

Exoplanets and Life Beyond Earth

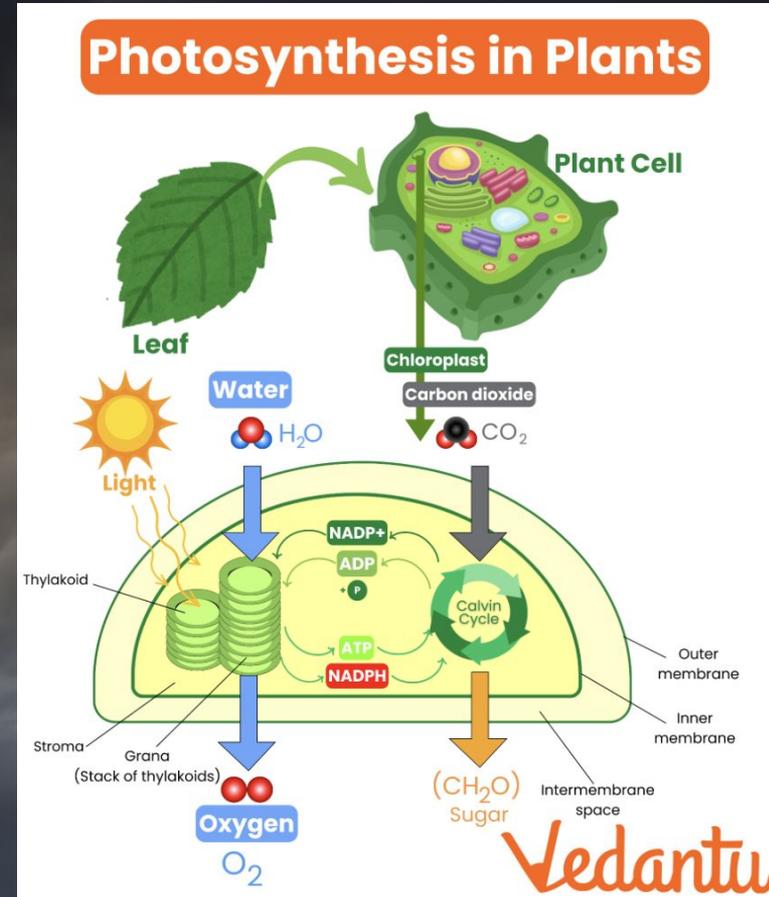
Lecture 6



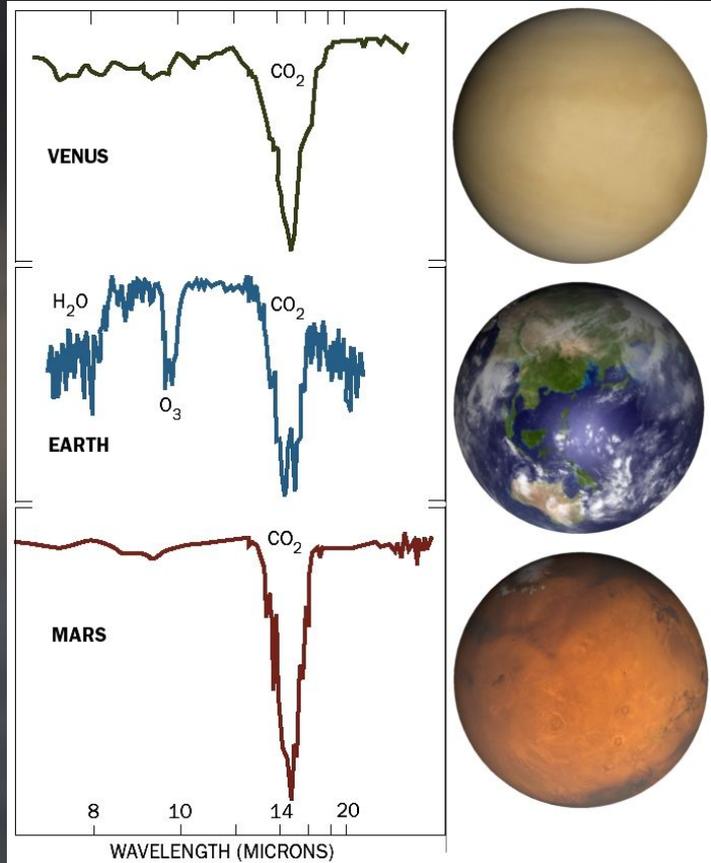
**Recap from last week:
How do we find aliens?**

Gaseous biosignatures

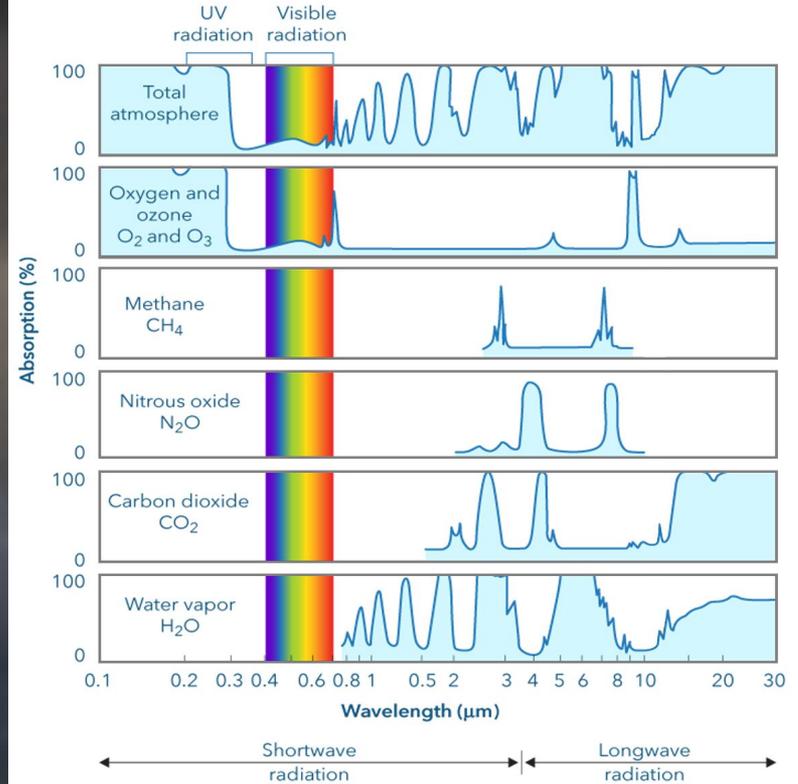
- Molecular oxygen (O_2)
- Plants use water and carbon dioxide to make energy and molecular oxygen
- Carbon dioxide is commonly produced around stars and star forming regions



How we can observe biosignatures



Earth's "Atmospheric Windows" to Solar Energy



The Drake Equation

$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$



The **number** of technologically advanced civilizations in the Milky Way Galaxy



The **rate** of formation of stars in the galaxy



The fraction of those stars with **planetary** systems



The number of planets per solar system with an **environment** suitable for life



The fraction of suitable planets on which **life** actually appears



The fraction of life-bearing planets on which **intelligent** life emerges



The fraction of those planets with intelligent life that develop **interstellar communication**

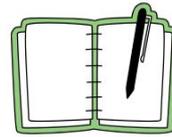


The **length** of time such civilizations release detectable signals into space

If life is common in the universe,
where are all the aliens?

WEEK FIVE

EXOPLANETS AND LIFE BEYOND EARTH



Biosignatures

1. A biosignature is a...

- sign of life in a planet's atmosphere
- spaceship made of plant-based materials
- rock

Plants make _____.

Methane is also called _____.

Ozone is written as _____.

If we see *oxygen* and *carbon dioxide* together, the planet likely has _____.

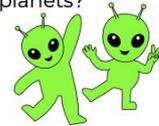
More Biosignatures

1. Which planets in the solar system have carbon dioxide in their atmosphere?

- Venus
- Earth
- Mars
- All of the above

2. Have we found alien life on other planets?

- Yes
- No



Fermi Paradox

Fill in the blank with the missing letter to spell out a secret word!

Scientists study distant p__anets using telescopes to look for b__osignatures in atmospheres. The Fermi paradox asks why we have not __ound aliens yet, even though the univ__rse is so big.

Secret Word: _ _ _ _

Drake equation

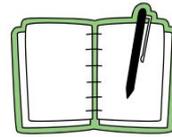
Circle True or False

T/F: The Drake equation shows that intelligent alien life must exist in the Milky Way Galaxy.



WEEK FIVE

EXOPLANETS AND LIFE BEYOND EARTH



Biosignatures

1. A biosignature is a...

- sign of life in a planet's atmosphere
- spaceship made of plant-based materials
- rock

Plants make oxygen

Methane is also called CH₄.

Ozone is written as O₃.

If we see *oxygen* and *carbon dioxide* together, the planet likely has Life.

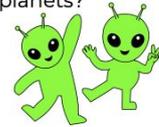
More Biosignatures

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Fermi Paradox

Fill in the blank with the missing letter to spell out a secret word!

Scientists study distant planets using telescopes to look for biosignatures in atmospheres. The Fermi paradox asks why we have not found aliens yet, even though the universe is so big.

Secret Word: L I F E

Drake equation

Circle True or False

True The Drake equation shows that intelligent alien life must exist in the Milky Way Galaxy.



How have we tried to **contact** other life forms?

So far, no alien has successfully contacted us, but we have sent messages into space

Search for Extraterrestrial Intelligence (SETI) - Breakthrough Listen

Breakthrough listen observes the closest 43 stars to our sun and over 1,000,000 other stars in total.

They also observe 100 nearby galaxies like the andromeda galaxy.

So far, no signs of intelligent life has been found.

This is the andromeda galaxy



Image credit: Brody Wesner

This is a telescope with which we search for intelligent life.

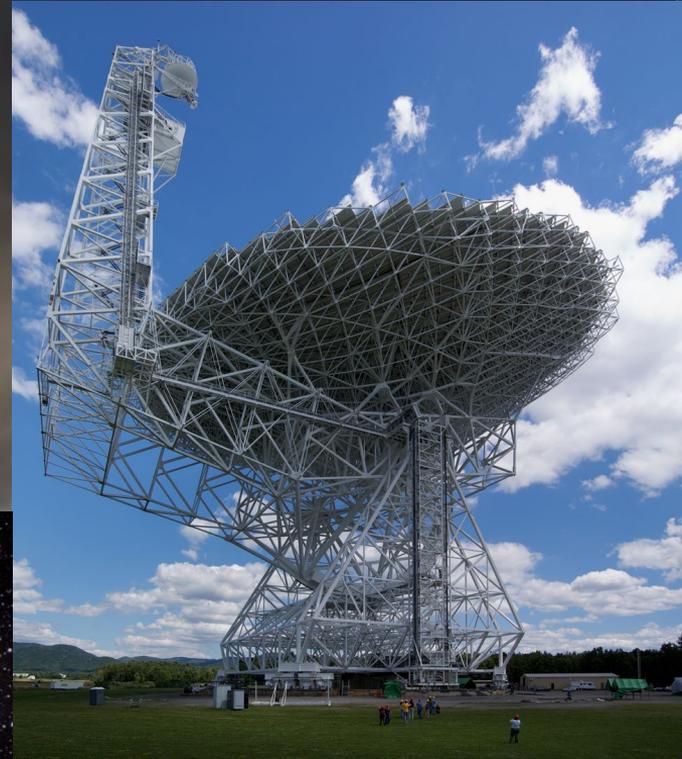
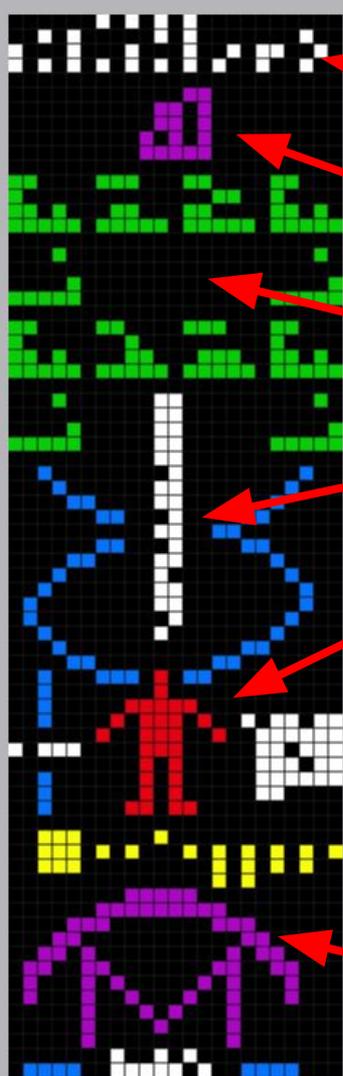


Image credit: Wiki/Geremia



Numbers 1 to 10

Atoms that make up DNA

Composition of DNA

DNA structure

Height and silhouette of a human

Number of humans on Earth

Solar System planets

The Arecibo telescope

The Arecibo Message

In 1974, this telescope has sent the message on the left into space.

We have never received an answer.



Voyager's Golden Disk

The satellite
Voyager with
the golden disk
attached

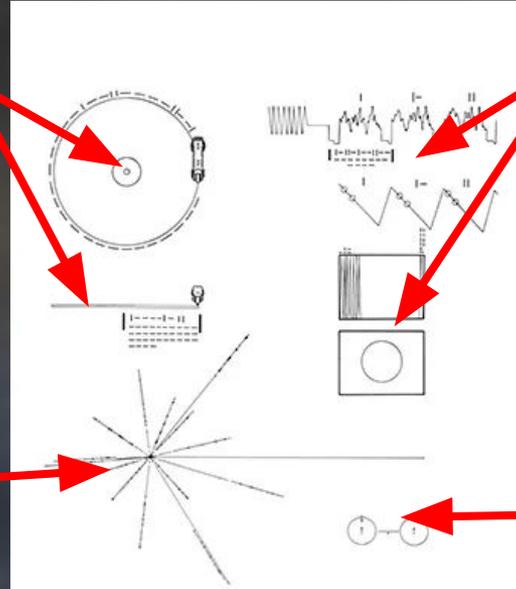


Instructions on how to play the
disk, given in fundamental
physical parameters

Instructions on how to create
videos from the disk

Map on how to find our Solar
System in our Galaxy

Hydrogen atom, used to get the
timing right to read the disk



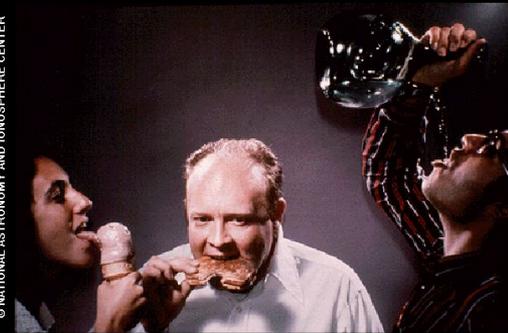
Voyager's Golden Disk

The disk contains many images of humans and their typical activities.

The disk contains audio recordings.



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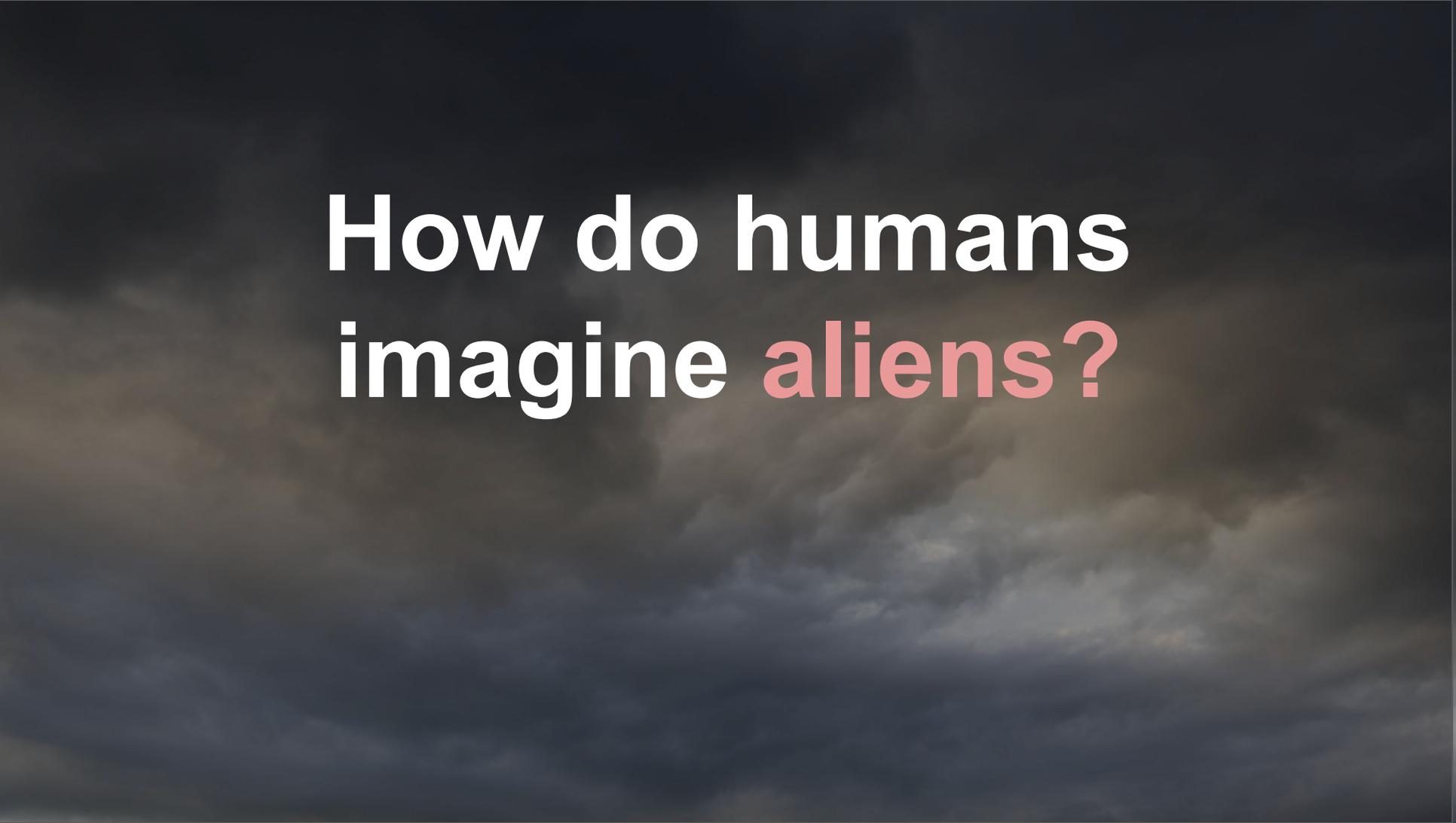


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Group Discussion: What would you put on the Golden Disk?





How do humans
imagine **aliens**?



A Trip to the Moon (1902)

This is the first depiction of an alien in a movie.

Humans are travel to the moon where they encounter aliens.

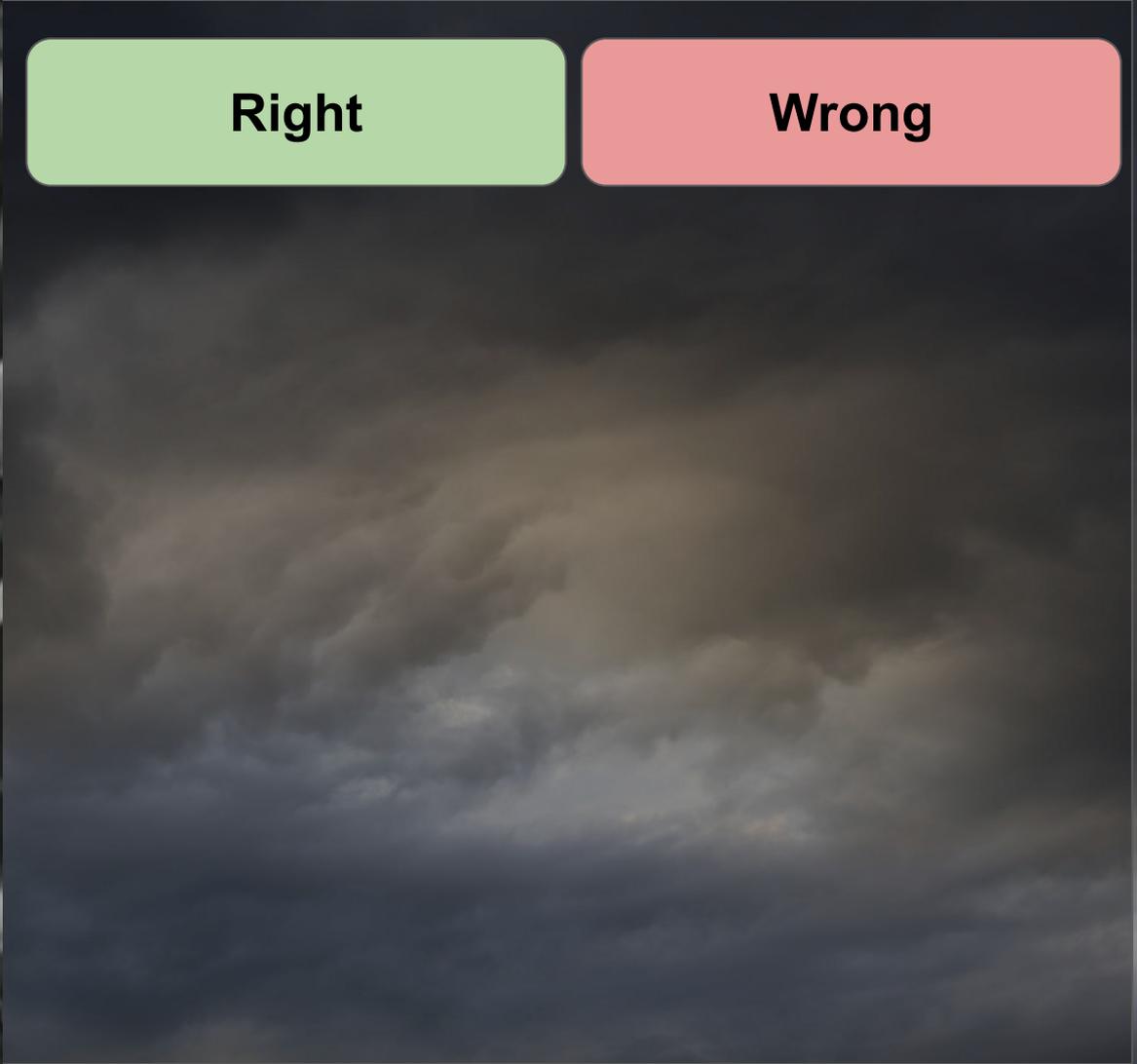
Let's watch a short clip and analyse how this movie imagines aliens.





Right

Wrong





Right

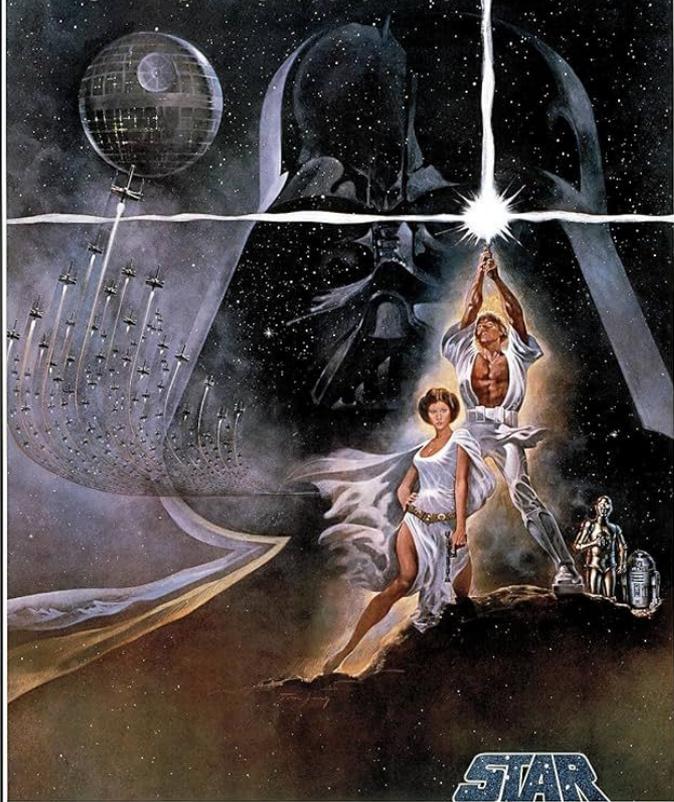
Life co-exists with other life forms (here plants).

Wrong

We know that there is no life on the moon.

There is no atmosphere on the moon which makes it difficult for life to exist because it can't breathe.

A long time ago in a galaxy far, far away...



STAR WARS

TWENTIETH CENTURY-FOX Presents
A LUCASFILM LTD PRODUCTION

STAR WARS

Starring MARK HAMILL HARRISON FORD CARRIE FISHER
PETER CUSHING

and

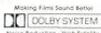
ALEC GUINNESS

Written and Directed by GEORGE LUCAS Produced by GARY KURTZ Music by JOHN WILLIAMS

PANAVISION® PRINTS BY DE LUXE® TECHNICOLOR®



© 1977 Twentieth Century-Fox Film Corporation



Star Wars (1977)

Star Wars features many different aliens.

Let's watch the cantina scene and take a closer look at the different aliens.

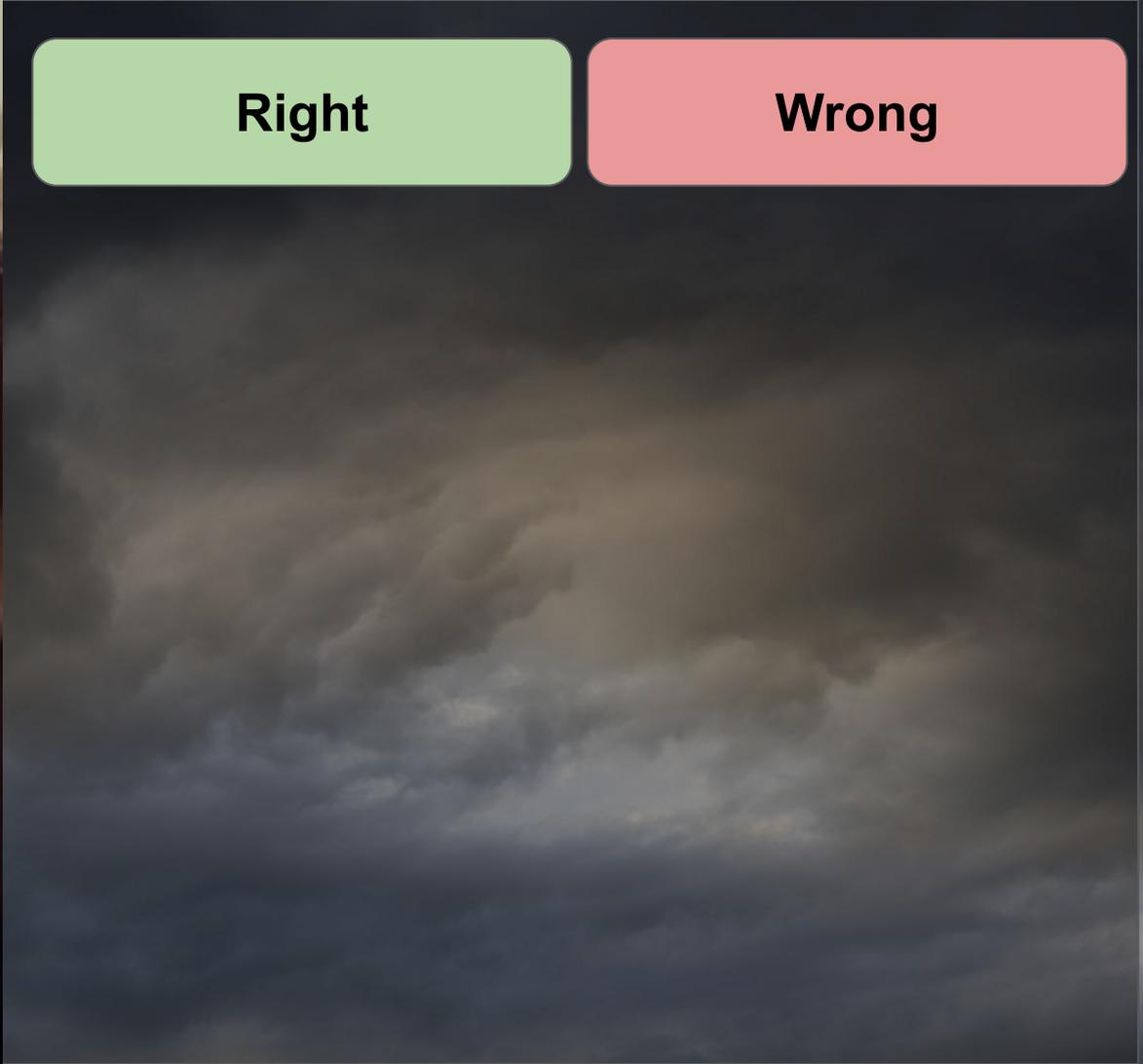
4K
ULTRA HD





Right

Wrong





Right

Aliens can look different from each other.

Wrong

It is unlikely that aliens look similar to humans.

It is unlikely that they:

- have two eyes
- have two arms
- are the same size
- breath the same air

Many films have human like aliens because it is cheaper to make the movie.

Planet 51 (2009)

This movie depicts the landing of the first alien.

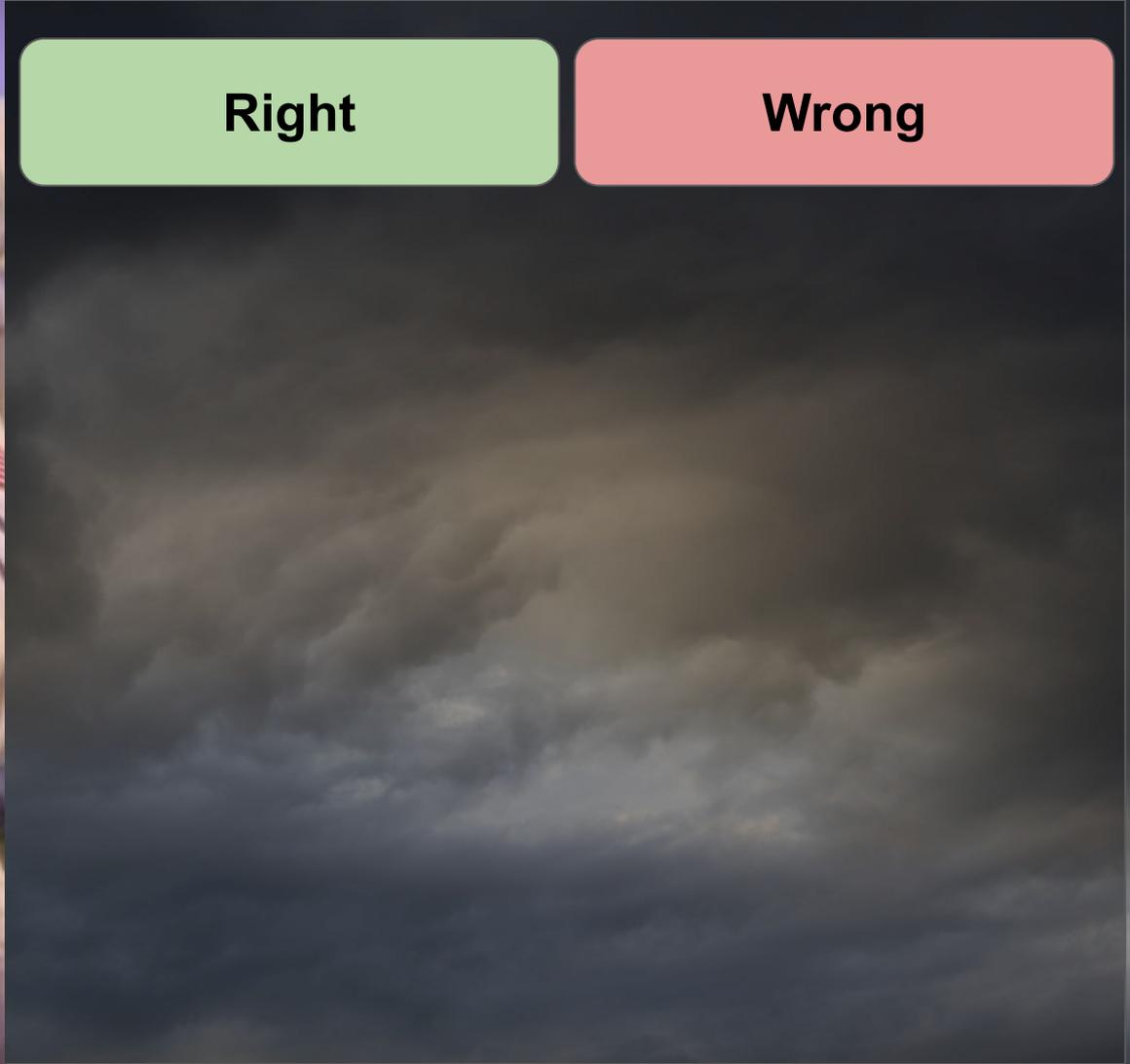
Let's watch a short clip and see the twist of the movie.





Right

Wrong





Right

Humans will look strange to other aliens.

Aliens might be afraid of us when we first meet them.

Wrong

Aliens will most likely not have burgers, and baseball, but will have their own culture.

Humans would travel in a group, not alone.

The spaceship is designed for the moon. It is too small to lift off any other planet.

AMY ADAMS JEREMY RENNER FOREST WHITAKER

Arrival (2016)

Aliens have landed on Earth in a strange ship.

The government has hired a linguist specialist to try and communicate with the aliens.

Let's see how humans communicate with the aliens.





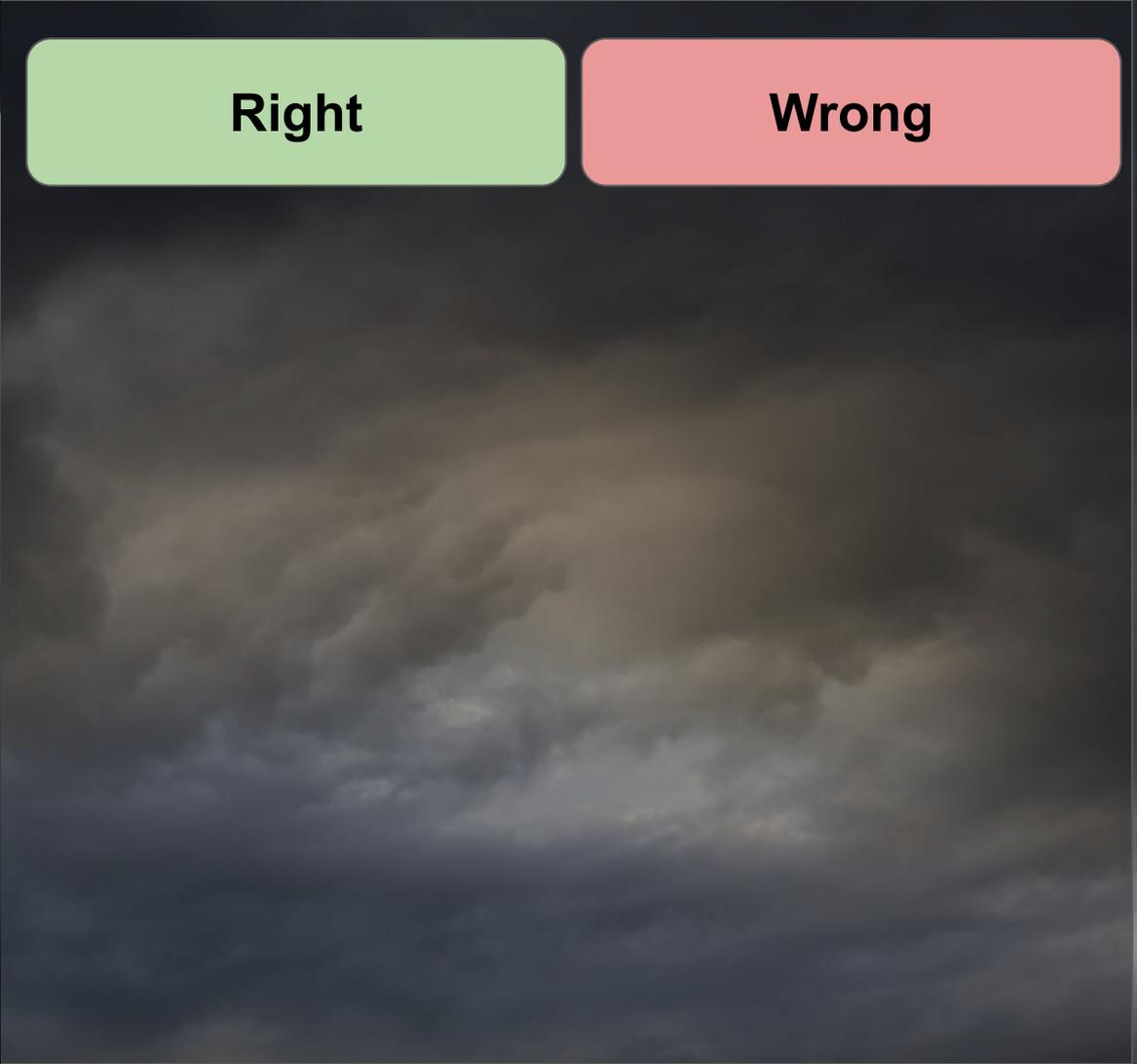
A R R I V A L

OFFICIAL CLIP



Right

Wrong





Right

Humans should protect themselves from aliens and their ship because it might be dangerous.

Aliens might look very different from humans.

Aliens will not have the same language as us and communication will be difficult.

Wrong

Writing human is not a good idea. Aliens can confuse it for a name. This has happened, for example with Yucatán: State in Mexico, which in the native language means: “hear how they talk”.

Video Recommendation: Kurzgesagt - What Actual Aliens Might Look Like



SKY WHALES

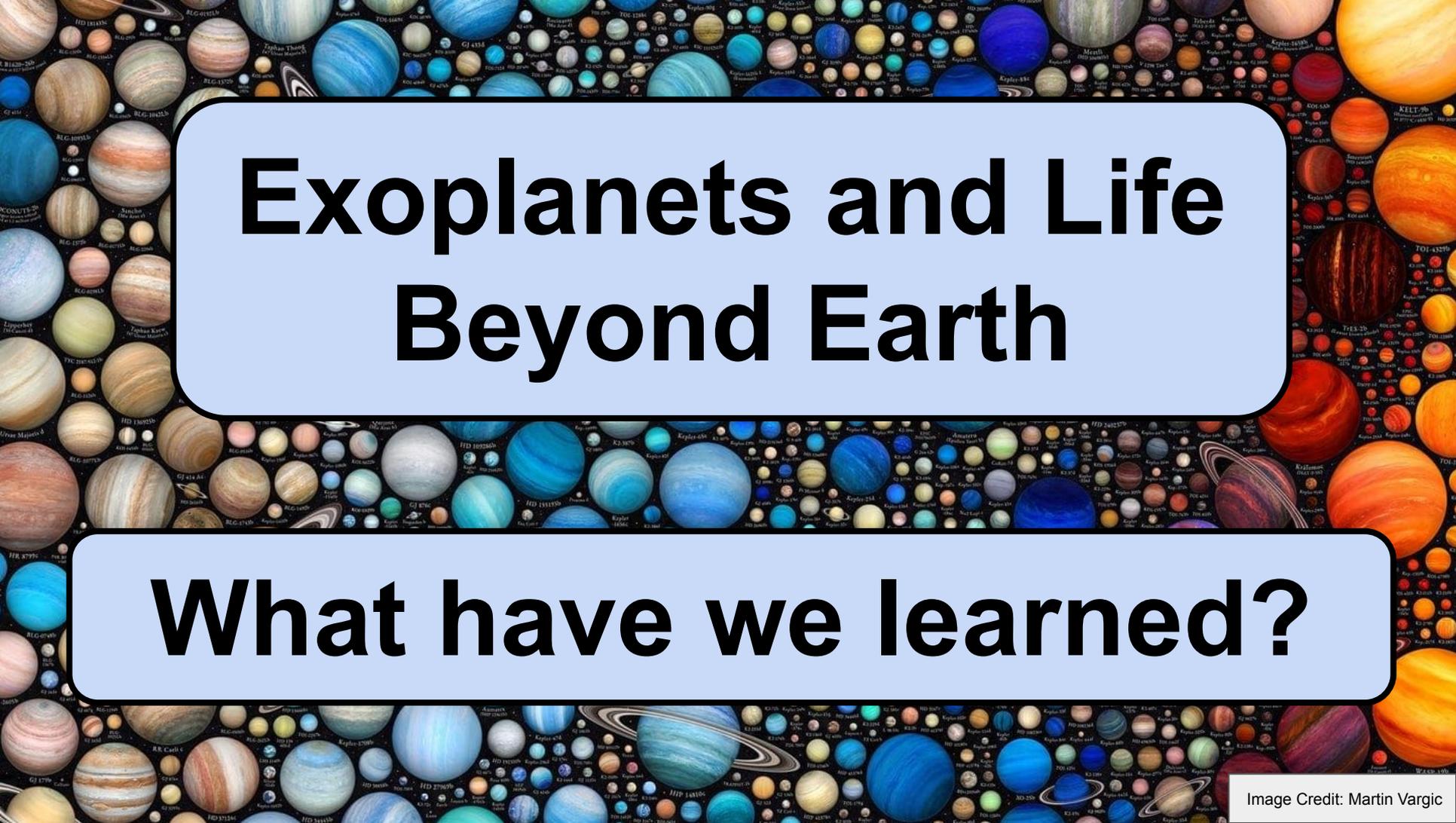


EIFFEL TOWER



10 min break

End of Course Survey! Fill it in now:



Exoplanets and Life Beyond Earth

What have we learned?

Lecture 1: Our Solar System

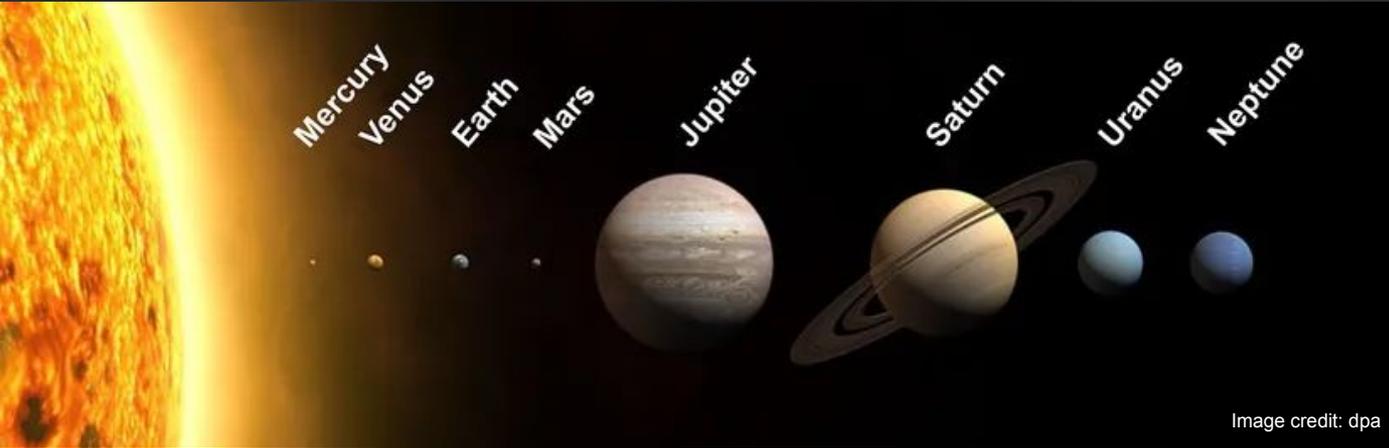
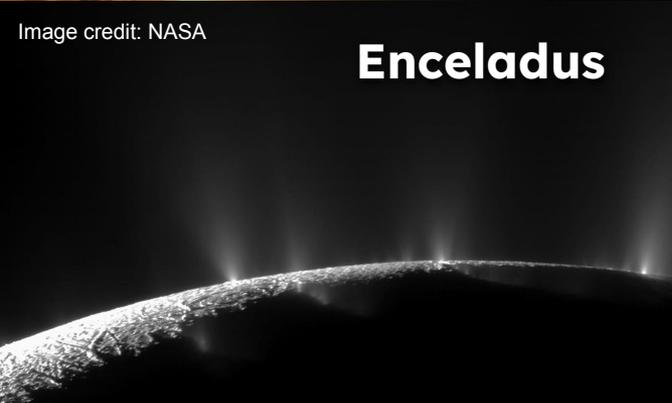


Image credit: dpa

We discovered our Solar System planets and moons!

We learned why Earth (and maybe Mars) are the only planets that could host life.



Enceladus

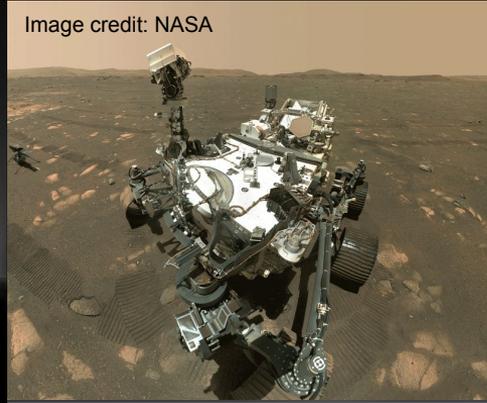
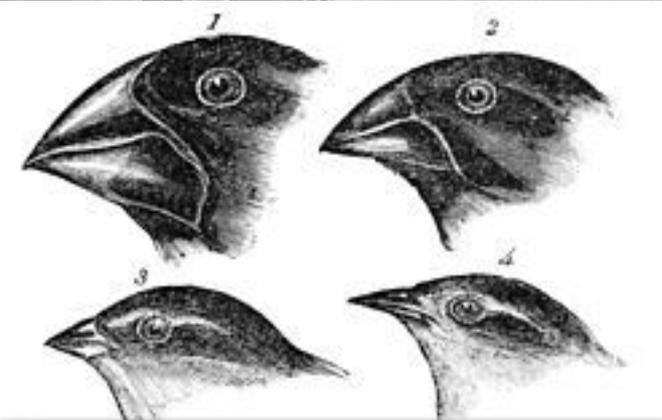
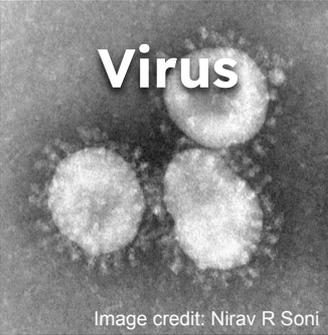
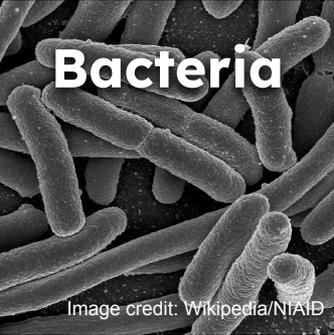


Image credit: NASA

Which Moons in the Solar System could host life?
Europa and Enceladus!

Lecture 2: What is life?



Textbook: Something that has all of these:

- 1) Body regulation
- 2) Made from cells
- 3) Eats “food”
- 4) Growth
- 5) Evolution
- 6) Reacts
- 7) Has children

Nasa:

“Life is a self-sustaining chemical system capable of darwinian evolution”

There are many different definitions of life.

We learned about where life could hide in the Solar System, like the water oceans on Enceladus and Europa hidden beneath ice.

What is Darwinian evolution?
A living being adapts to its environment over many generations.

Lecture 3: How do we observe exoplanets?

Microlensing

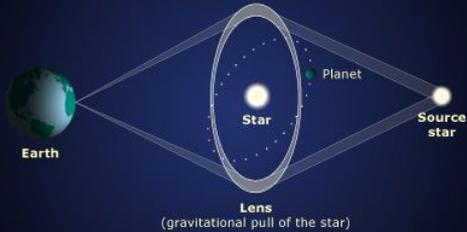


Image credit: S. Liebes et al. (1964)

Direct imaging

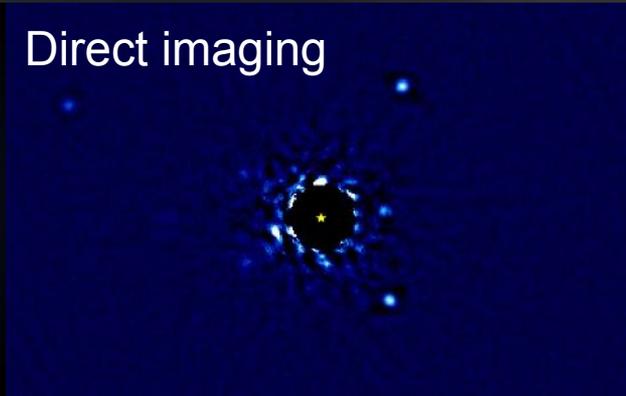


Image credit: Christian Marois

Doppler Method

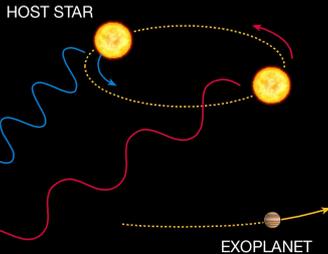


Image credit: ESO

Transit Method

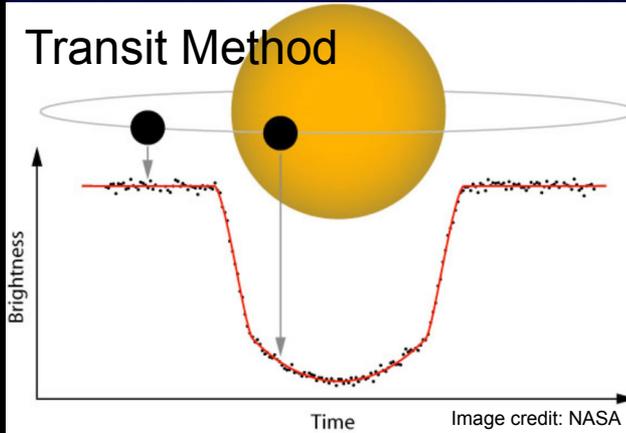


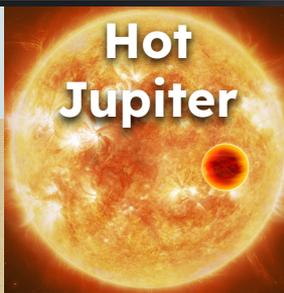
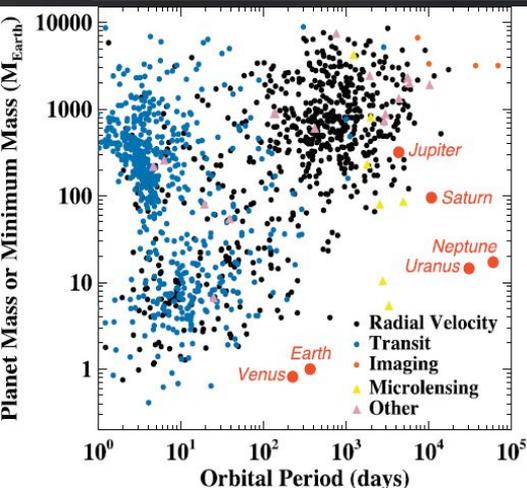
Image credit: NASA

The four methods to the left are used to detect new exoplanets.

So far, we have found over 6000 exoplanets.

Which method has discovered the most exoplanets?
Transit method

Lecture 4: Planets we don't have in our Solar System



Super Earths



Tidally locked planet



Exoplanets can be very different than Solar System planets.

Examples of this are:

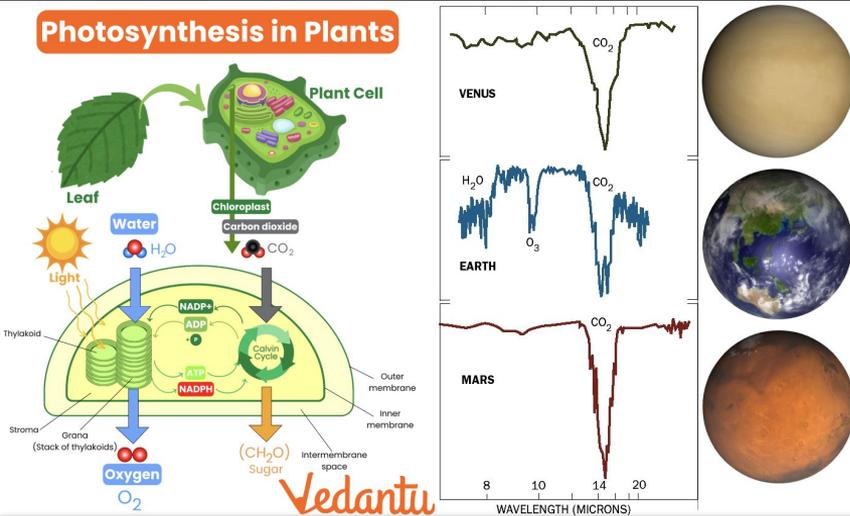
- Hot Jupiters
- Lava worlds
- Super Earths
- Tidally locked planets

What is the zone around a star called where liquid water could exist?

Goldilocks Zone

Lecture 5: How do we find life on exoplanets?

Photosynthesis in Plants



Biosignatures are gases in the atmosphere that are produced by life.

We explored the drake equation, which tells us how many alien civilisations are out there, and the Fermi paradox, which asks “where are all the aliens?”

The Drake Equation

$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$



What are potential biosignature gases?

Oxygen (O₂) and Methane (CH₄)

Lecture 6: How we imagine aliens!



We have sent two messages into space: the Arecibo message and voyager's golden disk.

Aliens in movies are often more “human” like than what we

How many aliens have we already found?
zero

Exoplanets and Life Beyond Earth

“The universe is a pretty big place. If it’s just us, seems like an awful waste of space.”

- Carl Sagan

