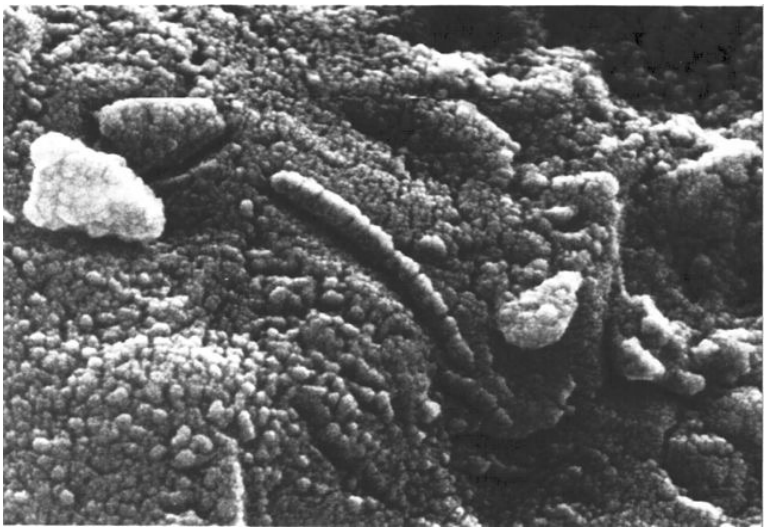
This planet is the cradle of the human mind, but one cannot spend all one's life in a cradle.
Konstantin Tsiolkovsky

Habitable Worlds

Hello Astronomy 111. In this module we'll tour the locations were we might find habitable worlds.



Credit: NASA

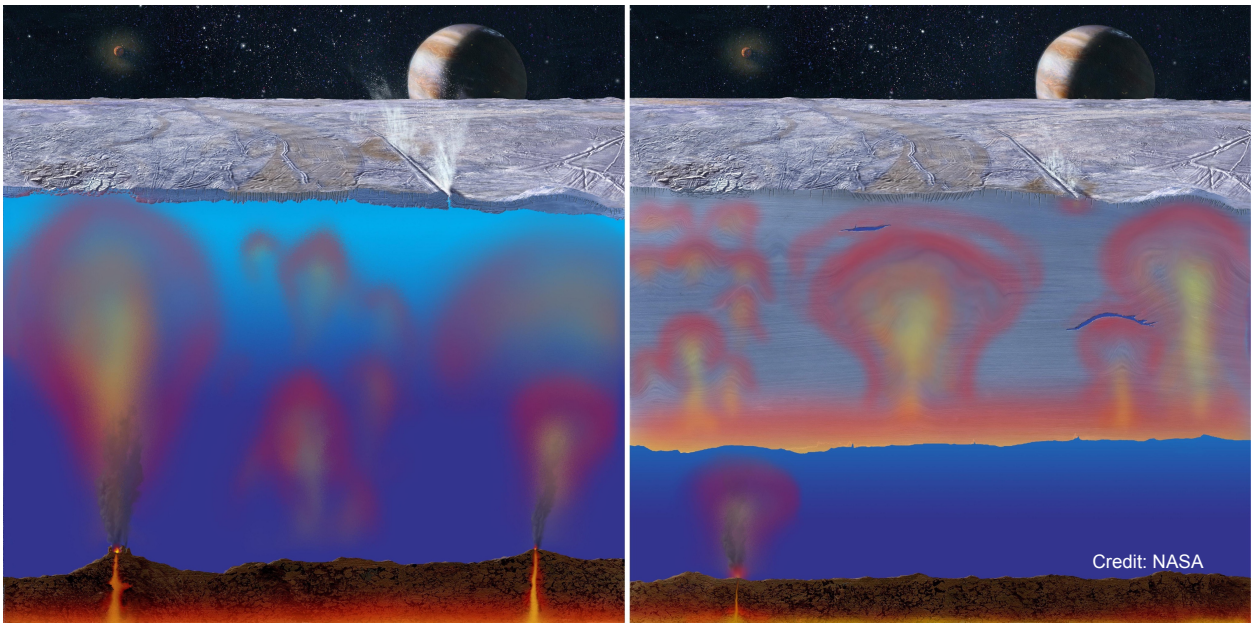
Could there be life on Mars? Well, Mars once had the three conditions that is favorable to life on Earth - a source of nutrients (food!), a source of energy (lightning, geothermal, etc) and liquid water. If life arose on Mars it might still survive in pockets of liquid water underground.

Life on Mars is the driver is for our continuing to visit to Mars. It would be very interesting to know, for example, if there was life on Mars, do the organisms have DNA like we do? Are they carbon-based like we do?

There's also the idea that we are the Martians. That life first arose on Mars because it had a more conducive location in the early solar system. Then one of the inevitable impacts ejected some of the rocks with organic material, and those rocks landed on on Earth. Making us the Martians. This is not so crazy as it might first sound. You can find pieces of Mars on Earth. You know they are from Mars because the abundance levels of key isotopes is very different than Earth rocks but a near perfect match for Mars. They got here by the impact ejection mechanism we just noted.

The image above left a famous Mars rock - Allan Hills Rock 84001. It was found in Antarctica. That's where most Mars rocks are found. Not because Antarctica is some sort of Mars rock magnet, but because erosion processes are a lot smaller in Antarctica and because rocks stick out against the ice.

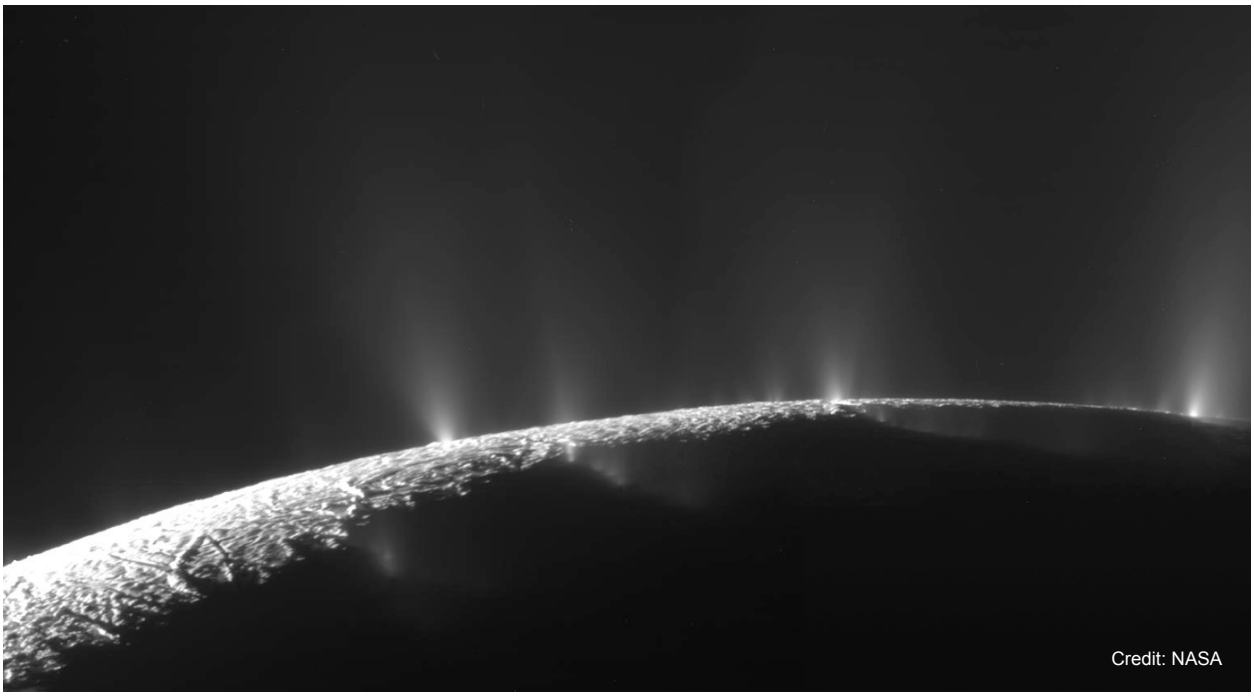
Deep within that rock are structures that looked like tube-like microfossils, as shown in the right image above. In 1996 there was a great deal of hubbub on life being found on Mars. Even the president of the United States got involved in the announcement. However, most scientists these days agree that it's not fossilized life, that there are too many compelling non-biological explanations. So an interesting miss in the annals of searching for life on Mars.

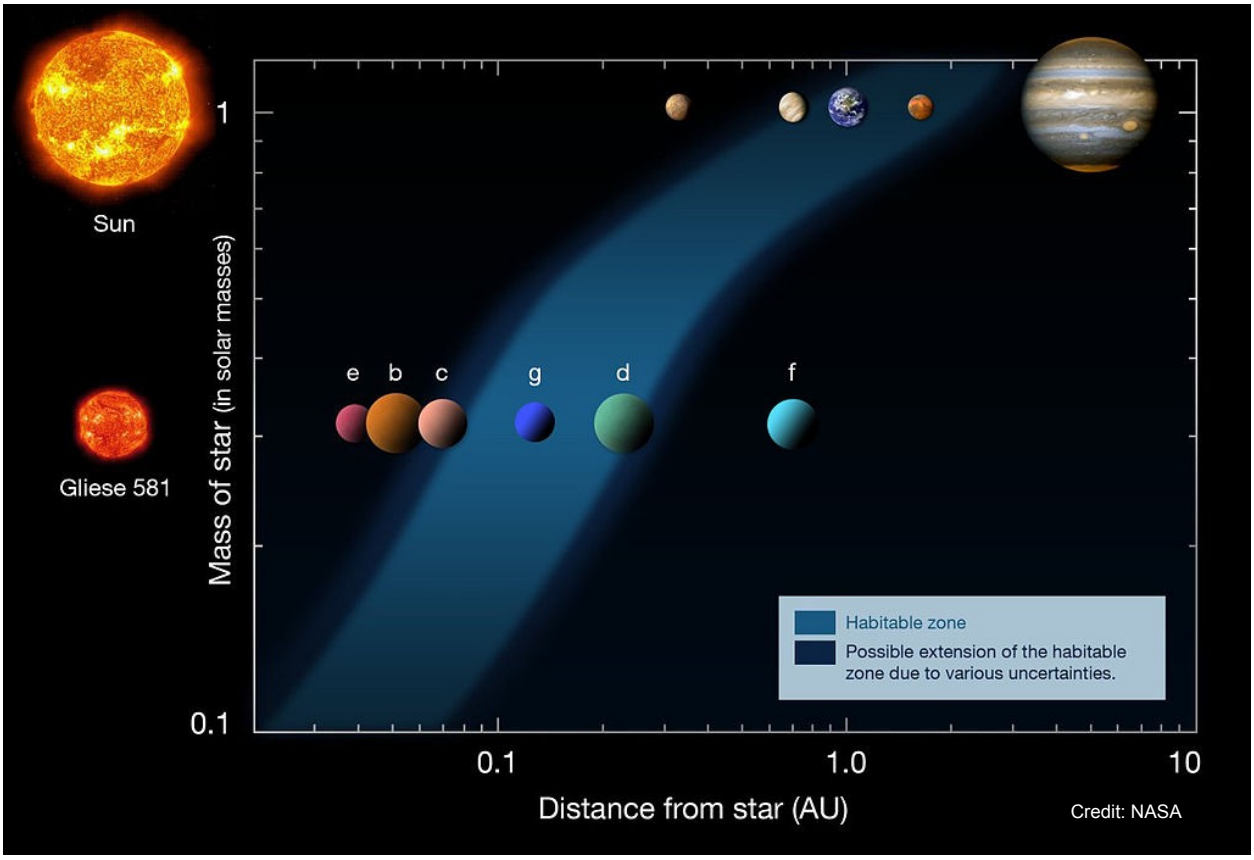


Europa is another world in our solar system where the search for life has been heating up. This is driven by the compelling evidence that Europa probably has a subsurface ocean of liquid water. It likely also has volcanoes on its ocean floor. If so, then it has conditions much like those on which life on Earth probably arose, making it a good candidate for life. And we are going to Europa in the 2020s to find out! A key question, as illustrated above, is how thick is the ice overlying the ocean? Just a kilometer or two as in the left panel or 10's to hundreds of kilometers as in the right panel? There will be vigorous effort at refining answers to this question before the launch date.

Other worlds in our solar system that could be interesting are Titan and Enceladus. Both are farther out, so even colder at their surfaces. Both however show signs of liquids beneath their surfaces, as the image below of the surface of Enceladus shows. Its probably too cold for liquid water. Maybe life can use some other liquid to move nutrients around.

So, Mars is not the only place in our solar system where we search for life.

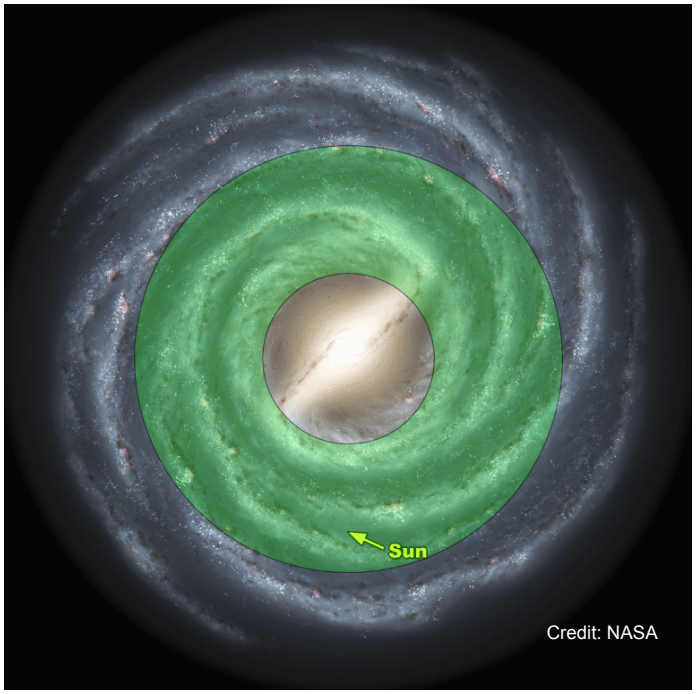

Credit: NASA


Sun
Gliese 581
1
0.1
Mass of star (in solar masses)
e
b
c
g
d
f
Habitable zone
Possible extension of the habitable zone due to various uncertainties.
0.1
1.0
10
Distance from star (AU)
Credit: NASA

What about other solar systems? Where might we find habitable planets? The classic habitable zone is defined by the distances from a star whether liquid water can exist. Too close to the star and the water boils off. This defines the inner edge of the habitable zone. Too far out and the water freezes This defines the outer boundary of the habitable zone. The image above shows the habitable zone for our solar system and the solar system around the star Gliese 581. In our solar system, both Earth and Mars are firmly within the habitable zone. For Gliese 581, one planet is squarely in the middle of its habitable zone with two others planets on the edges.

Led by the current Kepler mission and the upcoming TESS mission, we'll be looking to take spectra of the atmospheres of exoplanets. One goal is to discover the atmospheric composition and temperature. We want to be able to recognize planet atmospheres like Earth's with water vapor, oxygen, ozone, and carbon dioxide. Biosignatures are signs of life in an atmosphere. Earth's biosignatures are oxygen - produced only in large quantities by plants and photosynthetic bacteria. Nitrous oxide is also a gas also produced by life, but is difficult to detect. Methane is produced both biologically and non-biologically from volcanoes. Water vapor is considered a sign of habitability, because all life on Earth needs liquid water. Finding in the atmosphere is indicative of liquid water oceans on terrestrial-like planets.

Are Earth-like planets rare or common? We don't know. Arguments for and against can be made, but we currently lack the data to validate either of these arguments.



Just as there are habitable zones around stars, one can extend the idea to habitable zones in galaxies. Too close in, and there is too much light. It's going to be too hot. Too far out, and there isn't enough heavy elements like carbon, oxygen and iron. from which to build life.

Thanks! Bye Bye!