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I nfectious diseases have plagued humans throughout history. Sometimes, they even have shaped history. Ancient plagues, the Black Death of the Middle Ages, and the “Spanish flu” pandemic of 1918 are but a few examples.

Epidemics and pandemics always have had major social and economic impacts on affected populations, but in our current interconnected world, the outcomes can be truly global. Consider the SARS outbreak of early 2003. This epidemic demonstrated that new infectious diseases are just a plane trip away, as the disease was spread rapidly to Canada, the U.S. and Europe by air travelers. Even though the SARS outbreak was relatively short-lived and geographically contained, fear inspired by the epidemic led to travel restrictions and the closing of schools, stores, factories and airports. The economic loss to Asian countries was estimated at $18 billion.

The HIV/AIDS viral epidemic, particularly in Africa, illustrates the economic and social effects of a prolonged and widespread infection. The disproportionate loss of the most economically productive individuals within the population has reduced workforces and economic growth in many countries, especially those with high infection rates. This affects the health care, education, and political stability of these nations. In the southern regions of Africa, where the infection rate is highest, life expectancy has plummeted in a single decade, from 62 years in 1990–95 to 48 years in 2000–05. By 2003, 12 million children under the age of 18 were orphaned by HIV/AIDS in this region.

Despite significant advances in infectious disease research and treatment, control and eradication of diseases are slowed by the following challenges.

- The emergence of new infectious diseases
- An increase in the incidence or geographical distribution of old infectious diseases
- The re-emergence of old infectious diseases
- The potential for intentional introduction of infectious agents by bioterrorists
- The increasing resistance of pathogens to current antimicrobial drugs
- Breakdowns in public health systems

For an emerging disease to become established, at least two events must occur: 1) the infectious agent has to be introduced into a vulnerable population, and 2) the agent has to have the ability to spread readily from person to person and cause disease. The infection also must be able to sustain itself within the population and continue to infect more people.

C ooperative learning is a systematic way for students to work together in groups of two to four. It provides organized group interaction and enables students to share ideas and to learn from one another. Students in such an environment are more likely to take responsibility for their own learning. Cooperative groups enable the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. Materials must be managed, investigations conducted, results recorded, and clean-up directed and carried out. Each student must have a specific role, or chaos may result.

The Teaming Up! model* provides an efficient system for cooperative learning. Four “jobs” entail specific duties. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities so that each student has a chance to experience all roles. For groups with fewer than four students, job assignments can be combined.

Once a model for learning is established in the classroom, students are able to conduct science activities in an organized and effective manner. Suggested job titles and duties follow.

** Principal Investigator
- Reads the directions
- Asks the questions
- Checks the work

** Maintenance Director
- Follows the safety rules
- Directs the cleanup
- Asks others to help

** Reporter
- Records observations and results
- Explains the results
- Tells the teacher when the group is finished

** Materials Manager
- Picks up the materials
- Uses the equipment
- Returns the materials

Overview

Students will grow bacteria and/or fungi from a variety of locations and compare the results. They will learn that microbes are everywhere. Some microbes, such as bacteria and fungi, grow readily on sources of food and water. When provided with the resources they need, microbes can reproduce very rapidly.

MICROBES ARE Everywhere

Microbes grow and reproduce in habitats where no other organisms can survive. They can be found in hot springs and deep underground veins of water, in volcanic rock beneath the ocean floor, in extremely salty water in the Great Salt Lake and the Dead Sea, and below the ice of Antarctica. Not even radiation or high levels of deadly chemicals, such as lead or sulphur, can kill the hardest of microbes, referred to by scientists as “extremophiles.” Most extremophiles are single-celled organisms similar to bacteria, called Archaea. Many classifications place Archaea (or archaeabacteria) in their own kingdom or domain, instead of with bacteria.

Microbes also are found in more mundane places, such as on our hands, in the air and in soil. This activity is designed to help students understand the diversity of microorganisms present in our immediate surroundings and on our bodies. It also will teach students how to limit the spread of disease-causing microbes. In addition, students will observe examples of bacteria and fungi.

Bacteria are the most numerous living things on Earth. Each bacterium consists of a tiny cell that must be magnified at least 400 times to be visible. Even though individual cells are not visible without the aid of a microscope, bacterial colonies (clumps of bacteria) grow large enough to be seen clearly.

Yeast are fungi. They are small, single-celled organisms that can reproduce asexually by producing buds. They are known for their ability to obtain energy from food sources through a process known as fermentation. Fermentation yields alcohol and carbon dioxide gas as byproducts. It is used in the production of alcoholic beverages, such as beer and wine, and in making bread and other baked goods.

Molds, which also are fungi, consist of long, tangled filaments. Hair-like masses of molds often contaminate bread and cheese. They also are important, but usually unnoticed components of soil.

Extremophiles include microbes that grow both at or above pH 8 and at or above 60°C. The Three Buddhas geysers in the Nevada Hot Springs is one place where heat-tolerant microbes can be found.

University of Georgia, Savannah River Ecology Laboratory’s C. Zhang.

Curvularia geniculata is a fungus in soil that causes disease, primarily in plants. CDC\204 J. Carr, R. Simmons.

SCIENCE EDUCATION CONTENT STANDARDS
Grades 5–8

Inquiry
- Identify questions that can be answered through scientific investigations.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.

Life Science
- All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Some diseases are the result of damage by infection by other organisms.
- Populations of organisms can be categorized by the function they serve in an ecosystem.

Continued
In some instances, infections by bacteria or fungi can cause disease. Contamination by these organisms also can make food unsafe to eat. The slime found on food that has been in the refrigerator too long is made of clumps of bacteria and sometimes fungi. Eating spoiled food can make humans and other animals sick.

Bacteria can be transferred to food when people do not wash their hands after using the restroom, changing diapers or playing with a pet. Some foods, especially meats and poultry, can have bacteria on their surfaces that can be transferred to other foods if utensils and cutting boards are not washed with soap and hot water after each use.

In the laboratory, bacteria are grown on substances called culture media. The medium usually contains an energy source, such as a sugar dissolved in water, plus other nutrients, such as nitrogen. Culture media can be in liquid form (usually called a broth) or gelatin-like (called a gel).

In this activity, students will grow microbes on a semisolid gel refined from algae, a medium often referred to as nutrient agar.

**MATERIALS**

- 750 mL of nutrient agar (purchase as powder or bottled agar gel)
- 33 100-mm sterile, disposable Petri dishes (to prepare 30 dishes with agar and 3 dishes for templates for student drawings)
- 36 small, resealable plastic bags
- Chlorine bleach solution
- Cotton swabs, 100-count box
- Disinfectant (liquid soap or spray)
- Hot pads or pot holders
- Paper towels
- Resealable plastic bag, medium-size

**Per Group of Students**

- 5 prepared Petri dishes (one dish is the control)

**SETUP**

Place four sterile, cotton-tipped swabs in a resealable plastic bag.

Clean, empty Petri lid or dish (for use as a drawing template)

Container of distilled or boiled water

Magnifiers or low power microscopes

Masking tape

Permanent marker or wax pencil

Colored pencils or markers

12 sheets of white paper for observations (3 per student)

Graph or plain paper

Group concept map (ongoing)
completely melted. To avoid condensation in the Petri dishes, let the agar cool slightly before pouring it into the dishes.

Open each Petri dish slightly, pour in enough agar to cover the bottom, (approximately 1/8 in.), and immediately replace the cover. Let the agar cool and solidify, and then store the dishes upside down to prevent condensation.

During the activity, store sealed Petri dishes upside down in a dark, warm place (at or about 37°C or 98.6°F).

Have students work in groups of four.

SAFETY ISSUES
See sidebar, right.

PROCEDURE
Session 1: Getting Started
1. Ask students to share what they already have learned about where microbes might live and grow. Follow by asking, Do you think there are any microbes in this room? Where might they be? List students’ ideas on the board or overhead.

2. Follow by asking, How could we find out if any microbes are present in these places? Encourage students to share their ideas, reminding them of the activity in which they observed bacteria growing in yogurt. If not mentioned by students, suggest that the class could collect samples from different places, provide opportunities for microbes from the samples to develop, and observe the results.

3. Have each group of students select four places (or more, depending on the number of Petri dishes available) that they would like to test for the presence of microbes. Possibilities include the floor, a doorknob, unwashed hands, etc.

4. Have each group create a table with two columns: “Location Sampled” and “Predicted Results.” Students should record information on this chart as they collect samples. For example, a group might predict that a sample from the doorknob will have more microbes than a sample from the surface of the door.

5. Review Safety Issues with students (right sidebar). Then, give each group five Petri dishes. One dish will be a control. The remaining four dishes will be used to grow cultures (one per student). Have students label the bottom of all five dishes using masking tape and a marker, or by writing directly on the dishes using a permanent marker or wax pencil. (You may grow more than one culture per dish. Simply divide each dish in half or quarters, drawing lines on the outside with a permanent marker.)

6. Have students use a different clean cotton swab dipped in boiled or distilled water for each sample. You may want to have students think about why the water needs to be boiled or distilled. (Otherwise, the water may contain microbes.) Have students rub the moist swab several times over the area to be tested.

7. Instruct students to open the Petri dishes only enough to swab the gel surface. Tell them to rub the swab gently in a zigzag pattern over the surface of the nutrient agar without breaking the surface of the agar gel. Students may repeat the pattern in another direction. Have students close and seal the dishes by taping around the edges. Tell students that they will not be able to see streaks on the plate after swabbing. Have students rub (inoculate) the control dish with a clean, moist swab.

SAFETY ISSUES
Most bacteria are harmless to healthy people. However, because some kinds of bacteria can cause disease, it is important that the Petri dishes remain closed after students have started the cultures.

Students should not collect or test saliva, tears or other body fluids.

Dispose of used cotton swabs by placing them in a resealable plastic bag. Cover swabs with a 10% bleach solution (10 mL chlorine bleach mixed with 90 mL water). Seal the bag and discard.

Dispose of cultures immediately after the activity. Carefully remove the tape used to seal each dish and place each closed Petri dish in a separate, resealable plastic bag. Pour about 20 mL of a 10% bleach solution in the plastic bag. Seal the bag. Through the sides of the closed bag, loosen the cover of the Petri dish enough to allow the bleach solution to move inside and completely cover the contents of the dish. Dispose of cultures immediately. Carefully remove the tape used to seal each dish and place each closed Petri dish in a separate, resealable plastic bag. Pour about 20 mL of a 10% bleach solution in the plastic bag. Seal the bag. Through the sides of the closed bag, loosen the cover of the Petri dish enough to allow the bleach solution to move inside and completely cover the contents of the dish. Dispose of the plastic bag and its contents in the trash.

Follow all district and school science laboratory safety procedures. It is good laboratory practice to have students wash hands before and after any laboratory activity. Clean work areas with disinfectant.
EXTENSIONS

- Have students design additional experiments to test for the presence of microbes. They might examine water from different sources, compare washed vs. unwashed hands, or see which kinds of food grow the most kinds of microbes or spoil most quickly.
- Have students investigate what happens when similar samples are grown at room temperature and in the refrigerator. Based on their results, conduct a discussion about the importance of refrigerating leftover food.

8. Collect used swabs from students and discard as instructed in Safety Issues. Clean all work areas with paper towels and disinfectant.

Sessions 2–4: Follow-up

1. Distribute clean Petri lids or dishes. Have each student use a dish as a template to draw three separate circles, labeled “Day 1,” “Day 2” and “Day 3.” Have each group member observe and draw one of the group’s cultures each day. Ask one group member to prepare an additional sheet for observing the control. Students should take turns making control observations.
2. Have students observe the cultures daily for 1 to 3 days. If possible, have them use a low power microscope to observe the cultures through the lids of the dishes. Do not allow students to open the Petri dishes.
3. Conduct a class discussion. Ask, What has changed inside the Petri dishes? (Bacteria will discolor the surface of the culture medium and form smooth, wrinkly or slimy circular blotches, called “colonies,” of different colors. Molds, which form fuzzy or felt-like colonies, also may be present.)
4. Have students decide how many different kinds of organisms might be growing on their gels, based on differences they can observe. Do not allow students to open the dishes.

Some common microorganisms that might be present include fuzzy green *Penicillium* mold, black fuzzy or hairy bread mold, or various circular white, dark or colored colonies of bacteria. Yeast colonies usually are white. It is not important for students to be able to name all the microbes.

5. On Day 3, have students count the number of colonies, or measure and compare diameters of the colonies on their observation sheets. Have students decide which sample sources had the most microbes. Students’ drawings from all three days also can be used to estimate microbial growth by reviewing changes in the number or size of the colonies over time.
6. Have each group prepare a brief summary comparing its observations with its chart of sample locations and predicted results. Have groups share their summaries with the rest of the class.
7. Based on these reports, have students answer the question posed at the beginning of the activity: Are there any microbes in the room? If so, where are they? Promote discussion by asking questions, such as, If there are microbes all around us, why aren’t we all sick? Relate students’ findings to Activity 1, in which fluorescent powder was used to simulate microbes on students’ hands.
8. Also, discuss the multiple roles of microbes in the environment. Ask, Have you ever seen any colonies of microbes (particularly bacteria and molds) growing on food, on damp surfaces, or in natural environments? What do you think is happening when microbes grow on something? (The microbes are using the substance as a food source.) Discuss the important roles of microorganisms as decomposers of dead organic material in ecosystems.
9. Allow students time to add to their concept maps.