

Soil Microbes and Respiration: Background Information

What are soil microbes?

Soil microbes are organisms living in soil that cannot be seen without the aid of a microscope. They are grouped into two main groups, bacteria and fungi. Bacteria and fungi along with micro and macroscopic invertebrates make up the bulk of organisms living in soil. The species and amount of organisms living in soil is dependent on geology, climate, and location of the soil. Soil contains an extremely diverse and numerous collection of organisms where one teaspoon of soil can contain up to 100,000,000 bacteria, 1,000,000 fungi, and 1,000 invertebrates. There are more organisms in one teaspoon of soil than there are humans on the earth.

What do soil microbes do and why are they important?

Soil microbes have many important functions that are vital to regulating ecosystems on earth. In other words, without them humans and animals could not live. Soil microbes and invertebrates live and work together in an underground system that helps improve soil and water quality. Microbes are our planet's decomposers, starting with invertebrates that shred dead plant material into small enough pieces that microbes then break down smaller particles for plants to use. These organisms become food for each other while also providing nutrients for plants after they die. Fungi help bind soil particles together, which prevents erosion and helps retain moisture for plants to use during times of drought. Certain types of soil bacteria can filter and break down pollutants which can result in creating reduced or no harmful byproducts. Some microbes and invertebrates will consume invasive or unwanted organisms that can cause diseases in plants. They also mix nutrients into soil when they move within soil, creating spaces for oxygen and water move, such as when earthworms create burrows. The waste products created by microbes and invertebrates are typically full of nutrients which can be used by plants, such as worm castings. Certain bacteria also take nitrogen gas from the atmosphere and turn it into a form that plants can use. This is called nitrogen fixing, and is a symbiotic relationship between special bacteria and leguminous plants.

How do scientists measure soil biological activity?

One of the ways in which scientists measure the activity of soil is by measuring the rate of carbon dioxide (CO₂) given off by microbes and invertebrates. Most microbes and invertebrates are heterotrophic organisms, meaning they need their energy from carbon sources, similar to animals. They breathe in oxygen and give off CO₂ by means of cellular respiration, which can be measured using CO₂ and O₂ sensors. As time increases, CO₂ levels increase and O₂ levels decrease. The magnitude to which CO₂ gas levels increase determines the activity of the soil. For instance, since microbes are not very active in cold temperatures, CO₂ levels will be drastically lower than levels in midsummer. Temperature, pH, carbon availability, porosity, and moisture levels can all affect biological activity in soil.

References:

Hatfield, J., and Stewart, B. Soil Biology: Effects on Soil Quality. Florida, CRC Press, 1994.

<http://soil.gsfc.nasa.gov/>

<http://soils.usda.gov/>

Soil and Water Conservation Society (SWCS). 2000. *Soil Biology Primer*. Rev. ed. Ankeny, Iowa: Soil and Water Conservation Society.

Soil Biology: Resources

Soil Science Society of America Teacher Resource Page

<https://www.soils.org/lessons/>

United States Department of Agriculture National Resource Conservation Service Soil home page

<http://soils.usda.gov/>

The Encyclopedia of Earth Soil Page

<http://www.eoearth.org/article/Soil>

Smithsonian Soil Exhibit Companion Web Site

<http://forces.si.edu/soils/index.html>

NASA Soil Science Education home page

<http://soil.gsfc.nasa.gov/>

Iowa State University Invertebrate Identification Web Guide

<http://bugguide.net>

The web version of the NRCS Soil Biology Primer

http://soils.usda.gov/sqi/concepts/soil_biology/biology.html

Paper version of the NRCS Biology Primer

Soil and Water Conservation Society (SWCS). 2000. *Soil Biology Primer*. Rev. ed. Ankeny, Iowa: Soil and Water Conservation Society.

A simple, in-depth soil biology guide from bacteria to birds

Nardi, James B. Life in the soil : a guide for naturalists and gardeners . Chicago, University of Chicago Press, 2007.

FBI Metaphors: Introductory Activity

4-6th grade

Materials: FBI metaphor object cards only, tape

Instructions

Ask the students what are the 5 main components of soil (broken down pieces of rock –minerals, dead and decayed plants - organic matter, water, air and **living organisms**, called the FBI. Explain that the FBI are (F: fungi, B: bacteria, I: invertebrates) organisms living in soil which have many important functions essential for life to exist. Ask the students if they have ever heard of the word metaphor. Explain to them that a metaphor is an object (noun) or phrase that is used to compare 2 unlike things without using the words “like” or “as”. Give them an example of a metaphor (jumping for joy, apple of my eye). Place 1 FBI object card on each students’ forehead with the object facing out, including your own. Explain to them that these objects on their foreheads represent what the soil FBI are or do. Explain the process of playing “20 Questions” (can only ask yes or no questions to guess what something is). Ask them yes or no questions until you guess the object on your forehead to warm them up to the activity. In small groups, students play “20 Questions” until they guess the object on their forehead. Students remove the object once they have guessed and assist other students until everyone is done. If they need a hint, suggest that many of the objects are household items. Assist and help students until they have all guessed their object. After the objects have been guessed, have them get in small groups to decide what their object represents for the soil FBI. Assist them as needed. Have the entire group come back together a few minutes later to wrap up. Ask the students to explain their object and add additional information to the metaphors as needed.

7-8th grade

Materials: FBI metaphor, object, and conclusion cards

Instructions

Proceed same as above with introduction of soil, the FBI and metaphors. Have students break into 4 groups. Make sure each group has a full set of object and the small color coded metaphor cards. **The object cards match up with one of the metaphor cards, representing what the FBI are or do.** Have the students match up the object cards with the metaphor cards, keeping the colored metaphor cards in groups, separated from the other cards. Once students have matched up their cards, go around the class and explain the metaphors, adding any additional information as needed. Explain to them that all these functions the FBI perform have importance. Also, explain the reason for grouping them by color (these groups of functions have something in common). Pass out the final conclusion cards and have the students match up the appropriate conclusion with each of the 4 groups of metaphors and objects. Ask the students to explain the conclusion cards to wrap up. Assist them and add additional information as needed.

High School

Materials: FBI metaphor, object, and conclusion cards

Instructions

Ask the students what are the 5 main components of soil (broken down pieces of rock – minerals, dead and decayed plants - organic matter, water, air and **living organisms**, called the FBI. Explain that the FBI are (F: fungi, B: bacteria, I: invertebrates) organisms living in soil which have many important functions essential for life to exist. Ask the students to explain what a metaphor is or give an example of a metaphor. Explain to them that a metaphor is an object (noun) or phrase that is used to compare 2 unlike things without using the words “like” or “as”. Give them an example of a metaphor (jumping for joy, apple of my eye). Have students break into 4 groups. Make sure each group has a full set of all cards (object, metaphor and conclusion cards). Tell the students that each object card matches up with one metaphor card, representing what the FBI are or do. Have the students match up the object cards with the metaphor cards (they will use the conclusion cards later). Once students have matched up their cards, go around the class and explain the metaphors, adding any additional information as needed. Explain to them that all these functions the FBI perform are all important for a reason. Next, have them group the objects and metaphors by color, explaining that the functions share something in common. Give them a minute to think about how these functions might relate to one another, asking any group if they have come up with a connection. Have them match up the final conclusion cards with their appropriate group. Ask the students to explain the conclusion cards to wrap up. Assist them and add additional information as needed.

FBI Metaphor Introductory Activity

| Object | What it represents... | Card color | Conclusion |
|----------------|--|------------|--|
| Vegetables | Breaks down plant material into components that plants can use to grow. They are also food for each other | Blue | Biological processes occurring in soil. These functions are essential for life to exist. |
| Paper shredder | Decompose organic matter. Macroinvertebrates shred large particles for fungi and bacteria to break down further. | | |
| | | | |
| Mixer | Mixes nutrients and oxygen into soil | Green | Improve physical properties of soil |
| Glue | Bind soil particles together | | |
| Sponge | Absorb water from rainfall and runoff. They help retain moisture in soil when standing water dries up. | | |
| Bubbles | Aerates (put oxygen into) soil | | |
| | | | |
| Vitamin C | Provides minerals and nutrients for plants to grow | Red | Nutrients are necessary for plant growth |
| Toilet paper | Their waste products provide nutrients for plants | | |
| "Mr. Fix It" | Turns N ₂ gas from atmosphere into a form that plants can use | | |
| | | | |
| Super man | Stops bad guys from doing harm | Yellow | Helps keep soil and water safe for humans, plants and animals |
| Filter | Filters out pollutants | | |