

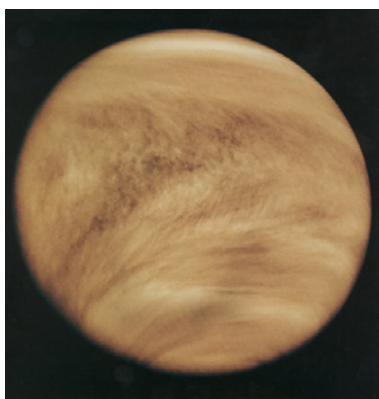
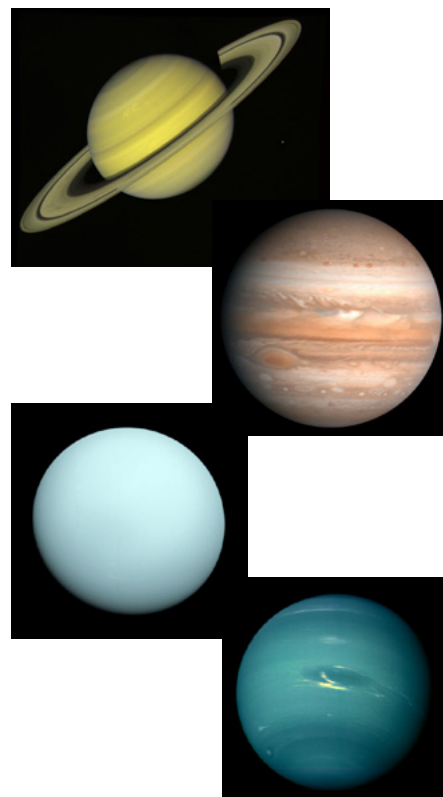
## Ambassador Space Science Master Badge

**Solar System Bodies**

Read about the conditions on different bodies in our Solar System.

The Gas GiantsJupiter, Saturn, Uranus, Neptune

- The temperature at the cloud tops is  $-200^{\circ}\text{C}$  while the interior temperatures reach tens of thousands of degrees. The churning of the atmosphere causes temperatures of the circulating gasses to change greatly over short distances and periods of time.
- The gas giants are made almost entirely of hydrogen and helium, with very small amounts of water.
- Gas giants release large amounts of their own energy, keeping internal temperatures high and causing their atmospheres to circulate constantly. The violent storms created by this circulation would subject life to rapid and extreme changes in temperature and pressure.
- Sunlight is dim but may be a viable energy source. Obtaining sufficient amounts of chemicals in a gaseous environment is difficult, making chemical energy an unlikely energy source.
- A gas environment is too diffuse to concentrate nutrients and make them available in a predictable, reliable way. Having life arise or survive in such a constantly changing environment is highly unlikely.

Venus

- Venus has a thick carbon dioxide atmosphere that traps heat efficiently. The average surface temperature is  $464^{\circ}\text{C}$ .
- There is no surface water. The atmosphere has trace amounts of water vapor (30 parts per million or 0.0000003%).
- Venus's atmospheric pressure is 92 times that of Earth's. It is 97% carbon dioxide.
- The thick clouds prevent much sunlight from reaching the surface, so any life would have to depend on chemical energy. Sulfuric acid clouds provide a potential source of chemical energy.
- In general, Venus and Earth have the same chemical composition, and Venus is volcanically active, giving it a way to cycle chemicals important to life.

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#### Earth

- The average surface temperature is 15°C. Earth's maximum temperature is 51°C (Libya) and its minimum is -89°C (Antarctica).
- On Earth, water exists in all three states. The water cycle delivers water to nearly every part of Earth.
- Earth's atmosphere shields the surface from harmful ultraviolet radiation and most meteorites, insulates the Earth, and serves as a source of nutrients such as nitrogen and carbon.
- Plants capture sunlight and make possible the food chain. High oxygen levels in the atmosphere enable life to use high-energy, carbon-based energy sources (e.g., sugar). Many microbes live off the chemical energy in inorganic compounds such as iron and sulfur.
- Everything organisms need to build and maintain their bodies is already on Earth. Earth has processes such as plate tectonics to cycle chemicals important to life.



#### Earth's Moon

- There is no atmosphere moderating temperatures, and temperature depends entirely on how much sunlight falls on the surface. While the overall average surface temperature is -23°C, the daytime average is 107°C and the nighttime average is -153°C.
- There is no known liquid water on the moon. In 1998, NASA's Lunar Prospector spacecraft detected water ice at each of the moon's poles.
- There is no atmosphere. Without an atmosphere, the surface experiences large and rapid temperature swings, which are hard for organisms to cope with.
- The moon receives the same amount of sunlight as Earth, making the sun a viable energy source. Chemicals made available by volcanic activity early in the moon's history may once have been a possible energy source.
- The moon and Earth have the same general chemical composition, but the moon lacks any processes that are necessary to cycle chemicals important to life.

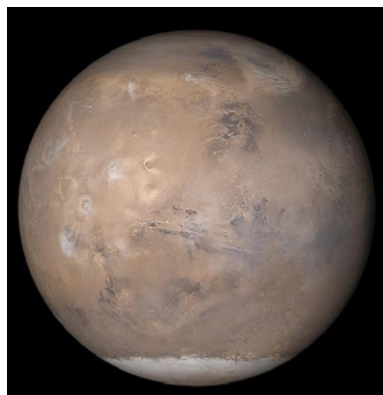
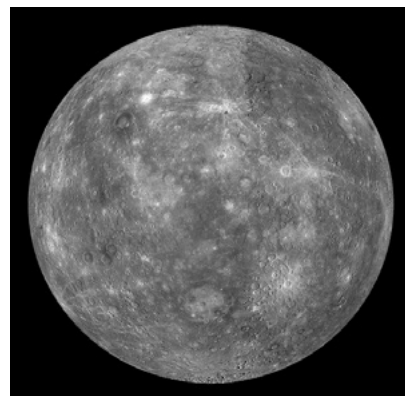
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Mercury

- The temperature on the side facing the sun is  $252^{\circ}\text{C}$ . On the dark side, it is  $-183^{\circ}\text{C}$ .
- There is no surface water or water in the atmosphere.
- There is essentially no atmosphere.
- Living on or near the surface is impossible, so life would have to live underground and depend on chemical energy.
- Mercury and Earth have the same general chemical composition, but Mercury lacks the processes that are necessary to cycle chemicals important to life.

Mars

- Even though the surface temperature can reach room temperature for a few minutes at mid latitudes, the average surface temperature is  $-63^{\circ}\text{C}$ .
- Though there is no surface water, features suggest that Mars once had flowing surface water. There are also indications of thick layers of permafrost, soil locked in water ice. The Northern and Southern ice caps contain water ice.
- The Martian atmosphere is 95% carbon dioxide. The atmospheric pressure is so low (one-thousandth that of Earth's) that surface water quickly boils away. The atmosphere is too thin to protect or insulate the surface of Mars significantly.
- Mars is on the edge of the Habitable Zone, making sunlight a possible energy source. Chemicals made available by volcanic activity early in Mars's history may once have been a possible energy source.
- Mars and Earth have the same general chemical composition. Mars was volcanically active for its first two to three billion years, giving it a way to cycle chemicals important to life.

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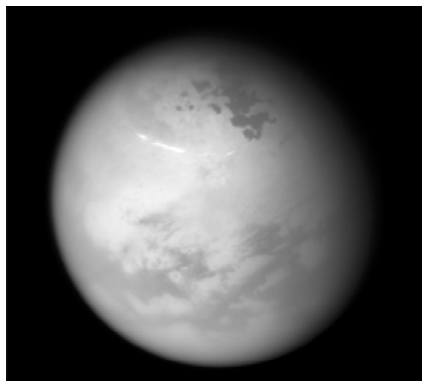
Pluto

- The average surface temperature is  $-225^{\circ}\text{C}$ .
- All water is permanently frozen as ice.
- There is essentially no atmosphere.
- At this distance from the sun, sunlight is too dim to be a viable energy source. Organisms would need to rely on chemical energy.
- Pluto and Earth have the same general chemical composition, but Pluto lacks any processes that are necessary to cycle chemicals important to life.

Titan

## Saturn's Moon

- The average surface temperature is  $-179^{\circ}\text{C}$ .
- Water-ice icebergs might float in an ocean of ethane-methane liquid or slush. There is virtually no water in the atmosphere.
- Titan has an atmospheric pressure 1.5 times that of Earth. It is 90–97% nitrogen and 3–10% methane, a composition more like Earth's than the carbon dioxide atmospheres of Mars and Venus.
- At this distance from the sun, sunlight is too dim to be a viable energy source. Organisms would need to rely on chemical energy.
- Sunlight-driven reactions can turn methane into amino acids, the building blocks of life. They could join into large, complex molecules and rain down on the surface. There, they could accumulate, covering the surface with thick, gooey deposits of hydrocarbons. These conditions may be similar to those on early Earth.





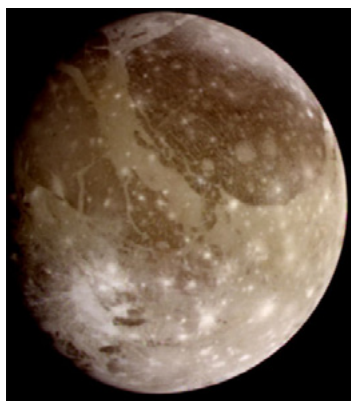
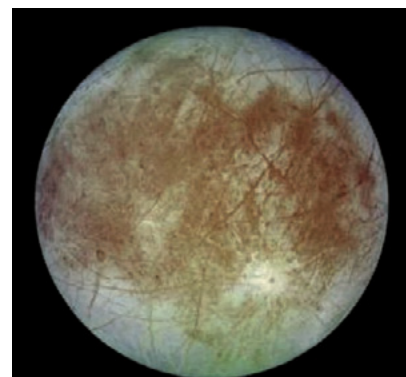
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Europa**Jupiter's Moon**

- At noon on the equator, the average surface temperature is  $-145^{\circ}\text{C}$ .
- Europa is covered with a one- to ten-kilometer-thick crust of water ice. There is strong evidence that this crust may cover a 60–100-km deep ocean of water. An ocean of this size would hold more water than there is on Earth!
- There is no atmosphere.
- Sunlight may be a viable energy source. Scientists think Europa's core is hot enough to have volcanic activity beneath its ocean. Such activity might make energy-rich compounds such as sulfur compounds available. Europa's ice crust is also thickly dusted with another potential energy source, sulfur compounds from Io's eruptions.
- Europa is a solid body and the materials for life are likely to be present. Possible volcanic activity and a large ocean provide several ways to cycle chemicals important to life.

Ganymede**Jupiter's Moon**

- At noon on the equator, the average surface temperature is  $-121^{\circ}\text{C}$ .
- Ganymede's surface and upper layers are an even mixture of rock and water ice. There is no known source of heat to melt the ice.
- There is virtually no atmosphere.
- Sunlight may be a viable energy source. There are no known geologic processes to make chemicals available to organisms that rely on chemical energy.
- Ganymede is a solid body and probably has the necessary materials for life. However, Ganymede seems to lack any processes that are necessary to cycle chemicals important to life.

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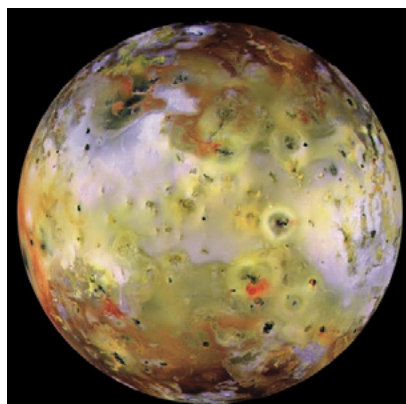
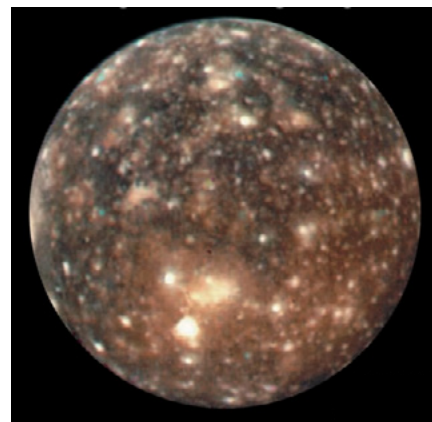
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Callisto

## Jupiter's Moon

- At noon on the equator, the average surface temperature is  $-108^{\circ}\text{C}$ .
- Callisto appears to be an ice-rock mix through and through. Its low density suggests that it contains large amounts of water ice. Some scientists think there is a salt-water layer beneath the surface.
- There is virtually no atmosphere.
- Sunlight may be a viable energy source. If there is a salt-water layer beneath the surface, organisms may be able to rely on chemical energy.
- Callisto is a solid body and probably has the necessary materials for life. However, Callisto seems to lack any processes that are necessary to cycle chemicals important to life.

Io

## Jupiter's Moon

- At noon on the equator, the average surface temperature is  $-150^{\circ}\text{C}$ . In areas with volcanic activity, the lava flowing across the surface can reach  $1,250^{\circ}\text{C}$ .
- Io experiences almost constant volcanic activity, making it the most active volcanic body in the solar system. This activity and the hot interior drive out any water, and there is no known liquid water or water ice on Io.
- There is essentially no atmosphere. A thin cloud of sulfur compounds from Io's constant volcanic activity surrounds Io.
- Sunlight may be a viable energy source. Volcanic activity has coated Io's surface with compounds such as sulfur and sulfur dioxide. On Earth, many microbes use such compounds as an energy source.
- Io is a solid body and the materials for life are likely to be present. Volcanic activity could cycle chemicals important to life.