Astrobiology Education Poster
Activity 2
Life: What is it? Where is it?

Learning Objectives:
Students will be able to:

- Explain the relationship between the characteristics of lifeforms and the environmental conditions in which they exist
- Discuss scientific ideas and results clearly and support their ideas with logic and evidence.

Standards Addressed:
As a result of this activity, students should understand the following aspects of scientific inquiry:

- Communicate and defend a scientific argument. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments.

- Results of scientific inquiry – new knowledge and methods – emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Student Prerequisites

- Students should be familiar with the characteristics of life and the conditions needed for life, including extremophiles. These are covered in Activity 1.
- Students should be familiar with using the library and/or the Internet to research topics.

Preparation
Reserve the computer lab, if desired, for students to research solar system objects online. Discuss the activity with the school librarian, so he/she can direct students to appropriate references about the planets, moons, comets, and asteroids in the solar system to aid in their research.

Activity

1. Recall Activity 1. Students brainstormed characteristics of life on Earth. They discussed the conditions needed for "familiar" life such as plants, animals and other organisms and for extremophiles. They saw that all life on Earth requires liquid water at some time in its life cycle. Students discussed how the study of extremophiles has changed scientists ideas about life and where it can exist, and wrote an essay answering the question: Why is the study of extremophiles on Earth important to the search for life on other planets?

2. Tell students that they are going to play the part of astrobiologists considering the possibility of life on other planets and determining where to look and why. They will need to use their knowledge of extremophiles and the conditions needed for life on Earth to explore solar system objects for a place (other than Earth) that might be habitable by life as we know it.

3. Divide the class into teams of three or four students. Members of each team will collectively choose a solar system object on which to focus a study of its potential habitability (ability to support life as we know it). Teams should ask and answer the following questions: Could life exist on this solar system object? If so, why? If not, why not?

   Students should draw on their knowledge of extremophiles and extreme environments on Earth to support their claims about the habitability of their chosen solar system object. Note that it is acceptable for a team to choose to study an object only to find that it is unlikely to support life. However, they must present evidence to support their appraisal of their object. Monitor and guide student teams to ensure that they do not all select the same solar system objects. Teachers can refer to the table "Characteristics of Some Solar System Objects" for background information to support this activity. This table is available in both pdf and Word format. The Word version can be modified (e.g., to remove the final line in each entry that says whether life is likely on the solar system object or not) for distribution to students, if desired.

   To aid students in their research, the following websites contain reliable information about the objects in the solar system:
   http://sse.jpl.nasa.gov/planets/index.cfm
   http://www.jpl.nasa.gov/solar_system/planets/planets_index.html
   http://nssdc.gsfc.nasa.gov/planetary/planetfact.html
   http://www.nineplanets.org/

For pictures of planets, moon, comets, and asteroids:
http://pds.jpl.nasa.gov/planets/welcome.htm

NOTE: There is a great deal of misinformation available online. Students may benefit from a discussion of techniques to evaluate websites for accuracy. Several webpages written by college librarians provide this information, including:
http://www.library.cornell.edu/olinuris/ref/webcrit.html – This website lists five criteria for evaluating web pages in a table format.
http://www.library.jhu.edu/elp/useit/evaluate/
http://www.library.cornell.edu/okuref/research/webeval.html
http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/Evaluate.html
Although these sites are geared for college students, the information contained in them will be useful to high school students, especially if discussed by the teacher.

4. Optional Extension – Have students create a lifeform that could live on their chosen solar system object. Students should be aware of how extremophiles have adapted to "extreme" conditions on Earth from Activity 1. Students have to justify why their lifeform has the characteristics they give it, that is, they have to describe the environmental conditions on their solar system object and show how their creature can survive in those conditions. These creatures can be described in written descriptions, or shown in whatever media the students select (drawing, sculpture, etc.). This could be developed into an interdisciplinary project with an art teacher, drawing upon and emphasizing concepts in art and design which students have learned or will learn.

5. Have each team present the results of their research to the class. This can be done graphically via a poster or powerpoint presentation, an oral presentation, or a combination of both. The goal in the presentation is to answer the questions posed in step 3: Could life exist on this solar system object? If so, why? If not, why not? In their presentations, students should compare and contrast the environmental conditions on their object with those where extremophiles on Earth live. If they think their object is habitable, they should report on which Earthly extreme environment and extremophile(s) is closest to the kind of environment and lifeform they might expect to find on their object. Students should also briefly acknowledge the impact that the discovery of extremophiles has made on the search for extraterrestrial life and on their own search for the possibility of

life on their chosen object. If desired, use the rubrics given below to evaluate presentations and/or posters.

6. Based on the presentations and/or posters, have the class vote on the three solar system objects they think are most likely to have life, that is, the places astrobiologists should target their search for any evidence of life. Have students give reasons for their votes. Accept any reasonable vote, as long as it is supported by a logical reason.

7. Explain that astrobiologists have determined that Mars, Jupiter's moon Europa, and Saturn's moon Titan are the solar system objects (other than Earth) most likely to either support life or provide information about how life might originate and emerge. Point to the pictures of each on the front of the poster as they are being discussed. The reasons for the scientists' choices are as follows:

   Mars – The red planet has abundant water locked up in the planet's polar ice caps. Winding channels on its surface resemble dry riverbeds on Earth. Mars has enormous dormant volcanoes, indicating it was once geologically active. Active volcanoes could add large amounts of gas to Mars' atmosphere, and make it easier for heat to escape from the planet's interior. As a result, scientists think Mars may have once had a thicker, warmer atmosphere and that liquid water may have once flowed on its surface. Obvious places to look for life include the winding channels that look like riverbeds, the polar ice caps, and deep underground.

   Europa – Jupiter's moon is encased in a layer of water ice about ten kilometers thick. Scientists think the ice may sit atop an ocean of liquid water perhaps a hundred kilometers deep. The most likely place to look for life on Europa is to tunnel through the ice into the ocean underneath.

   Titan – Saturn's moon has a thick atmosphere that contains organic molecules (the building blocks of life as we know it). Although its surface is thought to be too cold for liquid water, there may be lakes or oceans of liquid hydrocarbons (methane and ethane). Scientists think conditions on the surface of Titan may resemble those on the very young Earth, before or just as life began on it. Titan is a little different from Mars and Europa; it probably does not have lifeforms like those found on Earth. Any lifeforms would likely depend on liquid hydrocarbons, not liquid water. However, it is of major interest to astrobiologists because

it represents a place where they can study conditions that may have preceded the development of life and the development process itself. The most likely place to look for life would be on the surface and in the lakes or oceans.

8. Compare and contrast the class' votes for the three most likely places in the solar system (other than Earth) to support life with those of the scientists (Mars, Europa, and Titan). Point out that as our understanding of extremophiles increases and we find additional extreme environments on Earth that support life, we can conceive of more places in our solar system with similar extreme conditions where life may be possible.

Rubric to Evaluate Oral Presentations

	4 Exemplary	3 Accomplished	2 Passing	1 Not passing
Organization	Students present information in logical, interesting sequence which audience can follow	Students present information in logical sequence which audience can follow	Audience has difficulty following presentation because students jumps around	Audience cannot understand presentation because there is no sequence of information
Subject Knowledge	Students demonstrate full knowledge (more than required) by answering all class questions with explanations and elaboration	Students are at ease with expected answers to all questions, but fail to elaborate	Students are uncomfortable with information and are able to answer only rudimentary questions	Students do not have grasp of information; students cannot answer questions about subject
Graphics	Students' graphics explain and reinforce screen text and presentation	Students' graphics relate to text and presentation	Students occasionally use graphics that rarely support text and presentation	Students use superfluous graphics or no graphics
Delivery	Students speak clearly, did not read from notes, flawless speech patterns	Students spoke clearly, read directly from notes; speech patterns somewhat inexact, with pauses, repetition of some words, etc.	Students spoke clearly, read directly from notes; speech patterns inexact, using "like," "you know," more than one time	Students did not speak clearly, read notes; speech patterns inexact, using "like," "you know," often
Participation	All of group spoke	Most of group spoke	Some of group spoke	One member spoke

Rubric to Evaluate Student Posters

	4 Exemplary	3 Accomplished	2 Passing	1 Not Passing
Title And Text	Clear and succinct	Clear, but wordy	Not consistently clear	Unclear
Supporting Evidence	Clear correlations between organisms, their environments on Earth, and extraterrestrial environments are drawn	Correlations between organisms, their environments on Earth, and extraterrestrial environments are implied	Organisms, their environments on Earth, and extraterrestrial environments are discussed	No evidence included in poster
Graphics	Reinforce Evidence	Relate to Evidence	Relate to topic	Unrelated to topic
Fonts	Eye catching	Pleasing	Clear	Unclear
Resources and Citations	More than 2 resources correctly cited	2 resources correctly cited	Single resource correctly cited	No resources cited