Searching for Life in the Saturn System: Enceladus Life Finder

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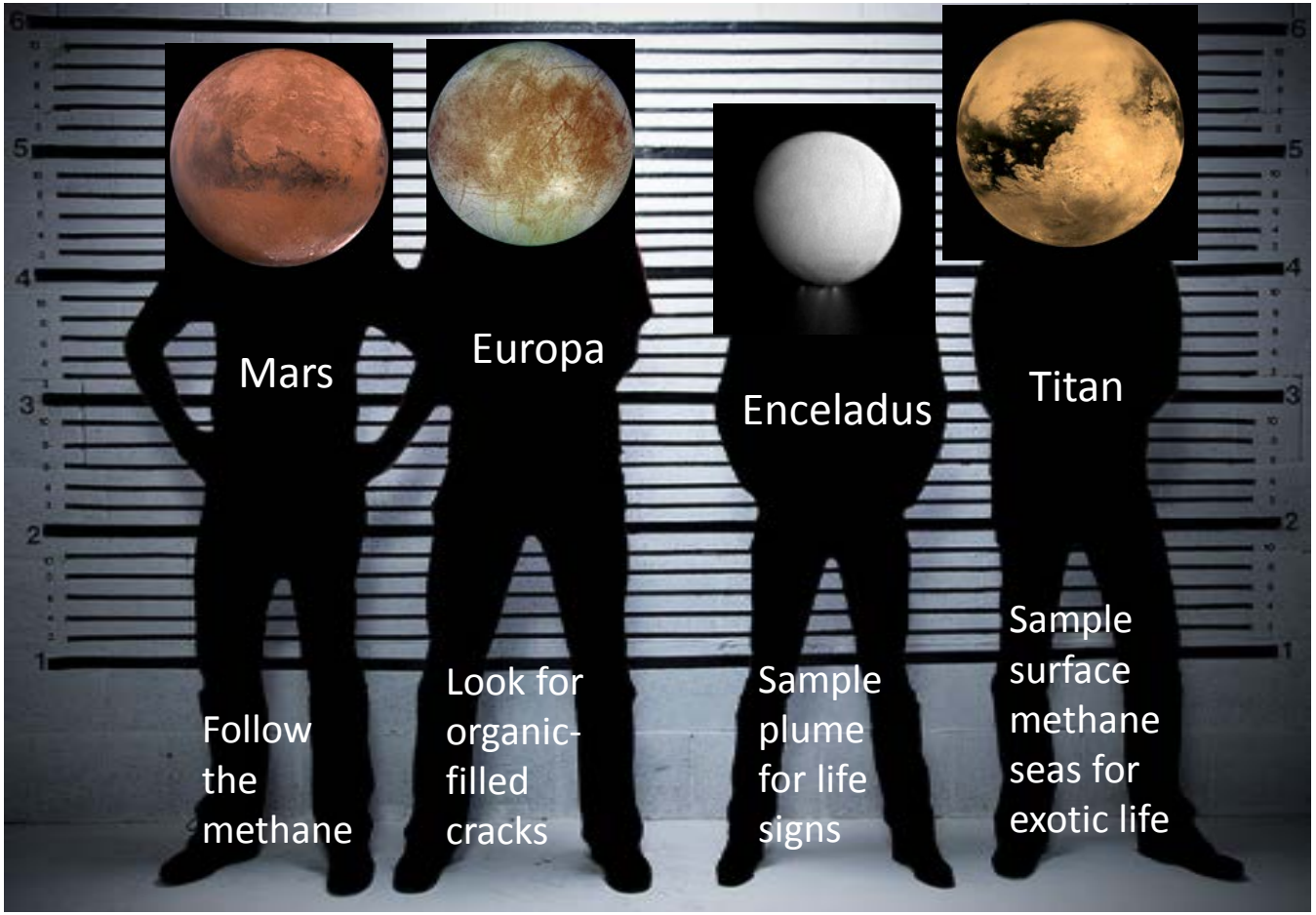
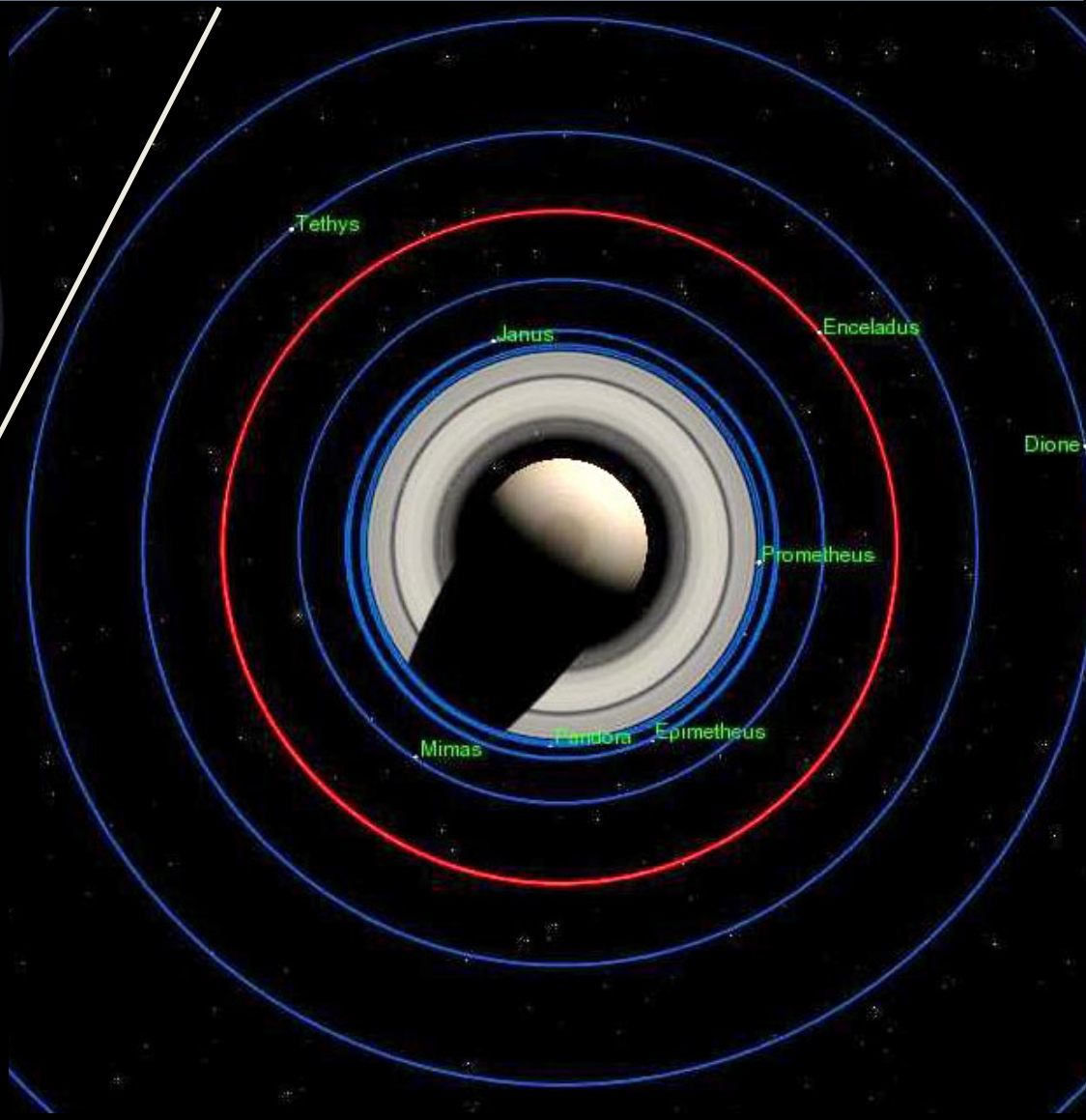
The lineup of solar system suspects in the search for life

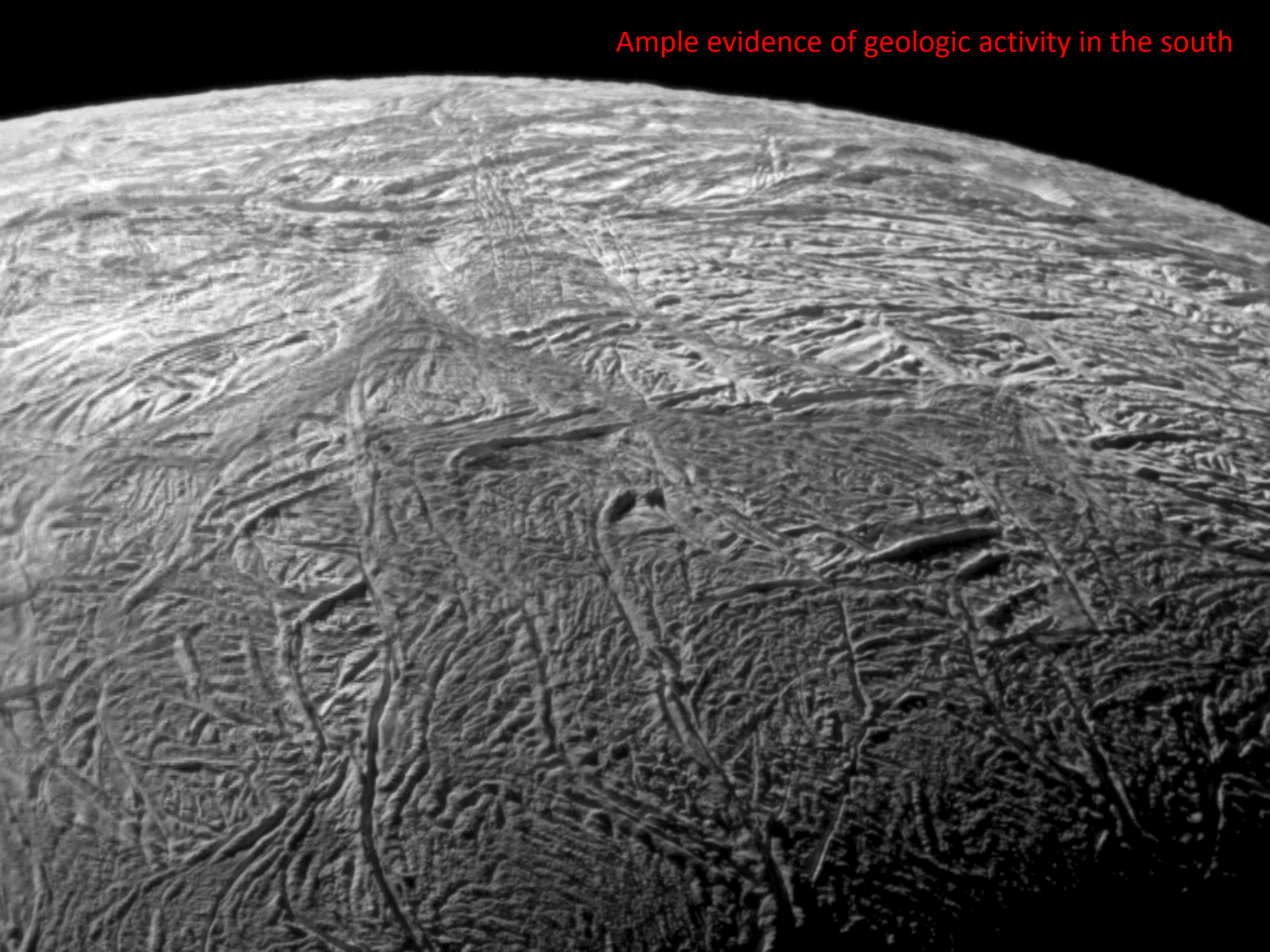


Cassini-Huygens: all 2500 kg (dry mass) of her….

Enceladus: A small moon quite close to Saturn

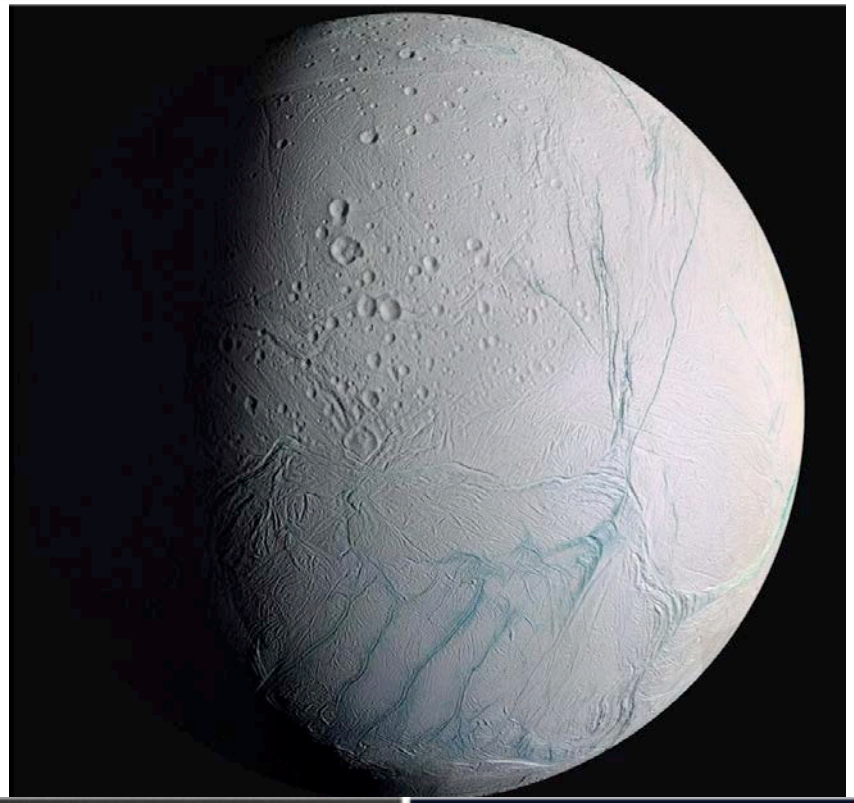


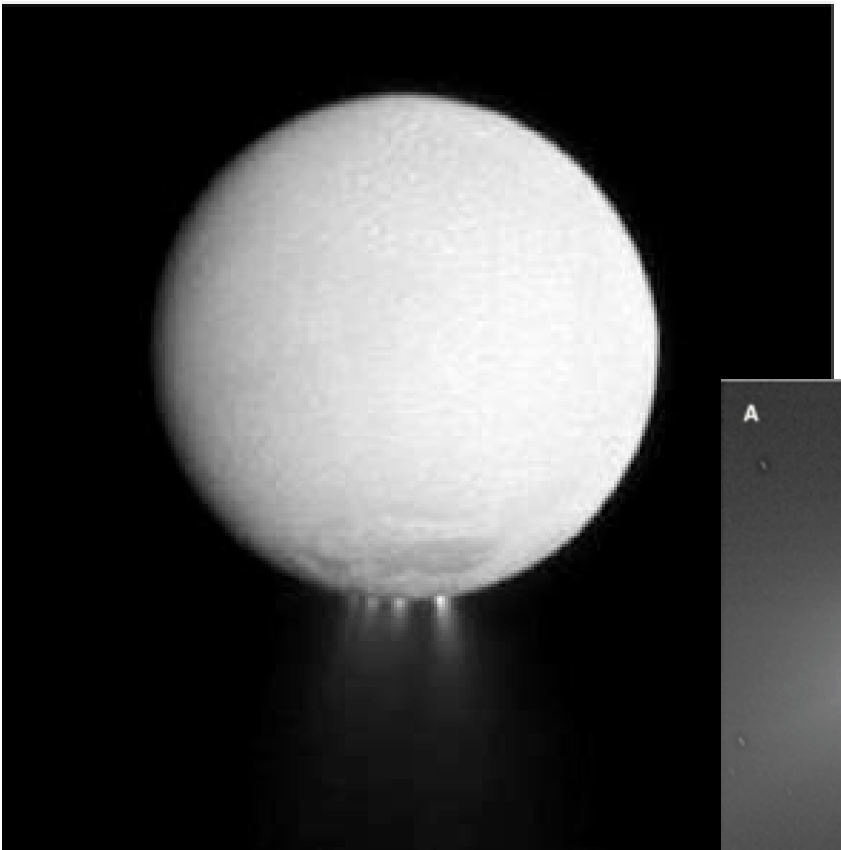
Ample evidence of geologic activity in the south

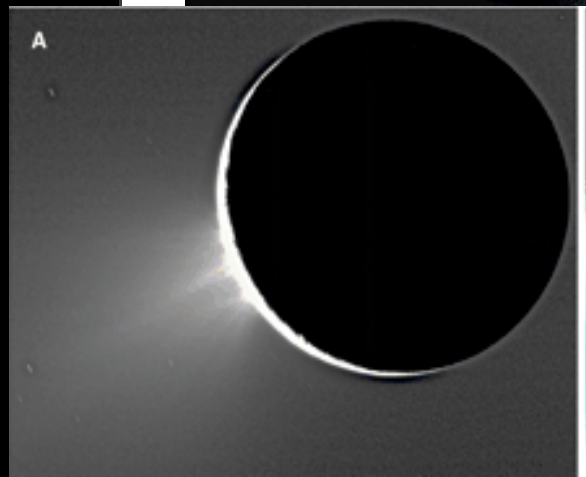


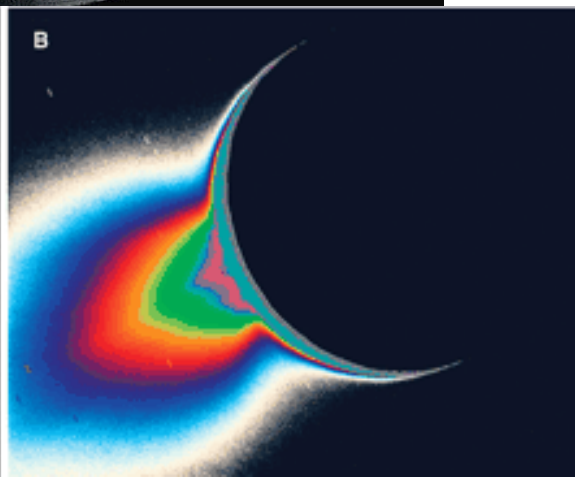
Enceladus Plumes

2005: Cassini discovers plumes and a south polar fracture system



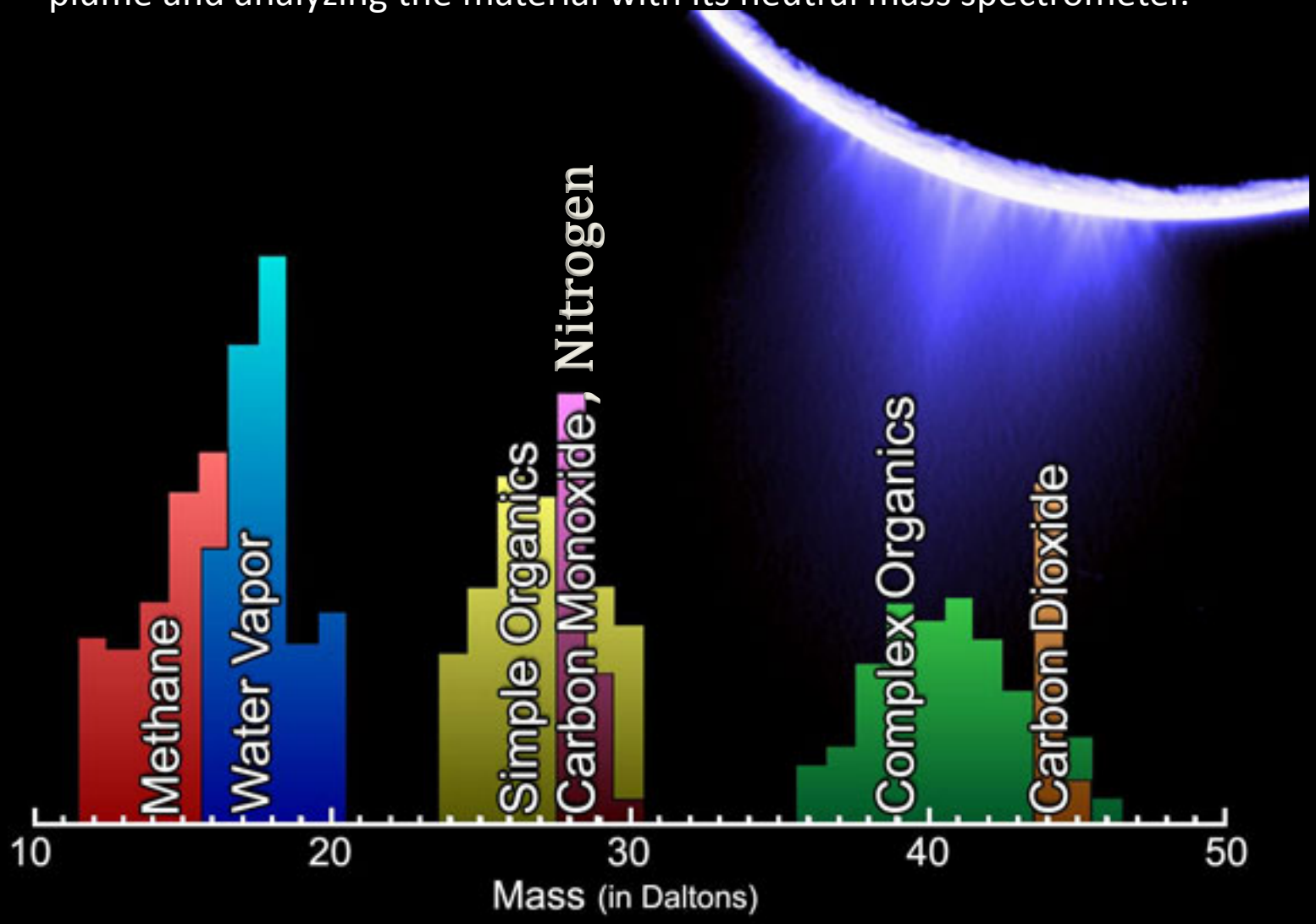






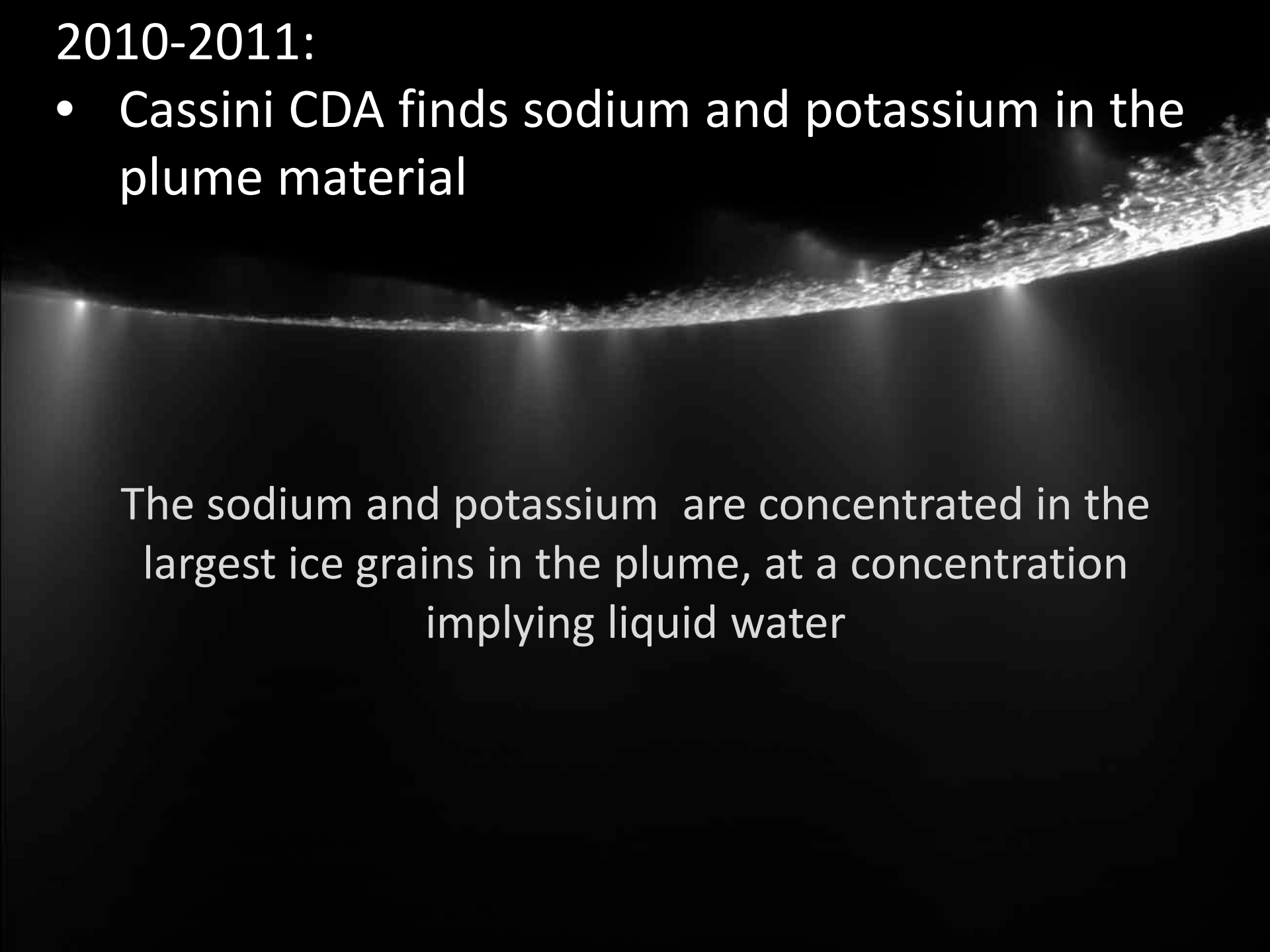
2008: Organics in the Plumes

Cassini INMS discovers organics, ammonia in the plume by flying through plume and analyzing the material with its neutral mass spectrometer.



2010-2011:

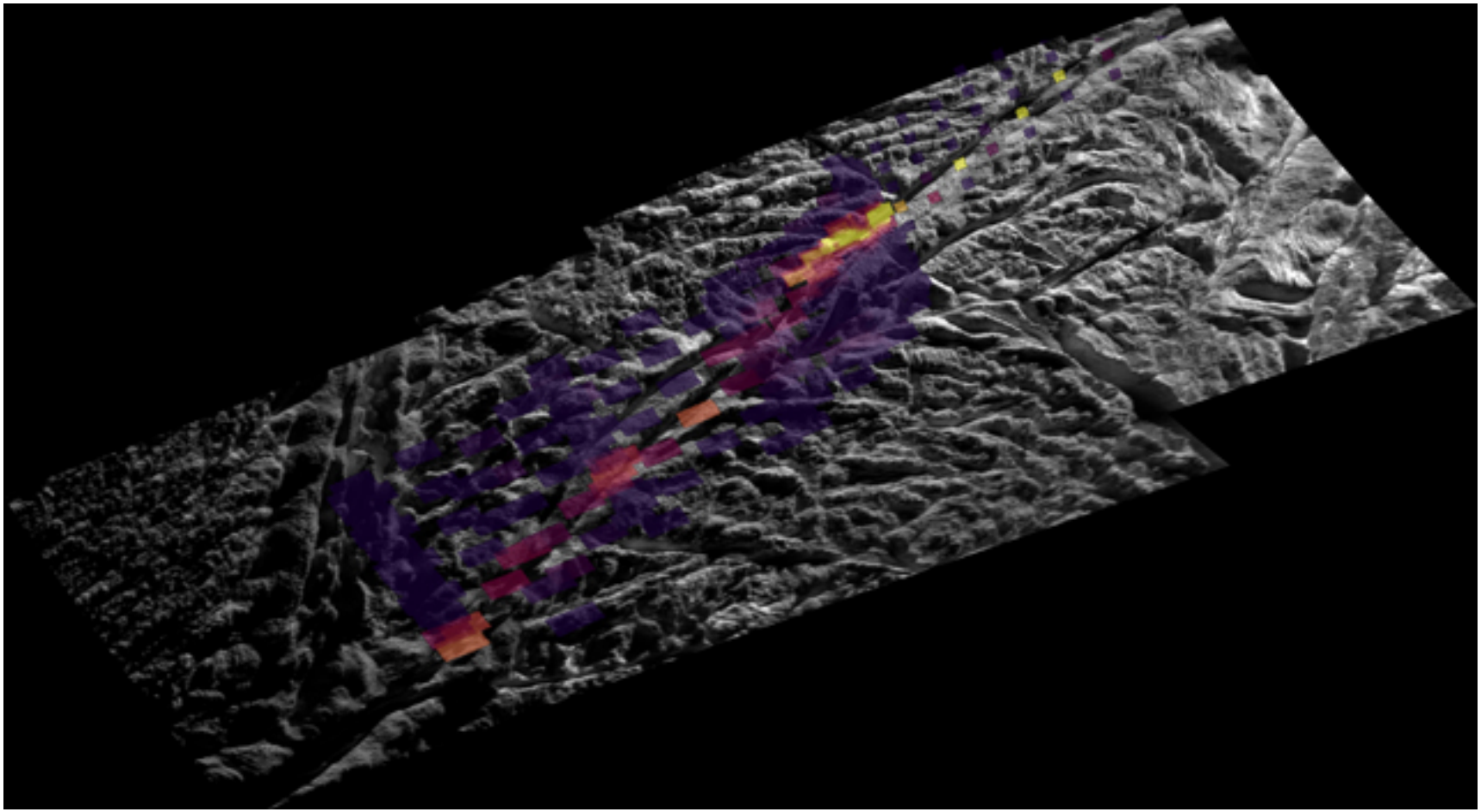
- Cassini CDA finds sodium and potassium in the plume material



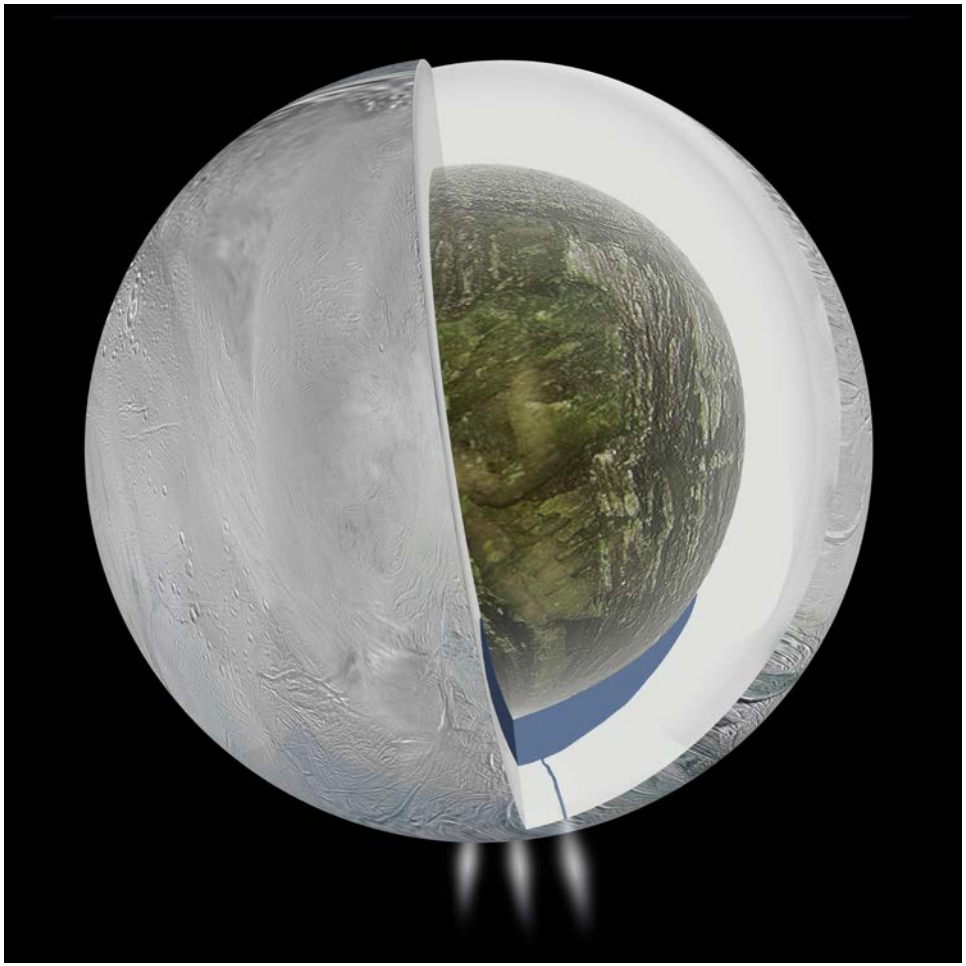
The sodium and potassium are concentrated in the largest ice grains in the plume, at a concentration implying liquid water

2008-2012: Excess heat at the south pole.

- Several GW from the south polar region, indicative of a warm interior

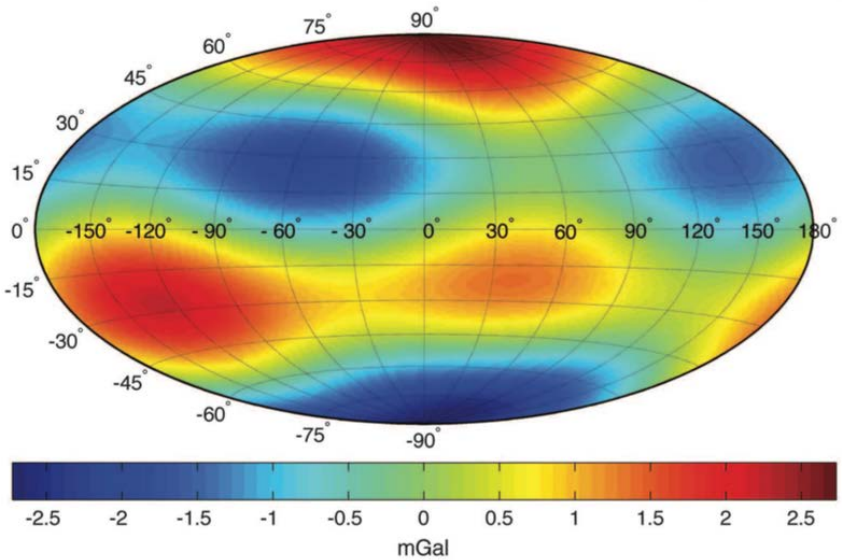


2014: Regional Sea under the Ice



Cassini discovers a regional sea beneath the South Pole: the smoking gun that beneath the jets is a region of liquid water, stable for very long time periods.

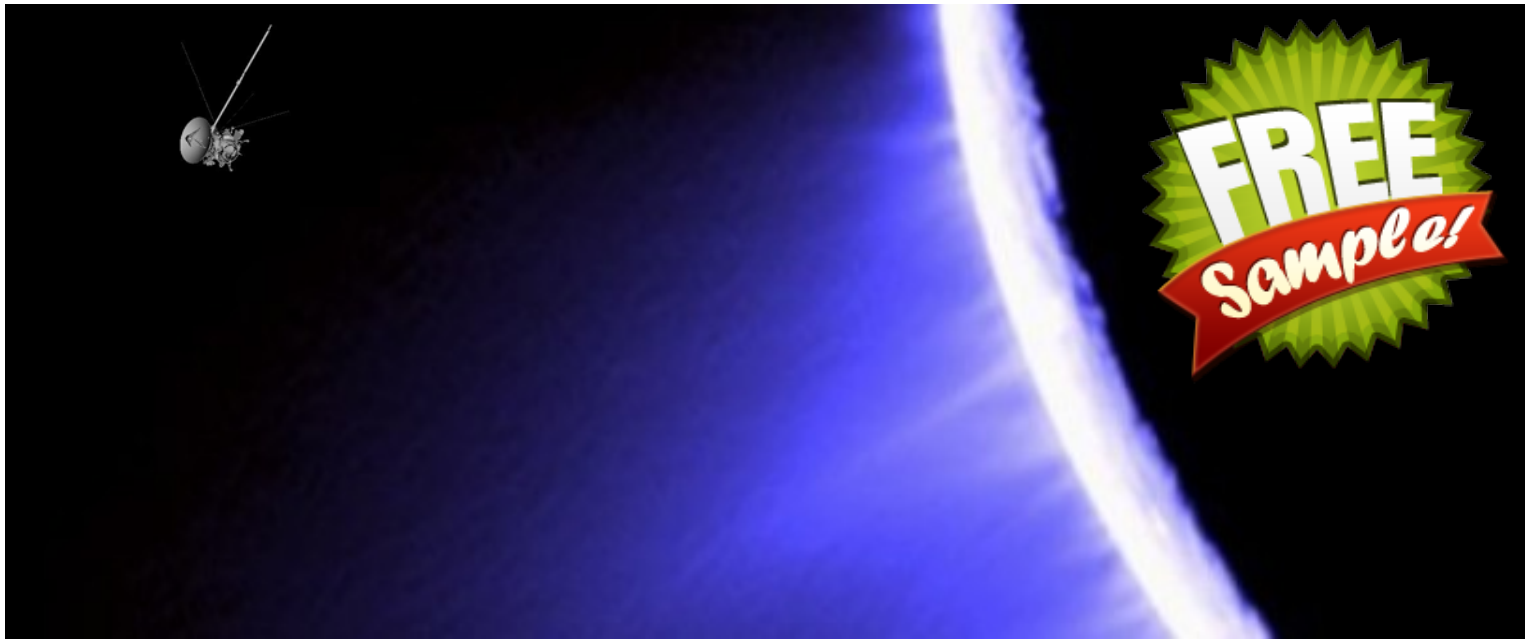
Iess et al., 2014. Science



Life *in* Enceladus?

Multiple factors *make plausible the idea that life exists there:*

- An accessible, salty (CDA) ocean (RSS+ISS)
- Organics (INMS)
- Energy (CIRS)



Last Cassini Flyby through Enceladus' Jets

- Flyby date: October 28, 2015
- 50-km closest approach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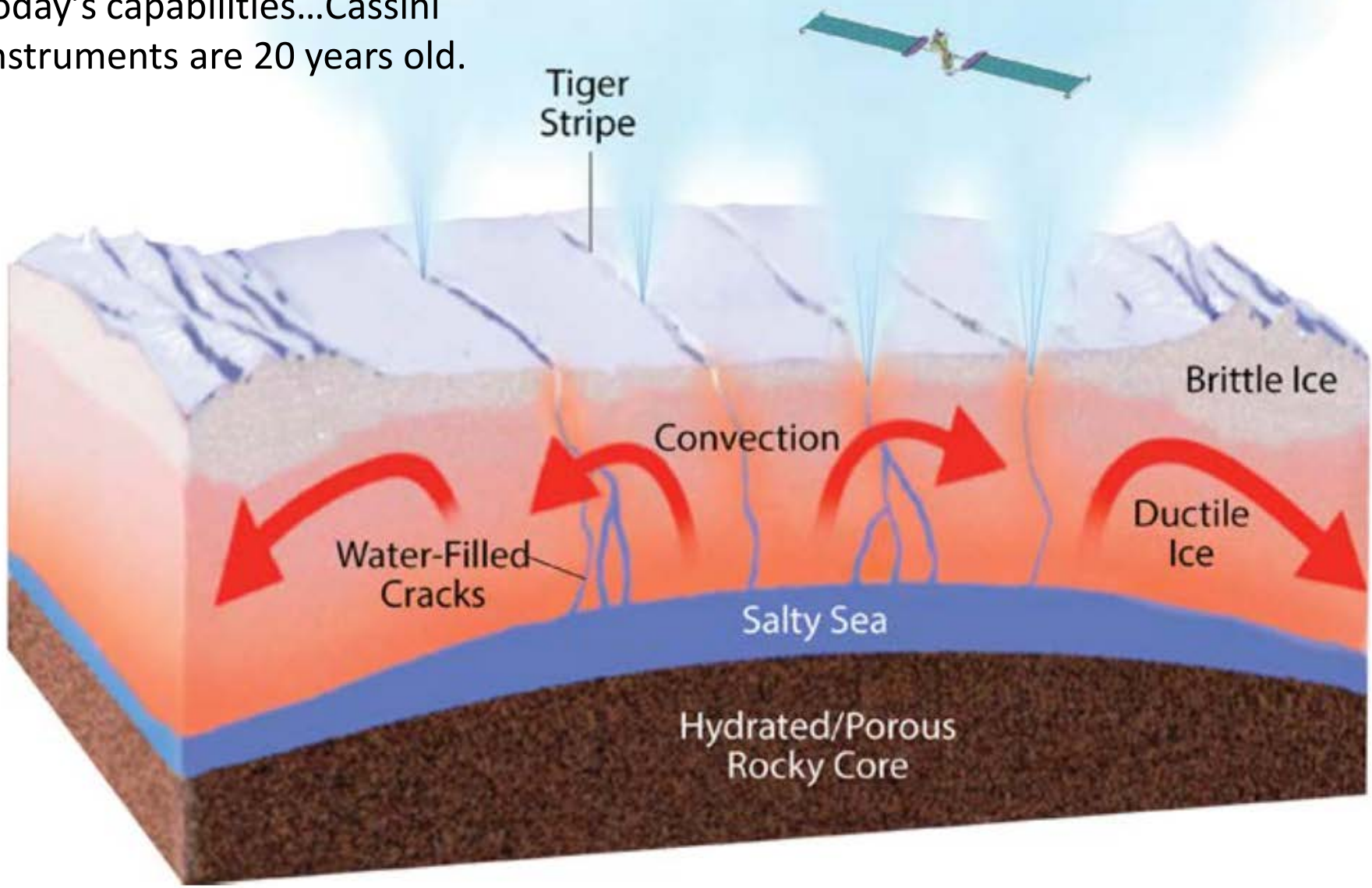
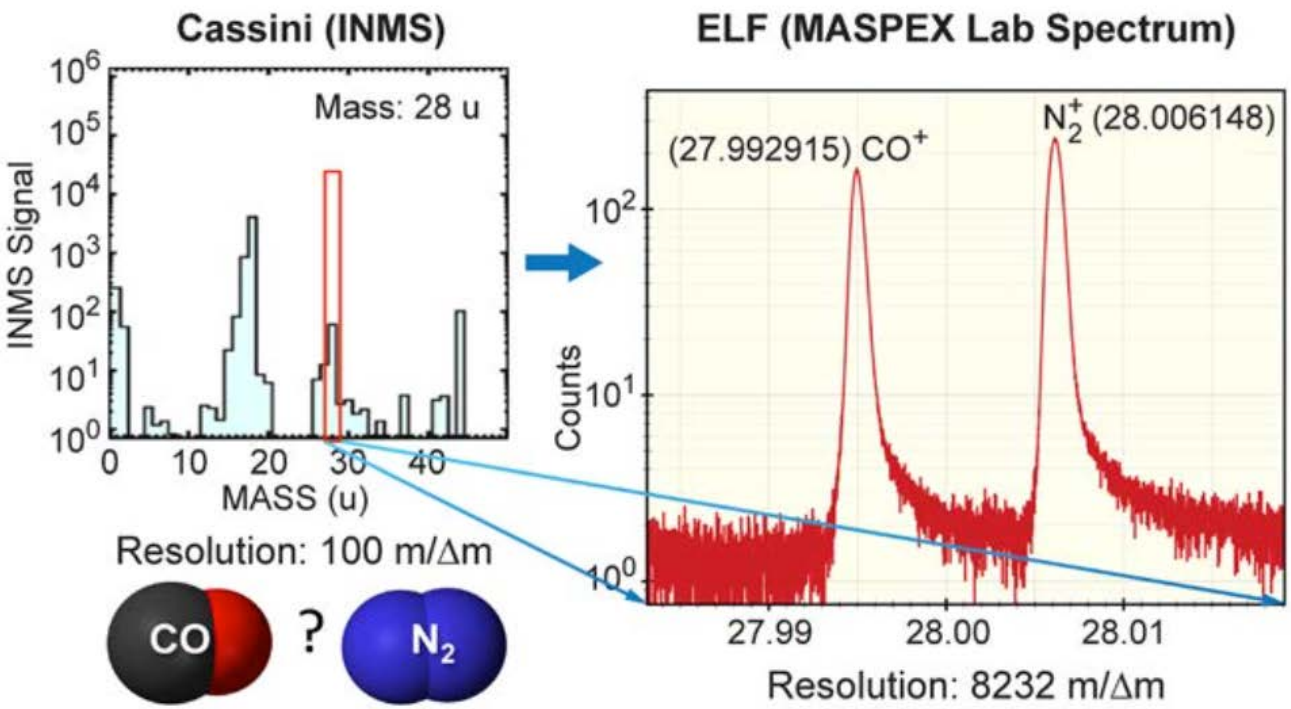
- Fly through the Enceladus plume just like Cassini did….

- But do it with instruments of today's capabilities…Cassini instruments are 20 years old.



1997 2020



ELF uses mass spectrometers of much higher resolution, range, sensitivity.

Three objectives addressing two science goals

What were the primordial sources of organic matter and where does organic synthesis continue today? (Planetary Habitats Question 4)

1. Determine if Enceladus' volatiles, including organics, have evolved over time.

Evolution

Beyond Earth, are there modern habitats elsewhere in the solar system with necessary conditions, organic matter, water, energy, and nutrients to sustain life, and do organisms live there now? (Planetary Habitats Question 6)

2. Determine if the ocean of Enceladus satisfies the basic requirements of habitability

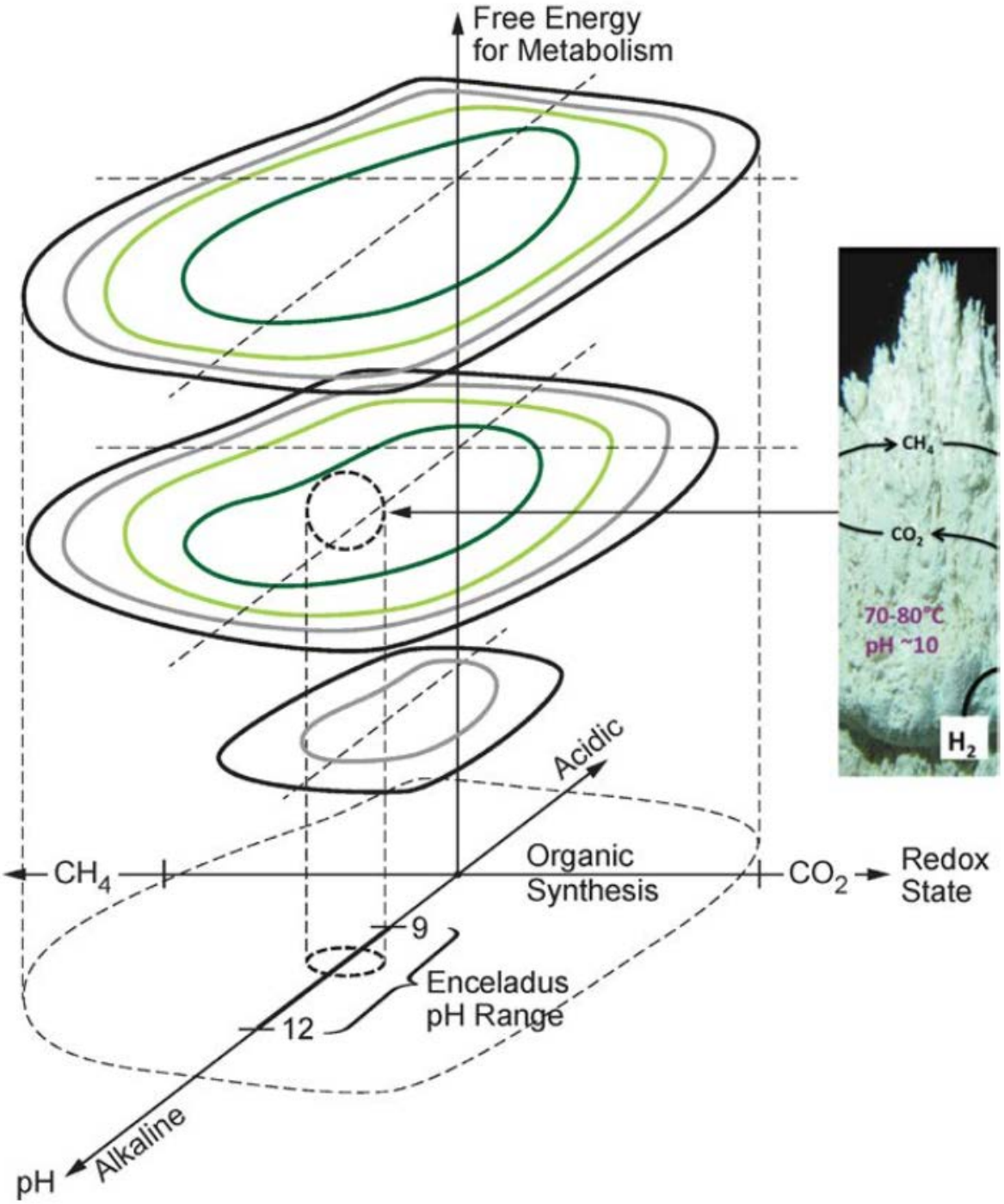
Habitability

3. Determine if the plume of Enceladus contains chemical signatures of biology.

Life

10 measurement objectives satisfied by two mass spectrometers, one optimized for gas, one for dust.

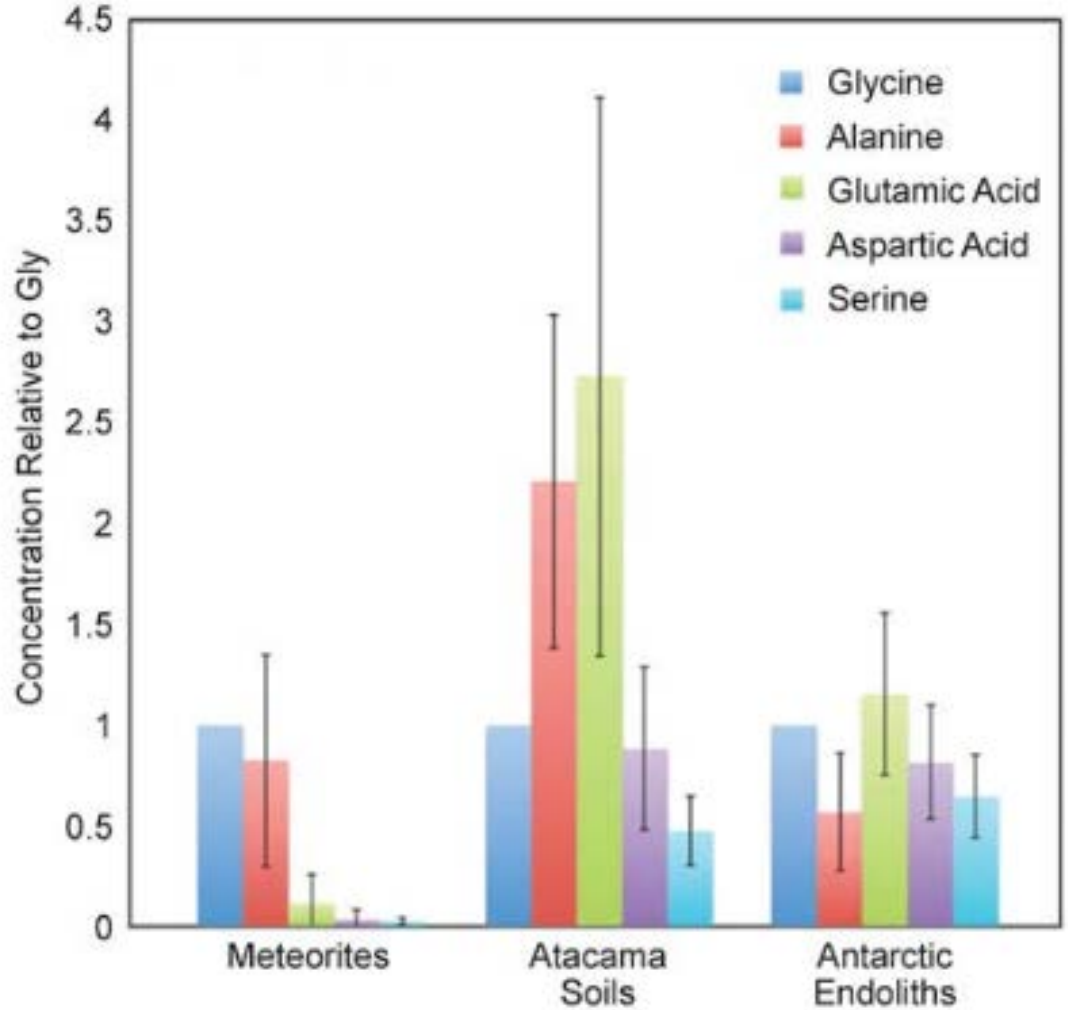
The mass spectrometers measure key chemical indicators of just how habitable Enceladus' ocean is: temperature, pH, oxidation state, and the amount of chemical energy available.



LEGO principle: life chooses a small number of building blocks out of the wide spectrum of available organic molecules.

Free energy corollary: Relative abundances of biomolecules are not determined by the thermodynamic gradients (free energies of formation) or kinetics of the system.

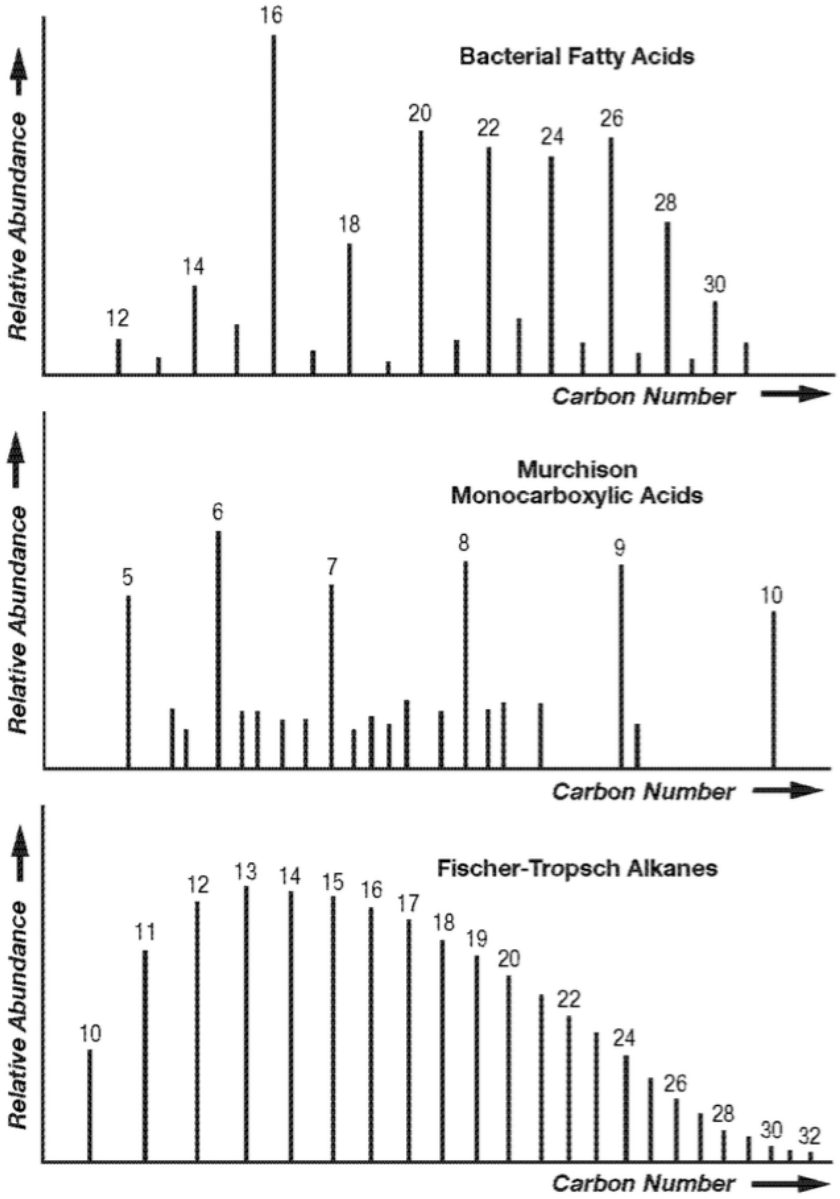
ELF's three tests for biological processes:



1. Amino acid pattern deviating from abiotic

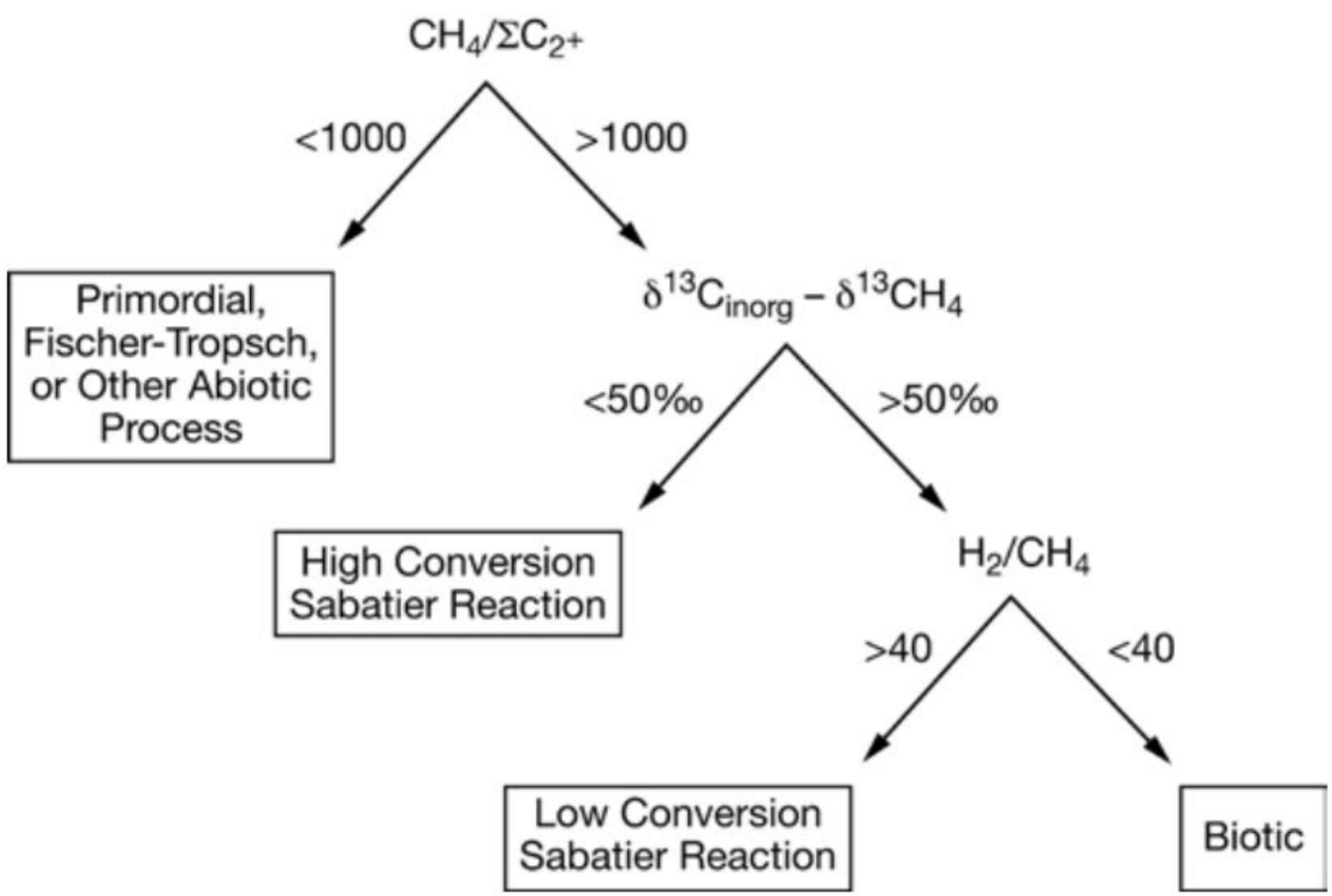
ELF's three tests for biological processes:

1. Amino acid pattern deviating from abiotic
2. Repeating subunits and clustering in membrane-building molecules

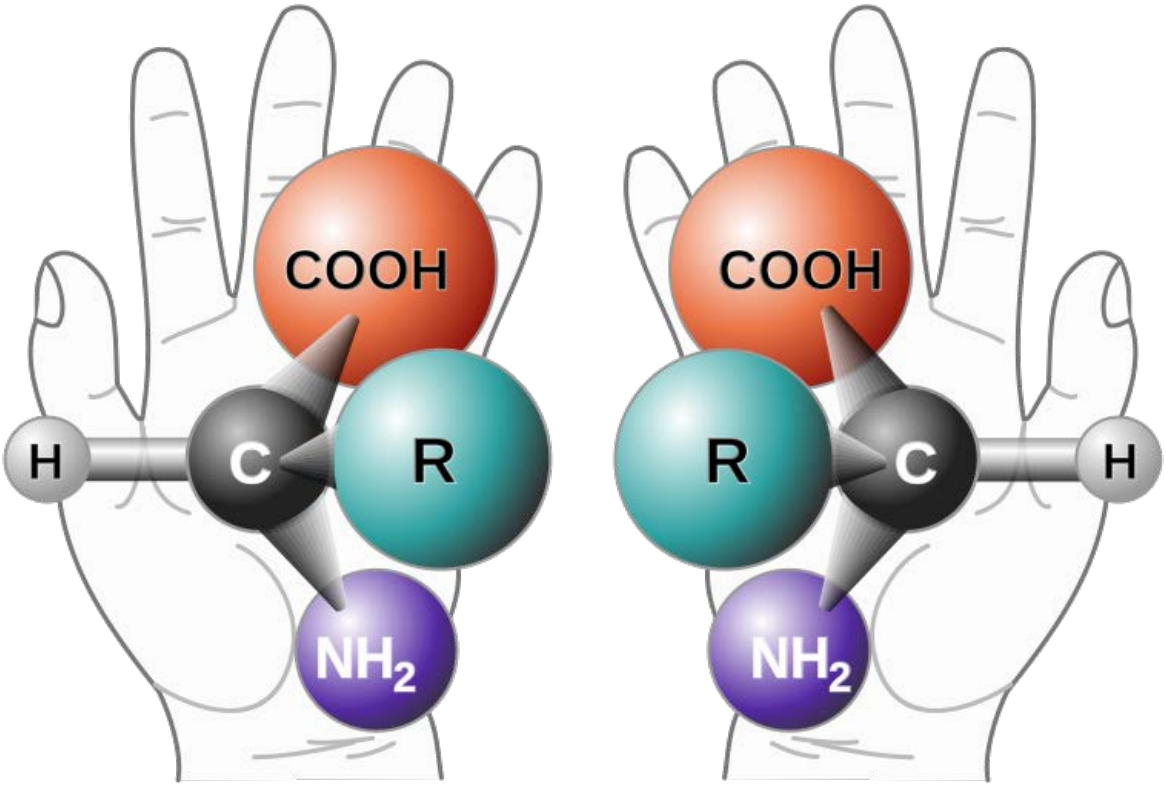


ELF's three tests for biological processes:

1. Amino acid pattern deviating from abiotic
2. Repeating subunits and clustering in membrane-building molecules
3. Combined isotopic and compositional trends



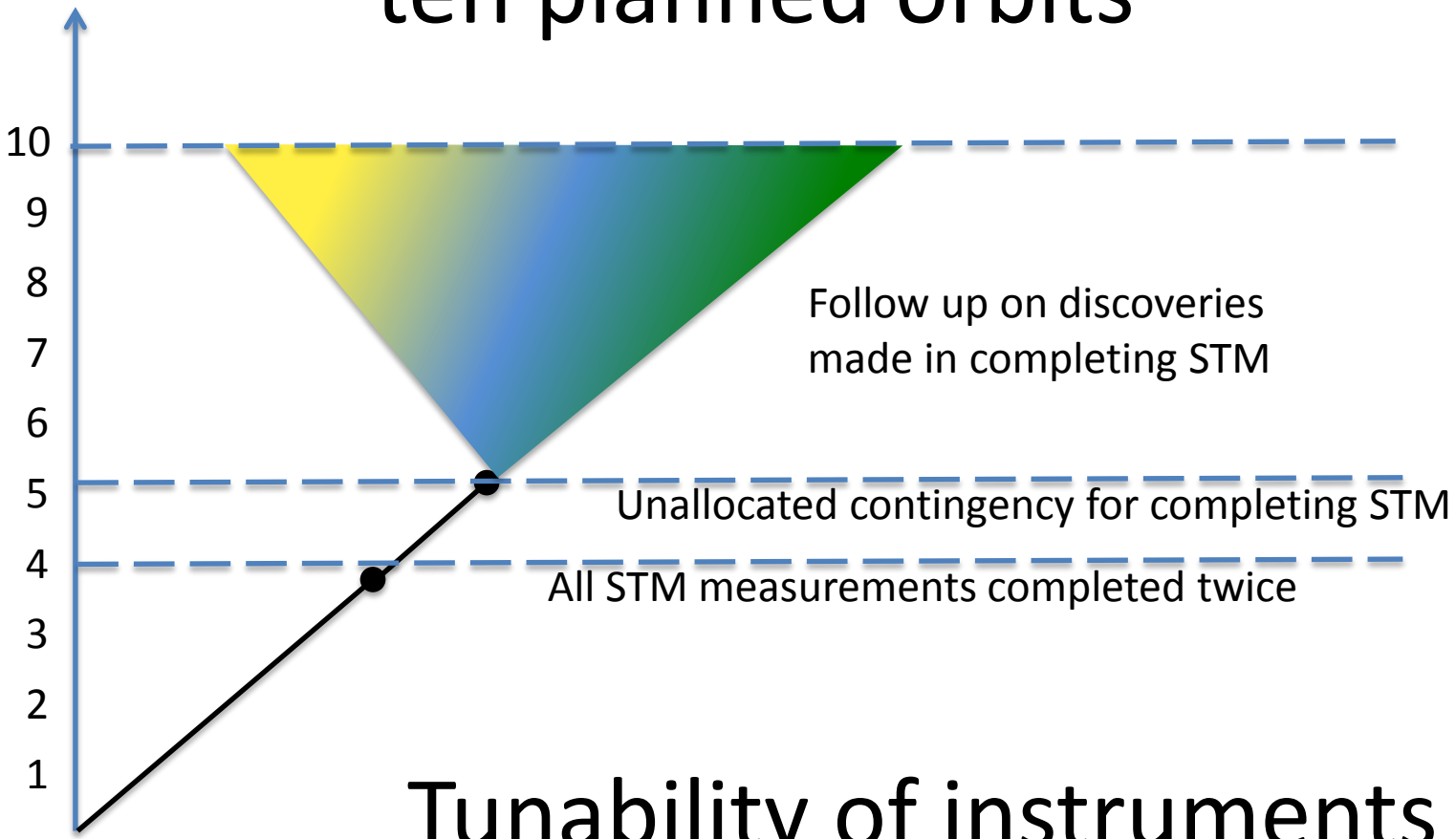
A fourth independent test, carried as a TDO, measures the entantiomeric ratios of chiral amino acids—are they overwhelmingly left- or right-handed, or a mixture?



This …. or that… or both?

Enceladus Organics Analyzer (EOA)--*microchip capillary electrophoresis:*
Provided by Dr. Richard Mathies at *UC Berkeley*

ELF completes its objectives in five of ten planned orbits



Tunability of instruments allows flexible follow-up






ELF

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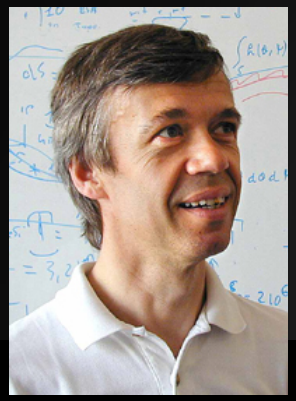

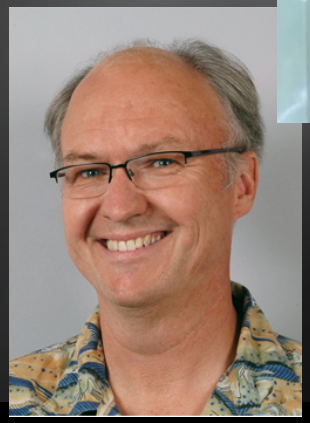


Enceladus Life Finder

10 flybys … 2 instruments … 1 profound question: Is there life beyond Earth?

Cassini discovered an icy plume erupting from a long-lived, salty ocean inside Saturn's moon Enceladus, and proved it contains organic molecules. ELF follows in Cassini's path, using two state-of-the-art instruments to measure the ocean's history, habitability and biotic state.

***Science Objectives** – questions our generation is now poised to answer*

Evolution of the organics: How have they changed over geologic time?
Habitability of the ocean: Does it have the right composition and chemical energy to host life?
Life on another world: Are there detectable life signs in the plume?

***Sophisticated and Mature Instruments** – taste the plume's telltale molecules*

MASPEX – gas mass spectrometer, 250x better resolution and 100,000x better sensitivity than Cassini
ENIJA – ice-grain mass spectrometer, >30x better resolution and 100x better sensitivity than Cassini

***Straightforward Mission Design** – already demonstrated by Cassini*

Ten 62-day orbits, ten plume fly-throughs, repetitive operations, 100% science downlink margin
Long-life, solar-powered JPL flight system with NASA Advanced Solar Arrays

If Enceladus has life, we will find it.