DISCOVER THE UNIVERSE

À LA DÉCOUVERTE DE L'UNIVERS

WORKSHOP FOR TEACHERS
LEVEL 2

WEEK 3
ARE WE ALONE?

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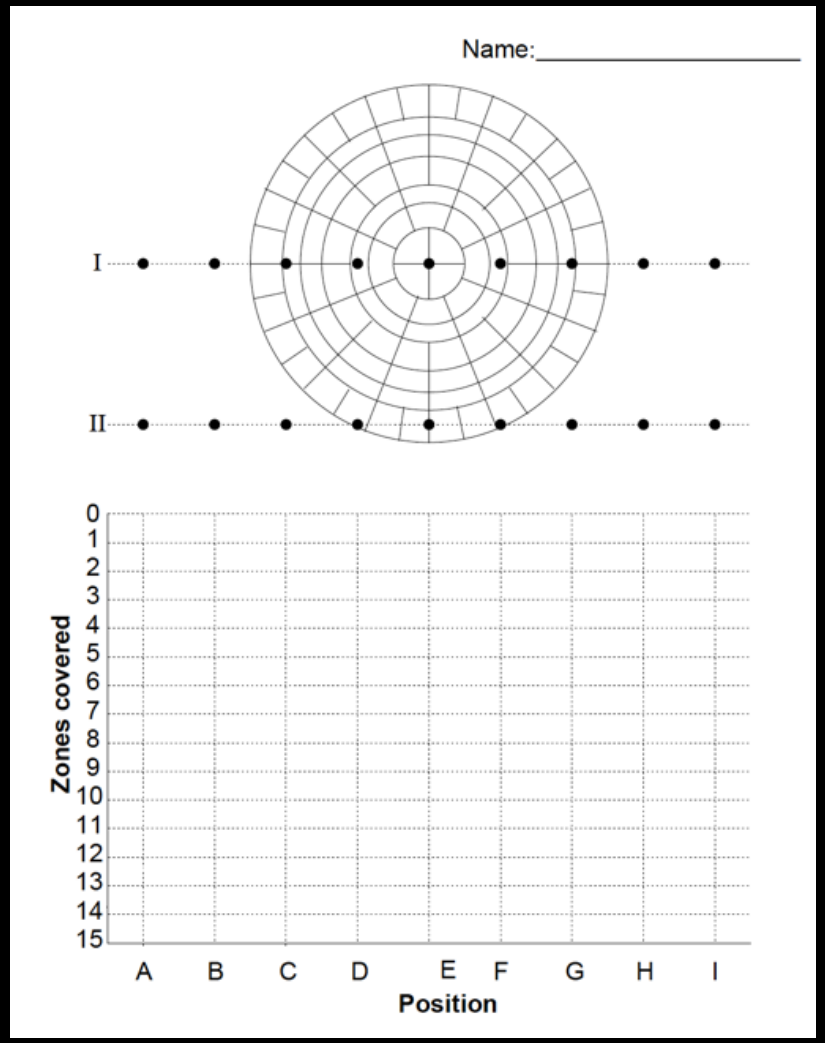
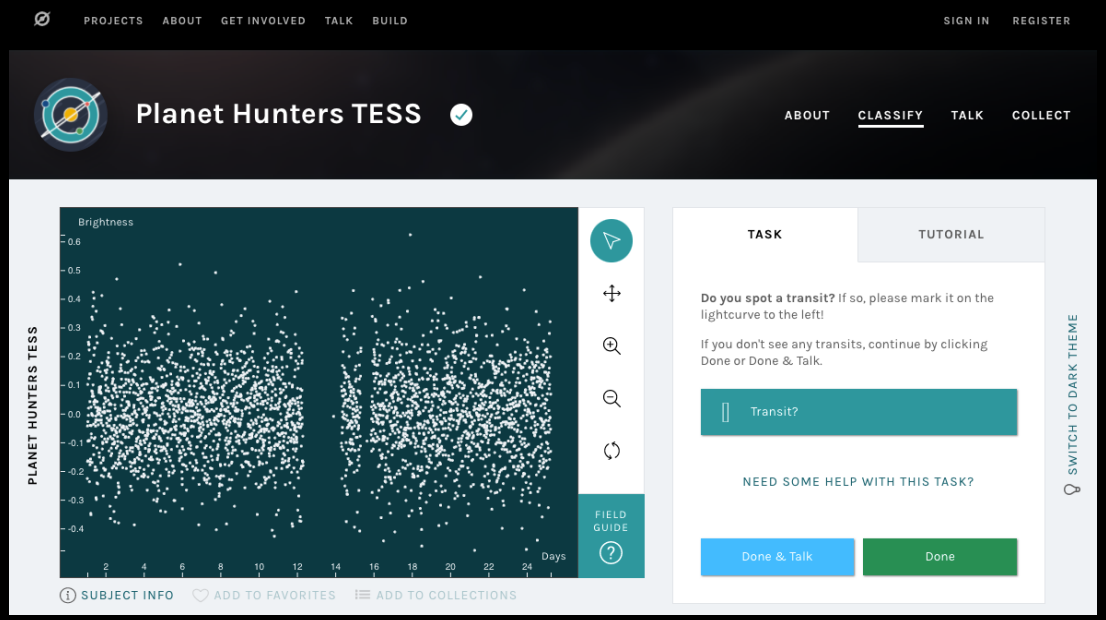
ACTIVITY

PDF document – Transit Activity

See video #5

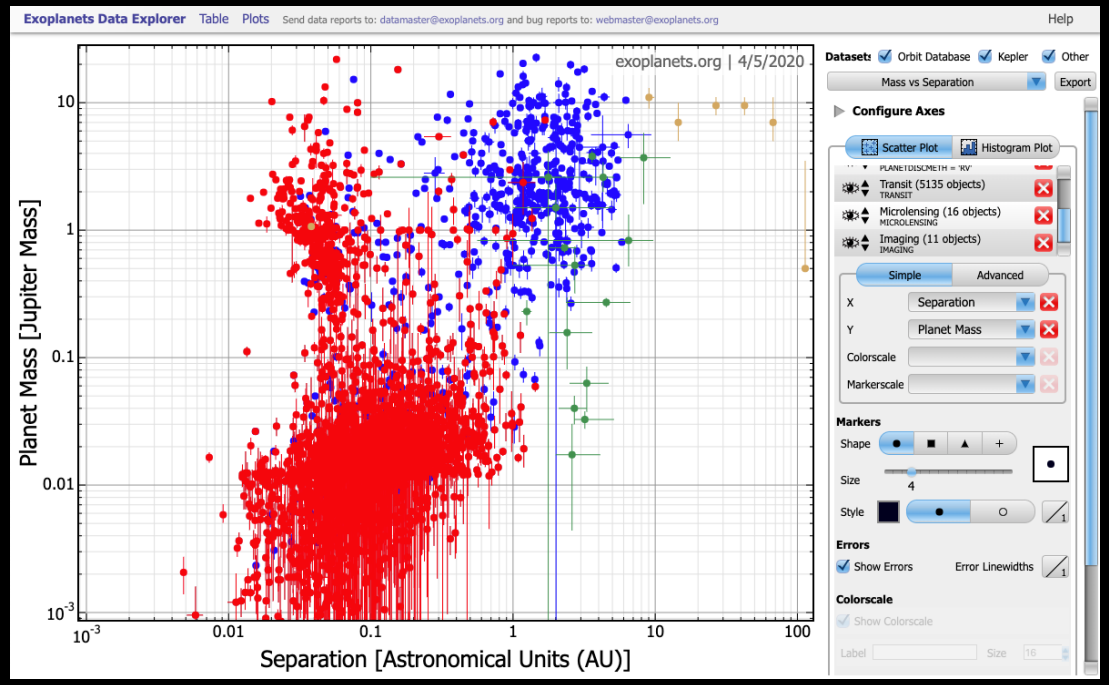


INTERACTIVE WEB SITES



PlanetHunters.org

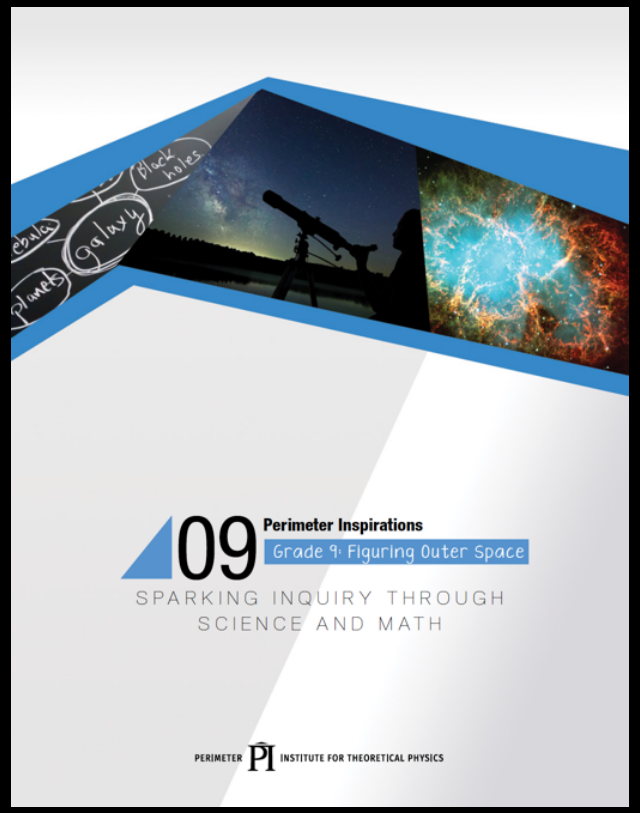
See video #6



Exoplanets.org

See video #7

PERIMETER INSTITUTE



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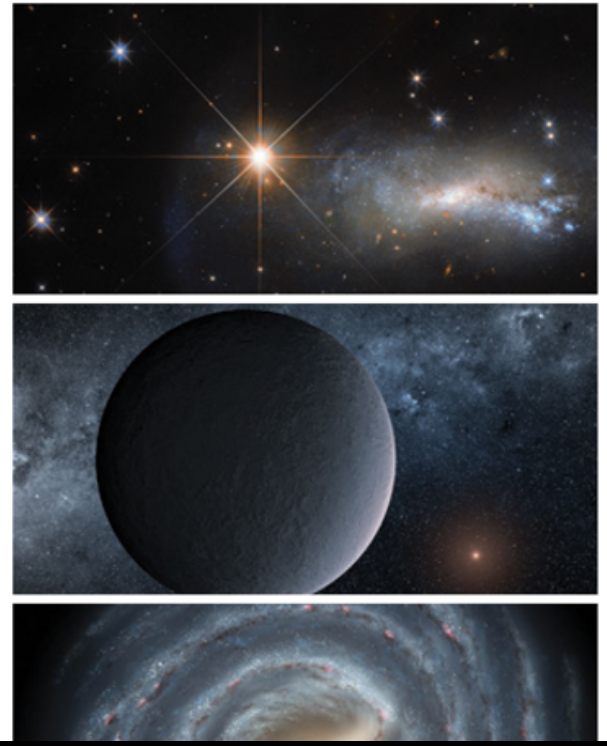

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CONDITIONS FOR LIFE

We only know one example of life: Earth-based life.

Although living species are very diverse, all life on Earth has similar characteristics (cells, DNA ...).

What are the conditions necessary for life as we know it?

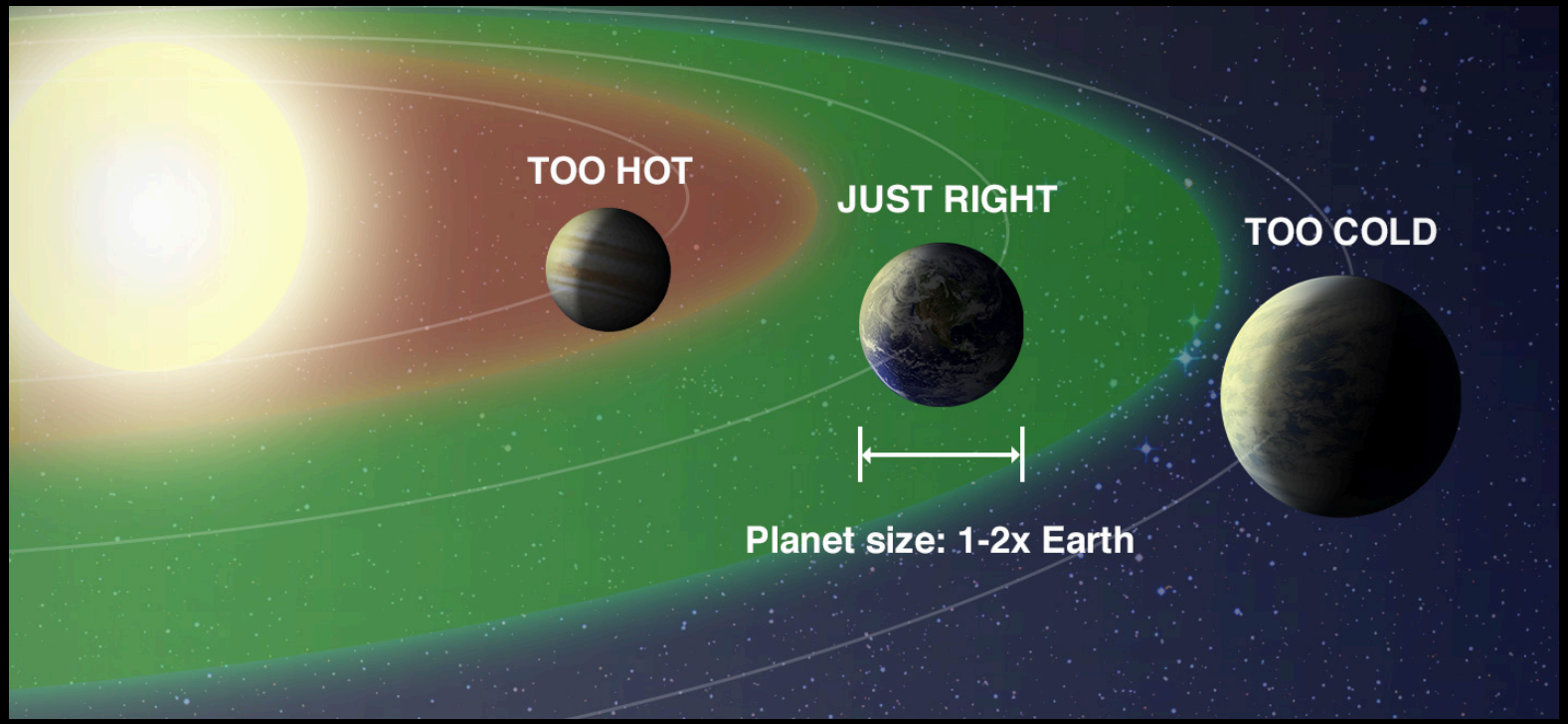
Credit: NASA
https://epic.gsfc.nasa.gov/

We're looking for a world (planet, moon) with a solid surface that receives energy from a star. This world must be neither too hot nor too cold.

Artist's impression

Life as we know it needs liquid water. Surface temperature must therefore be between 0°C and 100 °C.

It's possible to calculate the region around a star with these conditions: it's called the "habitable zone" (bad term!).

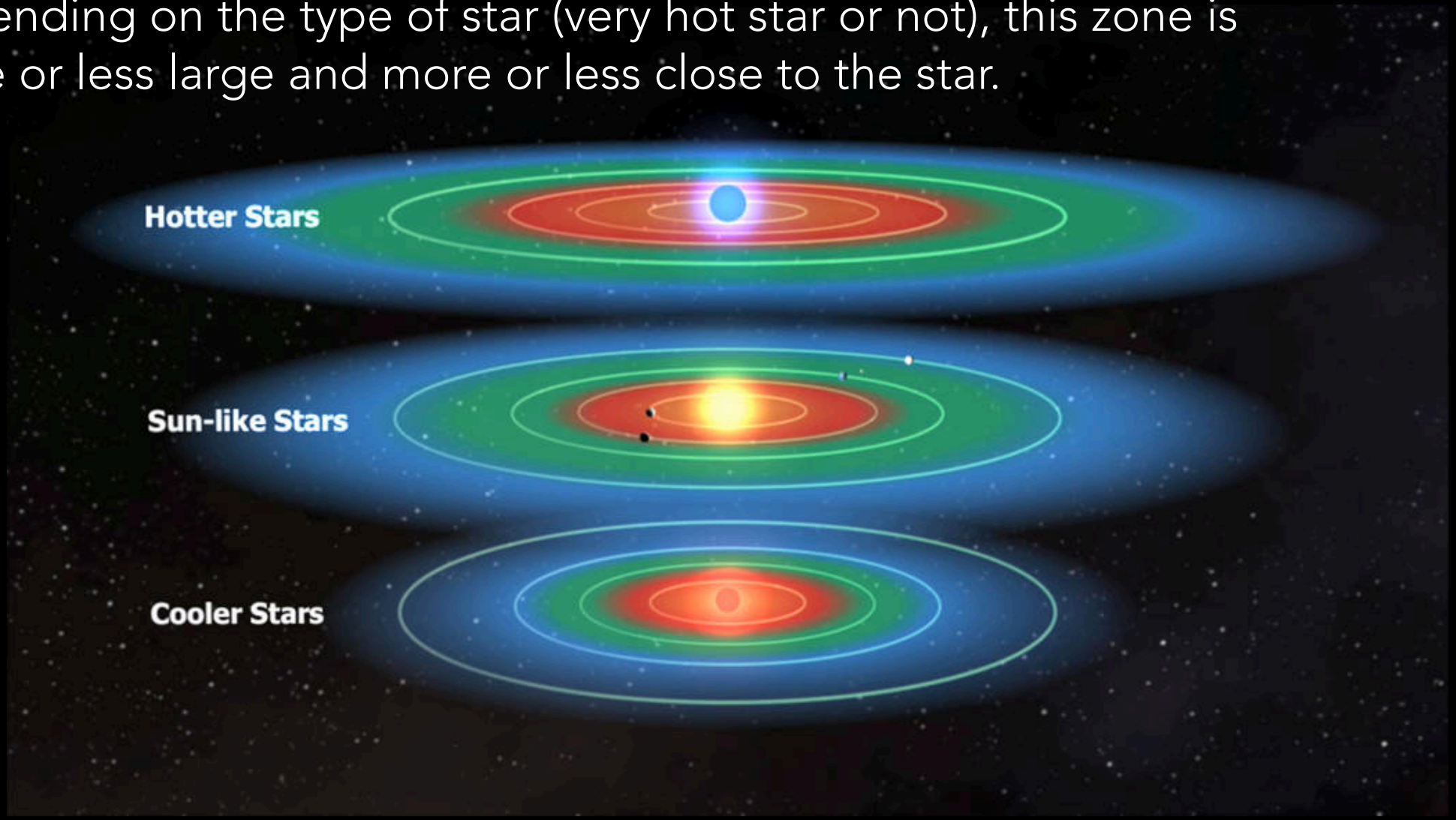


It doesn't mean:

- there's life on the planet, or
- that we could live there.

Credit: NASA
https://exoplanets.nasa.gov/what-is-an-exoplanet/how-do-we-find-habitable-planets/

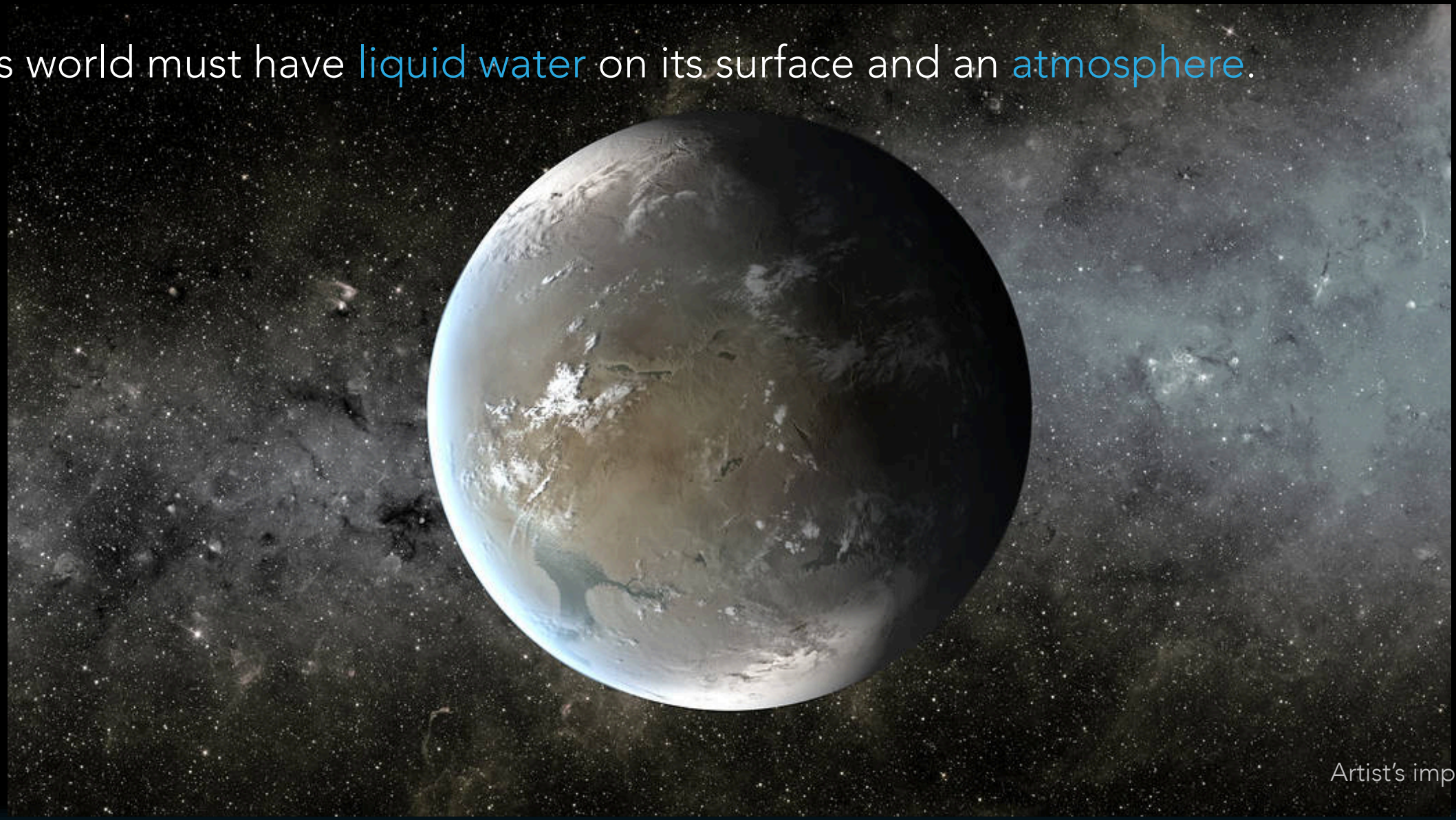
Depending on the type of star (very hot star or not), this zone is more or less large and more or less close to the star.



Artist's impression
Not to scale

Credit: NASA
https://www.nasa.gov/ames/kepler/habitable-zones-of-different-stars

This world must have liquid water on its surface and an atmosphere.



Artist's impression

Credit: NASA Ames/JPL-Caltech/T. Pyle
https://www.nasa.gov/content/kepler-62f-small-habitable-zone-world

CONDITIONS FOR LIFE

- Rocky planet or moon
- Good temperature (energy source)
- Liquid water
- Atmosphere
- Also: right elements for life (CHNO), magnetic field…

But…

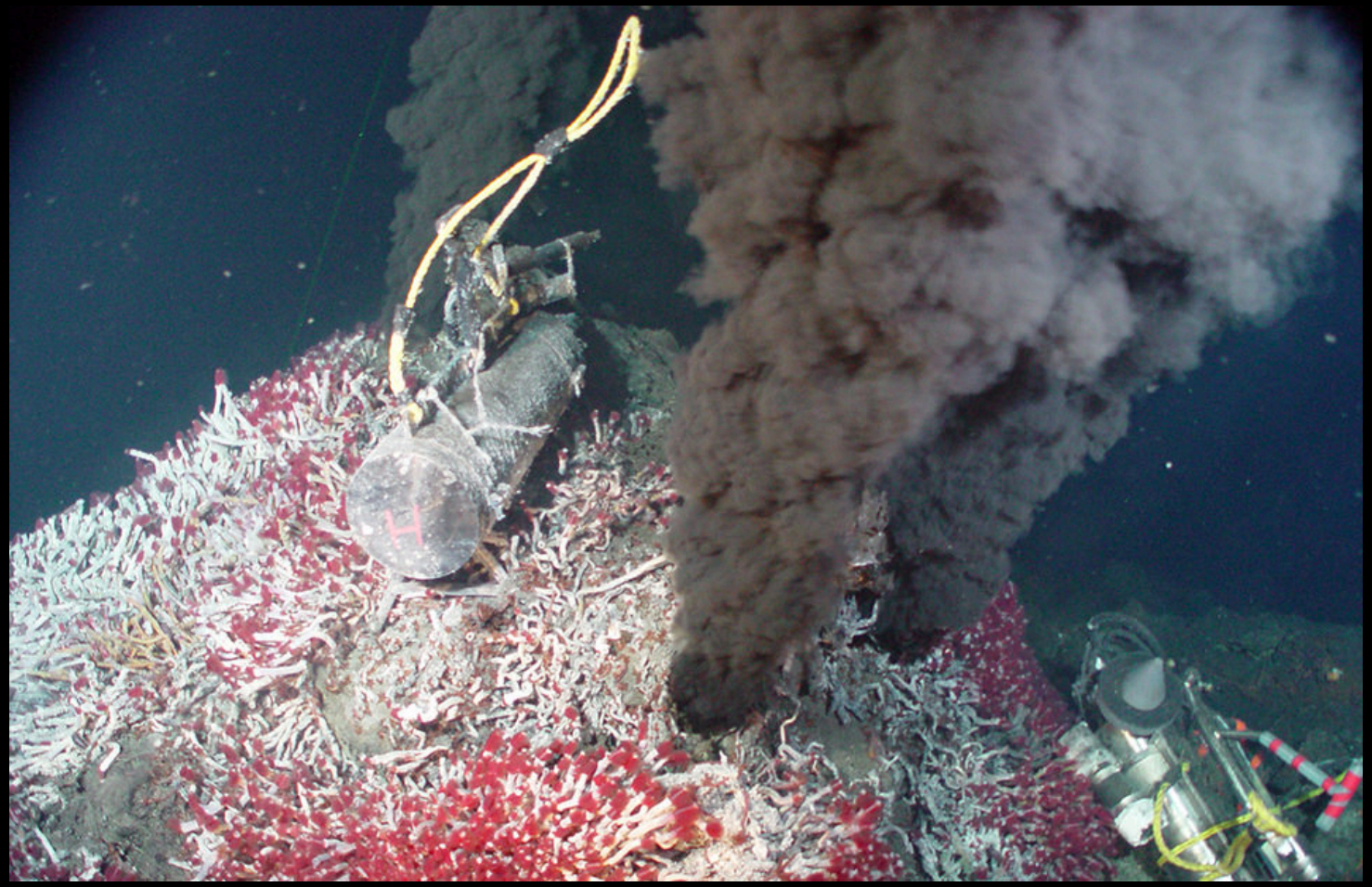
- extremophiles…
- other types of life?
- hydrothermal vents…

Tardigrades can survive heat, cold, high pressure, vacuum in space, radiation, dehydration…

Credit: Goldstein lab-tartigrade / Wikipedia
https://commons.wikimedia.org/wiki/File:Adult_tardigrade.jpg

Some species live off the energy generated by the Earth itself (not the Sun), near hydrothermal vents at the bottom of the ocean.

However, it would be very difficult to discover extraterrestrial life at the bottom of oceans…



Credit: NOAA
https://oceanservice.noaa.gov/facts/vents.html

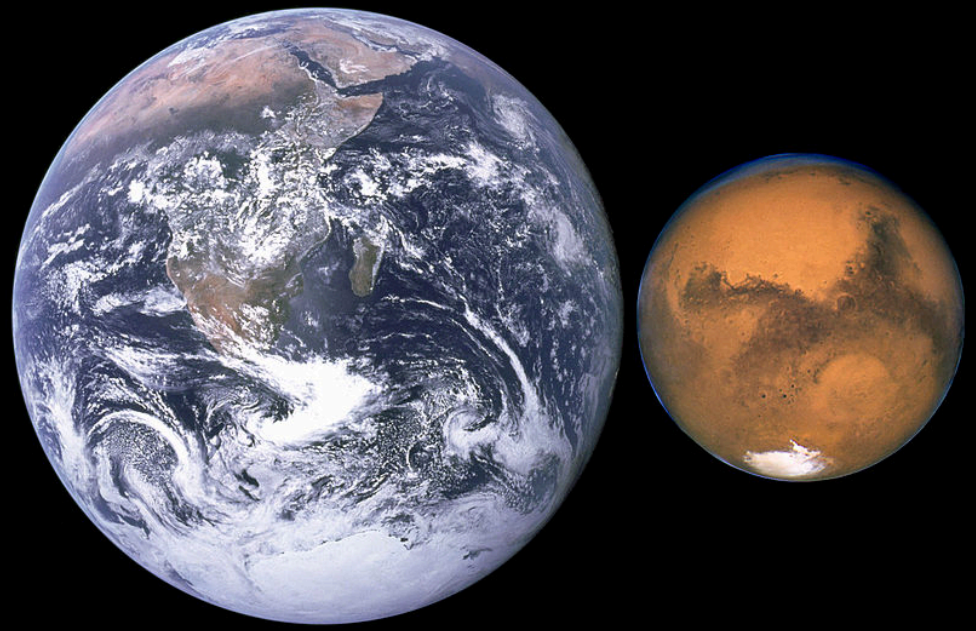
SEARCH FOR LIFE IN THE SOLAR SYSTEM

The search for *primitive* life in the Solar system is first and foremost a search for liquid water.

Where can we find liquid water today?

Where can we find proof of liquid water in the past?

MARS



EARTH

Day: 24 hours
Mean temperature: 14°C
Atmosphere: nitrogen, oxygen

MARS

Day: 24.6 hours
Mean temperature: -60°C
Atmosphere: carbon dioxide
Gravity: 37% Earth gravity

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Credit: NASA
https://commons.wikimedia.org/wiki/File:Mars,_Earth_size_comparison.jpg

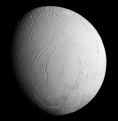
Ice can be found at the poles of Mars and below the surface. There is also water vapor in its atmosphere.

Several observations lead to the idea that Mars had liquid water on its surface in the past.

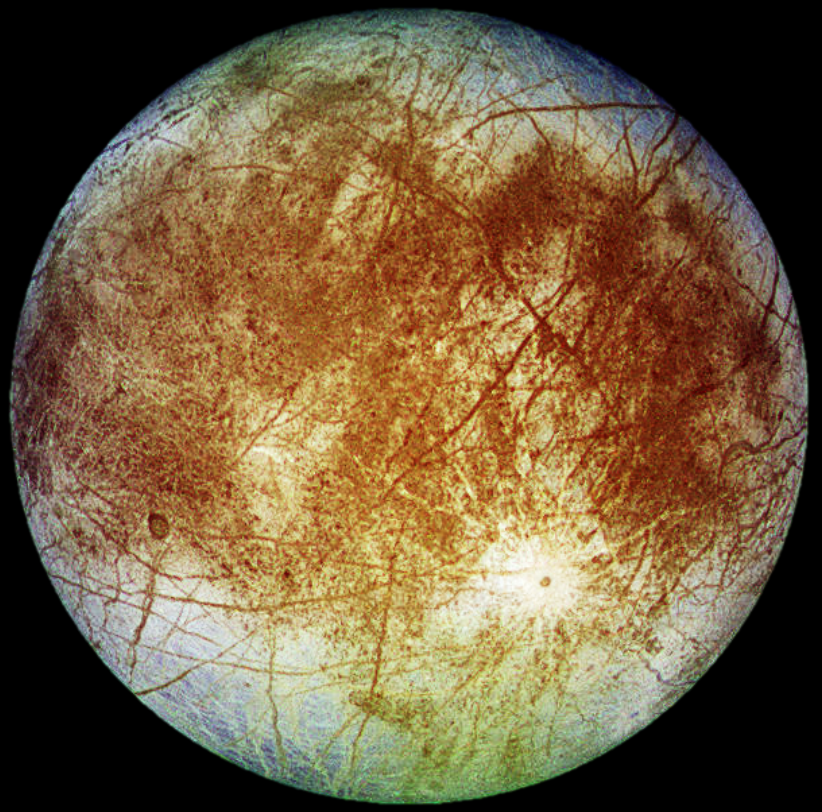
Has there ever been a primitive form of life?

Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA), J. Bell (ASU), and M. Wolff (Space Science Institute)
http://hubblesite.org/image/3733/news/62-mars

FROZEN MOONS



Enceladus, around Saturn

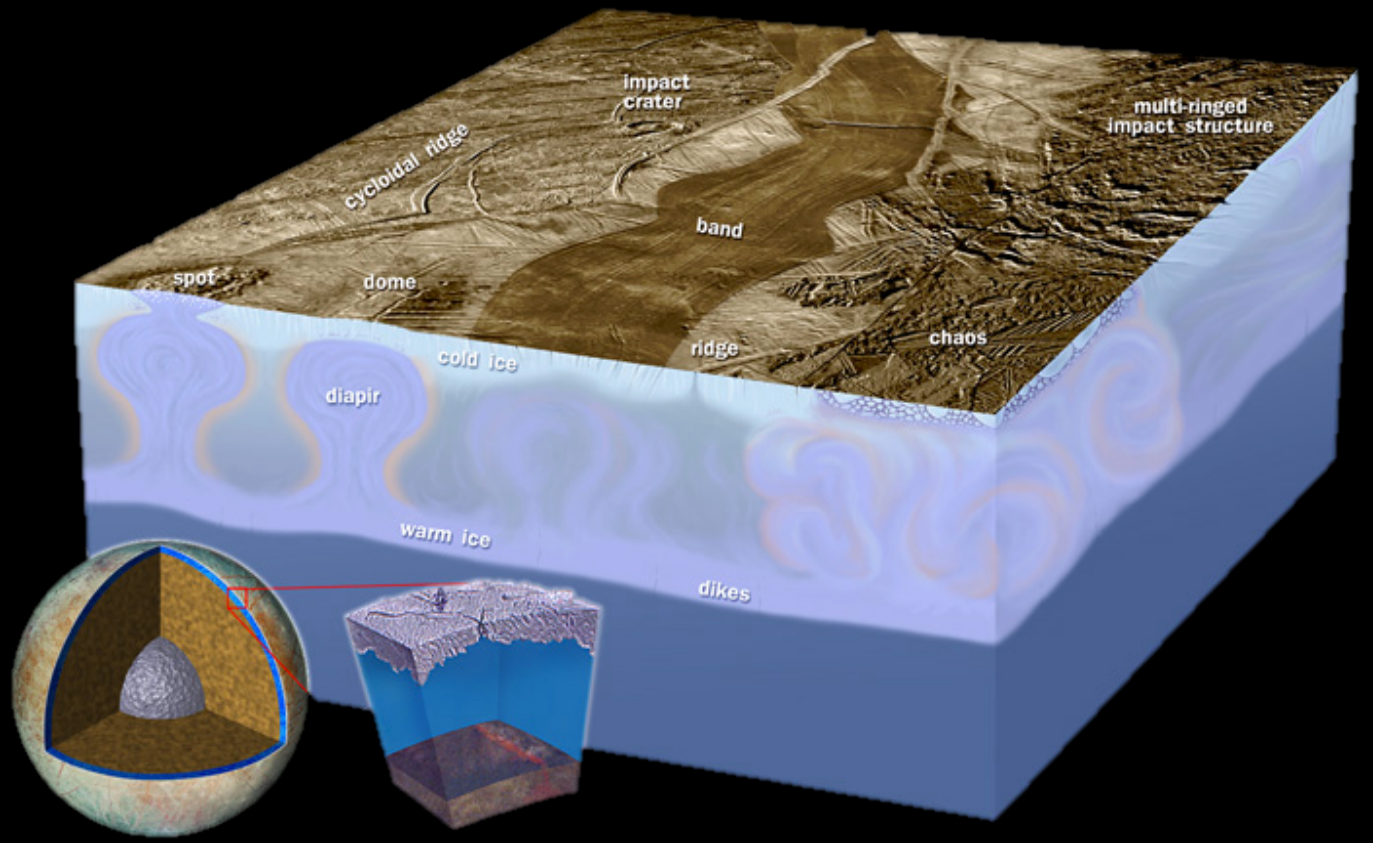


Europa, around Jupiter

Credits: : Europe: NASA/JPL/DLR, https://photojournal.jpl.nasa.gov/catalog/PIA00502
Enceladus: NASA/JPL-Caltech/Space Science Institute, https://photojournal.jpl.nasa.gov/catalog/PIA17202

EUROPA

Studies of Europa show that there would be a vast ocean of liquid water under its frozen surface. The total volume of water on Europa could be greater than the volume of water on Earth!

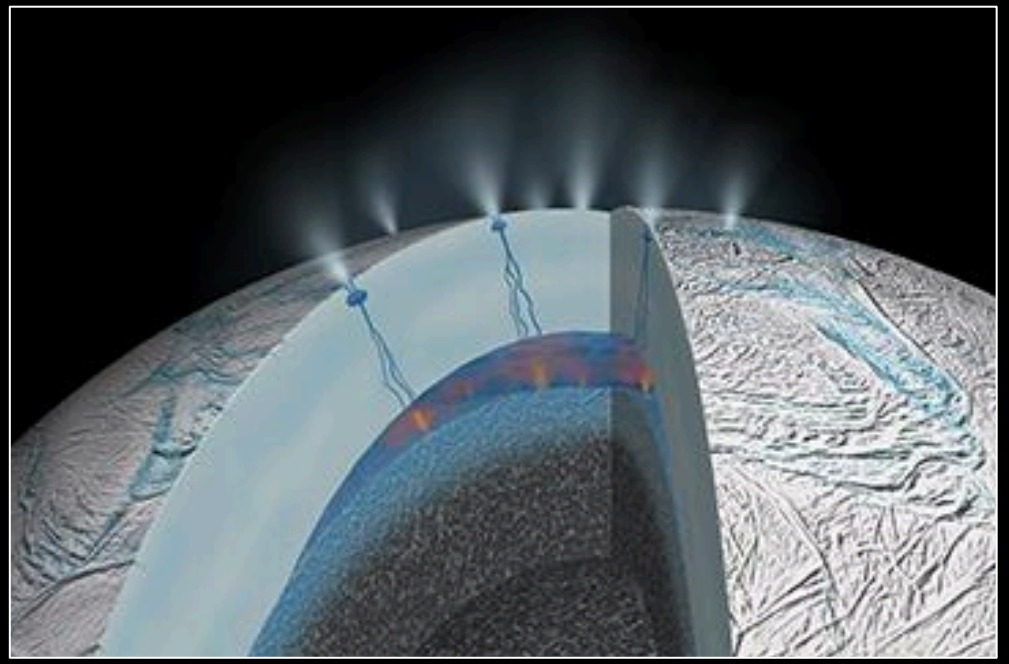


Credit : NASA
https://photojournal.jpl.nasa.gov/jpeg/PIA01669.jpg

ENCELADUS

We can see water-rich plumes on Enceladus' surface. These could be coming from hydrothermal vents at the bottom of the sub-surface ocean.

Picture taken by the Cassini spacecraft



Artist's impression

Credits: : Left: NASA/JPL-Caltech, Space Science Institute, https://photojournal.jpl.nasa.gov/catalog/PIA17184
Right: NASA/JPL-Caltech, https://saturn.jpl.nasa.gov/resources/6169/?category=images

SEARCH FOR LIFE OUTSIDE THE SOLAR SYSTEM

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EXOPLANETS

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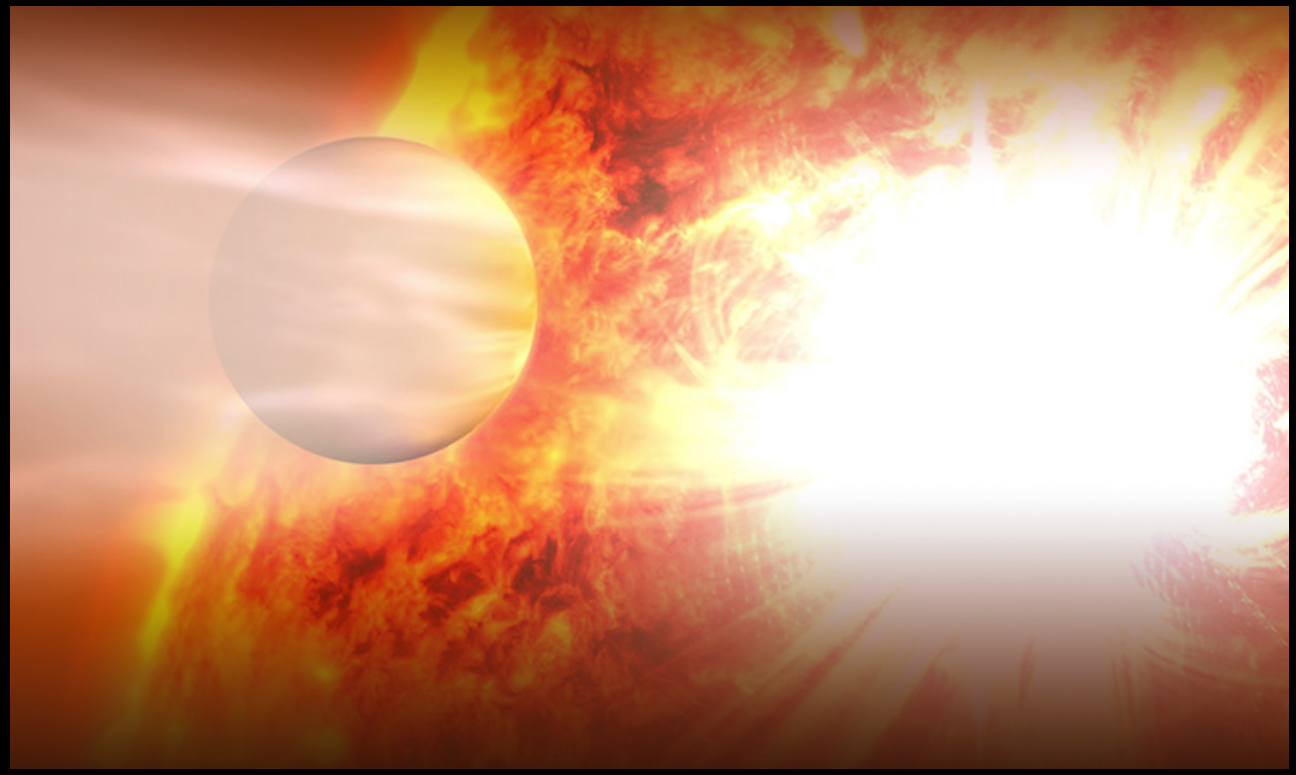
EXOPLANETS

The first exoplanet was discovered in 1995: 51 Pegasi b. This planet was surprising: it's bigger than Jupiter and extremely close to its star (orbits in 4 days).

Several such planets were discovered in the following years: hot Jupiters.



Artist's impression

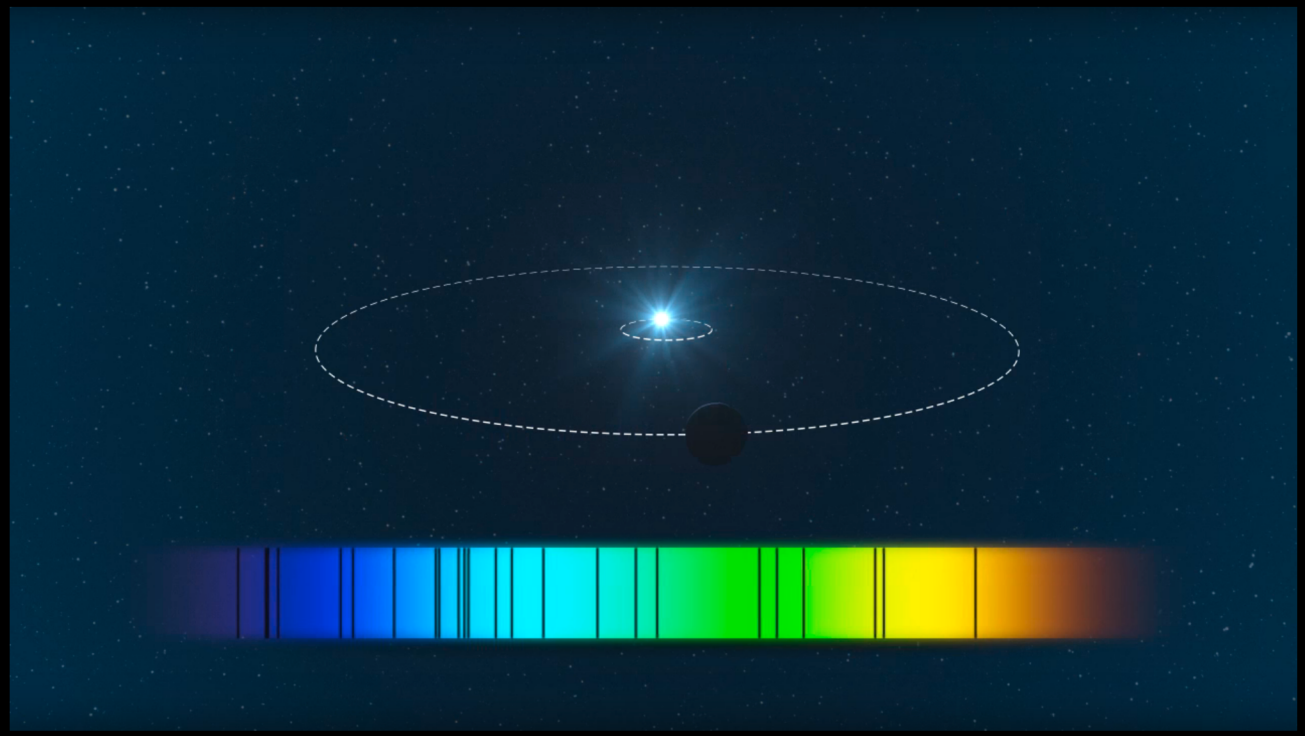
Credit: NASA
https://exoplanets.nasa.gov/resources/289/

Different methods exist to discover exoplanets even when we can’t see them (in the vast majority of cases).

Scientists are extremely creative to find ways to decode the information in the light coming from the stars….

The radial velocity method uses the motion of the star to discover the planet. This information is encoded in the spectrum of the star.

This methods only works if the planet is massive enough to make the star wobble.

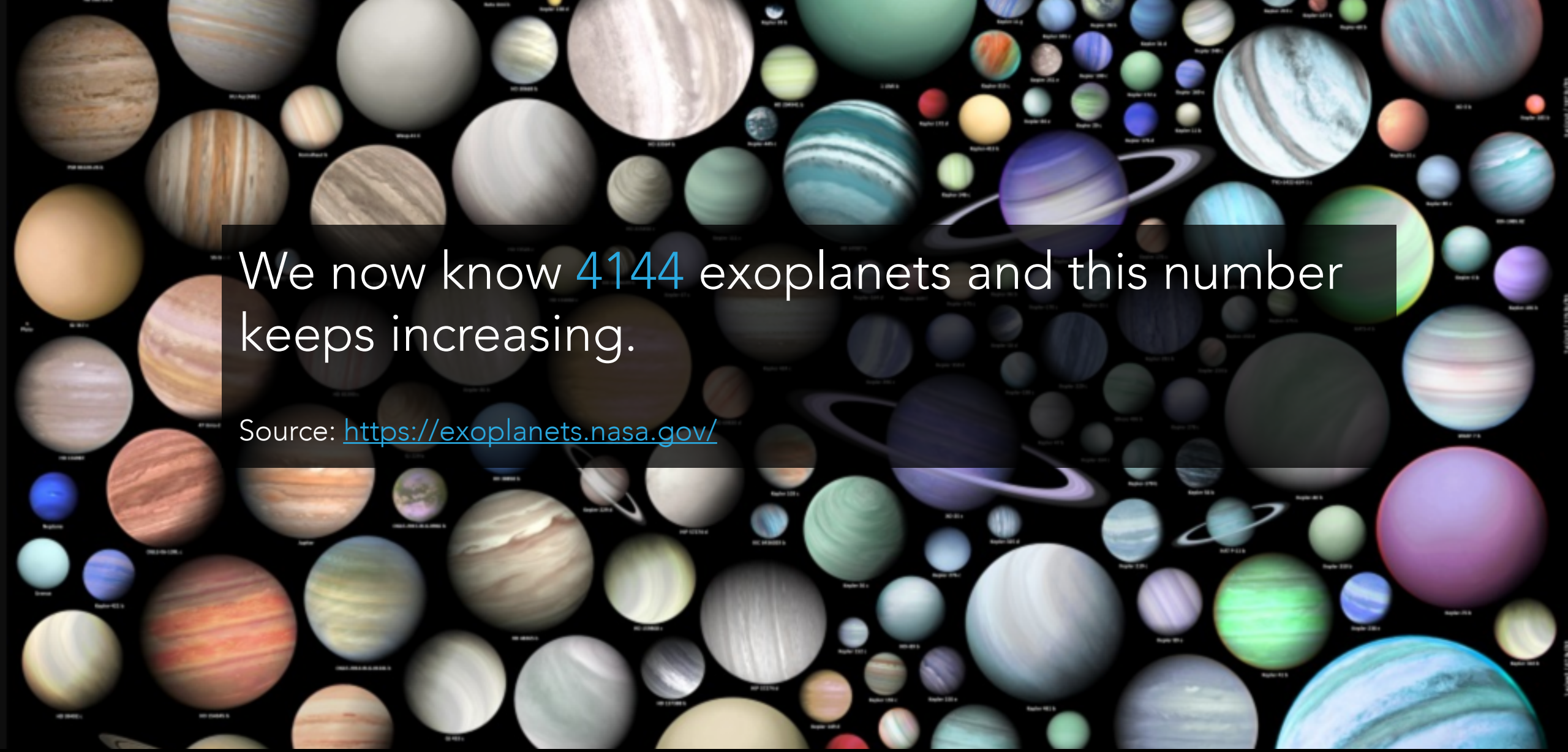


Credit: ESO/L. Calçada
https://www.eso.org/public/videos/eso1035g/

When the star moves away from us: spectral lines are red-shifted; when the star moves towards us: the spectral lines are blue-shifted. This is due to the Doppler effect.

www.eso.org

Credit: ESO/L. Calçada
https://www.eso.org/public/videos/eso1035g/



We now know 4144 exoplanets and this number keeps increasing.

Source: https://exoplanets.nasa.gov/

Artist's impression

Crédit: © Martin Vargic

https://www.halcyonmaps.com/exoplanets/

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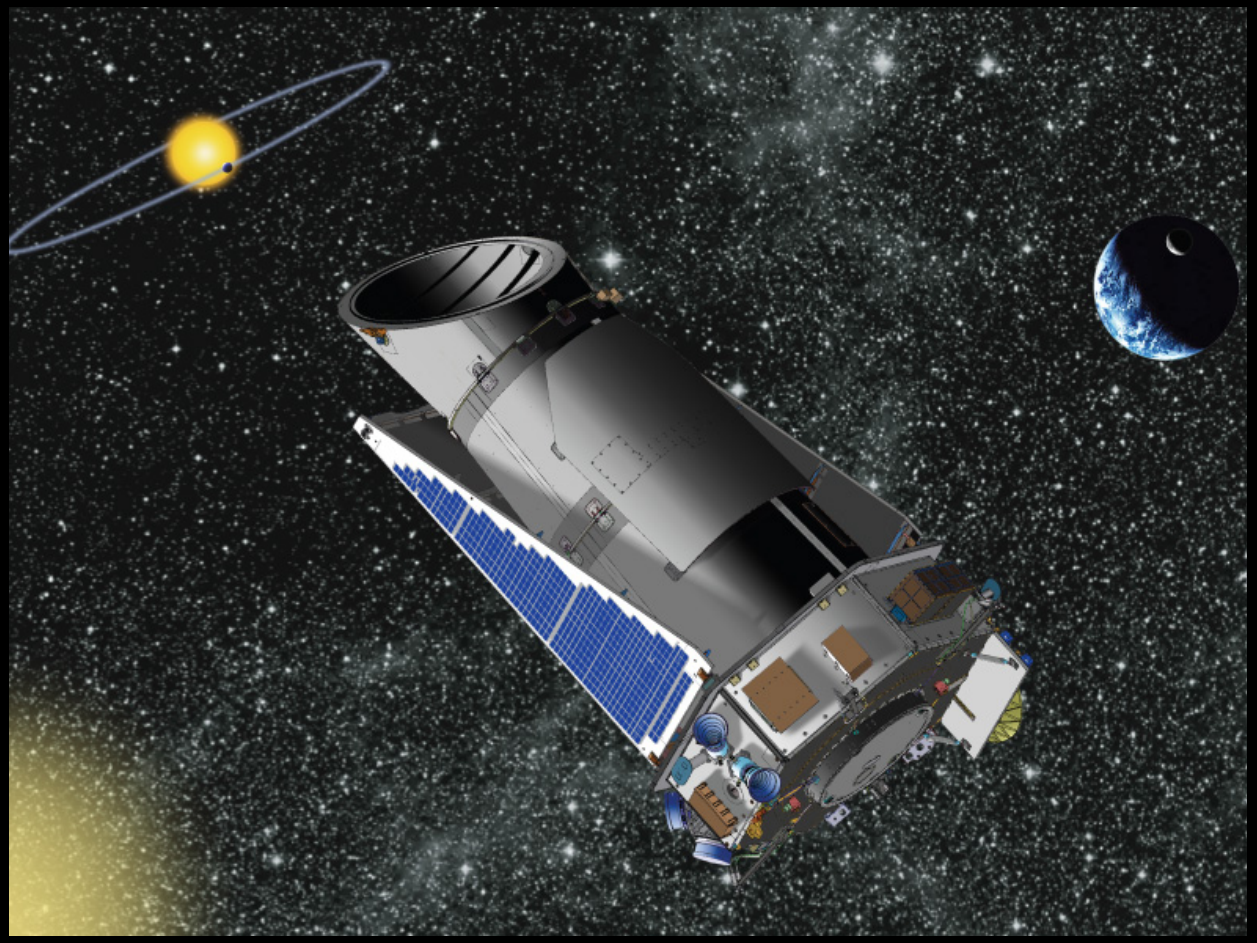
From 2009 to 2018, the Kepler space telescope discovered over 2500 exoplanets and revolutionized our understanding of exoplanets.

We now know there are more planets than stars in our galaxy…



Credit: NASA
https://www.nasa.gov/centers/ames/multimedia/images/2007/kepler_iotd.html

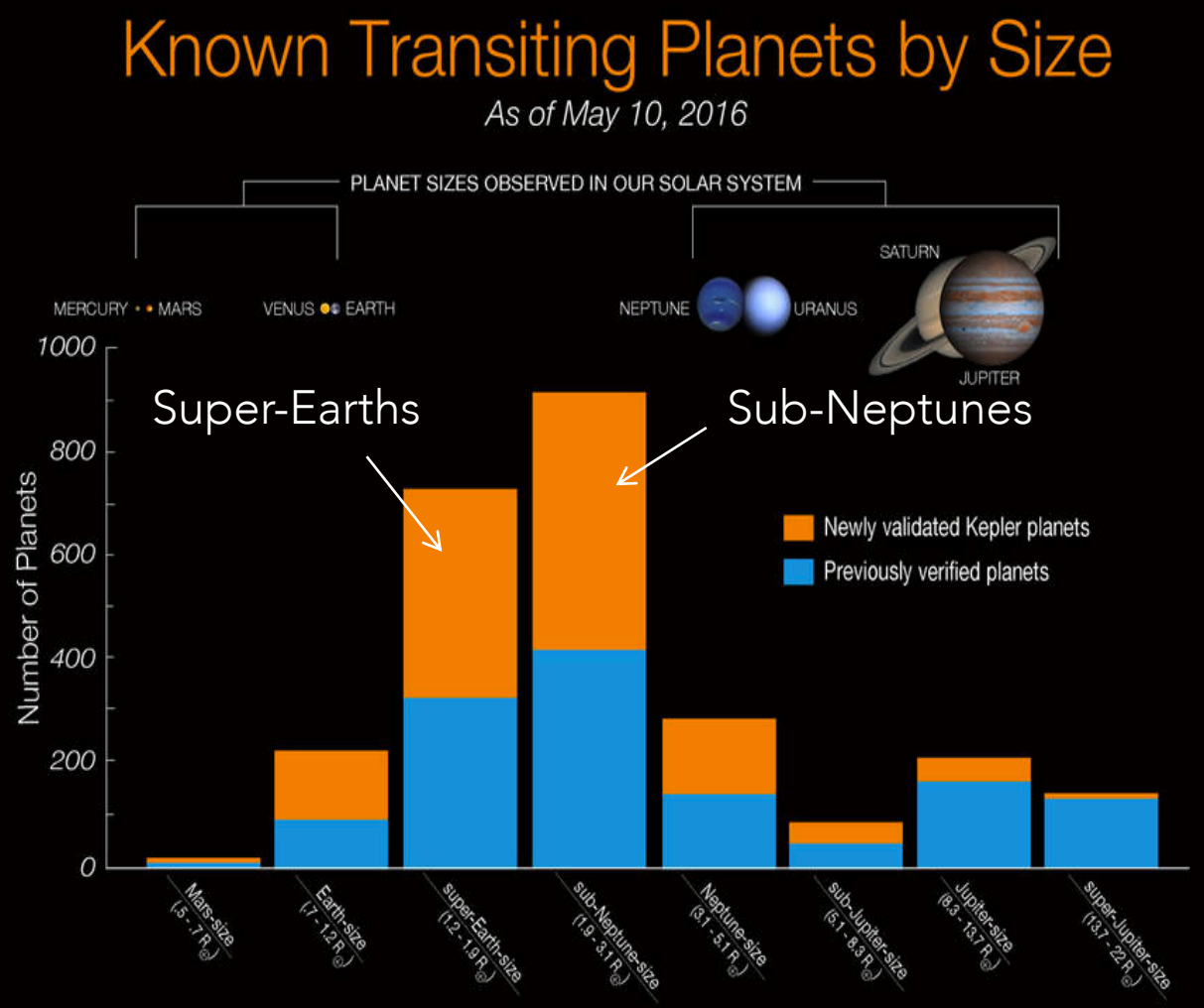
The Kepler telescope used the transit method to discover exoplanets.

Credit: NASA
https://exoplanets.nasa.gov/alien-worlds/ways-to-find-a-planet/#/2

Credit: NASA
https://exoplanets.nasa.gov/alien-worlds/ways-to-find-a-planet/#/2

Credit: NASA
https://exoplanets.nasa.gov/alien-worlds/ways-to-find-a-planet/#/2

In the Solar system, we find two main types of planets: small rocky planets and gas giants. The Kepler telescope showed that many more types exist…



Credit: NASA Ames / W. Stenzel
https://www.nasa.gov/feature/ames/kepler/briefingmaterials160510

In the media, when we talk about exoplanets which are

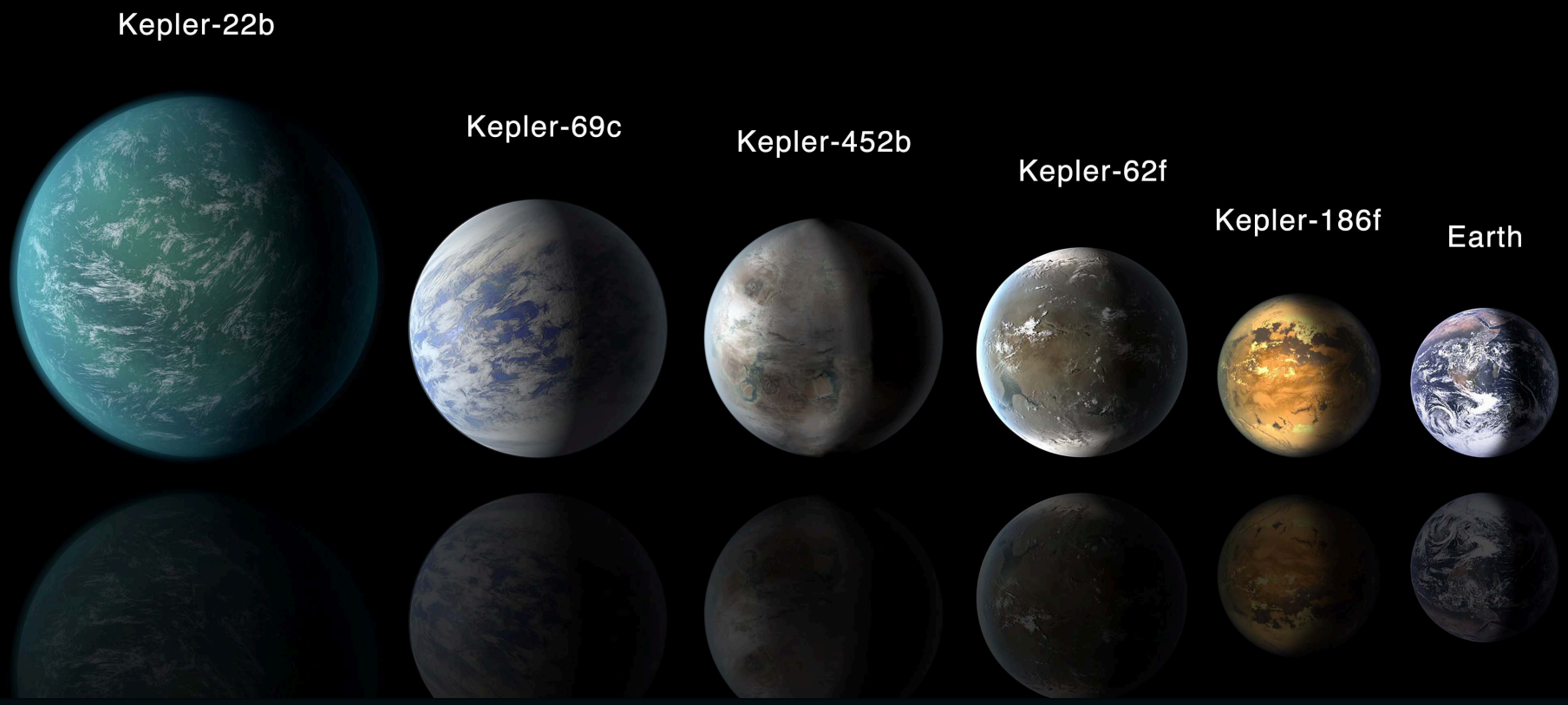
- habitable,
- Earth-like, or
- Earth twin;

it means:

- a planet with a size similar to Earth;
- and in the habitable zone around its star.

We don’t know what kind of atmosphere it has or the real conditions on its surface.

Scientists are just starting to be able to study exoplanet atmospheres. They'll be looking for biosignatures (oxygen, methane…)



Artist's impressions

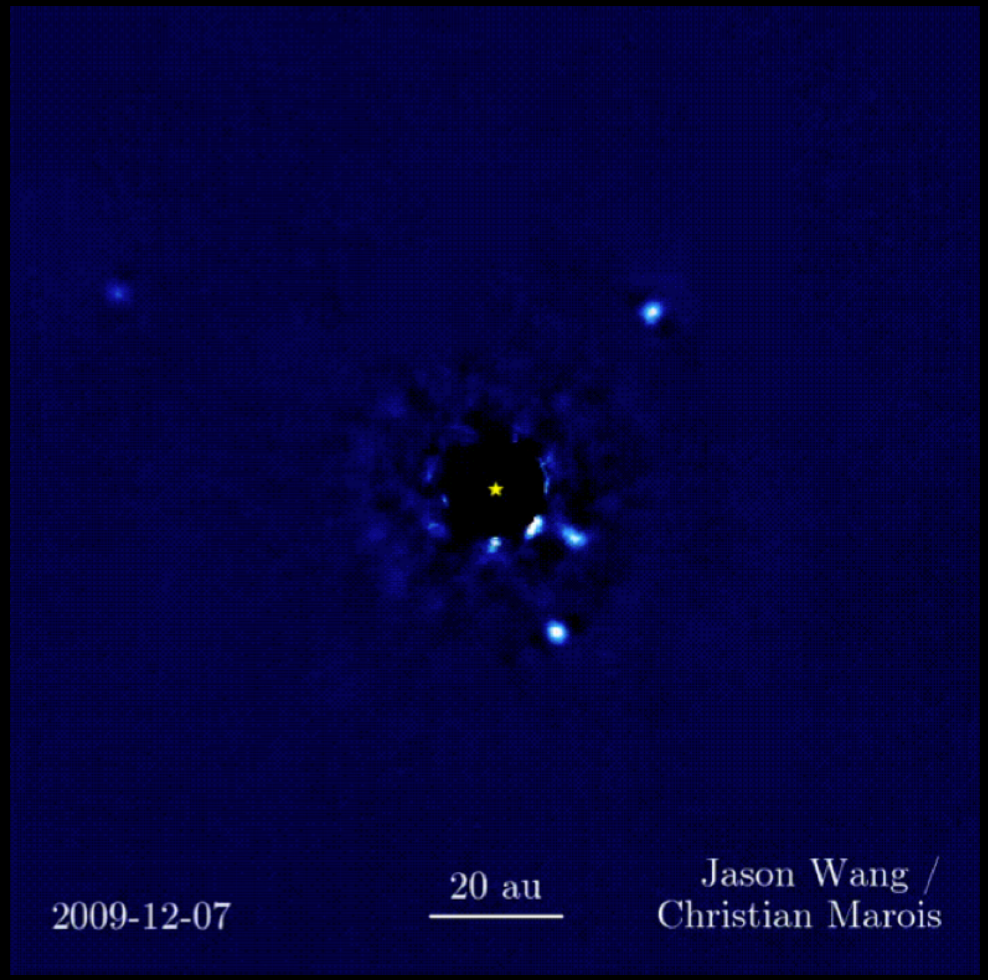
Credit: NASA/Ames/JPL-Caltech
https://exoplanets.nasa.gov/news/207/finding-another-earth/

The first picture of an exoplanet (direct imaging) was taken in 2008, by an international team of astronomers, including a few Canadians.

Christian Marois

René Doyon

David Lafrenière



Credit: Jason Wang et Christian Marois
https://commons.wikimedia.org/wiki/File:HR_8799_Orbiting_Exoplanets.gif

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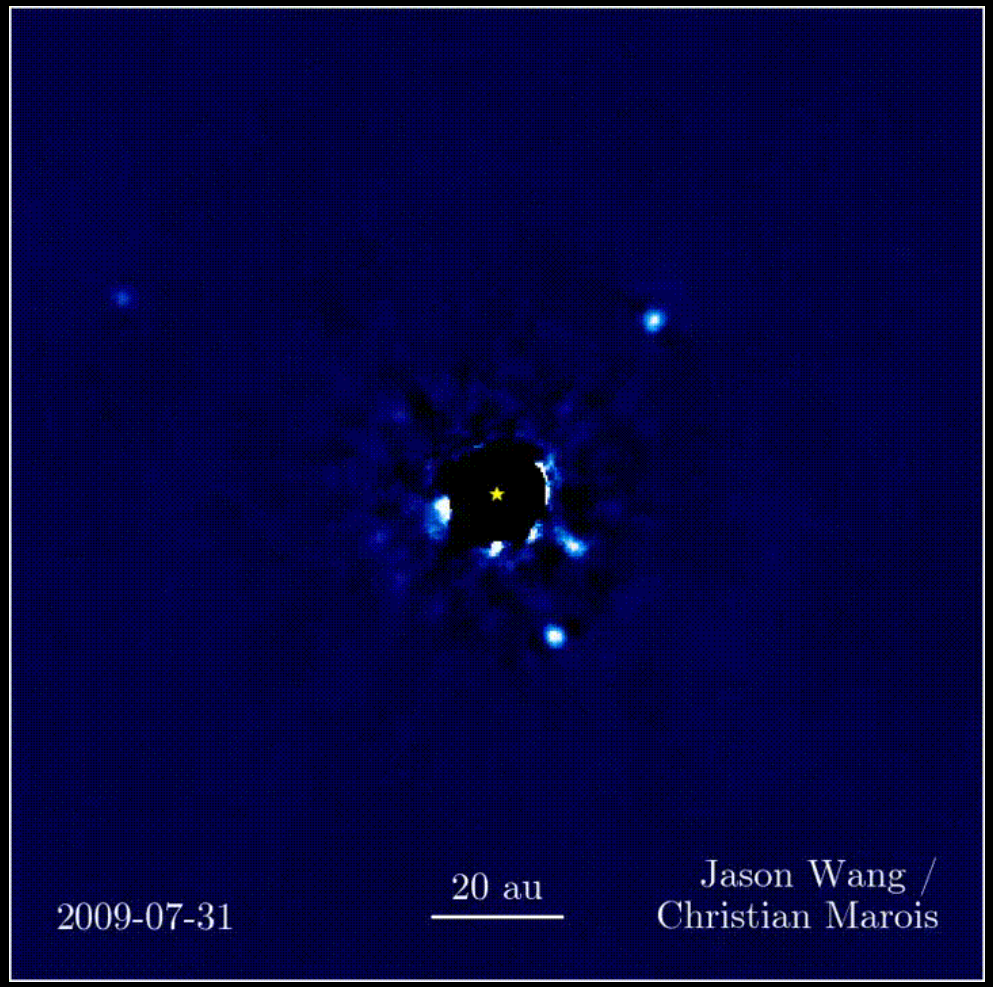
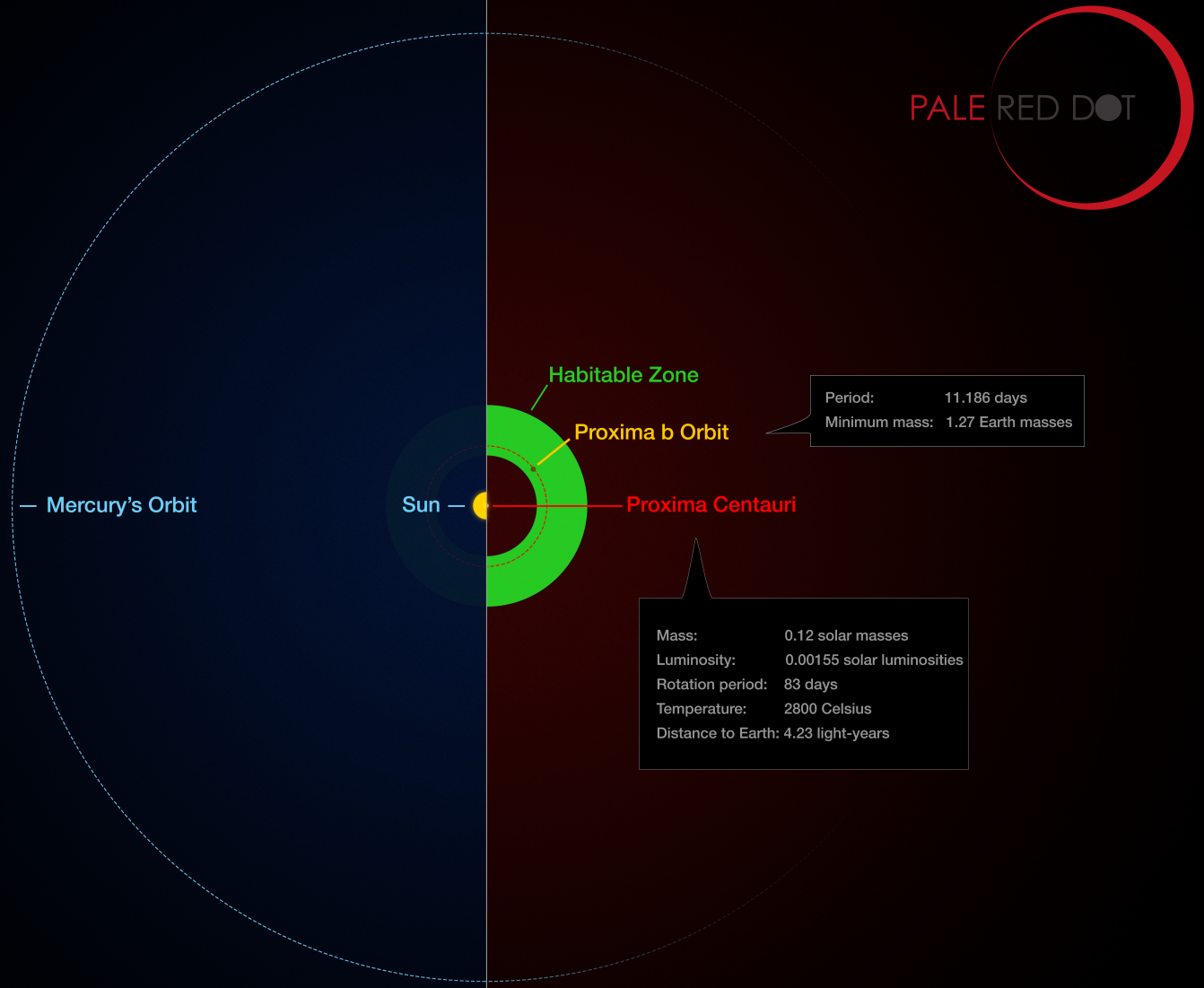


Credit: Jason Wang et Christian Marois
https://commons.wikimedia.org/wiki/File:HR_8799_Orbiting_Exoplanets.gif

A FEW INTERESTING PLANETARY SYSTEMS...

PROXIMA CENTAURI

Earth-size exoplanet in the habitable zone around our neighbour star only 4.2 light-years away.



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Credit: ESO/M. Kornmesser/G. Coleman
http://www.eso.org/public/news/eso1629/

Imagined view from the surface of Proxima Centauri b, with the three stars of the system seen in the sky.

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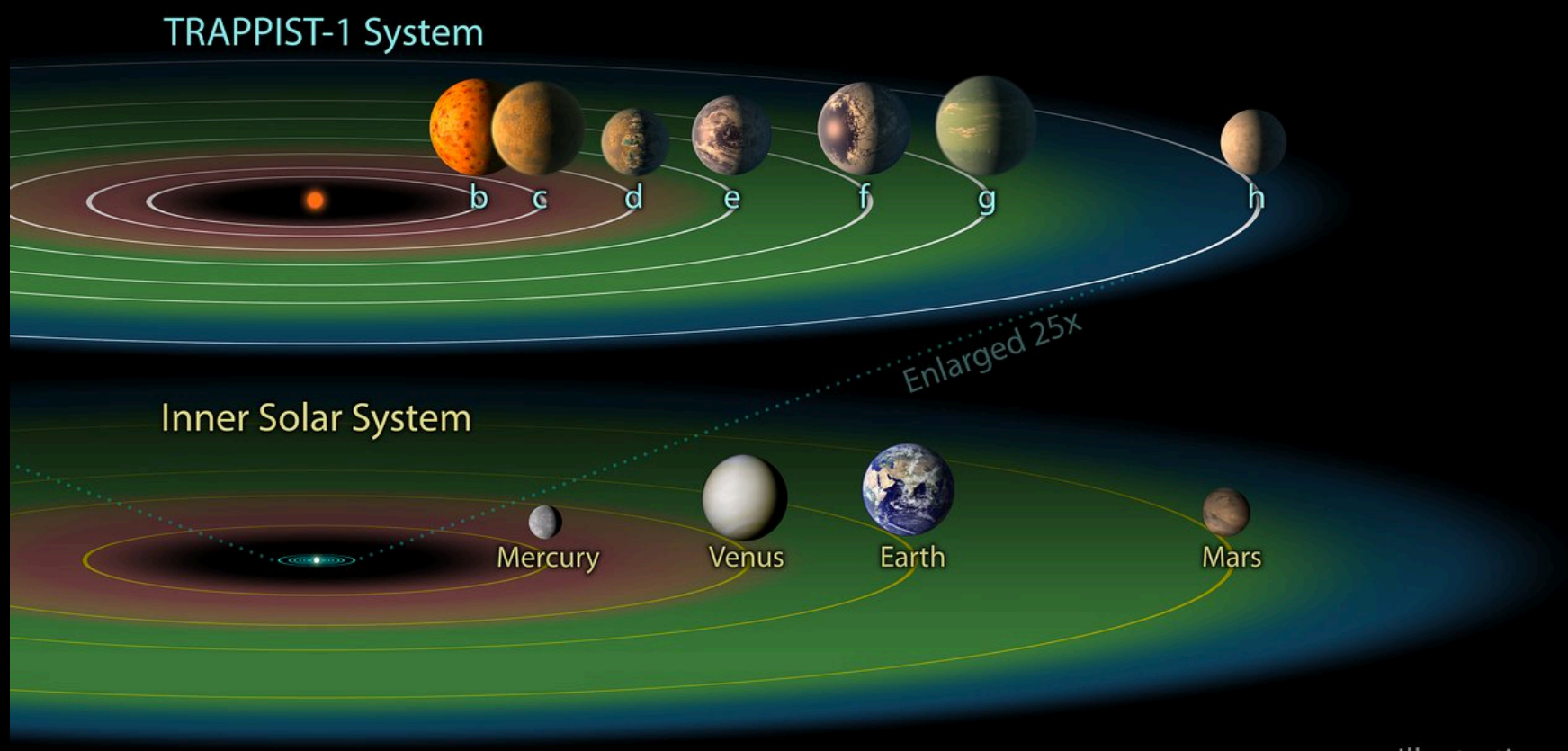
Credit: ESO/M. Kornmesser
https://www.eso.org/public/images/eso1629a/

TRAPPIST-1

System with 7 Earth-size exoplanets. Three of them could be in the habitable zone.

Distance: 39 light-years

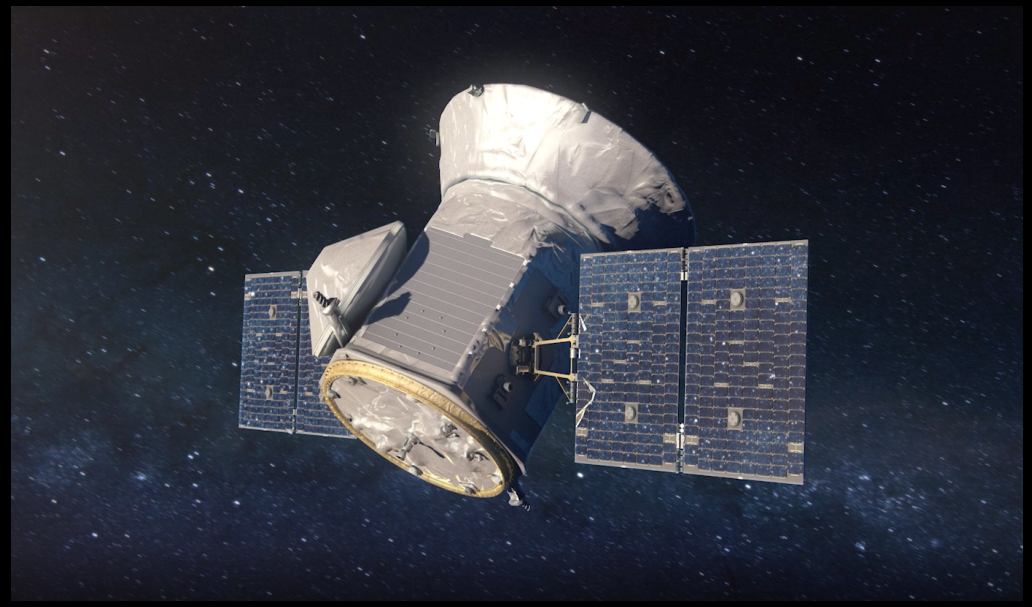


Illustration

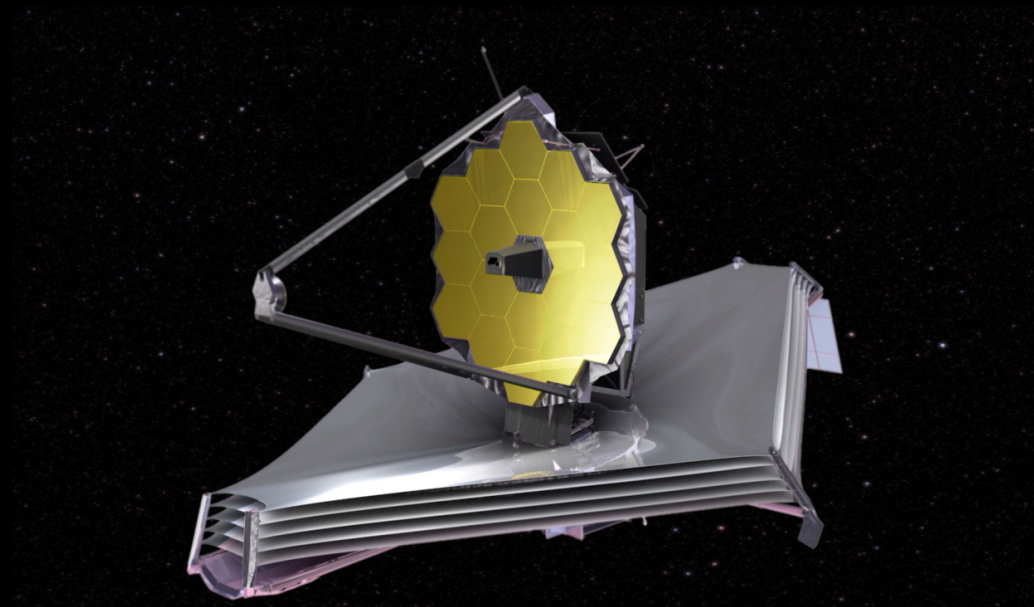
Artist's impression

Credit: NASA/JPL-Caltech
https://www.spacetelescope.org/images/heic1802d/

MANY MORE TO COME...



TESS



James Webb Space Telescope
(JWST)

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Credit :NASA Goddard Space Flight Center
https://svs.gsfc.nasa.gov/13238
https://svs.gsfc.nasa.gov/10660

INTERESTING QUESTIONS...

What would be the proof of extraterrestrial life (signal, biosignature, visit…?

How would humanity react?

What would it look like?

And what if we're really alone?

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Contact Us!

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info@discovertheuniverse.ca | info@decouvertedelunivers.ca

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