4-H Project Connection:

- Foods and Nutrition
- Healthy Lifestyles
- Animal and Veterinary Science
- Environmental Science

4-H Science Abilities:

- Categorize, order and classify
- Observe
- Use science tools

4-H Life Skills:

- Cooperation
- Communication
- Disease prevention

Colorado Standards:

Grade 7: (2) Life Science: 3. Cells are the smallest unit of life that can function independently and perform all the necessary functions of life.

Grade 5: (2) Life Science: 1.1. Different organism structures are adapted to different functions to ensure survival, and humans often manipulate these different structures for their own uses such as making building materials, food, and medicines.

Grade 4: (2) Life Science: 1. All living things share similar characteristics, but they also have differences that can be described and classified.

STEM Connections

Colorado State University Extension

Connecting Science, Technology, Engineering, and Math concepts to our everyday lives.

Good "Bugs", Bad "Bugs"

How can we find out what microbes do when they are so small we can't see them?

What foods would we not have if microbes did not help make them?

How do we keep microbes from making us sick?

Long ago, people told stories about invisible gods and goddesses to explain why things happened. In this activity, you are going to explore something else you can't usually see and learn how those "invisible" beings affect everything that goes on in our lives. These tiny organisms are called microbes, a term which describes any organism too small to be seen without a microscope.

You have probably been warned about microbes, often called germs, and you have learned that germs are a bad thing. However, microbes, just like most things, have good actors and bad actors. What do you know about those bad "bugs"? You know that bacteria and viruses can cause a nasty variety of illnesses. Bacteria can make people sick when the wrong kind grow in foods or beverages. You might know that fungi can cause athletes foot. If you know someone who has become ill from drinking untreated water, you may have encountered an illness caused by a protist.

But did you know that microbes are the oldest form of life on earth? Microbe fossils date back almost 3.5 billion years, thousands of millions of years before dinosaurs roamed the earth. Microbes are still everywhere. Microbes are in the air we breathe, the ground we walk on, the food we eat—they're even inside us. We couldn't digest food without them, plants couldn't grow, garbage wouldn't decay and there would be a lot less oxygen to breathe. Microbes convert nitrogen from the air into nitrates in the soil for plants to use. Microbes living in one of the cow's four stomachs called the rumen allow it to digest grass and ultimately produce milk. A yeasty loaf of bread, yogurt and cheese, pickles, pepperoni - none of these would be possible without microbes. In fact, without these invisible companions, our planet as we know it wouldn't survive!

In this activity you will learn about four kinds of microbes; viruses, bacteria, protist and fungi. What is each like? You may know that the instructions for the next generation of an organism are found in its genetic material (DNA or RNA – deoxyribonucleic acid or ribonucleic acid). How that material is placed in the organism helps classify each one.

- The very simple and very tiny virus is just a strand of generic material inside a tough protein coat. When a virus infects a cell, it takes over the genetic material of the cell and makes millions of copies of itself. The cell bursts and a million new viruses go looking for new host cells.
- Bacteria are more complicated. They are a bag of jelly-like substance called cytoplasm surrounded by a cell membrane and a rigid cell wall which holds everything in. Their DNA is organized into a chromosome which looks like a twisted ladder. This structure floats free in the cytoplasm. The absence of an organized structure, the nucleus, to contain the DNA is a defining characteristic of bacteria. Bacteria have three shapes. Cocci (singular coccus) are round, bacilli (bacillus) are rod shaped and spirilla (spirulum) are spiral shaped.
- Protist (the plural form doesn't have an s) can be either single celled, live in colonies and occasionally multi-celled. A tiny amoeba is a protist. So is kelp, a seaweed that can be hundreds of feet long. The DNA of protist is contained in a nucleus closed in by a nuclear membrane. They also have other small contained structures called organelles that carry out special jobs in their cytoplasm. Some protist like Euglena have chlorophyll so they can make their own food. Others hunt for food like animals. Most have some kind of movement.
- Last, but not least, fungi also have a nucleus and a rigid cell wall. Fungi can also be large enough to see without a microscope, when a huge mass of single cells clings together to make big structures like mushrooms. Actually the largest living thing found so far on earth is a fungus that covers 2,200 acres in Oregon's Malheur National Forest. Fungi include single cell creatures like yeast and molds which are a collection of single cells with holes in their cell walls so they can share cytoplasm and genetic material.

EXPLORE IT - DESIGN IT - DO IT

Grades: 4-7

Time: 1 hour

Materials:

Microscope

Simple organisms slide set

Glass slides- 5 per group

Coverslips – 5 per group

Rubbing alcohol

Lens tissue / tissue paper

Yeast

Sugar

Moldy bread (2-3 slices)

Live culture yogurt

Pipettes – 2 per group

Toothpicks

Small containers (2 T or 25 ml) to mix yeast and distribute yogurt samples

¼ tsp measure

Water

Microbe card sets

Paper for observations/sketches

Power Words:

Organism – a living thing

Microbe – organism too small to be seen without a microscope.

Virus - the simplest and tiniest microbes, 10,000 times smaller than bacteria. Viruses are a strand of genetic material (DNA or RNA) inside a protein coat.

Bacteria – microscopic organisms whose DNA is not in a contained nucleus and which have a cell wall.

Fungi - a group of organisms with a nucleus and cell wall which includes microorganisms such as yeasts and molds as well as mushrooms.

Protist- a group of organisms that don't fit into any other group, they can be animal-like, plant-like or fungus-like, but all have a nucleus. They can be one tiny cell to over 100 meters long.

4-H STEM: Connecting the Science, Technology, Engineering, and Math concepts to our everyday lives.

Experience / "What to Do" *Wash your hands!*

Today you will be making slides and using a microscope. Remember when working with microbes, there is always the possibility that something pathogenic (or disease causing) can be lurking around. Microbiologists are very careful to keep their work spaces sterile, wash their hands often, not inhale any of the samples, keep hair and clothing out of samples, and keep coughs and sneezes away from their work. As you make your slides, be very careful not to put your hands near your face and do not inhale close to any of the samples.

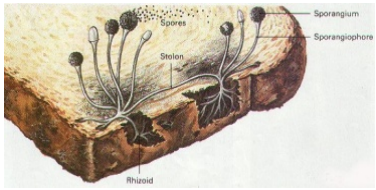
Activity One: Make a T chart. List all of the good things you can think of that microbes do in the "Good" side. List all the harmful things microbes do on the "Bad" side.

Activity Two: Use the microscope to look at some prepared slides of helpful and harmful microbes. Look at the "Bacteria Rap Sheet" and find out if your slide is helpful or harmful. Record 3 facts on the class chart and include a drawing of the specimen you saw.

Activity Three: Your group will prepare and study 3 slides – one of yeast cells, one of bread mold cells and one of active culture yogurt. Get a sheet of paper so you can record your observations and make sketches.

Prepare a clean slide and cover slip for each sample by wiping them with a piece of tissue moistened with rubbing alcohol and allowing them to dry.

Yeast: Fill your pipette with 1 ml of the yeast solution. To fill the pipette, squeeze the bulb, insert it into the liquid and release the bulb. Then carefully squirt this into 10 ml (1 Tablespoon) of water – draw water in and out of the pipette by squeezing to flush the yeast out. Draw a small amount of your yeast solution into the pipette and then drop a very small amount onto your cleaned slide. Use the pipette to smear it around a little. Hold a cleaned cover slip by its edges at a 45° angle at the edge of the smear. Lower it by reducing the angle until it lies flat over the smear. The far edge should touch the slide last. This prevents air bubbles from being trapped under the slide. Observe at 10X magnification. Use the knobs to move the slide around until you find a place with lots of individual cells. Ignore the air bubbles which will be circles with very dark rims. Observe. Change to the 40X magnification. Refocus. What shape are the cells? Can you see any budding? Sketch what you see. If you have time, make another slide after the yeast solution has been sitting for about 1 hour. Do you see any differences?



Bread mold: Place a drop of clean water on a cleaned slide. Using a toothpick, take a very small piece of mold from the bread sample. Be careful not to breathe in any of the mold. Swish the toothpick around in the water drop and then use the toothpick to spread the drop into a small smear. Cover with a cover slip. Observe under 10X and 40X. Also try using the digital zoom button to see how this affects what you can see. Sketch what you see. Look at the diagram and label your drawing.

"Live cultures" in yogurt.: Take a toothpick and put a small amount of yogurt on your clean slide. Cover with a cover slip. Observe under 10X and 40X. Change the digital zoom from 2 to 3 to 4 to see if you can see more. Write 1-2 sentences about what you have observed.

Take care of your used slides as directed by your teacher. **Wash your hands!**

Activity Four: Work with your group to put the deck of microbe cards into categories. Be able to explain to the whole class why you grouped them as you did. Your teacher will give you some other tasks to do with the cards.

Activity Five: Go back and look at your T-chart. What can you add?

Final Activity: Share all your materials with the whole group. Can you answer these questions? Why do you think bread has to rise for a period of time before you bake it? Why is it so easy for bread and other foods to become moldy? Why is eating live culture yogurt good for you?

Share/Reflect/Generalize/Apply :

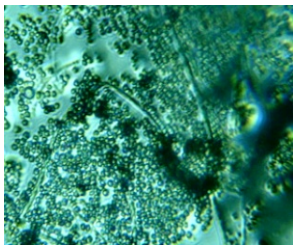
Why did we not look at a virus in our microscope work?

How has your opinion about microbes changed?

What is something you might do differently as a result of doing this activity?

What is a question you still have about microbes?

What are some other questions you could explore using the microscope?



Career Connections:
Microbiologists work in many different fields. Medical microbiologists can work anywhere from a hospital lab identifying the causes of patient illnesses to laboratories doing research on new diseases and cures. Some medical microbiologists work in the pharmaceutical industry finding new medicines that can be made by microbes. Veterinary microbiologists work to prevent and treat illness in animals. Food microbiologists enhance public health and safety by monitoring the safety of the food supply and tracing sources of food borne illnesses. Environmental microbiologists study the interaction of microbes with the soil, water, air, wildlife and plants. Their work may include finding ways to use microbes to combat pollution.

References

Bread mold diagram http://www.google.com/imgres?imgurl=http://www.silverfalls.k12.or.us/staff/read_shari/mysite/tigerbreadmold.jpg&imgrefurl=

http://www.aboutbioscience.org/microbiologist.html

http://www.microbeworld.org/

This STEM Connection was developed by: Christy Fitzpatrick. To find out more about 4-H STEM activities, contact your local county Extension office. http://www.ext.colostate.edu/cedirectory/countylist.cfm More activity sheets can be found at http://www.colorado4h.org/k12/activity_sheets/activity.php

Teacher Tips

- Remind students to wash their hands before and after this activity.
- For a great primer on microbes and complete instructions for the card game, go to http://www.k8science.org/resources/files/TSO_Mic_05_s.pdf.
- 3-4 days before this activity, place a few drops of water on 2-3 slices of bread, place into a sealed plastic bag and put it in a warm, dim place. To get bread mold samples, have students reach into the bag with a toothpick and take a very small bit of the mold. Seal the bag as soon as everyone has their sample and leave sealed when you throw it away. Students who have a mold allergy should not get too close to this experiment.
- Purchase a container of live culture yogurt. You can also use yogurt starter by mixing a ¼ tsp into warm water about 20-30 minutes before class.
- Twenty to thirty minutes before class, start the yeast solution growing by placing ¼ tsp. Yeast and ¼ tsp sugar into 25 ml.(2 Tablespoons) of warm water. Groups will use this to make a diluted solution to put on their slide. Tell them that precise dilutions are a strategy used by microbiologists to count organisms in a sample.
- Work in groups of 3 or 4. Each group can make a set of slides. Different groups doing different activities will keep them busy while waiting for the microscope.
- If students place their slides and cover slips on a sheet of color paper, they are much easier to find.
- For Activity 2, make each group a Bacteria Rap Sheet with the Gram stain definition on the back. To do the activity, give each group a "Bacteria Rap Sheet" and a helpful and a harmful sample. Each group should make a drawing of each of their microbes and a list of 3 facts to share. Create a class poster of helpful and harmful bacteria that includes data from each group.
- In Activity 3, students can use the photography feature on the microscope to do photos of their slides instead of drawings. There are directions with the microscope paperwork. The pictures are a nice quality and easy to print or import into a document.
- Putting used slides and slips into a container of warm soapy water will prevent losses in the drain and allow careful washing and drying later.

Bacteria Rap Sheet—The Good, The Bad and The Ugly

Hay bacilli (Bacillus subtilis)

Bacillus subtilis, also called **hay bacillus** or **grass bacillus**, is a Gram-positive bacteria commonly found in soil. *B. subtilis* is rod-shaped, and is able to form a tough, protective endospore that lets it survive extreme environmental conditions. Bacillus subtilis colonizes the roots of plants metabolizing phosphates and nitrates, plant nutrients, into more available forms. *It is also* used as a fungicide on flower, ornamental seeds, and agricultural seeds including seeds for cotton, vegetables, peanuts, and soybeans because it competes with disease causing fungi on plant roots. *Bacillus subtilis* secretes large quantities of industrially important enzymes, for example, enzymes produced by *B. subtilis* are used on laundry detergents. It is easy to manipulate the genes in B. subtilis so lots of research is done on these bacteria. Some strains can decompose explosives and radioactive materials into harmless compounds and clean up oil slicks.

http://www.ebi.ac.uk/2can/genomes/bacteria/Bacillus_subtilis.html http://ilovebacteria.com/spore.htm

Milk souring bacteria (Streptococcus lactis)

Lactococcus lactis(formerly called Streptococcus lactis) is a Gram-positive bacteria used in the production of cheese and buttermilk and has recently also become famous as the first genetically modified organism to be used alive for the treatment of human disease. *L.. lactis* cells are cocci that group in pairs and short chains. The ability to produce lactic acid is one of the reasons why *L..lactis* is one of the most important microorganisms in the dairy industry. *L. lactis* is of crucial importance for manufacturing dairy products, such as buttermilk and cheeses. When *L. lactis* is added to milk, the bacterium uses enzymes to produce energy molecules from lactose, a sugar found in milk. The byproduct of the energy production is lactic acid. The lactic acid curdles the milk that then separates to form curds, which are used to produce cheese. Other uses of this bacterium include the production of pickled vegetables, beer or wine, some breads, and other fermented foodstuffs, such as soymilk and kefir. http://textbookofbacteriology.net/lactics_5.html

Intestinal bacteria (Escherichia coli)

Escherichia coli is a Gram-negative, rod shaped bacterium commonly found in the lower intestine of almost all warm-blooded organisms. The gastrointestinal tract of human babies is usually colonized by these bacteria within a few hours after birth. Most *E. coli* strains are harmless, but some strains can cause serious gastrointestinal diseases in humans. Other diseases caused by E. coli include urinary tract infections and neonatal (newborn) meningitis. Harmless strains that are part of the normal population of the intestine benefit their hosts by producing vitamin K and Vitamin B12 and by crowding out the growth of harmful bacteria within the digestive tract. Since the *c*ells can stay alive outside the body for a while, they can be used to indicate contamination by sewage and manure and are used in testing water, milk, and food. Since E. Coli can be grown easily and inexpensively in a laboratory setting, it has been widely studied and is an important species in biotechnology work.

http://www.textbookofbacteriology.net/e.coli.html

Typhoid bacteria (Salmonella paratyphi)

Salmonella are rod-shaped, Gram-negative, bacteria found worldwide in cold- and warm-blooded animals (including humans), and in the environment. *Salmonella belongs to the same genus, Enterobacter, as E. coli and Shigella*. Some species of Salmonella causes illnesses like typhoid and paratyphoid and others are an important cause of food-borne illnesses. Many infections are due to ingestion of contaminated food. In many countries today they are the most important bacterial diarrhea-causing pathogens in man. As they are mostly transmitted from animals to man through consumption of foods of animal origin, salmonellae are classified as zoonoses ("zoonosis" is the scientific term for all diseases which can be transmitted by pathogens from animals to man). The sample you see here is the kind that causes paratyphoid, a life-threatening disease that is not common the US, but that you may be vaccinated for if you go to other parts of the world.

http://www.bfr.bund.de/en/salmonella_and_their_importance_as_pathogens-10638.html

Bacillary dysentery (Shigella dysenteriae)

s. dysenteriae is a small, Gram-negative rod-shaped bacteria. *S. dysenteriae* is found worldwide, but especially in areas where there is overcrowding and malnutrition and a lack of good sanitation and safe drinking water supplies. *S. dysenteriae* has caused endemic(continuous) dysentery in Africa, Southeast Asia, and the Indian subcontinent. Humans are the only natural hosts for *S. dysenteriae*, though houseflies may transmit the bacterium. *S. dysenteriae* is a threat to public health by causing shigellosis, especially in developing countries. Shigellosis is associated with 5-15% of cases of diarrhea and 30-50% of cases of dysentery worldwide. According to a joint UNICEF-WHO report, an estimated 1.5 million children under the age of five die from diarrhea each year –- more than AIDS, malaria and measles combined.

http://www.circleofblue.org/waternews/2009/ http://microbewiki.kenyon.edu/index.php/Shigella_dysenteriae

Putrefaction bacteria (Proteus vulgaris)

Proteus vulgaris is a rod shaped, Gram-negative bacteria that is most commonly found in the soil in decomposing organic matter. It is also found in the intestinal tracts of humans and animals which also means it is found in fecal matter (poop). It is known to cause urinary tract and wound infections. Proteus is one of the organism that commonly causes hospital acquired infections and is difficult to treat because it is resistant to many kinds of antibiotics. People whose immune systems are suppressed are especially likely to be infected by this organism, causing urinary tract infection, pneumonia or septicemia.

http://www.ijpsr.info/docs/IJPSR10-01-09-01.pdf

Pus bacteria (Staphylococcus pyogenes)

Streptococcus pyogenes is a Gram-positive bacterium which occurs as long chains of cocci, and occasionally in pairs. Many people carry the bacteria without harm, however it has the potential to cause both mild and severe diseases. *Streptococcus pyogenes* has claimed many lives, including that of Muppet's creator, Jim Henson. *Streptococcus pyogenes* is the most common bacterial cause of sore throat.[6] A painful, red throat with white patches on your tonsils is characteristic of strep throat. This organism can also cause impetigo and cellulitis, and also necrotizing fasciitis, a rare, but very serious infection caused by *Streptococcus pyogenes*, popularly termed "flesh eating bacteria".

http://pyogenesgonewild.com/

Bacteria from human mouth

Scientists from the Forsyth Institute in Boston are studying what lives in your mouth. The view reveals hundreds of different kinds of bacteria, viruses, yeast, fungi, and other micro-organisms. The scientists have found 615 different species of bacteria - and they're still counting. "In one mouth, the number of bacteria can easily exceed the number of people who live on Earth (more than 6 billion)," notes Sigmund Socransky, associate clinical professor of periodontology at Harvard. "These bugs don't colonize your mouth in a random way; rather, they form communities in a pattern that is dictated both by other bugs and by the environment. Although they touch each other, the floor of the mouth is populated by different communities than the bottom of the tongue, and the top of the tongue hosts a biota unlike that on the roof of your mouth." Here are some examples of the sorts of bugs that can be found in the mouth. *Streptococcus mutans* (S. mutans) and similar related species cause tooth decay. The bacteria digest the sugars and starches in foods and produce acids which dissolve tooth enamel. *Porphyromonas gingivalis* are associated with periodontal (gum) diseases. Other types of mouth bacteria include *Staphylococcus epidermidis*, *Streptococcus salivarius*, and *Lactobacillus sp.*

http://news.harvard.edu/gazette/2002/08.22/01-oralcancer.html

Bacteria from cheese

Many human foods are plants or animal products which have been fermented by lactic acid bacteria. Foods such as ripened cheeses, fermented sausages, sauerkraut and pickles have not only a greatly extended shelf life compared to the raw materials from which they are derived, but also aroma and flavor characteristics contributed directly or indirectly by the fermenting organisms. Lactic acid bacteria (LAB) are the principal organisms involved in the manufacture of cheese, yogurt, buttermilk, cottage cheese, sour cream and cultured butter. Some of these organisms can be seen in the yogurt slide you prepared! Generally LAB that are important in the fermentation of food products (dairy, meat, vegetables, fruits, and beverages) include only certain species of the genera *Lactobacillus, Lactococcus, Streptococcus, Leuconostoc* and *Pediococcus*. Some of these species are also members of normal flora of the mouth and intestine of mammals.

http://textbookofbacteriology.net/lactics_3.html

Bacteria from leavened products

The word leaven, as applied to baking, means to lighten dough (i.e., cause it to rise), Leavening with yeast is a process based on fermentation, biologically changing the chemistry of the dough or batter as the yeast works. Unlike chemical leavening, which usually activates as soon as the water combines the acid and base chemicals, biological leavening requires a waiting period which allows the yeast or bacteria time to reproduce and consume carbohydrates in the flour. Microorganisms that release carbon dioxide as part of their life cycle can be used to leaven products. Yeast is most commonly used, especially the Saccharomyces species, but some recipes rely on certain bacteria. Wild yeast and/or wild bacteria can enter dough left exposed to the air. Lactic bacteria of the various types are found, such as Bacillus pastorianum, B. delbrucki, B.ternoas as well as acetic acid bacteria or Acetobacter and these enhance the flavor of sour dough breads.

http://ranprieur.com/readings/natleavbread.html

What is Gram Positive and Gram Negative?

Gram staining is a technique used to identify bacteria by separating them into two groups. In this procedure, bacteria are stained with crystal violet, treated with strong iodine solution, decolorized with ethanol or ethanol-acetone and counterstained with a contrasting dye, usually safranin. The iodine alters the structure of the cell wall in gram-positive bacteria so that the crystal violet is locked within the cell. Organisms that retain the crystal violet stain are deep purple in color and are classed as gram-positive and those losing the crystal violet stain are stained a second time with a red dye called safranin and are classified as gram-negative. This technique is used in both research and medical settings where it is a very important tool for identifying the causes of disease.

http://medical-dictionary.thefreedictionary.com/Gram's+stain

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