A person stands on a beach at night, looking out at the ocean. In the dark sky above, a large, glowing, translucent sphere with a bright, textured core is visible. The sphere has a blue and white glow. The background is a dark, starry sky with some nebulae and a bright star. The overall scene is dark and atmospheric, with a blue and white color palette.

# **Hunting for Life Beyond Earth**

**Seth Shostak  
SETI Institute**

A deep-field astronomical image showing a vast field of galaxies and stars against a black background. The image is filled with numerous galaxies of various shapes and sizes, including spiral, elliptical, and irregular forms. Some galaxies are bright and clear, while others are faint and distant. The stars appear as small, bright points of light, some with diffraction spikes. The overall scene conveys the immense scale and diversity of the universe.

Why do we think we have cosmic company?

There are  $10^{22}$  stars visible to our telescopes.



One trillion planets

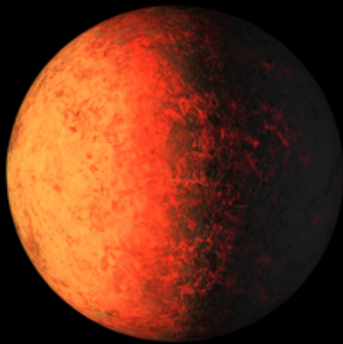
A large, glowing orange-red star dominates the left side of the frame. A small, dark, Earth-like planet is positioned in front of the star, appearing as a tiny sphere. To the right, the Kepler Space Telescope is shown in detail, with its large circular aperture and various instruments. The background is a deep blue space filled with numerous small, distant stars.

At least 100 million Earths in the Milky Way ... ?

Kepler Space Telescope

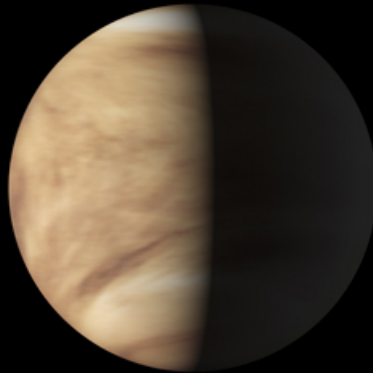
Or ... 10,000,000,000,000,000,000 Earths in  
the visible universe

Kepler-20e



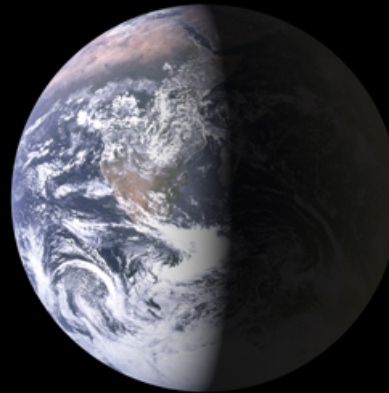
1400 F

Venus



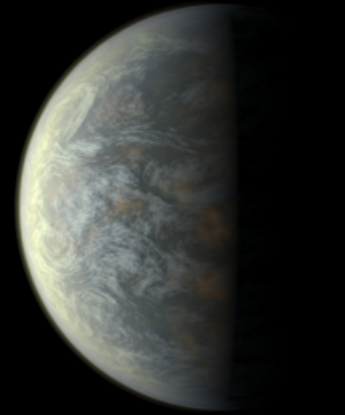
860 F

Earth



59 F

Kepler-20f

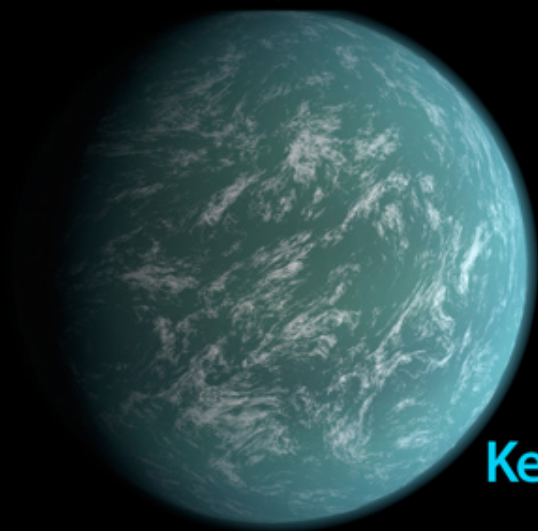


800 F

# Kepler-22 System

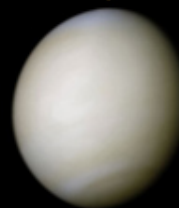
## Solar System

Habitable Zone



Kepler-22b

Mercury



Venus

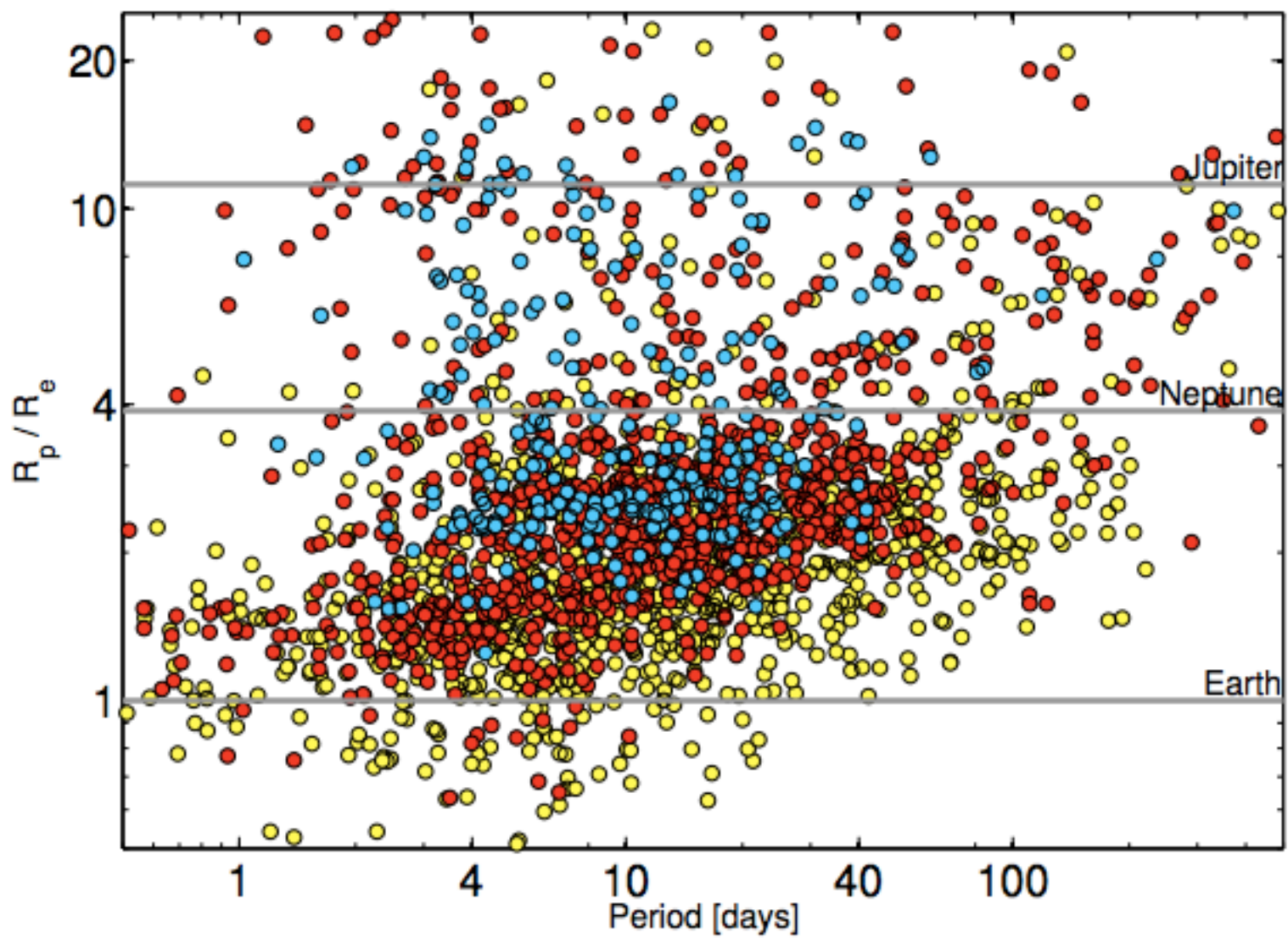


Earth



Mars

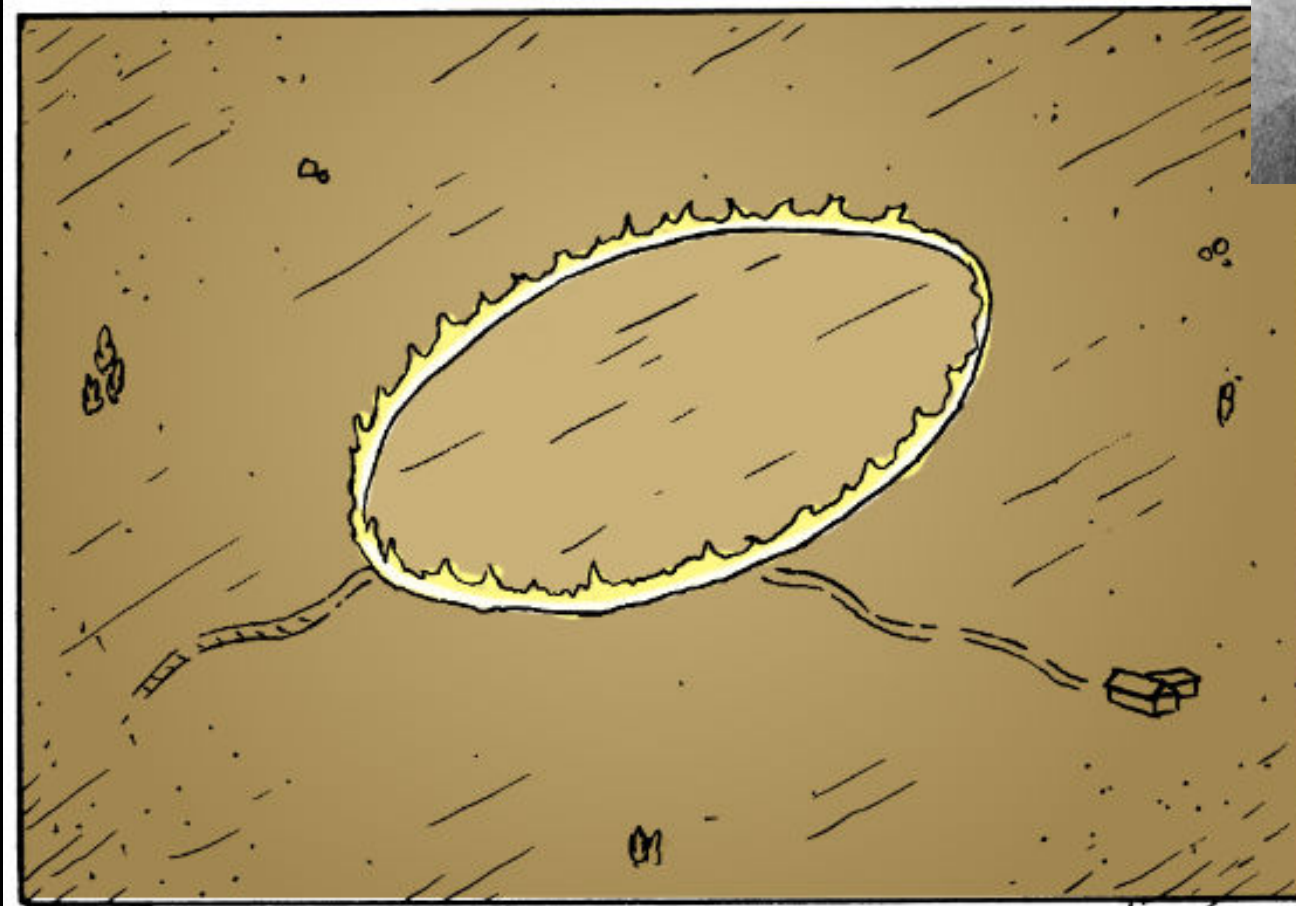
Planets and orbits to scale





So if alien life is out there, how do we find it?

Joseph von Littrow (Austrian)  
1781-1840



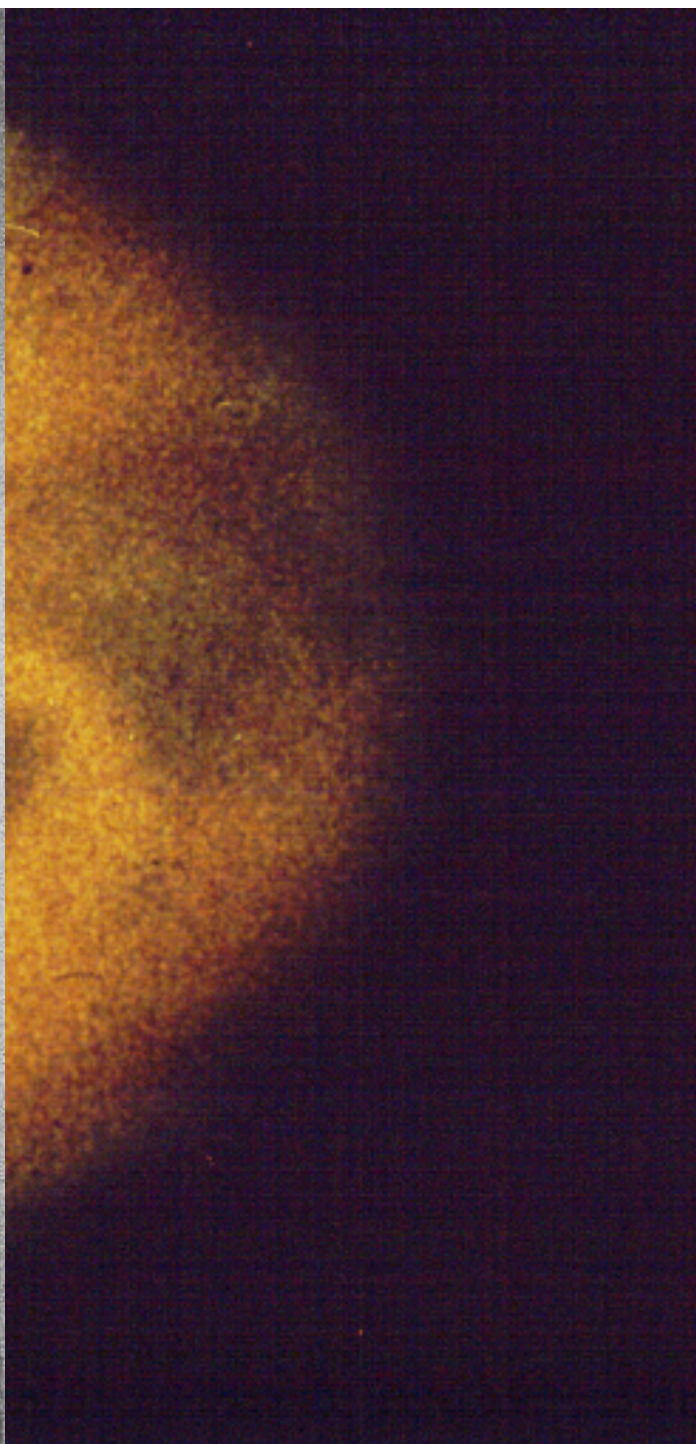
# The Great Moon Hoax of 1835

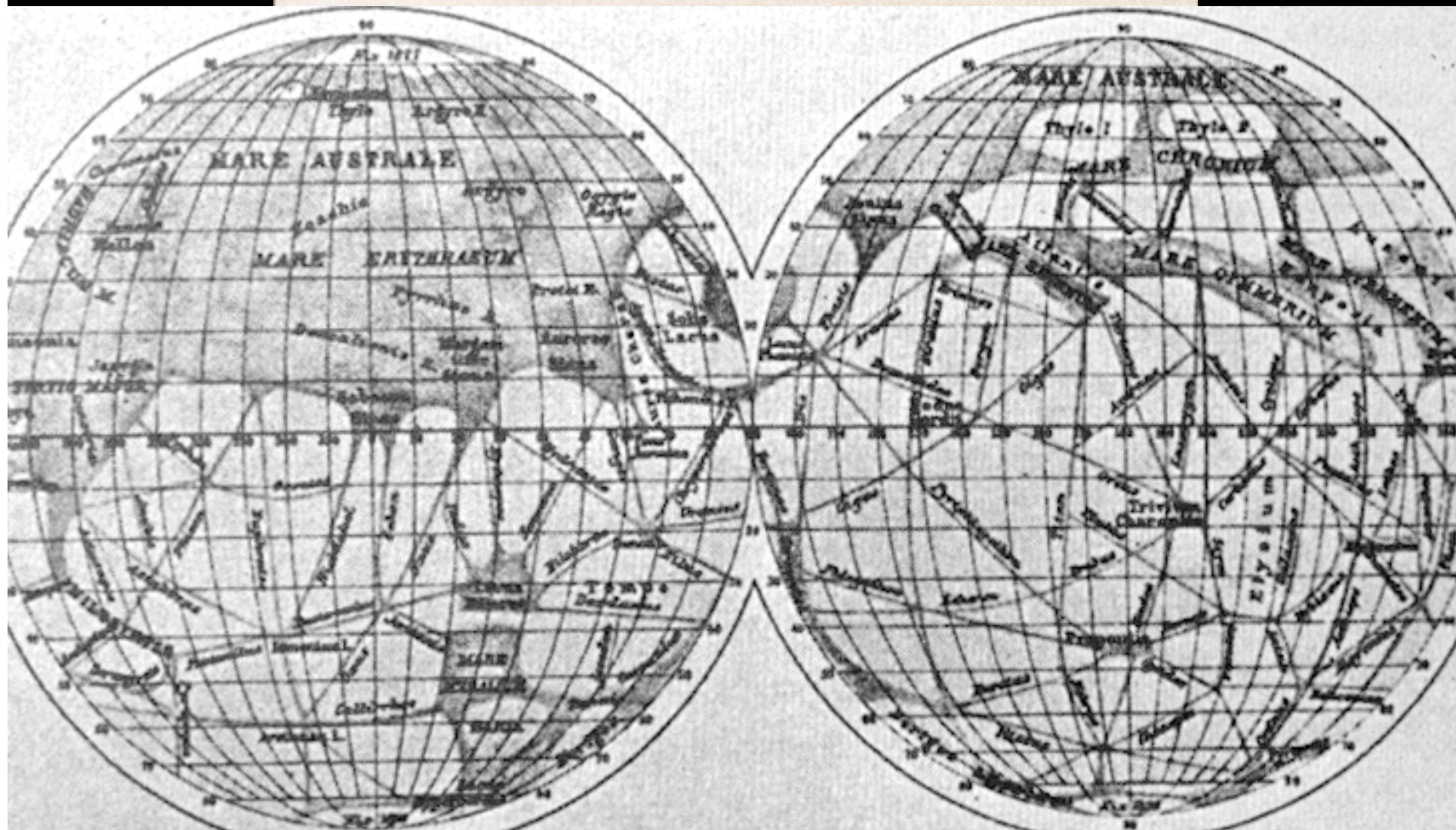
*N.Y. Sun*



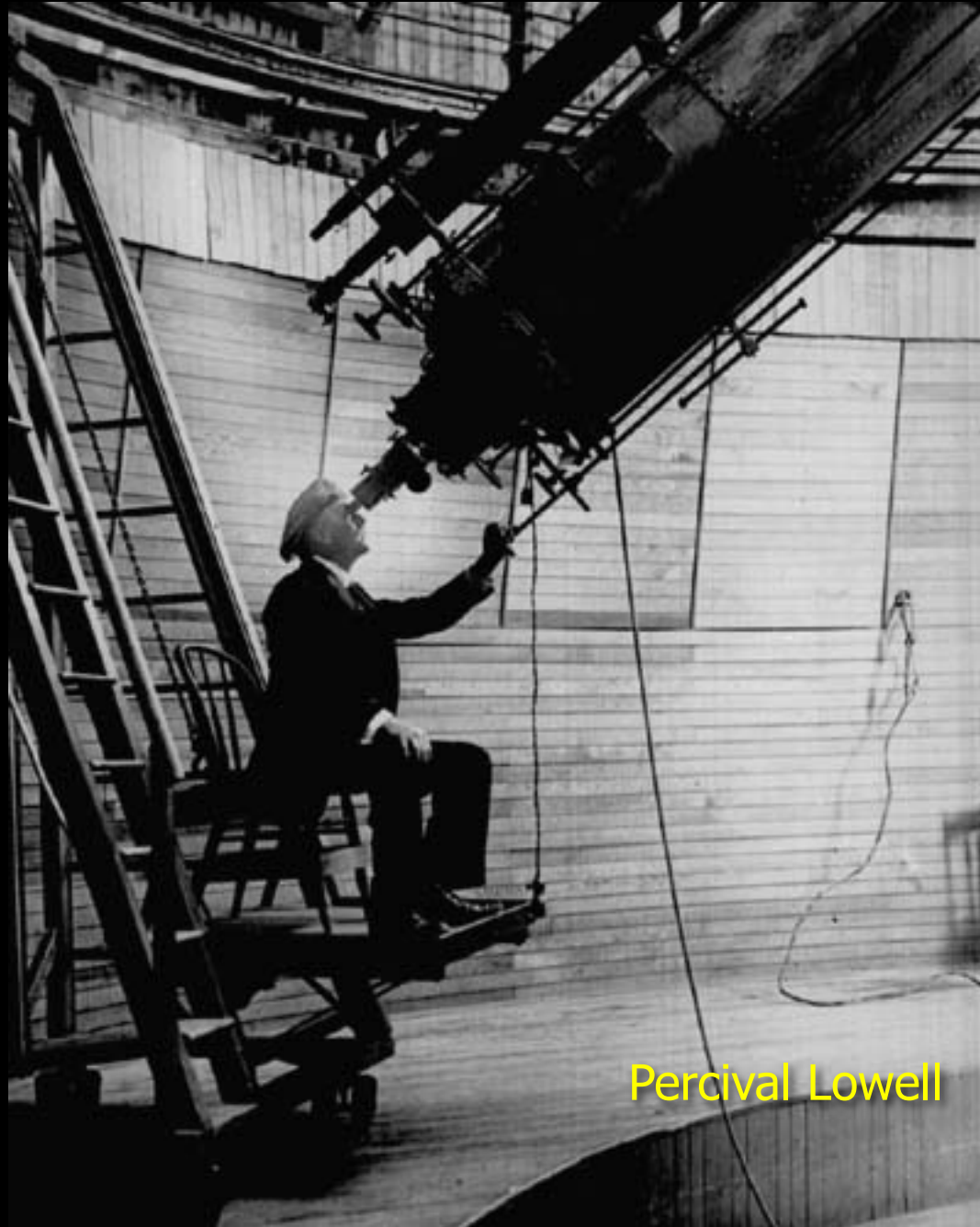


Bill Herschel



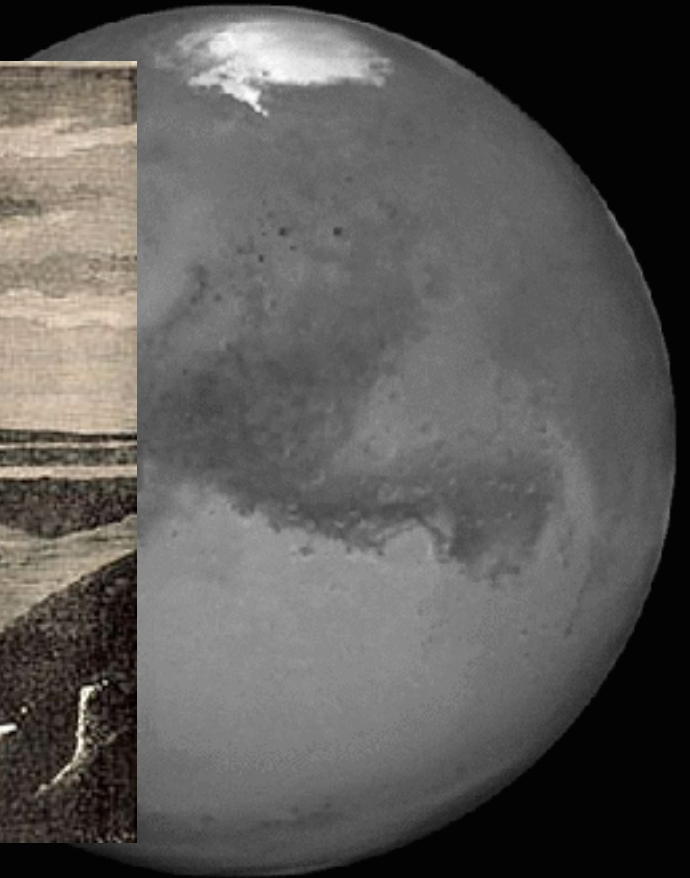
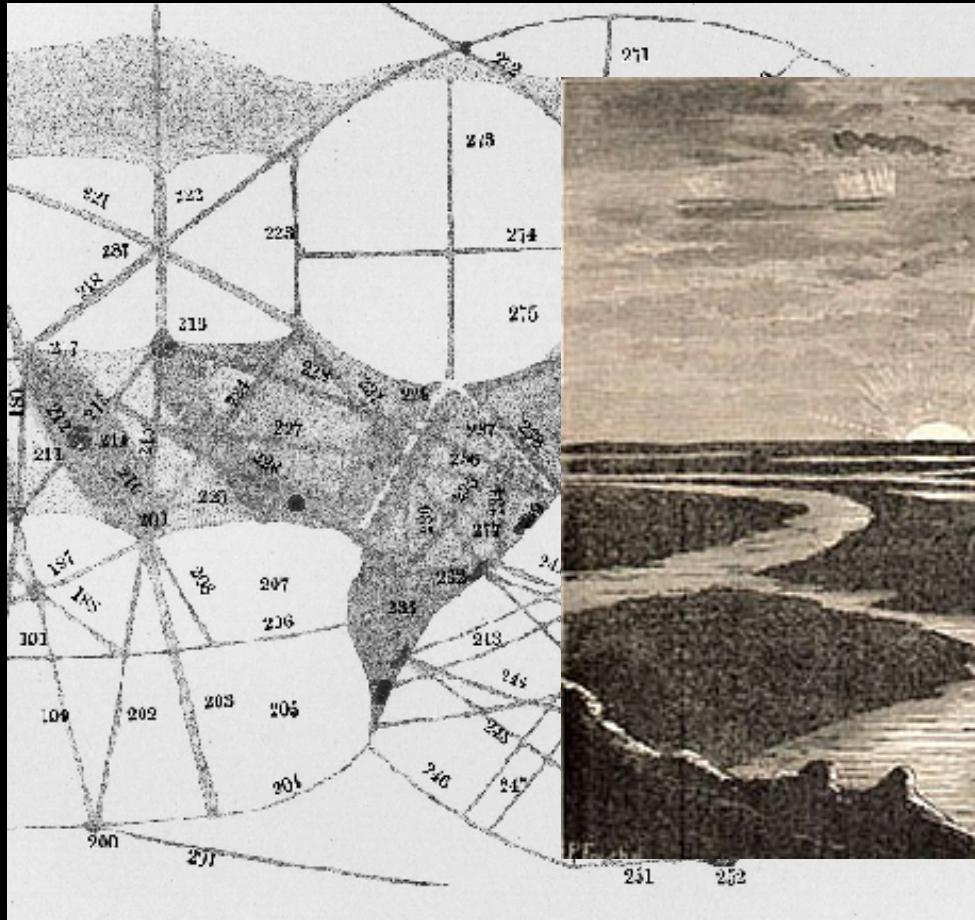


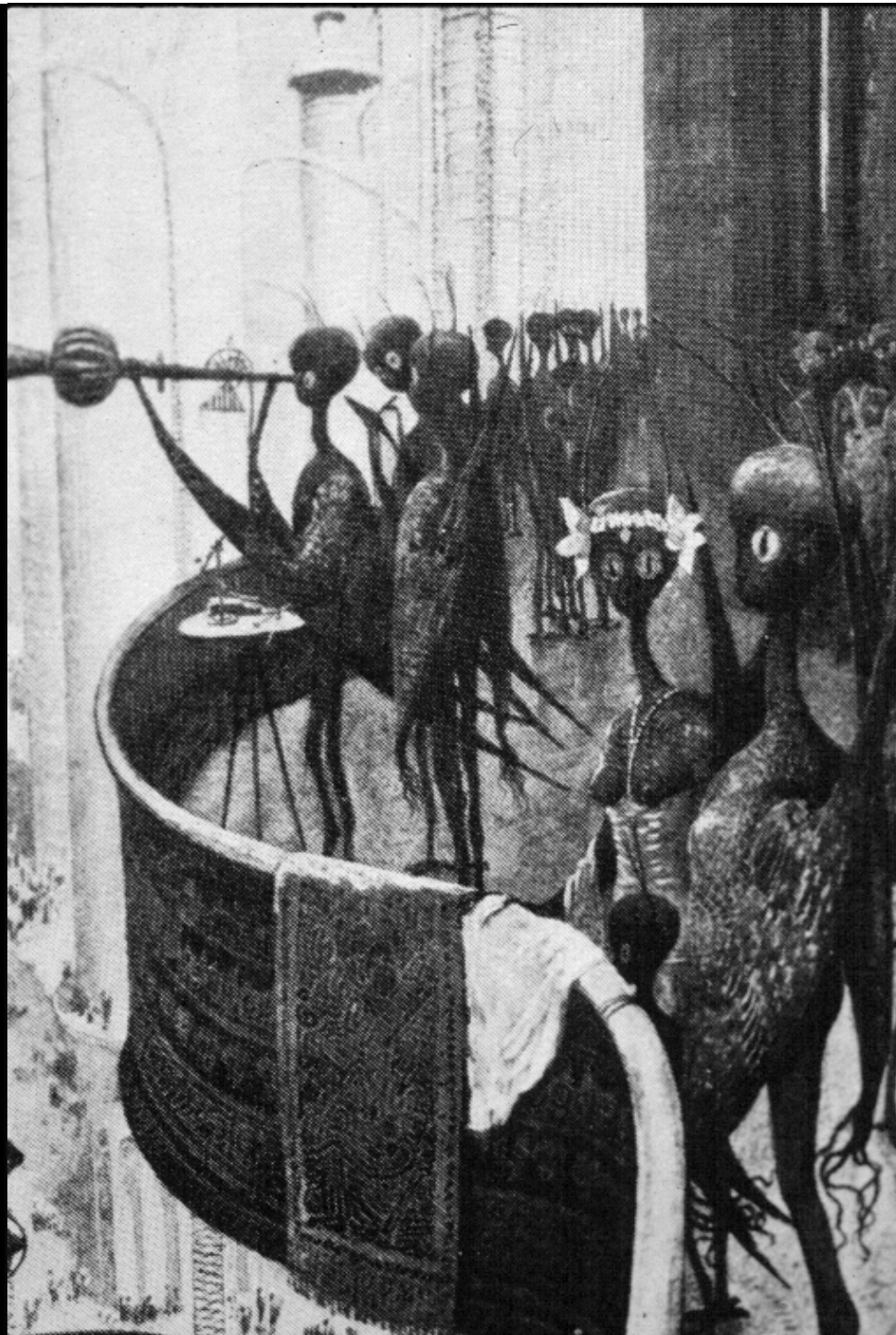
Giovanni Schiaparelli

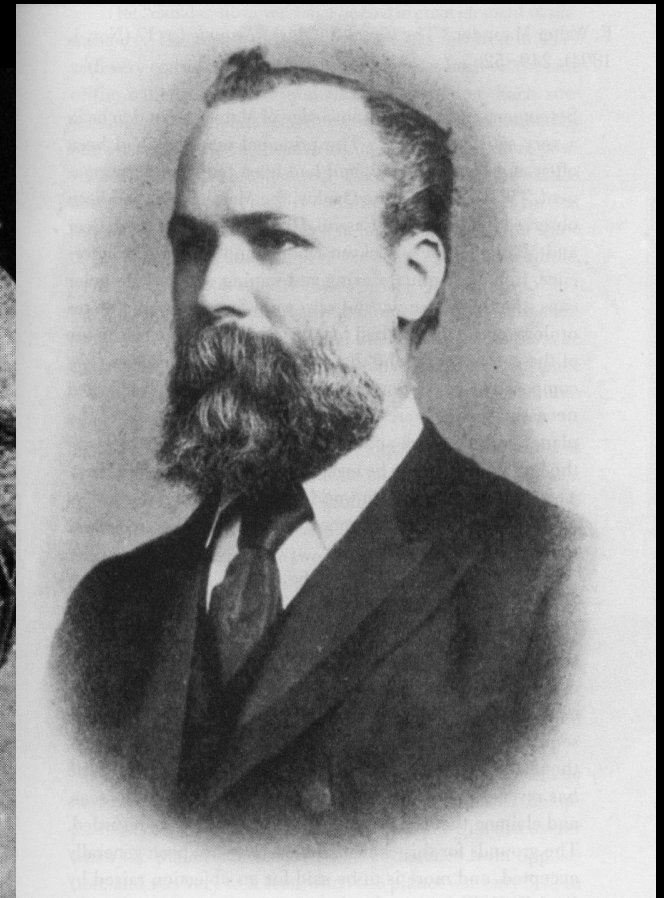


Percival Lowell

Twentieth century  
search ...







Edward Maunder

There's a three-way horse race  
to find cosmic biology ...

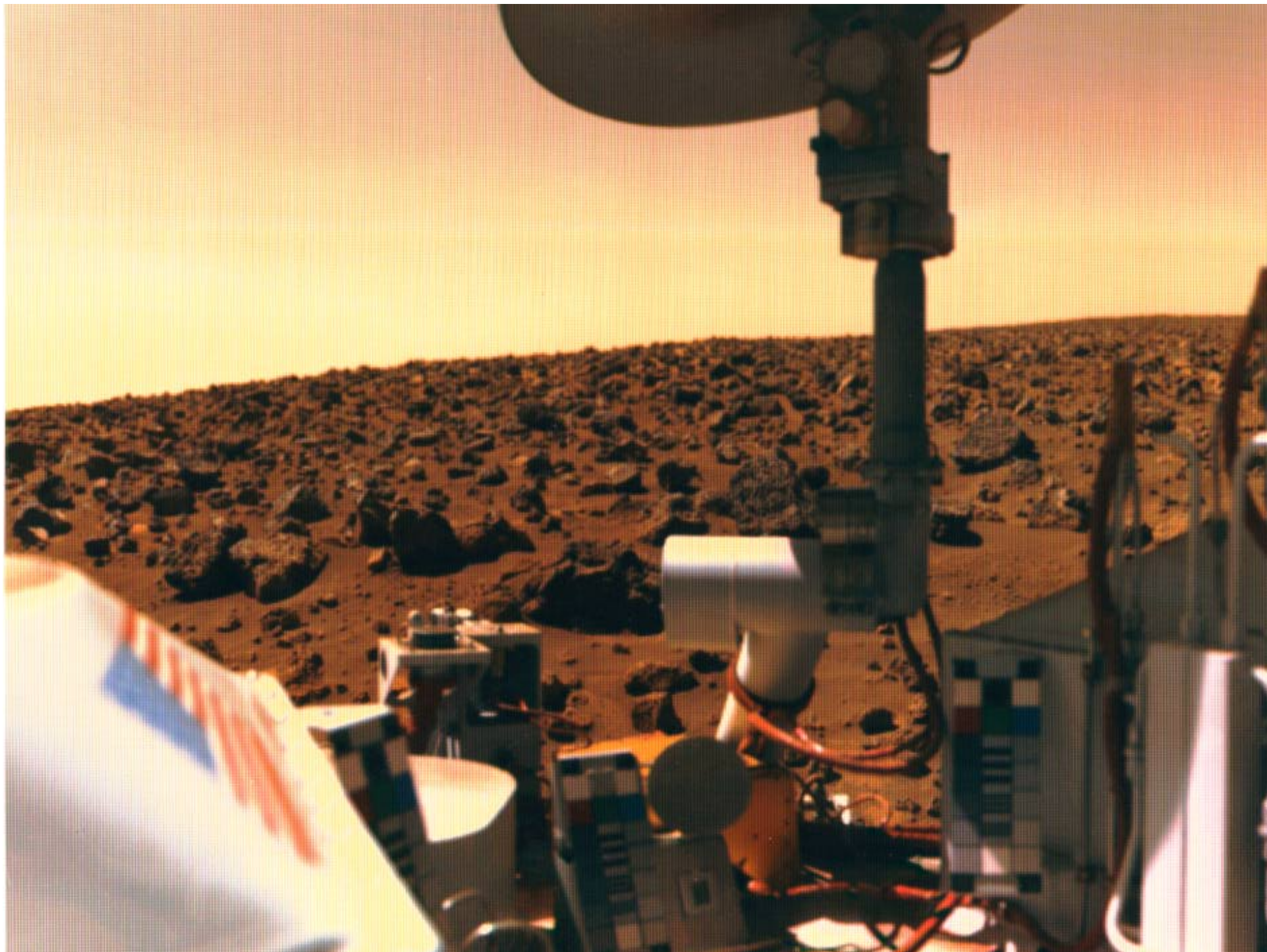


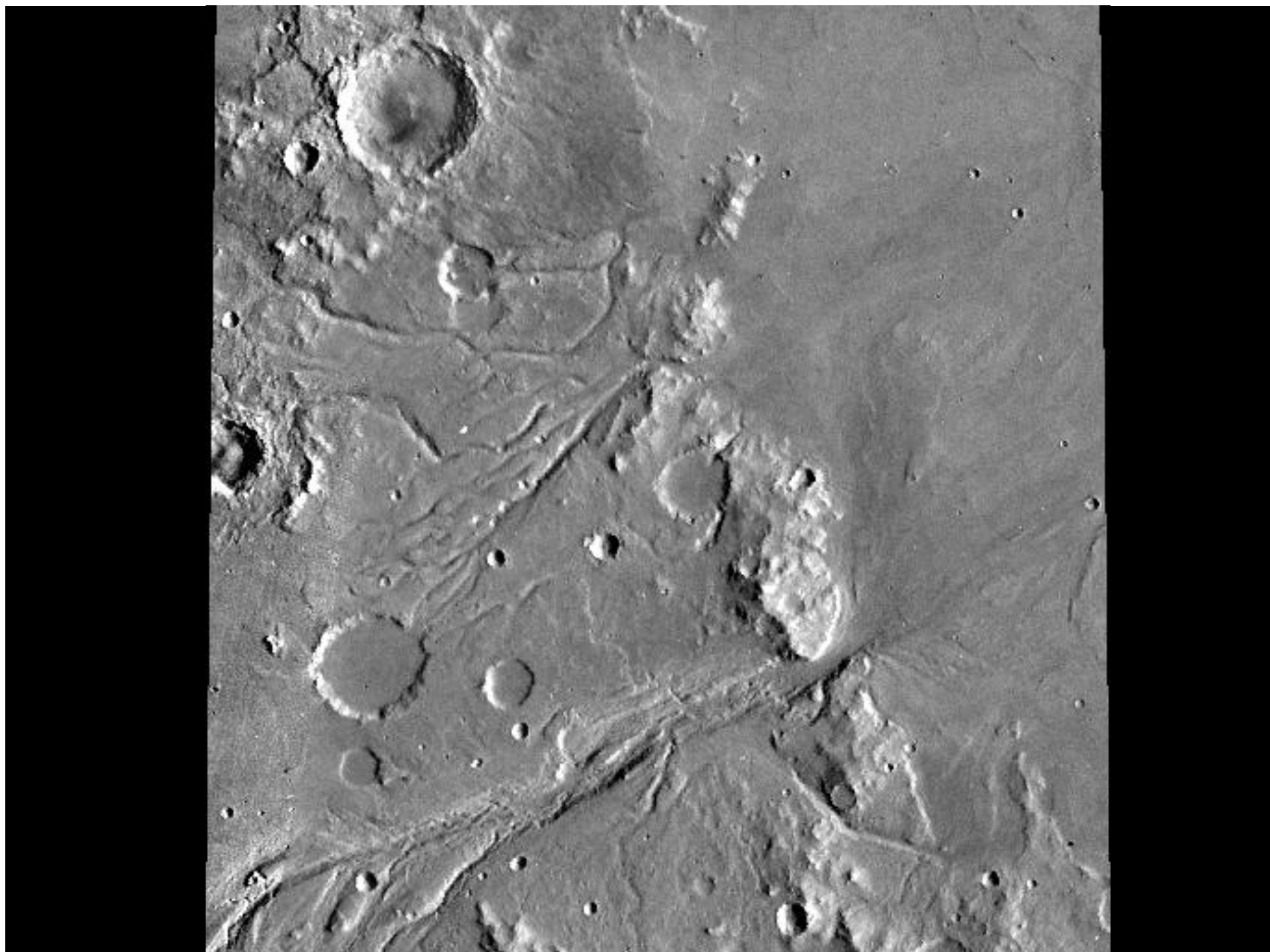
## The nags:

- Find it nearby

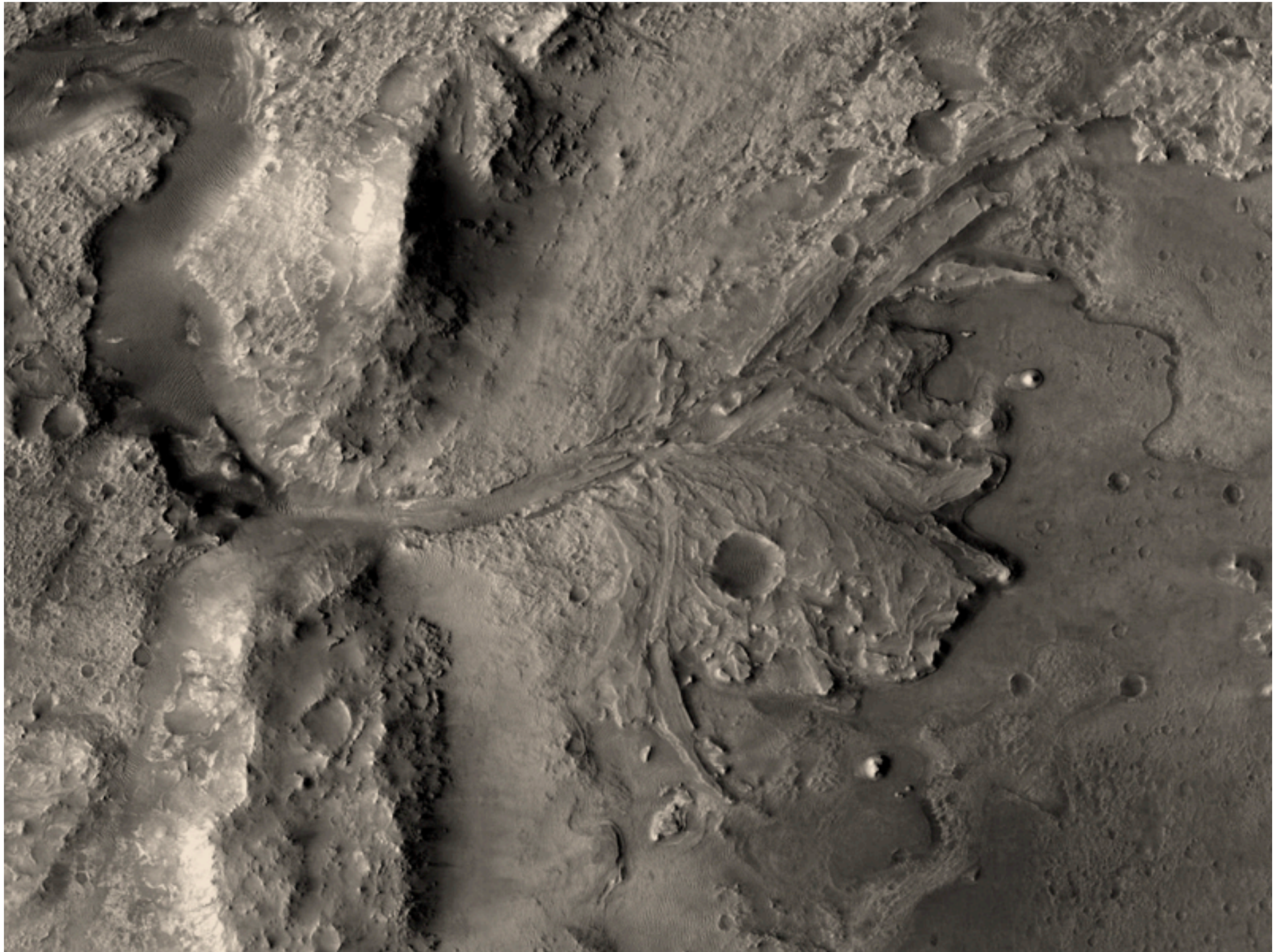
## Pre-WW II Martian...

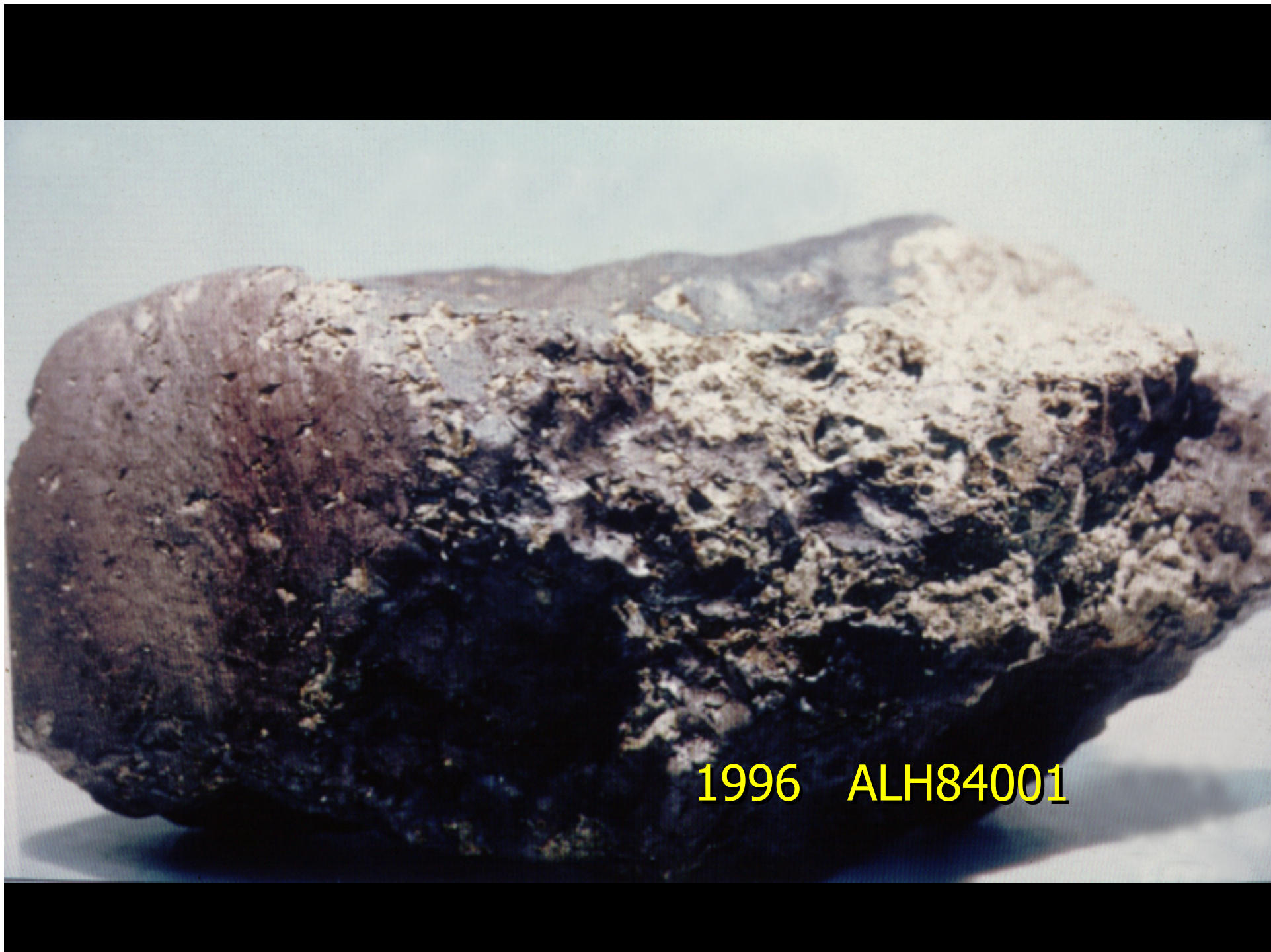






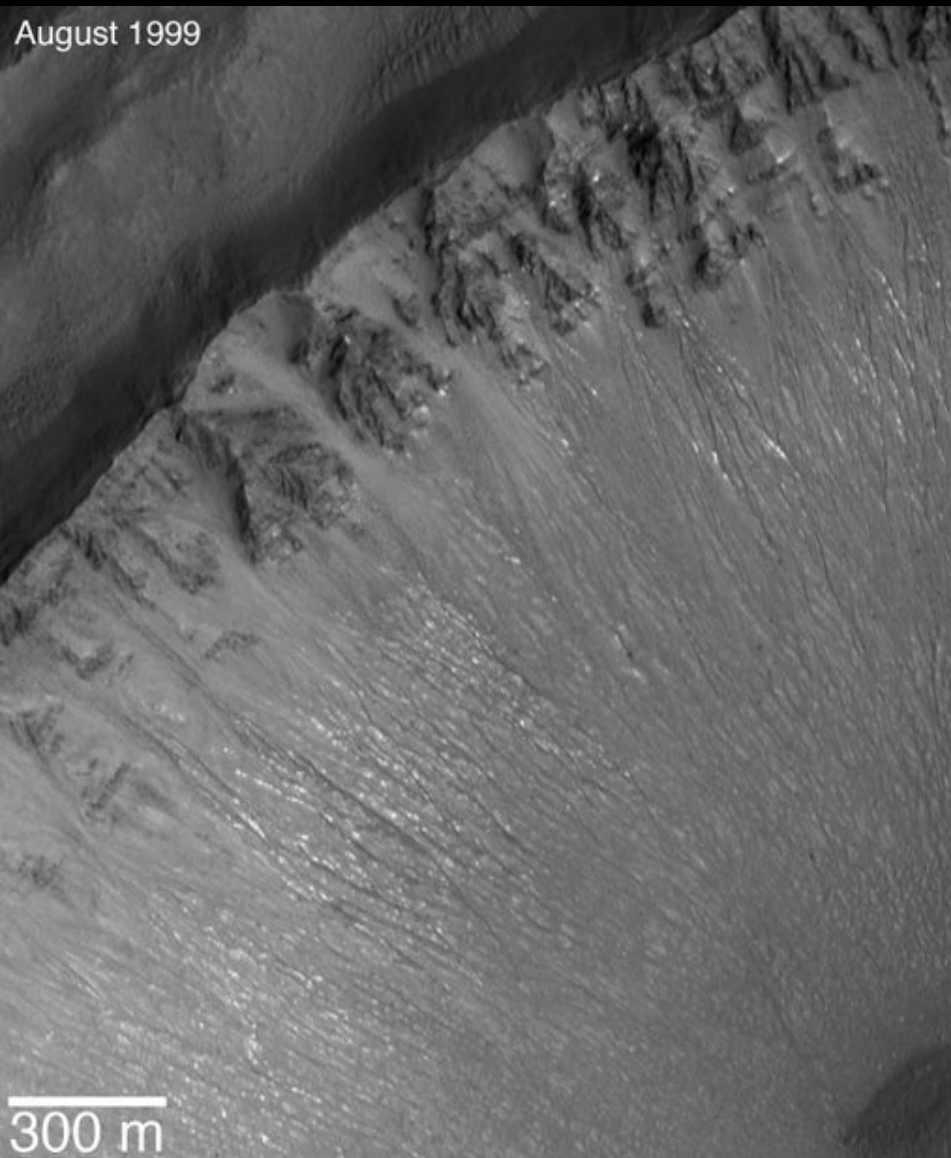








August 1999



300 m

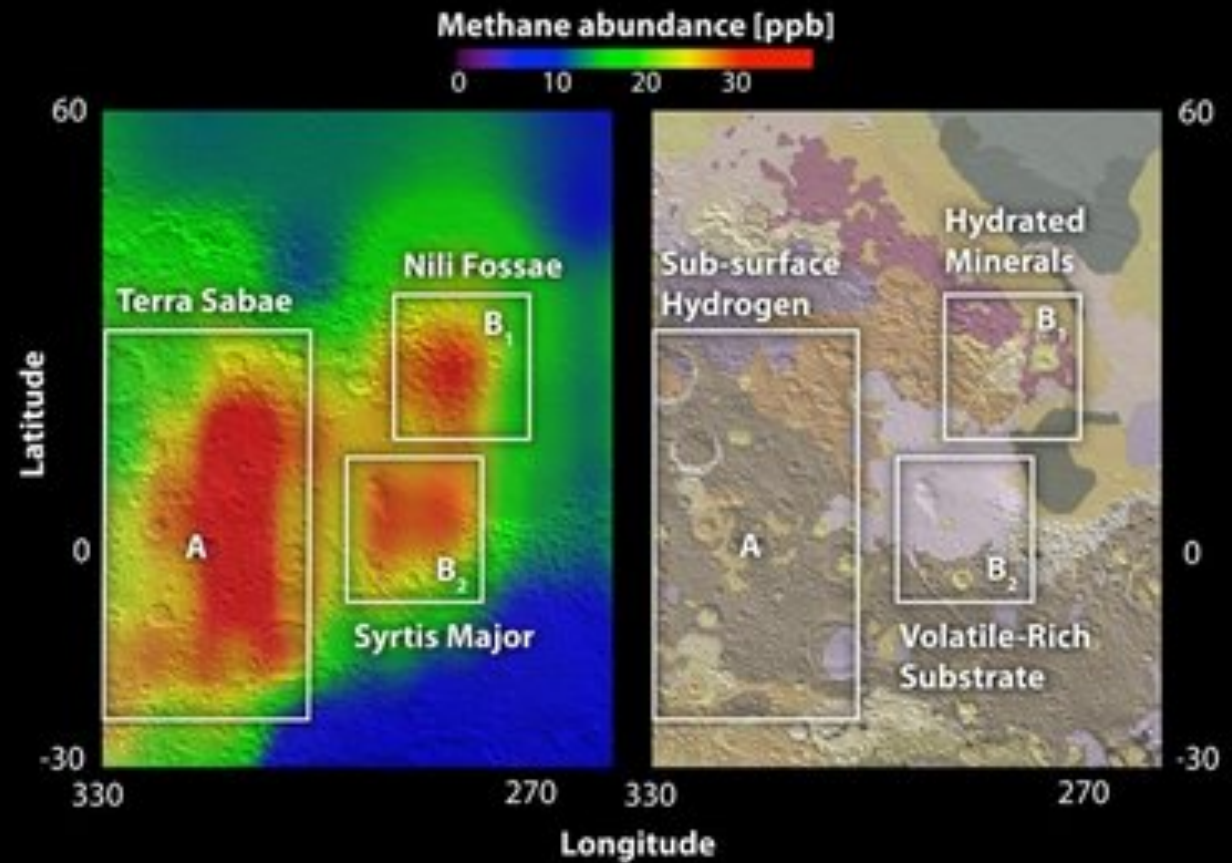
September 2005

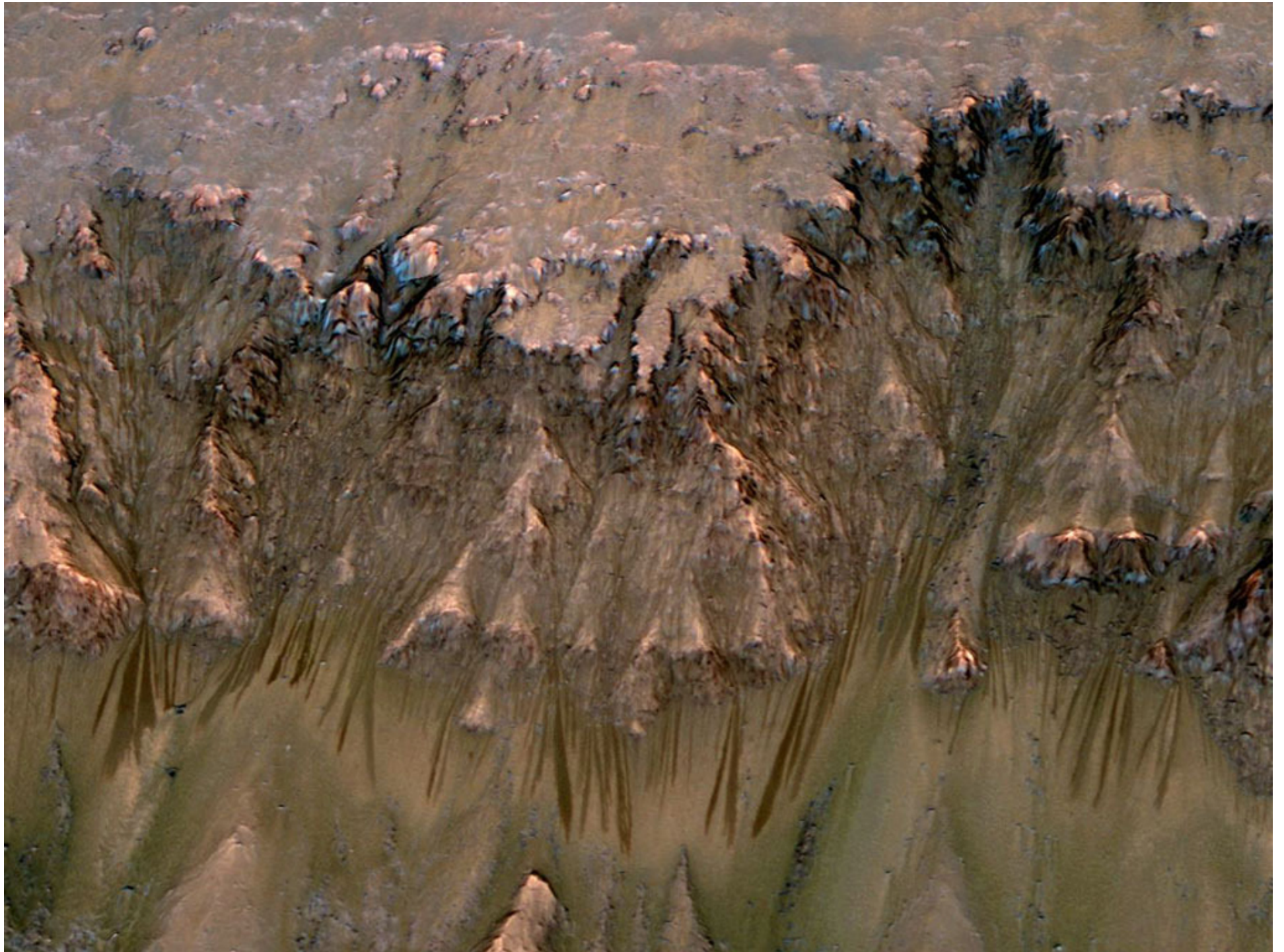


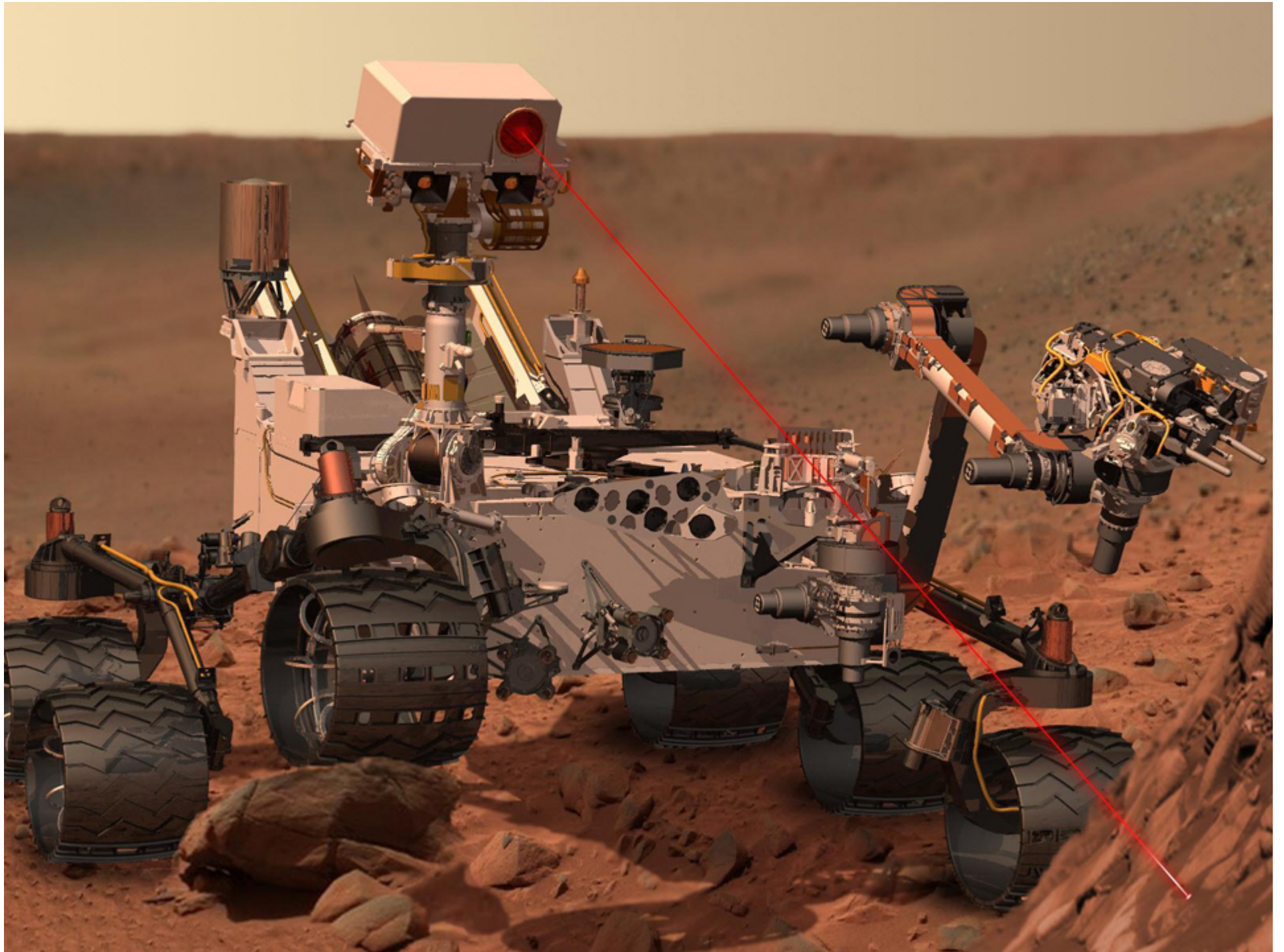
North

new deposit

# Martian methane

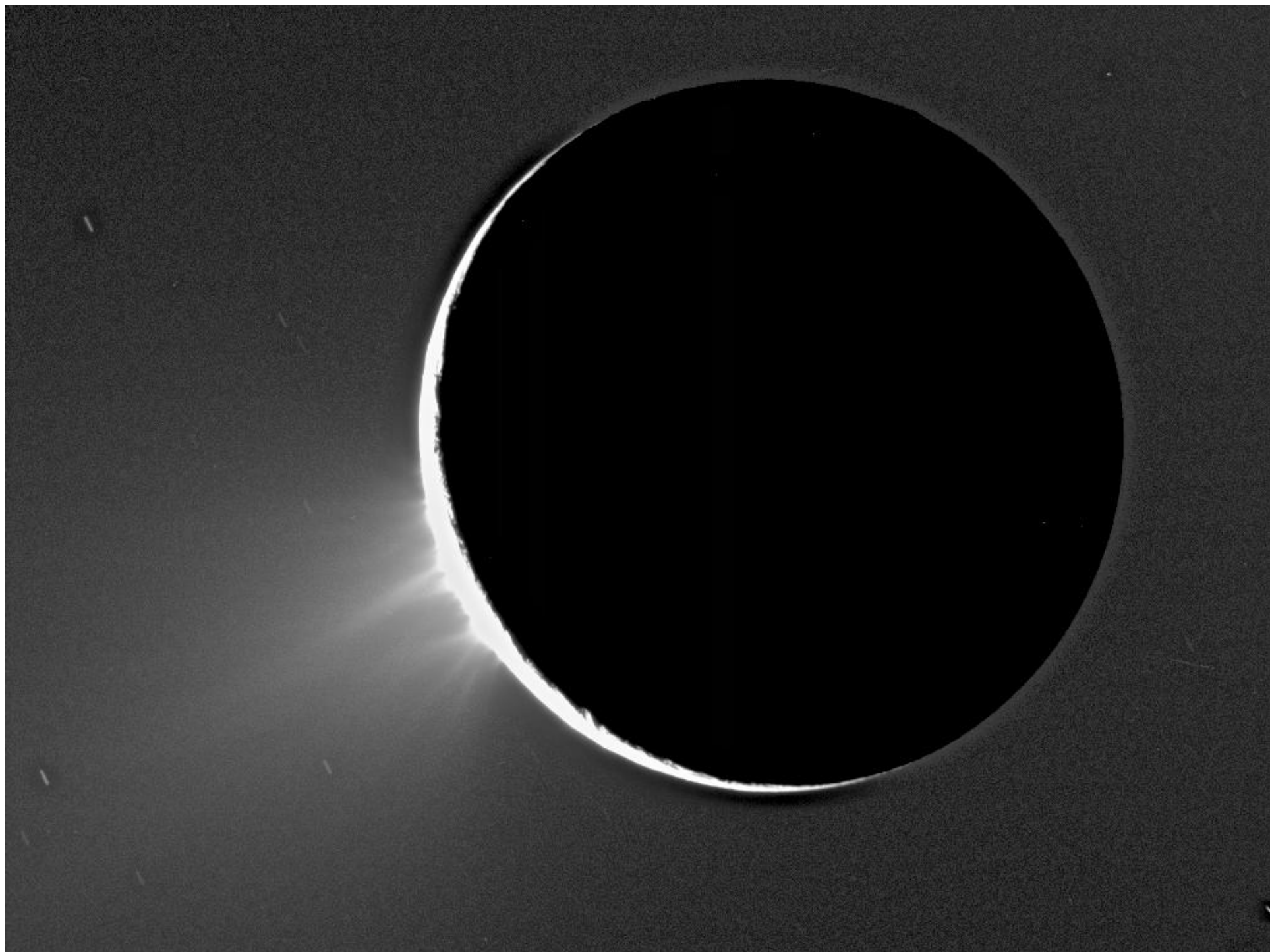






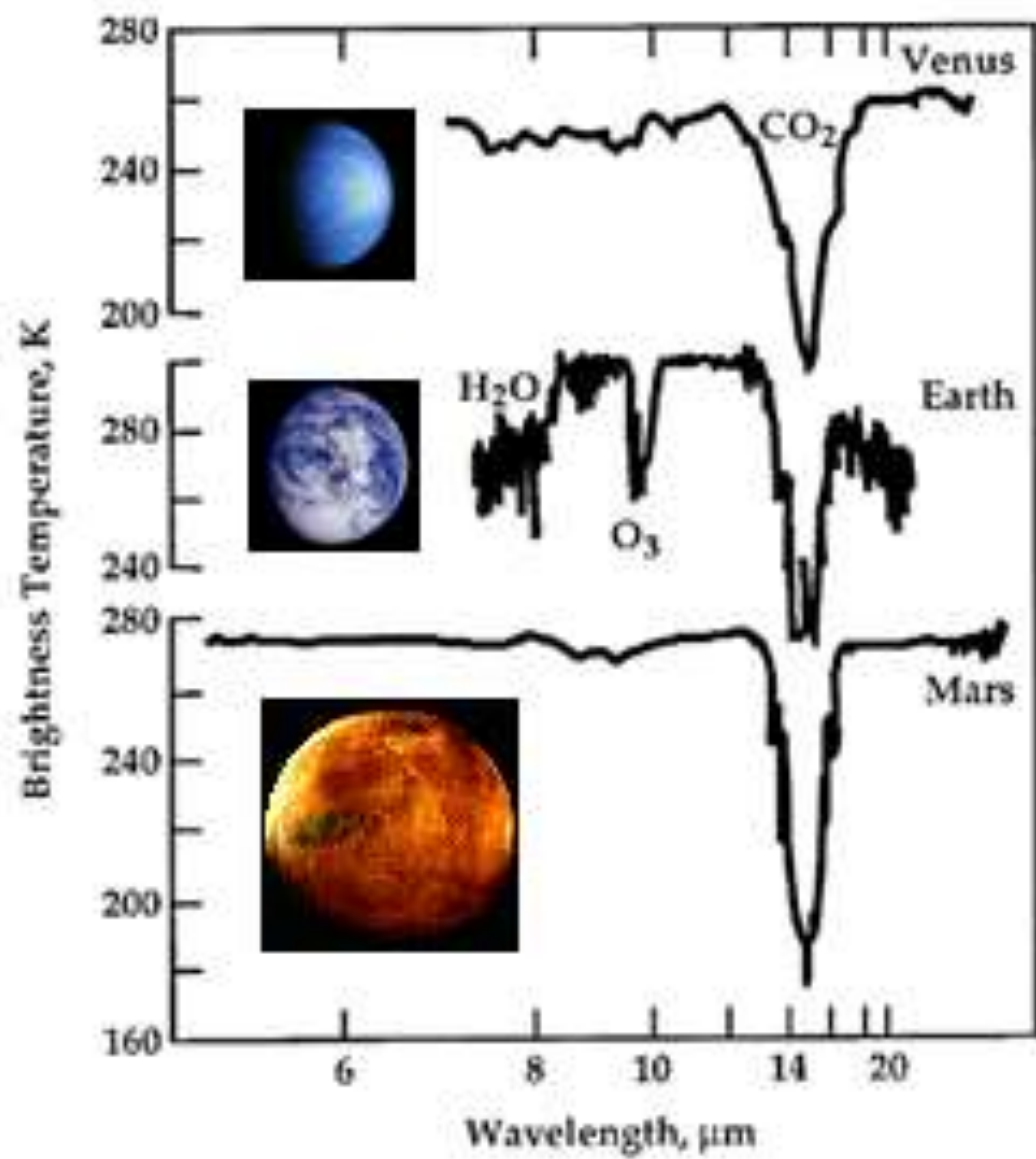


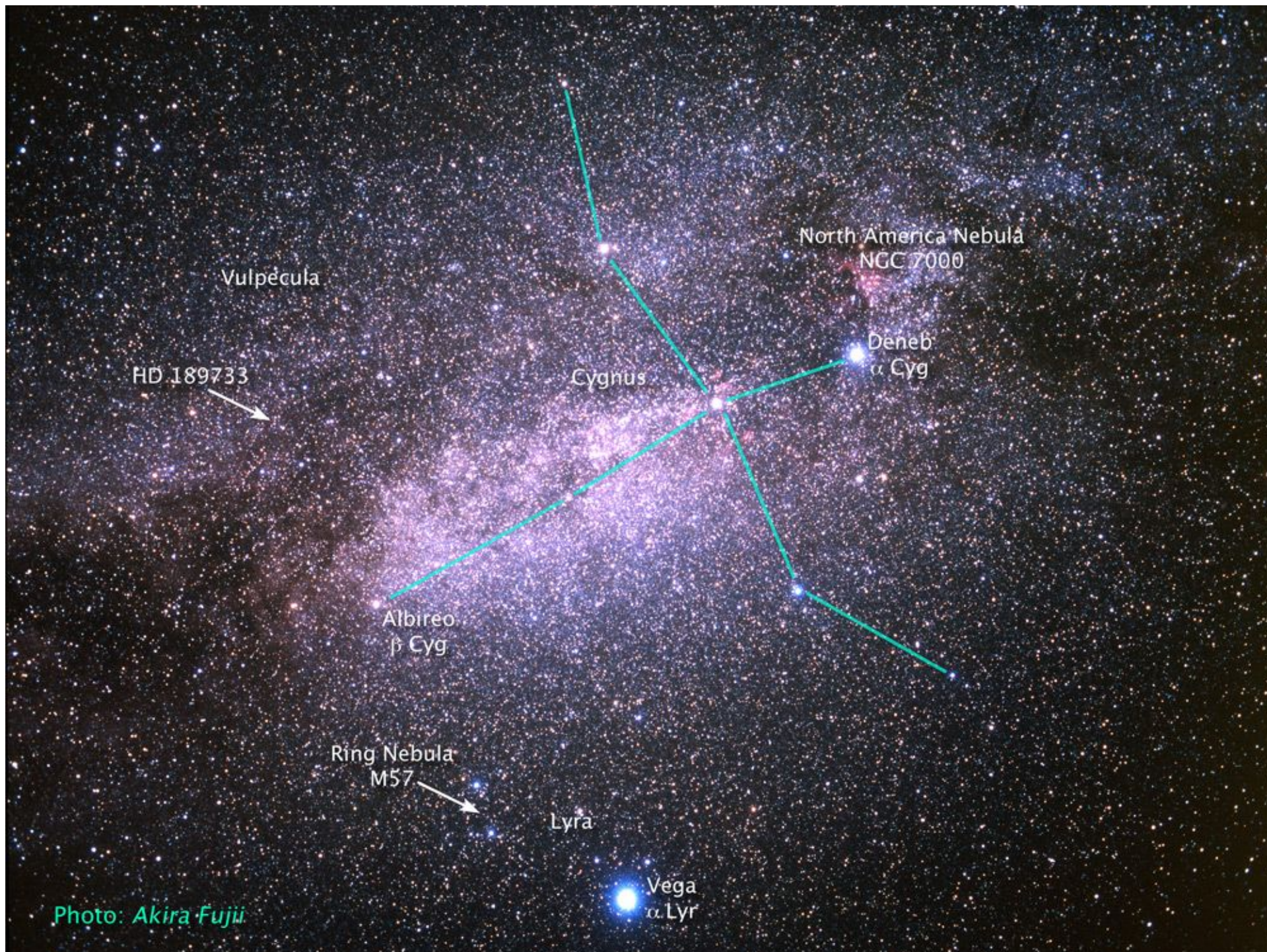


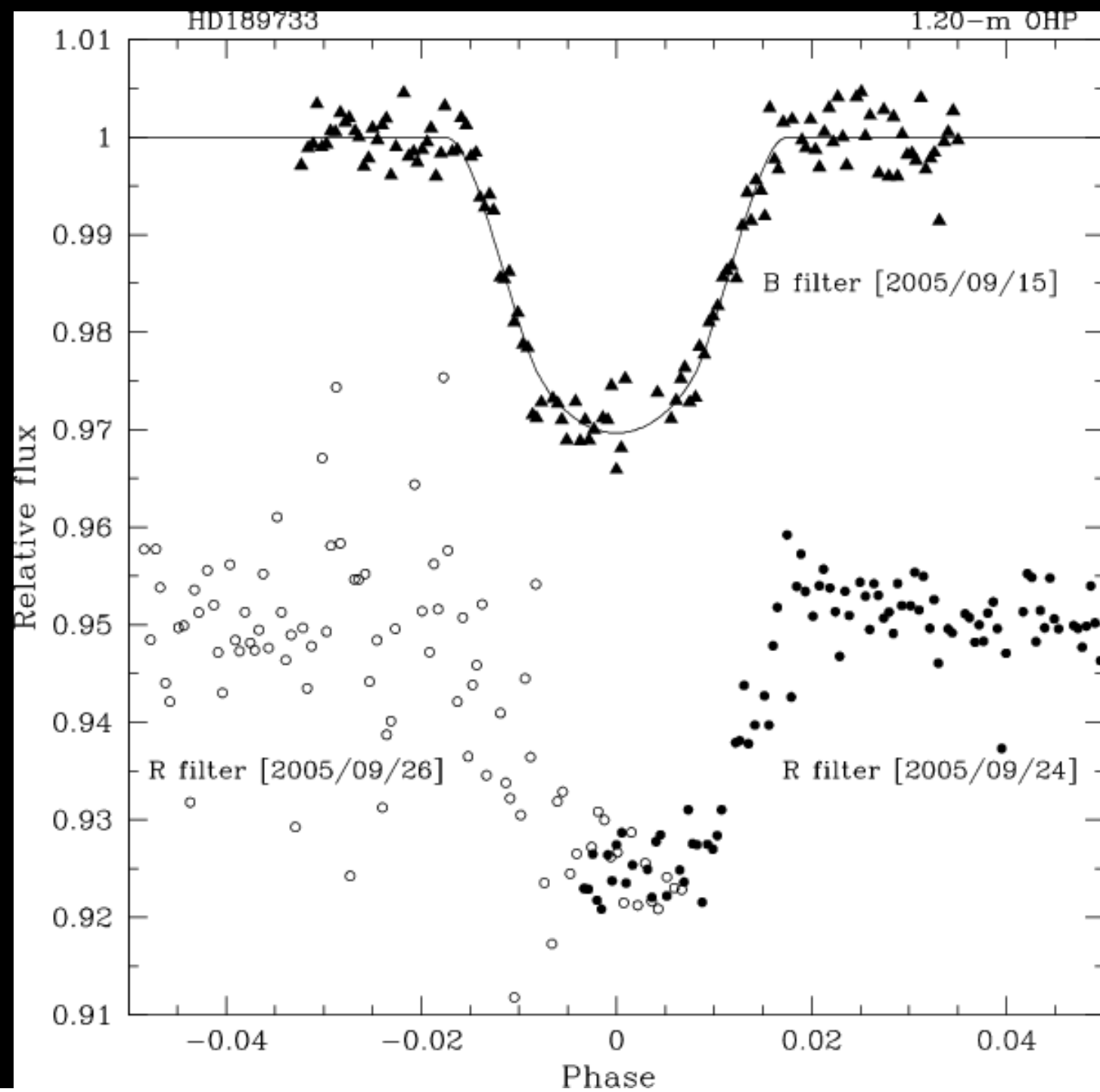


The nags:

- Find it nearby
- Sniff it out



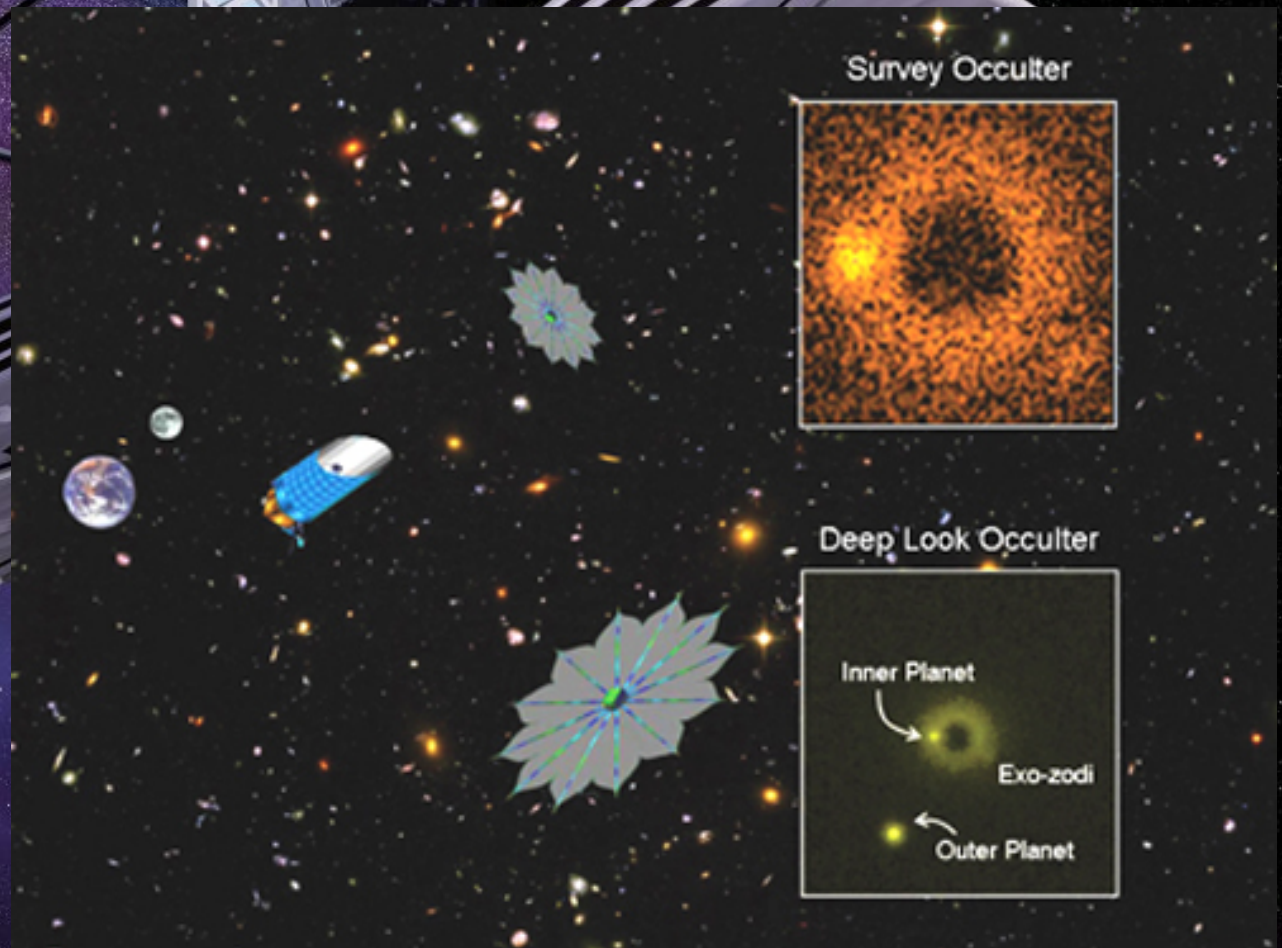






HD209458b transits every 3.5 days.  
Reduces stellar luminosity by 1.5%.  
Sodium found in atmosphere.

James Webb Telescope might find  $\text{CO}_2$ ,  $\text{O}_3$ ,  $\text{H}_2\text{O}$ , chlorophyll.



## The nags:

- Find it nearby
- Sniff it out
- Find evidence left by intelligence

# Allen Telescope Array



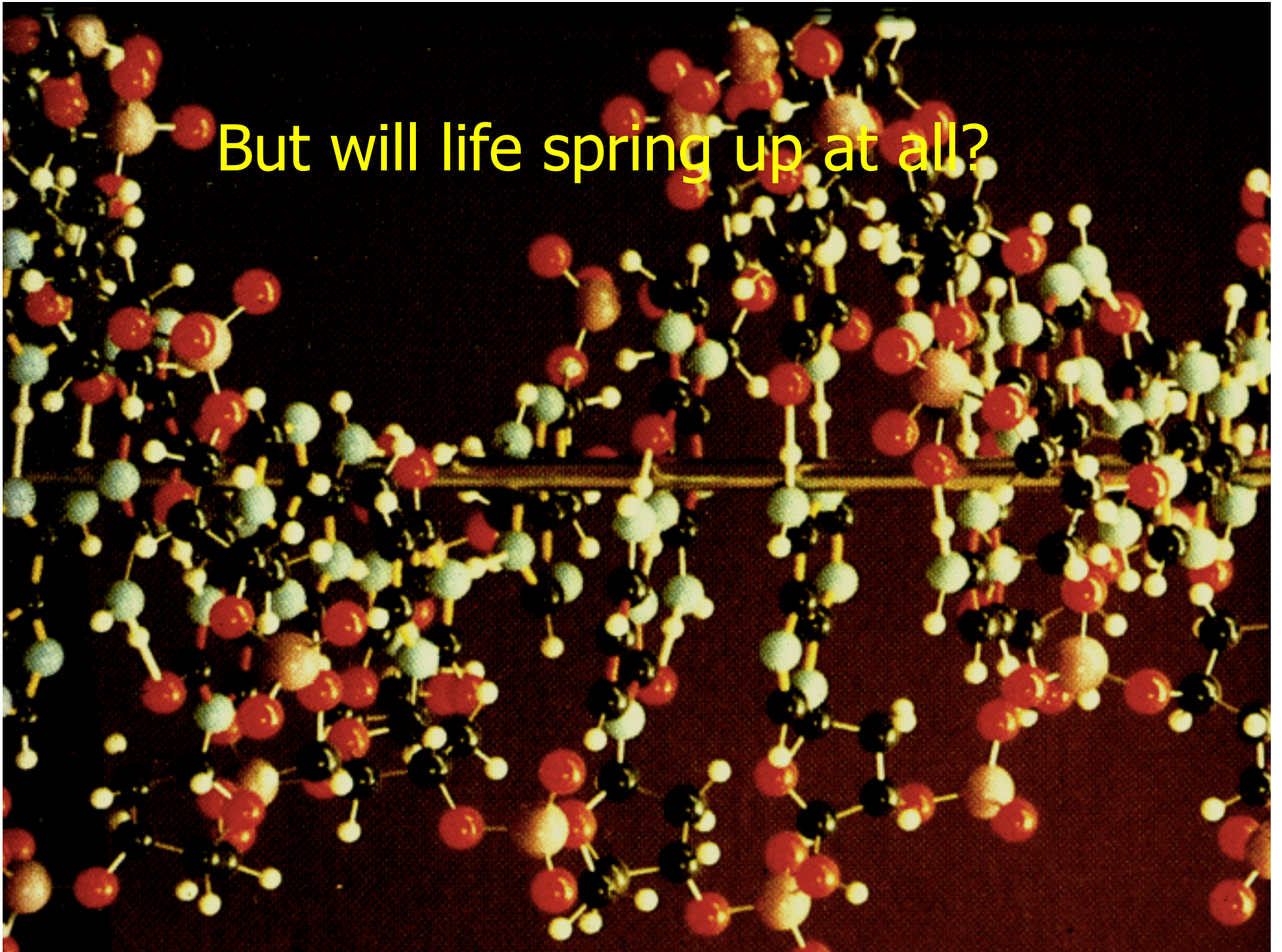
The nags:

- Find it nearby
- Sniff it out
- Find evidence left by intelligence

The nags:

- Find it nearby
  - Sniff it out
  - Find evidence left by intelligence
- ] *stupid life*

But will life spring up at all?





Jack Szostak



# Biology: An Easy Thing?



If Earth is the only world with life,  
then it's a miracle

Astronomers are leery of miracles

