CURRENT SEARCHES FOR INTELLIGENT EXTRATERRESTRIAL INTELLIGENCE

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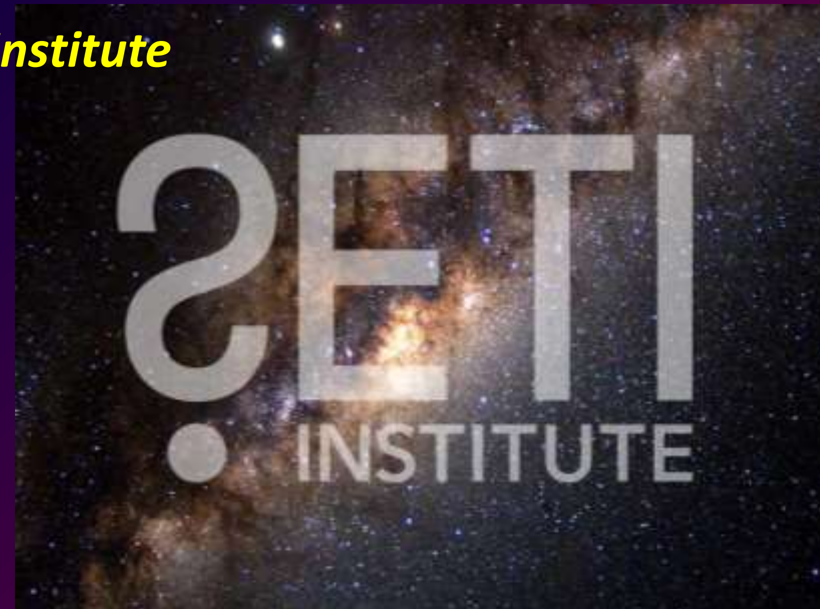
class 3

"The probability of success is difficult to estimate, but if we never search, the chance of success is zero",
Cocconi, G. and Morrison, P. (1959) Searching for interstellar communications, *Nature*, **184**, *844- 846.*

From Advancing the Search for Extraterrestrial Intelligence, Jill Tarter, director of SETI Institute:

- ***Is the origin of life unique, rare, or commonplace?***
- ***Is the emergence of intelligence an unlikely eccentricity of our own evolution or an expected product in any sufficiently rich habitat?***

We left off last time talking about the SETI Institute



6 research divisions:

- Astrobiology
- Astronomy & Astrophysics
- Climate & Bioscience
- Exoplanets
- Planetary Exploration
- SETI

https://seti.org/core-research

and the Frontier Development Lab: Using AI to help search for extraterrestrial life

https://frontierdevelopmentlab.org/

ASTROBIOLOGY

(Captain Picard is taken back in time to primordial Earth.)

the study of the origin, evolution, distribution, and future of life in the universe, both extraterrestrial life and life on Earth.

NASA establishes NASA Astrobiology Institute (NAI) in 1998.

Fundamental questions that formed the roadmap for research:

- **How does life begin and evolve?**
- **Does life exist elsewhere in the universe?**
- **What is life's future on Earth and beyond?**

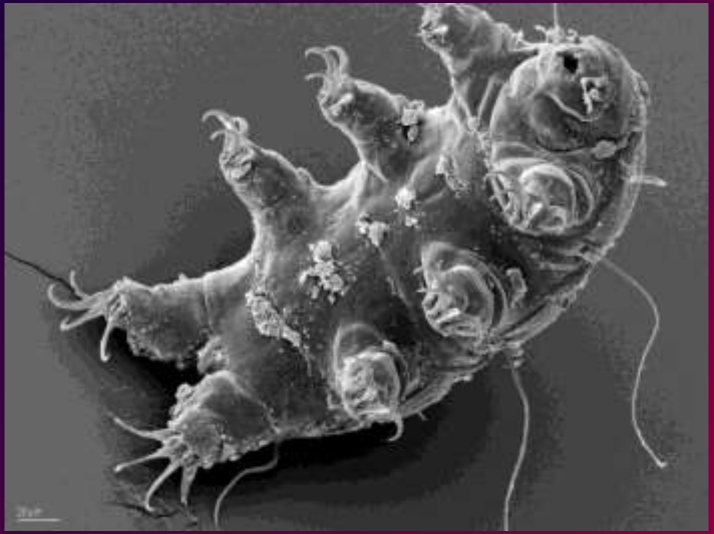
from An Astrobiology Strategy for the Search for Life in the Universe
National Academies of Science, Engineering, & Medicine, 2018

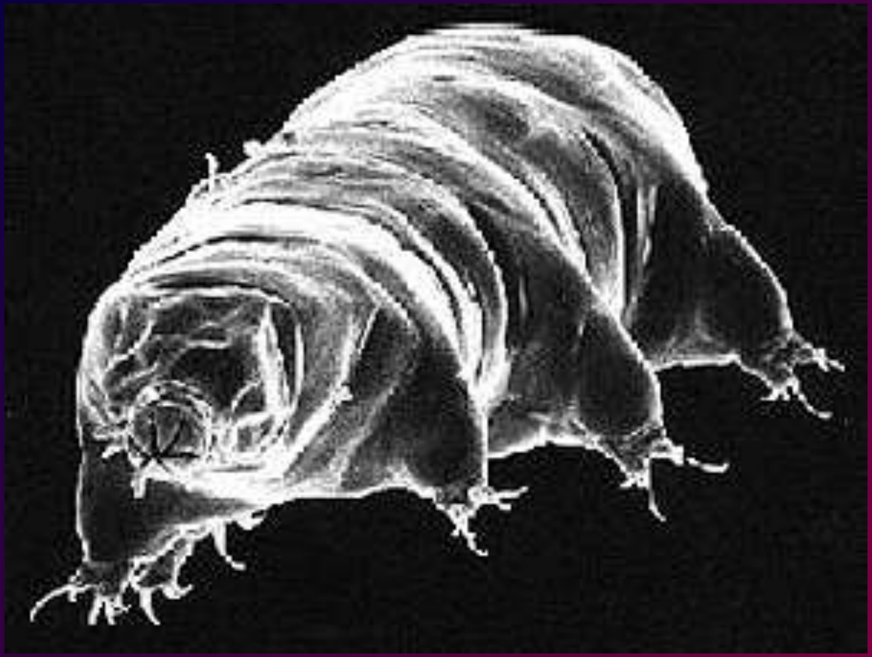
Evidence that gives us hope that the universe is more bio-friendly than we previously thought:

1. The discovery that basically for every star in our galaxy, there is at least one planet, many within the habitable zone of their parent star.

2. The large diversity of newly-discovered extremophiles, critters found on Earth in harsh environments that were thought not to support any life.

Tardigrades: Extremophile microanimals that can dehydrate to a few percent body weight of water, can survive the vacuum of space in Low Earth Orbit (LEO) and have a high tolerance for ionizing radiation.





Could tardigrades,
or some similar organisms,
possibly exist under
oceans on watery worlds
or in the soil of rocky planets
like Mars?

Actual tardigrades in visible light microscope, Goldstein Lab, UNC Chapel Hill

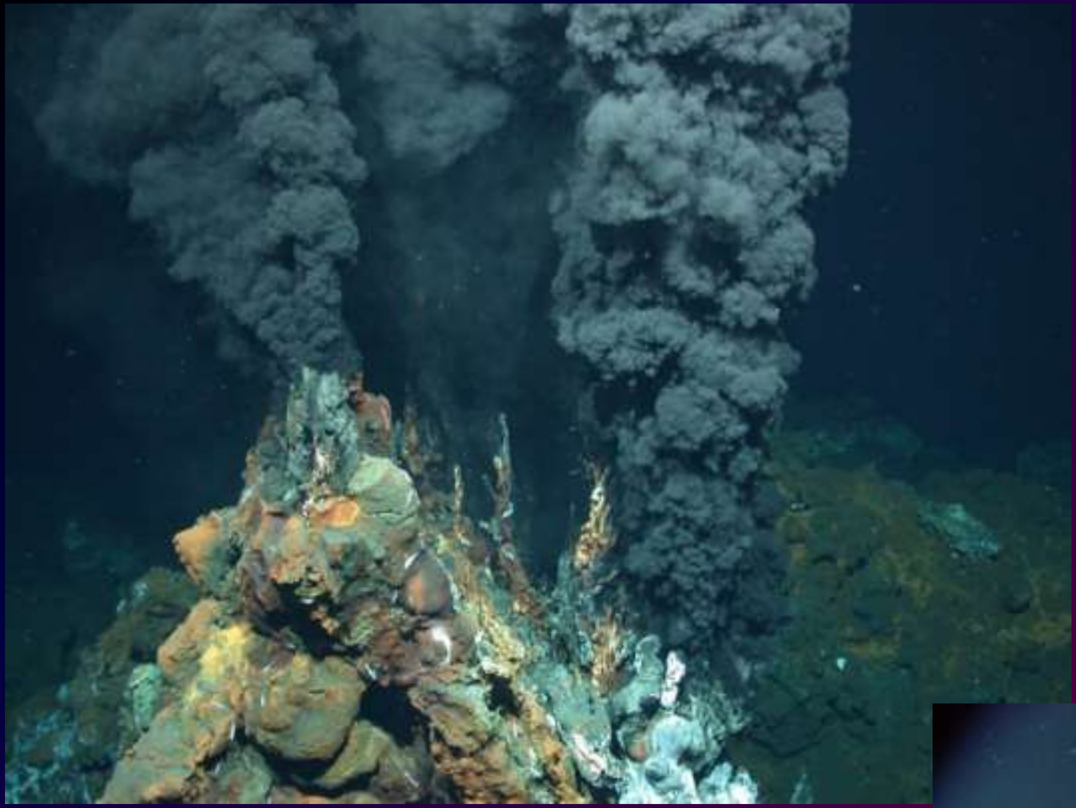
SETI institute scientists find abundant microbial life in extreme environments on Earth.

El Tatio Geyser Field
in the Chilean Andes
may be similar to environments
on Mars at one time.

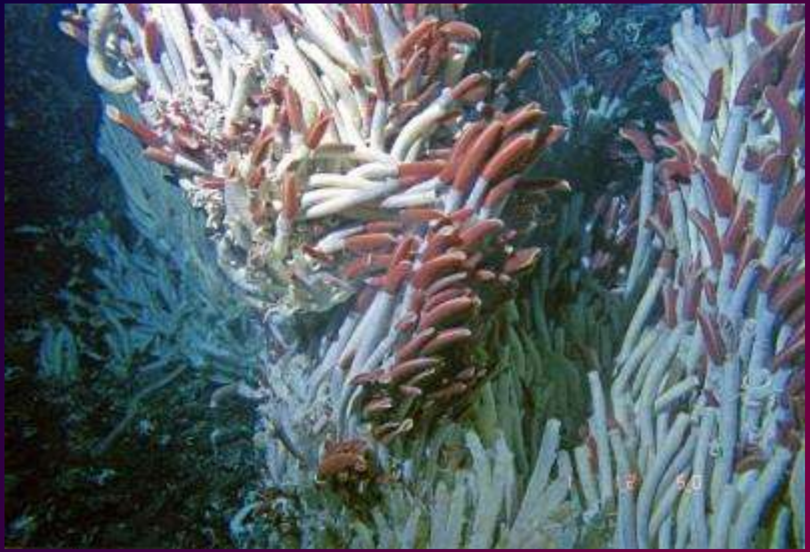
Hydrothermal springs in Yellowstone National Park contain numerous strains of thermophilic bacteria which produce these colors.

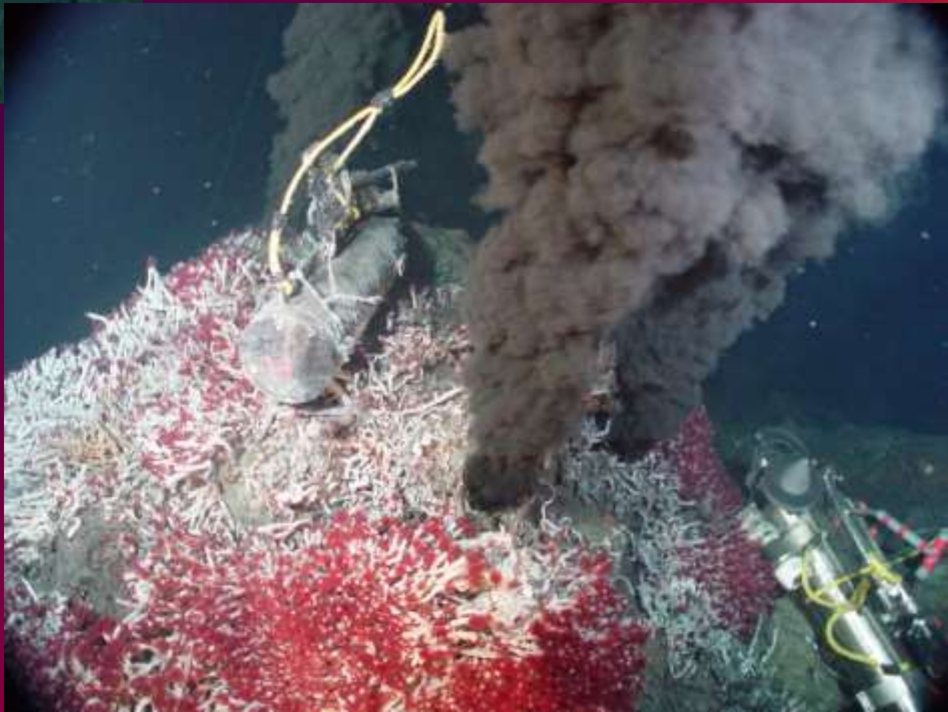
Algae in runoff channel in Yellowstone.

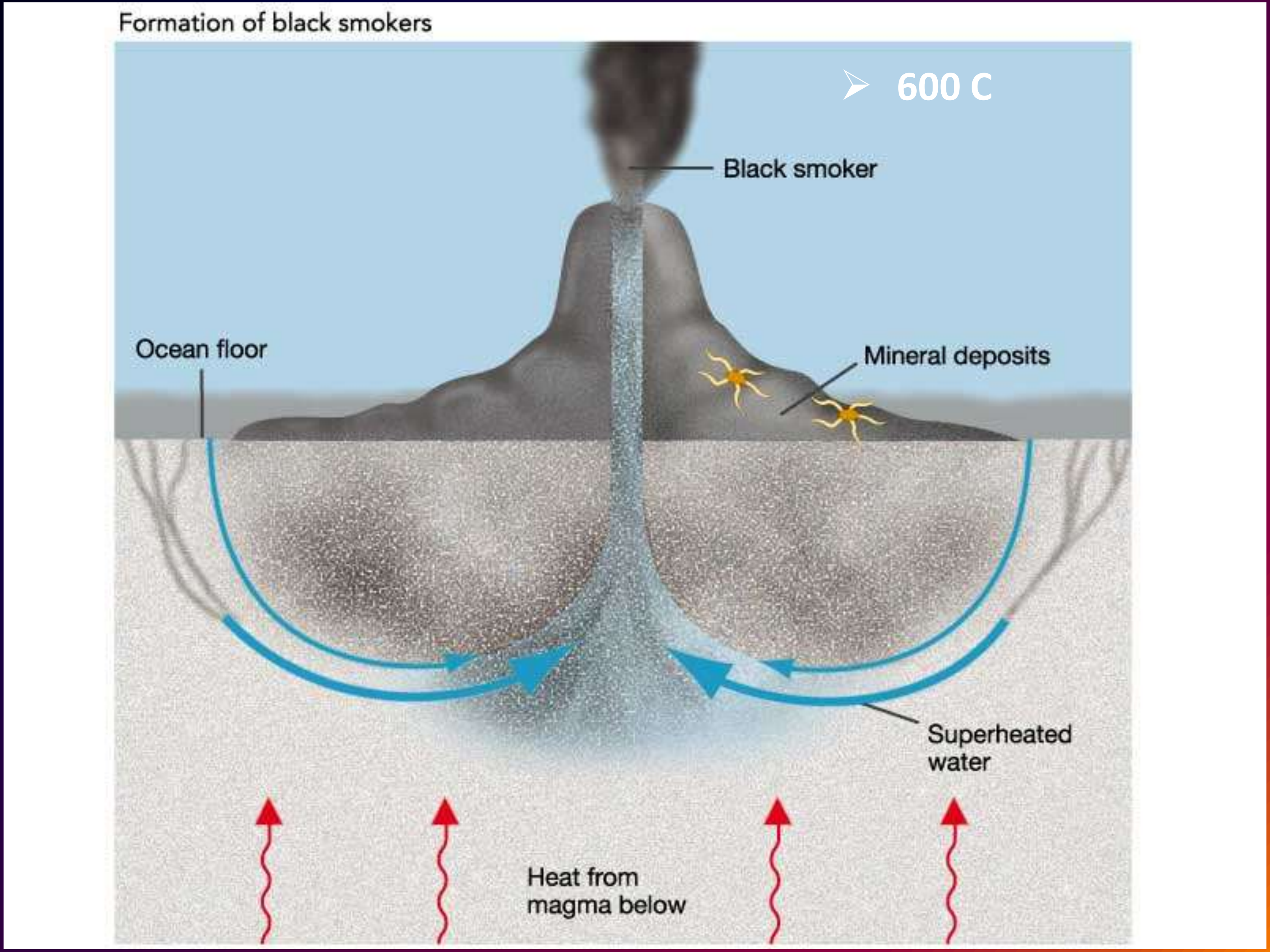
Microbial life that thrives in harsh environments on Earth may be consistent with microbial life existing on other planets, as their habitats on Earth may be analogous to conditions on other planets.



"black smokers" – hydrothermal vents at the bottom of Earth's oceans are teeming with microbial and animal life

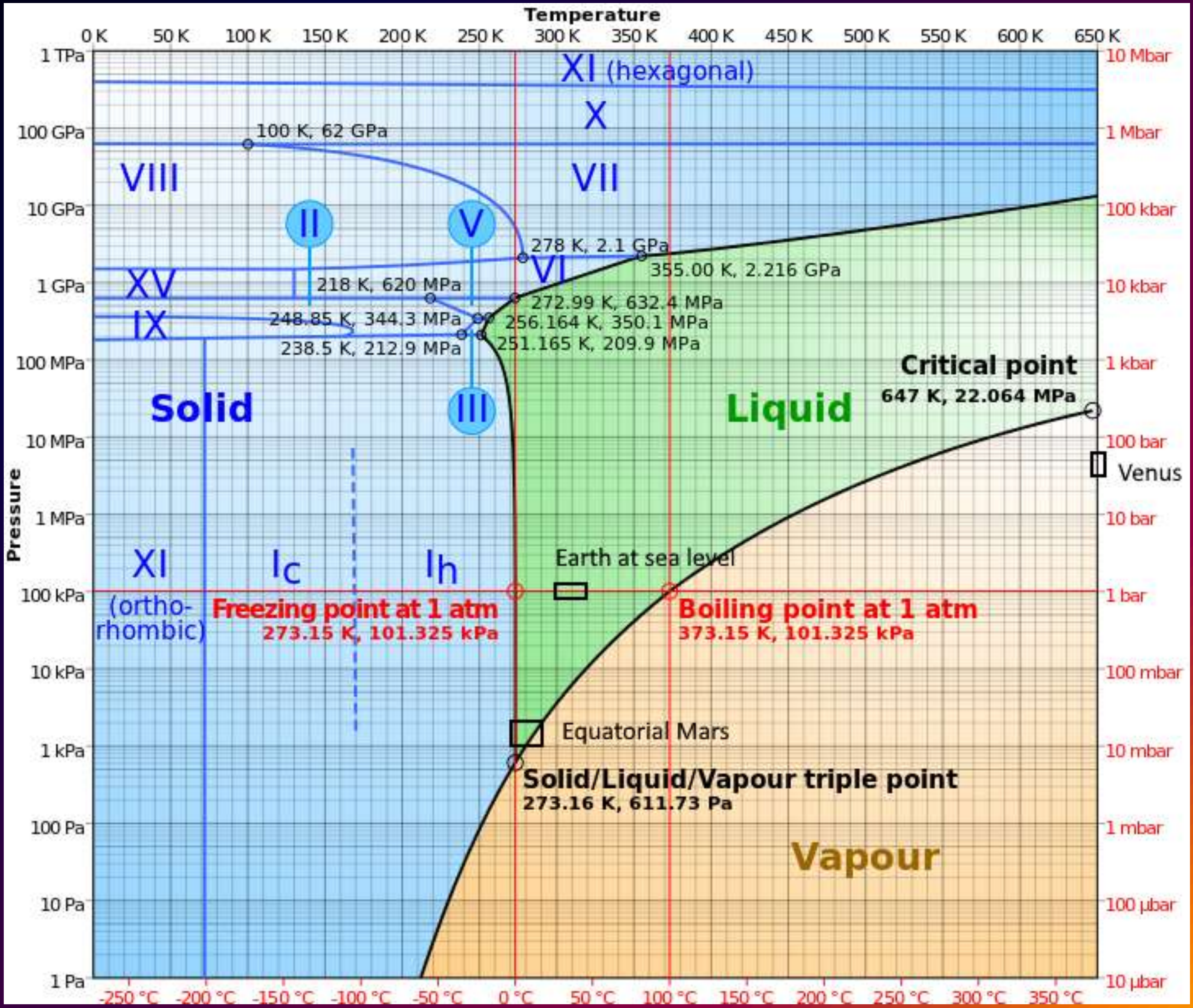




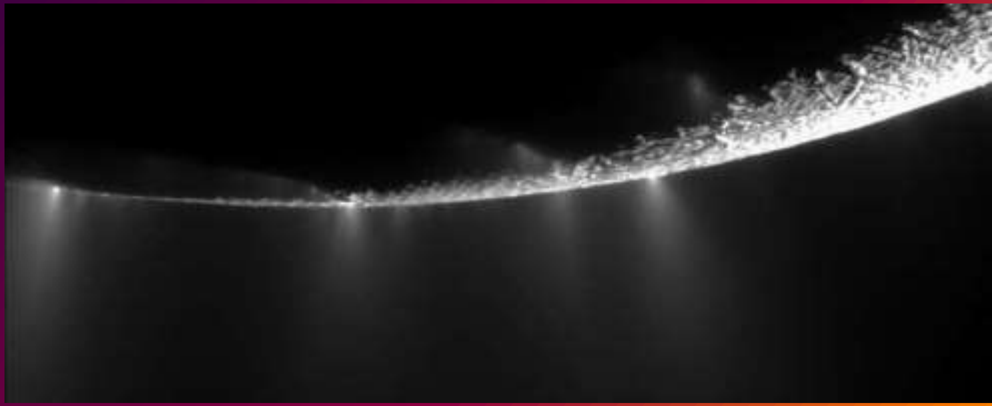


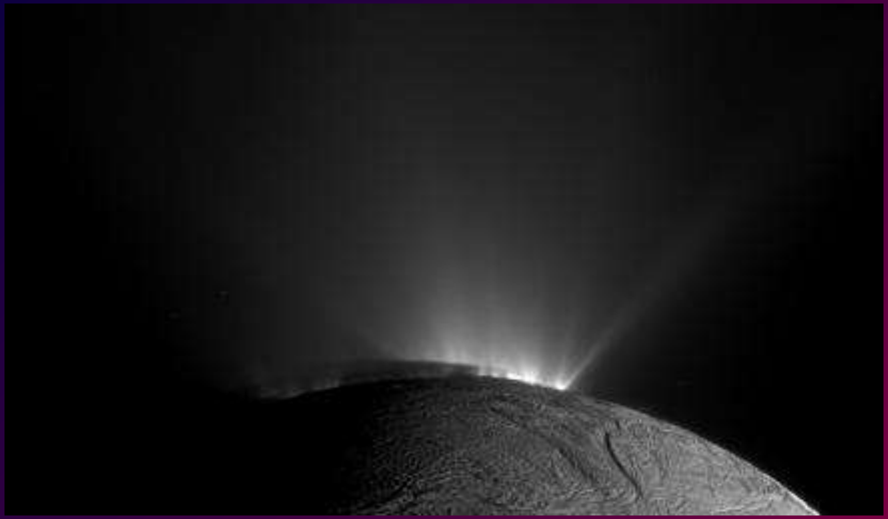
Formation of black smokers
600 C
Black smoker
Ocean floor
Mineral deposits
Superheated water
Heat from magma below

PHASE DIAGRAM FOR WATER



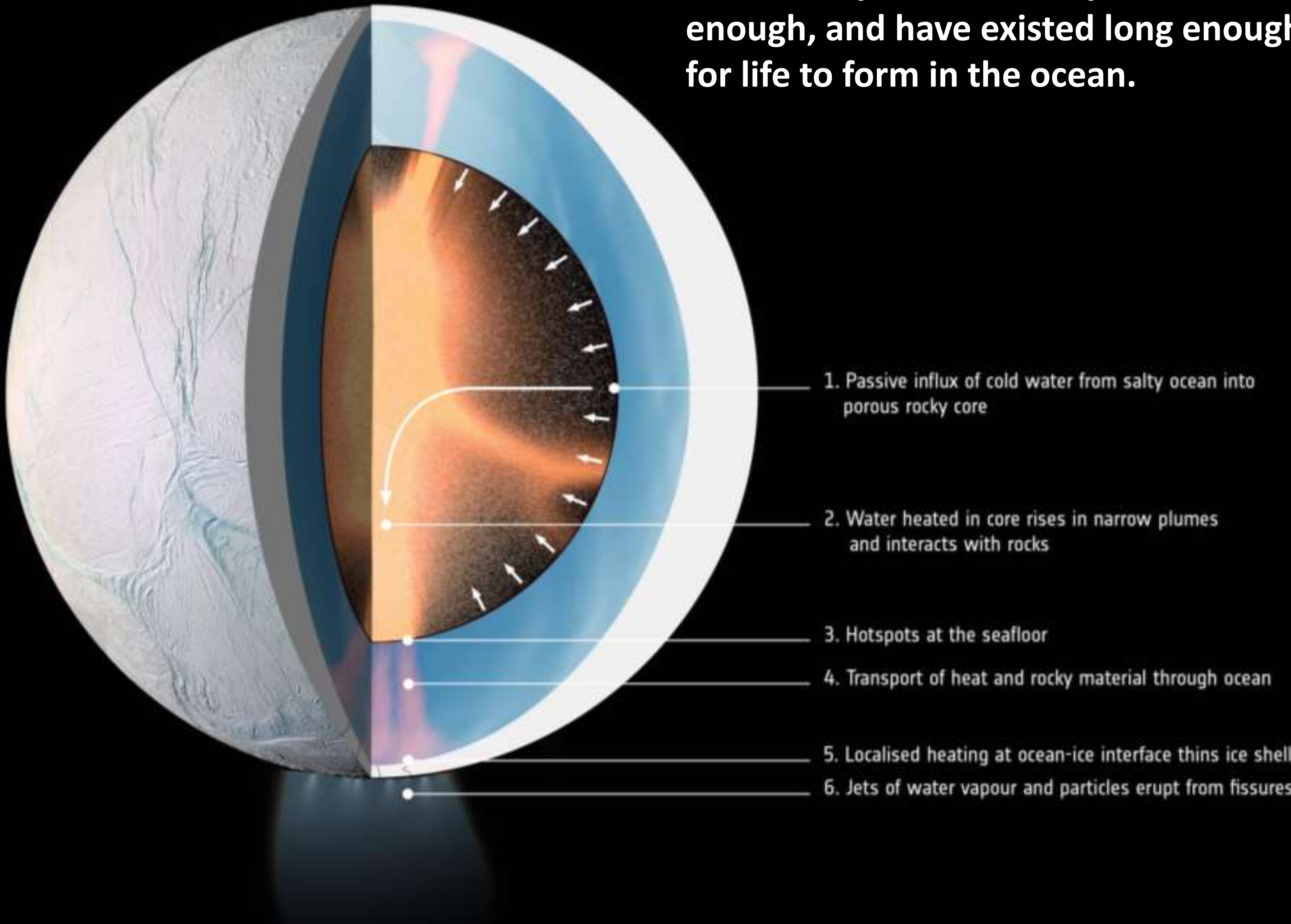
Saturn’s moon Enceladus: icy surface with global salty ocean below. Jets of water ejected from its south polar region include salts, silica dust, carbon dioxide, ammonia, methane, and other hydrocarbons.



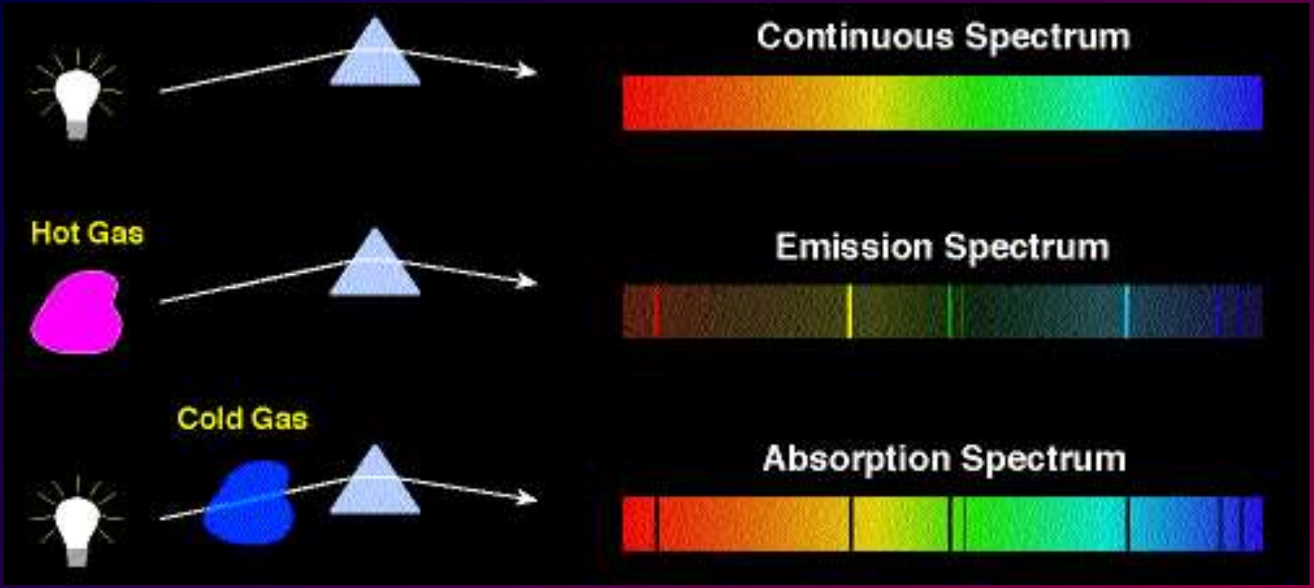


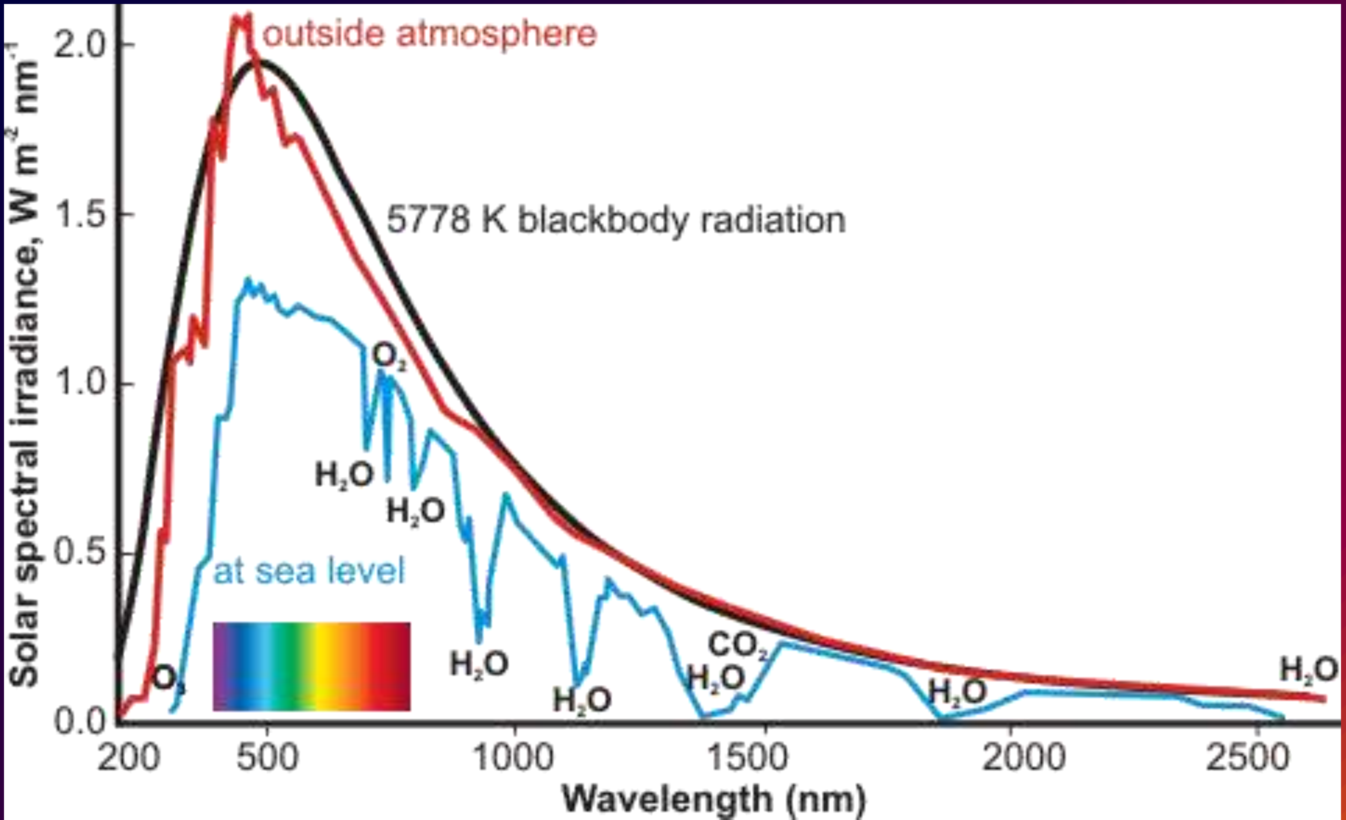
The plumes of Enceladus as imaged by the Cassini Orbiter.

Saturn's moon Enceladus – global ocean beneath icy surface – may be warm enough, and have existed long enough, for life to form in the ocean.

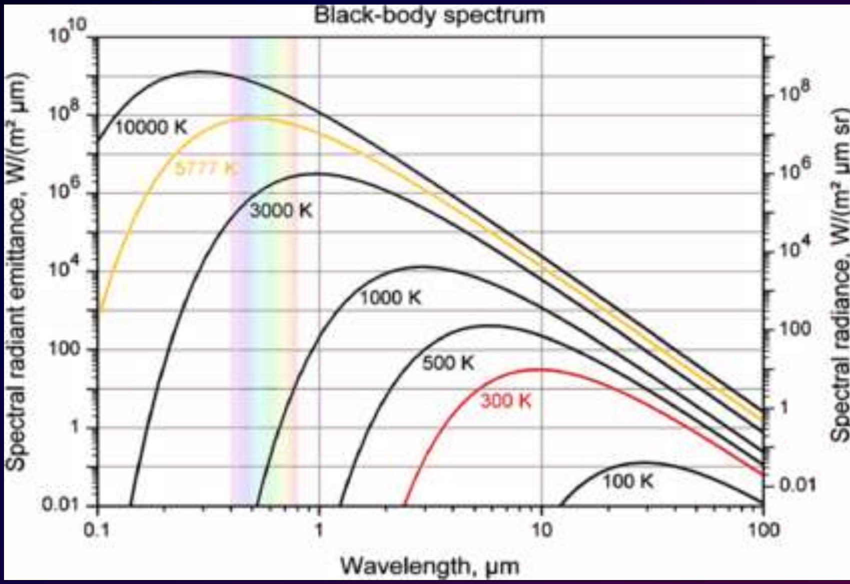


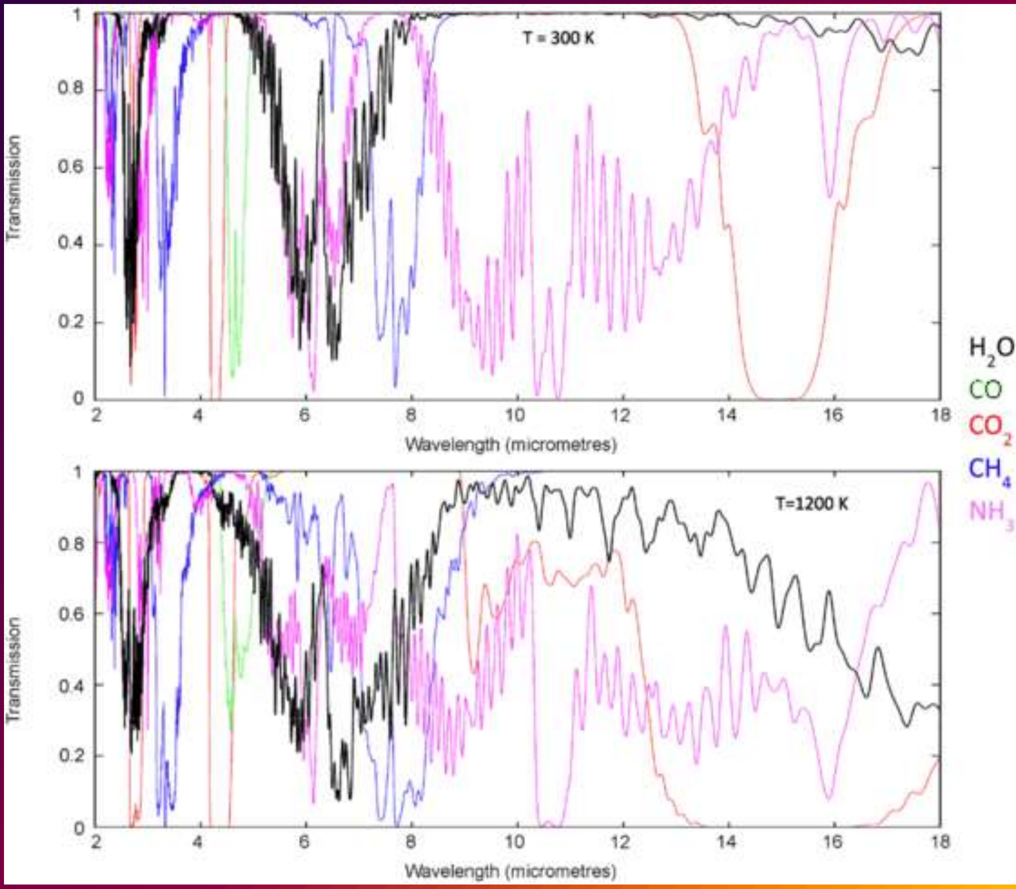
Definition of absorption and emission spectra





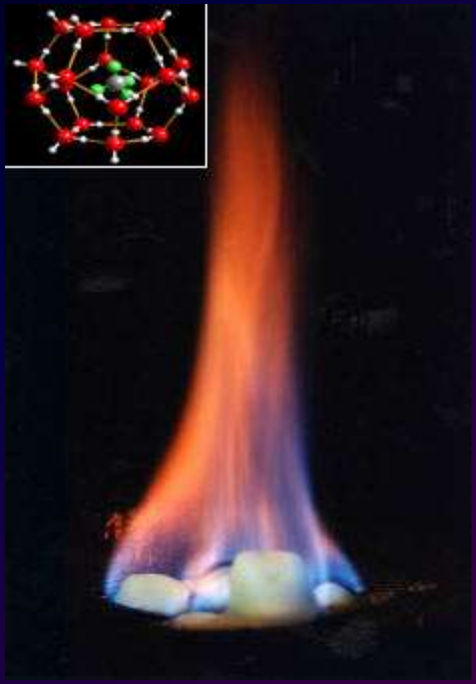
Method for finding biomarkers in planetary atmospheres:
High resolution transmission spectroscopy – transmission/absorption of light through planetary atmospheres by different gases
source: https://link.springer.com/article/10.1007/s00159-013-0063-6





Top: black body spectra
Right: transmission spectra for water, CO, CO_2, CH_4 (methane) and NH_4 (ammonia) at 300K (top) and 1200K (bottom).

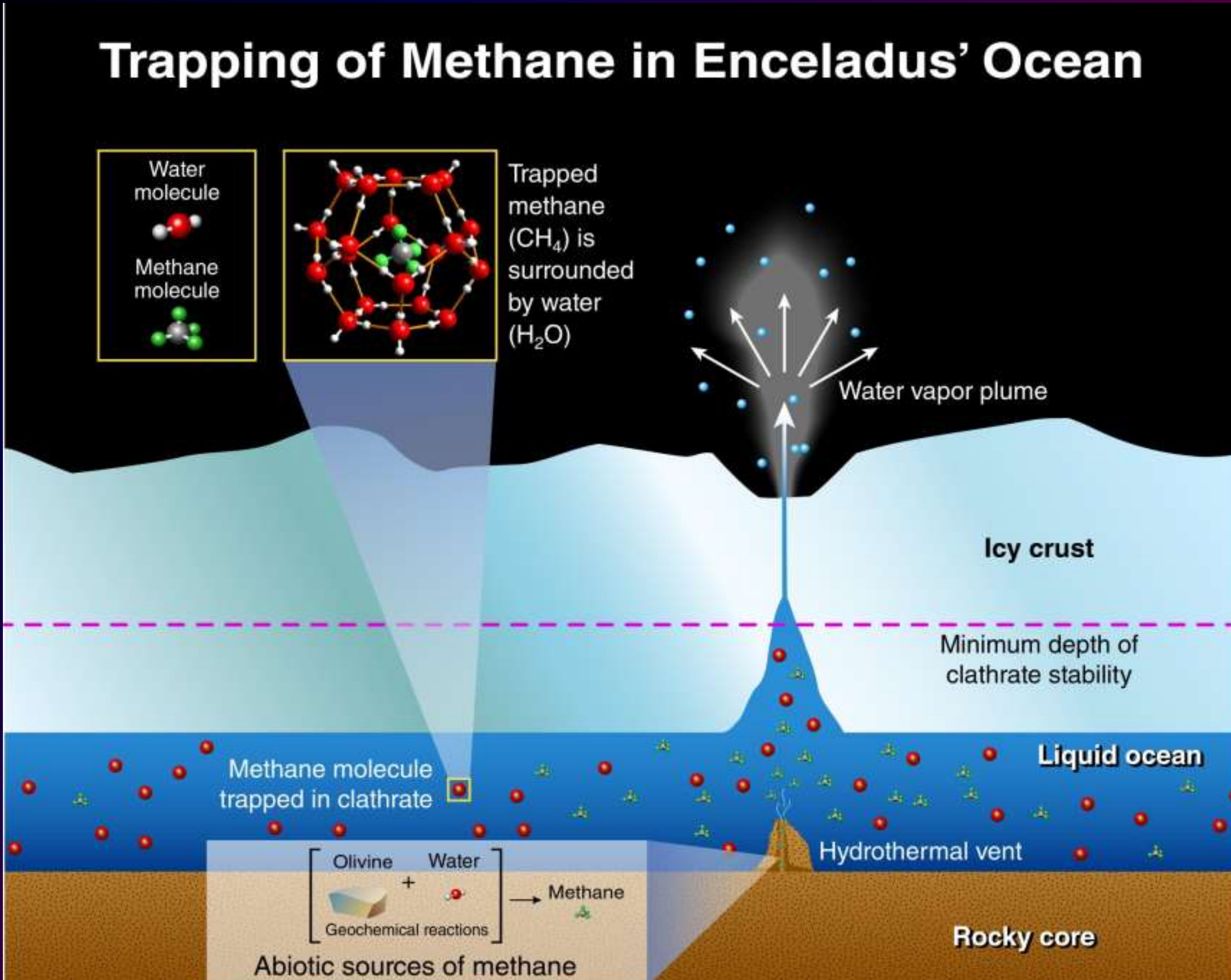
Clathrate hydrates, or simply clathrates, are crystalline water-based solids physically remembling ice, in which small (non-polar) molecules – typically gases – are trapped inside hydrogen-bonded frozen water molecules. (Wikipedia)



methane clathrate: "flammable ice"

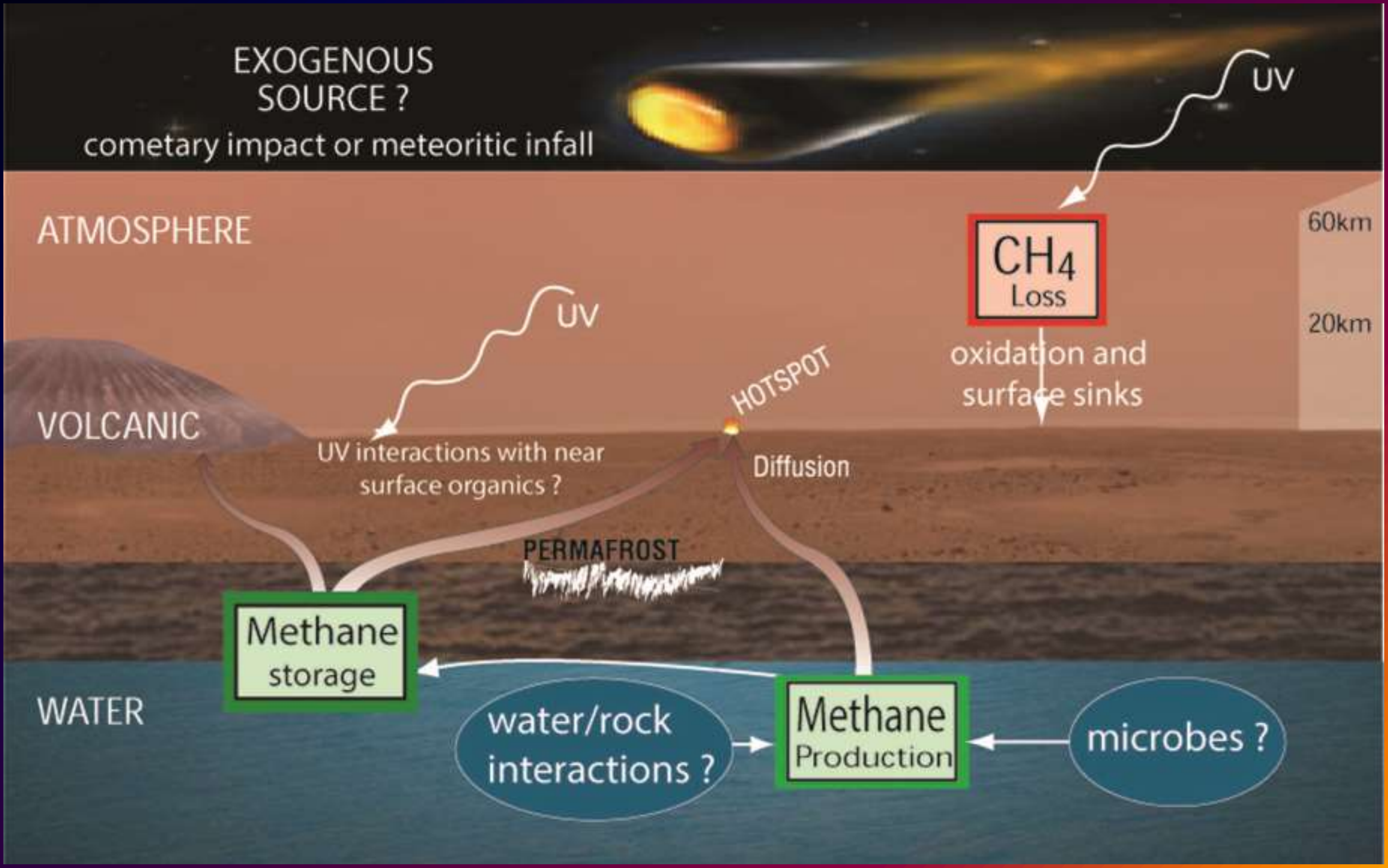
Methane clathrates are found on Earth in the ice shield of Antarctica and sea floor deposits.

Methane clathrates found on Mars are evidence for ice and water.



https://solarsystem.nasa.gov/news/13023/hydrothermal-activity/

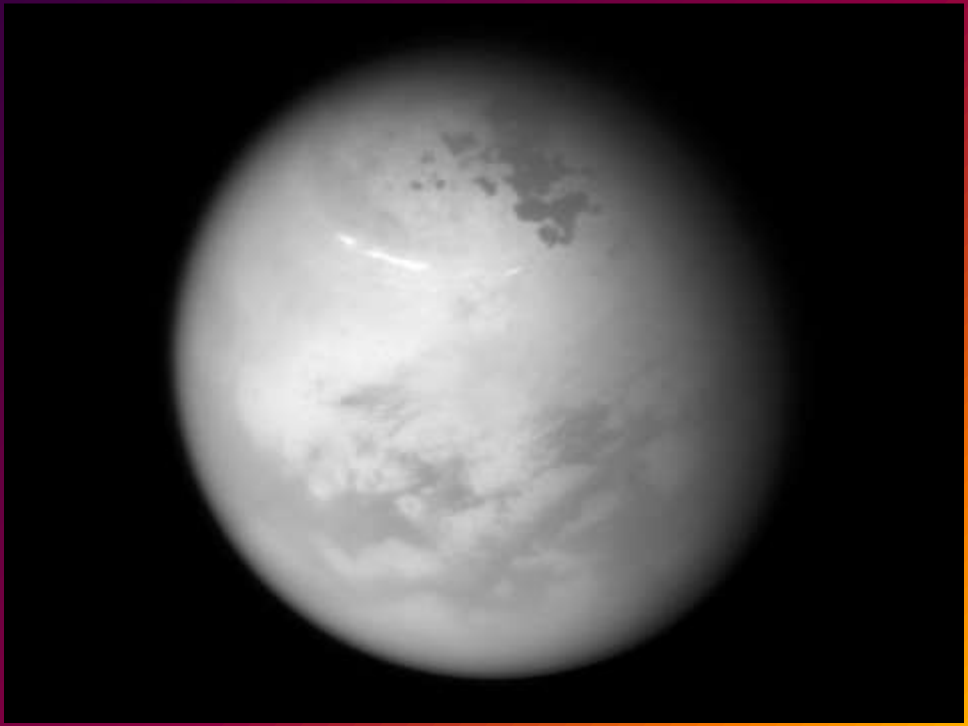
Methane on Mars



Images of Saturn’s largest moon, Titan, taken with the Cassini probe.

Could there be life in the subsurface water of Titan?

- Substantial atmosphere, mostly nitrogen
- Surface pressure 50% greater than sea level on Earth
- Clouds, rain, rivers, lakes, seas made of liquid hydrocarbons such as methane and ethane



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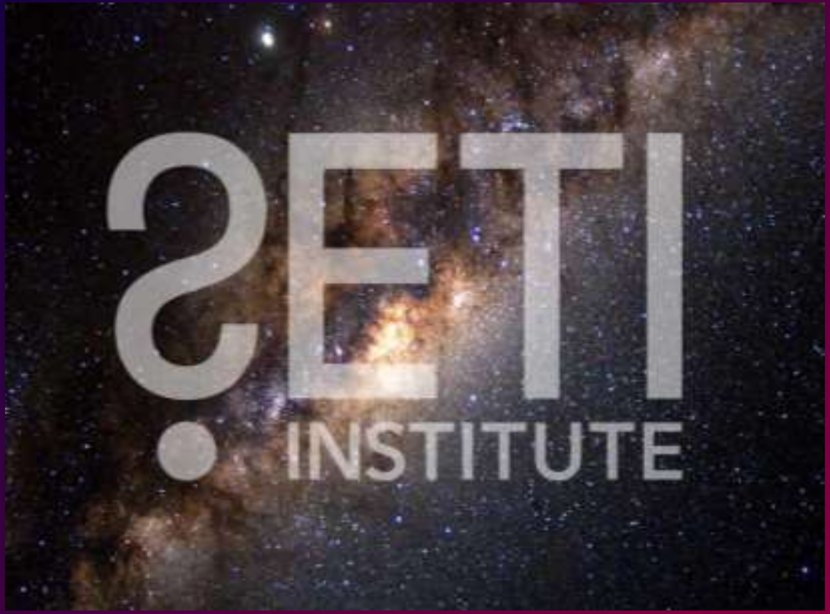
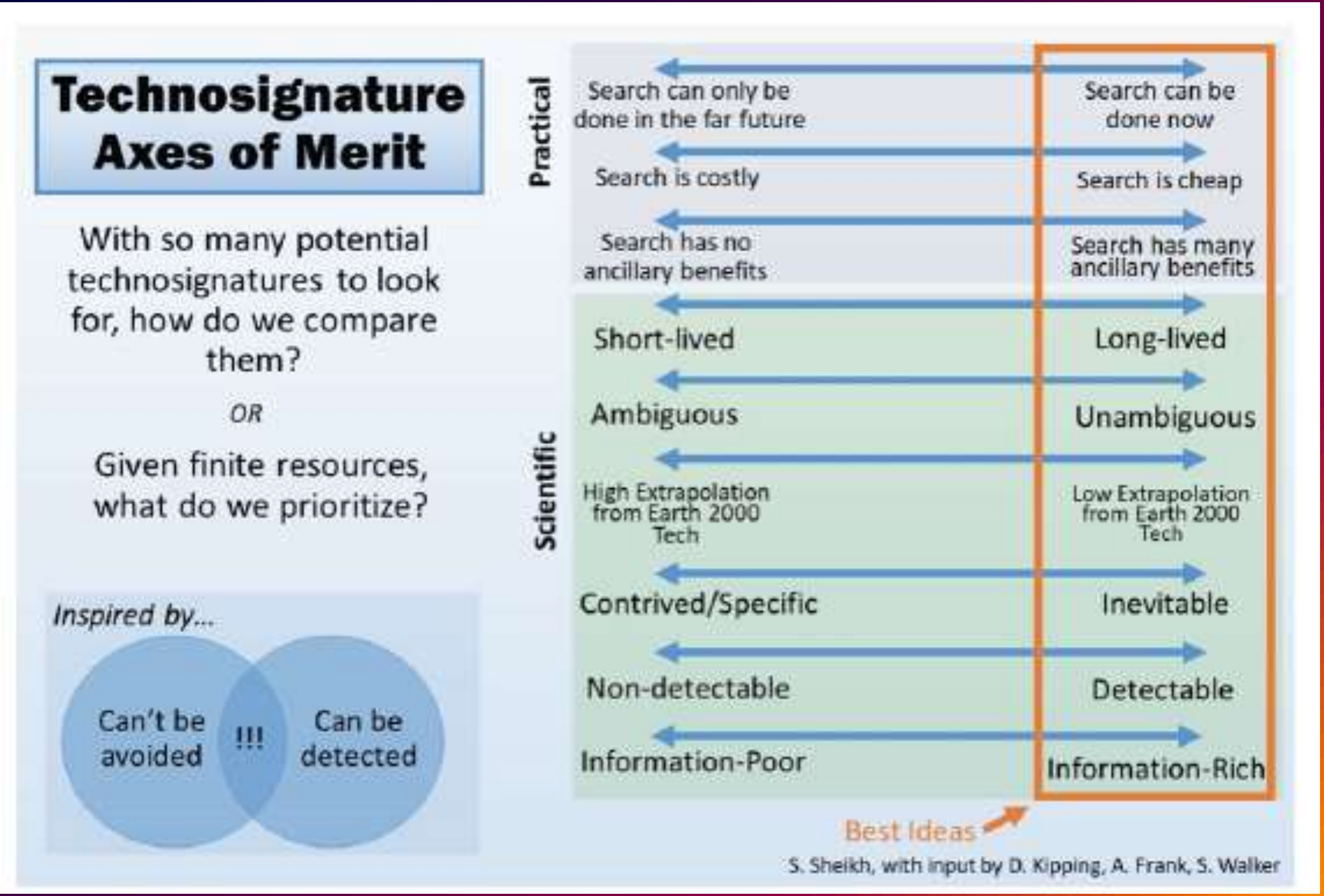


Intelligent life, if it exists in the universe – would it be more advanced than us? Could intelligent life have evolved elsewhere such that we can detect signatures of its technology which would be similar to ours?

SEARCH FOR TECHNOSIGNATURES

from the 2018 NASA conference on Technosignatures:

Technosignatures represent *any* sign of technology that we can use to infer the existence of intelligent life elsewhere in the universe, including familiar objects of searches for extraterrestrial intelligence such as narrow-band radio signals or pulsed lasers.



Theoretical physicist Freeman Dyson's "First Law of SETI Investigations:"
Every search for alien civilizations should be planned to give interesting results even when no aliens are discovered.

Searching for technology that we have, or are close to having:

Continuous radio searches
Pulsed radio searches
Targeted radio searches
All-sky surveys

Allen Telescope Array, built and operated by the SETI Institute. Credit: Seth Shostak/SETI Institute.

Optical:
Continuous laser and near IR searches
Pulsed laser searches

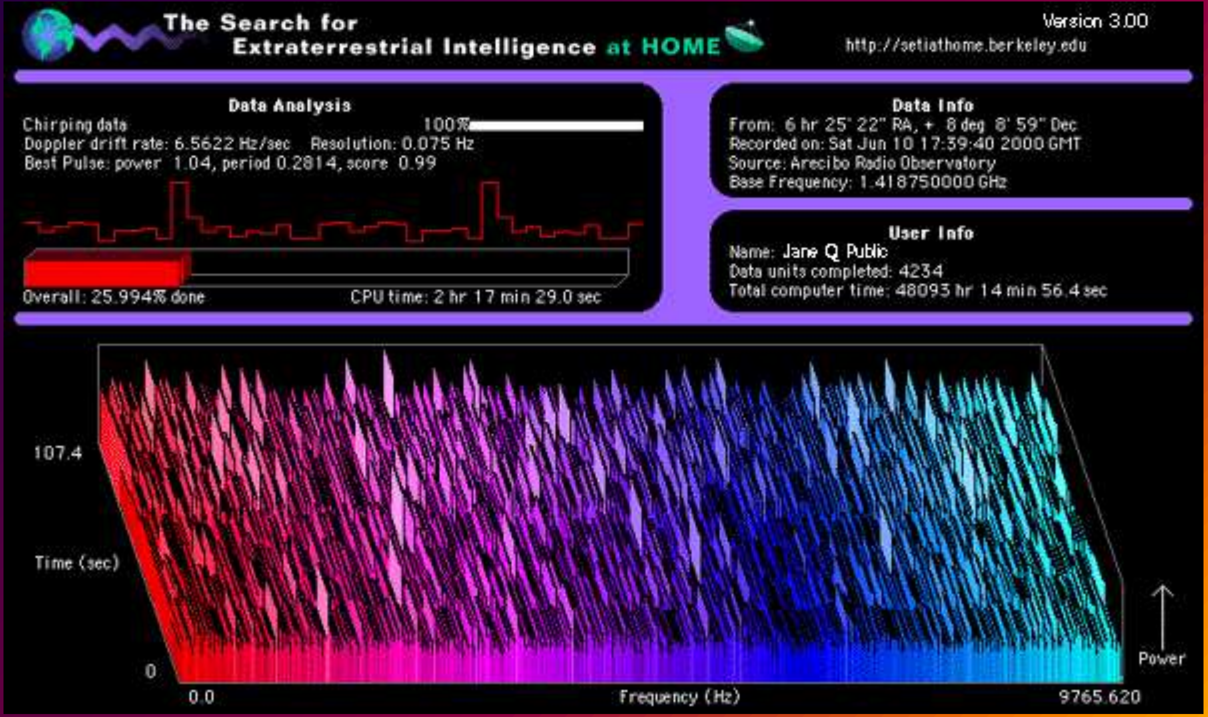
Each type of survey requires algorithms and strategies

SETI@home

https://setiathome.berkeley.edu/

SETI@home is a scientific experiment, based at UC Berkeley, that uses Internet-connected computers in the Search for Extraterrestrial Intelligence (SETI). You can participate by running a free program that downloads and analyzes radio telescope data.

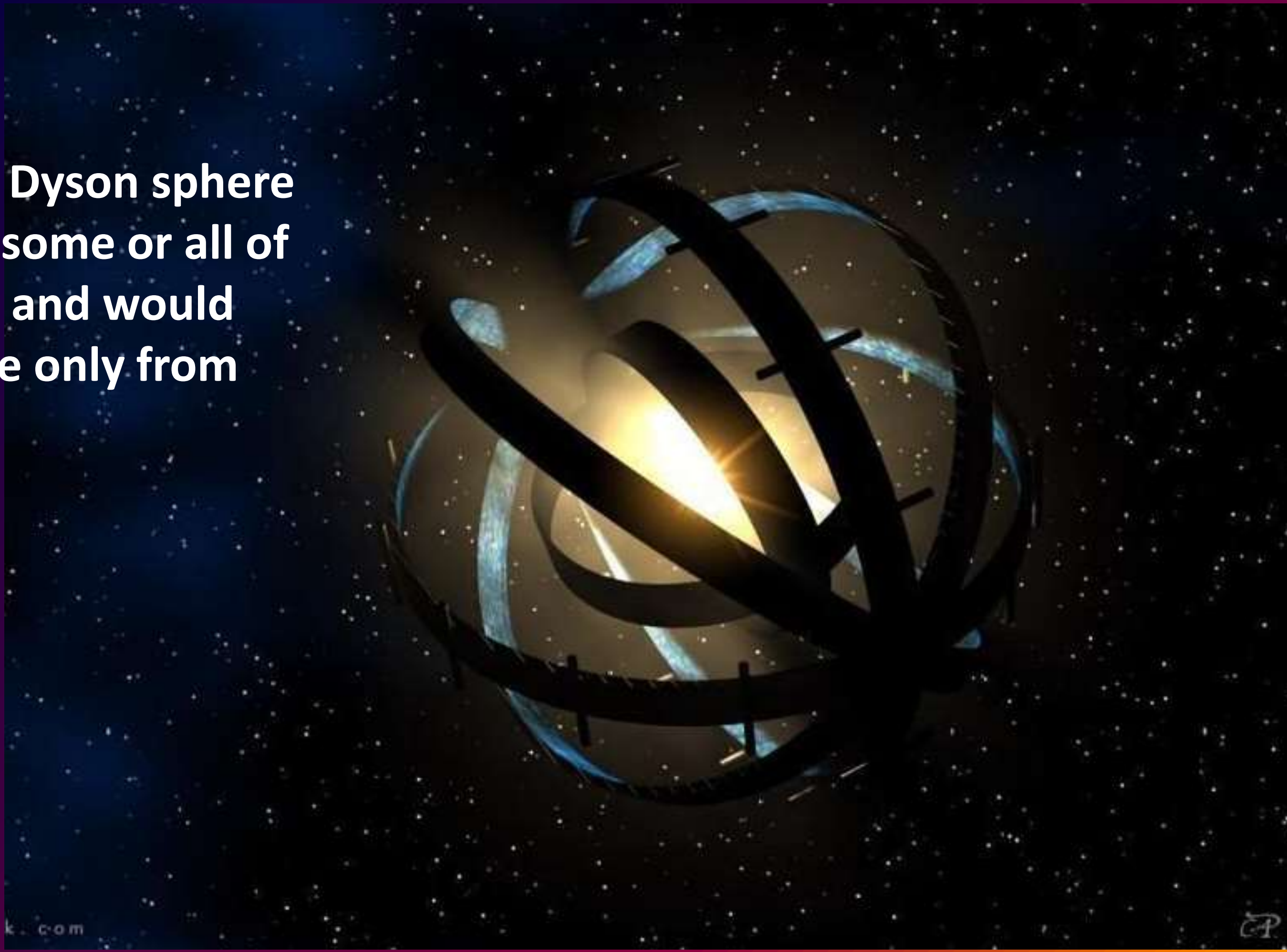
SETI uses radio telescopes to listen for narrow-bandwidth radio signals from space. Such signals are not known to occur naturally, so a detection would provide evidence of extraterrestrial technology.

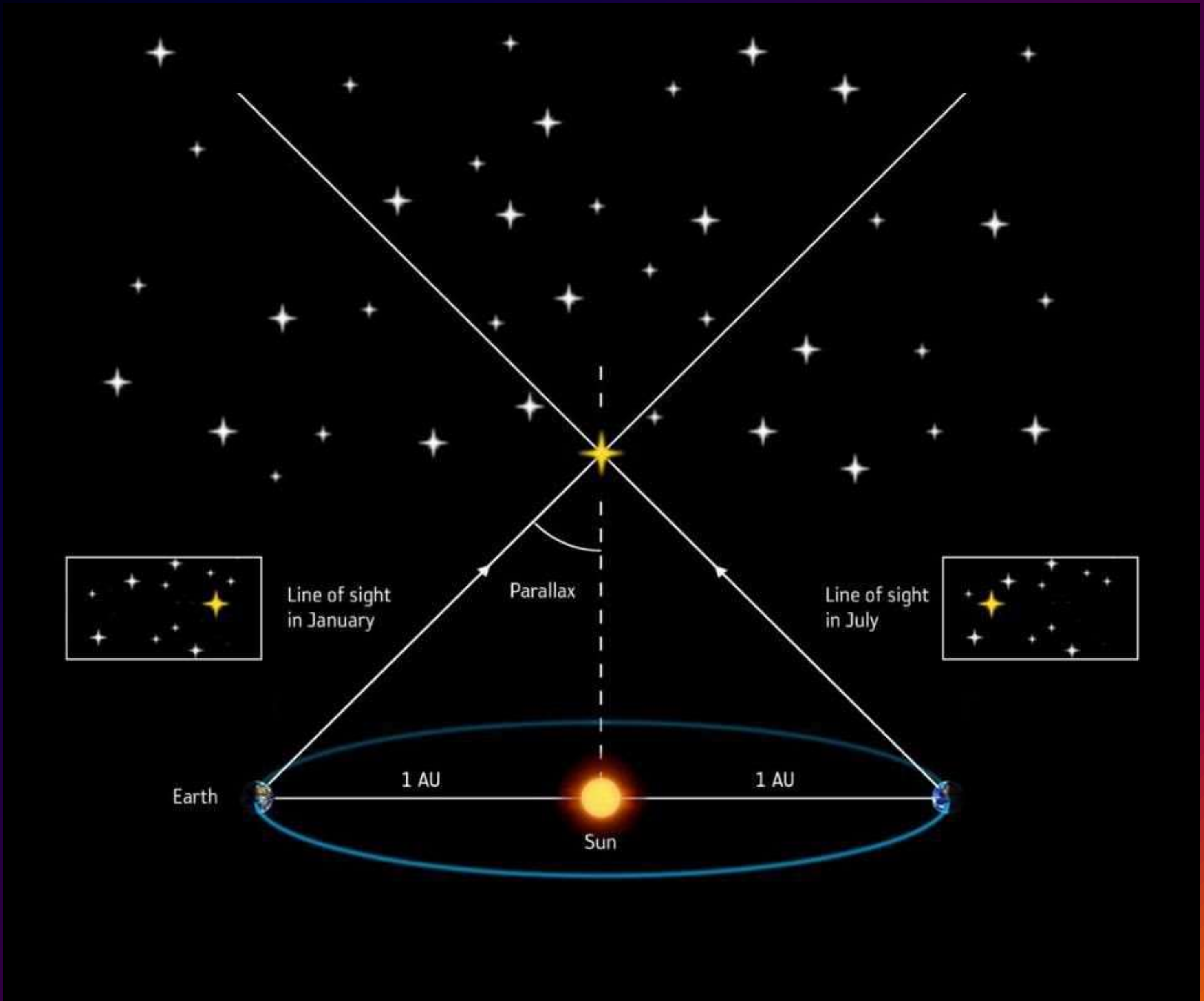


Searching for ET technology that we don't have

Waste heat and stellar obscuration searches

hypothetical Dyson sphere would block some or all of a star's light, and would be detectable only from its inf





If a star is found radiating infrared, such that its distance measured by parallax is greater that its distance as calculated by its luminosity, it could be surrounded by such a Dyson sphere…

Kardashev Scale:
a method of measuring a civilization's level of technological advancement based on the amount of energy they are able to use. Devised by Nikolai Kardashev in 1964.

A **Type I civilization**—also called a planetary civilization—can use and store all of the energy available on its planet.
A **Type II civilization**—also called a stellar civilization—can harness the total energy of its planet's parent star (the most popular hypothetical concept being the Dyson sphere—a device which would encompass the entire star and transfer its energy to the planet(s)).
A **Type III civilization**—also called a galactic civilization—can control energy on the scale of its entire host galaxy

https://en.wikipedia.org/wiki/Kardashev_scale