Could There be Life on Europa?

Ben, Nico, Rylan, and Ben

The Big Question

- Are we alone in the universe?
- Could life exist in our solar system
- Search for life is now scientific

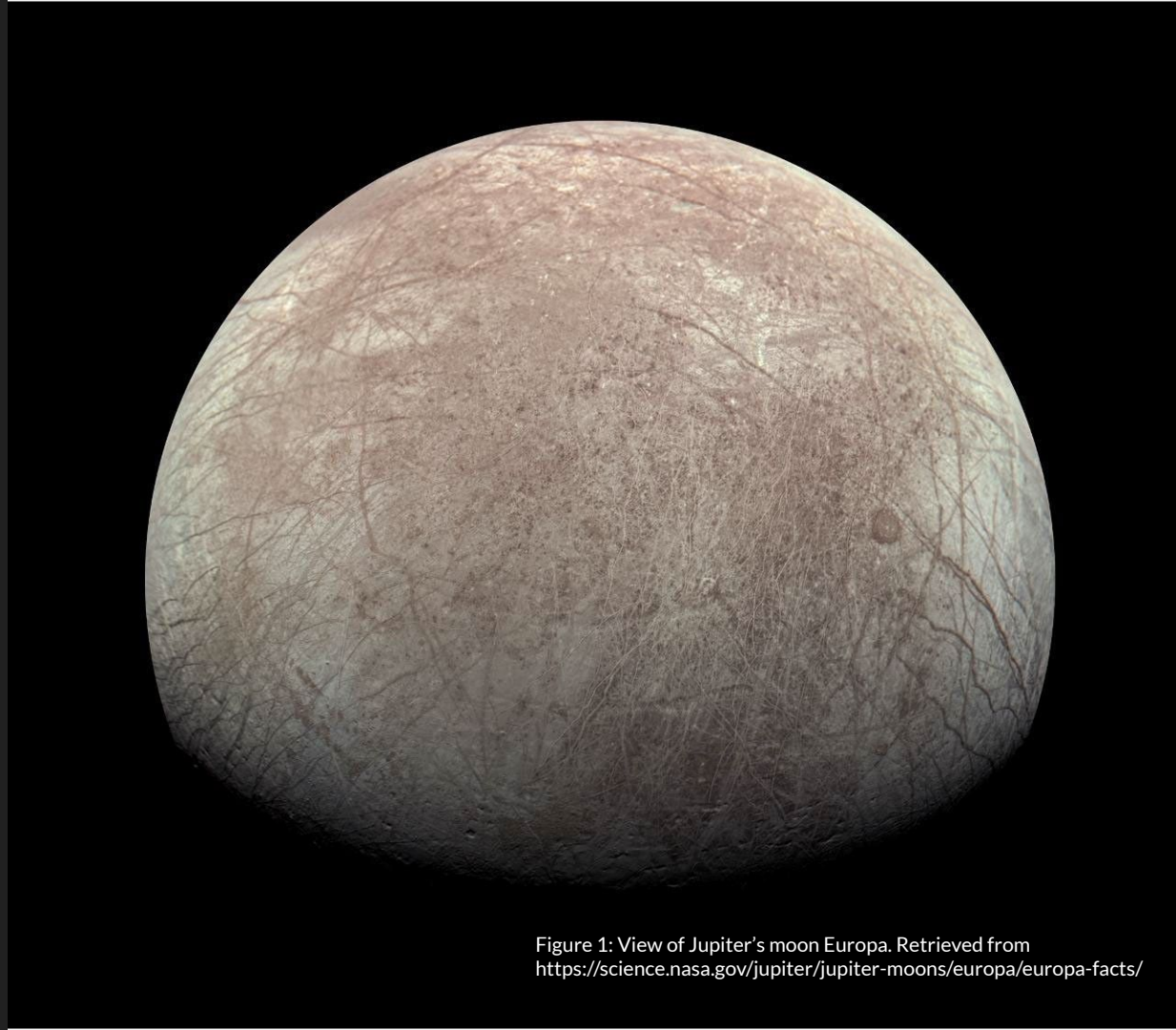


Figure 1: View of Jupiter's moon Europa. Retrieved from https://science.nasa.gov/jupiter/jupiter-moons/europa/europa-facts/

Rethinking Habitability

- Liquid water may be more common than we thought
  - May exist beyond the habitable zone

- Not just on Planets, also on Moons

(Howell & Pappalardo, 2020, para 1)

Figure 2: An illustration of NASA's Europa Clipper spacecraft above the surface of Europa and in front of Jupiter. Retrieved from https://science.nasa.gov/solar-system/ocean-worlds/

Figure 3: Illustration of NASA's Europa Clipper spacecraft above Jupiter's ocean moon Europa. Retrieved from https://science.nasa.gov/solar-system/ocean-worlds/

The Habitable Zone

- The “Goldilocks Zone”
- Right temperature for water
- Where we think life can form

(Tobie et al., 2026, para 3)

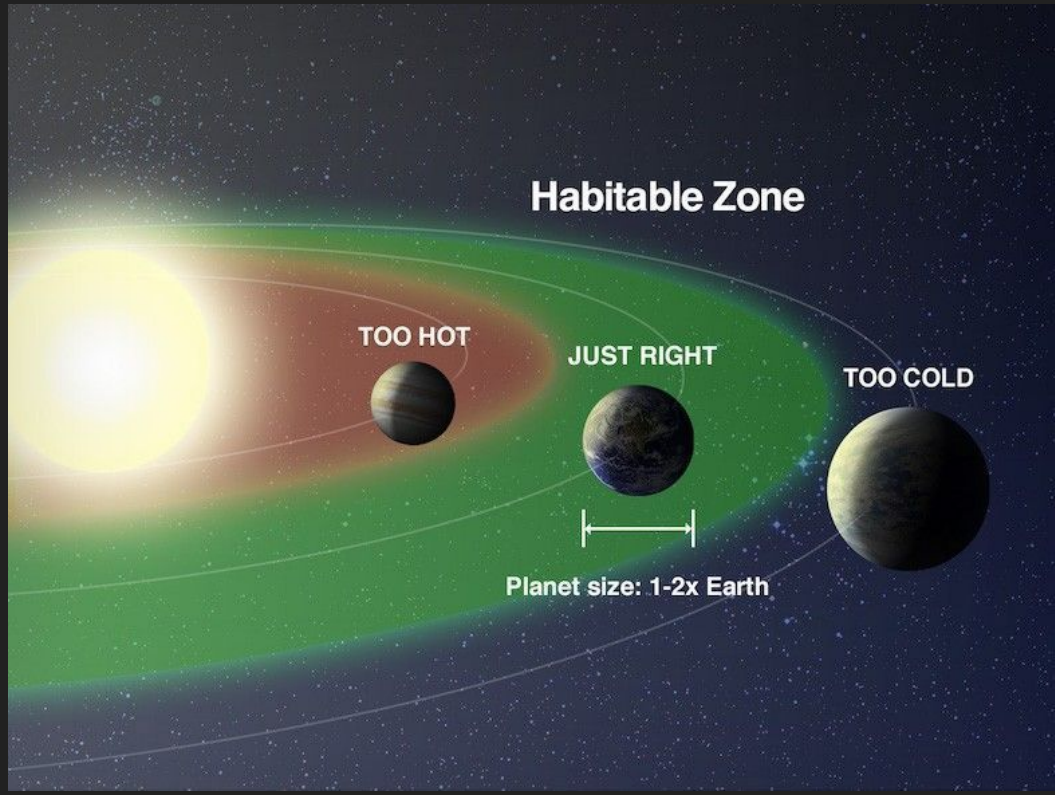


Figure 4: Traditional picture of the habitable zone – not too hot, not too cold. Retrieved from https://science.nasa.gov/exoplanets/habitable-zone/.

Introducing Europa

- ~5 AU from the Sun
- Extremely cold, icy surface
- Yet, it's a promising candidate for life

(Barnett, 2025, para 1 & 4)

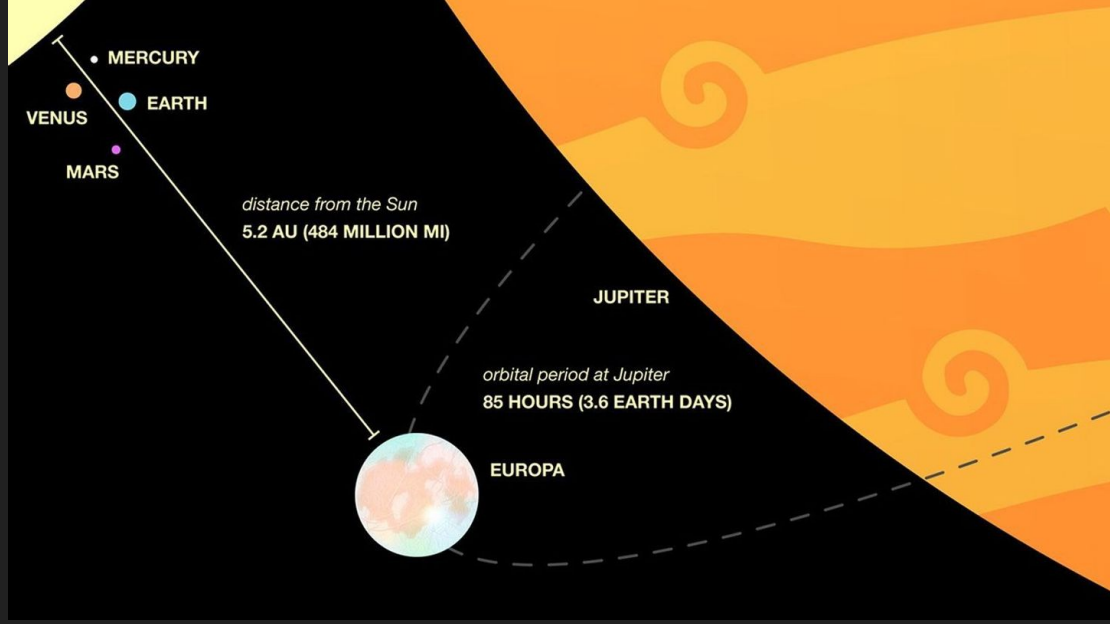


Figure 5: Illustration of Europa's distance from the Sun. Retrieved from https://science.nasa.gov/missions/europa-clipper/europa-a-world-of-ice-with-potential-for-life/

Why Europa Matters

- 4th largest of Jupiter's Moons
- ¼ the size of the Earth
- Liquid water beneath the surface

(Barnett, 2025, para 1)

Figure 6: This composite image shows from left to right, Io, Europa, Ganymede, and Callisto. Retrieved from https://www.space.com/16452-jupiters-moons.html

Figure 7:Size Comparison: Earth, Moon, and Europa. Retrieved from https://www.scienceabc.com/nature/universe/europa-could-there-be-life-on-jupiters-icy-moon

Subsurface Ocean

- Ice shell: 15-25 kilometers thick
- Ocean: 60-150 kilometers deep
- More water than Earth

(Barnett, 2025, para 1)

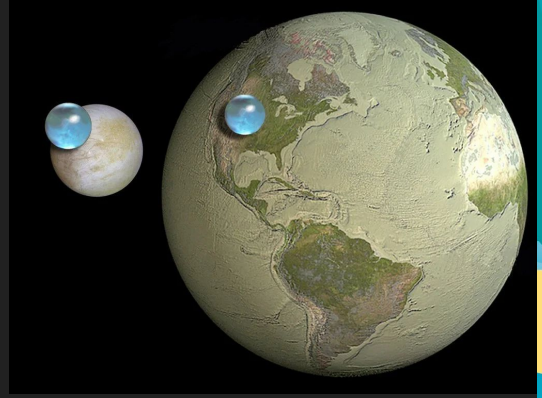


Figure 8: A graphical comparison shows the amount of water on Jupiter's moon Europa as compared with Earth's water. Retrieved from https://www.reddit.com/r/spaceporn/comments/u28yi/a_graphical_comparison_shows_the_amount_of_water/?solution=0b2d3a8b94bed53f0b2d3a8b94bed53f&js_challenge=1&token=bbbe4bf1c9a2b5160829c4be34da58619e4d305e3982dfaa3d868a5be45b632d

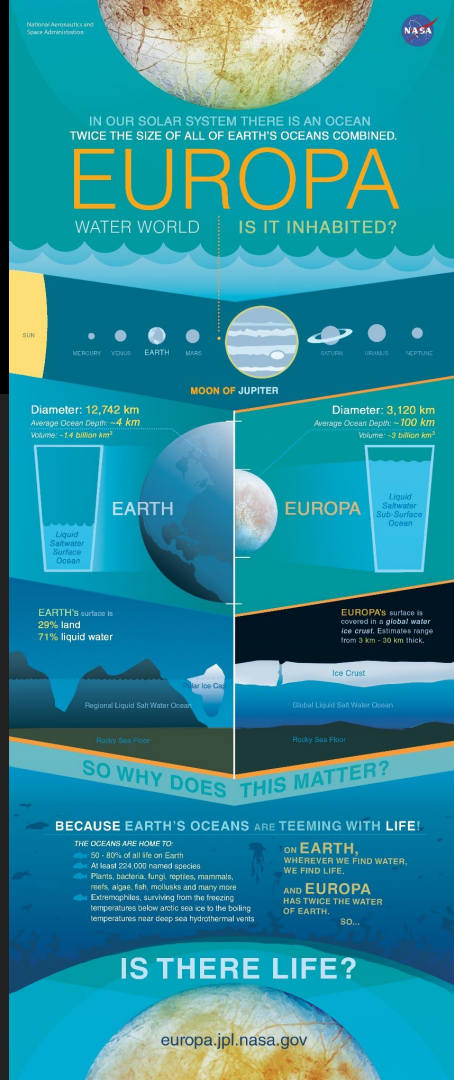


Figure 9: Jupiter's Europa harbors an ocean twice the size of all Earth's oceans combined.Retreived from https://science.nasa.gov/missions/europa-clipper/europa-clipper-resources/europa-water-world-infographic/

Requirements for Life

- Scientists look for three main requirements
- Liquid water is one of them
- Does Europa have all three?

(Barnett, 2025, para 3)

Figure 10: Illustration of Europa's water plumes. Retreavied from https://www.ku.ac.ae/europas-water-plumes-are-harder-to-detect-than-previously-thought

Movement in Space

- Tidally locked to Jupiter
- Europas path around Jupiter is elliptical
- Jupiter's gravity stretches and relaxes Europa

(Barnett, 2025, para 5)

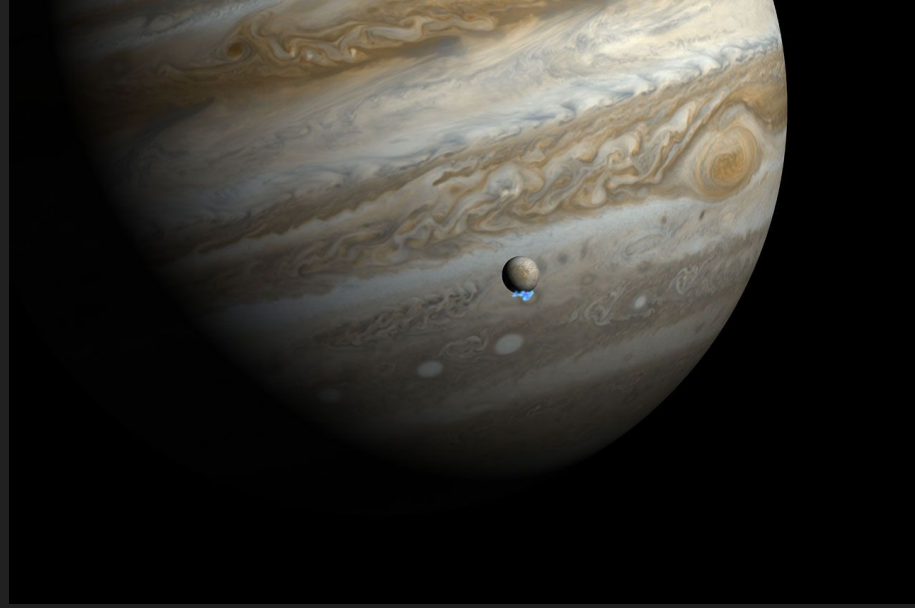


Figure 11: Water vapour plumes on Jupiter's moon Europa (artist's impression). Retrieved from https://esahubble.org/news/heic1322/

Surface Features

- Cracks and ridges
- Reddish streaks
- Young active surface, 40-90 million years old

(Barnett, 2025, para 8)

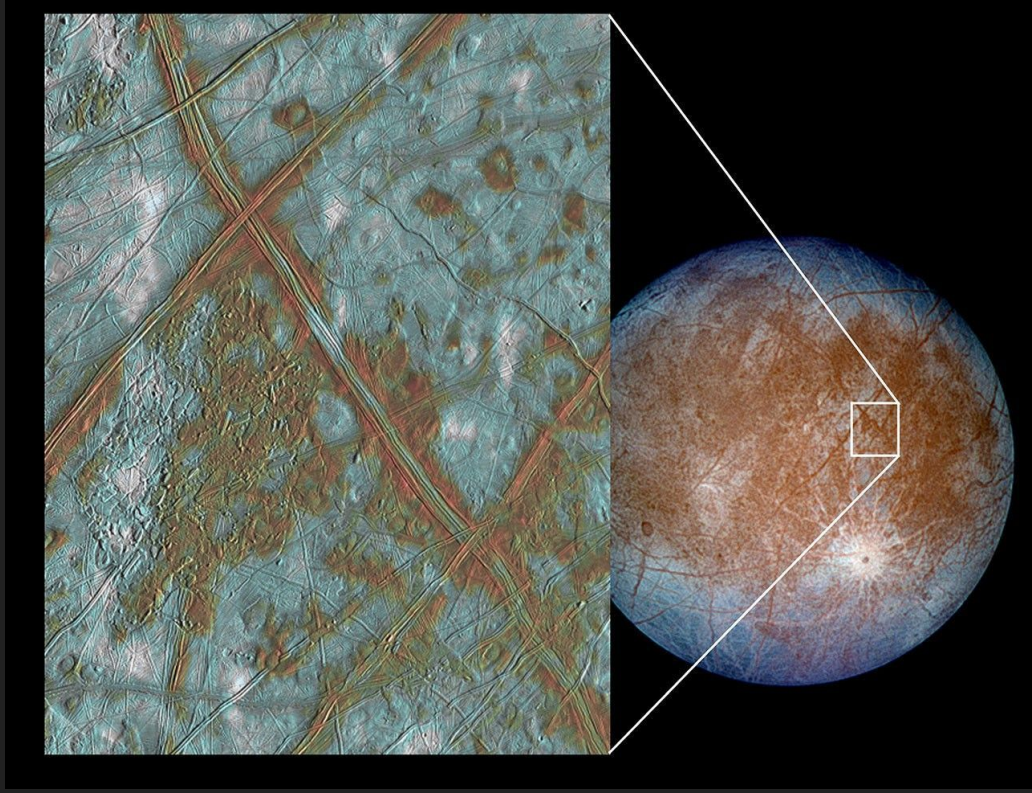


Figure 12: The image on the left shows a region of Europa's crust made up of blocks which are thought to have broken apart and "rafted" into new positions. Retrieved from https://science.nasa.gov/jupiter/jupiter-moons/europa/europa-facts/

Clicker Question: Why does Europa have long cracks along its surface?

a) Asteroides hit its surface frequently and the impacts cause the ice to crack

b) Jupiter is heating Europa and causing the ice to melt and fracture

c) Tidal flexing from Europa's elliptical orbit stretches and relaxes the surface

d) Those aren’t cracks at all, they’re underwater highways for Aliens

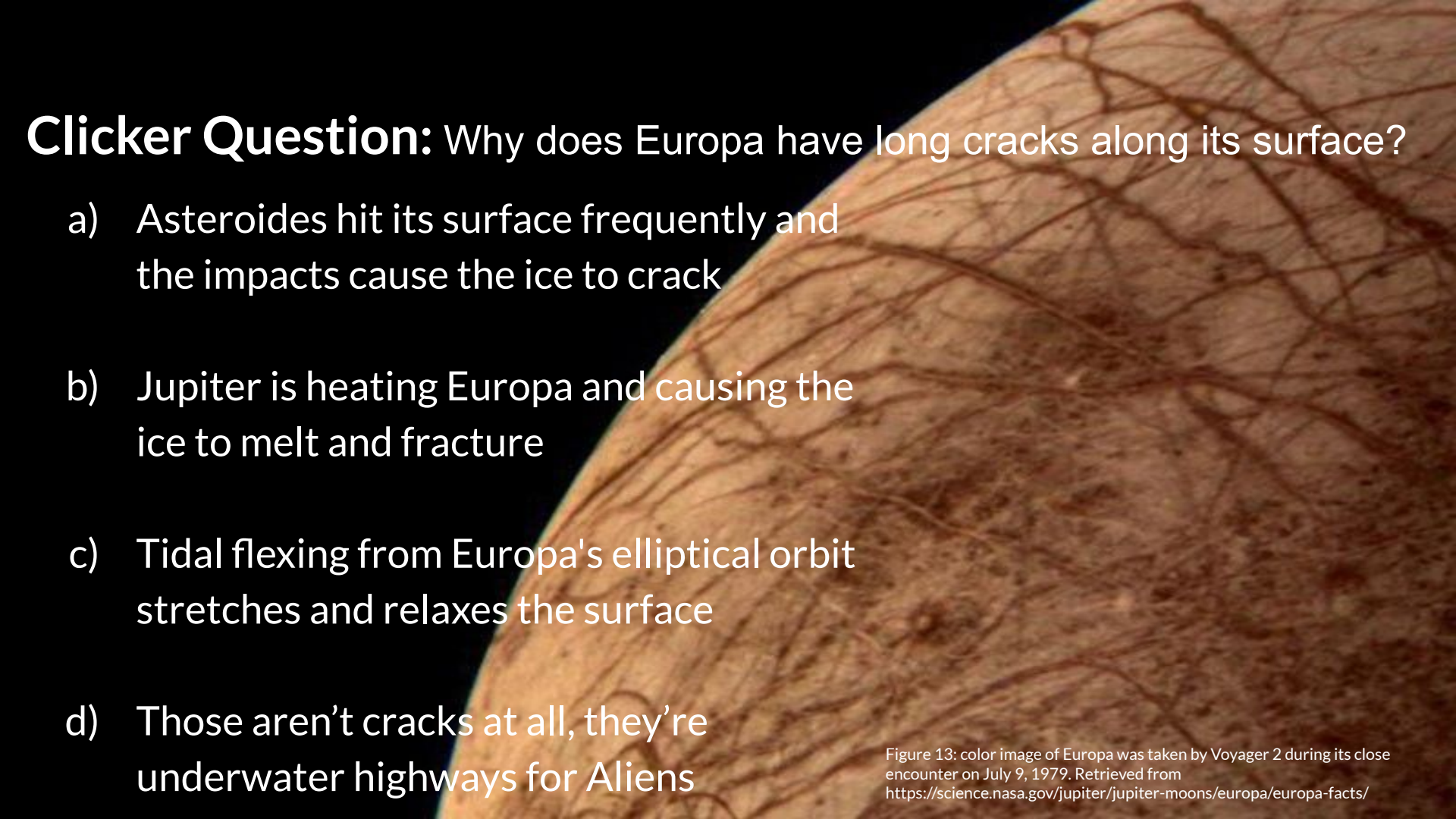


Figure 13: color image of Europa was taken by Voyager 2 during its close encounter on July 9, 1979. Retrieved from https://science.nasa.gov/jupiter/jupiter-moons/europa/europa-facts/

Europa's Geophysics

- 60-150 kilometers deep
- 15-25 Kilometers of Ice
- Twice as large as all of Earth's oceans

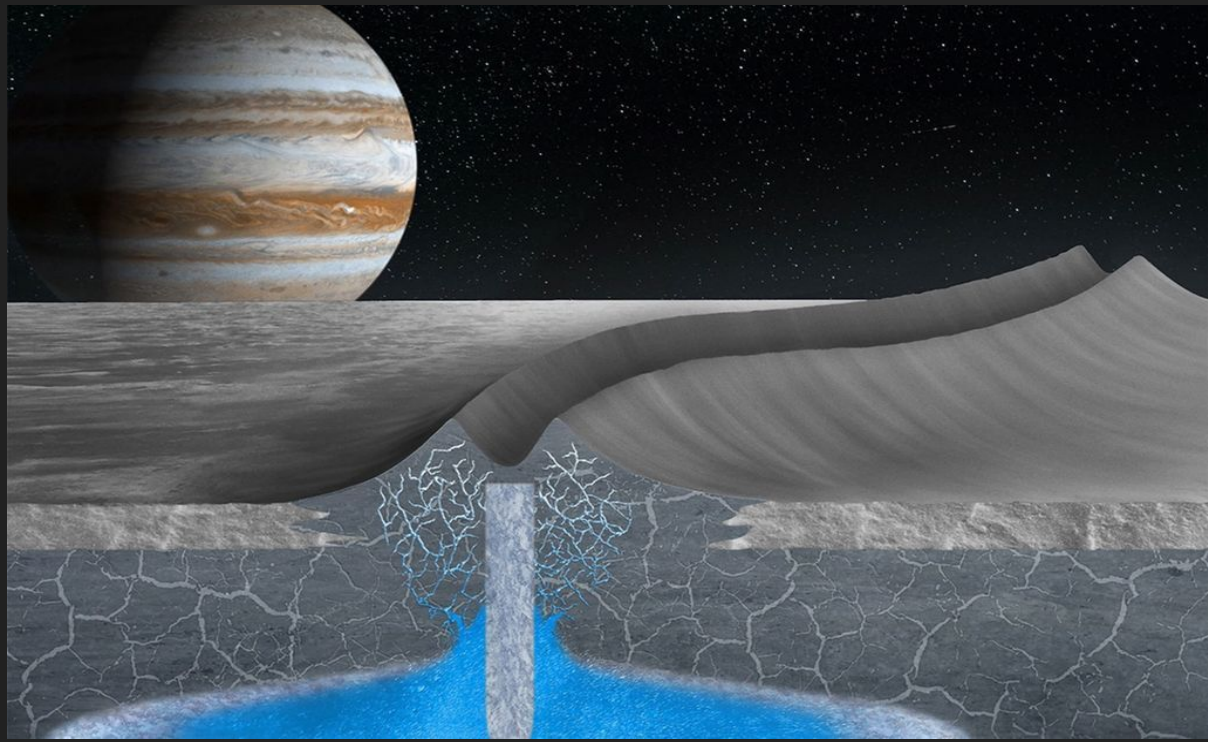


Figure 14: Image of Europa and how it's icy shell may be habitable for life
https://www.smithsonianmag.com/smart-news/europas-icy-shell-may-be-habitable-for-life-180979944/

Geophysical Process Breakdown

-Jupiters massive gravity pulls on its moons

-Creates a permanent tidal; shift

-The moons orbit in non-circular paths

-Gravitational tug constantly changes in strength

-”Rubber Band”

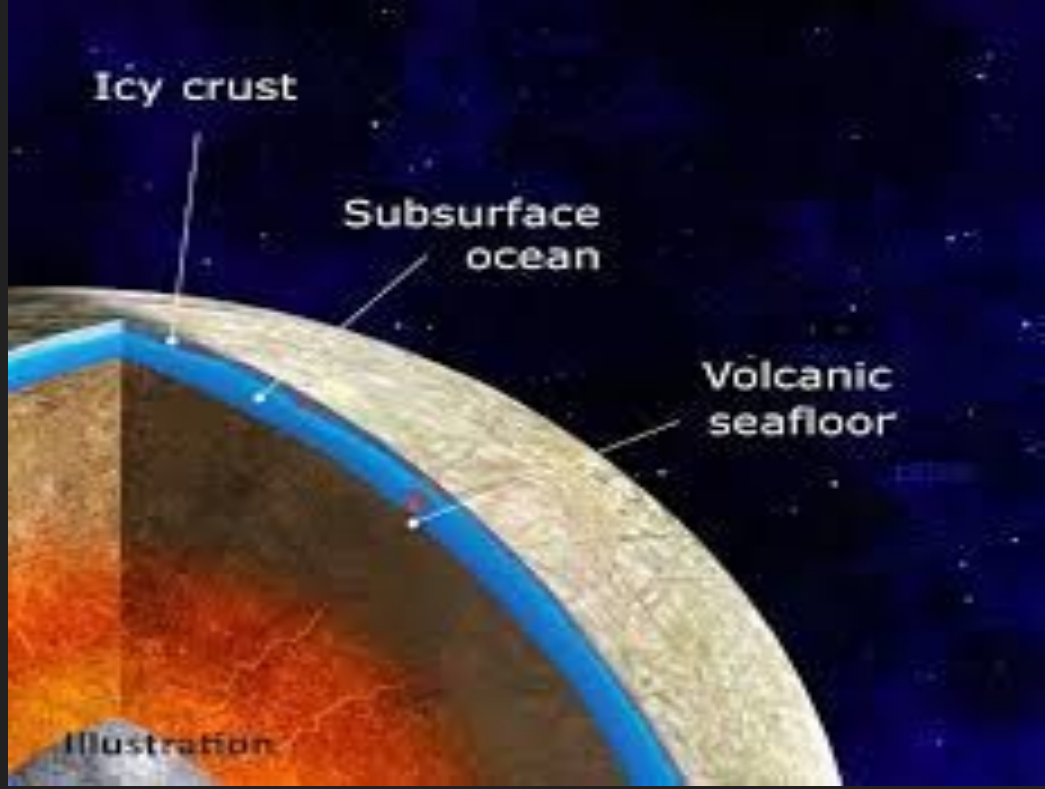


Figure 15: DIagram of the Geophysical process breakdown of Europa
https://www.jpl.nasa.gov/news/europas-interior-may-be-hot-enough-to-fuel-seafloor-volcanoes/

Jupiter's Moons

- Approximately 79 Jovian moons

- Create internal geophysics activity

- Subsurface Oceans

- Moon-moon tides

FIgure 16: Picture of the four largest moons of Jupiter: Io, Europa, Ganymede and Callisto
https://news.arizona.edu/news/jupiters-moons-could-be-warming-each-other

The role of Laplace Resonance

- May be the most responsible for the heating

- A 1:2:4 orbital resonance

- Keeps Europa in a non-circular orbit

- Key role in Europas habitability and geological activity

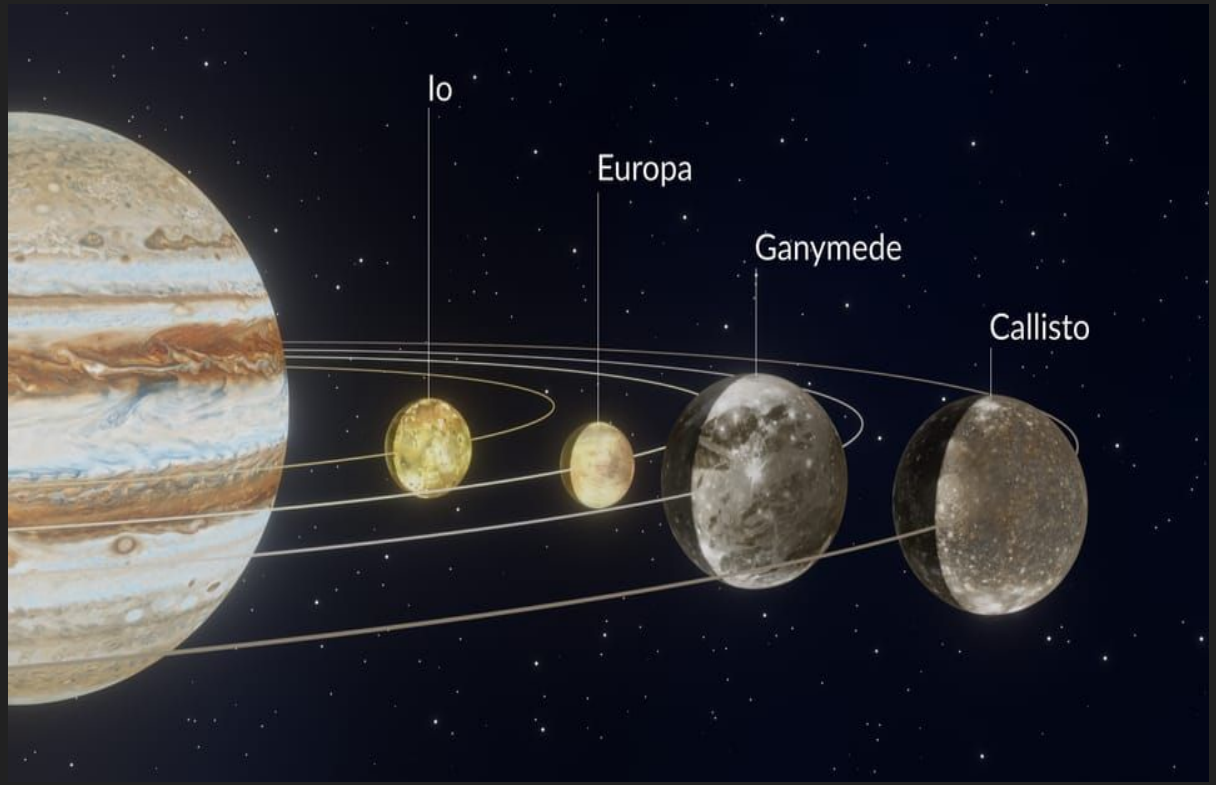


Figure 17: The 4 largest Jovian satellites; Io, Europa, Ganyemede and Callisto.
https://starwalk.space/en/news/jupiter-galilean-moons

4 theories for why Europa has liquid water

1) Tidal Heating

2)Insulating Ice shell

3)Radioactive

4)Saline Composition

Figure 18: A satellite and a small section on Europa
https://science.nasa.gov/mission/europa-clipper/europa-exploration-history/

Tidal Heating

-Heating is uneven

-Higher at Europa’s poles and lower at the points of moon that are opposite and facing jupiter.

-Provides a constant, renewable internal heat source

-Prevents it from Europa's water from solidifying

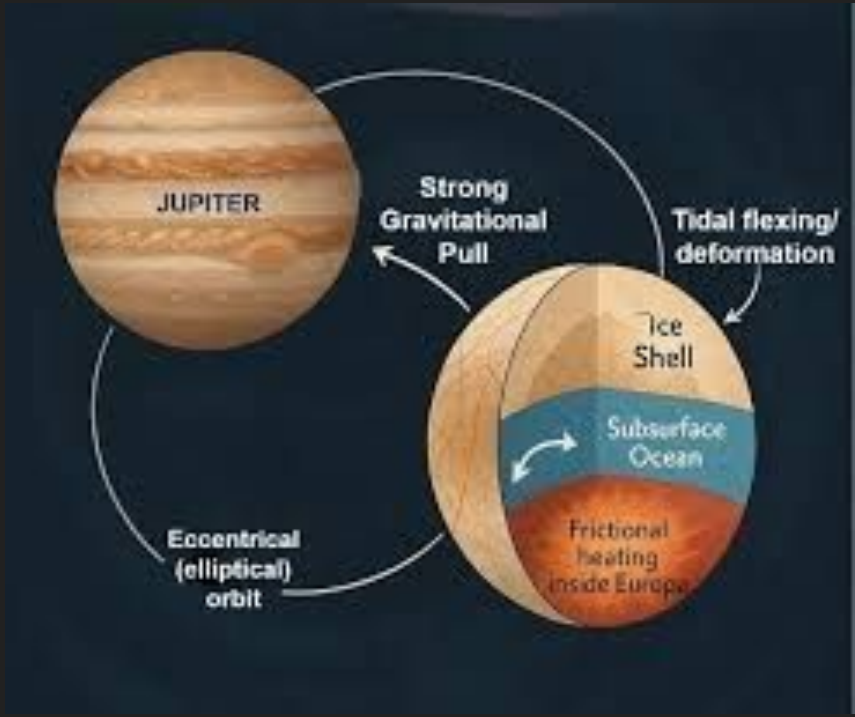


Figure 19: A diagram of the tidal heating process of Europa. https://www.researchgate.net/figure/Diagram-illustrating-the-tidal-heating-mechanism-in-Europa-where-Jupiters-strong_fig1_395768160

Insulating Ice Shell

-Roughly 15-25 kilometers thick of ice

-Acts as an insulator

-Trapping the tidal heat within the moon

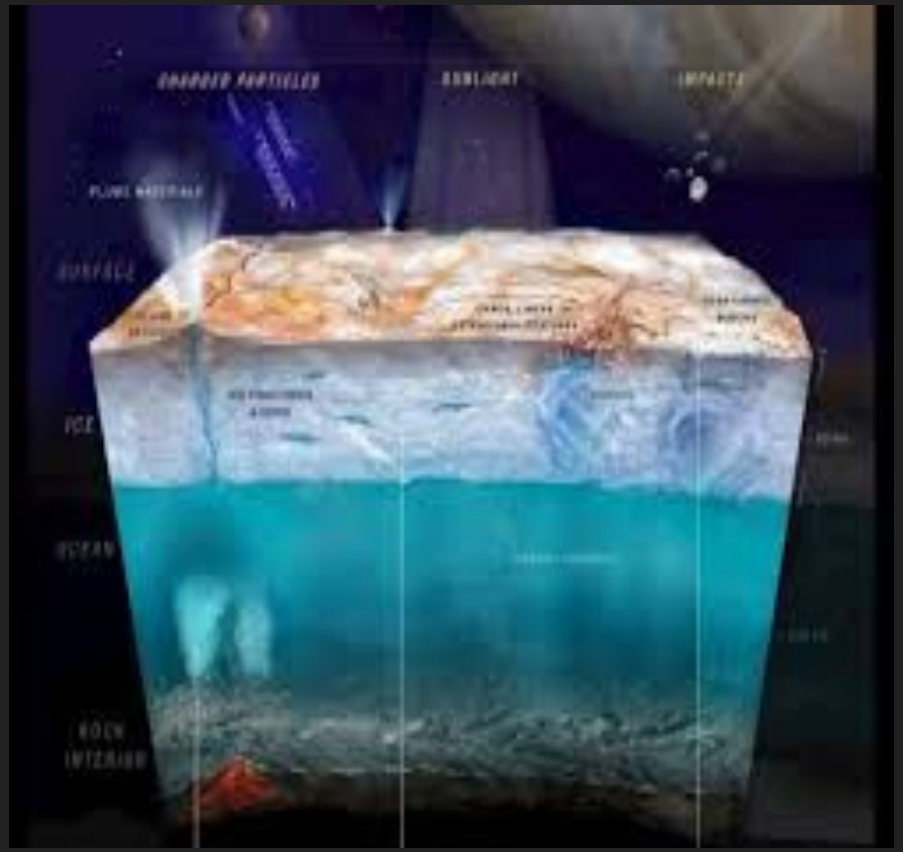


Figure 20:Picture of the composition of Europa with the upcoming Europa clipper mission
https://link.springer.com/article/10.1007/s11214-024-01069-y/figures/1

Radioactive Decay

-Forms the moon silicate layer

-Also contributes to keeping the ocean warm

-Europas mantle

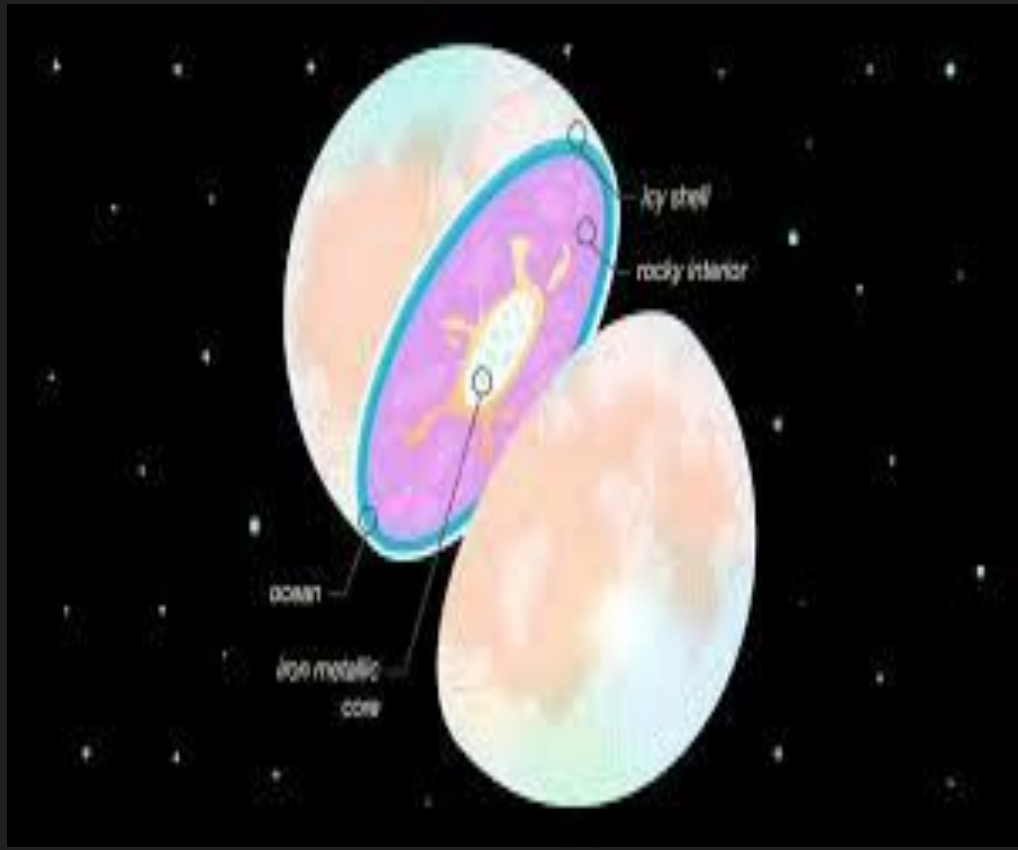


Figure 21: Radioactive Decay of Europa and how it could possibly lead to water on Europa. https://universemagazine.com/en/europas-radioactive-ocean-what-could-alien-life-feed-on/?srsltid=AfmBOooDJeNeSZlyNKO_vmTCAfKZGdp_441cIgiAf13ret_DcfF7s8sI

Saline Composition

-Evidence from Galileo

-Indicates an electrically conductive layer

-Sodium Chloride in younger regions]

-Magnesium sulfate in older regions

-Indicates oceans materials

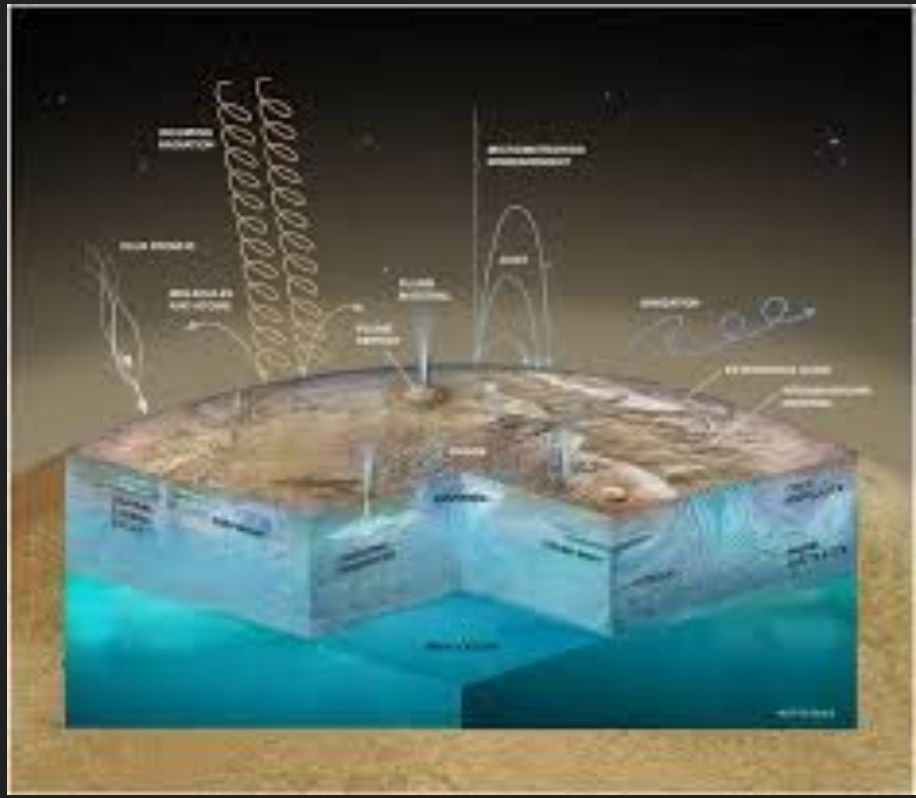


Figure 22:Saline Composition of Europa
https://link.springer.com/article/10.1007/s11214-024-01069-y

Clicker Question: What is NOT one of the 4 theories of why Europa has liquid water?

A) Saline Composition

B) Insulating in Shell

C) Aliens urine

D) Radioactive Decay

Figure 23: Picture of 3 aliens
https://gurps.fandom.com/wiki/Grey_Alien

Exploration of Europa: Early Discoveries

- First observed by Galileo Gallilei in 1610 using a homemade telescope
- Discovered along with the other **Galilean moons** (Io, Europa, Ganymede, Callisto)

(Europa Exploration History, NASA, 2025, Para 1)

Figure 24: Europa
https://science.nasa.gov/jupiter/jupiter-moons/europa/

Exploration of Europa: Major Space Missions to Europa and Observations

- Pioneer 10 & 11 (1973-1974)
- Voyager 1 & Voyager 2 (1979)
- Galileo spacecraft (1989-1997)
- Hubble Space Telescope Observations (2016)
- Juno Spacecraft (Flybys still ongoing) (Europa Exploration History, NASA, 2025, para 3-14)

Figure 25: Artist's concept of Europa water vapor plume
https://science.nasa.gov/asset/hubble/artists-concept-of-europa-water-vapor-plume/

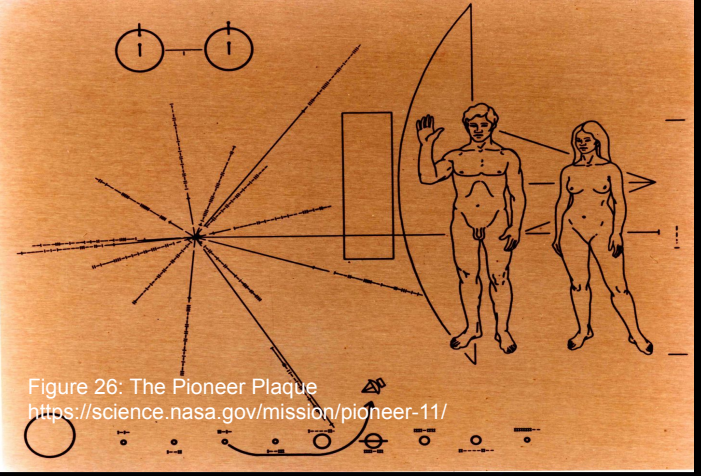


Figure 26: The Pioneer Plaque
https://science.nasa.gov/mission/pioneer-11/

Figure 27: First image of Europa
https://science.nasa.gov/mission/europa-clipper/europa-exploration-history/

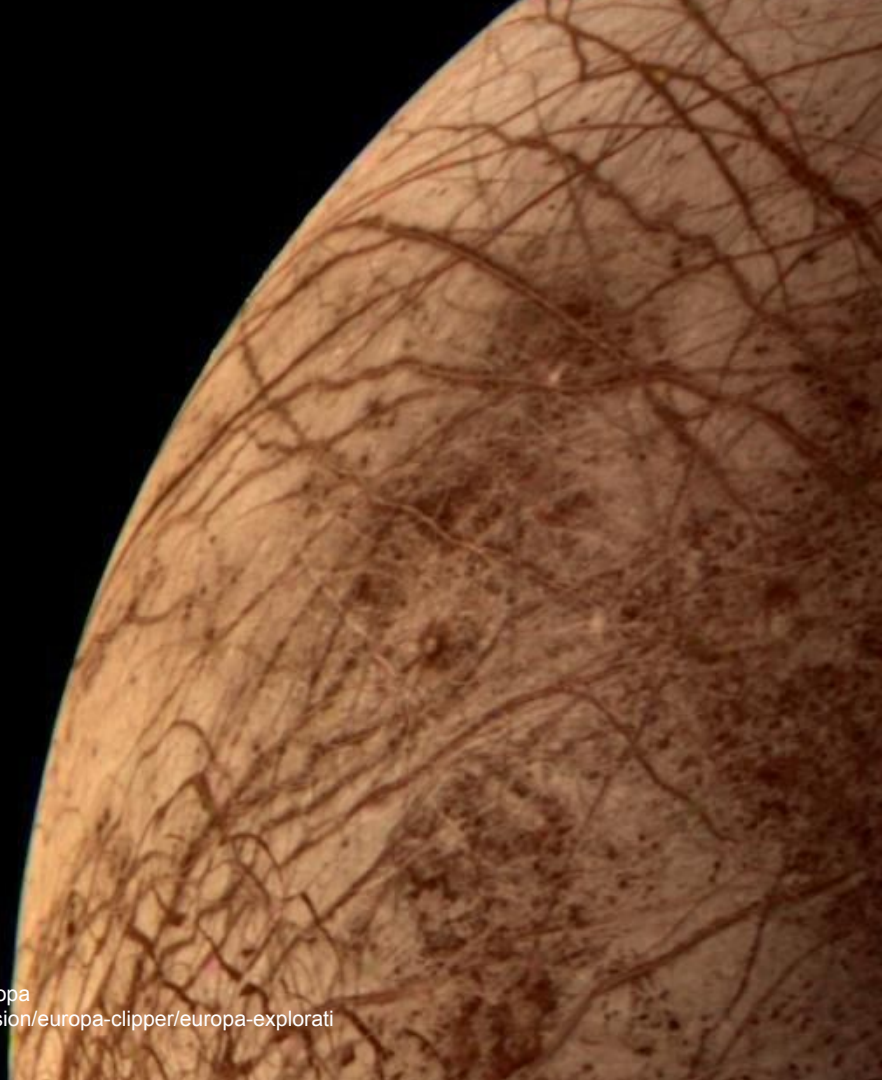


Figure 28: First image of Europa
https://science.nasa.gov/mission/europa-clipper/europa-exploration-history/

Exploration of Europa: Challenges of Exploring Europa

- Extreme radiation
- Extreme distance
- Navigation Difficulties
- Very cold temperatures
- Difficult landing conditions

(Van Kane, 2014, Para 1-4)

Figure 29: Artist concept of Europa Ice Shell
https://science.nasa.gov/photojournal/europas-ice-shell-artists-concept/

So Could Life Exist On Europa?????

3 Key Ingredients For Life:

1. Water
2. Chemistry
3. Energy

(Carney, 2025, para 1)

Figure 30: Image form new article highlighting the possibility of life on Europa. Retrieved from https://www.express.co.uk/news/science/960145/alien-news-europa-nasa-jupiter-space-extraterrestrial-aliens-solar-system

Water

- Europa has lots of it
- Water is essential for life
- Geology suggests warm ice
- Tidal flexing

(Carney, 2025, para 2)

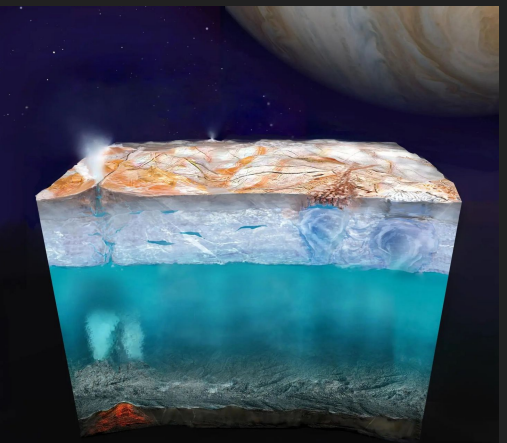


Figure 31: Image of Europa's possible layers. Retrieved from https://science.nasa.gov/mission/europa-clipper/mission-science/

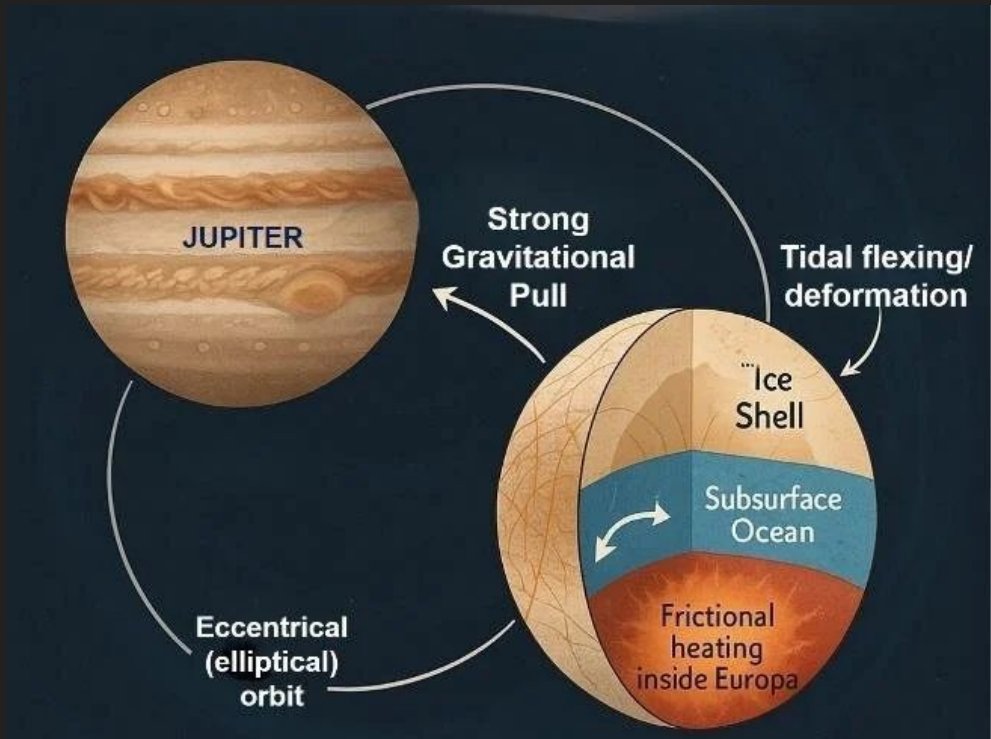


Figure 32: Diagram depicting the tidal heating mechanism in Europa. Retrieved from https://www.researchgate.net/figure/Diagram-illustrating-the-tidal-heating-mechanism-in-Europa-where-Jupiters-strong_fig1_395768160

Chemistry

Building Blocks of Life:

- Hydrogen
- Carbon
- Nitrogen
- Oxygen
- Phosphorous
- Sulfur (Carney, 2025, para 7)

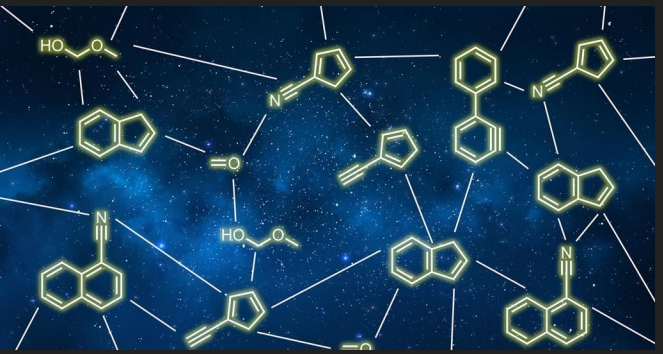
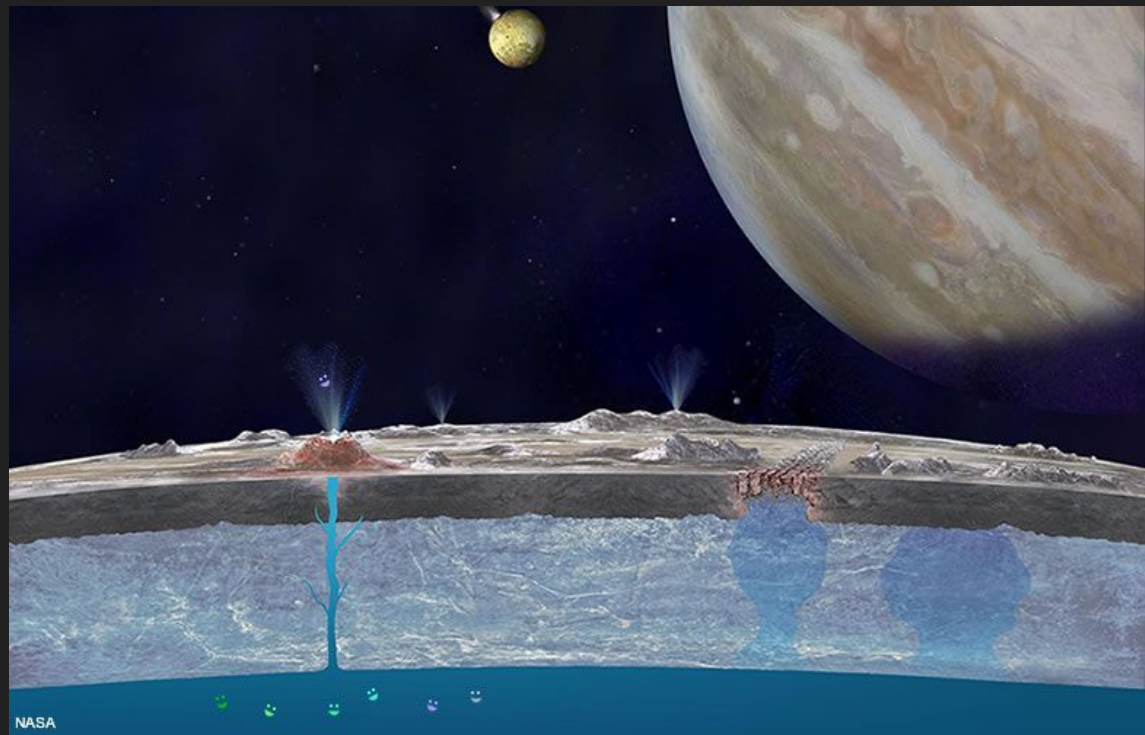


Figure 33: Image showing organic chemistry in interstellar space. Retrieved from https://www.chemistryworld.com/features/the-surprising-organic-chemistry-in-interstellar-space/4019144.article)

Figure 34: Diagram of Europa's top layers. Retrieved from https://www.newscientist.com/article/2419981-europa-may-have-less-oxygen-to-fuel-life-in-its-seas-than-we-thought/

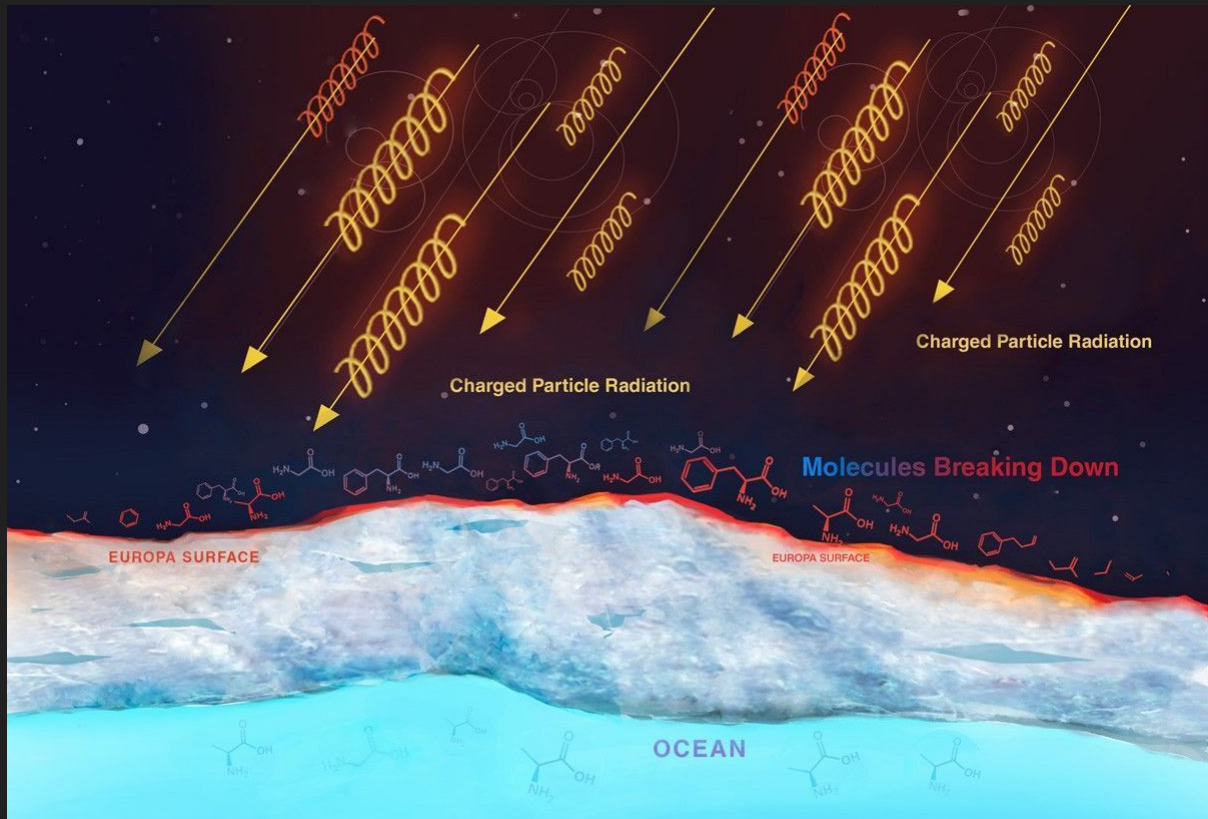


Energy

- All life forms need energy
- Most comes from the Sun on Earth
- Chemical reactions?
- Radiation
- Tidal flexing

(Carney, 2025, para 10)

Figure 35: Depiction of radiation at Europa's surface. Retrieved from https://science.nasa.gov/mission/europa-clipper/why-europa-ingredients-for-life/



So What Are We Doing About It?

NASA: Juno

- Arrived at Jupiter in 2016
- Measured Europa's ice crust (Massengill, 2026, para 1)

NASA: Europa Clipper

- Launched 2024
- Arriving 2030 (Carney, 2025, para 1)

ESA: Juice

- Launched 2023
- Arriving 2031 (European Space Agency, n.d., para 1)

NASA: Antarctic Ocean Samples

- Deep dark water molecules (Barry, 2026, para 1-9)

NASA: Galileo Data Analysis

- Ammonia bearing compounds (Alanis, 2026, para 1-3)

Figure 36: Rotating image of NASA's Europa Clipper. Retrieved from https://science.nasa.gov/mission/europa-clipper/spacecraft-meet-europa-clipper/

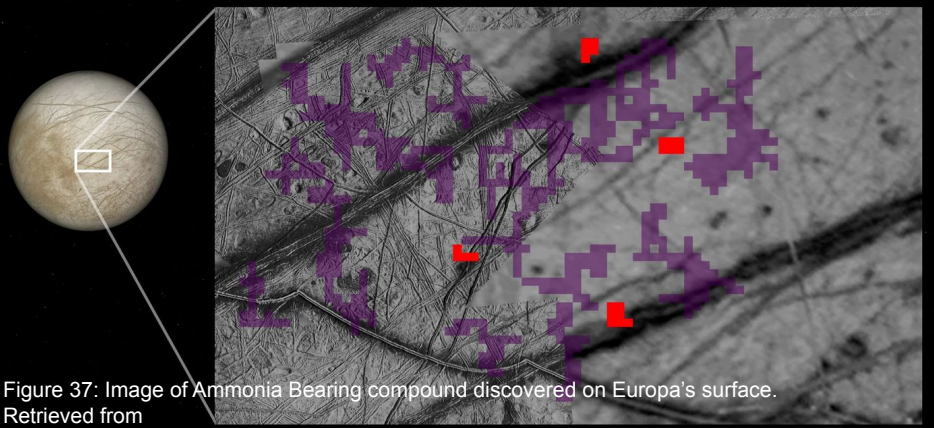


Figure 37: Image of Ammonia Bearing compound discovered on Europa's surface. Retrieved from https://science.nasa.gov/photojournal/ammonia-bearing-compounds-discovered-at-surface-of-jupiters-moon-europa/

Clicker Question: Is There Life On Europa?

A) One million percent
B) Eh, I guess it could be
C) It’s definitely possible
D) No way
E) Aliens are everywhere

Figure 38: Image of an alien holding a question mark. Retrieved from https://dribbble.com/shots/26690071-Cute-Alien-Holding-Question-Mark-Mascot

Thank you!

Questions?