RX FOR SURVIVAL
A GLOBAL HEALTH CHALLENGE

How Safe Are We?

Germs—which include bacteria, viruses, amoeba, fungi, and protozoa—are everywhere. Fortunately, most are harmless and many are beneficial. We've only known about germs for about 150 years. Once we understood they existed, people started figuring out how to treat and prevent the diseases they caused. This understanding also led to identifying preventive actions, such as monitoring, surveillance, and vaccination. These and other public health measures that control the growth and spread of microbes have helped increase life expectancy and improve overall health across the globe.

ACTIVITY AT A GLANCE

PURPOSE: To model how health investigators evaluate a building's potential for harboring microbes

OVERVIEW: Students map their school for hotspots of microbial growth. They swab different locations around the school and culture the samples in Petri dishes. From the microbial abundance and diversity in their cultures, students gain insight into how the environmental conditions at each location influence the presence of microbes. They conclude the activity by recommending ways to decrease the school's microbe population and the potential for spreading infectious disease.

LEVEL: Grades 7–12

TIME: One class period to introduce the activity and conduct sampling. Then, up to four days to grow samples. Conclude with one class period to measure growth and analyze results.

CORE CONCEPTS

- Sampling a site to determine which microbes are present is part of how health workers investigate a disease outbreak.
- Conditions favoring non-disease-causing microbes can also favor disease-causing microbes.
- Bacteria and fungi can be distinguished macroscopically and microscopically, based on general morphological differences.

MATERIALS

- Student sheet for each student
- 2 individually wrapped sterile cotton swabs
- 2 nutrient agar Petri dishes, 10 cm diameter, per student team
- Incubator or warm place to grow cultures
- Percent Cover Estimation diagrams
- 1 Differentiating Bacteria and Fungi sheet per student team (optional)

STANDARDS CONNECTION

Life Science

- 5–8: Structure and Function in Living Systems; Diversity and Adaptations of Organisms
- 9–12: The Cell; Matter, Energy, and Organization in Living Systems

Science in Personal and Social Perspectives

- 5–8: Personal Health
- 9–12: Personal and Community Health

Health

- Standard 1: Comprehend concepts related to health promotion and disease prevention.
- Standard 2: Access valid health information and health-promoting products and services.
- Standard 3: Practice health-enhancing behaviors and reduce health risks.
- Standard 5: Use interpersonal communication skills to enhance health.
- Standard 6: Use goal-setting and decision-making skills to enhance health.
- Standard 7: Advocate for personal, family, and community health.

PROGRAM CONNECTION

Over the past 150 years, advances in medical research and public health have greatly increased life expectancy and overall health across the globe. The advent of epidemiology, the study of disease in a population, provided new strategies for identifying the nature of infectious disease. When the cause of an infectious disease (the bacteria, virus, parasite, amoeba, or fungus) is known, strategies for treating and preventing the spread of disease can also be developed. This program traces the history of investigating infectious disease, from identifying the source of the cholera epidemic in 19th century London to today's efforts to prevent new SARS outbreaks and the ongoing battle against HIV/AIDS. The role of government, research, and international cooperation is highlighted in each story presented in the film. This program is about how new diseases emerge, why emerging diseases can be so dangerous, and what the world needs to do to control them.

In this activity, students play the role of health investigators and identify potential hotspots for microbes in their school. They collect and culture microbial samples, identify factors that promote the growth of microbes, and recommend ways to reduce their numbers and the potential for spreading infectious disease.

BEFORE WATCHING

In a class discussion (or in small groups), elicit students' existing ideas about the nature of infectious diseases and infectious agents. Specifically, ask students:

- to brainstorm a list of diseases. Then have them categorize which are infectious and which are non-infectious (i.e., chronic).

  Infectious diseases are caused by infectious agents, such as bacteria or viruses and can be transmitted from one host to another. Examples include: flu, HIV/AIDS, tuberculosis, malaria, and pneumonia. Chronic diseases, such as asthma, heart disease, cancer, Downs syndrome, and diabetes, are not caused by an infectious agent and cannot be transmitted.

- how they would define the term *germs*. What do they know about microbes? What distinguishes infectious microbes from non-infectious ones?

AFTER WATCHING

- In the program, which disease-causing microbes were shown? Describe how these infectious diseases are spread.
- Describe ways public health officials try to prevent the spread of disease in a population.

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FOR MORE INFORMATION

pbs.org/rxforsurvival

PROCEDURE

1. Demonstrate how easy it is for germs, such as *E. coli*, to spread from person to person. Place a small amount of fine-sized glitter on the right palm of several students. Ideally, use a different color of glitter each time. Have them shake hands with their classmates. The activity works equally well with students staying at their desks or circulating in a small area. The advantage of having students circulate is that everyone—not only those whose hands were initially dusted with glitter—can shake hands multiple times, dispersing different colors of glitter rapidly through the class. After a minute, have the class examine their palms and report the quantity and color of glitter. Ask students what the glitter represents. (*Germs*) What parts of the school building would have large deposits of glitter if everyone's hands were covered in glitter? (*Doorknobs, desks, writing implements, lockers, and computer keyboards*) Brainstorm ways to avoid transmitting the glitter. (*Washing hands; taking a vaccine that doesn't let the glitter stick; avoiding direct contact; and reducing the amount of glitter present in the environment.*)

2. In small groups, have students discuss the four questions in step 1 of the student sheet. After 5–10 minutes, conduct a class discussion to establish how much they know about the nature of "germs" and the difference between disease-causing microbes and other microbes in the environment. See the Assessment section for answers to the questions and for key discussion points.

3. Tell the class that their task is to map the school for hotspots of microbial growth. In doing so, they will be mirroring how health detectives investigate disease outbreaks. Specifically, the goal is to determine what conditions promote microbial growth and which of the school's cleaning methods are most effective. Create student pairs or teams and have them complete steps 2–5. Step 6 asks you to approve their testing plan. Keep track of the locations students have selected. Ensure that the class investigates as much of the school as is feasible.

SAFETY NOTE: *Students might be tempted to cough onto a dish. However, sampling bodily fluids is unsafe. It is possible that infectious microbes dangerous to humans might grow on the dishes in such large numbers that it could pose a hazard to anyone opening the dishes.*

4. Before distributing Petri dishes for testing, demonstrate the proper sampling technique.
   - *Label a Petri dish with the date, sampling location and condition, and experimenters' initials.*
   - *Unwrap the sterile swab without touching the end to fingers or any surface.*
   - *Gently brush the end of the swab over an inch or two of the surface to be sampled.*
   - *Tilt the Petri dish lid to about 45 degrees and so that it is still partially covering the dish.*
   - *Gently brush the end of the swab in a zigzag pattern fully across the agar, brushing eight to ten times across the surface. Cover all parts of the dish.*
   - *Seal the dish with tape so that the top and bottom are firmly secured together.*

5. Store dishes upside down in a warm, dark place. Be sure to keep pairs of dishes in the same conditions for the same amount of time.

6. Have students check daily for growth. Some plates will grow faster than others. So that students can see the colonies well enough to count them, refrigerate the quickly growing plates. When a plate becomes half covered in growth, refrigerate it until the entire class set is ready to analyze. Note the number of hours it took for these plates to become half covered.

SAFETY NOTE: *Do not store dishes in a refrigerator used for food storage.*

7. After several days, students examine the dishes and record their observations (steps 8–12 on the student sheet). Create a map of hotspots of microbial growth based on the class data.

SAFETY NOTE: *To safely dispose of the closed Petri dishes, put them in a sturdy plastic bag. Add some bleach to the bag and close it tightly. Put the bag into another sturdy plastic bag, and tie the second bag tightly. Use a hazardous waste disposal facility, if available. If not, place the double-bagged dishes in the regular trash.*

8. Discuss questions 13–14 as a class. Discussing the environmental conditions that seem to promote microbial growth will give students ideas about how to reduce their numbers by eliminating favorable conditions. Based on the student data, have the class make a recommendation to the school principal for steps the school could take to

continued

PROCEDURE (continued)

reduce student exposure to microbes. In addition, consider discussing the following questions:

- Do all of the microbes growing on the dishes cause disease?

  No. Most microbes are harmless to humans; many are beneficial, such as the bacteria in the gut and those that decompose dead material. One would have to grow the bacteria on selective media to determine which ones cause disease.

- How well does the growth on the dishes represent the disease-causing microbes present in the school environment?

  With this test, one cannot tell disease-causing bacteria from harmless ones. However, one can infer that places that harbor many bacteria or many kinds of bacteria may support the survival of disease-causing bacteria, too.

GOING FURTHER

In a Petri dish, bacterial and fungal colonies can look very similar. To differentiate them with certainty, students would need to grow them in dishes with specially treated growth medium. Nevertheless, students may still be able to tell whether the growth on their plates is bacterial or fungal. Often, fungi look dry and fuzzy while bacterial colonies may look wet, shiny, or sticky.

Have students follow the procedure on the Differentiating Bacteria and Fungi student sheet. They use a microscope to examine a sample from the plates stained with methylene blue and should be able to differentiate the bacteria from the fungi. Before they begin, demonstrate the following technique for creating a slide of a sample from a Petri dish.

- Wearing gloves, tilt the cover of the plate just far enough to fit a toothpick between the cover and the bottom of the plate.
- Gently touch the toothpick to the growth on the plate two or three times.
- Rub the toothpick onto a microscope slide, spreading the sample as thinly as possible.
- Place a drop of methylene blue on the sample.
- After two minutes, shake the slide to remove most of the methylene blue dye. Then, place a coverslip over the sample.
- Observe the sample at 400x (or 1000x with oil immersion, if available).

Generally, individual bacteria cells can be distinguished at 400x, though this is not possible for all species. You may want to review bacterial morphology in your textbook with the students. Many fungi will appear to be fibrous at 400x magnification. Again, even under a microscope, it may not be possible to distinguish bacteria from fungi in every case, but if a range of samples are observed from the students plates, you should expect to have some examples where a distinction can be observed.

ASSESSMENT

Students' responses to the questions on the student sheet should incorporate the points discussed in the answers included in this section. In addition, consider the following when assessing student work:

- Supported the team by contributing to the discussion, listening to others' ideas, discussing a variety of views, and helping the team develop a consensus.
- Chose sampling sites that helped the class's effort to pinpoint hotspots of microbial growth.
- Followed directions, asked appropriate questions about sampling and culturing, and conducted their testing and culturing in a safe manner.
- Made carefully observations of the growth on the Petri dish and reported data completely and accurately.
- Drew conclusions about the two tests that accurately reflected their data. Related conclusions to the predictions. Applied these conclusions to the class challenge of identifying hotspots for microbial growth and the environmental conditions that foster this growth.
- Related their results to class results and wrote thoughtful responses to student sheet questions reflecting class sampling data and discussion.
- Demonstrated an understanding of the conditions that favor microbial growth and how health investigators evaluate a building's potential for harboring microbes.
- Devised a thoughtful strategy to reduce student exposure to microbes. Based recommendations on factors that affect microbial growth, such as temperature, presence of food sources, moisture, light, cleaning methods, and toxicity of disinfectants.

ANSWERS TO *HOW SAFE ARE WE?* STUDENT SHEET

1. As a group, answer the following questions. Be prepared to share your ideas with the class.

(a) What are "germs"? What types of organisms are they and what do they look like?

The term germs *is used to describe microbes, such as bacteria, viruses, fungi, amoeba, and protozoa. Though the individual microbes are microscopic, bacteria can form visible colonies on Petri dishes, fungi can grow filaments and colonies that can be seen, and bacteria and protozoa can turn water cloudy.*

(b) Do disease- and non-disease-causing microbes exist in the same general places? Explain.

Places that harbor harmless microbes may harbor disease-causing microbes, too.

(c) List environmental conditions that might affect how well microbes grow in a particular place.

Answers might include: Amount of moisture available; the amount of air circulation; the number of people passing by; how often the location is cleaned; and the amount of light.

(d) How might one determine whether microbes are present and what kinds they are?

One would have to sample a location and culture the samples to see if anything grew on them. If so, one would then have to examine the characteristics what grew on the plates to tell what kinds of microbes were present. One could also use selective media, which promotes the growth of a specific kind of microbe. One could use it to distinguish bacteria from fungi as well as distinguish specific types of bacteria and fungi.

2. Name some places that you predict will have: (a) Many microbes (b) Few microbes

Horizontal surfaces near where people congregate, such as desks, tables, and floors, tend to have high numbers of microbes. Objects that people touch, such as doorknobs, pens, pencils, calculators, lockers, and computer keyboards, will also have high numbers of microbes. Shoes track dirt from outside and carry material and microbes around the school. As a result, floors often have high numbers and a diversity of microbes.

3. Think about the ways your school is cleaned. Choose a cleaning method, such as mopping a floor, sponging a table, vacuuming a rug, or disinfecting a sink. Predict how much change there will be in the number of microbes before and after someone cleans using this method.

To test the effectiveness of the school's cleaning program, students could sample at a single location before and after cleaning. They could also test whether different cleaning methods have a different effect. For example, the frequency of cleaning, what time of day cleaning takes place, the thoroughness of mopping and sponging, and the kind of cleanser or disinfectant used will all likely affect the number and diversity of microbes.

For the questions in steps 4–12, answers will vary based on the situations that students sample.

13. What kinds of environmental conditions do microbes seem to prefer?

Microbes typically prefer moist locations away from direct sunlight. People help spread microbes. Thus, microbes also exist in large numbers in places frequented by people.

14. Examine the data from all of the comparisons carried out by your class. Based on these results, write a recommendation to the school principal for strategies to reduce student exposure to microbes.

Recommendations might include: Cleaning more frequently; cleaning with antiseptic or anti-bacterial cleansers; improving ventilation to reduce humidity and filter the air; launching a hand-washing campaign; adding disinfectant to mop water and changing it frequently; making a concerted effort to mop up spills and dry out moist areas; reminding people not to come to school when they are contagious; and reminding everyone to use medicines correctly: If taking antibiotics, follow the doctor's directions and finish the full course, if indicated.

Percent Cover Estimation Diagrams

The six diagrams below show what different amounts of growth on a Petri dish look like. Choose the diagram that most closely matches the amount of growth on your plates.

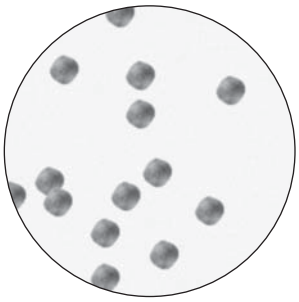


PLATE 1: 15% COVERAGE

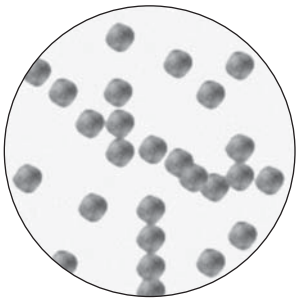


PLATE 2: 30% COVERAGE

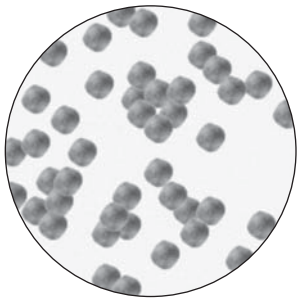


PLATE 3: 45% COVERAGE

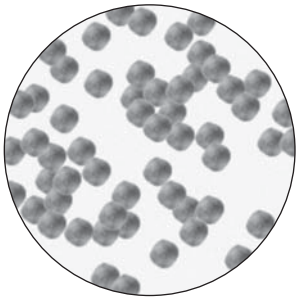


PLATE 4: 60% COVERAGE

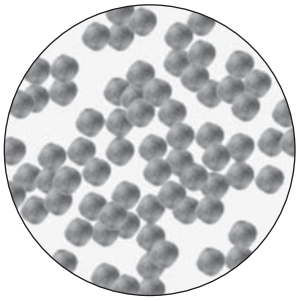


PLATE 5: 75% COVERAGE

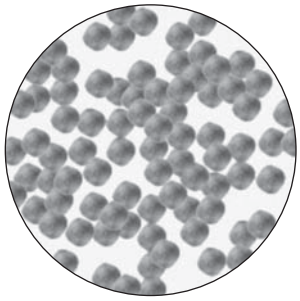


PLATE 6: 90% COVERAGE

RESOURCES

RELATED RX FOR SURVIVAL WEB SITE FEATURES (see pbs.org/rxforsurvival)

Why Global Health Matters: Learn why we should all be involved in global health initiatives.

Global Health Atlas: Examine levels of infectious disease around the globe.

Deadly Diseases: Learn about some of the diseases that are humanity's most feared killers.

Global Health Champions: Learn about present-day men and women who have profoundly changed global health outcomes and saved lives in many parts of the world.

Ask the Experts: Post a question about pandemics—past and possibly future.

Get Involved: Find meaningful ways to take action.

Dispatches from the Field: Hear first-person accounts from people on the frontlines of health care.

LINKS

American Experience: Influenza 1918
pbs.org/wgbh/amex/influenza
Learn how a deadly strain of the flu triggered the worst epidemic in American history.

Epidemic! The World of Infectious Disease
amnh.org/exhibitions/epidemic
Take a virtual tour of the American Museum of Natural History's exhibit on infectious disease.

NOVA: The Most Dangerous Woman in America interactive activity
pbs.org/wgbh/nova/typhoid/detective.html
Play the role of an epidemiologist investigating a mysterious disease outbreak.

UNAIDS
unaids.org/en/default.asp
See how the Joint United Nations Programme on HIV/AIDS is responding to this global threat to public health.

World Health Organization: Communicable Disease Surveillance & Response
who.int/csr/en
Find out how WHO's epidemiologists identify and contain potential outbreaks of disease.

BOOKS

Chanda's Secrets Allan Stratton. Toronto: Annik Press, 2004.
Read the moving story of Chanda, a 16-year old girl from sub-Saharan Africa, whose mother and best friend are dying from AIDS.

DK Eyewitness Books: Epidemic Brian Ward. New York: Dorling Kindersley, 2000.
Examine highly detailed, full-color photographs of disease-causing microbes and learn the history of humankind's attempts to control and eliminate them.

Fever 1793 Laurie Halse Anderson. New York: Simon & Schuster, 2000.
Experience the horrors of the yellow fever epidemic that took the lives of 5,000 Philadelphians in three months.

Invisible Enemies: Stories of Infectious Disease Jeanette Farrell. New York: Farrar, Straus and Giroux, 2005.
Read medical histories and personal stories from sufferers of seven of the most dreaded infectious diseases: smallpox, leprosy, plague, tuberculosis, malaria, cholera, and AIDS.

Outbreak: Disease Detectives at Work Mark P. Friedlander. Minneapolis: Lerner Publishing Group, 2003.
Meet the people whose job it has been—from ancient Greece to the present day—to track, control, and if possible, contain outbreaks of disease before they escalate into epidemics.

SARS—A Case Study in Emerging Infections A. McLean, R. May, J. Pattison, and R. Weiss, Eds. Oxford: Oxford University Press, 2005.
Follow a team of scientist-detectives racing to contain the 2003 outbreak of Severe Acute Respiratory Syndrome (SARS).

When Plague Strikes: The Black Death, Smallpox, AIDS James Cross Giblin. New York: Harper Trophy, 1997.
Discover striking parallels in the history and social impact of the Black Death, smallpox, and AIDS.

RX FOR SURVIVAL
A GLOBAL HEALTH CHALLENGE

How Safe Are We?

Stephen Schudlich ©WGBH Educational Foundation

Health investigators track down disease the way detectives track down criminals. They inspect buildings where disease outbreaks occur. They take samples to find out where disease-causing microbes live. They find out how areas are cleaned and interview people to learn what they do and how they move around a building. If an illness were going around your school, where would you look to find the cause? Your challenge is to predict places in your school where microbes might like to grow. Then you will test your predictions and recommend ways to limit students' exposure to microbes, thus reducing people's chances of getting sick.

1. As a group, answer the following questions. Be prepared to share your ideas with the class.

(a) What are "germs"? What types of organisms are they and what do they look like?

DID YOU KNOW?

95% of all microbes are not harmful to humans.

(b) Do disease- and non-disease-causing microbes exist in the same general places? Explain.

(c) List environmental conditions that might affect how well microbes grow in a particular place.

(d) How might one determine whether microbes are present and what kinds they are?

DID YOU KNOW?

The influenza epidemic of 1918 killed 25 million people in one year.

2. Your class's challenge is to test the school and find where microbes like to live. To tell whether the number of microbes growing in your test area is high or low, you need to make a comparison. Name some places that you predict will have:

(a) Many microbes _____

(b) Few microbes _____

Explain why you think these places have different numbers of microbes.

_____

_____

DID YOU KNOW?

Microbes are the oldest form of life on earth—some types have hardly changed in billions of years.

3. Think about the ways your school is cleaned. Choose a cleaning method, such as mopping a floor, sponging a table, vacuuming a rug, or disinfecting a sink. Predict how much change there will be in the number of microbes before and after someone cleans using this method.

Location being cleaned: _____

Method used to clean this location: _____

(a) Predicted abundance of microbes before cleaning: High Medium Low

(b) Predicted abundance of microbes after cleaning: High Medium Low

Explain how you think the cleaning process affects the numbers of microbes.

_____

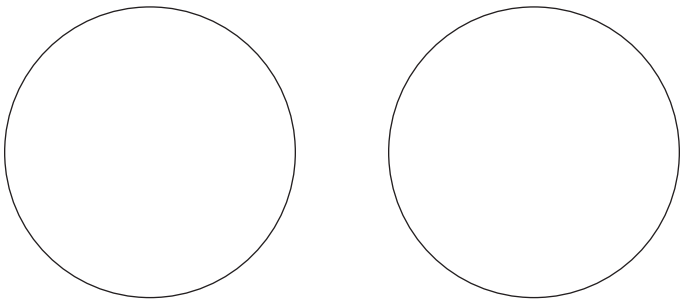
_____

4. Your teacher will give you and a partner two Petri dishes. This will let you take two samples. You could sample two different locations. Alternatively, you could do a before-and–after test to see how well a cleaning method works. Describe the test you and your partner plan to do.

_____

_____

5. Sketch how much growth you think will be on the Petri dishes after several days.



PREDICTION FOR SITUATION 1 **PREDICTION FOR SITUATION 2**

DID YOU KNOW?

Experts recommend closing the toilet lid before flushing, as aerosolized bacteria from the bowl can land up to 20 feet away.

6. After your teacher approves your testing idea, get two Petri dishes. Label the bottom of each one with your initials, the date, and where and when you will obtain the sample.

DID YOU KNOW?

Germ warfare is not new. In 1346, the Tartars held the city of Kaffa under siege. To force a surrender, they hurled the dead bodies of plague victims over the city walls.

7. Use the following sampling technique to collect microbes for your investigation.

- Unwrap the sterile swab without touching the end to fingers or any surface.
- Gently brush the end of the swab over an inch or two of the surface to be sampled.
- Tilt the lid of the Petri dish at 45 degrees and so it still is over the dish. Keep the lower edge of the lid in contact with the base of the plate. (**FIGURE A**)
- Gently brush the end of the swab in a zigzag pattern fully across the agar, brushing eight to ten times across the surface. Cover all parts of the dish. (**FIGURE B**)
- Close the lid and seal the dish with tape, firmly securing the top to the bottom. (**FIGURE C**)
- Store all dishes in a warm, dry place, as designated by your teacher.

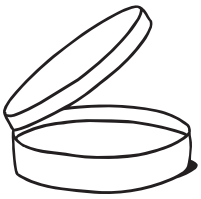
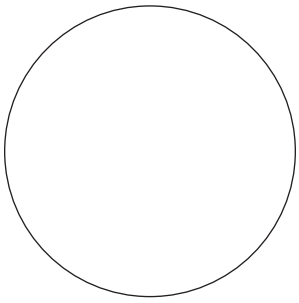
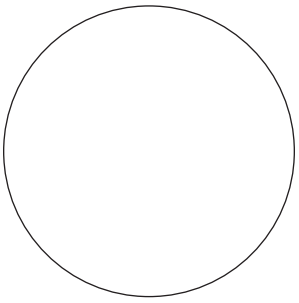


FIGURE A

8. After several days, examine the Petri dishes. Sketch what the growth in each dish looks like.



SITUATION 1



SITUATION 2

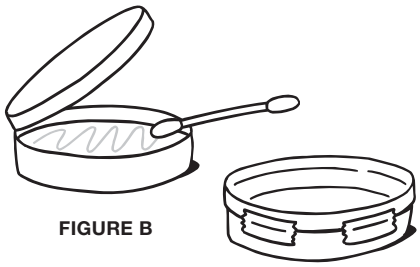


FIGURE B

FIGURE C

9. Determine the amount of growth in each dish. Get a Percent Cover Estimation sheet from your teacher and decide which picture most closely matches the appearance of your dishes.

Estimated percent coverage for the:

Situation 1 dish _____% Situation 2 dish _____%

10. Different types of microbes can have different colors, shapes, and textures when growing in colonies on a Petri dish. How many different types of microbes can you identify? If possible, use a hand lens and estimate the number of different kinds of microbes growing on the:

Situation 1 dish _____ Situation 2 dish _____

11. How well did your results match your predictions? Explain.

_____

12. What do your results reveal about the presence of microbes in the two situations you tested?

_____

13. What kinds of environmental conditions do microbes seem to prefer?

_____

14. Examine the data from all of the comparisons carried out by your class. Based on these results, write a recommendation to the school principal for strategies to reduce student exposure to microbes.

_____

_____

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GOING FURTHER: Differentiating Bacteria and Fungi Student Sheet

To accurately tell fungi and bacteria apart, you must culture samples separately, examine them both on the Petri dishes and under the microscope, and apply specialized stains or conduct other biochemical tests. In many cases, however, you can make a reasonable guess about whether a sample is bacterial or fungal based on its appearance on the Petri dish and observing a stained sample under the microscope.

A. CHOOSE SAMPLES

Bacteria and fungi growing on a Petri dish can look nearly identical. However, many fungi look dry and fuzzy while many bacteria are likely to grow in rounded, sticky clumps. Under 400x or 1000x magnification, bacteria appear as rounded or long, narrow individual cells. They may be clumped together, but the individual cells are usually visible. Fungi, on the other hand, usually appear as long thin fibers. Individual cells are usually not visible. On your Petri dishes, identify what you think is a colony of bacteria and a growth of fungi.

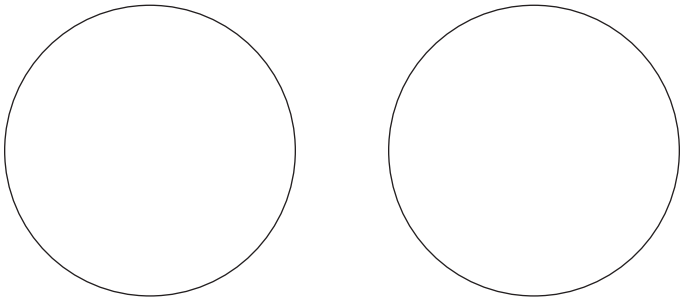
B. PREPARE MICROSCOPE SLIDES

Make one slide that you think represents bacteria and one that you think represents a fungus. Prepare a stained sample following these steps:

- Wearing gloves, tilt the lid just enough to fit a toothpick between it and the bottom of the dish.
- Gently touch the toothpick to the growth on the dish two or three times. Rub the toothpick onto the center of a microscope slide, spreading the sample as thinly as possible.
- Add a drop of methylene blue to the sample.
- After two minutes, shake the slide to remove the methylene blue and place a coverslip over the sample.

C. MAKE OBSERVATIONS

Observe the sample at 400x (or 1000x with oil immersion, if available). Even under the microscope, it can be difficult to distinguish between these fungi and bacteria. Can you identify individual bacteria cells or long thin fibers of fungal cells? Sketch what you see on each slide.



SLIDE 1 **SLIDE 2**

SLIDE 1: Do you think this is a sample of bacteria or fungi? Explain.

SLIDE 2: Do you think this is a sample of bacteria or fungi? Explain.