

# Europa and the Quest for Life



# Europa and the Quest for Life

The NASA Clipper Mission  
to Jupiter's Icy Moon

Norfolk Collegiate O.A.K.S.  
FIRST Lego League Team #24277

This special edition of Europa and the  
Quest for Life is a proof copy for the  
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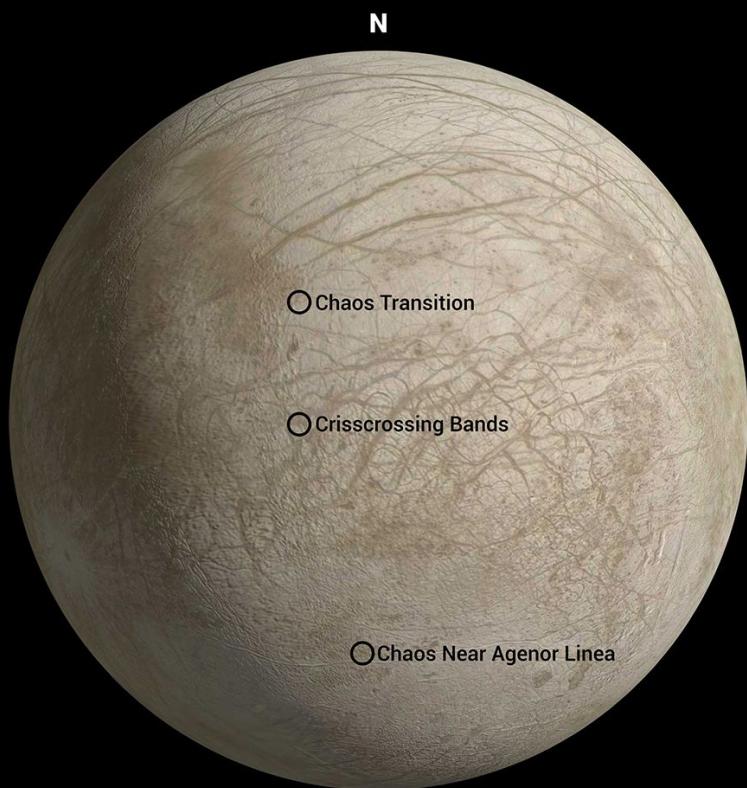
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# Europa and the Quest for Life

What is Europa and why are we interested, you ask? Next October in 2024, NASA is going to launch the Europa Clipper on a Falcon Heavy rocket. It is going to survey Europa's surface and sub-surface. We think Europa has liquid water and icy lakes that may contain life. This is the first-ever mission to conduct detailed investigations of Europa. This book will explain about Europa and the Europa clipper.

So join us as we journey into Europa and the Clipper Mission. We hope you enjoy it!



# What is Europa?

Have you heard about Europa? Europa is one of Jupiter's ninety-plus moons and also one of the four Galilean moons. The Galilean moons are named after the famous astronomer, Galileo Galilei, who discovered them in 1610. While some scientists think Europa could support life in its oceans, we just aren't positive. So we are sending a probe to there to find out for sure if it could support life.

Life, as we know it needs water, energy and food. We think Europa has all these things. There may be water under the icy surface, which is heated by tidal flexing. We don't have any certainty regarding the food availability, but if there is abundant life, they may feed off of each other.



# Astronomy Prior to Galileo Galilei

Aristarchus  
of Samos



Mars  
Retrograde  
Motion



Astronomy began by serving the Babylonians and ancient Romans not as science but as part of their religion. They largely believed that the Earth was the center of the universe and everything rotated around it. And can you blame them? When we stand on earth, it really looks like the sun, moon, stars, everything rotates around the earth. And you can't feel the earth moving. So it makes sense.

But not everyone believed this. Some people felt that this explanation was missing something. For example, there were some “stars” that moved among the other stars. Of course we now know these are planets, even though when looking at them from earth, they look like stars. What’s more, these “stars” (planets) moved in very weird patterns. They would sometimes stop, move backwards for a bit (called “retrograde” motion), then continue in the original direction. What could possibly explain that?

Aristarchus of Samos, around 280 BC, was one person who suggested the Sun might be the center of the so-called universe. Then in 1543 Copernicus also published a book placing the sun at the center of the universe. Still, most people thought the earth was the center for many years to come.

Almost 2000 years after Aristarchus, Galileo Galilei tried to change the way people thought about the universe.

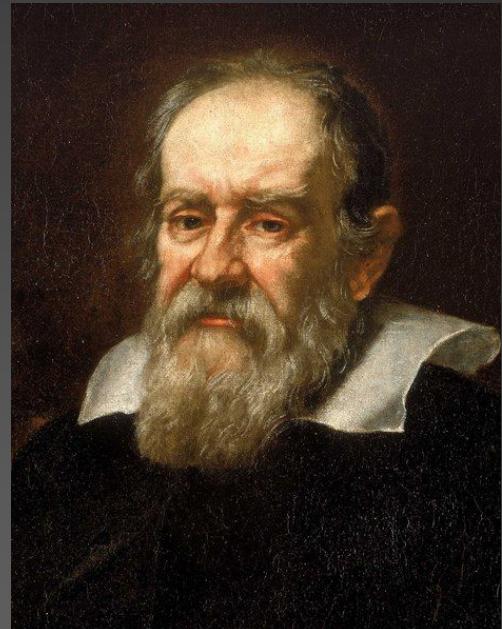
# Galileo Galilei



# Galileo Galilei

In 1610 Galileo Galilei pointed his telescope at what he thought was a bright star. This “star”, in particular was noted to move a little bit each night, and was brighter than most of the other stars. He was surprised to see four other stars near the bright star when observing through the telescope. He looked again the next day and the four stars had moved. He came to the conclusion that Jupiter was a planet, just like earth, and the four stars around Jupiter were actually moons, just like Earth’s moon.

Galileo’s conclusion was not received very well by many people. They wanted to believe that everything in the universe revolves around the Earth. The possibility that some other moons might be revolving around other planets was unacceptable.



Galileo’s journal entries show what he saw through his telescope in 1610. Can you tell what the different symbols are?

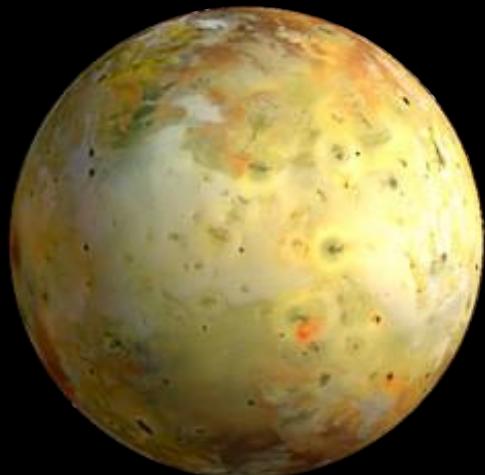


Galileo’s original telescope is stored at the Museo Galileo in Florence, Italy

# Galilean Moons



**Europa**



**Io**

These are the four Galilean moons: Io, Europa, Callisto, and Ganymede. Europa is the 6th closest moon to Jupiter, and the smallest of the Galilean Moons. Some of the other moons around Jupiter have ice, and the biggest is Ganymede. In addition to those four moons, Jupiter has at least 86 more moons (as of late 2023).

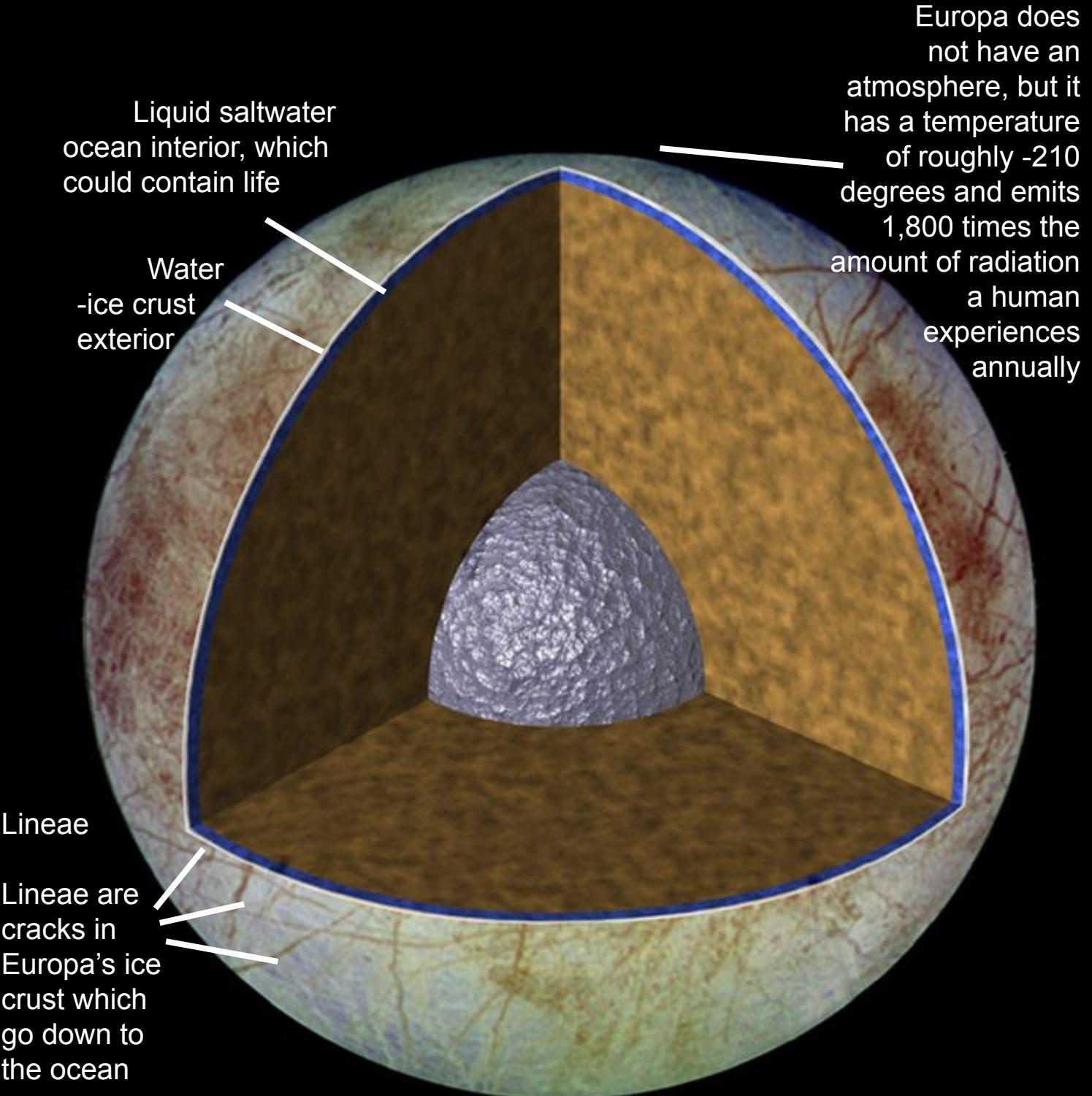


**Callisto**



**Ganymede**

# Europa Composition

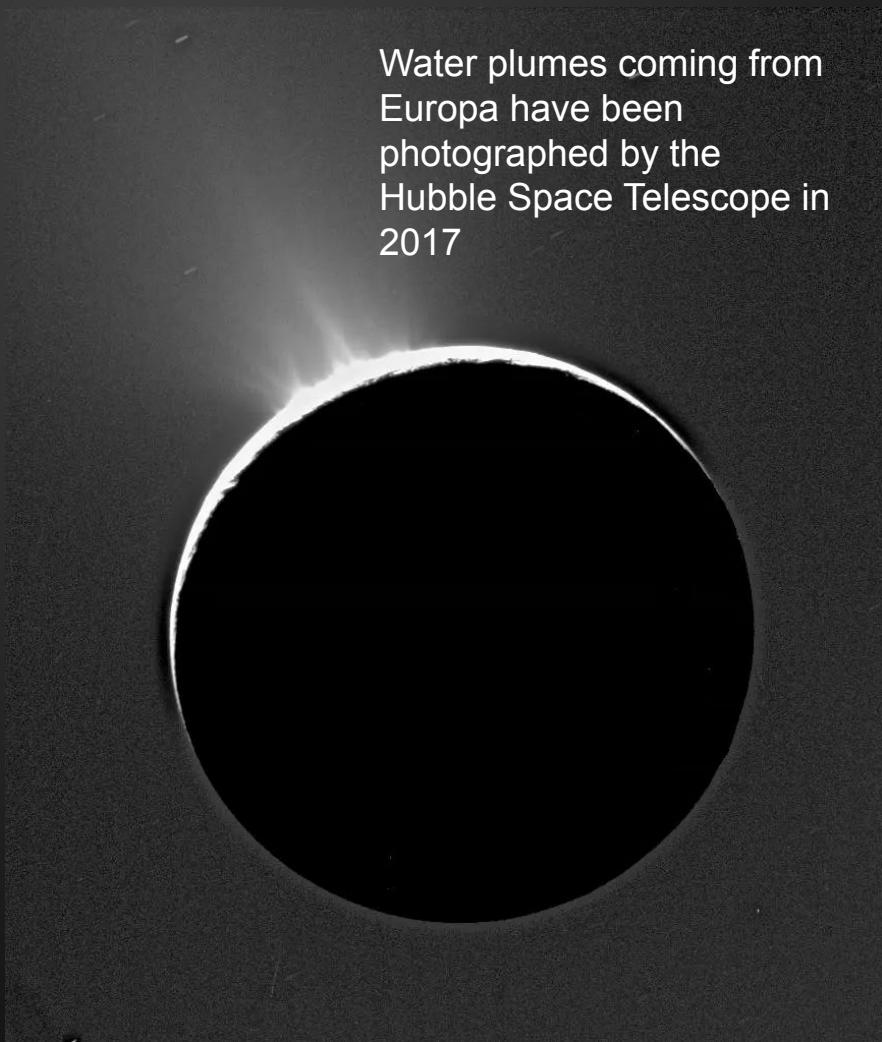


# How can Europa have Liquid Water?

A process called “tidal flexing” heats the subsurface of Europa, which melts the ice into water. Tidal flexing is when a celestial body orbiting another planet gets warped because of its gravitational forces. Another way theorized that Europa is able to have liquid water is that the core may contain radioactive materials, which heat up the surrounding water.

Water plumes coming from Europa have been photographed by the Hubble Space Telescope in 2017

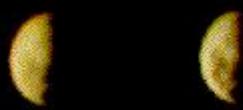
Scientists think these cracks in the surface of Europa are caused by tidal flexing



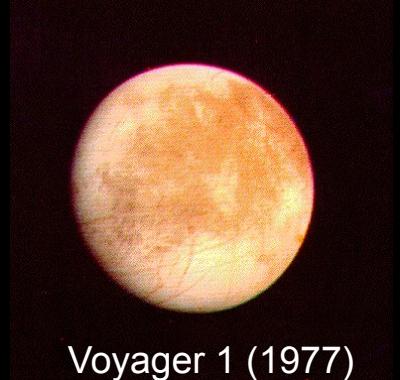
# Jupiter and Europa Exploration



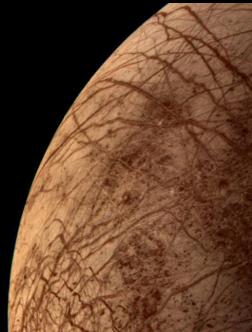
Galileo Galilei (1610)



Pioneer 10 (1973)



Voyager 1 (1977)



Voyager 2 (1977)



Hubble Space  
Telescope (1997)



Galileo Probe (1998)



Juno Probe (2013)

## Future missions:

- JUICE (European Space Agency)
- Clipper (NASA)

None of the early missions were dedicated to investigating the possibility for life on Europa, unlike the Clipper mission

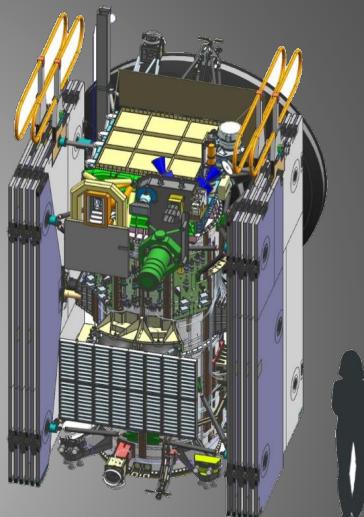
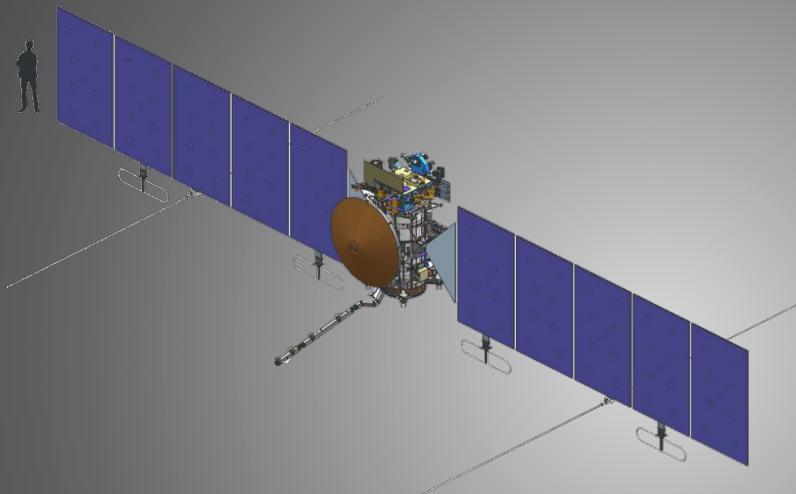
# Possibility of Life on Europa



Europa may have the resources or ingredients to have life. Underneath its icy surface, it may have the possibility to support life, but we just don't know for sure. Understanding Europa's composition will help scientists understand the possibility of finding any life beyond Earth and guide us in our search.

# Europa Clipper Launch

The Europa Clipper is going to launch in October of 2024 from the Kennedy Space Center in Florida. It takes a big rocket to fly a probe of this size all the way to Jupiter. The Falcon Heavy rocket is just the thing! A Falcon Heavy rocket has 27 big engines that combined have more than 5 million pounds of thrust when it is time for liftoff. It will be impressive!



Each of the boosters on the Falcon Heavy rocket has nine engines

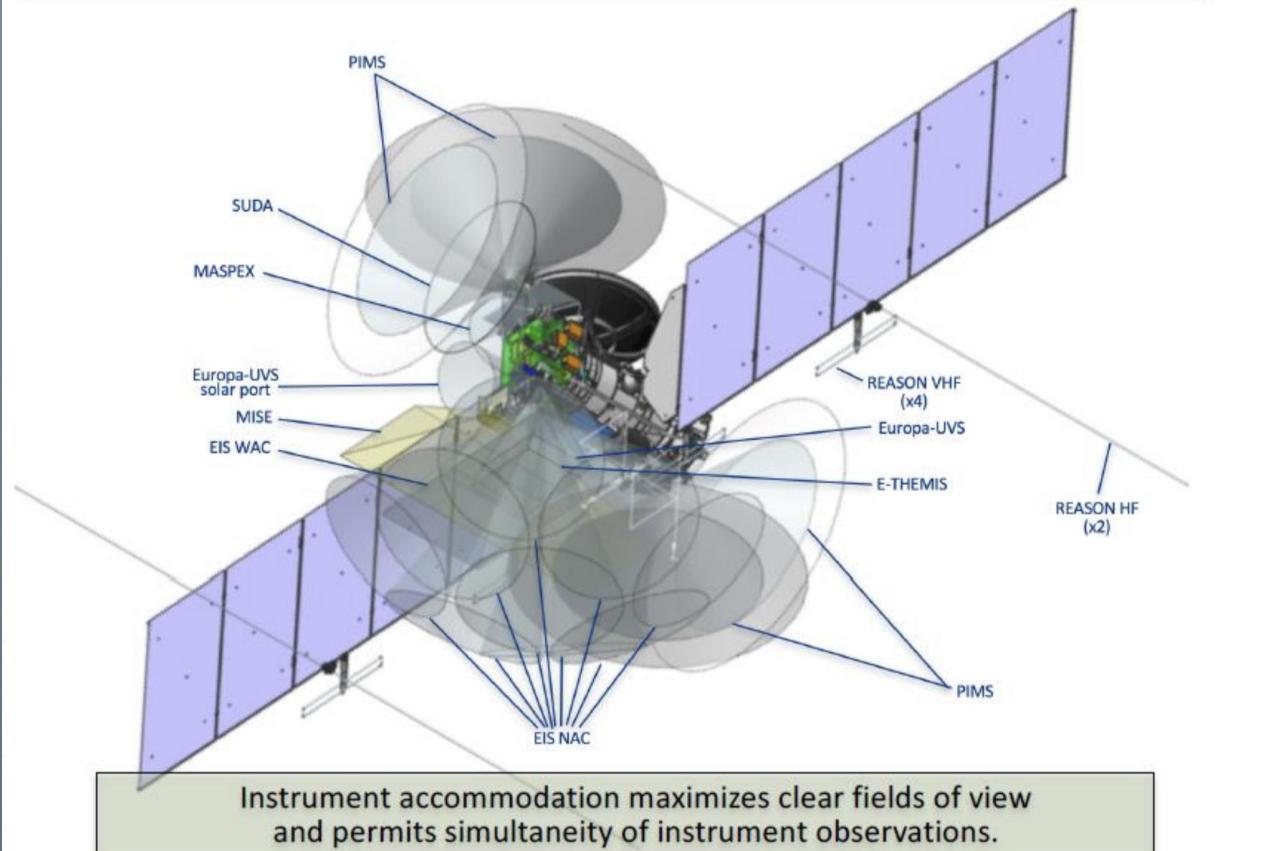
# What science instruments will be on the Europa Clipper?

Europa Clipper's main science goal is to determine whether there are places on the moon that could support life. To support that goal, there are three science objectives:

- 1) Determine the thickness of the ice
- 2) Investigate the moon's composition
- 3) Study the geology

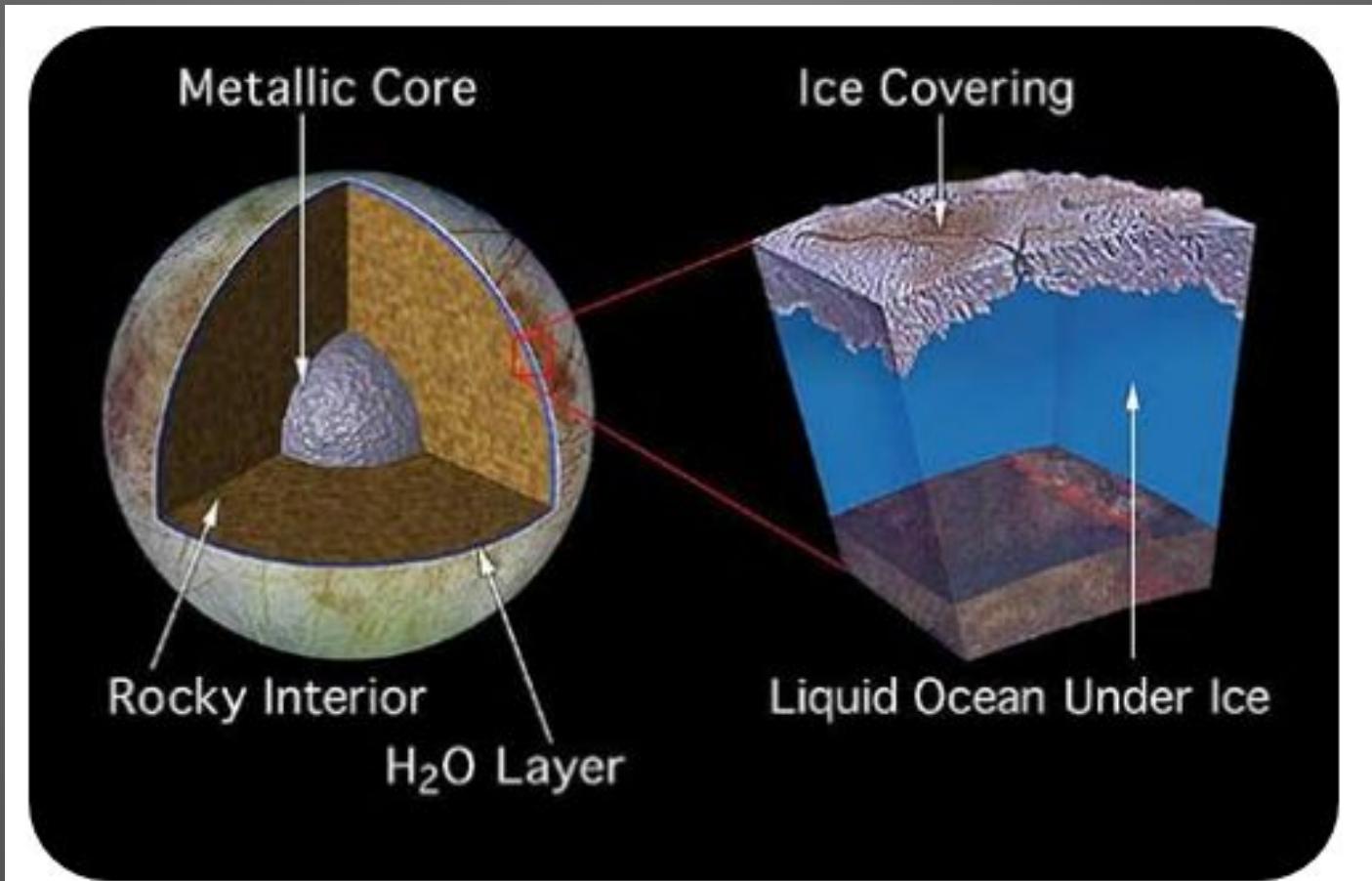
There are ten science instruments on the Europa Clipper dedicated to answering these questions, each with very specific purposes. Of course there are cameras on the Clipper. But they are not just regular cameras. The Clipper's cameras are "stereoscopic", which means "3D". You can learn all about the science instruments on the Clipper webpage.

## Instrument Accommodation



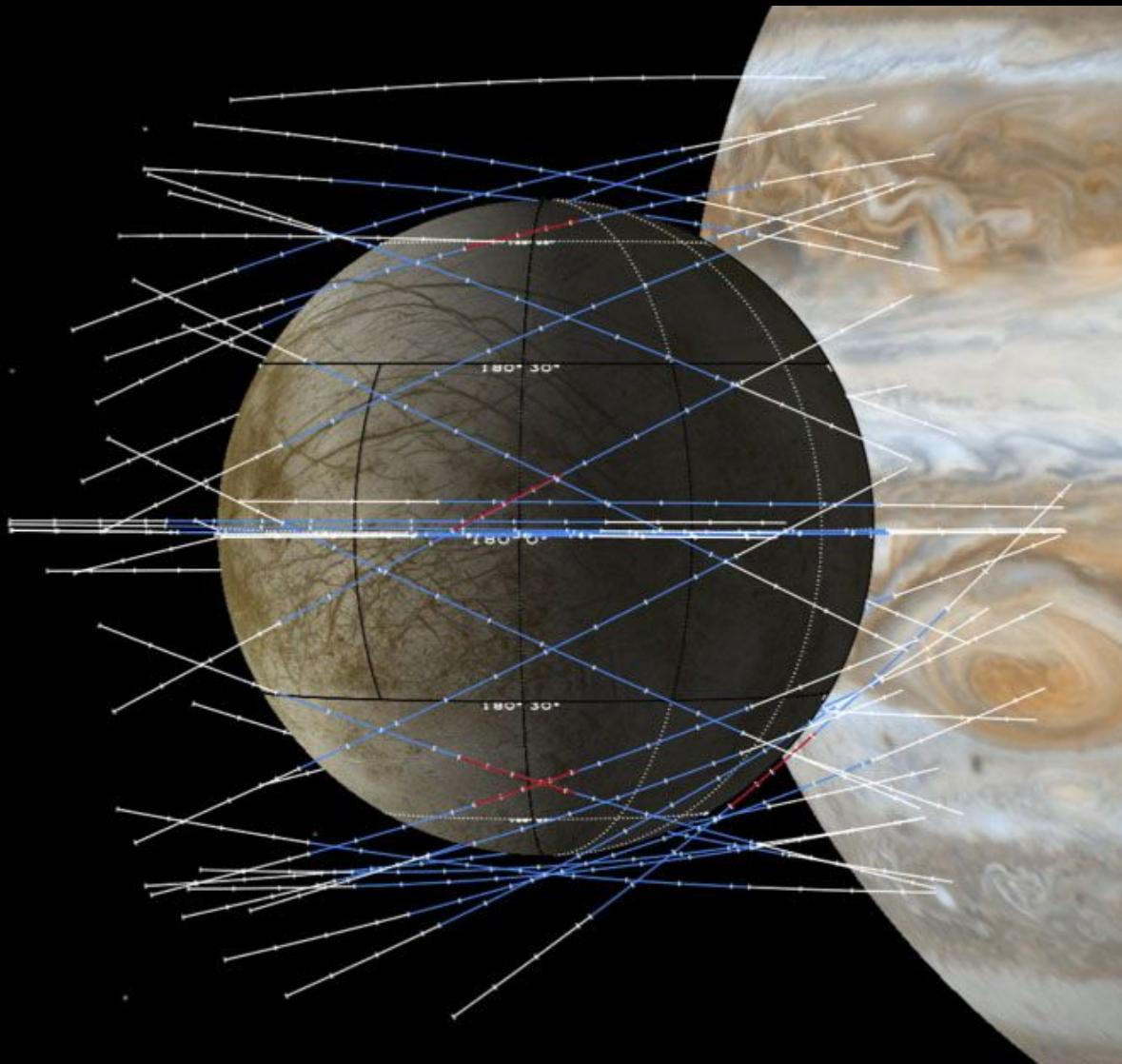
# Europa Clipper Goals

The three objectives for the Europa Clipper are to know more about the rock inside Europa, how thick the ice is, and what makes up Europa. The rock under Europa's surface may contain hydrothermal activity, which could allow life to exist there. The thickness of the ice is important to NASA's future missions to Europa, so that they can drill through the surface. The make up of Europa might contain some elements which are essential for life to exist.



*Evidence from NASA's Galileo mission suggested that there might be a liquid water ocean underneath Europa's icy crust. Image credit: NASA/JPL*

# What will the Europa clipper do once it is at Europa?

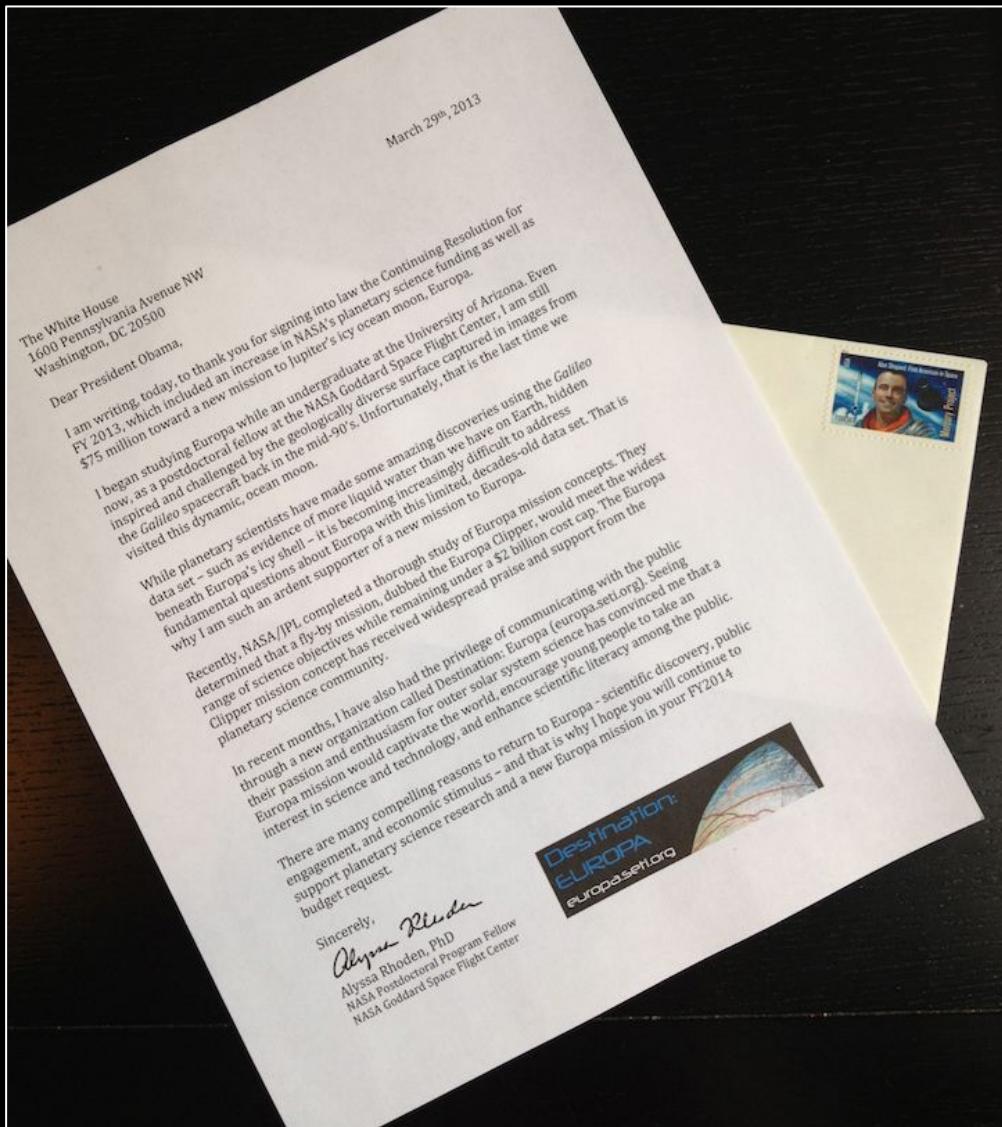


These are the different fly-by paths that the Clipper is expected to take. Most of the surface of Europa will be scanned and investigated by the Clipper.

When the Europa Clipper reaches its destination, it will begin orbiting Jupiter rather than Europa because of the moon's extreme radiation. Once in range, it will conduct detailed surveys to look for signs of potential living organisms under the ice of the frozen moon. The Europa Clipper will pass Europa 40 - 45 times over about three years. It will also get to about 15 miles away from the icy moon on its closest flybys.

# History of the Europa Clipper

Large space missions like this are expensive. In America, congress approves and funds NASA missions. The idea for the Europa Clipper was proposed to congress in 1997 as a part of NASA's Discovery program, but the idea was quickly shut down. In 2011, the project came back, and in 2013 some scientists were permitted to continue the research of making the Clipper with a budget of 75 million dollars. Congress has since approved continual funding for the Europa Clipper, and in fact has started hearings and even approved some initial planning funding for a follow-on Europa Lander Mission!

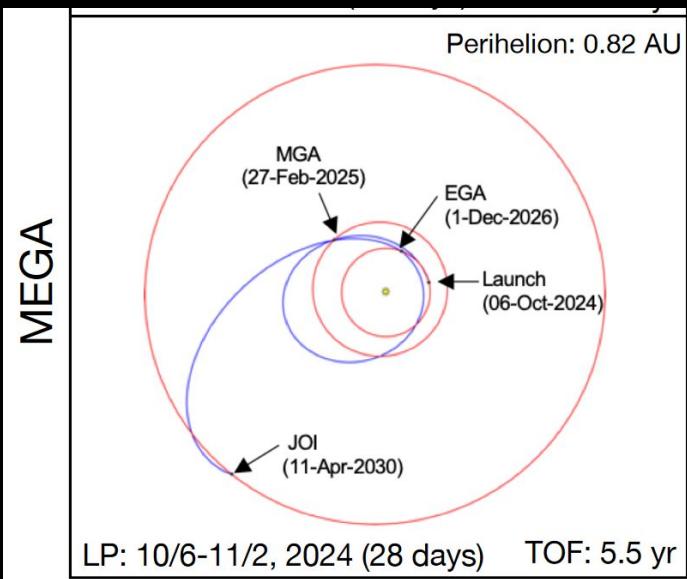


# How Much will the Europa Clipper Cost?



The Europa Clipper mission is not cheap. An estimation in 2022 projected the Clipper cost was between 4.25 billion and 5 billion US dollars. To put that into perspective, in 2022, 168 million tax returns were filed. If we take the cost of the Europa Clipper, and divide it by the number of tax returns, the average American taxpayer would pay about \$3 per year (ten years total) since the mission was approved.

# How do you get to Europa?



MEGA is a NASA abbreviation for “Mars-Earth Gravity Assist. This picture shows the flight path that the Clipper will take to Jupiter. After the launch in 2024, the Mars Gravity Assist (MGA) is in 2025, and the Earth Gravity Assist (EGA) is in 2026. Finally, the Jupiter Orbital Insertion (JOI) is in 2030. The Time of Flight (TOF) is 5.5 years and the Launch Period (LP) is from 10/6 to 11/2 2024.

In October of 2024, the SpaceX Falcon Heavy rocket that is carrying the Europa Clipper will launch from the Kennedy Space Center. The launch will all depend on the weather of the time, but the launch period opens on the 10th of October 2024.

You might think Clipper would fly straight to Jupiter after launching, but it's not. To get to Jupiter, the Europa clipper will have to slingshot off Mars, and later Earth. The first leg of the trip takes Clipper close to Mars. This should then give the Europa Clipper enough energy to swing back to Earth. Upon returning to Earth, the Europa Clipper will swing around Earth at about 2,000 miles above Earth's surface. This swing around the earth will give the Europa clipper the rest of its needed energy to get to Jupiter.

The Europa Clipper will end up arriving, if all goes according to plan, at Jupiter in April of 2030. This whole journey will have taken the Europa Clipper, from its launch, five and a half years. Which means five birthdays all alone.

# What's Next?

After all this reading you've probably been asking yourself, "Is there life on Europa?" and soon we may find out. Remember, the Clipper is not designed to detect life directly, but instead will determine if Europa is hospitable. The Europa Lander is a future project from the NASA Jet Propulsion Lab. It features a special microscope that can be used to detect life. The project timeline has not yet been released, but it will start being prepared to launch in 2037.



# What would it mean to find life on Europa?



Microbes  
from a lake in  
Antarctica

Imagine this: We find life elsewhere in the universe. With that life, we could change everything. Those organisms could be the key to solving world hunger. By studying how those life forms were able to survive on Europa, we could learn how to colonize other planets. The Europa Clipper is the first big step for mankind, and after that, we'll have a whole other planet to live on, and sooner or later, we'll have humans living in the whole solar system.

# Where else might there be life in our solar system?

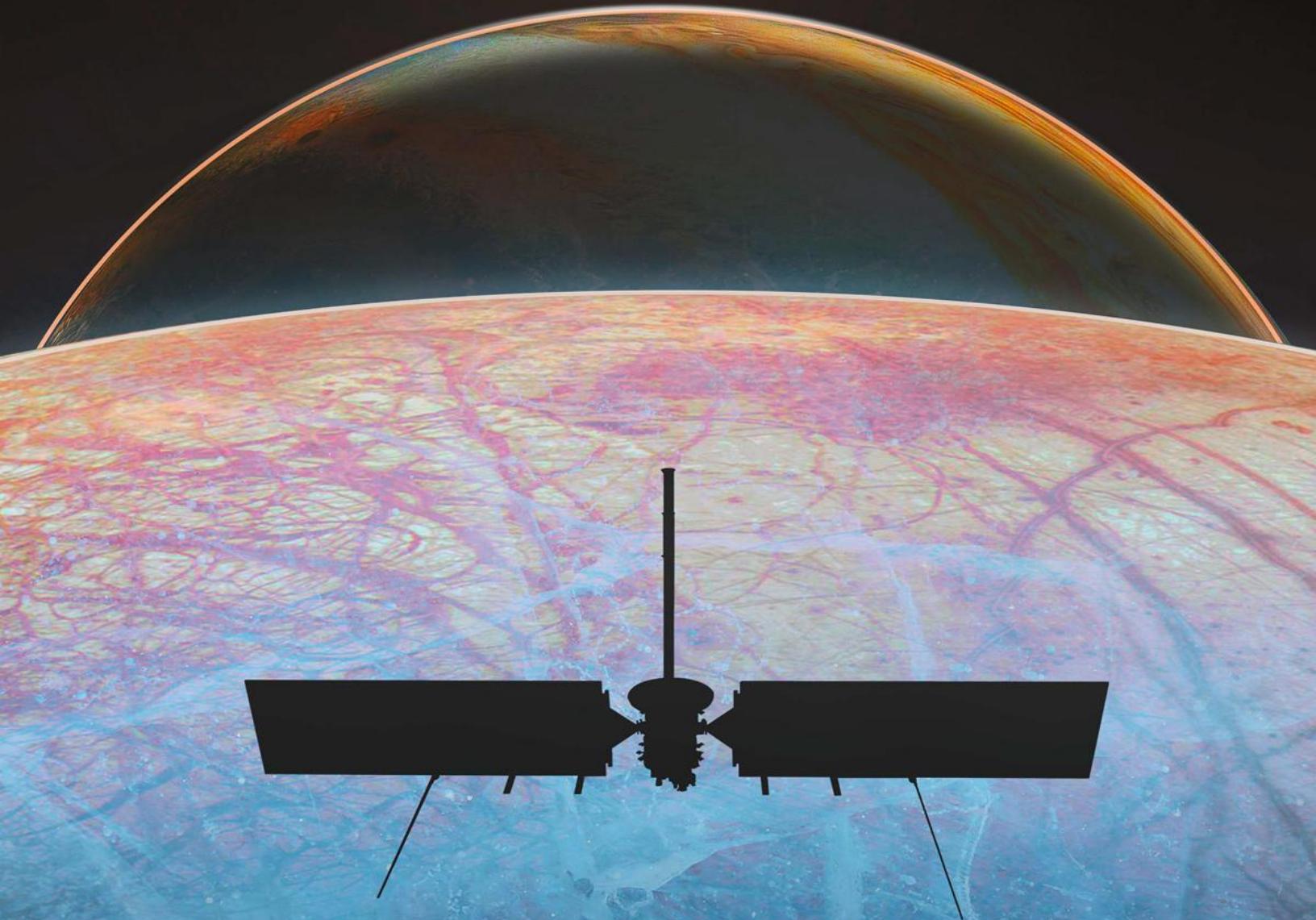
These are some of the known icy moons in our solar system, all of which have the potential of life. On the bottom left is Europa, and on the bottom right is Ganymede. All of these Icy moons have the same potential for life as Europa, and these will be the future missions after the Europa clipper gets information on Europa and Ganymede. Currently it seems that icy moons are much more common than scientists used to think.

And it's not just moons! Scientists think asteroids, comets and even Pluto have the potential to support life. Pluto is in the upper right, and Ceres, a dwarf planet in the asteroid belt between Mars and Jupiter, is in the upper left.



# Conclusion

National Aeronautics and  
Space Administration



We are very excited to learn more about Europa. The launch in late 2024 will mark the beginning of a new era of discoveries. Clipper's pictures of Europa in the 2030s will enable scientists and other earth-bound humans to enlighten their minds with thoughts about life outside of Earth.

Can you imagine?

# The Mythology of Europa

Europa is the Queen of Crete in Greek myths.

She was playing with her friends in Tyre when Zeus kidnapped her in

the form of a bull and took her to Crete. Later she bore three sons of Zeus: Minos, Rhadamanthys, and Sarpedon. Zeus bestowed three gifts upon Europa as well. They were Talos; Laelaps, a dog that could hunt anything; and a javelin that could hit any target.

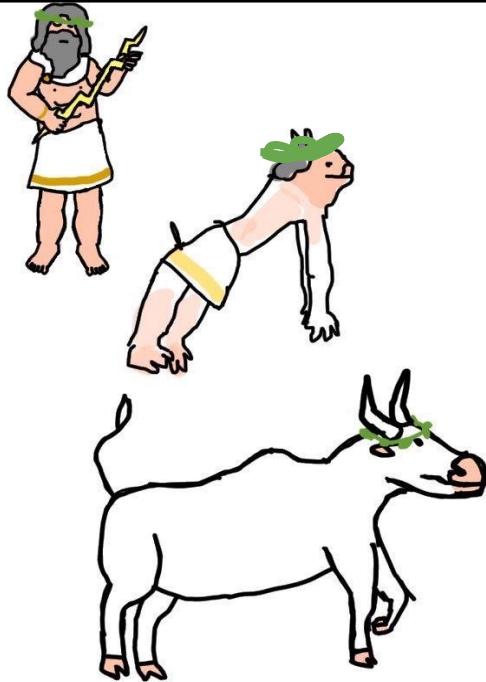


A Baroque painting of Europa by Guido Reni

# Mythology of Europa



Zeus turns into a bull in attempt to catch Europa's attention

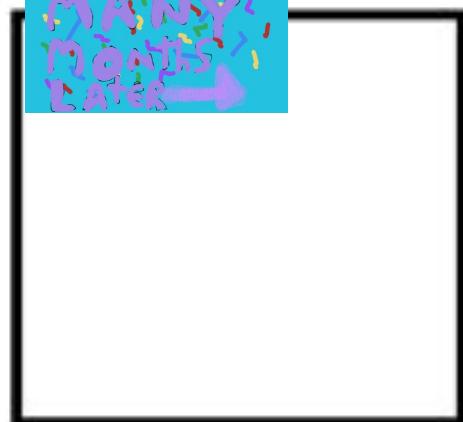


Europa decides to take him for a ride





MANY  
MONTHS  
LATER →



# Acknowledgements

Hello! We hope that you enjoyed this trip to Europa. We wrote this book as a project for our FIRST Lego League Team in the fall of 2023. We are the Norfolk Collegiate O.A.K.S., team #24277. This year we learned about Europa and the Clipper Mission from several people. This book simply would not have been possible if it were not for them.

First, we would like to thank the experts with whom we talked. Mr. Ron Miller is a legendary space artist who inspired us with his incredible artwork.

Dr. Kevin Hand taught us about the science instruments on the Clipper and explained the requirements for life.

Kevin Trinh researches icy moons and taught us about how the water and ice that we see on Europa is actually quite common and we think we are going to see many other moons with similar makeups.

Dr. Rutu Parekh studies planetary geology and she taught us about the makeup of Europa.

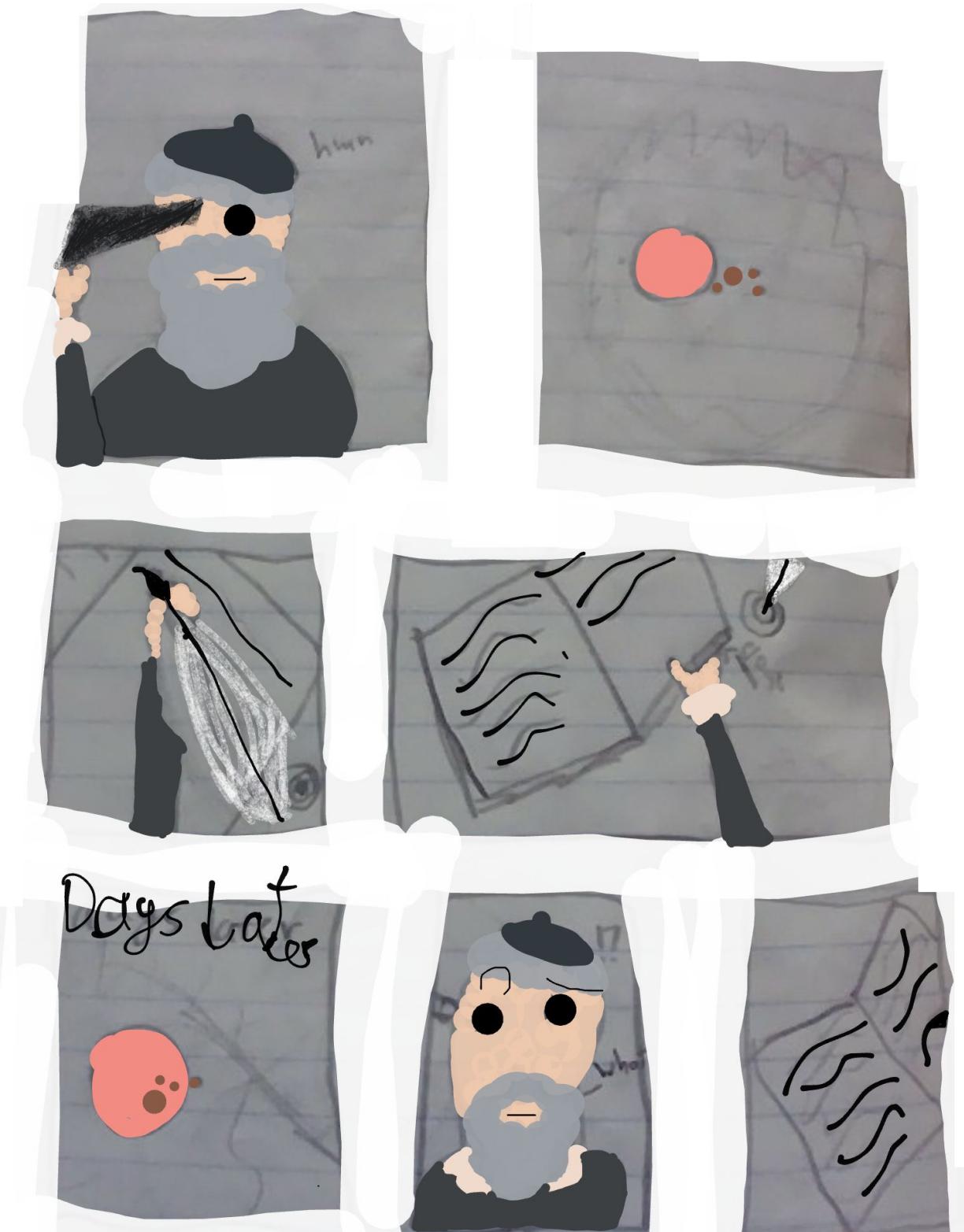
Finally, we would like to thank our friends, families, coaches and volunteers within the Virginia-DC FIRST Lego League. You are all awesome!

# Illustrations

Page	Image Title/Location	Source
Cover	Background image	<a href="https://images.nasa.gov/details/GSFC_20171208_Archive_e000890">https://images.nasa.gov/details/GSFC_20171208_Archive_e000890</a>
2	Table of contents background image	<a href="https://commons.wikimedia.org/wiki/File:Europa_and_the_Bull_MET_DP802582.jpg">https://commons.wikimedia.org/wiki/File:Europa_and_the_Bull_MET_DP802582.jpg</a>
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4	Ingredients for Life	<a href="https://europa.nasa.gov/news/33/europa-a-world-of-ice-with-potential-for-life/">https://europa.nasa.gov/news/33/europa-a-world-of-ice-with-potential-for-life/</a>
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7	Galileo's Notes	<a href="https://commons.wikimedia.org/wiki/File:Galileo_Galilei_(1564_-_1642)_-_A_di_7_di_Gennaio_1610_Giove_-_Manuscript_of_observations_of_Jupiter_and_its_satellites,_Januar_y_1610.jpg">https://commons.wikimedia.org/wiki/File:Galileo_Galilei_(1564_-_1642)_-_A_di_7_di_Gennaio_1610_Giove_-_Manuscript_of_observations_of_Jupiter_and_its_satellites,_Januar_y_1610.jpg</a>
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9	Europa Composition	<a href="https://europa.nasa.gov/resources/113/interior-of-europa/">https://europa.nasa.gov/resources/113/interior-of-europa/</a>
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18	Europa Clipper	<a href="https://smd-cms.nasa.gov/wp-content/uploads/2023/04/Europa_PSS_Sept_2016.pdf">https://smd-cms.nasa.gov/wp-content/uploads/2023/04/Europa_PSS_Sept_2016.pdf</a>
19	Europa Clipper Earth-Mars flybys	<a href="https://tfaws.nasa.gov/wp-content/uploads/TFAWS23-PT-2-Presentation.pdf">https://tfaws.nasa.gov/wp-content/uploads/TFAWS23-PT-2-Presentation.pdf</a>
20	Europa Lander	<a href="https://www.jpl.nasa.gov/missions/europa-lander">https://www.jpl.nasa.gov/missions/europa-lander</a>
21	Microbes	<a href="https://climate.nasa.gov/news/825/scientists-find-ancient-microbes-in-antarctic-lake/">https://climate.nasa.gov/news/825/scientists-find-ancient-microbes-in-antarctic-lake/</a>
22	Icy moons	Various nasa.gov
23	Clipper Background image	<a href="https://europa.nasa.gov/resources/173/europa-clipper-journey-to-an-ocean-world-poster/">https://europa.nasa.gov/resources/173/europa-clipper-journey-to-an-ocean-world-poster/</a>
24	Europa Painting	<a href="https://commons.wikimedia.org/wiki/File:Reni_Guido_-_Europa_and_the_Bull_-_Google_Art_Project.jpg">https://commons.wikimedia.org/wiki/File:Reni_Guido_-_Europa_and_the_Bull_-_Google_Art_Project.jpg</a>
25+	Original Artwork	

Still working on these

Years later, Galileo is finding jupiter through his new invention, the telescope.





# Feedback

## Ron Miller:

Just sort of skimmed over it...and am pretty impressed!

A very nice job indeed!

I am working on a history of NASA for young adult readers that will be published next Fall. I will put this book in the reading list (though I will need to eventually get a link from you so readers can find it).

As for the art, I think you need to include sources. This can take the form of either a tag below an image or a list at the end of the book. Of course, anything from NASA is public domain but images found on the internet can be iffy...even if they seem to be free to use.

Probably the only thing I noticed in the text as I was browsing was Galileo might be given a little too much credit for instigating a heliocentric solar system: it kind of glosses over Copernicus and Giordano Bruno, who came before him.

Oh...just noticed this :"...when Zeus kidnapped her in the form of a bull." No: Zeus, in the form of a bull, kidnapped her. The way it's written now suggests that Europa was in the form of a bull. You make this clear in the little cartoon...but the text appears first.

Speaking of the cartoons, they are great!

PS

I presume the kids have seen the SF movie, "Europa Report"?

PPS

Scientists have added Titan, Ceres and even Pluto to the list of worlds where they would like to search for life!

I do think it's very important to include sources (a good habit for the kids to get into anyway).

## Rutu Parekh:

I am so happy to hear about the progress from you and the Europa book looks fantastic. Currently I am on travel so give me some time to go through and will get back to you on this soon.

Regarding putting copy of Europa, let me get in touch with Clipper mission PI, Robert Pappalardo and check with him. We have official clipper website but before uploading anything on website, it needs to go through layers of permission. I am not aware of exact process but I know people who can certainly help with this. Once we have the final version of the book, we can start working on sharing part.

Very much excited for the final result!

Rutu

## Marcel-Jan Krijgsman, Planetary Society Member:

Well done. It's a pretty thorough story on Europa Clipper. And reading through it, I could not find scientific errors yet.

## David Frankis, Planetary Society Member:

That's really good!

Things I really liked:

You don't oversell the mission and explicitly say on p20 that Clipper is not designed to detect life directly.

The taxpayer calculation on p18: something that seems beyond the ability of most adults, especially journalists.

Comments:

The only major thing is that the picture on p10 is of Enceladus, not Europa. Hubble's pictures of Europa's (probable) plumes are much less dramatic, and I think scientists are cautious about their existence or longevity. Googling Europa plumes Hubble will get you to NASA sites about this.

P11 nitpick - The Galileo mission had two parts, an orbiter and a probe (which went into Jupiter). The picture is from the orbiter not the probe (though tbh any mission can be called a 'probe' as you do with Juno).

Really nitty nitpick on p9: there's lots of radiation at Europa's surface, but it isn't emitted by Europa - it's particles (sulphur and other ions) caught in Jupiter's magnetic field in space that slam into Europa.