

Exoplanets and Life Beyond Earth

Lecture 2

Recap from Last week

We have learned about the sizes, atmospheres, and number of moons of the Solar System planets.

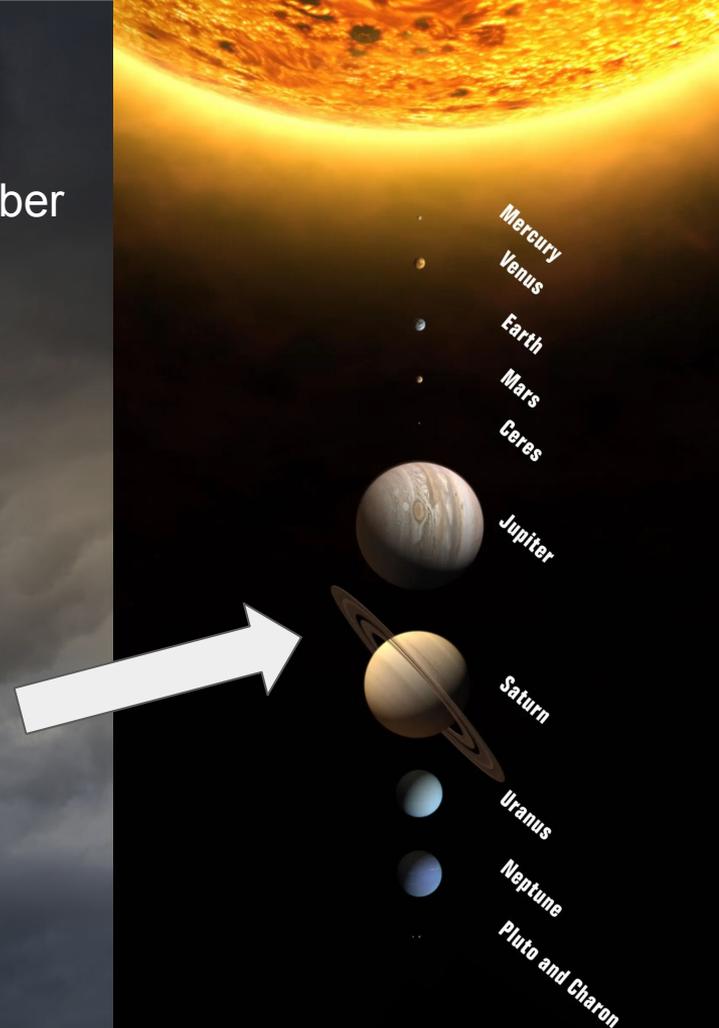
- Mercury has no atmosphere
- Venus has a very thick atmosphere
- **Earth is the only planet that we know has life**
- We saw a video of the Mars rover exploring Mars

We have learned about the moons in our Solar System.

- Mars' moons Deimos and Phobos are not round.
- Jupiter has 97 moons and Saturn has 274 moons!
- **Jupiter's moon Europa is icy and has a liquid water ocean under its surface.**

We have observed with our telescopes!

- **We saw the bands of Jupiter and three of its moons**
- We saw the craters on the moon





Today's Topic:

What is **Life?**

What is your definition of life?

- **Form groups**
- **Discuss how each of you defines life**
- **Do your definitions agree?**

This is how biology textbooks define life:

Textbook: Life is something that has all of the following:

- 1)
- 2)
- 3)
- 4)
- 5)
- 6)
- 7)

This is how biology textbooks define life:

Textbook: Life is something that has all of the following:

- 1) Homeostasis → Keeping balance
- 2)
- 3)
- 4)
- 5)
- 6)
- 7)

A living being can keep its body in balance. This includes:

- It can sweat to cool down.
- It can increase or decrease its blood sugar content.
- it can drink water and pee to keep the fluids in balance.



Sweating to cool down

How do we define Life? - Textbook

Textbook: Life is something that has all of the following:

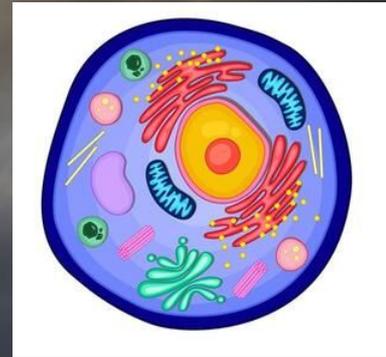
- 1) Homeostasis → Keeping balance
- 2) Organisation → Made from cells
- 3)
- 4)
- 5)
- 6)
- 7)

A living being is made from cells.

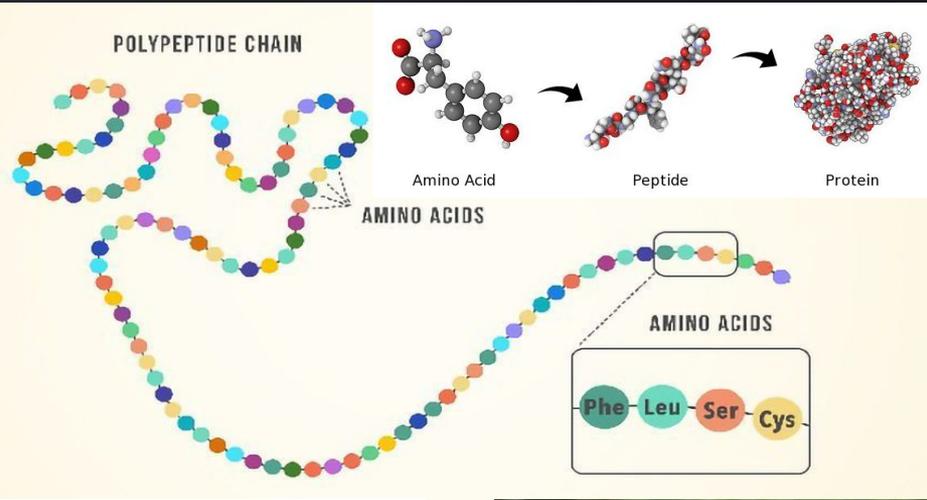
Cells are the smallest unit of our body.

Our muscles, skin, tongue, eyes, heart, brain are all made from cells.

An illustration
of a human cell



Quick Excursion: The Building Blocks of Life



Amino acids are the building blocks for life. Many amino acids together form a protein.

Cells are the building blocks for Humans. Humans are made from many cells.

The asteroid Bennu has amino acids! But we have not found cells nor life on Bennu.

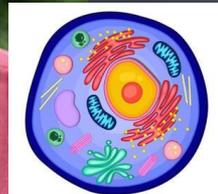
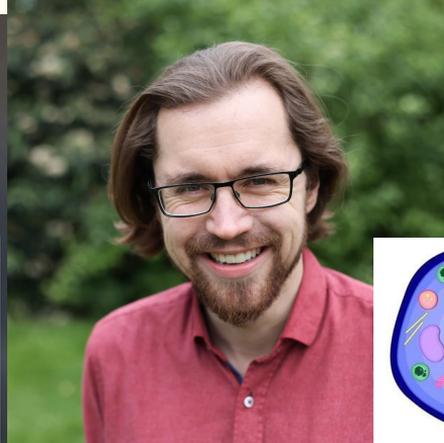


Image credit Human cell: vecteezy
Illustration acids: Technology Networks // Lego: Lego
protein: peptidesciences // Image credit Bennu: NASA



Nucleus

Mag. 1000X

How do we define Life? - Textbook

Textbook: Life is something that has all of the following:

- 1) Homeostasis → Keeping balance
- 2) Organisation → Made from cells
- 3) Metabolism → Eats “food”
- 4)
- 5)
- 6)
- 7)

A living being uses energy to perform a task. e.g. you use energy when moving your legs to walk

This energy can come from food or the sun. The energy is used to keep the body functioning, move, or grow.

Photosynthesis



How do we define Life? - Textbook

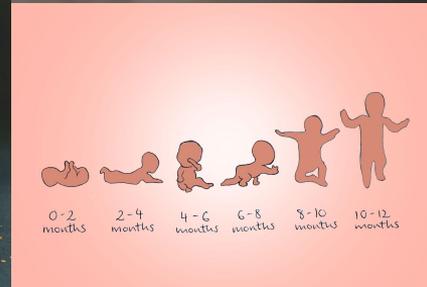
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- 4) Growth
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- 6)
- 7)

A living being grows.

Humans grow from baby to adult.

Plants grow from a seed.



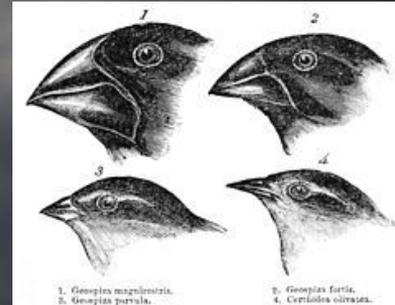
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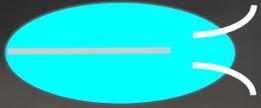
A living being adapts to its environment over many generations.

Darwin discovered that finches have different beaks depending on what food they have available.



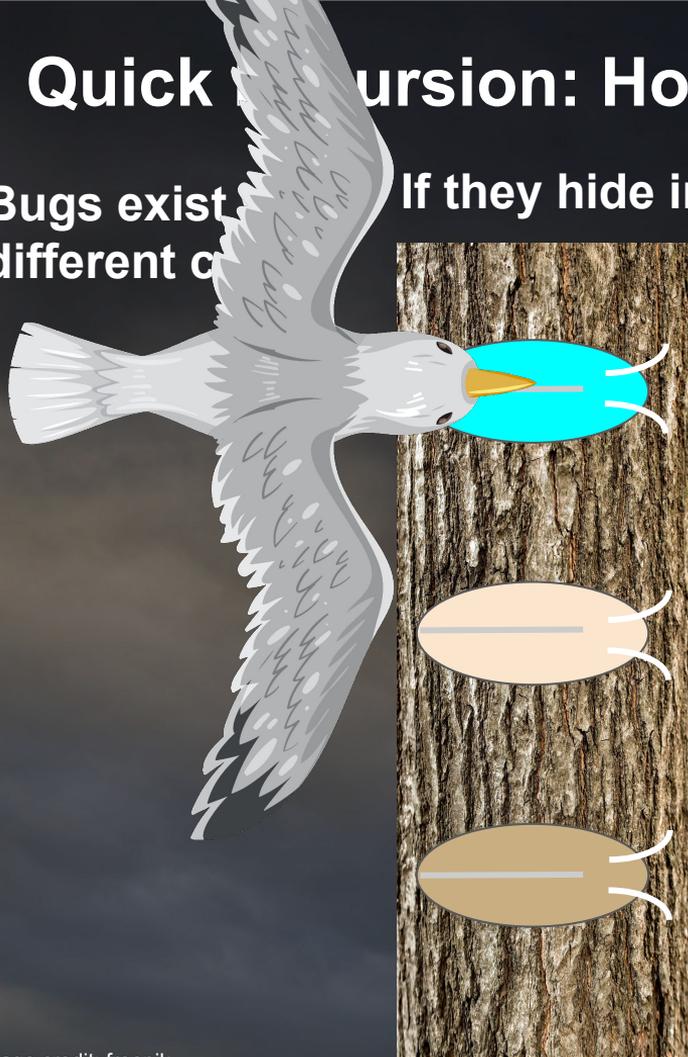
Quick Excursion: How does darwinian evolution work?

Bugs exist with different colors



Quick Overview: How does darwinian evolution work?

Bugs exist in different colors
If they hide in a tree

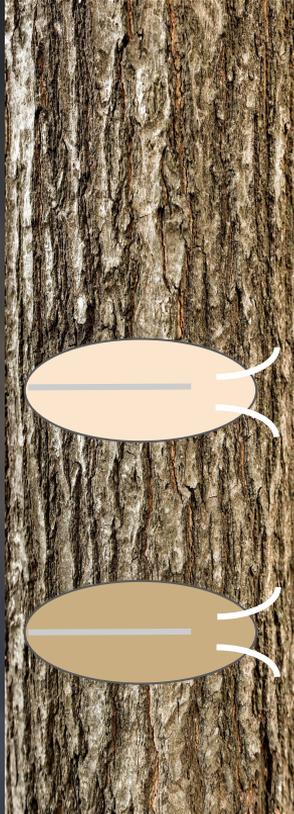


Quick Excursion: How does darwinian evolution work?

Bugs exist with different colors

If they hide in a tree

Colorful bugs get eaten first



Quick Excursion: How does darwinian evolution work?

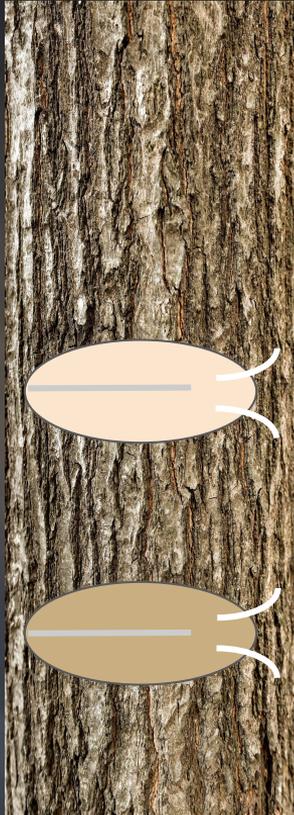
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Colorful bugs get eaten first

Surviving bugs have babies

Color change happens through mutations!



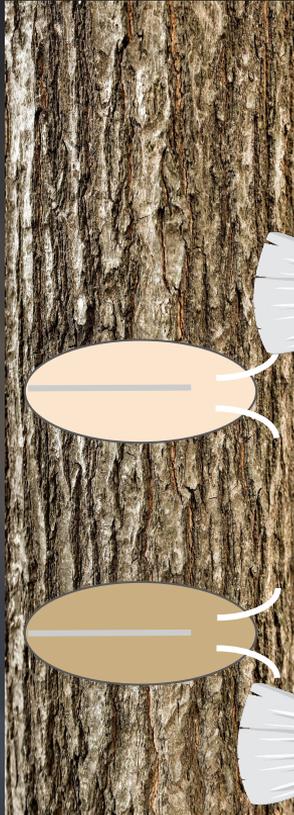
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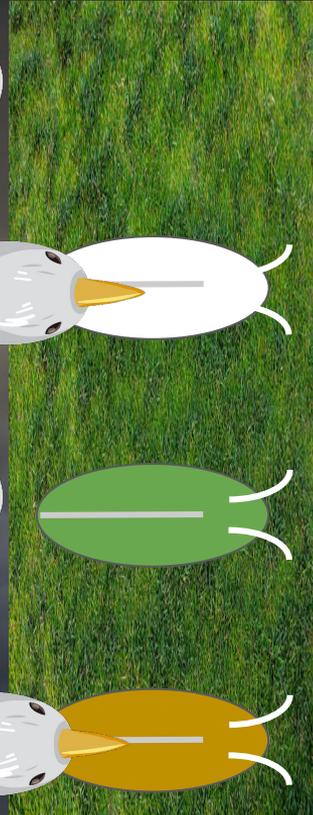
Color change happens through mutations!

If they hide in a tree



Surviving bugs have babies

If they move to grass



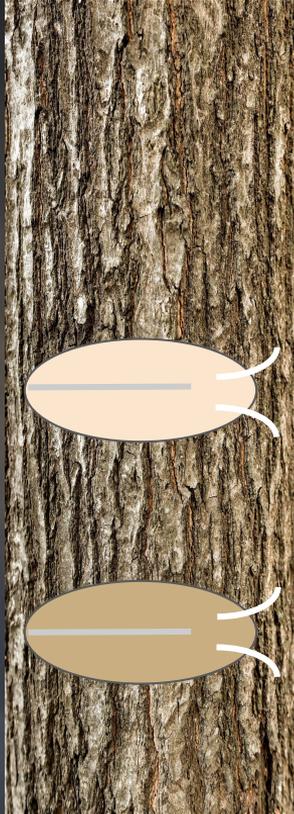
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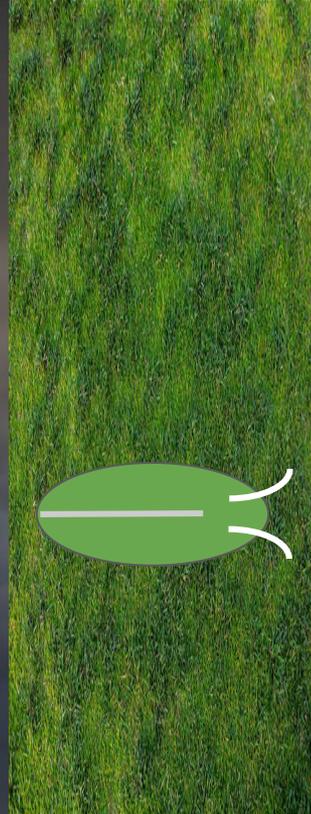
If they hide in a tree



Surviving bugs have babies

Non green bugs get eaten first

If they move to grass



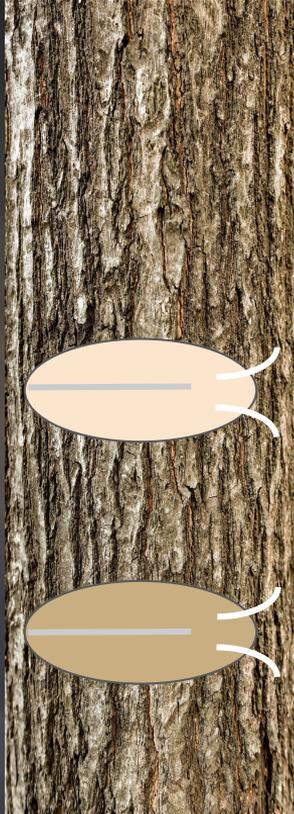
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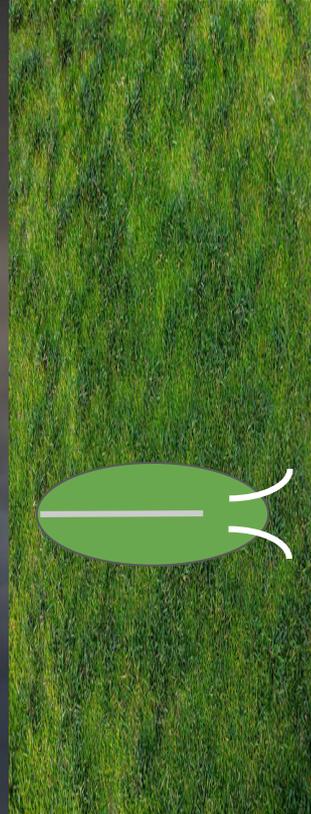
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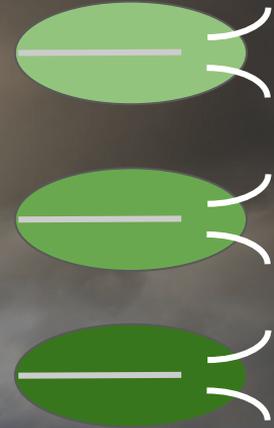
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Non green bugs get eaten first

If they move to grass



All new bugs will be green



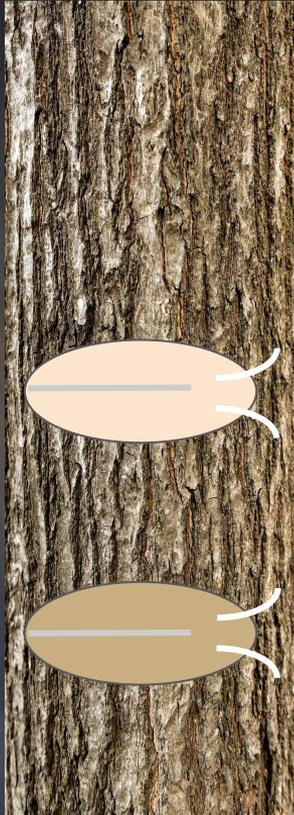
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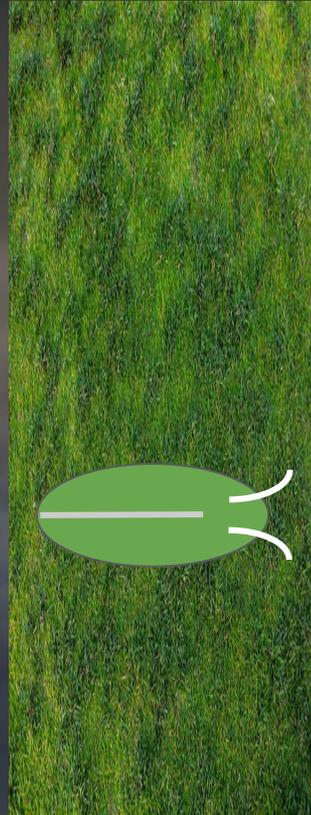
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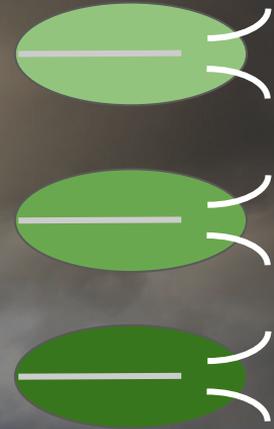
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Darwinian evolution lead to green bugs

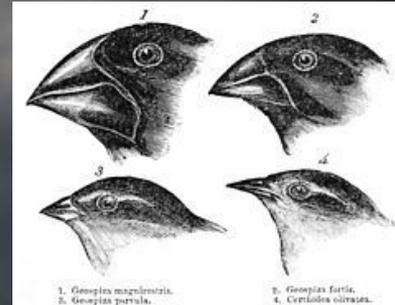
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- 5) Adaptation → Evolution
- 6) Response to stimuli → Reacts
- 7)

A living being reacts to the environment.

Some ways to react are to shield your eyes from the sun, or turn your head when you hear a loud noise.

**Protect
your eyes
from the
sun**



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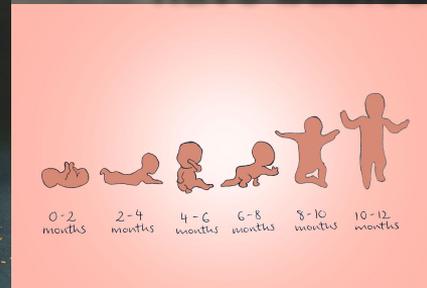
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- 6) Response to stimuli → Reacts
- 7) Reproduction → Has children

A living being creates children that lives longer and can have children that can have grandchildren.

Trees have seeds



Humans have babies



How do we define Life? - NASA

NASA:

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

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Meaning:

“Life is something that can keep itself going and make children that are a little different from itself.”

Textbook: Something that has all of these:

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- 2) Made from cells
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- 6) Reacts
- 7) Has children

Common Definitions of Life

Physics:

“A system with decreasing entropy”

Entropy is the amount of chaos, disorder, or randomness.

High entropy = Chaos



Image credit: freepik

Low entropy = Ordered



Image credit: AFP photo

Common Definitions of Life

NASA:

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

Physics:

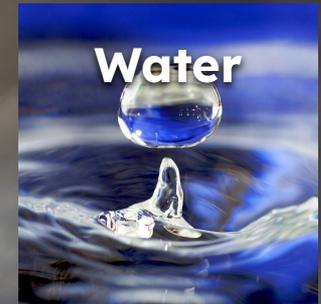
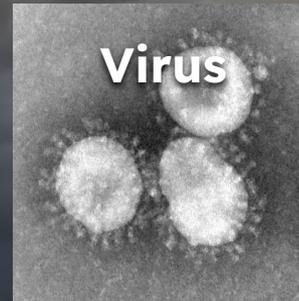
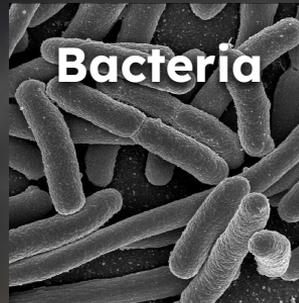
“A system with decreasing entropy”

Your definition of life

Textbook: Something that has all of these:

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- 6) Reacts
- 7) Has children

Is it alive?



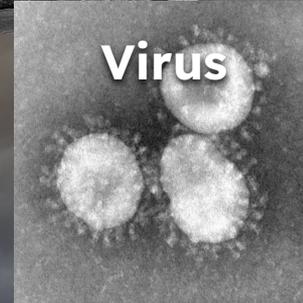
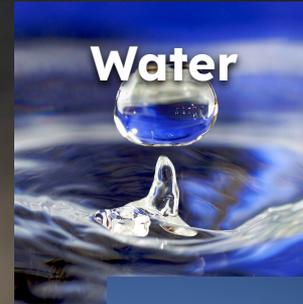
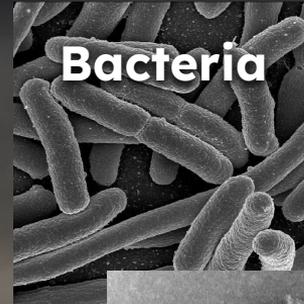
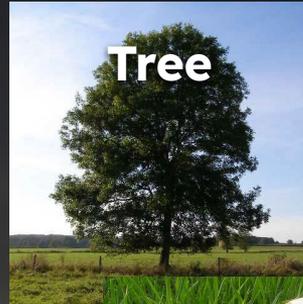
Is it alive?

YES!

MAYBE?

NO!

Is it alive?

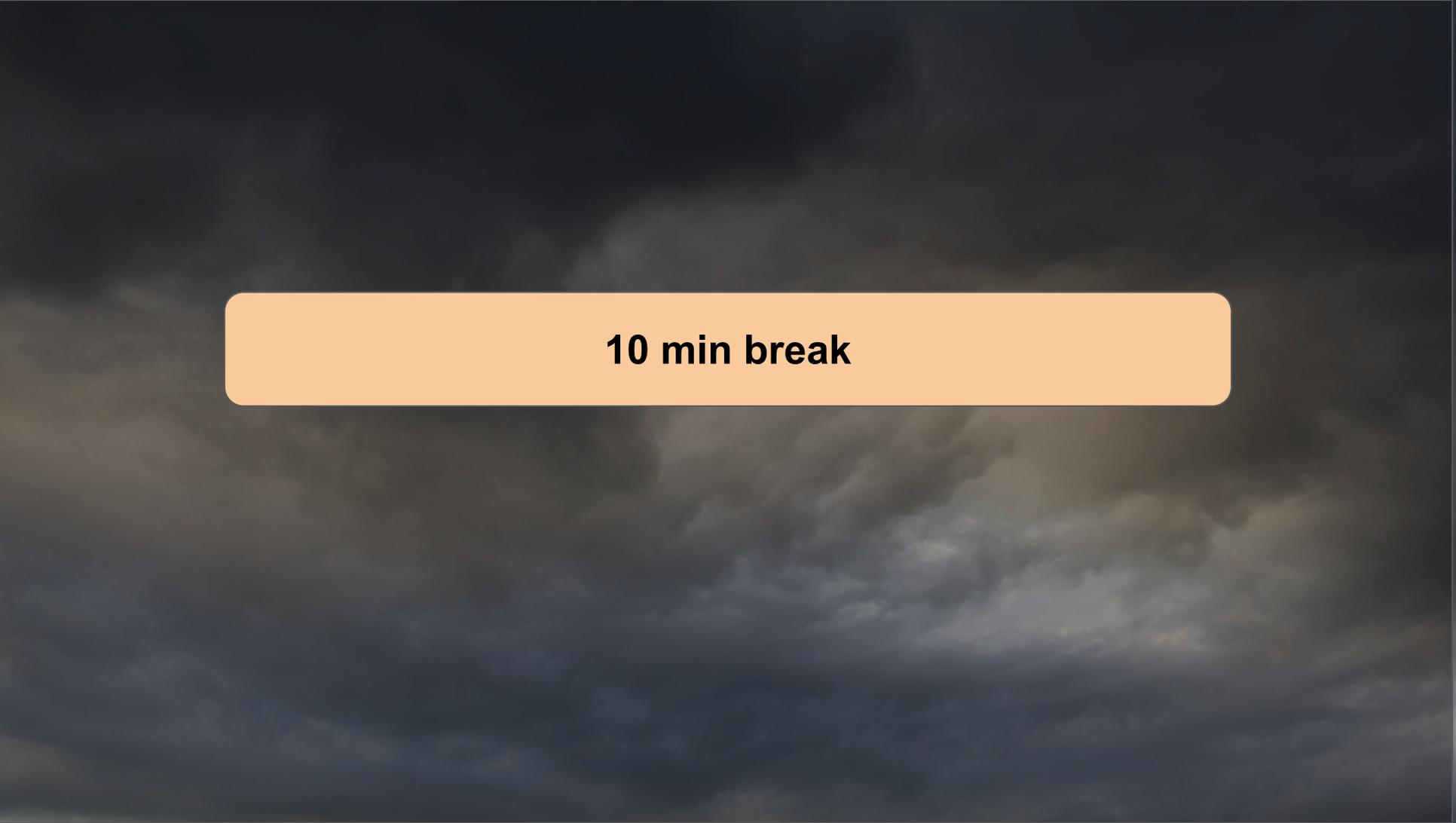


YES!

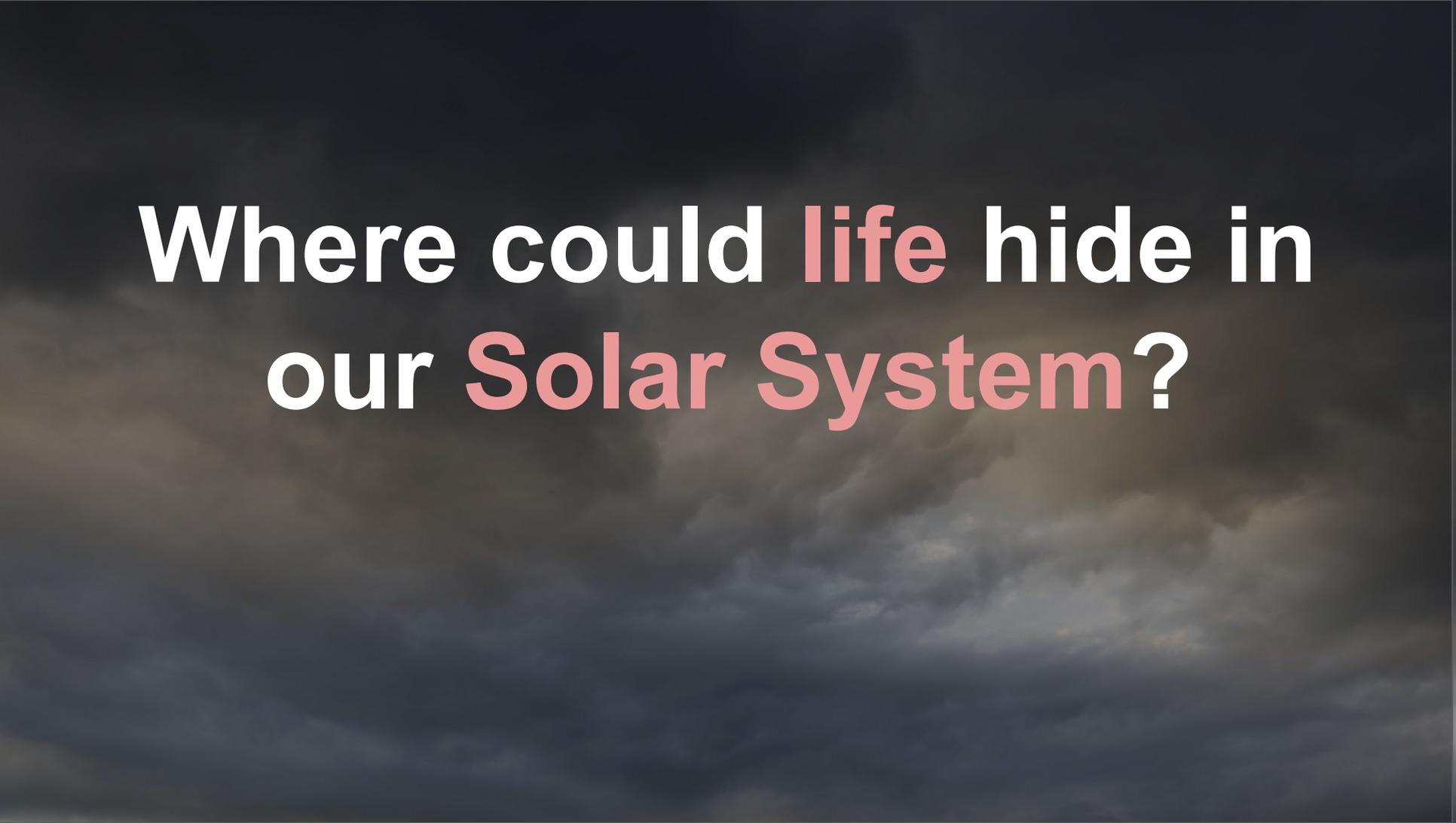
ALSO YES!

MAYBE?

NO!



10 min break



Where could **life** hide in
our **Solar System**?

Where should we search for life outside Earth?

- **Form groups**
- **Where should we start looking for life? On other Planets? On Moons? Or somewhere completely different?**
- **Remember last week's lecture!**

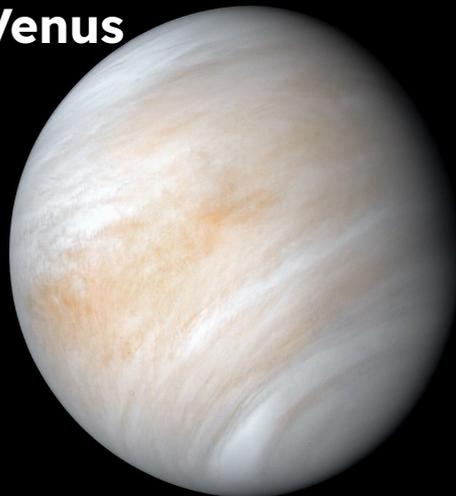
Can we find life on the rocky planets?

Mercury



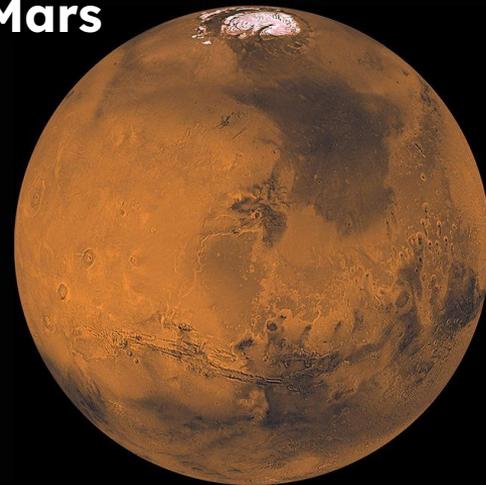
Mercury has no atmosphere so it is impossible to breath.

Venus



Venus is too hot for life to exist.

Mars



Mars is complicated, let's look at it closer.

Can we find life on the rocky planets?

Mars is a rocky planet with liquid water.

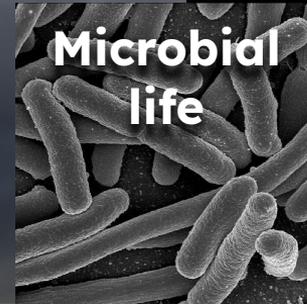
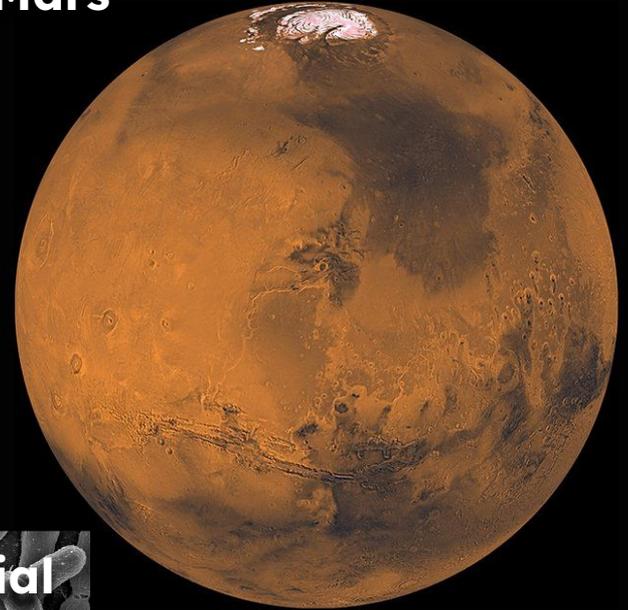
We have not found life or evidence of past life on Mars to date.

However it does not have a magnetosphere or thick atmosphere like Earth making it difficult for life to form.

The most likely place for life to exist on Mars is within or under its ice.

This would likely be microbial life.

Mars



**Microbial
life**

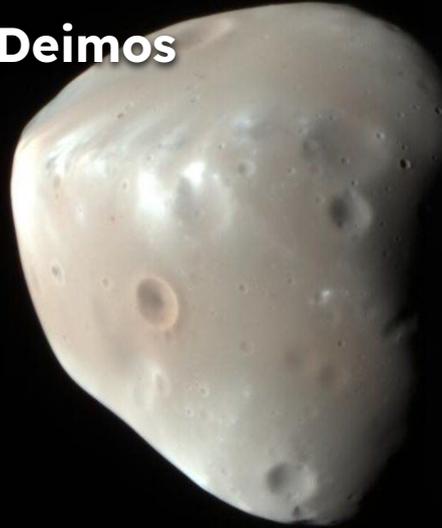
Can we find life on a moon?

**Our
Moon**



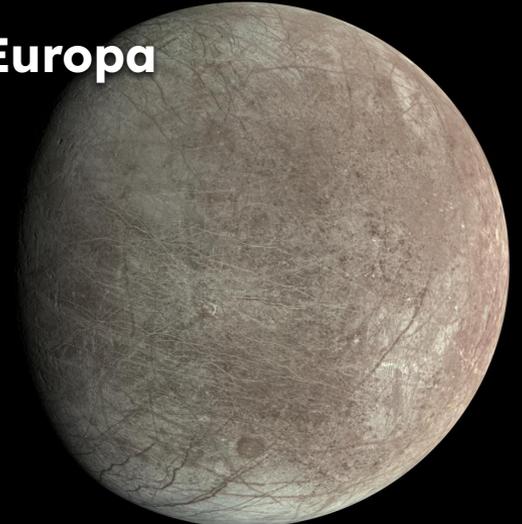
Our moon is a bare rock with no atmosphere. No life is possible there.

Deimos



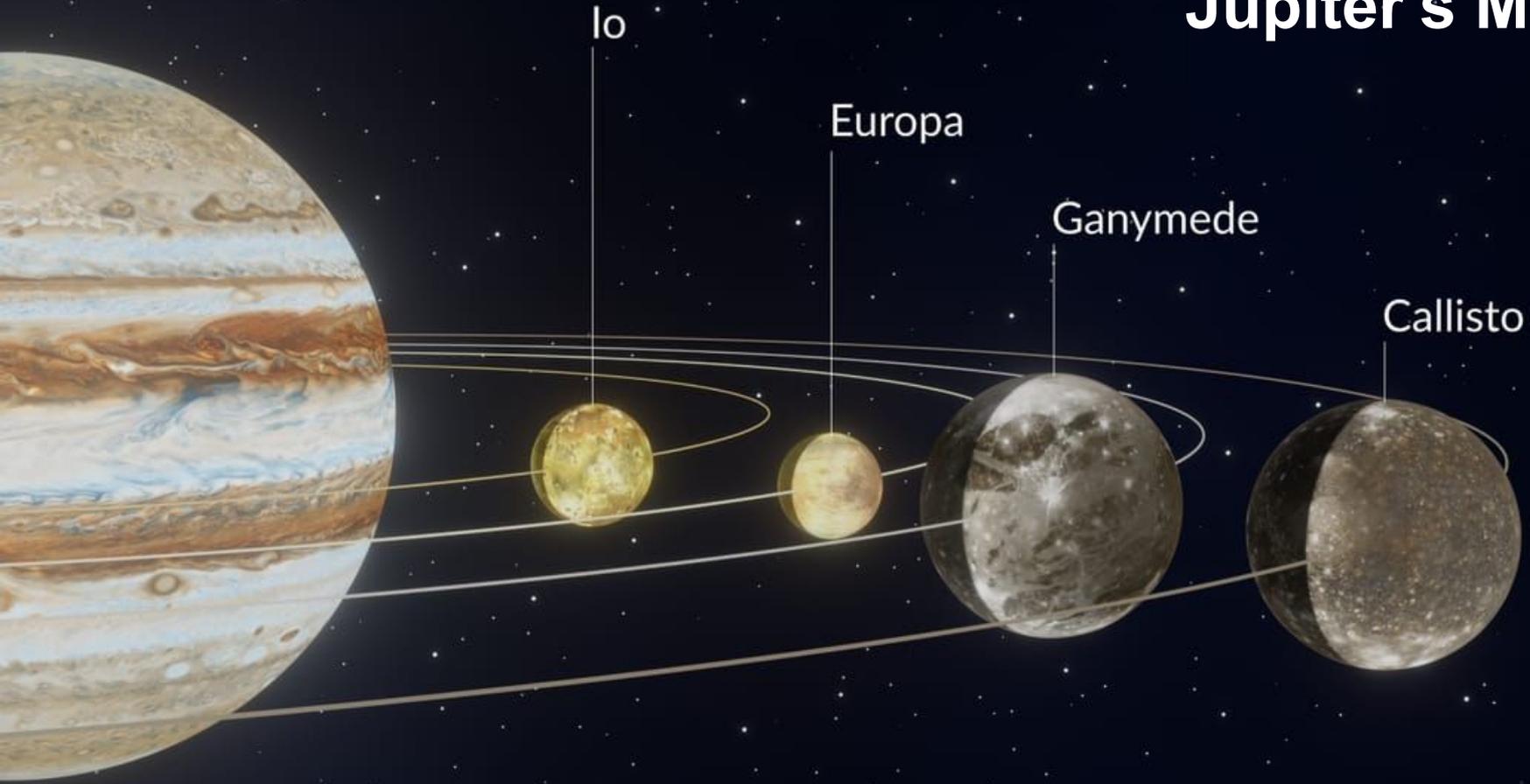
Mars' moon Deimos is also not suitable for life for the same reason.

Europa



Europa is complicated, let's look at it closer.

Jupiter's Moon



Can we find life on a moon? - Europa

Europa is a moon of Jupiter.

Europa has no atmosphere

It has a liquid water ocean under the surface.

Life might exist in its water ocean.

This would likely be microbial life.

We have not found life on Europa to date.

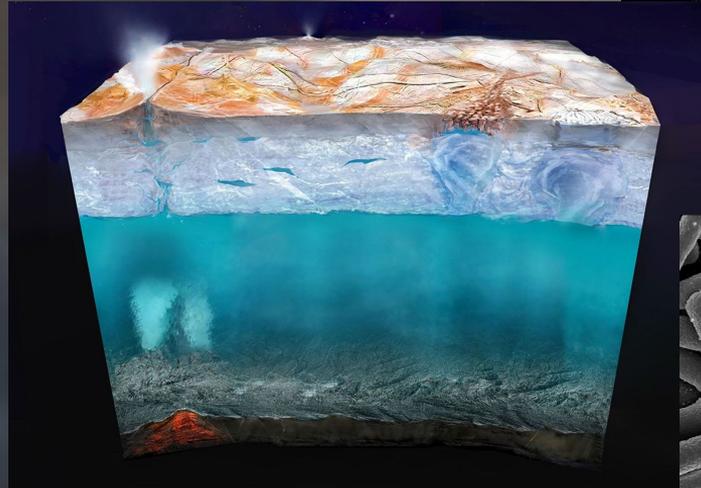
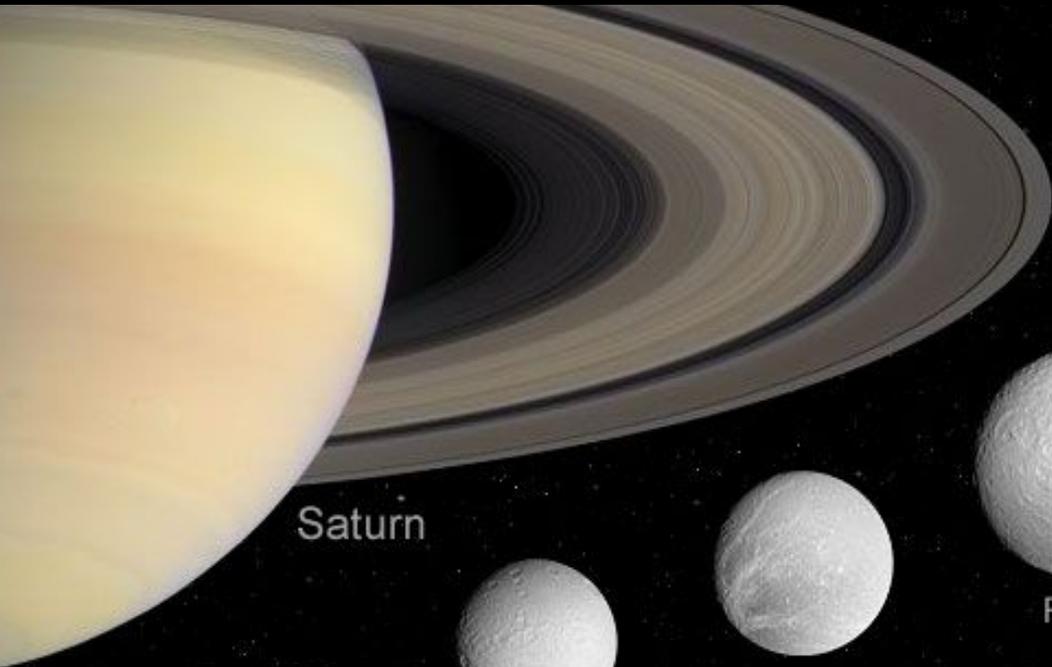


Image credit Eurooa: NASA / JPL
Image credit Microbes: Wikipedia/NIAD
Europa Layers: NASA/JPL-Caltech



Saturn



Mimas



Enceladus



Tethys



Dione



Rhea



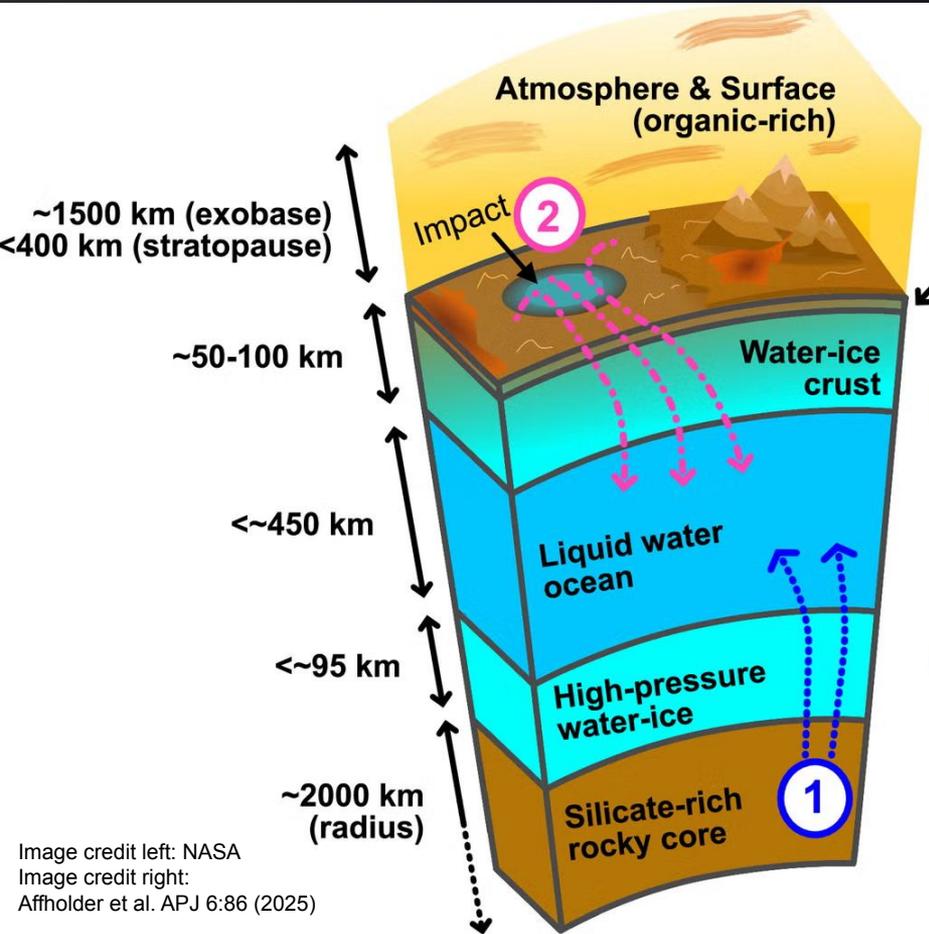
Titan



Iapetus

Saturn's Moons

Can we find life on a moon? - Titan

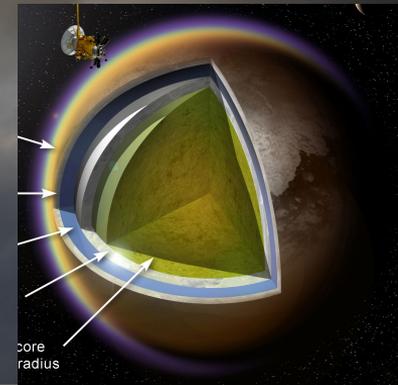


Titan has an atmosphere and liquid methane on the surface. All water on the surface is frozen.

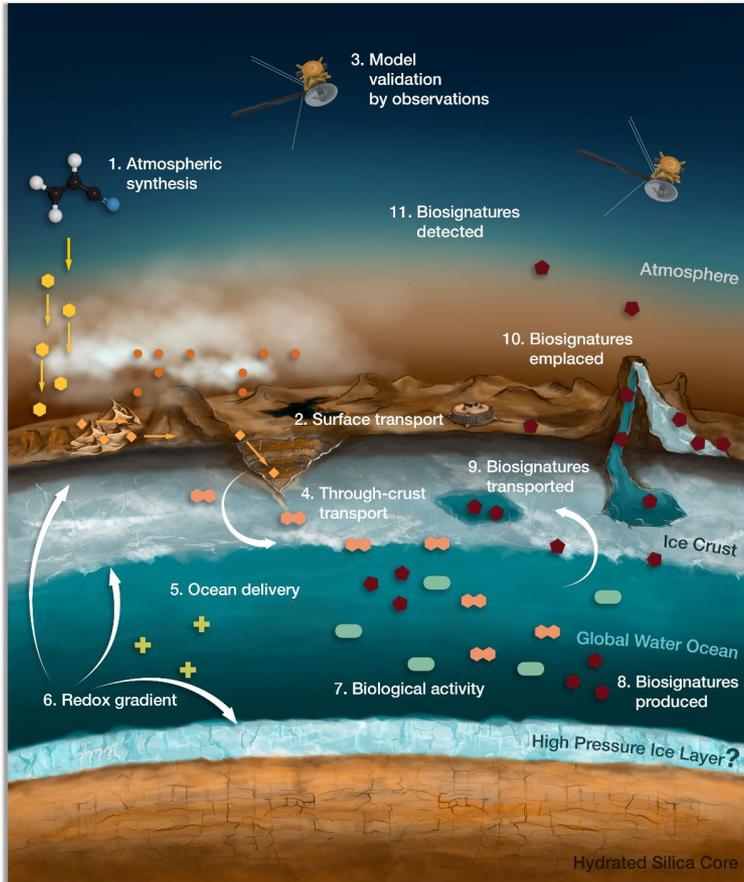
Under the water-ice crust there is a liquid water ocean. Under the water ocean, there is ice and rocks.

It is difficult for life to exist on the surface of Titan. Life could exist in the underground ocean.

We have not found life on Titan yet.

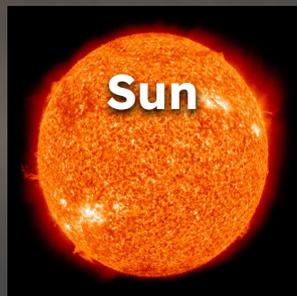


Can we find life on a moon? - Titan



- ◆ Surface Sediments
- Atmospheric Fallout
- Potential Life
- ⊕ Inorganic Ions
- ⬢ Delivered Organics
- Volatile Methane
- ⬠ Potential Chemical Biosignatures

Could we find life there?

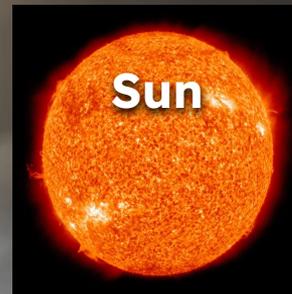


Could we find life there?

YES!

NO!

Could we find life there?



YES!

MAYBE?

PROBABLY NOT?

NO!

Optional Homework

EXOPLANETS AND LIFE BEYOND EARTH

LECTURE 2 WORKSHEET

DEFINING LIFE

FIND WORDS THAT DEFINE LIFE

Cells, Growth, Food, Reacts
Evoltuion, Children, Regulation

X G R O W T H A T T
Y W O J U L Q N R F
Q K X L S Y S T U O
X C H I L D R E N O
E V O L U T I O N D
R E G U L A T I O N
N L E O J Q L L O K
O U D C Y P I N J Y
O J B C E L L S V S
R E A C T S T O B K

WHICH ARE LIFE?

CIRCLE THINGS THAT ARE ALIVE



TRUE OR FALSE

T/F: Mars is a gas giant.

T/F: Jupiter has an icy moon called Europa with water under the surface.

T/F: Venus is so hot that life cannot exist

MULTIPLE CHOICE

What is Darwinian Evolution?

- Animals adapt to their environment.
- Animals using more energy to perform a task.
- Animals growing from baby to adult.

Humans are made from ____.

- amino acids
- proteins
- cells
- plants

Optional Homework

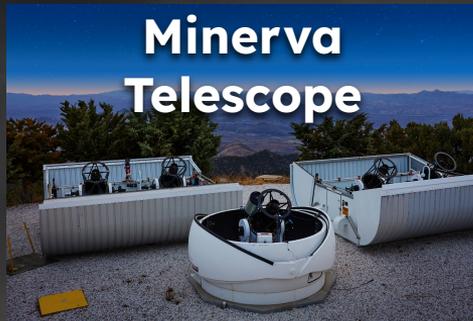
- Checkout NASA telescopes: science.nasa.gov/universe/observatories/
Which one are most suitable to find life outside Earth?
- Learn how we discover planets outside of our Solar System by watching this video:
<https://www.youtube.com/watch?v=AnX7ExBjrHw>

How are we Searching for Life?

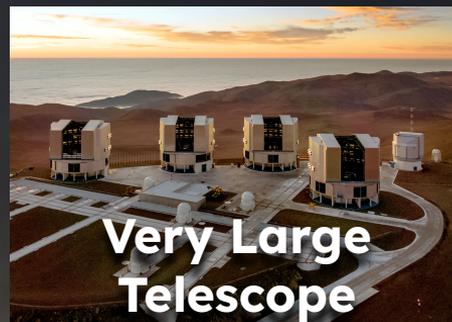
**James Webb
Space Telescope**



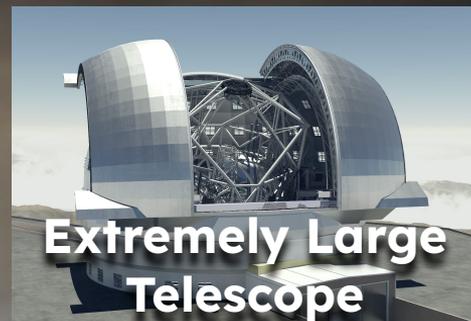
**Minerva
Telescope**



**Very Large
Telescope**



**Extremely Large
Telescope**



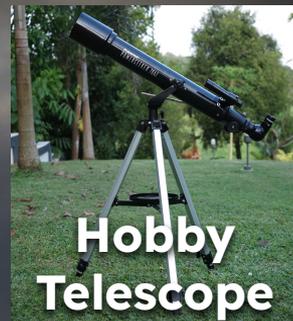
**Hubble Space
Telescope**



**Large Interferometer
For Exoplanets**

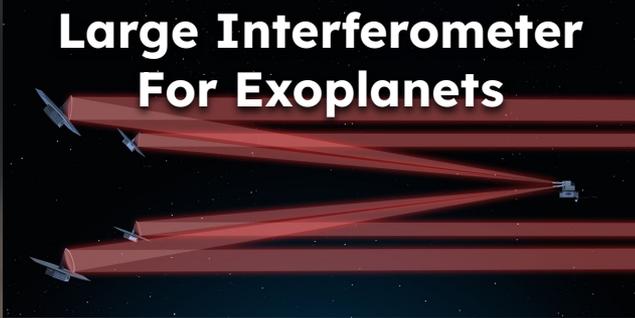


**Hobby
Telescope**



How are we Searching for Life?

**Large Interferometer
For Exoplanets**



**Very Large
Telescope**

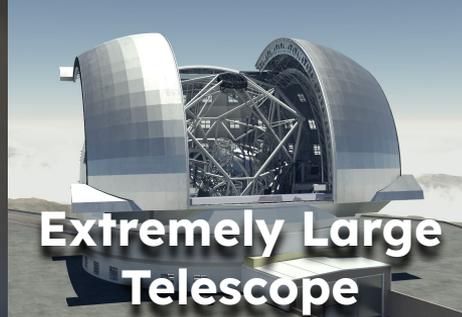
**Minerva
Telescope**



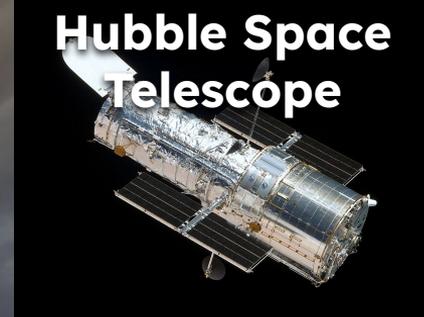
**James Webb
Space Telescope**



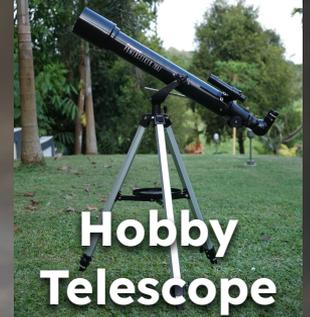
**Extremely Large
Telescope**



**Hubble Space
Telescope**



**Hobby
Telescope**



YES!

PROBABLY NOT?

NO!