

Facilitator Information

(All you need to know about Astrobiology to survive the day)

What is Astrobiology?

Astrobiology is a branch of biology concerned with the search for life outside the Earth and with the effects of extraterrestrial environments on living organisms.

What is an extremophile?

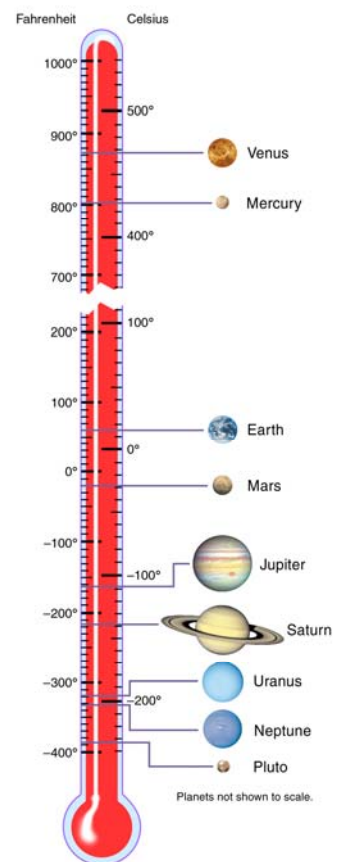
An extremophile is a living thing that thrives in "extreme" conditions, such as very high temperatures or very salty or acidic water. They can live where most organisms cannot because they have adapted special mechanisms for survival.

What does life need?

Life as we know it needs an energy source, nutrients, protection from the elements, and liquid water. For this day, we are simplifying these to include three things - liquid water, something to eat, and protection.

We find organisms only where **liquid water** exists. Liquid water is special. It remains a liquid over a wide range of temperatures - between 0 C (32F) and 100 C (212F) in its pure form – and can be liquid outside of this range under special circumstances. Water under high pressure, such as that in the deep sea, can remain a liquid at higher temperatures, and saline water has a lower freezing temperature – a good thing for fish in the Antarctic! Water expands when it freezes, unlike most other liquids, which means it floats and keeps our oceans from freezing from the bottom up. A lot of important things dissolve in liquid water and chemical reactions abound. In addition, liquid water moves, and can transport nutrients within cells or across global oceans.

All organisms require some **form of energy** to run their life processes (for example to break down nutrients or remove waste). Organisms with which we are familiar use either light energy or chemical energy. Plants get their energy from light. Microbes at deep-sea vents do not have access to light; they get their energy by breaking down chemical compounds dissolved in water circulating from Earth's interior. Light energy available to a planet diminishes with distance from the Sun. It also diminishes with distance from a planet's surface (for example the ocean bottom or in deep caves).



All organisms also require **nutrients**, the raw materials used to maintain their bodies. Plants get the nutrients from soils and the atmosphere. Animals get them from food. Like energy sources, nutrients must be replenished. This occurs on planets that are geologically active – those that have tectonic and / or volcanic processes – that constantly recycle materials to make the chemical nutrients available.

Finally, all organisms require **protection** from the extremes of the space environment. Existing underground or in deep water are ways that organisms can protect themselves. Atmospheres can offer protection at the planet's surface from harmful ultraviolet radiation, extreme changes in temperature, and small- and medium-sized meteorite impacts. Atmospheres also moderate day-night and seasonal temperature swings. However, to serve as an effective shield or insulator, the atmosphere has to be fairly substantial, as it is on Earth, Venus, and Titan. A planet or moon depends on its interior processes to make an atmosphere (is it hot enough to have volcanic activity, which replenishes the atmosphere?) and its gravitational field to hold an atmosphere. A small-sized body such as Pluto or Earth's Moon has too little gravity to hold onto an atmosphere, making life on or near the surface difficult.

What are the extreme environments where we find life?

Based on what we know, life exists in just about any environment with liquid water. The water can be intermittently or constantly available. It may be at the surface, or beneath the surface. The range of temperatures between which life is active is about -15°C (5°F) to $+121^{\circ}\text{C}$ (250°F). Higher temperatures break down cellular material. Lower temperatures cause chemical reactions to be too slow to maintain life functions.

Organisms that live in conditions that would kill most living things are called "extremophiles." These are organisms that thrive at extreme temperatures, such as *Pyrolobus fumarii*, the vent dweller that lives at temperatures of 113°C (235°F), or the *Cryptoendoliths* that live at temperatures of -15°C (5°F) just under the surfaces of sandstone rocks in the Antarctic. Extreme environments include extreme depths; certain bacteria dwell 3.2 kilometers below Earth's surface. There also are organisms that live under extreme pressures deep in the ocean trenches, in extremely acidic or alkaline or saline waters, or under severe radiation conditions. The majority of these are microbes and they belong to an ancient domain of life, recently identified, called the Archaea (the other two domains are the bacteria and the eukaryotes).

What other planets may have – or have had – life?

From: Windows to the Universe, Life on Other Planets

http://www.windows.ucar.edu/tour/link=/life/life_other_planets.html&edu=mid

Venus - Venus is very hot, almost 800 degrees (Fahrenheit) at the surface. Venus also has a very heavy atmosphere. With a heavy atmosphere, there is a lot of pressure (about 91-94 times sea level pressure on Earth). Venus also has corrosive clouds of sulfuric acid. We know, however, that there are life forms on Earth which can survive in very harsh environments. Bacteria and very simple plant life can survive in unexpected places. However, because of the very high temperature, pressure, and corrosive atmosphere the environment of Venus seems unfriendly toward life as we know it on Earth.

Mars - In spite of the fact that Mars has an atmosphere, the environment of Mars seems unfriendly toward life as we know it on Earth. Mars is small, so there is not much gravity and it is geologically inactive. For this reason, much of the atmosphere of Mars has drifted away. With little atmosphere, and no ozone layer, there is less protection from the ultraviolet radiation of the Sun, which is very harmful to life.

With little atmosphere, there is only a small buffer between the surface and space itself. This means that the temperature above the surface is cold. With little atmosphere, there is only a little pressure, which sophisticated life forms such as humans need to keep blood from boiling. We know, however, that there are life forms on Earth which can survive in very harsh environments.

In the past, liquid water flowed on the surface of Mars. With a liquid water habitat and a thicker atmosphere, life may have once thrived. More exploration of Mars is needed to determine if life was once present there.

Jupiter's Moon Europa - At first glance Europa may seem unfriendly to life as we know it on Earth. Like other icy moons, Europa is small, with no air to breathe, with direct exposure to space and the charged particle environment of Jupiter's magnetosphere. On the surface, the temperature is very very cold. Nevertheless, the interior of Europa may have been warm enough at one time to contain a liquid layer just under the surface. On Earth, we know that there are some creatures which can survive in an environment of very cold water, such as under the ice of the north pole. This means that, if the conditions are just right, there may be living creatures on Europa under the icy surface!

Saturn's Moon Titan - Titan's atmosphere is a lot like the Earth's, except that it is very cold, from -330 degrees to -290 degrees! Like the Earth, there is a lot of nitrogen and other complex molecules. There also may be an ocean of methane, or perhaps a liquid water layer inside the moon. Except for the cold, these signs

would be favorable for some sort of life. Some creatures on Earth are known to live in an environment of very cold water.

In the atmosphere there are layers of clouds composed of complex molecules such as methane. Moreover there is energy from ultraviolet light, and the charged particles of the magnetosphere. This type of environment, aside from the cold, is the kind of environment in which scientists think life began.

Overall, the environment sounds unfriendly to life as we know it on Earth, because of the cold. Since not much is known about the moon Titan, up close exploration of this moon, with a probe, as shown in this drawing, would help scientists better understand if life could survive there.

Why is Earth special?

Earth falls in the "Habitable Zone," the region of space where conditions are favorable for life as it is found on Earth. In general, in the habitable zone, the temperatures are just right for liquid water to exist. Closer to the Sun, the temperatures are too high and the water would vaporize. Farther from the Sun, the temperatures are too low and the water would freeze. Scientists can define the habitable zone for other stars – where it is depends, in part, on the mass of the star. If the star is small, the habitable zone is closer, if the star is big, the habitable zone is farther away. Scientists can help to focus their efforts on identifying places likely to have life by looking for planets in the habitable zones of other stars.