SUB-MODULE 1

MudWatt

NGSS TEACHER'S GUIDE

Meet The Microbes!

TABLE OF CONTENTS

INTRODUCTION

Learning Objectives

Students are introduced to the idea that microbes exist virtually everywhere, even in extreme environments, and that some microbes are beneficial while others are harmful to other organisms or the environment.

Essential Questions

1. **What is a microbe?**
2. **Are microbes good/beneficial or bad/harmful?**
3. **What do microbes look like?**
   - How big are microbes?
   - Student Activity: How big are microbes?
4. **What shape are microbes?**
   - Student Activity: Make a Microbe
5. **Where do microbes live?**
   - Extremophiles
   - Student Activity: Extremophile Wanted Poster

By The End of This Lesson...

Students will understand that:

- Bacteria, viruses and fungi are three different types of microbes
- Microbes are found virtually everywhere
- Many microbes live in extreme environments
- Microbes have both positive and negative impacts on humans, other organisms, and the environment

Students will be able to:

- Define what a microbe is
- Use distinguishing characteristics to differentiate between bacteria, viruses and fungi
- Identify positive and negative attributes of microbes
- Explain how microbes are a crucial part of our daily life

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

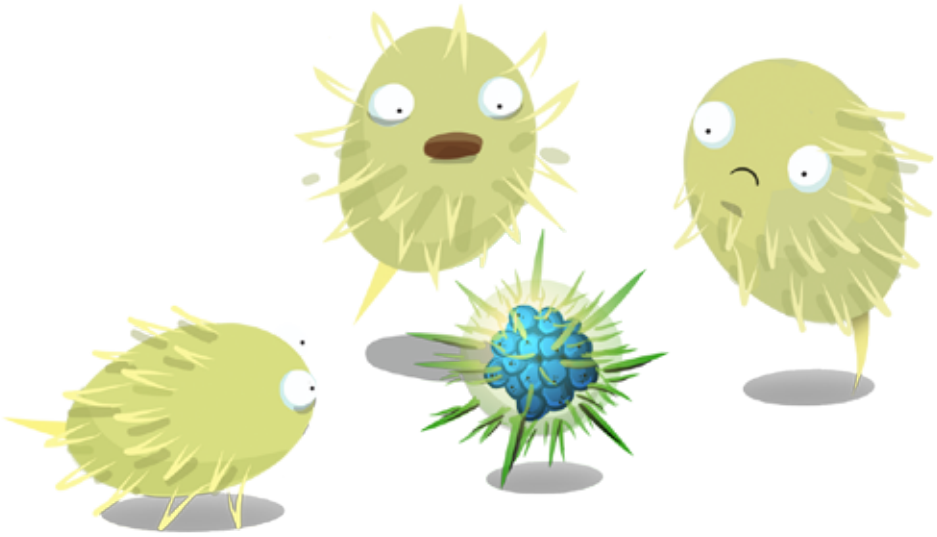
- ☐ Patterns
- ☑ **Cause and effect: Mechanism and explanation**
- ☐ Scale, proportion, and quantity
- ☐ Systems and system models
- ☑ **Energy and matter: Flows, cycles, and conservation**
- ☐ Structure and function
- ☐ Stability and change

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

Vocabulary

Microbe	Bacteria	Extremophile
Microscopic	Fungi	
Macroscopic	Virus	



Pre-Assessment: Free Response

Ask students to write down their ideas on the following questions using only what they already know:

1. What is a **microbe**?

2. What are **germs**?

3. What do you think microbes look like? **Draw a picture** to go with your answer:

4. **Where** are microbes found?

5. In what ways can microbes be **good/beneficial** to other living organisms?

6. In what ways can microbes be **bad/harmful** to other living organisms or the environment?

7. What **questions** do you have about microbes?

Pre-Assessment: Multiple Choice

Ask students to answer the following questions using only what they already know:

1. **The term "Microbes" refers to _____**
    a. Bacteria
    b. Fungi
    c. Protozoa
    d. All of the above [i.e. it's another term for "microorganism"]

2. **Microbes are _____ humans and other organisms**
    a. good for
    b. bad for
    c. good or bad for (depends on the type of microbe)

3. **Microbes are important to the environment because they**
    a. act as a food source for larger organisms
    b. break down dead organisms and waste
    c. clean up toxic waste sites
    d. all of the above

4. **What scale would be best to measure the size of microbes?**
    a. meters
    b. centimeters (hundredths of a meter)
    c. millimeters (thousandths of a meter)
    d. micrometers (millionths of a meter)
    e. nanometers (billionths of a meter)

True or False:

5. **All microbes carry disease and cause people to be sick** TRUE FALSE
6. **Microbes are on your skin and in your body** TRUE FALSE
7. **Microbes only live in dead organisms** TRUE FALSE
8. **Microbes only live in soil** TRUE FALSE
9. **Microbes can only grow in darkness** TRUE FALSE
10. **Microbes can only live if oxygen is present** TRUE FALSE
11. **Microbes can only live in temperatures between 0°- 80 ° C** TRUE FALSE

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

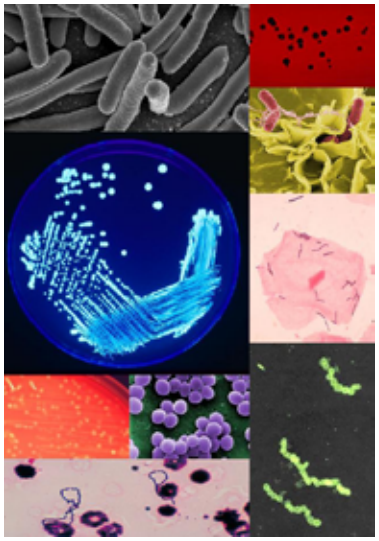


Photo by PeskyPlummer (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

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

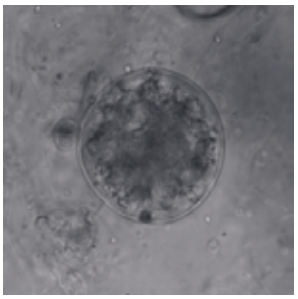


Photo: http://upload.wikimedia.org/wikipedia/commons/2/2c/Spizellomycete.jpg

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!

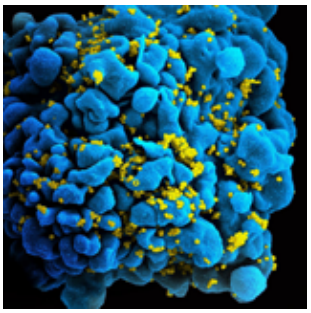
Photo: http://commons.wikimedia.org/wiki/File:Flammulina_velutipes.JPG

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

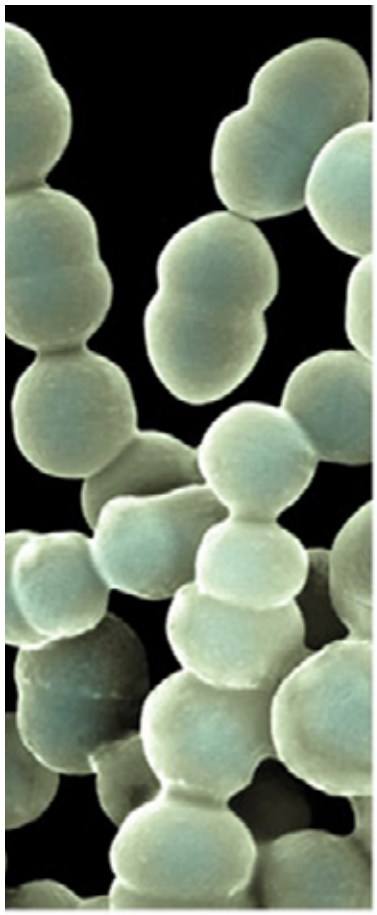
The Good, The Bad and The Ugly!

	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

Activity 1: How Big Are Microbes?

Microbes are too small to see with an unaided eye and therefore it is difficult to gain perspective of their size. In this activity you will make a scale model showing the relative sizes of viruses and bacteria in comparison to a human blood cell and a human hair.

(Adapted from: http://www.microbeworld.org/microbeworld-experiments/lets-get-small)

Time: 50 minutes

Materials:

- Metric ruler or meter stick
- Access to large, open area (field, gymnasium, empty parking lot)
- Magnifying glass
- **Activity 1: Relative Size Chart**
- Pictures of human hair, human red blood cell, bacterium, virus (use those provided in **Activity 1: Images** or find/draw your own)

Procedure

1. Examine an actual human hair **with** and **without** magnification.
2. Using the information in the **Relative Size Chart**, mark off a distance equal to the **width of a human hair**. Place an image of a human hair at this distance.
3. Repeat this process, measuring and marking the scale distances representing the diameter of a **human red blood cell**, the size of a **bacteria** and the size of a **virus**.

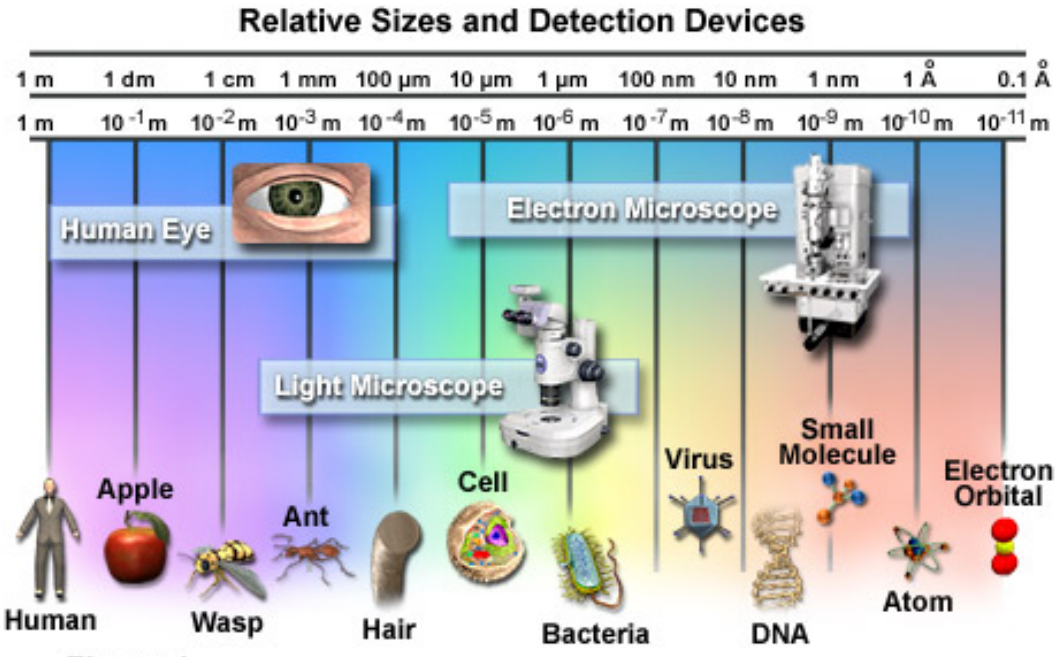
Questions

1. **List in order of increasing size:** bacteria, virus, human red blood cell, human hair.
2. **How much bigger is a bacterium than a virus?**
   (Approximately how many times bigger is a bacterium than a virus?)
3. **How much bigger is a human red blood cell than a bacterium?**
   (Approximately how many times bigger is a human red blood cell than a bacterium?)
4. **Why do we need to make a model to show the relative sizes of these objects instead of simply looking in a microscope?**
   (Explain the benefits of using a model.)

Activity 1: Relative Size Chart

	Actual Size	Scale Size
Human hair (width)	0.1 mm wide	10 m
Human red blood cell (diameter)	10.0 µm (0.01 mm)	1 m
Bacteria	0.5-2.0 µm (0.005-0.002 mm)	5-20 cm
Virus	20-100 nm (0.00002-0.0001 mm)	2 – 20 mm

Key:
cm = centimeters (hundredth of a meter)
mm= millimeters (thousandths of a meter)
µm = micrometers (millionths of a meter)
nm = nanometers (billionths of a meter)

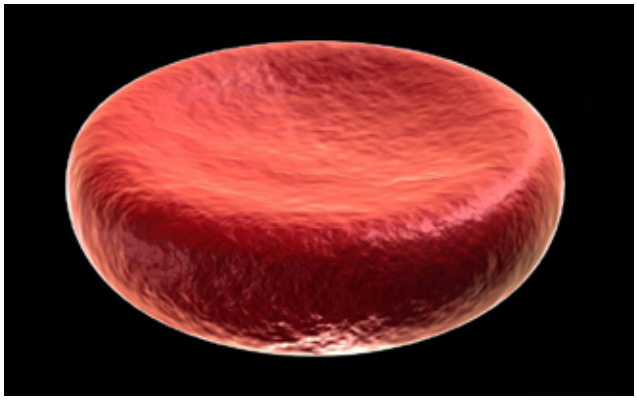


http://micro.magnet.fsu.edu/cells/images/cellsfigure1.jpg

Activity 1: Images

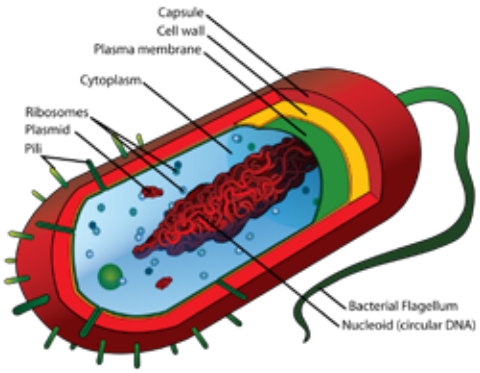
Human Hair

By Titus Tscharntke [Public domain], via Wikimedia Commons



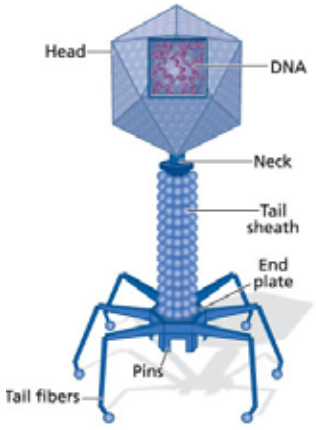
Human Red Blood Cell

By Rogeriopfm (Own work) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons



Bacterium

http://upload.wikimedia.org/wikipedia/commons/thumb/5/5a/Average_prokaryote_cell-_en.svg/1258px-Average_prokaryote_cell-_en.svg.png



Virus

http://www.sholtoainslie.com/wp-content/uploads/2013/03/VirusStructure1.jpg

Activity 2: Make A Microbe!

In this activity students will view different types of microbes using images provided (**Student Handouts A and B**). They will use their understanding of what microbes look like to create a microbe out of clay. Each student will decide whether their microbe is **useful** or **harmful** and should create a **name** for their microbe.

Students will present their microbes to the class and should explain what **features** were selected and why they were chosen. Students should also be able to explain whether the microbe is helpful or harmful to humans or other organism.

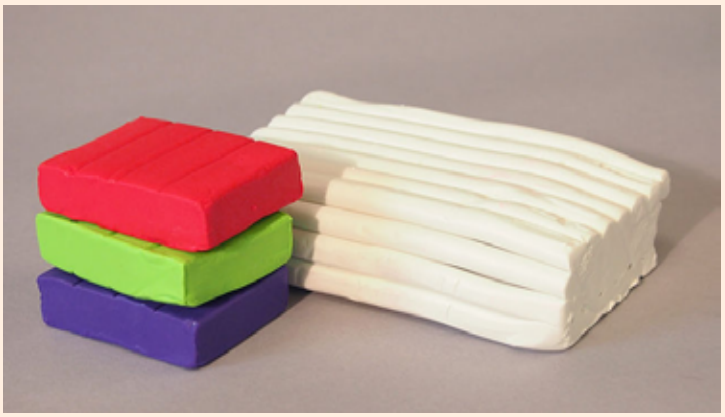
Time: 1 class period

Materials:

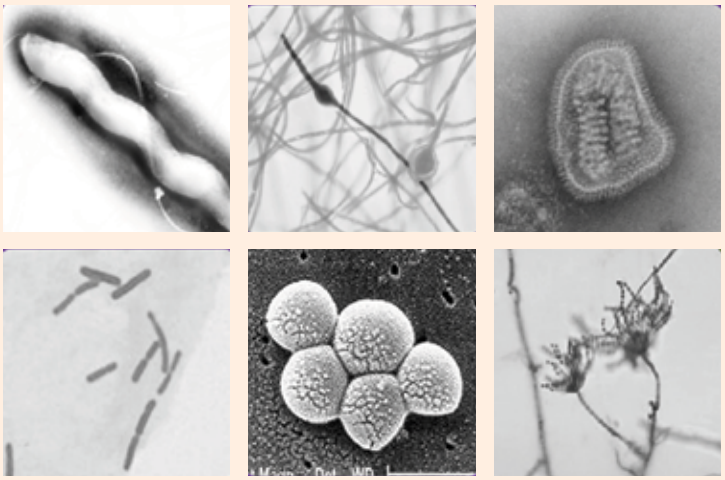
- Images of microbes
- Petri dishes
- Clay (many colors)
- **Student Handout A: What are Microbes?**
- **Student Handout B: Microbe Trivia**
- **Student Handout C: Make Your Microbe**

e-Bug

Student handouts adapted from www.e-bug.eu.



"Polymer clay examples" by Dan Bollinger - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Polymer_clay_examples.jpg#mediaviewer/File:Polymer_clay_examples.jpg



Microbe images by www.e-bug.eu

Activity 2: Student Handout A: What Are Microbes?

What are microbes?

1. Microbes are **living organisms** (except for viruses).
2. They are **so small** we need a microscope to see them.
3. They come in **different shapes and sizes**.
4. They are found **EVERYWHERE**!
5. Some microbes are **useful** or even good for us.
6. Some microbes can make us **ill**.

The 3 types of microbes in order of size:

Viruses

- Viruses are the **smallest**, even smaller than bacteria, and can sometimes live INSIDE bacteria!
- Some viruses make us **sick**.
- Diseases like **chickenpox** and the **flu** are caused by viruses.
- Viruses can spread from one person to another but it depends on the type of virus.

Influenza

Bacteria

Spirals

Campylobacter

Rods

Lactobacillus

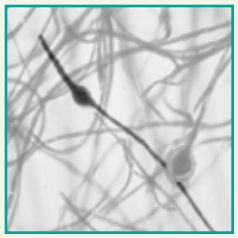
Balls

Staphylococcus

- They are **so small** that 1000's of bacteria could fit on the period at the end of this sentence.
- Some bacteria are **helpful** in cooking, for example, making yogurt and cheese.
- Some bacteria are **harmful** and cause infection.
- Bacteria multiply very **fast**.
- There are three different types of bacteria: **spirals, rods, and balls.**

Fungi

- Fungi are the **largest** of all microbes.
- Fungi can be found in the air, on plants and in water.
- **Mold**, which grows on bread, is a type of fungus.
- Some **antibiotics** are made by fungi!



Dermatophyte

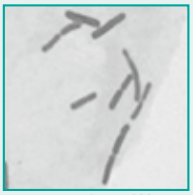
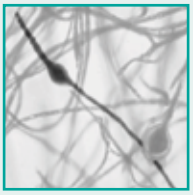
Penicillium

Handout adapted from www.e-bug.eu

Activity 2: Student Handout B: Microbe Trivia

There are 3 different types of **microbe** – bacteria, viruses and fungi. From the pictures and descriptions below, can you work out which microbe is which?

Hint: Remember there are three types of **bacteria**: rods, spirals, and balls.

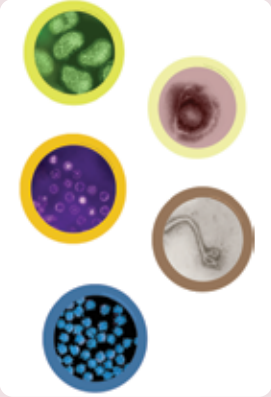
		What kind of microbe am I?
 *Staphylococcus*	I am **round** in shape and I like to live in your nose or armpits! If I live on your skin I can give you spots. If I get into your bloodstream I can make you ill!	
 *Influenza*	My friends call me the "**flu**". I'm very generous; I like to give people headaches and fever. I easily spread from one person to another through coughing and sneezing.	
 *Lactobacillus*	People call me "friendly" because I change milk into **yogurt**! When you eat me in yogurt, I live in your guts and help you digest other food.	
 *Penicillium*	You'll find me growing on old oranges or stale bread making them look **moldy**. Humans use me to make an antibiotic known as Penecillin, which can make them better, but only from bacterial infections!	
 *Dermatophyte*	I like to live on your skin. I especially like living in **damp** places like between the toes on sweaty feet! When I live there I give people athlete's foot!	
 *Campylobacter*	I have a pretty **spiral** shape and I like to live in chickens but if I get into your tummy I make you very ill – I can give you diarrhea!	

Handout adapted from www.e-bug.eu

Activity 2: Student Handout C: Make Your Microbe

Design a microbe of your choice with what you've learned so far: either a **bacterium**, a **virus**, or a **fungus**, using materials provided. Decide if your microbe will be **helpful** or **harmful**.

Viruses



Bacteria

Fungi

Name Your Microbe: _____

Helpful or Harmful? _____

Handout adapted from www.e-bug.eu

Activity 3: Extremophile Profile

In this activity students will explore some of the **craziest places** microbes can be found. Students will conduct online research to gather information about a specific **extremophile** (an organism that is able to survive in extreme conditions). Using this information, students will create a **'Profile Page'** for the extremophile. Students should be encouraged to be creative while still being factual and accurate with the information.

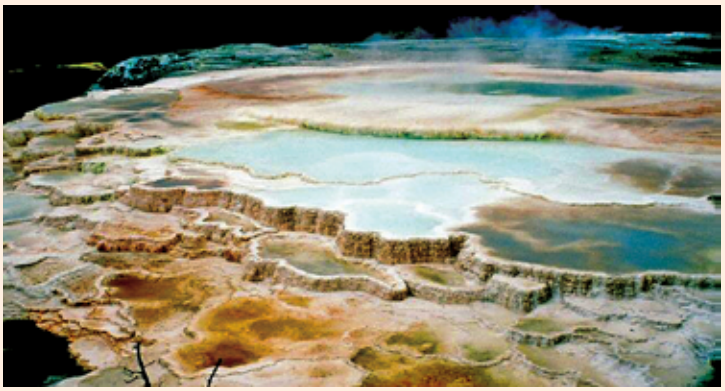
Time: 1 class period

Materials:

- Internet for online research
- **Activity 3: Research Notes**
- **Activity 3: Extremophile Profile**

Procedure

1. The teacher may assign or have students choose **one extremophile** to research.
2. Students should research the **Features, Conditions, Geographic Location, Habitat, Special Features, and Other Information** about their extremophile online and/or with information provided in this lesson.
3. Students take notes on their extremophile using **one Activity 3: Research Notes sheet per source**.
4. Students should fill out the **Activity 3: Extremophile Profile Page** about their extremophile with the information they gathered.



By William Waterway (water author/researcher/photographer) [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Activity 3: Research Notes Sheet

Fill out **one** of these sheets **for every different source** used during research.

Extremophile Type: _____

Source of Information: _____

Extreme Environment: _____

Notes	
Features Detailed description of appearance, shape size, color, texture, etc.	
Conditions What is it like where these organisms live? Describe the environment (temperature, salinity, pressure, acidity ranges, etc.)	
Geographic Location Where on Earth are these conditions found?	
Habitat Specific setting where your organism is found (under a rock, in shallow water, near the shoreline, surrounded by plants, etc.)	
Special Features Special adaptations that help them survive in their extreme environments (e.g., a coating of mucous to neutralize the acidity)	
Other interesting information	

Activity 3: Extremophile Profile

Cover Photo of Extreme Environment

Profile Picture

Extremophile Name

Extreme Environment

Geographic Location

Profile Information	
Features	
Conditions	
Habitat	
Special Features	
Other Interesting Information	

REFERENCES

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http://www.ucmp.berkeley.edu/alllife/virus.html

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