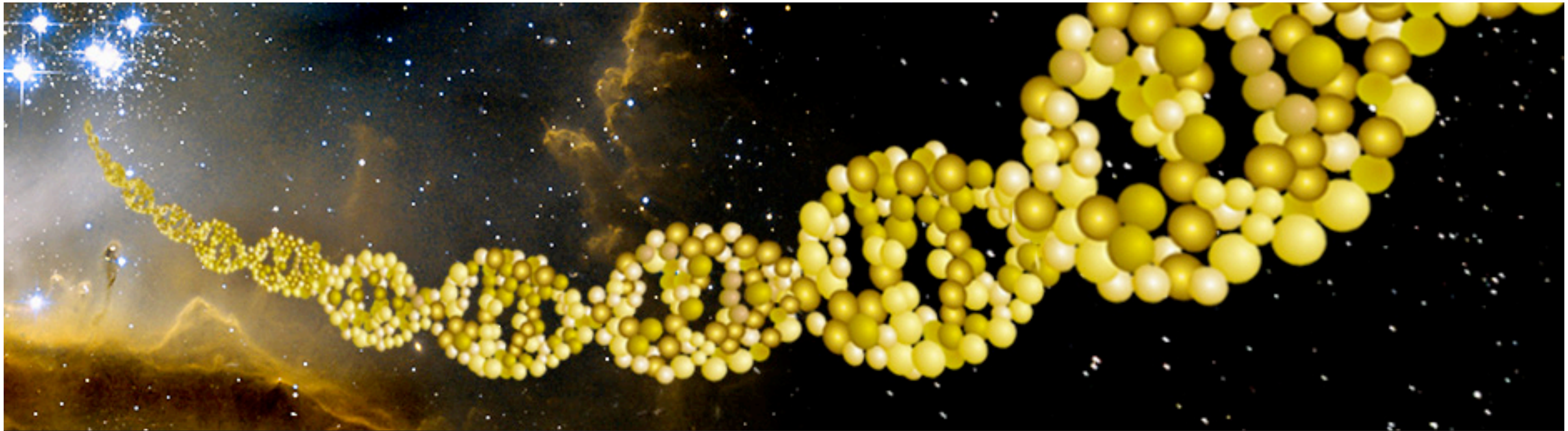


L'Universo e la vita

Amedeo Balbi

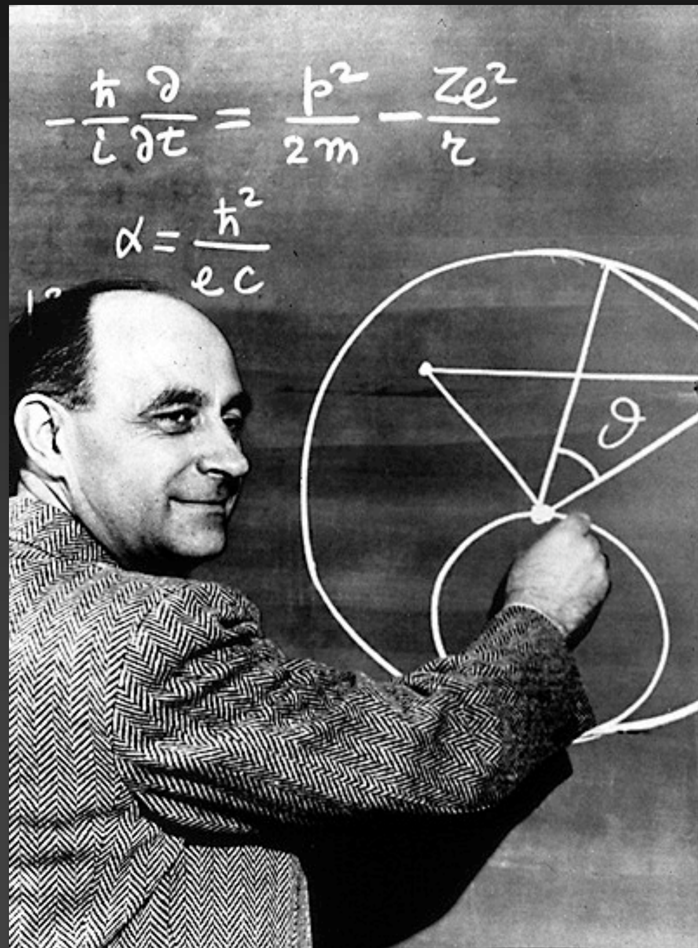
Dipartimento di Fisica & INFN

Università di Roma Tor Vergata

http://www.keplero.org

“Se esistono, allora dove sono?”

— Enrico Fermi, 1950



“Perché è impossibile ch’un razionale ed alquanto svegliato ingegno possa imaginarsi, che sieno privi di simili e megliori abitanti mondi innumerabili, che si mostrano o cossì o più magnifici di questo.”

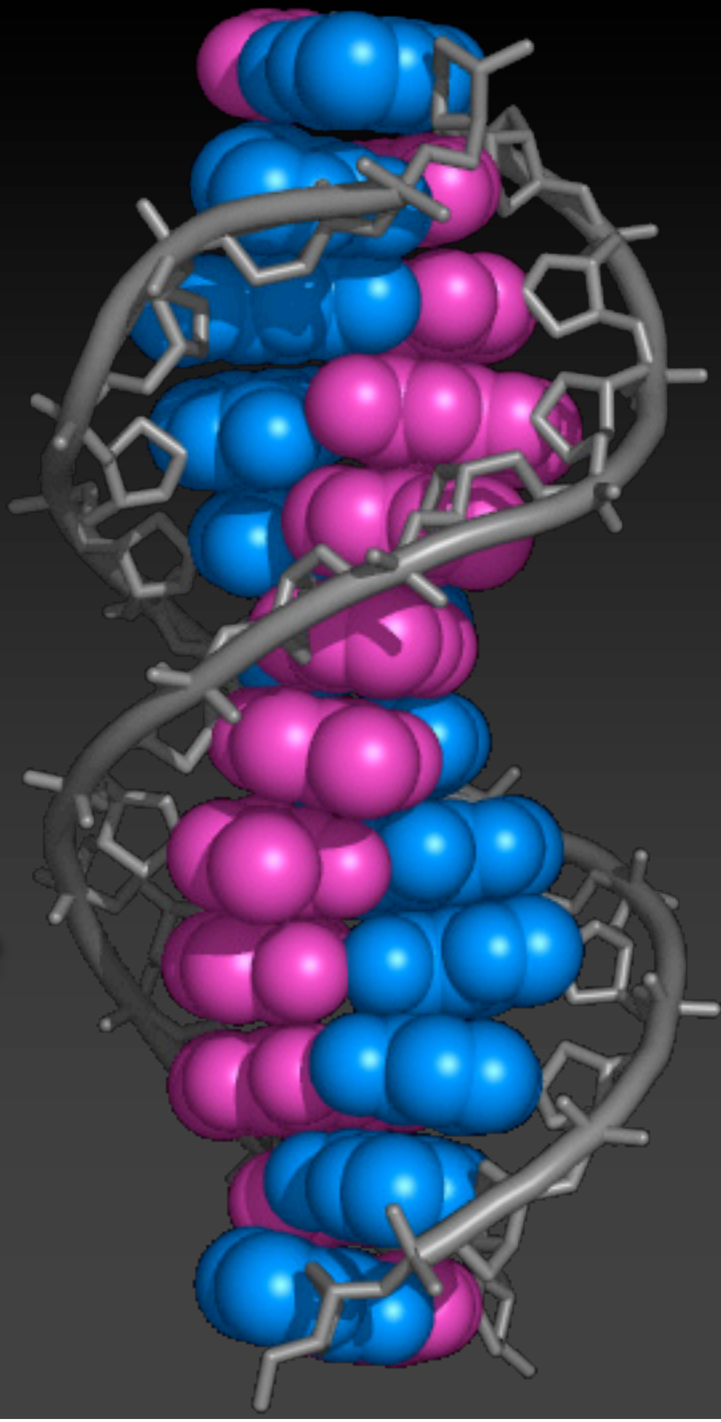
— Giordano Bruno, *De l’Infinito, Universo e Mondi*, 1584

Cos’è la vita?

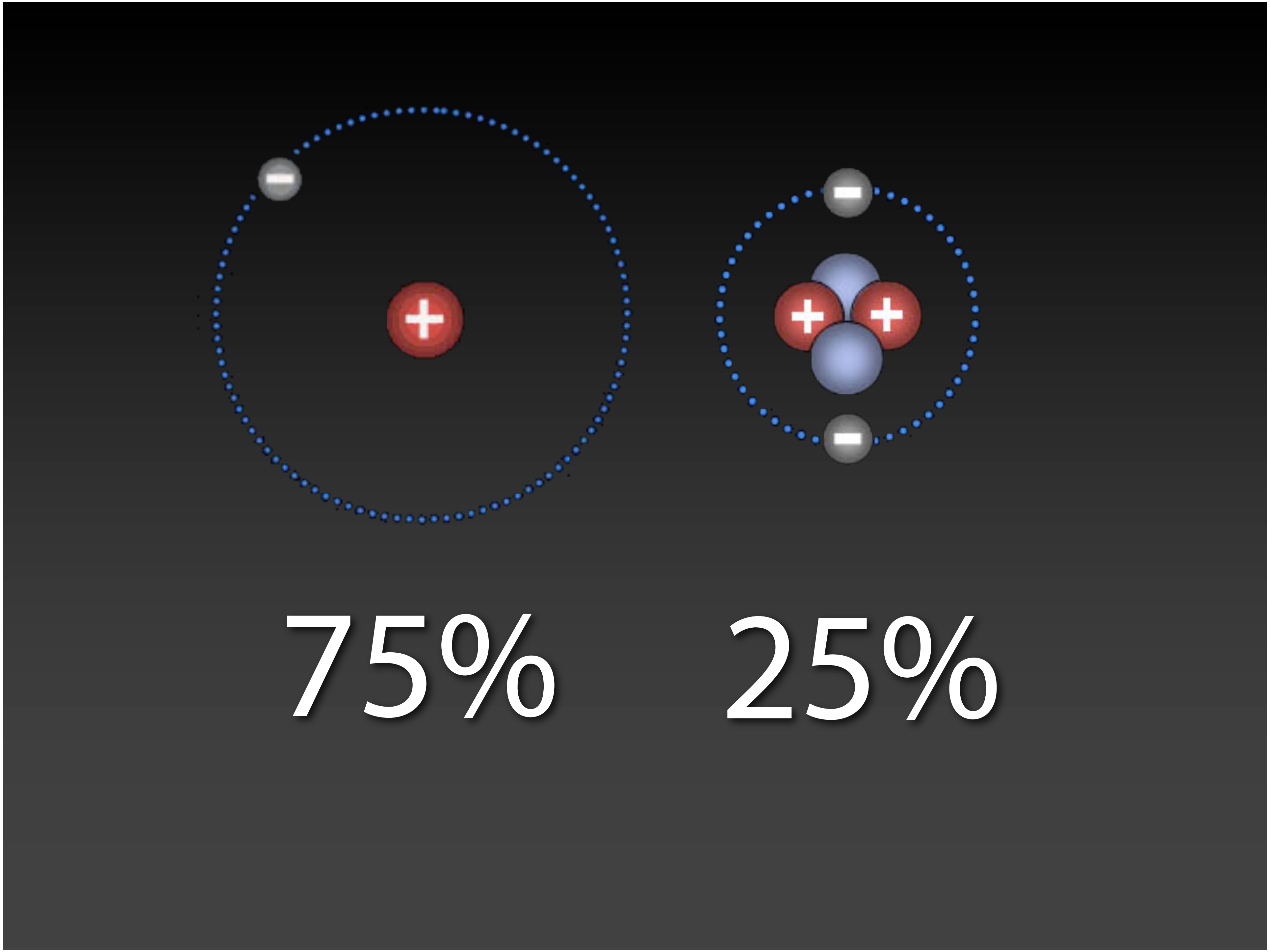
Crescita?	Cristalli
Riproduzione ed evoluzione?	Virus di computer
Capacità di immagazzinare ed elaborare informazione?	Calcolatori elettronici

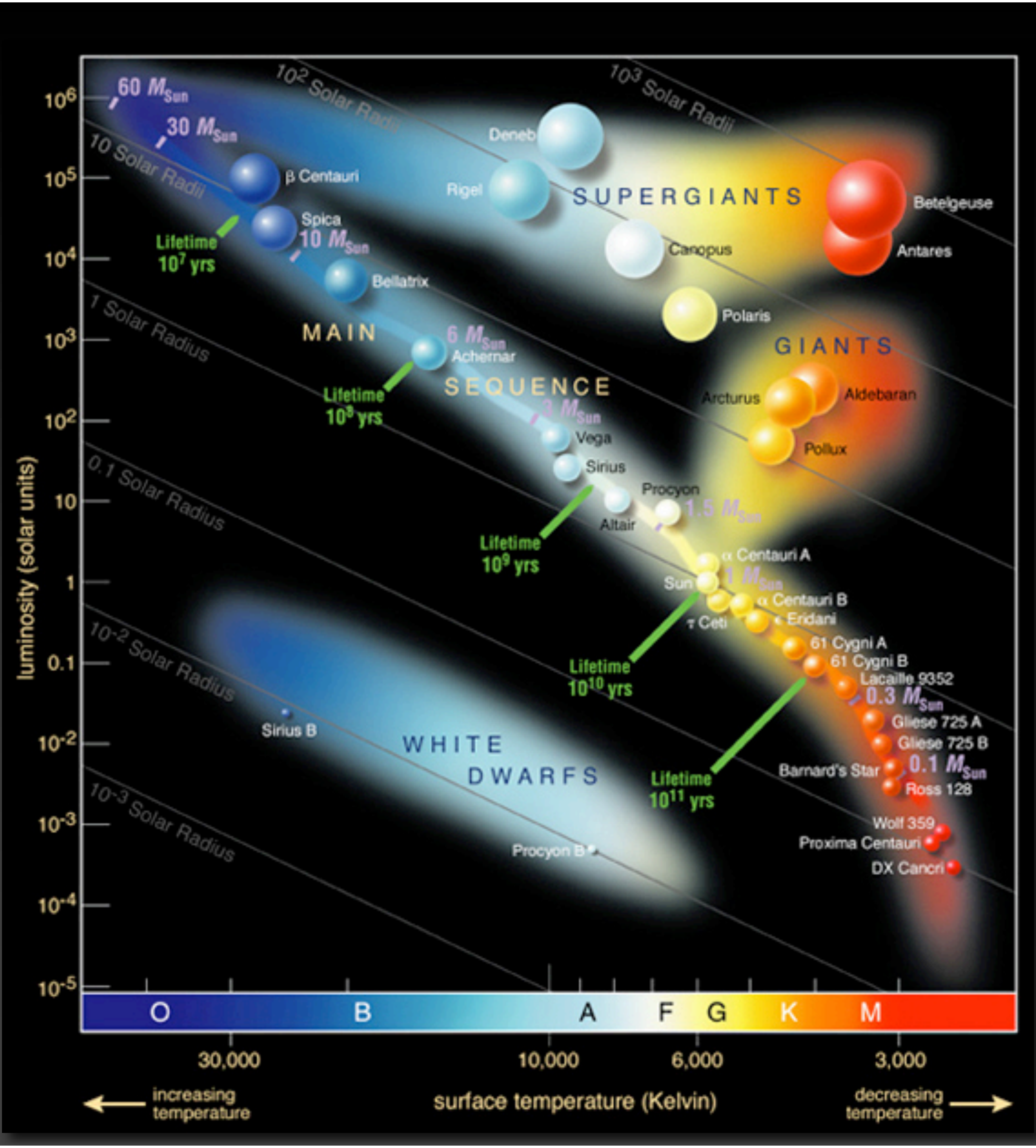
Un unico caso di studio

Ingredienti minimi

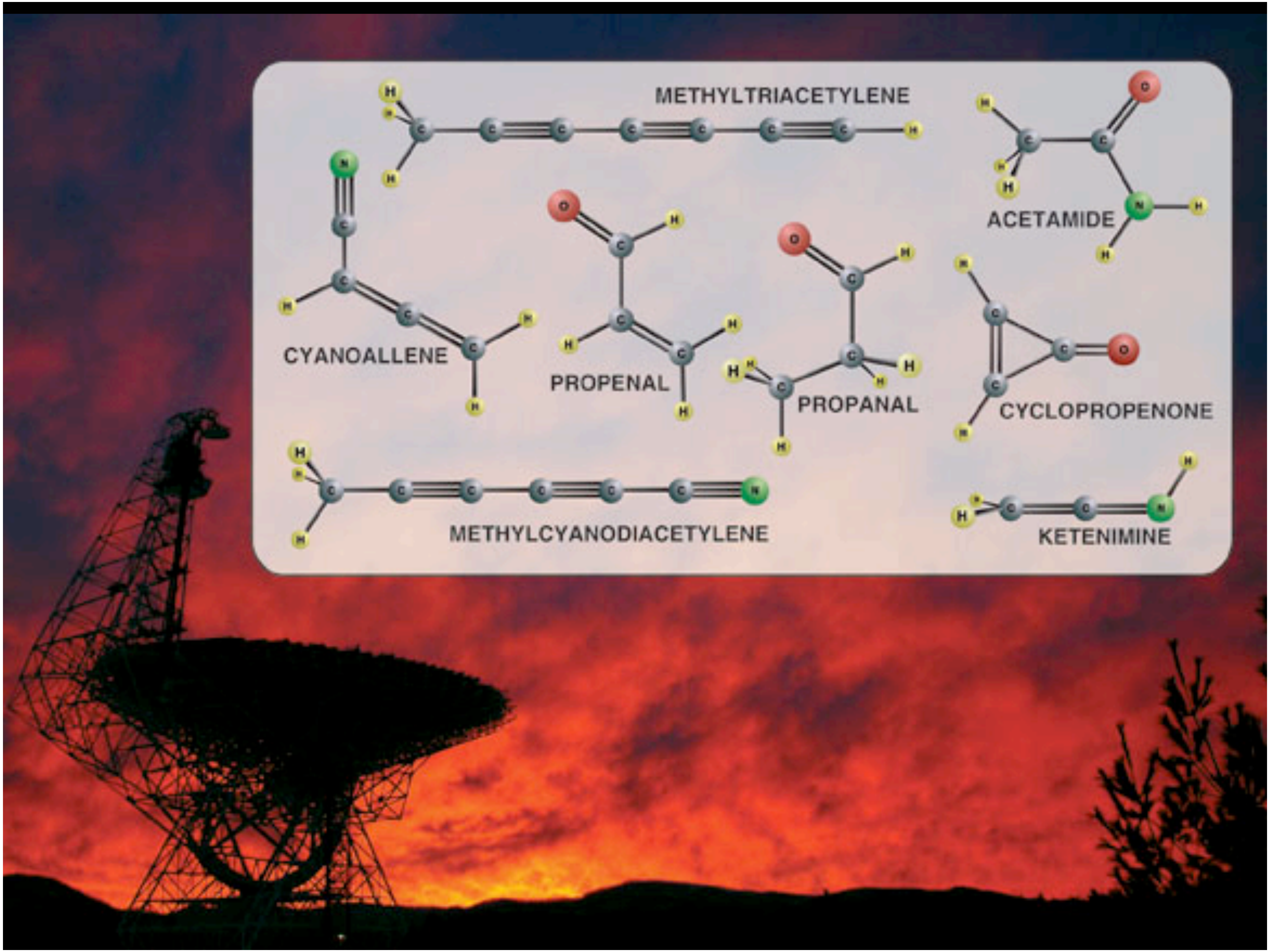


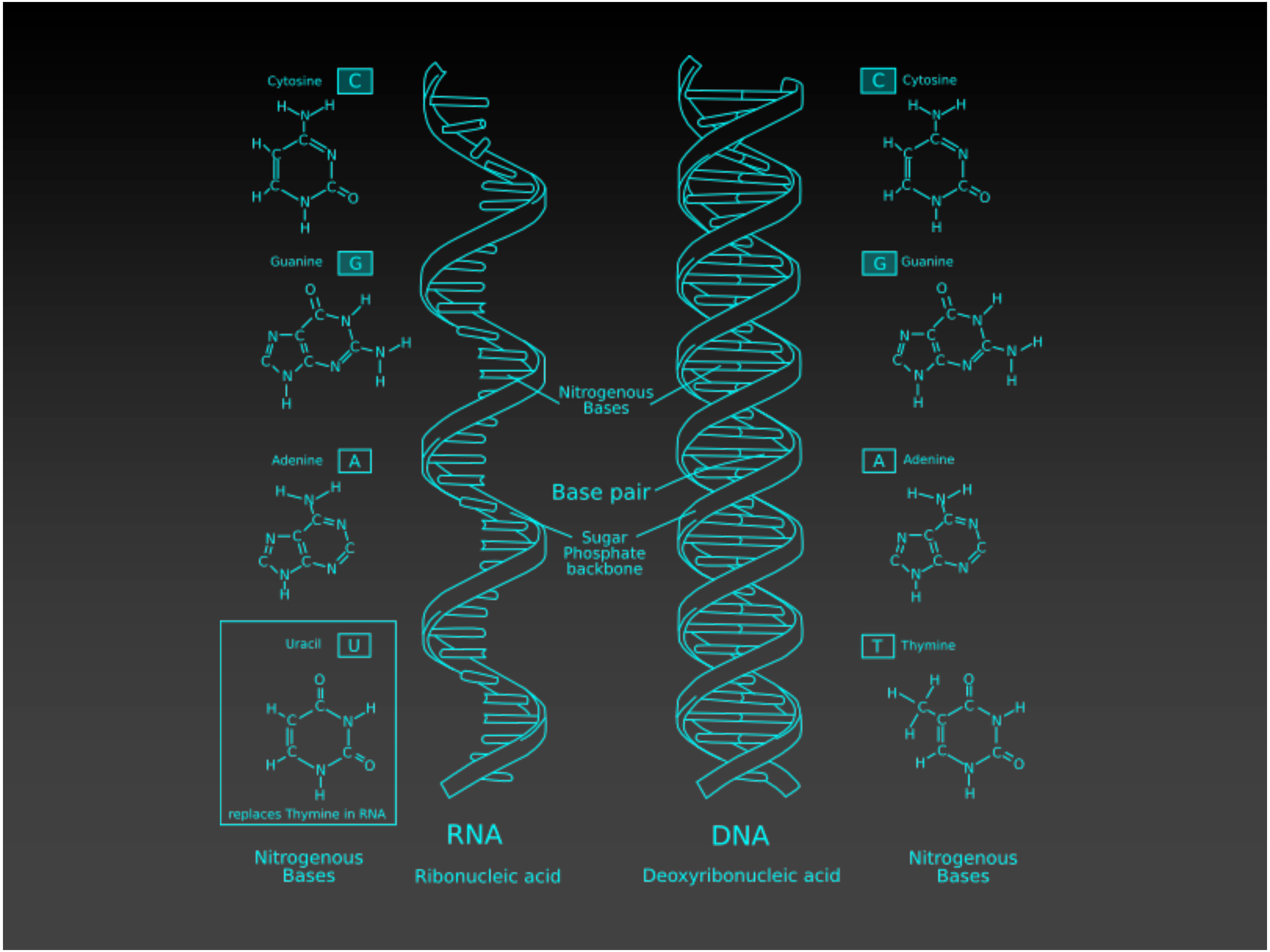
- ✓Molecole organiche complesse (CHONPS)
- ✓Un solvente liquido (acqua?)
- ✓Una sorgente di energia


75%
25%

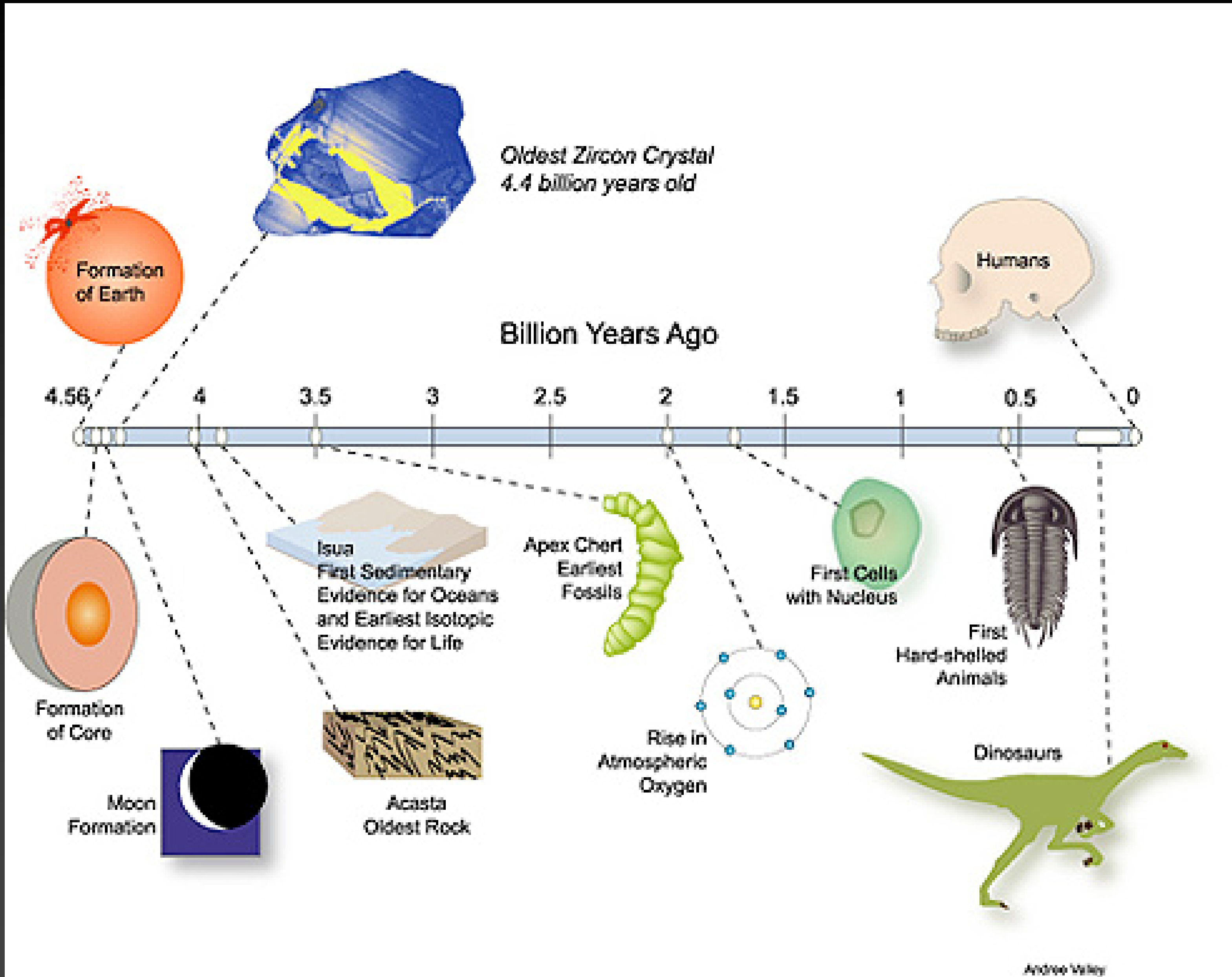


luminosity (solar units)
surface temperature (Kelvin)
increasing temperature
decreasing temperature
SUPERGIANTS
GIANTS
MAIN
SEQUENCE
WHITE
DWARFS
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
Deneb
Rigel
Canopus
Polaris
Betelgeuse
Antares
Arcturus
Aldebaran
Pollux
β Centauri
Spica
Bellatrix
Achernar
Vega
Sirius
Procyon
Altair
α Centauri A
Sun
α Centauri B
τ Ceti
ε Eridani
61 Cygni A
61 Cygni B
Lacaille 9352
Gliese 725 A
Gliese 725 B
Barnard's Star
Ross 128
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
Procyon B
O B A F G K M
30,000
10,000
6,000
3,000

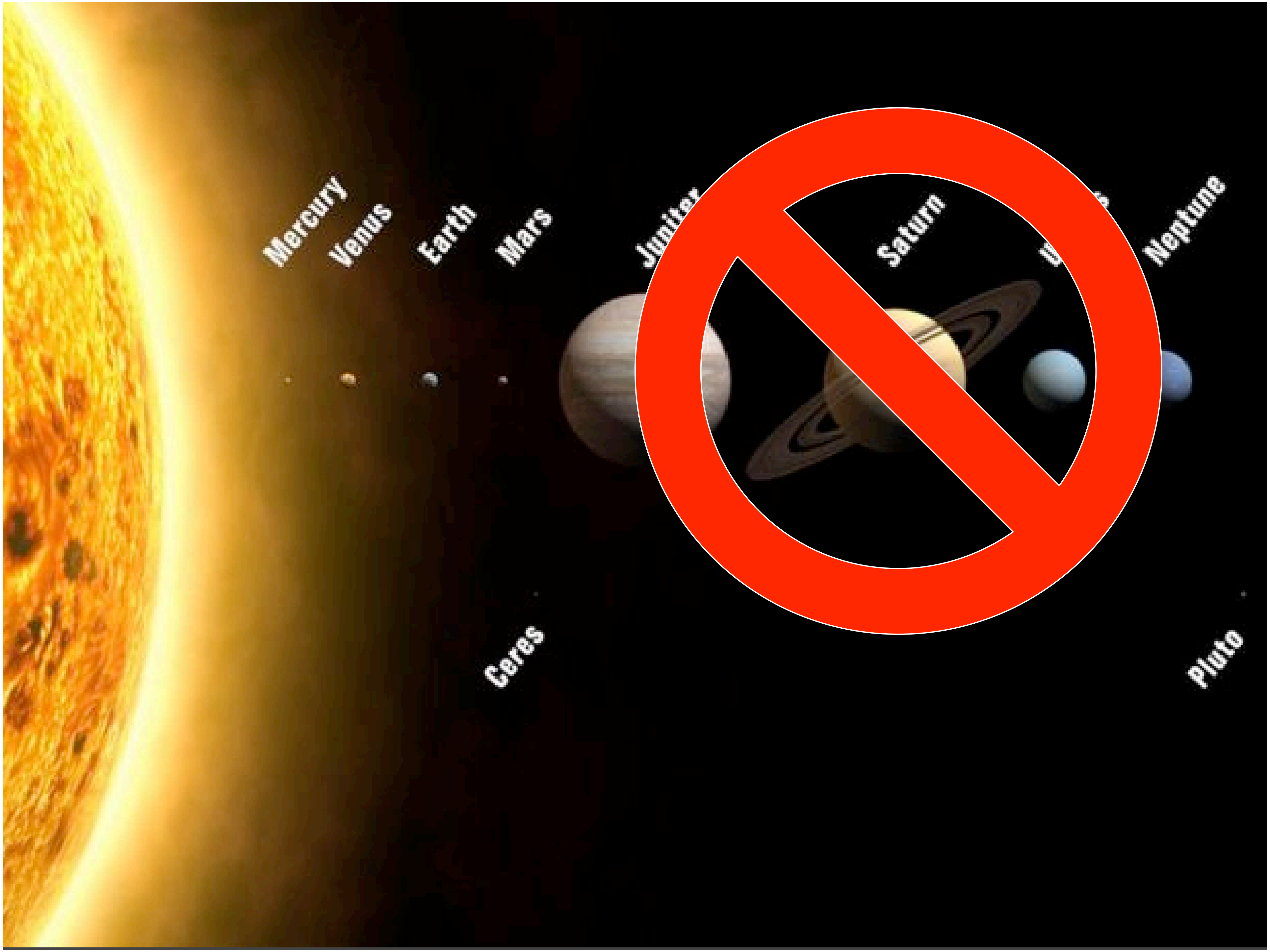

METHYLTRIACETYLENE
ACETAMIDE
CYANOALLENE
PROPENAL
PROPANAL
CYCLOPROPENONE
METHYLCYANODIACETYLENE
KETENIMINE

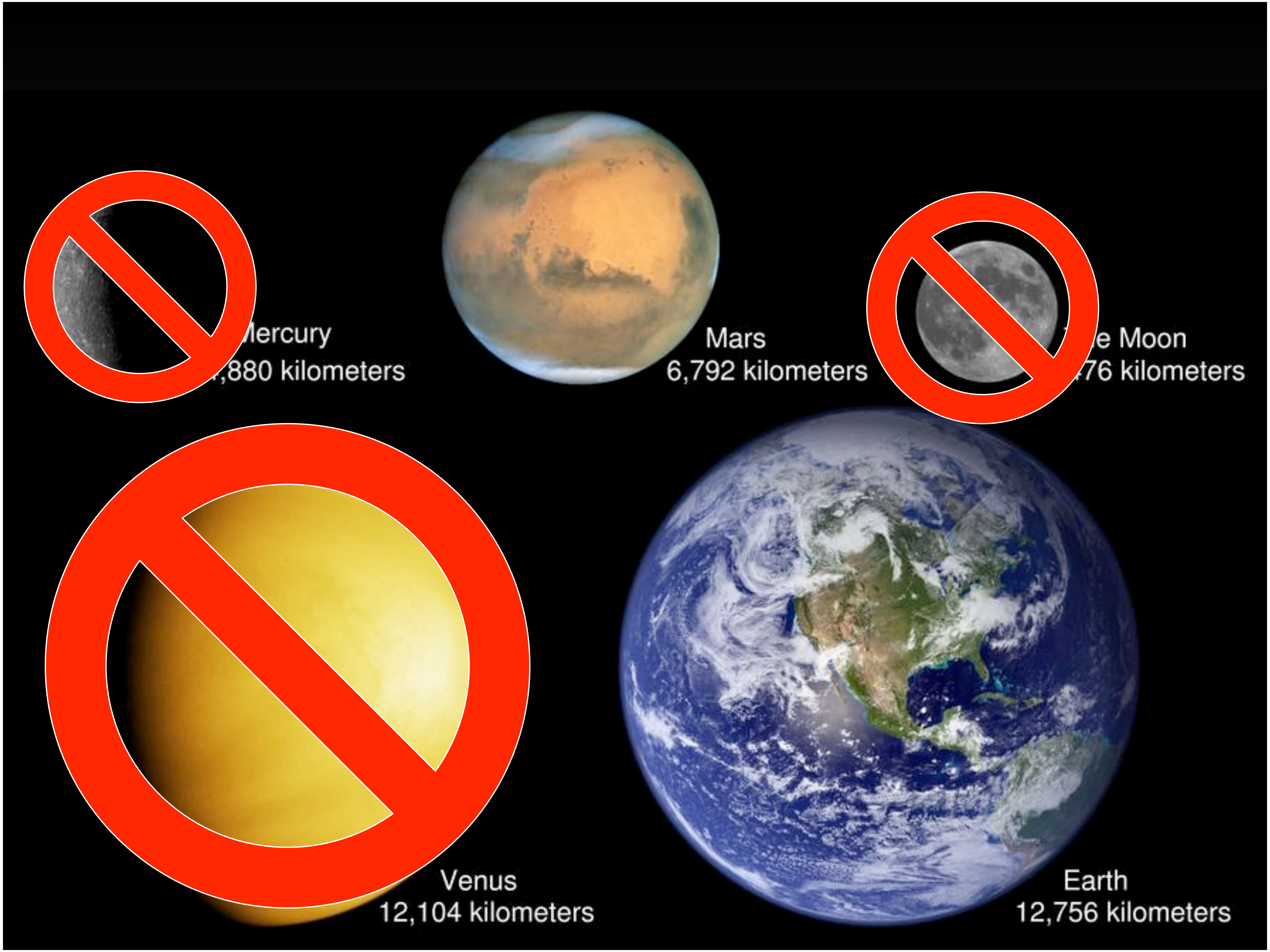


Cytosine
C
Guanine
G
Adenine
A
Uracil
U
replaces Thymine in RNA
Thymine
T
Nitrogenous Bases
Base pair
Sugar Phosphate backbone
RNA
Ribonucleic acid
DNA
Deoxyribonucleic acid
Nitrogenous Bases
Nitrogenous Bases

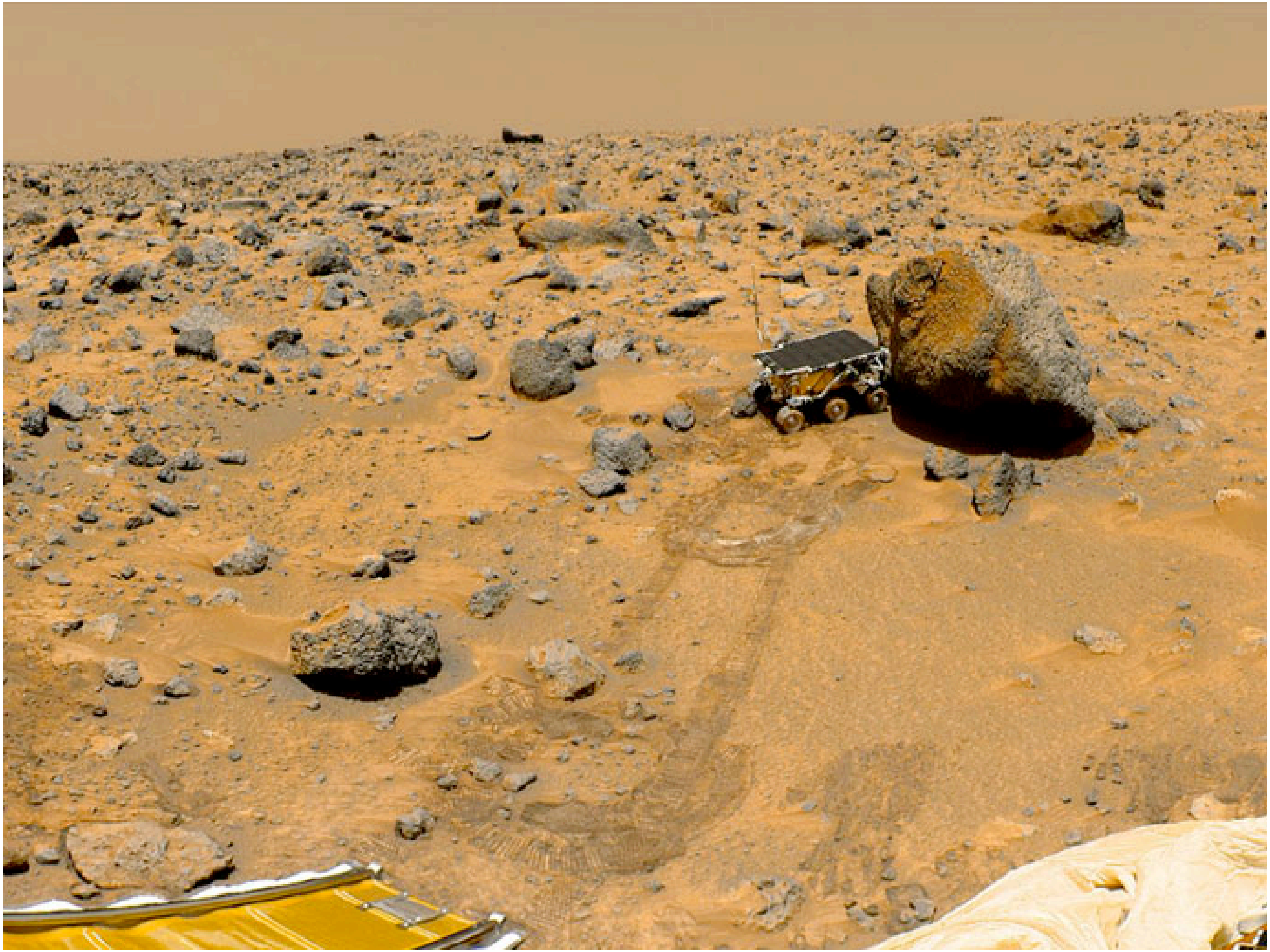


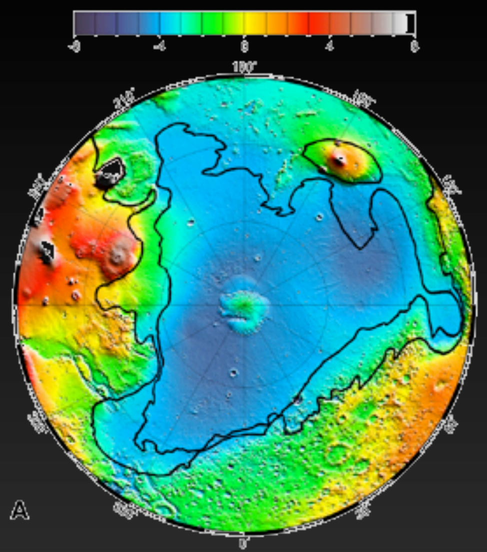
Oldest Zircon Crystal
4.4 billion years old
Formation of Earth
Humans
Billion Years Ago
4.56
4
3.5
3
2.5
2
1.5
1
0.5
0
Isua
First Sedimentary Evidence for Oceans and Earliest Isotopic Evidence for Life
Apex Chert
Earliest Fossils
First Cells with Nucleus
First Hard-shelled Animals
Formation of Core
Moon Formation
Acasta
Oldest Rock
Rise in Atmospheric Oxygen
Dinosaurs

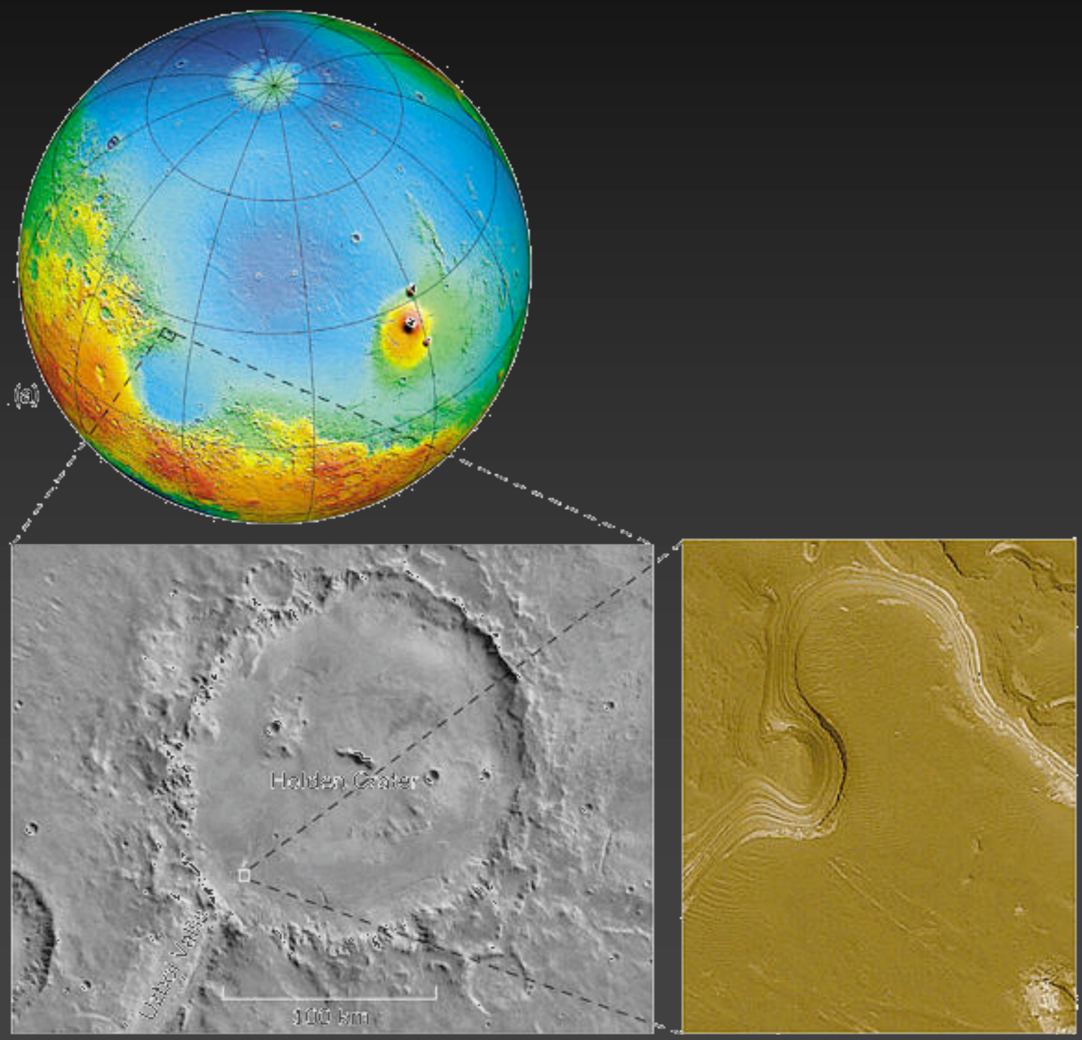

Mercury
Venus
Earth
Mars
Saturn
Neptune
Ceres
Pluto

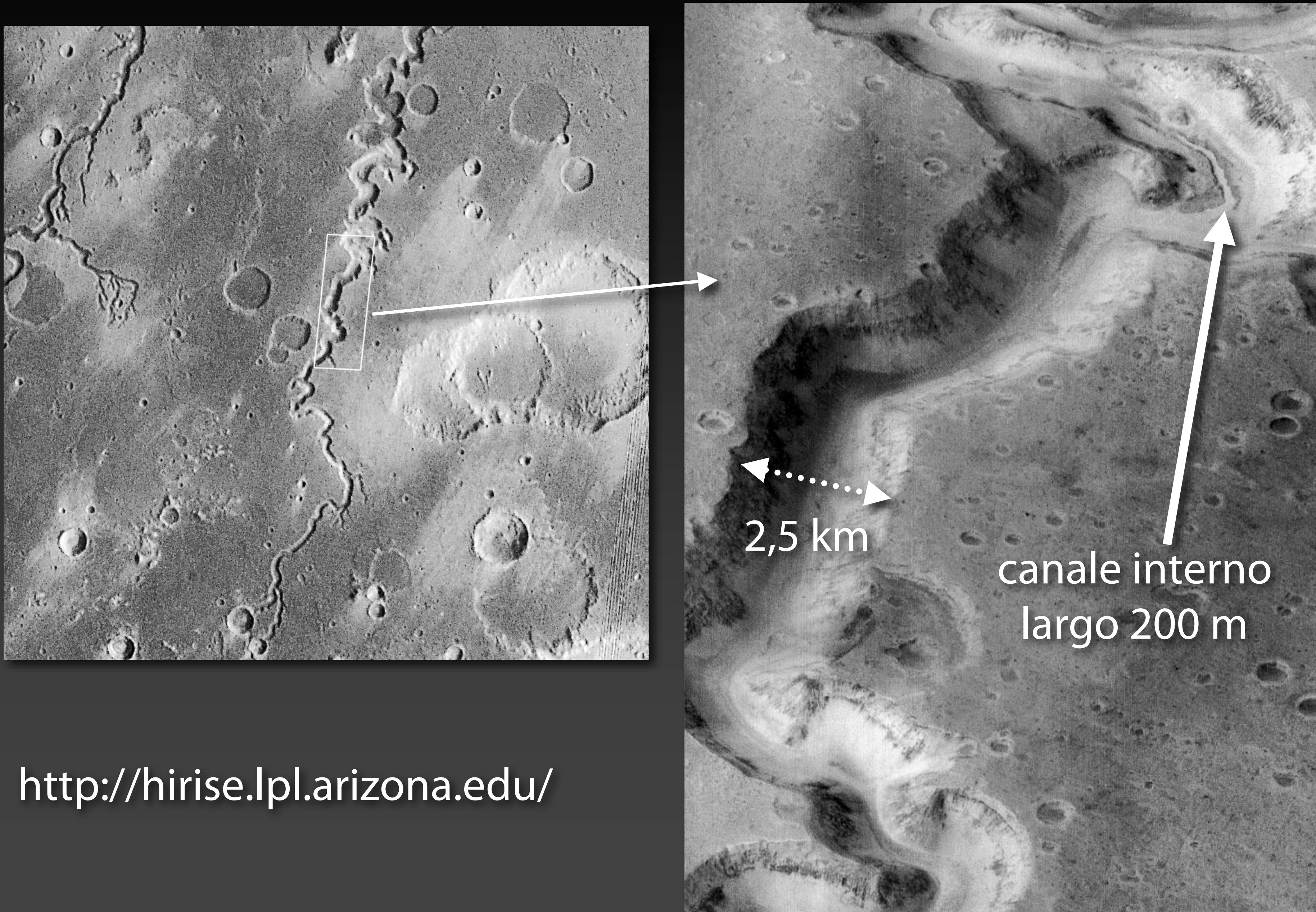


lercury
,880 kilometers
Mars
6,792 kilometers
e Moon
76 kilometers
Venus
12,104 kilometers
Earth
12,756 kilometers

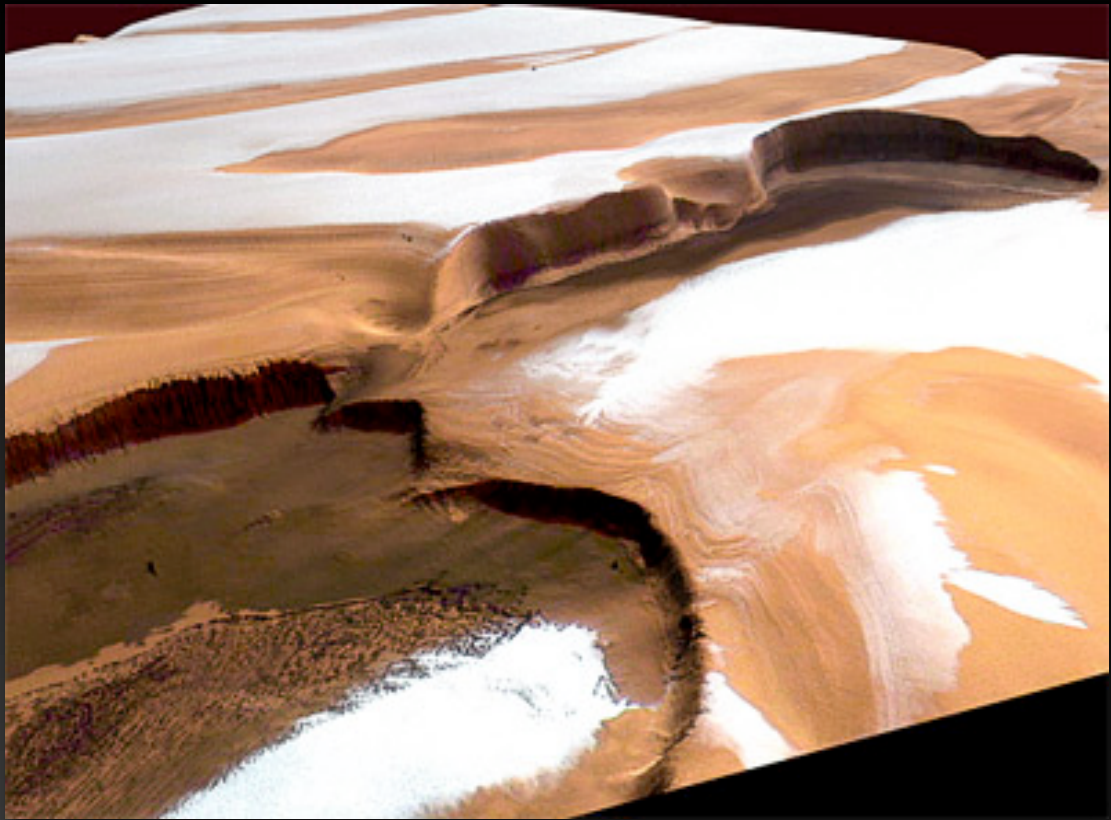
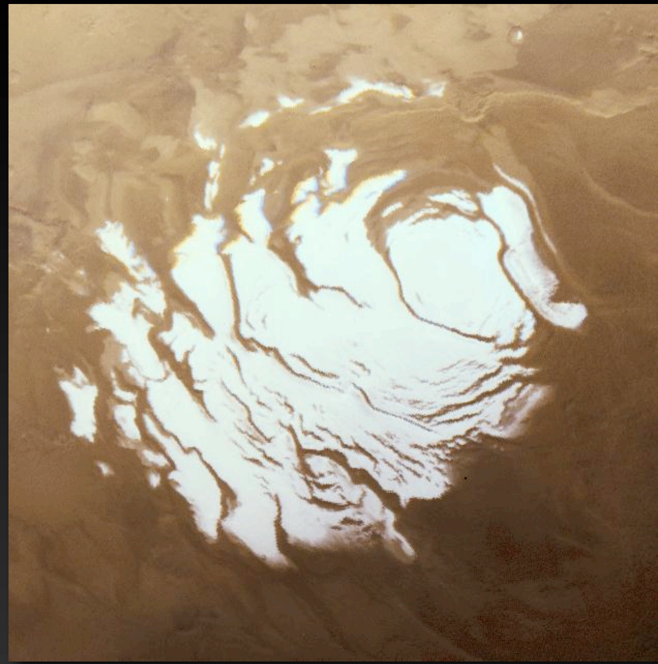
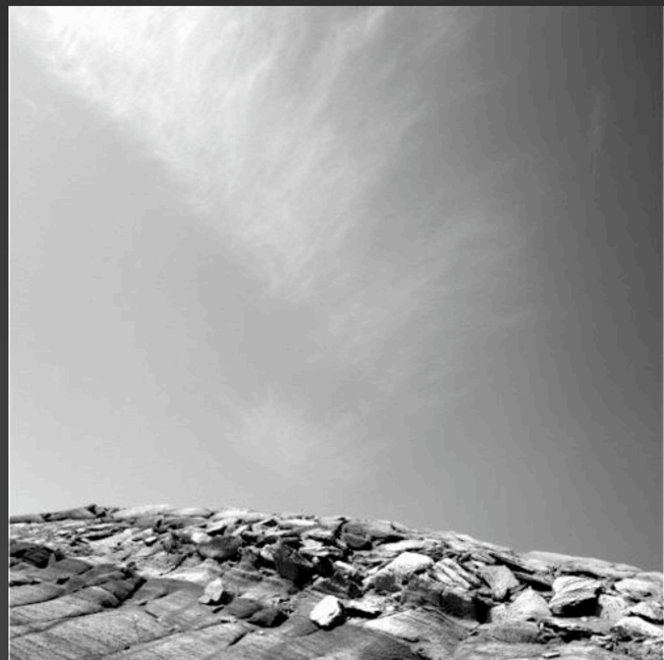


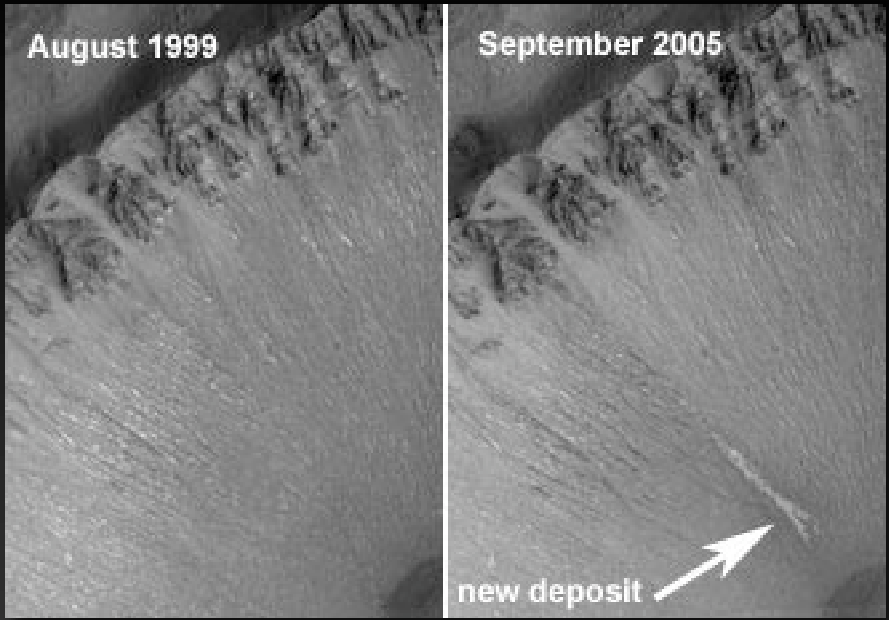

-8
-4
0
4
8
180°
A

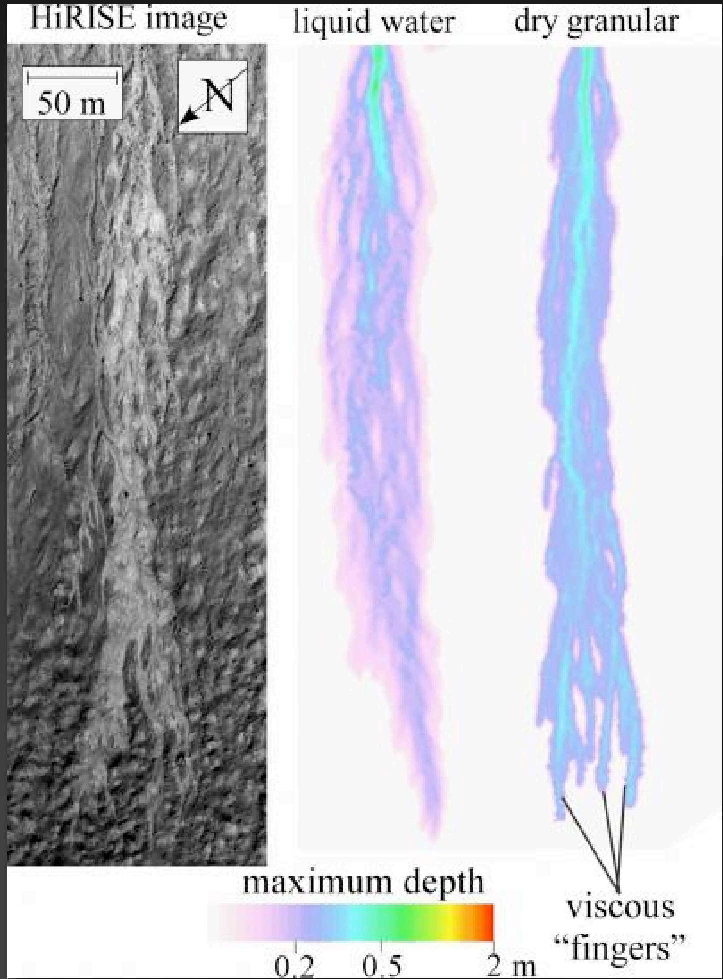

(a)
Holden Crater
Uzboi Vallis
100 km



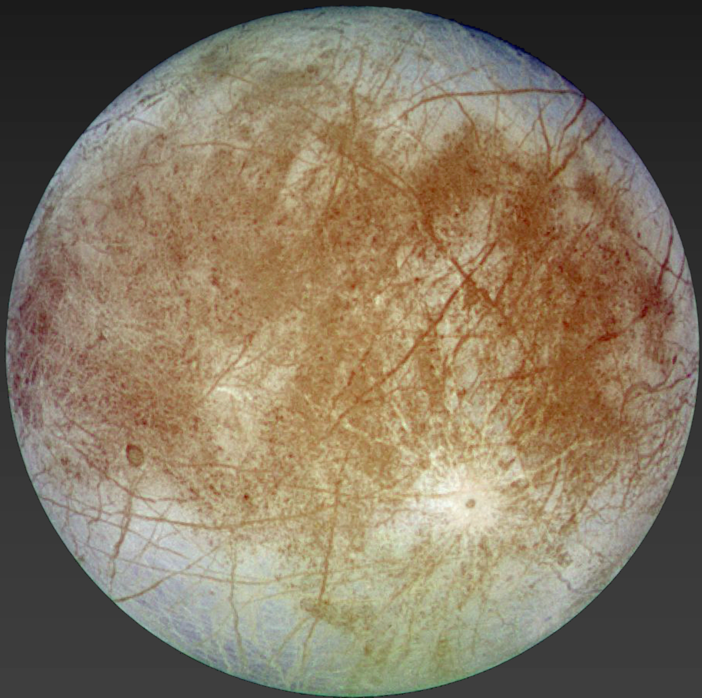
http://hirise.lpl.arizona.edu/

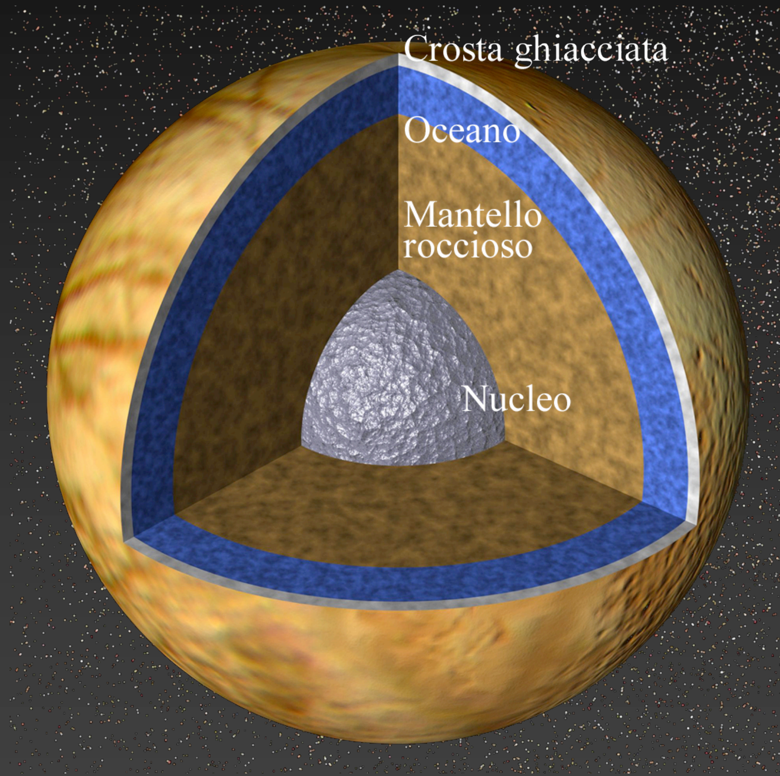




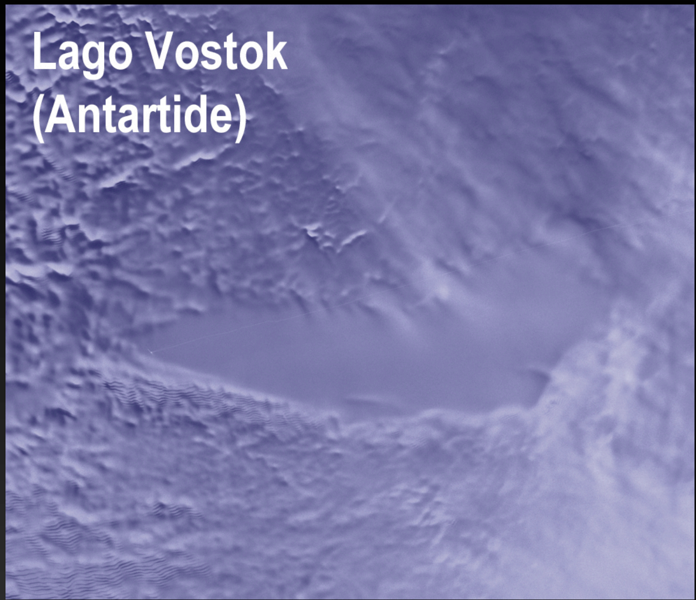

August 1999
September 2005
new deposit

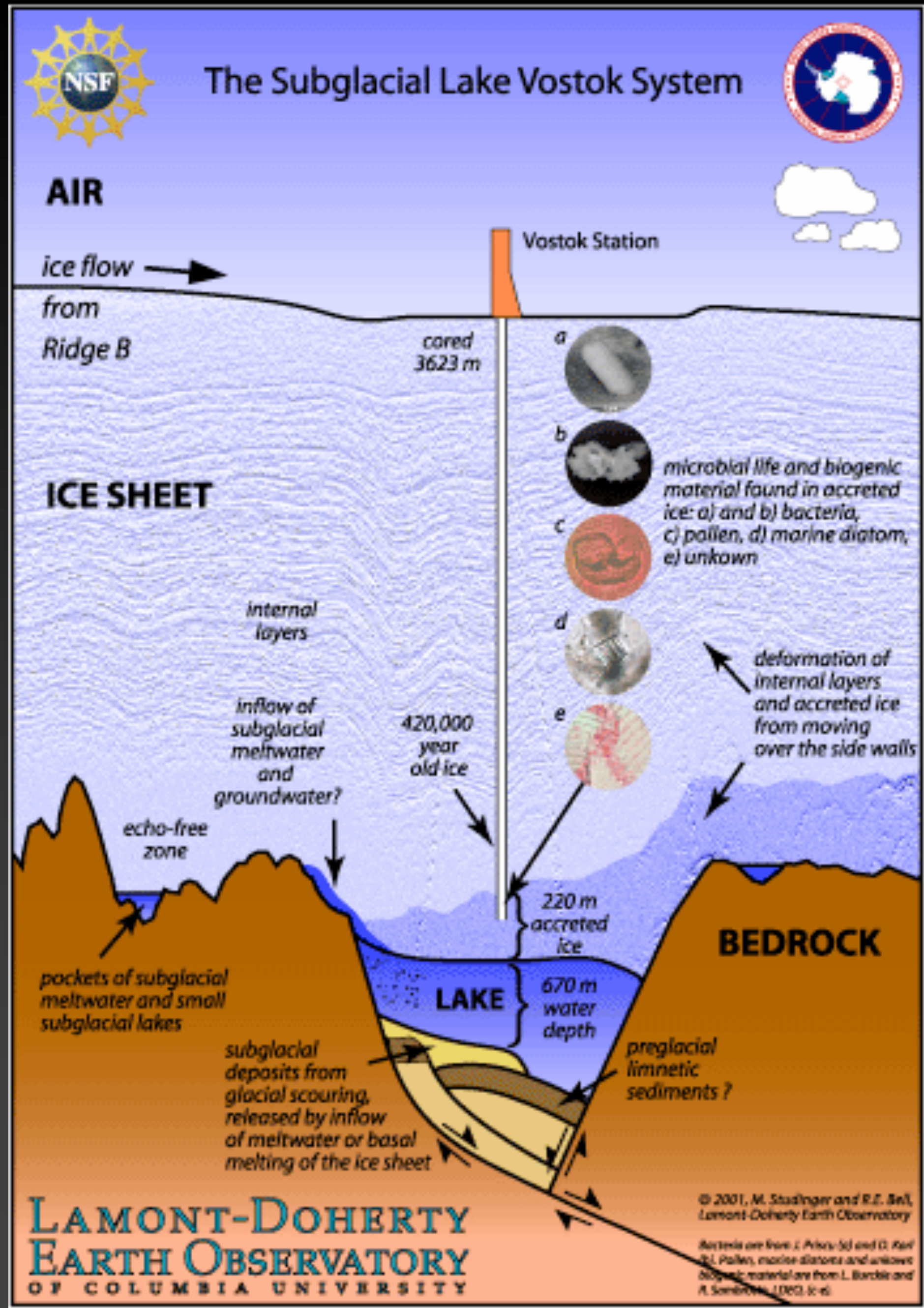

HiRISE image
liquid water
dry granular
50 m
N
maximum depth
0.2
0.5
2 m
viscous
"fingers"

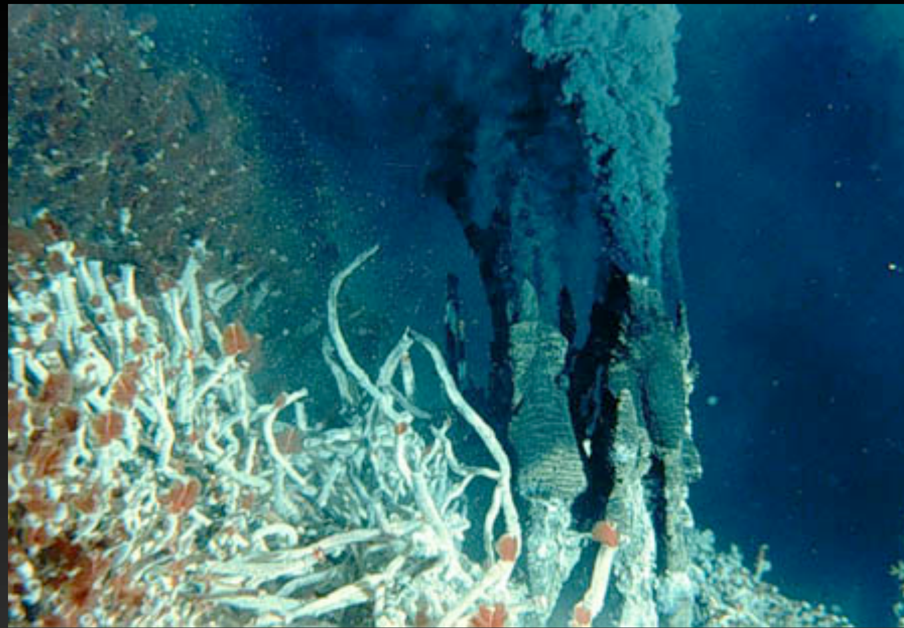
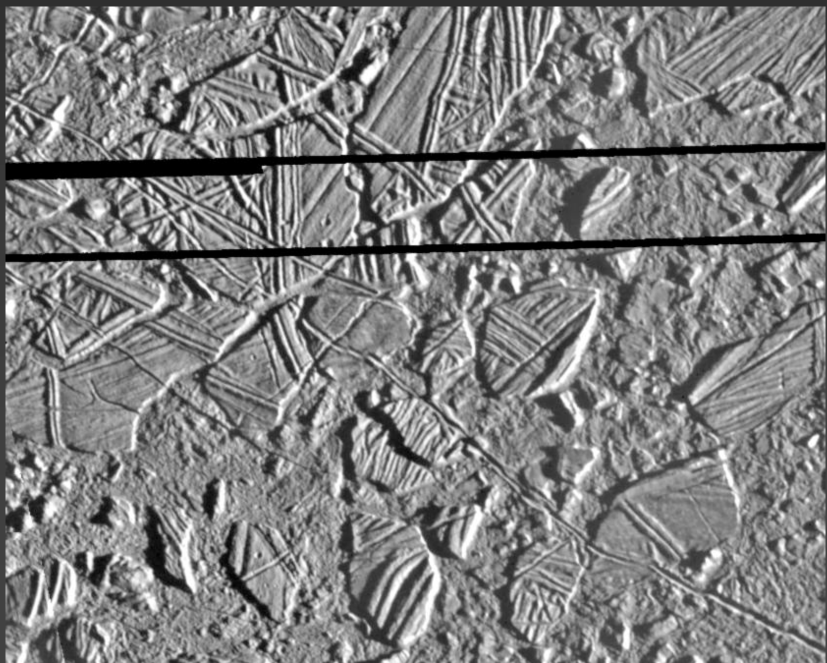
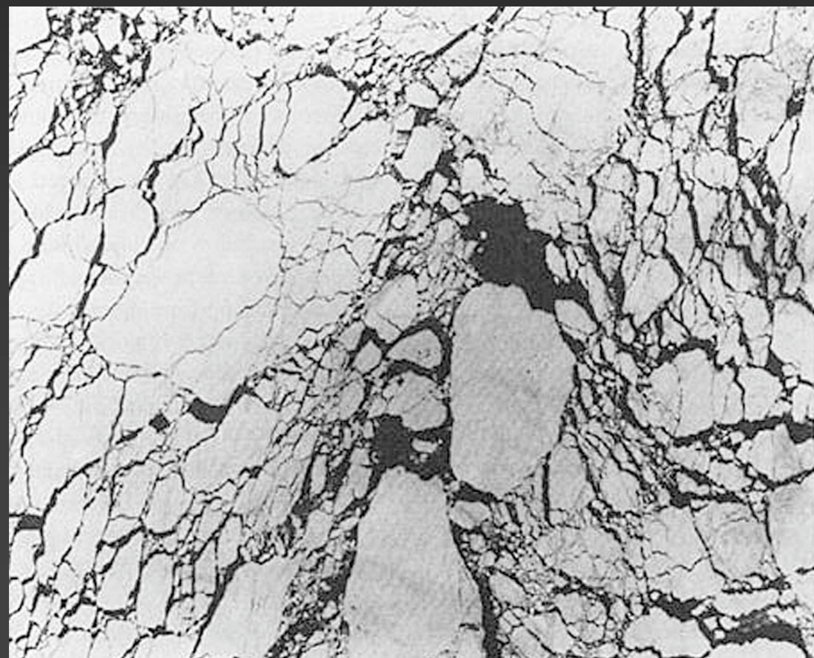

Ganymede
5262 km
Titan
5150 km
Mercury
4880 km
Callisto
4806 km
Io
3642 km
Moon
3476 km
Europa
3138 km
Triton
2706 km
Pluto
2300 km
Titania
1580 km

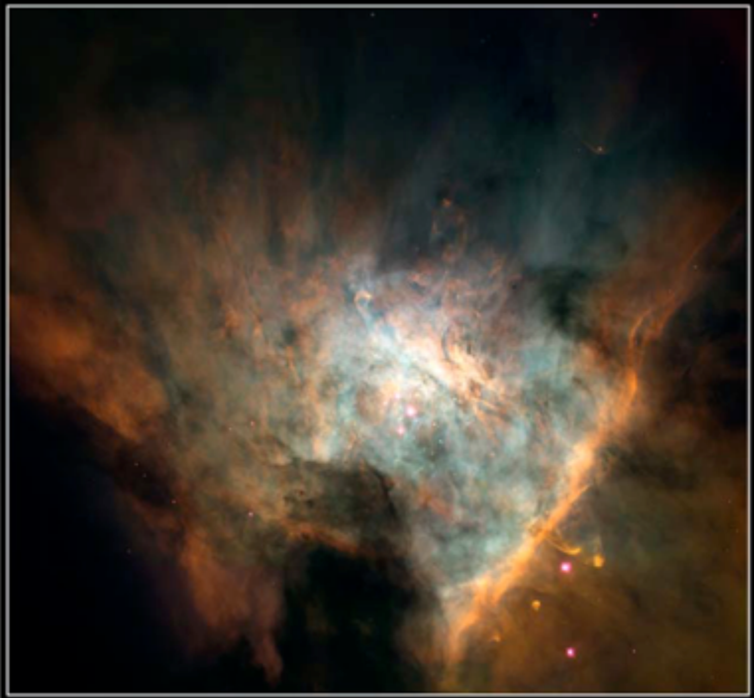


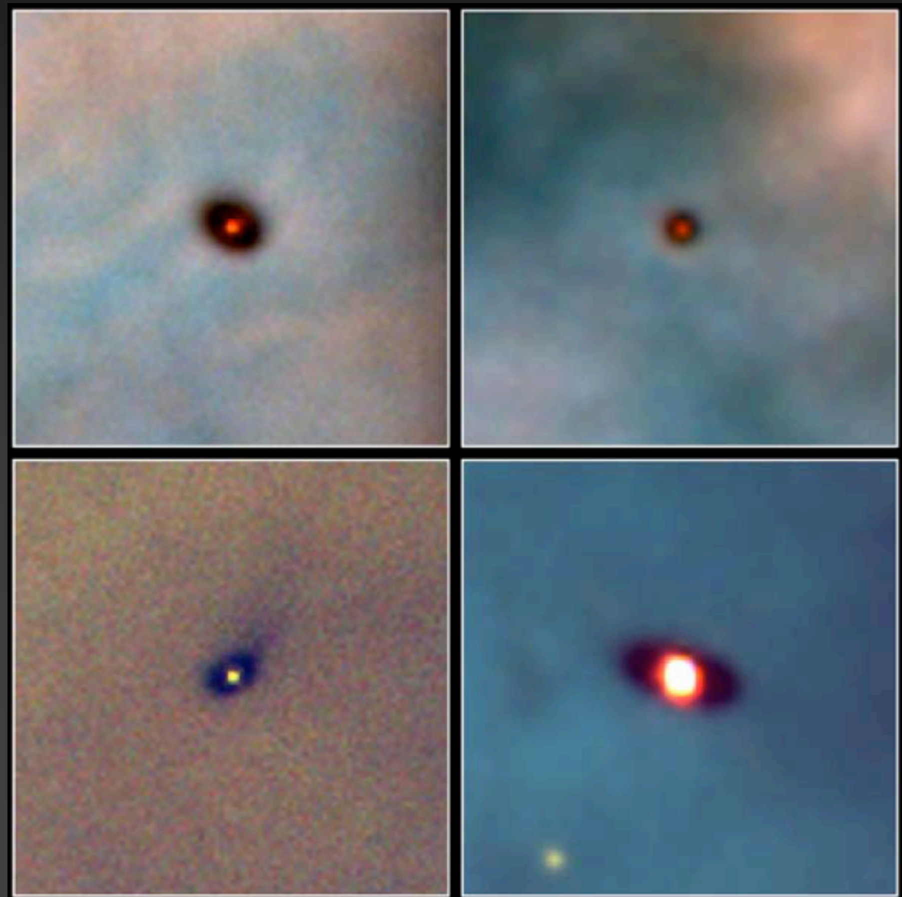

Crosta ghiacciata
Oceano
Mantello roccioso
Nucleo

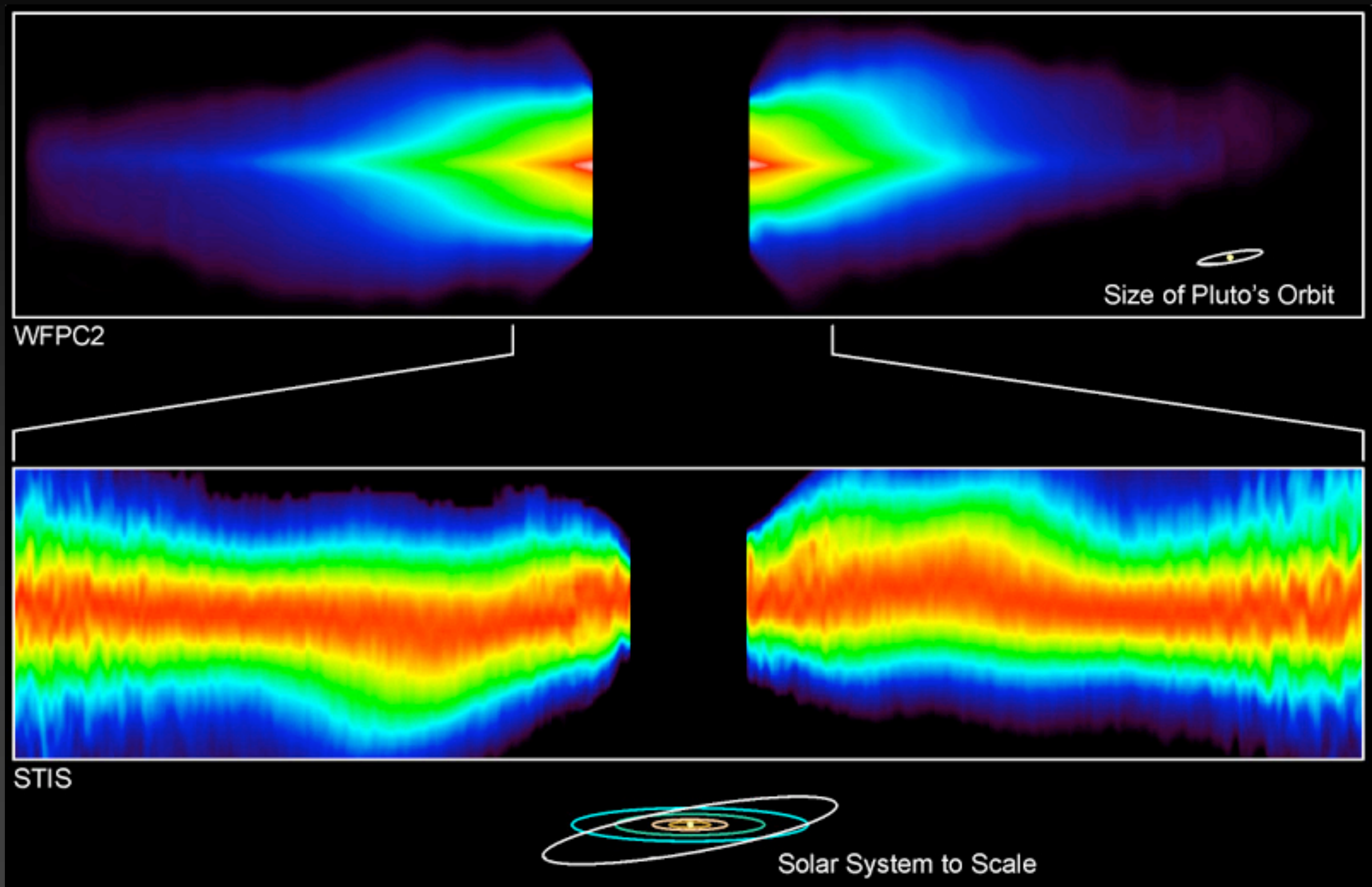

Lago Vostok
(Antartide)


NSF
The Subglacial Lake Vostok System
AIR
Vostok Station
ice flow
from
Ridge B
cored
3623 m
a
b
c
d
e
microbial life and biogenic material found in accreted ice: a) and b) bacteria, c) pollen, d) marine diatom, e) unkown
ICE SHEET
internal
layers
deformation of internal layers and accreted ice from moving over the side walls
inflow of subglacial meltwater and groundwater?
420,000 year old ice
echo-free
zone
220 m
accreted
ice
BEDROCK
LAKE
670 m
water
depth
pockets of subglacial meltwater and small subglacial lakes
subglacial deposits from glacial scouring, released by inflow of meltwater or basal melting of the ice sheet
preglacial limnetic sediments ?
LAMONT-DOHERTY
EARTH OBSERVATORY
OF COLUMBIA UNIVERSITY
© 2001, M. Studinger and R.E. Bell, Lamont-Doherty Earth Observatory

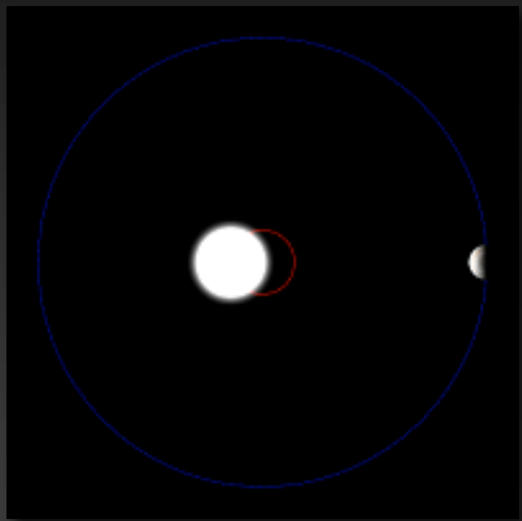





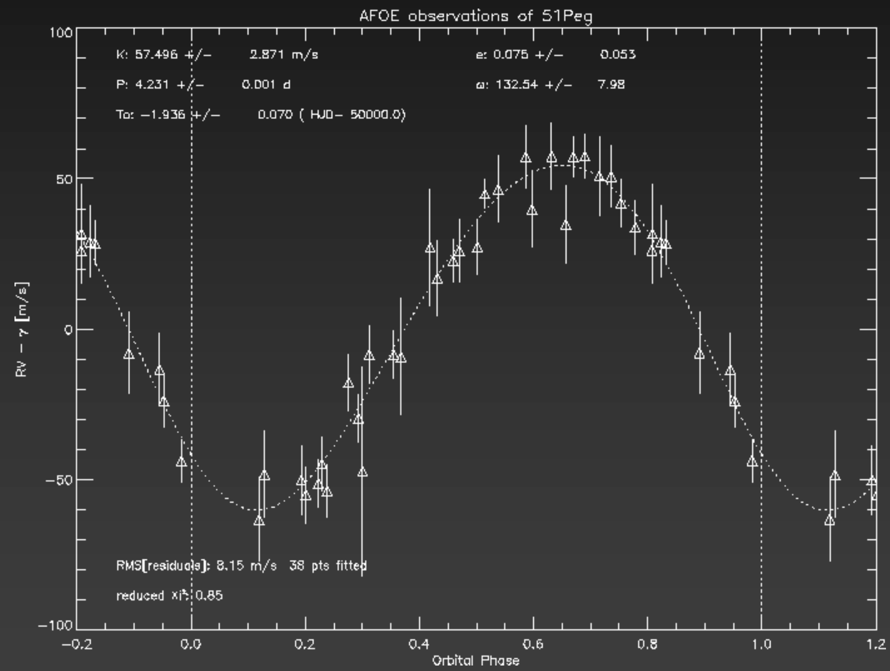




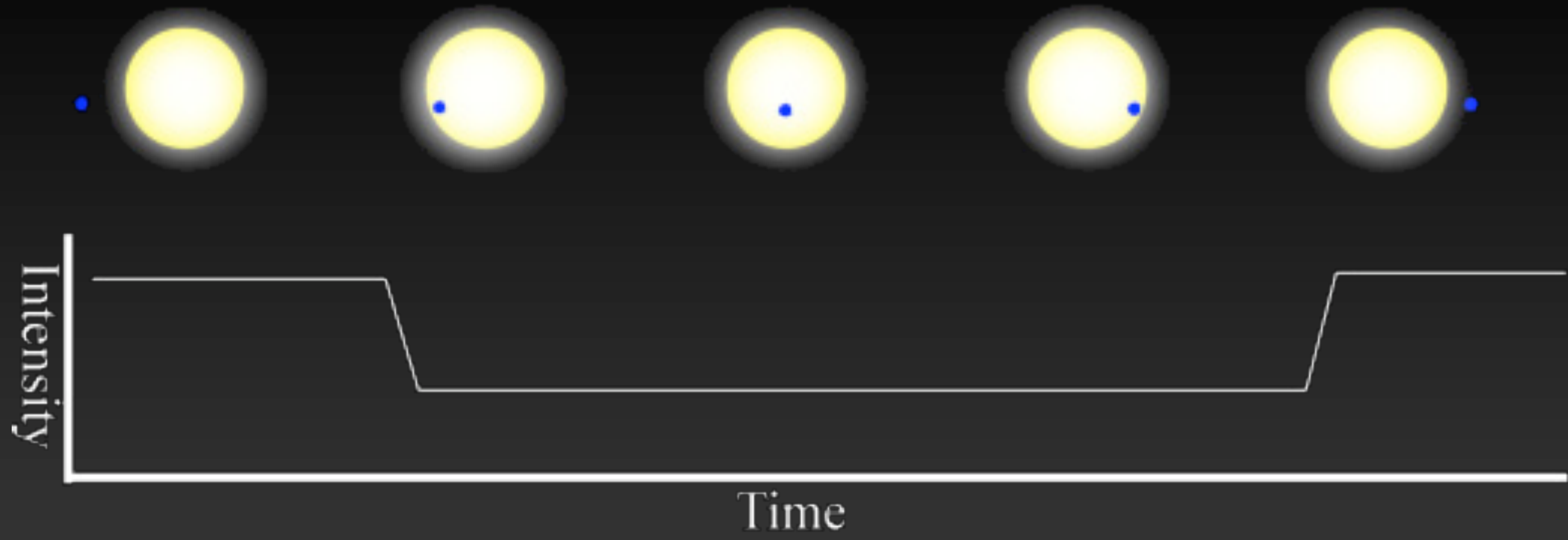


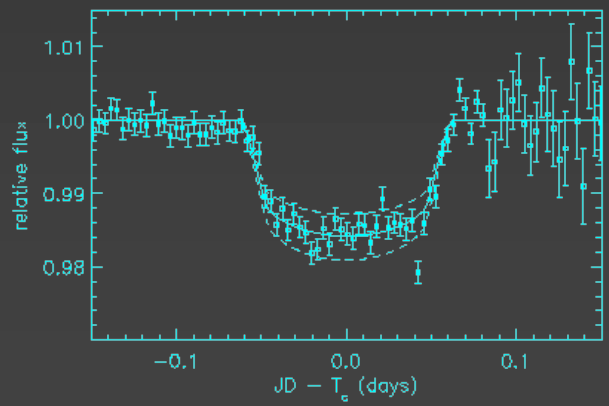
Size of Pluto's Orbit
WFPC2
STIS
Solar System to Scale

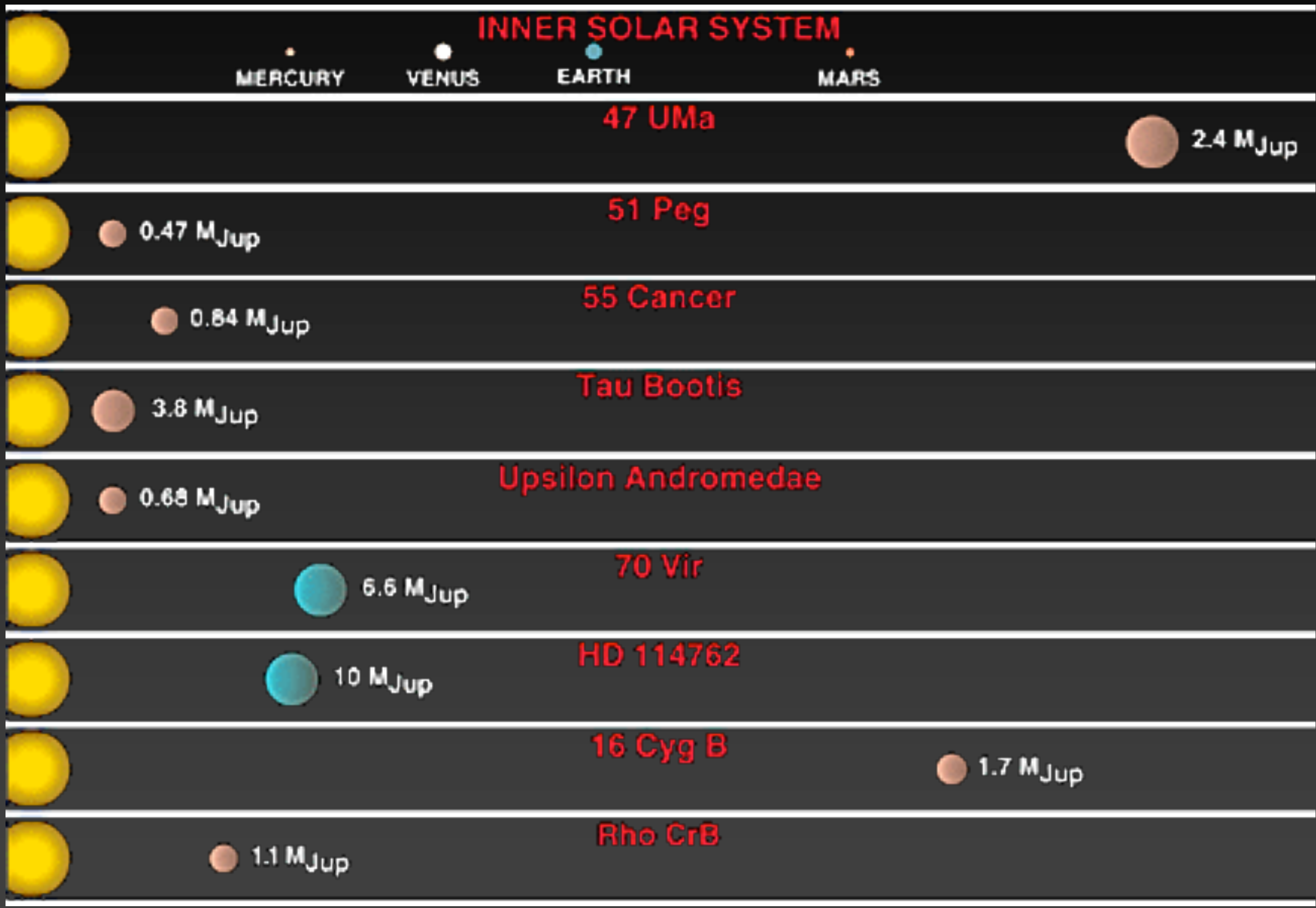




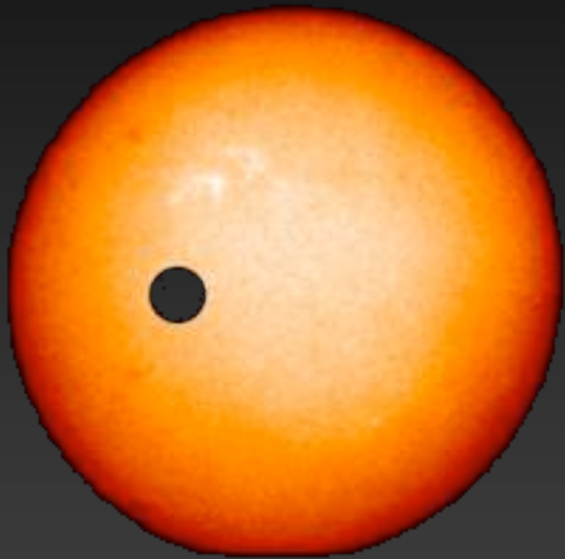
AFOE observations of 51Peg
K: 57.496 +/- 2.871 m/s
P: 4.231 +/- 0.001 d
To: -1.936 +/- 0.070 (HJD- 50000.0)
e: 0.075 +/- 0.053
ω: 132.54 +/- 7.98
RMS[residuals]: 8.15 m/s 38 pts fitted
reduced Xi²: 0.85
RV - γ [m/s]
Orbital Phase
100
50
0
-50
-100
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2


Intensity
Time


1.01
1.00
0.99
0.98
relative flux
−0.1
0.0
0.1
JD − T$_c$ (days)

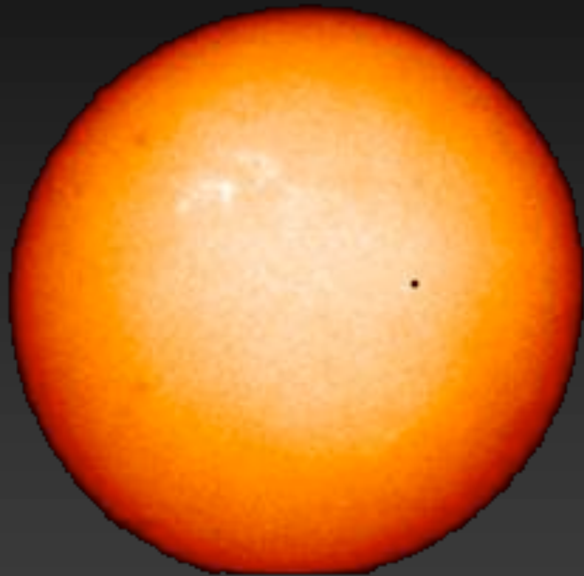


INNER SOLAR SYSTEM
MERCURY
VENUS
EARTH
MARS
47 UMa
2.4 M_{Jup}
51 Peg
0.47 M_{Jup}
55 Cancer
0.84 M_{Jup}
Tau Bootis
3.8 M_{Jup}
Upsilon Andromedae
0.68 M_{Jup}
70 Vir
6.6 M_{Jup}
HD 114762
10 M_{Jup}
16 Cyg B
1.7 M_{Jup}
Rho CrB
1.1 M_{Jup}



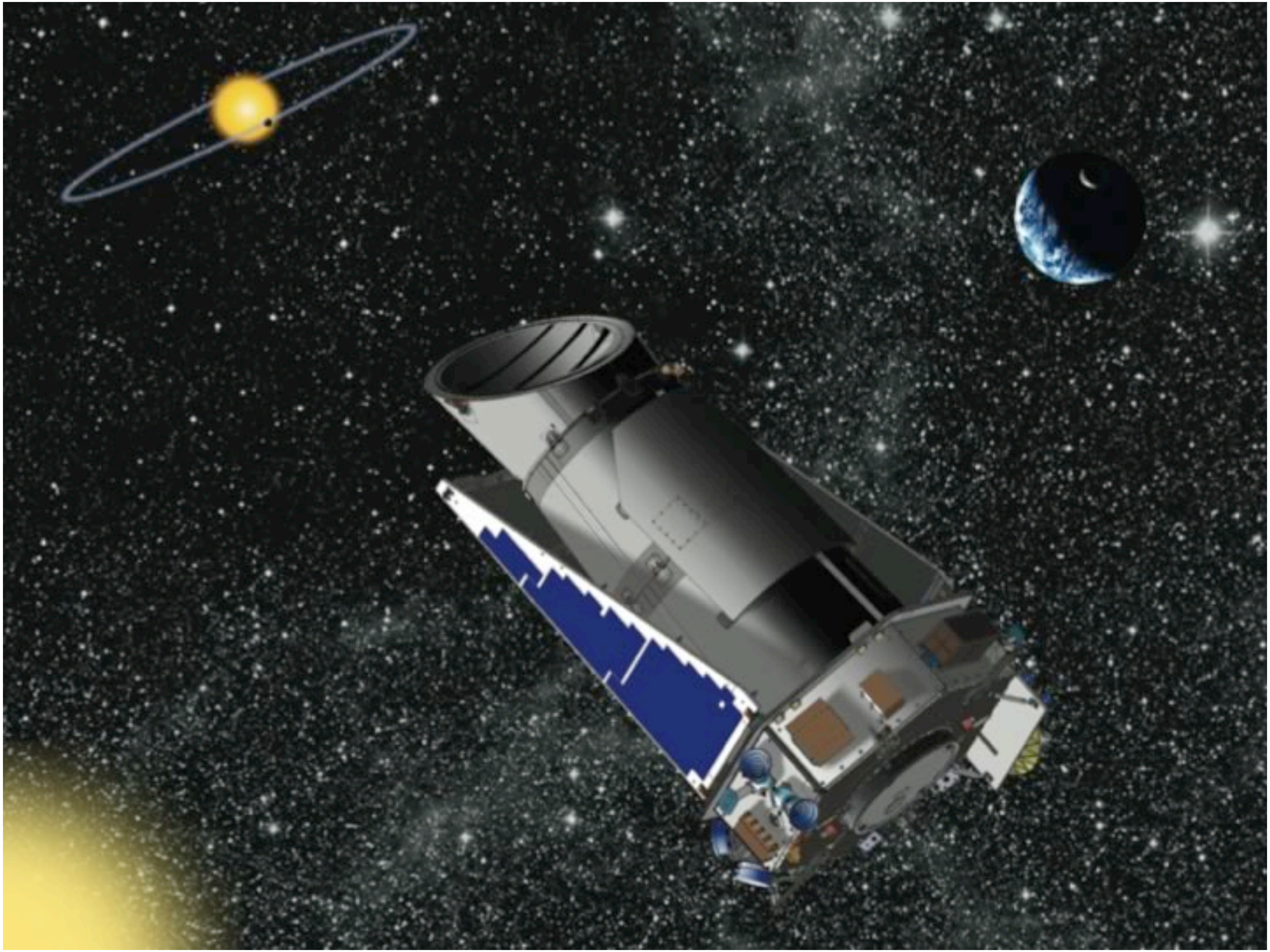
Giove

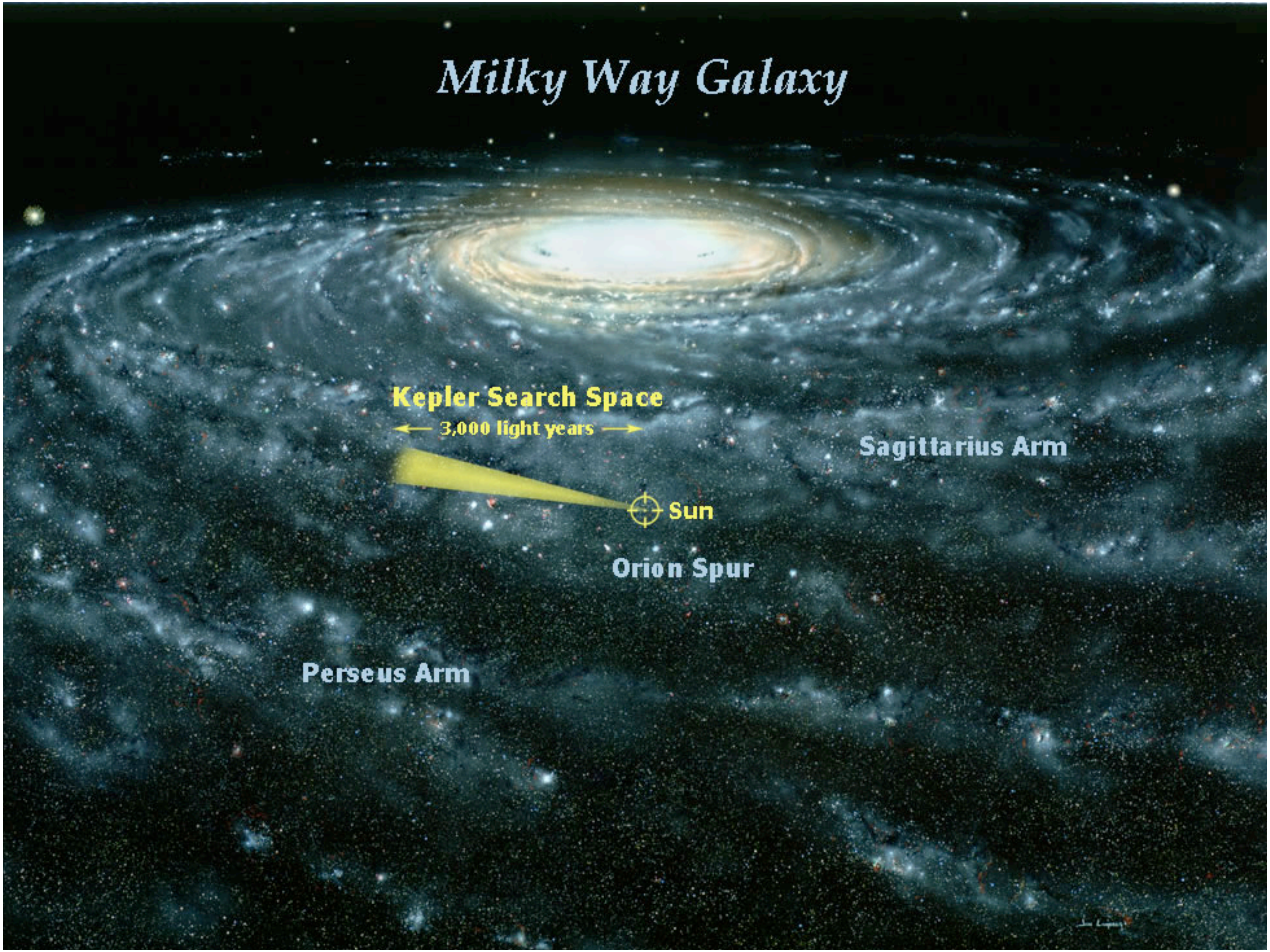
1/100 dell’area del Sole

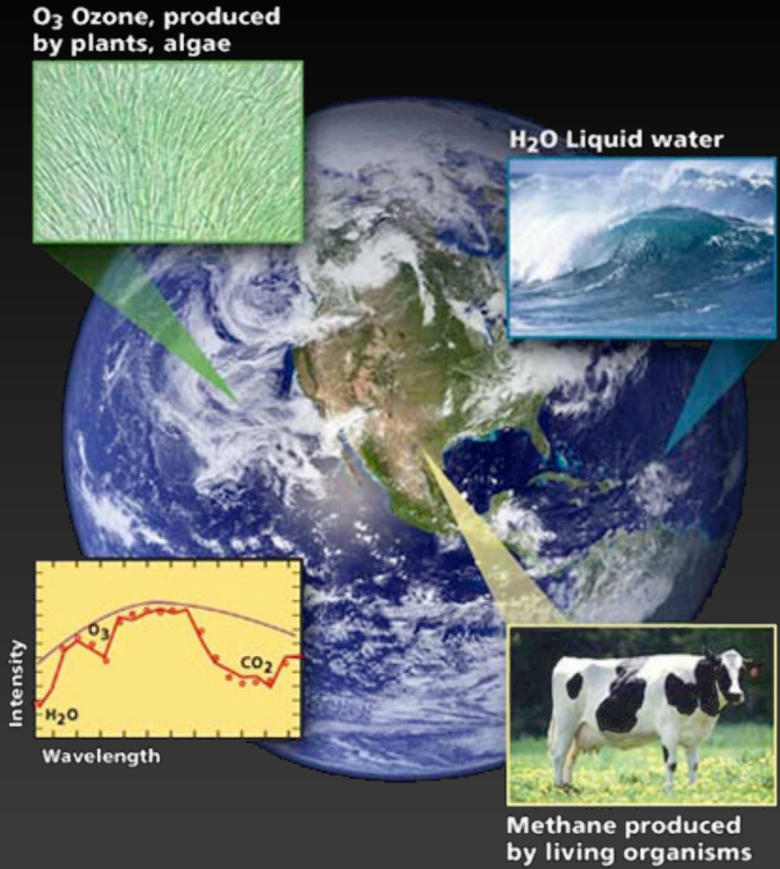


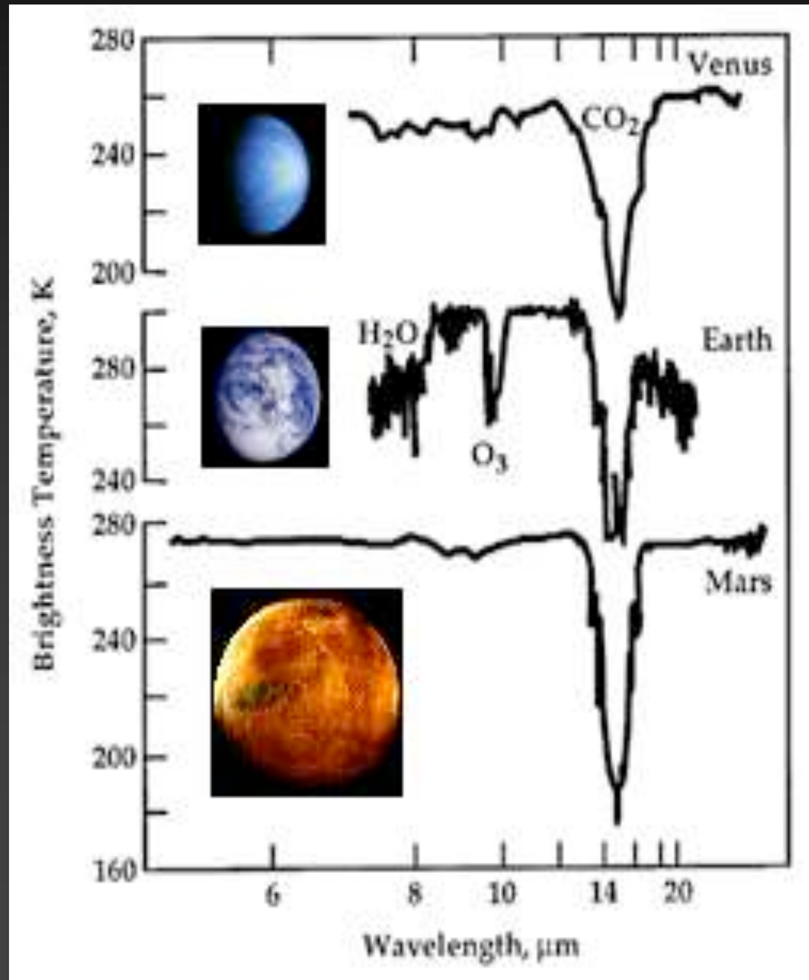
Terra

1/10 000 dell’area del Sole




Milky Way Galaxy
Kepler Search Space
3,000 light years
Sagittarius Arm
Sun
Orion Spur
Perseus Arm


O_3 Ozone, produced by plants, algae
H_2O Liquid water
Intensity
O_3
CO_2
H_2O
Wavelength
Methane produced by living organisms


Venus
CO_2
Earth
H_2O
O_3
Mars
Brightness Temperature, K
280
240
200
280
240
280
240
200
160
6
8
10
14
20
Wavelength, µm


TIME
The Real Reagan
Showman Of Science
Astronomer
Carl Sagan

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
Cornell University, Ithaca, New York

No theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation; (2) origin of life; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence. What sort of a channel would it be?

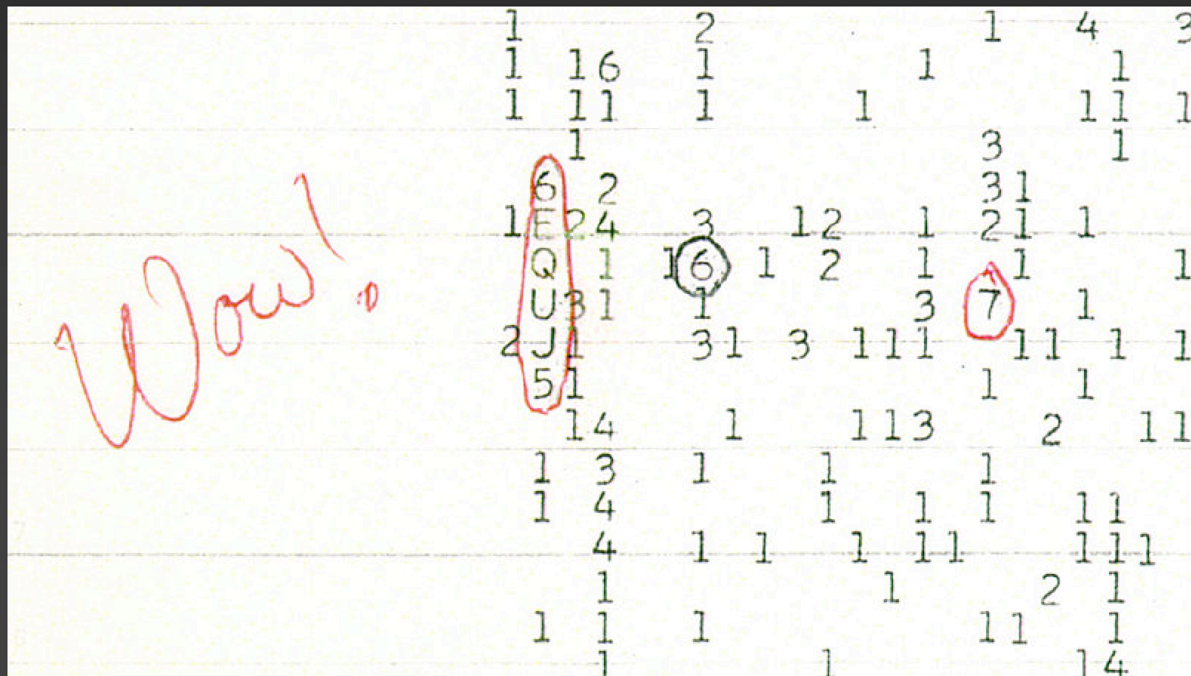
The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves.

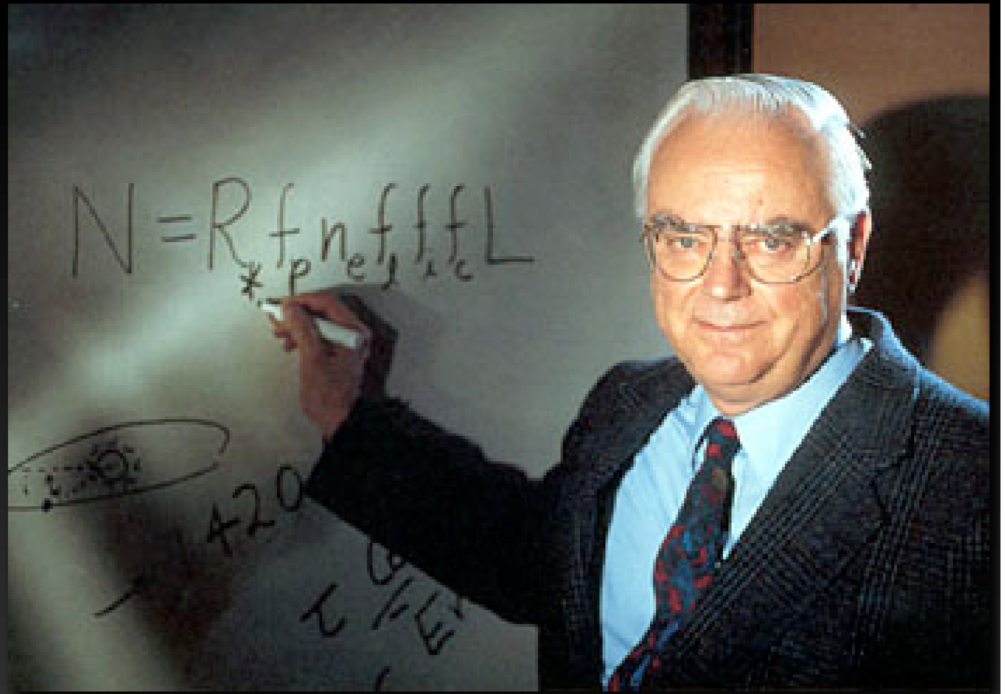
Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

* Now on leave at CERN, Geneva.

† Now on leave at the Imperial College of Science and Technology, London, S.W.7.



Frank Drake, 1961



$$\boxed{N = R_{*} \times f_p \times n_t \times f_v \times f_i \times f_c \times T}$$

Il grande silenzio

"La probabilità di successo è difficile da stimare: ma se non cerchiamo mai, la possibilità di successo è zero."

— Giuseppe Cocconi e Philip Morrison,
"Searching for intestellar communications",
Nature, 1959

“Esistono due possibilità: siamo soli nell’Universo, oppure no. Entrambe sono spaventose.”

— Isaac Asimov