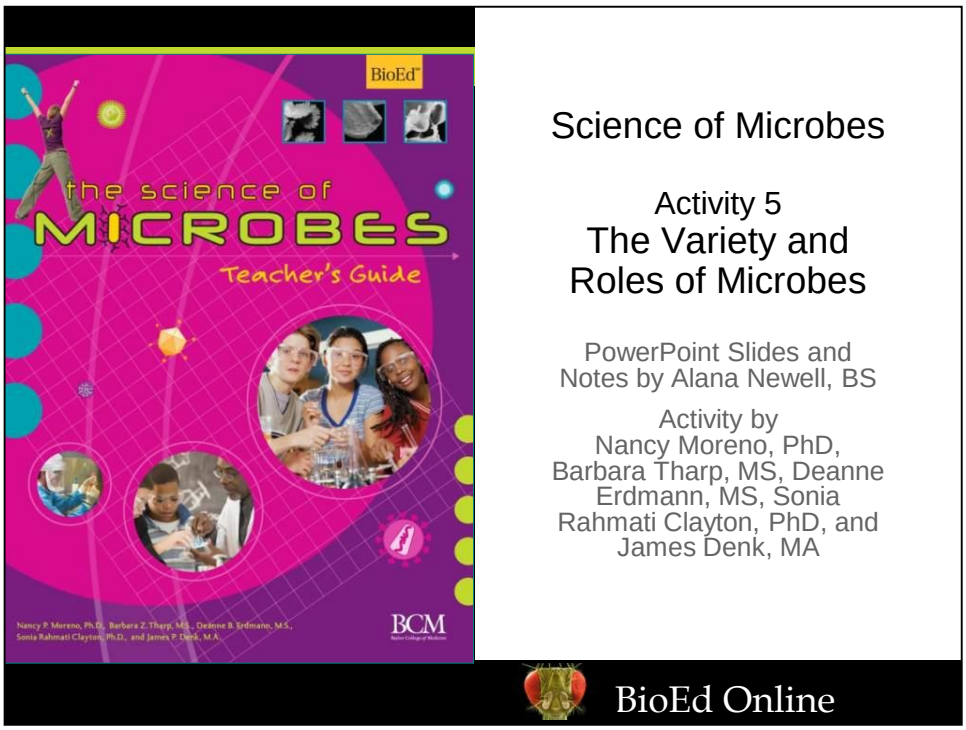

Science of Microbes

The Variety and Roles of Microbes is the fifth lesson in the unit, *The Science of Microbes*. This lesson addresses National Science Education Content Standards related to Inquiry and Life Science. See the downloadable lesson PDF at the web addresses below for a complete list of the standards addressed.

In this activity, students will learn the four major groups of microbes: bacteria, fungi, protists and viruses. They also will learn about beneficial roles that microbes play in the natural world and in various human manufacturing processes.

Viewing this presentation fulfills part of the requirements for completing the short course on *The Science of Microbes*, offered on BioEd Online for professional development contact hours. *The Science of Microbes* Teacher's Guide may be obtained in its entirety from the Center for Educational Outreach at Baylor College of Medicine (1-800-798-8244). You can download a PDF of this lesson and other lessons from the Science of Microbes unit (including a unit pre/post assessment) from www.BioEdOnline.org or www.K8Science.org.

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Materials for Each Group of Four Students

BioEd Online

Materials for Each Group of Four Students

In preparation for this activity, use cardstock to make two sets of cards for each group of four students. One set of cards will consist of a cut-out copy of the *Microbe Groups* sheet; the other set will be a cut-out copy of the *Microbe Examples* sheet. Store the two sets of cards together in a zip top bag.

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Image Reference:

Denk, J. (2009). Materials for activity 5. Baylor College of Medicine. Houston, TX.

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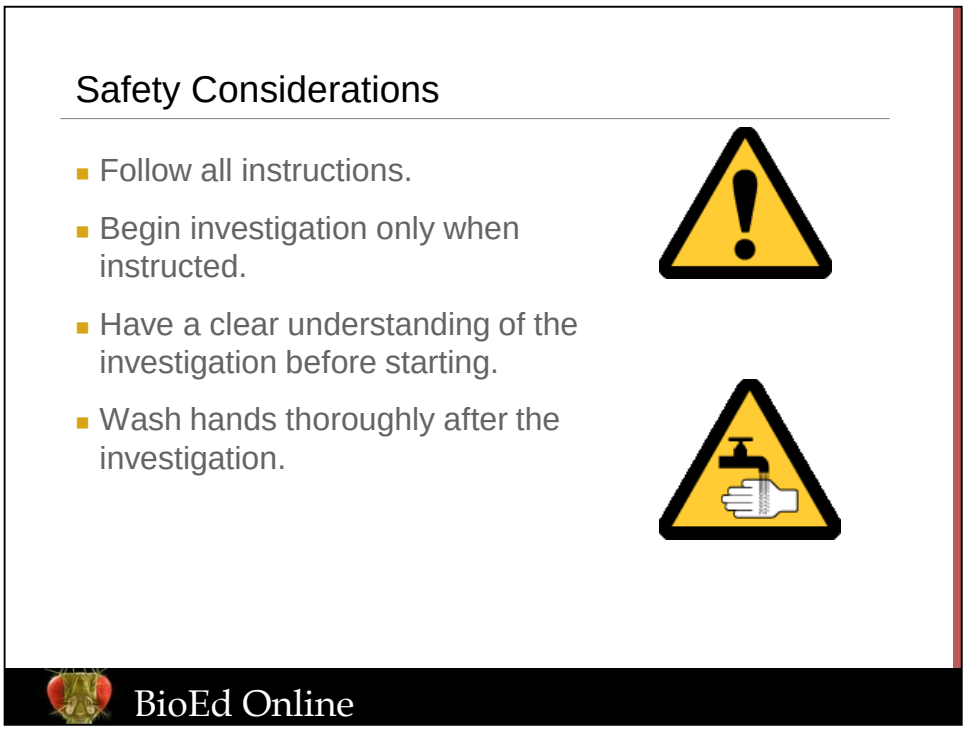

Safety Considerations

It is important that students always think about safety when conducting a science investigation. This slide may be used to review safety with your class before starting the activity. Keep the following points in mind.

- Always follow district and school safety guidelines.
- Have a clear understanding of the investigation in advance (practice any investigation with which you are not familiar).
- Continually monitor the area where the investigation is being conducted.

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What Do You Know About Microbes?

- Can you name some different types of microorganisms?
- What roles might microorganisms play in nature?
- What roles might microorganisms play in humans?
- What roles might microorganisms play in industry?

Paramecium sp.

BioEd Online

What Do You Know About Microbes?

Begin the lesson by asking students about different categories of microbes and the various roles they play in nature, human populations, and industry. If students have trouble thinking of examples, remind them of the yeast and yogurt they observed in Activity 4 of this unit. Discuss their ideas, and encourage them to think of alternative roles of microbes.

In this activity, students will look at specific roles that microbes play in the natural world, and in producing various materials and resources used by humans. Students also will learn about the four designated groups of microbes (viruses, bacteria, protists and fungi), characteristics of each group, and the uses and functions of selected microbes within these groups.

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Image Reference:

Neumeyer, R. *Paramecium sp*. MicroImaging Services, Canada. ©

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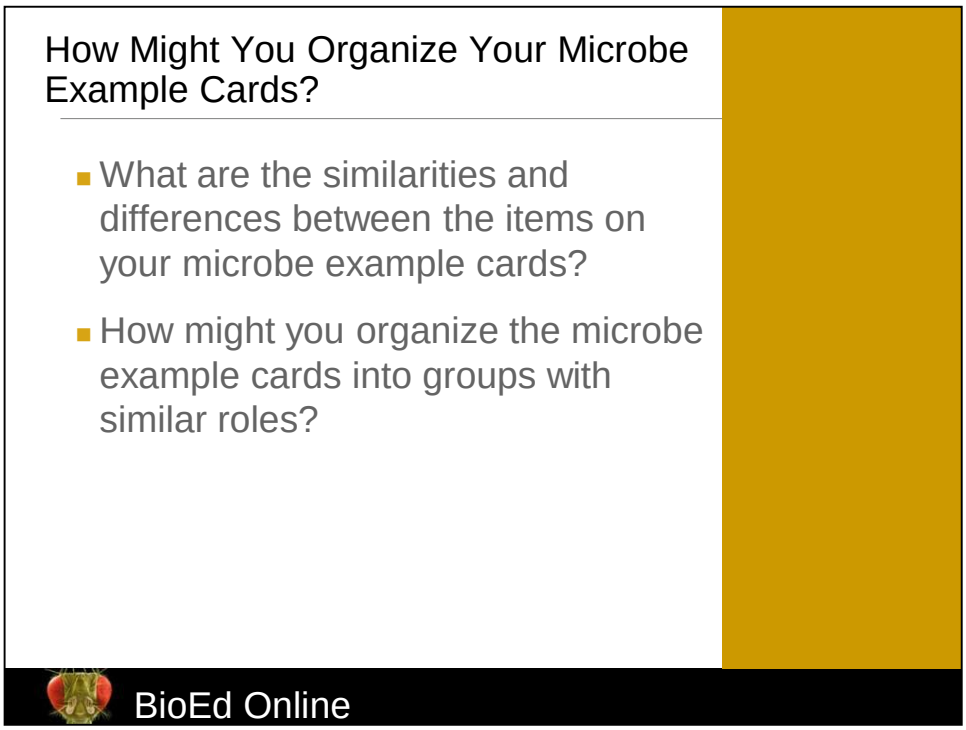

Organizing Your Cards

Pass out one bag of cards to each group, and have students remove the 20 smaller cards (Microbe Example) from the bag. Instruct students to read the cards, and then discuss and decide as a group the best way to sort the cards into categories.

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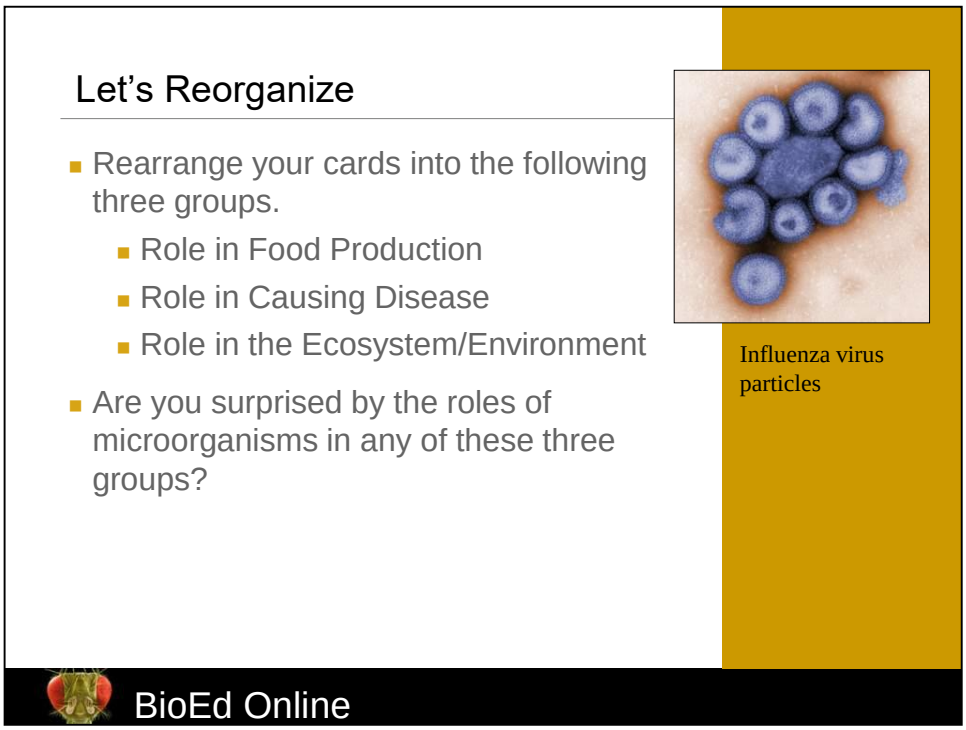

Let's Reorganize

If they have not done so already, direct students to arrange their cards by "role in food production," "role in causing disease," and "role in the ecosystem/environment." Then, lead a discussion about the items in each of the three groups. Notice that some microbe cards may fit into more than one group. What similarities and differences do the students notice about the cards in each group? Are there any surprises? Make a particular note of the role microbes play in food production. This may surprise your students.

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Goldsmith, C. Influenza virus particles, ## 10072. Centers for Disease Control and Prevention (CDC) Public Health Image Library.

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A Closer Look at Microbes' Roles

- Role in Food Production
  - Microbes are used to prepare many foods, including bread, yogurt and cheese.
- Role in Disease
  - Pathogenic microbes invade a host and harm the host's cells.
- Role in the Environment
  - Microbes have important roles in all ecosystems, and play a key part in the decay of organic materials.

Lactobacillus sp. is used for production of yogurt and many other foods.

Malaria parasite (*Plasmodium sp.*) inside a red blood cell.

BioEd Online

A Closer Look at Microbes' Roles

Food: One of the most common uses of microbes in food preparation is the process of fermentation. Although oxygen usually is necessary to transform food into energy, some species of bacteria and fungi are able to complete this transformation in an oxygen-free environment. Even without oxygen, these microbes break down food, often sugar and other carbohydrates, thereby creating by-products such as CO_2, ethyl alcohol and lactic acid. This naturally-occurring process has been utilized by humans to prepare many kinds of food products.

In ethanol fermentation, for example, microbes release ethyl alcohol and CO_2. This process is used to produce many alcoholic beverages, including wine (from fermented grapes), as well as foods like bread (in which the alcohol is baked off, and CO_2 causes the bread dough to rise during baking). The other most common type of fermentation used in food production is lactic acid fermentation, which gives foods like yogurt and pepperoni sausages their slightly sour flavors.

Disease: Pathogens are microbes that infect and cause disease in host organisms, which may be humans, plants, animals or even other microbes. Many species have immune system responses designed to slow or stop the growth of different microbes. However, in some cases, it is necessary to use additional antimicrobial agents.

The majority of microbes are *not* harmful, and many are helpful to humans and other organisms. For example, vitamin K—which is required to form one of the blood clotting factors (prothrombin) in the liver—is produced by bacteria in the large intestine.

Environment: Microbes are naturally occurring almost everywhere. From backyard compost piles to acidic hot springs, they play a role in every ecosystem. Most microbes help the environment, living peacefully and symbiotically with the other organisms on the planet.

Microbes play a major role in converting the essential element, nitrogen, into a usable form. Although nitrogen is the most common gas in our atmosphere and is used in the DNA and other important molecules in plants and animals, neither plants nor animals are capable of converting it from its unusable, gaseous form (N_2) into other, usable compounds. However, through a process called nitrogen fixation, several microbes in the soil and in water *are* able to change nitrogen gas into forms that plants can use, such as ammonium (NH_4^+). Animals then obtain this important element by eating plants.

Microbes also are responsible for decomposing organic material (plants, animals, insects, etc.). Through decomposition, microbes break down dead organisms and deposit nutrients back into the soil for other organisms to use. This "recycling" of organic material is vital to sustain life on Earth.

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Image Reference:

Melvin, M. Malaria parasite *(Plasmodium sp.)* inside a red blood cell, # 1456. Centers for Disease Control and Prevention. Retrieved from http://phil.cdc.gov/phil/

Lactobacillus sp. National Center for Complementary and Alternative Medicines, National Institutes of Health. Retrieved from http://nccam.nih.gov on 08-16-2007.

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Comparing Groups of Microbes

	Viruses	Bacteria	Protists	Fungi
Single-celled?	None	All	Some	Some
Multicellular?	None	None	Some	Some
Cell membrane?	None	All	All	All
Organelles?	None	None	All	All
Well-defined nucleus?	None	None	All	All
Cell wall?	None	Some	Some	Some
Autotroph?	None	Some	Some	None
Heterotroph?	None	Some	Some	All
Microscopic?	All	All	Some	Some
Motile?	None	Some	Some	None

BioEd Online

Comparing Groups of Microbes

Next, have your students discuss the physical and biological similarities and differences between the four groups that contain at least some microscopic members (viruses, bacteria, protists and fungi). Use the table on this slide as a guide.

Viruses are not considered to be cells, because they are made only of genetic material (RNA or DNA) in a protein coat. In fact, they are not even considered living organisms, because these microscopic pathogens cannot grow or reproduce on their own. Instead, they invade a host cell and use its cellular machinery to produce new copies of themselves, sometimes at great harm to the host organism.

All bacteria are single-celled and microscopic, with cell membranes and usually cell walls. Bacteria do not have membrane-bound organelles or well-defined nuclei. Bacteria are a diverse group. Some use CO_2 as a carbon source to obtain energy (autotrophic) through processes like photosynthesis. Others obtain energy by breaking down organic material as a carbon source (heterotrophic). Many bacterial microbes carry out important roles in the environment and ecosystem, but some can cause disease.

Protists are an extremely diverse, informal group of organisms classified under different kingdoms of the Eukarya domain. Some are microscopic; others macroscopic. Some are single-celled, while others are multi-celled. All protists have cell membranes, well-defined nuclei and organelles. Some also have cell walls. There are three informally recognized groups of protists.

Algae: Plant-like, single- or multi-celled, autotrophic. Brown algae (seaweed) are multicellular and can grow 180 feet in a single year.

Protozoa: Animal-like, single-celled, heterotrophic.

Water and Slime Molds: Fungus-like, single- or multi-celled, heterotrophic.

Fungi are another diverse group, which contain microbes, whose sizes vary from micro- to macroscopic. Some fungi are single-celled, while others are multicellular. All fungi have a cell membrane, well-defined nucleus and organelles. Most have cell walls. These organisms obtain their nutrients from dead or decaying materials in the environment, making them natural recyclers. It is interesting note that fungi secrete digestive enzymes to breakdown organic matter externally and then reabsorb the digested organic matter, unlike the internal digestion systems of many animals.

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Organizing by Microbe Groups

After discussing the information on each Microbe Group card, have students sort the Microbe Example cards related to food production into the appropriate Microbe Group. If students are having difficulty sorting certain cards, let them know that the cards contain clues about the different types of microbes. For instance, if a Microbe Example card says the microbe does not have a cell membrane, lead students in the right direction by asking, "Which types of microbes do not have cell membranes?" Other hints on the cards are phrases such as "single-celled," "animal-like," and other words describing distinctive features of the microbe. Characteristics such as whether or not the microbe can be treated with antibiotics may be helpful during the sorting process.

Discuss anything that surprised your students. Point out that protists and viruses are not involved in food processing, (although some forms of algae are consumed as food).

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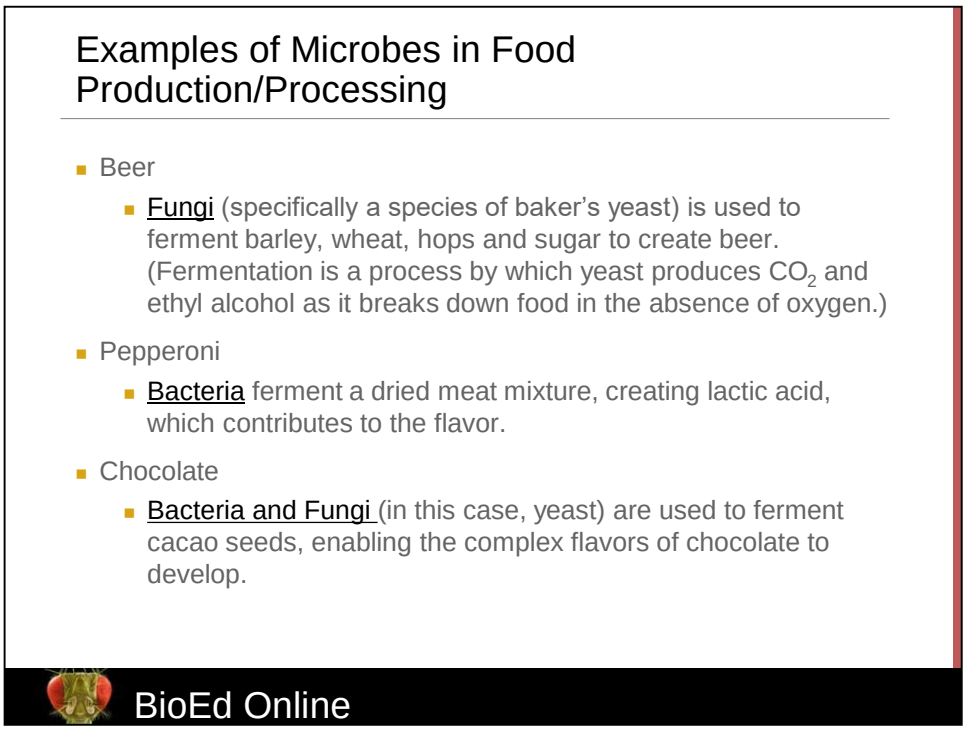

Microbes in Food

One of the most common uses of microbes in food preparation is the process of fermentation. Although oxygen usually is necessary to transform the energy in food, some species of bacteria and fungi are able to complete this transformation in an oxygen-free environment. In the absence of oxygen, these microbes break down food, often sugar and other carbohydrates, thereby creating by-products such as CO_2, ethyl alcohol and lactic acid. This naturally-occurring process has been utilized by humans to prepare many kinds of food products.

In ethanol fermentation, for example, microbes release ethyl alcohol and CO_2. This process is used to produce many alcoholic beverages, including wine (from fermented grapes), as well as foods like bread (in which the alcohol is baked off, and CO_2 causes the bread dough to rise during baking). The fermentation of rice results in saki. Vodka is made from fermentation of grains or potatoes.

The other most common type of fermentation used in food production is lactic acid fermentation, which gives foods like yogurt and pepperoni their slightly sour flavor.

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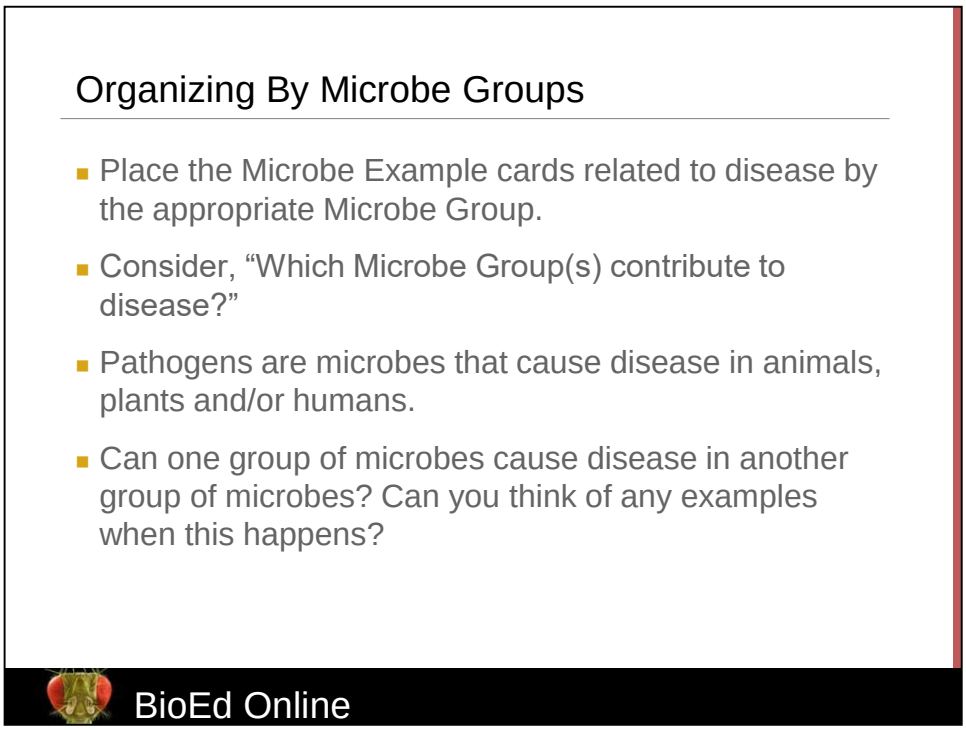

Organizing By Microbe Groups

Next have the students sort the Microbe Example cards related to disease into the appropriate Microbe Group. Be sure they understand that all four microbe groups can contribute to disease in other organisms, such as plants or animals (including humans). For the last question on the slide, you might mention that viruses called bacteriophages can infect bacteria.

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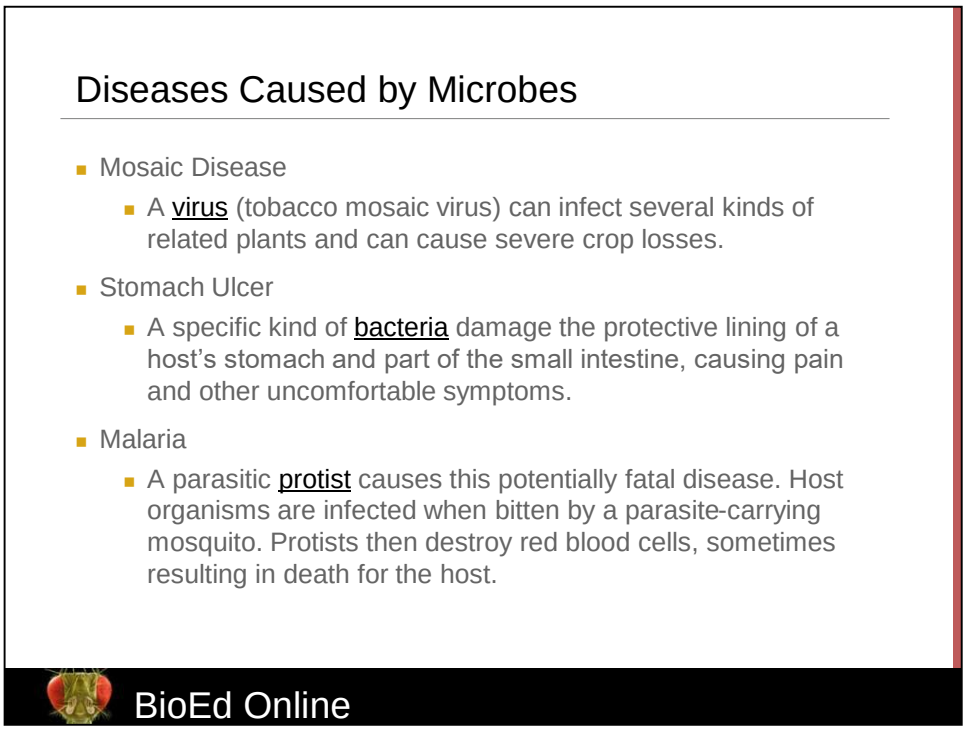

Examples of Microbes as Causes of Disease

The majority of microbes are *not* harmful, and many are helpful. But some microbes, called pathogens*, infect and cause disease in host organisms, which may be humans, plants, animals or even other microbes. Many species have immune system responses designed to slow or stop the growth of different microbes. In addition, in cases of diseases in humans or domesticated plants and animals, it is possible to use additional antimicrobial agents.

Ask students to identify differences and similarities between microbes used in food production and those that cause disease. Lead a discussion about the different roles of microbes, making sure that students understand that different types of microbes have overlapping roles (e.g., both bacteria and fungi carry out fermentation). Ask the students to make general statements about the roles of microbes and the various microbe groups (e.g., "Some microbes are helpful, but others can be dangerous.").

Finally, ask students to explain why we should care about microbes, and have them record any new ideas on their concept maps.

*****A pathogen is any disease-causing organism.

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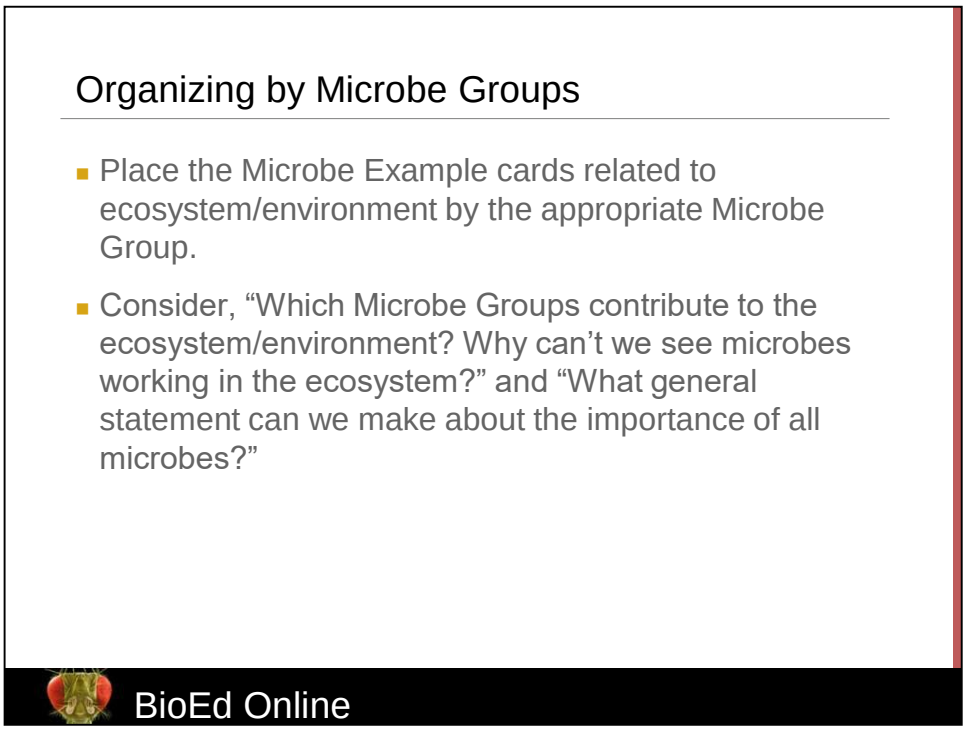

Organizing By Microbe Groups

Have students sort the Microbe Example cards related to ecosystem/environment into the appropriate Microbe Group. Be sure students understand that bacteria, protists and fungi are part of the nutritional and other cycles in ecosystems/environments, and that viruses are not (although viruses, which invade host cells, can affect population balances). Viruses are not essential to ecosystem functions. We usually cannot see microbes working in the ecosystem/environment because most are microscopic. Emphasize that although microbes are very small, their contributions are essential.

Ask students to make general statements about the roles of microbes (e.g., “Some microbes are helpful, but others can be dangerous.”).

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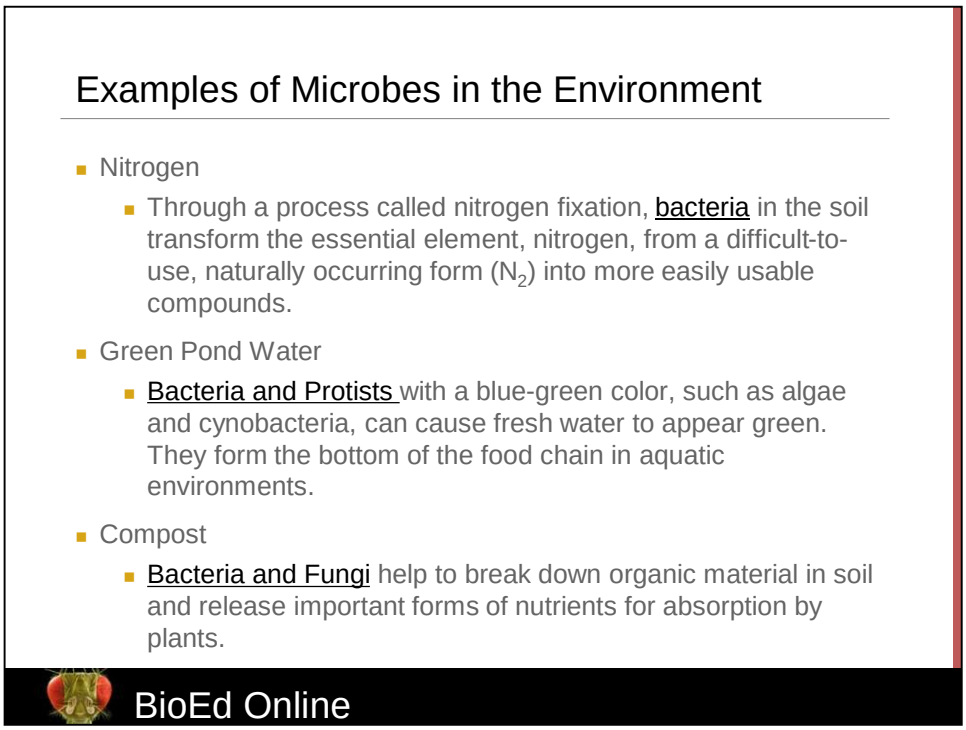


Examples of Microbes in the Environment
Microbes are naturally-occurring almost everywhere. From backyard compost piles to acidic hot springs, they play multiple roles in every ecosystem. Some of these roles include decomposition, symbiotic relationships with other organisms, nutrient cycling, and manufacture of compounds needed by other organisms.

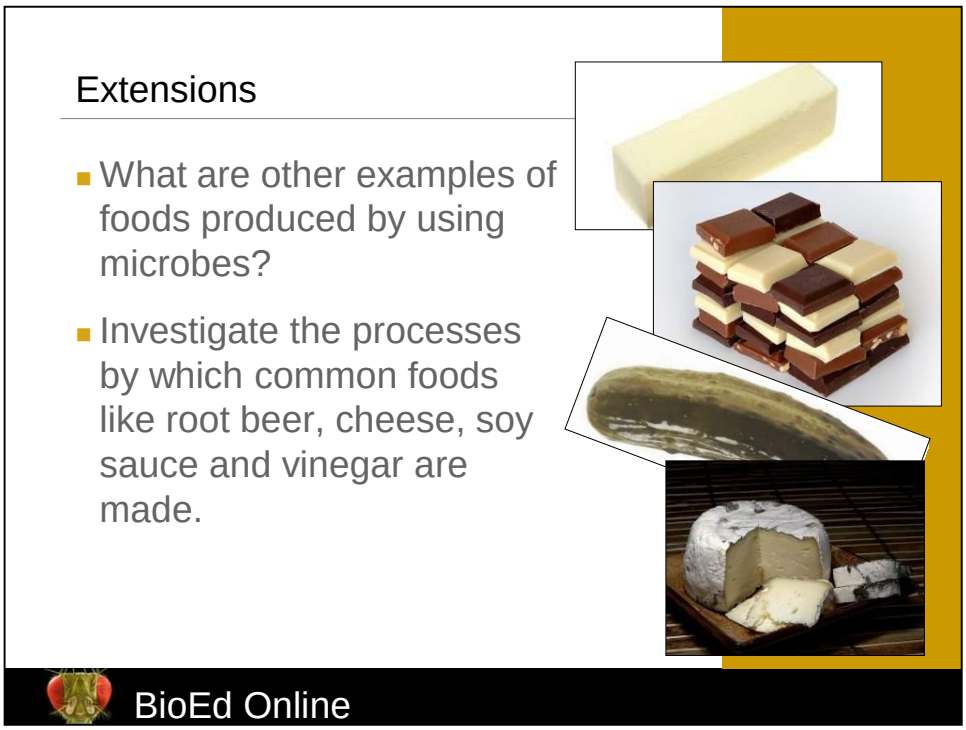
Viewing this presentation fulfills part of the requirements for completing the short course on *The Science of Microbes*, offered on BioEd Online for professional development contact hours. *The Science of Microbes* Teacher's Guide may be obtained in its entirety from the Center for Educational Outreach at Baylor College of Medicine (1-800-798-8244). You can download a PDF of this lesson and other lessons from the Science of Microbes unit (including a unit pre/post assessment) from www.BioEdOnline.org or www.K8Science.org.

Reference:
Moreno, N., Tharp, B., Erdmann, D., Rahmati Clayton, S., Denk, J. (2008). *The Science of Microbes Teacher's Guide.* Houston, TX: BioEd.

Image Reference: [THERE IS NO IMAGE]

The Science of Microbes and accompanying online professional development content were supported, in part, by Science Education Partnership Award number 5R25RR018605 from the National Center for Research Resources, National Institutes of Health (NIH) to Baylor College of Medicine. The unit was developed in partnership with the Baylor-UT Houston Center for AIDS Research, an NIH-funded program

(AI036211). The opinions, findings, and conclusions expressed in this presentation are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine or the sponsoring agencies.



Extensions

Students might not realize that many ordinary foods are made with microbes. Vinegar, for example, is soured wine. Different vinegars obtain their flavors from the type of wine fermented (e.g., apple cider vinegar is made from apple cider wine, which is fermented apple cider) or from their surroundings after/during fermentation (e.g., balsamic vinegar is flavored by the balsamic fir wood barrels in which it is aged). Sauerkraut, soy sauce, coffee and chocolate also are produced with the help of microbes.

A recipe to make vinegar can be found at this address: http://recipes.howstuffworks.com/how-vinegar-works2.htm.

To see how cheese is made, visit http://recipes.howstuffworks.com/cheese.htm. (Scroll to the bottom of the first screen to see the short video demonstrating several steps in the cheese making process.)

Another cheese video is available at http://videos.howstuffworks.com/hsw/15890-rotten-but-not-forgotten-the-key-ingredients-of-cheese-video.htm.

A great video on the making of chocolate can be viewed at http://video.aol.com/video-detail/how-chocolate-is-made/3813527574.

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Reference:

Moreno, N., Tharp, B., Erdmann, D., Rahmati Clayton, S., Denk, J. (2008). *The Science of Microbes Teacher's Guide.* Houston, TX: BioEd.

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