# Mission 8
# What is Life?

SETI INSTITUTE **What Can We Observe to Test for Life?**

## Overview

In mission 8, students confront the difficulty of distinguishing living organisms from nonliving objects. In mission 8.1, students play a game called Five Alive! to explore their ideas about the characteristics of living organisms. Students create a list, of such characteristics. Students begin to appreciate some of the ambiguities associated with identifying living and nonliving matter and processes. This will provide valuable background material for future missions in which students will acquire the information necessary to finalize the designs of their spacecraft-lander systems from mission 5, which will be built to test for life on other planets.

## Notes

*In mission 7, students identified water, a chemical that is vital for life. But exactly what is "life"? Before it is possible to test for the presence of extraterrestrial life, it is vital to know what constitutes life on Earth. Although this might seem simple at first thought, it is in fact extremely complex. There is no single property that characterizes all living things and only living things. There is no one exact definition of life, or one single test that can determine the presence or absence of life. Instead, there are* many *characteristics that most living things share.*

## Mission 8.1
## Materials

### For a Class of 30

- Butcher paper
- Plastic plant and a living plant of similar appearance

### For Each Student

- "Characteristics of Life" worksheet
- Pencil

## Getting Ready

1. Set up the classroom to accommodate large- and small-group discussion. Post butcher paper or ready another means to collect student responses (or use the chalkboard).

2. Copy the “Characteristics of Life” worksheet for each student.

## Classroom Action

1. **Preliminary.** Because students will be searching for life on other worlds, tell them that they will first need to examine what it means to be living by playing the game Five Alive! Explain that you will use the term *object* to refer to a nonliving thing and the term organism to refer to a living thing.

   Explain to the class that Five Alive! Is similar to Twenty Questions, except that participants can only ask five questions. Each team will think of an object (nonliving) or an organism (living); the teacher or the rest of the class will try to determine whether this thing is living or nonliving from the team's answers to five yes-or-no questions. Explain that the questioner cannot ask “Is it alive?” or similar direct questions; instead, the questioner can only ask questions about what it does or doesn't do (behavior), about what it takes in or produces (function), and about its appearance (structure).

   Caution students to word their questions carefully. Carelessly asked questions about the objects can be truthfully answered in ways that are misleading about whether the objects are alive or not. For example, a cloud: “Does it move?” Yes. But a cloud is not, however, self-propelled, which is probably what the questioner now thinks. Prompt students to ask clear questions, and prompt teams to ask questioners to clarify their questions. Also be sure that teams explain why they answered as they did at the end of each set of five questions. (A list of “carefully worded” characteristics appears in step 4.)

   Divide the class into teams of two to six students each. If smaller teams are used, there probably will not be time for all of them to present their object or organism, although everyone still participates in the questioning. Draw lots to see who will present their challenge each round or choose the order yourself.

2. **Demonstration.** Give teams a few minutes to secretly think of their object or organism, and then begin. Demonstrate how to play by picking one team and asking a team member to write the name of the team's object or organism on the chalkboard (the teacher should keep his or her back to the chalkboard) so that the rest of the class can see what you are trying to guess. For each question you ask, the team tells you whether the answer is yes or no. If the rest of the class wants to argue about the team's answer to your question, let them do so, even if this could possibly give away the answer. Their discussion of the attributes of life is the objective of this activity. You should include a few poorly phrased questions and encourage the team to ask you to clarify your meaning. After you've asked five questions and guessed whether or not the thing is alive, have the team reveal their object or organism and explain their answers to your questions.

3. **Activity.** Play the Five Alive! game a few times. If a game is taking too long, restrict the number of teams that can participate in each game. When it seems to be the right moment, reverse the roles. Now the teacher will think of an organism or object and the class will try to determine whether or not the thing is alive or not by asking five yes-or-no questions about its

activities (or lack of activity) and appearance. Choose your examples to present certain concepts, bringing in ideas that have not yet come up.

Make sure students realize that nonliving objects can possess some of the characteristics of life. Some nonliving things that have several characteristics of living things include a crystal, a car, a forest fire, a jigsaw puzzle, a river, dried flowers, a stalactite, and a computer. Characteristics of life include movement, growth, consumption of raw materials (eating), production of waste products, reproduction, complex forms that may have symmetry, and organic molecules. For instance, a flame moves, grows, uses raw materials, produces waste products, "reproduces" new fires, and has a complex form. However, it is not alive.

Make sure students realize that some living organisms may appear to be nonliving objects. Not all life-forms are as obvious as large plants and animals. Some living organisms that are non-obvious examples of life include fungi, lichens, stony marine algae, sponges, molds, bacteria, brine shrimp eggs, chicken eggs, lizard eggs, and plant seeds. Remind students of previous activities involving bacteria.

After the class has guessed whether or not your example is alive, reveal your organism or object and explain your answers to students' questions. Play several games with the roles reversed.

4. **Discussion.** Point out to students that it is obviously important to learn to ask the right questions! Ask the class what they now think "life" is. How could they tell whether or not something was alive? Ask students to name characteristics of something that is alive.

   Let students discuss their ideas. Record on the chalkboard or on butcher paper all the characteristics of life that they feel are important. This list must be readable and usable by everyone in the room when they do their worksheets. Discuss each characteristic as it is presented and see if the entire class can reach a consensus on whether or not individual characteristics are valid. Students should realize that a single exception makes the suggested characteristic invalid. For example, if "the ability to think" is offered as a characteristic, ask students if they can think of any exceptions. For example, a carrot cannot think, but a carrot is alive; so, thinking is not a universal characteristic of life.

Lead students toward developing a list similar to the following:

Living things produce waste products.

Living things reproduce.

Living things grow.

Living things breathe in air or water (exchange gases of some kind).

Living things require liquid water.

Living things eat (consume raw materials).

Living things are complex in form and may have symmetry.

Living things move by their own efforts.

Living things produce heat.

Living things die (cease to function).

Indicate to the class that their list of characteristics may change as their study continues and they learn more.

**Note:** There are additional characteristics of life that are valid but that may not occur tostudents if they lack a lack a background in biology, chemistry, or physics. These characteristics are also complicated to explain, and may distract students from the focus of this mission. They are not used in the remainder of this guide. Be prepared when introducing any of the following characteristics:

Life is composed of a cell or many cells.

Life has DNA and/or RNA to store information.

Life evolves and adapts to the environment.

Life exchanges energy with the environment.

Life is probably based on carbon (*i.e.*, it is composed of organic molecules, as life on Earth is).

**Teacher's Note:** *If you want to take two days with mission 8, this is the logical spot to break. Be sure to save the list of characteristics for the next day.*

5. **Demonstration.** Once a final list is agreed upon, show the class a living plant and a plastic plant of similar appearance. Ask them how they could tell which of them is alive. Tell students that they can use their characteristics of life but that they cannot ask any questions. ("Reality" is a new game in itself plants can't talk!) What should they look for? What tests should they use?

   After students have decided how to classify the two plants as living or nonliving, ask how this would be different if all they had to work with was a photograph of the living plant and the plastic plant. Which of the characteristics of life would still be useful? What other tests or experiments would work? Could they tell?

   Ask students how this would be different if the living plant and the plastic plant were located on Mars. Students could still photograph the plants, but encourage them to come up with new

techniques. Now which of the agreed upon characteristics of life would still be useful? What other tests or experiments would work?

Ask students if it would be possible to have a spacecraft or lander look for each characteristic, assuming that it sights something interesting (such as a plantlike form) in its vicinity. Ask them to look at the list of characteristics of life and choose the two best characteristics that could be detected by a spacecraft flying over another world. Have students choose the two best characteristics that could be detected, with photographs or specially designed experiments, by a lander landing on another world. Try not to give away specific answers during this discussion. Give enough suggestions to allow students to develop their own experimental plans.

6. **Activity.** Hand out the "Characteristics of Life" worksheet to each student. Have students complete them in their teams.

7. **Discussion.** Have each team, or selected students, state which two of the characteristics of life they felt would be the most useful for detecting life on another world. Conduct a poll to find the top five characteristics that the class chose as a whole. Then indicate the five characteristics of life that this guide has chosen to focus on. (Produces waste products, reproduces, grows, exchanges gases, requires liquid water.) Discuss why these five will work well. Have students circle these five on their worksheets.

   Next, ask teams or students to share their ideas on specific experiments that could detect life on an alien world. Tell them that they will have the opportunity to continue to work on their ideas in later missions.

# Going Further

## Activity: Super Five Alive!

Now that students know the game Five Alive! and are familiar with the characteristics of life, have them play a variation: instead of just thinking of the name of an object or an organism, one must use a picture of the object or the organism, or even better, the object or the organism itself! This will not be very exciting if the chosen object or organism is obvious, such as a pencil or a fly! However, if the chosen object or organism is a real puzzle, then the game is really fun.

**Living organisms that are easy to obtain:**

lichen on rocks
plant seeds
mold on bread

**Living organisms that can be shown in a photograph:**

marine sponge or some other invertebrate
stony (encrusting) marine algae

bacteria or unicellular protozoans

**Nonliving objects that are easy to obtain:**

crystals (quartz, calcite)
salt, sugar, sand, or lead shot
radio (turned on)

**Nonliving objects that can be shown in a photograph:**

robotic assembler (car factory)
computer
Commander Data (android from *Star Trek)*

Teacher challenges class: In this version, the teacher researches all chosen objects or organisms and can answer all questions.

Class challenges class: In this version, students form teams. Each student team must know all about their object or organism. Provide them with written information or have them research the chosen object or organism outside of class so that they can answer all questions about it.

Class challenges teacher: In this version, each student must know all about an object or organism that they have brought into class. Have students research their chosen object or organism outside of class so that they can answer all questions about it.

## Activity: Extraterrestrial Five Alive!

Macro-extraterrestrial life: In this version of the game Five Alive! each student or team of students creates a large (macro-size) extraterrestrial object or organism. Have students create mental images, draw pictures, make models, or create collages by cutting and pasting together portions of photographs. Teams challenge the teacher or other teams to discover if life is present.

Micro-extraterrestrial life: In this version, each student or team of students creates a small (micro-size) extraterrestrial object or organism. Teams challenge the teacher or other teams to discover if life is present.

Discuss with students the differences between the macro life and micro life games. How does size matter?

## Activity: More to Life Than This!

Depending upon allotted time, class background, available equipment, and personal preference, have students demonstrate additional characteristics of life. These include the following:

Life is composed of a cell or many cells.

Life has DNA and/or RNA to store information.

Life evolves, and adapts to the environment.

Life exchanges energy with the environment.

Life is probably based on carbon (i.e., composed of organic molecules, as life on Earth is).

If you have access to microscopes and slides of plants and animals, you could demonstrate that all living organisms are either single cells or composed of cells, while nonliving objects are noncellular.

Ask students to prepare slides of their own cells by scraping the insides of their cheeks with toothpicks. This demonstrates that they, too, are composed of cells.

Use a model of the DNA double helix to briefly discuss the fact that DNA stores information on how to produce an entire organism. Use microscope slides to show DNA. Show slides of horse evolution, noting that DNA is responsible for the mutations that are "naturally selected" by the environment, resulting in adaptation to the environment.

# What Is Life?
# What Can We Observe to Test for Life?

## Characteristics of Life—Teacher's Key

1. Student answers will vary. Accept all reasonable attempts. Here is a fairly complete list of possibilities:

   Living things produce waste products.

   Living things reproduce.

   Living things grow.

   Living things breathe in air or water (exchange gases of some kind).

   Living things require liquid water.

   Living things eat (consume raw materials).

   Living things are complex in form and may have symmetry.

   Living things move by their own effort.

   Living things produce heat.

Living things die (cease to function).

Living things are composed of a cell or many cells.

Living things have DNA and or RNA to store information.

Living things evolve and adapt to the environment.

Living things exchange energy with the environment.

Living things are probably based on carbon (i.e., are composed of organic molecules,as life on Earth is).

2. Student answers will vary. Accept all reasonable attempts.

3. Student answers will vary. Accept all reasonable attempts. If only photos can be taken, growth, death, or reproduction might be seen over time in photos of a true living plant, but none or only some of these might be expected in a photo of a nonliving plant-like object.