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# K-12 Partnership Lesson Plan

# Tomomi Suwa, Sandy Breitenbach

# *Mutualism in Action*

## Overview

Students will learn about the mutualistic relationship between plants and nitrogen fixing bacteria. The effect of environmental conditions on this relationship will be investigated in two inquiry activities.

**Objectives**

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

* Define mutualism
* Describe the mutualistic relationship between nitrogen fixing bacteria and legumes (biotic interactions)
* Describe how changing environmental conditions can alter the relationships between organisms (abiotic interactions)

**Length of Lesson**

The first part of the lesson can be completed in a 55 min. class period.

Design and setup of experiment II will require a second 55 min. class period. Additional class time will be needed to analyze the results of experiment II.

**Grade Levels**

Middle school and high school.

**Standards covered (NGSS)**

Disciplinary Core Ideas:

* **MS-LS2-1**: analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
* **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-LS2-4**: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
* **MS-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms

Cross Cutting Concepts:

* Patterns
* Cause and effect

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **L.EC.E.1**: interactions – Organisms interact in various ways including providing food and shelter to one another. Some interactions are helpful; others are harmful to the organism and other 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
* **B1.1C**: conduct scientific investigations using appropriate tools and techniques.
* **B1.1E**: describe a reason for a given conclusion
* **B3.3B**: describe environmental processes (carbon and nitrogen) and their role in processing matter crucial for sustaining life.
* **B3.5E**: recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems

**Materials**

* Bean seeds
* Fertilizer
* Cups (for planting)
* Inoculum (purchased from garden center or made up from field soil)
* Vermiculite
* Tray (to dispose soil)
* Ruler
* Balance
* Stereo microscopes (optional to look at the roots)

**Background**

**Mutualism** is a relationship between two organisms or species in which both benefit from the association. Flowering plants and pollinator interactions are a classic example of mutualism. Interactions between plants and rhizobia mutualism is another example of mutualism.

**Rhizobia** are symbiotic bacteria living inside root nodules of host plants. Rhizobia are one of a few microbial groups that posseess the metabolic capacity to convert atmospheric nitrogen (N2) to ammonia (N3H-). Rhizobia provide leguminous host plants, such as soybeans, with reduced N in exchange for organic carbon (C). In turn, plants can provide photosynthetic carbon to rhizobia.

However, depending on the environmental conditions, plants may not always benefit from rhizobia. For example, in high nutrient environments, plants do not need to obtain nitrogen from rhizobia. Instead, they can directly get it from the soil. Thus, in such a condition, it would be more costly for plants to associate with than without rhizobia. While plants do not need rhizobia for nitrogen acquisition, they still need to provide photosynthetic carbon to rhizobia. Similarly, under low light environments, plants may not be able to photosynthesize to meet rhizobia carbon demand. Therefore it might be more costly to associate with than without rhizobia. In this lesson, students can explore mutualism under different under different abiotic conditions.

### Activities of the session

1. Pre-assessment of student background knowledge
   1. Handout with questions for students to complete individually or in small groups.
   2. Whole class discussion of questions.
2. Overview of mutualism and nitrogen fixing bacteria. Power point presentation in resources section.
3. Analysis of Experiment I.
   1. Student groups look at bean plants that have been grown with and without nitrogen fixing bacteria and collect the following data:
      1. Measure plant height
      2. Count the number of true leaves
      3. Count the number of nodules on the roots
      4. Mass the plants
      5. Students analyze data by constructing a graph of the data they collected and then form a conclusion about the relationship between the plants and the bacteria.
   2. Students look at a second group of plants set up the same as the first group except that they are grown in reduced light.
      1. Measure plant height and mass
      2. Count the number of nodules on the roots and leaves
      3. This new data is added to the graph and a comparison is made between each of the four treatment (with and without light, with and without rhizobia in each condition).
      4. Students draw conclusions about the effect of an environmental condition (light) on the mutualistic relationship between the plants and bacteria.
4. Set up an experiment to investigate another environmental factor and its affect on the relationship between legumes and bacteria.
   1. Students identify environmental factors that may affect the plant -bacterial relationship.
   2. Students design experiments to test the identified environmental factor.
   3. A protocol for testing the affects of added nitrogen on plant/rhizobia relationship is included with this lesson.
5. At the conclusion of this lesson students go outside to look for plants that have a symbiotic relationship rhizobia. They can dig up some of these plants and look for nodules on the roots. They can observe environmental conditions that may be affecting this relationship.

**Resources**

* Powerpoint
* Two versions of student handout
* Post activity assessment (all available on “Mutualism in Action” lesson page on the KBS GK-12 website)

**Assessment**

Pre-activity and post-activity assessment questions provided on the “Mutualism in Action” lesson page of the KBS GK-12 website.