MODULE 1

MAGICAL MICROBES

NGSS TEACHER'S GUIDE

Meet The Microbes!

NGSS Alignment

CORE IDEAS

Core Idea LS1: From Molecules to Organisms: Structures and Processes

LS1.A: Structure and Function

Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

CROSS CUTTING CONCEPTS

- ☐ Patterns
- ☑ **Cause and effect: Mechanism and explanation**
- ☐ Scale, proportion, and quantity
- ☐ Systems and system models
- ☑ **Energy and matter: Flows, cycles, and conservation**
- ☐ Structure and function
- ☐ Stability and change

PRACTICES

- ☑ **Asking questions (for science) and defining problems (for engineering)**
- ☐ Developing and using models
- ☐ Planning and carrying out investigations
- ☐ Analyzing and interpreting data
- ☐ Using mathematics, information and computer technology, and computational thinking
- ☑ **Constructing explanations (for science) and designing solutions (for engineering)**
- ☑ **Engaging in argument from evidence**
- ☐ Obtaining, evaluating, and communicating information

BACKGROUND

What is a microbe?

The term microbe, short for **microorganism**, is used to describe any tiny organism that is **too small individually to be seen with the naked eye**. To see a microbe you need to use a powerful microscope. Microbes get a bad rap – yes, microbes can cause disease or illness, but microbes are also essential players in the recycling of nutrients and in making it possible for Earth to sustain life! There are three main types of microbes: bacteria, fungi and viruses.

https://www.flickr.com/photos/kaibara/2234750993/

Bacteria

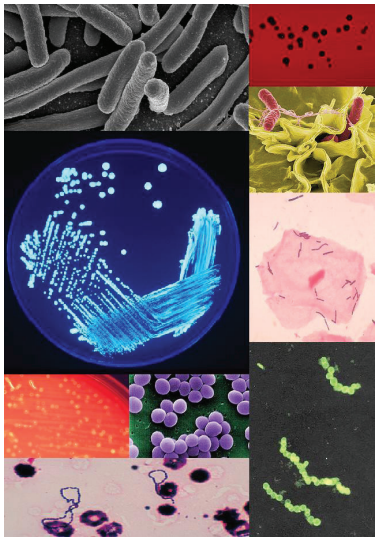


Photo by PeskyPlummer (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

To many people when they hear the term bacteria they think only of "germs," invisible organisms that can make us sick. In reality, bacteria are quite important, essential in fact, to the lives of many organisms, including humans, and to the health of our planet.

They help with food digestion, decomposition of organic material including garbage, and even help provide essential life sustaining materials including oxygen, upon which so many organisms depend. Bacteria consist of **only a single cell**, but don't let their small size and seemingly simple structure fool you. They are amazingly complex and diverse microorganisms that exist virtually everywhere.

Did you know there millions, no – billions of microbes in and around you right now? There are more of them on a person's hand than there are people on the entire planet! Microbes are even inside of us. Did you know that for every human cell in your body there are 10 microbes!! **That means that you are more microbe than human!!**

Bacteria have been found living in every imaginable type of environment, even those thought to be uninhabitable. They have been found in water, soil, ocean sediments and air. They are capable of living in temperatures that exceed the boiling point of water (>100°C or 212°F) and in temperatures so cold that it would freeze your blood. Bacteria have also been found in acid volcanoes and under extremely high pressure at the bottom of the ocean. There's even a species of bacteria that can withstand blasts of radiation 1,000 times greater than a human being can withstand. They

"eat" everything from sugar and starch to sulfur and iron and produce 70-80% of the oxygen in our atmosphere!

Some bacteria are able to **reproduce rapidly** – doubling in numbers in as little as 20 minutes, while some bacteria can survive in a **resting stage** for centuries. Each square centimeter of your skin averages about 100,000 bacteria. In natural waters (lakes, streams, oceans) there are approximately 1 million (10^6) bacteria in every 1 mL of water on the surface of the Earth, and approximately a billion (10^9) bacteria in every ml (cm^3) of soil and sediments.

Fungi

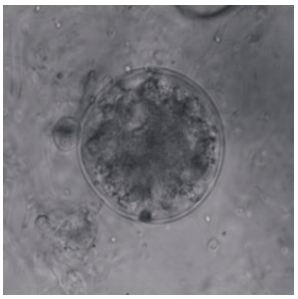


Photo: http://upload.wikimedia.org/wikipedia/commons/2/2c/Spizellomycete.jpg

Fungi are a group of organisms that can **range in size** from a microscopic single cell (eg, yeasts) to enormous macroscopic chains of cells that can stretch for miles. Fungi may look like plants, but most **cannot produce their own food** from soil and water. Instead, they live off other animals and plants. Fungi are one of the few types of organisms capable of breaking down the strong structural material found in plants called cellulose and lignin.

Fungi grow in the form of a finely-branched network of strands called **hyphae** which are 5-10 µm in diameter. These hyphae release digestive enzymes and are able to absorb nutrients. Fungi are only capable of absorbing small molecules like glucose (a simple sugar) which is produced when the cellulose is broken down by the digestive enzymes. Fungi are most commonly found on land, and are rare in aquatic environments. On land, the amount of hyphae in the soil is measured in hundreds or thousands of meters of length per gram of soil. For example, the total length of hyphae in a gram of soil (about the amount that would fit on the fingernail of your little finger) can reach up to 1,600 meters!

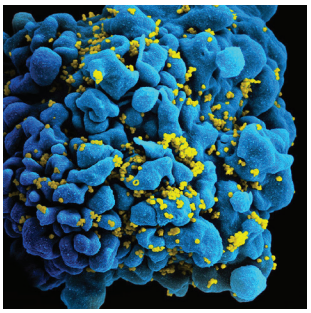
Photo: http://commons.wikimedia.org/wiki/File:Flammulina_velutipes.JPG

Viruses

Viruses are the **simplest and tiniest** of microbes. Viruses themselves are not actually alive. They are unable to metabolize or reproduce unless they are inside another living cell, or **"host"**. They can be as much as 10,000 times smaller than bacteria. They consist of genetic material (DNA or RNA) surrounded by a protective protein viral

coat, called a capsid. When viruses come into contact with living cells they "take over" the host cell. The virus triggers the host cells to engulf them, or they fuse themselves to the cell membrane of the host so they can release their DNA into the cell.

Once inside a host cell, viruses take over the machinery to **reproduce**. Viruses override the host cell's normal functioning with their own set of instructions. These instructions shut down production of host proteins and direct the cell to produce viral proteins to make new virus particles.



By NIAID (HIV-infected T cell) [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons

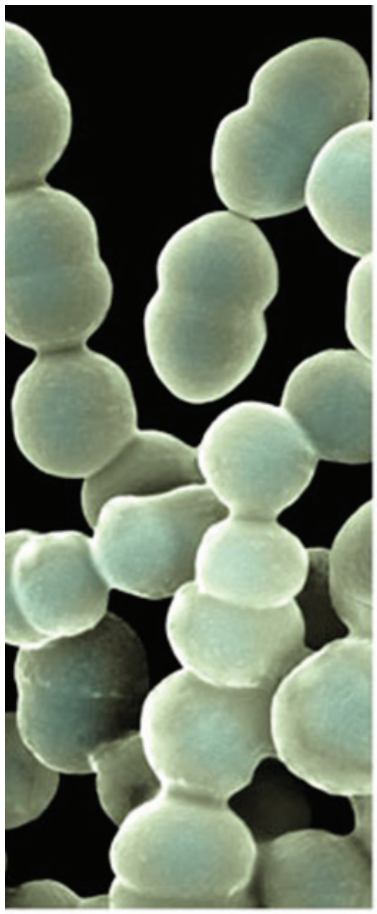
The Good, The Bad and The Ugly!

	Helpful	Harmful
Bacteria	Allow milk to be turned into cheese, yogurt, and other dairy products while bacteria in our digestive systems help digest food and produces Vitamin K. Photosynthetic bacteria that live in water produce large amounts (70-80%) of the oxygen in our atmosphere, while certain soil bacteria are able to convert free nitrogen (Nitrogen gas, N_2) into a form that plants can use to grow. There are even bacteria in soil, sediments and wastewater that give off electrons which can be used to generate electricity!	Cause illness and disease such as tuberculosis, staph infections, strep throat, meningitis, pneumonia, and food poisoning.
Fungi	Fungi are responsible for breaking down dead organic material, which helps recycle nutrients. Soil fungi have also been used to develop important drugs, such as penicillin, and other antibiotics.	Cause a number of diseases in animals (ringworm and athlete's foot in humans), and in plants (rusts, smuts, and leaf, root, and stem rots).
Viruses	We tend to think of all viruses as bad for the host organism but there are some bacteria that are actually beneficial to the host organism such as: one type of soil bacteria - has viral genes that help protect it from heavy metals and other harmful substances in the soil.	Cause many commonly known diseases: smallpox, the common cold, chickenpox, influenza, shingles, herpes, polio, rabies, Ebola, and the *Human Immunodeficiency Virus (HIV)*. It is also thought that cervical cancer may be caused by the *Human papillomavirus*. There are vaccines against many viral diseases.

What Do Microbes Look Like?

Bacterial microbes come in many different shapes but the most basic shapes are:

Round
(coccus)



1 µm

Rod
(bacillus)

2 µm

Spiral
(spirillum)

5 µm

http://www.ppdictionary.com/bacteria/bacteria_sizes.jpg