How Big Is It?

This activity helps students visualize the relative sizes of microbes that have the potential to cause disease.

Materials (for every pair of students):
• the sheet attached that shows images of various kinds of microbes.
• scissors

What To Do:
1. Students use scissors to cut out each of the 12 boxes that describe various kinds of microbes, cells, and other tiny objects in nature.
2. Students line the cards in order, starting with what they believe is the smallest object and ending with the largest object.
3. Once every group has made a guess, they conduct Internet research to find the actual size of these objects and put them in the correct order. Were they surprised?

What’s Going On?

Students often hold ideas about the size and scale of microscopic life that are inaccurate and interfere with learning concepts such as disease transmission and prevention. For example, students who believe that viruses are larger than cells have a hard time understanding how viruses can multiply using the cells own genetic material. By starting the study of microbiology with activities like this one, students develop a more accurate concept of the size and scale of microbes that will lead to deeper understanding of - for example - the life cycle of microbes, their role in disease, and the symbiotic relationships that exist between microbes and various other forms of life.
<table>
<thead>
<tr>
<th>E. Coli Bacteria</th>
<th>HIV Virus</th>
<th>Red Blood Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>This dot</td>
<td>An Ant</td>
<td>A Human Egg</td>
</tr>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>Human Sperm</td>
<td>Dust mite</td>
<td>Strand of Human DNA</td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
</tr>
<tr>
<td>Human Neuron</td>
<td>Influenza Virus</td>
<td>A Water Molecule</td>
</tr>
<tr>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Bacteria and Viruses: Visualizing the “Teeny Tiny”

This activity helps students visualize the relative size and structural differences between microbes that have the potential to cause disease.

Materials:
• rulers and meter sticks
• scissors
• construction paper
• balloons
• glue and tape
• toothpicks
• clay
• chenille craft sticks
• other misc. disposable objects that students can use to construct a model

What To Do:
1. Groups of students will be constructing scale models of different types of bacteria and viruses. On the attached page there are images of some bacteria and viruses that cause illness in humans. Each image is labeled with the diameter of the actual microbe and other information.

2. Give students the following scale:

   Let 1 centimeters = 1 nanometer = 1000 micrometers

   therefore

   Let 10 centimeters = 10 nanometers = 10,000 micrometers

3. Based on this scale, groups of 2-3 students will work together to build a scale model of one of the viruses on the attached page. The models will be built using the materials on the table. The models should include (a) an exterior that has spikes, bumps, indentations, or other structures listed in the virus descriptions, (b) an outer shell made of “proteins”, (c) an interior that enclosed the genetic material of the virus (RNA or DNA strands).

4. After the students finish their models, have each group present their virus to the rest of the class. Note the varying shapes, structures, and sizes of viruses.
5. Have each group of student figure out how big each of the bacteria species would be at the scale they were using.

6. A typical red blood cell is 8 micrometers in diameter. A lymphocyte is about 10 micrometers in diameter. How large would a scale model of a red blood cell be if 1 centimeter = 1 nanometer? What about a lymphocyte?

**What's Going On?**
For students to understand disease processes in the body, it's helpful for them to be able to conceptualize the relative sizes of viruses (much are much smaller than the cells they invade) and bacteria (which are about the size of most cells that some feed upon).

**Some Background**
There are major differences between bacteria and viruses. Even through both can cause us to become ill, the microbes themselves are as different as night and day. In fact, viruses and bacteria differ greatly with respect to (1) size, (2) form, and (3) method of reproduction.

(1) **Size:**
Viruses are much smaller than bacteria. If the average virus were enlarged so it was the size of an orange, an average bacterial would be about the size of a sofa.

(2) **Form:**
A virus is a very simple thing - it consists of a strand of DNA or RNA surrounded by a shell made of proteins. Some viruses are surrounded by another envelope. But even through viruses are constructed out some of the same building blocks that make up other organisms, a virus is not actually alive. On it's own, an individual virus can not reproduce nor can it combine somehow with another virus.
In order to replicate, it must invade another organism and use it's host's reproductive machinery to replicate itself. Viruses come a variety of different shapes - some are long and skinny, some a round and spiky, some are multisided, and others are brick-like in shape. Here is an example of the structure of a virus ...
Bacteria are single celled organisms and are living things. They are part of the kingdom called prokaryotes. Bacteria - like all prokaryotes - have an important characteristic in common - they do not have their genetic materials (or DNA) enclosed within a nucleus. Bacteria, like all prokaryotes, have no nuclei. Also, individual species of bacteria typically have three basic shapes: rods, spheres, and spirals. Individuals can exist alone or they can form chains, clumps, and other groups. This is an example of the structure of a bacteria …

(3) Reproduction

A virus’s only mission is to make more copies of itself. But since it has no reproductive machinery of its own, it invades other organisms and like a very bad house guest, it sponges off the reproductive resources of its host. Viruses are picky about their hosts - each virus has a unique organism it prefers to pirate. For example, some viruses infect liver cells (and cause hepatitis), some infect cells in the lung (and cause viral pneumonia) and still others infect mucous membrane cells lining your nose (and cause “colds”).

There are two kinds of viruses - those made of DNA and others made of RNA. If a virus is made of DNA, its genetic material then inserts itself directly into the host cell’s DNA. If the virus is an RNA virus, it must first turn its RNA into DNA using the host cell’s own machinery before inserting itself into the host’s DNA.

Whether their insides are made of DNA or RNA, viral genes are copied over and over again using the machinery the host cell would normally use to reproduce its own DNA. The virus also uses the host cell’s enzymes to make new protein coats. New viruses - all identical copies of the invader - are either released from the host cell without destroying the host cell or eventually build up to a large enough number that they burst apart the cell.
Bacteria are living things that create copies of themselves. Each bacterium has its own DNA and all the machinery needed to reproduce. Does that mean that a virus could potentially use the reproductive engine of a bacteria to reproduce itself? Can a bacterium be infected by a virus? The answer is yes! A virus that targets bacteria is called a bacteriophage and there are many known kinds. The discovery of bacteriophages may lead to new treatments for bacterial infections that don’t rely on antibiotics. Imagine – one day your doctor might prescribe a virus to help you fight off a bacterial infection!

Resources

(A great interactive tool for studying the size and structure of various microbes)

Stalking The Mysterious Microbe: [http://www.microbe.org/index.html](http://www.microbe.org/index.html)
(A great overview of the difference between microbes. Has great student activities, too)

The Big Picture Book Of Viruses:
[http://www.tulane.edu/~dmsander/Big_Virology/BVHomePage.html](http://www.tulane.edu/~dmsander/Big_Virology/BVHomePage.html)
(No kidding - this is a virtual library of literally thousand of known viruses. Some are computer models, but others are actual electron microscope images!)

The Microbe Zoo: [http://commtechlab.msu.edu/sites/dlc-me/zoo/](http://commtechlab.msu.edu/sites/dlc-me/zoo/)
(A fabulous virtual “zoo” where you can take trips to microbes (especially bacteria) living in a variety of different environments. Perfect for your students!)

Textbook Of Bacteriology: [http://www.textbookofbacteriology.net/](http://www.textbookofbacteriology.net/)
(An on-line interactive “textbook” of everything you ever wanted to know about bacteria. The most comprehensive site I’ve seen.)

Some Viruses

Rabies
Shape: Bullet-like
Length = 180 nanometers
Width = 75 nanometers
Spikes = 9 nanometers
Inside: RNA

Hepatitis B (Hepadnaviridae)
Shape: Cocktail weiner
Length: 45 nanometers
Width: 30 nanometers
Spikes: (none)
Inside: DNA
Other: Concentric rings of proteins

Norwalk Virus (Calicivirus)
Shape: spherical
Diameter: 30 nanometers
Spikes: (none)
Inside: RNA
Other: Cup-shaped depressions on surface and 6-sided symmetry giving virus a “Star-of-David” look under microscopy. Similar to the exterior of the rhinovirus
Human Immunodeficiency Virus (HIV)
Shape: Spherical
Diameter: 100 nanometers
Spikes: 8 nanometers
Inside: RNA

Rhinovirus (200 types cause colds)
Shape: Spherical
Diameter: 20 nanometers
Inside: RNA
Other: A 20-sided structure with depressions on its protein surface.
**Some Bacteria**

**Borrelia burgdorferi (Lyme Disease)**
Shape: string-like, sprial  
Type: spirochete  
Length: 15 micrometers (15,000 nanometers)  
Width: 0.3 micrometers (300 nanometers)

**Bordetella pertussis (Whooping Cough)**
Shape: long oval rod  
Type: rods  
Length: 1 micrometer (1000 nanometers)  
Width: 0.3 micrometers (300 nanometers)

**E. Coli (intestinal infection)**
Shape: long oval rod  
Type: rods  
Length: 10 micrometers (10,000 nanometers)  
Width: 2 micrometers (2000 nanometers)  
Other: beneficial E. coli make vitamin K for us.
Helicobacter Pylori (stomach ulcers)
Shape: long rod
Type: rod
Length: 3 micrometers (3000 nanometers)
Width: 1/2 micrometers (500 nanometers)

Streptococcus ("Strep" Throat)
Shape: round
Type: sphere
Diameter: 1 micrometer (1000 nanometers)
Other: This is an image of two bacteria just after cell division. You might notice tiny protein fibers (about 50 nanometers long) coming off the bacterial surface.