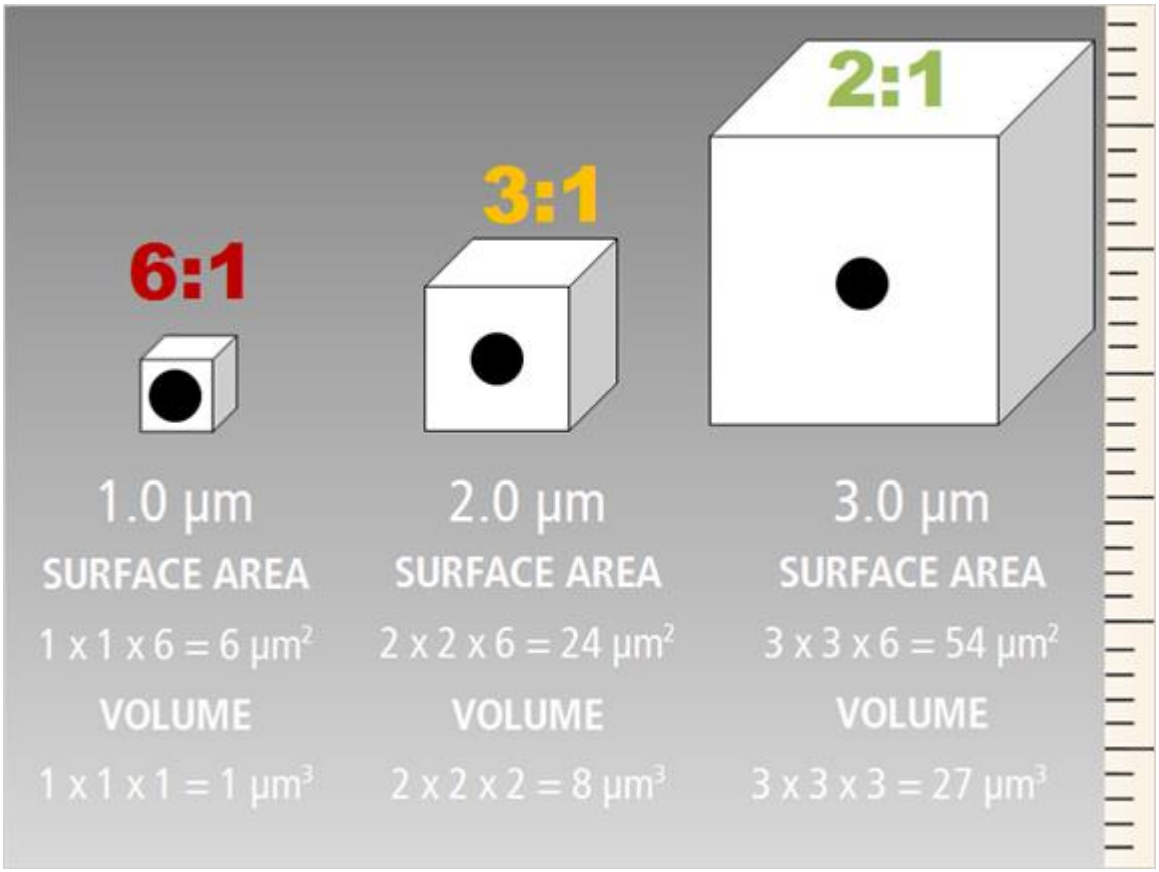

Now that you have calculated the surface area and the volume, you can compare the values for each cell and determine the surface to volume ratio. In the smallest cell, the surface area is 6 μm^2 and the volume is 1 μm^3. The surface to volume ratio is 6 to 1.

In the medium-sized cell the surface area is 24 μm^2 and the volume is 8 μm^3. This can be simplified to a surface to volume ratio of 3 to 1.

The largest cell has a surface area of 54 μm^2 and a volume of 27 μm^3. This can be simplified to a surface to volume ratio of 2 to 1. Click ***NEXT*** to continue.

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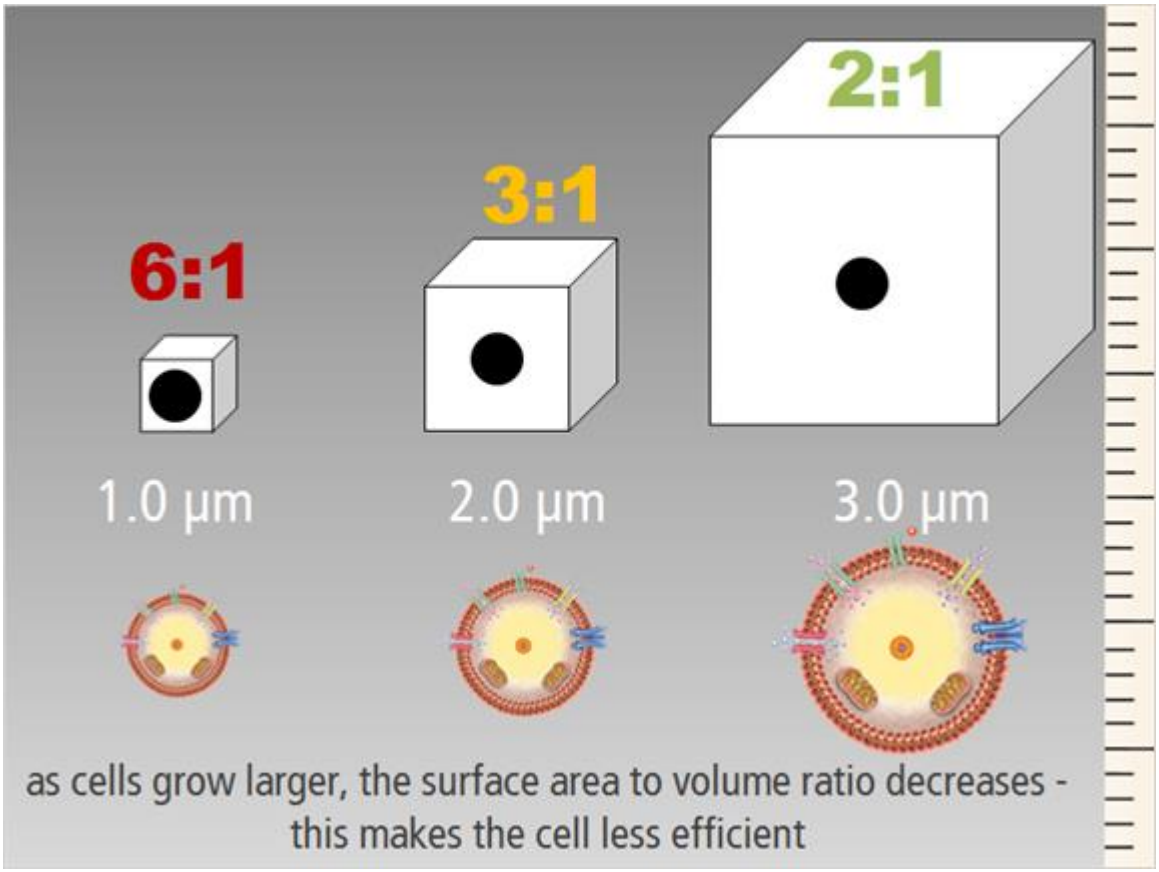

As you can see, when the cell grows larger, the surface area to volume ratio decreases. You can also see that the space between the surface of the cell and the nucleus grows larger as the cell grows larger, thus increasing the amount of time it takes for materials to get in and out of the cell. At some point, the surface area to volume ratio becomes so small that the cell cannot efficiently transport materials in and out of the cell in order for the cell to function. This is the point where the cell cannot grow any larger.