FYI Habitability

Earth is the only world known to support life. Though we are looking for life elsewhere, we have not yet found it.

Just about any place you look on Earth, you will find life. It's almost everywhere here. But why is that? What makes Earth **habitable**—able to support life as we know it? Is Earth unique, or are other worlds likely to be habitable too?

Habitability is the set of conditions that allow an organism to live, grow, and reproduce successfully. By studying what life here on Earth needs, we are learning about the conditions required by life, wherever it exists.

Figure 4-4: Photograph of Earth taken by the Galileo spacecraft

Water is vital to all life known on Earth.
From studying life on Earth, we know that virtually any place with liquid water has life. With water present, life seems to find a way to grow and reproduce, even in the watery films in Antarctic ice sheets and between rock grains deep underground. Indeed, water is so essential to and so linked with life here on Earth that the search for life on other worlds could conceivably be reduced to the search for liquid water.

Extremophile Example: Xerophiles are **extremophiles**—organisms that can survive in conditions that are considered extreme in some manner. These organisms can grow and reproduce in conditions with a very low availability of water. However, even they require *some* water.

Life exists on Earth at a broad range of temperatures.
Human beings can only live within a certain range of temperatures. We wear hats and jackets to help keep us warm or T-shirts and shorts to help keep us cool. We heat our homes when it's cold outside or air condition our homes when it's hot. When we go to places that are especially hot or cold, such as hiking in Death Valley or skiing in the Rockies, we are even more careful to control our exposure to those temperatures.

Other forms of life, however, aren't as troubled by temperatures that are too hot or too cold for human beings. Indeed, as we continue to explore our own planet, we continue to find life even in the most extreme of environments, such as in very hot steam vents on the ocean floor or buried in glacier ice. Thus, we do not yet have a limit on the temperatures appropriate for life.

Extreme Environment Example: The Antarctic Dry Valleys are very dry (less than 10 mm of precipitation per year) and very, very cold (usually below -30°C). Despite this, scientists have found life (algae, fungi, and bacteria) in these valleys.

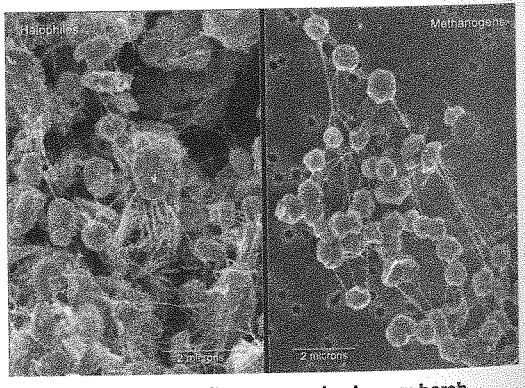

Figure 4-5: Extremophiles can survive in very harsh conditions

Life needs energy.
Without energy, the processes of life are not possible. Energy sources are different for different forms of life. For example, plants need sunlight; human beings need food. But all life needs some source of energy.

Extreme Environment Example: Deep Sea Hydrothermal Vents are fissures in the ocean floor from which very hot, geothermally heated water is emitted. Surprisingly, these vents are teeming with life, though they have absolutely no access to solar energy.

Radiation can be dangerous to life.
The sun emits electromagnetic radiation and sends it throughout the solar system. This radiation is vital to life, but some of it can also damage and even kill organisms.

Extremophile Example: Deinococcus radiodurans is a highly radiation-resistant bacterium. These bacteria can withstand a dosage of radiation that is 3,000 times greater than a dosage that would kill a human being.

Life needs particular raw materials.
When you eat, drink, and breathe, you are taking in the raw materials that you need for survival. Other forms of life also need access to raw materials. Interestingly, while our sources of these raw materials are very different from the sources needed by other forms of life, the basic building blocks that are required are the same. The element carbon, in particular, is vital to life as we know it.

Extremophile Example: An oligotroph is an organism that can live in an environment extremely low in one of the fundamental building blocks of life—carbon. Oligotrophs grow slowly and have low metabolic rates, but still they live, despite concentrations of carbon that are lower than one part per million.

In our search for life on other worlds, we are charged with identifying a minimum set of requirements that we would expect to be present in order for life to exist. If we know the minimum requirements, we can look for them on worlds in our solar system and then target those worlds for missions. Planetary characteristics that are considered especially important to a world's ability to support life include:

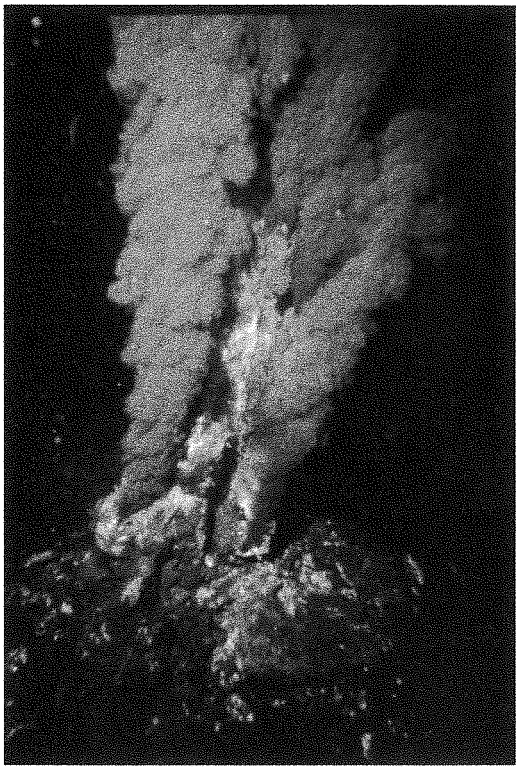

Figure 4-6: Image of a hydrothermal vent on a mid-ocean ridge—home of many extremophiles

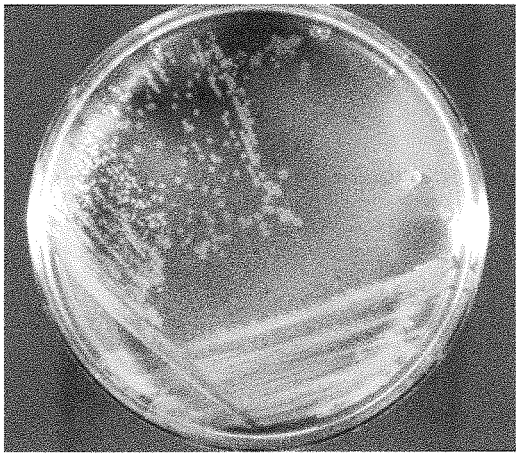

Figure 4-7: Image of deinococcus radiodurans growing in a nutrient agar dish

- Whether or not the world has water
- The temperature of the world
- The availability of energy on the world, such as from the sun
- Whether or not the world has any shielding, such as an atmosphere, from dangerous radiation
- The composition of the world, especially in terms of supplying the raw materials necessary for life

Checking In

1. What characteristics of Earth make it habitable?
2. What characteristics should we look for when we are searching for other habitable worlds?