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# K-12 Partnership Lesson Plan

# *Microbes on Trial*

# *A case for the benefits provided by microbes in ecosystems*

## Overview

Students will examine their preconceived notions about microorganisms. The intent is to focus on the benefits microorganisms provide in several diverse ecosystems. In the first part of the lesson students will use petri plates to grow microorganisms from various outdoor habitats. In the second part of the lesson students research various topics related to microorganisms and present their findings to the class.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Describe the role of microbes in ecosystems
* Describe symbiotic relationships between microorganisms and other organisms
* Describe how microorganisms can change biotic and abiotic components of an ecosystem

**Length of Lesson**

Two class periods

**Grade Levels**

Middle school, high school (grade appropriate resources noted below)

**Standards covered (NGSS)**

Disciplinary Core Ideas:

 *Middle School*

* **MS-LS1-3**: use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells
* **MS-LS2-3**: develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem
* **MS-LS2-2**: construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems

*High School*

* **HS-LS2-3:** construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions
* **HS-LS2-6**: evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem

Cross Cutting Concepts:

* Systems and system models

Science and Engineering Practices

* Planning and carrying out investigations
* Constructing explanations and designing solutions
* Obtaining, evaluating, and communicating information

***Previous Michigan Standards Met:***

* **B3.3**: element recombination: as matter cycles and energy flows through different levels of organization of living systems
* **B3.4**: changes in ecosystems
* **B3.5x**: environmental factors: the shape of population growth curves vary with the type of organism and environmental conditions, such as availability of nutrients and space. As the population increases and resources become more scarce, the population usually stabilizes at the carrying capacity of that environment
* **B3.5e**: recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems
* **L.EC.M.2**: relationships of organisms
* **L.EC.06.21**: describe common patterns of relationships between and among populations (competition, parasitism, symbiosis, predator/prey)
* **L.EC.06.22**: explain how two populations of organisms can be mutually beneficial and how that can lead to interdependency
* **L.EC.06.23**: predict how changes in one population might affect other populations based upon their relationships in the food web

**Materials**

* Preti plates with media for growing microorganisms (can be purchased pre-poured from Carolina biological)
* Clip boards
* Poster paper or computers (for preparing student presentations)
* Internet resources (or printed articles) listed below

**Background**

A human’s body is composed of more bacterial cells than human cells. Additionally, our guts contain more bacterial genes than human genes. Many students and adults are primarily familiar with the negative role microbes play in disease, but do not know how microbes sustain every ecosystem in which they are found and contribute to biological diversity. Five main roles that microbes play in ecosystems are listed below.

1) Green algae and especially cyanobacteria (‘blue-green algae’ that are actually bacteria) are responsible for the majority of the world’s oxygen production. Most of this photosynthesis occurs in the ocean.

2) Bacteria and fungi can break down complex organic nutrients into simple, inorganic forms which plants can use far more readily. If it weren’t for such decomposition at the molecular level, life as we know it would stop fast! In aquatic ecosystems, bacteria and archaea play this role, while in terrestrial ecosystems, all three groups fulfill this function.

3) Bacteria and fungi can also improve food quality for an organism by making indigestible food into sugars and other more readily broken-down molecules that the organism can digest. For example, were it not for cellulose-degrading bacteria in a cow’s stomach, the cows couldn’t break down the grasses they eat for food! In many species bacteria also synthesize important amino acids and vitamins from raw materials in poor-quality food which higher organisms (including humans) can then use.

4) Nitrogen-fixing bacteria are also capable of removing gaseous nitrogen from the atmosphere and ‘fixing’ it into a solid, inorganic form which plants can then use. For example, legumes have

rhizobia in their roots—bacteria that live in root nodules which trade resources like nitrogen in exchange for a good home (the root). Such nitrogen fixation is extremely important for improving the quality of soils and increasing available nutrient concentrations in a habitat.

5) Beneficial bacteria protect animals from infection. When nondisease-causing microbes (the vast majority of them) inhabit an organism, they competitively exclude disease-causing microbes.

Additionally, they often provide many of the benefits previously mentioned, which can improve the host’s overall health and resistance to infection.

### Activities of the session

Day 1 (half a class period)

1. Discuss different types of organismal interactions (competitive, cooperative, parasitic, predatory; symbioses, commensalism, mutualism, amensalism)
2. Have students prepare a list of things they “know” and things they “want to learn” about microorganisms
3. Visit outdoor areas where microorganisms might be present (plants, soil, water, etc). List observations and evidence for microorganisms.
4. Put samples from various habitats on prepared plates. Leave in warm place for microorganisms to grow.
5. Discuss observations from the field and student prediction about what samples will grow microorganisms.

Day 2 (full class period)

1. Check plates and record observations of microorganisms.
2. Divide students into groups. Each group is assigned a topic (“The Human Body”, “Species Interactions”, “Water and Waste”) and tasked to research the role of microorganisms in the context of that topic using the resources below.
3. Each group prepares a summary (poster or oral presentation) about the role of microorganisms.
4. Groups present their findings.

**Research Resources**

Each group should focus on one of the three topics below (“The Human Body”, “Species Interactions”, “Water and Waste”). Advanced students can use the internet to find additional resources.

*General Resources (all groups)*

* <http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/microbes/microbes.html>
	+ high school reading level
* <http://www.biology4kids.com/files/micro_goodbad.html>
* <http://www.microbeworld.org/types-of-microbes/bacteria>

*The Human Body*

* <http://www.sciencedaily.com/releases/2010/06/100614171907.htm>
* <http://www.wired.com/2010/04/sushi-guts/>
* <http://www.wired.com/2009/02/bacteriablood/>
* <http://www.npr.org/templates/story/story.php?storyId=92677188>
* <http://www.npr.org/templates/story/story.php?storyId=104662183>

*Species Interactions*

* <http://whyfiles.org/2011/biology-critters-that-should-not-exist/>
* <http://www.backyardnature.net/lichens.htm>
* <http://evolution.berkeley.edu/evolibrary/article/0_0_0/endosymbiosis_01>
* <http://www.bioedonline.org/news/nature-news/predatory-bacteria-could-make-antibiotics/>
* <http://www.the-scientist.com/?articles.view/articleNo/22091/title/Bacteria-help-plants-grow/>
	+ High school reading level
* <http://archive.bio.ed.ac.uk/jdeacon/microbes/nitrogen.htm>
	+ High school reading level
* <http://www.genomenewsnetwork.org/articles/08_01/Symbiosis.shtml>
	+ High school reading level
* <http://www.scientificamerican.com/article/bacteria-spurs-speciation/>
	+ High school reading level

*Water and Waste*

* <http://www.scientificamerican.com/article/fertilizer-runoff-overwhelms-streams/>
* <http://www.livescience.com/7858-powerful-ideas-bacteria-clean-sewage-create-electricity.html>
* <http://news.nationalgeographic.com/news/2005/11/1109_051109_rocketfuel.html>
* <http://people.westminstercollege.edu/faculty/tharrison/gslfood/studentpages/Bacteria.html>
* <http://ohioline.osu.edu/a-fact/0009.html>
* <http://www.waterencyclopedia.com/Mi-Oc/Microbes-in-the-Ocean.html>
* <http://www.nature.com/climate/2008/0804/full/452162a.html>
	+ High school reading level

**Resources**

* Bioprospecting for Cellulose Degrading Microbes. Developed by an RET at the GLBRC center in Madison Wisconsin. Students take samples from the environment and culture on cellulose containing plates. If microbes are present they work to isolate a pure colony and conduct a test to identify the presence of cellulose degrading enzymes: <http://www.glbrc.org/education/classroom-materials>

**Assessment**

 Students can be assessed by the quality of their class presentations.