Life in the Universe

Chapter 30

The Copernican Principle

- The Copernican principle is that we should not assume we are the center of the Universe, or special in any way.
- Thus if life formed here, it should form other places. We dont know that to be true, it is just a reaction to our erroneous idea that we were the center of the Universe before.
- We start with guessing that Earth is an ordinary planet in an ordinary solar system in an ordinary galaxy. Then we try to understand how life formed here and therefore where else in the universe it is likely to form.

The Fermi Paradox

- Assuming intelligent life like ours something that normally happens on at least Earth like planets and taking the fact that there are 100 billion planets in our galaxy we now have a new problem.
- Where is everybody else? This point was raised by Fermi and is called the Fermi paradox.
- There are many proposed solution. Maybe life is common, but intelligent life is rare. Maybe intelligent life communicates by a means we haven't discovered yet. Maybe intelligent life tends to self-destruct in a short time. With only one example we don't know.

https://www.youtube.com/watch?v=sNhhvQGsMEc

Astrobiology

- In order to know if a planet have life start on it we need to know how life started on Earth. But we don't fully understand that.
- We know life is based on organic molecules
- We know life uses DNA to encode information and proteins to perform functions but we don't know how that came about.
- We know plants photosynthesize energy from the Sun and produce oxygen

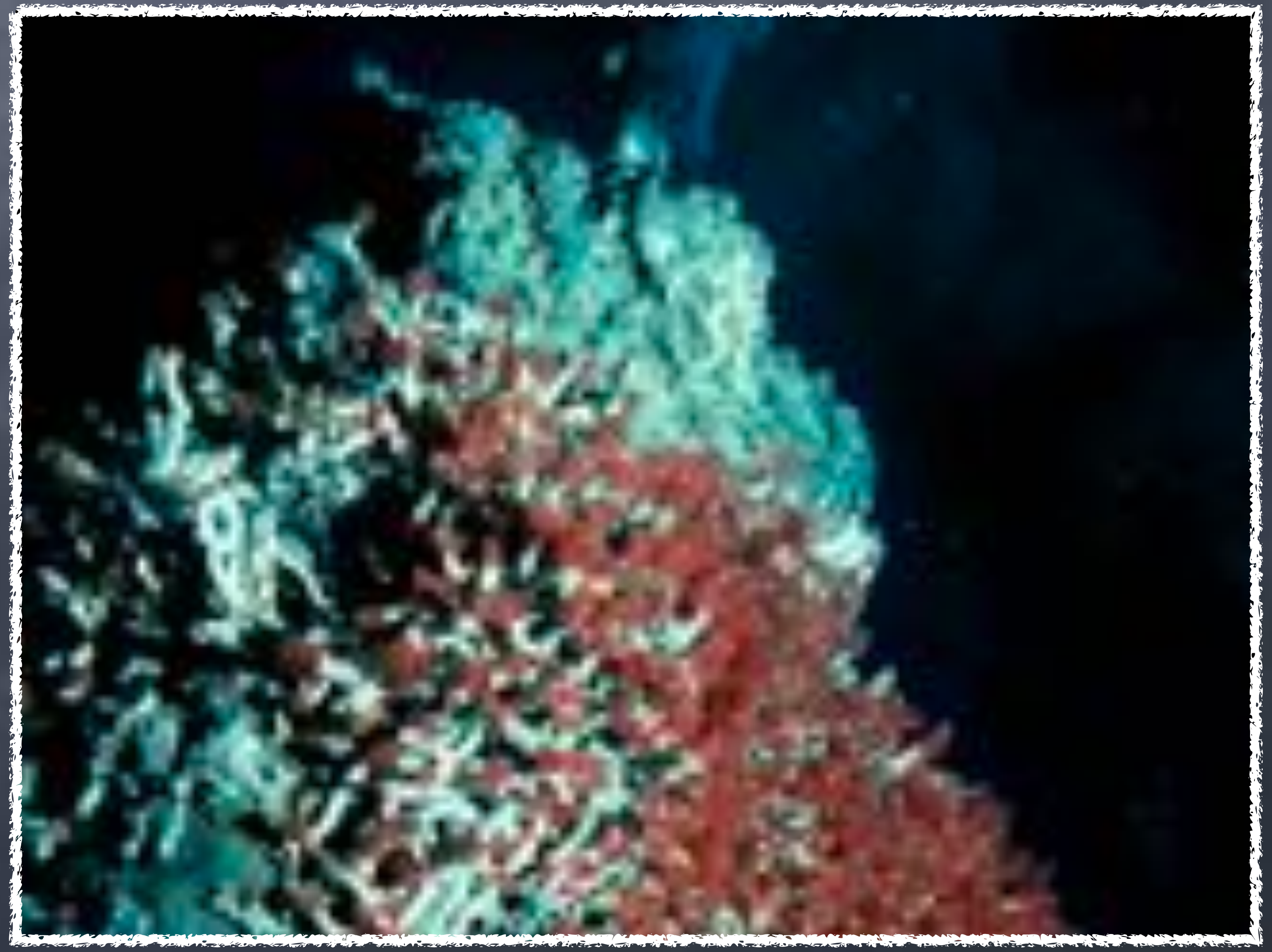
Organic Molecules

- We have found that organic molecules are common in space.
- Molecular clouds contain 100s of organic molecules like formaldehyde and alcohol.
- Meteorites have been found with amino acids and sugars.
- So the basic building blocks of life are available wherever planets form.

Habitable Environments

- The billions of planets in the galaxy have very different conditions. Let's consider what conditions a planet must have to be habitable for life as we know it.
- Life requires a solvent (a liquid in which chemicals can dissolve). On Earth that solvent is liquid water.
- Life requires biogenic elements called CHNOPS for carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.
- Life requires energy, most life on Earth gets its energy directly or indirectly from the Sun, but some microbes get energy from other sources of heat.

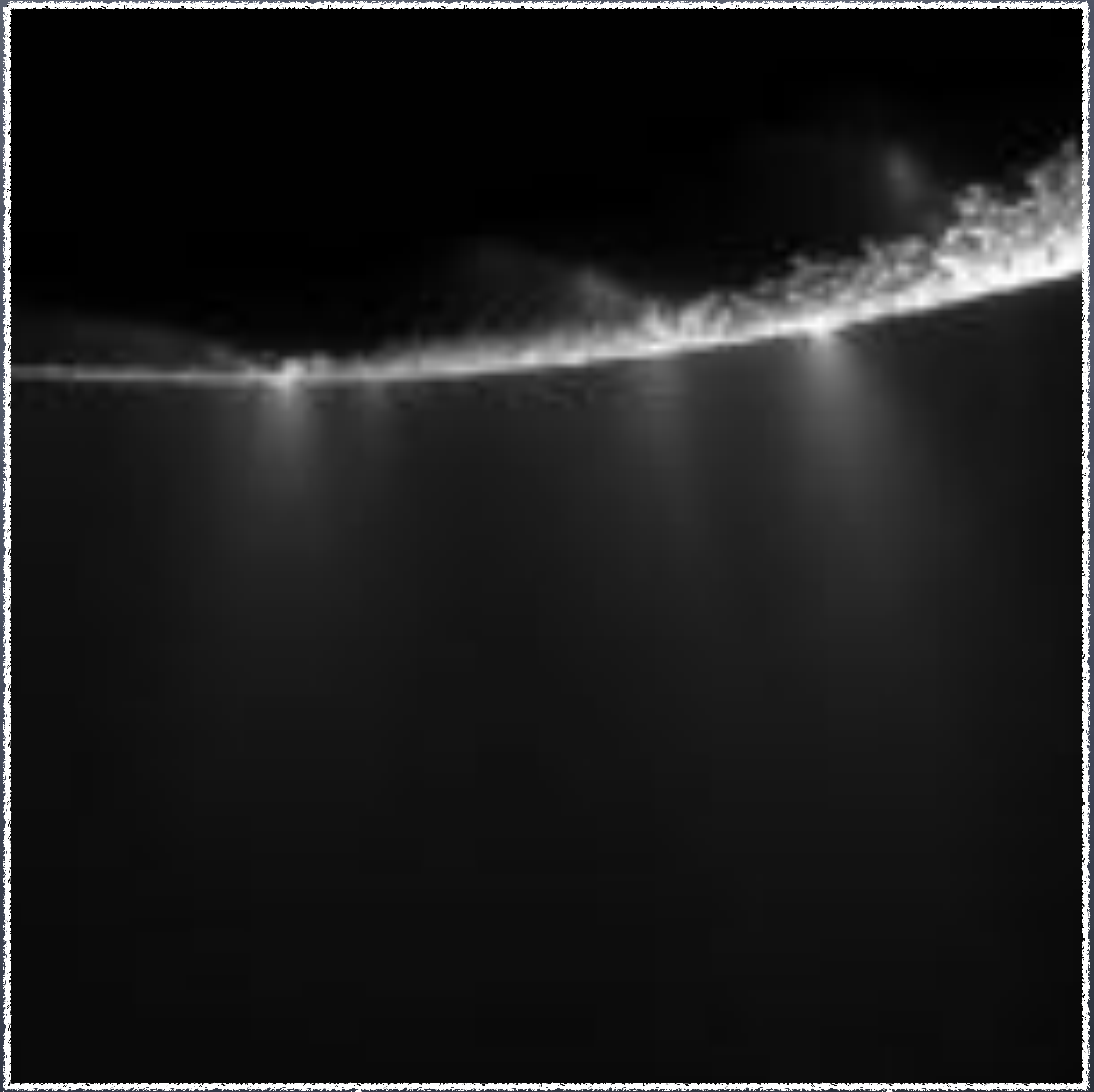
On Earth there are actually lots of places that seem inhospitable to life, but where nevertheless life is found. Hot springs, thermal vents, acidic rivers, and salt works all contain thriving communities of life.



Life in Our Solar System

- It is very possible that life (probably just microbes) exists in our solar system.
  - Mars had liquid flowing water in the past. There may be reservoirs of ice and liquid water could still exist today.
  - Europa almost certainly has liquid water and that water is in contact with a rocky mantle that may provide geothermal energy for life to survive.
  - Enceladus we know has liquid water and it too seems to be in contact with warmer rock below.
  - Titan has liquid hydrocarbons. This could support a very different form of life than we know.

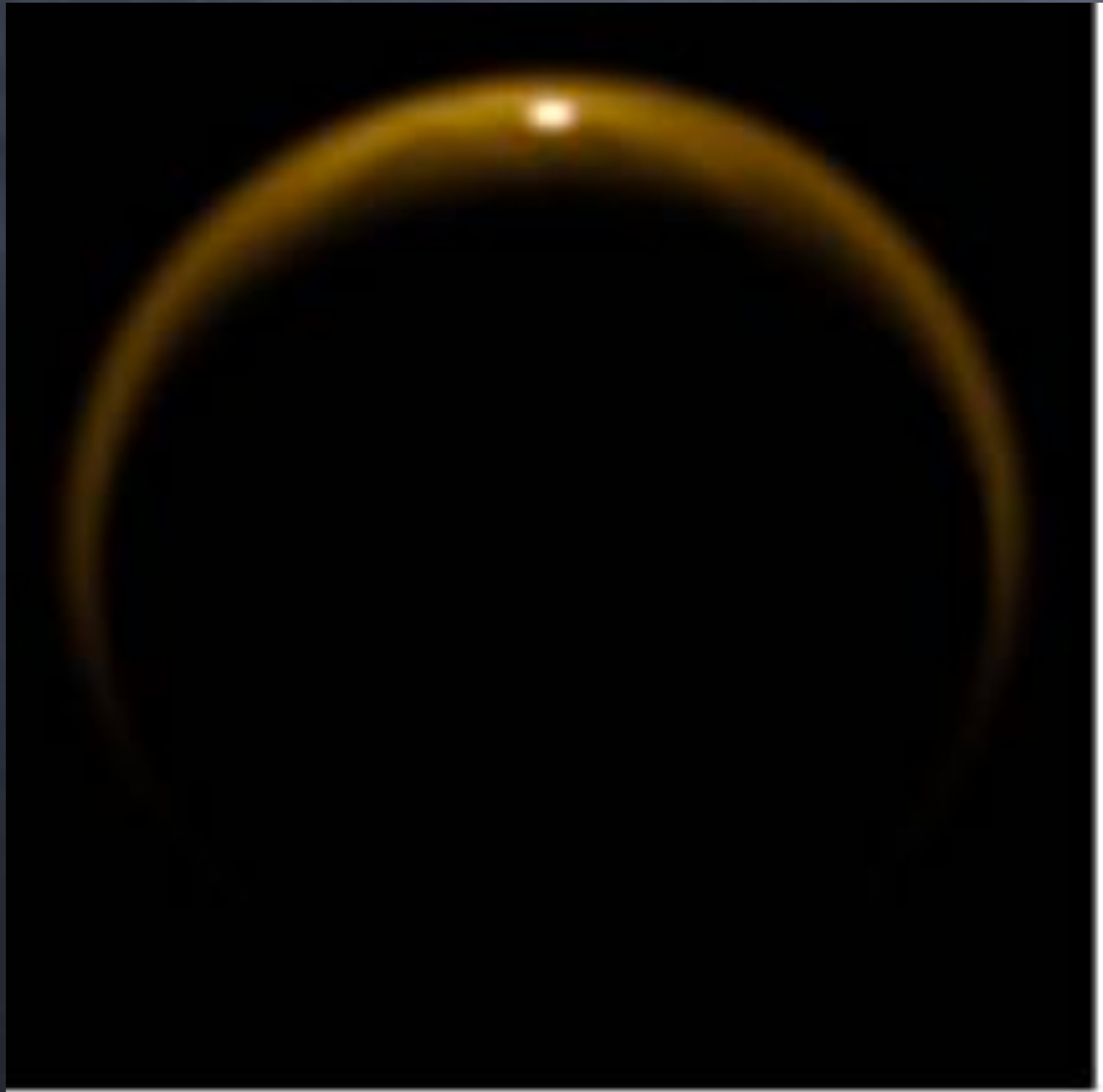
Holes drilled by a rover looking for water on Mars.



On Enceladus the water is just flying out from the surface.

Jupiter's Moons could be hospitable to life (the inner 3) because they are heated by tidal heating from Jupiter. Thus there is energy to support life and likely liquid water on Europa.

Titan has rain and lakes, flowing liquids on its surface. If life can as easily exist in hydrocarbons then it is likely to be there.



Habitable Planets Orbiting Other Stars

- For extrasolar planets we define a habitable zone based on the surface temperature we expect a planet to have based on the temperature of its star and the planets distance.
- In our solar system, Venus is too hot for liquid water while Mars is too cold. Only Earth has liquid water on its surface. However, this is not just because of distance but also the greenhouse effect on each planet.
- If Venus and Mars swapped orbits they both might be able to have liquid water. So the planets atmosphere is also important in determining habitability.

http://phl.upr.edu/projects/habitable-exoplanets-catalog

Biomarkers

- Earth size planets in the habitable zone might be rather common in the Galaxy, maybe 40% of stars have a least one.
- Next we would like to find some evidence of life on these planets. We aren't going to be seeing in directly anytime soon, but we can look for biomarkers, chemicals that are associated with living organisms.
- An oxygen atmosphere is the most notable of these, only Earth has oxygen in its atmosphere in our solar system. Other markers like nitrous oxide and methane have been suggested.
- One of the main goals of the next generation of extremely large telescopes is to have the ability to look for this gasses in the atmosphere of extra solar planets.

Transmission in Earth's atmosphere some of these could be signals to aliens that life exists on Earth.

The Search for Extra Terrestrial Life

- Given the extreme difficulty of installer travel it is very unlikely we are going to visit any nearby planets, or that aliens have visited us.
- Communication between stars on the other hand is relatively easy. Radio waves being the easiest way since it isn't absorbed by interstellar dust and it passes through Earth's atmosphere.
- Using the Copernican principle we are unlikely the be the most advanced civilization out there, so listening for a signal is going to be easier than broadcasting a signal.

Interstellar Travel

- Despite what you see in movies, interstellar travel takes a very long time and is very expensive.
- Science does not know of method of faster than light travel, so going to the nearest stars would take decades and farther away stars would take centuries.
- Even if one had a perfect engine (100% fuel conversion) a trip to the nearest star and back at 70% the speed of light takes the energy of hundreds of thousands times the yearly electricity use of the U.S.

- Even if all we plan to do is detect the signal from an alien planet there are many challenges:

1. From which direction (which star) is the message coming?
2. On what channels (or frequencies) is the message being broadcast?
3. How wide in frequency is the channel?
4. How strong is the signal (can our radio telescopes detect it)?
5. Is the signal continuous, or does it shut off at times (as, for example, a lighthouse beam does when it turns away from us)?
6. Does the signal drift (change) in frequency because of the changing relative motion of the source and the receiver?
7. How is the message encoded in the signal (how do we decipher it)?
8. Can we even recognize a message from a completely alien species? Might it take a form we don't at all expect?

Even though the challenge is great people have been attempting to find alien broadcasts since 1960. Today many giant radio telescopes are involved in the search.