



Super STEM Sleuths: 1

Teacher's Guide and After School Activities

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Super STEM Sleuths: Part 1

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Materials List for Super STEM Sleuths: Part 1

Here are the recommended supplies for a class of 24 students. Groups consist of four students. Teams of students are student pairs.

Activity 1 – Modeling the Spread of Germs

Per Class

- Small container of Glo Germ™ powder
- Large black light
- Bar soap
- Liquid soap
- Pre-moistened towels
- Antibacterial cleaner
- Roll of paper towels

Activity 2 – Magnification

Per Student Pair

- 2 clear, plastic cups, 7- or 8-oz size
- Set of materials in plastic bag including
 - loose and tightly woven fabric,
 - feather, penny, pencil, piece of dollar bill, newsprint
- Clear flat-sided takeout salad box
- Cooking oil
- Paper towel
- Eyedropper
- 2 hand lenses
- One clear marble (Optional, See “Wrapping Up” section for note about sources and instructions)
- One large “glass gem” (Optional. See “Wrapping Up” section for sources and instructions)
- Wet-dry® sandpaper, coarse 220 grit
- Wet-dry® sandpaper, medium 320 grit
- Wet-dry® sandpaper, fine 600 grit
- Wet-dry® sandpaper, very fine 1,000 grit

Note: Wet-dry® sandpaper is a high-grade form of sandpaper: Coarse 220 grit, medium 320 grit, and fine 600 grit (purchase from a hardware store, and very fine 1,000 grit (may need to purchase it at an auto parts or boat store)

Activity 3 – Microbe Scavenger Hunt

Per Class (see Setup)

- Nutrient agar

Per Student

- Petri dish
- Potato slice (large baking potatoes)
- 3 cotton swabs (Q-tips®)
- Plastic sandwich bag

Per Student Pair

- Small cup
- Distilled/filtered water
- Permanent marker pen
- 2 Hand lenses
- Clear tape
- Bleach or small plastic trash bag

Activity 4 – Microbes in Food

Per Group

- Set of “Microbes Cards”
- Re-sealable plastic bag

Activity 5 – Food and Fermentation

Per Student Pair

- 100 ml water about 110° F
- 2 plastic cups OR 2 empty one-half-liter water bottles
- 2 plastic spoons
- 2 packages rapid-rise yeast
- Single-serving package of sugar OR 2 tsp of sugar
- Metric ruler
- Masking tape
- Marker
- Copy of “Energy for Life” student page

Activity 6 – Mold Cultures

Per Student Pair

Variety of breads and tortillas, with and without preservatives, with labels
Paper towel
Index card
Small cup
Water
2 re-sealable plastic bag, sandwich size
Masking tape
Plastic knife
Metric ruler

Activity 7 – The Size of Microbes

Per Class

Large paper square of butcher paper,
2.5 m x 2.5 m

Per Group

Set of 4 prepared text strips
4 hand lenses
4 metric rulers marked in millimeters
4 pairs of scissors
Assorted markers or colored pencils
Meter stick
Paper or science notebook
Several sheets of colored or plain paper, or a roll of chart or craft paper
Tape or glue
Copy of the “Microbe Scaling Chart” student sheet

Activity 8 – Make a Virus

Per Student

Virus pattern for each student
Scissors
Straight edge rulers
Ballpoint pens
Clear tape
Colored marker pens (do not use crayons!)

Activity 9 – Spreading Infectious Disease

Per Student

Number tags for each player
Tag logs for each player (see master)
Pens or pencils
Jar or box with small slips of paper, each with the same numbers as the number tags

Activity 10 – Population Density and Disease

Per Class

2-liter empty soft drink bottle
Small balloon
1 tsp of talcum powder

Per Student Pair

Tape measure
Graph paper
Pencil
Ruler
Classroom outline maps for “Planning your Home”

Activity 11 – Inside the Cholera Epidemic of 1854

Part 1

Per Group

Four part London Soho district Map
Victim List
Overhead projector transparency sheets for printers
Clear tape
Scissors

Part 2

Per Student

Information on Dr. John Snow

Activity 12 – Fight Vibrio Cholera!

Per Class

Nutrient agar (see Setup)

Per Student Pair

Petri dish (see Setup)
2 safety goggles
2 pairs of plastic or latex gloves
Antibacterial soap
Water sample from a local source: Collect the sample just before it is needed.
Eyedropper
Miscellaneous: Coffee filters, fabric, plastic bottles, charcoal (purchase from an aquarium store), sand, cotton balls, etc.

Activity 14 – Disease from the Inside Out

Per Class

Osmosis Jones (2001) video

1) Modeling the Spread of Germs

Super STEM Sleuths Introduction

Time Needed

Activity: 1 – 2 sessions

Before You Start

If using a black light fixture, setup an area of the room to place the fixture.

You'll Need This Stuff

Per Class

Glo Germ™ powder
Fluorescent “black light” lamp with fixture (18 in. – 24 in. tube), compact fluorescent black light, or a small hand held UV light.

Several types of hand soap (bar and liquid), pre-moistened towels, antibacterial cleaner
Paper towels
Access to a sink

Notes about sources

Glo Germ™ power is available from science supply companies and the Glo Germ Company www.glogerm.com

Fluorescent black lights and hand-held UV lights are available from a variety of sources including Amazon.com, science supply catalogs, and from the Glo Germ Company.

What It's About

Students are familiar with the term “germ.” From a young age they are told that germs are everywhere and are told to wash their hands, cover their cough or sneeze, or not to share food or drink.

“Germ” is a generic term that is used for a variety of disease-causing microbes. Microbes are the most prevalent organisms on our planet, both in mass and number. They comprise a diverse group and include bacteria, microscopic algae, yeast cells, and even protozoa. Most biologists also consider viruses to be microbes, even though according to many definitions, viruses are not true “living” organisms.

Not all microbes are disease-causing germs. Their roles are many. In this unit, we focus primarily on microbes directly related to our health. In this and activities that follow students become amateur microbiologists as they study the roles of these tiny organisms that consist of a single cell or a cluster of a few similar cells.

What's the Question?

Microbes are microscopic. That means we can't see them unless we magnify them using a microscope. How do microbes (germs) spread?

What To Do

1. Rub Glo Germ™ powder on your hands and then casually shake hands with all students as they enter the room or as appropriate.
2. For two minutes, have students, working with partners make a list of everything they see in their immediate environment.
3. Have each team share their observations, one at a time in a round robin discussion. List each observation on a white board. If a team runs out of new things to add to the list they can pass. Continue until all teams run out of observations.
4. Ask students, *What is missing?* (Things that you cannot see! Germs.) Germ is a generic term for what are considered bad microbes. Microbes are organisms too small to be

observed by the naked eye. Have students examine their hands. Ask, *Do you see anything? Why do you wash your hands before eating?* (Germs.)

5. Explain that you have used a model germ that they can only see under black (ultraviolet or UV) light. Ask your students, *Do you have any "germs"?*
6. If using UV lights, invite teams of students to examine their hands, pencils, paper, etc.
7. Ask, *How did the mystery substance spread?* Discuss.
8. Explain to the students that during the course of the next 6 – 9 weeks they will be investigating the way germs spread as they collect, grow, observe and make models of microbes. They will also use microbes in food preparation and solve an epidemiological mystery as they track down the cause of an infectious disease.
9. Have students, working in teams of two, set up a hand-washing investigation with variables such as type of soap, water temperature, and length of time washing. Display a number of types of cleaners, including bars and bottles of soap, pre-moistened towels, and anti-biotic liquid for students to choose from. Have students devise a uniform strategy for "infecting" their hands with Glo Germ™ powder before they begin the investigation and then examine them under the black light after washing. Have students compare and contrast methods and results. Ask, *What worked best? Was time important factor? Other factors?*
10. Encourage students to create a presentation to share with younger students on appropriate methods for hand washing.

Tip: It is recommended for best results to coat hands with suds, scrubbing front and back of hand, between fingers and nails for as long as it takes to sing "Happy Birthday" twice.

Wrap It Up

Ask students, *What conclusions can be drawn from the way the Glo Germ™ powder spread?* Like the powder, germs are insidious. They are everywhere! Proper washing is important.

Extras

- Have students create hand washing posters for school restrooms. The poster shown is an example of a poster from Yale University.

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2) Magnification

Is Seeing Believing?

Time Needed

Setup: 15 minutes to

Activity: 1 session

Before You Start

Set up a computer and LCD projector to show the Powers of Ten video. Find the video at:

www.powersof10.com/film

Prepare sets of materials for observation in small plastic bags. See the list below for materials ideas.

You Need This Stuff

Per Student Group

2 Clear plastic cups, one half filled with water
2 Pennies
Pencil
Set of materials including fabric, feather, penny, newsprint, etc.
4 five-cm square pieces of clear plastic cut from a flat-sided takeout salad box
Cooking oil
4 paper towels
Index card
Eyedropper
4 hand lenses
Optional: Obtain a clear marble and a large glass gem (see "Extras.")

What It's About

The world contains much more than we can see or imagine. Beneath the normal range of our vision lies a universe of microorganisms thriving on nearly every surface. To see this universe, we need magnification.

Magnifiers and microscopes consist of curved transparent lenses that bend light, making tiny objects appear larger to our eyes. Hand magnifiers, consisting of a single lens, usually double or triple the normal size of objects. (Note: Lenses do not have to be made of glass or plastic. A water drop makes a great magnifier.) When lenses are combined, the magnifying power is increased many times. Jeweler's eye loupes consist of two or three lenses that magnify 10 times or more. Microscopes are tubes with lenses mounted on opposite ends. Depending upon the curvature of the lenses, microscopes can magnify several hundred times to more than 1,000 times. It is with microscopes that we can explore the tiny world of microbes.

In this activity students will examine and sketch common materials and objects using simple magnifiers. In doing so, they will begin to learn about how we view the tiny world and about how lenses work to magnify the miniscule.

What's The Question?

What causes magnification? How does the appearance of objects/materials change when viewed through a convex transparent material?

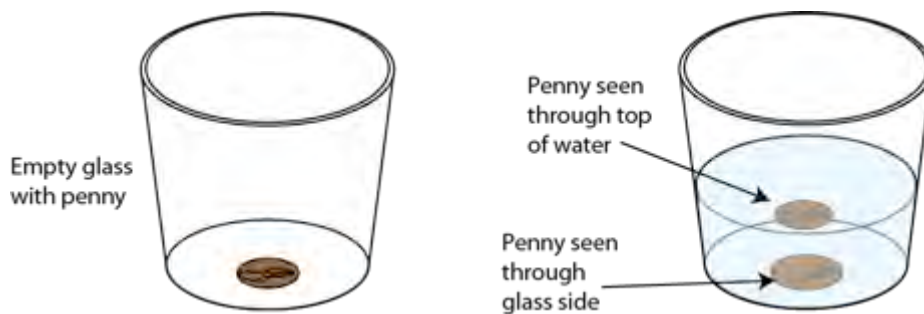
What To Do?

1. Introduce students to the world of the seemingly invisible by showing students the nine-minute Powers of Ten video. This famous 1968 presentation begins with a couple having a picnic in a Chicago park near Lake Michigan. The view zooms outward every 10 seconds to a distance 10 times farther away. Soon, we see the edge of the universe. The view then reverses back to a hand on one of the picnickers. The view is magnified ten times every ten seconds. The journey continues until it reaches a proton of a carbon atom within a DNA molecule in a white blood cell. This is a true journey of scale. It is a real magnification experience.

2. Discuss the video with students and how the magnification changed by powers of 10. (If appropriate for your students, discuss exponential numbers. See FYI below.) Explain that they will be investigating how magnification works. Ask if anyone has any ideas about how magnification is possible. Let students share ideas.

Powers of Ten. The *Powers of Ten* video takes our imagination on a trip from a tiny space 0.000,000,000,000,000,1 meters across to a space 1,000,000,000,000,000,000,000,000 meters across. Scientists prefer to use a mathematical shortcut for these numbers. The number 0.000,000,000,000,000,1 is 10^{-16} . The number 1,000,000,000,000,000,000,000,000 is 10^{24} . These shortcut numbers are called scientific notation (count the zeros). Scientific notation is based on powers of 10, which is where the movie title comes from.

3. Next, have students place a penny in the center of the bottom of a clear plastic cup. Prompt them to observe the penny in the cup from different sides and heights. Next, have students fill the cup half full with water and again observe from different positions. Ask, *Does the penny always look the same?* Hopefully they will notice that the penny looks larger when viewed from the side of the glass, but not from the top!



4. After observations, ask students if they know why the penny looks larger when viewed through the side of the cup filled with water. Encourage students to share possible explanations. The light bends as it passes from one substance (air) into another (water) of different density. To demonstrate the bending, have students place a pencil in the cup of water. Ask, *Does the pencil still look straight? Why or why not? How might this relate to a magnifying glass (hand lens) or glasses?* Discuss.



5. Hold up a magnifier or hand lens. Ask students, *How many of you have used something like this? What can it be used for?* (Lenses can be used to focus light on a single point, and also are used in eyeglasses, cameras, etc.) Tell students they will be using hand lenses to make observations.

6. Distribute material sets to each team of students. Have students observe and draw each item in their bags using the hand lenses. Ask, *Did you discover anything on these objects that you have never observed before?* Have students report their observations informally. If you have Lincoln pennies from 1959-2008, ask students how many “Lincolns” are on the penny. (There are two. Check the inside of the Lincoln Memorial with a lens.)
7. Have students observe the same materials through a clear marble and draw what they observe. It is necessary to hold the marble close to the eye when observing objects. Ask students to estimate how many times the marble magnifies objects.
8. Next, have each student make a water drop magnifier following these steps.
 - Cut out a 5-cm square of flat plastic from the side of a takeout salad box or other clear flat-sided plastic food package.
 - Coat one side of the square lightly with cooking oil. Dab a piece of paper towel into the oil and wiping the plastic surface.
 - Transfer a drop of water to the oil side of the plastic. Replace the water drop as needed.

Note: Oil and water do not mix which causes the water drop to be more spherical and produce a greater magnification. Have students compare a drop on an oiled surface with a drop on a surface without oil. Ask students if they if students see a difference. If yes, ask them, *What is the difference, and why?*
9. Next direct students to observe the newsprint through water drop and the other items in the bag of materials. Have students draw their observations as before.
10. Discuss students’ observations. Ask, *What happened when they looked through the water drop?* (Printed items and other objects were magnified.) *Are there any similarities between the magnifier, the marble, and the drop?* (clear, transparent, curved surface) Help students understand that the magnifying lens, marble and the water drop share similar characteristics. If students need additional clarification, have them observe the newsprint through a glass or plastic slide or other flat clear surface. The slide will not magnify (or shrink) the image, because the surface is not curved.

Wrap It Up

Discuss the importance of magnification to the detection of disease. Knowing what is causing a person to get sick helps the doctor determine the treatment. Microbes cause many diseases. One way to know which microbe(s) are causing the problem is to examine samples under a microscope. Magnifiers and microscopes are important tools for medical science.

Extras

Tell students they will be making a magnifier that they can keep. They will need a “glass gem” and some wet-dry sandpaper. See the source notes below for where to get the materials. As students make their magnifiers, have them conduct before and after observations at each step. Ask students to explain why the view through their magnifiers improves with each sanding step.

- Pick out a gem with a relatively smooth flat bottom. Using the coarsest wet-dry sandpaper and sand the bottom of the gem as smooth as possible. To do so, place the paper on a flat surface and wet it slightly with a few drops of water. Press the gem to the paper and rub it several hundred times.

- Repeat the rubbing with a finer piece of wet-dry paper.
- Repeat twice more, each time with a finer piece of wet-dry paper. Wash the lens off. It is ready to be used.

Source for Glass Gems

Glass gems are available in craft stores, usually in the floral section. They are used for decorative accents for vases. Choose the largest clear gems available. The gems are round glass drops that are flat on one side and convex on the other.

Source for Wet-Dry Sandpaper

Wet-dry paper is a high-grade form of sand paper used for producing glossy finishes for auto touch-ups and for polishing glass. You can find the paper at auto, boat and hardware stores. Pick several grades: Coarse 220 grit, medium 320 grit, fine 600 grit, and very fine 1,000 grit. Start with the coarse grit to get rid of large bumps in the glass gem bottom. Work your way up to the finest grit. Each finer grade will improve the glass surface than the previous grit. After using the 1,000-grit sandpaper, the lens is complete.

- Take a peak at the microscopic world with these online resources.

Secret Worlds: The Universe Within

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html>

Virtual Scanning Electron Microscope

<http://micro.magnet.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

3) Microbe Scavenger Hunt

Microbes are Everywhere

Time Needed

Session 1: Collect and transfer samples

3 – 7 days of observation for incubation of samples

Session 2: Compare samples after incubation

Before You Start

Order a nutrient agar kit from a school science supplier or order individually 20 Petri dishes and nutrient agar. (See instructions for preparing Petri plates and the option to use potato slices instead of agar. If you choose this option, you will need white potatoes.)

You'll Need This Stuff

Per Student Team

- 2 - 4 prepared nutrient agar Petri plates or Petri dishes with potato slices. (You can substitute plastic bags for the Petri dishes if working with potato slices.)
- 2 cotton swabs (like Q-tips®) per sample
- Small container for water
- Permanent marker pen
- Magnifying lenses
- Colored pencils or markers
- 4 - 8 Plastic sandwich bags
- Clear tape

What It's About

Our world is filled with microorganisms. A microorganism or microbe is simply a very tiny organism that requires a microscope to be seen. Generally, the term applies to one-cell living things such as bacteria, fungi, and plankton. Of major concern to our health are harmful microorganisms that can lead to infections.

Because bacteria are microscopic, we are mostly unaware of our contact with them. Usually, exposure is benign but occasionally harmful microorganisms enter our systems. Touching a surface, such as a doorknob, can lead to an infection if bacterium present finds a way past the body's defenses. For example, someone who has failed to wash his or her hands after going to the bathroom touches a doorknob transfers small moist droplets to its surface. Those microorganisms are then transferred to your hand when you touch the knob. If you bring your hands to your mouth, rub your eyes, or have an open sore, the bacteria can enter into your body.

In this activity, students conduct a microbe scavenger hunt. Using cotton swabs, students will collect samples of microorganisms from various surfaces such as doorknobs, computer keys, light switches, desktops, pencils and pens, etc. They will then inoculate, or transfer the sample to the surface of the nutrient agar or potato plates. The nutrient agar or potato provides nourishment for any bacteria or fungi that contacts them and the microorganisms begins to reproduce and grow into a visible colony (only certain microbes will find the medium suitable for growth). After a few days of incubation, students will compare the plates and determine which surfaces had the most microbes.

What's the Question?

Which surfaces (doorknobs, computer keyboards, counter tops, sinks, toilets, etc.) produce the greatest bacterial or mold growth? What can we do about these surfaces to reduce our chances for infection?

Preparing the Petri Dishes

Follow the directions that come with the nutrient agar. Heat the agar in a microwave until it melts. Remove Petri dish lids and place them upside down in an area where they will not be disturbed. Pour just enough nutrient agar into the bottom plate and allow to cool. Cover with lids when cooled. Turn the petri dishes over and draw a line across the middle with permanent marker. Option: As an alternative to nutrient agar, white potatoes can serve as the media. Boil a couple of white potatoes until almost cooked. Cut the potatoes into $\frac{1}{4}$ to $\frac{3}{8}$ th inch slices and place one slice in each Petri dish being careful not to contaminate them. While in the Petri dishes, slice the potatoes in half so that there are two half-circle pieces in each. Allow the slices to cool and cover with the lids. If using plastic bags for the slices, the slices can be cut in half and the halves placed in separate bags.

Tip: You can slice the potatoes at home and transport them in the boiled water.

several days at room temperature. If using plastic bags, seal the bags when inoculated with microbe and mark the source

What to Do

1. Announce to your students that they will embark on a Microbe Scavenger Hunt. Microorganisms, or microbes, are very tiny life forms, some of which are beneficial and some which can transmit diseases to humans. They will be looking at a particular kind of microbe called bacteria although they may also find another kind of microbe called mold, a form of fungi. They will swab various surfaces with moistened cotton-tipped applicators and then transfer any microbes picked up from those surfaces to agar or potato plates.
2. Demonstrate the sampling procedure below. Mention to students that they will not be able to see the microbes that they are transferring. The same basic procedure should be used for agar or for potato slices and Petri dishes/plastic bags.
 - Wash hands thoroughly before collecting samples. (Ask students if they have ever seen television shows where doctors and nurses are washing their hands. Why do they do this?)
 - Hold the cotton swab on one end only and do not touch or breathe on the other end. Discuss why this is important. What might happen if they touch or breathe on the sample end?
 - Dip the swab in the bottled water and shake off the excess. Stick the moistened end into a plastic sandwich bag to cover it until needed.
 - Select a surface to sample and lightly rub the moistened swab over that surface. Twirl the swab to make sure the entire swab end contacts the surface. The moisture on the swab will pick up some of the microbes on the surface being tested.
 - Remove the lid of the Petri dish, being careful not to touch the inside of the dish or the lid. *Lightly* rub the moistened swab (inoculate), now with the sample, across $\frac{1}{2}$ of the agar or over a half potato slice several times in a zigzag pattern. (Doing so will transfer some of the sample to the medium.)

- Cover the Petri dish with the lid and write on the edge of the lid where the sample was taken. Set the covered Petri dish in a place where it will be undisturbed for

Tip: Use a bit of cellophane tape to seal the Petri dish lids to prevent the dishes from being accidentally opened after inoculation with microbes.

3. Give the students the sampling instructions and send them out in the building to sample two different surfaces. Each student should carry a prepared Petri dish (covered) or two plastic bags, one with potatoes as well as one with two moistened cotton swabs with the moistened end protected by a plastic bag.
4. When students return, place the Petri dishes (or bags) in a designated location. Dispose of the cotton swabs and sandwich bags in the trash.

Three to Seven Days Later

Microbes transferred to the agar or potato plates will have found an environment to grow and reproduce. Spots of growth or zigzag growth will cover the surface of the agar or the potato slice. Depending on what is found on the surfaces sampled, the growth may consist of bacterial or mold colonies. Bacteria colonies tend to be circular and may be colorful. Molds tend to be fibrous and may grow upward from the agar or potato surface.

1. Have student teams examine their Petri dishes as often as possible using hand lenses. Do not let teams open the dishes.
2. Have teams make sketches and observations for their lab notebooks. Encourage students to create a picture timeline, a flipbook, or a foldable showing the microbe growth.
3. Hold a group discussion and have teams report their results. How many different colonies did they discover and where were their samples collected? Which sample locations seemed to produce the most colonies? Were there any similar looking samples? Where did they find the most microbes? Were there any surprises?

Disposal

At the end of the activity, dispose of all of the Petri dishes and the samples they contain. Seal them in several layers of plastic bags and place them in the trash. A more proper way to dispose of the samples is to immerse the Petri dishes in a 10% chlorine bleach solution. This will require opening the dishes to disinfect the insides. Wear hand and eye protection while doing this. Remove the dishes and seal them in a plastic bag and place them in the trash.

Wrap It Up

Hold a discussion with the group. Ask what they learned by collecting and growing microbe samples. Explain that the technique they followed to explore for microbes will be used again as a way of testing the effectiveness of ways of fighting infectious disease. For example, do disinfectants really work? Can harmful bacteria be removed from water to make the water safe to drink? These are questions that sampling can help answer.

Extras

- Microbiologists have discovered that bacteria and slime mold colonies can be beautiful. With a little bit of imagination, many microbiologists have been creating interesting microbial art, even holding microbial art competitions. (Visit <http://www.microbialart.com/more/>.)

Words To Know

Bacteria: (singular, bacterium – plural) Single cell prokaryote microorganisms. Prokaryote microorganisms are single cell life forms that lack a nucleus or other membrane-bound organelles (Golgi apparatus, mitochondria, etc.)

Bacteriologist: A scientist who studies bacteria.

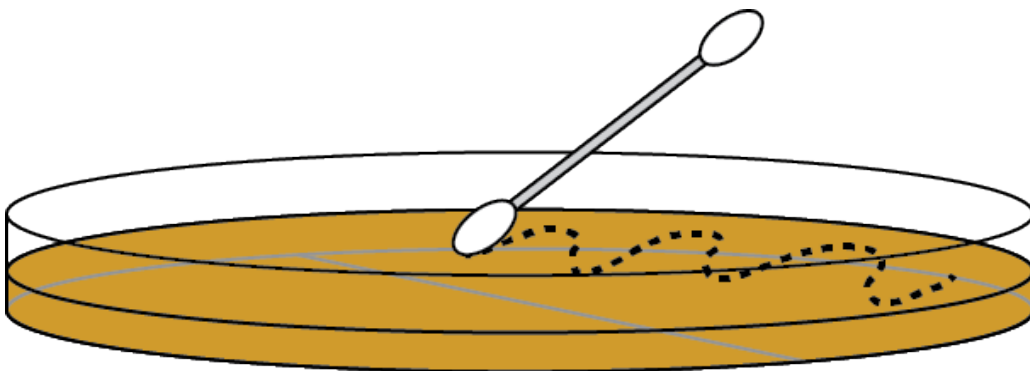
Microorganism: (also called microbe) Organisms too small to be seen with the naked eye.

Fungi: A group of organisms that build cell walls with materials that typically do not contain cellulose (plant do have cell walls made with cellulose). Fungi do not produce their own food but gain energy by absorbing organic substances. Yeasts and molds are microscopic fungi.

Microbe Hunters

Sampling Instructions - Petri Dishes (Agar or Potato Slice)

1. Wash your hands thoroughly before collecting samples.
2. With the Petri dish still covered or the plastic bags still sealed, write the locations and surfaces where the samples will be taken on the dish side or the upper edge of the bag.
3. Hold the cotton swabs on one end only and do not touch or breathe on the other end.
4. Dip the swabs in water and shake off the excess. Stick the moistened ends into a plastic sandwich bag to cover them until needed.
5. Select your first sampling location and lightly rub the moistened swab over the surface you selected. Twirl the swab as you do this to make sure the entire swab end contacts the surface.
6. Remove the lid of the Petri dish or open the first bag, being careful not to touch the inside of the dish or the lid or bag. Lightly rub the moistened swab (now with the sample) across one half of the agar or across the potato slice several times in a zigzag pattern. Twirl the swab as you do so. Discard the swab in the trash.
7. Cover the Petri dish or close the bag until you repeat the procedure with your second sampling location.
8. Cover the Petri dish with its lid or seal the bags. Set them in a place where they will be undisturbed for several days.
9. Wash your hands thoroughly after collecting samples.



4) Microbes in Food

The Good, the Bad and the Ugly!

Time Needed

Setup: 20 minutes
2 sessions

Before You Start

Print the microbe cards on card stock paper and cut out the cards and place them in resealable plastic bags.

You'll Need This Stuff

Per Student Group

One set of microbe cards
(copy on card stock)
Plastic resealable bag

What It's About

Microbes are nearly everywhere. They are found on and within other living organisms. They are found in the soil and the oceans and even within solid rock. They thrive in all climates and in the most extreme environments such as hot springs, glacial ice, and hydrothermal vents on the ocean bottom.

Microbes can be good, bad, or really ugly depending upon what they do. Many microbes—including most bacteria—are helpful. Much of the oxygen released into the atmosphere through photosynthesis comes from algae and blue-green bacteria in the oceans. Many fungi and bacteria are essential for cycling nutrients in ecosystems and decomposing (breaking down) dead organisms and the waste of living things. We depend on microbes for food. What would a hamburger be without a bun, cheese and pickles (all of which are produced with direct assistance from microbes)? The cattle used for beef also rely on microbes to digest the tough grasses they eat. In our own intestines, microbes aid in digestion, make several essential vitamins and help prevent disease. On the other hand, some microbes can make us sick or even kill us, but these are a very small percentage.

This activity focuses on the diverse microbes and their role in food production.

What's the Question?

Microbes are used all over the food industry for processing food and for enhancing flavors. Here are a few of the foods "good" microbes are used to make:

Bread	Beer
Root Beer	Wine
Cheese	Cultured Butter
Sour Cream	Sauerkraut
Olives	Soy Sauce
Yogurt	Kimchi

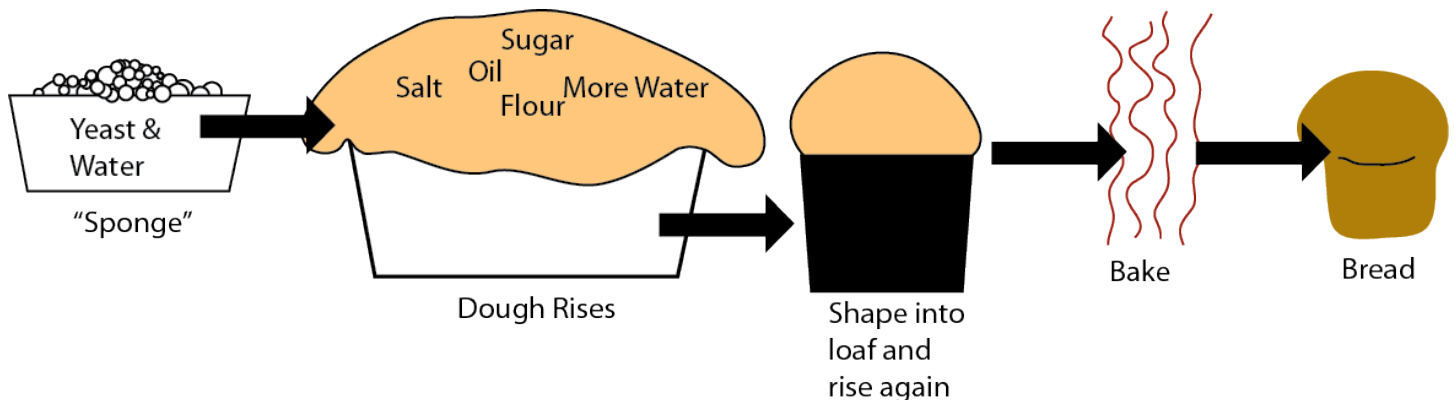
There are other ways microbes are involved in the food industry. Would you take a drink of milk that is past the expiration date or make a sandwich with bread that has blue spots on it? Watch out, decomposer microbes are busy at work.

What are the ways in which food and microbes are related?

What To Do

1. Remind students of the organisms they observed growing on their plates in the Microbe Scavenger Hunt activity. How were all the growths similar/different? Different size, color, shape. Explain that there are many kinds of microorganisms with different roles? What are some examples? Discuss students' ideas.
2. Give each student group a bag of 20 Microbe cards, which describe roles performed by certain microbes. Instruct student groups to read, discuss and decide the best way to sort the cards into categories. Have groups make notes about how they made their decisions. Then, have a spokesperson from each group explain how and why they sorted their cards. Discuss the different sorting strategies as a class.
3. If students did not organize the cards by "role in food production," "role in causing disease," and "role in ecosystem/environment," have them sort the cards into these new categories.
4. Tell students that they will be further investigating the role of microbes in food production. Have the groups pick food that depends on microbes and research online that food and the microbes involved. Have teams create a short presentation in a storyboard format, describing what they learned. Foods might include: root beer, yogurt, sauerkraut, Swiss cheese, chocolate, pepperoni, bread, pickles, and hot sauce.

One way to make a storyboard:



Wrap It Up

Obtain samples of each food for a tasting session the next time the teams meet. Have students present their information to the class during the next session. Follow the presentations with a tasting session. Slice a fresh-baked loaf of bread (French or Italian) and a piece of Swiss cheese. Have students examine the holes. Where did the holes come from? Ask students if they can taste the microbes.

Microbe Cards (Set 1 of 2)

<p>MALARIA is caused by a single-celled parasite with a complex life cycle. The animal-like parasite is carried from an infected person to a healthy person by certain kinds of mosquitoes.</p>	<p>CHOCOLATE comes from cacao seeds that are broken down and fermented by two kinds of microbes.</p>	<p>GREEN POND WATER gets its color from tiny photosynthetic microorganisms that are not members of the Plant Kingdom.</p>	<p>HIV is transmitted through the exchange of infected blood or other body fluids. It invades and kills one type of white blood cell needed to fight disease. Once people are unable to fight infections, they are said to have AIDS.</p>	<p>MOSAIC DISEASE affects tomatoes, peppers and other food sources. It is caused by a tiny microbe that invades and destroys cells.</p>
<p>ANTHRAX is an infectious disease that spreads from animals to other animals and humans. Anthrax is caused by a single-celled microbe without a defined cell nucleus.</p>	<p>BEER is a mixture of barley, wheat, hops, and sugar that is fermented by a microbe. The microbe is quite large. Still, it must be magnified about 100 times to be visible.</p>	<p>COMPOST results from the breakdown of plant materials by microbes and other organisms, such as earthworms and insects.</p>	<p>MEASLES is a disease spread by coughing, sneezing, or contact with people infected by a microbe that does not have a cell membrane or cell wall.</p>	<p>IRISH POTATO BLIGHT is a plant disease that killed most Irish potato crops between 1845 and 1851. It is caused by a fungus-like microbe infecting leaves and stems of potato plants.</p>

Microbe Cards (Set 2 of 2)

<p>NITROGEN is introduced into the food chain by very tiny single-celled microbes that live in water and soil.</p>	<p>PENICILLIN is an antibiotic that kills certain kinds of bacteria. It is a form of natural protection produced by a microbe that forms fuzzy clumps.</p>	<p>RED TIDE is an overgrowth of a microbe that produces a poison. The poison affects the nervous system of fish. The animal-like microbe lives in the ocean.</p>	<p>BREAD is a baked mixture of ingredients, including flour, water and a single-celled microbe. When the microbe multiplies and releases bubbles of gas, it causes the bread to "rise."</p>	<p>THRUSH is a disease that causes painful whitish patches in the mouth and on the tongue. The microbe causing this infection is single-celled, has a defined nucleus and must be magnified about 100 times to be visible.</p>
<p>TUBERCULOSIS is a deadly, contagious disease transmitted through the air. It's also referred to as "TB." Not all antibiotics are effective against the microbe that causes TB.</p>	<p>STOMACH ULCER is a sore in the lining of the stomach or small intestine that leads to burning pain. Most stomach ulcers are caused by an infection that can be treated with antibiotics.</p>	<p>PEPPERONI SAUSAGE is made of chopped meat that is aged and fermented to improve the flavor. The microbes used to produce this sausage must be magnified around 1,000 times to be clearly visible.</p>	<p>RINGWORM is a circular scaly or red rash caused by single-celled microbes in the surface layers of skin (not a worm). The rash, similar to athlete's foot, can be spread by animals, people, or contaminated clothing.</p>	<p>YOGURT is milk or cream fermented by certain kinds of heat-loving microbes that are much smaller than yeast.</p>

The Variety and Roles of Microbes – Answer Key

ROLES: (D) = Disease; (E) = Ecosystem; (F) = Food Production

BACTERIA

Anthrax (D) is a disease of the blood that affects humans as well as animals such as cattle, deer and camels. *Bacillus anthracis*, the bacterium that causes anthrax, typically is found in soil. People can catch anthrax by handling products from infected animals or by coming in contact with the dormant (inactive) forms of the bacteria, called spores. Anthrax is treated with antibiotics.

Pepperoni Sausage (F) is a dried meat mixture that is fermented by lactic acid-producing bacteria. The process produces acids that contribute to the flavor.

Nitrogen (E) - Certain bacteria assimilate (“fix”) nitrogen from the atmosphere into nitrogen-containing compounds that can be taken up by plants.

Stomach Ulcer (D) is a disease of the stomach and the first part of the small intestine that damages the protective lining of these organs. The most common cause is infection by a bacterium, *Helicobacter pylori*. Infections are treatable with antibiotics.

Tuberculosis (D) is a disease of the lungs caused by the bacterium, *Mycobacterium tuberculosis*. Some strains of the bacterium have developed resistance to the antibiotics once commonly used to treat tuberculosis.

Yogurt (F) is milk or cream fermented by one or more kinds of heat-loving bacteria.

FUNGI

Beer (F) is a mixture of barley, wheat, hops and sugar that is fermented by baker's yeast, a single-celled fungus known formally as *Saccharomyces cerevisiae*.

Penicillin (D) is a chemical substance produced by the fungus *Penicillium* that is toxic to many kinds of bacteria. It is the basis for many modern antibiotics.

Ringworm (D) is a contagious disease of the skin and scalp caused by several different kinds of fungi. Growth of the fungus on the skin often causes a circular, reddish, itchy rash. Ring-worm and related infections, such as athlete's foot, are treatable with antifungal lotions and creams.

Sandwich Bread (F) is a baked mixture of flour, water and baker's yeast that rises when the yeast

cells begin to rapidly multiply and emit bubbles of carbon dioxide gas. A small amount of alcohol is produced, but evaporates during baking.

Thrush (D) is a disease of the tongue and mouth caused by a single-celled yeast, called *Candida albicans* (not the same as baker's yeast). Thrush is most common in infants or in adults with weakened immune systems. It may be treated with certain antifungal products.

PROTISTS

Irish Potato Blight (D) is a disease caused by a fungus-like protist, which killed most Irish potato crops between 1845 and 1851. Since potatoes were the main food source for most of the population, this led to widespread famine. There were many social consequences of the Irish potato famine—including the immigration of more than one million Irish citizens to the United States.

Malaria (D) is a sometimes fatal, mosquito-borne disease caused by parasitic protozoans of the genus *Plasmodium*. The parasite invades and destroys red blood cells. Malaria is spread by certain mosquitoes that bite an infected person who then become infected themselves; these mosquitoes transmit the disease by biting other people. Worldwide, more than 350 million cases of malaria are reported each year.

Red Tide (D) is a rapid overgrowth of dinoflagellates, a type of protist found in marine plankton, which gives a reddish hue to water. Dinoflagellates produce a neuro-toxin (poison that affects the nervous system) that can be concentrated enough to kill fish.

BACTERIA & FUNGI

Chocolate (F) - Cacao seeds must be fermented by yeast (fungi) and bacteria, in order for the complex flavors of chocolate to develop.

Compost (E) - Bacteria and fungi help to decompose leaves and other decaying organic materials found in compost piles. Some protists, such as slime molds, also may participate. Compost is used to enrich soil.

BACTERIA & PROTISTS

Green Pond Water (E) - When fresh water appears greenish, many forms of algae, protists, and blue-green bacteria (cyanobacteria) may be present.

5) Food and Fermentation

Energy for Life?

Time Needed

Setup: 20 minutes

Activity: 1 session

Before You start

Obtain a warm water supply. If the room doesn't have a sink, put warm water (about 110° F) in a thermos bottle for teams to share.

You'll need this stuff

Per Student Pair

100 ml water heated to 110°

2 empty 1/2-liter water bottles

2 Plastic spoons

2 Packages of rapid-rise yeast

1 Single serving sugar packs

Metric ruler

Thermometer

Masking tape and marker

Student page

What It's About - Fermentation

All living things on Earth require energy to move, grow, and maintain themselves. Some organisms, especially plants and algae, are able to build all of the materials they need from simple substances. Using energy from light, these organisms (producers) are able to make food in the form of carbohydrates from water and carbon dioxide (CO₂).

When other organisms (consumers) consume food, the food is broken down and energy is released. Oxygen is consumed during this process and CO₂ is given off as a waste product. One of the processes used by some organisms for consuming food is called fermentation. Fermentation is also a process used in making many foods we consume. Yeast is a microbe used in making breads and many beverages. Yeast cells break down food (glucose or sugar) through fermentation and produce ethyl alcohol and CO₂ as waste products. The holes in bread are CO₂ bubbles that were fixed in the dough during baking. The fizz in beer and champagne are CO₂ bubbles from fermentation.

Some bacteria also obtain energy through fermentation. By-products of bacterial fermentation include CO₂ and acetic acid or lactic acid. The acids give food a characteristic sour flavor. The byproducts or waste products of different species of bacteria produce different flavors and tastes. For example, the bacteria used in yogurt produce lactic acid, which lowers the pH, changes the milk proteins and thickens the mixture. Many foods processed through bacterial fermentation, such as sausage or sauerkraut, also have added salt. The salt favors the growth of desirable strains of bacteria that are tolerant to salty conditions. It also prevents the growth of harmful bacteria.

What's the Question?

What do yeast cells need to reproduce?

What To Do - Fermentation

1. Begin a discussion on energy and living things. What are the basic needs of living things? What do microbes need to live?
2. Distribute the materials, the instructions and data sheets to each student pair.

3. Have students set up their investigation according to the instructions on the student page. Instruct them to hold off adding the sugar until every team is ready.

4. Tell the teams to add the sugar to one bottle and swirl both bottles gently. After 1 minute, start the timing. Teams should record the height of the mixtures in each bottle.

Tip: If students are unsure about measuring, have them practice by measuring the height of the bottles and other objects. Compare answers to identify who is having measuring problems.

5. After 5 minutes, have teams measure the height again and record their data and observations.

Tip: While waiting to take measurements, review how the graphs are to be used. The first measurement will be placed somewhere on the 0 minute vertical line (Y axis) according to how high the top of the solution is for each cup. Make a sample graph on a board and show how to plot points and connect them with lines.

6. Repeat observations every 5 minutes until 30 minutes have passed.

7. Discuss student observations while the experiment is running. Ask, *Why is there a difference between the two cultures? What is causing foam to form?*

Important Note: Do not disturb either bottle after the experiment begins.

Wrap It Up

Review the process of fermentation. Why is sugar needed? What are the bubbles made of? What food categories rely on fermentation during processing? Have students report on the result of their investigation. Which culture showed the most change? Ask how is yeast used in manufacturing food? How does this relate to bread making?

Extras

Use the recipe that follows to make quick pan rolls to enjoy for the next session.



Yeast cells growing (budding)

Photo: Wikimedia User: Masur. Public Domain



Carbon dioxide bubbles released by the growing yeast in beer

Photo: Ildar Sagdejev. CC-BY-SA 3.0.

Quick Pan Rolls

Use the recipe below to make quick pan rolls. The rolls can be made in a counter top convection or toaster oven. Plan on about 15 to 20 minutes baking time with a toaster over. Baking time will be reduced to about 10 to 12 minutes with a convection toaster oven.

Make copies of the recipe below and distribute to your students for making quick pan rolls at home.

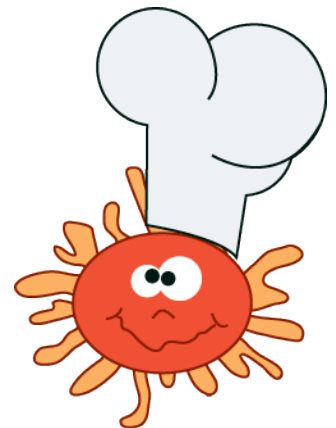
The Microbe Gourmet

Welcome to the Microbe Gourmet. In today's show, we microbes are going to prepare hearty pan rolls. Hot and savory, the rolls go great with butter and jelly. Roll up your sleeves and wash your hands. Let's get baking.

Here is what you will need:

- 2 1/2 cups of Bisquick®
- 1 packet of rapid rise yeast
- 3/4 cup of warm water (about 110°)
- Butter or baking spray to grease pan
- Clean surface to knead the dough
- Wax paper to cover kneading surface
- Mixing bowl
- Large spoon
- 8-inch cake pan
- Measuring cup
- Butter knife

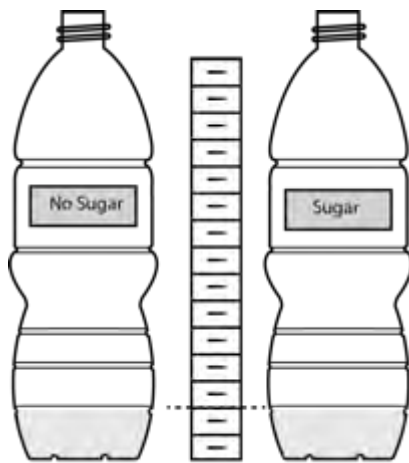
1. Place two teaspoons (1 packet) rapid rise yeast in the bowl.
2. Add water and stir to mix.
3. Add 2 1/2 cups of Bisquick® to the bowl and stir well for 2-3 minutes.
4. Turn out bowl on clean surface and knead until the dough is smooth and springy.
5. Flatten the dough into a 14 x 6 inch rectangle.
6. Using the butter knife, slit the dough lengthwise in thirds. Then make 6 equally spaced crosswise cuts.
7. Take each dough piece and roll into a ball. Place in greased cake pan.
8. Let the dough rise for about 15 minutes and bake. When rolls are brown on top, remove from oven and turn out rolls to cool on a rack or a plate. Enjoy!



Well, that's the show for today. Next week, it's Cheesie Microbes.

Energy for Life

1. Read all of the instructions before starting. Answer questions 1 below and then begin the experiment.
2. Prepare the experiment.
 - Mark each bottle as shown with tape and a marker and write “No Sugar” on one and “Sugar” on the other.
 - Divide the warm water equally between the two bottles. Check the water temperature with the thermometer. The temperature should be about 105 to 115 degrees F (40 - 45° C).
 - Pour a teaspoon of yeast into each bottle.
 - When your teacher tells you to do so, pour 1 teaspoon of sugar into the bottle marked “Sugar.”
 - Gently swirl both bottles to dissolve the ingredients.
 - Measure how high the surface of the solution is in each bottle. Record your data on the Data page. When your teacher tells you, measure and record the heights again.



Roll and tape a paper funnel from a half sheet of paper. Use it to add yeast and sugar to the bottles.



Answer this question before the experiment begins.

1. Predict what you think will happen when you add...

Yeast and Water _____

Yeast, Sugar, and Water _____

Answer these questions after you have done the experiment.

2. What happened to the yeast and water? Use your data to help you with your answer.

3. What happened to the yeast, sugar, and water? Use your data to help you with your answer.

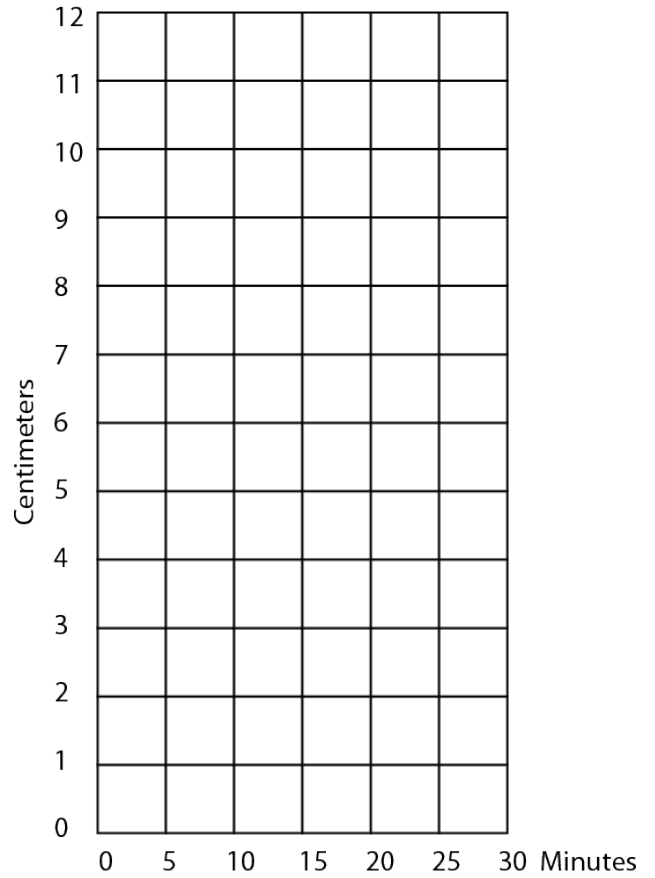
4. What was the role of the sugar in this experiment?

Energy for Life

Data Page

Yeast and Water

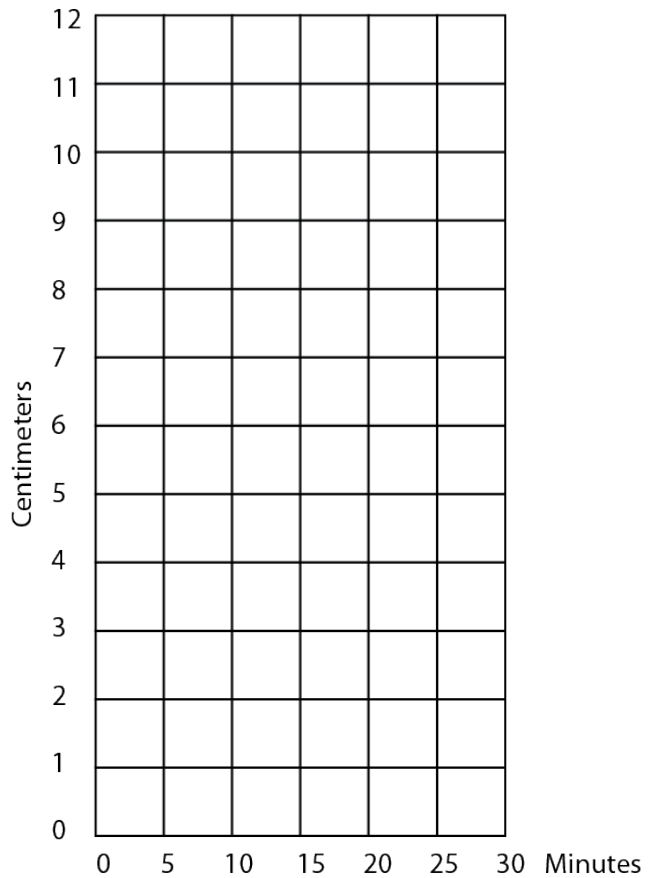
Time Minutes	Appearance	Height cm
0		
5		
10		
15		
20		
25		
30		



5.

Yeast, Sugar, and Water

Time Minutes	Appearance	Height cm
0		
5		
10		
15		
20		
25		
30		



6) Mold Cultures

What's Growing on That Bread?

Time needed

Setup: 15 minutes
1 session with periodic observation following

Before You Start

Purchase the bread needed the day before the students gather.

You'll Need This Stuff

Per Student Pair

Variety of breads, tortillas, and pitas with and without preservatives
2-4 Plastic resealable bags
Paper towel sheet
Marking pen
Tape
Plastic picnic knife
Metric ruler
Small cup of water
20 cubic centimeter transparent cm grid

What It's About

Molds are naturally present nearly everywhere in our environment. In nature, molds break down substances, such as leaves, and thereby provide organic matter that enriches soil. When present in food, molds may grow and cause an unsightly appearance and unappealing and unusual flavors. Some molds produce toxins, which are hazardous to human health. Dampness, warmth, oxygen, favorable pH, and the absence of light result in the optimum growth conditions for yeast, mold, and pathogenic bacterial growth.

What To Do

1. Have teams of two students measure and cut a 10 x 10 cm square from each bread and tortilla sample.
2. Next have them cut a 5 x 5 cm square of paper towel for each sample and dampen with water. Place into a zip-locking sandwich bag.
3. Have teams slide each bread or tortilla sample on to the dampened paper square in the bags, and seal the bag. They should seal and then tape the bags shut as a safety measure. For a control, have each sample placed in bag without moisture.
4. List the ingredients from the information label on the food package wrapper in your lab book or write the information on a paper slip and tape it to the back of the bags. Identify the kind of flour, yeast, and preservatives.
5. Place in a warm, dark place for several days.
6. Have students make daily observations of the samples in their lab books at the same time each day or as often as possible. Describe the types of mold present by noting the color and appearance of the molds and the rate of mold growth. If possible, have students take pictures and assemble them in a notebook or a slide presentation. Also, research and compare pictures on the Internet if possible.
7. Measure the amount of mold surface area growth by placing a transparent centimeter grid over the sample. Make a flipbook of your daily observations. Sketch the first appearance of mold on the first flip book page.

Over the next several days, continue sketching the mold growth. Join the pages together and fan the pages to see an animated display of the mold growth

8. Record the data on the Student Data Sheets.
9. Examine the mold with a magnifier. If available, use a stereo microscope to make observations.
10. Have students write and illustrate brief reports in their lab books on the mold growth in their experiment (size, color, texture, etc.) Which bread type(s) exhibited the most mold growth? Were there any breads that had no mold growth? Molds vary in color and appearance. Many are white and resemble cotton while others are green, brown, black, pink, or gray. Although some molds will grow on a variety of foods, others grow best on fresh fruits or vegetables. Have students report their findings to the rest of the group. What caused one bread or tortilla to produce more mold than another? (Check the ingredients for clues.) Ask, what conclusions can be drawn regarding types of bread and mold growth. Ask, did moisture make a difference?

Tip: Bread and tortilla ingredient labels may not directly identify preservatives used. The following list are chemicals used in bread making to inhibit mold growth:

Calcium propionate	Sodium propionate
Potassium sorbate	Sodium diacetate
Vinegar	Sodium benzoate
Lactic acid	Calcium acid phosphate

Wrap It Up

Conclude the activity with a debate. The question: "Are microbes good or bad?"

Extras

Entertain your students with a microbe art show. These sites show the artistic efforts of scientists working with Petri dishes and algae, fungi, and bacteria.

<http://www.newscientist.com/gallery/microbe-art>

<http://www.microbialart.com/>

For More Information

Bacteria: More than Pathogens: Action Bioscience.org

<http://www.actionbioscience.org/biodiversity/wassenaar.html>

Microbe Zoo:

<http://www.commtechlab.msu.edu/sites/dlc-me/zoo/>

Caution: Molds should be handled carefully. Do not open the zip-locking plastic bags. Molds disperse in air. They may spread throughout the classroom and could cause allergic reactions.

TOP SECRET

Dossier

Bacteria – Good or Bad?

Bacteria are single celled microorganisms. They do not have a nucleus or other interior structures surrounded by a membrane, such as mitochondria. Bacteria are the most common life form on Earth. It is estimated that there are approximately five nonillion (the number 5 followed by 30 zeros) bacteria living on Earth at any time. The total mass of bacterial on Earth exceeds the combined mass of all of Earth's animal and plant life. Just one gram of soil, about 1/4 teaspoon, contains about 40 million bacteria cells!

Most forms of bacteria have yet to be identified by bacteriologists (scientists who study bacteria). Bacteriologists do know that many forms of bacterial are beneficial. Bacteria are essential in recycling nutrients and helping plants use atmospheric nitrogen. Bacteria are found in the gastrointestinal tracts (GI) of humans and are essential to digestion of food and the processing of waste. The human GI tract is estimated to contain approximately 100,000 billion bacteria. (That's about ten times the number of cells in the human body.) On the other hand, bacteria can also be harmful. Harmful bacteria are a primary cause of infectious disease such as cholera, anthrax, leprosy, and bubonic plague.



Photo: CDC\4248

7) The Sizes of Microbes

Scale Matters

Time Needed

Setup: 20 minutes
1 session

Before You Start

Using the 12-point Arial/Helvetica font, type this line and repeat it 24 times.

“The period at the end of this sentence is larger than a/an _____.”

Print the page and cut the text into strips. Do not photocopy because it will reduce the sharpness of the text. Piece together butcher paper to make a square 2.5 meters across to represent the period enlarged 5,000 times. Place materials in trays for each group.

You'll Need This Stuff

Per Class

2.5 m-square of paper

Per Student Group

Set of 4 text strips

4 hand lenses

4 metric rulers marked in millimeters

Scissors

Assorted markers or colored pencils

Meter stick

Paper or science notebook

Several sheets of colored paper

Tape or glue

Student sheet

Paper or science notebook

Several sheets of colored or plain paper, or roll of chart or craft paper

What It's About

Students will create scale models of microorganisms and compare the relative sizes of common bacteria, fungi and protozoa (microscopic members of the protist group) using metric measurements. Students will learn that microbes come in many different sizes and shapes, and frequently are measured in micrometers (μm). 1 meter = 1,000,000 micrometers.

What's the Question?

How big are microbes?

What to Do

1. Ask students to examine the period at the end of the text strips, first with eyes only and then with a hand lens. Tell students to draw in their lab books what the period looks like in each case. Discuss their observations. Ask, *Did the period appear the same when it was magnified as when observed it with a naked eye?* (When magnified, the period is a square.)
2. Ask, *What can you say about the size of the period?* Tell students the period is about 0.5 millimeters (mm), or 500 micrometers (μm), in length and width. Have students identify the centimeter and millimeter markings on a centimeter ruler. *How many periods could be lined up, end-to-end, to equal a meter?* (2,000)
3. At this point you may wish to review the metric system. Explain that the meter is the fundamental unit of length in the metric system. At 39.37 inches, a meter is slightly longer than a yard (36 inches). Ask, *How many centimeters make a meter?* (100) The prefix, “centi,” is Latin for one hundred. *How many millimeters make a meter?* (1,000) The prefix, “milli,” signifies one thousand. Thus, one centimeter (cm) is equivalent to 10 millimeters (mm).
4. Introduce students to an even smaller measure, the micrometer (μm), or micron, is one millionth (1×10^{-6}) of a meter. A micrometer is too small for to see without special equipment. One centimeter contains 10,000 micrometers. Ask, *What is the size of the period in micrometers?* (500 μm) *Why is the ruler not divided into micrometers?* (Markings would be too small).

5. Ask students, *What do you know about scale models?* and, *Why do we make scale models?* (To understand the relative position, size or distance of objects such as road maps and solar system models)
6. Tell students that they are going to make a scale model of microbes, called a Microbe Mural, using the size of the period as the scale standard. Ask, *If I increased the length and width of the period by 5,000 times, what shape would it have? (square) How large do you think it would be?* (Multiply 0.5 mm x 5,000. Answer: 2,500 mm x 2,500 mm, or 2.5 m x 2.5 m.)
7. Bring out the prepared square of paper (period model) and display it on the wall. Again, explain that the sheet represents the size of the period enlarged 5,000 times. Ask, *If we enlarged most microbes 5,000 times, do you think they would be larger or smaller than the period?* (If enlarged 5,000 times, each microbe models will fit on the period.)
8. Distribute the student sheets and microbe scaling charts. Instruct each student group to make scale drawings or artwork of all microbes, based on the line drawings and sizes provided on the chart. Depending on students' ages and experience, you may want to give them only the information from one or both of the "approximate actual size" columns, and have each group calculate the scale sizes of their organism models.

Note: Make certain every group is assigned at least one microbe large enough to draw (organisms 1–5). The microbe sizes described on the Microbe Scaling Chart represent typical measurements within the normal size range for each kind of organism. Students may find references to different sizes if they are conducting additional research about the organisms. In addition, some organisms named on the chart actually represent relatively large groups of related species or forms. For example, there are approximately 150 different known species of *Euglena*.

9. Have students place their models on the large paper square.
10. Discuss the mural with students. Ask students if they could use the names of the any of the microbes on the mural to complete the sentence on their sentence strips.

Wrap It Up

Ask where does your microbe live. Create poster drawings of a microbial landscape for a microbe you choose. For example: *Bacteroides thetaiotaomicron* in the intestines!

Extras

- It can be difficult to imagine the relative sizes of microbes. The CELLS alive! Website has a useful animation to help students visualize and compare the sizes of different microbes on the head of a pin. The animation may be viewed or downloaded for single use or for use in a classroom:
<http://www.cellsalive.com/howbig.htm>.
- The word "meter" comes from the Greek word for "measure." The meter (m) is the standard unit of length in the International System of Units (SI). Below are definitions of SI units for length. Learn more about the metric system at the following National Institute of Standards and Technology website: <http://www.nist.gov/pml/wmd/metric/common-conversion.cfm>

Microbe Scaling Chart

Model Scale Size
0.5 cm = 1 μm

	GROUP	ORGANISM	APPROXIMATE ACTUAL SIZE OF A SINGLE UNIT		MODEL SCALE SIZE
			Micrometers (μm)	Millimeters (mm)	Centimeters (cm)
		"Period" character - Helvetica type, 12-point size.	500	0.5	250
1	Protists	<i>Amoeba</i> - Group of single-celled organisms known for their constantly changing shape. Some cause human disease.	300	0.3	150
2	Protists	<i>Paramecia</i> - Group of slipper-shaped single-celled organisms that are a key link in freshwater food webs.	250	0.25	125
3	Protists	<i>Euglena</i> - Group of single-celled freshwater organisms that perform photosynthesis.	130	0.13	65
4	Bacteria	<i>Spirillum</i> - Bacteria with a twisted spiral shape. One species causes dental plaque.	60	0.06	30
5	Protists	<i>Trypanosoma</i> - Causes African trypanosomiasis, or "sleeping sickness," and is transmitted by a biting fly.	50	0.05	25
6	Fungi	<i>Saccharomyces</i> - Baker's yeast, a single-celled organism used to make bread rise.	10	0.01	5
7	Bacteria	<i>Clostridium</i> - One type of this bacteria can cause tetanus and another can cause food poisoning.	6	0.006	3
8	Fungi	<i>Cryptococcus</i> - Some members of this group of fungi can cause lung infections.	5	0.005	2.5
9	Bacteria	<i>Bifidobacterium</i> - Type of bacteria that is found in the intestines of many mammals and aids in digestion.	5	0.005	2.5

Actual size: 1 millimeter (mm) = 1,000 micrometers (μm). Drawings not to scale.
Micrometers also are referred to as "microns."

8) Make a Virus

HIV Model

Time Needed:

1 session

Before You Start:

Print the virus pattern on heavy card stock paper. Make a few extra copies in case of cutting mistakes. Assemble a virus model for students to compare as they construct their own models. Cut out a second model to use for demonstrating how to fold and tape together.

You Need This Stuff

- Virus pattern for each student
- Scissors
- Straight edge rulers
- Ballpoint pens
- Scissors
- Cellophane tape
- Colored marker pens (do not use crayons!)

What It's About

Viruses are tiny infectious agents that can only replicate within the cells of living organisms. Viruses infect all types of organisms. It is estimated that there are millions of kinds of viruses but only a few thousand have been studied in detail. Viruses cause diseases such as influenza, hepatitis, cancer, smallpox, and ebola. The human immunodeficiency virus or HIV is an especially nasty virus that leads to acquired immunodeficiency syndrome or AIDS.

Viruses enter living cells to replicate. Because they require a living cell, many researchers argue that viruses themselves are non-living material. However, when they use cells to replicate, they can cause havoc. Like all viruses, HIV actually "hijacks" the cell's reproductive system to create millions of replicas. HIV attacks white blood cells in humans. During replication, these cells are destroyed. White blood cells are essential to the body's immune system. With greatly reduced white blood cell numbers, the body is open to many infections that can be fatal.

All it takes to acquire HIV (ultimately leading to AIDS) is to be infected by a single HIV particle. This happens by exchanges of body fluids that can occur during drug needle sharing, unprotected sex, and even infected mothers to child during pregnancy. Drugs are now available to hold HIV at bay once infected but the best strategy is to avoid risky behavior. Worldwide, HIV/AIDS is a major cause of death. More than 35 million people have died from AIDS-related diseases. Another 34 million people are infected and their numbers keep growing.

Viruses come in many shapes. The HIV particle takes on a geometric shape of the icosahedron with small projections extending from its side to attach to white blood cells.

What's The Question?

What does the HIV particle look like?

What To Do

1. Ask students, *Have you ever seen a virus?* (It is not possible to observe viruses directly, because they are extremely small.) Encourage students to share what they already know about viruses. List their ideas on the board.

Also be sure to list the following items.

- Small infectious agents that need living cells to replicate themselves
- Most are too small to be seen with microscopes
- Responsible for many diseases
- Contain genetic material surrounded by protective coat

2. Tell your students they will be constructing a paper model of an HIV particle. The model will show both the exterior and interior of the particle.
3. Demonstrate how to cut, fold, and tape the model. Cut the model on the solid lines. Fold the model on the dashed lines. To make precise, sharp folds, draw a line over the dashed fold lines with a ballpoint pen. Use the straight edge of a ruler to draw the lines. Press into the paper to leave a shallow groove. When folding, the paper will bend along the groove. Start the taping with two adjacent triangles. Bring their edges together and tape the seam. Continue taping but do not tape the last triangle that is marked "Do Not Tape." Leaving this triangle un-taped provides a door to the model's interior.
4. Have students work pairs to make their models. Teamwork aids in the taping process. Prior to taping, permit students to color their models with markers. Do not use crayons because the tape will not stick well to the waxy surface.
5. Show students the capsid model. It is a small box with a lid that fits inside the model. Show how the capsid insert fits inside the box.
6. Have students make their capsid models. These can be colored too.

FYI: Viruses do not have color. They are smaller than the wavelengths of the colors in the visible spectrum. Scientists studying viruses add colors to their pictures to make parts of the viruses easier to distinguish.

7. When the virus models are completed, talk about how the virus works. Hold up one model and explain that the circles are the ends of spike-like projections (proteins) that attach to white blood cells in the bloodstream. Once attached to a white blood cell, the virus merges with the cell and the capsid is released inside the cell. The genetic material of the capsid hijacks the cell's inner workings and reproduces thousands of new virus particles that are released back into the blood stream. Gradually the cell is destroyed. The virus replicas invade other white blood cells. Remind students that white blood cells are the advanced force in the body's immune system. When enough of the cells are destroyed, the body becomes open to many infections and, without continuous medical treatment, eventually dies. More than 35 million people have died because of HIV/AIDS.

Wrap It Up

Encourage students to learn more about the HIV/AIDS epidemic by looking up various organization websites such as the Center for Disease Control and UNAIDS. These sites provide frank discussions of this serious world problem.

<http://www.unaids.org/en/>

<http://www.cdc.gov/hiv/>

Extras

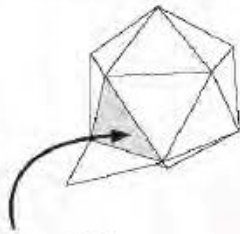
The Science of HIV/AIDS Teacher's Guide provides a more detailed description of the HIV model and additional activities centering on the spread of HIV/AIDS. The guide is available for download from BioEdOnline at the following web address:

<http://bioedonline.org/resources/hivaidsindex.cfm>

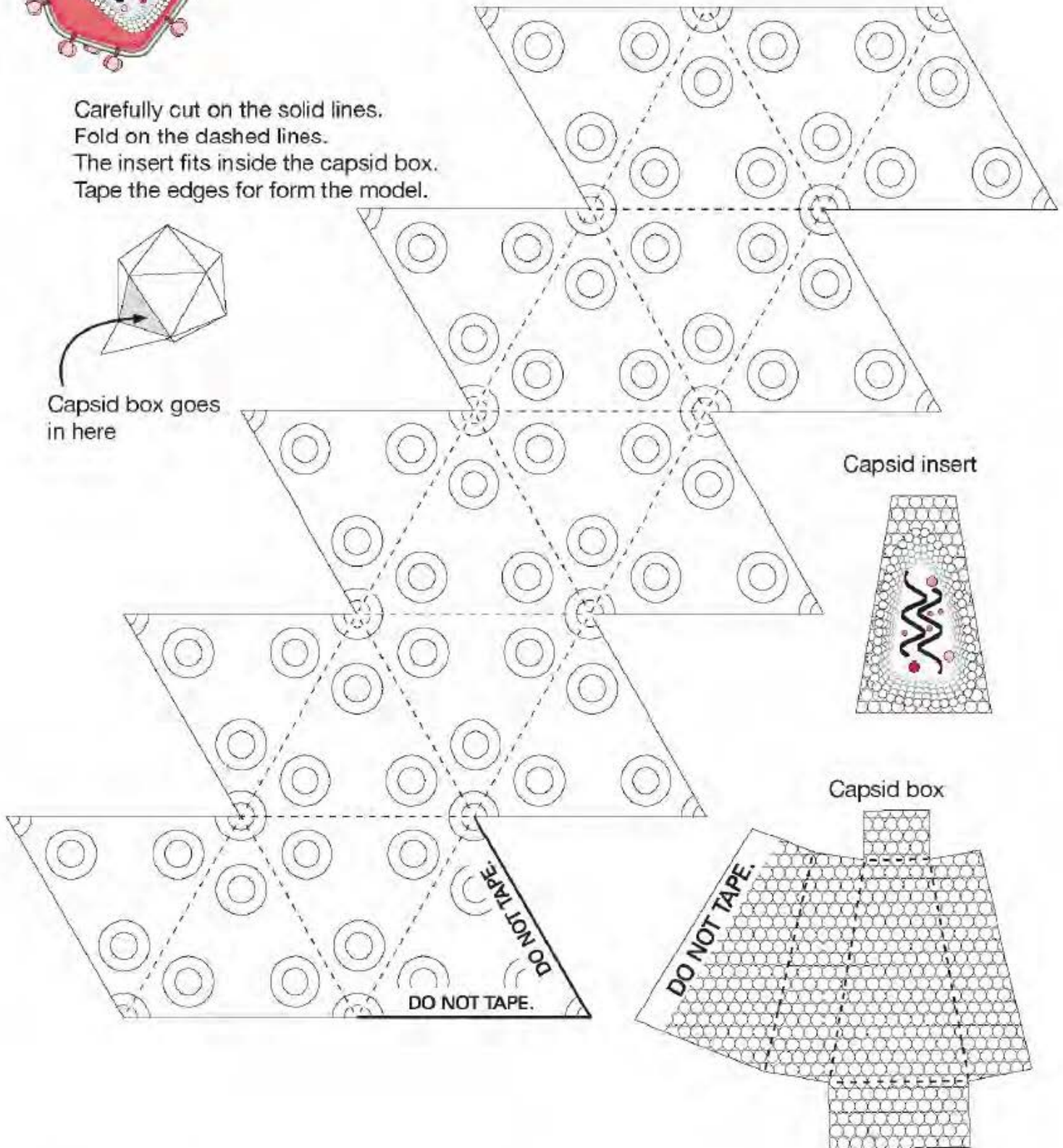
Human Immunodeficiency Virus Model



Carefully cut on the solid lines.
Fold on the dashed lines.
The insert fits inside the capsid box.
Tape the edges for form the model.



Capsid box goes in here



9) Spreading Infectious Disease

Catch!

Time Needed

1 session

Before You Start

Make up number tags for each player. Each number tag should have a different number starting with number 1. Clip-on meeting tags can be used or make tags from file cards and string to be worn around necks. Place corresponding numbered slips of paper in a jar or box.

You Need This Stuff

Number tags for each player
Tag logs for each player (see master)
Pens or pencils
Container with small slips of paper, each with the same numbers as the number tags

What It's About

Help your students understand how infectious diseases pass from person to person. In a simple game of tag, all players walk around and tag two persons on the shoulders. Each player keeps track of who tags whom. After three rounds, the players find out that one of them was sick with the Creeping Crud. How many are now sick? How many people did the disease pass to?

During cold and flu season, germs spread from person to person. How does it happen? How can it be prevented?

Coughing or sneezing into hands and then touching others is an easy recipe for passing on infections. Getting kids to wash their hands frequently or use disinfectant products is a challenge. So is the challenge of getting them to cough or sneeze into their elbows instead of their hands.

In this activity, one player is infected with the Creeping Crud. No symptoms have appeared yet and the player is unaware of having the infection. During the game, all players make deliberate contact with two other players by tagging them on their shoulders. In doing so, the infected player passes on the infection to two other players and to other players that tag him or her. All players use a log to keep track of each person they touched and who touched them. Eventually, the infection is passed on to most or all of the players.

What's the Question?

How are infectious diseases passed from person to person?

What to Do

1. Have players sit on chairs arranged in a wide circle. Pass out number tags and tag logs to each player. Make sure each player has a pencil or pen for recording tags.
2. Explain that during each of the three rounds, players will get up, walk over to another player, and lightly tag that player on the shoulder. Have each player then sit down and write the number of the player they tagged on their logs for the first round. Also have them write down the number of any player who tagged them.
3. Announce "Begin."

4. When completed with the first round and players have recorded their tags, hold a second round and repeat the process. Repeat one more time with a third round.
5. At the end of the third round, with everyone standing in front of their chairs and all tags recorded, announce that one of the players was infected with the Creeping Crud. Draw a number from the container to find out who the infected person is.
6. Tell the infected player to sit down.
7. Have the remaining players check their logs for the first round. Tell anyone, tagged by the infected player or who tagged the infected player, to sit down. They now have the Creeping Crud too. (An additional one or more players will be infected and have to sit down.)
8. Have the uninfected players still standing check their tag logs for the second round of the game. Tell them to sit down if they were tagged by any of the infected players (now seated) or if they touched any of those infected players. They now have the Creeping Crud. (There should now be four or more players seated.)
9. Have any remaining standing players check their logs for round 3. Were they tagged by or did they tag any infected person seated? Have them sit too. Who is left? (There should be at least 8 infected players seated.)
10. Ask your students to speculate what would happen if there were a 4th round. (All or almost all players will be infected. - epidemic.)

Wrapping Up

Hold a discussion with the group.

Each day, we make contact with many people and each contact is an opportunity to spread infectious diseases. While most contact doesn't result in the spread of disease, when someone is infected, the infection can easily jump to others. Look at how quickly the Creeping Crud spread among our group.

During cold and flu season, many people get sick by contacting someone who is already infected. Coughing or sneezing into one's hands and then touching others is a sure recipe for passing the infection. Other common ways of passing on infections are kissing, not washing hands, and sharing drinking glasses.

What are some diseases that are passed by contact with others or by touching contaminated surfaces or breathing air with droplets that contain microbes from a sneeze or cough?

Common cold virus

Influenza: H1N1, Avian flu, Swine flu

Polio (contact with stool of infected person – failure to wash hands after going to the bathroom)

Herpes virus

What are some ways can we protect ourselves, and others from contracting infectious diseases?

Cough or sneeze into elbow

Wash hands frequently with soap and water, especially after going to the bathroom

Use disinfectant wipes or gel

Don't share food or beverages from the same plates or bottles

Wear a facemask

- Play the game again but this time draw two additional numbers. Tell these players that they practice good infection control (wash hands, etc.) and have prevented themselves from catching the CREEPING CRUD. How does this affect the results at the end of round 3 when two players are protected?

Extras

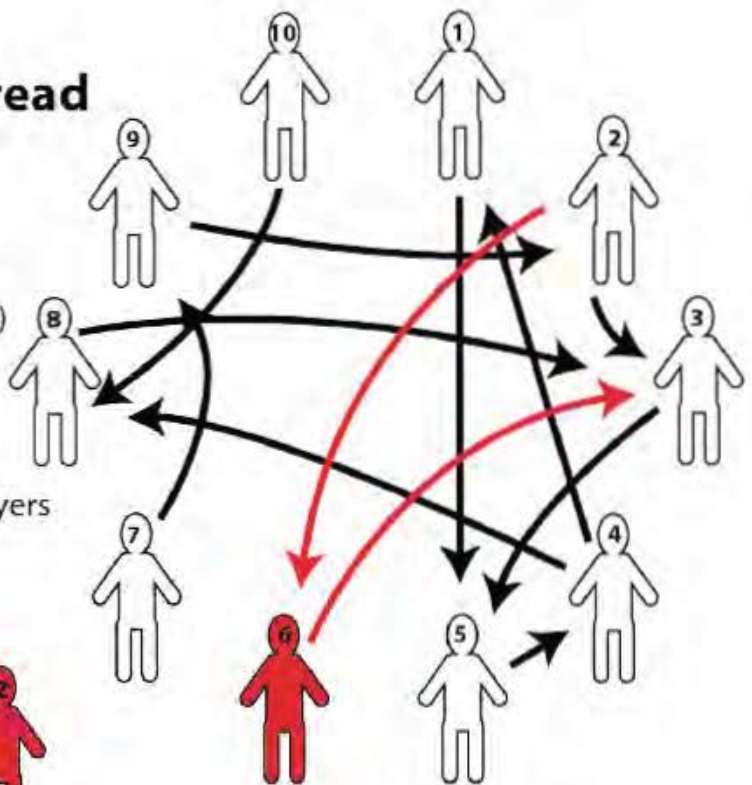
- How would your life change if you had to wear a face mask? Obtain masks for each student and have them try them out for a few minutes.
- Give each student a small package of disinfectant wipes to take home.
- Have students create posters reminding people to use safe infection control practices and hang the posters near rest rooms at the school.

Sample Game Showing One Possible Infection Spread

Red lines show that an infection has passed to another player.

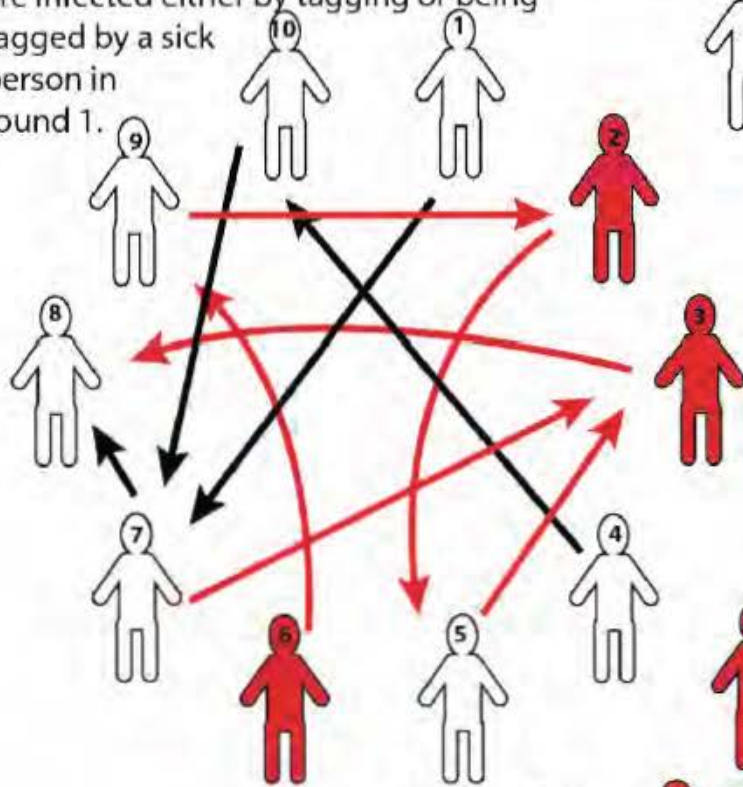
Round 1

At the start of the round, only 10% (1) of the players are infected.



Round 2

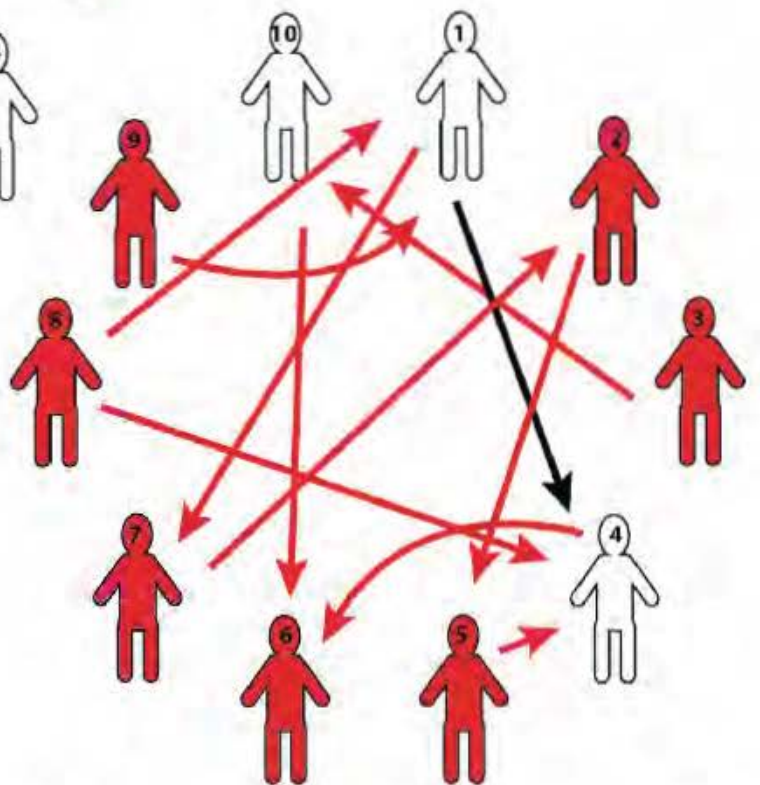
At the beginning of round 2, 30% of the players are infected either by tagging or being tagged by a sick person in round 1.



Players do not become contagious until the next round.

Round 3

At the beginning of round 3, 70% of the players are infected either by tagging or being tagged by a sick person in round 2.



If a round 4 were held, 100% of the players would be infected at the start.

CATCH!

Your Number

ROUND 1

Who did you tag?
Who tagged you?

ROUND 2

Who did you tag?
Who tagged you?

ROUND 3

Who did you tag?
Who tagged you?

CATCH!

Your Number

ROUND 1

Who did you tag?
Who tagged you?

ROUND 2

Who did you tag?
Who tagged you?

ROUND 3

Who did you tag?
Who tagged you?

CATCH!

Your Number

ROUND 1

Who did you tag?
Who tagged you?

ROUND 2

Who did you tag?
Who tagged you?

ROUND 3

Who did you tag?
Who tagged you?

10) Population Density and Disease

The Gang's All Here

Time Needed

1 session

Before You Start

Construct a sneeze bottle.
(See instructions.)

You'll Need This Stuff

Tape measure
Graph paper
Pencil
Ruler
Calculator
Classroom outline maps for
"Planning Your Home"
(see instruction 1)
Empty 2-liter soft drink
bottle

- Small balloon
- Talcum powder

What It's About

The speed at which an infectious disease spreads is determined, in part, by the density of a population. An uncovered sneeze or cough from a person with the flu causes little problem if no one else is around to be exposed to the spray of infected droplets. However, if the sneeze or cough takes place in a crowded bus, many new infections are likely.

Many of the great pandemics in history, like the Spanish Flu pandemic of 1918 that took at least 50 million lives, began in densely populated areas. The Spanish Flu occurred while World War I was raging. Military staging camps with thousands of troops in close quarters and massive troop movements accelerated the disease's person-to-person spread worldwide.

The role of population density in the spread of disease is investigated in this activity.

What's the Question?

Why do we always worry about a new strain of influenza (flu) in China?

Long ago, the appearance of a new disease in a remote region usually went unnoticed by the rest of the world. Because people in the region were few and travel was slow, outbreaks usually remained where they began and diminished on their own. Today, that's no longer true. The world population has grown to seven billion people and, with modern transportation, any two points on Earth are just hours away. Diseases are able to spread over vast distances in frighteningly short times.

In this activity, students will learn about the concept of population density or the number of people per unit of area. They will then imagine they live in a single room in a very poor region of the world. Using a simple map of the classroom, they will draw a picture of how they will live in that room.

What to Do - Togetherness

1. Divide your students into teams of two or three. Ask the teams if they have heard of the term "population density." Explain that population density is simply a measure of the number humans (or birds, rabbits, etc.) per unit area. For

example, the population density in the US averages about 87 people per square mile. In India, the population density is about 942 people per square mile. This is more than ten times the US population density.

2. Demonstrate how population density is determined. Draw a square on a white board that represents one square mile. Place 10 dots inside the square, representing 10 people. Tell the students that the population density of this square is 10 people per square mile. Add another 10 dots. Now, the population density is 20 people per square mile. To determine the population density of a larger area, such as the state of Alaska, divide the population of Alaska by its area in square miles. Alaska's population density is just over 1 person per square mile. Do the same for Mexico City and you will arrive at a population density of almost 15,450 people per square mile!

Tip: The population density of cities, states, and countries can be found on Wikipedia. Wikipedia provides area, total population, and population density among many other useful facts. Search for a state or a country name.

3. Challenge teams to determine the current population density of the room they are located in. Their answers will be in people per some number of square meters.

Ask the teams to come up with ideas of how they would determine the population density of the room. When someone asks how big the room is, distribute tape measures to each team and explain how to determine the area of the room. Have them measure the room's length and width and multiply the measurements together to arrive at how many square meters the room covers.

Example

- The room is 8 meters long and 8 meters wide.
- Multiply 8 by 8. The area of the room is 64 square meters.
- Count the number of people in the room. For example, there are 10 people.
- Divide 64 by 10. The population density is 1 person per 6.4 square meters.

Compare team answers. All answers should be close to each other.

4. Tell students to spread themselves equally around the room. Announce that the population density of the room is _____. Answer from #3.

Move to the middle of the room and extend your arms to the right and left. Tell all students to move to one side of you. Now, the population density of the "half room" is twice the density of the whole room (See illustration. In our example, the population density is now 1 person per 3.2 square meters.).

Swing one arm so that your two arms form a right angle. Tell all the students to move to the space marked between your two arms (1/4th of the total room). The population density has now increased to 4 times that of the whole room or one person per 1.6 square meters.

Move to divide the remaining space in half again and again. The illustration shows what happens to the population density when the room is divided 6 times. The population density becomes 64 times greater than it was when students were spread out among the entire

room space. If the entire room were to have the same population density as the small square in which the students are now crowded into, the room would hold 640 people!

5. Ask the teams why population density is important when it comes to spreading disease. (The more dense the population, the closer people are to each other and the easier a disease can pass from person to person.)

What to Do – Take a Whiff!

1. Ask your students to spread themselves equally throughout the classroom again.
2. Stand in one corner and light a wooden match. (Peeling an orange works too.) Let it burn for a few moments and then blow it out. Ask students to raise their hands when they can smell the sulfur and smoke from the match (or the scent of the orange).
3. A few minutes later, when the air has cleared from the burning match smell, ask you students to crowd into a corner of the classroom so that the population density is about 1 student per 5 square feet. Stand in the middle of the group and strike another match. Have students raise their hands when they can smell the sulfur and smoke (or orange scent).
4. Discuss the two cases. In which case did the smell pass the most quickly among the students? What if the sulfur and smoke were instead disease-causing microbes and someone in the group coughed or sneezed without covering it? How would a high population density affect the spread of an infectious disease?

What to Do – Planning Your Home

1. Students will draw an outline map of your classroom on graph paper to a scale such as 1 centimeter on the paper equals 1 meter in real life (1:100 scale). Show where the door and any windows are but do not draw any furniture inside the outline. Have students draw the outline of the room on graph paper using the chosen scale. For example if the room is 6 meters by 9 meters, the outline map will be 6 by 9 centimeters on a scale of 1 cm equals 1 meter.
2. Tell your students to imagine living 150 years ago with few possessions. Their family consists of four adults (two parents, an aunt, and one grandparent) and five children, including themselves. The entire family lives in a single room, the size and shape of the classroom. To help pay the rent, the family has permitted another family of four to live with them in the same room along with two single men who are day laborers. The one-room house is home for 15 people. The only furniture in the room is a single table with two chairs and a shelf holding some plates and food items. There isn't a refrigerator. Beds are blankets laid on top of straw laid on the floor. Cooking is done in a wide stone fireplace along one wall. There is a large shared wash bucket and a rope stretches from wall to wall for hanging clothes to dry. The toilet is a wooden outhouse built over a pit a short distance behind the house.
3. Ask your students to imagine what life would be like for the people living here. Use the floor map to draw a picture of how the room would be arranged. How much space would be needed for beds (blanket piles)? Where should they place the table and chairs?

4. Have your students write a short story describing what a day would be like living in this house. What would they eat and drink? Have them speculate on the potential health problems of the people living there.

Wrap It Up

Hold a discussion with the group. Ask them to share their drawings and stories. Ask, *Why might population density be important in the study of infectious diseases? How easy would it be for a disease to pass from person to person in a room with only a few people compared to a crowded room?*

Make a sneeze bottle and describe how it works. The bottle represents your chest (ribs, etc.). The balloon inside the bottle represents your lungs. The baby powder represents tiny, mostly invisible, moisture drops that are expelled during the sneeze. Point the bottle away from the group and fake a sneezing sound while giving the bottle a rapid and strong squeeze. A large cloud of powder will shoot out of the model. Have students describe what they observed. Ask, *Why is important to sneeze into your elbow? Sneezing into your elbow helps reduce the spreading of the sneeze spray.*

Extras

Why do people say "God bless you" after you sneeze? Sneezing is often an indicator that a person may have a disease. Saying "God bless you" is a way of wishing a person well.

There are many legends surrounding this practice. One legend comes from the dark ages when bubonic plague ravaged the European population. Pope Gregory the Great, of the sixth century, uttered the phrase after people sneezed because sneezing was one of the symptoms of bubonic plague.

Here are some other sneeze legends and practices.

- Thousands of years ago, Romans were purported to say "Jupiter preserve you" or "salve," which means "good health to you."
- Greeks would wish sneezers "steen eyia su" - meaning "long life."
- Germans say "gesundheit" after a sneeze - meaning "health."
- Arabic people say "Alhamdulillah" - meaning "praise be to God."
- Polish say "Na zdrowie," "Health" - meaning may you get healthier.
- Russians say "bud zdorov" - meaning "be healthy" to children that sneeze.
- Chinese say to children "bai sui" - meaning "may you live 100 years."

How to Make a Sneeze Bottle

You'll Need This Stuff

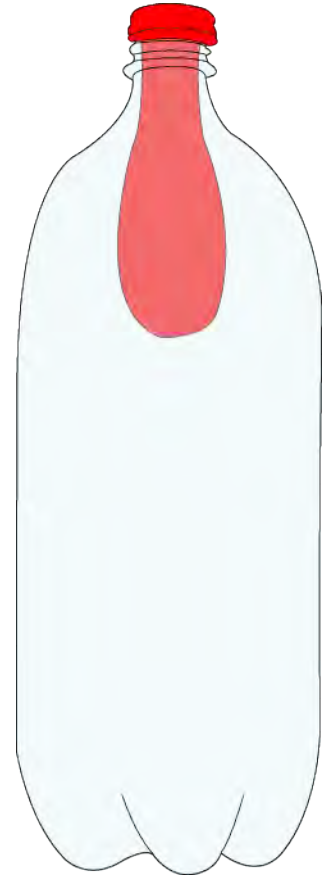
2-liter soft drink bottle

Small balloon

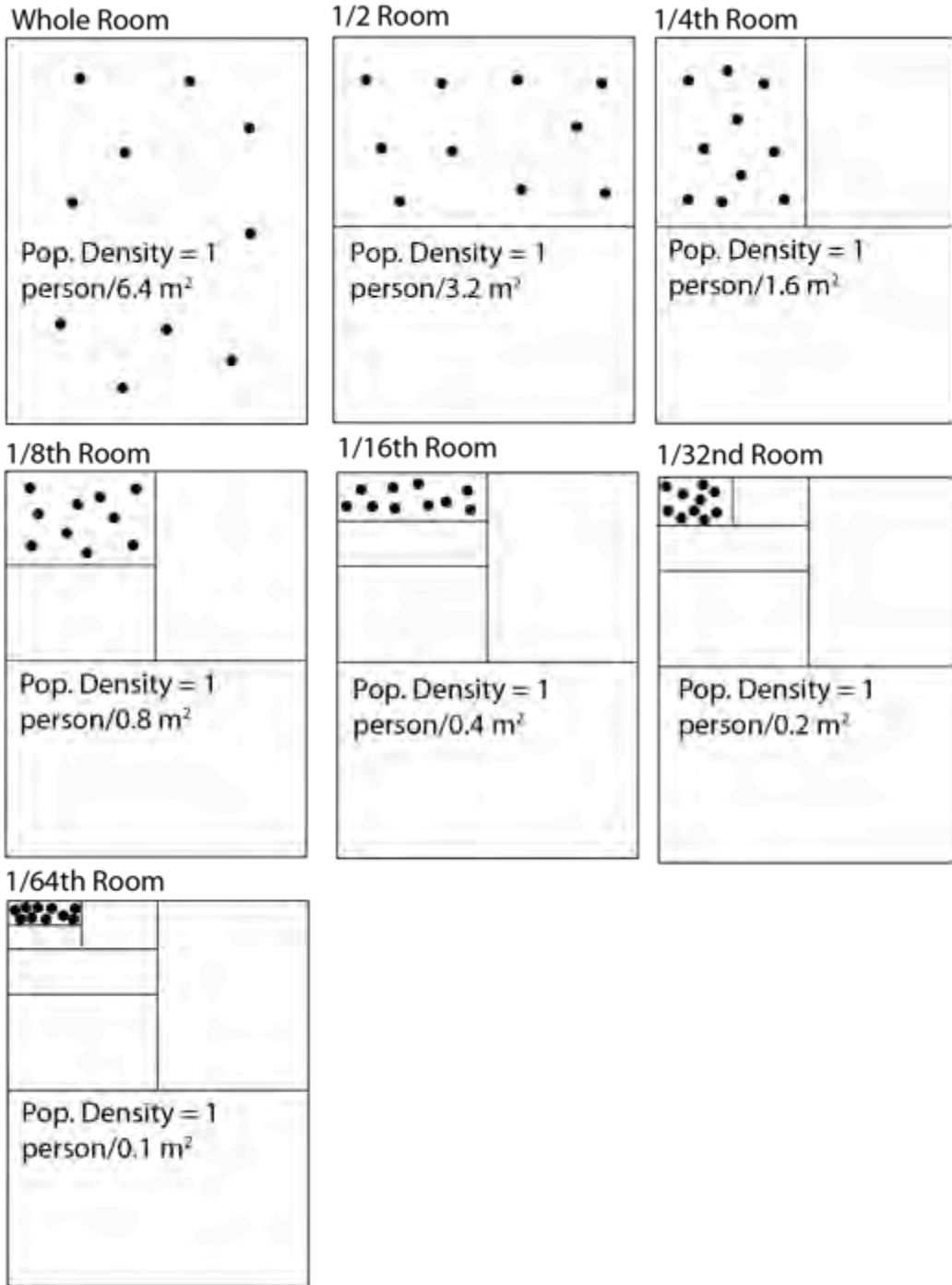
Talcum or baby powder

1. Remove the label from the bottle and rinse the inside. Permit the bottle to dry inside.
2. Pre-inflate the balloon to stretch it. Insert the balloon into the bottle as shown and spread the nozzle over the bottle lip. Lightly squeeze the sides of the bottle while stretching the balloon over the spout. The bottle will inflate slightly when you release pressure from the sides and pull the balloon inward.
3. Pour about a teaspoon of talcum or baby powder into the balloon.
4. Point the bottle away from people and give the bottle sides a sharp squeeze as you make a fake sneezing sound.
5. The cloud of powder produced simulates the tiny droplets of microbe-laden spray from a normal sneeze.

GROSS OUT! When flushing the toilet, put the lid down first. If you leave the lid up, flush water may blow air inside the bowl upward. Like sneezing into an elbow, the lid prevents you from being blasted by a toilet sneeze.



How Population Density Changes with Space



11) Inside the Cholera Epidemic of 1854

The Ghost Map

Time Needed

2 or 3 sessions

Before You Start

Download The Ghost Map slide set about the 1854 London epidemic from BioEdOnline.org.

Make copies of the four quadrant maps of the London Soho district and copies of the coordinate codes for each team.

You'll Need This Stuff

Four-part London Soho district map
Victim list
Overhead projector
transparency sheets for printers
Clear tape
Scissors

What It's About

The 1854 London cholera epidemic helped establish the branch of medical science called epidemiology and built the foundation for modern public health and hygiene. Epidemiologists track the patterns of health and illness in relation to the population. The Greek physician Hippocrates is thought to have been the first to investigate the occurrence of disease in relation to environment. Dr. John Snow, of London, England, used this approach to track a cholera outbreak to a single public water pump contaminated with infected human waste.

In this activity, students will use Dr. Snow's data to create a map (The Ghost Map) of the London Soho district where the first victims fell on August 31, 1854. The data has been recast into a geographic grid to make plotting victims easier. The two previous activities ("Population Density and Disease," and "Spreading Infectious Disease") have prepared the students to understand relationship between dense populations and the spread of disease.

What's the Question?

"Epidemic" is the name given to any disease that strikes a given population at an occurrence rate greater is normally expected. For example, a few cases of flu, across a large city, are not uncommon and not much cause for concern. However, hundreds or thousands of cases of flu appearing in a short time and close together is cause for concern – an epidemic. The 1854 cholera epidemic in London, England struck hundreds of people in a small area in a frighteningly short time. Using epidemiology techniques, Dr. John Snow determined the source of the epidemic and suggested a microbe origin (though not the particular microbe responsible).

How did Dr. Snow determine the source of the 1854 London cholera epidemic?

What to Do

1. Introduce the 1854 London cholera epidemic with The Ghost Map slide set. Download this presentation from BioEdOnline. (

2. Read aloud the story *Summer of Death*. Talk about what it must have been like to live in Soho in 1854. Remind students about their classroom maps and short stories they created in the *Population Density and Disease* activity. Compare their made-up stories with what it was really like to live in Soho London in 1854.
3. Divide the students into teams of 4. Give each team the four quadrant maps that, when combined, make up the complete map of the London Soho district. Also give each team copies of the victim list with coordinates. Have teams divide up the quadrants between themselves and work on two at a time. Tip: Plotting is easiest if one team member reads the coordinates and another does the map plotting. After finishing one quadrant, reverse reading and plotting roles on the next quadrant.
4. Demonstrate how to plot victims on the map. Instructions on how to do this are included with the victim list. When teams locate the appropriate square for a particular location, the number of victims is written on the map. The numbers should be written over the gray-shaded blocks and not the white streets. Relate the plotting grid on the Soho maps to how cities and towns are located with grid coordinates on standard state highway maps.

Tip: If your students are unfamiliar with highway maps, bring a few maps and have students explore them. Point out the grid system. Challenge students to find out of the way towns by giving them only the grid coordinates.
5. Tell student teams that each quadrant map covers only some of the victims of the epidemic. They will have to search the entire coordinate list to find those that fall on a particular coordinate.
6. When teams complete their victim maps, trim the maps with a scissors along the dashed lines. Carefully align the four quadrants to match up streets and hold them together with transparent tape.
7. Provide teams with the polar chart and map scale printed on overhead projector transparencies. Copy the chart and scale with a printer or make tracings of the polar chart with a fine point permanent marker on write-on transparencies.
8. Have teams slide the polar chart over the map and try to encircle as many of the victims as possible within the 500-yard circle on the chart. When done properly, the center of the polar chart will lie close to the intersection of Broad and Cambridge streets. Students may ask what the black dots that appear across the map are. The dots represent the location of public water pumps that raise water from the underground water distribution pipes. The water in the pipes is drawn from the Thames River that winds through London.
9. Ask students to speculate on what the source of the cholera infection might be. Ask, *Where or how did the Soho residents catch the disease?* List ideas on a board. Also list information that will be needed to determine the answer. The dossier on cholera will provide valuable clues towards answering this question.

Wrap It Up

Read aloud the “Dr. John Snow” article to your students or make copies for them to read and discuss.

Extras

Challenge students to find pictures of the Broad Street Pump on Google Earth. Google Earth features detailed maps of the world and street views from their roaming cameras. Street view pictures of the Broad Street Pump show what the pump and the surrounding buildings and streets look like today. Use the search function to travel around the Google Earth site. Let students find out for themselves that the name of Broad Street in London has been changed to Broadwick Street.

Google Earth can be downloaded from the following site: earth.google.com

Summer of Death

The Soho district in nineteenth century London, like many other London districts, was a mass of tightly packed humanity. Cobble stone streets were crowded on either side with dingy, smoke-stained shops, wood and brick apartment buildings, cowsheds, pigsties, slaughterhouses, and grease-boiling dens. Narrow alleys intersected the main streets and opened to hidden courtyards providing access to still more apartments, sheds, and animal pens. Sooty air hung over the district. The air was filled with smoke mingled with the smells of human and animal wastes, decaying animal carcasses, and rendered grease (grease left over from animal processing that is boiled and used in soap and candle making). At the end of August in 1854, the conditions were ripe for a medical disaster.

There were few public services in the district. Drinking water was drawn from the Thames River and distributed by a system of pipes running beneath the streets. At scattered locations, water lines were tapped with hand pumps that all citizens shared. Running next to and over and under the water lines were other pipes for sewage. Many of these pipes were old and cracked or broken. The pipes were generally overwhelmed by the quantity of waste attempting to run through them. What waste that did make it through, poured directly into the Thames River, in some cases up stream from the water intake pipes. On every street human and animal waste ran freely along the curbs.

A typical Soho district apartment consisted of a single room in which one or more families lived. Children, parents, aunts, uncles, and grandparents shared the cramped spaces. Furniture was sparse. Cooking and heating was done with wood, coal, or charcoal in a fireplace or grill. The air was always smoky. Food had to be eaten quickly. There wasn't any refrigeration and leftovers soon became rancid, adding to the smells. Washing was done in tubs with water carried in from the pumps. Wastewater was dumped back on to the streets.

Beneath warped boards in the cellars of most building were cesspits that served as toilets. A typical cesspit was circular, brick-lined hole about 6 feet across and 10 feet deep. Urine and fecal matter collected there until overflowing. Many cesspits had never been emptied since they were first dug. The smell was terrible.

In 1831, a new disease had struck the citizens of London. The disease was named Asiatic cholera because the disease originated in the Ganges delta of the Indian subcontinent (India). Today, we just call the disease cholera. Since ancient times, cholera ravaged the Indian population. Gradually, cholera spread along land and sea trade routes and it was believed that it was brought to London was by one or more infected merchant ship crews.

The symptoms of cholera were as swift as they were horrifying. Victims were quickly debilitated with fast-acting and profuse diarrhea and vomiting. This led to dehydration and imbalances of the electrolytes that control nerve and muscle function. The loss of body fluids caused victims to have sunken eyes and wrinkled hands. Untreated, death usually resulted a day or two later and sometimes within hours.

Between 1831 and 1854, four outbreaks of cholera raged across the densest parts of London and left tens of thousands of people dead. At the time, most medical authorities believed cholera was due to a "miasma in the atmosphere" or bad air. Certainly, the air was putrid but the disease, when it struck, seemed to be confined to the warmer months only. The air in many London districts was bad all year round.

August 31, 1854

The summer of 1854 began uneventfully for the residents of the crowded London Soho district. But everything changed on the night of August 31. Cholera struck again. Over the next three days, 127 people, men, women, and children died. Virtually every family, living near the intersection of Broad Street and Cambridge Street, lost one or more members. Some families were completely wiped out.

The Soho incident was part of a larger outbreak that claimed hundreds of lives but the swiftness and intensity of the Soho outbreak was especially terrifying. Within just a week, nearly three-quarters of the surviving Soho residents fled to other parts of London and to the countryside. Soho became an instant ghost town.

Cholera was killing people but what was cholera and how was it spread? No one knew but a London physician, Dr. John Snow had his suspicions. He set out to prove his ideas. His first step was find out who got sick and where.

What Did Dr. John Snow Do?

Dr. John Snow compiled lists of the cholera epidemic victims according to their addresses and marked their numbers on a map. Dr. Snow drew small dashes on his map to indicate individual victims. In doing so, he made an important observation. Virtually all of the initial victims lived within 250 yards of the public water pump on Broad Street. During his investigation of earlier cholera outbreaks, he had begun to suspect that the cholera was related to drinking water. The prevailing hypothesis of the time was that cholera was spread by bad air. Dr. Snow disagreed. Plotting the map of Soho would provide him with the data he needed to confirm his ideas.

Although the Soho map showed a convincing case for cholera being a water-borne infection, there were a few problems. Not all of his data fit the pattern. There were additional victims far removed from the Broad Street pump. How did they get the disease? Dr. Snow decided to find out.

What Dr. Snow Found Out

- Most of the 1854 Soho outbreak deaths occurred within about 250 yards of the intersection of Broad and Cambridge streets.
- The death rate in the Soho district topped 12.8% of the population (double the death rate for cholera in other areas of London at the time).
- A widow living in Hampstead, about three miles the center of Soho, was stricken and died from cholera on September 2nd. Her niece, who lived in Islington, two miles northeast of the center of Soho, died the following day. Dr. Snow was troubled by these two deaths. Their distance from the center of Soho seemed to contradict his ideas about the cause of the epidemic. Dr. Snow visited the widow's home and talked to her son. The son said his mother once lived near Broad Street and liked the taste of the water from the Broad Street pump. She sent a servant with a cart to bring back a large bottle of the water from the pump every day. The widow's niece had visited his mother and had drunk from the bottle that had been fetched on August 31, the first day of the outbreak.

- Five hundred and thirty people lived in the Poland Street workhouse just around the corner from the Broad Street and Cambridge Intersection. Only five of the inmates contracted cholera. Snow observed that the workhouse building had its own water well and most inmates drank from that well.
- None of the 70 workers at the Broad Street brewery contracted cholera. The brewery gave all of its workers an allowance of free beer every day and, consequently, the workers never drank the local water.
- An army officer living in St. John's Wood, about two miles from the Broad Street and Cambridge Street intersection, died from cholera. The night before, he had dinner on Wardour Street, not far from the intersection. During dinner, he drank a glass of water from the Broad Street well.
- Dr. Snow examined water samples from local pumps. Under a microscope, water from the Broad Street well revealed "white flocculent particles." Flocculent particles resemble bits of fluffy wool fibers. While Snow could see the particles, he could not tell what they were. He believed the particles were the source of the disease.
- Dr. Snow learned that in late August a child had taken ill with cholera symptoms. The child's nappies (English term for diapers) had been rinsed in water. The dirty water was dumped into a leaky cesspool located only 3 feet from the Broad Street water pump. The widespread cholera outbreak followed shortly after.

Tip: When going through the bullet points above, place a complete Soho map on the board and mark the location of these incidents. Add labels to the outside of the map and connect them to the locations with lines or strings. The map will resemble the crime maps often portrayed in police detective TV shows.

What Dr. Snow Concluded

Without question, Dr. John Snow concluded that the source of the 1854 cholera outbreak in Soho was due to contaminated water from the Broad Street pump. Cholera microbes had seeped into the water lines from the nearby cesspit and the outbreak began. Dr. Snow's conclusions led to the removal of the pump handle so that no more water could be drawn at that location.

By the end of September 1854, the cholera epidemic had subsided. The Soho death toll stood at 616 residents. It is likely that the epidemic would have subsided on its own without the removal of the pump handle, Dr. Snow's conclusions had a major impact on medical thinking. He helped establish epidemiology as a respected branch of medical research. He also helped establish the relationship between good sanitation and health.

Because of the work Dr. John Snow and many others, cholera is now a very rare infection in developed



countries such as the United States. Unfortunately, the cholera microbes are still present in the environment. Recent outbreaks include the country of Haiti that was struck with a devastating earthquake in 2010. The quake wrecked havoc on the country's already minimal sanitation systems. Clean water became difficult to find and cholera followed.

TOP SECRET

Dr. John Snow

John Snow was born in York, England in the year 1813. He was the first child in a family of nine children. His father was a laborer at a coal yard. John spent many of his early years in school and, at age 14, left his home to become a medical apprentice. A medical apprentice was generally a teenage boy who became an assistant to a practicing doctor. The apprentice learned medicine through practical experience by assisting in treating patients, cleaning and other duties. Eventually, John Snow apprenticed with three different doctors across Yorkshire.

When John Snow was 18, the first Asiatic cholera epidemic struck in parts of England. He developed a fascination with the disease and solving the mystery of its cause became a life-long mission.

In 1844, John Snow earned his doctor of medicine degree and became a very successful physician in London. One of his specialties was anesthesiology (the use of chemicals to reduce pain during surgery). He developed a device to improve the delivery ether gas to patients. After assisting in the delivery of a baby for Queen Victoria, Dr. Snow's fame spread across England.

Following the second cholera epidemic in 1848-1849, Dr. Snow and others founded the London Epidemiological Society. Epidemiology is the study of patterns of health and illness. It is an evidence-based practice that seeks to identify diseases and their treatments by collecting data across segments of the population. In other words, who got sick, when did the sickness strike, what do all the victims share in common with each other, and other such questions.

Eventually, Dr. Snow formed a hypothesis about the cause of the cholera but he needed data to confirm or reject his hypothesis. As the Soho death toll mounted, Dr. Snow gathered data. He became more and more confident that he was on the right track. If he were right, cholera could be stopped.



Wikimedia Commons, Public Domain.

TOP SECRET

Dossier

Cholera

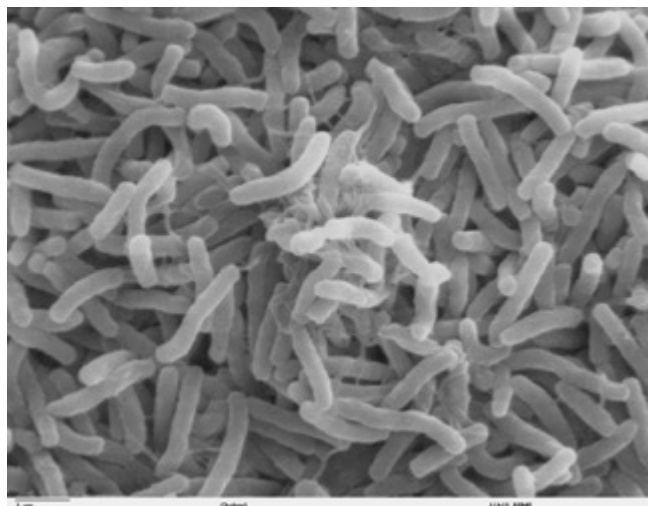
Cholera is an infection of the small intestine by the *Vibrio cholerae* bacterium. The bacterium responsible for cholera was isolated in 1855 by Italian scientist Filippo Pacini but his results were generally not known. Thirty years later, Prussian physician Robert Koch identified the bacterium responsible for cholera.

Transmission or the spread of cholera is primarily accomplished by consuming water or food contaminated by the bacteria. Once infected, a victim experiences rapid diarrhea and vomiting that leads to dehydration (excessive loss of body water) and electrolyte (various salts critical to conducting electric impulses in body cells) imbalances. Untreated, death can result within hours. With poor sanitation, waste from victims further contaminates water and food supplies and the bacterium are passed on.

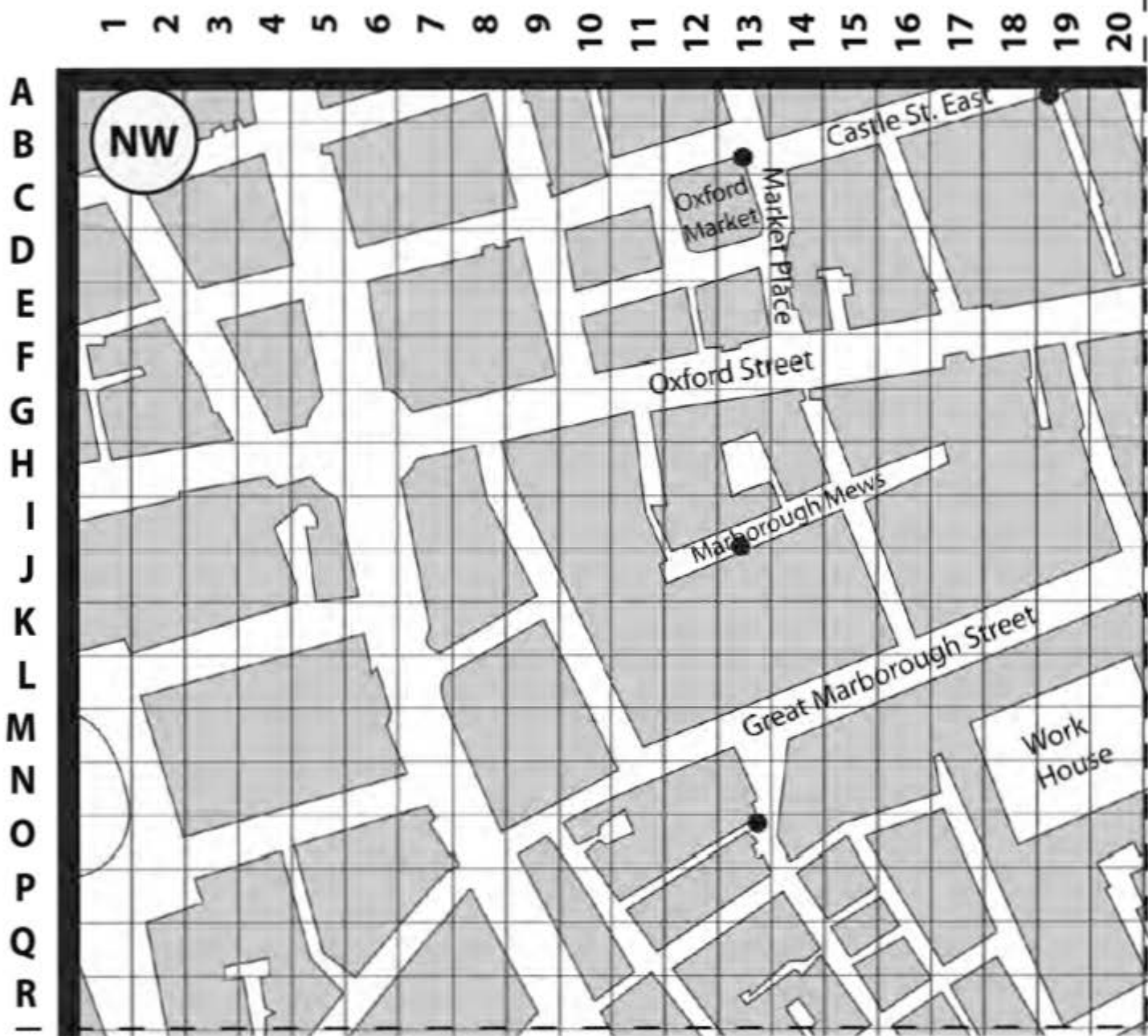
Cholera originated in India and was once referred to as “Asiatic Cholera.” Slowly, the disease traveled to other nations through shipboard and overland trade routes. Cholera arrived in England in 1831. The 1854 epidemic was one of several that struck England, killing tens of thousands of people. The epidemic traveled through Europe and to North America. Though striking heavily in poor area where sanitation was questionable, not all victims were poor. American president James K. Polk died from cholera as did Charles X, king of France. Recently, a cholera epidemic struck the nation of Haiti following the devastating 2010 Earthquake. Worldwide, between 3 and 5 million cases of cholera occur annually and 100,000 deaths occur, mostly in countries where finding clean water is a challenge. Cholera is treatable but treatment must begin quickly to be effective.

Treatment

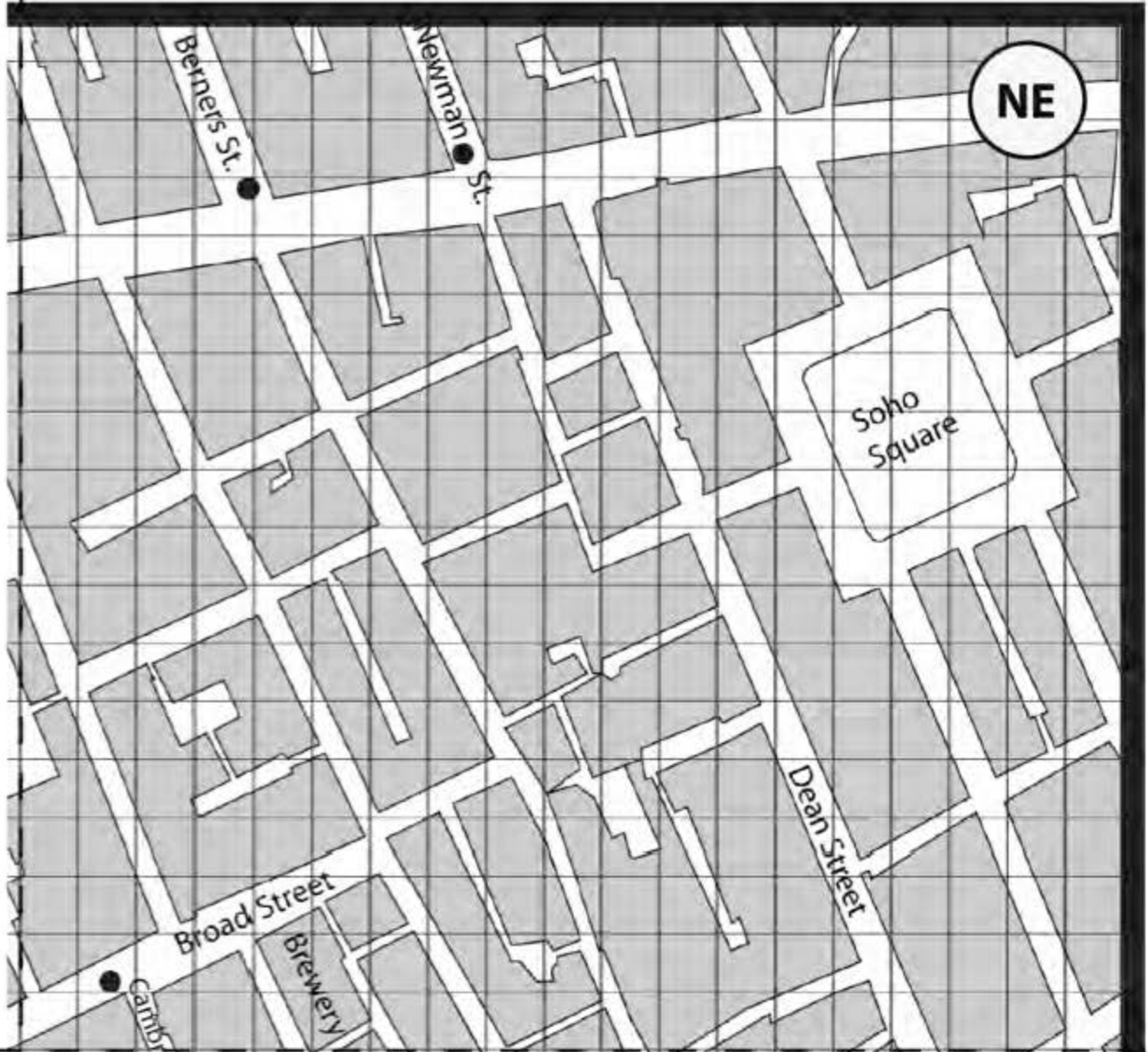
The goal of cholera treatment is to replace lost body fluids and electrolytes as quickly as possible. A simple rehydration (replacing body water) solution, called ORS for Oral Rehydration Salts, starts as a powder that is dissolved in a bottle of water. The victim drinks the solution.



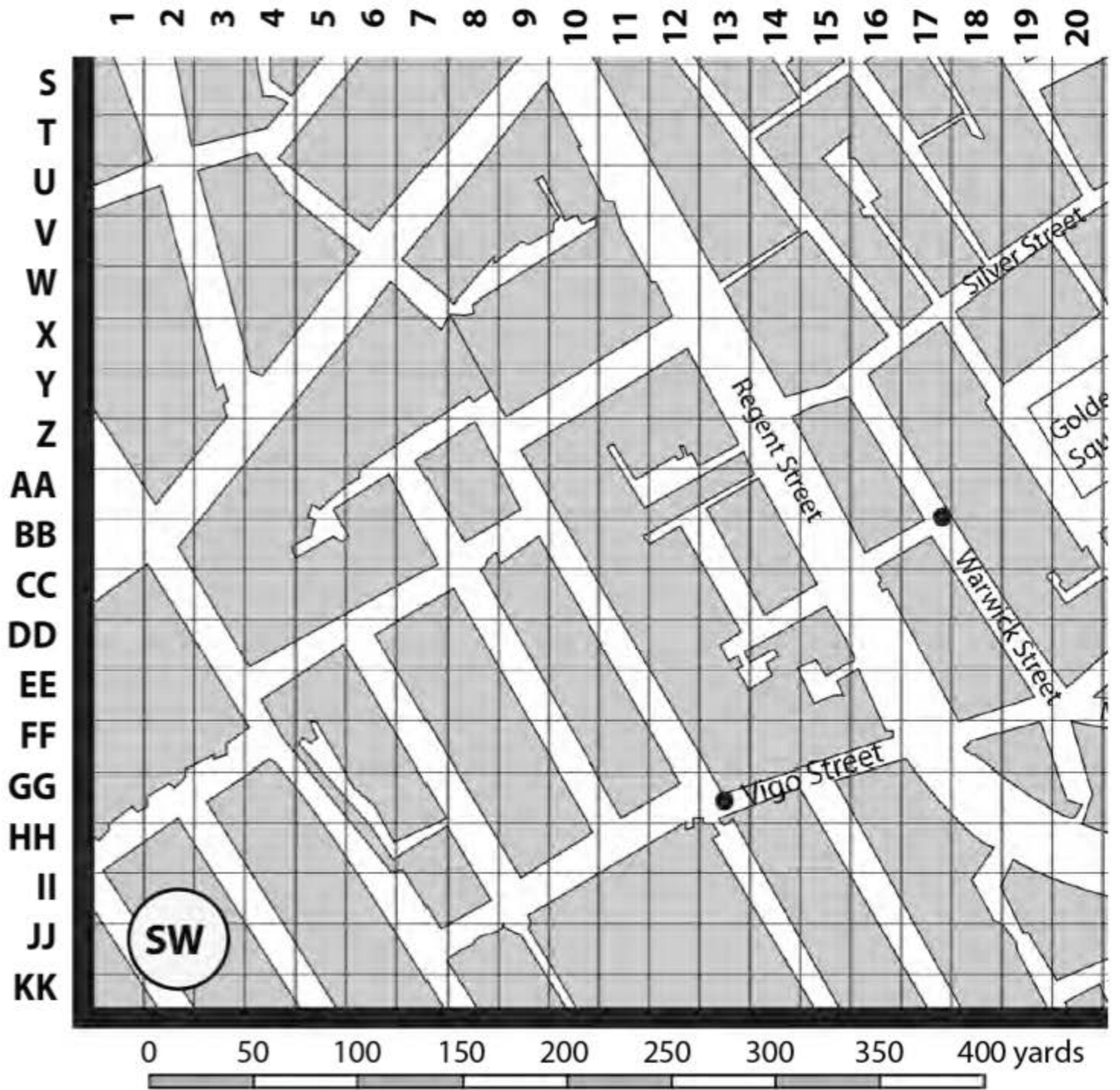
Dartmouth Electron Microscope Facility,
Public Domain

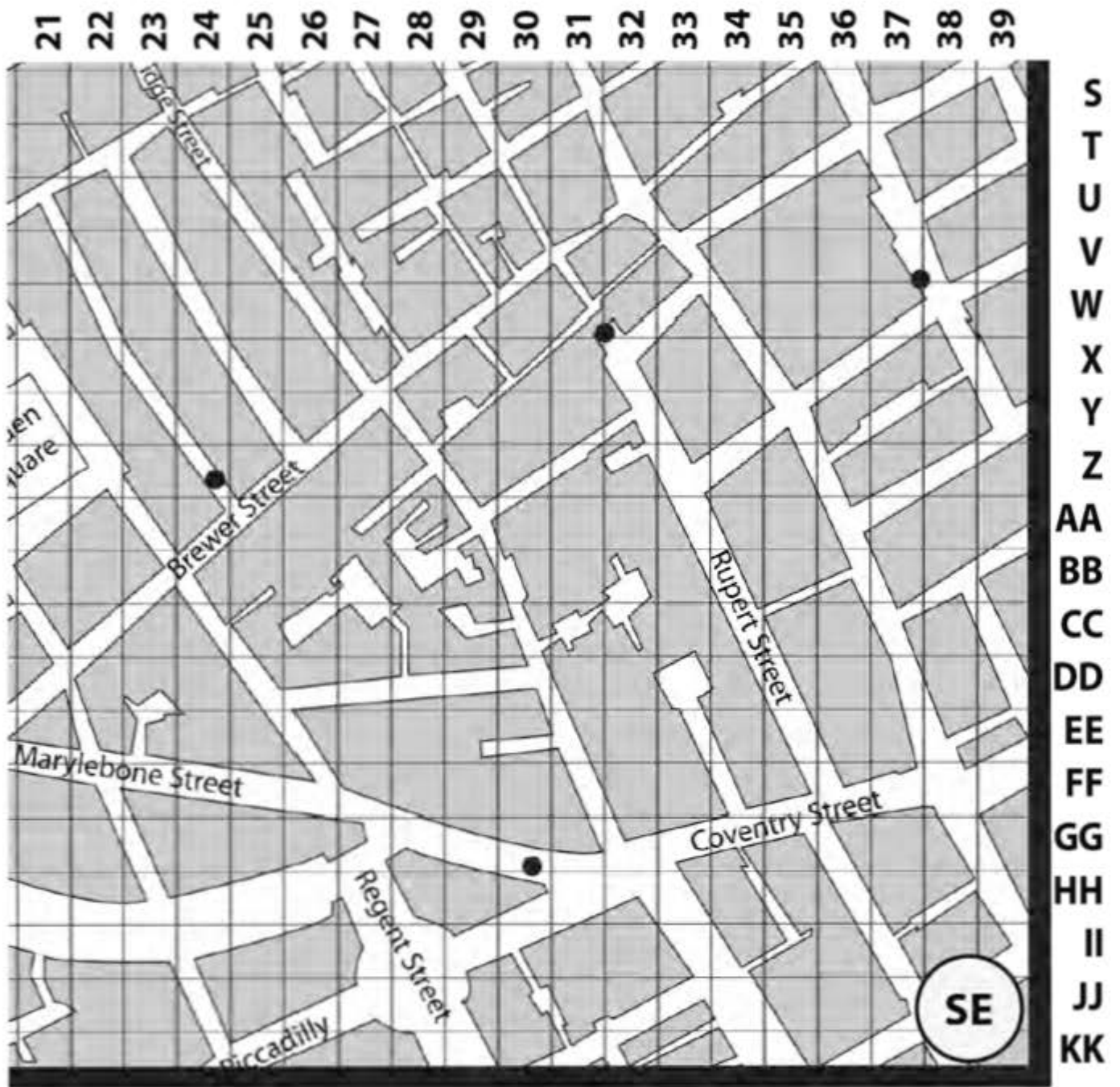


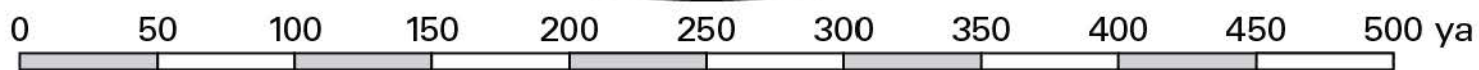
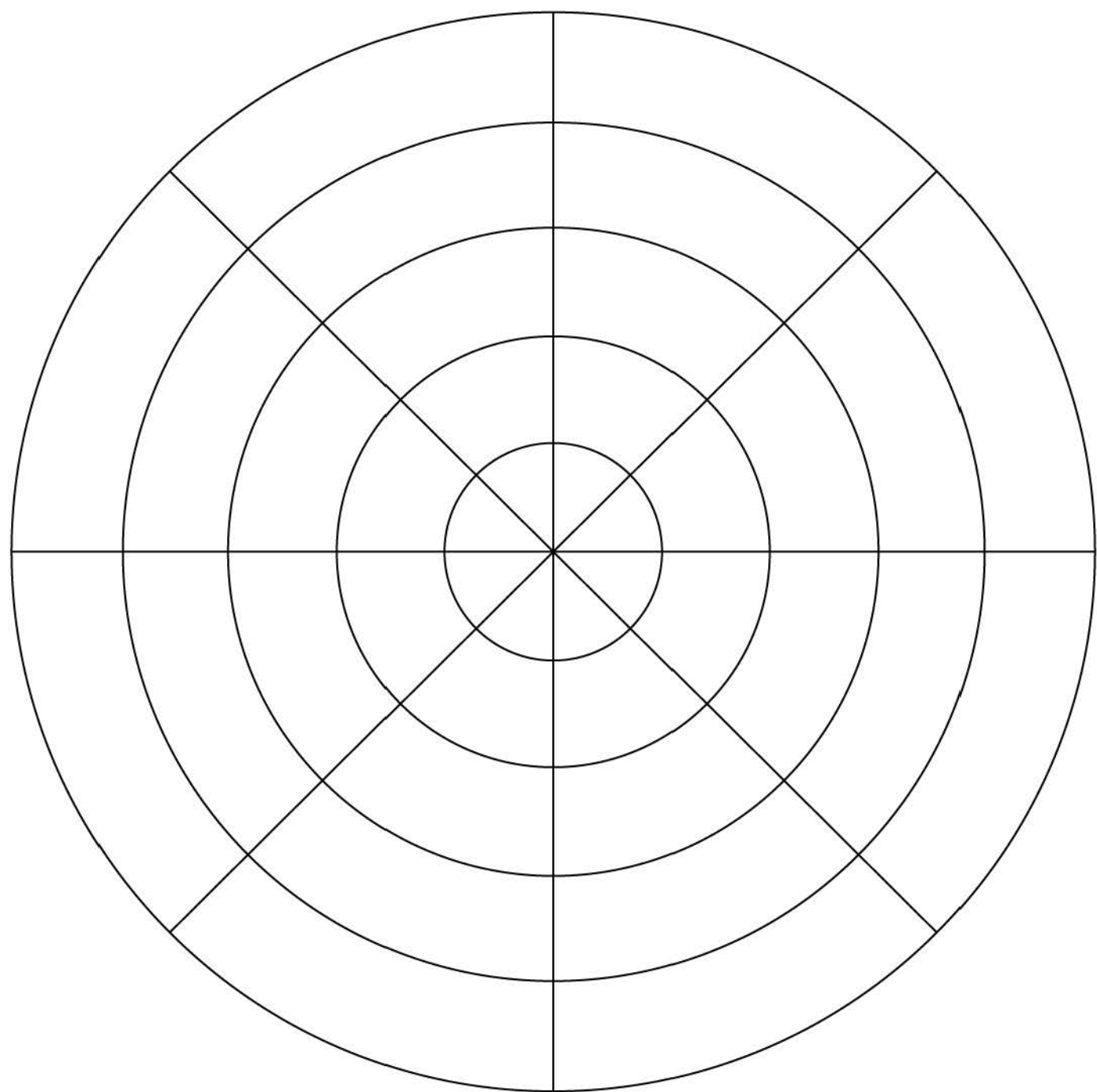
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1854 Soho Cholera Deaths Coordinates

Instructions

Each code on this list provides two pieces of information. The letters and first numbers tell the location of cholera deaths in the 1854 London Soho epidemic. The second number (after the dash) tells how many victims lived at each location. Use these codes to plot the location and number of victims across Soho.

The Soho district map has been divided into four quadrants so that four teams can work together to rapidly plot all the cholera victims. As in all epidemics, determining where the disease started and how it spreads is key to establishing a treatment program. The sooner the better.

How to Plot Location

1. The letters and first number refer to a grid on the map quadrant provided to your team.
2. Look at the letters and numbers along two sides of your quadrant map. Next, look at the code table and find a code that falls on your quadrant. For example, if you have quadrant SW (southwest), code AA12-1 falls on your map.
3. Locate the AA row and start on the left. Slide your finger to the right until you reach column 12. This is the code location.

Plotting Victims

According to the AA12-1 code, one person fell victim to cholera at that location. Write in the number 1 in that square. Do the same for all the other codes that apply to your map. Find the location and write in the victim numbers.

AA12-1	K32-6	O16-4	Q20-1	S23-3	U24-4
BB12-3	L21-1	O18-2	Q21-5	S24-7	U25-2
BB29-2	L23-1	O20-3	Q24-8	S25-7	U29-1
BB34-1	L24-2	O22-2	Q26-1	S27-5	U31-1
CC35-1	L25-3	O24-12	Q27-5	S29-11	V18-6
DD14-1	L26-2	O25-7	Q28-5	S30-1	V19-2
E29-2	L28-1	O26-5	Q29-1	S32-2	V20-2
F27-1	L31-3	O27-1	R14-2	S34-2	V23-2
G19-1	L32-2	O29-2	R17-8	T14-2	V24-2
G23-1	M20-5	O30-6	R18-2	T15-3	V25-1
H26-1	M21-3	P14-1	R19-5	T19-1	V27-1
H27-1	M22-4	P15-4	R20-2	T20-5	W16-1
I13-1	M25-3	P16-1	R21-23	T21-3	W20-1
I21-1	M26-3	P17-3	R22-13	T22-4	W22-1
I25-1	M28-1	P18-4	R23-4	T23-6	W24-2
J18-3	M29-4	P19-2	R25-3	T24-1	W26-1
J19-2	M30-1	P22-4	R26-2	T25-1	W30-2
J21-2	N14-4	P23-4	R27-2	T26-9	X18-1
J22-3	N17-2	P24-6	R29-3	T31-1	X19-2
J23-1	N22-1	P27-2	R30-1	T34-2	X25-3
J24-1	N23-2	P28-1	R32-2	T35-1	X26-1
J28-1	N24-3	P30-6	S13-1	U17-1	X27-2
K22-3	N25-2	Q12-1	S15-4	U18-1	X31-1
K23-3	N26-8	Q13-4	S16-1	U19-4	Y32-1
K24-1	N27-2	Q15-2	S17-7	U20-2	Z23-4
K25-1	N28-1	Q17-4	S18-5	U21-2	
K27-1	N29-1	Q18-5	S19-6	U22-2	
K31-7	N30-1	Q19-1	S20-9	U23-1	

Script for The Ghost Map Activity

- Slide 1 The Ghost Map
- Slide 2 By the mid nineteenth century, London became the world's largest city. It was the capital of the British Empire and the world center for trade, money, and power.
- By 1854, two and a half million Londoners lived within 9 miles of each other. London was a busy, crowded city packed with homes, businesses, and industries. Crisscrossing London were railroads, streets, and bridges.
- Travel in the city was accomplished by walking, on horse-drawn vehicles, and by train. Coal fuel fueled the industry and homes of London, making the air foggy and sooty
- Slide 3 There were really two Londons: London for the rich and London for the poor.
- The rich lived in fine homes tended by small armies of servants. Life was safe and good.
- The poor, millions of them, lived in overcrowded and unsanitary slums. For them, life was dangerous and always a struggle.
- Slide 4 As the month of August 1854 drew to a close, and old fear made itself known again. It began in the Soho District in the heart of London.
- Slide 5 The Soho District was a quarter square mile tract of London where more than 10,000 people lived in poverty.
- Its many narrow streets were covered with cobblestones, making walking difficult. On either side of the streets were dingy, smoke-stained shops, wood and brick apartment buildings, cowsheds, pig-stys, and slaughterhouses.
- Note:* Cobblestones are rounded stones set into the street. The bumps in the stones helped horses find traction as they clopped along with carriages or wagons in tow.
- Slide 6 Narrow alleys intersected the main Soho streets and opened to hidden courtyards where there were still more apartments, sheds, and animal pens stuffed into every space possible.
- The air was filled with smoke mingled with the smells of human and animal wastes and rendered grease.
- Note:* Rendered grease comes from animal scraps that are boiled down into fat for making lard for cooking and tallow for candle making.

- Slide 7 There were few public services in the district. Drinking water was drawn from the Thames River and distributed by a system of pipes running beneath the streets. At scattered locations, water lines were tapped with hand pumps that all citizens shared. Running next to the water lines were other pipes for sewage. Many of these pipes were cracked or broken and waste flowed out on to the streets.
- What waste water that made it through the sewer lines poured directly into the Thames River, in some cases up stream from the drinking water intake pipes. On every street, human and animal waste ran freely along the curbs.
- Slide 8 A typical home consisted of a single room in which one or more families lived. Cooking and heating was done with wood or coal in a fireplace or grill. The air was smoky. Windows provided light during the day and candles were used at night.
- Food had to be eaten quickly because leftovers soon became rancid. Washing was done in tubs with water carried in from the pumps. Wastewater was dumped back on to the streets.
- Beneath warped boards in the cellars were cesspits that served as toilets. Cesspits were circular, brick-lined holes about 6 feet across and 10 feet deep. Urine and fecal matter collected there until overflowing. The smell was terrible.
- Slide 9 The night of August 31, the Asiatic Cholera returned. It was called Asiatic because the disease originated in the Ganges delta of the Indian subcontinent (India).
- Since ancient times, cholera ravaged the Indian population. Gradually, cholera spread along land and sea trade routes. It was believed that one or more infected merchant ship crews brought cholera to London.
- The return of the disease to London, the fourth time since 1831, made the headlines of all the newspapers. Panic ensued.
- Slide 10 Read the newspaper story on the screen.
- Slide 11 The symptoms of cholera were as swift as they were horrifying. Victims were quickly debilitated with fast-acting and profuse diarrhea and vomiting. This led to dehydration and imbalances of the electrolytes that control nerve and muscle function.
- The loss of body fluids caused victims to have sunken eyes and wrinkled hands. Death usually resulted a day or two later and sometimes within hours.
- Note: Electrolytes are chemicals that can conduct electricity. They are important for many body functions. After exercising, athletes may drink solutions containing electrolytes to replenish body supplies.

- Slide 12 The Soho cholera outbreak was part of a larger epidemic across London that claimed hundreds of lives. But the swiftness of the Soho outbreak was terrifying. Over three days, 127 people – men, women, and children – died. Entire families were wiped out. Soho became an instant ghost town as residents fled the area.
- Slide 13 Cholera was killing people but what was cholera and how was it spread? No one knew but a London physician, Dr. John Snow, had his suspicions.
- Dr. Snow was born in 1813. At age 14, he became an apprentice to a surgeon and began his study of medicine. Years later, Dr. Snow became an expert in the use of anesthetics during childbirth. He helped deliver Queen Victoria's last two children and became famous for doing so.
- Note: Anesthetics are drugs or gases administered to patients to prevent pain during surgery.*
- Slide 14 This is a map of the Soho District of London. It covers an area of approximately one-quarter square mile. Shown on the map are streets (white), clusters of buildings (gray), and public water pumps (black dots).
- Dr. Snow collected data on the cholera deaths. He plotted the numbers of deaths by the locations where the people died. The distribution of the deaths provides what Dr. Snow thought were valuable clues as to the probable cause of the cholera epidemic.
- Slide 15 Our task will be to recreate Dr. Snow's work. We will construct our own maps and see if any patterns appear. If there are patterns, they will go a long way to confirming Dr. Snow's ideas about the cause of cholera.
- Slide 16 We will organize into four survey teams. The Soho map has been divided into four parts. Your team will receive one-quarter of the map. You will also receive a table of coordinates for all of the Soho deaths.
- Team Tasks
1. You will identify the coordinates on the table that fall on your team's map.
 2. You will write the number of deaths that occurred in the coordinate squares on your map.
 3. When finished plotting deaths, the four map quarters will be reunited to make the complete Soho map
- Slide 17 Example Plot
- Slide 18 Plotting Distance
- Slides 19 Your Mission
- Slides 20–24 Read the text on each slide.

12) Fight *Vibrio cholerae*!

Time Needed:

2 – 3 sessions

Before You Start

Cholera Today presentation.

Prepare agar plates.

Obtain water sample for testing.

You'll Need This Stuff

Prepared agar plates (two per team)

Safety goggles

Plastic or latex gloves

Antibacterial soap

Water sample from local source. Collect the sample just before it is needed.

Eye dropper

Miscellaneous: Coffee filters, fabric, plastic bottles, charcoal (aquarium store), sand, cotton balls, etc.

What It's About

Clean water and good sanitation are things we take for granted. We turn on a tap and out comes clean water that is safe to drink. It is not so in many parts of the world. For the poorest of countries, sanitation and drinking water systems are not much better than the system in London in 1854. Many are worse.

Cholera has killed tens of millions of people and it is a killer that still stalks the world. Wherever human wastes and drinking water mix, there is the potential for new cholera outbreaks.

Thanks to the work of Dr. John Snow, public health has improved in many countries. The technology employed in water and sanitation systems in the US, for example, ensure that public water supplies are safe to drink. The key to their success is to safely collect and treat human wastes and to purify drinking water supplies so that pathogens, such as the cholera pathogen *Vibrio cholerae*, are not recycled through the population.

In regions without waste and water treatment systems or regions with inadequate systems for the population size, disease can quickly spread. Many non-governmental organizations (NGOs) are seeking to help the people in these regions by providing waste and water treatment systems. Because funds to support this work are limited, very creative methods are being developed to provide safe water.

In India for example, the cotton fabric for old saris is employed as a filter to reduce cholera infections. Four to eight layers of the fabric are stretched across a bucket or bowl and potentially contaminated water is poured through.

Still another water treatment method employs plastic water bottles. The bottles are refilled with water from a questionable water source and laid across a black roof. Solar heat kills any pathogens in the water in about an hour or two on a hot sunny day.

Sari water filters and plastic water bottles are just two of the creative technology ideas that are saving lives in impoverished areas of the world.

How Does Sari Fabric Purify Water? Multiple layers of sari fabric are placed over a bucket or bowl and polluted water is scooped on top to soak through. The fabric acts as a filter. Old sari fabric is the most effective for water treatment because the weave tightens with repeated washings. The technique works as cholera bacteria has a tendency to cling to copepods—a tiny water crustacean about 1 to 2 millimeters long. While the fabric will not catch *Vibrio cholerae*, it traps the copepods. Although an imperfect method of water filtration, the sari fabric does block many copepods and reduces the chance of catching cholera by almost 50%. This technique is similar to the high-tech ceramic filters used for water filtration by hikers. It makes effective use of easy-to-obtain materials in impoverished areas.

Student teams are challenged to develop a water treatment system for an impoverished country. Using inexpensive, commonly found materials, teams will try to clean a contaminated water supply and test their systems using prepared nutrient Petri plates.

What's the Question?

The developed nations of the world have sufficient resources to ensure an ample clean and healthy water supply. That means effective treatment of waste and purification of water. This is not so in poor areas of the world. Resources are extremely limited and people are at extreme danger of becoming infected with deadly diseases. How can people, living in poor countries, obtain water that is safe to drink? What can be done to educate people on developing and protecting safe water supplies? How do plastic water bottles purify water?

What to Do

1. Review the previous activity on cholera and explain that cholera is a disease that still stalks the poor areas of the world. The 2010 earthquake in Haiti devastated the country and damaged water supplies. A cholera epidemic followed. Approximately 3 to 5 million people contract cholera every year and in spite of treatment, more than 100,000 people die from the disease, many of whom are children.
2. Review the dossier on cholera from the Ghost Map lesson with your students. Hold a discussion and lead students towards thinking about ways to fight the disease. Cause – water contaminated with *Vibrio cholerae*. Prevention – safe drinking water. How can water be made safe?
3. Challenge small teams to design and test a water purification system that will work with the limited resources available in a poor country. Have teams brainstorm ideas and make sketches along with a list of materials needed to construct a prototype of their proposed system.
4. Collect the needed materials and tools for the next session. Have teams construct their systems.
5. Obtain a water sample from a local source such as a pond. A simulated polluted sample can be made by adding some garden dirt to clean water and shaking or stirring it to distribute the soil particles. Discuss safe handling procedures. Students should wear gloves and eye protection when handling the water. They should avoid splashing and clean all containers and surfaces when finished. Have antibacterial soap available for hand washing.

6. Using the eye dropper, have each team place four equally-spaced drops of untreated water on the surface of one agar plate, cover it, and set it in a safe place where it will be undisturbed for several days. Note: Refer to the instructions for making agar plates or their potato alternative in the *Microbe Scavenger Hunt* activity.
7. Have teams pour a cup of polluted water into their system and collect the treated water. If the system absorbs the initial water, slowly add some more until a small, purified sample is collected.
8. Repeat the water drop procedure for the second agar plate using the treated water.
9. Dispose of any remaining polluted water, clean up work spaces, have teams dispose of gloves, and wash hands with the antibacterial soap.
10. Compare the two agar plates several days later to see if the systems designed by the teams improved the quality of the water. Look for bacterial growth on the plates. Less is better. Have teams make sketches or take pictures of their before and after agar plates.

Wrap It Up

Have teams report on their designs and how successful they were in treating water. In what ways could they improve their systems? Discuss ways that systems from different teams could be combined to improve their effectiveness.

Extras

Obtain sari fabric and evaluate with agar plates how well it filters water. Examine sari fabric under a low-power microscope or magnifier. Older sari fabric works better as a water filter than new sari fabric. Prior to the activity, repeatedly wash and dry a large square of sari fabric. Cut representative squares of the fabric and similar squares of new fabric to give to each team for comparison under the microscope.

Place filled plastic water bottles (remove the labels) on a dark surface for an hour on a sunny day. Measure before and after temperatures. Test the ability of the bottles to clean water using the agar plate procedure. To do a comparison of before and after water quality, the bottles with polluted water should remain in sunlight for six hours before samples of the treated water are tested.

TOP SECRET

Dossier

Cheap Water Purification for the Third World

In many of the poorer areas of the world, safe drinking water supplies are not available. Nearly half the people of Africa, for example, do not have safe drinking water. During warmer months, polluted water is a medical disaster waiting to happen. People become infected by one of the common pollution-related diseases such as cholera or typhoid fever and pass it on. It starts with a few cases and then becomes an epidemic that spreads like flames on dry grassland. Limited hospital facilities and medical staff become overwhelmed. In time, the disease may run its course and the epidemic ends but, along the way, thousands will have died. Soon, conditions are ripe again and the infection cycle starts over.

One way to fight infectious disease spread through contaminated water is to purify it before it is used for drinking. Boiling kills microorganisms like bacteria and protozoa in dirty water. Though very effective at killing off the microorganisms, fuel for fires may be in short supply. Another technique for making water safe involves plastic water bottles.

Plastic (PET) bottles are filled with contaminated water and capped. The bottles are placed on a dark metal roof, on a rack, or even on the ground and then exposed to sunlight for 6 hours to two days depending on cloud conditions. Sunlight enters the bottles and some of its heat energy is trapped by the "greenhouse effect." Sunlight heats the water and microorganisms are killed. At the same time, any dirt particles suspended in the water, settle to the bottom, leaving the rest of the water clean. This process is called SODIS which stands for solar water distillation.



SODIS at work in Indonesia. Photo: Wikimedia User: SODIS Eawag CC-BY 3.0.

13) Disease Video from the Inside Out

Osmosis Jones Video

Time Needed

This video can be shown over several sessions

Before You Start

Set up the television or LCD projector, DVD player, and speakers. Obtain snacks for movie watching.

You'll Need This Stuff

Osmosis Jones (2001),
produced by Warner
Brothers (US)
Popcorn
Individual bowls
Beverages

What It's About

Movie Plot Summary

Frank Detomello is a zookeeper with very poor dietary and cleanliness habits. His daughter Shane tries to improve his slovenly behavior. Frank becomes sick after he swallows a germ-infected hard-boiled egg. At first, Frank's sickness appears to be nothing more than a cold. However, a really nasty and black-hearted virus named Thrax entered his body on the egg. Thrax tries to overheat Frank's body and kill him from the inside out. Thrax's plans are eventually thwarted by a white blood cell policeman by the name of Osmosis Jones who works for the immune system of the "City of Frank," the name of the inside of Frank's body.

What's the Question?

The animated sequences in the City of Frank shows the constant battle of the body's immune system with invading microbes. How does the immune system provide protection against infectious diseases?

What to Do

1. Announce that you are proud of the accomplishments of your students. As a celebration of their dedication to fighting infectious diseases, you will show "Osmosis Jones."
2. Dish up popcorn and drinks and have your students settle around the TV or LCD projector.
3. Before starting, ask *Do you know what the immune system is?*
4. Kick back and enjoy the movie.

Wrap It Up

Ask your students to become movie reviewers and rate the movie. On a 10-point system, how many stars did the movie rate?

What did they like about it? What did they dislike?

Did they learn anything about the immune system? What did they learn? List their observations.