

01 / LEARNER PAGE

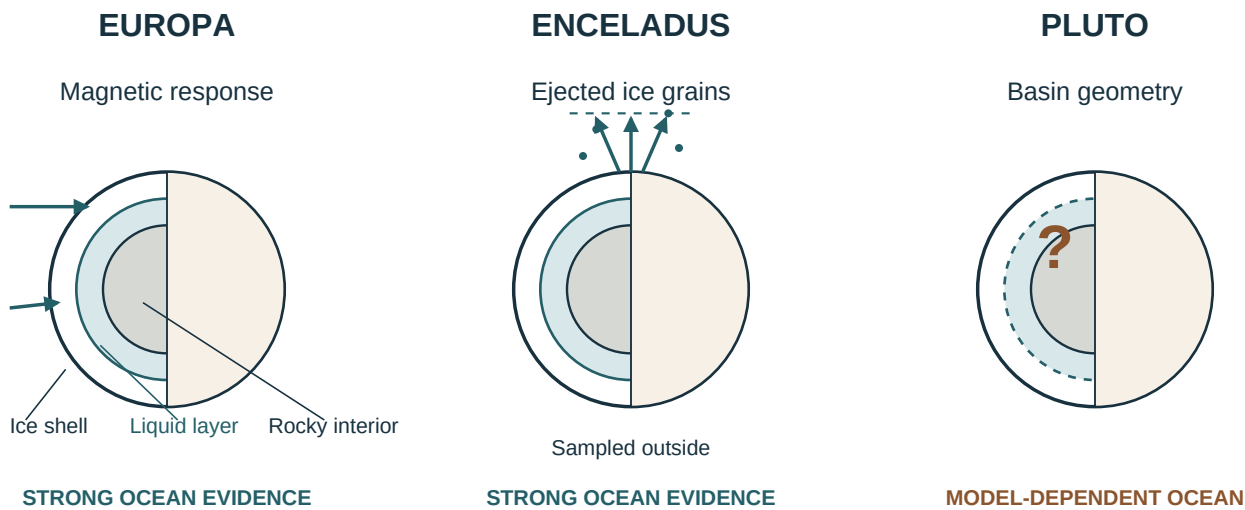
Investigate an Alien Ocean

Three worlds. Three evidence trails. One careful claim.

35-45 minutes | Suggested ages 12+ | Pencil + printed guide

An ocean can hide beneath ice, beyond a camera's reach. Compare three evidence trails and decide how each supports a claim. Read the clues, mark what was measured, and write a conclusion that includes a limit.

An interior inferred from an exterior signal



Layers and sizes are schematic. Dashed liquid boundary: disputed interpretation.

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Original teaching schematic, not to scale. No spacecraft photographed these cutaway layers. Europa and Enceladus have strong ocean evidence; Pluto's present ocean remains a model-dependent interpretation. Sources S1-S5.

Start here / Circle one interior feature in the diagram that is inferred. Which exterior observation could support it?

03 / Challenge the headline

Rewrite: 'Phosphorus found, so life is confirmed on Enceladus.' Keep the exciting result and remove the unsupported conclusion.

02 / LEARNER PAGE

Follow the evidence.

Use the source numbers to check the clues. Write before reading the discussion.

EUROPA / S1

Galileo measured a response as Jupiter's surrounding magnetic field changed. A conducting subsurface layer fits the signal; salty liquid water is the leading interpretation. The signal alone does not give a unique ocean depth or composition.

ENCELADUS / S2-S3

Cassini measured the moon's small rotational wobble, supporting an ice shell separated from its interior by a global ocean. Its instruments also detected phosphates in salt-rich ice grains from the E ring, which is fed by the plume. The grains carry chemistry, not a detection of life.

PLUTO / S4-S5

New Horizons mapped Sputnik Planitia and its position relative to Charon. An ocean-uplift model can explain an inferred mass excess; an impactor-remnant model offers an alternative without a substantial ocean. There is no direct gravity map proving the ocean.

01 / Separate the observation from the inference

World	Measured clue	Ocean inference	Still open
Europa			
Enceladus			
Pluto			

02 / Choose and defend a target

Choose a world for a follow-up ocean investigation. Support your choice with a measured clue and a limit. Different targets can be reasonable.

04 / Design a useful next test

Name a measurement that could narrow an uncertainty. Explain which result would favor one interpretation and what it still would not prove.

03 / ANSWER DISCUSSION

Discuss the reasoning.

These are defensible explanations, not a demand for identical wording. Return to the measured clue or the stated case assumption whenever a claim becomes too broad.

01 / Keep each step in its lane

Europa: magnetic response is measured; a conducting layer and salty ocean are inferred; thickness and conductivity remain entangled. Enceladus: shell wobble and grain chemistry are measured; a global ocean and a connection to source water are inferred; grain transport can alter the sample. Pluto: surface shape and basin position are measured; mass excess and interior structure are modeled; competing impact histories remain possible. Accept equivalent wording that preserves these distinctions.

02 / A defensible target has a bounded claim

Enceladus is a strong choice when the question concerns sampling ocean-related material, because it ejects grains into space. Europa is a strong choice for combining magnetic and geological constraints. Pluto is a valuable target for distinguishing competing interior models. The task is not to declare one universal winner. A good answer explains why a particular observation bears on a particular question and acknowledges the remaining uncertainty.

03 / Ingredients do not establish inhabitants

One defensible revision is: 'Cassini data revealed phosphate-bearing ice grains linked to Enceladus, strengthening the chemical case for a potentially habitable ocean.' Phosphorus is relevant to Earth life, but its presence does not identify an organism or prove that life arose. The measured chemistry is a substantial result even while the biological question stays open.

04 / A test should narrow a named uncertainty

An example is to compare magnetic measurements under changing field conditions at Europa while checking the surrounding plasma. That can help constrain a conducting layer and its geometry. Repeated chemical sampling at Enceladus could test whether grain composition varies with location or conditions. A better gravity measurement at Pluto could help constrain interior models, though it would not by itself uniquely identify water. Reward a discriminating prediction and a stated limit.

A useful answer connects a clue, an interpretation, and a limit. Scientific uncertainty is part of that answer.

04 / SOURCES + FACILITATION

Keep the source trail.

Primary mission explanations and published research. Links are clickable in the PDF; complete addresses remain available on paper.

S1 / NASA Europa Clipper: Why Europa, evidence for an ocean

Magnetic induction and the reasoning behind a subsurface-ocean interpretation.

<https://science.nasa.gov/mission/europa-clipper/why-europa-evidence-for-an-ocean/>

S2 / NASA: Cassini finds a global ocean (2015)

The measured libration and the inference of a decoupled ice shell.

<https://science.nasa.gov/missions/cassini/cassini-finds-global-ocean-in-saturns-moon-enceladus/>

S3 / NASA/JPL: Phosphates in Enceladus ice grains (2023)

E-ring grain chemistry, laboratory interpretation, and the absence of a life detection.

<https://www.jpl.nasa.gov/news/nasa-cassini-data-reveals-building-block-for-life-in-enceladus-ocean/>

S4 / Nimmo et al.: Reorientation of Sputnik Planitia (2016)

Author manuscript of the ocean-uplift interpretation published in Nature in 2016.

<https://arxiv.org/abs/1903.05574>

S5 / University of Bern: How Pluto got its heart (2024)

The research team's impactor-remnant interpretation and its contrast with ocean uplift.

https://mediarelations.unibe.ch/media_releases/2024/media_releases_2024/how_pluto_got_its_heart/index_eng.html

For teachers and astronomy clubs

Give learners pages 1-2 first. Allow about 10 minutes to annotate the diagram and clues, 20 minutes for the questions, and 10 minutes to compare claims. Use the discussion on page 3 after learners have committed to an answer. Look for an observation, a justified inference, and a limit rather than an unsupported confidence score.

Optional Atlas extension: choose Europa or Enceladus in the relevant viewer, then identify which details come from spacecraft maps and which are illustrations. Replaying the animation adds no new measurement.

Continue the investigation

Read Oceans Beyond Earth

<https://darksciencedocs.com/guides/oceans-beyond-earth/>

Examine Europa's Evidence File

<https://darksciencedocs.com/evidence/how-we-know-europa-has-an-ocean/>

Explore Europa in the Jupiter viewer

<https://darksciencedocs.com/map/jupiter/#jupiter-scene>

Print and share this complete guide with attribution. Print pages 1-2 for learners; reserve pages 3-4 for discussion. Use US Letter at actual size, or fit to A4. Color is optional; labels carry the meaning.