

LIFE BASED ON
METHANE ON SATURN'S
MOON TITAN ?

Eduardo Janot-Pacheco
University of São Paulo, Brazil

Claudia Lage
Rio de Janeiro Federal University, Brazil

Talk scheme:

Introduction: what do we know about TITAN?

Titan after CASSINI and HUYGHENS

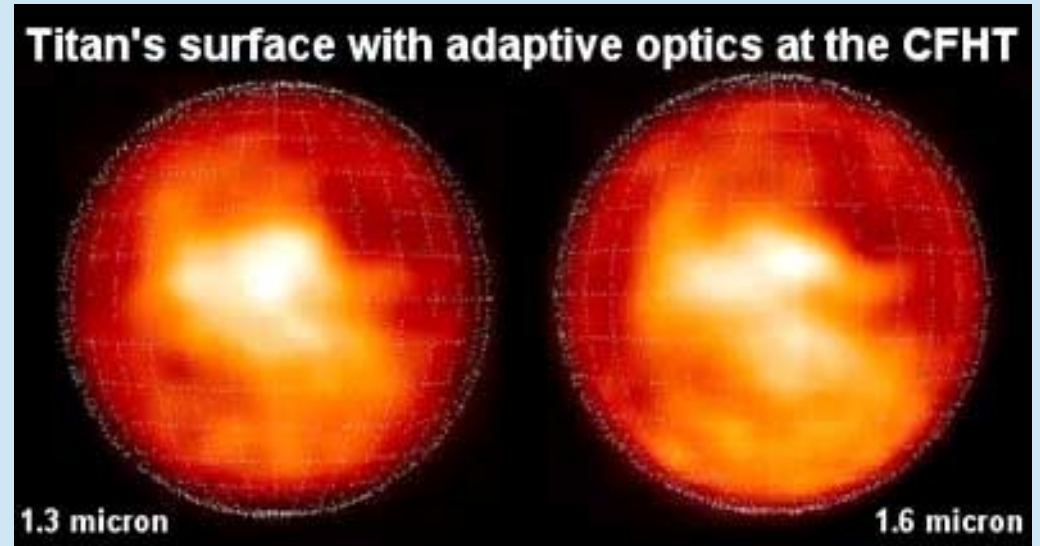
Methane-based metabolism?

Future perspectives

What do we know about Titan?

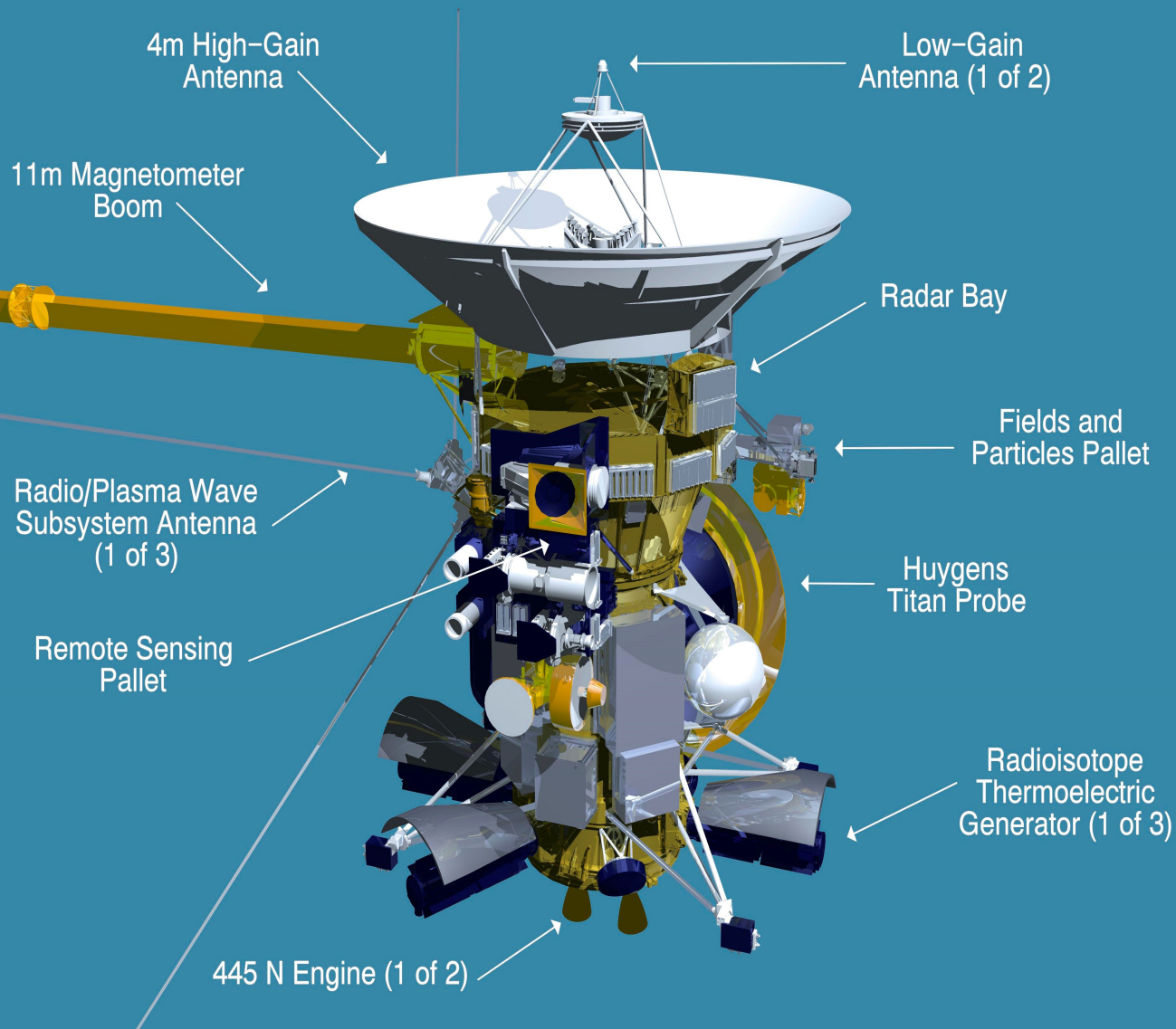


Christiaan Huygens
discovered Titan in
1655



Typical ground-based pictures
of Titan in the pre-CASSINI era.

CASSINI SPACECRAFT

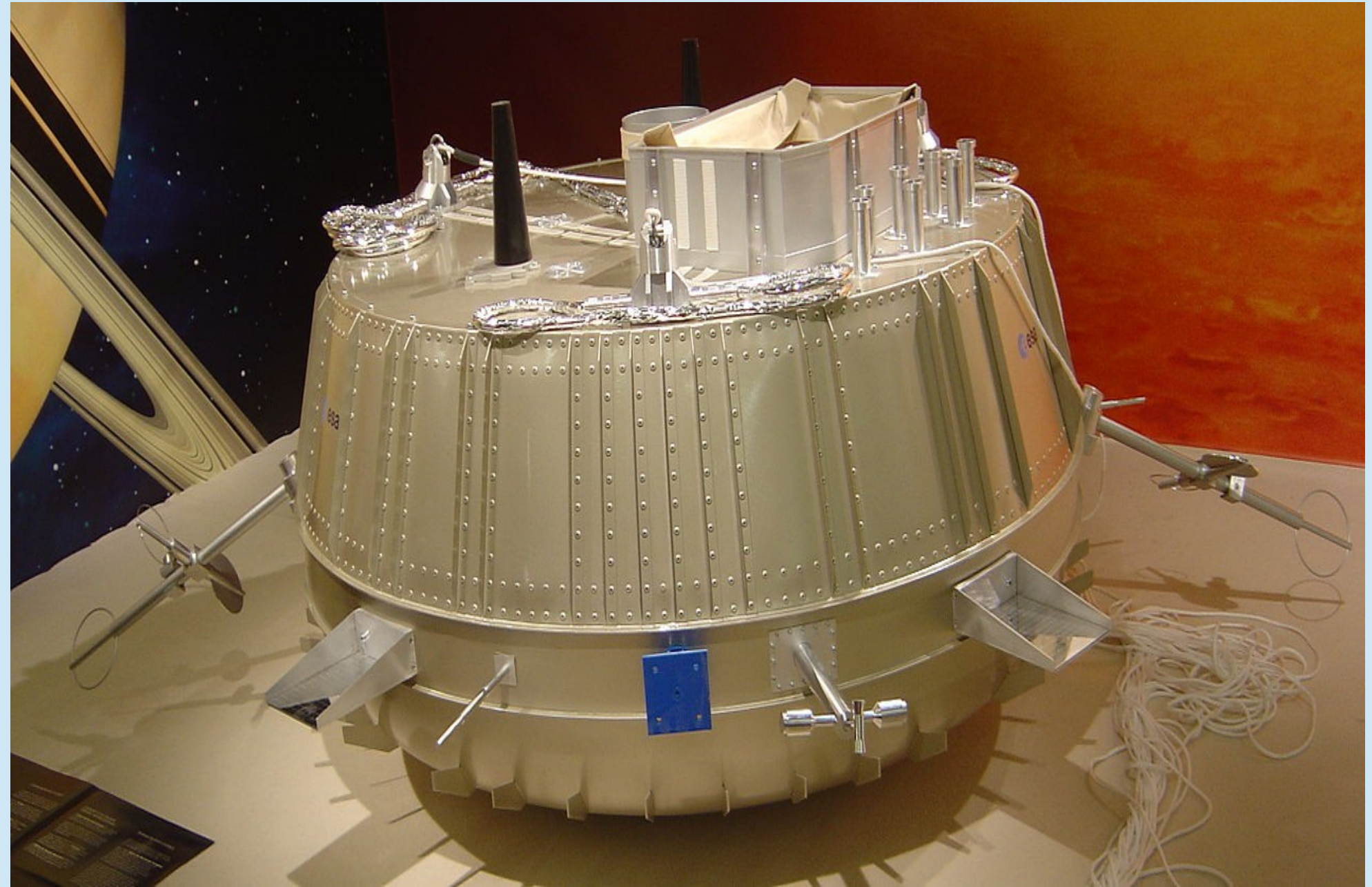


Titan as seen by CASSINI



CASSINI spacecraft

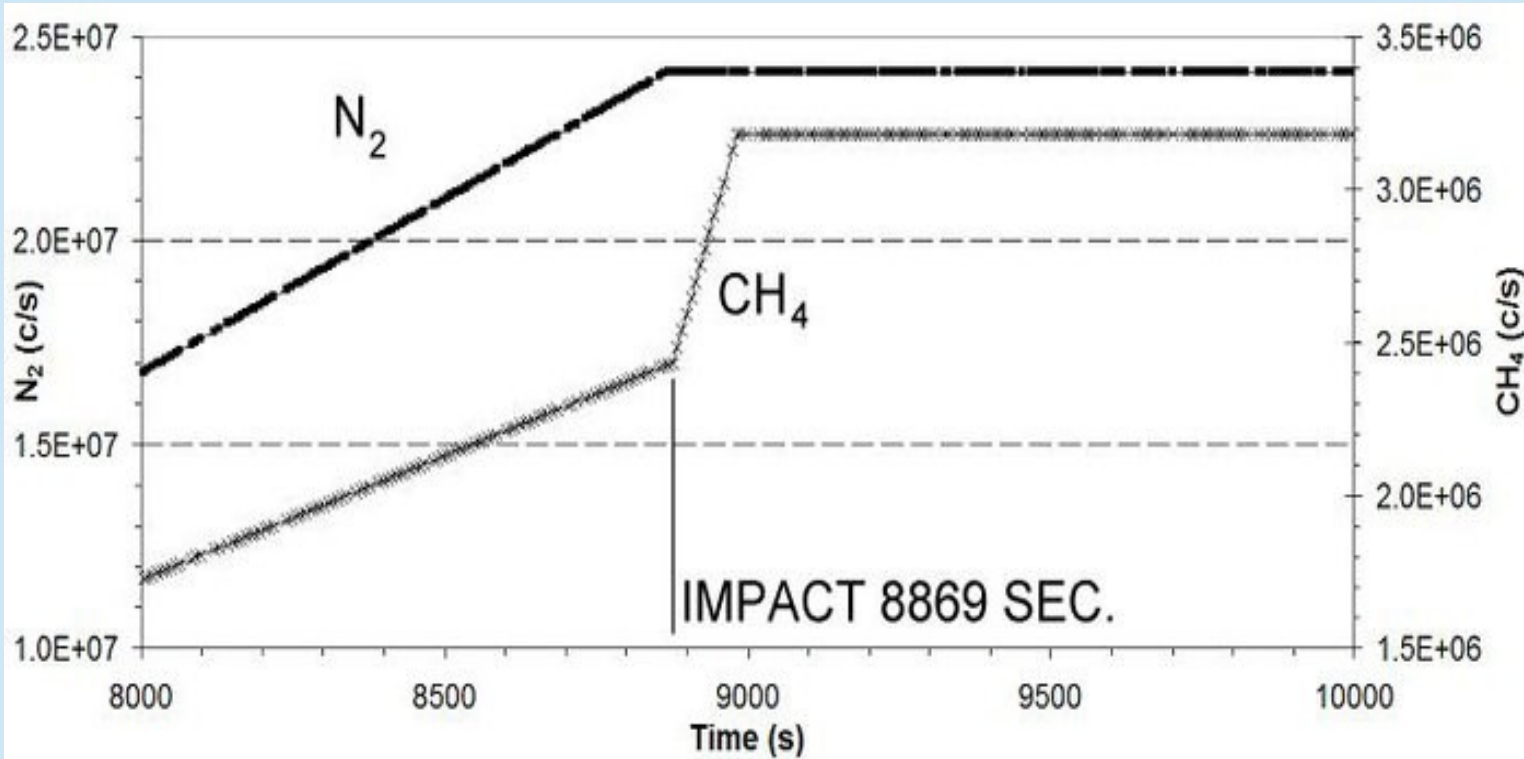
Huyghen's probe (~1.30 m across)



2005.01.14

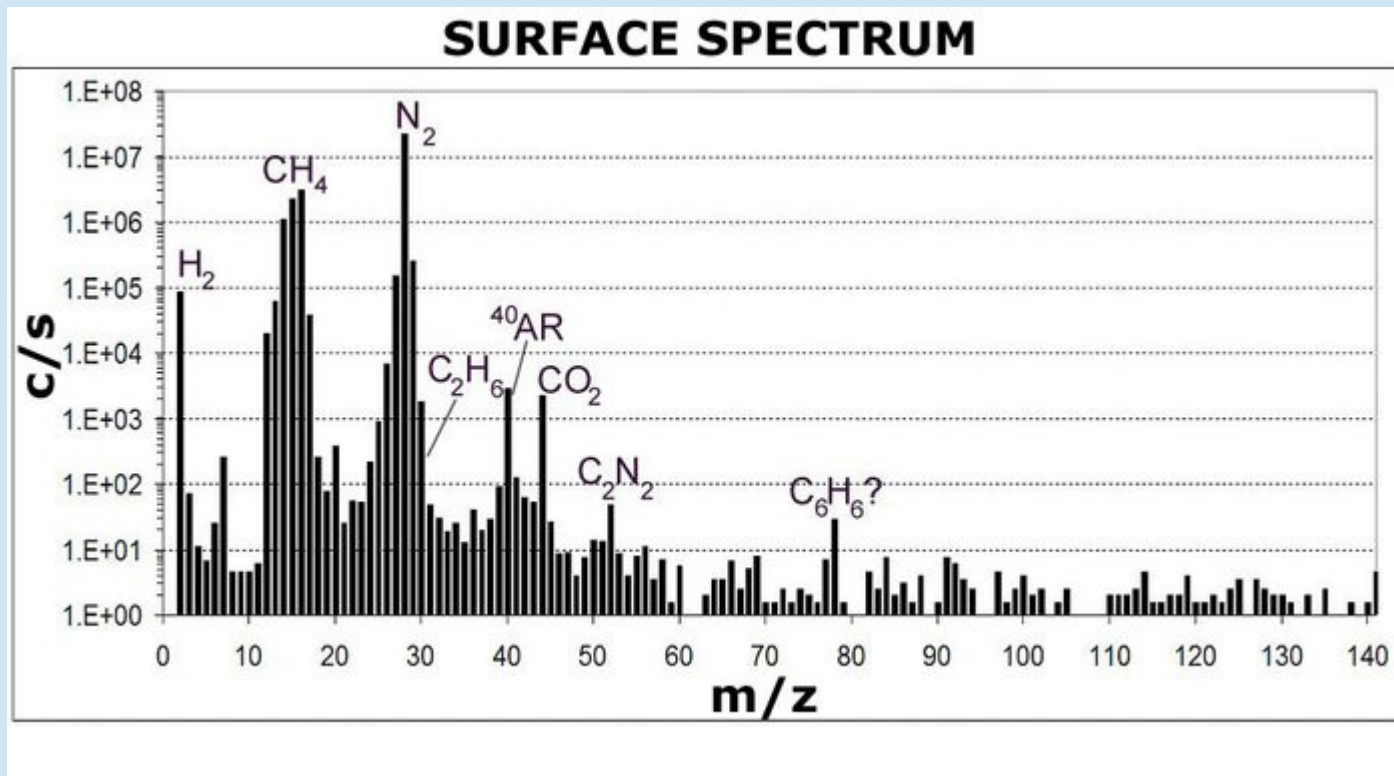
EXOATMO Nice, Oct 2015

HUYGHENS result # 1



GCMS → surface wet with CH_4 that evaporated after being heated by the warmer probe.

HUYGHENS result # 2



GCMS → Surface rich in organic compounds (ethane, cyanogen...) ≡ complex chemistry

¹²C/¹³C measured in CH₄ → continuous/periodic replenishment of CH₄
→ no evidences of active bio systems

Aerial View of Titan Around the Huygens Landing Site from 10 km Altitude

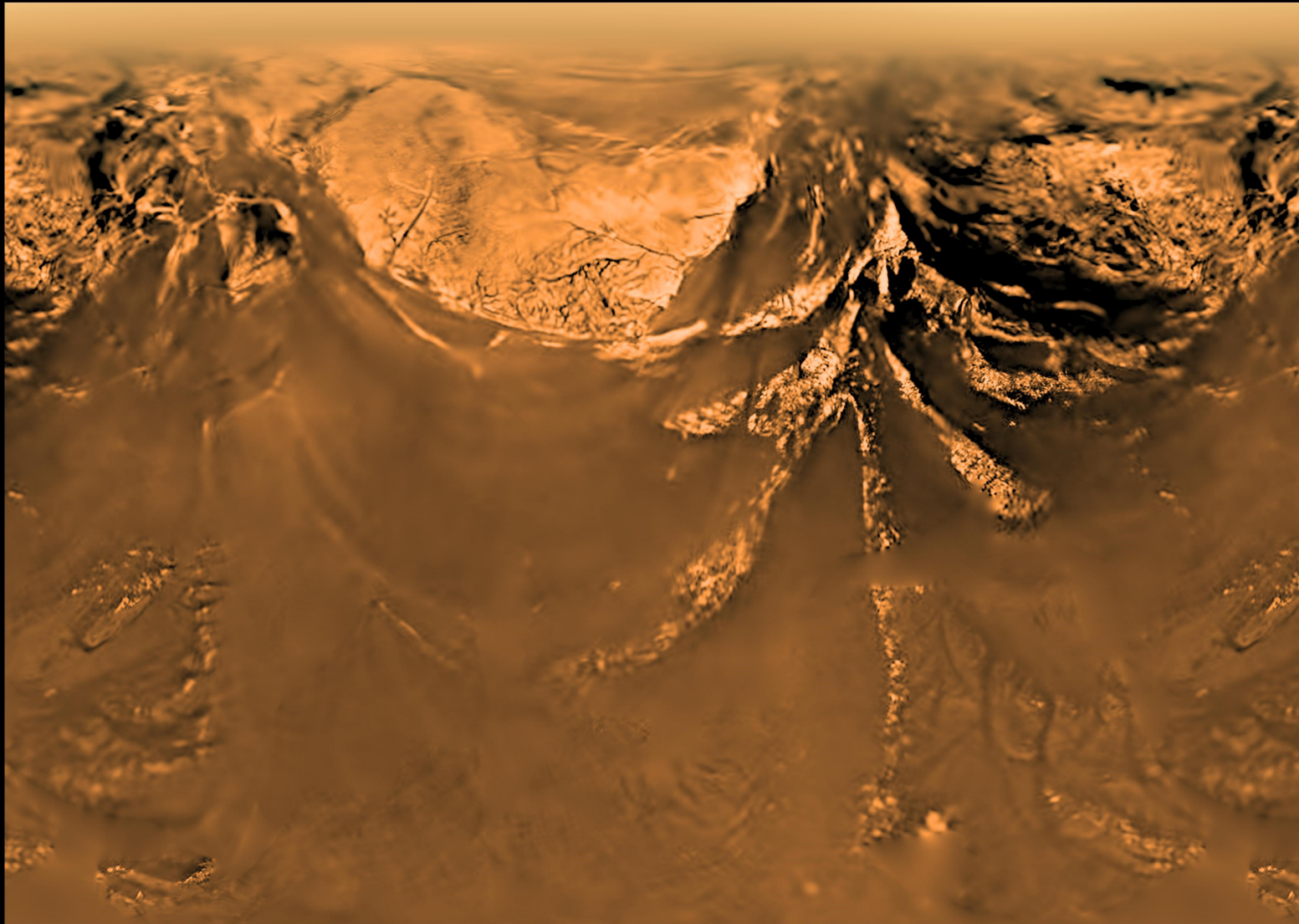
South

West

North

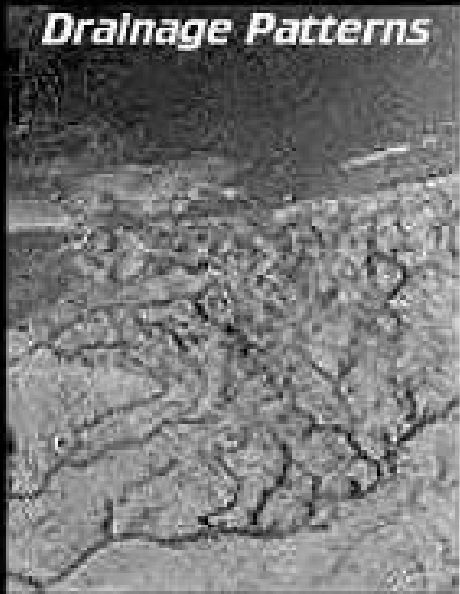
East

South

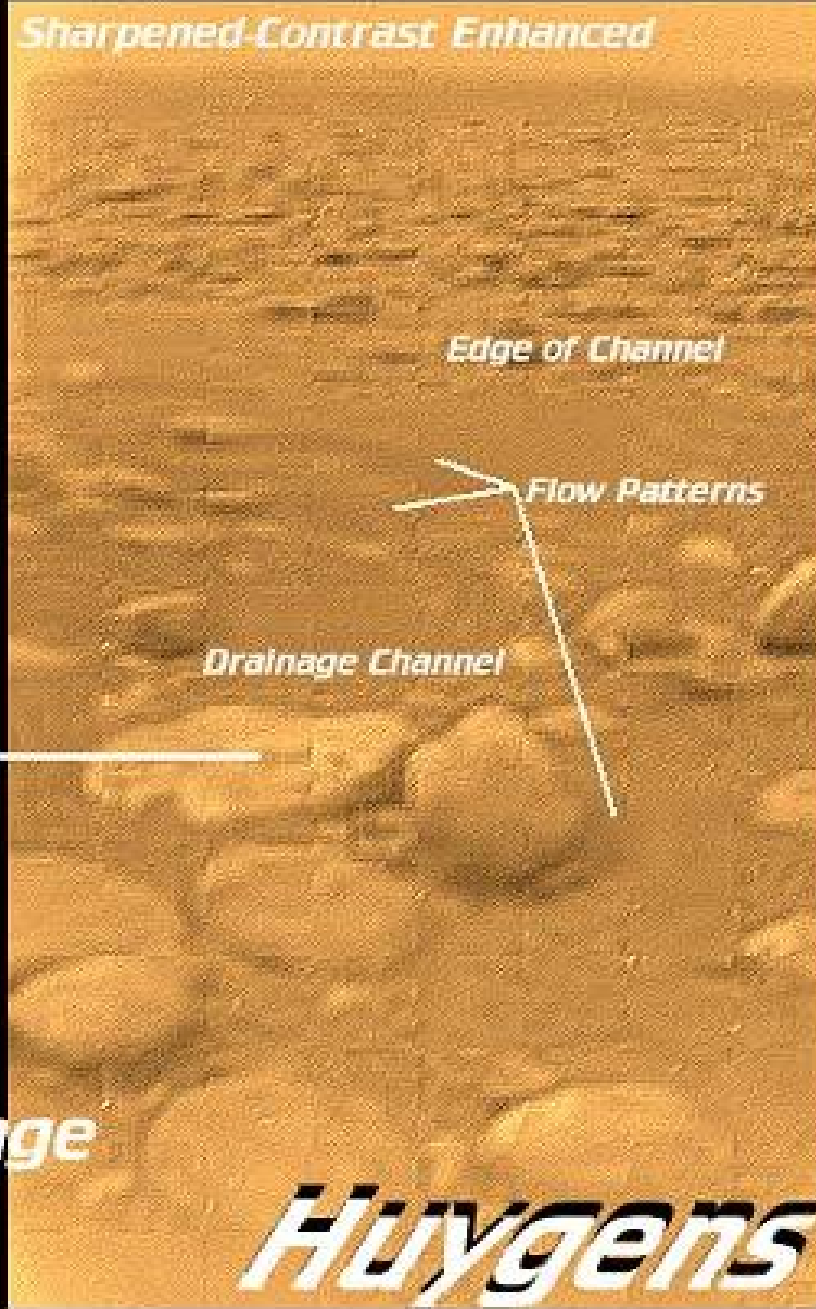


Huyghen's Descent Imager/Spectral Radiometer

EXOATMO Nice, Oct 2015



Drainage Patterns



Sharpened-Contrast Enhanced

Edge of Channel

Flow Patterns

Drainage Channel

15 cm (6 inches)

First Color Image

Huygens on Titan

Released by ESA

(methane haze)

What do we knew/know about Titan ?

Saturn's largest moon and 2nd biggest one in the solar System (> than Mercury)

Mass $\sim 0.024 M_{\text{earth}}$ Radius $\sim 0.4 R_{\text{Earth}}$

Mean Density $\sim 1.9 \text{ g/cm}^3$ (Earth's $\sim 5.5 \text{ g/cm}^3$)

Orbital period: 16 days inclination $0.3^\circ \rightarrow$ Saturn's equator

Eccentricity: 0.03 Tidally locked

The only moon in the solar system with a dense atmosphere

$P_{\text{Titan}} \sim 1.45 P_{\text{Earth}}$

Titan's ID after **CASSINI** and **Huyghens**

113 close flybys (as for 24 Sep 2015):

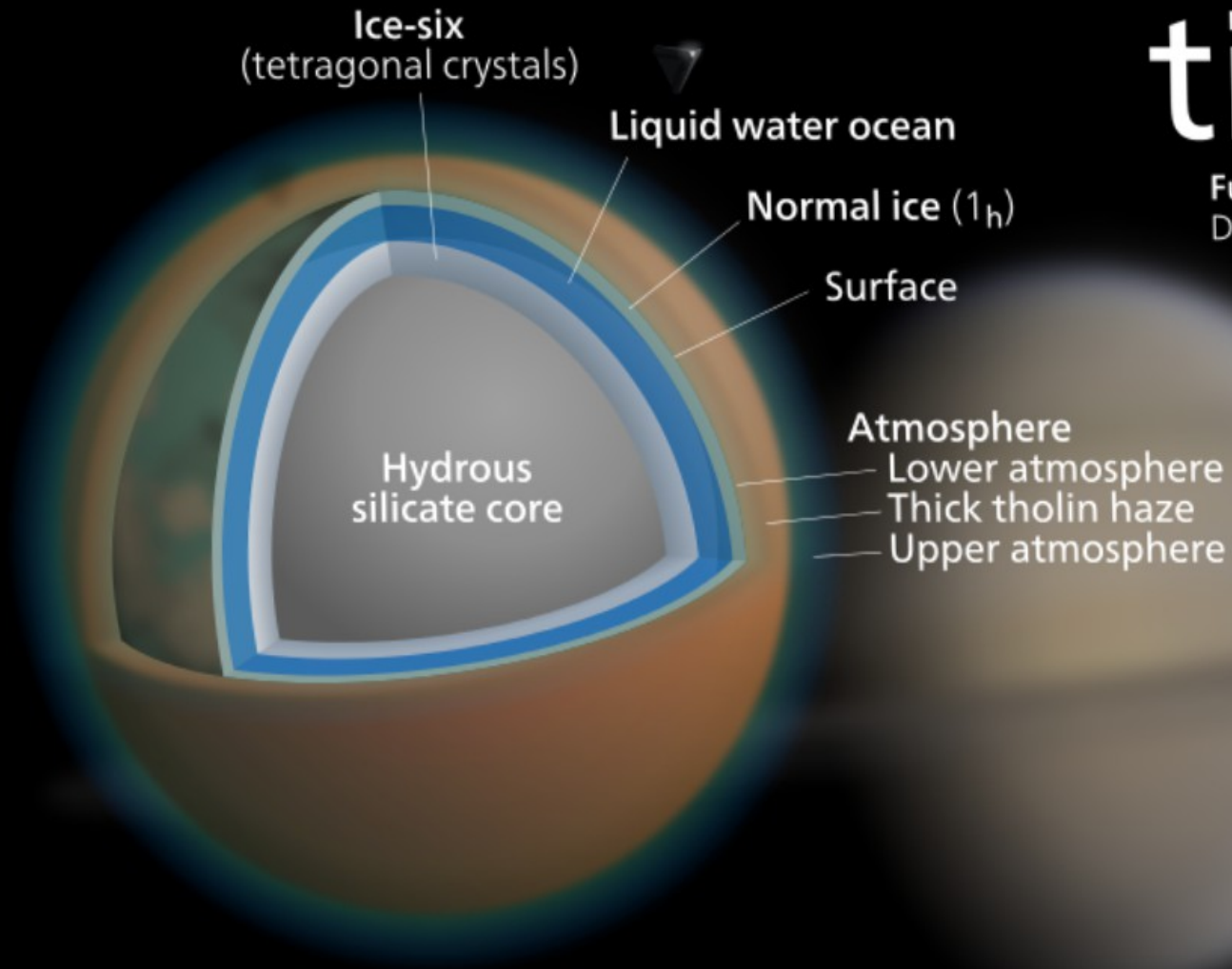
Atmosphere: 98% N_2 2% CH_4 + hydrocarbons (traces)

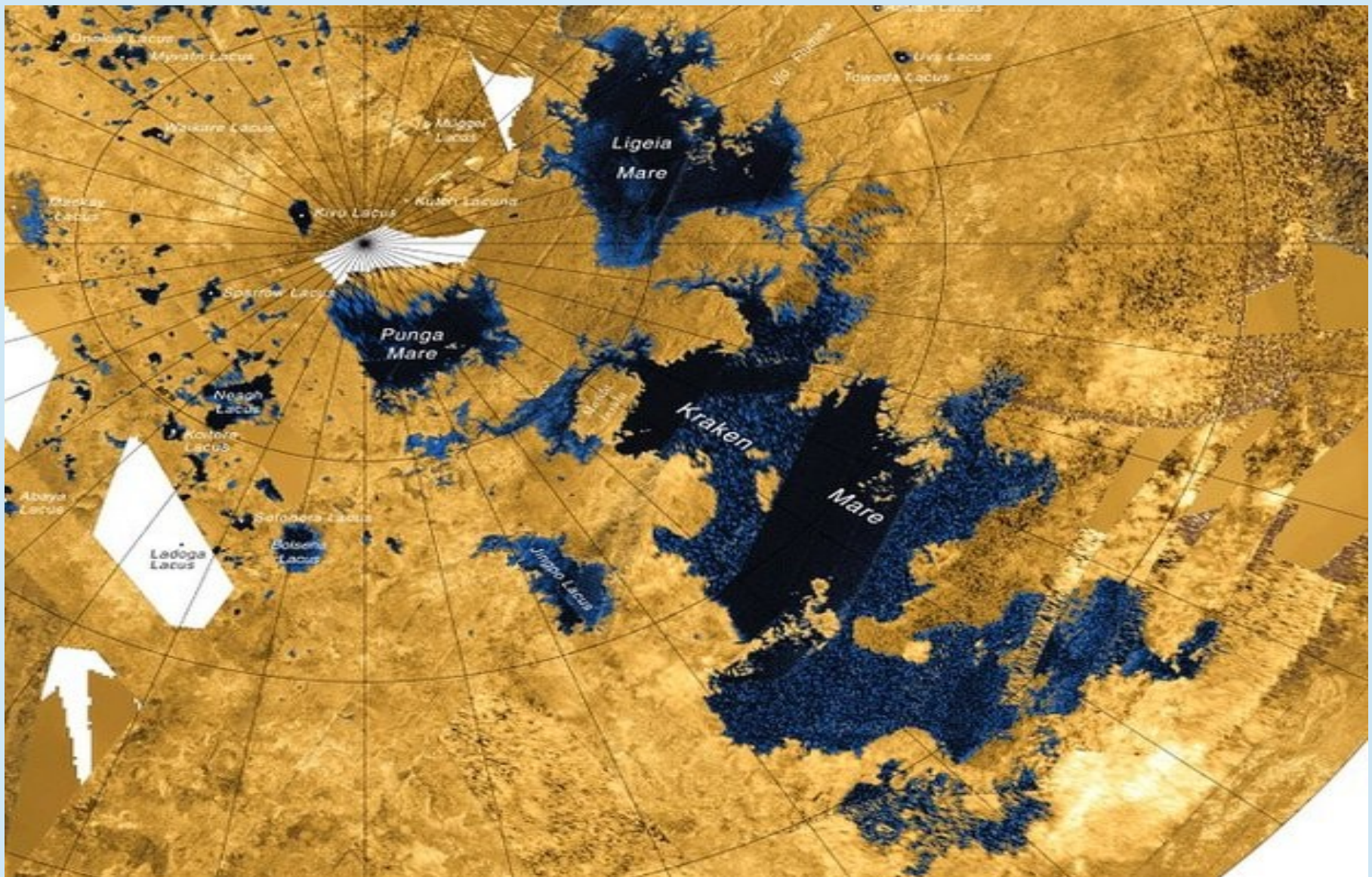
- ◇ surface temperature $-180\text{ }^\circ\text{C}$ (liquid methane)
- ◇ surface humidity 50% 5% methane abundance
- ◇ lakes of ethane (76%), methane (10%) and propane (8%)
- ◇ cryovolcanoes expelling H_2O ice (?)
- ◇ subsurface mixtures of liquid ammonia & water ?
- ◇ subsurface ocean

titan

Fully differentiated dense-ocean model
Drawn to scale

(Copyright Stephen Liu)





Permanent liquid hydrocarbon lakes (near north pole)



Ligeia mare (NASA - GSFC)

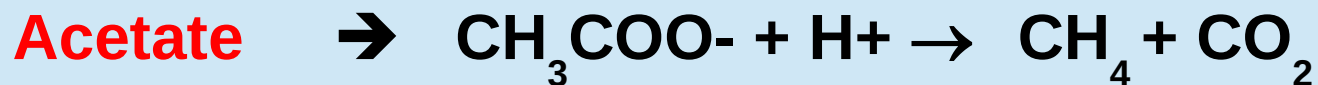
EXOATMO Nice, Oct 2015

Weird life on the surface of Titan ?

Methanogenic archea could live on **Titan** using a number of metabolic pathways, where terrestrial O_2 is changed by H_2

Such organisms would inhale H_2 in place of O_2 , metabolize it with **acetylene** instead of **glucose**, and exhale **methane** instead of **carbon dioxide**

(e. g. Abbas & Schulze-Makuch 2002; McKay & Smith 2005)



\rightarrow **Methanogenic archea on Earth** can survive on the energy levels released by these reactions

BUT:

If microorganisms are consuming **Hydrogen** and **Acetylene** on **Titan**'s surface, the abundances of them should be measurably **lower** than otherwise expected (McKay & Smith 2005)

Indeed, **Strobel (2010)** found a greater abundance of **H₂** in the upper atmospheric layers of Titan compared to the lower layers and

Clark et al. (2010) fail to find **Acetylene** on the surface of Titan from CASSINI's VIMS data.

Other explanations are possible → →

→ → Must wait for more flybys

February 2015:

Stevenson et al., Sci Adv 2015, 1: →

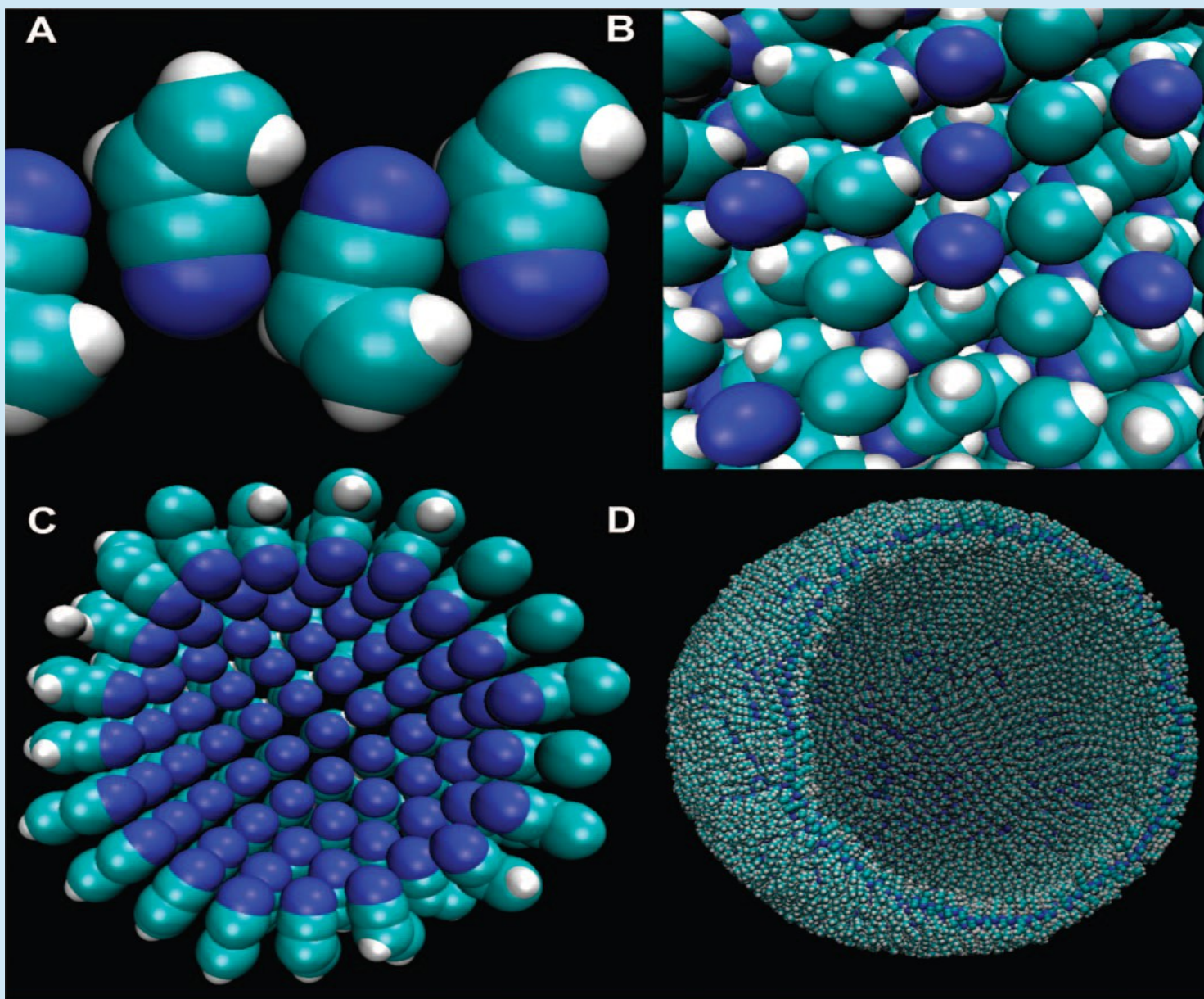
As liquid bilayer membrane NOT possible without liquid water.

ALTERNATIVE: Molecular simulations →

→ New type of membrane, composed of small organic nitrogen compounds, capable of forming and functioning in liquid methane at cryogenic temperatures.

The "azotosome" has properties similar to lipidic membranes.

It can be formed from compounds observed in Titan's atmosphere.



Acrylonitrile azotosomes and final vesicle

(CH_2CHCN)

EXOATMO Nice, Oct 2015

A vibrant sunset or sunrise over a body of water. The sun is low on the horizon, creating a bright orange and yellow glow that reflects on the water. The sky is a mix of deep blue, purple, and green. A large, bright moon is visible in the upper right corner of the sky. The overall scene is peaceful and scenic.

THANK YOU!