

life  
on  
mars  
what to know  
before we go

david a. weintraub

# ***The Principle of Plenitude***

***Extraterrestrial beings must exist because God's goodness demands that all worlds (Sun, Moon, Mercury, Venus, Mars, Jupiter, Saturn, all stars) should be populated with intelligent, God-worshipping denizens.***

This concept can be traced back to:

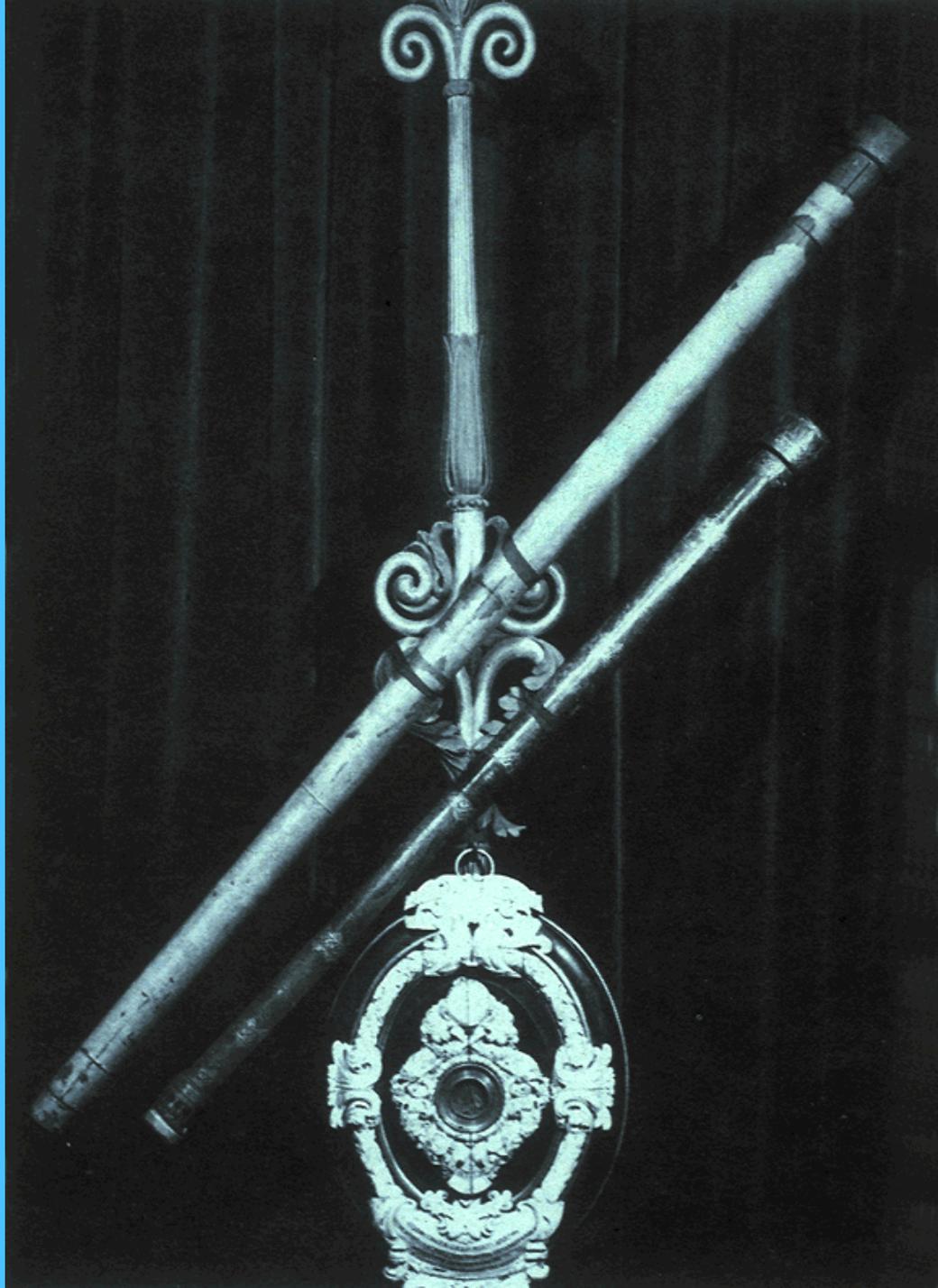
- Plato: in the ideal universe, all possibilities must exist (4<sup>th</sup> century B.C.E.)
- Epicurus: every possible explanation is true, somewhere in the universe (3<sup>rd</sup> century B.C.E.)
- St. Augustine: better to have a universe full of all kinds of beings, even if some of them suffer or create evil (4<sup>th</sup> century C.E.)
- Giordano Bruno: we live an infinite universe with an infinite number of beings (1580s)

**A predisposition to assume life exists on Mars (and everywhere else) was our cultural inheritance when the telescope arrived (1609)**

Game Changer: 1609



Galileo Gallilei



# Moon

Pre-telescopic era:

- “seas”
- mountains



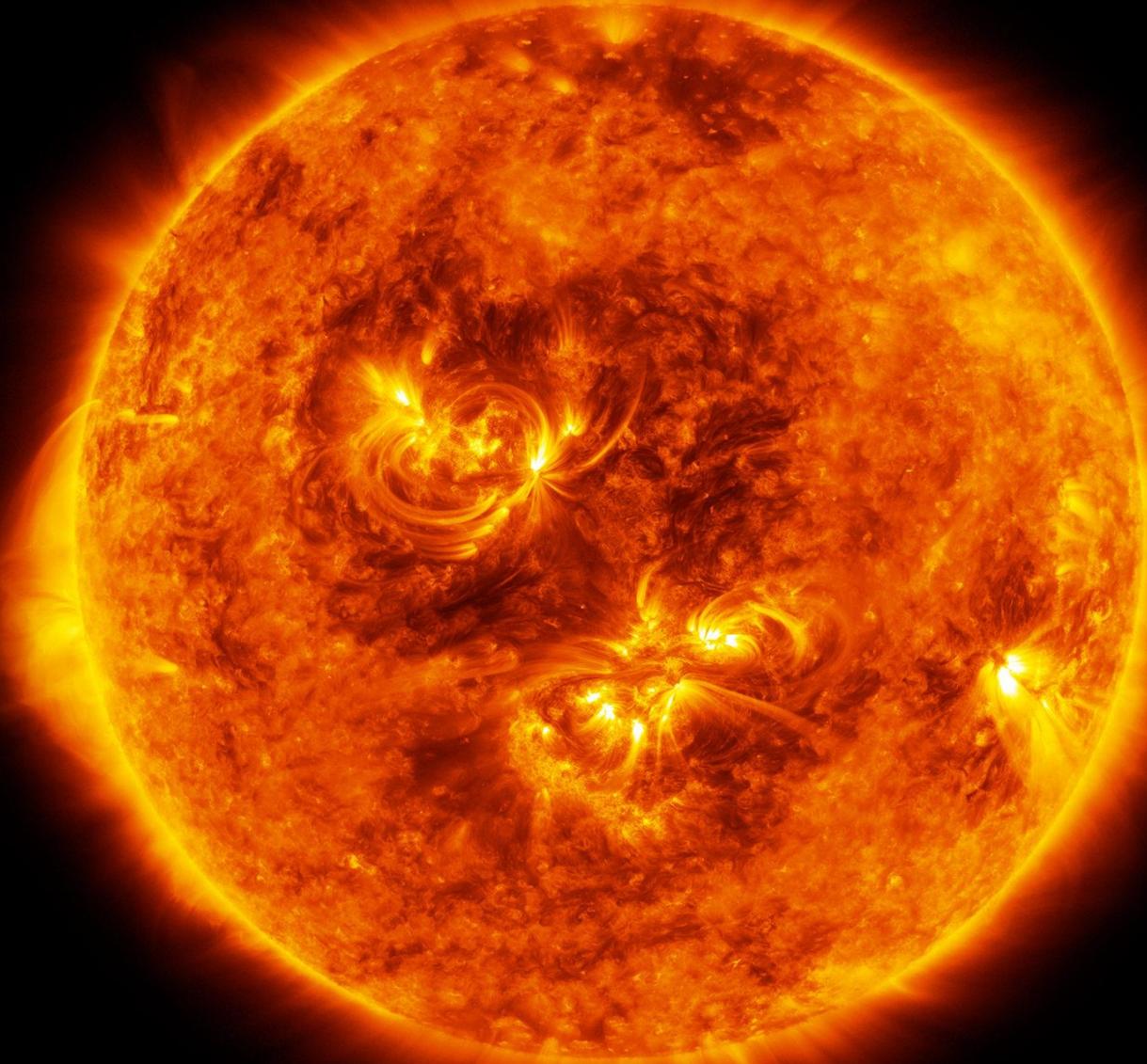
With a telescope:

- No atmosphere (Bessel)
- “seas” not water

# Sun

In the era of  
'modern' physics:

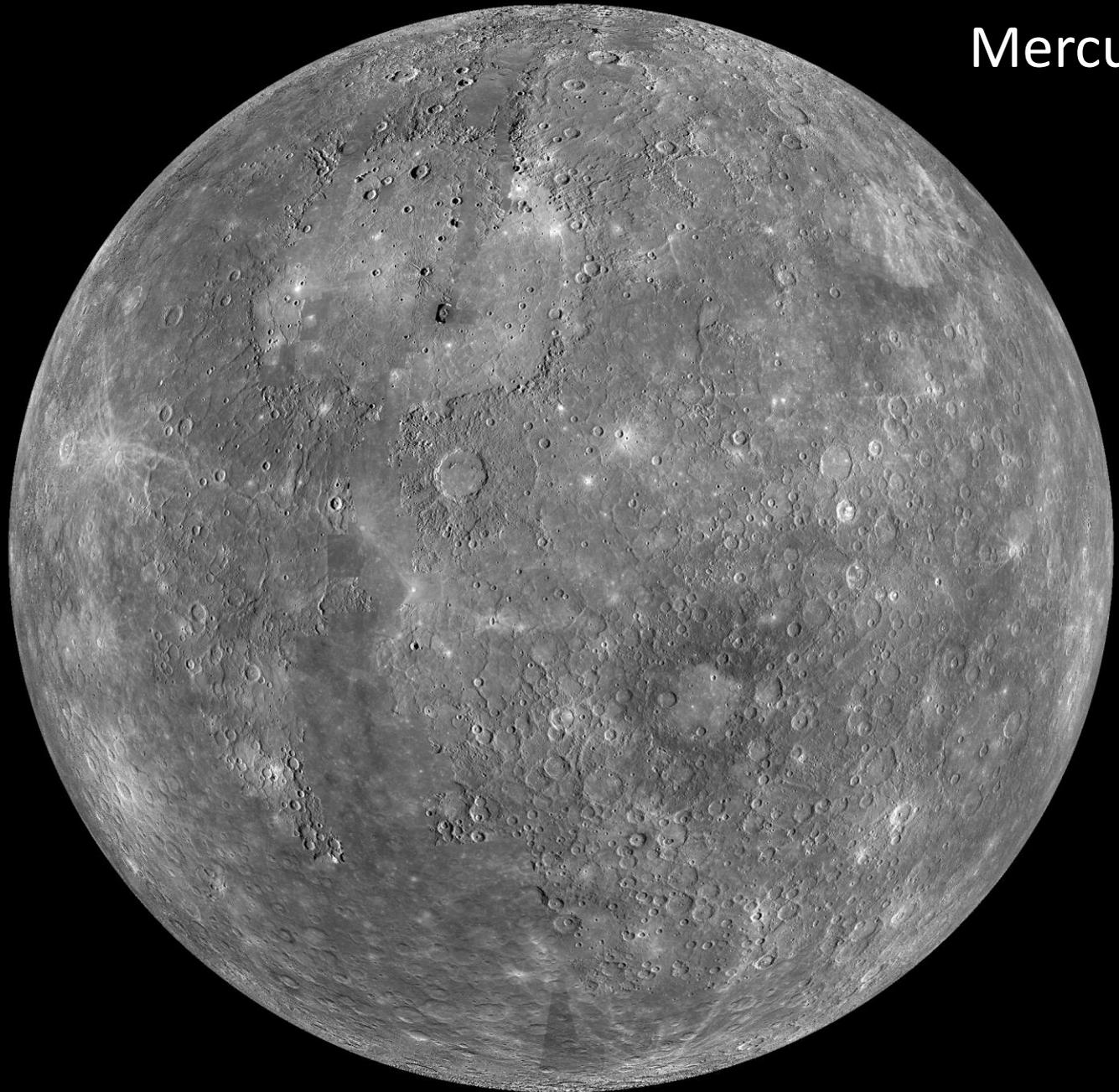
- Source of heat and light
- Must be scorchingly hot and bright
- unlivable



# Mercury

## Early telescopic era:

- Boring (just a speck) of light
- Too hot



## Modern ideas

- No atmosphere
- 801 F at noon
- -297 F at midnight
- too hot
- too cold
- too dry

Early days of  
telescopes:

- Boring

Modern ideas

- Hellishly hot
- Poisonous  
atmosphere
- Bone dry

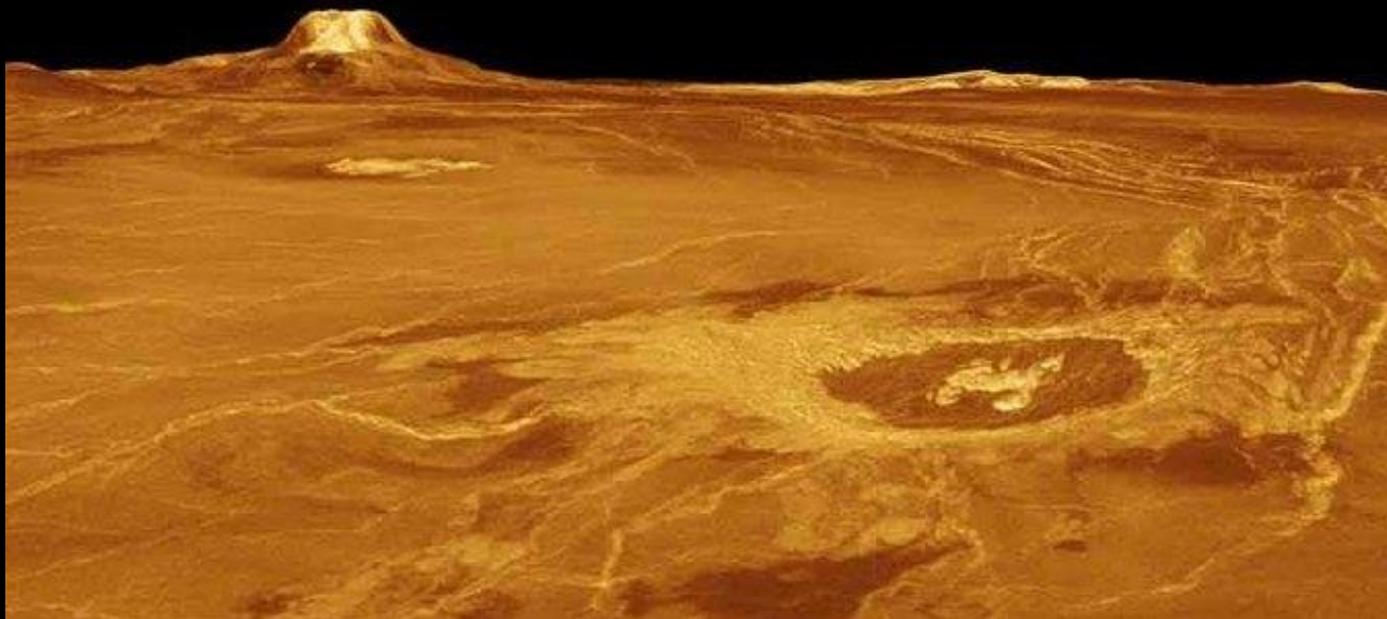


Visible light



Venus

ultraviolet light



Radar map

# Jupiter

Early days of  
telescopes:

- Too far from Sun
- Too cold
- Too small to study



Modern era:

- Too cold
- Mostly H and He
- Gravity too strong
- Intense radiation environment

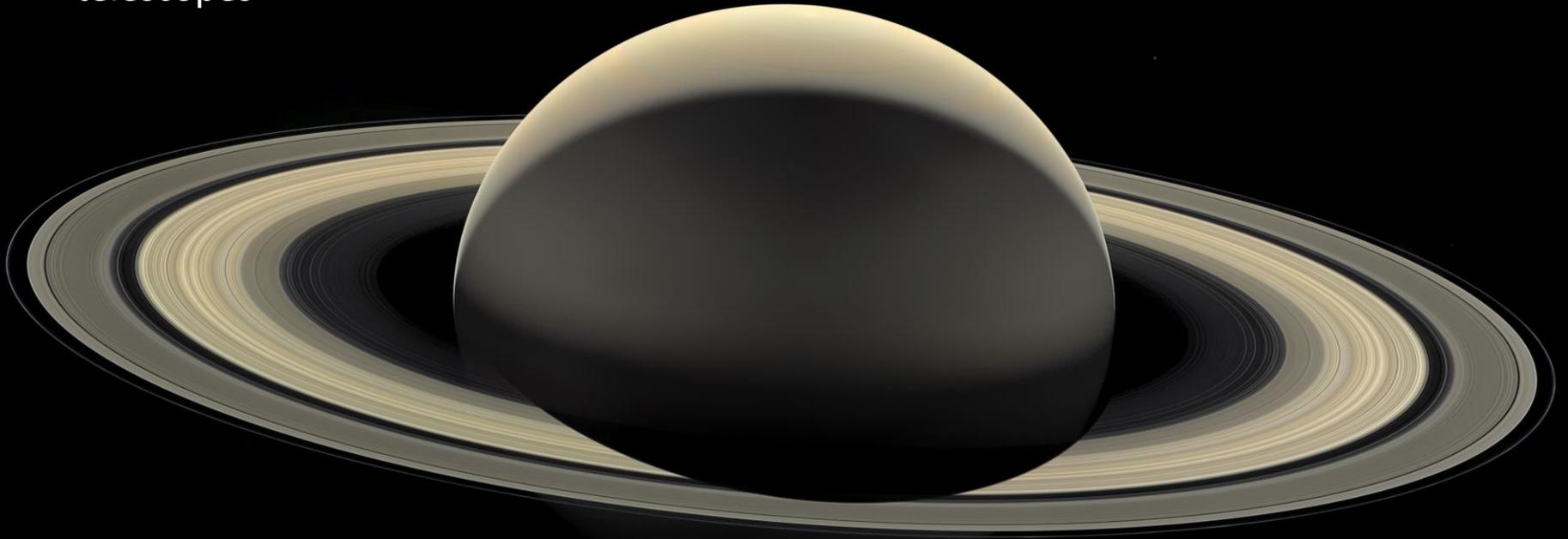
# Saturn

## Early

- even farther from Sun
- even colder
- even harder to study with primitive telescopes

## Modern

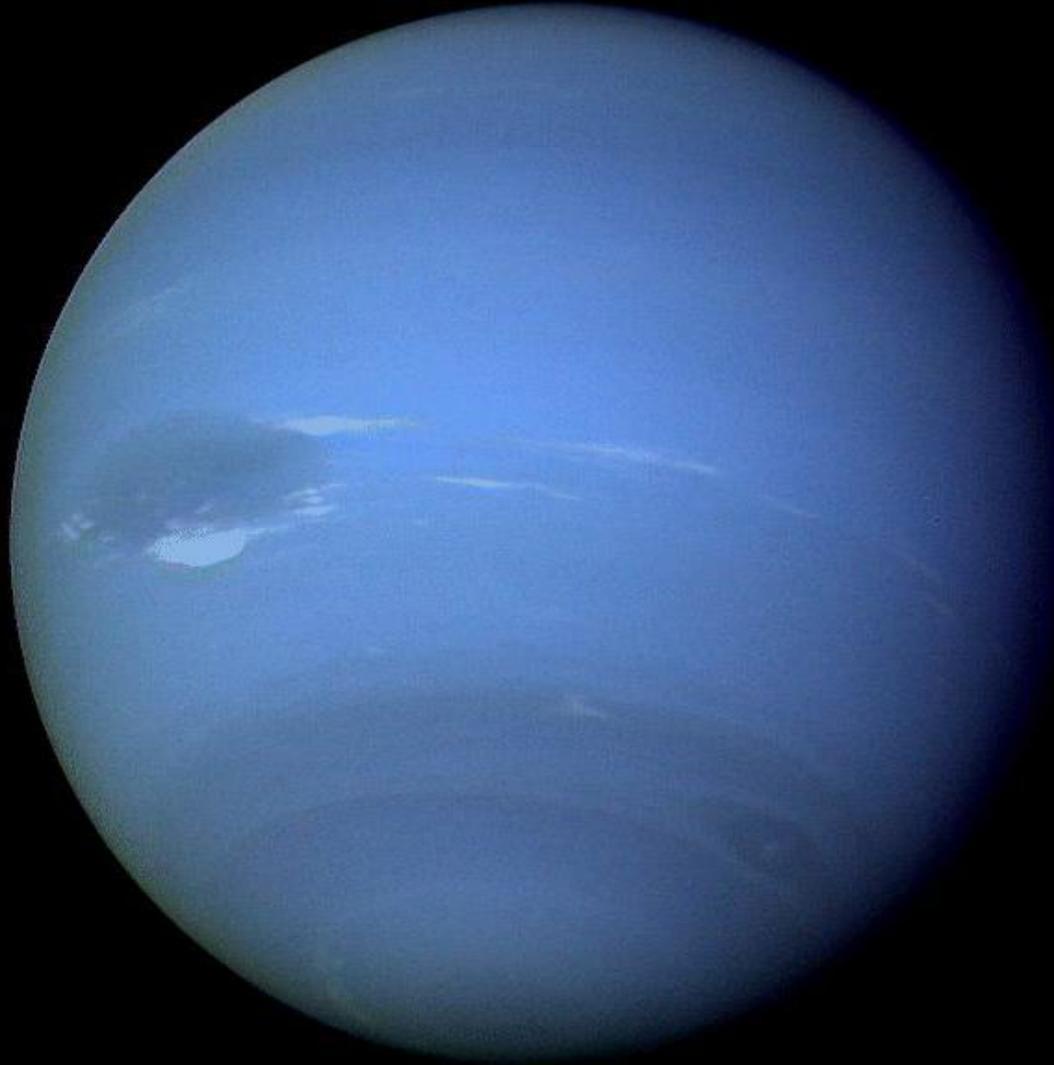
- Too cold
- Mostly H and He



# Uranus

Discovered in  
1781

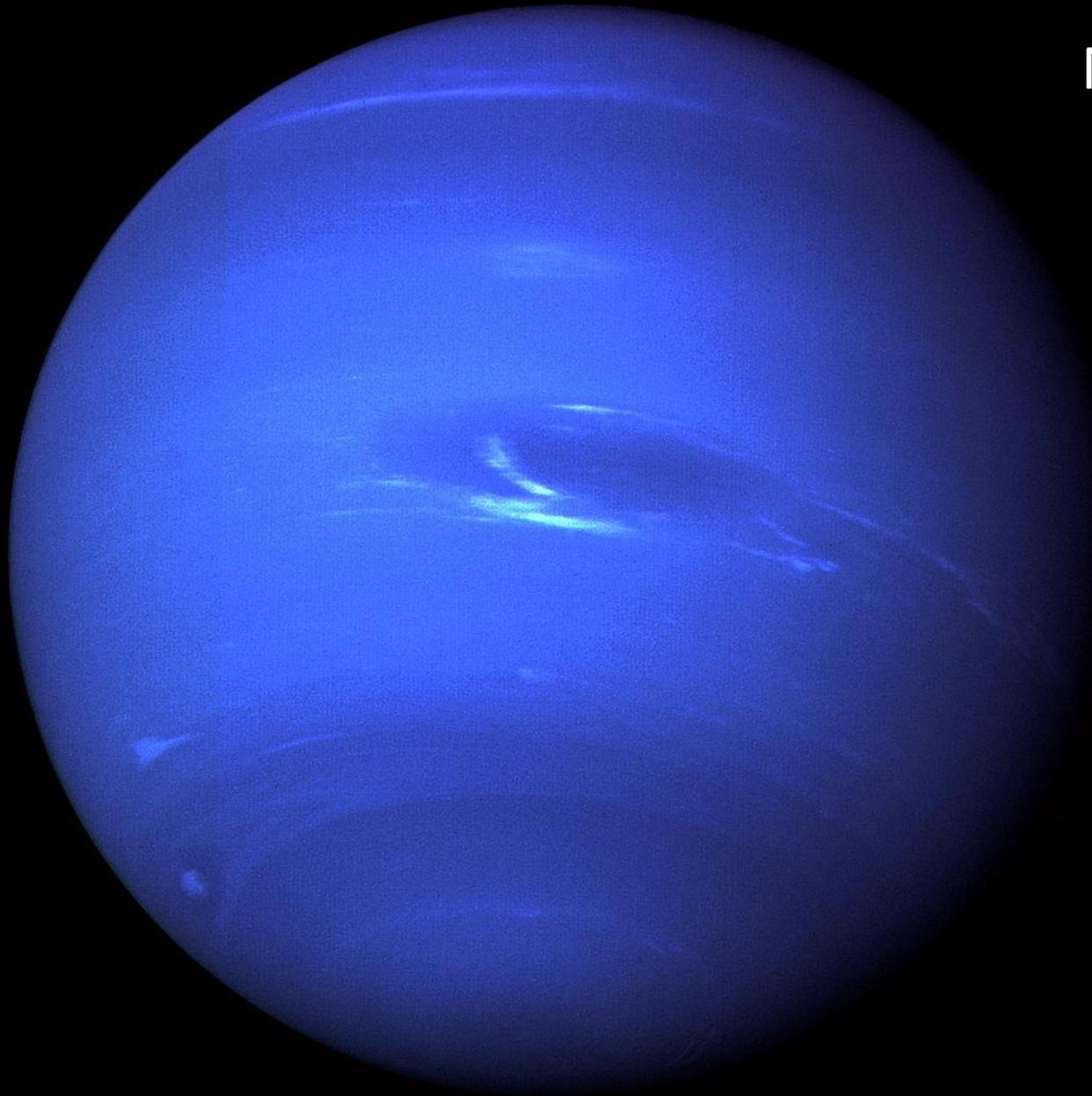
- Principle of plentitude fading
- Never of interest for life



# Neptune

Discovered in  
1846

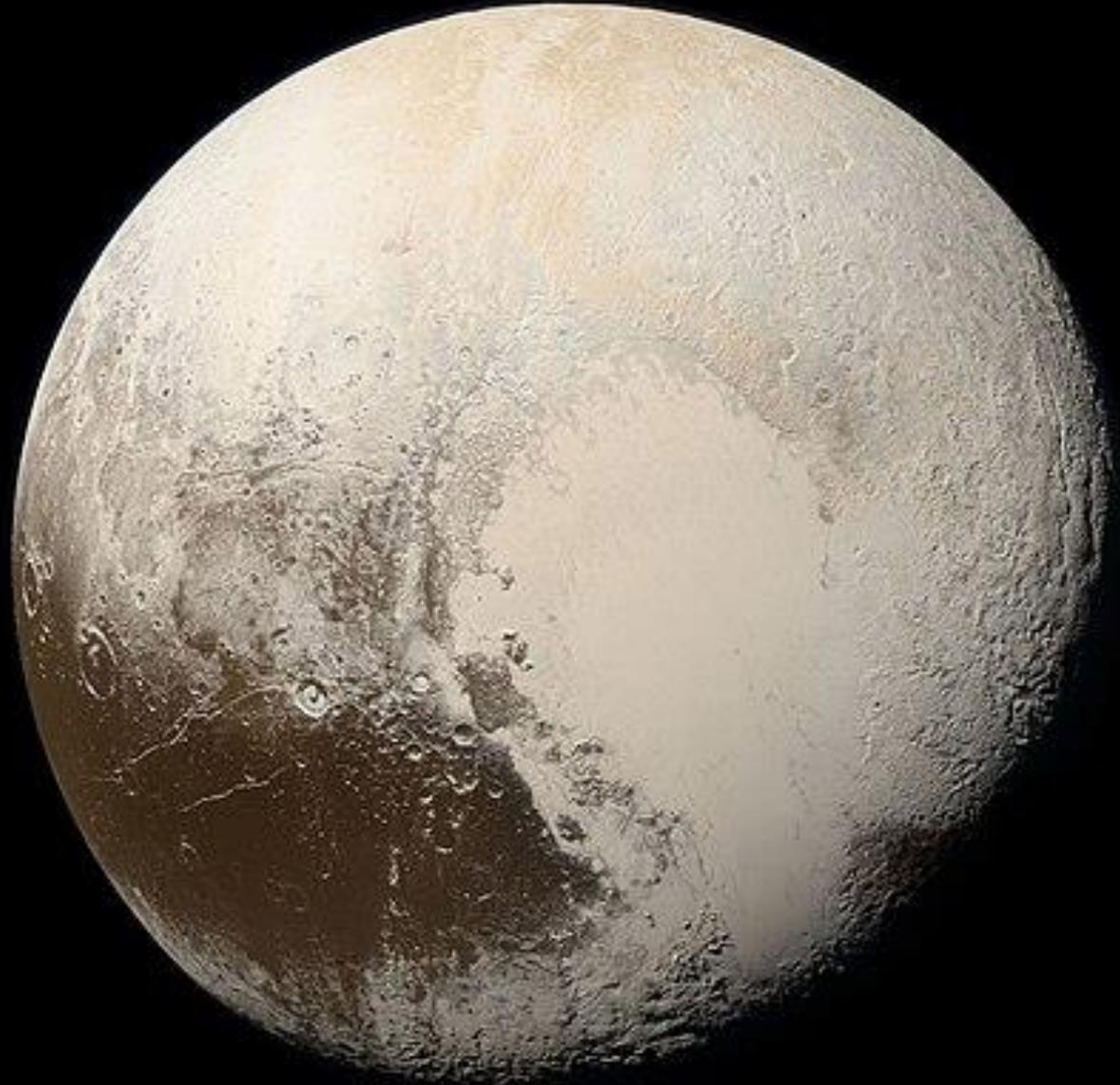
- Principle of plentitude a relic
- Never of interest for life



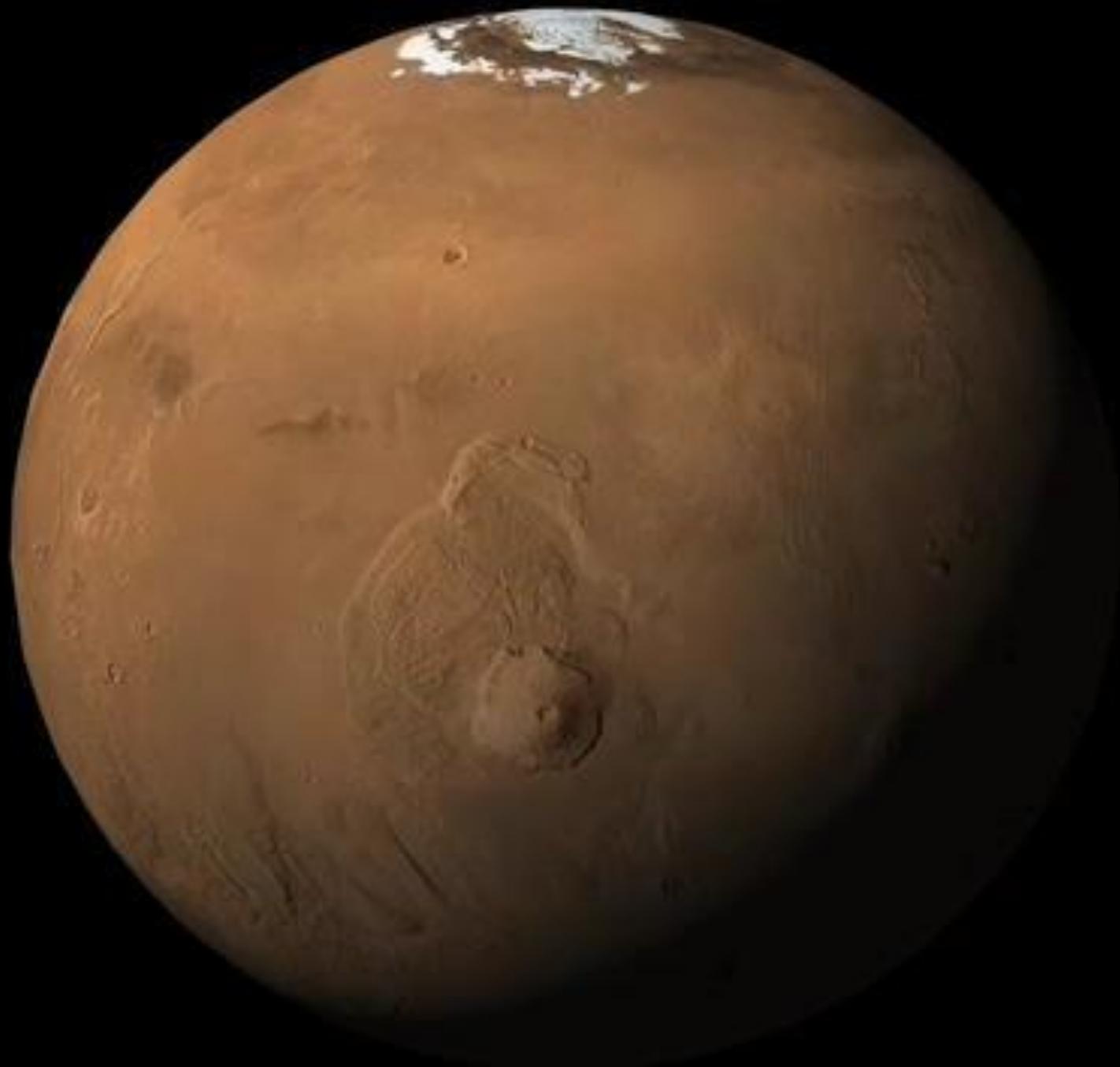
# Pluto

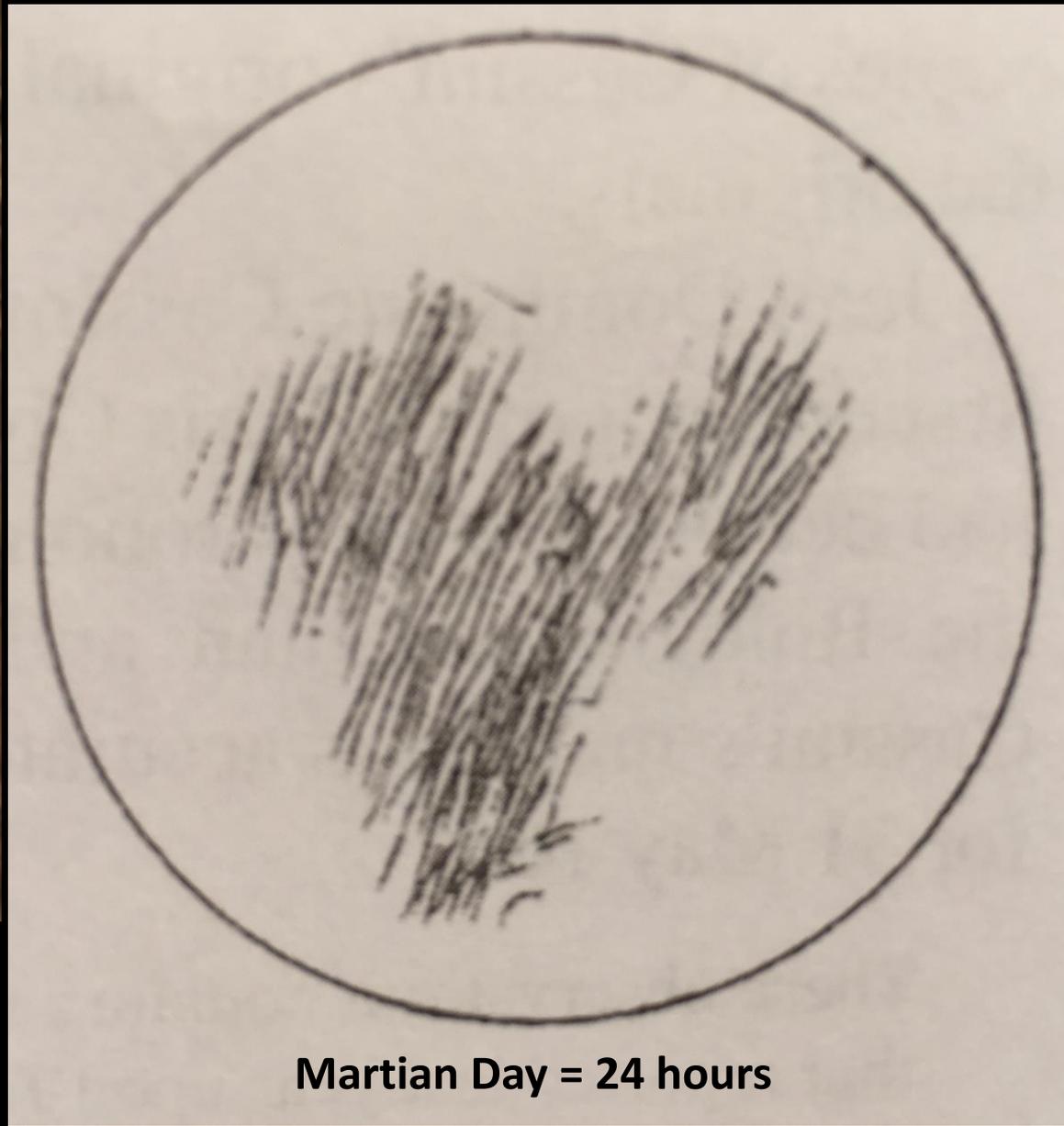
Discovered in 1930

- Too small
- Too cold
- Until 2015, just a point of light
- Never of interest for life



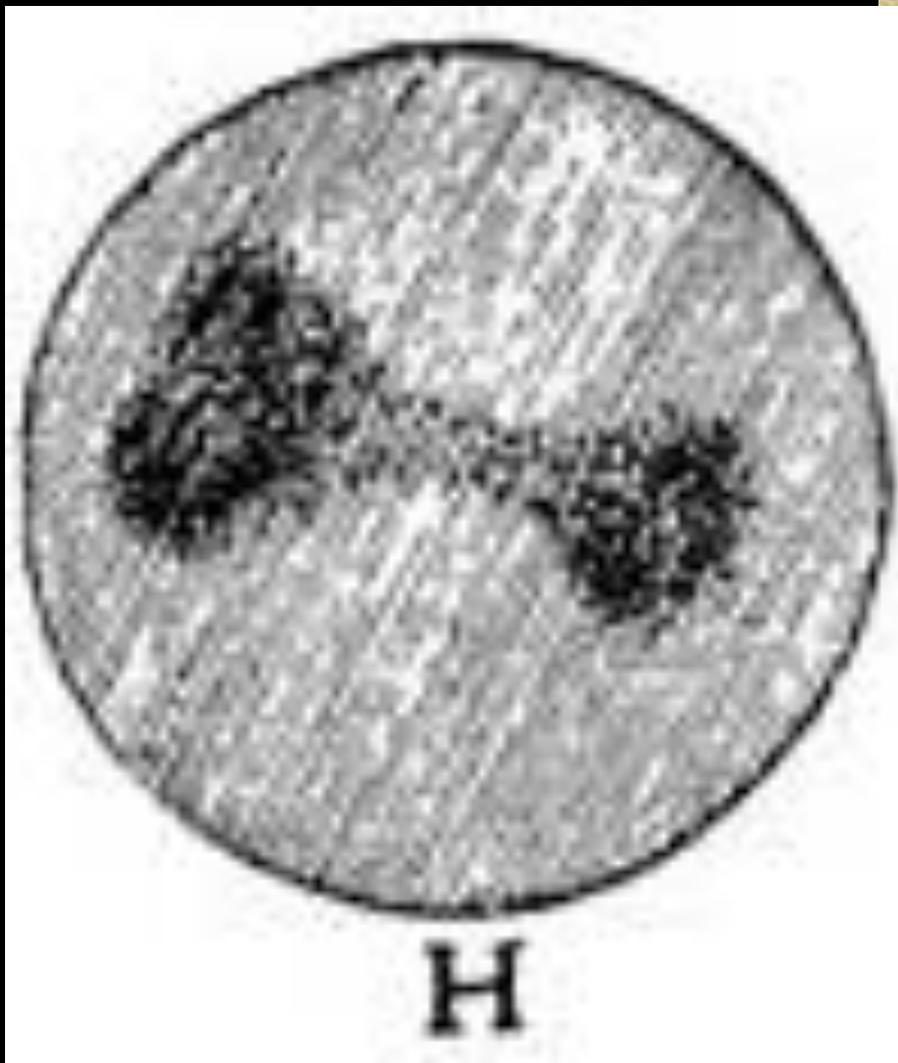
Mars





**Martian Day = 24 hours**

**Christiaan Huygens: 1659**



**Giovanni Cassini: 1666**



**Martian Day = 24 hours 40 minutes**



**Giacomo Maraldi:  
1704, 1719**



- **Martian Day = 24 hours 39 minutes**
- **Dark patches that vary in form and location**
- **Bright polar patches that change in size**

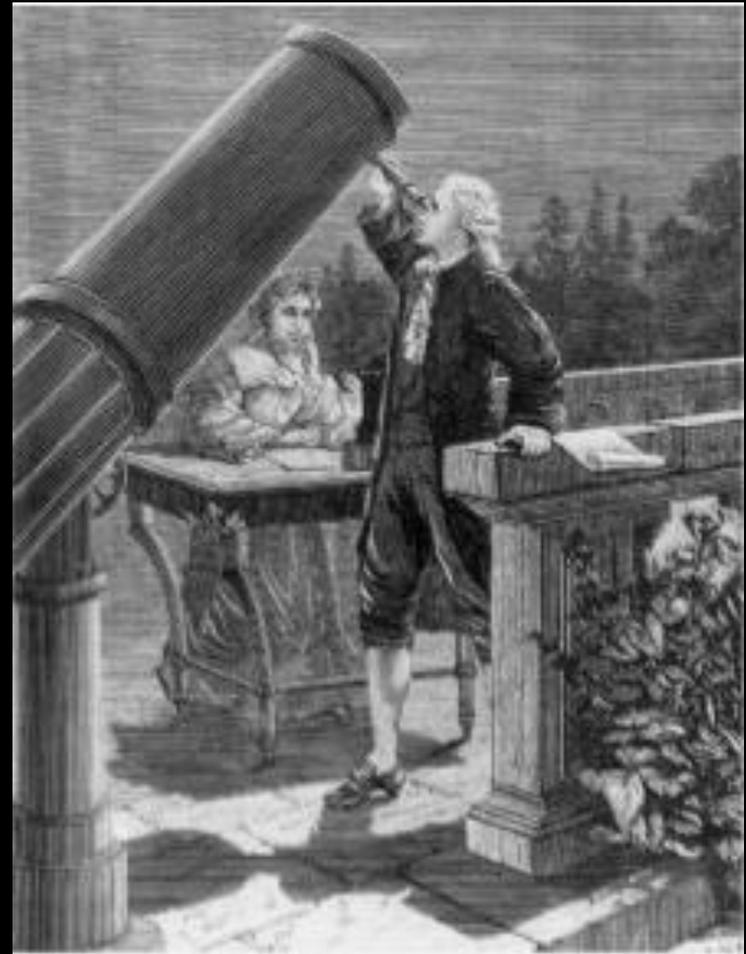
**Martian Day =  
24 hours 39 minutes 21.67 seconds  
(Actual: 24:39:35)**

### **Polar caps**

- **Wax and wane antisynchronously**
- **Must be the result of seasons**

### **Atmosphere**

- **Variations in brightness due to clouds and vapors**
- **Stars dimmed when close to Mars**



**William Herschel  
1777-1783**



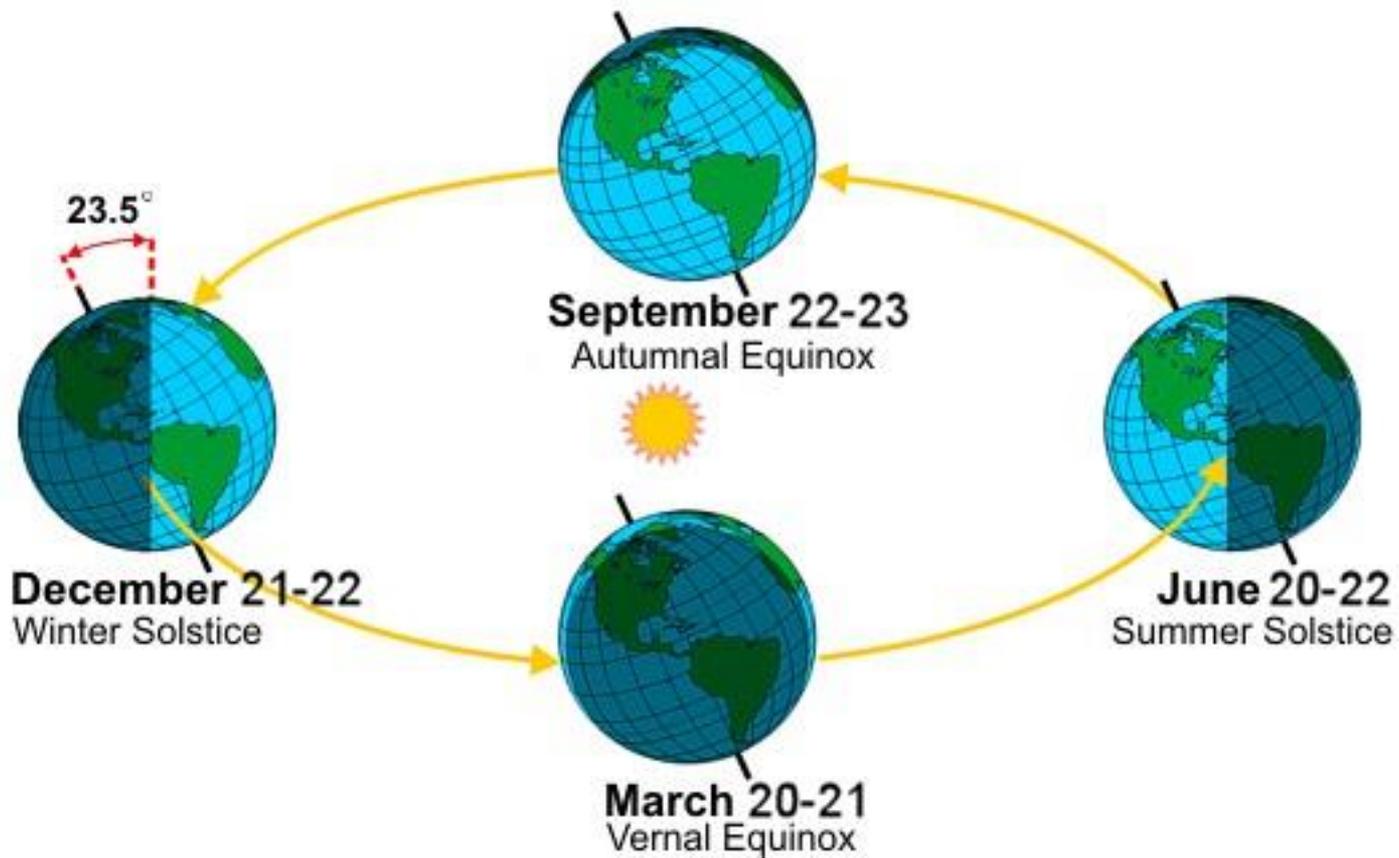
**Earth**  
**23°**



**Mars**  
**25°**

**Tilt of Mars' rotation axis → seasons**

**Martian tilt = 28.7° (actual = 25.2°)**



“The analogy between Mars and Earth is certainly more evident than for any other planets in the Solar System. Their diurnal movement is almost the same; the obliquity of the ecliptic, causing the seasons, is analogous; of all the superior planets, the distance of Mars from the Sun most nearly resembles that of Earth, and as a result the Martian year is not enormously different from ours.”

--- William Herschel, March 11, 1784

--- address to the Bath Philosophical Society, England

1800

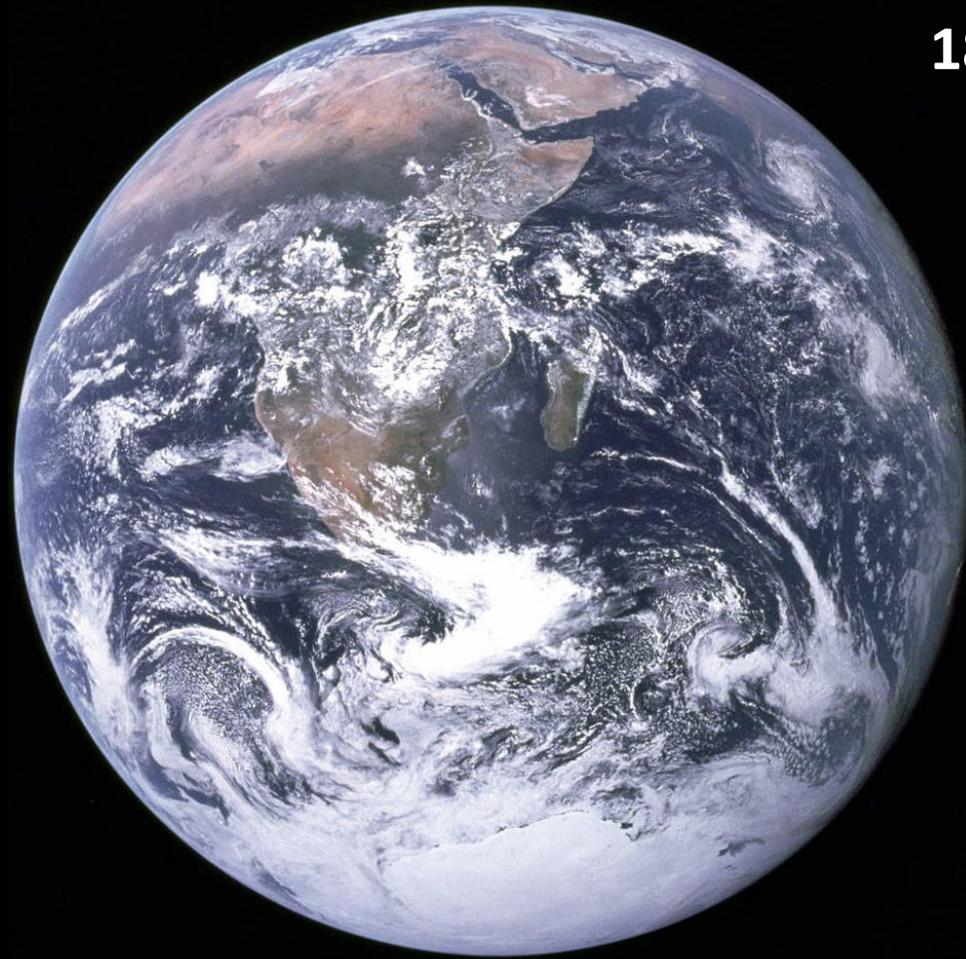
**MARS:**

- 24 hour, 39 minute day
- 687 earth-day year
- polar caps
- seasons
- thin atmosphere
- clouds

Another Earth?????

**EARTH:**

- 24 hour day
- 365 earth-day year
- polar caps
- seasons
- thin atmosphere
- clouds



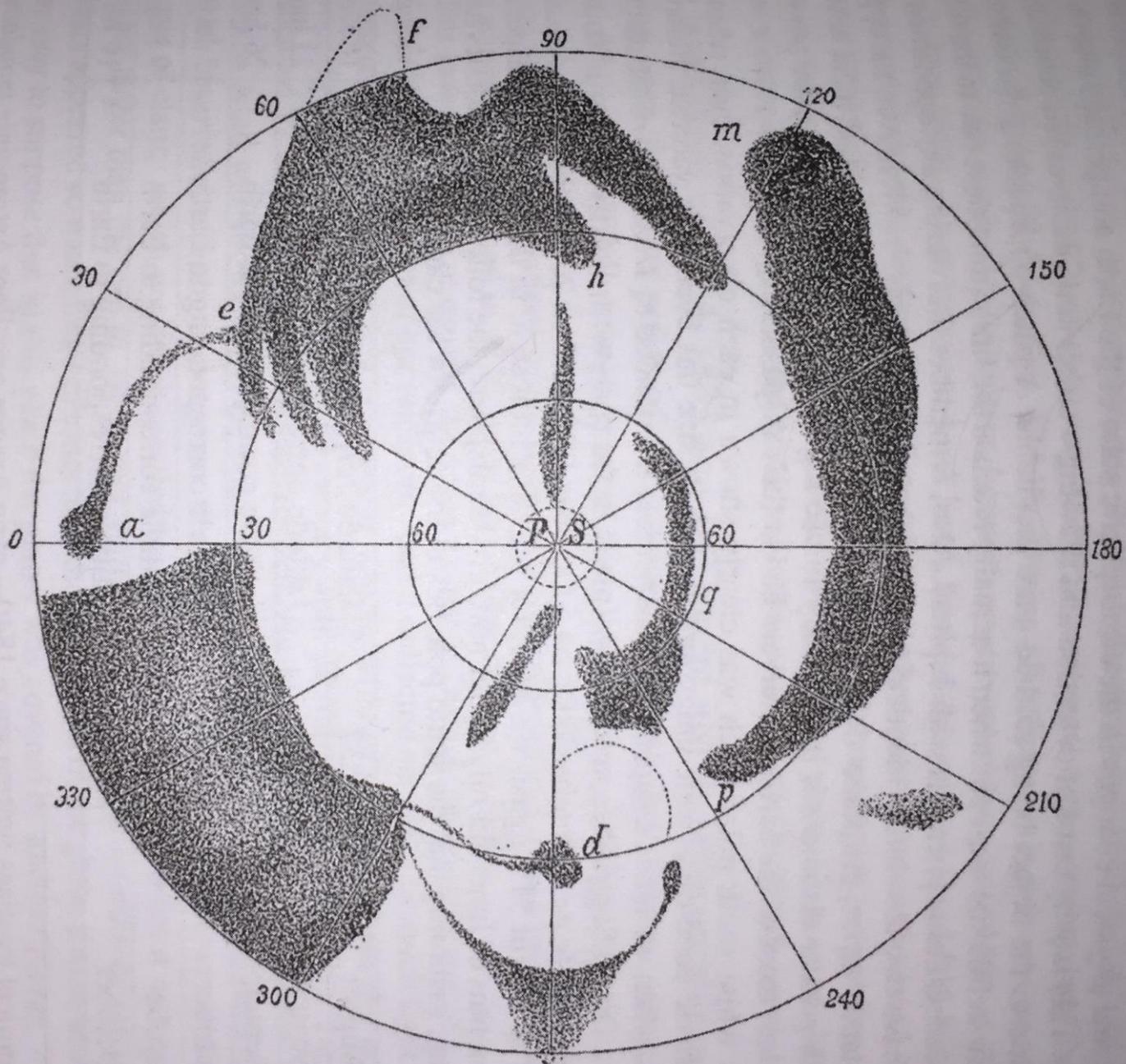
**1830 - 1839**

**Wilhelm Wolff Beer**

- Banker by trade
- Astronomer by hobby



**Johann Heinrich von  
Mädler**

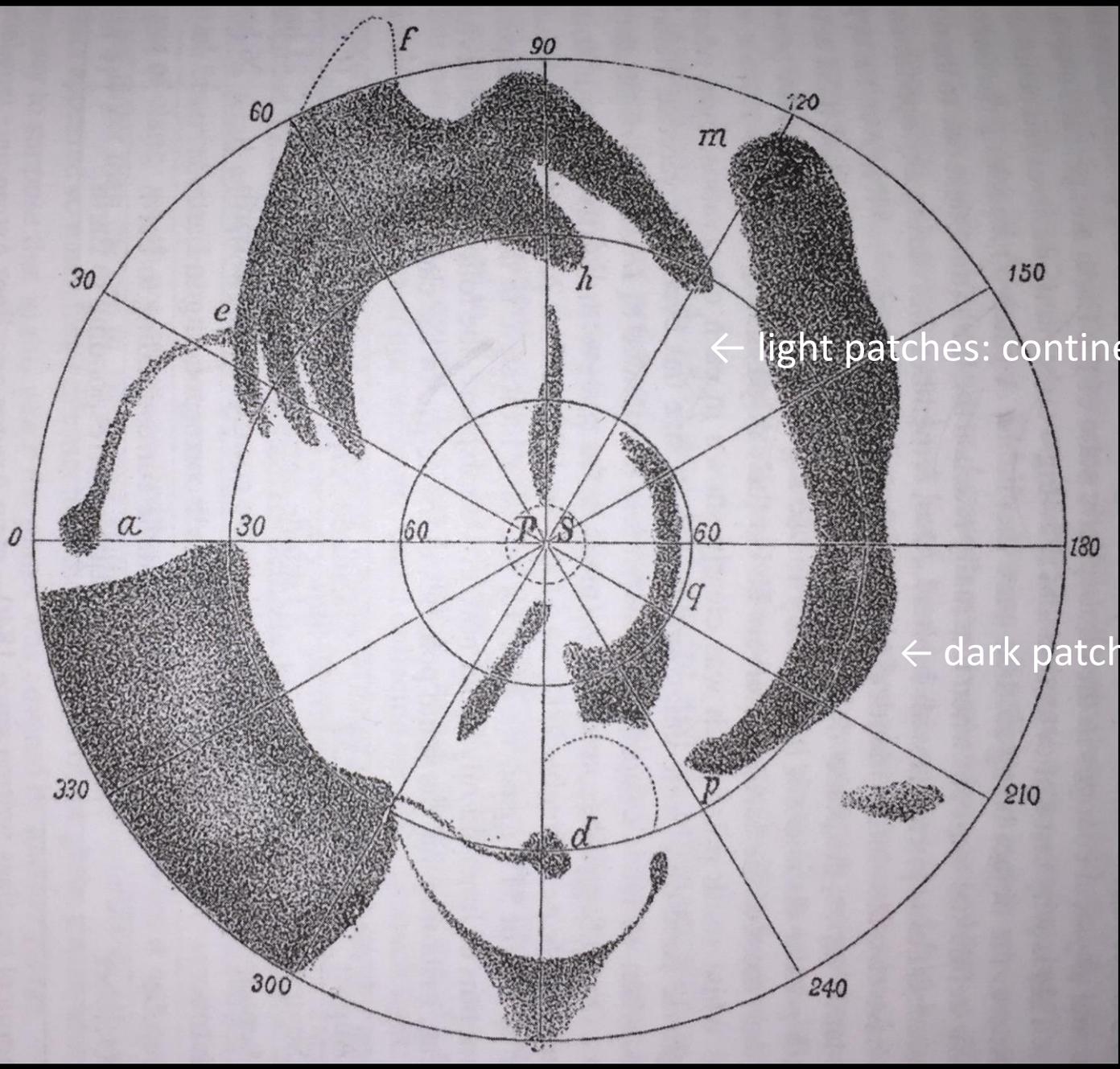


- defined longitude system from 'a' (Meridian Bay)
- Identified dark and bright patches
- Claimed reddish color of dark spots as proof that Mars has an atmosphere (wrong!)
- Claimed polar patches "genuinely made of snow" (wrong!)



← light patches: continents

← dark patches: oceans



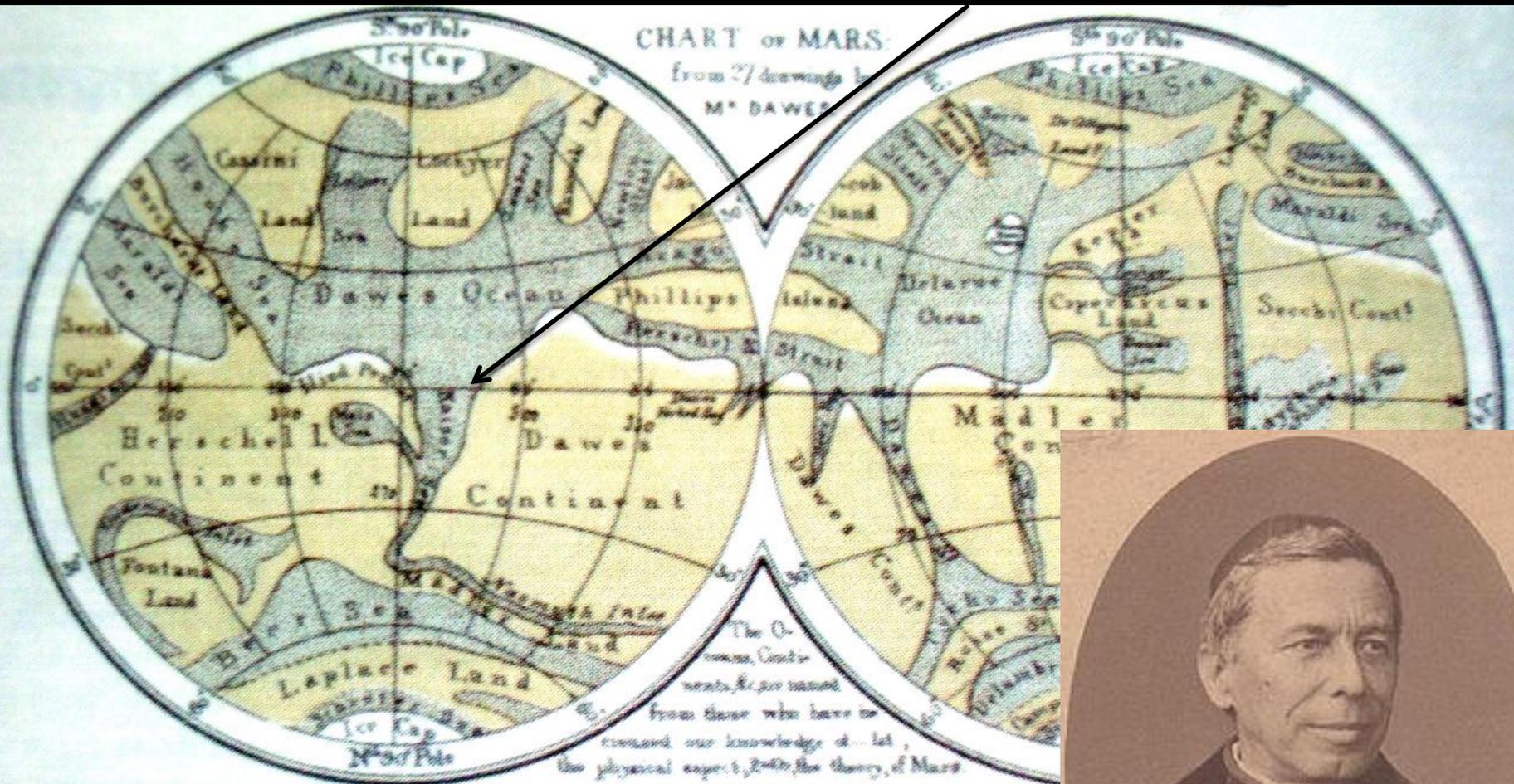
← light patches: continents (wrong!)

← dark patches: oceans (wrong!)

The polar patches are “genuinely made up of snow, shrinking with the onset of summer.” As the polar ice melts and evaporates, “the surface close to the evaporating snow will become extremely humid,” creating “wet marshy soil. ... It is not going too far to claim that Mars bears a strong resemblance to the Earth, even with regard to physical conditions.” ---- Beer and von Mädler, 1840

1858: "canali"

The Atlantic Canal (Syrtis Major)



Angelo Secchi

This Chart has been wholly formed from M<sup>r</sup> Dawes' drawings, which far surpass all others I have met with. I have consulted, however, upwards of 200 drawings of Mars, by Hooke, Cassini, Maraldi, Sir W. Herschel, Beer, and excellent and consistent series of views by M<sup>r</sup> Lockyer in 1842. I have also consulted charts of Mars by Beer and Müller estimate Mars' Rotation-period at  $24^h 37^m 23.6^s$

From a comparison of a view by Hooke on Mar 3, 1666 (O.S. - Mar 13, 1666) M<sup>r</sup> Dawes on Nov 28, 1864 (in which interval Mars rotated 79740 times, I make  $24^h 37^m 22.73^s$  with a probable error of 0.02 sec.

(sketch by Richard Proctor, 1880, using 1864-65 drawing by William Dawes)



### Suez Canal:

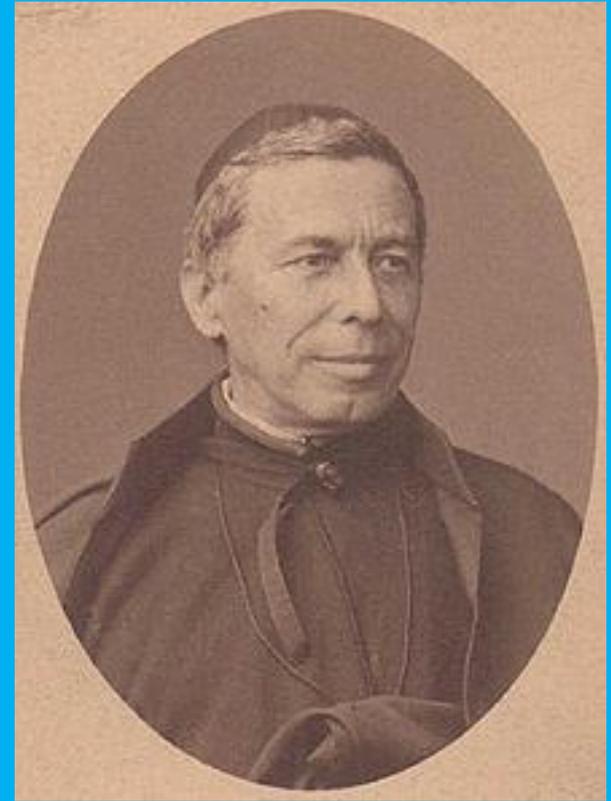
- Planning stage 1854-1858
- Construction: 1859-1869
- Length (original): 102 miles

Secchi, 1862

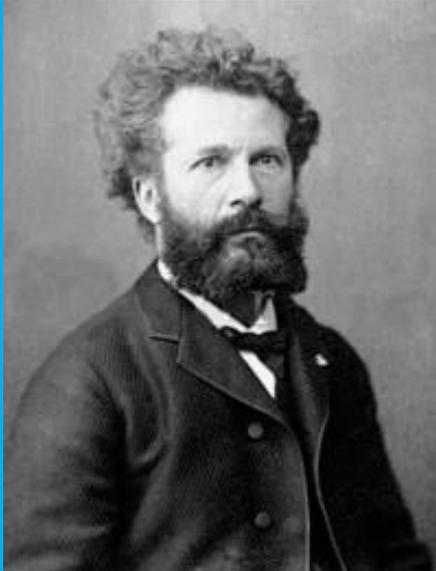
“the Atlantic Canal, a name given for brevity to this large blue patch which seems to play the role of the Atlantic which, on Earth, separates the Old World from the New.”

“these two canali enclose a reddish continental area. ... The reddish regions, like the bluish ones, seem too permanent for their nature to be doubted; it is probable that the former are solid the latter liquid.”

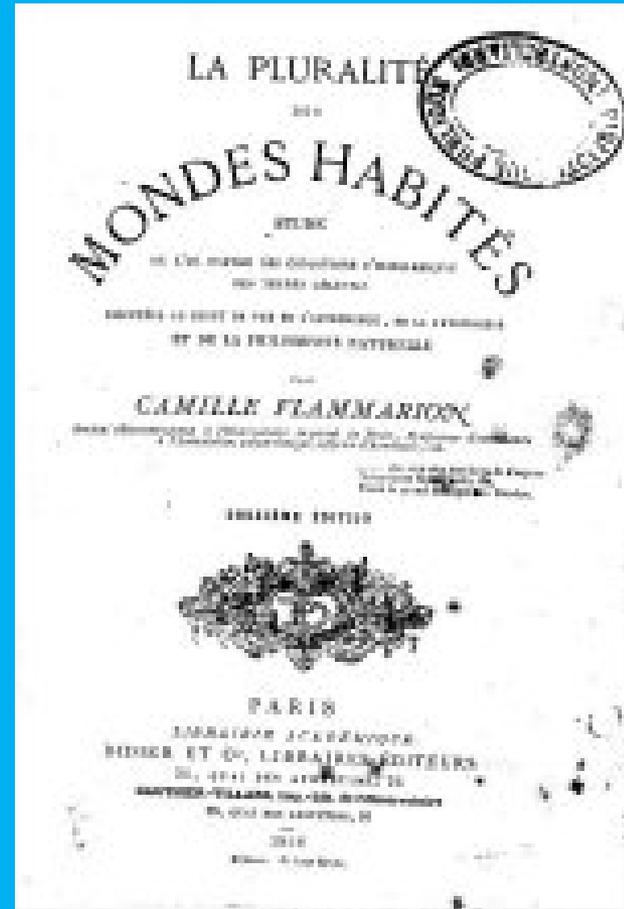
The variations in the sizes of the polar patches and in the appearances of clouds “proved that liquid water and seas exist on Mars ... the existence of seas and continents, and even the alternations of the seasons and the atmospheric variations, have been today conclusively proved.”



Camille Flammarion



*Plurality of Popular Worlds*  
1862



“The atmospheric envelopes which surround it and Earth; the snows which appear periodically over the poles of both planets; the clouds which extend from time to time in their atmospheres; the geographical arrangement of their surfaces in terms of continents and seas; the seasonal variations and the climates common to these two worlds; leads us to believe that both planets are inhabited by beings whose organization is of similar character.”



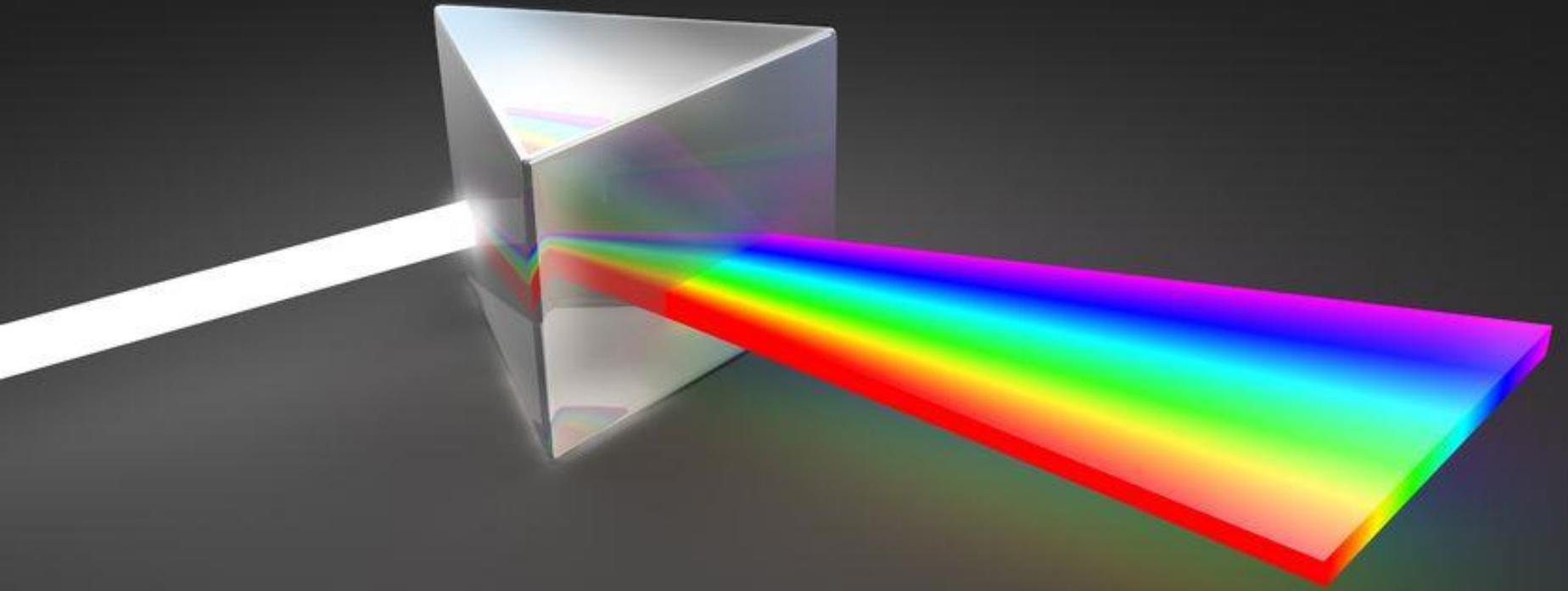
Water everywhere on Mars!!!!  
Canals, rivers oceans, seas, bays

Red color: evidence of vegetation!!!!

ALL WE NEED IS PROOF

*TIME TO INVENT ASTROPHYSICS*

spectroscopy



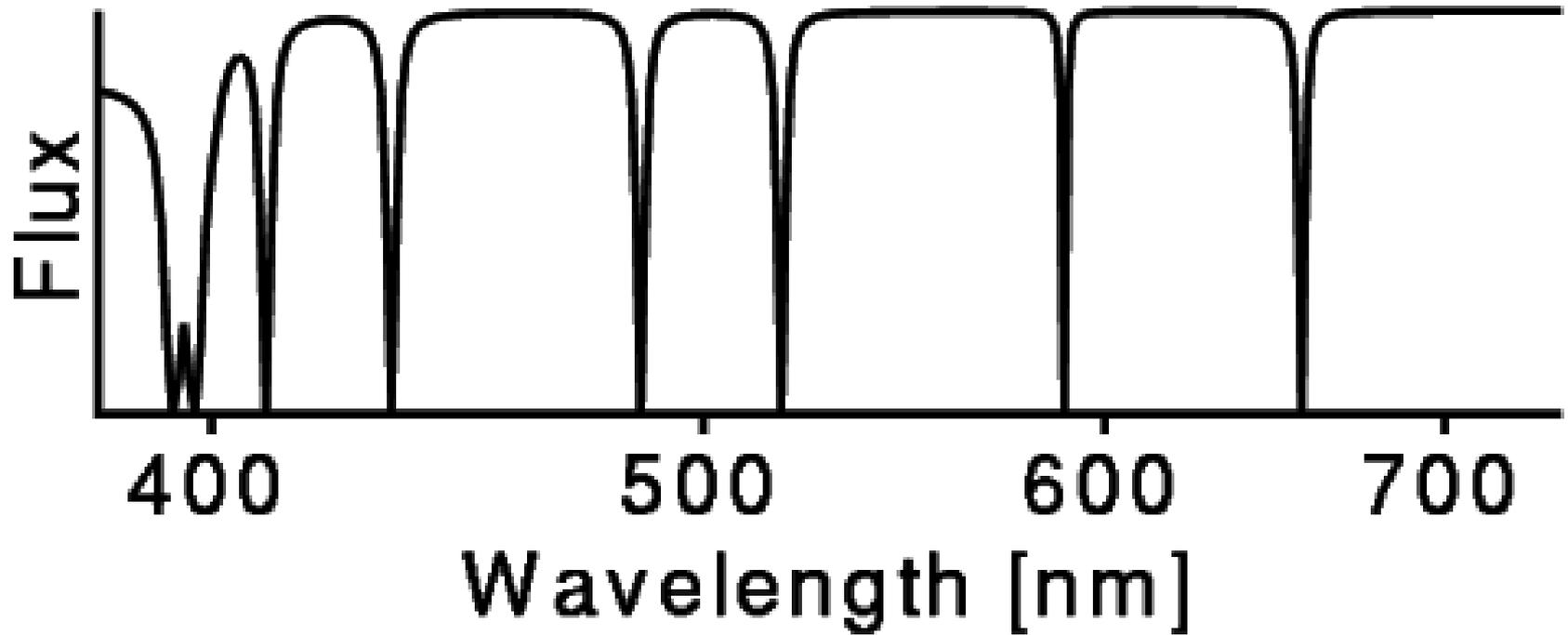
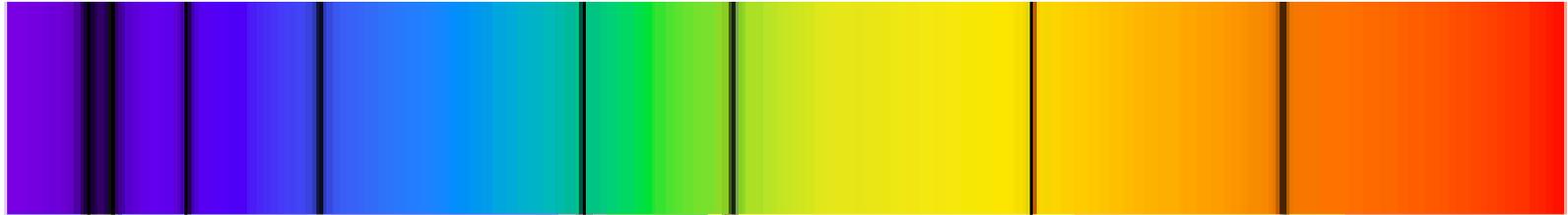
Spectral lines

400

500

600

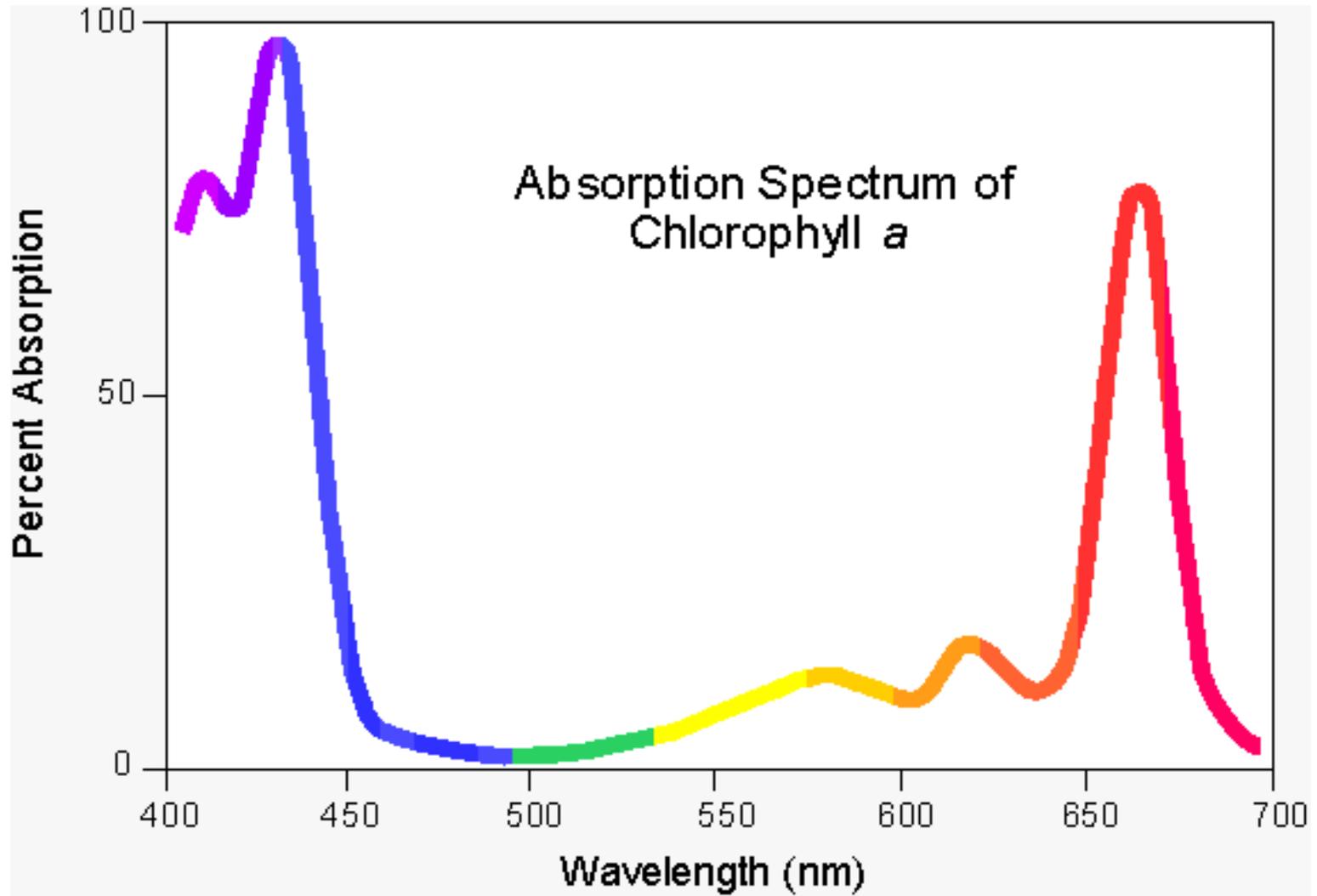
700



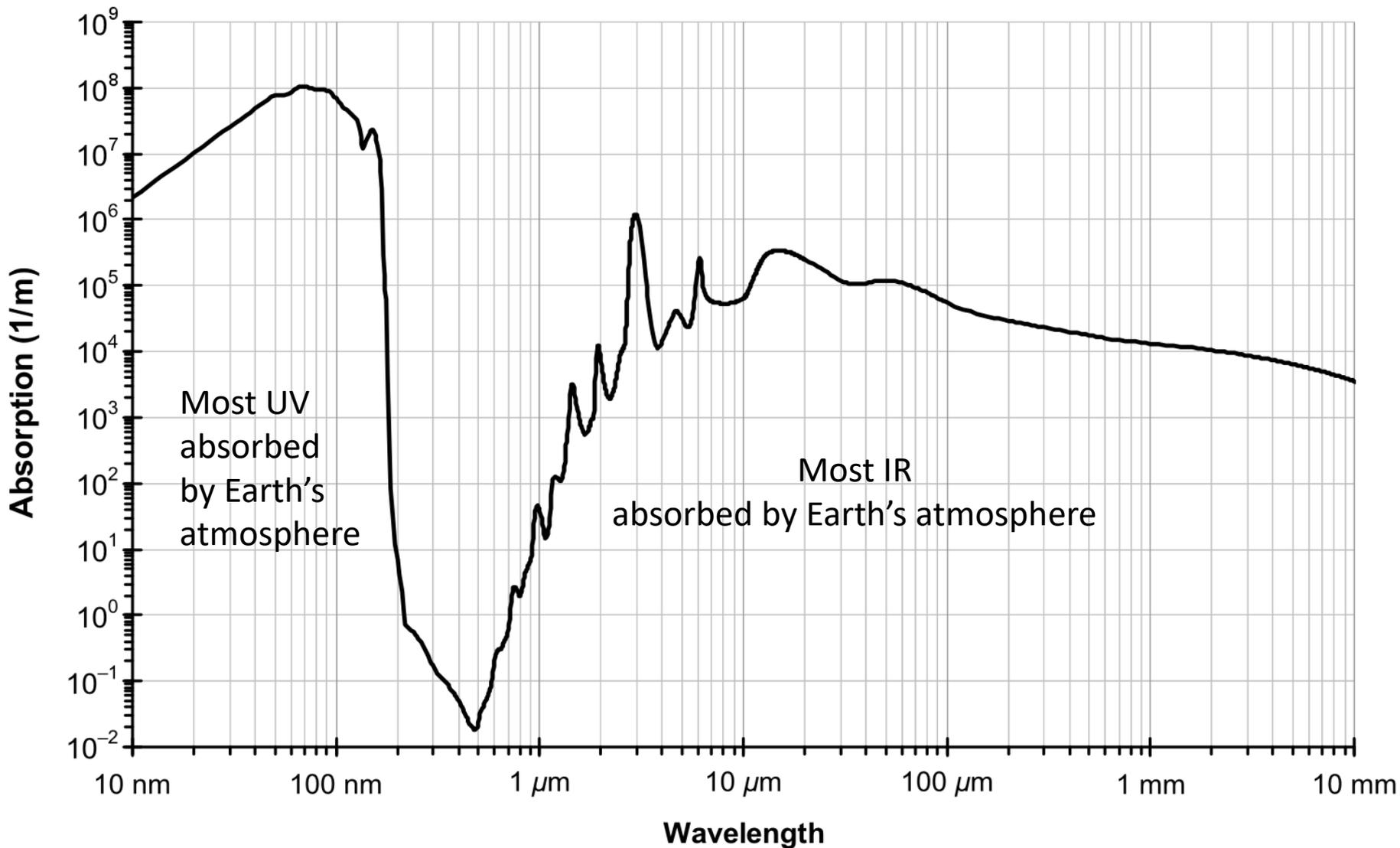
Blue absorbed

green gets through

red absorbed



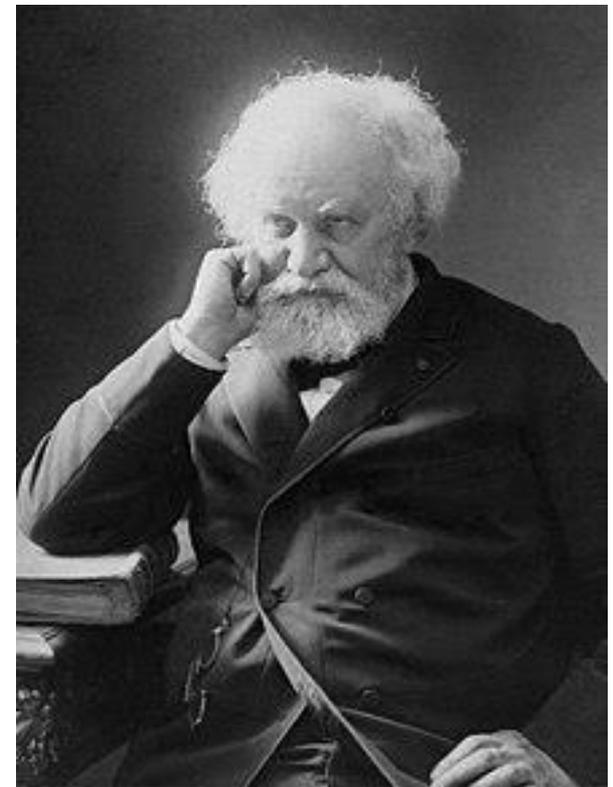
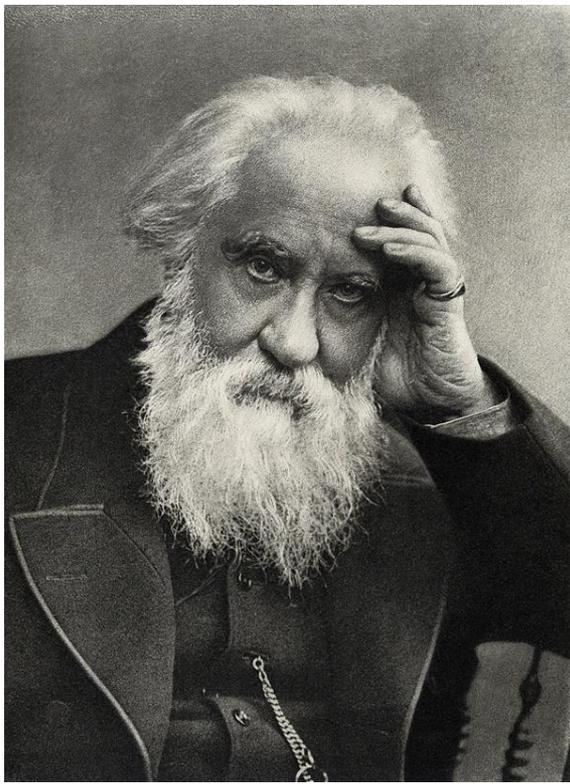
# Water vapor absorption



Most UV  
absorbed  
by Earth's  
atmosphere

Most IR  
absorbed by Earth's atmosphere





William Huggins (1824 – 1910)  
Gold Medal, RAS (1867, 1885)  
President, RAS (1876-1878)  
Fellow, Royal Society (1865)  
President, Royal Society (1900-1905)

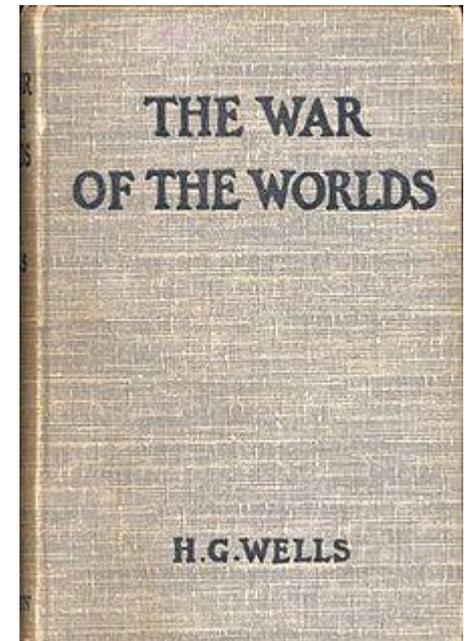
Jules Janssen (1824-1907)  
Co-discovered Helium  
Director, Meudon Observatory

William Allen Miller (1817 – 1870)  
Chemist, King's College, London

Insert cornhill stuff:Huggins as great hero

1898

## The Rise of Mars in Popular Culture



# Radio Listeners in Panic, Taking War Drama as Fact

*Many Flee Homes to Escape 'Gas Raid From Mars'—Phone Calls Swamp Police at Broadcast of Wells Fantasy*

A wave of mass hysteria seized thousands of radio listeners throughout the nation between 8:15 and 9:30 o'clock last night when a broadcast of a dramatization of H. G. Wells's fantasy, "The War of the Worlds," led thousands to believe that an interplanetary conflict had started with invading Martians spreading wide death and

and radio stations here and in other cities of the United States and Canada seeking advice on protective measures against the raids.

The program was produced by Mr. Welles and the Mercury Theatre on the Air over station WABC and the Columbia Broadcasting System's coast-to-coast network, from 8 to 9 o'clock.



**A PROPHETIC ROMANCE**

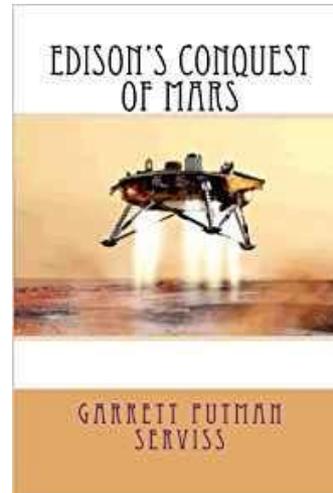
MARS TO EARTH  
JOHN F. MCCOY



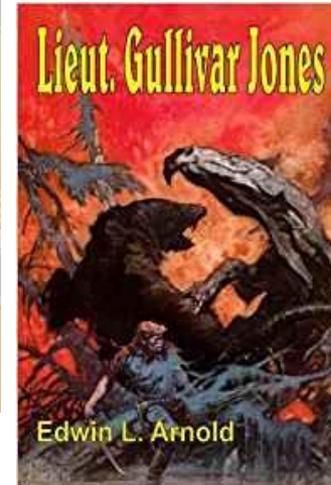
John McCoy  
*A Prophetic  
Romance: Mars  
to Earth*  
1896



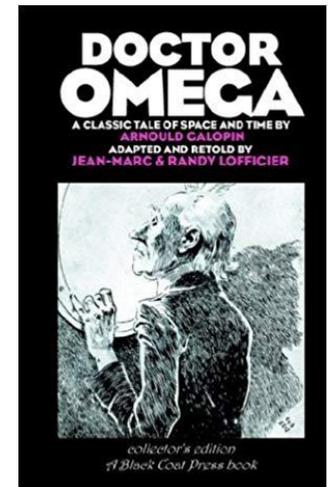
George du  
Maurier  
*The Martian*  
1897



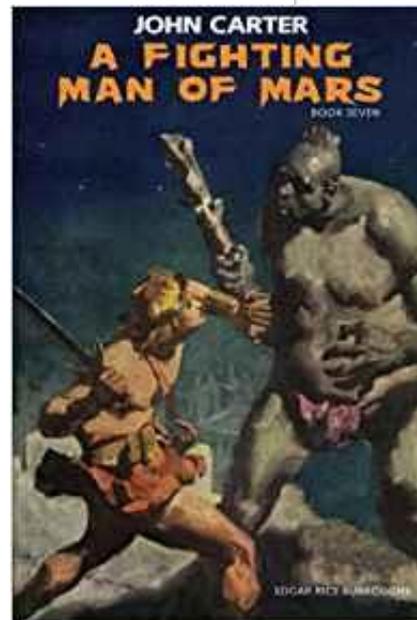
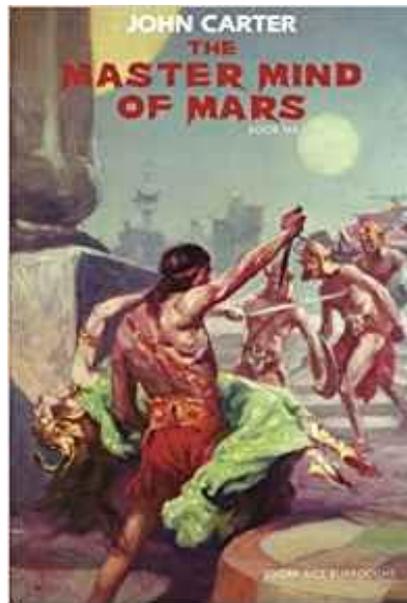
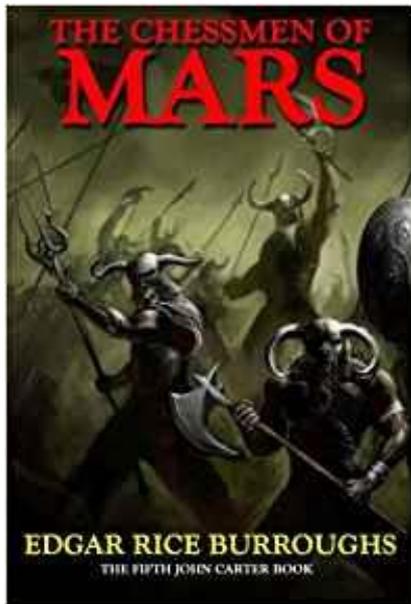
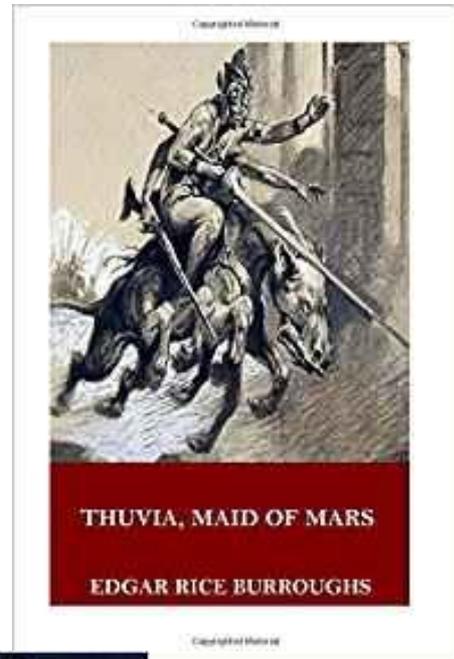
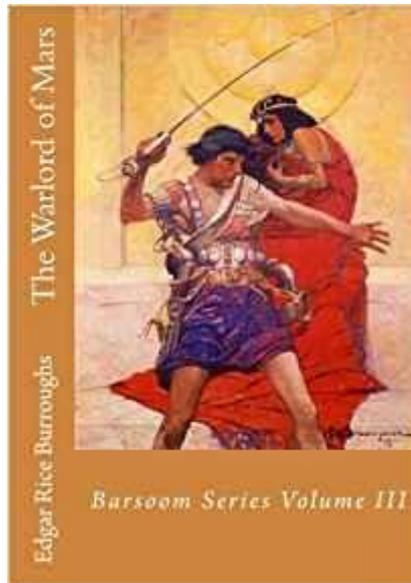
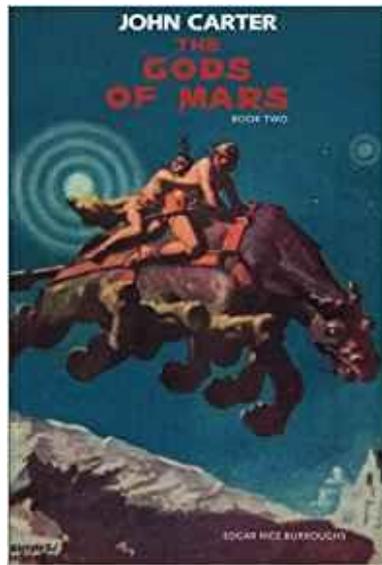
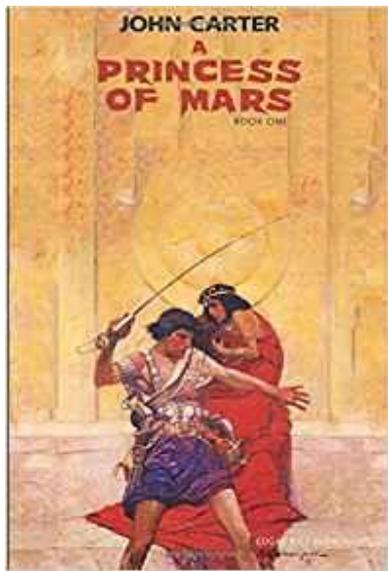
Garret P.  
Serviss  
*Edison's  
Conquest of  
Mars*  
1898



Edwin Arnold  
*Lieut. Gullivar  
Jones: His  
Vacation*  
1905



Arnould  
Galopin  
*Doctor Omega*  
1906



*Barsoom*  
Series  
by  
Edgar Rice  
Burroughs  
(1912+)



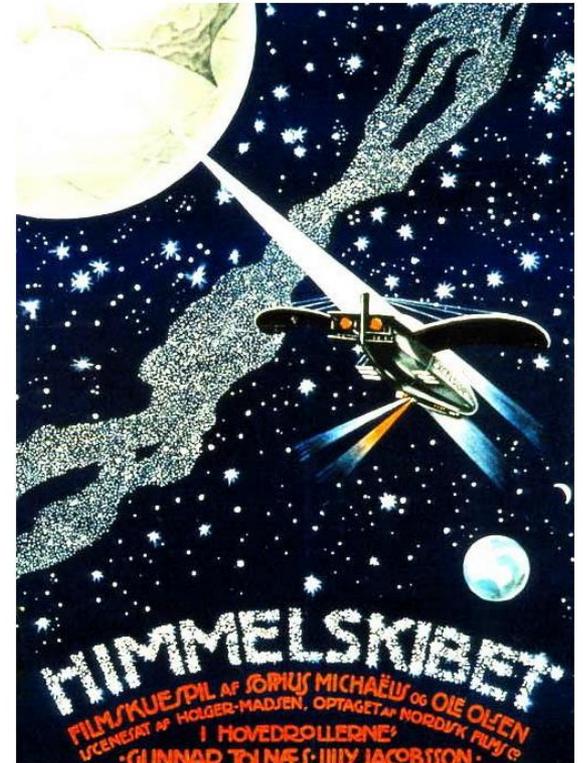
Director: Ashley Miller  
1910  
The Edison Company  
Short (5 min.)

<https://www.imdb.com/title/tt1515725/>



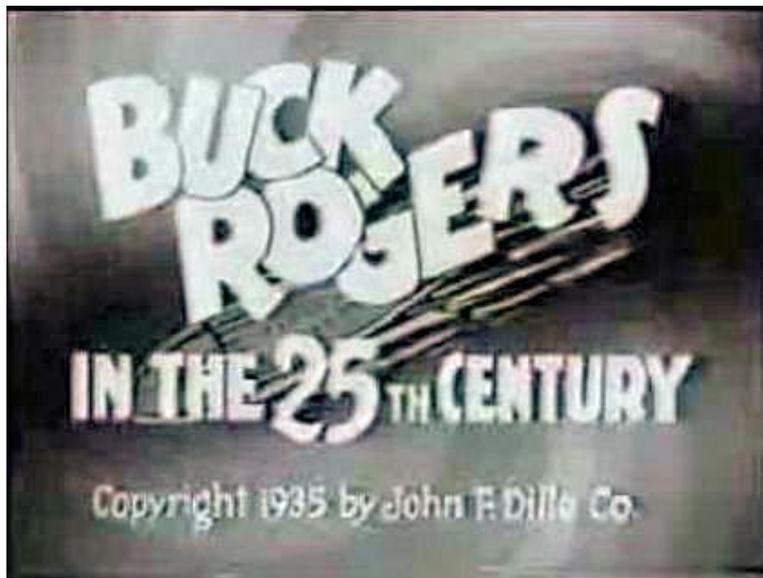
Director: Wallett Waller  
1913  
Full length (69 min.)

<https://www.imdb.com/title/tt0316241/>



Director: Holger-Madsen  
1918  
Full length (80 min.)

<http://horrornews.net/76688/film-review-a-trip-to-mars-1918/>

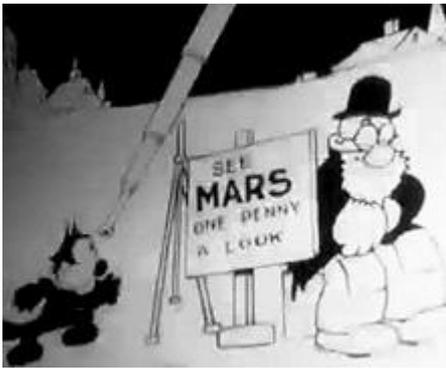


*Buck Rogers in the 25<sup>th</sup> Century:  
An Interplanetary Battle with the Tiger Men of Mars (1934)*

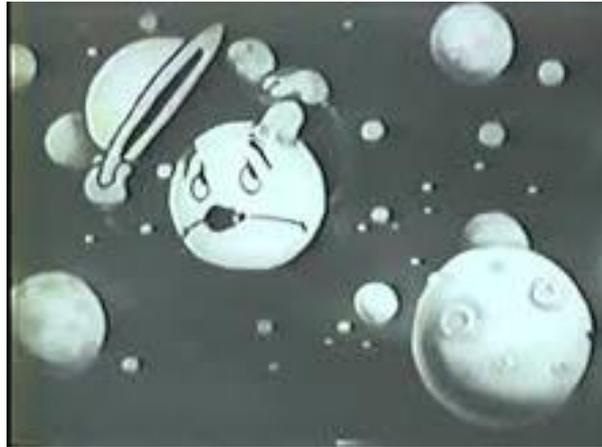
*Flash Gordon's Trip to Mars (1938)*

[http://gotomars.free.fr/buck\\_rogers\\_1934.htm](http://gotomars.free.fr/buck_rogers_1934.htm)  
<https://www.imdb.com/title/tt0030138/>





*Felix the Cat Flirts  
With Hate  
(1926)*



*Bimbo Up to Mars  
(1930)*



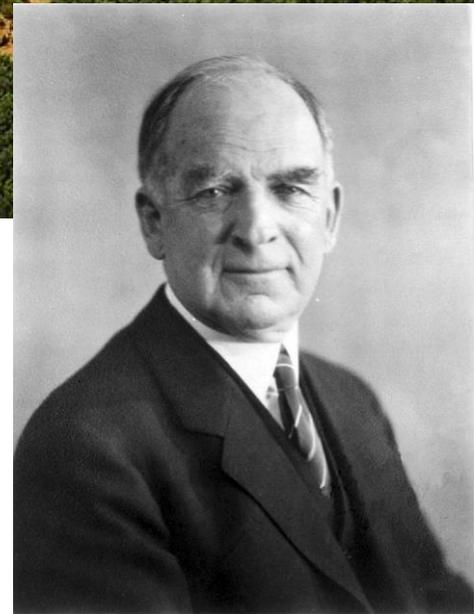
*Oswald the Lucky  
Rabbit: Mars  
(1930)*



*Popeye's Rocket to Mars  
(1946)*



William Wallace Campbell (1862 – 1938)  
Director, Lick Observatory (1901-1930)





36-inch refractor: largest telescope on Earth (1888-1897)

1890s: “The spectra of Mars and the Moon ... seem to be identical in every respect.”



## HIGH-DISPERSION SPECTRA OF MARS

C. C. KIESS, C. H. CORLISS, HARRIET K. KIESS, AND EDITH L. R. CORLISS

National Geographic Society

and

National Bureau of Standards, Washington, D.C.

*Received April 19, 1957; revised June 10, 1957*

### ABSTRACT

In July, 1956, a concave-grating spectrograph was set up at the Slope Observatory of the U.S. Weather Bureau, near the summit of Mauna Loa, Hawaii, for the purpose of photographing spectra of Mars with high dispersion. Several sets of spectrograms with spectra of the moon and Mars in juxtaposition were obtained with dispersions of 5 and 2 Å/mm. The shortward shift of the spectrum of Mars, due to the Doppler-Fizeau effect, was sufficient to separate Martian lines of O<sub>2</sub> and H<sub>2</sub>O in the B and "a" bands from those of terrestrial origin. No such shifted lines were detected. After opposition, our spec-

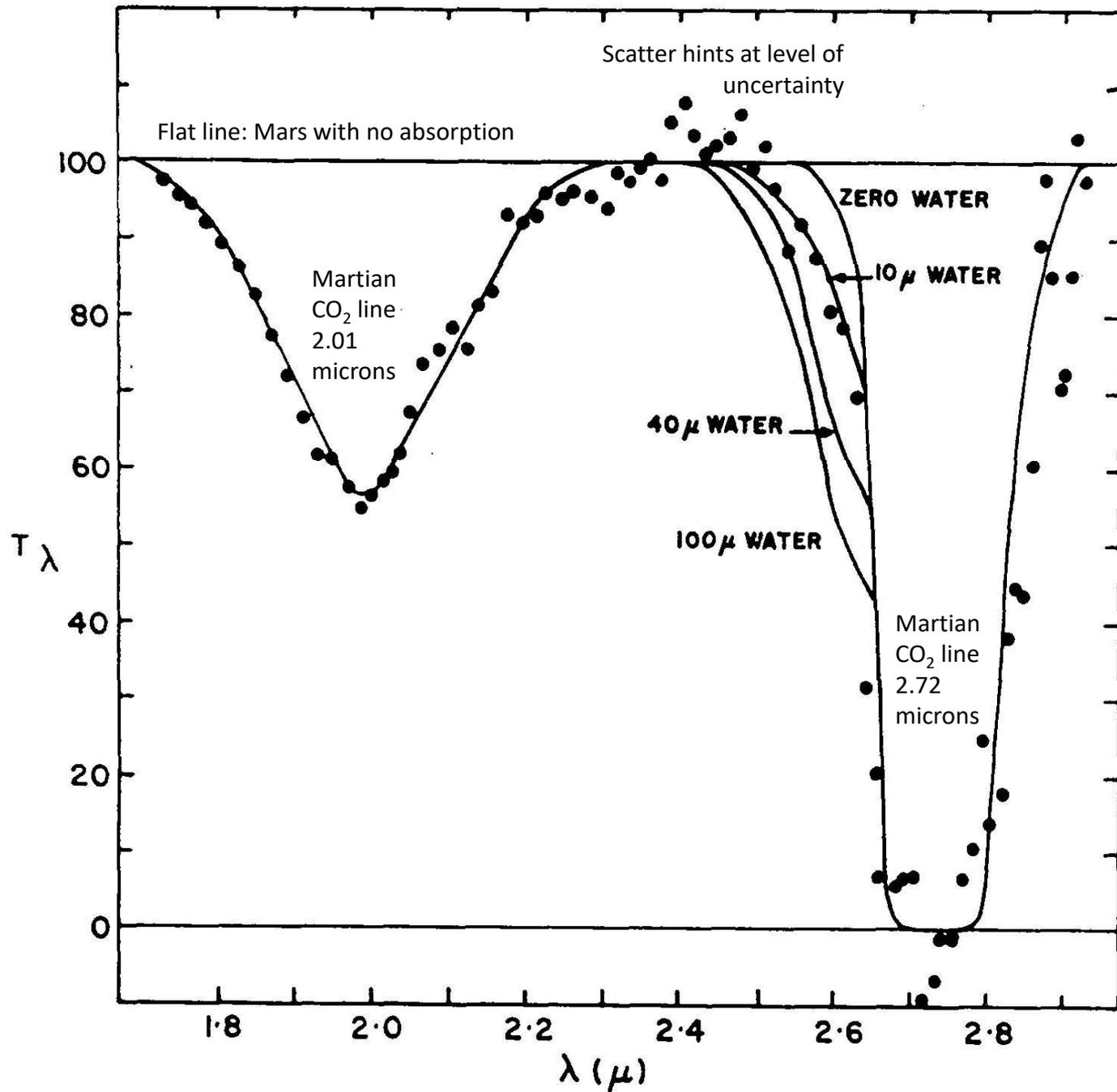
< 80 micron thick  
layer of water on  
Mars



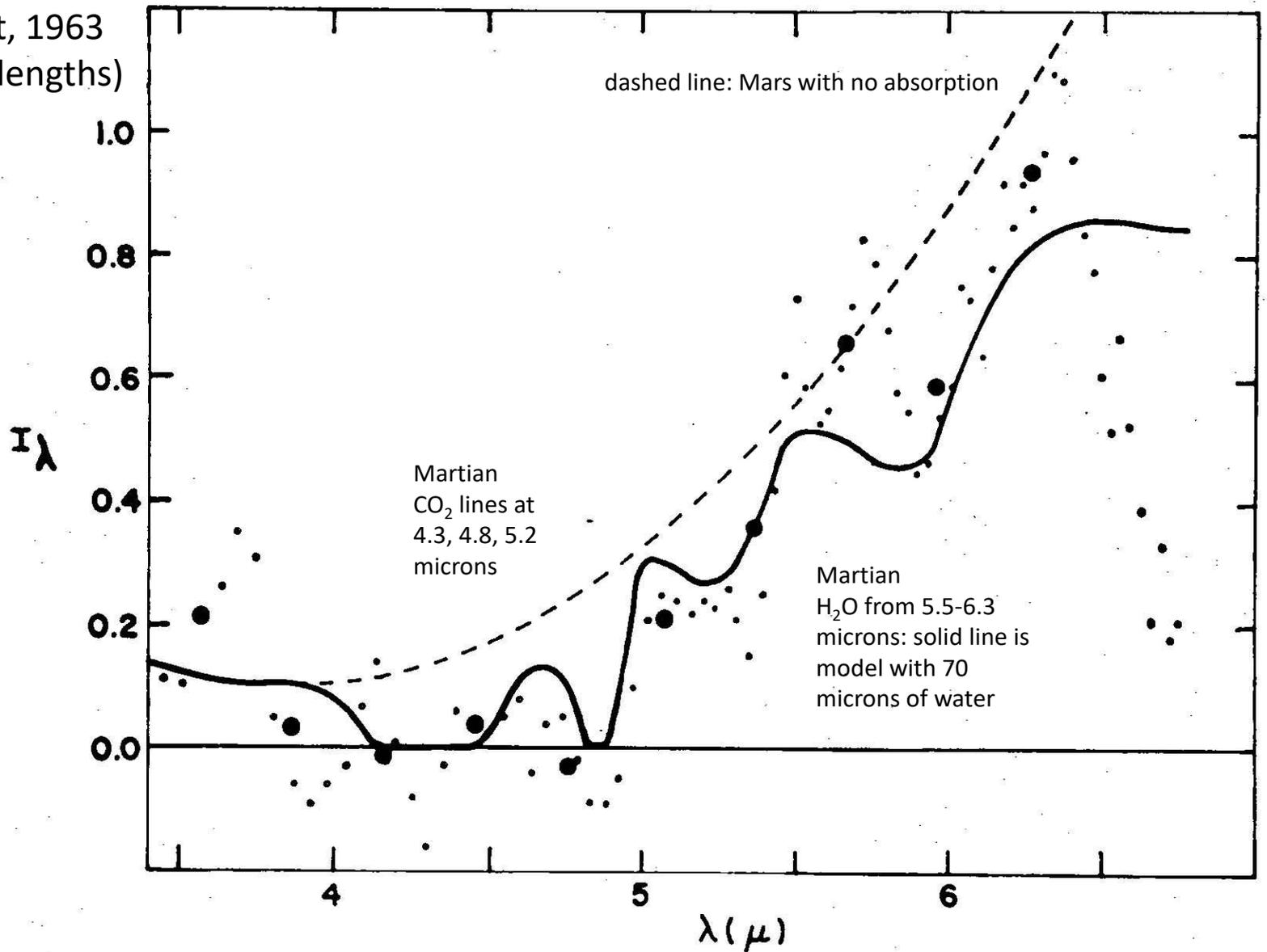
Stratoscope II high-altitude balloon experiment, 1963 (short wavelengths)

Press conference: "it's pretty certain" we detected water on Mars"

WSJ headline: "Lower Life Forms May be able to Live in Mars Atmosphere, Balloon Findings Show"

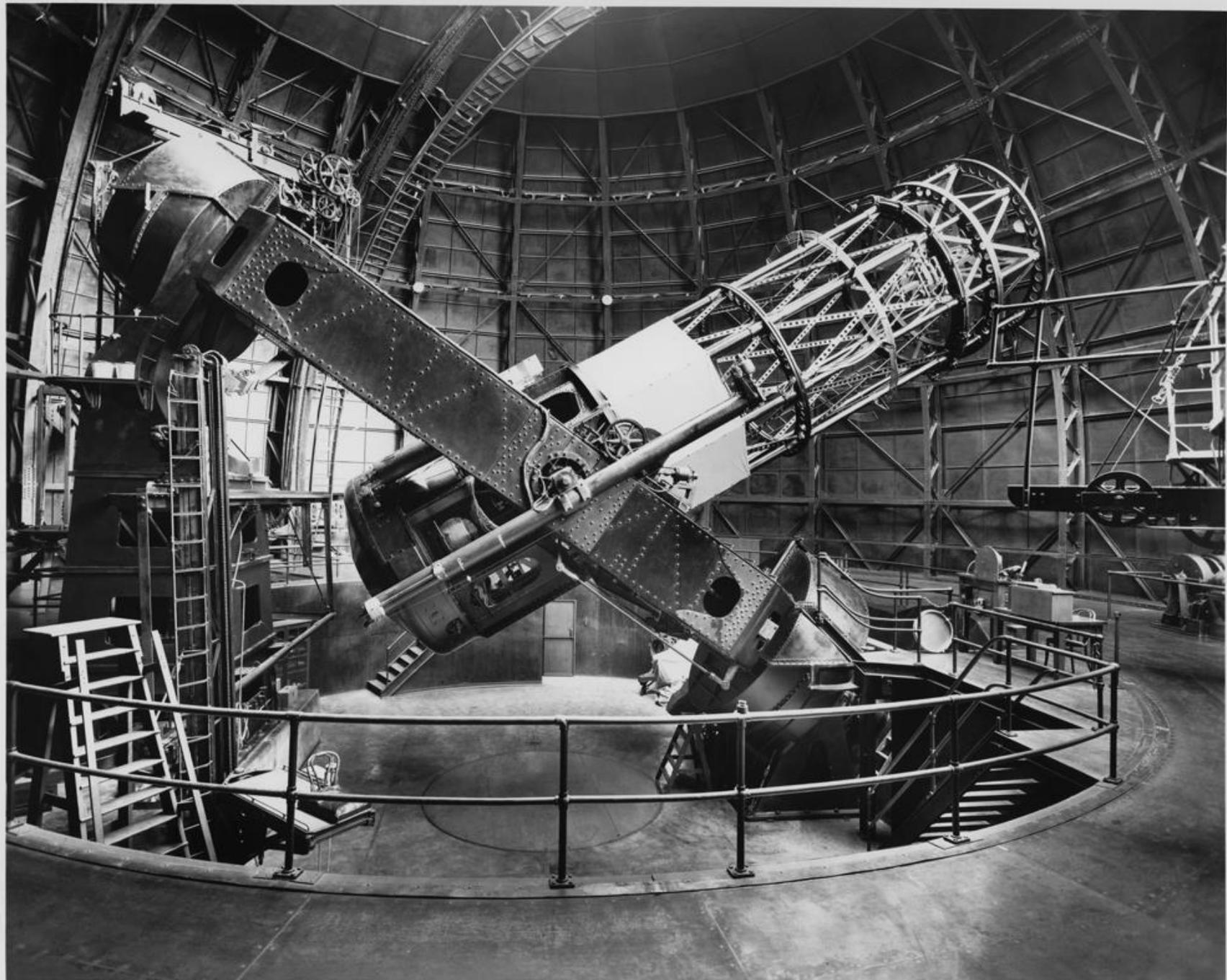


Stratoscope II high-altitude balloon experiment, 1963 (long wavelengths)





Dome for 100-inch Hooker Telescope, Mt. Wilson, CA (1917)



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NUMBER 1

## AN ANALYSIS OF THE SPECTRUM OF MARS

LEWIS D. KAPLAN, GUIDO MÜNCH, AND HYRON SPINRAD

Space Sciences Division, Jet Propulsion Laboratory and Mount Wilson and Palomar Observatories  
Carnegie Institution of Washington, California Institute of Technology

*Received November 11, 1963*

### ABSTRACT

On a high-dispersion spectrogram of Mars taken at Mount Wilson rotational lines of H<sub>2</sub>O near  $\lambda$  8300 and CO<sub>2</sub> near  $\lambda$  8700 have been detected. Recent laboratory measurements of line strengths by D. Rank have been used to determine the amounts of H<sub>2</sub>O and CO<sub>2</sub> in the atmosphere of Mars:  $14 \pm 7 \mu$  precipitable water and  $55 \pm 20$  m atm CO<sub>2</sub>. From the absence of O<sub>2</sub> in the Martian spectra, we set an upper limit of 70 cm atm for the O<sub>2</sub> content.

By suitably combining the CO<sub>2</sub> amount with observations by Kuiper and Sinton of the strongly saturated bands in the 2- $\mu$  region, a surface pressure of  $25 \pm 15$  mb has been derived.

The implications of the results on the composition of the Martian atmosphere are discussed.

1971: “Water exists on Mars. The water vapor varies with location on the planet, the season on Mars, and from year to year. The water appears to cycle through the polar caps, which are partly H<sub>2</sub>O. The total amount of water in the atmosphere of Mars is at most a few cubic kilometers.”

[would yield a global layer ~25 microns deep;  
compare to width of human hair --- 17 to 180 microns]

1992: the work of Huggins and Janssen “are no longer believed”

