



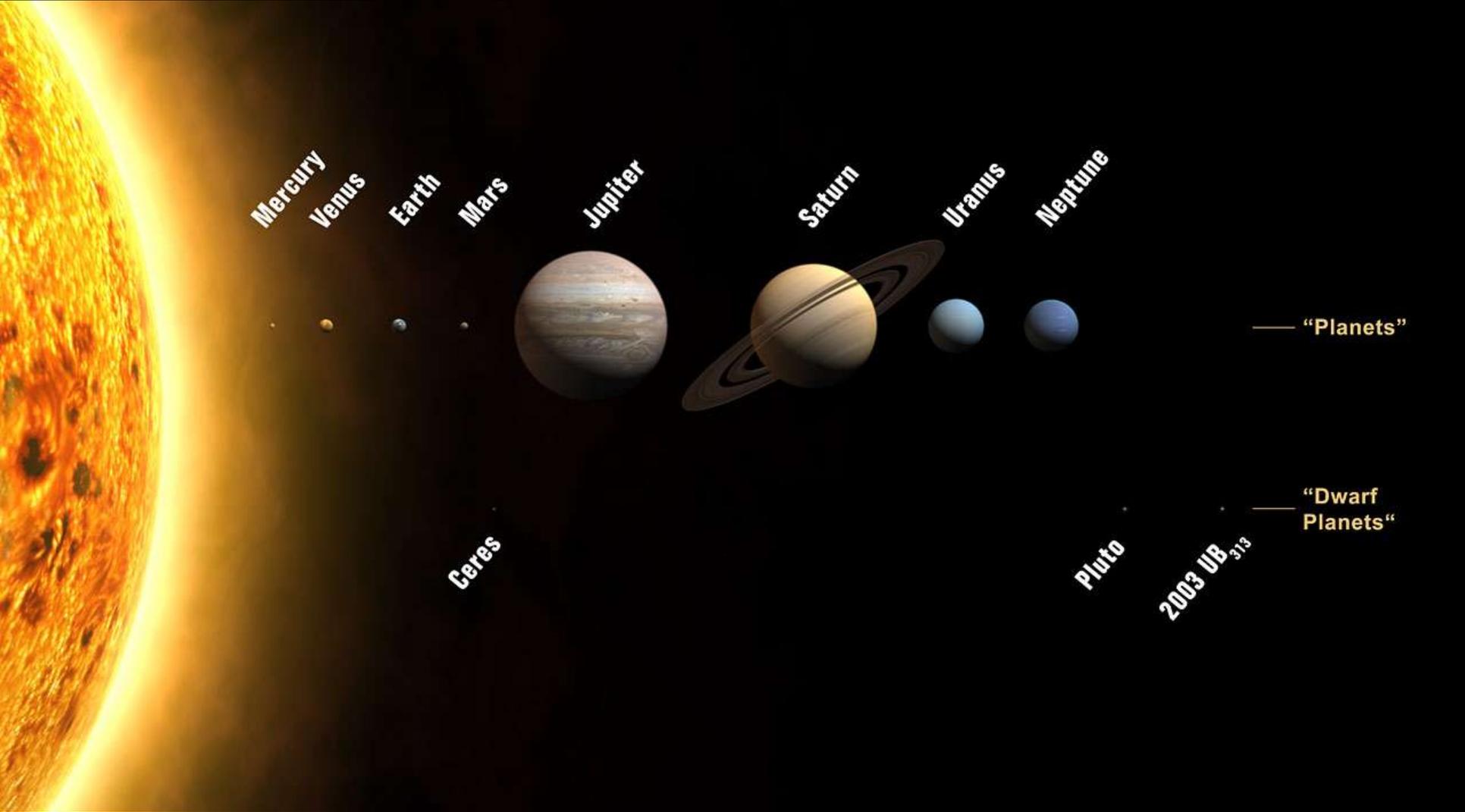
*Extra-terrestrial life:
Is there anybody out there?...*

**Martin Hendry
University of Glasgow**



Orkney

Dec 2011



Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

— “Planets”

— “Dwarf Planets”

Ceres

Pluto

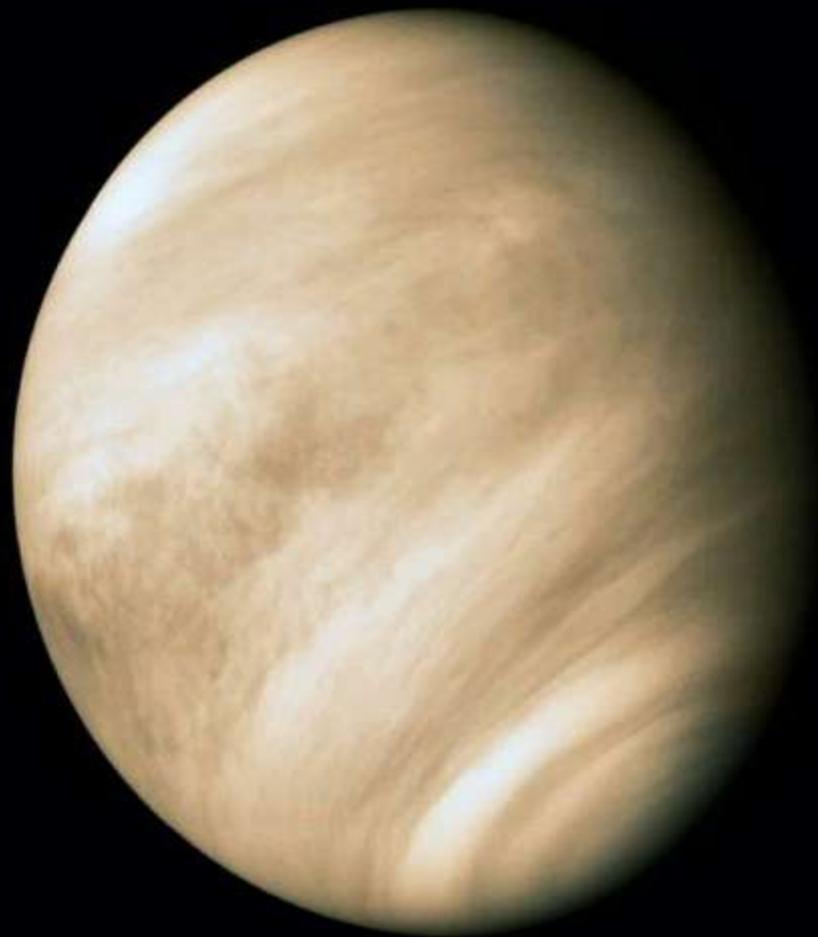
2003 UB₃₁₃

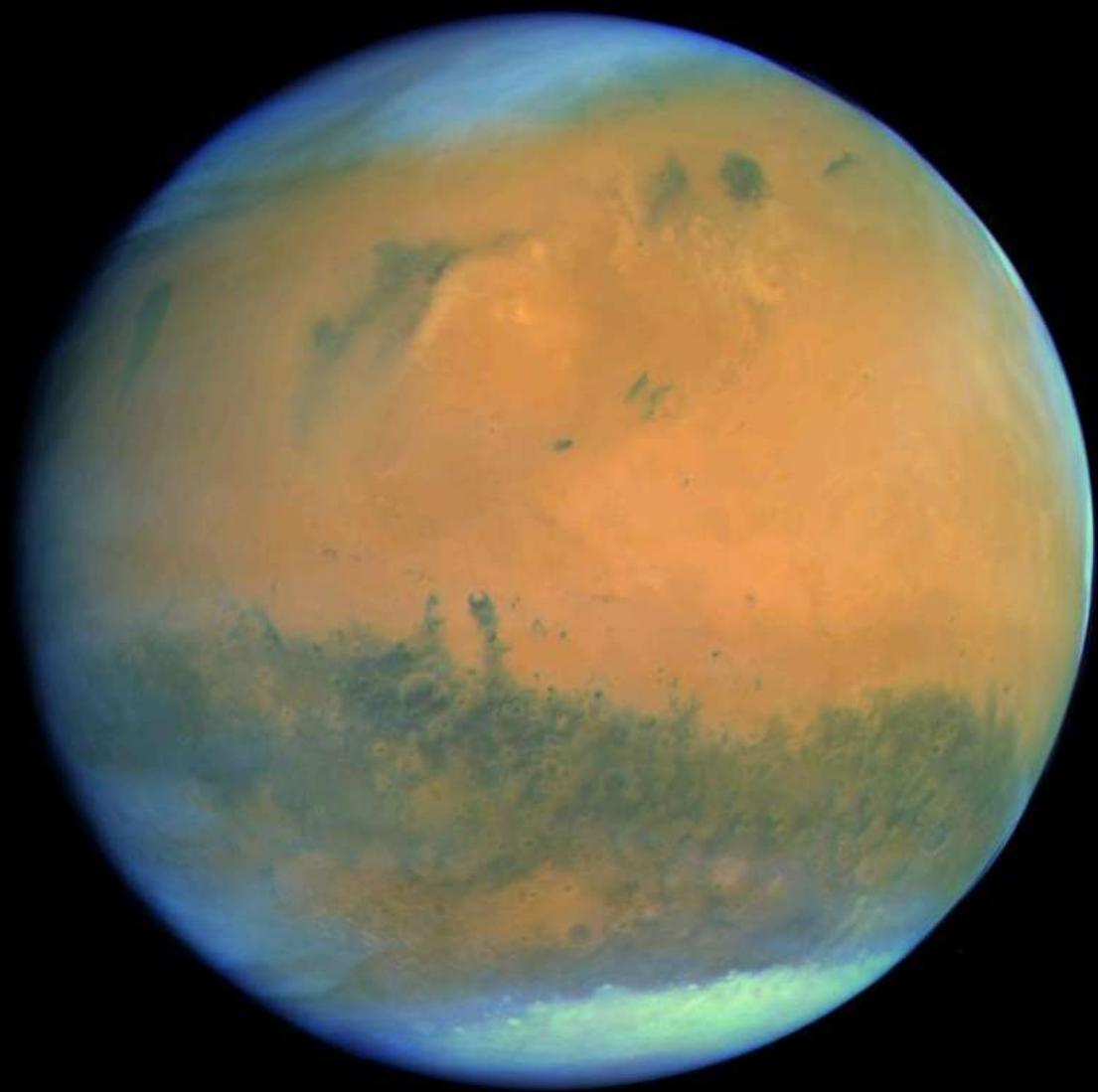




- Liquid Water
- Oxygen
- Carbon Dioxide

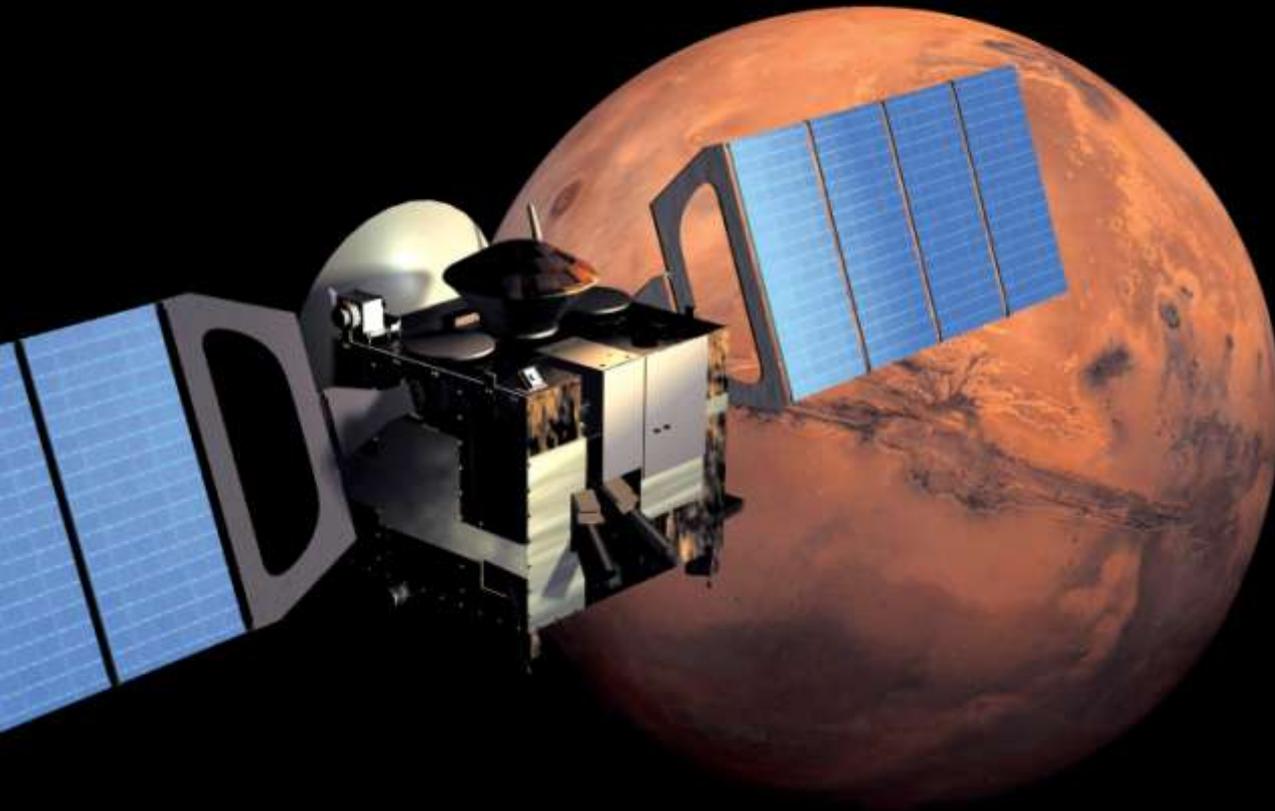
= life!

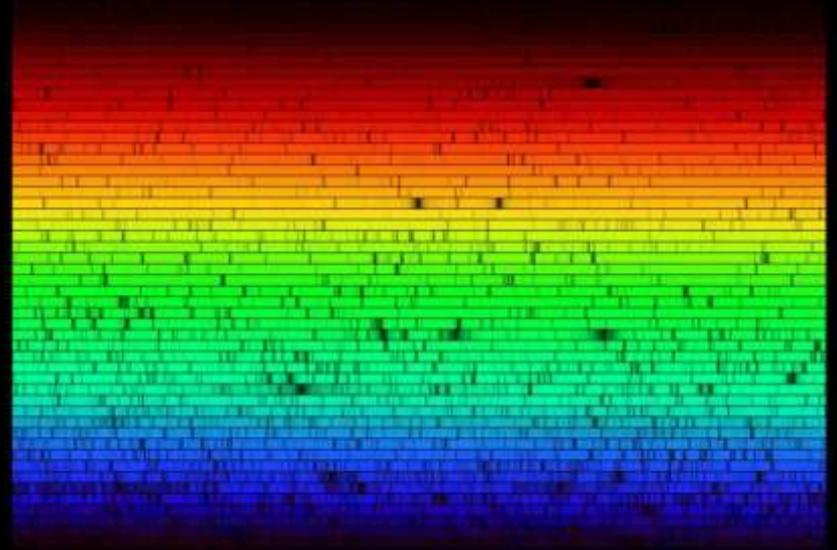
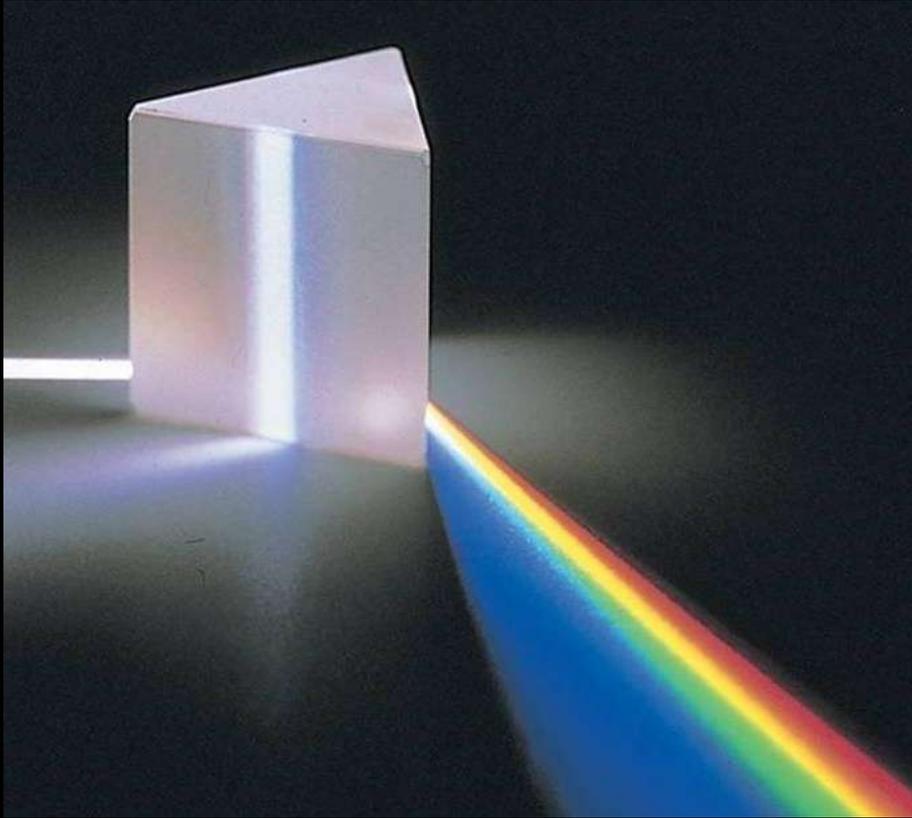




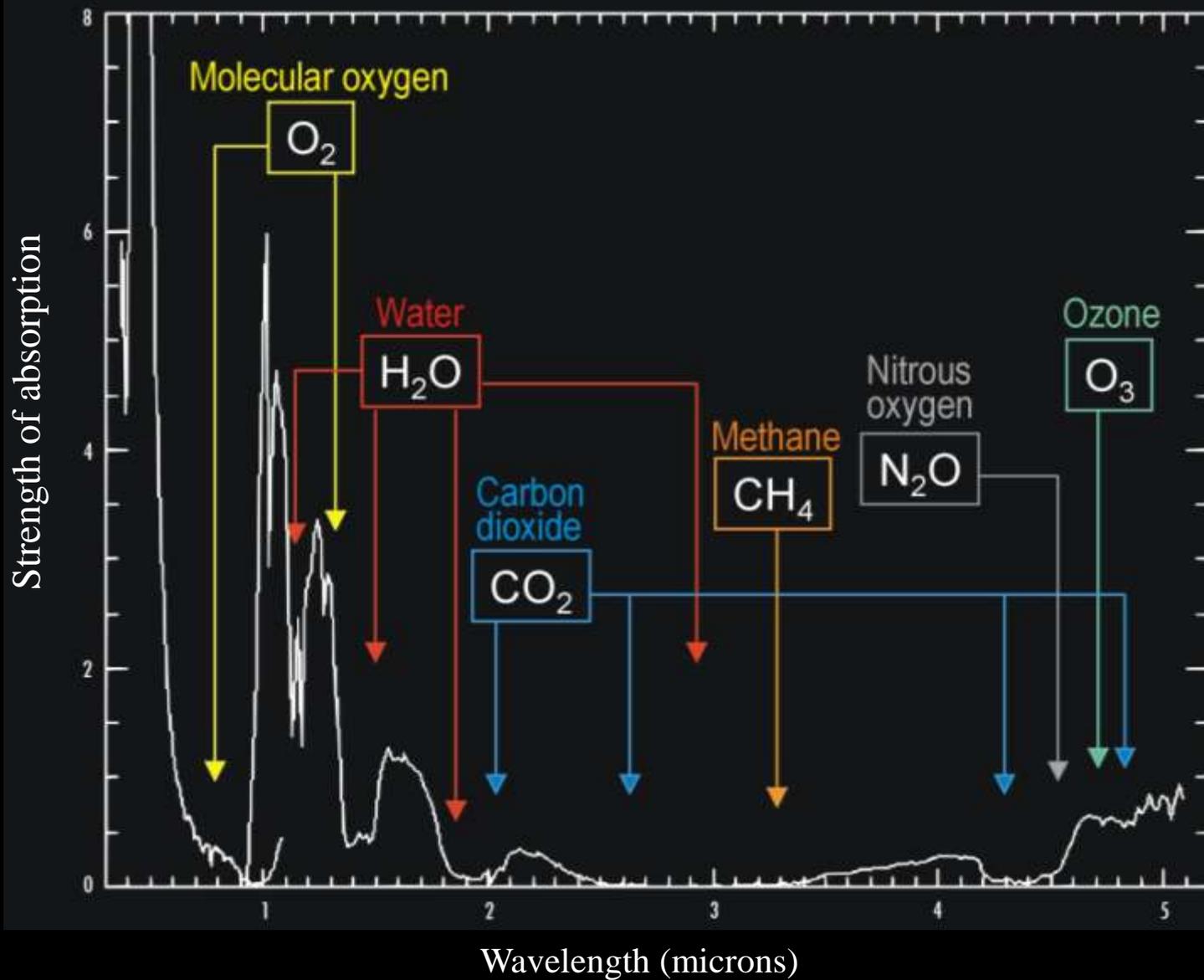
Mars is the best bet:

- Mars Express (+ Beagle 2)
- Spirit + Opportunity





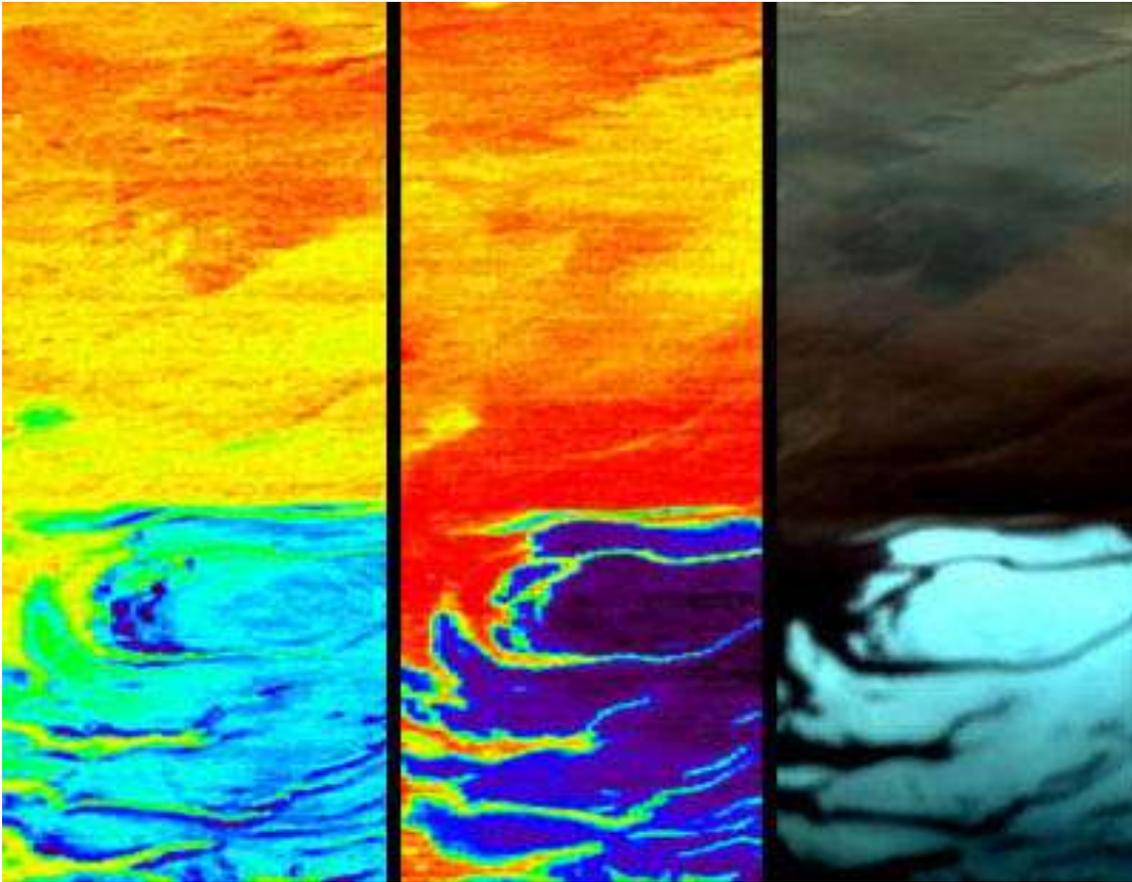
We can use **spectral lines**, like fingerprints, to identify the chemicals that stars and planets are made of.



Composition of the Earth by the Mars Express OMEGA Spectrometer

2004:

Mars Express
Orbiter detects
frozen carbon
dioxide **and** water
at the South Pole
of Mars.



↑
H₂O

↑
CO₂

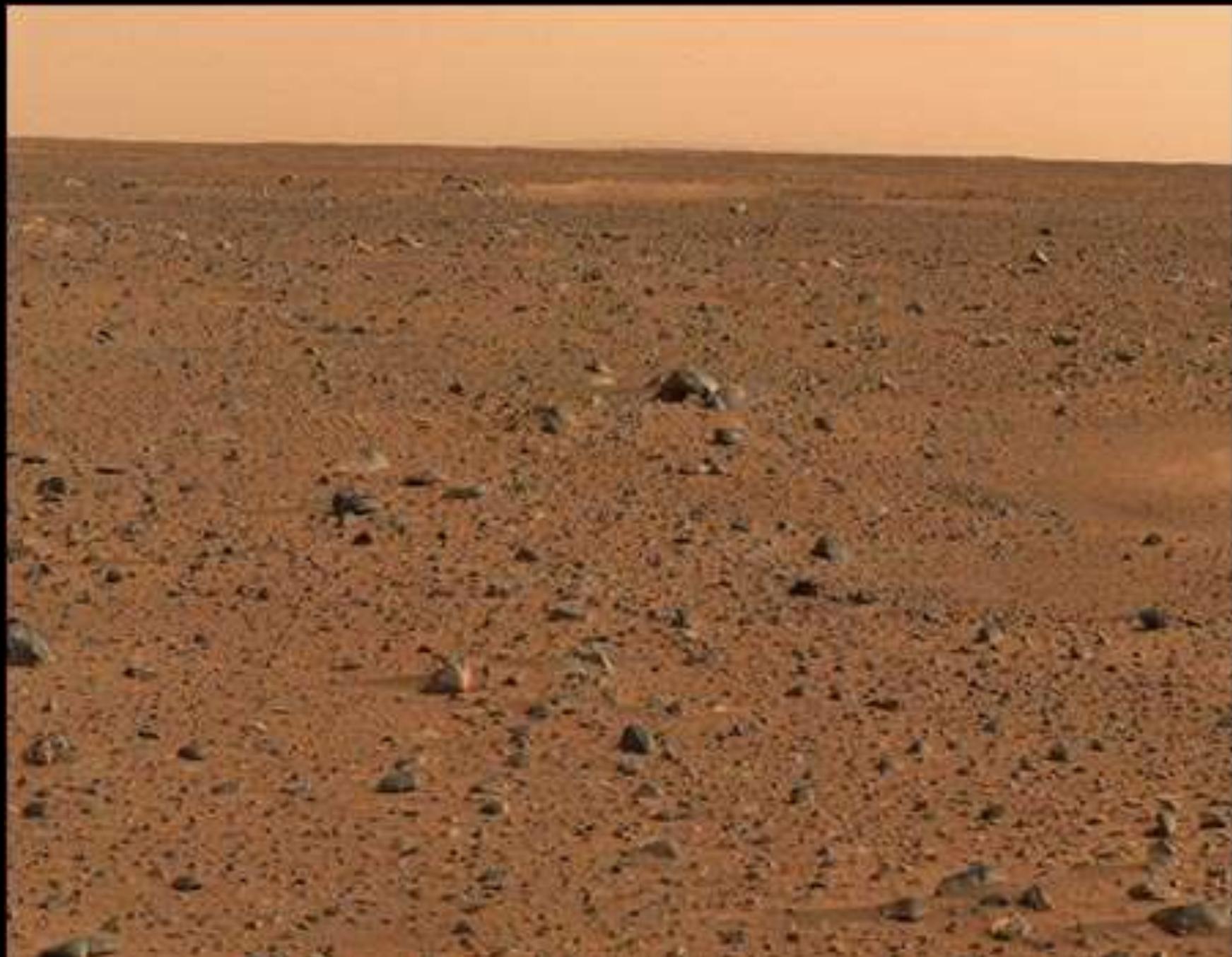
↑
Visible light

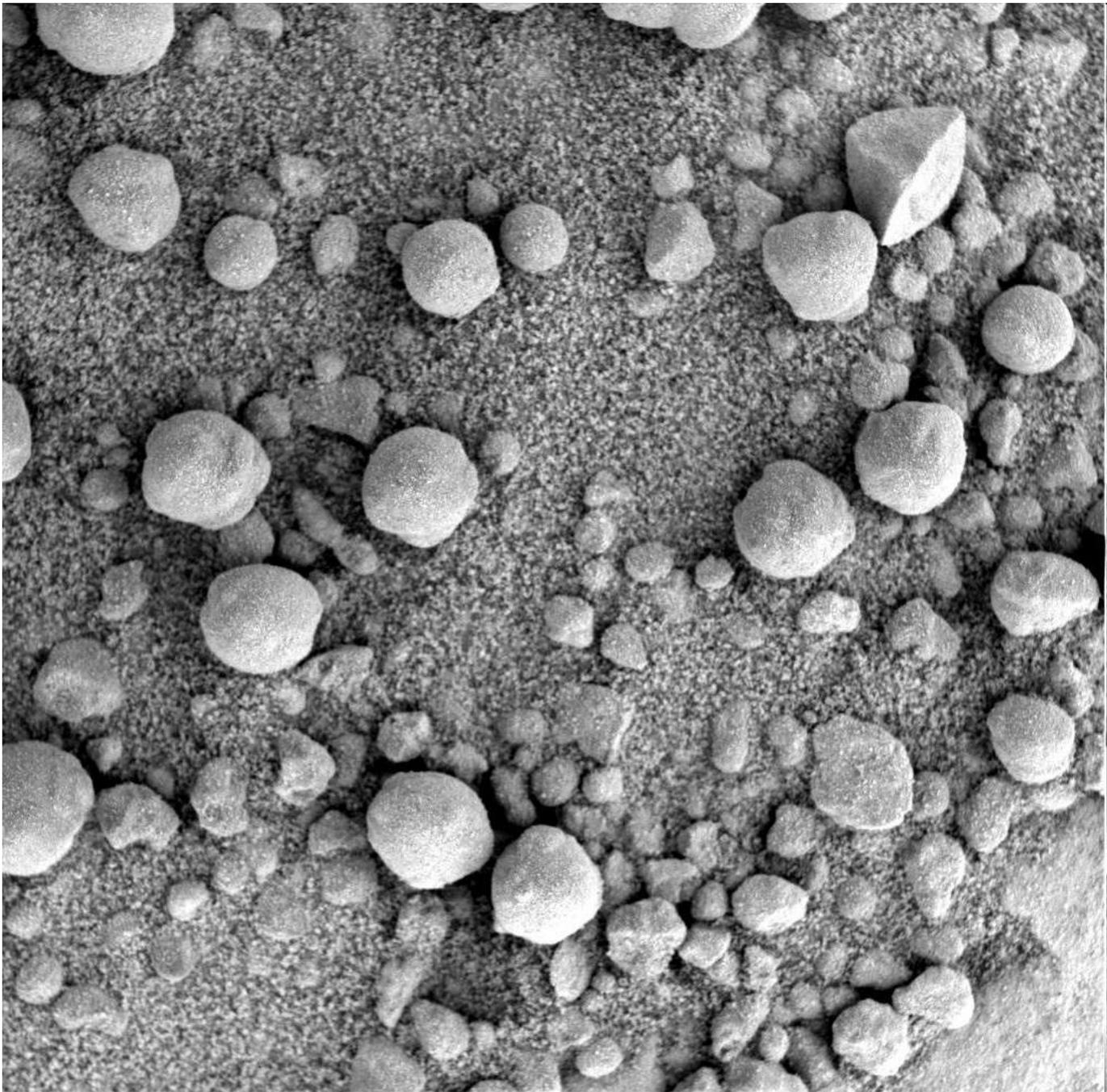


Signs of past **running water** in many Martian photographs

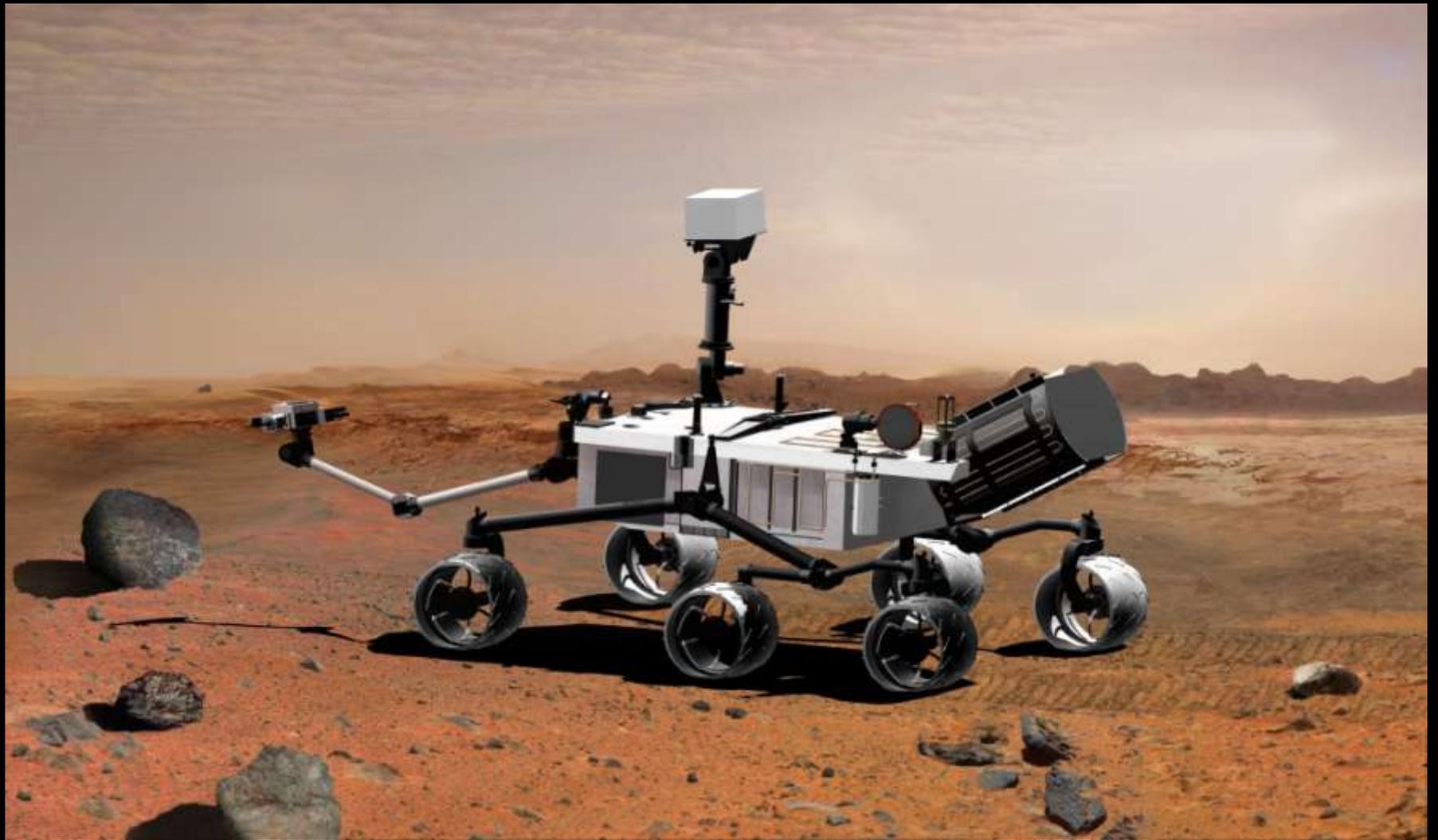






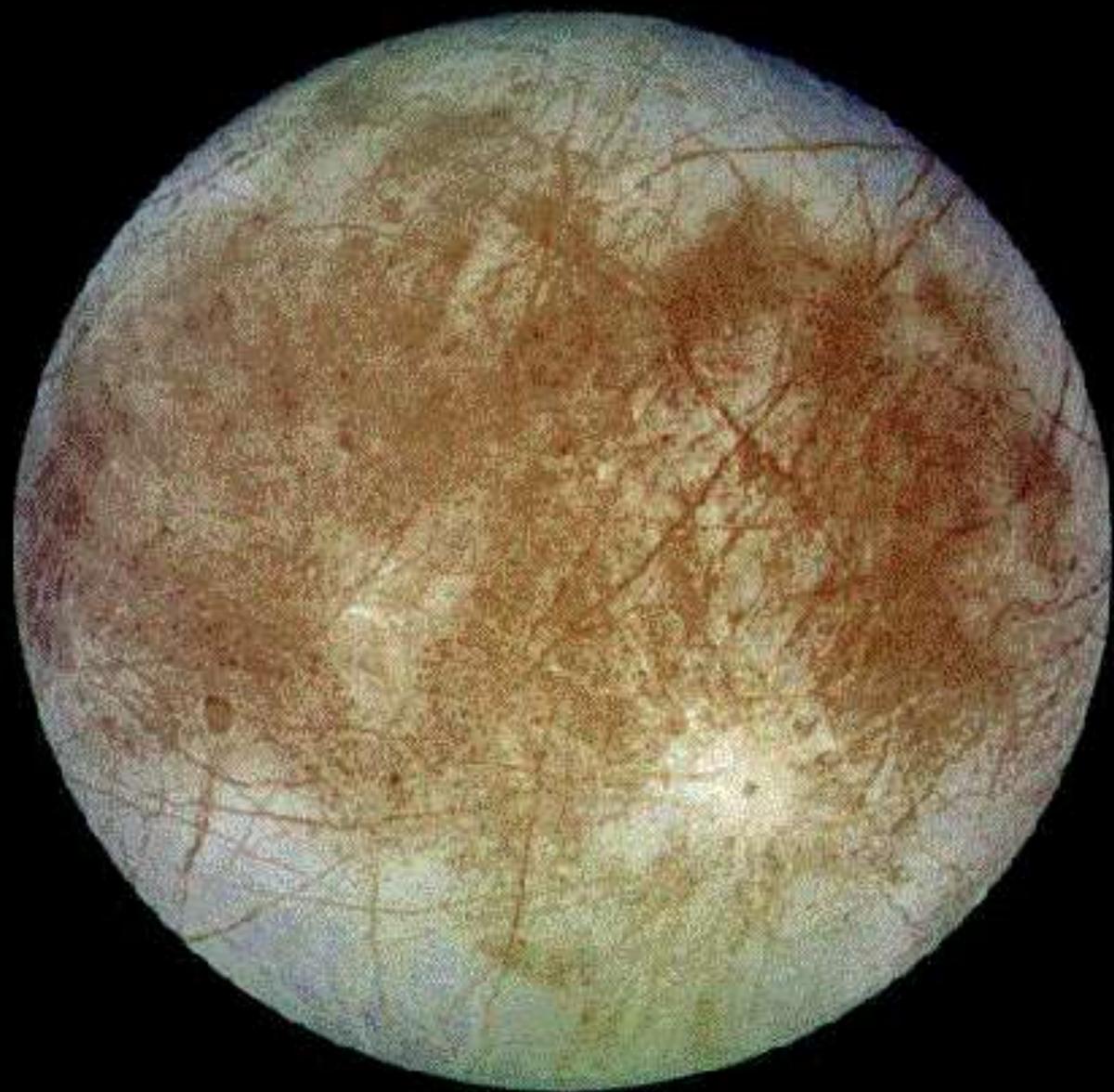




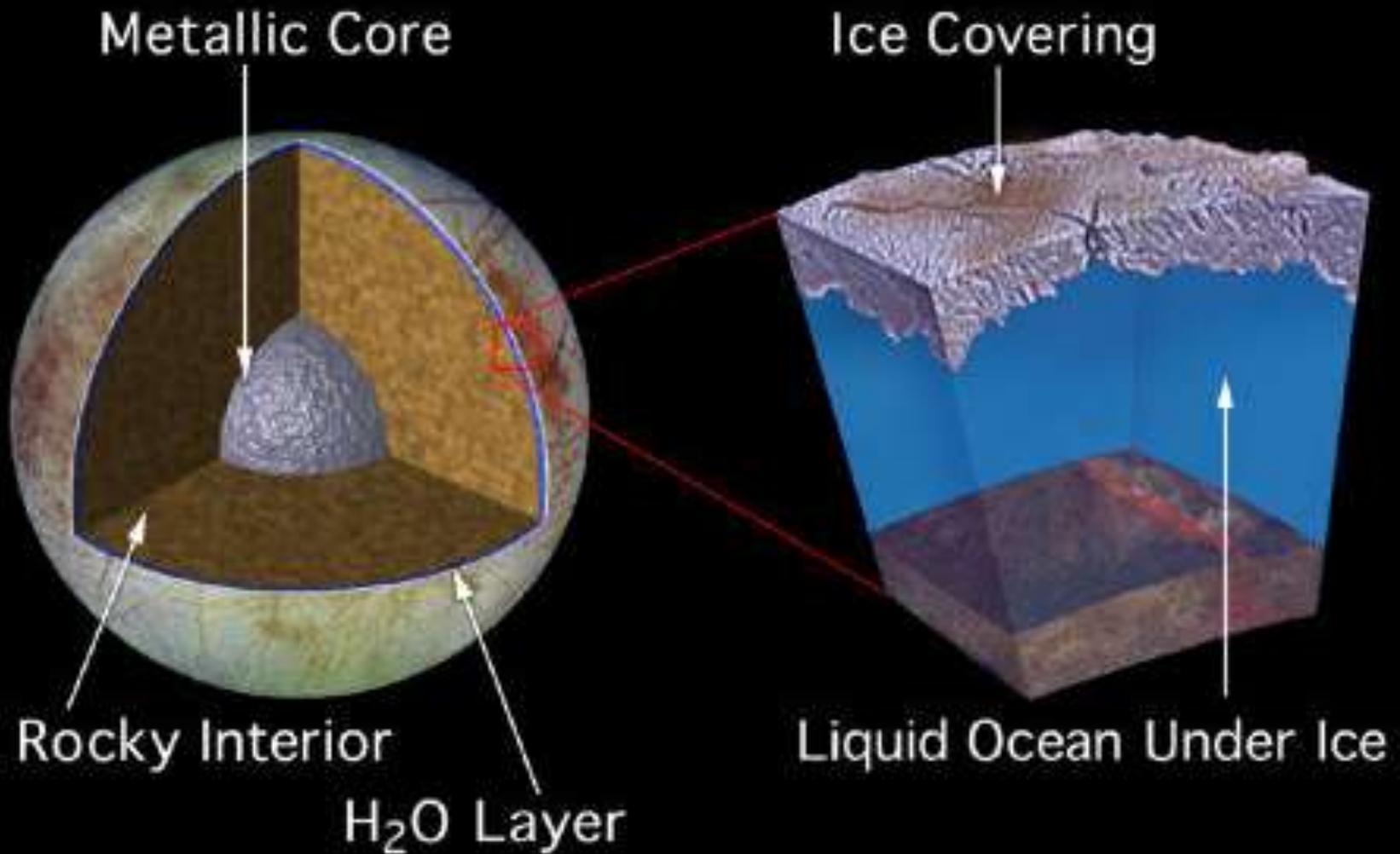


The moons of Jupiter



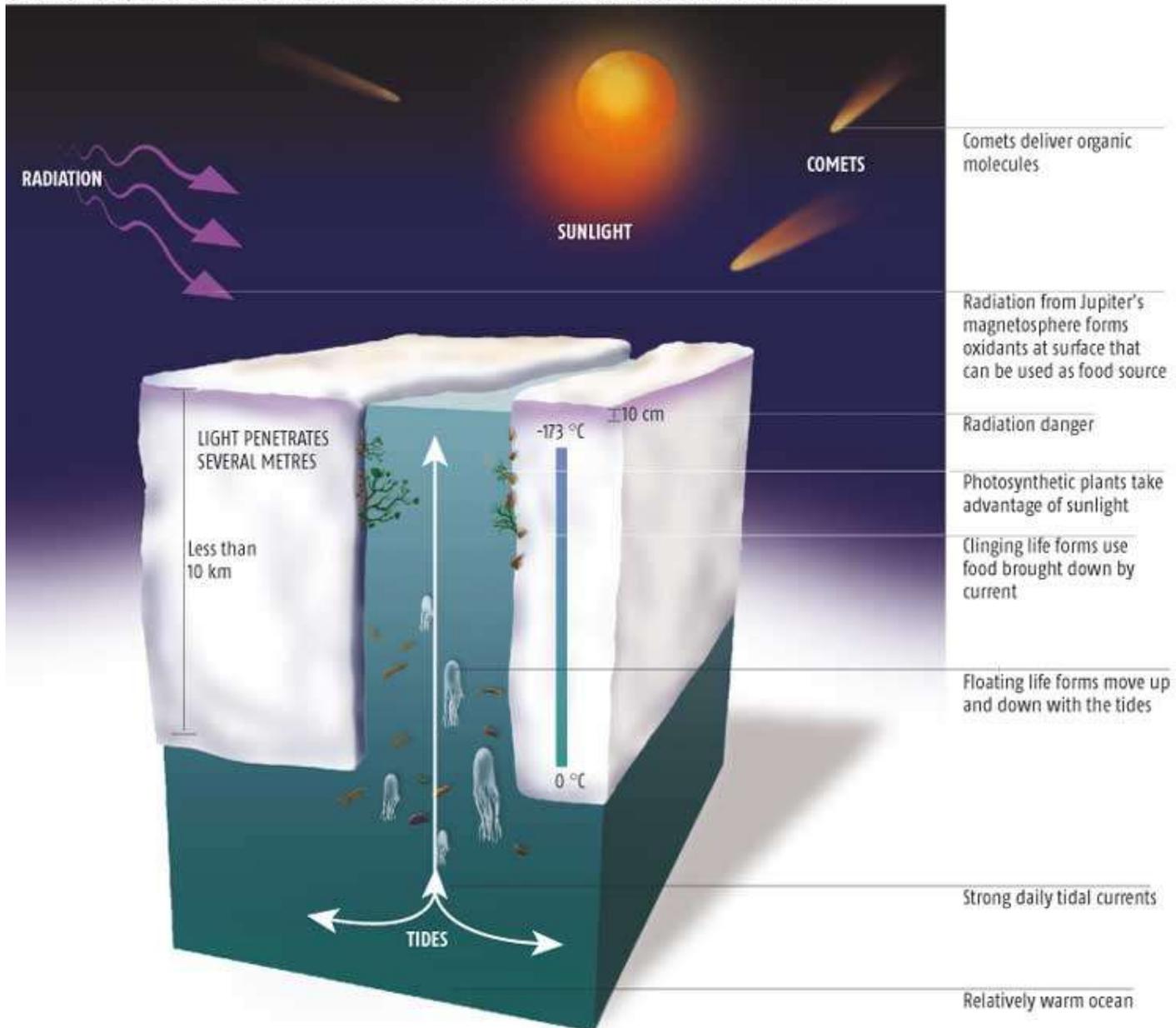


Inside Europa

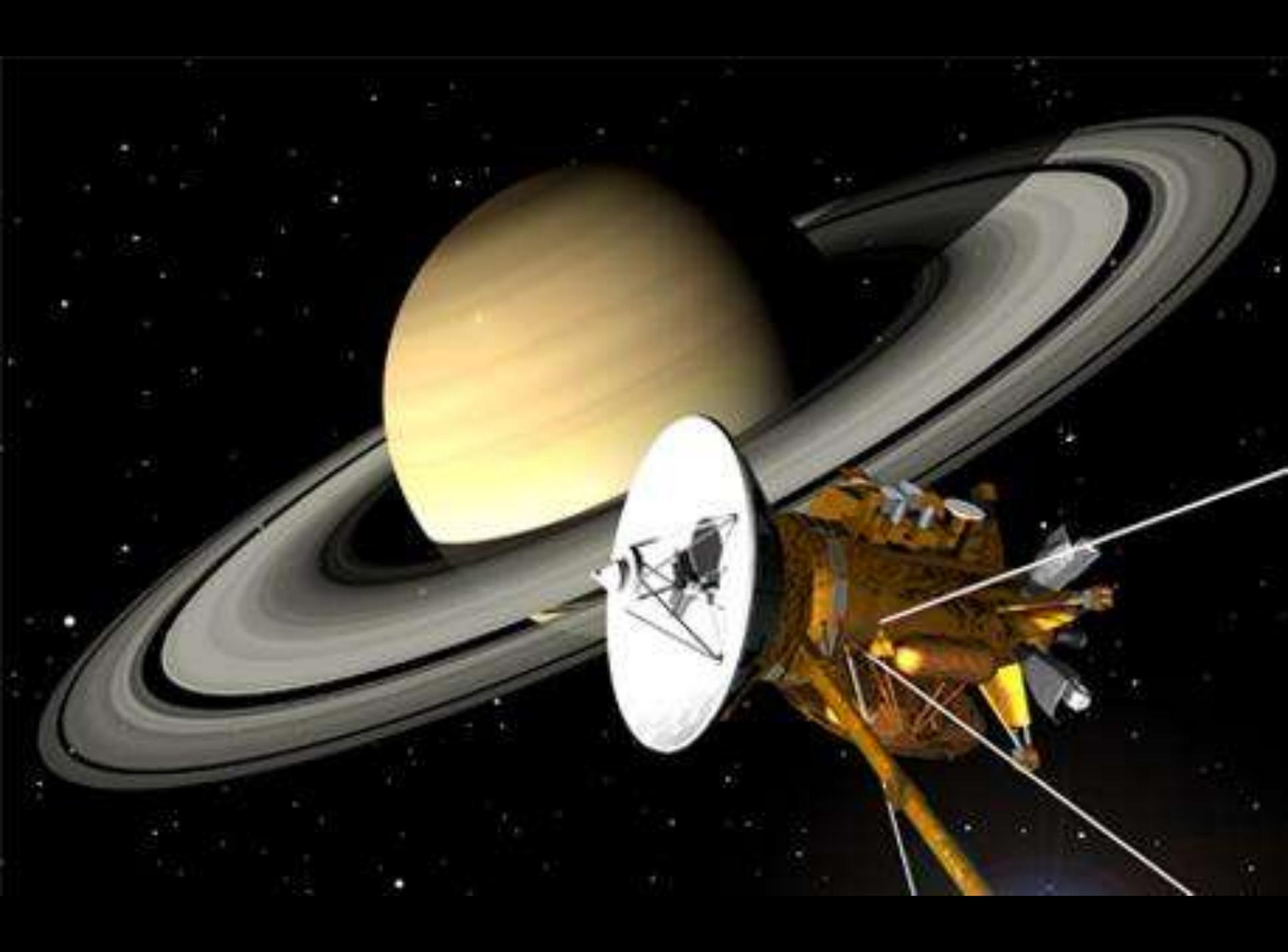


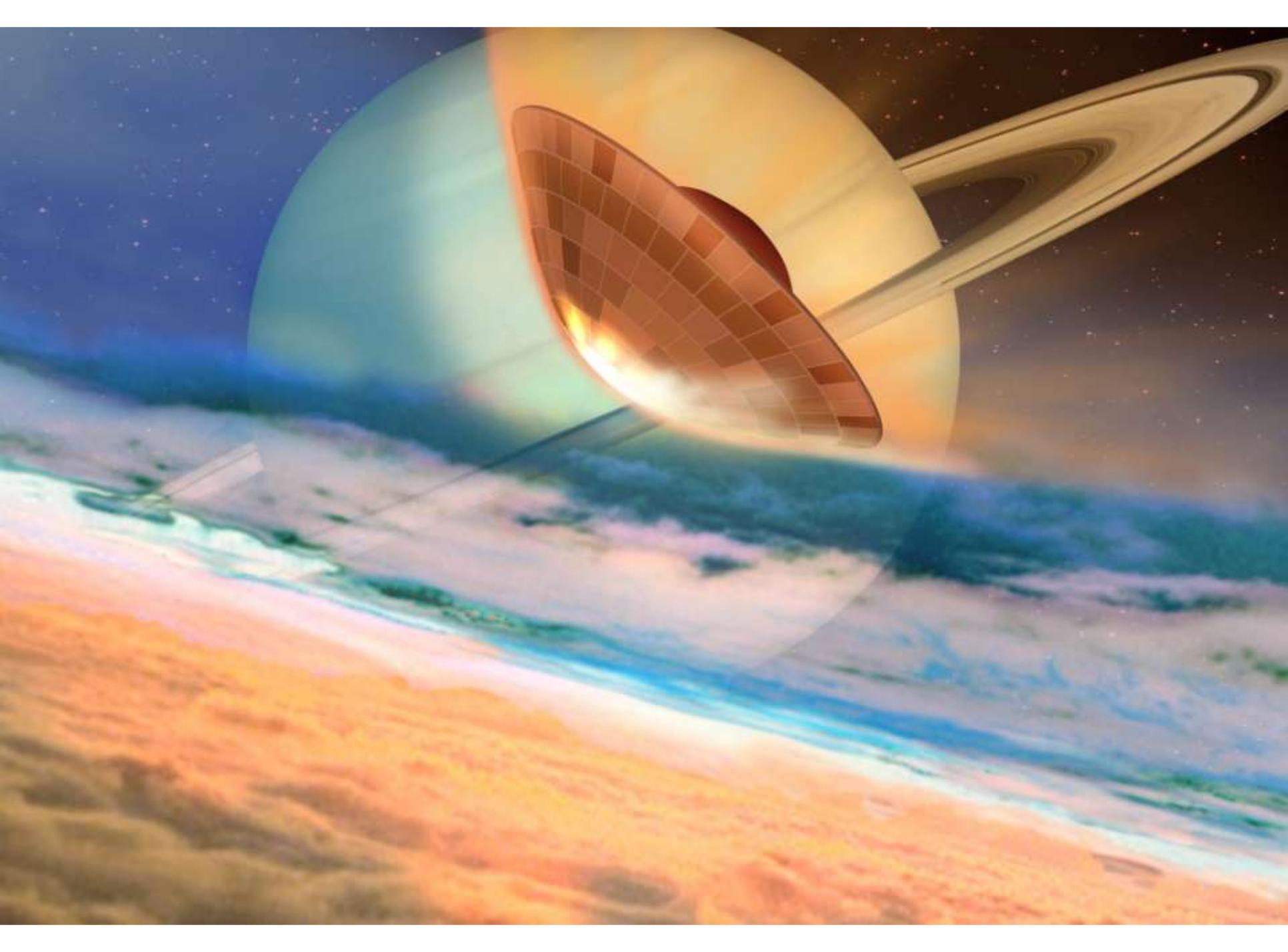
IS THERE LIFE ON EUROPA?

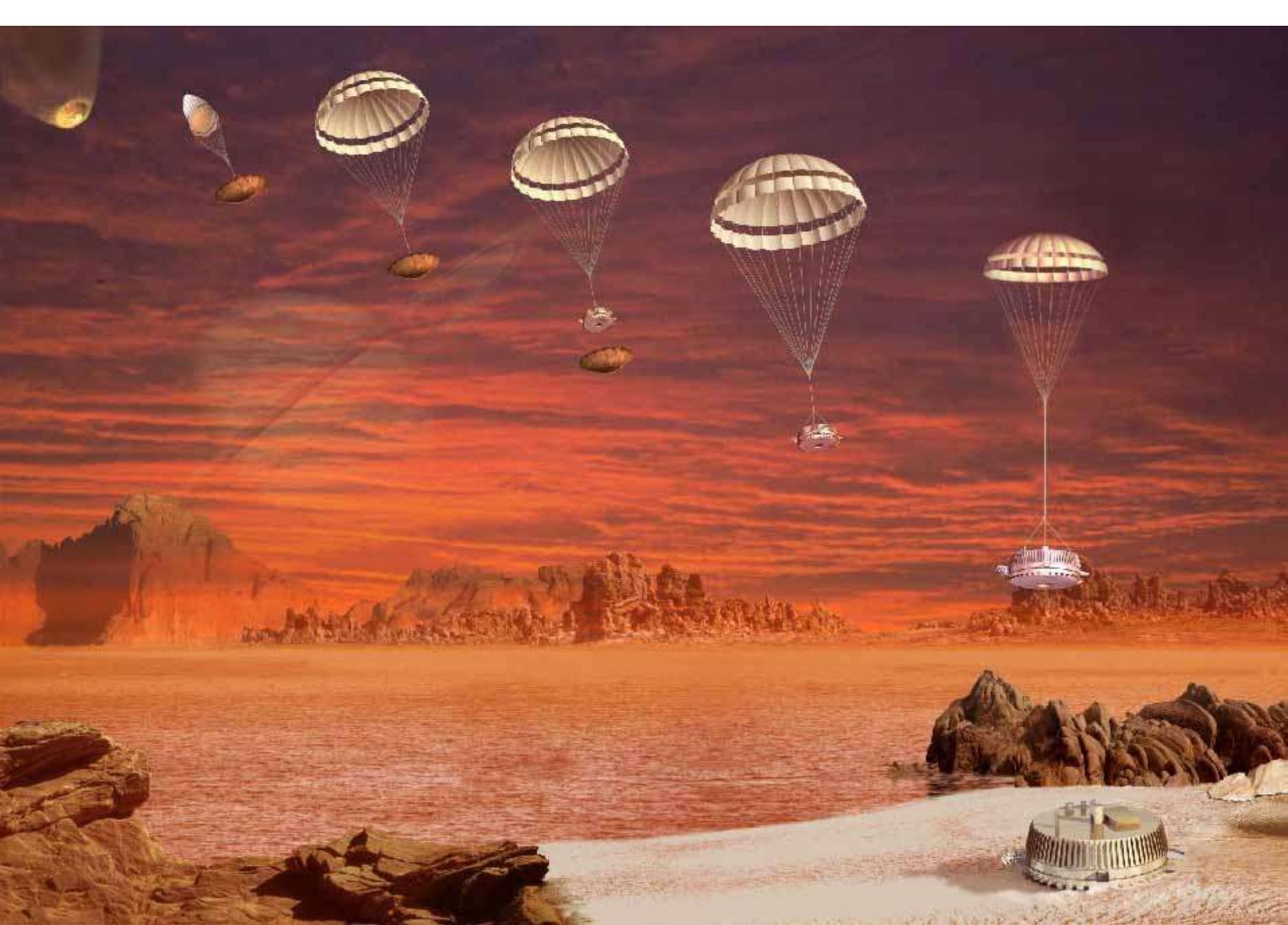
If Europa's icy crust is thin enough, cracks would provide a habitat where life could thrive

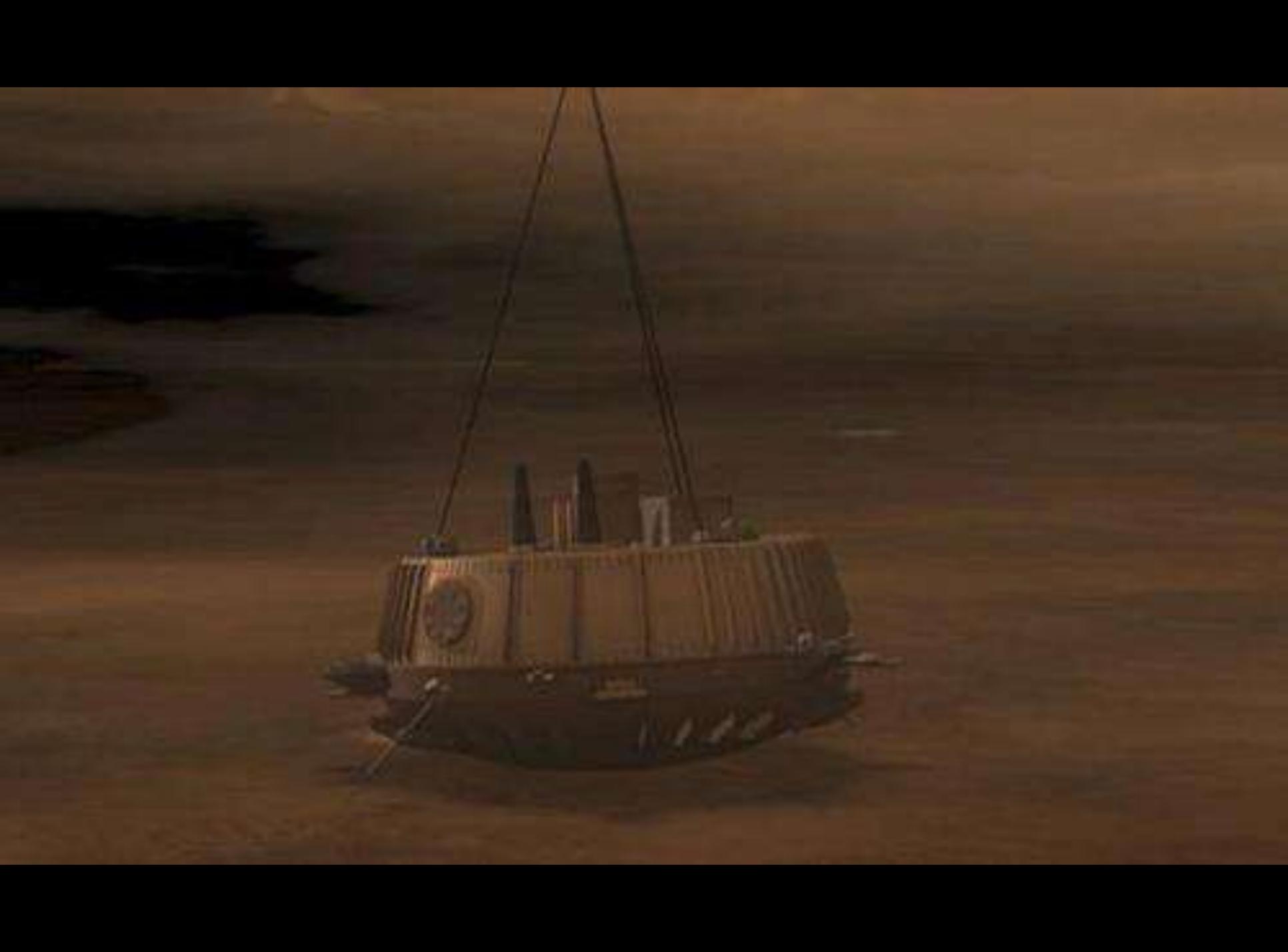


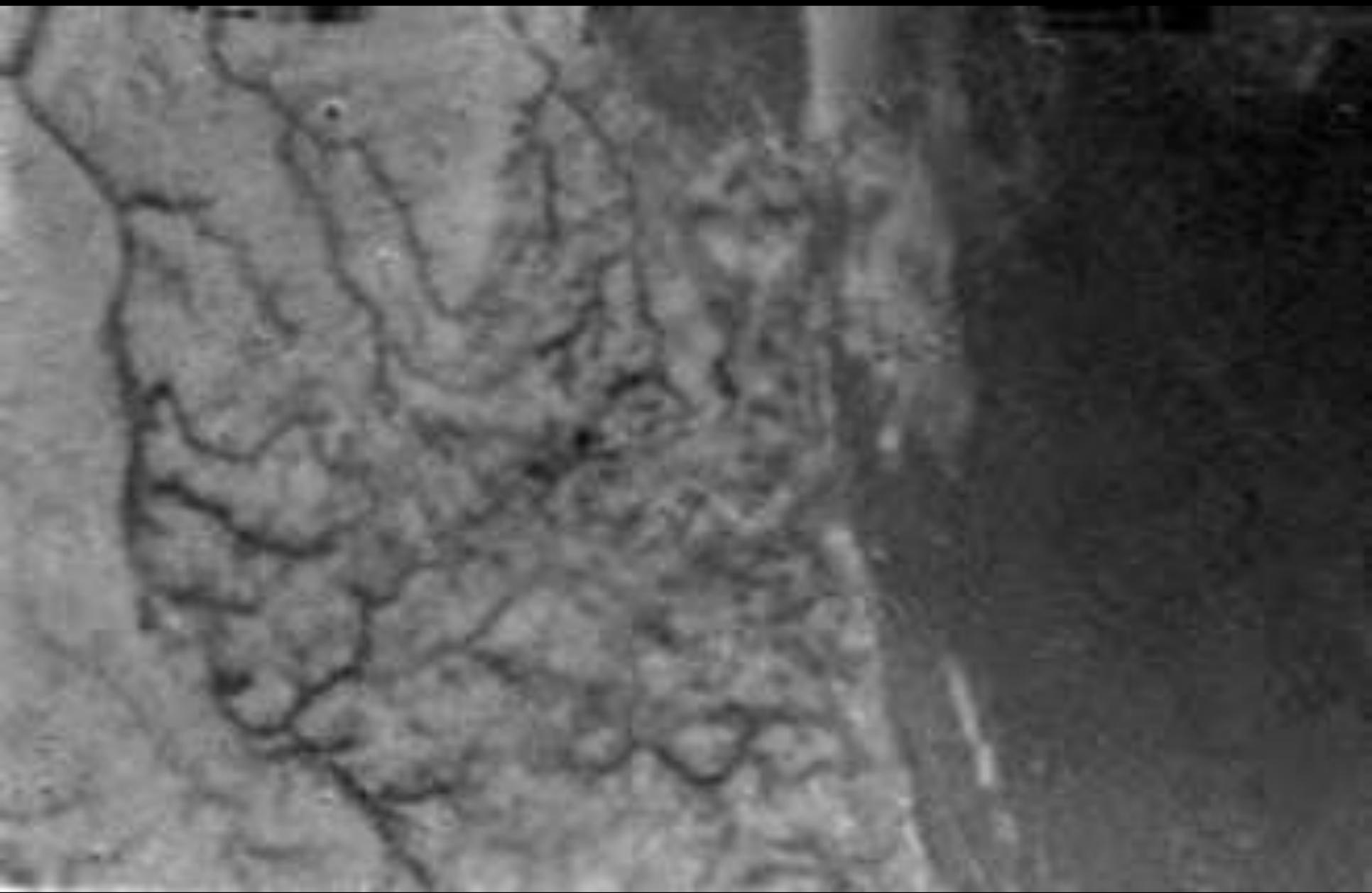


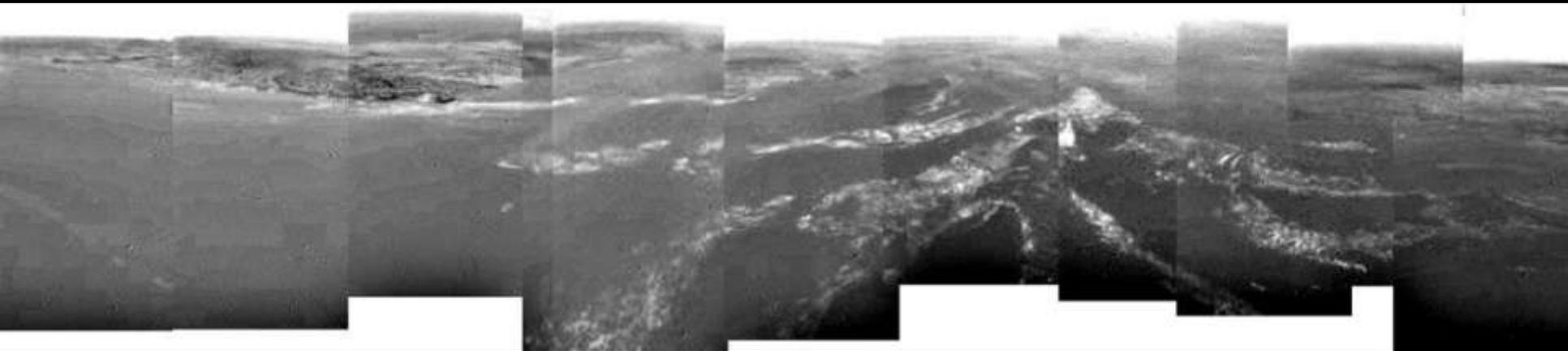


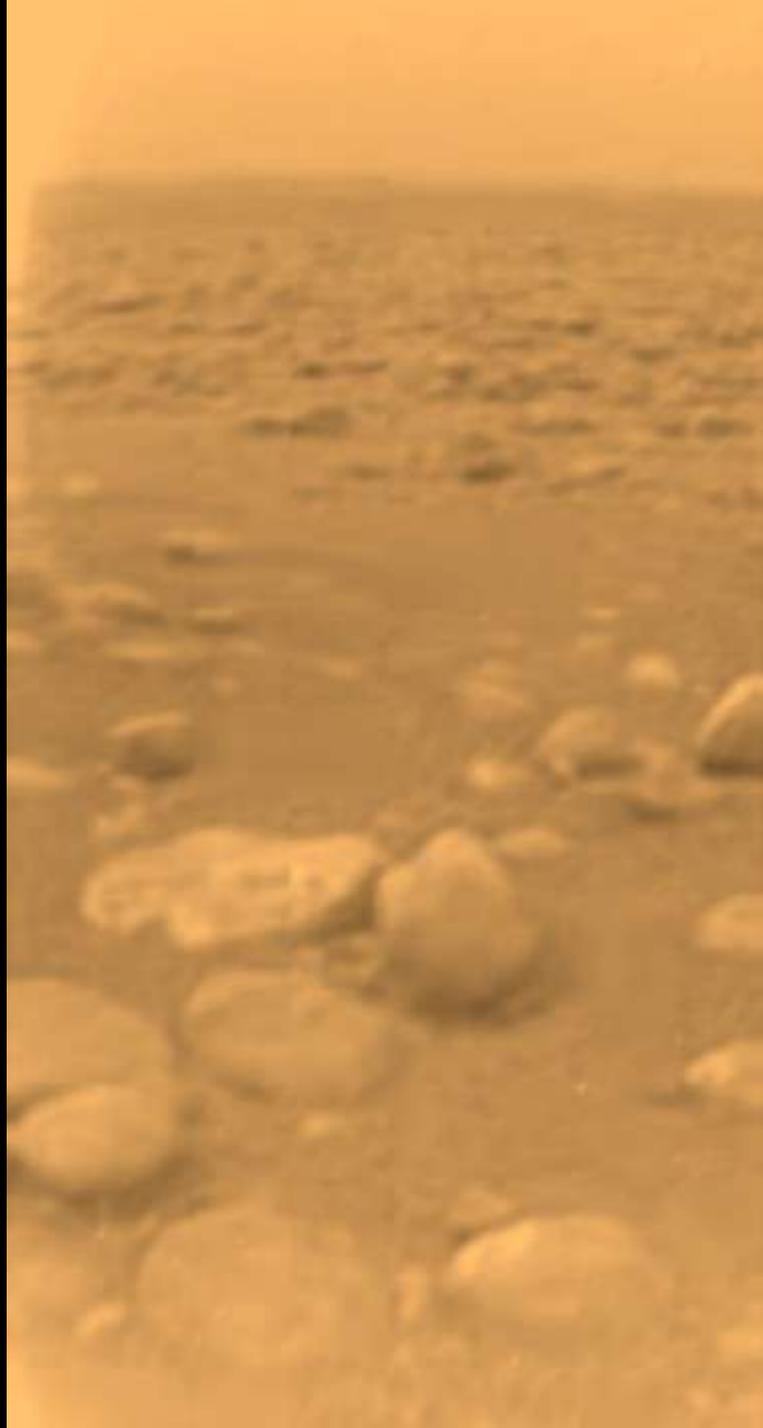


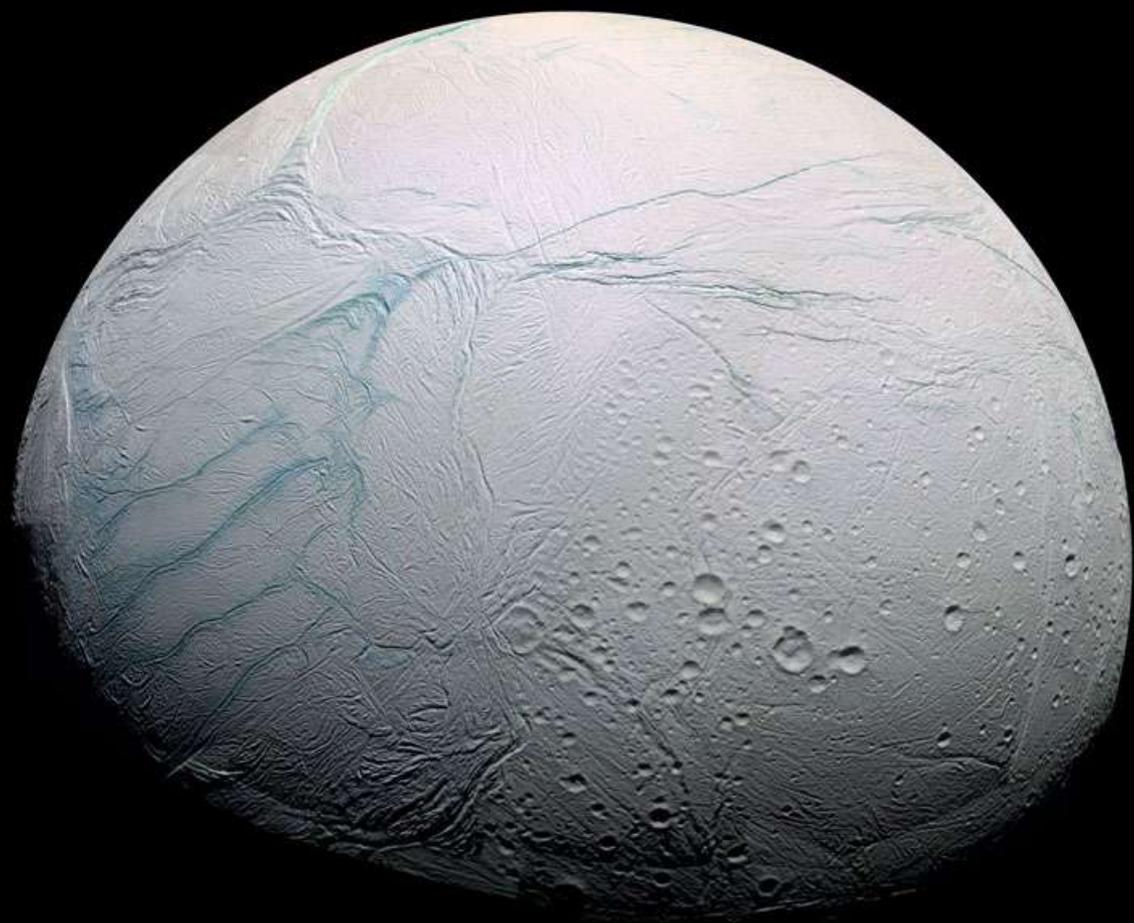




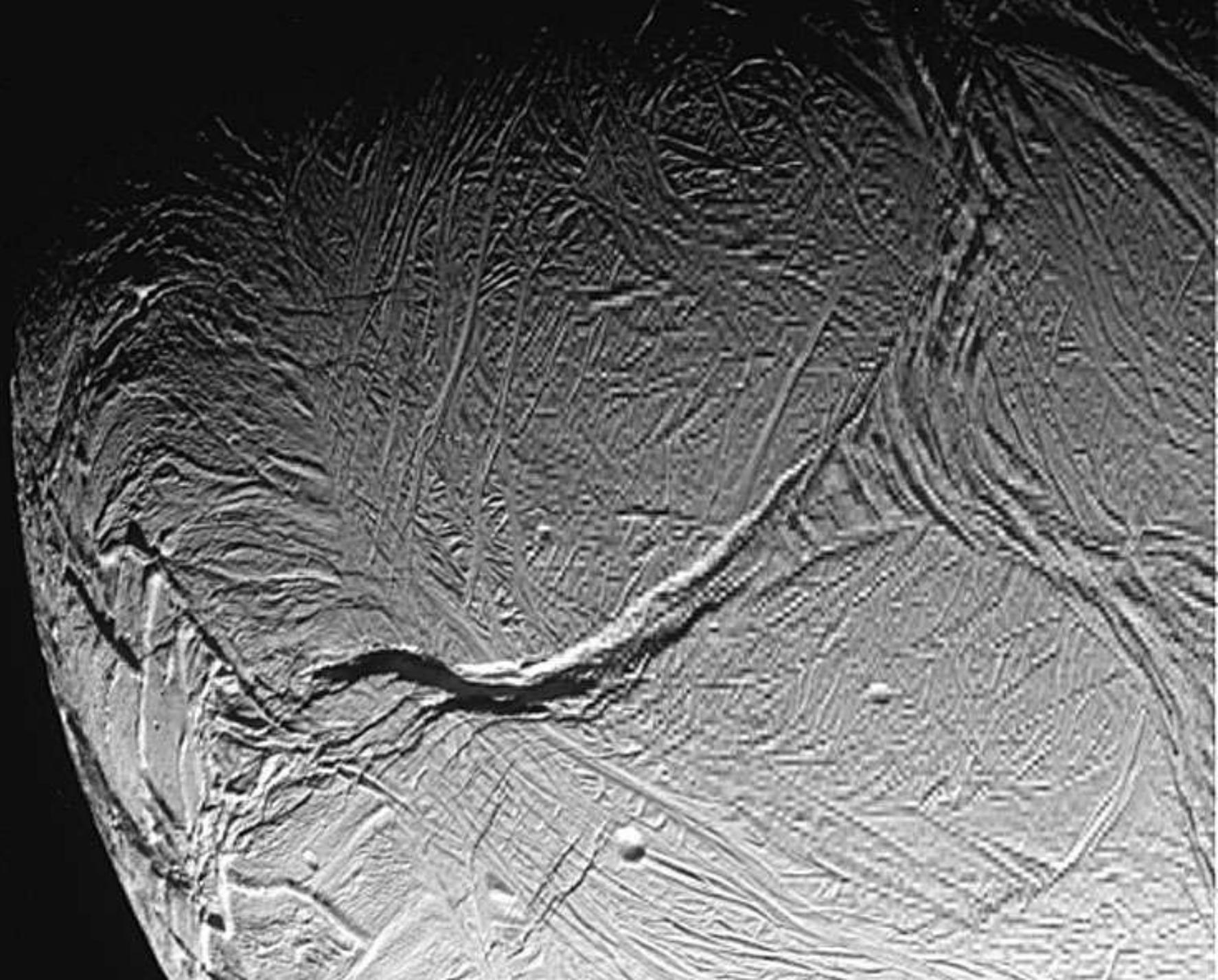












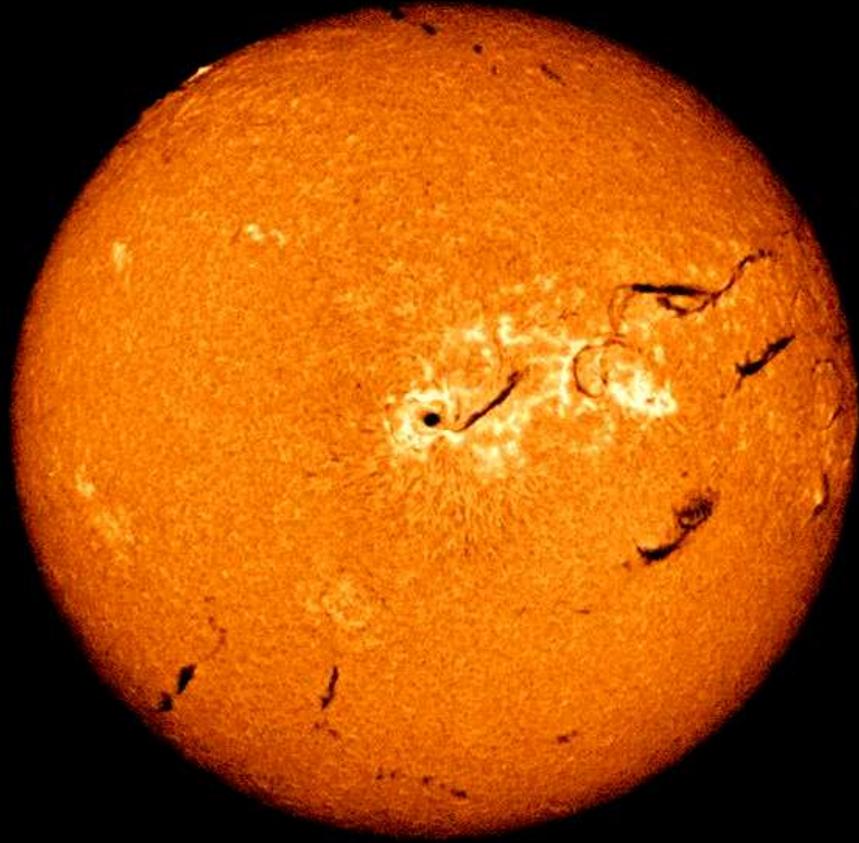




How can we detect planets around other stars?

This isn't easy because:

- other stars (and their planets) are very far away
- planets don't shine by themselves, they just reflect light from their star, so they get lost in the glare.



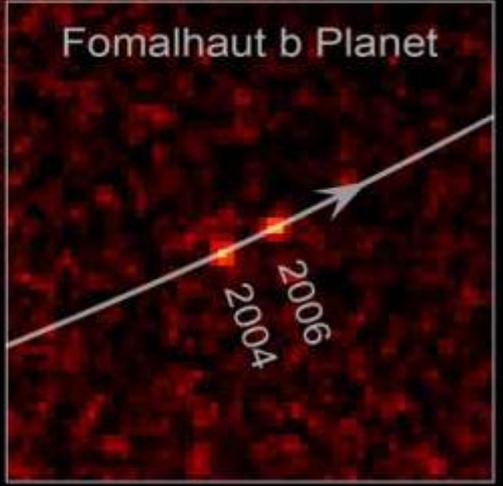
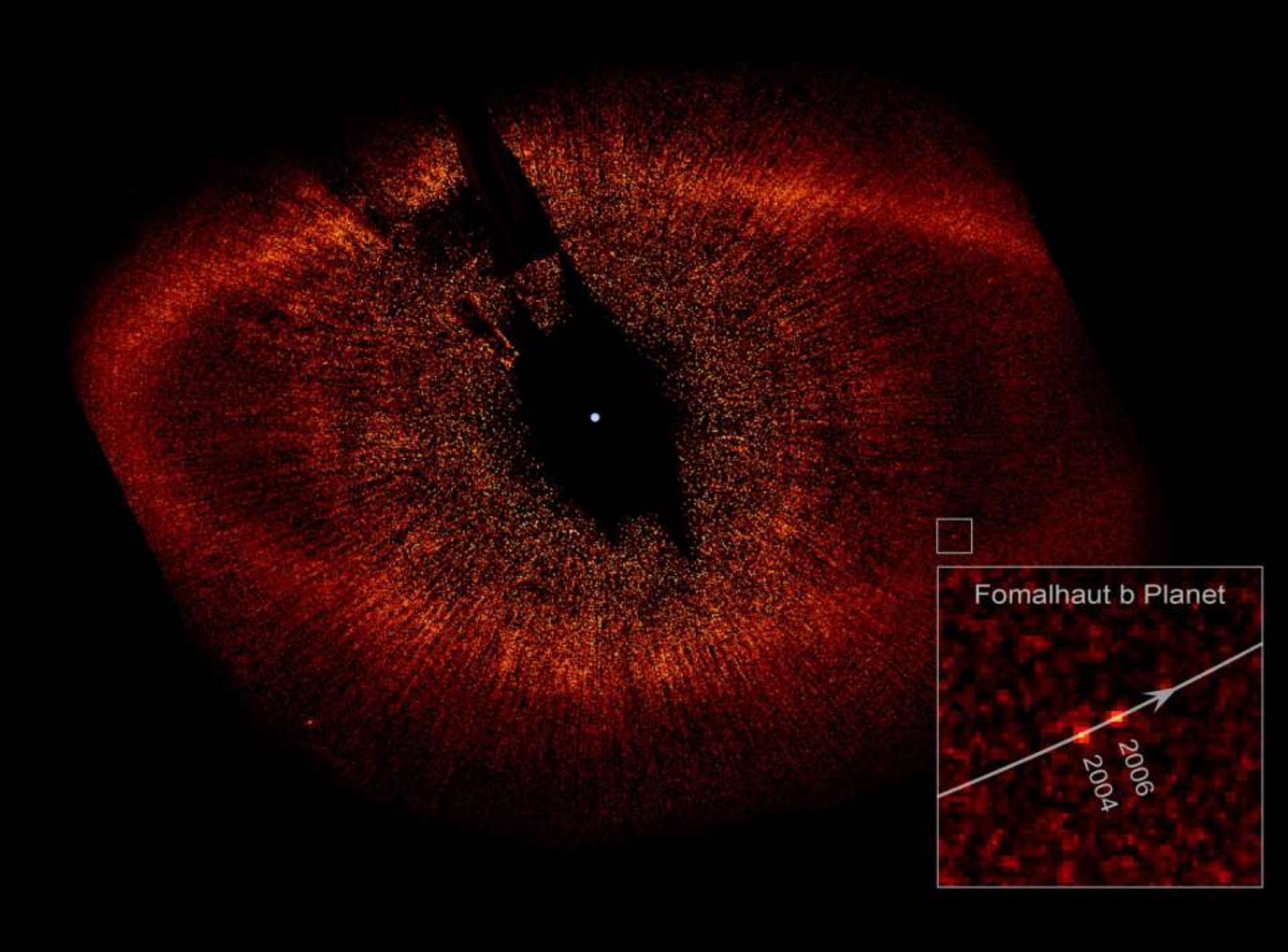
The distance from the Earth to the Sun is **150 million km**.

It takes sunlight more than **eight minutes** to travel this distance.

The light from the *next* nearest star, Alpha Centauri, takes more than **four years** to reach the Earth.

Exoplanets are 'drowned out' by their parent star. That makes them very hard to see directly with current telescopes (~10m mirrors)...

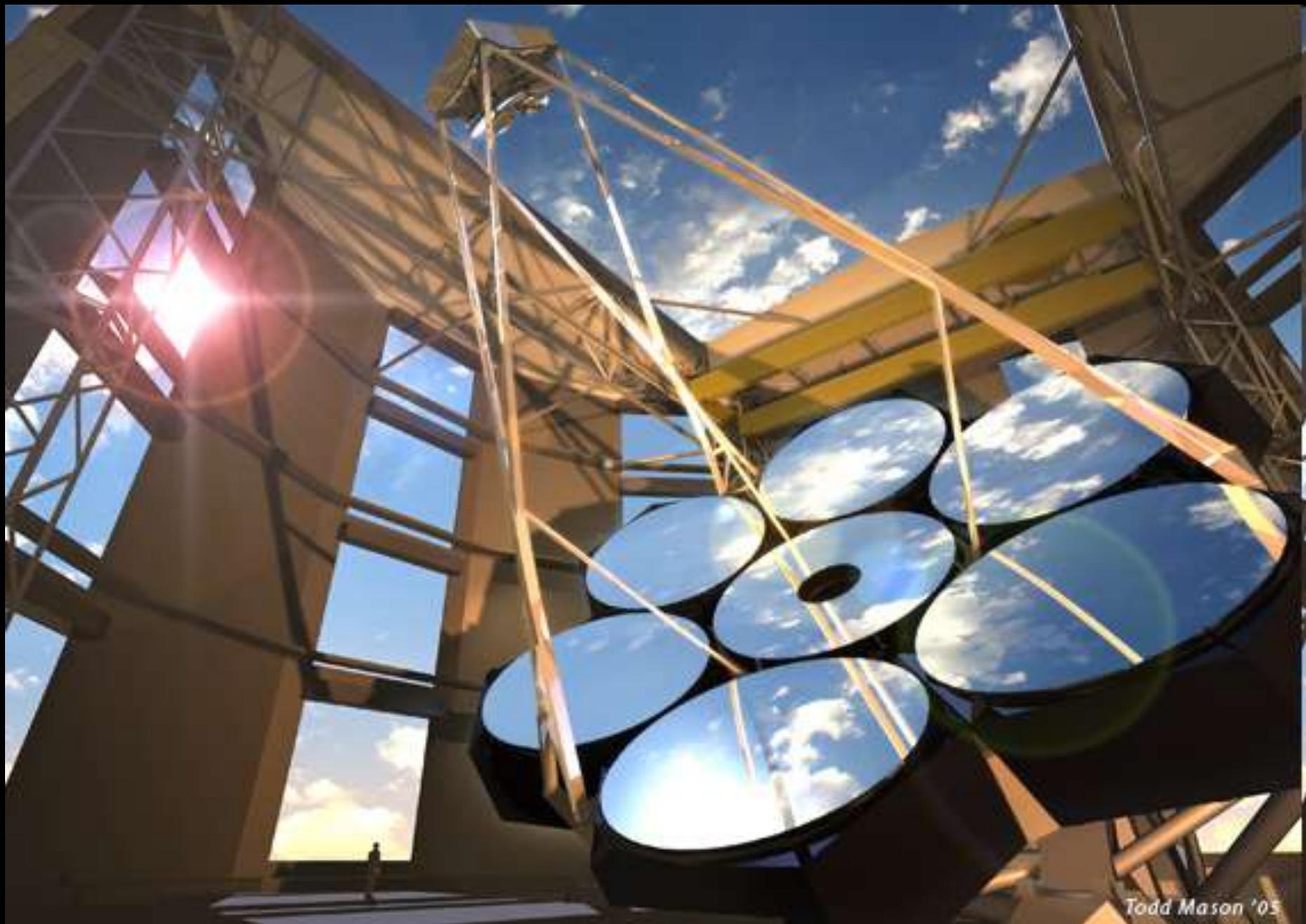




Fomalhaut b Planet

2004

2006



Todd Mason '05

The European Extremely Large Telescope project

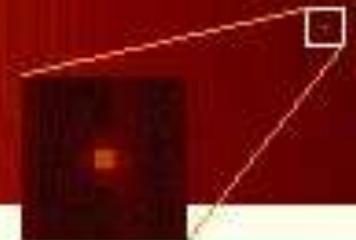


The European Extremely Large Telescope project

42m mirror: to be completed by 2020



'Jupiter' at 30 l.y.



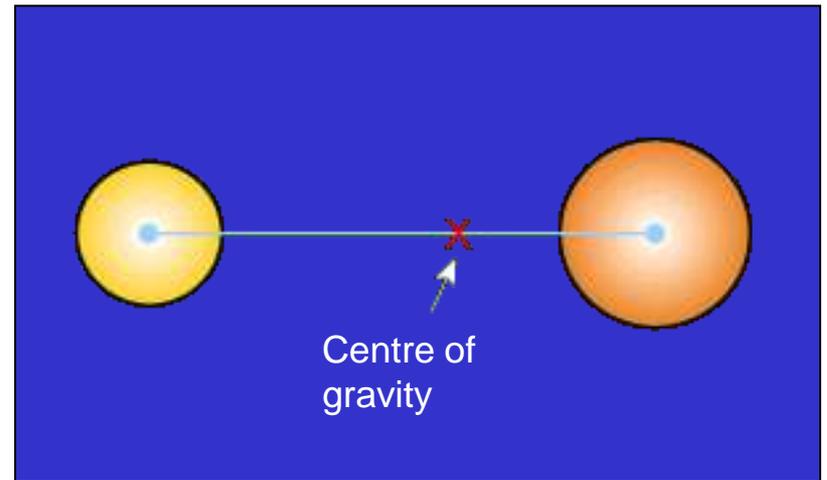
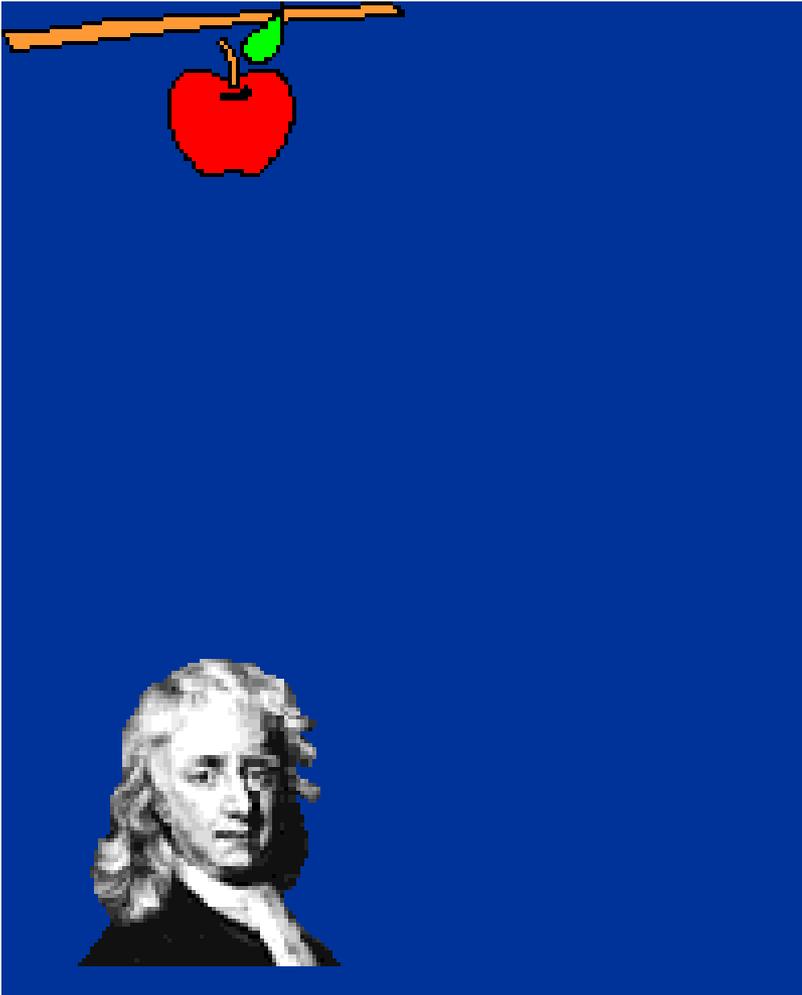
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This isn't easy because:

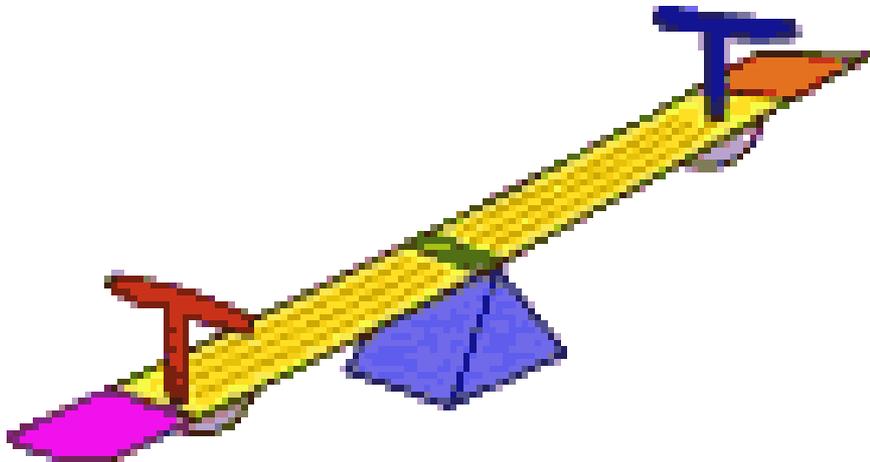
- other stars (and their planets) are very far away
- planets don't shine by themselves, they just reflect light from their star, so they get lost in the glare.

We can tell that planets are there by the effect they have on their star.

Planets cause their parent star to 'wobble'



Star + planet orbit
about centre of gravity



Star + planet orbit
about centre of gravity

Can see star 'wobble',
even when we can't see
the planet.

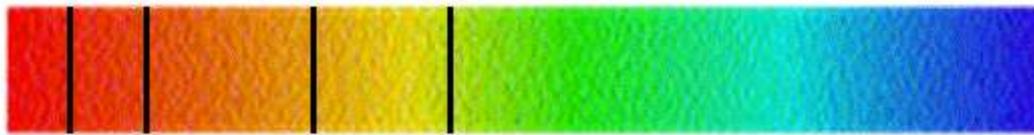


Star + planet orbit
about centre of gravity

We can also see the
motion of the star
from its spectral
lines.



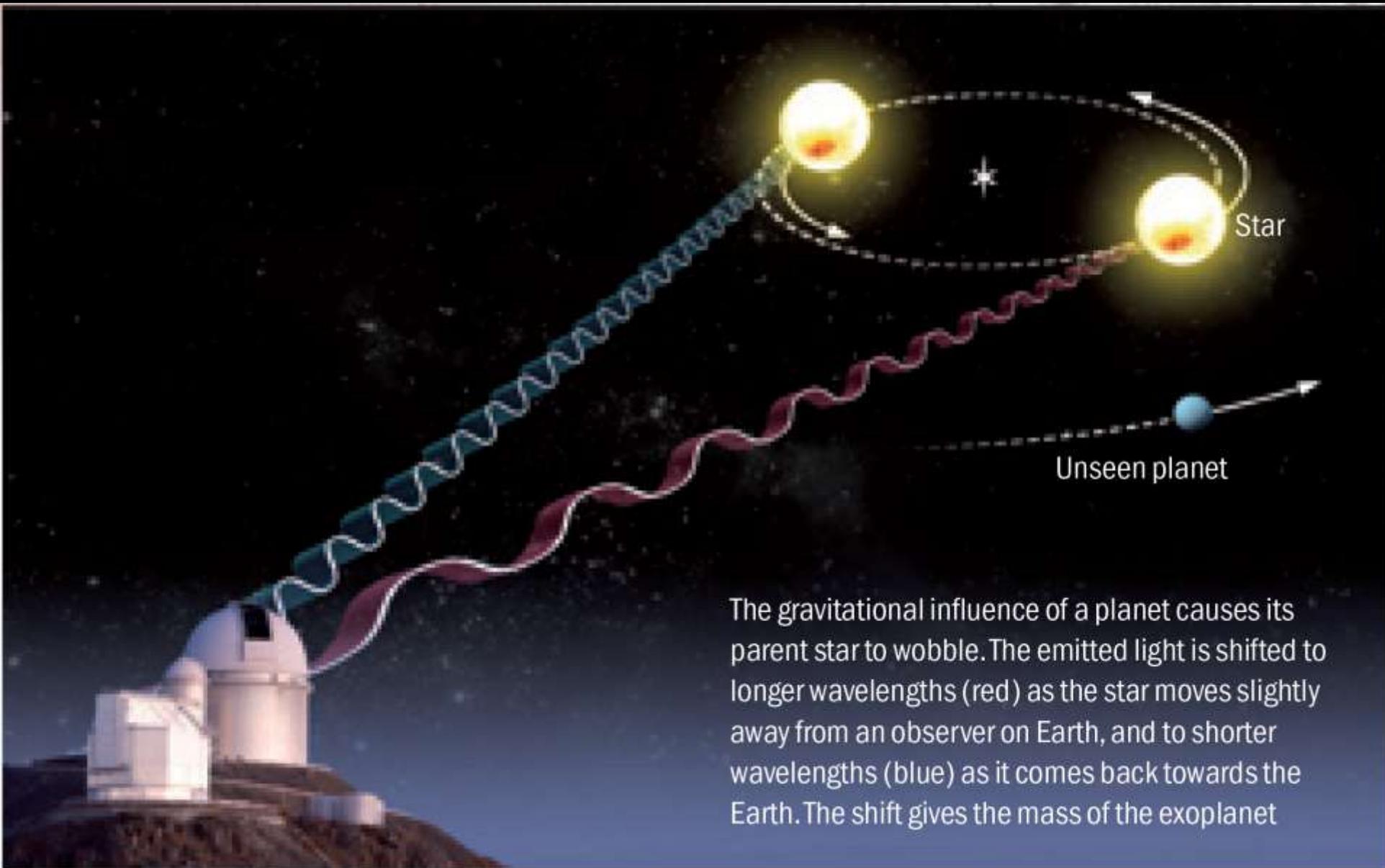
Direction
to Earth



Star



Laboratory



The gravitational influence of a planet causes its parent star to wobble. The emitted light is shifted to longer wavelengths (red) as the star moves slightly away from an observer on Earth, and to shorter wavelengths (blue) as it comes back towards the Earth. The shift gives the mass of the exoplanet

In the past 16 years we have found many planets orbiting other stars in our galaxy...

The screenshot shows the Planet Quest website interface. At the top left is the NASA logo and the text "Jet Propulsion Laboratory California Institute of Technology". To the right is a navigation menu with links for "JPL HOME", "EARTH", "SOLAR SYSTEM", "STARS & GALAXIES", and "SCIENCE & TECHNOLOGY". Below this is a social media section with the text "BRING THE UNIVERSE TO YOU:" and links for "JPL Email News", "RSS", "Podcast", and "Video", along with icons for Twitter, Facebook, and YouTube.

The main header features the "PLANET QUEST THE SEARCH FOR ANOTHER EARTH" logo. To its right, a statistics box displays "2,326 CANDIDATES = 3,035 EXOPLANETS" with "709 CONFIRMED" listed below. Further right is a box for "DISCOVER NEW WORLDS ATLAS a visual guide to exoplanets".

A navigation bar contains links for "NEWS", "SCIENCE & TECHNOLOGY", "IMAGES & VIDEO", "INTERACTIVES", and "EDUCATION", followed by a search bar with "SEARCH" and "GO" buttons.

The main content area features a large background image of a red planet (Mars) and a bright star. On the left, a "TOP STORY" section is titled "Tiny trio" and contains the text: "Astronomers using data from NASA's Kepler mission have discovered the three smallest planets yet detected orbiting a star beyond our sun." Below this is a "read more" link and a video player control bar.

At the bottom, there are two promotional boxes. The left one is titled "ALIEN vs. EDITOR" and features a photo of astronomer Steve, with the text: "Astronomer Steve answers your questions", "January 12, 2012", "Austin announcements", and "NASA brings the exos to Texas". The right one is titled "EXPLORE" and features a box for "EXTREME PLANET MAKEOVER" with an image of a planet.

3. Could some of those planets be like the Earth?

Most planets we've found so far are 'hot Jupiters':

gas giants, much bigger and closer to their parent star than the Earth is to the Sun.



These are not good places to look for life like us:

no water,
no oxygen,
much too hot!

In the past 16 years we have found many planets orbiting other stars in our galaxy...

The screenshot shows the NASA Jet Propulsion Laboratory website for Planet Quest. At the top, it features the NASA logo and the text "Jet Propulsion Laboratory California Institute of Technology". Navigation links include "JPL HOME", "EARTH", "SOLAR SYSTEM", "STARS & GALAXIES", and "SCIENCE & TECHNOLOGY". A secondary navigation bar says "BRING THE UNIVERSE TO YOU:" with links for "JPL Email News", "RSS", "Podcast", and "Video", along with social media icons for Twitter, Facebook, and YouTube.

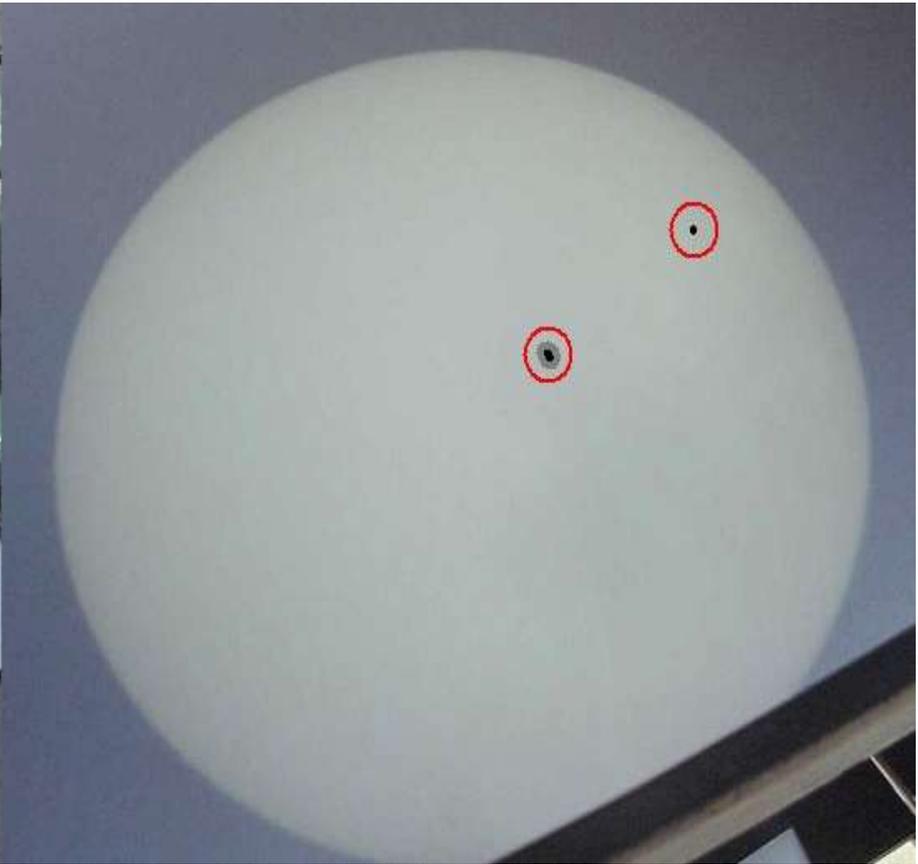
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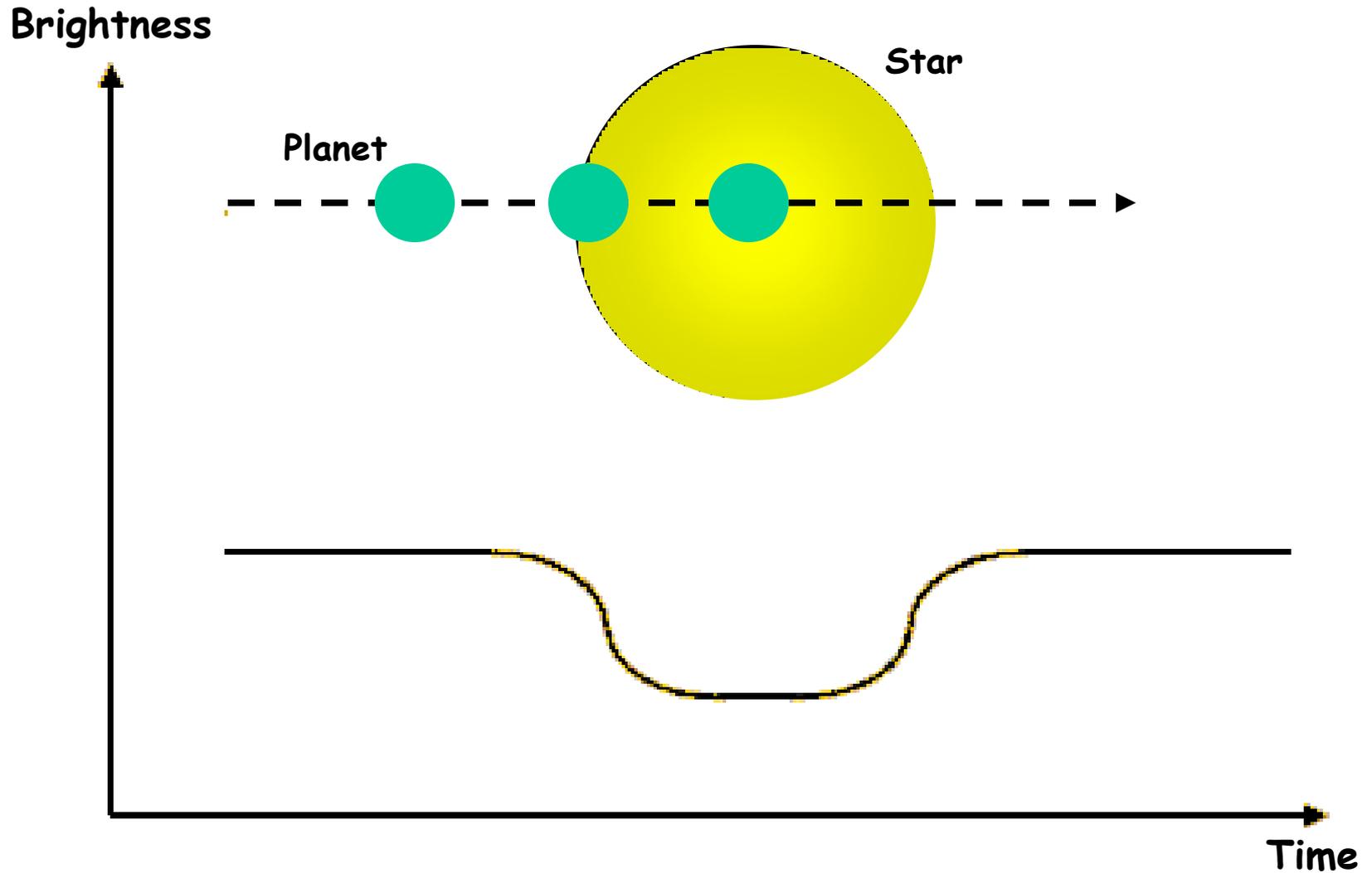
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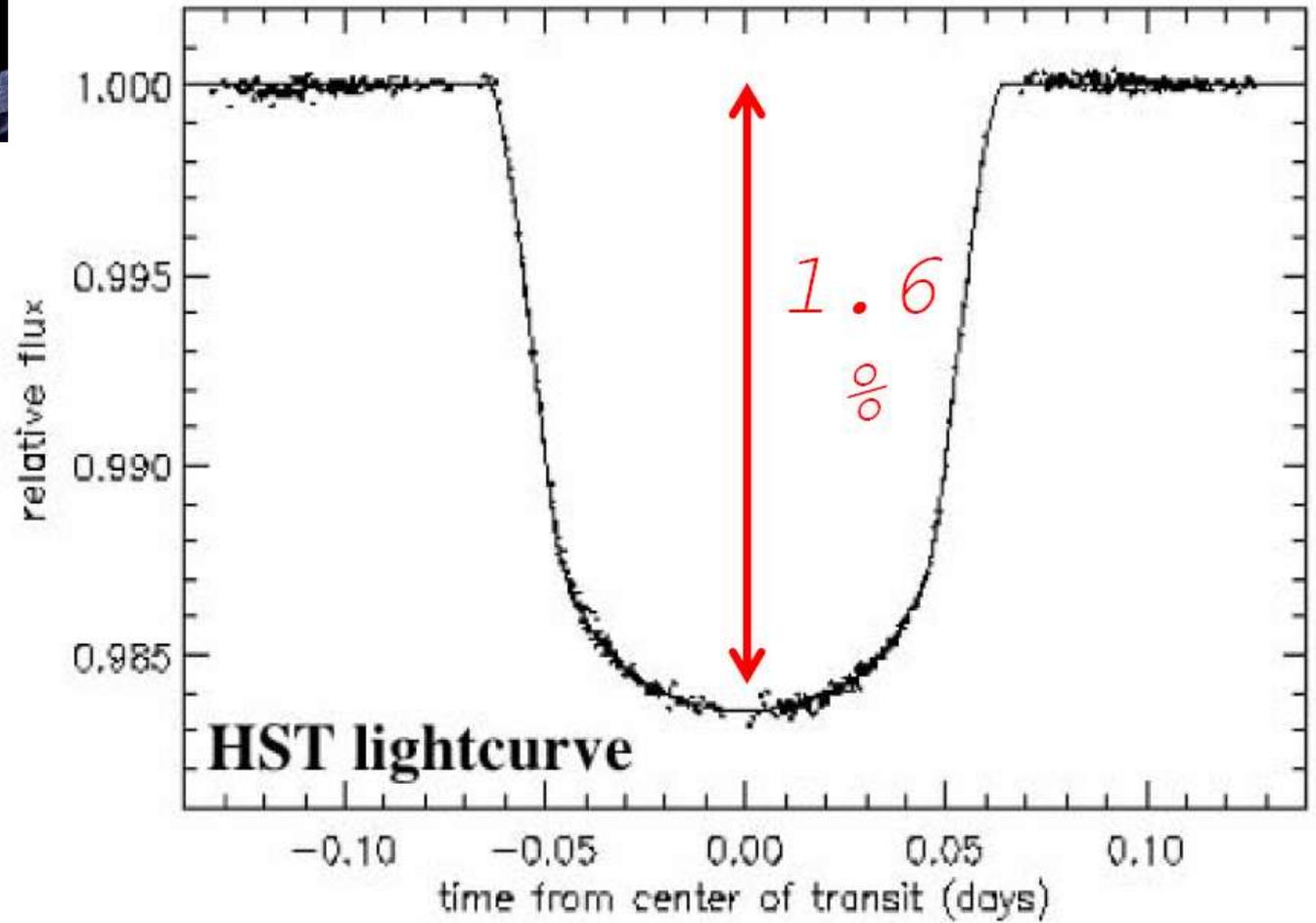
No Earth-like planets, yet?



Transit of Mercury: May 7th 2003

Detecting exoplanets from transits



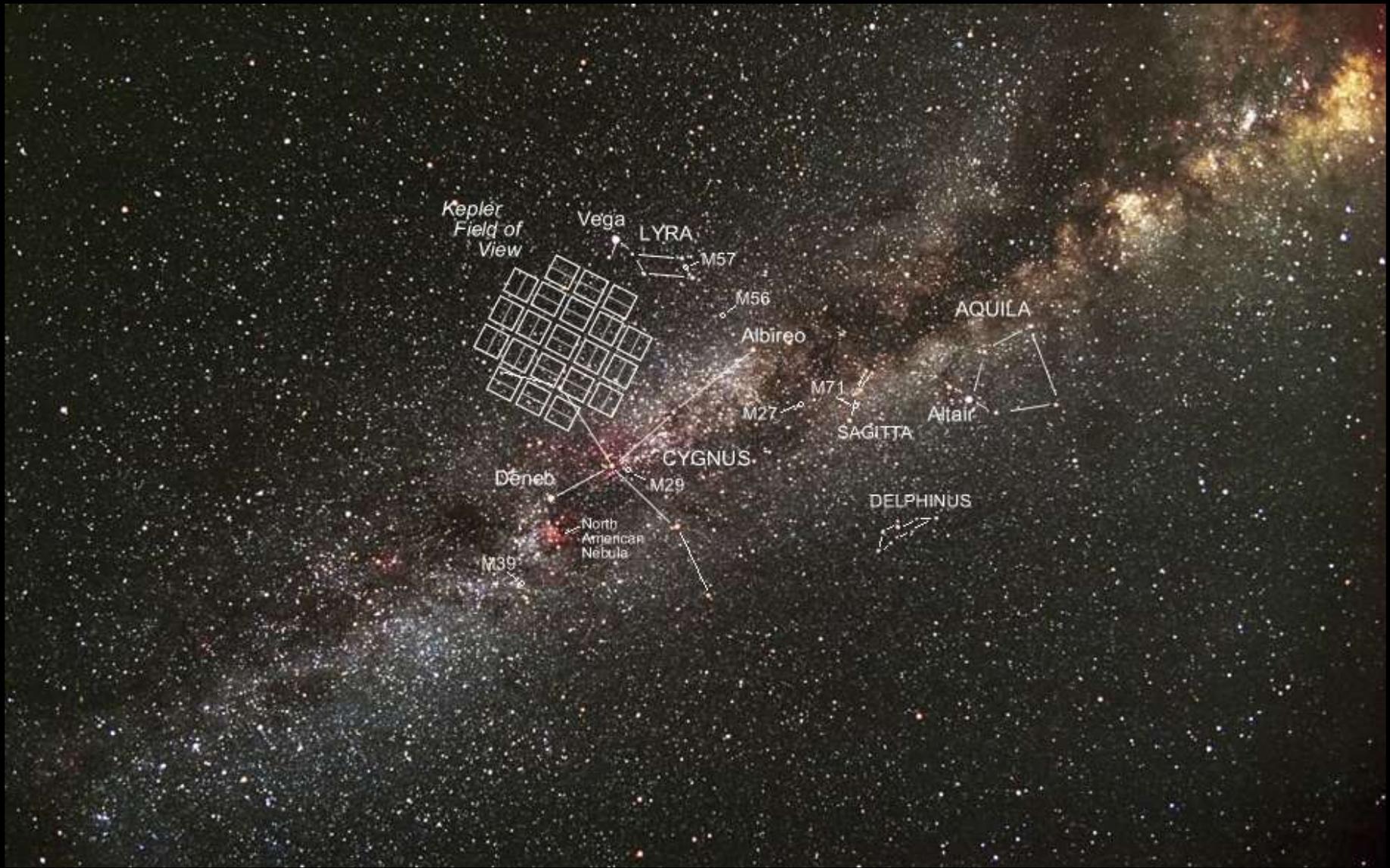


Kepler

NASA's first mission capable of finding Earth-size and smaller planets

Launched: March 5th 2009





Kepler
Field of
View

Vega

LYRA

M57

M56

Albireo

AQUILA

Altair

SAGITTA

CYGNUS

Deneb

M29

DELPHINUS

North
American
Nebula

M39

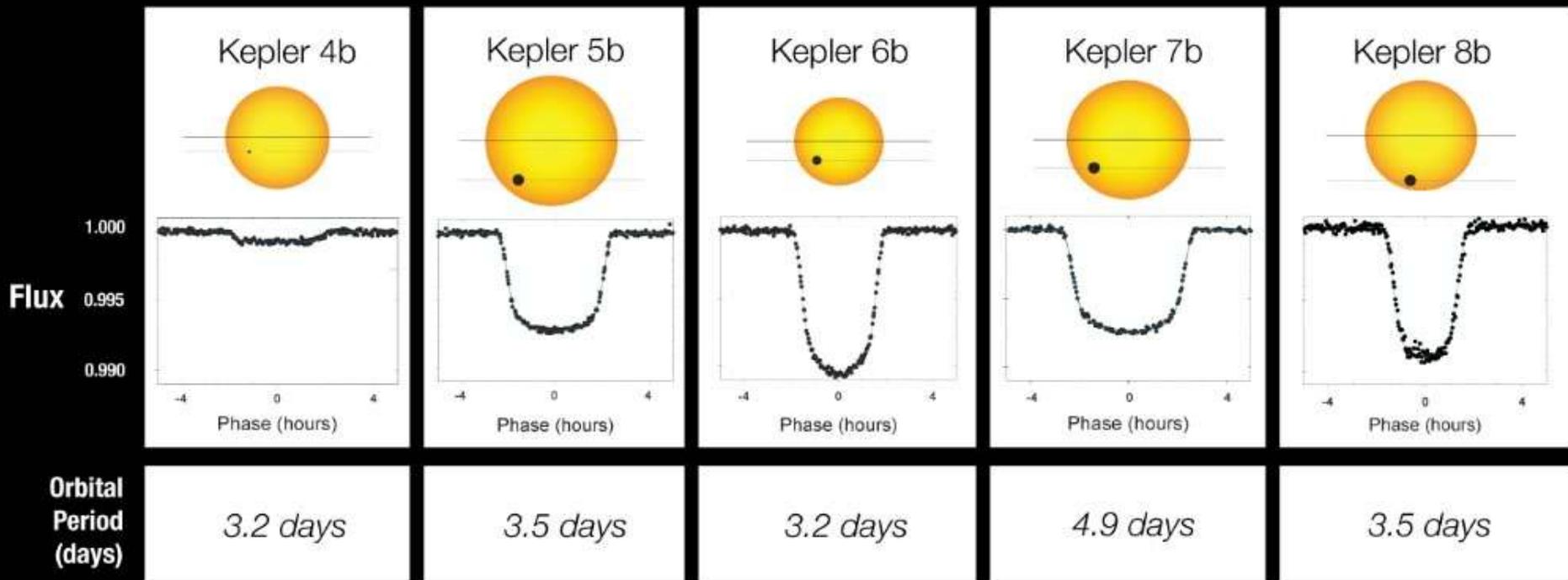


BRIGHTNESS

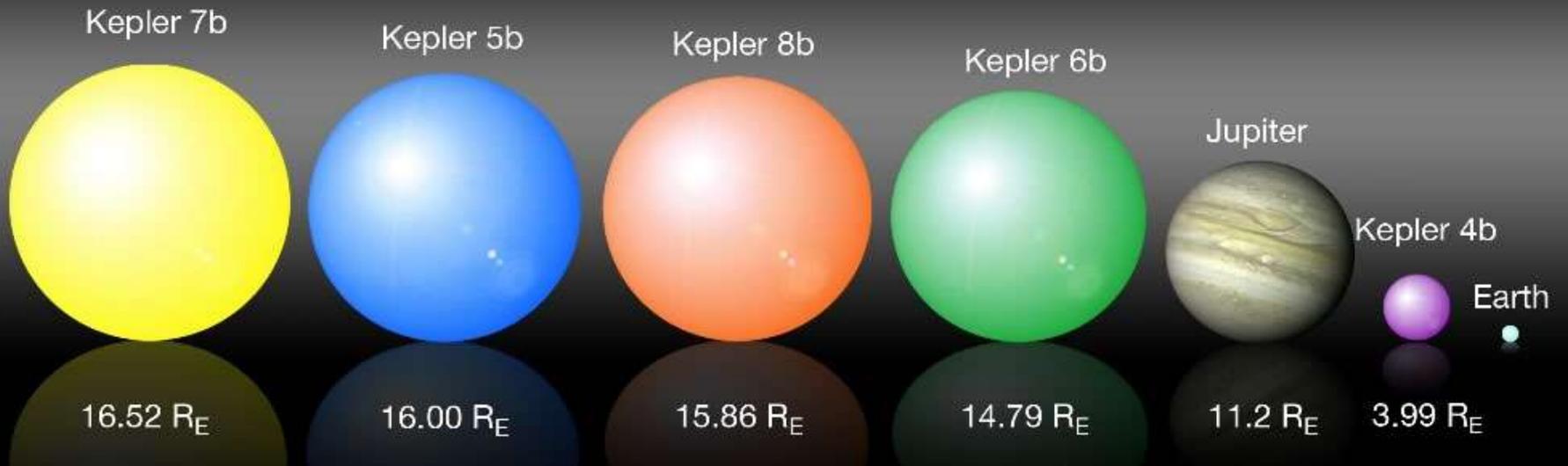


TIME IN HOURS

Transit Light Curves

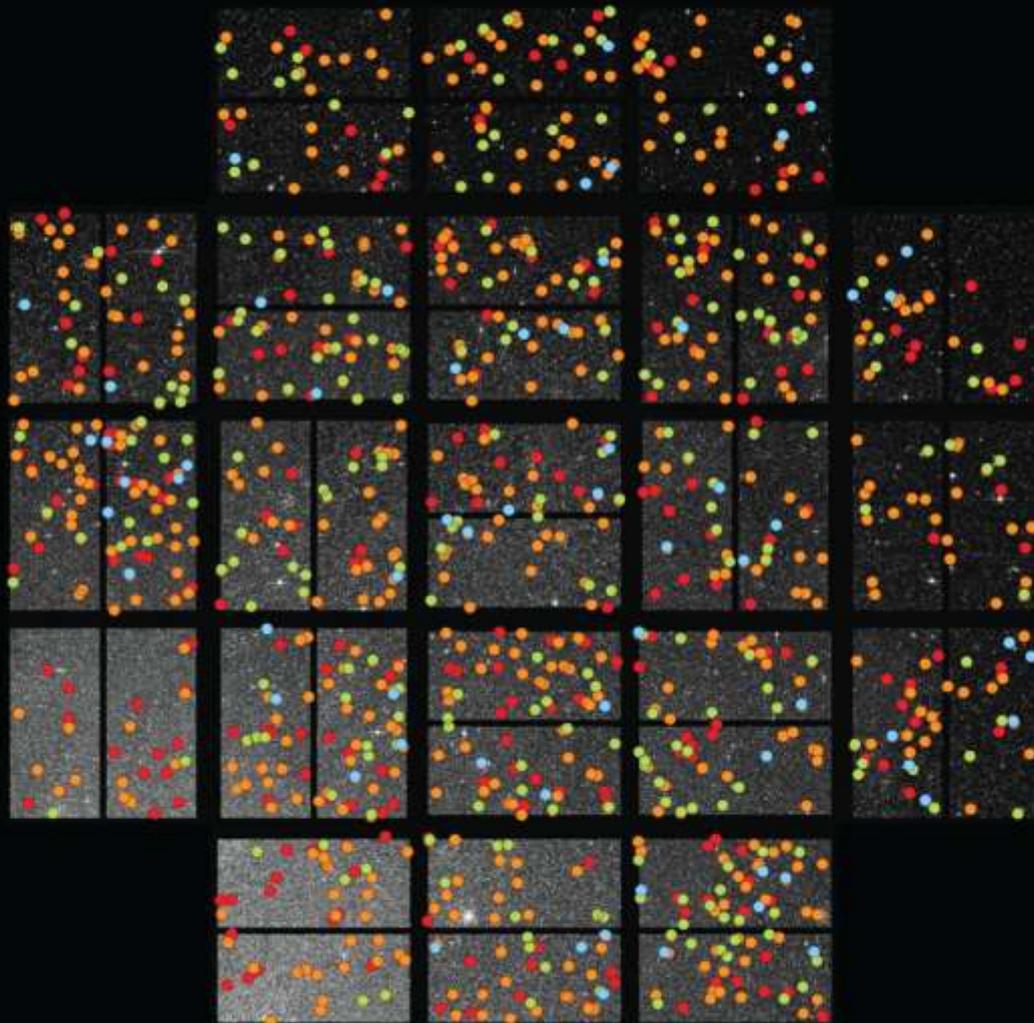


Planet Size



Locations of Kepler Planet Candidates

- Earth-size
- Super-Earth size
1.25 - 2.0 Earth-size
- Neptune-size
2.0 - 6.0 Earth-size
- Giant-planet size
6.0 - 22 Earth-size



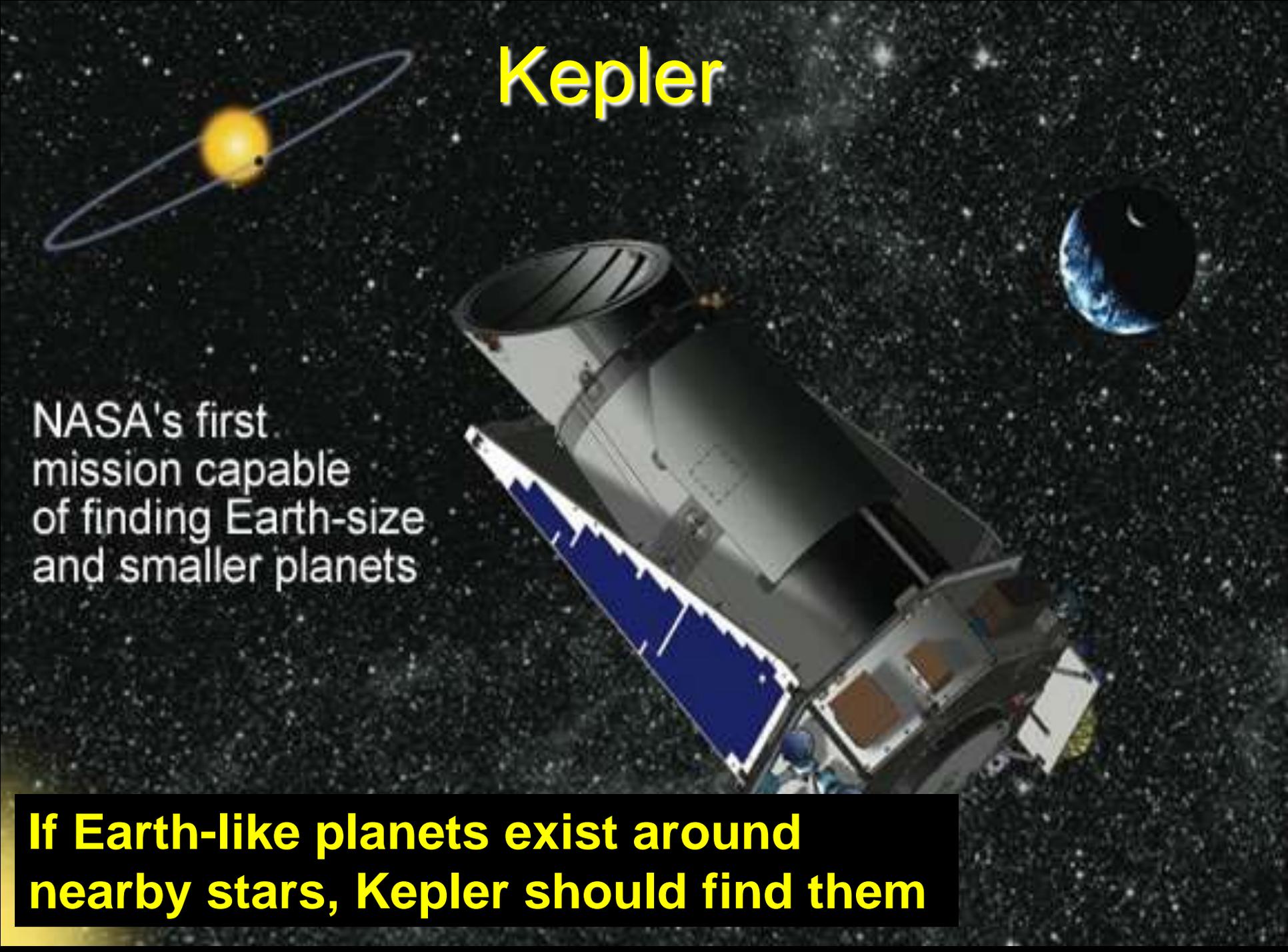




Kepler

NASA's first mission capable of finding Earth-size and smaller planets

If Earth-like planets exist around nearby stars, Kepler should find them



Kepler-22 System

Solar System

Habitable Zone



Kepler-22b

Mercury



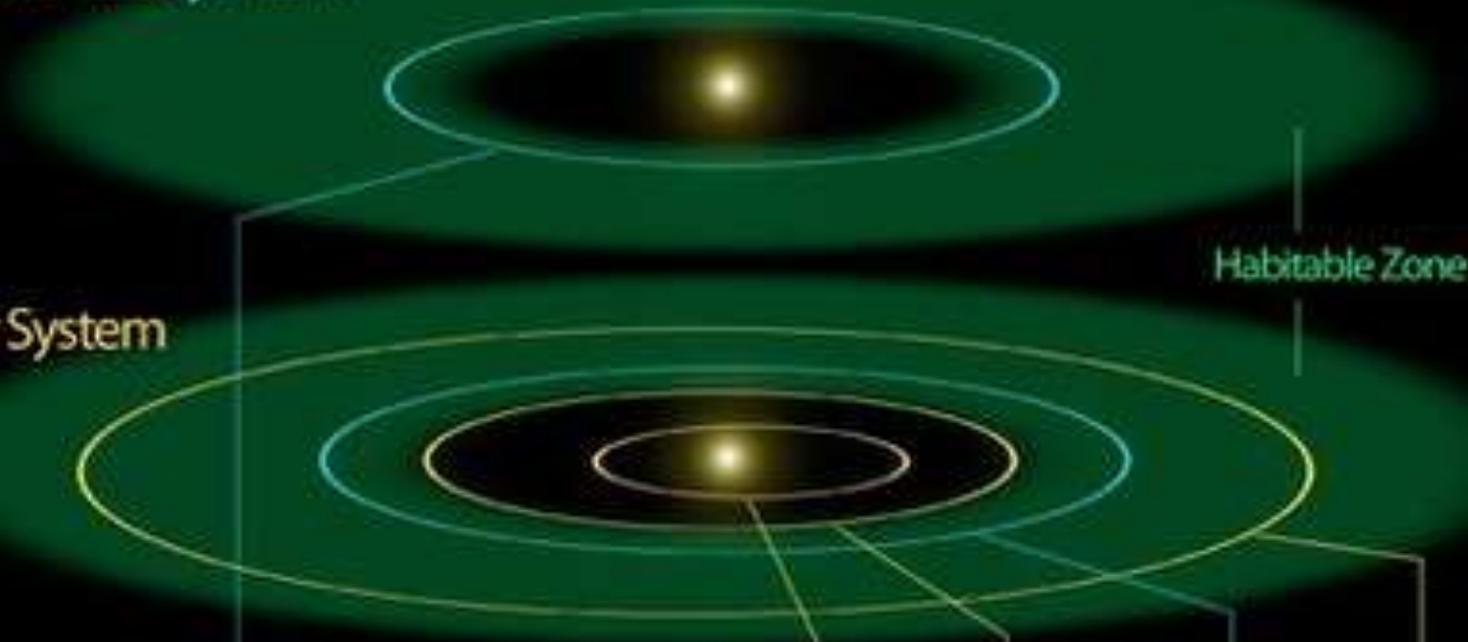
Venus



Earth

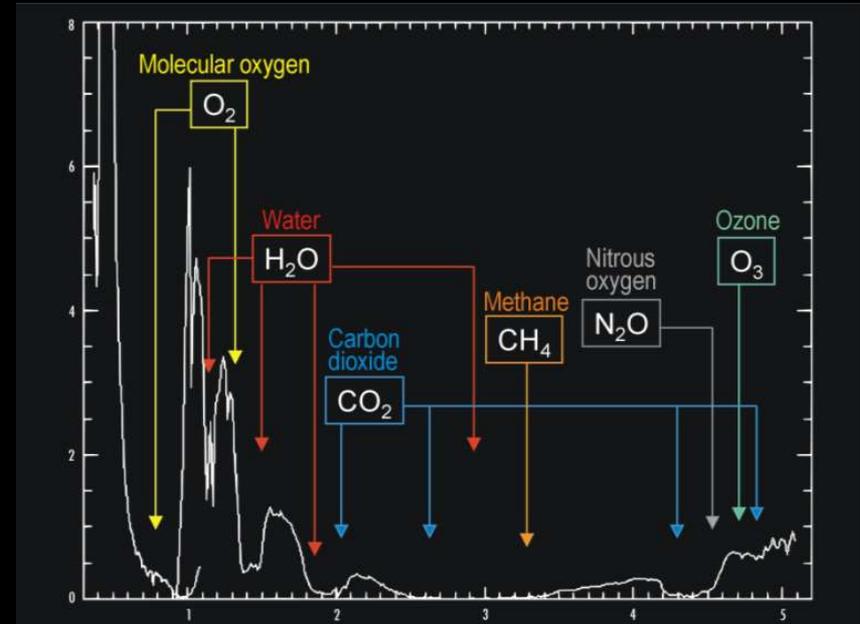


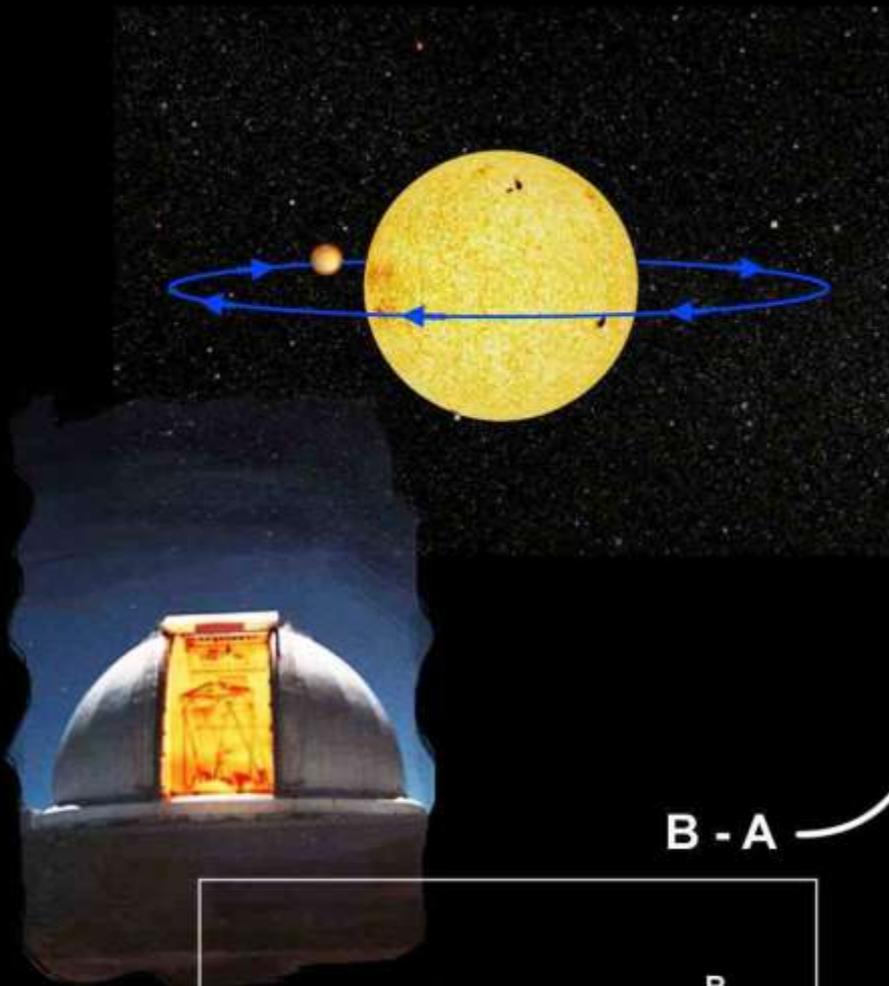
Mars



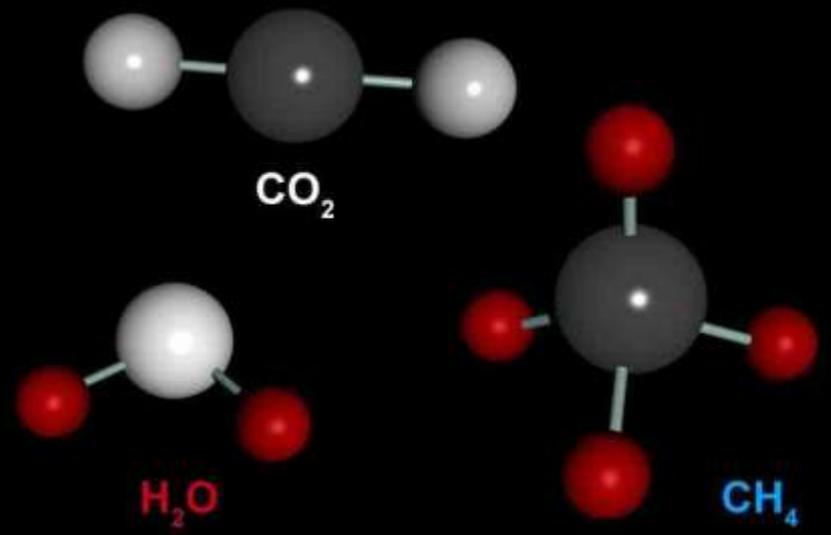
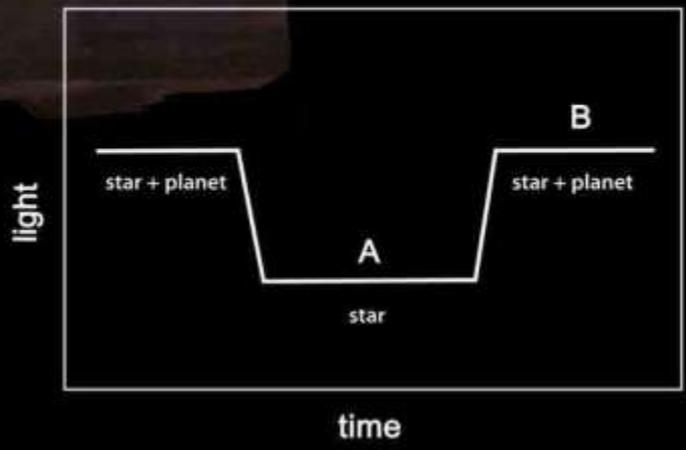
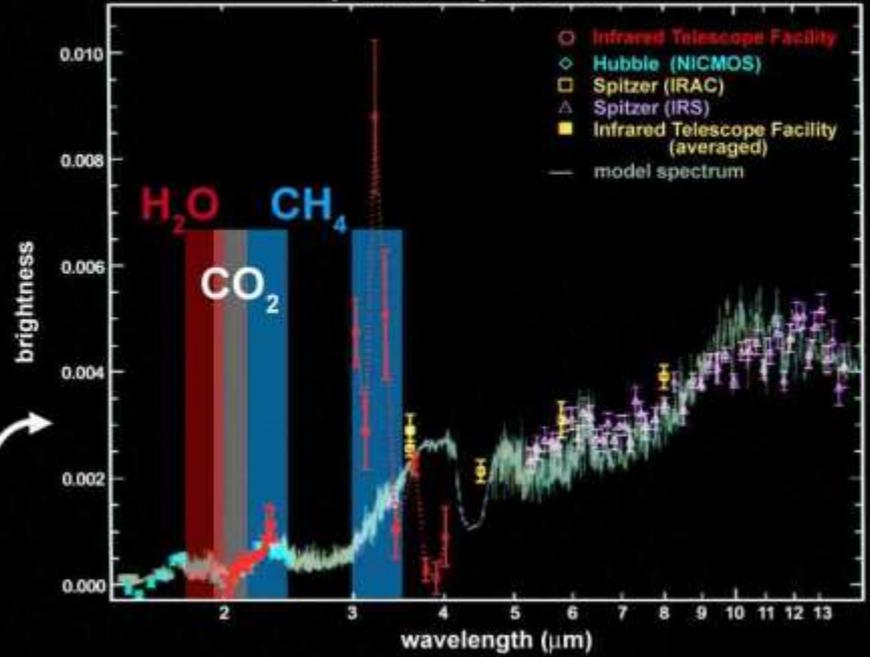
Could there be ET life like us on those planets?

Finding water, carbon dioxide, and especially **oxygen** would be a very big clue, but we really don't know!





planet spectrum



Could there be ET life like us on those planets?

Finding water, carbon dioxide, and especially **oxygen** would be a very big clue, but we really don't know!

If life *does* exist, what would it look like?

How would this depend on the type of planet and star?...

