



Is it Alive?

Grades: Middle School

Prep Time: ~30 Minutes

Lesson Time: ~105 Minutes

WHAT STUDENTS DO: Generate Criteria for Living vs. Non-Living.

This lesson is designed to be a review of the characteristics of living things. In **Part A**, students will use research to develop their criteria for determining if something is alive. The class will combine their ideas in a teacher-guided discussion. In **Part B**, they will then use their criteria to determine whether there is anything alive in three different “soil” samples. They will make observations and draw pictures as they collect data from the sample and investigation. The purpose of this lesson is for students to use a critical thinking and a collaborative approach to identifying and applying the criteria needed for life. Students will:

- Use scientific observations to establish criteria,
- Differentiate between living and non-living objects, and
- Attribute criteria as Earth-based definitions of life.

NRC FRAMEWORK / NGSS CORE QUESTION

HOW DO ORGANISMS LIVE, GROW, RESPOND TO THEIR ENVIRONMENT, AND REPRODUCE?

NGSS Core Question: LS1: From Molecules to Organisms: Structures and Processes

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able

IO1: Generate a list of criteria for the characteristics of life and conduct an investigation using changes over time among three samples as evidence for living/nonliving material.



1.0 Materials

Required Materials

Part A:

- Dictionaries, encyclopedias, or technology access
- Examples of living and non-living things (should include plants, animals, and microorganisms – pictures can be substituted for the real thing)

Part B (per class of 30 students):

- Approx. 2.5 pounds (40 oz.) clean sand (e.g.; bag of sand used for playgrounds)
- 45 small paper cups (5 oz.)
- 3 cups granulated sugar
- Instant Active Dry Yeast – 15 teaspoons (~2.5 oz. jar)
- Effervescent tablets crushed and powdered– 15 tablets
- Hot water (not too hot to kill the yeast) – 90 oz. (~12 cups or $\frac{3}{4}$ gallon)
- Pitcher and cups for distributing hot water
- Marker to mark the Sample Bags and Cups

Prepare Part B Materials:

- Fill each of the three gallon-size ziplock-type bags with $\frac{1}{3}$ of the clean sand;
- Label bags as **A**, **B** and **C**;
- Add 1 cup of granulated sugar to all 3 bags, close and shake to distribute the sand and sugar mixture. **Bag A** is finished, set **Bag A** aside;
- To **Bag B**, add the ~2.5 oz. of Instant Active Dry Yeast. Close and shake to distribute the sand, sugar and yeast mixture; and
- To **Bag C**, add the crushed and powdered effervescent tablets. Close and shake to distribute the sand, sugar and yeast mixture.

Per pair of students:

- 3 small paper cups - empty (~5 oz.) – labeled **A**, **B** & **C**
- Magnifying lens

Please Print:

From Student Guide:

- | | |
|----------------------|-----------------|
| (A) Student Sheet #1 | – 1 per pair |
| (B) Student Sheet #2 | – 1 per pair |
| (C) Data Chart #1 | – 1 per pair |
| (D) Data Chart #2 | – 1 per pair |
| (F) Reflections | – 1 per student |



🍌 **NGSS Teacher Tip:** Print the (F) *Reflection of Science and Engineering Practices* on blue paper and (F) *Reflection Crosscutting Concepts* on green paper to match the color-coded posters and standards.

Optional Materials

Per pair of students:

- Dissecting Scope
- Microscope

From the Lesson:

(E) Sample Organizational Table

From the Alignment Document:

- (L) “Is It Alive?” Assessment Rubrics
(M) Alignment of Instructional Objective(s) and Learning Outcome(s) with Knowledge and Cognitive Process Types

NGSS Materials:

“A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas” (NRC, 2012), also known as the Framework, articulates a vision of exemplary science instruction based upon current research. This vision centers on 3-dimensional learning in which Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts in science and engineering are coherently integrated in instructional design. It isn’t enough, however, that students engage in the Practices as they develop a deep understanding of the Core Ideas. Students must also be cognitively aware of what they are doing and what the Practices are. The reflection assignment will engage students in thinking about the Practices, about what those Practices are, and how the Practices relate to doing science.

This lesson will assist you in integrating this activity and will suggest resources.

Please Print:

NGSS Practices Poster
NGSS Crosscutting Concepts Poster
NGSS Understanding about the Nature of Science Poster

Please Read:

[Appendix F – Science and Engineering Practices in NGSS](#)
[Appendix G – Crosscutting Concepts](#)
[Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards](#)



2.0 Vocabulary

Characteristics	distinguishing traits, qualities, or properties of an object or phenomenon
Criteria	a standard list of “rules” established so judgment or decisions are based on objective and defined ideas rather than subjective ones
Inference	drawing a logical conclusion based on observations and data collection
Inquiry	a systematic investigation used to search for relationships and knowledge
Life	a state defined by the capacity for metabolism, growth, reaction to stimuli, and reproduction
Metabolism	the chemical processes by which cells produce the substances and energy needed to sustain life.
Observations	the act of noting facts or occurrences that are unique or interesting and can lead to a scientific research question
Organism	an individual able to carry out the activities of life
Prediction	a declaration of results made prior to an investigation



3.0 Procedures

STEP 1: ENGAGE (~15 minutes)

Identifying Prior Knowledge

- A. At the beginning of the lesson very briefly tell students that scientists and engineers engage in certain practices when they are doing science or engineering and certain fundamental ideas are applicable to all science and engineering, called crosscutting concepts.
- B. Provide either wall posters ([11 x 17 format](#)) or individual handouts ([8.5 by 11 format](#)) briefly describing the Practices and Crosscutting Concepts (be sure to include the Nature of Science also).
- C. Tell students that they will be asked to identify if they do any of these practices at the end of the activities.

🍷 **NGSS Teacher Tip:** The descriptions of the Practices and Crosscutting Concepts on the poster or handout are brief; therefore, you may wish to become more familiar with the Crosscutting Concepts and the Understandings about the Nature of Science. You can get very good information from the Next Generation Science Standards (NGSS) [web site](#). Recommended are [Appendix F – Science and Engineering Practices in NGSS](#), [Appendix G – Crosscutting Concepts](#), and [Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards](#). These resources will help you to assist your students if they say that they don't understand the Practices, Crosscutting Concepts, or the Nature of Science. Also, in the Alignment document provided for this lesson the instructional designers have indicated the Crosscutting Concepts they have determined to be most appropriate.

- D. Display a picture of the Opportunity or Curiosity Mars Rover.
- E. Ask the students, “Are these alive?” Record the number of students that vote “yes”.
- F. Display a video clip of Spirit or Opportunity roving on Mars. Ask the students again, “Are these alive?” Again, record the number of votes.
- G. Ask the students “What characteristics are you using to decide if they are alive or not?” and “On what planets have scientists found living things?”

Opportunity:

<http://marsrover.nasa.gov/gallery/artwork/hires/rover3.jpg>

<http://marsrover.nasa.gov/gallery/video/movies/RoverAnimPart3.mov>

Curiosity:

http://www.nasa.gov/mission_pages/msl/multimedia/pia16457.html

<http://mars.jpl.nasa.gov/msl/multimedia/videos/index.cfm?v=2>



STEP 2: EXPLORE (~60 minutes)

Part A: Brainstorming Ideas

- A. Explain to students that their job is to come up with ideas of how living things can be detected. Brainstorm in small groups and then debrief with entire class.
- B. Ask students to then make a list of characteristics that determine if something is alive or not. If time allows, encourage students to find pictures and definitions of living and non-living things. Allow the students to use dictionaries, encyclopedias, and technology. Students will use the (A) *Student Sheet # 1* to record their ideas.

🚫 **Misconception Alert:** Students' lists might point out the more obvious signs, such as an organism needs to consume energy, while other may point to misconceptions such as **movement**. The more subtle but fundamental signs of life are:

- i. Complex organization (composed of cells)
 - ii. Metabolic processes that show chemical exchanges which may be detected in some sort of respiration or exchange of gases or solid materials.
 - iii. Some type of reproduction, replication, or cell division.
 - iv. Growth
 - v. Reaction to stimuli
- C. As a class, discuss the indication of life, asking for examples from a diverse sampling of living things. The teacher will paraphrase and group criteria on the blank chart, then guide the student to summarize the groupings to reflect the fundamental criteria for life. (A sample data table you can copy on the board, which you can use to organize criteria and objects for the class and to help students identify their misconceptions such as "legs", is provided in the (E) *Sample Organizational Table*.)

Part B: Observing Materials

- A. Give each group a magnifying lens (one each if possible) and (C) *Data Chart 1* and (D) *Data Chart 2*;
- B. Have a member of the team come forward and take a small sample (filling ~1/4 of 3oz cup) of each of the **A, B and C Bags**. This amount of sample will be enough for the entire experiment.
- C. Explain to the students that each team has been given a set of "soil" samples. No one knows if there is anything living in the samples. The assignment is to make careful observations and check for indications of living material in them, based on the previously identified criteria.
- D. Ask students to observe all three samples. They can smell, touch, view, and listen to the samples but not taste them. Encourage students to put a few grains on (C) *Data Chart 1* (or a flat white surface) and observe them with a hand lens (magnifier). Students should then record their observations at the top of the sheet.



🍎 **Teacher Tip:** As a classroom management tip, it is recommended that the class perform each step together. Have students make observations of all 3 cups prior to pouring water, then as a class ask them to pour water only into cup **A**. They will then observe/record data. Add water to cup **B**, observe/record data. Add water to cup **C**, observe/record data. Debrief the class together, starting with the dry **A**, **B** and **C** samples – then the wet **A**, **B** and **C** samples.

- E. Give each group a cup of water. Use hot (~50°C) tap water for best results. Ask students to pour the water so that each sample is covered with the water.
- F. Wait 20 – 30 minutes and repeat observations of all 3 samples. Students should record these observations on *(D) Data Chart 2*. Students should look for and record differences caused by adding water. After recording the first observations have students go back and observe again (~10 minutes later, Sample B will show even more activity.)
 - 1. Sample **A** is a simple physical change where sugar dissolves
 - 2. Both **B** & **C** are chemical reactions
 - 3. Sample **B** sustains long-term activity
 - 4. Sample **C** reaction stops

🍎 **Teacher Tip:** Prepare a 20-30 minute mini-lesson or activity. Once the initial observations have been completed, allow the samples to set for 20-30 minutes while the students complete the mini-lesson or activity.

STEP 3: EXPLAIN (~60 minutes)

Develop Explanations

- A. Discuss which samples showed indication of activity (**B** & **C**).
 - i. Does the presence of activity mean there is life in both Sample **B** & Sample **C** and no life in Sample **A**?
 - ii. Are there other explanations for the activity in either Sample **B** or Sample **C**?
- B. Students should realize that there could be other tests that would detect life in Sample **B** (e.g., there might be microbes in the soil that would grow on a culture medium).
- C. Determine which samples(s) contain life by applying the fundamental criteria for indicating life developed in Part 2.
- D. Tell students that Sample **B** contained yeast and Sample **C** contained effervescent tablets. Discuss how scientists could tell the difference between a non-living chemical change (effervescent tablet) and a life process (yeast), which is also a chemical change. Complete *(B) Student Sheet #2*.
- E. Organize students into groups of size and composition you know to be most effective.



- F. Hand out *(F) Reflections*.
- G. Allow discussion for 10 – 15 minutes.
- H. Ask each group to share its best thinking about which Practices and Understanding of Nature of Science were done, when it was done, and what the group's reasoning was for this. Record the results from each group in columns on the board.

🍎 **Teacher Tip:** The most important part of these activities is to engage students' thinking about the Practices, Crosscutting Concepts and the Nature of Science. The emphasis is on the rationale the students provide rather than what Practices or Crosscutting Concepts were identified in the Alignment document. Be prepared to ask questions to elicit more complete reasoning for the group's decision. Allow discussion if groups do not initially agree. The discussions will help to develop deeper understandings.

STEP 4: ELABORATE (~30 minutes)

Astrobiology Connection

- A. Ask the students to share how they believe the criteria scientists use to determine if something is living or not were developed or decided on? Where do these criteria apply? (Guide the conversation to Earth. These criteria are based on our observations of life on Earth.)
- B. Is it possible that life on other planets may not fit our definition? Give some examples on Earth that loosely fit some of the criteria, but are not considered living.
 - a. Virus – Nonliving: do not metabolize or respond to stimuli and require a host for reproduction.
 - b. Fire – Nonliving: consumes fuel (energy), grows, and produces “offspring”, reacts to stimulus (dies with water) however fire does not contain genetic material

STEP 5: EVALUATE (~10 minutes)

Revisit Rover Image.

- A. Place the image and/or video of the Spirit or Opportunity Mars Rovers back up on the screen. Ask students to compare their finalized criteria for life to these rovers to determine if they are alive. During your discussion, clarify that these are machines, and while they may exhibit some characteristics of life, they are unable to reproduce, grow, nor have a metabolism.
- B. Ask students to complete *(A) Student Sheet #1*, *(B) Student Sheet #2*, *(C) Data Chart #1* and *(D) Data Chart #2* to demonstrate their understanding of the characteristics of life.



4.0 Extensions

- As a homework activity, ask students to follow their curiosity about Mars. Ask them to go online (with parents or guardians, if their age suggests it), and ask “Dr. C” at least 3 questions about Mars. Have them write down the following url:
<http://marsdata1.jpl.nasa.gov/DrC>
- Have students measure the level of sand in each cup before adding water, after adding water, and over time. Students can use a stopwatch to measure changes over time, develop rate graphs and connect to Common Core Math Standards.
- Use a microscope or magnifying glasses to view the materials prior to adding water, then again after the 20-30 minute wait time. Using a microscope will require preparing a wet mount and using Methylene blue in order to observe the individual yeast cells. Can they see the yeast cells?
- Use BTB (Bromothymol Blue Indicator) to measure the presence of CO₂ in the solution and connect to cellular respiration, anaerobic processes, and/or chemical reactions.

5.0 Evaluation/Assessment

Use the *(L) Is It Alive? Rubric* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the Next Generation Science Standards.

**(A) Student Sheet #1**

NAME: _____

Thing or Object	Is it Alive?	Why or Why Not?

Name 2 things you think all things need in order to be called “Alive”?



(B) Student Sheet #2

NAME: _____

What are the 5 criteria used to identify something as living?

Is the Spirit or Opportunity Rover on Mars alive? Why or why not?



(B) Student Sheet #2

Which of the samples has life? What evidence did you use?

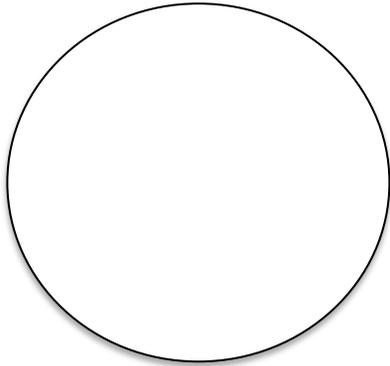
Did the sample have to meet all 5 criteria? Why or why not?



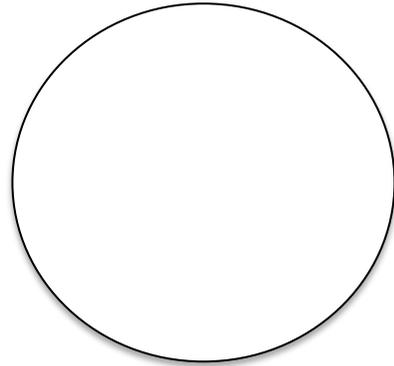
(C) Data Chart #1

NAME: _____

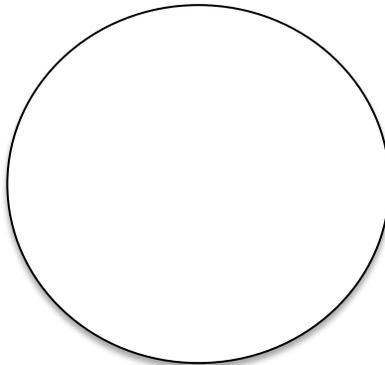
Initial Drawings: (No Water Added)



Sample A



Sample B



Sample C

Initial Observations: (No Water Added) – Write your observations of each sample

Sample A:

Sample B:

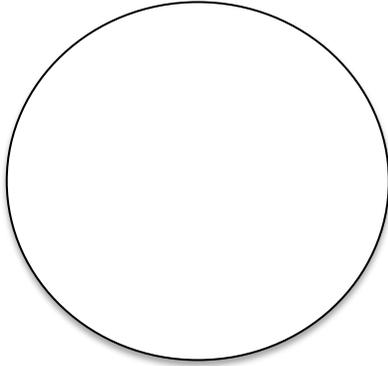
Sample C:



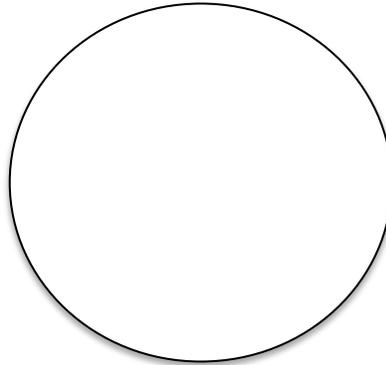
(D) Data Chart #2

NAME: _____

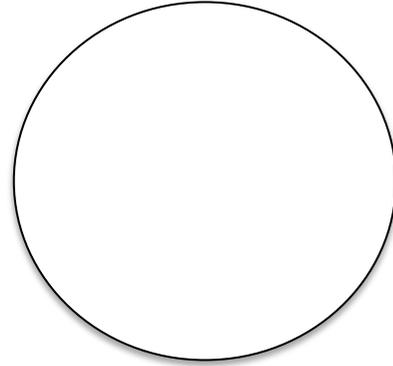
Initial Drawings: (After Water is Added to Cup):



Sample A



Sample C



Sample B

Observations: (After Water is Added)

Sample A:

Sample B:

Sample C:

**(E) Sample Organizational Table****Part A:**

Object or Organism	Criteria 1 Has legs	Criteria 2 Has Offspring	Criteria 3 Grows	Criteria 4 Energy	Criteria 5 Sleeps
Bear	✓	✓	✓	✓	✓
Chair	✓				

Part B:

Cups	Cup A		Cup B		Cup C	
	Before	After	Before	After	Before	After
Movement				✓		✓
Reproduces				✓		
Grows				✓		
Needs or produces Energy				✓		
Reacts to Stimuli				✓		✓

**(F) Reflection – Science and Engineering Practices (1 of 6)**

When scientists study phenomena to better understand how the natural world works or when engineers design solutions to a problem, they engage in certain processes called practices. These practices are, essentially, how science or engineering is done.

These Practices are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Furthermore, there are 4 understandings about the Nature of Science that scientists have that are a foundation for the practices.

These Understandings about the Nature of Science are:

1. Scientific investigations use a variety of methods.
2. Scientific knowledge is based on empirical evidence (knowledge obtained by observation and experimentation).
3. Scientific knowledge is open to revision in light of new evidence.
4. Science models, laws, mechanisms, and theories explain natural phenomena.

**(F) Reflection – Crosscutting Concepts (2 of 6)**

Some concepts are important to all studies in science and engineering. Seven of these **Crosscutting Concepts** – ideas that are important to any science (biology, physics, chemistry, ecology, astronomy, geology, etc.) and to all engineering – have been identified.

1. **Patterns.** Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
2. **Cause and effect: Mechanism and explanation.** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. **Scale, proportion, and quantity.** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.
4. **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. **Energy and matter: Flows, cycles, and conservation.** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.
6. **Structure and function.** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
7. **Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Furthermore, there are 4 understandings about the Nature of Science that are closely related to the Crosscutting Concepts.

These Understandings about the Nature of Science are:

1. Science is a way of knowing.
2. Scientific knowledge assumes an order and consistency in natural systems.
3. Science is a human endeavor.
4. Science addresses questions about the natural and material world.

**(F) Reflection – Science and Engineering Practices (3 of 6)**

Name: _____

In your group, reflect carefully on the activities you have just completed and answer the following questions using the table on the next page.

- What Science and/or Engineering Practices did you do and which of the understandings about the Nature of Science were important to what you did? (There is probably more than one.)
- When? During which activities?
- Explain your reasoning.
- Be prepared to explain your best thinking about what Practices you used and when you were doing them in a full class discussion.

Nature of Science	When?	What is your reasoning?
Scientific investigations use a variety of methods.		
Scientific knowledge is based on empirical evidence (knowledge obtained by observation and experimentation).		
Scientific knowledge is open to revision in light of new evidence.		
Science models, laws, mechanisms, and theories explain natural phenomena.		

**(F) Reflection – Science and Engineering Practices (4 of 6)**

Practice	When?	What is your reasoning?
Asking questions (for science) and defining problems (for engineering)		
Developing and using models		
Planning and carrying out investigations		
Analyzing and interpreting data		
Using mathematics and computational thinking		
Constructing explanations (for science) and designing solutions (for engineering)		
Engaging in argument from evidence		
Obtaining, evaluating, and communicating information		

**(F) Reflection – Crosscutting Concepts (5 of 6)**

Name: _____

In your group, reflect carefully on the activities you have just completed and answer the following questions using the table on the next page.

- a. What Crosscutting Concepts did you do and which of the understandings about the Nature of Science were important to what you did? (There is probably more than one.)
- b. When? During which activities?
- c. Explain your reasoning.
- d. Be prepared to explain your best thinking about what Crosscutting Concepts you used and when you were doing them in a full class discussion.

Nature of Science	When?	What is your reasoning?
Science is a way of knowing.		
Scientific knowledge assumes an order and consistency in natural systems.		
Science is a human endeavor.		
Science addresses questions about the natural and material world.		

**(F) Reflection – Crosscutting Concepts (6 of 6)**

Crosscutting Concepts	When?	What is your reasoning?
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		