What does life require?

Astrobiologists begin their assessment of whether a planet or moon is a promising candidate for life by seeing if any liquid water, energy sources, and nutrients are present.

Many astrobiologists use the availability of **liquid water** as the primary criterion for judging whether a planet is a candidate for life. While other liquids do exist (e.g., ammonia, methane, or ethane), they exist at temperatures far below the level conducive for life. The life discovered to date seems to be limited to a temperature range of about minus 15°C to 115°C. Under the right conditions, water can be liquid over this entire range. Furthermore, water is an important vehicle for transporting and delivering dissolved chemicals as well as being an important chemical reactant in its own right. Therefore, planets and moons with a way to cycle liquid water such as geothermal or atmospheric cycles have a mechanism for delivering the chemicals required by living organisms.

All life requires energy. Organisms use either light energy or chemical energy to run their life processes. **Light energy** is available only to organisms that live on or close to a planet or moon's surface. For life to exist there, the surface must be within a temperature range conducive for life and be protected from harmful ultraviolet radiation and charged solar particles. Strong magnetic fields and thick atmospheres around some planets and moons provide just this kind of protection. At some point, light energy from the sun becomes too dim to be a viable energy source. Thus, on planets that are unprotected or too distant from the sun, the only option for organisms is to live beneath the ground and to depend on **chemical energy** for their needs. Some microbes on Earth obtain energy from organic (carbon containing) compounds. Others rely on inorganic (without carbon) compounds such as sulfide and manganese compounds. There are even microbes that can use both organic and inorganic compounds as a source of energy. In each case, microbes break complex compounds into simpler ones to obtain a small amount of energy from this chemical change. This energy is sufficient to power microbial life. For life to arise and persist for billions of years, organisms need a constant supply of these compounds. Processes such as volcanic activity, weathering, lightning, and even the activity of life itself make these energy-supplying compounds available.

Nutrients are the raw materials organisms need to construct and maintain their bodies. While the solid planets and moons in our solar system all have the same general composition, local conditions and processes have led to variations in the concentrations and availability of different chemical compounds. As a result, nutrients required by life are more available on some planets and moons than on others. Atmospheres can also serve as a source of nutrients. For example, nitrogen from nitrogen gas can be used to make proteins and carbon from carbon dioxide or methane can be used to make carbohydrates and fats.

Habitable planets are ones that are able to provide organisms a dependable supply of liquid water, nutrients, and energy. Since chemistry works by the same rules throughout the universe, most scientists think that extraterrestrial life will use the same things for their life processes as life on Earth does. Consequently, when searching for extraterrestrial life, astrobiologists search both for direct evidence of life and for habitable conditions.

This information is from the NASA Astrobiology Institute

What makes a world habitable?

Temperature	At about 125°C, protein and carbohydrate molecules and genetic material (e.g., DNA and RNA) start to break down. Cold temperatures cause chemicals in a living cell to react too slowly to support the reactions necessary for life. Thus, life seems to be limited to a temperature range of about minus 15°C to 115°C.
Water	Life as we know it requires liquid water. It can be available on an irregular basis with organisms going dormant until it becomes available, but, eventually, it needs to be available. On a cold planet or moon, there must be internal heat to melt ice or permafrost. On a hot planet or moon, the water will boil away or evaporate unless it is far beneath the surface.
Atmosphere	Atmospheres can insulate a planet or moon and protect life from harmful ultraviolet radiation and small- and medium-sized meteorite impacts. In addition, atmospheres can serve as an important source of biochemicals. For example, nitrogen from nitrogen gas can be used for proteins, and carbon from carbon dioxide and methane can be used for carbohydrates and fats. 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 gravity 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.
Energy	Organisms use either light or chemical energy to run their life processes. At some point, light energy from the sun becomes too dim to be a viable energy source. On Earth, many microbes obtain energy from the sulfur, iron, and manganese compounds present in the Earth's crust and surface layers. When they absorb such compounds and break them down, they obtain a small amount of energy from this chemical change. This energy is sufficient to power microbial life.
Nutrients	The solid planets and moons in our solar system have the same general chemical composition. As a result, the necessary raw materials to construct and maintain an organism's body are in place. However, a planet or moon needs to have processes such as plate tectonics or volcanic activity to make these chemicals constantly available. In addition, liquid water is a powerful solvent and is an important vehicle for transporting and delivering dissolved chemicals. Therefore, planets or moons with volcanic activity, plate tectonics, or a way to cycle liquid water have a way to supply the chemicals required by living organisms.

This information is from the NASA Astrobiology Institute

Name____Period_____

What Makes a World Habitable?

<u>What does life require?</u>

Answer the following questions from the article "What does life require?"

1. What are three main requirements for life to exist on a planet?
2. Why is liquid water important for living things?
3. What two things allow organisms to be protected from ultraviolet radiation and charged solar particles?
4. If organisms live below ground and can't use light energy, what kind of energy could they use?
5. What kinds of organisms use organic or inorganic compounds for energy?
6. What processes provide energy-supplying compounds to living things?
7. What are nutrients used for?
8. What is nitrogen used for in living things?
9. What is carbon used for in living things?
10. What assumptions do scientists make when looking for life on other planets?

<u>What makes a world habitable?</u>

Answer the following questions from the article, "What makes a world habitable?"

11. What happens to living things above 125 °C?
12. Why can't living things survive below –15 °C?
13. On a cold moon or planet, what would have to happen in order to have liquid water?
14. Why is there no liquid water on a hot moon or planet?
15. What are four things that an atmosphere does to help living things survive?
    a.
    b.
    c.
    d.
16. Why do small planets or moons not have an atmosphere?
17. What are two places living things can get energy from?
18. What is required in order to make nutrients available to living things?

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Now you will apply what you have learned to decide which of the following planets/moons might possibly have life. Put a check in the box and then explain your reason for your choice. Be very descriptive in your explanation.

Planet/Moon	Life is likely	Life is possible	Life is unlikely	Explanation
Mercury				
Venus				
Earth				
Earth's moon				
Mars				
Gas Giants – Jupiter, Saturn, Neptune, Uranus				
Jupiter's moon Io				
Jupiter's moon Europa				
Jupiter's moon Ganymede				
Jupiter's moon Callisto				
Saturn's moon Titan				
Pluto				

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