**Teacher Guide–The Soil is Breathing!**

**Cellular Respiration and Slump Testing**

Guidelines for NGSS 3-Dimensional Learning

**NGSS Alignment:**

* HS-ESS3-4: Earth and Human Activity
* HS-LS1-7: From Molecules to Organisms: Structures and Processes
* HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics
* MS-ESS3-3: Earth and Human Activity
* MS-LS1-7: From Molecules to Organisms: Structures and Processes

 **Performance Expectations:**

* HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
* HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
* MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
* MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

**ESS3.C: Human Impacts on Earth Systems**

* Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
* Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

**LS1.C: Organization for Matter and Energy Flow in Organisms**

* As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
* As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

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

* Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

**LS1.C: Organization for Matter and Energy Flow in Organisms**

* Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
* PS3.D: Energy in Chemical Processes and Everyday Life
* Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (secondary)

**Science and Engineering Practices:**

* Developing and using models
* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence

**Crosscutting Concepts:**

* Cause and Effect
* Energy and matter
* Systems and system models

**Alignment to Illinois Career Tech Courses:**

* Basic Environmental Science
* Crop Science
* Environmental Science
* Introduction to the Agricultural Industry
* Precision Agriculture
* Specialty Crop Production
* STEM in AFNR

**Overall lesson objective:**

Using the anchoring phenomenon of “The Importance of Earthworms for Soil Structure,” students explore the ways in which organisms benefit soil. Building on that model, students are introduced to cellular respiration as a way in which they can check soil for microorganism communities. They then build on that knowledge as they carry out slump tests and discover the relationship between communities of microorganisms and soil structure.

**Accommodations for students on IEPs and ELL students:**

Provide additional explanations on directions to ELL students or students on IEPs. Allow students to dictate written work to a teacher or paraprofessional. Provide opportunities for the articles to be read aloud as students need.

**Teacher Handout Engagement Phase**

***I Notice, I Wonder, It Reminds Me Of***

**Purpose of *I Notice, I Wonder, It Reminds Me Of* Activity:** The purpose of *I Notice, I Wonder, It Reminds Me Of* is to engage students in making detailed observations from an article.

**Learning Objective Addressed in *I Notice, I Wonder, It Reminds Me Of* Activity:** Students read an article and make observations

**Driving question**: How do organisms benefit soils?

**Overview of *I Notice, I Wonder, It Reminds Me Of* Activity:** Students will read the article, complete the “***I Notice, I Wonder, It Reminds Me Of”*** handout, and engage in discussion about their observations.

**Time:** One 50-minute class period

**Materials:**

*Student materials:*

* Student handout: *I Notice, I Wonder, It Reminds Me Of*
* Copies of “The Importance of Earthworms for Soil Structure”

**Procedure--Part I--Structure Introduction:**

The teacher will introduce the structure: “As you read the article, make careful observations in the “I Notice” box. Once you’ve completed that, think about what questions you may have about what you read. Record those questions in the “I Wonder” box. Finally, think about what you may have seen before or in other contexts that you can connect this reading to. Record those thoughts in the “It Reminds Me Of” box.”

 **Procedure--Part II--Reading:**

Provide students time to read the article independently or read the article aloud to the class. While they are reading, students should complete the *I Notice, I Wonder, It Reminds Me Of handout.*

**Procedure–Part III–Share Observations:**

Have students share their observations from the “I Notice” box in small groups, comparing and contrasting. Next, call on students to share observations in the whole class setting.

Repeat this sharing-out procedure with the “I Wonder” and “It Reminds Me Of” boxes. Highlight questions that ask why there is a difference in behavior.

**Procedure–Part IV–Connect to Explore Phase:**

Say: “Many of you wondered whether only earthworms have this impact on soils. Now, we will look for evidence of other organisms living in the soil.”

**Teacher Handout Explore Phase**

***The Soil is Breathing!***

**Purpose of The Soil is Breathing! Activity:** The purpose of this activity is for students to observe cellular respiration happening in soil organisms to demonstrate their presence in the soil.

 **Learning Objective Addressed in The Soil is Breathing! Activity:** Students explore and make observations of cellular respiration activity in different soil samples.

 **Driving question**: Which soils have more organisms?

**Overview of The Soil is Breathing! Activity:** Following an introduction to cellular respiration,students will carry out a balloon demonstration of cellular respiration on various soil samples.

 **Time**

● 1 50-minute class period

**Procedure:**

1. The teacher will lead the class in an introduction to cellular respiration using [this video](https://www.youtube.com/watch?v=eJ9Zjc-jdys).
2. Students will carry out the cellular respiration balloon investigation using the following methods.

**Investigation Materials:**

Each group will need:

* Soil samples (one from a non tilled area, one from a tilled area, one additional sample)
* A small plastic bottle (about the size of a 16 oz soda bottle) for each soil sample
* A balloon for each soil sample
* A rubber band for each soil sample
* Masking tape and markers to label samples

**Investigation Procedure:**

1. Fill each bottle about ⅔ full of soil then add water to moisten. Use tape and a marker to label each bottle with the appropriate soil sample.
2. Place a balloon over the opening of each bottle and secure it with a rubber band.
3. Observe the soil samples over time, watching for the balloon to rise. In 5 minute intervals, record what is happening with each sample’s balloon.

As students carry out the investigation, they record their observations on the Student Handout: The Soil is Breathing! Data Sheet. They may also want to take photos at these time intervals.

**Teacher Handout Explain Phase**

 ***Claim, Evidence, Reasoning Writing Activity***

**Purpose of Claim, Evidence, Reasoning Writing Activity:** The purpose of the Claim, Evidence, Reasoning Writing Activity is for students to develop skills in analyzing evidence and constructing explanations.

 **Learning Objective Addressed in Slake Test Demonstration Activity:** Comparing their observations from the slake test demonstration and the soil observation activity, students will draw conclusions and develop an explanation for which soil characteristics impact soil behavior in a slake test.

**Driving question**: Which soils have more organisms?

**Overview ofClaim, Evidence, Reasoning Writing Activity:** Thinking back to the The Soil is Breathing! activity, students analyze the data they collected.

**Time:** One 50-minute class period

 **Materials:**

* Claim, Evidence, Reasoning Writing Activity Student Handout
* Claim, Evidence, Reasoning Slide Deck

**Procedure:**

Introduce students to the Claim, Evidence, Reasoning writing format using [the provided slide deck](https://docs.google.com/presentation/d/13cIgasiTNdunnsCalhCPZWJ7wCN-9T_MOaG3veQhx8w/edit?usp=sharing). Give students time to construct their responses. You may wish to allow students to peer edit before submitting their work. After work is submitted, evaluate their responses with the [provided rubric](https://docs.google.com/document/d/1o_UVSOC55mOLS2s4CrEOB9O-Aggqa4S8LZAMLa5Och0/edit?usp=sharing).

As students develop writing skills in this method, it is helpful to provide written comments and allow them to resubmit new drafts. Frequent feedback may include:

* Your claim should clearly answer the question asked.
* Provide specific evidence based on the observations you made in the activities.
* Your reasoning should explain *why and how* the evidence you provided backs up your claim.

To transition into the Elaborate phase, the teacher says, “You have figured out which soils have larger communities of organisms. Now you will explore how that may impact soil structure.”

**Teacher Handout Elaboration Phase**

***Slump Test***

**Purpose of *Slump Test* Activity:** The purpose of *the Slump Test* Activity is for students to explore the behaviors of various soil samples.

**Learning Objective Addressed in *Slump Test* Activity:** Students carry out a slump test and make observations.

**Driving question**: What’s the relationship between the amount of life in soil and its slump test behavior?

**Overview of *Slump Test* Activity:** Students will carry out a slump test, make observations, and relate these observations to what they discovered about organisms in the soil samples.

**Time:** One 50-minute class period

**Materials:**

*Student materials:*

* Student handout
* Soil samples from the same locations used in the Explore phase
* One sink strainer per soil sample
* Water
* Cups the sink strainers will rest on top of
* Flat surface to dump soil samples onto for easy clean up (bucket lid, frisbee, etc.), one per soil sample

*Teacher materials:*

* [video of a slump test](https://www.youtube.com/watch?v=oY4pqIVMfNA)

**Procedure--Part I--Slump Test and Structure Introduction:**

The teacher will show the [video of a slump test](https://www.youtube.com/watch?v=oY4pqIVMfNA) (or demonstrate one in class) to instruct students on carrying out the test.

 **Procedure--Part II--Student Slump Tests:**

Provide students time to carry out the slump tests and complete the handout to record their observations. As students work, circulate the room to check their work and offer help as needed.

**Procedure–Part III–Lab “Report” Project:**

Working from their observations on the handout, students will choose a creative project to make sense of and report what they figured out about the relationship between the organisms in soil samples and slump test behavior. Each project should answer the driving question, provide evidence to support the answer, and provide scientific reasoning as to why the evidence supports the answer.

Some projects to choose from may include: a comic book or comic strip, a children’s book, an infographic or a video. Score projects using [this rubric](https://docs.google.com/document/d/1SV1ypE5QZz3ZX9beZJPej3KJyzXcZ4QKXX-IuiO1NWo/edit?usp=sharing).

**Teacher Handout Evaluation Phase**

The lesson includes multiple opportunities for assessment to monitor students’ understanding of both science content knowledge and scientific practices. In the Engage phase, students demonstrate their ability to make observations from text. In the explore phase, students demonstrate their ability to carry out an investigation. In the Explain phase students demonstrate their ability to use data to support a claim. In the Elaborate phase, students demonstrate their ability to connect multiple lines of evidence to answer a question. This array of assessments is designed to meet the needs of students’ diverse academic strengths.