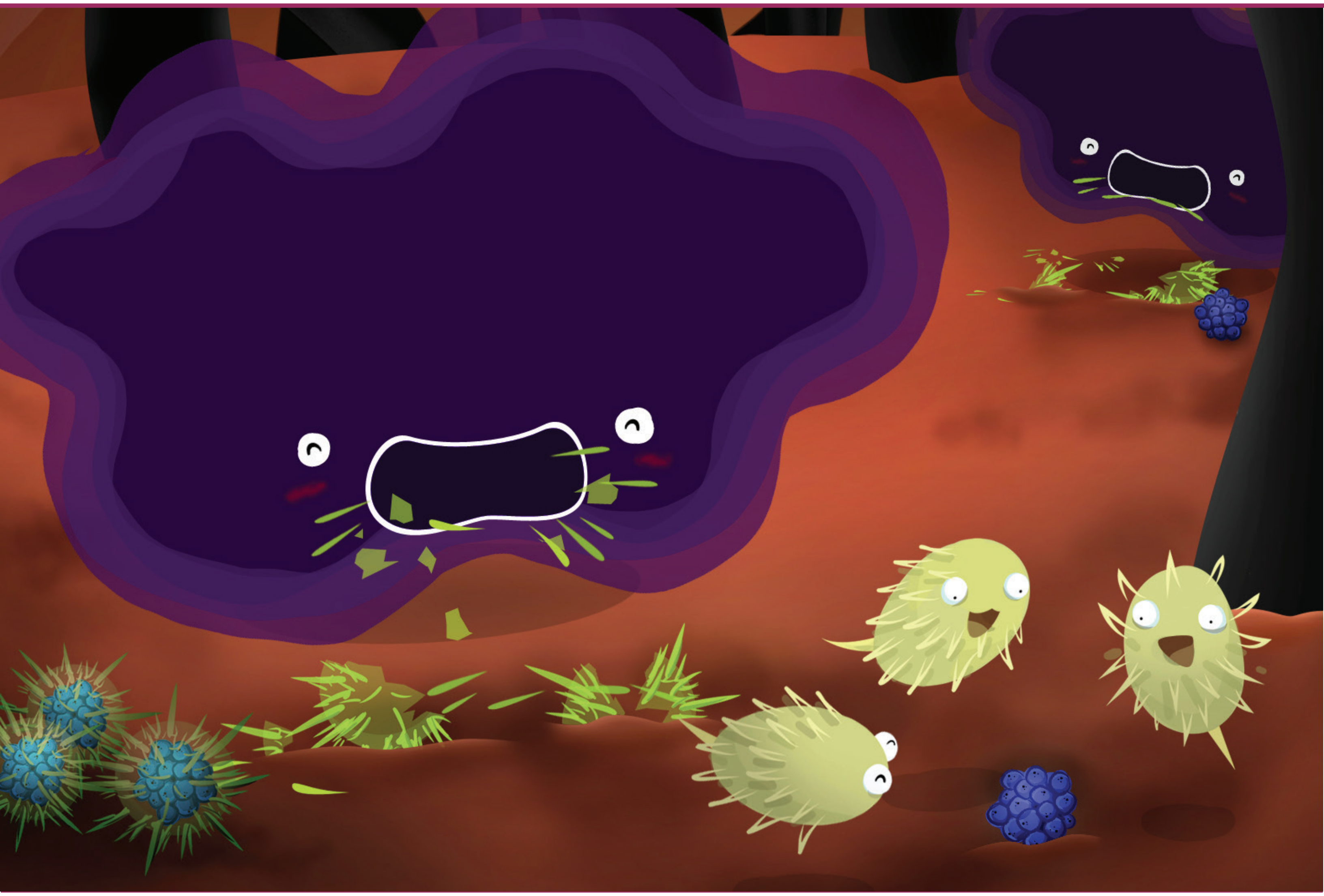
MODULE 3

MAGICAL MICROBES

NGSS TEACHER'S GUIDE

Soil Ecology and Nutrient Cycling



NGSS Alignment

CORE IDEAS

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

LS1.A: Structure and Function
LS1.C: Organization for Matter and Energy Flow in Organisms

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

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

Core Idea PS3: Energy

PS3.B: Conservation of Energy and Energy Transfer
PS3.D: Energy in Chemical Processes and Everyday Life

Core Idea ETS1: Engineering Design

ETS1.A: Defining and Delimiting an Engineering Problem
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

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

INTRODUCTION

Teaching Rationale

Microbial fuel cells (MFCs) represent an exciting, emerging technology for generating electricity that is clean and reliable. In this module students will learn how electricity is produced by certain bacteria during their natural metabolic process and how a microbial fuel cell works.

The progression of lessons provided in this module has been designed to give students the background and instruction necessary to engage in their own exploration of microbial fuel cells. Each lesson builds upon the learning in the preceding activity and it is recommended that the lessons be done sequen tially.

The reading material and lab activities help provide concrete learning opportunities for abstract concepts. Students with minimal background knowledge in microbiology and electricity can perform these activities (see suggested prerequisites).

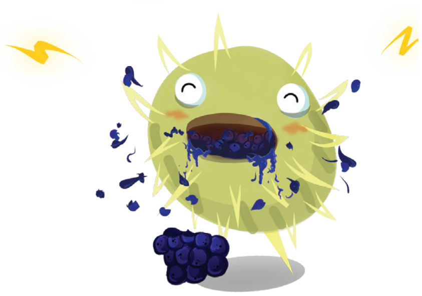
PREREQUISITES

Note: This module is intended for Middle School Students.

Prior to starting these investigations it is recommended that students have a basic understanding of:

- **Characteristics of all living organisms and microbes (specifically bacteria)**

If additional background information is required prior to starting this module students may complete **Sub-Module 1: Meet the Microbes and Sub-Module 2: Electricity and Circuits**.



TEACHER BACKGROUND

Teacher Notes

In this module students will build an understanding of what **soil** is, how it is formed and how it is able to support the diverse population of organisms from macro- to microscopic that live in it.

Begin the unit by asking students what soil is. Accept all responses while guiding them towards the idea that soil is a mixture of living and non-living components. The non-living, **inorganic**, components consist of small pieces of broken down rock in varying sizes, or sediments, which are categorized by size (see size chart in student section). Sand, silt and clay are the most typical sizes of soil particles but larger sized particles (pebbles and boulders) are occasionally found as well.

In the first activity students characterize different **soil samples**. They will make qualitative observations of the color, smell and feel of the soil as well as quantitative measurements to determine the relative amounts of each type of sediment. For best results provide students with different soil types so that there can be an opportunity to compare results and see any relationships between texture and color or color and amount of organic matter in the soil. If time is limited, use **Lesson 1A** which gives a procedure for determining the composition of the soil sample. If time permits, use **Lesson 1B** where students are challenged to create their own procedure for determining the soil composition. Students may need to be guided by the teacher towards the solution of using settling rates to determine how much of each different sediment type is in the soil.

In **Lesson 2** students examine the **soil ecosystem** through several lenses. First students get a sense of the biodiversity within the soil ecosystem by collecting, counting and identifying the macro fauna. Depending on the amount of time available and the availability of resources to make the Berlese funnels, students may be directed to isolate the organism with a manual method or with the Berlese Funnel, which they must make prior to using. Students will use a simple identification key to identify the organisms found in their samples.

Next students will explore the characteristics and interactions of both **macro** and **micro fauna**.

Finally students investigate how microbes are essential to the recycling of essential nutrients through the microbes' role in **decomposition**. Students will construct decomposition jars with which they can monitor how quickly different materials decompose. As an extension, students can be challenged to test different conditions so that they can better understand what conditions allow the maximum decomposition to occur.

LESSON 1: BACKGROUND

STUDENT HANDOUT

Soil Composition and Formation

Objective: In this module you will build an understanding of what soil is, how it is formed and what factors affect soil formation.

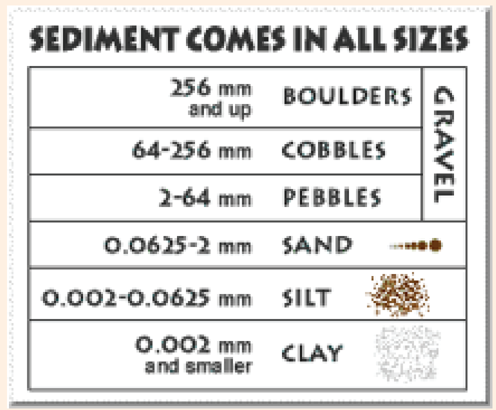
Soil Composition: What is Soil?

Introduction:
Soil is a natural substance that is made up of both living and non-living components. The non-living, **inorganic** components consist of small pieces of broken down rock in varying sizes. Sand, silt and clay are the most typical sizes of soil particles but larger sized particles (pebbles and boulders) are occasionally found as well, as shown in ***Figure 1***.

How much **sand**, **silt**, and **clay** is in the soil determines its **texture**.

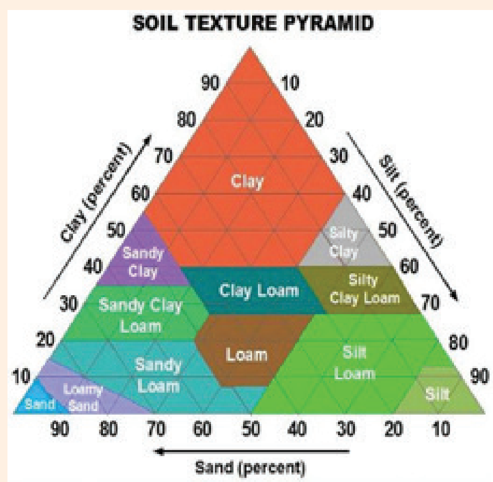
The percent of each type of sediment in soil is used to classify soils, using the Soil Texture Pyramid as Pyramid shown in ***Figure 2***.

In addition to sand, silt and clay soil contains dark **organic** (living or once living) matter called **humus** which is formed when materials such as dead leaves and dead organisms **decompose**.



http://geomaps.wr.usgs.gov/parks/rxmin/sediment.html

Figure 1. Sediment types and sizes

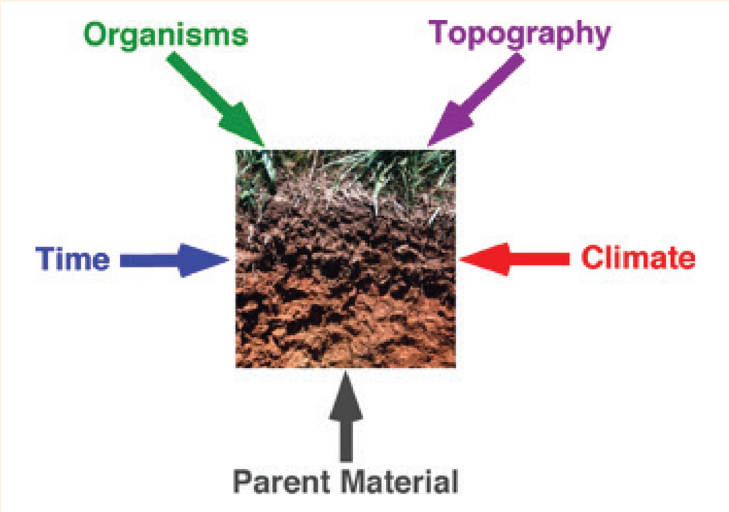


http://www.todayshomeowner.com

Figure 2. Soil Texture Pyramid

Soil Formation: How do soils form?

Soil is formed from the breakup of rock and the decomposition of once living (organic) material. Soils “evolve” through time. There are five main factors that control soil formation (***Figure 3*** below):



http://www.physicalgeography.net/fundamentals/10u.html

Figure 3. Five Factors of Soil Formation

original material, or **parent rock material**. Animals contribute to the break down of rock when they burrow and dig while plants such as lichens chemically dissolve rock material. When plants and animals die and decompose important nutrients are returned to the soil.

The amount of **time** required for soil to form varies depending on the other factors involved, but it can take 500 years for as little as 1 cm of soil to form!

The nature of **parent rock material** impacts soil formation. Soft rock materials, such as sandstone or limestone, can be weathered faster than much harder rock, such as granite.

The **climate** of an area determines how wet or dry an area is, and how many times the ground freezes and thaws, or gets wet and dries out again. Climate also affects how quickly rocks are weathered. For example, areas that have higher temperatures have a faster rate of breakdown of the underlying rock.

Quick Check:

Which parent rock material would form soil more quickly: **softer** or **harder** parent rock material?

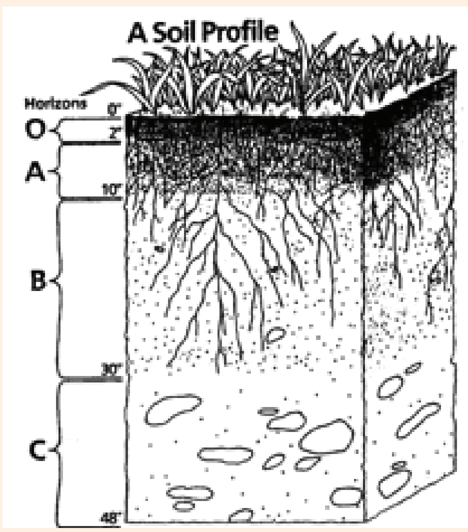
The topography (how hilly or flat the area is) also affects how windy, wet or dry, and warm or cold the area is. Areas that have a lot of mountains and hills can experience very wet conditions in the valleys and dry conditions higher up. Conversely, snow is commonly found on the top of some mountains while deserts exist in the rain shadow of these same mountains.

Living organisms also play a significant role in the formation and maintenance of soil. Some organisms burrow and dig helping to both aerate and further weather the soil.

When living organisms die they decompose and the resulting organic matter becomes part of the soil.

Quick Check:
Which location would have faster soil formation: the **Brazilian Rain Forest** or **Arizona**?

As more weathering occurs distinct zones or **horizons** form, creating the soil profile. From the surface each horizon contains progressively less organic material and more parent rock material. (See **Figure 4** below.)



http://printablecolouringpages.co.uk/?s=soil+horizons

Figure 4. Soil Horizons

"O" Horizon: mostly organic material (dark color)

"A" Horizon: has a mixture of organic and sand, silt and clay

"B" Horizon: layer has little organic matter (slightly lighter in color)

"C" Horizon: is primarily broken pieces of the parent material

The very top, the **"O" horizon** is comprised mostly of decomposing organic material and is usually very dark in color.

The next horizon is the **"A" horizon** which is still darker than the lower horizons because is has a mixture of organic material, sand, silt and clay. This layer is often referred to as "topsoil."

Water moving through the "A" horizon dissolves and carries away with it (leaches) many nutrients and other materials.

These leached materials travel further down into the **"B" horizons** where they stop flowing. The "B" layers layer has little organic material in it.

Usually there is a deeper **"C" horizon**, which is mainly broken pieces of the parent material. Parent material does not have to be a solid rock - it can be material that was deposited from a flood.