Conditions for Life on

By Erik, Olivia, Evan, and Hailey

Europa

The Frozen Moon

Coming right up…….

- Discovering Europa
- What we know about Europa
- Inside Europa
- Potential for life on Europa
- Future missions!

What is Europa?

- One of 79 moons of Jupiter
- One of the four Galilean moons of Jupiter
- Discovered 1610 by Galileo Galilei
- Also (sort of) simultaneously discovered by Simon Mayr

(Big Europa)

Galileo

- Born 1564 in Pisa Italy
- Awesome mathematician
- Designed a 20x telescope
- Saw a variety of objects with a telescope

(Galileo)

Naming of Europa

- Galileo proposed the Medician Stars after former pupil and Grand Duke of Tuscany - Cosimo de Medici
- Wanted Patronage from the wealthy Duke
- Became the Astronomer and Mathematician to the Grand Duke

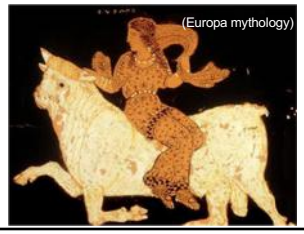

(Fancy Duke)

Simon Mayr

- Had observed Jovian moons before Galileo
- Didn't know what he was looking at
- Proposed moons be named after "consorts" of Zeus


(Simon Mayr)


(Galileo)


(Europa mythology)

Which of the following is Europa?

a) The official website of the European Union
b) A European soccer league
c) A freezer manufacturer
d) An asteroid


(Europa and Jupiter)

All of them!

How we know stuff about Europa

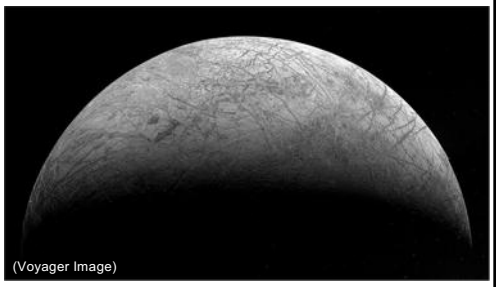
- 5 spacecraft have observed Europa
- Pioneer 10 and 11 in 1973 and 1974
- Produced low-resolution images


(Pioneer 10 Image)


(Pioneer 10)

How we know stuff about Europa

- Voyager probes got better images in 1977
- Provided evidence of tidal flexing due to orbit around Jupiter


(Voyager Image)

How we know stuff about Europa

- Galileo Probe in 1995
- Discovered more evidence that europa has a liquid sea
- Discovered information on Europa's atmosphere


(Galileo Probe)

Introduction Image References

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Pioneer 10 Image of Europa. (1972). *Wikipedia*. [Image] Retrieved from https://en.wikipedia.org/wiki/Europa_(moon)

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Galileo Probe. (1982). *Wikipedia*. [Image] Retrieved from https://en.wikipedia.org/wiki/Galileo_(spacecraft)#/media/File:Galileo_in_1983.jpg

Future Missions Image References

Probe in Space. (2017). *European Space Agency*. [Image] Retrieved from http://sci.esa.int/juice/59341-juice-mission/

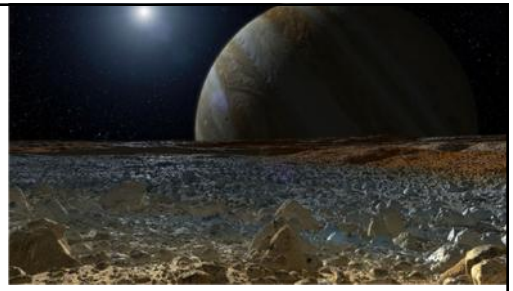
Physical Characteristics: Size & Orbit

- Radius of 1560 km
- 4th largest satellite in Jovian System
- Earth's moon radius is 1737 km
- 3.5 days to orbit Jupiter
- Tidally locked = one hemisphere always facing the planet

(Europa, Earth and Moon size comparison)

Gravity & Sunlight

- Europa surface gravity 1.32 m/s2
- Earth surface gravity 9.81 m/s2
- Sunlight takes 45 mins to reach Europa
- 25x fainter on Europa than Earth



(Simulated Europa Surface)

In a gravity of 1.32 m/s2, what would happen to you?

a) you would quickly float off into space

b) you would slowly float off into space

c) you could walk normally

d) you could jump higher than normal but you would return to the surface

(Jupiter, Io and Europa)

d) You can jump higher but you would return to the surface

(Moon landing)

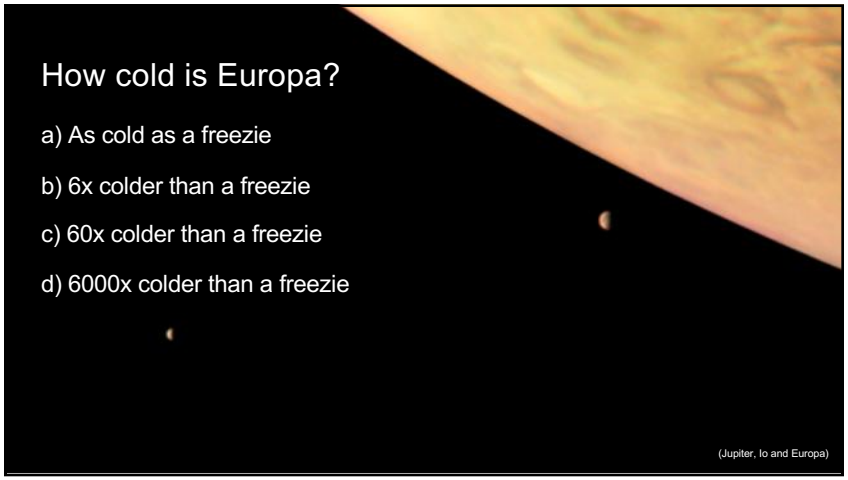
How cold is Europa?

a) As cold as a freezie

b) 6x colder than a freezie

c) 60x colder than a freezie

d) 6000x colder than a freezie

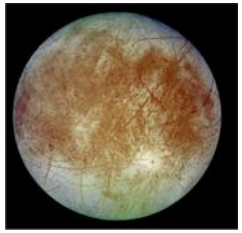


(Jupiter, Io and Europa)

c) 60x colder than a freezie

(Freezie)

X 60 =



(Natural and False Color Views of Europa)

Surface & Temperature

- estimated mean temp. of -190 C
- very thick layer of water ice crust
- approximately 15-25 km thick

(Europa Ice Rafting View)

Chemistry, Radiation & Pressure

- Chemistry: atmosphere mostly oxygen
- Radiation: 1 million times more intense than in Earth's belts
- Pressure: very low surface pressure of 1e-12 bar, Earth ~ 1 bar
- Could be much higher pressure elsewhere

(Europa Rising)

Physical Characteristics Image References

Europa, Earth and Moon size comparison. (2015). *Wikipedia* [image]. Retrieved from https://en.wikipedia.org/wiki/Europa_(moon)#/media/File:Europa,_Earth_%26_Moon_size_comparison.jpg

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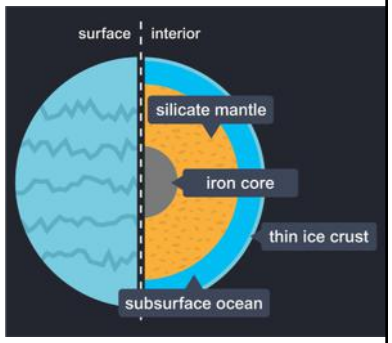
Europa: Winter Wonderland

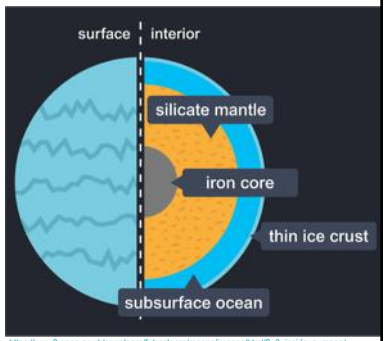
- Potential massive ocean underneath ice
- Believed to have silicate rocky mantle and iron nickel core
- Nearly circular orbit around Jupiter



https://www2.open.ac.uk/openlearn/futurelearn/moons/images/html/2_3_inside_a_moon/2_3_europa.html

Europa: The Galaxies Best Waterpark?

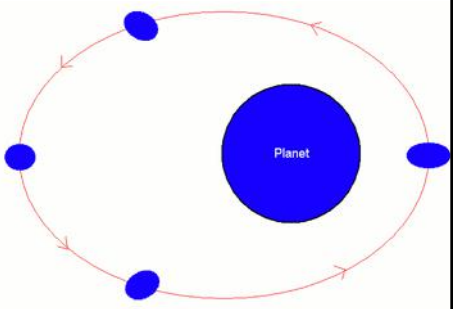
- *Nearly* circular orbit
- Tidal Flexing
  - Gravitational pull of Jupiter flexes Europa's core
  - Creates friction
- Creates water and surface cracks



https://www2.open.ac.uk/openlearn/futurelearn/moons/images/html/2_3_inside_a_moon/2_3_europa.html

Tidal Flexing - How does it work?

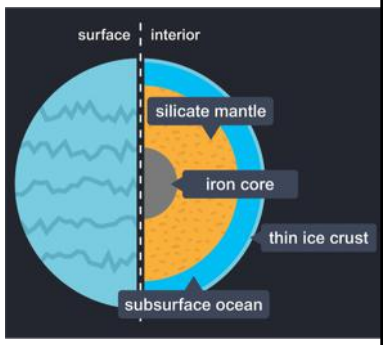
- Gravitational pull varies during orbit
- Changing gravitational pull deforms Europa's core
- Deformation creates friction heat
- Analogy: repeatedly bending coat hanger

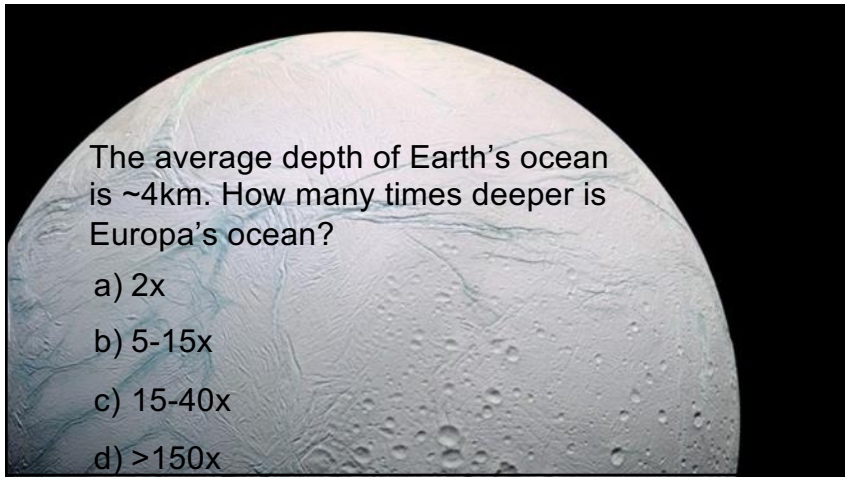


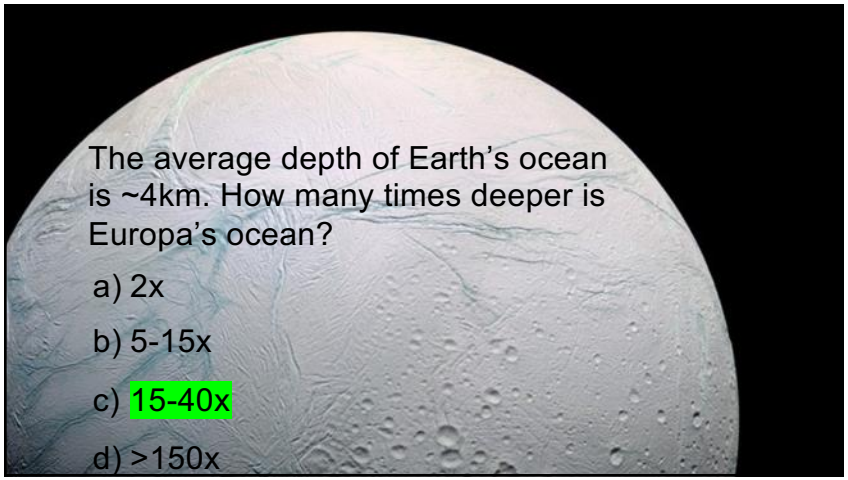
http://large.stanford.edu/courses/2007/ph210/pavlichin2/

Europa: The Galaxies Best Waterpark?

- Tidal flexing generates heat
  - Europa: 0.19 W/m
  - Earth: 0.08 W/m
- Other heat sources?
  - Radioactive decay
- Melting ice = lots of water







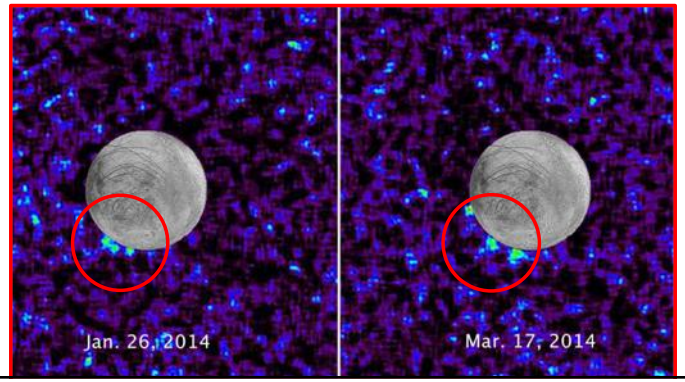
Europa: The Galaxies Best Waterpark?

- Europa: ¼ diameter of Earth's
- Europa: 60 - 160 km deep ocean
  - Challenger deep: 11km
- 2-3x Earth's water

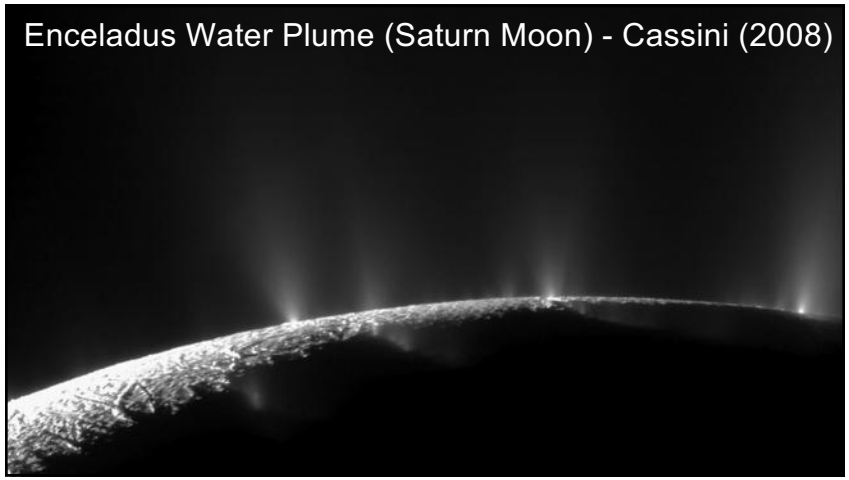
Europa: The Galaxies Best Waterpark?

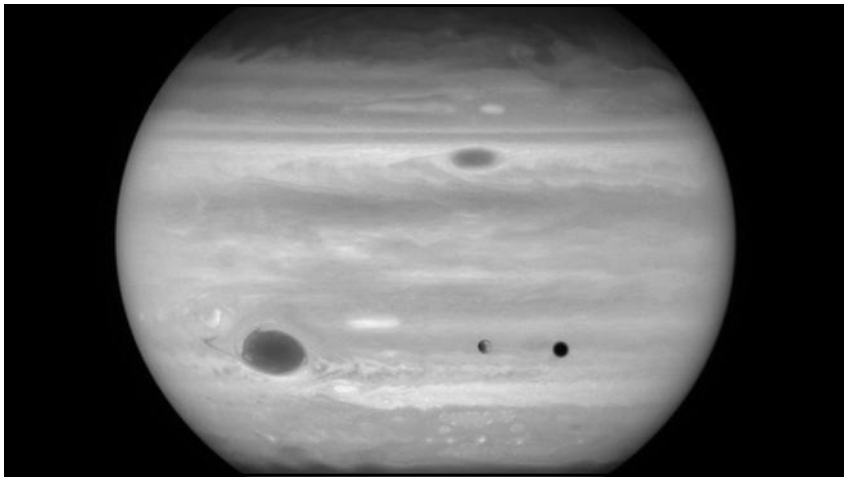
- Europa: ¼ diameter of Earth's
- Ocean: 60 - 150 km deep
- 2-3x Earth's water
- Possible water geysers seen by Hubble Space Telescope

Evidence of Water Geyser (UV) - Hubble Telescope



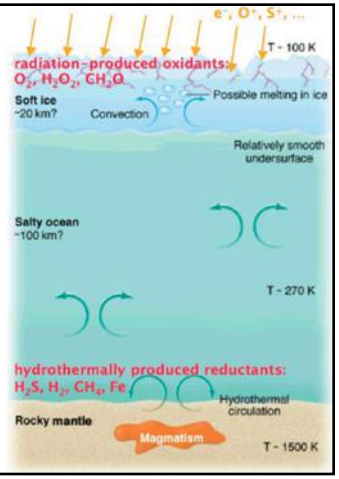
Enceladus Water Plume (Saturn Moon) - Cassini (2008)





Rocky Mantle

- Earth like chemistry?
  - Possible volcanic activity
- Oxidants produced at surface
  - Made by Jupiter's radiation
- Reductants possibly produced at mantle
  - Radioactive decay
- Reduction + oxidation = energy!



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About Europa. (n.d.). NASA [image]. Retrieved March 29, 2019 from https://europa.nasa.gov/about-europa/ten-things/

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LIFE ON EUROPA?

Are we alone in the universe?

EXTREMOPHILES

(extreme - loving)

What kind of animal is this?

a) That's not an animal
b) Sponge
c) Worm
d) Sea bug

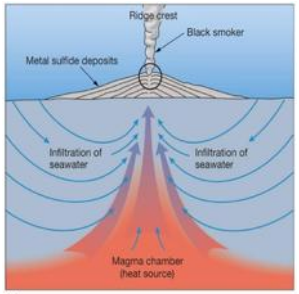
What kind of animal is this?

c) Worm!!! (Giant tube worm)

Found in the deep dark depths of the ocean

ADAPTING TO COMPLETE DARKNESS

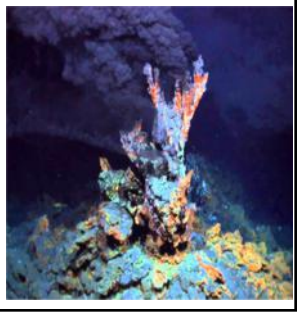
Hydrothermal Vents



Discovered in 1977

'Underwater hot springs'

Releases Hydrogen Sulphide

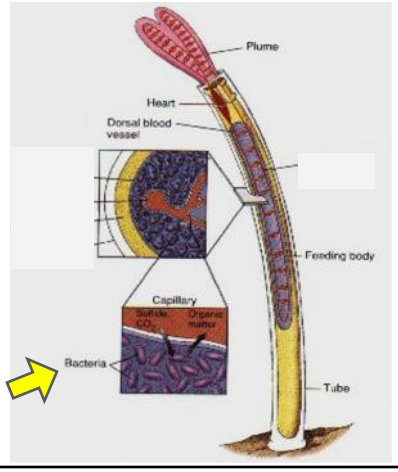


A GIANT TUBE WORM

With a tiny and very helpful friend!

Tube Worm + Bacteria = ♡

MUTUALISTIC SYMBIOTIC RELATIONSHIP



ADAPTING TO COMPLETE DARKNESS

Chemosynthesis

Hydrogen Sulphide + Oxygen → Sulphur + Water + Energy

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

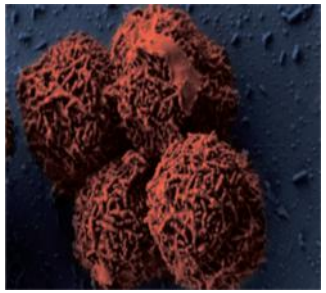
ADAPTING TO EXTREME COLD

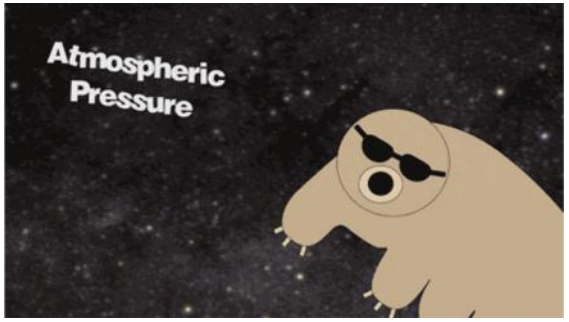
Cryophiles

Planococcus halocryphilus

Bacteria - 'cold weather champion'

- Live in permanently frozen ground
- Antifreeze systems to prevent ice crystal formation



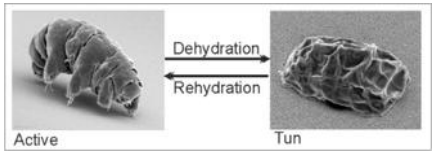


ADAPTING TO EXTREME PRESSURE AND RADIATION

The Tardigrade

'The water bear'

"The world's toughest animal"

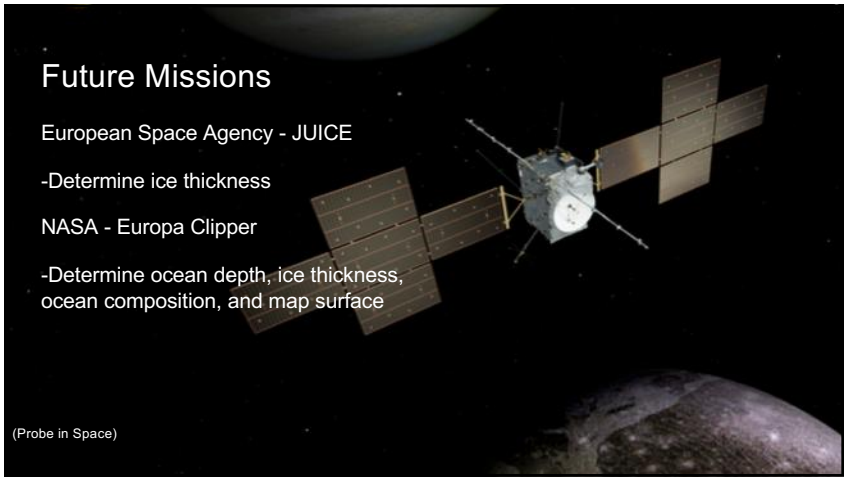


Survived direct exposure to solar radiation during a mission with the ISS!

Life has potential to exist in these extreme environments on Europa but is it likely that life could have **originated** in these extreme environments?

Life originated elsewhere and 'traveled' to Europa = Panspermia Hypothesis

Transfer of life between celestial bodies



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