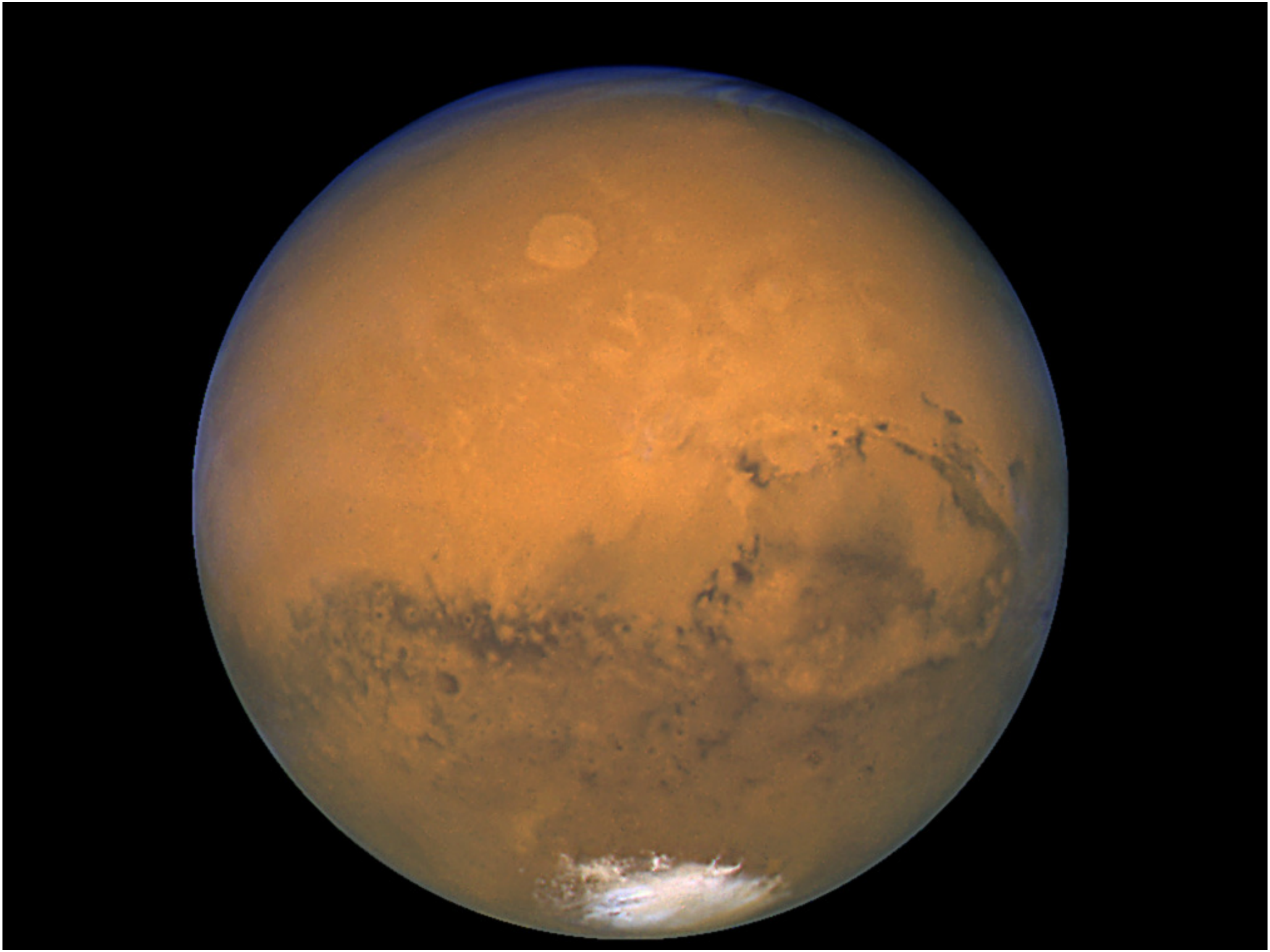
Titanic Science

Dr. Joseph F. Skovira
NASA/Jet Propulsion Lab
Solar System Ambassador
Cornell University

al Lifeforms

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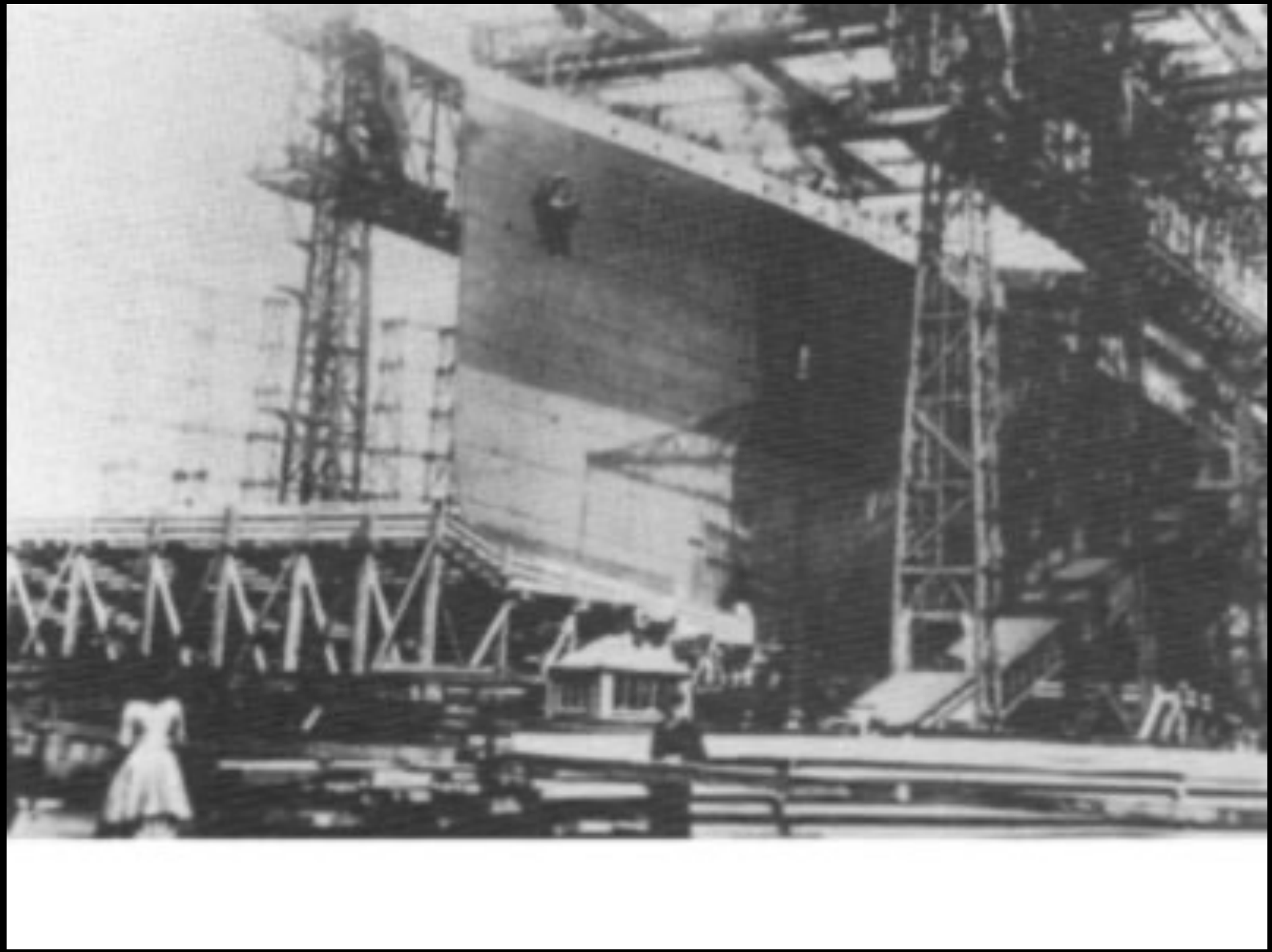

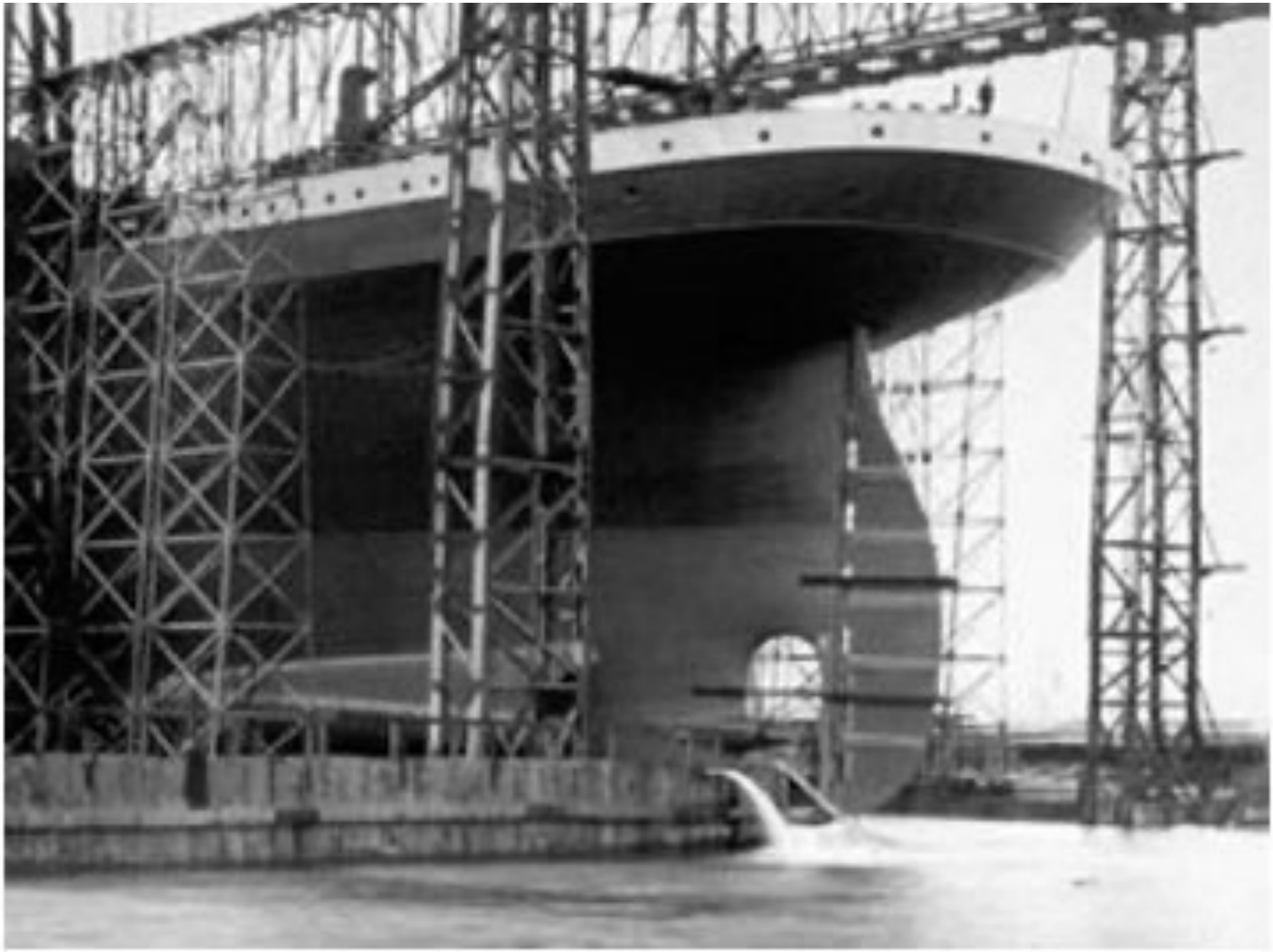

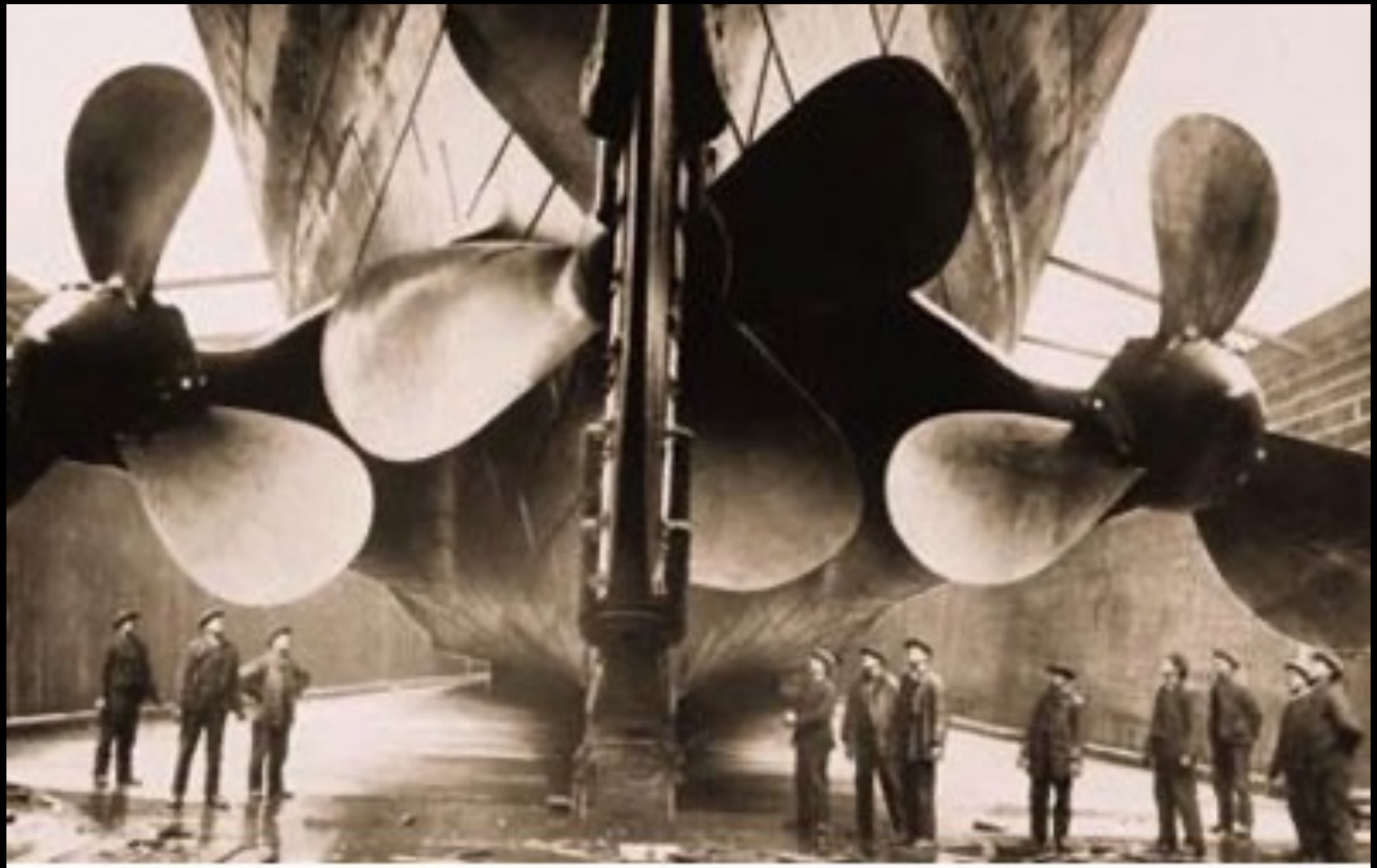


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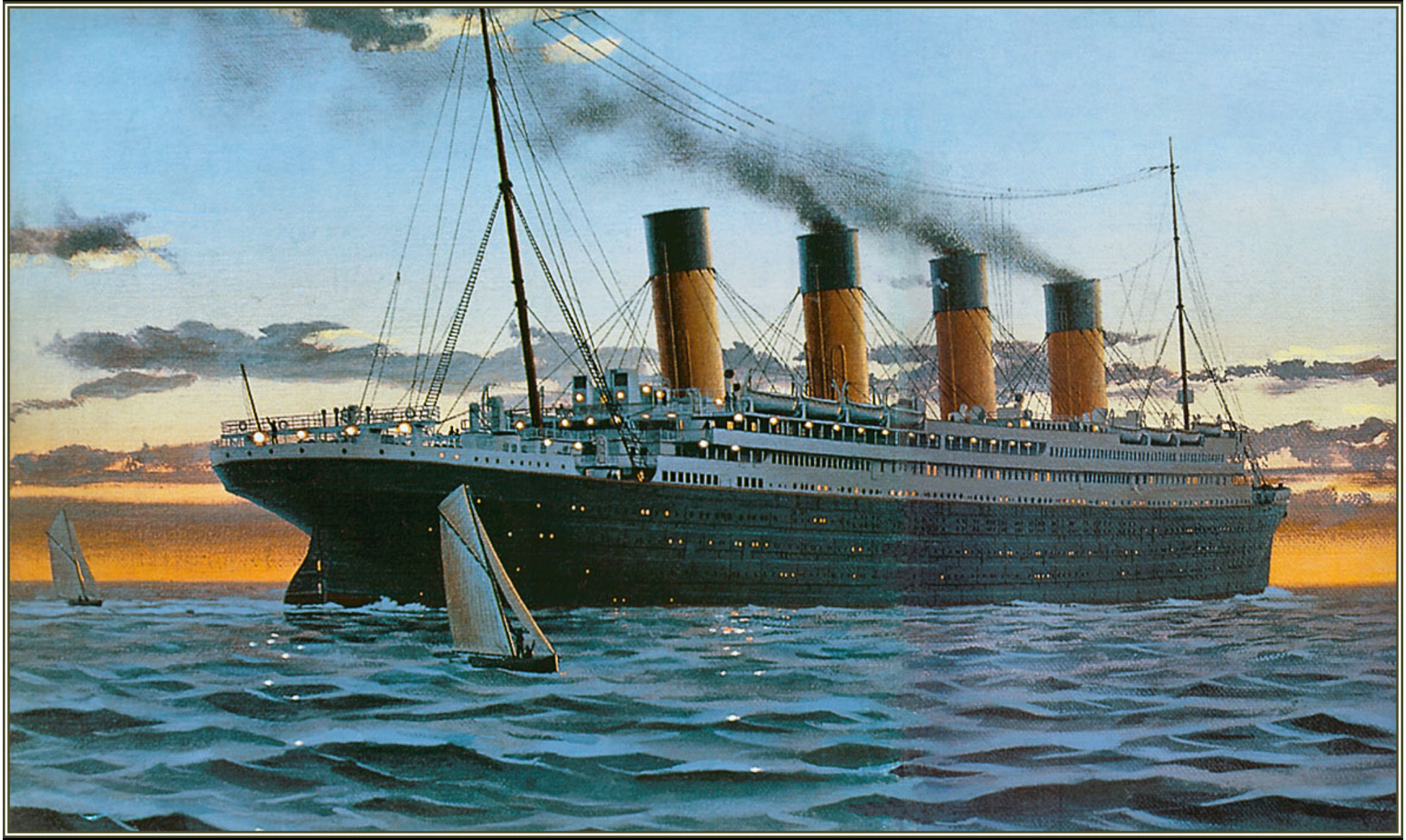

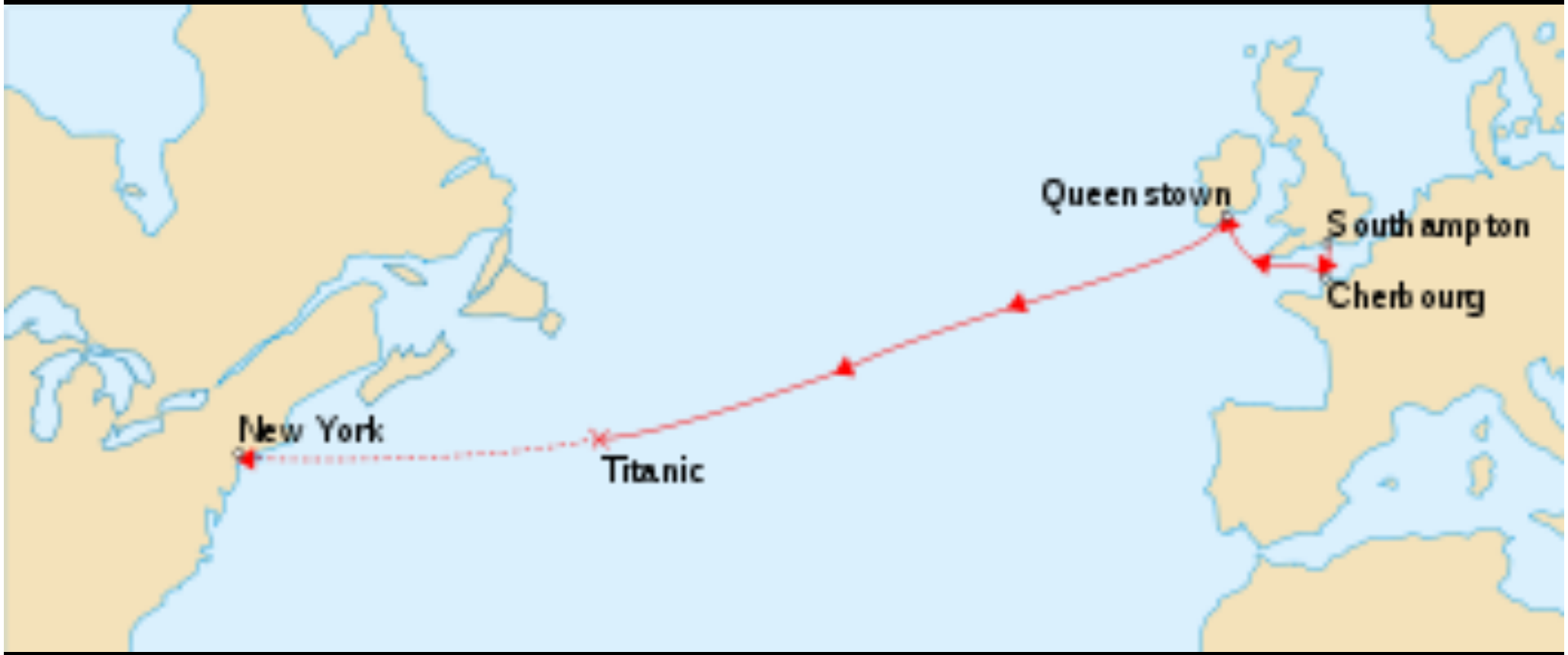
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Southampton
Cherbourg
New York
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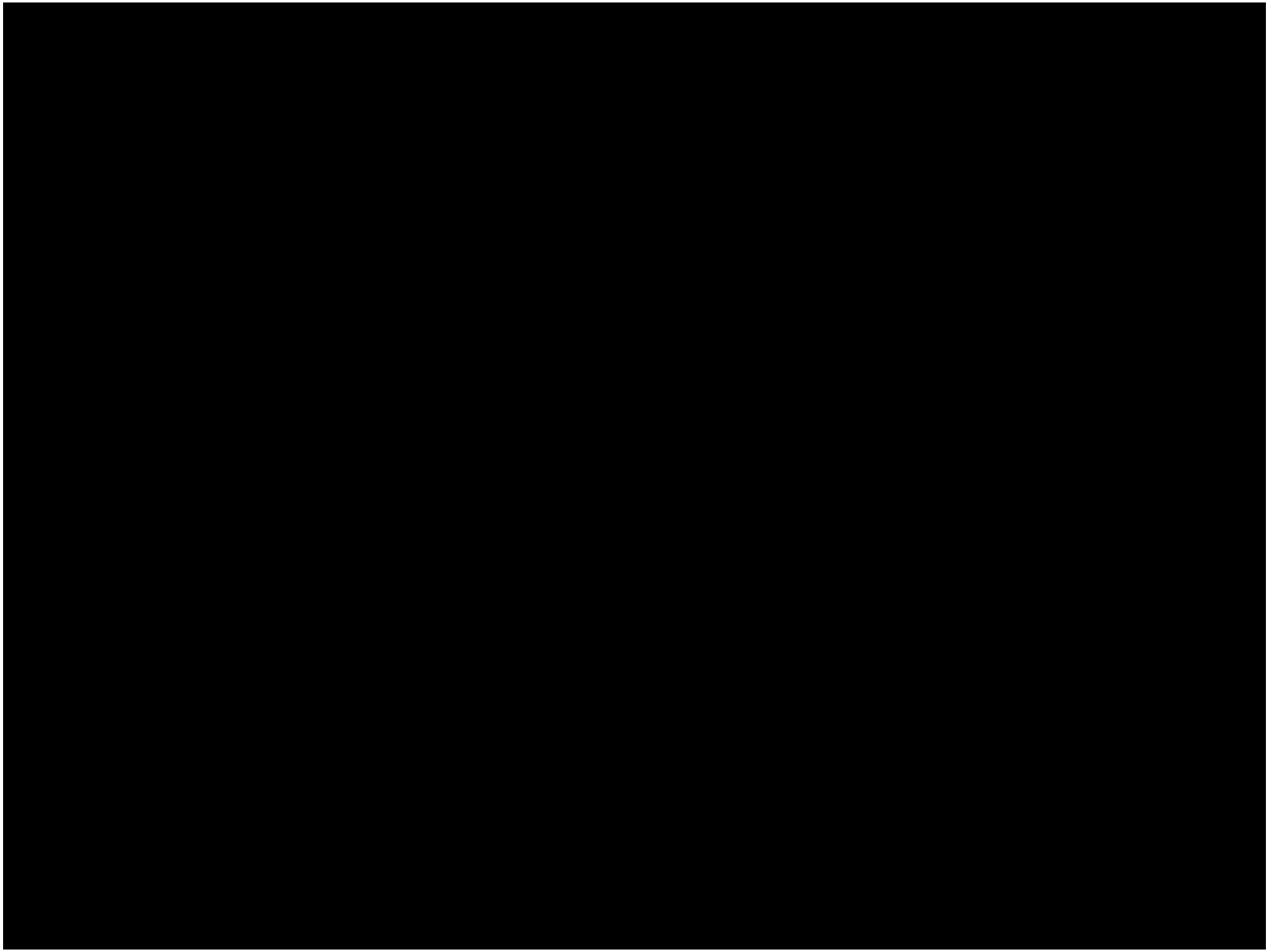
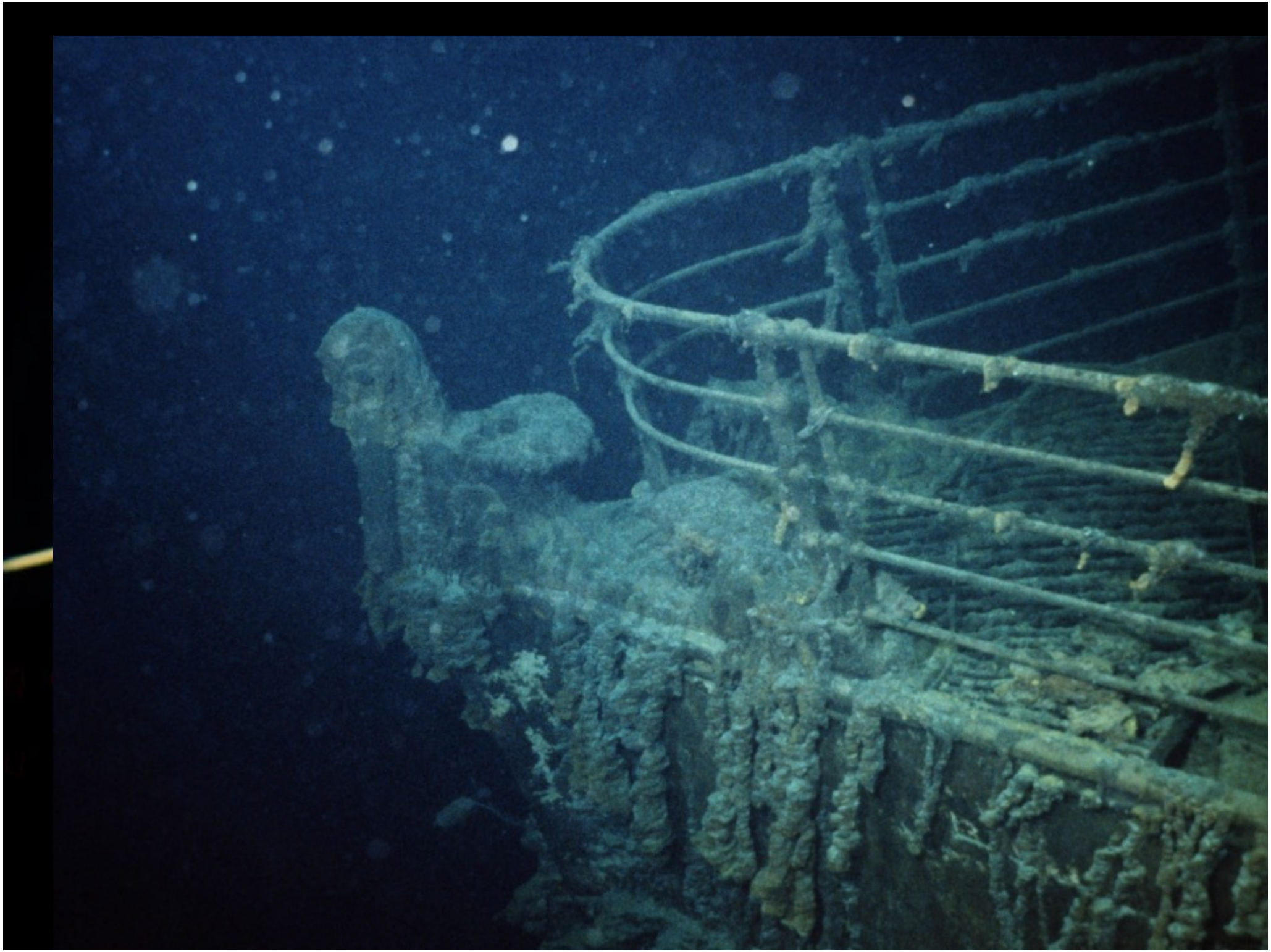
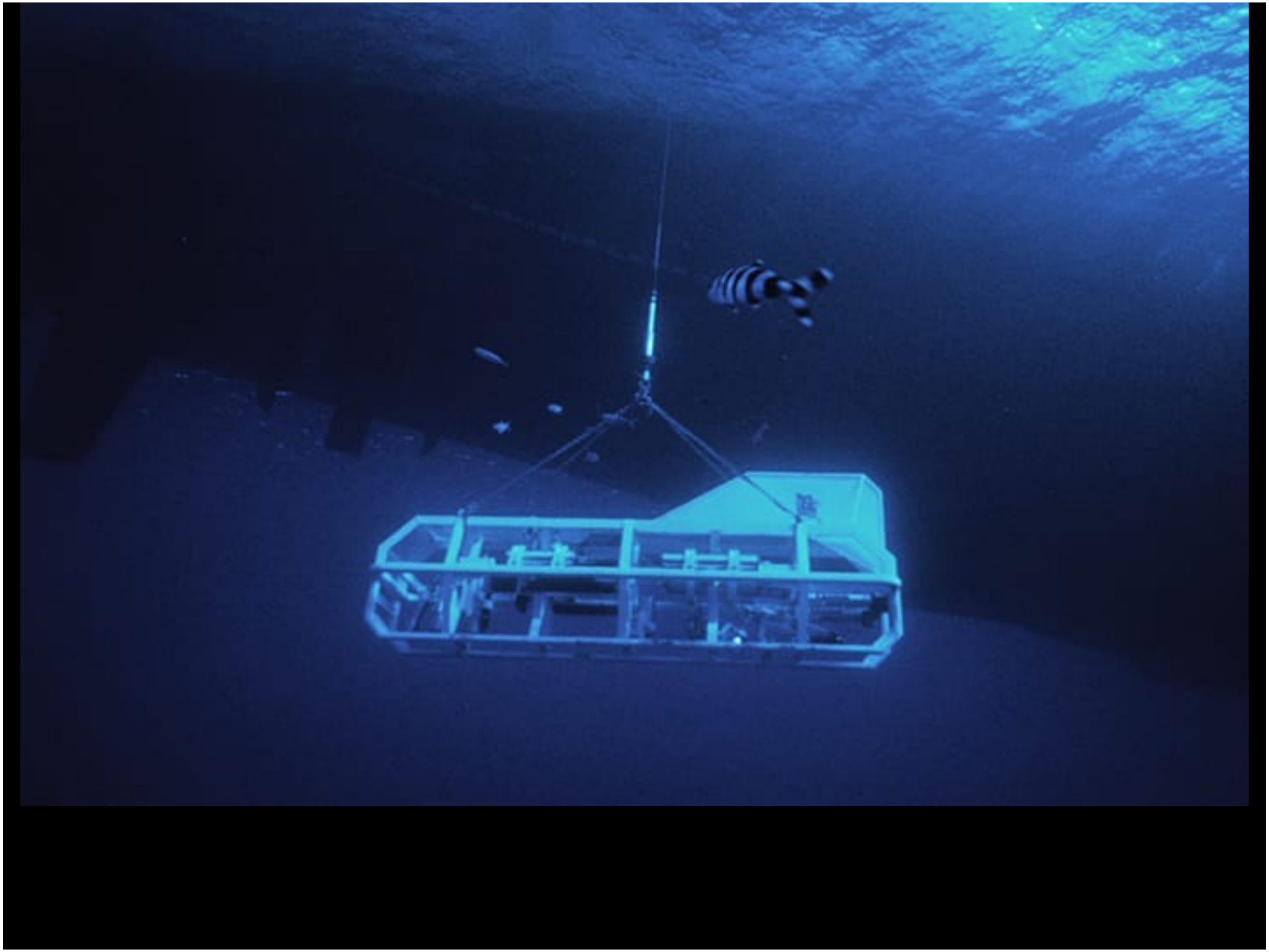
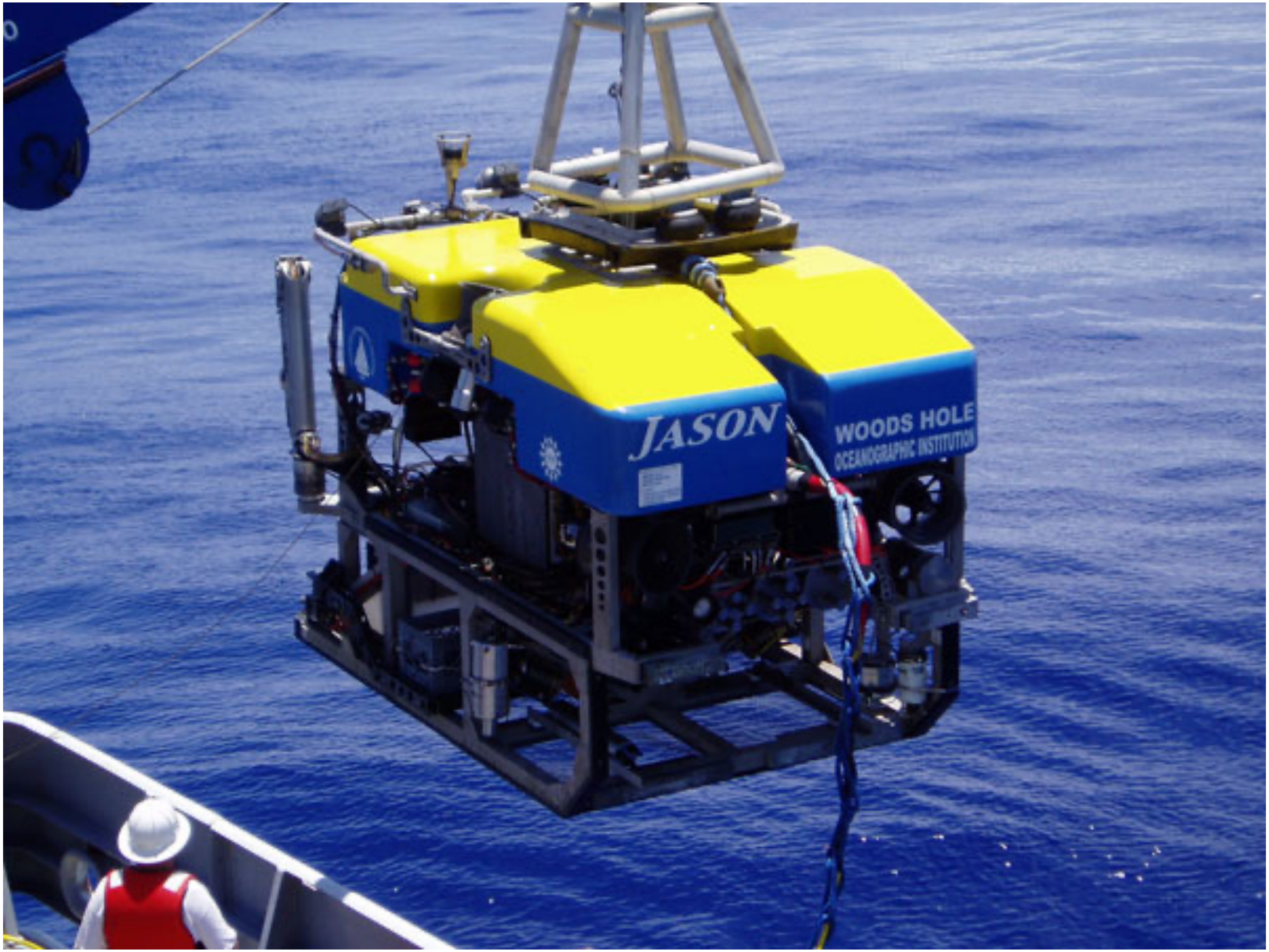
TITANIC

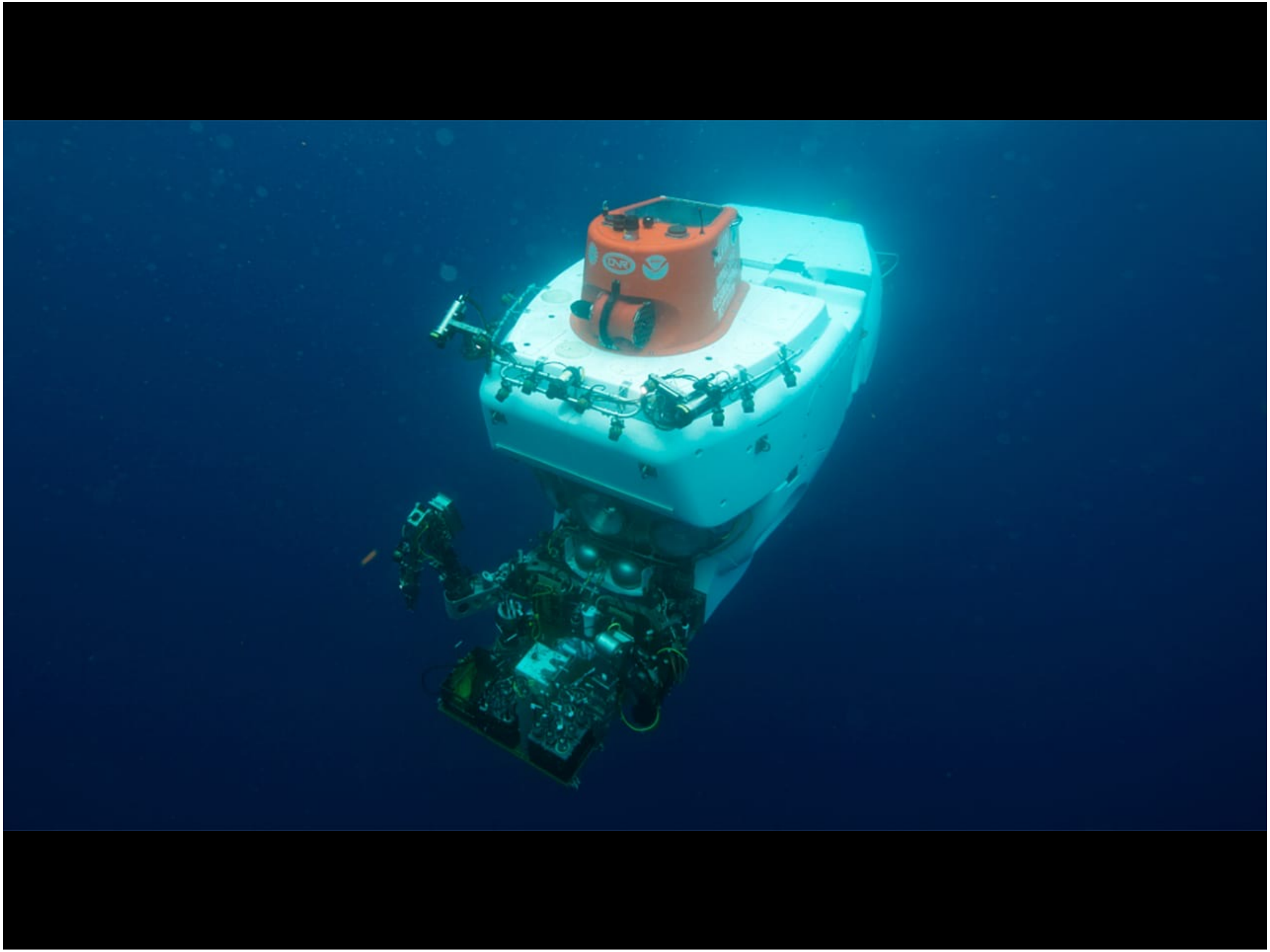



INSTITUTE FOR EXPLORATION






JASON
WOODS HOLE
OCEANOGRAPHIC INSTITUTION

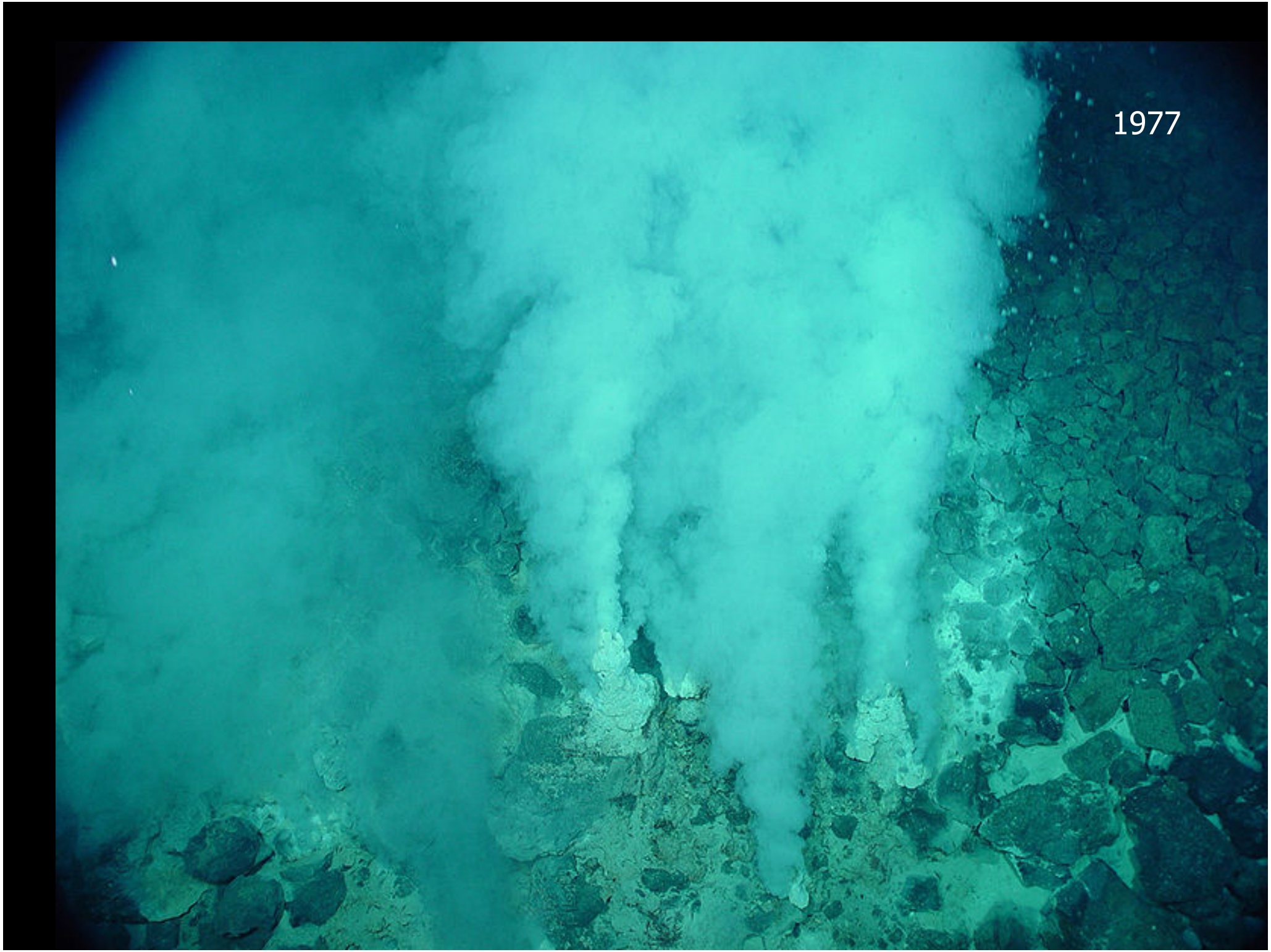



September 1985


Masschall '87©


Ken Marshall 1988


KEN MARSCHALL 1992


1977

Life Finds a Way to Thrive

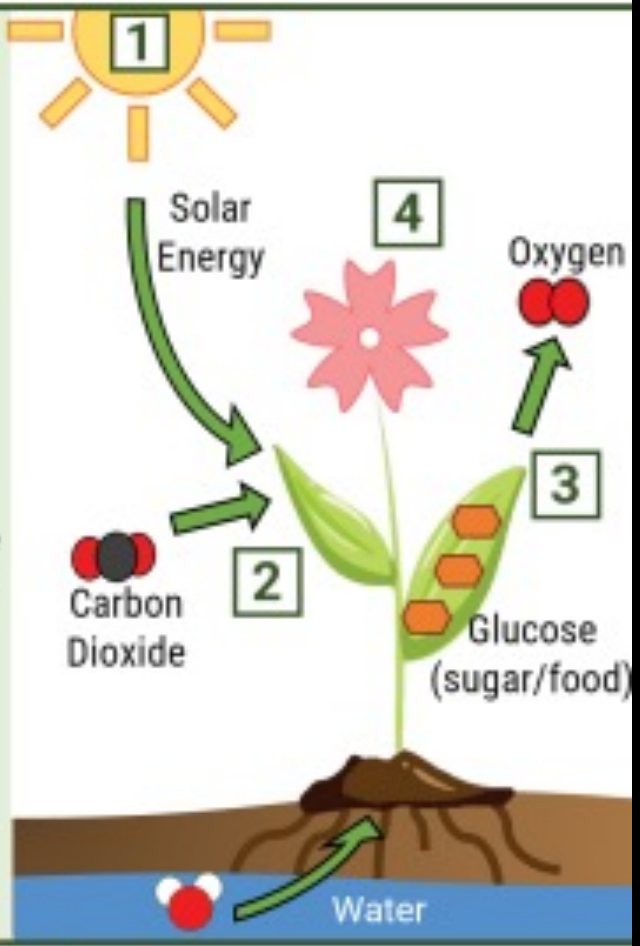
Some definitions

- Photosynthesis
- Chemosynthesis
- Extremophile

PHOTOSYNTHESIS

The process plants use to convert carbon dioxide and water into sugars (food), using energy from the sun.

1. The sun gives off energy in the form of light.
2. Plants absorb sunlight and take up water from the soil and carbon dioxide from the air.
3. The plants use energy from the sun to combine carbon dioxide and water to make food (glucose/sugar).
4. The plants grow and reproduce and are eaten or hosted as internal symbionts in animals, like corals.



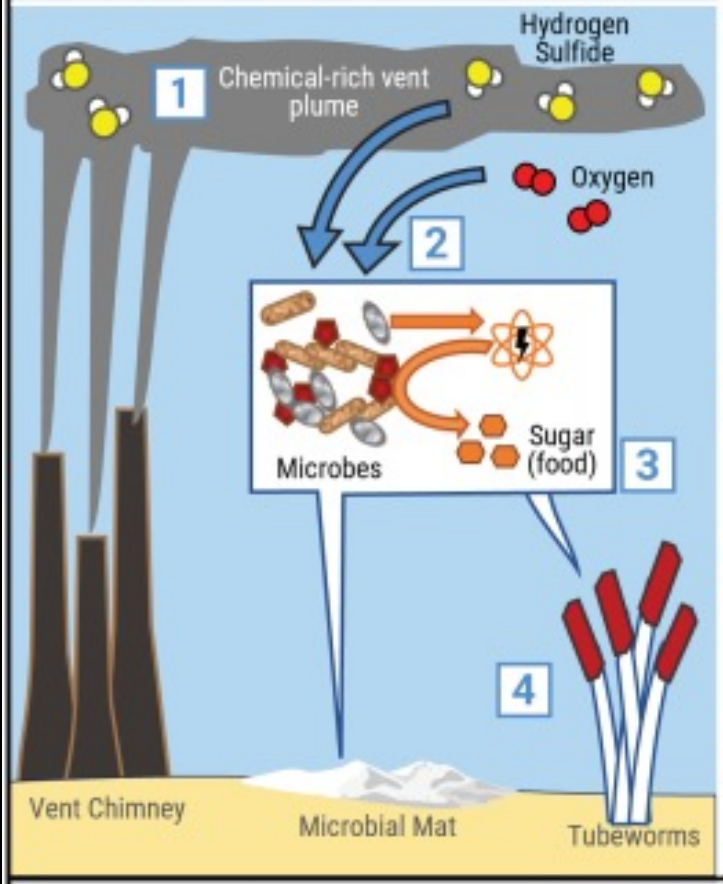
$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{Solar Energy}} C_6H_{12}O_6 + 6\,O_2$$

Carbon Dioxide + Water → Glucose (sugar/food) + Oxygen

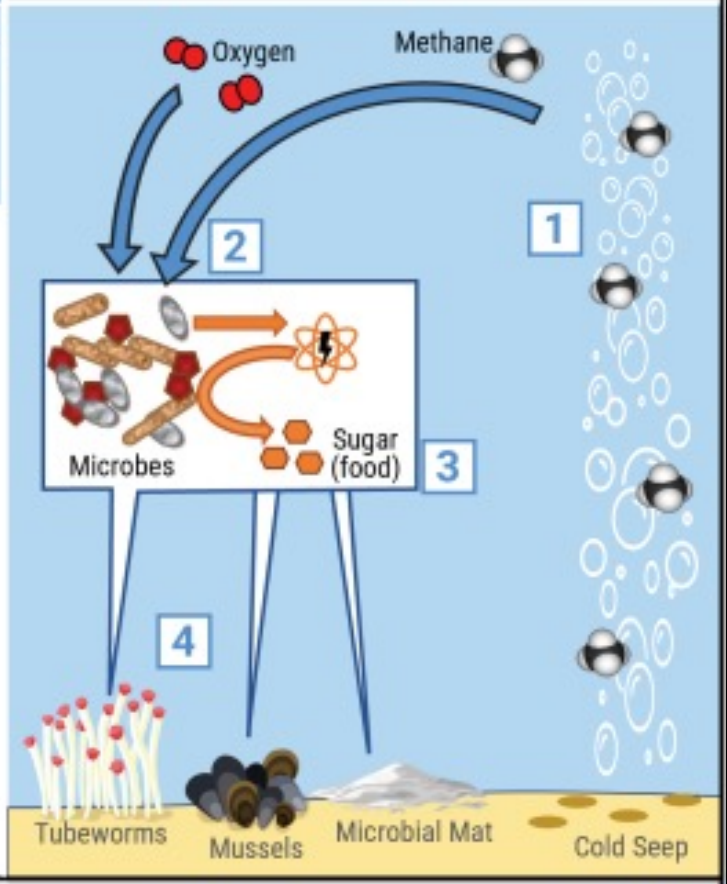
CHEMOSYNTHESIS

The process by which microbes create sugars (food) using energy released from chemical reactions

Hydrothermal Vents



Cold Seeps



1. Chemical-rich waters emerge from beneath the seafloor at hydrothermal vents and cold seeps.
2. Some chemical reactions release chemical energy. Chemosynthetic microbes harness the chemical energy released during reactions with vent or seep chemicals.
3. The microbes use the chemical energy convert inorganic carbon to organic molecules, or food, through the carbon fixation process.
4. The microbes grow and reproduce, and are eaten, or hosted as internal symbionts by other animals like tubeworms and mussels.

2 Energy releasing chemical equation

$H_2S + 2O_2 \rightarrow SO_4^{2-} + 2H^+ +$ (chemical energy)

Hydrogen Sulfide + Oxygen → Sulfate ion + Hydrogen ion + Chemical energy

$CH_4 + 2O_2 \rightarrow CH_3OH + 2H_2O +$ (chemical energy)

Methane + Oxygen → Methanol + Water + Chemical energy

3 Carbon fixation processes produce sugar (food)

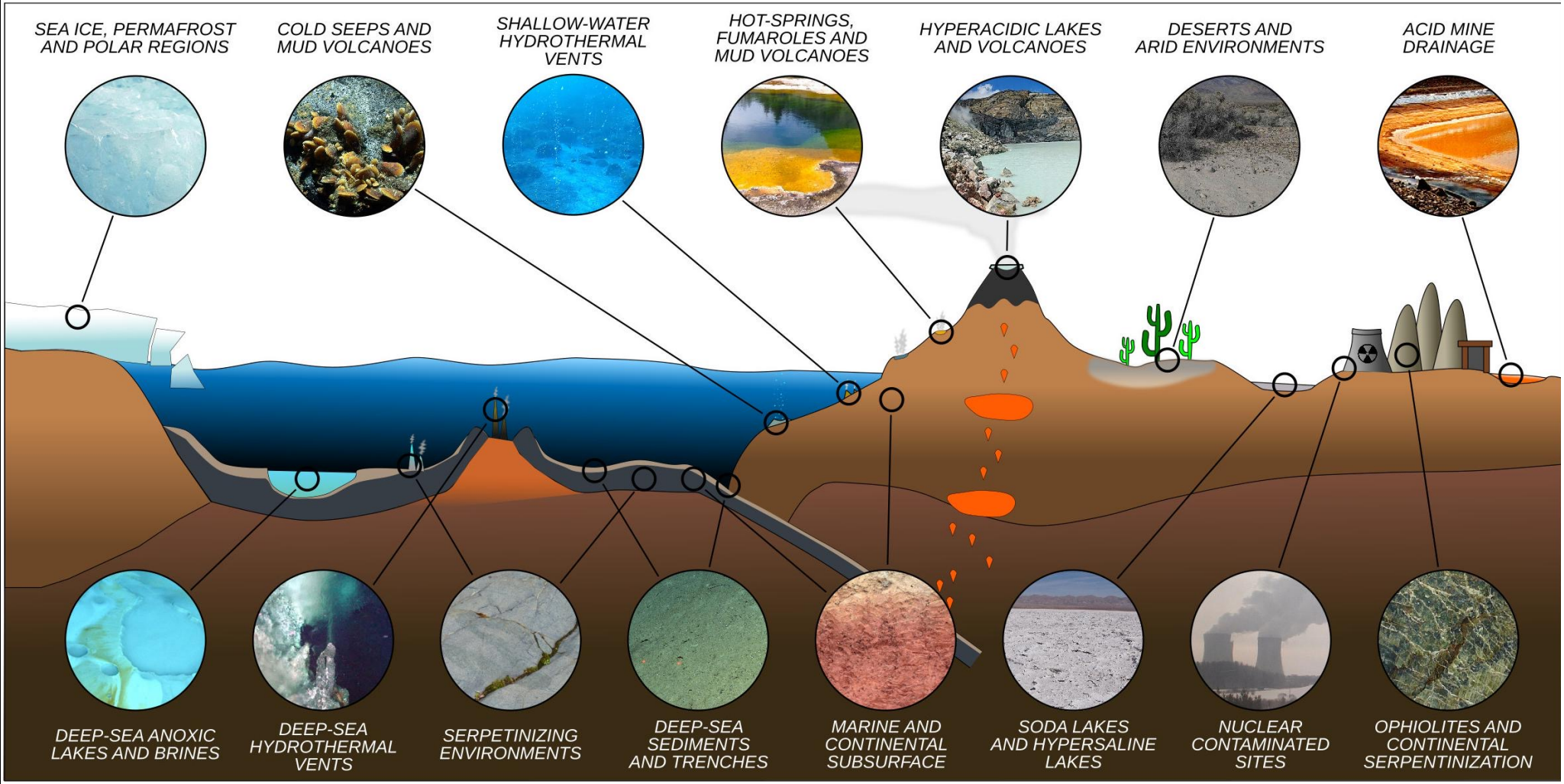
$CO_2 \rightarrow$ (Carbon fixation process) $\rightarrow C_6H_{12}O_6$

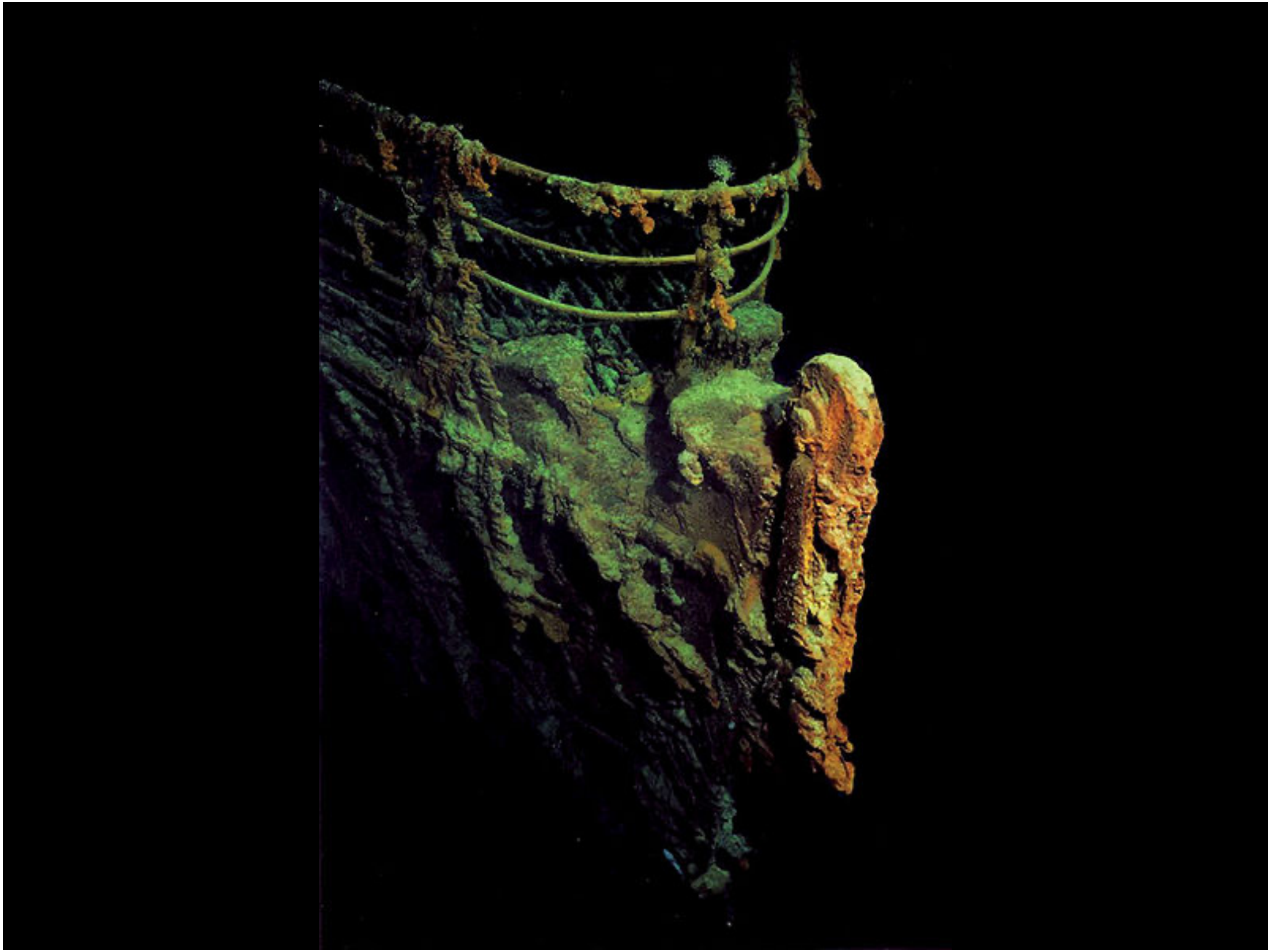
Carbon Dioxide → Carbon fixation process → Glucose (sugar)

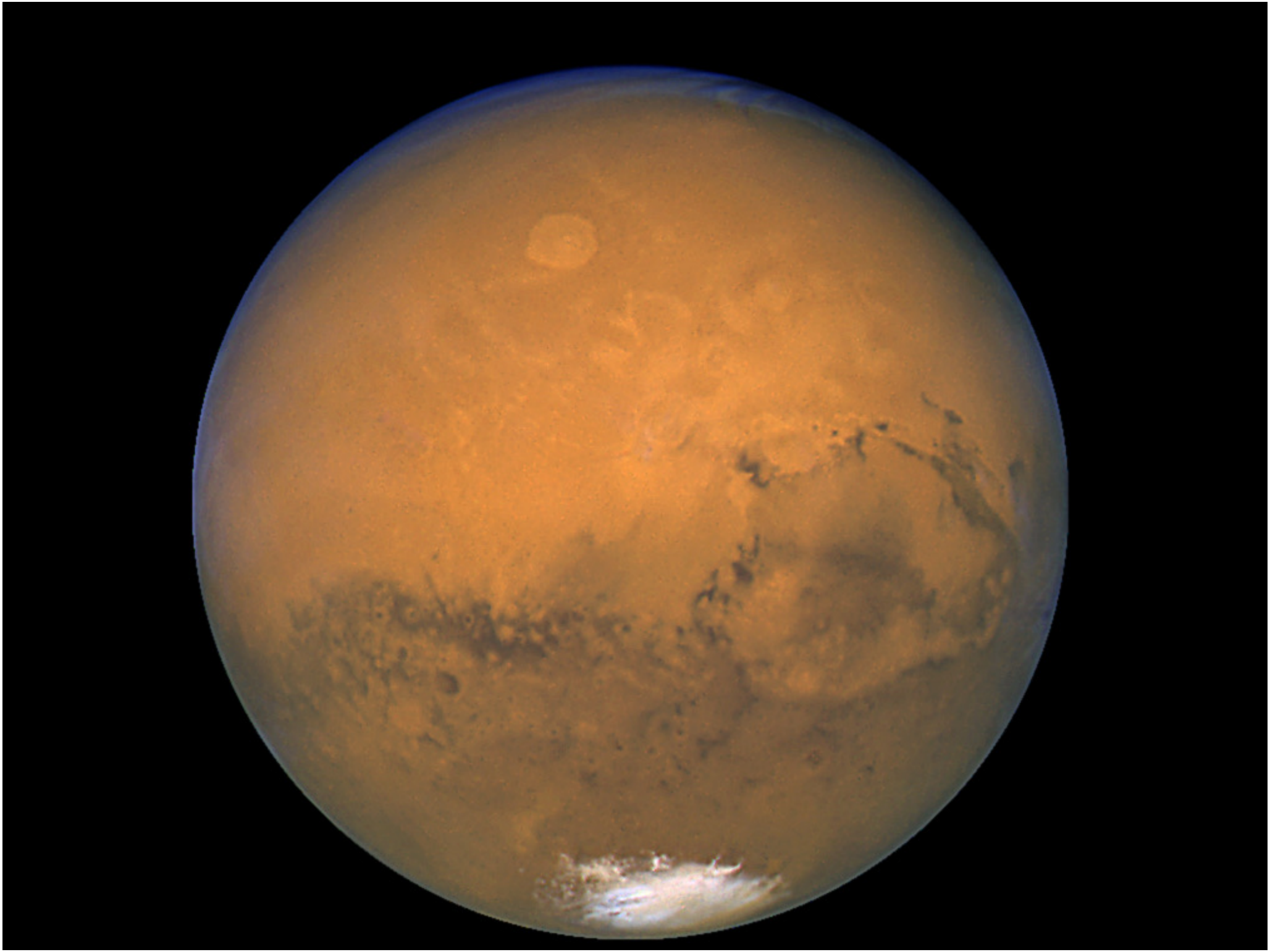
$CH_3OH \rightarrow HCHO \rightarrow$ (Carbon fixation process) $\rightarrow C_6H_{12}O_6$

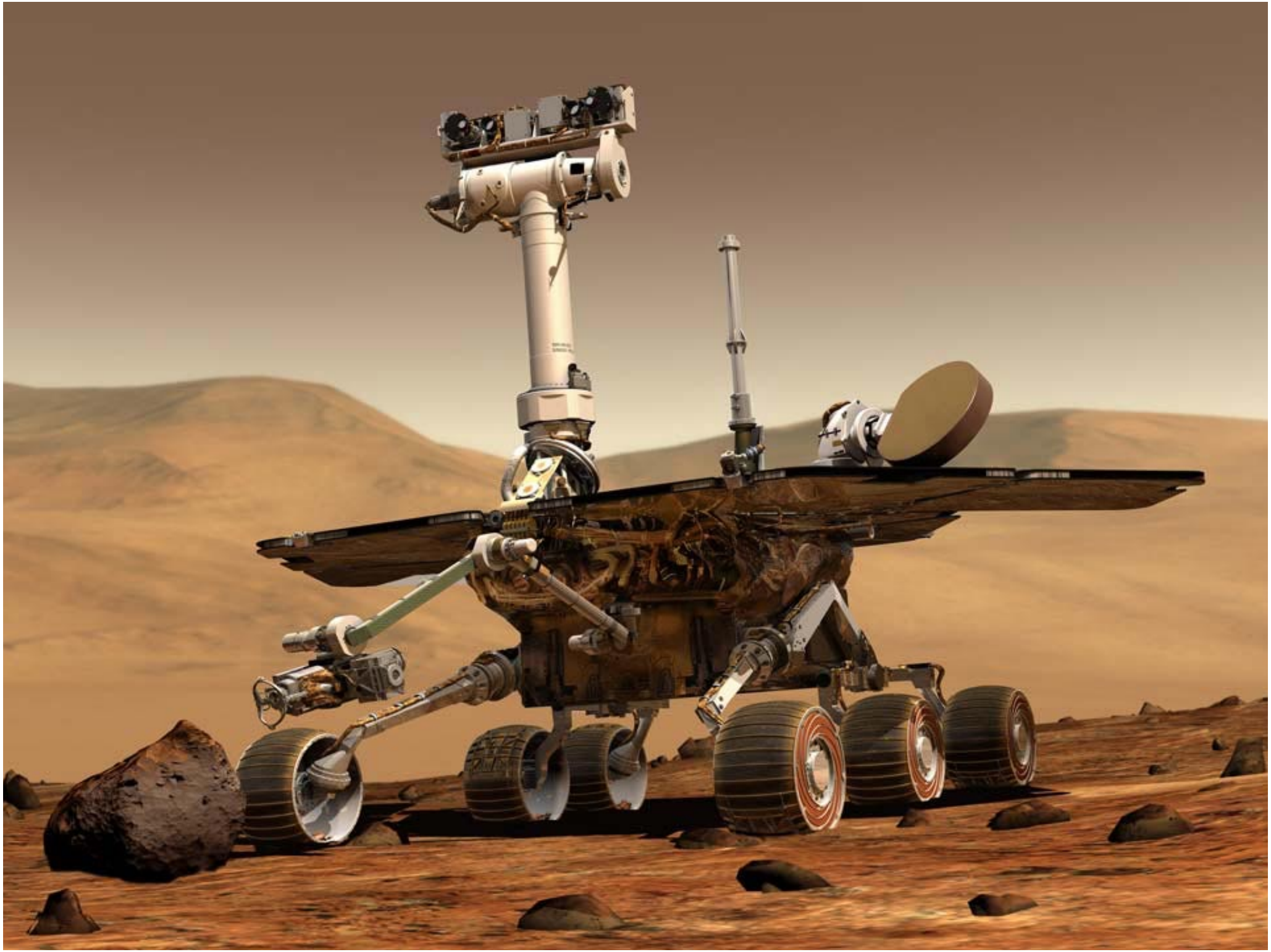
Methanol → Formaldehyde → Carbon fixation process → Glucose (sugar)

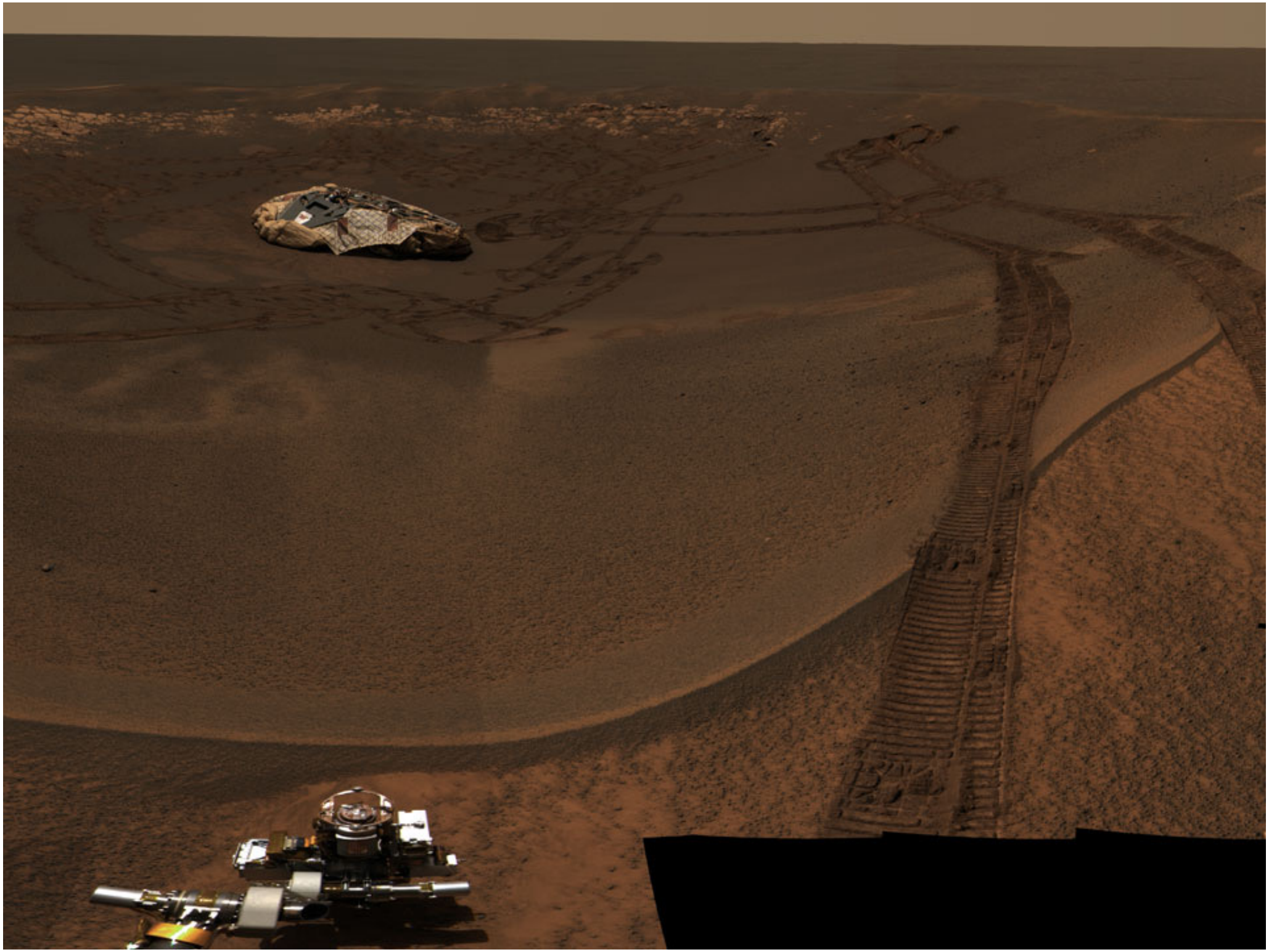
Note: This diagram only includes one chemosynthetic pathway for vents and seeps. Due the the complex microbial diversity and chemicals found in these environments, there are several biochemical pathways that support the chemosynthetic communities found at each.

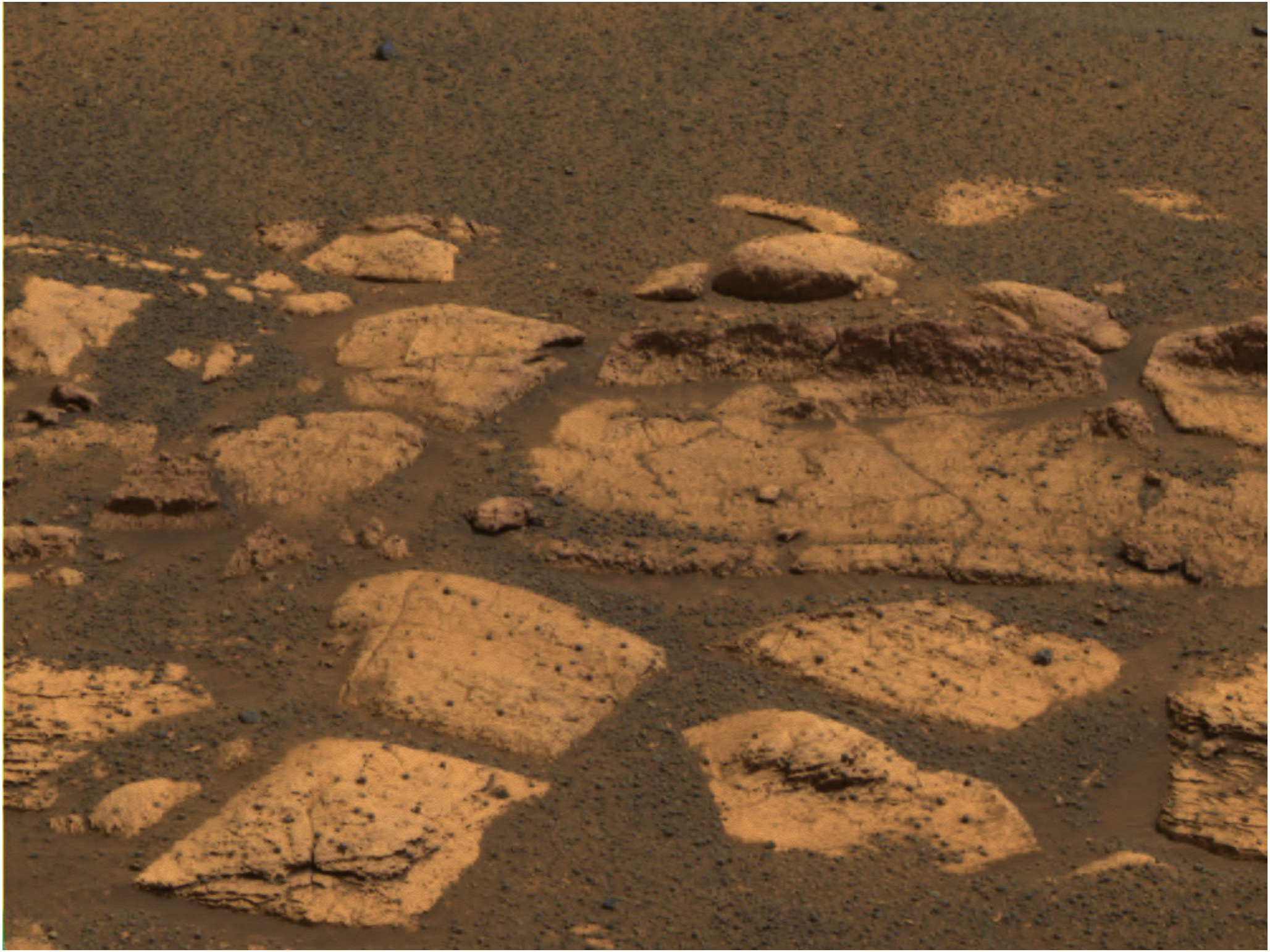

SEA ICE, PERMAFROST AND POLAR REGIONS
COLD SEEPS AND MUD VOLCANOES
SHALLOW-WATER HYDROTHERMAL VENTS
HOT-SPRINGS, FUMAROLES AND MUD VOLCANOES
HYPERACIDIC LAKES AND VOLCANOES
DESERTS AND ARID ENVIRONMENTS
ACID MINE DRAINAGE
DEEP-SEA ANOXIC LAKES AND BRINES
DEEP-SEA HYDROTHERMAL VENTS
SERPETINIZING ENVIRONMENTS
DEEP-SEA SEDIMENTS AND TRENCHES
MARINE AND CONTINENTAL SUBSURFACE
SODA LAKES AND HYPERSALINE LAKES
NUCLEAR CONTAMINATED SITES
OPHIOLITES AND CONTINENTAL SERPENTINIZATION



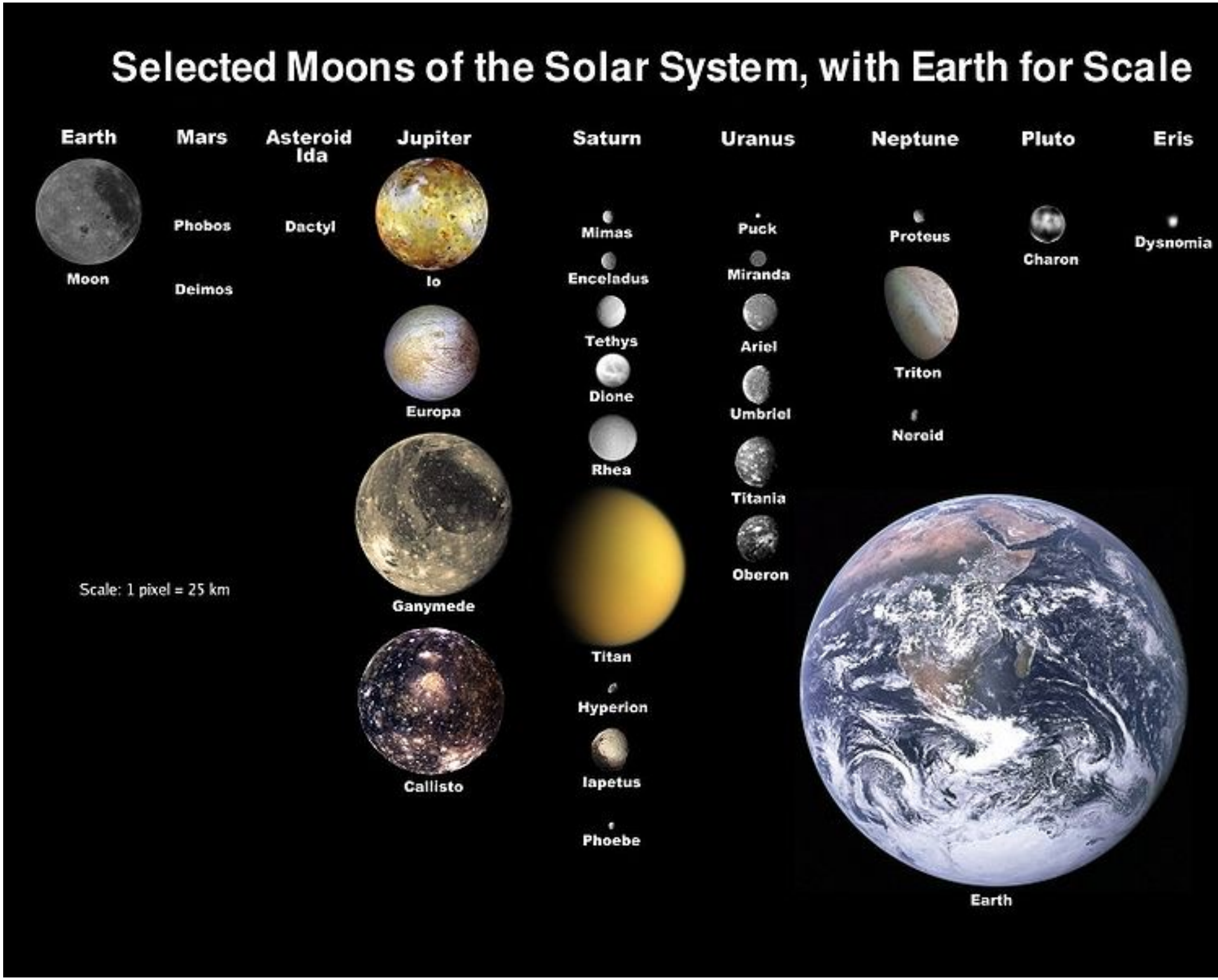


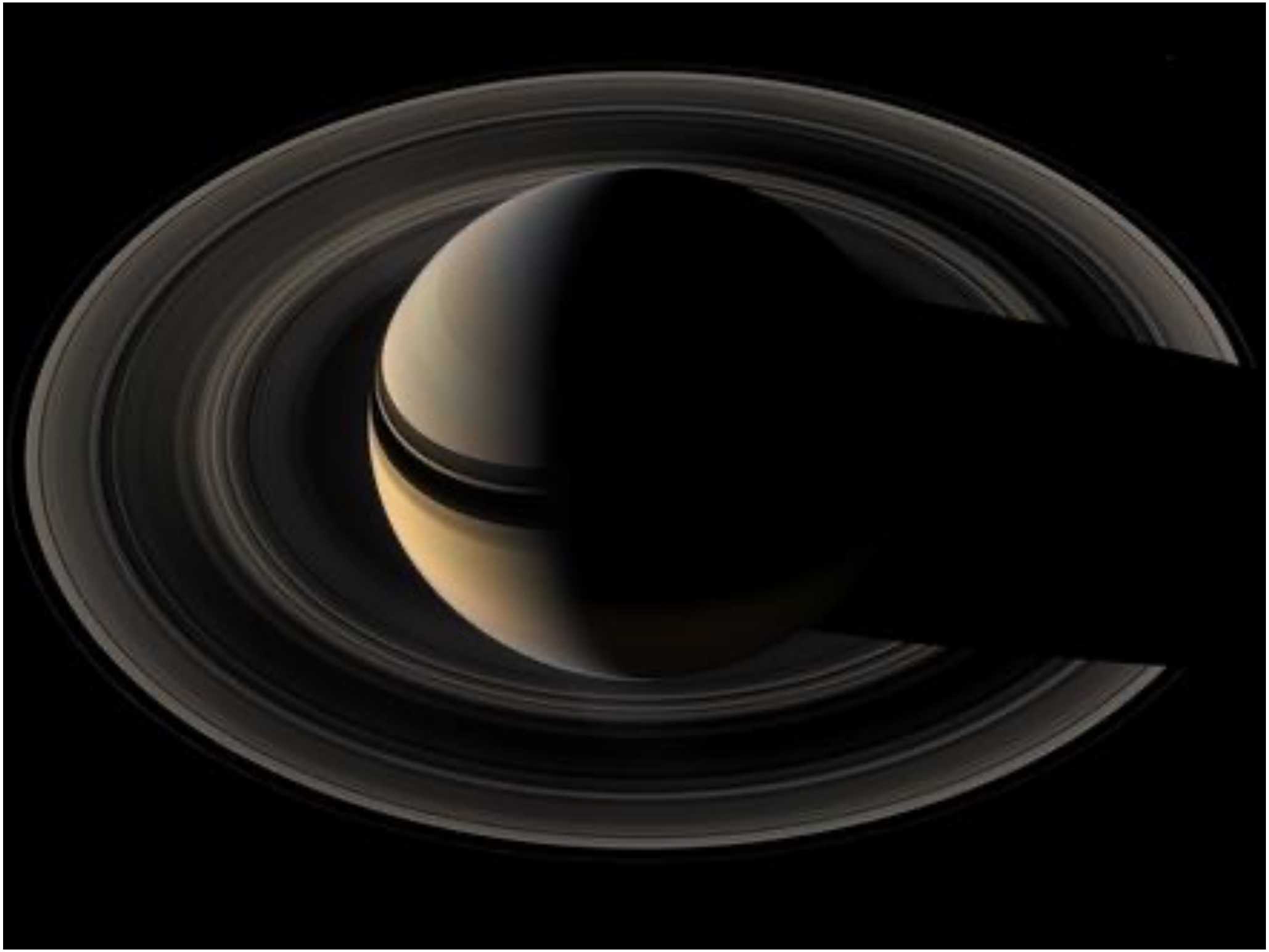






Selected Moons of the Solar System, with Earth for Scale





A Scale Model

If Earth is 2 centimeters, then

the Moon would be 1/2 centimeter.

And Mars would be 1 centimeter

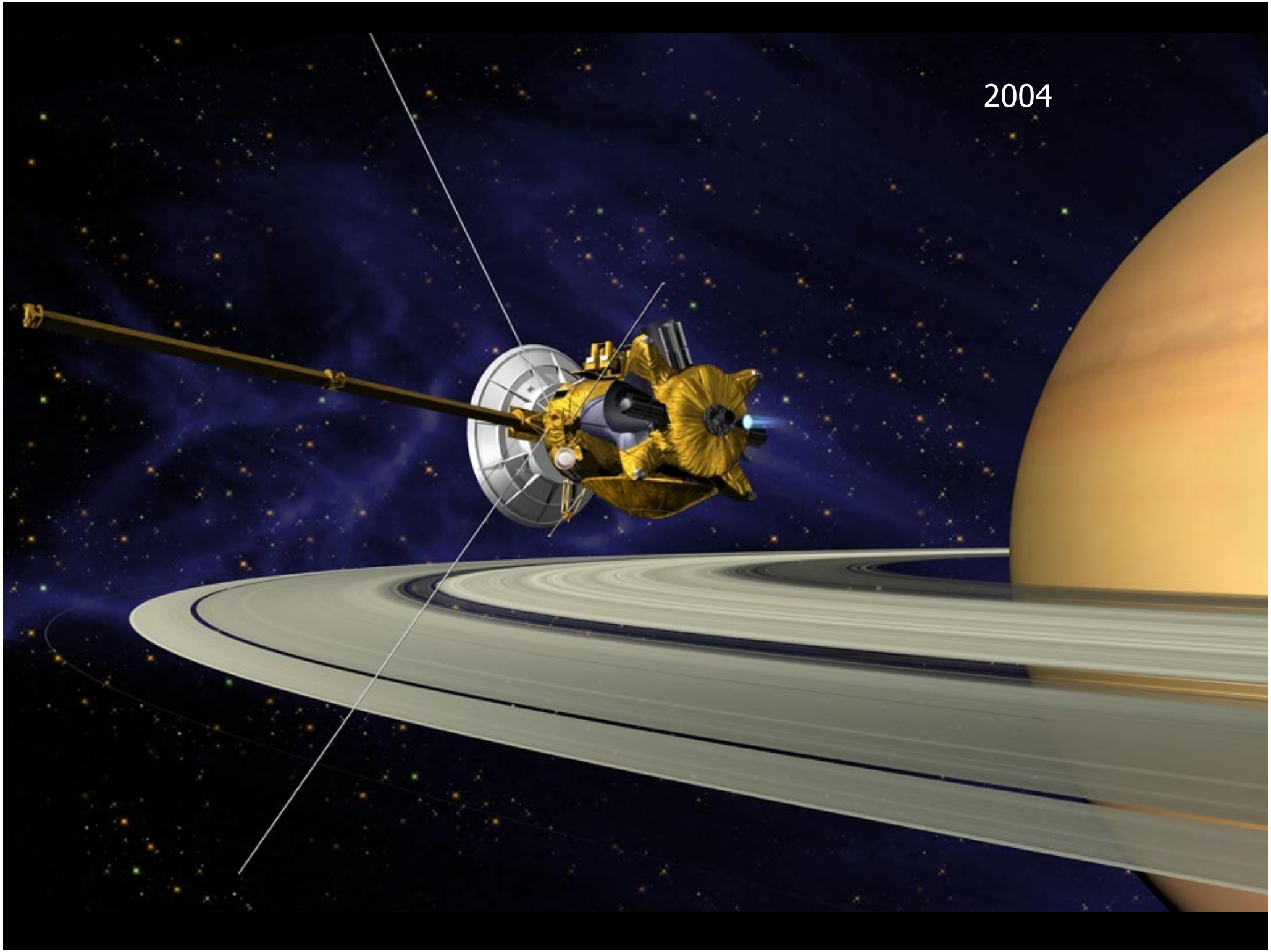
And Saturn would be 20 centimeters

And the Earth and Moon are separated by 58 centimeters = 23 inches

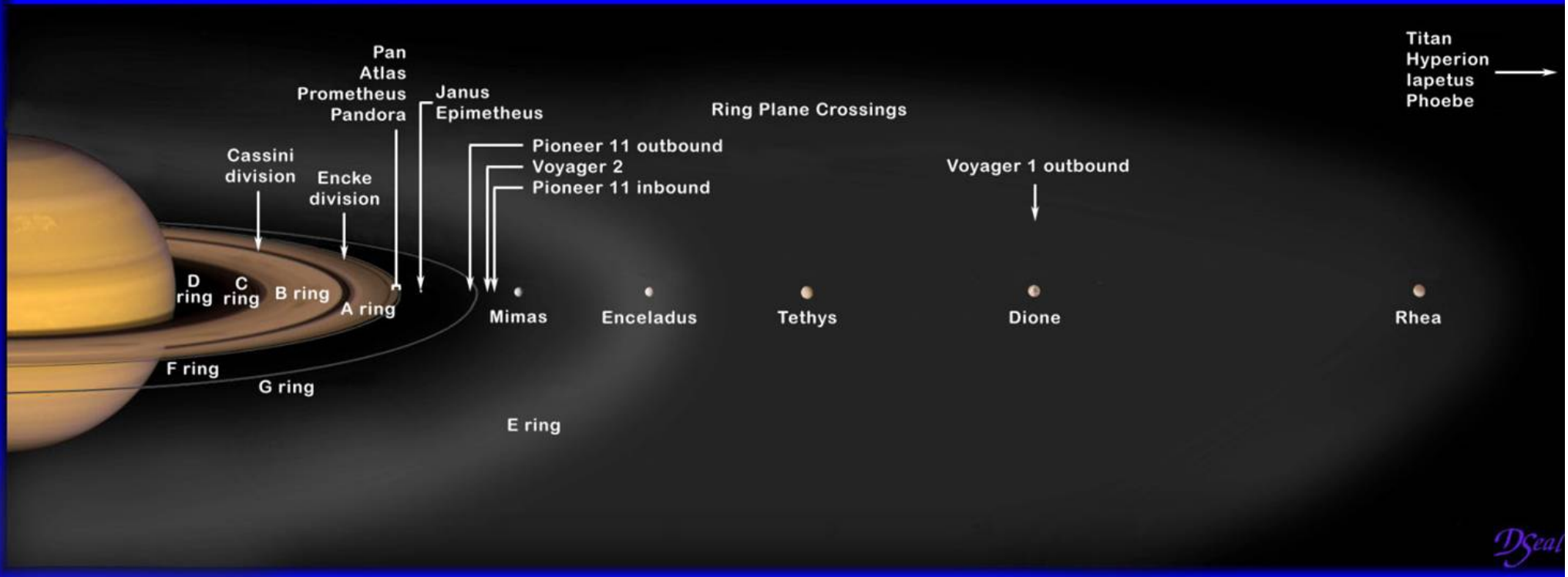
And the Earth and Mars are separated by 13000 cm = ***426 feet***

And the Earth and Saturn are separated by

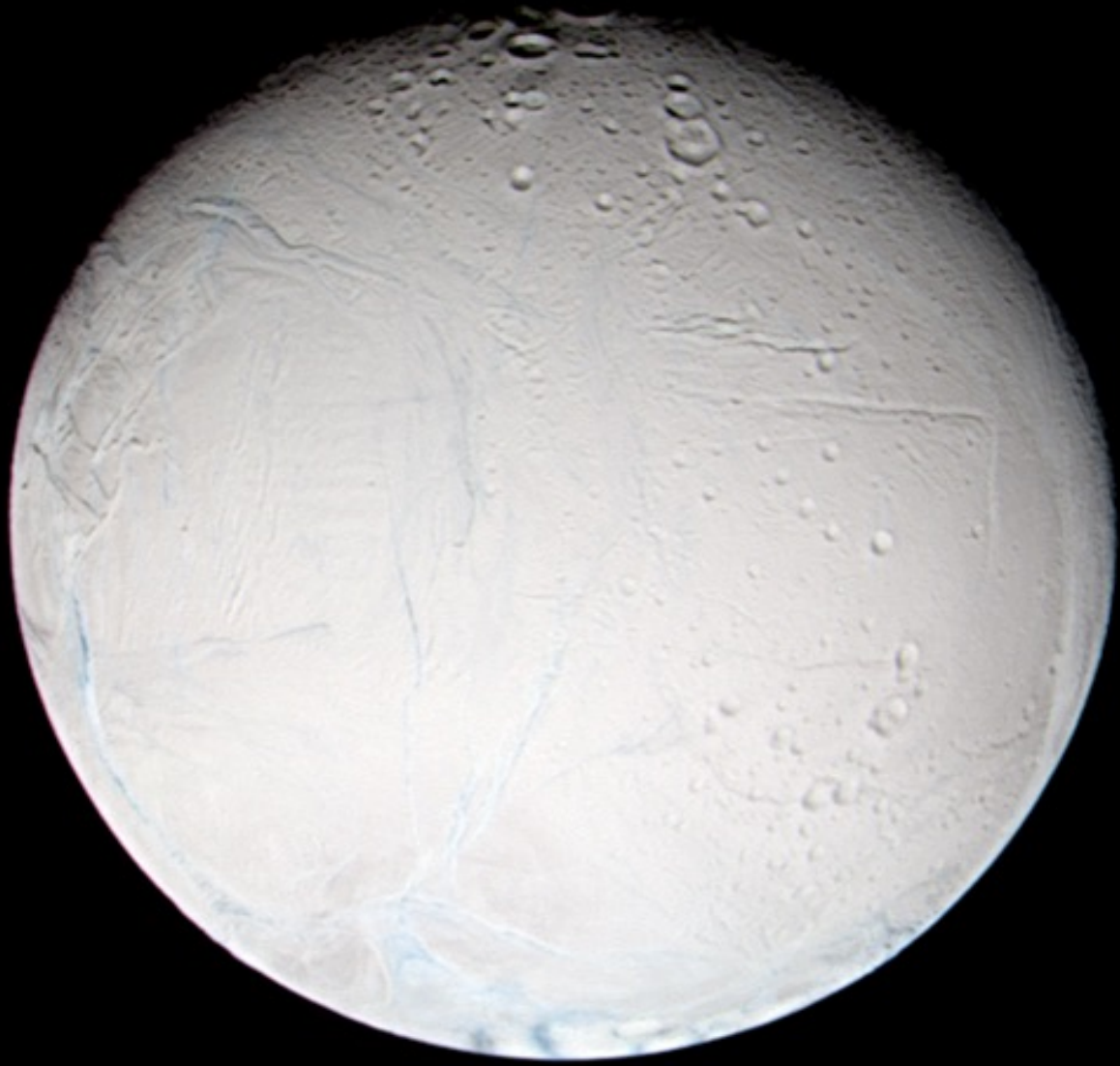
212,000 cm = ***1.6 miles***

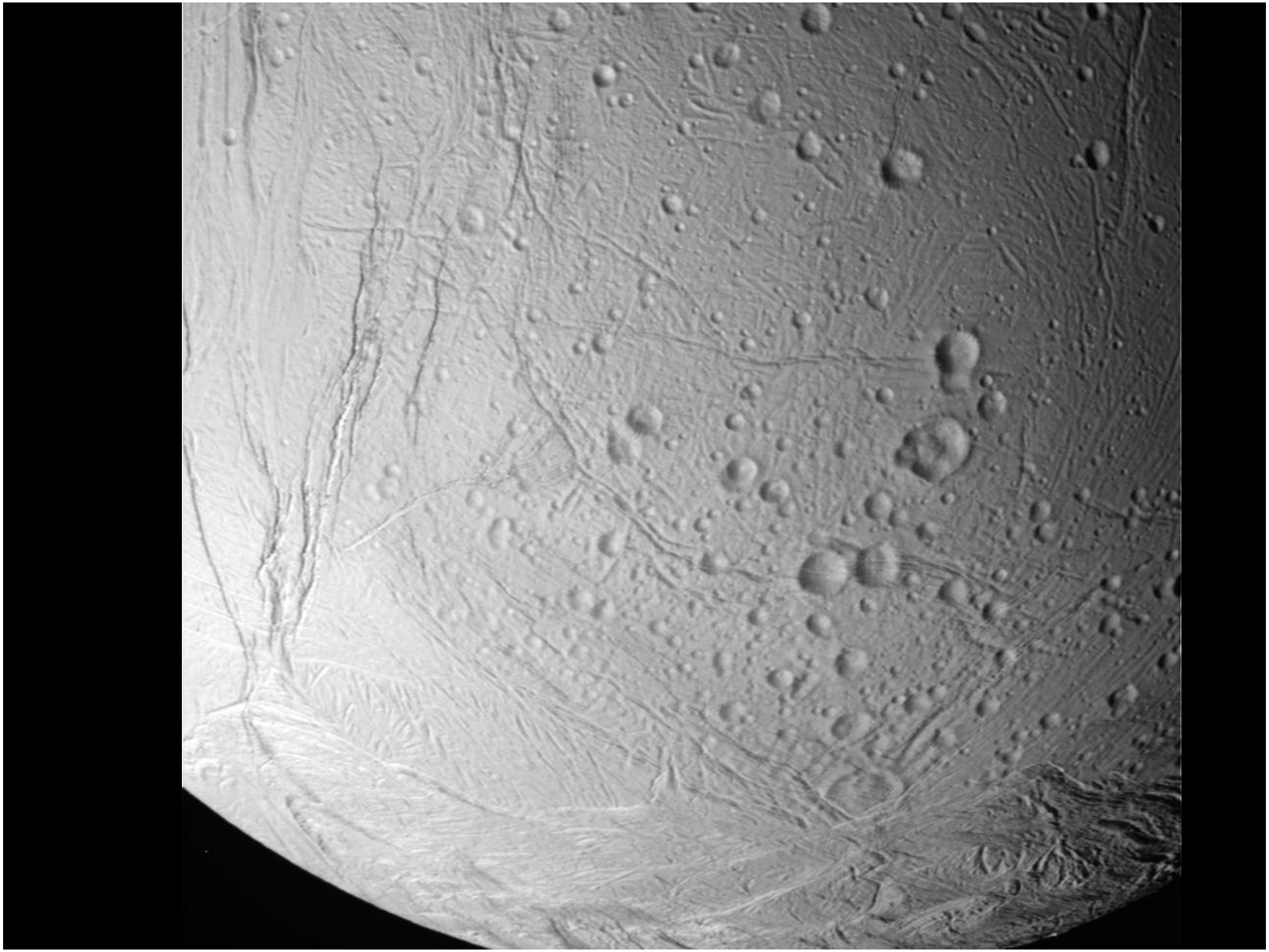

2004

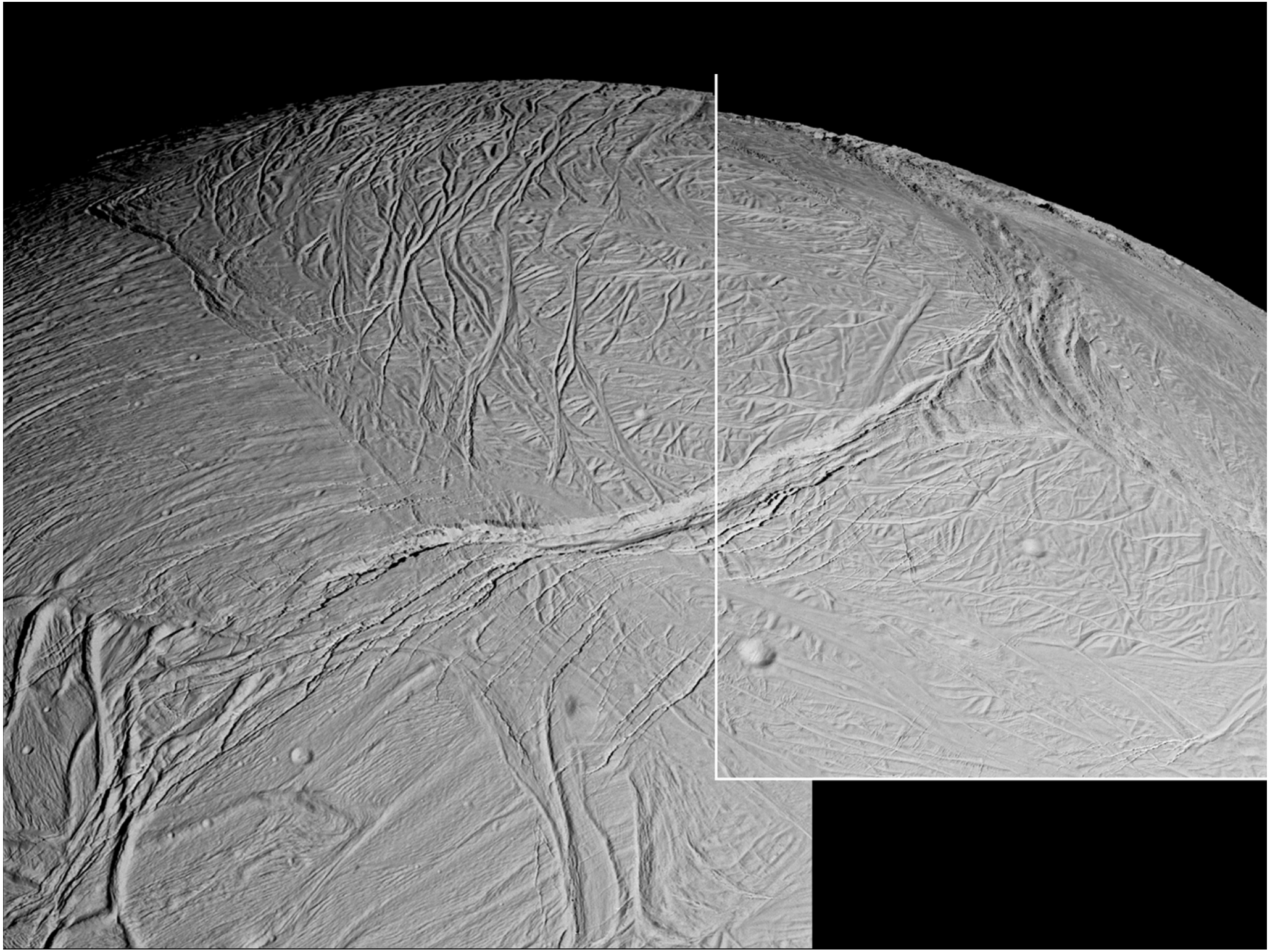
Saturn's Satellites and Ring Structure

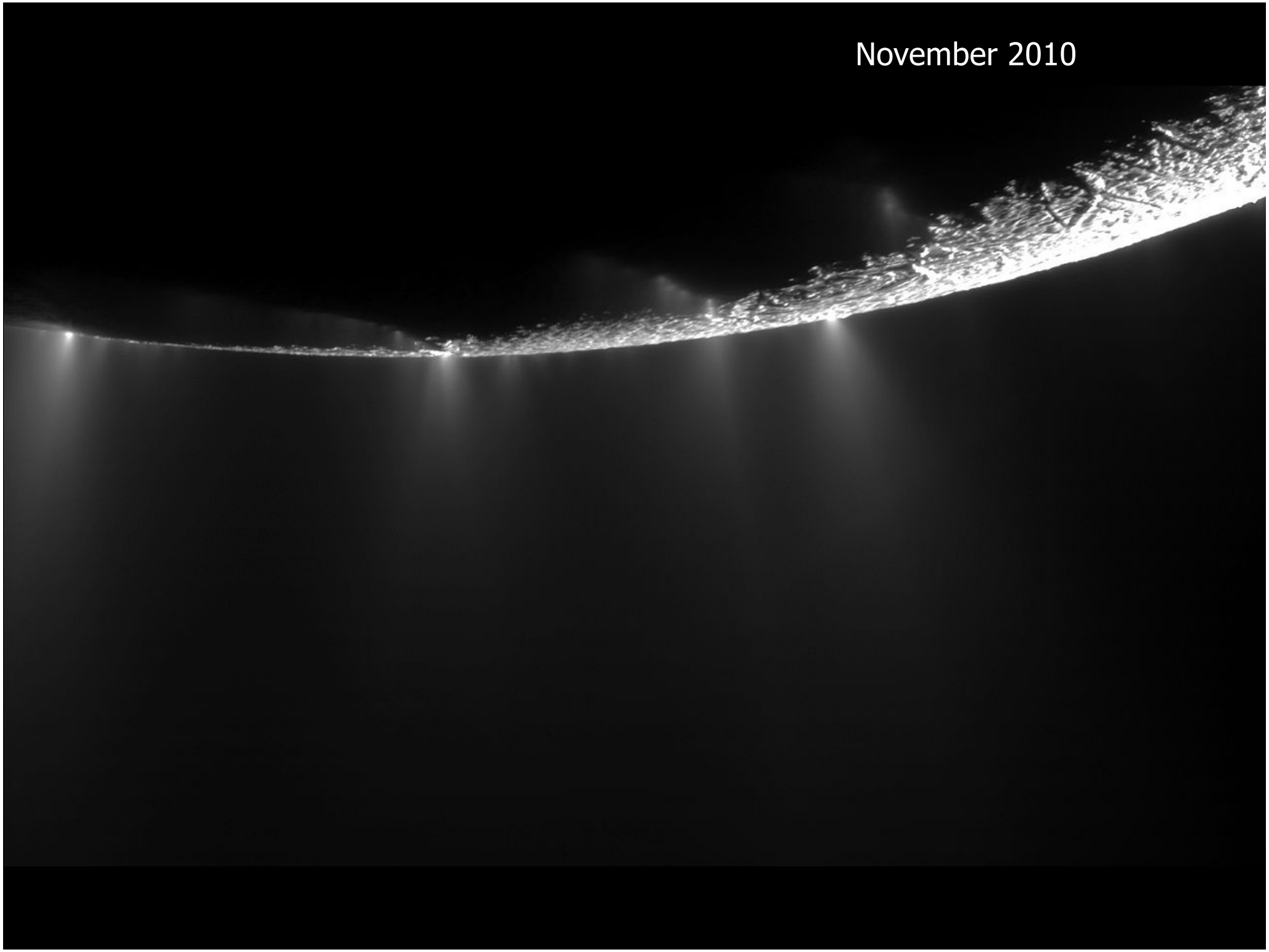


Enceladus



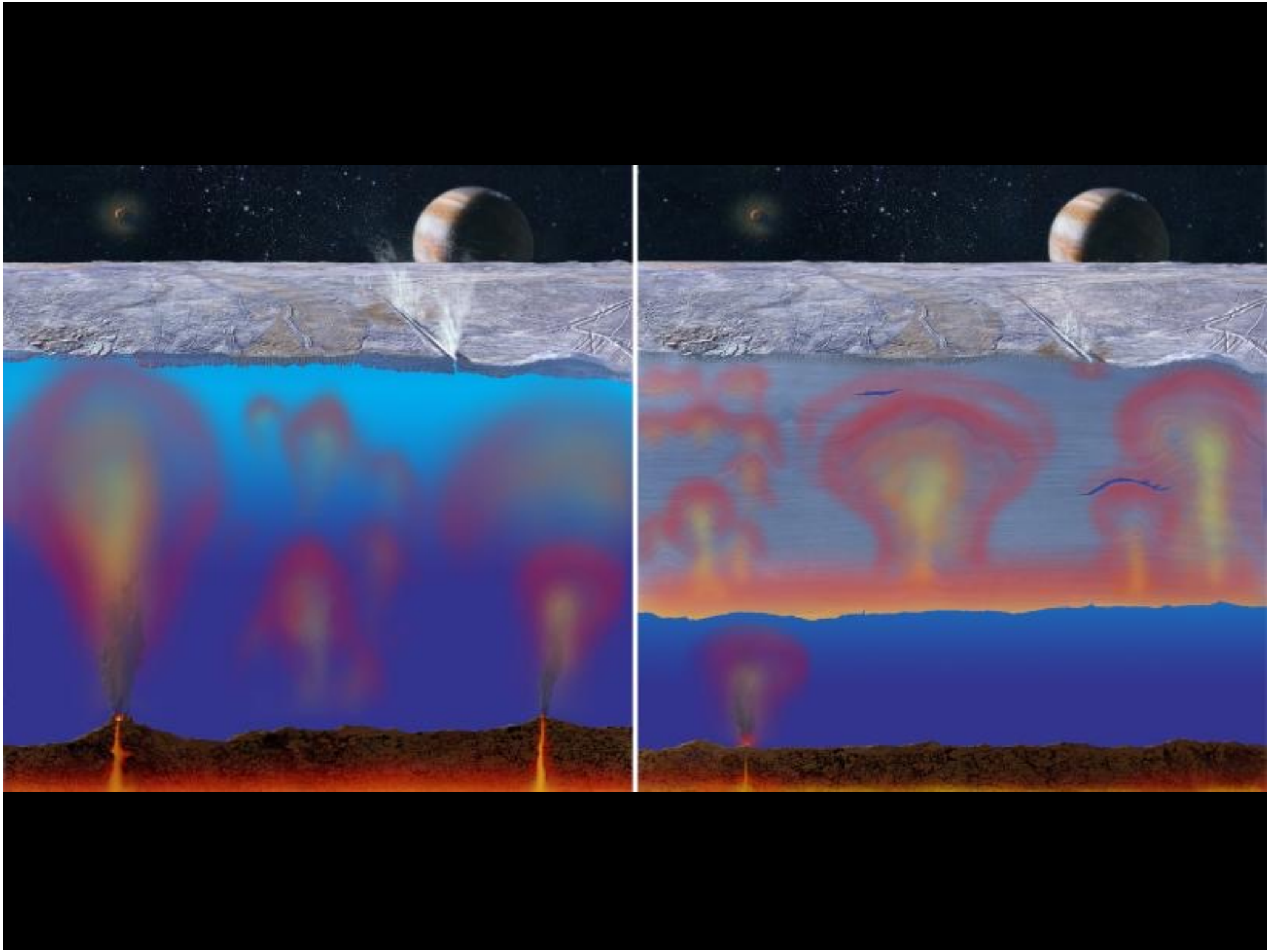


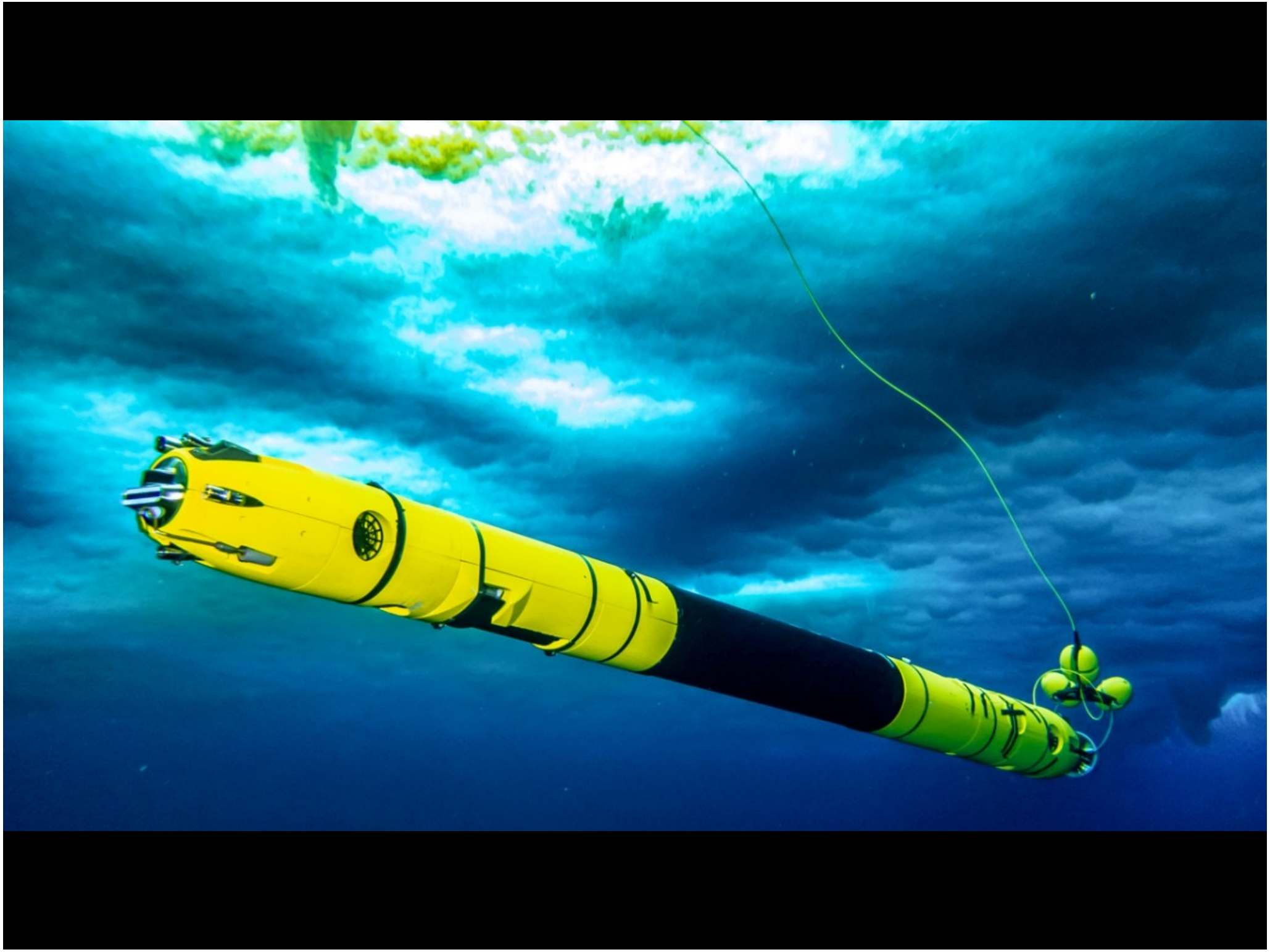


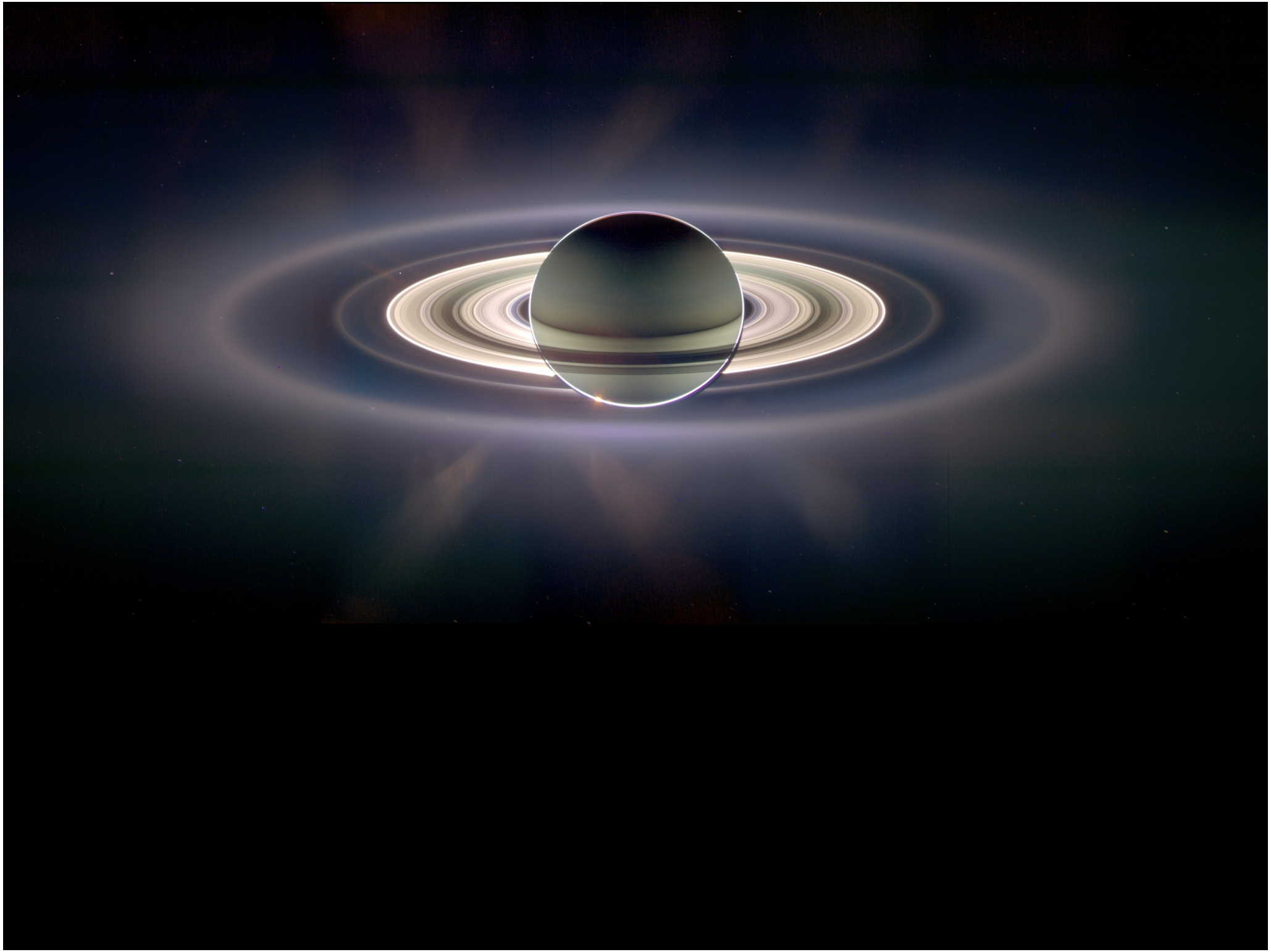

November 2010

Essential for Life

- Energy Source
- Water
- Earth Based Chemistry
  - Oxygen
  - Hydrogen
  - Carbon
  - Sulphur
  - Phosphorus







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