

Exploring Extraterrestrial Life in the Universe

Grade Levels:

6-8 (can be modified for all age groups)

Time:

Part 1: One class (45 min. – 1 hour)

Part 2: One class (45 min. – 1 hour)

Part 3: One class (45 min. – 1 hour) or can be expanded to a larger research project/assignment that takes a few days

Number of Students:

Normal class size (25-30 students per teacher)

Seating Arrangement:

Students are in groups of 4-5

Objective: To introduce students to the search for extraterrestrial life. Extraterrestrial includes all life existing outside of the Earth. Students will learn what life is, what is being done to search for life, where we think life may be found beyond Earth and what kinds of life we are expecting to find.

Materials:

- Paper
- Pencils/pens
- Markers/crayons
- Poster board (optional)
- Sample newspaper article clippings

Background Information:

- *What is life? What are life's limitations? Where can life be found on Earth?*

The question, "What is life?" is not easily answered. Scientists continue to question and debate what characteristics are necessary to label something as alive. However, many scientists have come to a basic consensus about the seven main characteristics of living things. These include:

- 1) Are composed of cells
- 2) Require energy
- 3) Maintain a steady energy balance

- 4) Are able to reproduce
- 5) Inherit traits from the parent organisms (heredity)
- 6) Respond to the environment
- 7) Are able to adapt to their environment to evolve.

In the past, we thought about life as being extremely fragile and limited. However, as we learn more about life on Earth we are realizing that it can thrive in a wide range of extreme and unexpected habitats. Life can persist in high and low temperatures, pressures, salinities, and in a wide range of pH zones in environments such as hydrothermal vents, deep below the Earth's crust, in high salinity lakes, and in the ice of Antarctica.

- *What are extremophiles? What are some examples of extremophiles on Earth? How can extremophiles be used/studied to predict what forms of life we will find elsewhere in the universe?*

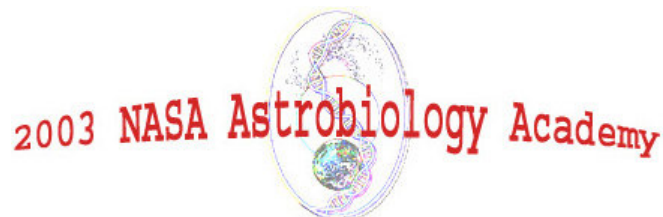
Extremophiles have evolved to survive under adverse conditions, seeming to defy the conventional limitations of life. These limitations include the presence of oxygen, the boiling and freezing points of water and low toleration of acidity and alkalinity extremes.

We can find life almost anywhere we look on Earth. Environments that were once disregarded as being too extreme for life have revealed a plethora of organisms. The search for life in harsh environments on Earth has showed scientists the incredible range of conditions in which living things can exist.

By studying our own planet's most challenging environments, we can look for comparisons to what may be the normal conditions on other planets in the universe. For example, the Antarctic Dry Valleys may represent the conditions on Mars and the oceans of Europa could support life forms similar to those that inhabit the hydrothermal vents in oceans on Earth. We want this type of research to give us an idea of what we may be looking for when we search the universe for signs of life so that we are more prepared to recognize new life forms on other planets.

- *Who is searching for extraterrestrial life?*

Exobiologists and astrobiologists are two of the main groups of people searching for extraterrestrial life. Exobiology is the study of organisms that originate from outside of Earth. Although there has been no conclusive evidence of extra-terrestrial life, exobiologists are still searching for extra-terrestrial life, and studying the theories study of what life outside Earth might be like.



- *What is astrobiology?*

Astrobiology is the study of all living things within the universe, where they might be found and how they were formed. There is no real agreed definition of astrobiology - it is a multidisciplinary field with many overlapping scientific disciplines.

The three big astrobiology questions are:

- 1) How did life originate on Earth?
- 2) Is there other life out there in the universe?
- 3) What is the future of life on Earth and beyond?

- *What methods are scientists/researchers using to search for extraterrestrial life?*

In the past, we've used a number of different methods to search for extraterrestrial life. Probes such as Voyager, Magellan and Pathfinder have been used to examine the other planets in our solar system for life whereas Mars and Venus have been explored with the Mariner, Pioneer and Pathfinder probes. The first interplanetary probes consisted of only satellites, or orbiters. Later on, landers began to be used to conduct experiments on the planet surface.

Finding life inside our solar system is easier than looking outside. The most feasible way to look for life outside our solar system is by sending out and listening to radio or laser transmissions. However, this assumes that the life you are trying to contact is listening, interested in communication, and intelligent enough to communicate.

In hopes of discovering more technologically advanced life, the sky has been searched for intelligent signals from other stars with the SETI (Search for Extraterrestrial Intelligence) project. We've even sent out our own transmissions in the hope that we will get a reply. While SETI has been portrayed as simply searching the airwaves for radio signals from other stars (ie. the movie Contact), it also conducts a great deal of other research. Many SETI researchers believe that alien civilizations might be sending out pulses of laser light encoded with information. These scientists want to send back laser pulses aimed at other stars that are likely to harbor habitable planets.

- *What type of life will we most likely find in the universe?*

When most people hear the words 'extraterrestrial' they think of Hollywood's little green men interpretation. However, this is not the type of life we will most likely find in the universe. Most scientists agree that if life is found, it will probably be a microbial life form. The properties of these organisms will highly depend upon the environment where it originated.



- *Where are we most likely to find life in the universe?*

In order to determine where in the universe we can find planets that might have life on them, scientists have to first establish what characteristics a planet needs to have to be habitable. If we assume that for life to evolve a planet needs to have water for a long period of time, we can say that most stars about the size of our sun will be able to sustain stable habitable zones (regions around the star where planets can sustain life).

Once you've found your star, you need to find out if there are any terrestrial (rock-based) planets within the star's habitable zone. Next, you need to determine if you have a large number of asteroid impacts on your planet. If this is the case, life will be wiped out every time it tries to evolve.

Right now Mars and Europa (one of Jupiter's moons) are two of the locations where scientists believe life could exist within the universe.

- *Why should we search for extraterrestrial life?*

There are many benefits that come about from the search of extraterrestrial life. First, by finding alien life, we will understand more about how life evolved on Earth and the different forms of life in the universe. Second, the search for life inspires new technologies and technological spin-offs (just as other portions of the space program have) that can also be used for applications on Earth.

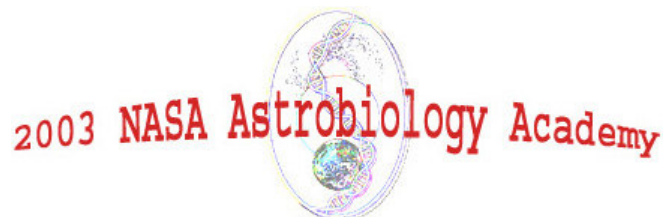
Even if we don't find life, new questions are brought up such as: If we are in fact are the only planet with life that we know of, why is Earth so special? Astrobiologists will then try to seek answers to these new questions.

- *What is the Drake Equation?*

Frank Drake, a radio astronomer, devised the Drake Equation. This equation estimates the number of civilizations in the galaxy that might be capable of interstellar radio communication.

Drake's equation is $\mathbf{N} = \mathbf{R}^* \times \mathbf{f}_p \times \mathbf{n}_e \times \mathbf{f}_l \times \mathbf{f}_i \times \mathbf{f}_c \times \mathbf{L}$.

- \mathbf{N} = the total number of civilizations within our galaxy that are capable of communicating with Earth from a technology standpoint.
- \mathbf{R}^* = the average rate of star formation in our galaxy which is estimated to be 20 stars per year.
- \mathbf{f}_p = the fraction of stars that have their own planetary systems. This value is an unknown factor.
- \mathbf{n}_e = the number of planets that have environments suitable to the development of life as we know it is represented by the variable.
- \mathbf{f}_l = represents the fraction of the planets that actually have life.



- f_i = the fraction of the planets that have intelligent life.
- f_c = the fraction of the species of intelligent life that have developed successful technology for interstellar communication.
- L = represents the length of time that civilizations release detectable signals into space.

An interesting aspect of this equation is that the calculation can stop at any point in the equation to determine other factors, such as the number of earth-like planets in the galaxy.

Activity Procedure:

Part 1: Newspaper article on newly discovered extra-terrestrial life

1. Start off the class by making the exciting announcement that extraterrestrial life has been discovered. Inform the class that they are all newspaper reporters and have the assignment of a lifetime, to inform the public of this groundbreaking discovery.
2. Divide the class into groups of 4-5 people each
3. Give them no requirements other than their articles must include the following:
 - i. Where was the life discovered?
 - ii. How was it discovered?
 - iii. What does it look like? (description and picture must be included)
 - iv. What are its daily activities?
 - v. Include a catchy headline
 - vi. Use proper newspaper format (bring in examples for them to look at)
4. Have each group share their article with the class and compare what everyone came up with.

Part 2: Interactive Lesson on the Search for Extraterrestrial Life

1. Brainstorm: What is life? Come up with some definitions. What are life's limitations? Where can it be found on Earth? (Worksheet: Is this alive? –teachers guide also included)
2. What are extremophiles? What are some examples of extremophiles on Earth? How can extremophiles be used/studied to predict what forms of life we will find elsewhere in the universe? (optional activity handout – teachers guide also included)
3. Talk about the type of life we will likely find. Does it look like the extraterrestrial life you described in your article? Why is there a difference?
4. Talk about likely places for life in the universe
5. Talk about scientists/researchers who are searching for extraterrestrial life and the methods they are using. What type of people are searching (ie. astrobiologists)? What scientific missions are contributing to the effort to find E.T. life?



Part 3: Revising your newspaper article on newly discovered extraterrestrial life.

1. After learning about the work being done to search for life elsewhere in the universe, have the class create another newspaper article with using their new knowledge to inform the public about a more realistic life form that has been discovered. (This version of the article could be done in the same way or typed up on computer in a newspaper format, or done on poster board and displayed, etc...)
2. Make sure they answer all the same questions required from the 1st article.
3. Share your new articles with the class and see how they changed

Elaboration:

This activity can be altered for both younger and older student groups. Elementary school children could simply draw their own extraterrestrial picture, have a more simplified lesson and draw some bacteria. On the other hand, high school aged students could do some more research on SETI work and include that in a more detailed newspaper article (include research on the Drake equation).

Conclusion: *Extreme Thoughts*

These questions can either be discussed in class or given out as a homework assignment for students to think about.

1. How would the public react differently to each of your articles?
2. What type of proof does a discovery of extraterrestrial life require? Ex. ALH84001
3. Scientists often have different views/theories on what is fact. As a reporter, how do you determine what is fact and what is fiction?
4. What makes Earth so special? Why do we have intelligent life on our planet but have not found it anywhere else?
5. What do you think is the chance that we are alone in the universe?
6. What are the ethical questions we would need to think about if we found extraterrestrial life?
7. Why is it important to search for extraterrestrial life?
8. What is the Drake equation? What is it used for?

Resources:

<http://library.thinkquest.org/C003763/index.php?page=findlife01>
<http://www.stanford.edu/class/humbio107>



Activity Developed by the NASA Ames Astrobiology Academy, Summer 2003, Moffett Field, CA

Contact

Please direct questions and comments to Steve Mitchell, Outreach Coordinator for the 2003 NASA Astrobiology Academy, at steve@mitchellengineering.net



Worksheet: Is it Alive?

Come up with three definitions for a living thing:

- 1.
- 2.
- 3.

Test your definitions by using them to determine if the following things are alive (circle yes or no) and why.

Thing	Is it Alive based on Definition 1?	Is it Alive based on Definition 2?	Is it Alive based on Definition 3?
Tree	Yes No Why?	Yes No Why?	Yes No Why?
Dog	Yes No Why?	Yes No Why?	Yes No Why?
Computer	Yes No Why?	Yes No Why?	Yes No Why?
Earth	Yes No Why?	Yes No Why?	Yes No Why?
Apple	Yes No	Yes No	Yes No

	Why?	Why?	Why?
Human	Yes No Why?	Yes No Why?	Yes No Why?
Rock	Yes No Why?	Yes No Why?	Yes No Why?
Piece of paper	Yes No Why?	Yes No Why?	Yes No Why?

Worksheet: Is it Alive? – Teacher's Guide

Come up with three definitions for a living thing:

Definitions will vary.

Some characteristics of living things are:

- *Composed of cells*
- *Require energy*
- *Maintain a steady balance (homeostasis)*
- *Are able to reproduce*
- *Inherit traits from the parent organisms (heredity)*
- *Respond to the environment*
- *Able to adapt to their environment to evolve.*

Test your definitions by using them to determine if the following things are alive (circle yes or no) and why.

Tree – yes

Dog – yes

Computer – no

Earth – no

Apple – yes

Human – yes

Rock – no

Piece of paper – no

Worksheet: Your Guide to Extremophiles: “Lovers of the Extreme”

What is an extremophile?

For each of the following types of extremophiles write down your guess at the definition and then get the real definition from your teacher. Compare your answers.

Thermophile

Your Guess – _____

Definition – _____

Lithophiles

Your Guess – _____

Definition – _____

Mesophile

Your Guess – _____

Definition – _____

Barophile

Your Guess – _____

Definition – _____

Piezophile

Your Guess – _____

Definition – _____

Halophile

Your Guess – _____

Definition – _____

Acidophile

Your Guess – _____

Definition – _____

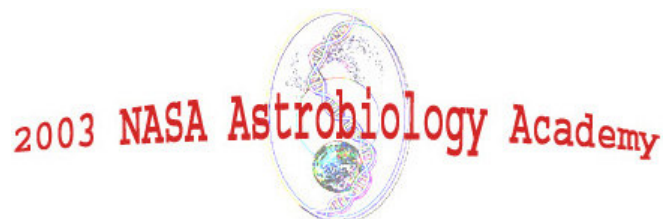
Word Search

Search for words forwards, backwards and diagonally.

Y	A	V	W	F	E	S	R	E	V	I	N	U	H
U	G	N	I	R	E	E	N	I	G	N	E	L	I
E	X	O	B	I	O	L	O	G	Y	W	C	A	N
T	L	E	L	I	W	P	B	J	U	Y	N	K	L
T	C	E	V	O	L	U	T	I	O	N	E	P	S
D	S	S	M	X	I	C	E	R	A	R	I	L	A
E	N	R	B	W	F	B	G	H	I	L	C	A	D
Q	U	S	C	H	E	K	O	I	R	L	S	N	R
U	N	R	A	L	I	E	N	R	E	E	I	E	M
S	K	A	O	K	M	E	R	U	T	U	F	T	T
E	J	M	D	P	N	R	F	I	C	S	S	E	A
R	P	F	O	E	A	H	T	R	A	E	A	N	S
E	T	R	E	L	B	A	T	I	B	A	H	F	K
T	N	E	G	I	L	L	E	T	N	I	H	G	H
A	M	E	T	S	Y	S	R	A	L	O	S	B	B
W	Z	A	B	X	A	S	A	N	E	G	T	R	R
J	H	E	X	T	R	E	M	O	P	H	I	L	E

Word Bank

- | | | | |
|--------------|--------------|----------|-----------|
| Alien | Astrobiology | Bacteria | Earth |
| Engineering | Environment | Europa | Evolution |
| Exobiology | Extremophile | Future | Habitable |
| Intelligent | Life | Mars | NASA |
| Planet | Rare | Science | SETI |
| Solar System | Sun | Universe | Water |



Worksheet: Your Guide to Extremophiles: “Lovers of the Extreme” – Teacher’s Guide

What is an extremophile?

An organism that lives in an extreme environment

For each of the following types of extremophiles write down your guess at the definition and then get the real definition from your teacher. Compare your answers.

Thermophile

Your Guess –

Definition – *“Lovers of heat” (hyperthermophiles – those living at highest temperatures)*

Lithophiles

Your Guess –

Definition – *“Rock lovers”, organisms that live up to several kilometers below the surface of the Earth in water that fills the pore spaces within rock*

Mesophile

Your Guess –

Definition – *Organisms that live at temperatures between 15-60°C (ie. humans)*

Barophile

Your Guess –

Definition – *Weight-loving organism*

Piezophile

Your Guess –

Definition – *Pressure loving organism*

Halophile

Your Guess –

Definition – *Salt-loving organism*

Acidophile

Your Guess –

Definition – *Low pH-loving organism*

Word Search

Search for words forwards, backwards and diagonally.

Y	A	V	W	F	E	S	R	E	V	I	N	U	H
U	G	N	I	R	E	E	N	I	G	N	E	L	I
E	X	O	B	I	O	L	O	G	Y	W	C	A	E
T	L	E	L	I	W	P	B	J	U	Y	N	K	N
T	C	E	V	O	L	U	T	I	O	N	E	P	V
D	S	S	M	X	I	C	E	R	A	R	I	L	I
E	N	R	B	W	F	B	G	H	I	L	C	A	R
N	U	S	C	H	E	K	O	I	R	L	S	N	O
U	N	R	A	L	I	E	N	R	E	E	I	E	N
S	K	A	O	K	M	E	R	U	T	U	F	T	M
E	J	M	D	P	N	R	F	I	C	S	S	E	E
R	P	F	O	E	A	H	T	R	A	E	A	N	N
E	T	R	E	L	B	A	T	I	B	A	H	F	T
T	N	E	G	I	L	L	E	T	N	I	H	G	H
A	M	E	T	S	Y	S	R	A	L	O	S	B	B
W	Z	A	B	X	A	S	A	N	E	G	T	R	R
J	H	E	X	T	R	E	M	O	P	H	I	L	E

Word Bank

Alien	Astrobiology	Bacteria	Earth
Engineering	Environment	Europa	Evolution
Exobiology	Extremophile	Future	Habitable
Intelligent	Life	Mars	NASA
Planet	Rare	Science	SETI
Solar System	Sun	Universe	Water