Conceitos Fundamentais em Astrobiologia
MPA5007

Amâncio Friaça, IAG-USP

A Mãe de Todas as Revoluções*

De revolutionibus orbium coelestium (1543)

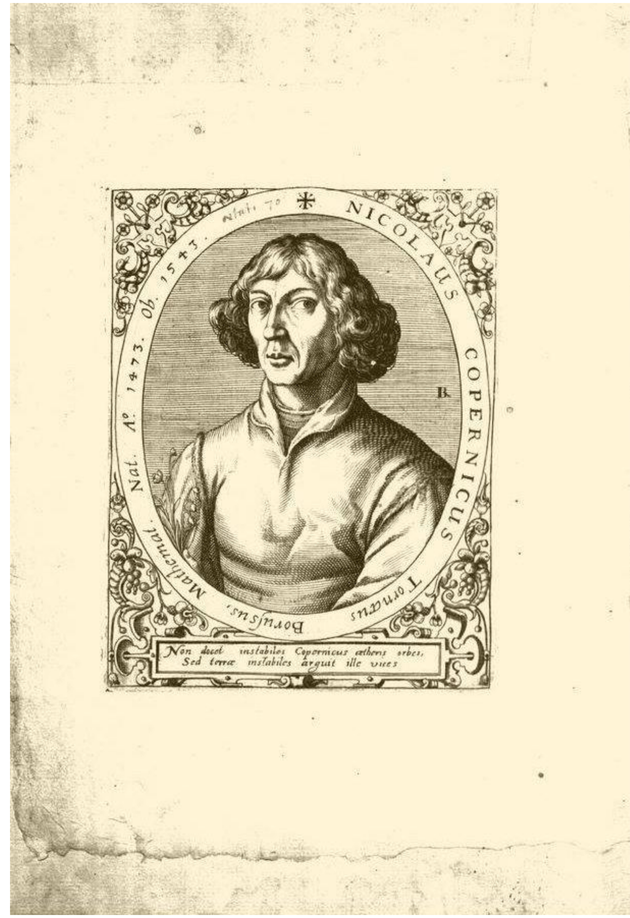
NICOLAI COPERNICI TO-RINENSIS DE REVOLVTIONI-bus orbium cœlestium, Libri VI.

IN QVIBVS STELLARVM ET FIXARVM ET ERRATICARVM MOTVS, EX VETERibus atq; recentibus obseruationibus, restituit hic autor. Præterea tabulas expeditas luculentasq; addidit, ex quibus eosdem motus ad quoduis tempus Mathematum studiosus facillime calculare poterit.

ITEM, DE LIBRIS REVOLVTIONVM NICOLAI Copernici Narratio prima, per M. Georgium Ioachimum Rheticum ad D. Ioan. Schonerum scripta.

Cum Gratia & Priuilegio Cæs. Maiest.

BASILEÆ, EX OFFICINA HENRICPETRINA.



*Hanna Arendt, *Da Revolução*

Non, Sire, c’est une révolution

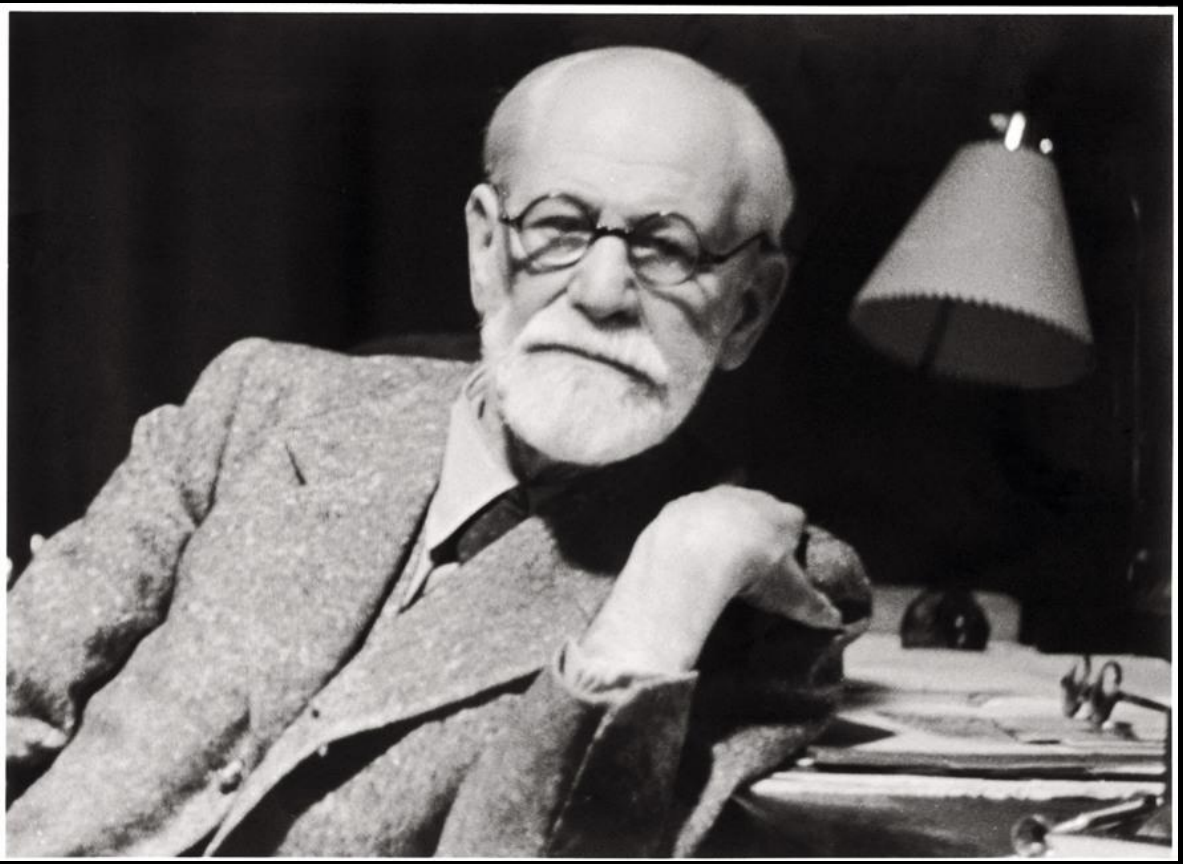
•Significado astronômico original: desprovido das conotações posteriores de novidade, começo e violência

•Significado astronômico original: contém a ideia de irresistibilidade

•O primeiro uso do termo com o significado atual foi na noite de 14 de julho, quando o rei Luís XIV recebeu do duque de La Rochefoucuald-Liancourd a notícia da queda da Bastilha

•O rei: *C’est une révolte*

•Liancourt: *Non, Sire, c’est une révolution*



As três feridas narcísicas:

- o heliocentrismo copernicano
- a evolução darwiniana
- o inconsciente freudiano

"Uma das afirmações menos modestas da história intelectual"
(Stephen Jay Gould, *Três Aspectos da Evolução*)

O Otimismo cósmico

na esteira do

De revolutionibus orbium coelestium


NICOLAI
COPERNICI TO-
RINENSIS DE REVOLVTIONI-
bus orbium cœlestium,
Libri VI.

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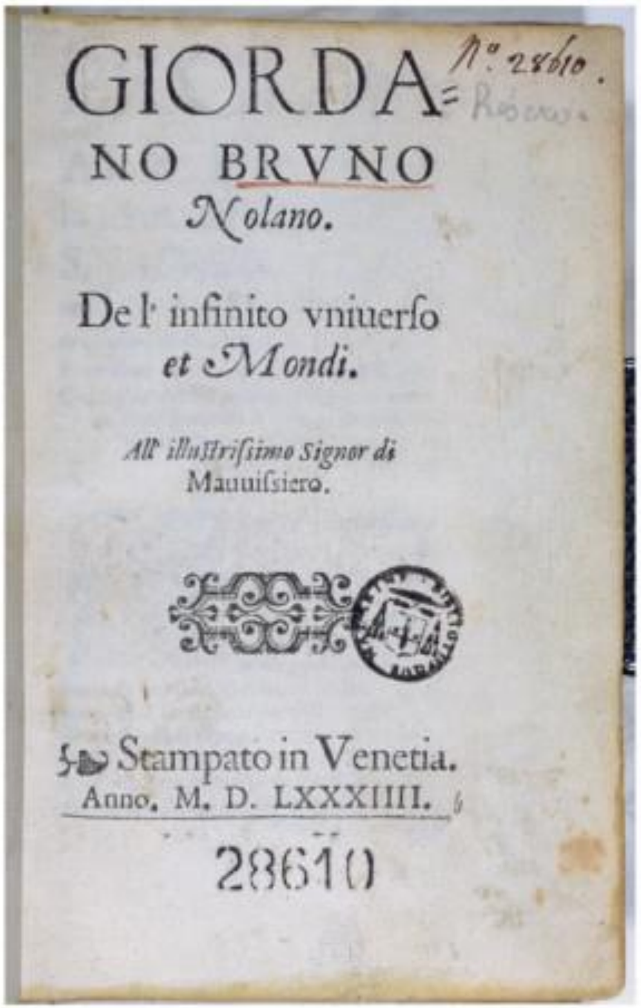
Cum Gratia & Privilegio Caes. Maiest.

BASILEAE, EX OFFICINA
HENRICPETRINA.

Giordano Bruno (1548-1600)

De l'Infinito Universo et Mondi **(1584)**



GIORDA=
NO BRVNO
Nolano.

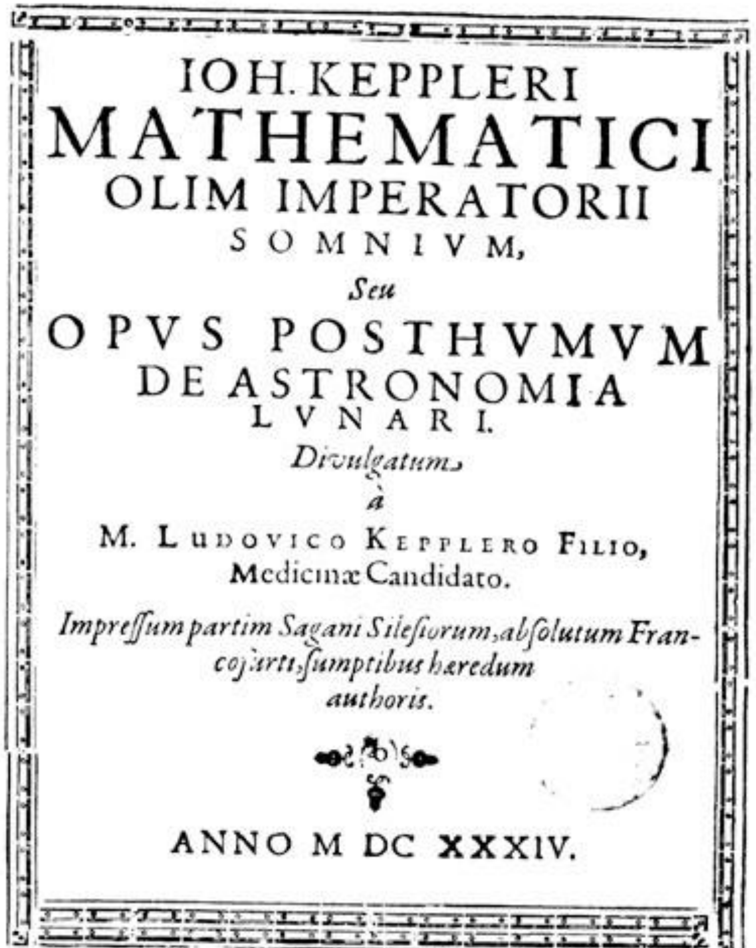
De l' infinito vniuerſo
et Mondi.

All' illuſtriſsimo Signor di
Mauuiſsiero.

Stampato in Venetia.
Anno. M. D. LXXXIIII.

Johannes Kepler (1571-1630)

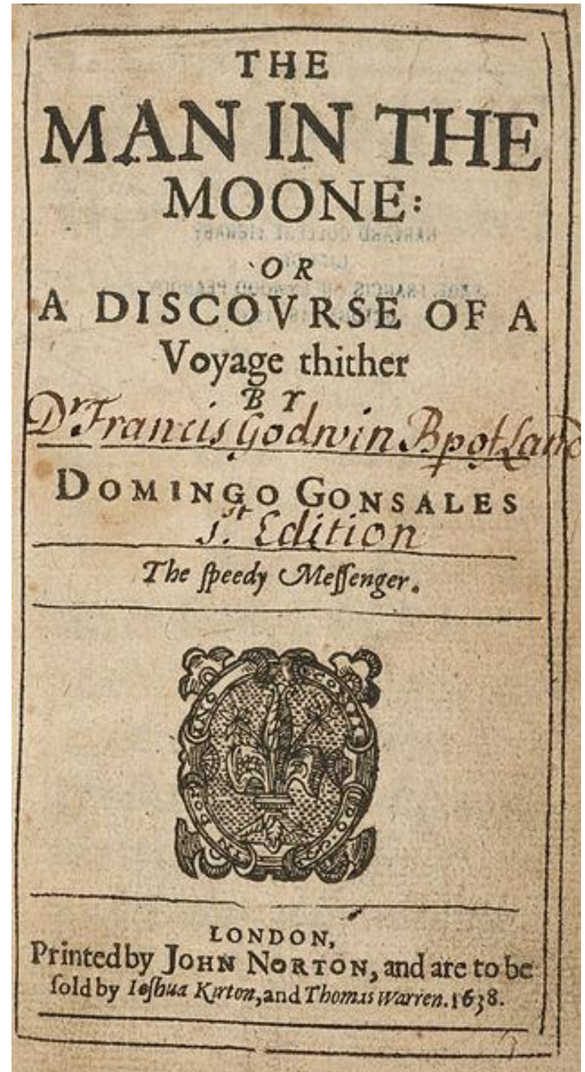
Somnium (1609)



IOH. KEPPLERI
MATHEMATICI
OLIM IMPERATORII
SOMNIVM,
Seu
OPVS POSTHVMVM
DE ASTRONOMIA
LVNARI.
Divulgatum
à
M. LUDOVICO KEPPLERO FILIO,
Medicinæ Candidato.
Impreſſum partim Sagani Sileſiorum, abſolutum Francofurti, ſumptibus hæredum authoris.
ANNO M DC XXXIV.

Francis Godwin (1562–1633)

The Man in the Moone (1638)



THE

MAN IN THE MOONE:

OR

A DISCOVRSE OF A Voyage thither

BY

Dr. Francis Godwin Bp of Land

DOMINGO GONSALES

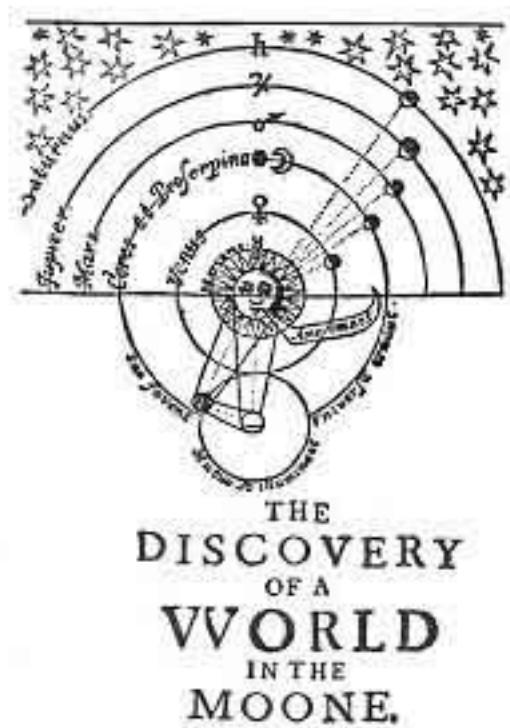
1st Edition

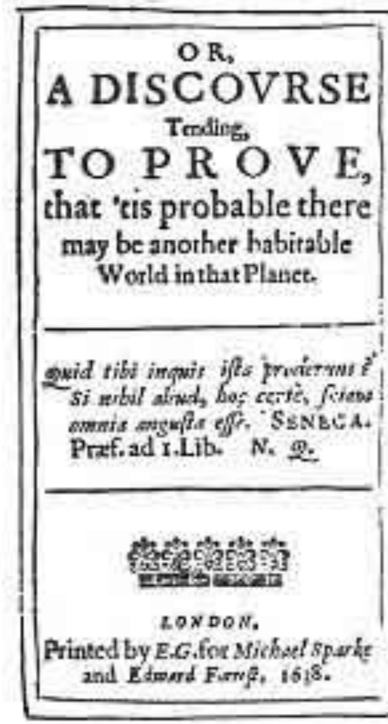
The speedy Messenger.

LONDON,
Printed by JOHN NORTON, and are to be sold by Ioshua Kirton, and Thomas Warren. 1638.

John Wilkins (1614-1672)

The Discovery of a World in the Moone (1638)



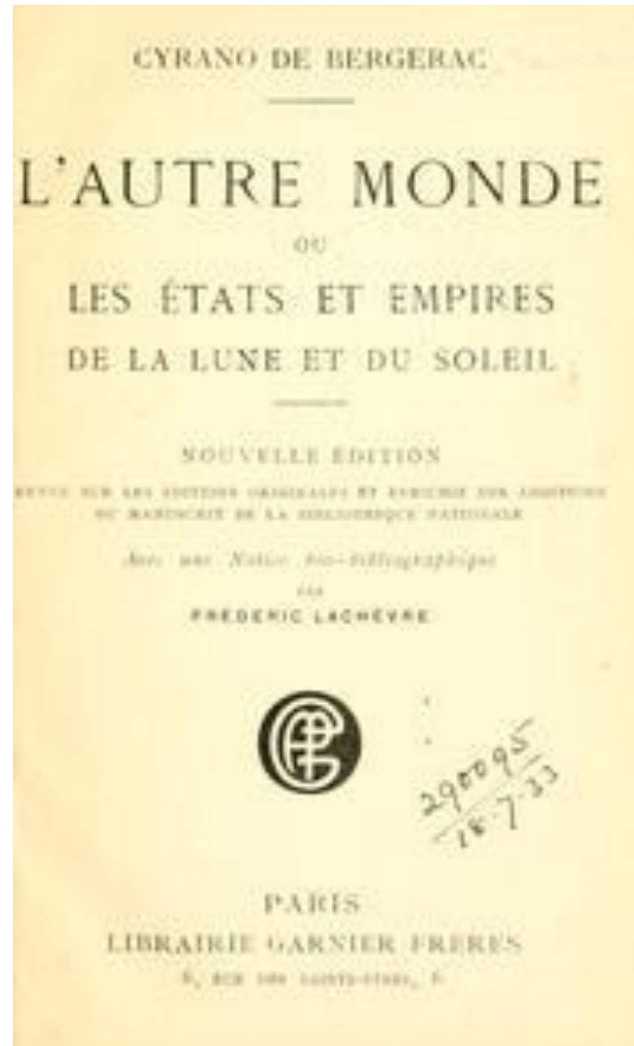


OR,
A DISCOVRSE
Tending,
TO PROVE,
that 'tis probable there
may be another habitable
World in that Planet.

Quid tibi inquis ista proderunt? Si nihil aliud, hoc certè, sciam omnia angusta esse. SENECA. Præf. ad 1. Lib. N. Q.

LONDON,
Printed by *E.G.* for *Michael Sparke* and *Edward Forrest*, 1638.

Cyrano de Bergerac (1619-1655)
L'Autre Monde (1657)



CYRANO DE BERGERAC

L'AUTRE MONDE

OU

LES ÉTATS ET EMPIRES

DE LA LUNE ET DU SOLEIL

NOUVELLE ÉDITION

FRÉDÉRIC LACHÈVRE

PARIS

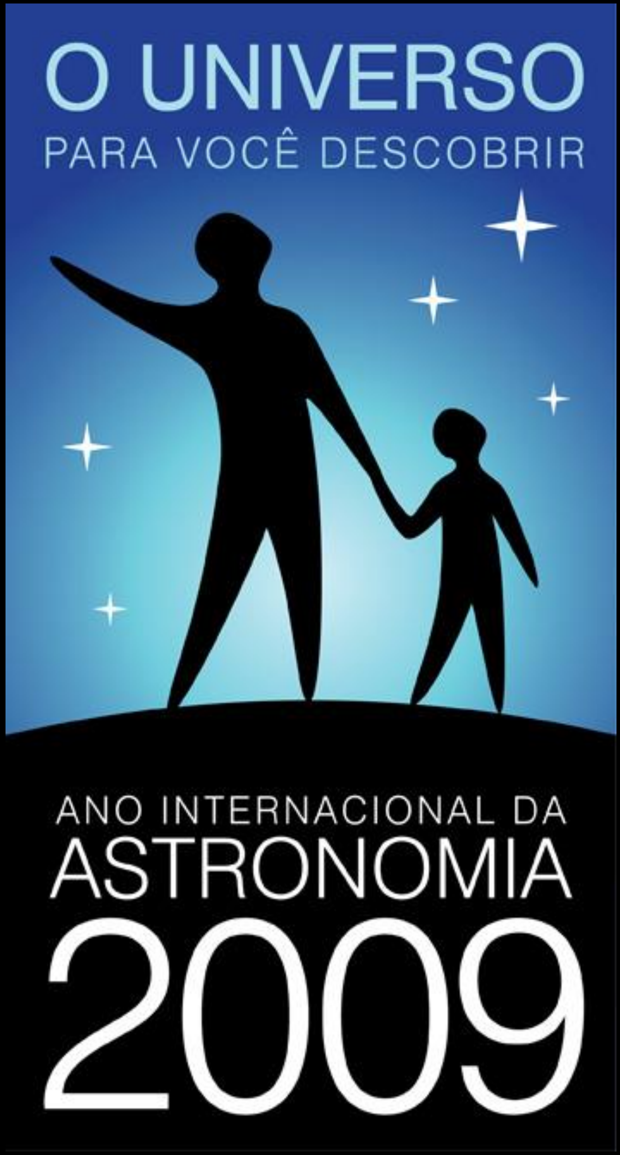
LIBRAIRIE GARNIER FRÈRES

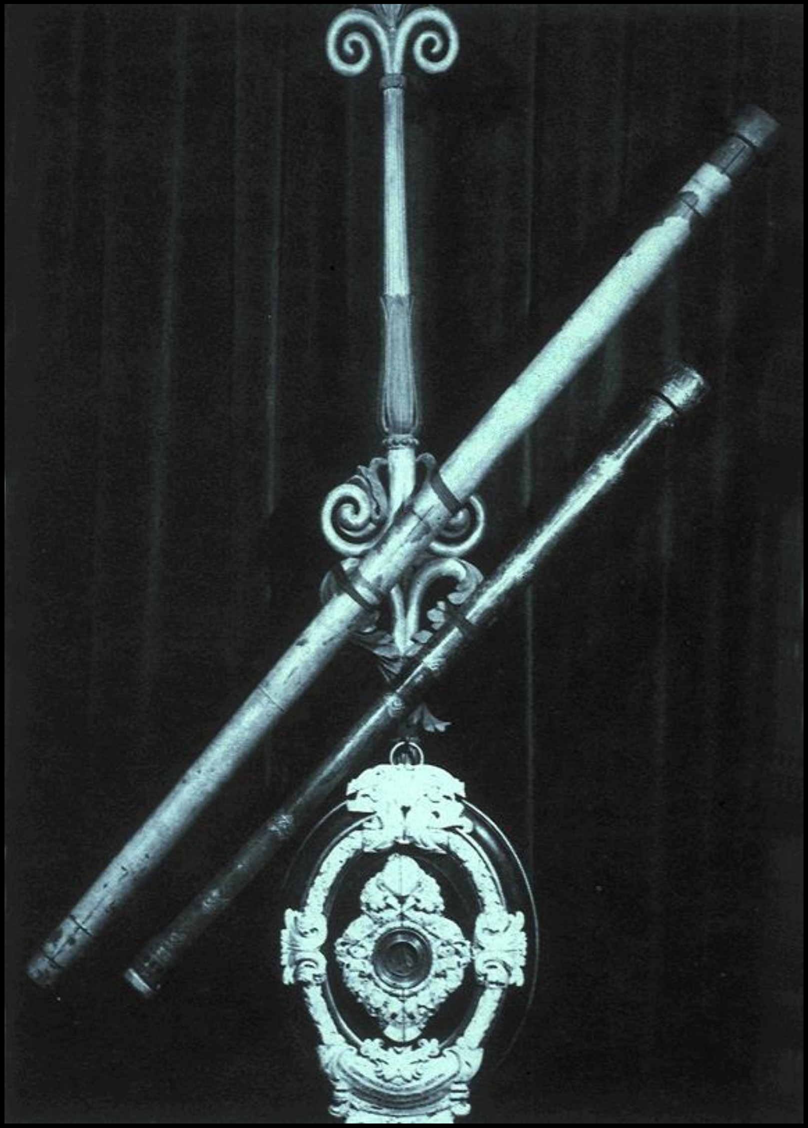
Leveza (cf. Italo Calvino)

Rapidez (Italo Calvino)

"Se o discorrer sobre um problema difícil fosse como carregar pesos, caso em que muitos cavalos podem levar mais sacos de trigo do que um só cavalo, eu concordaria que muitos discursos fariam mais que um só; mas o discorrer é como o correr, e não como o carregar, e um cavalo berbere sózinho correrá mais que cem cavalos frísios"

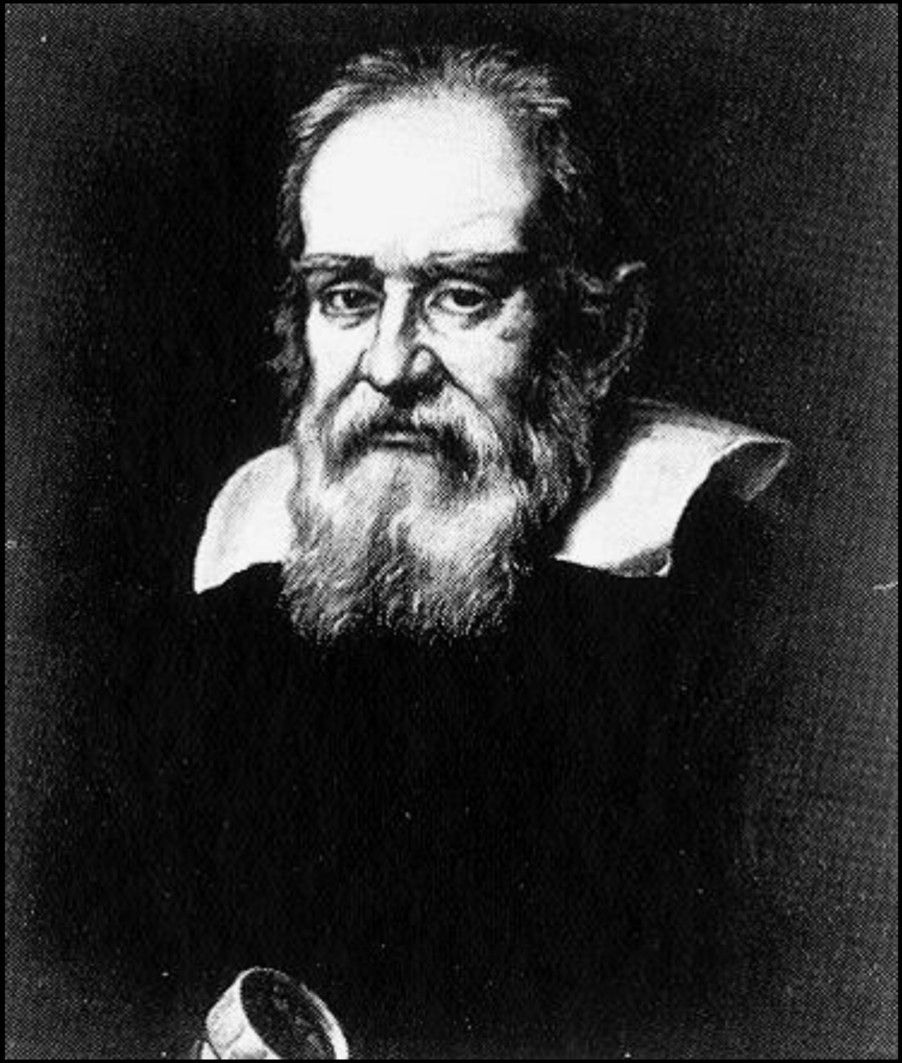
Galileo Galilei, *Il Saggiatore*

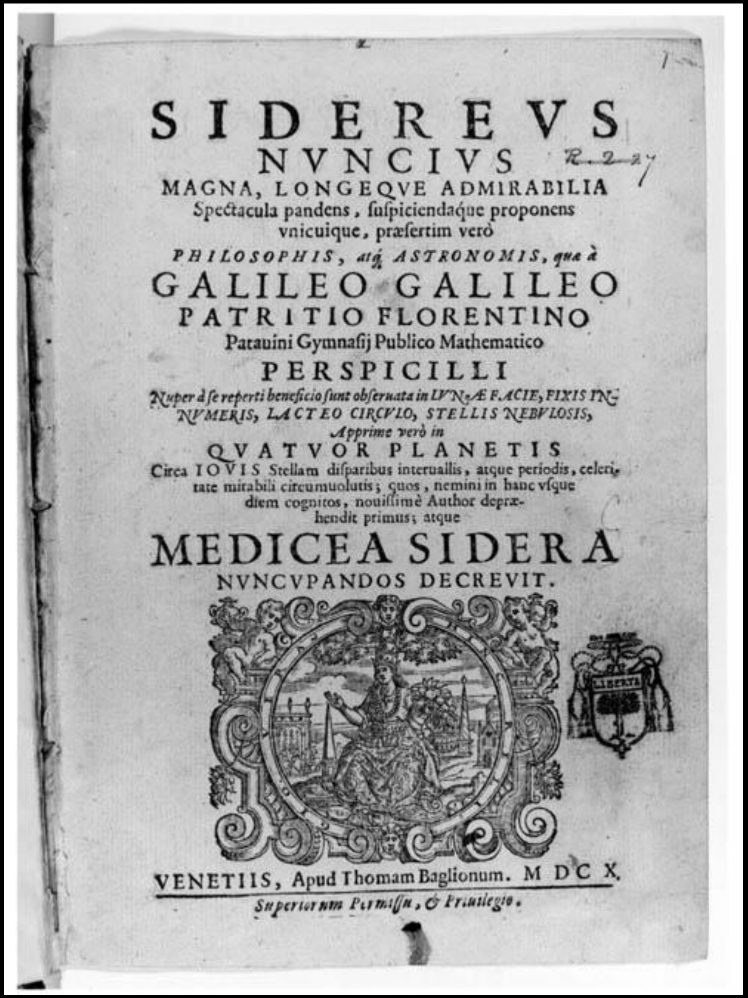




400 anos do uso astronômico do telescópio

Galileu Galilei (1564-1642)





SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò
PHILOSOPHIS, atq; ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS INNVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in
QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeritate mirabili circumuolutis; quos, nemini in hanc vsque diem cognitos, nouissimè Author depræhendit primus; atque
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.

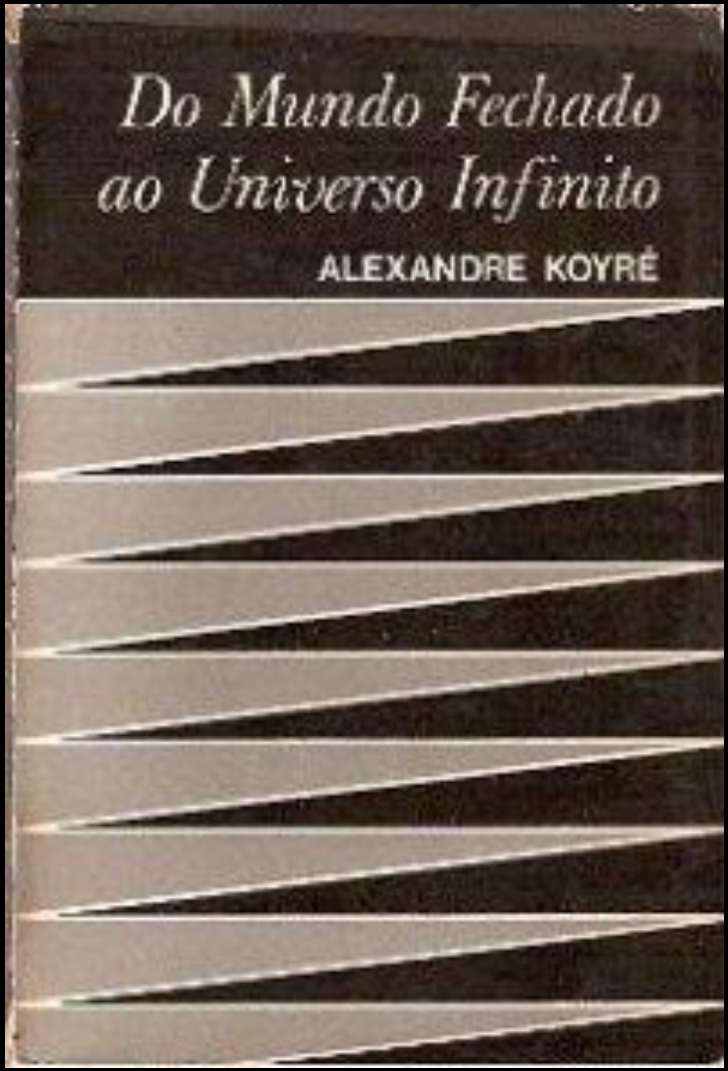
VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.


Vi coisas que olhos humanos jamais viram antes
Galileu Galilei

O CÉU QUE NÃO NOS PROTEGE

- O silêncio desses espaços infinitos me apavora (Pascal)
- A natureza é uma esfera infinita cujo centro está em toda parte e cuja circunferência em parte alguma (Pascal, Pensamentos)
- A natureza é uma esfera ***apavorante*** cujo centro está em toda parte e cuja circunferência em parte alguma. (Pascal, manuscrito, ver “A Esfera de Pascal” de J.L. Borges)
- A máquina do Universo é uma esfera infinita cujo centro está em toda parte e a circunferência em parte alguma (Nicolau de Cusa)

Do Mundo Fechado ao Universo Infinito

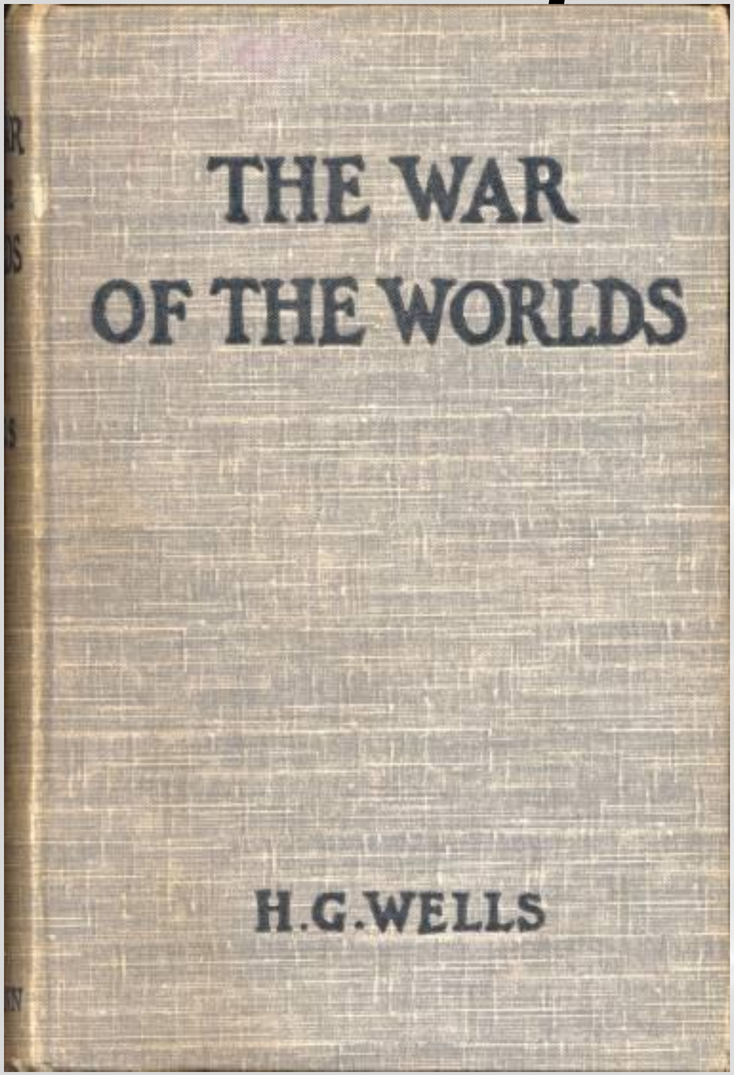


- Destruição do Cosmos
- Espacialização do Universo

Quem é o outro cósmico?

- Uma super-inteligência
- Um longevo senil
- Um anjo cósmico
- Um predador high-tech

The War of the Worlds (1898)



H.G. Wells (1866-1946)

SIGNATURES OF A SHADOW BIOSPHERE

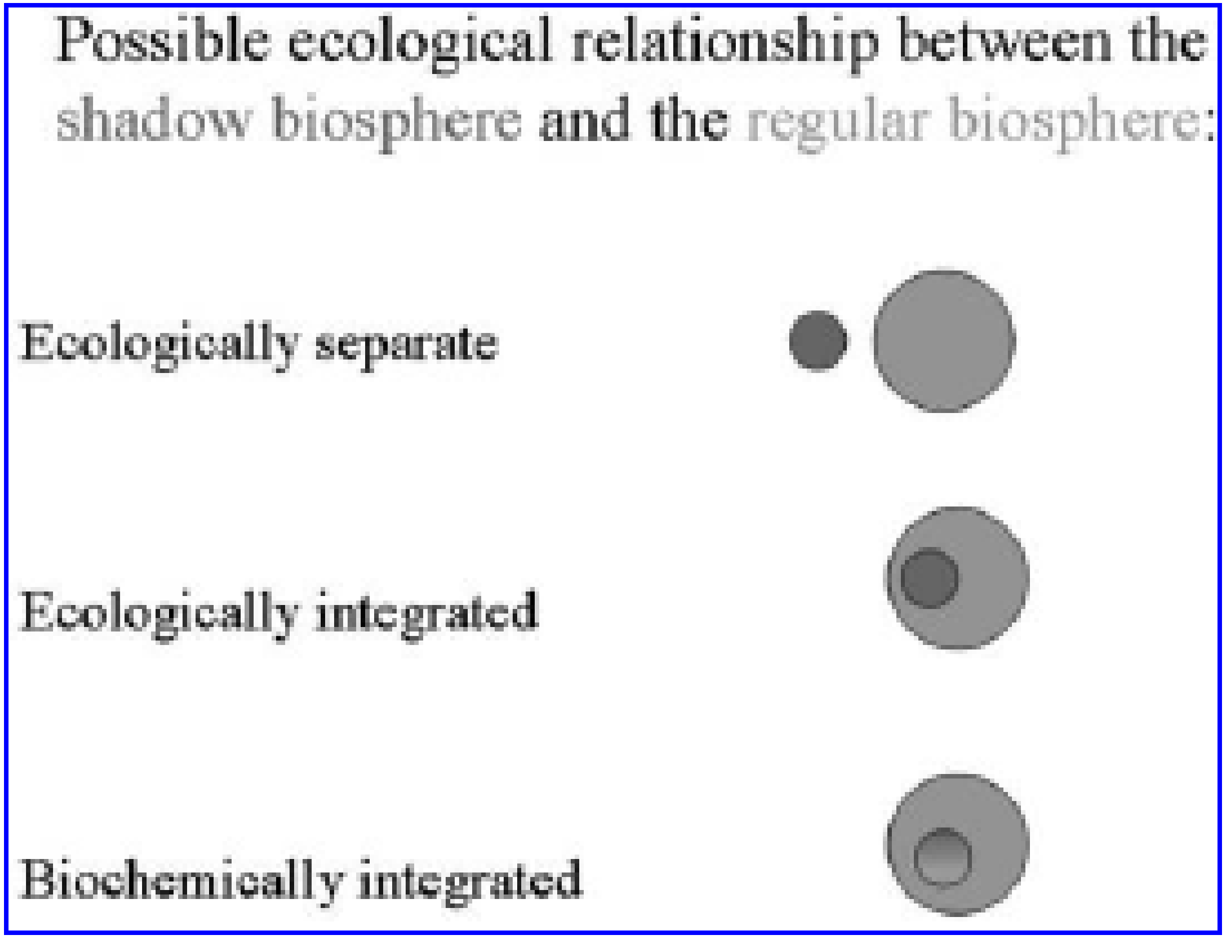
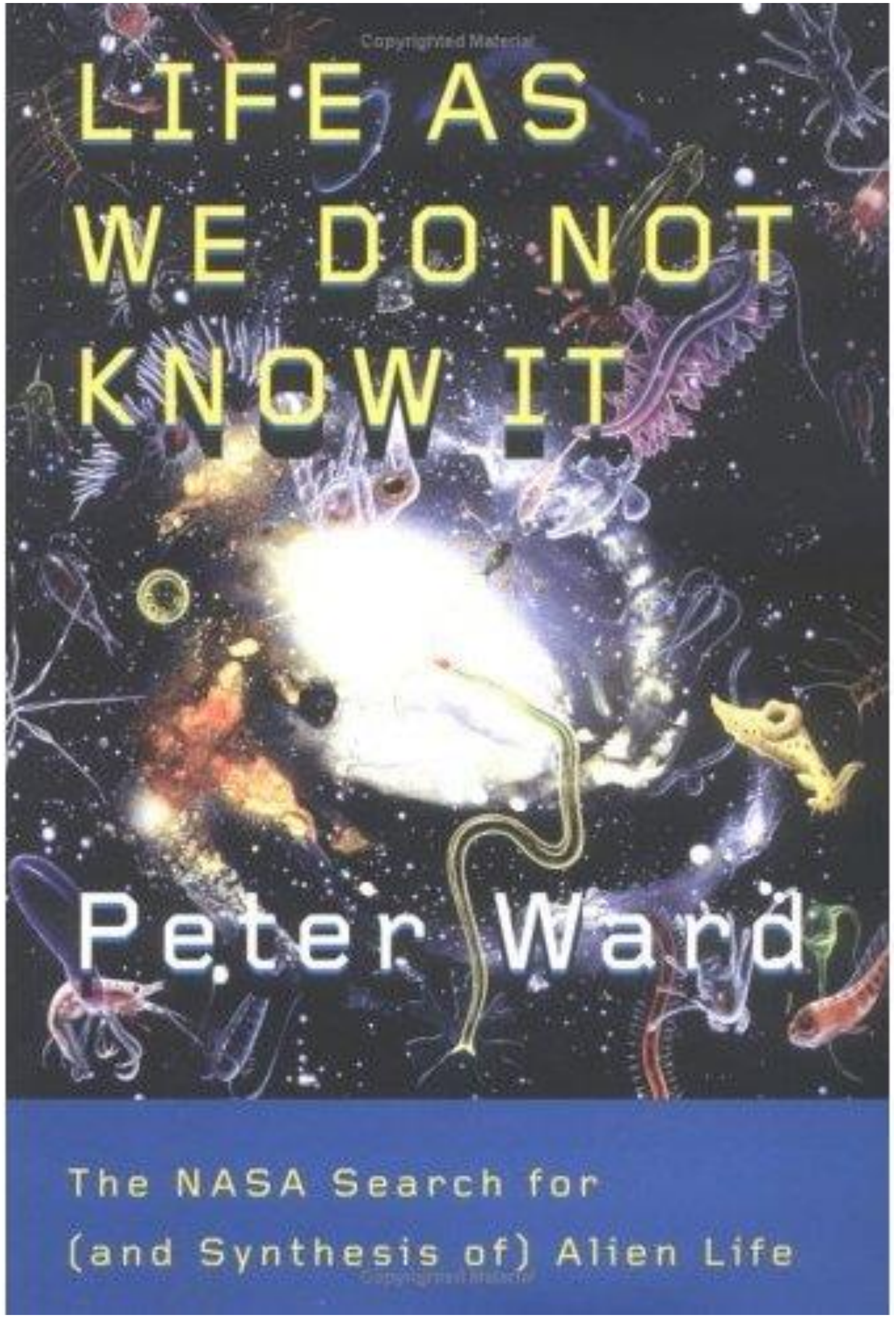


FIG. 1. Schematic representation of various possible relationships between known and weird life.



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LIFE AS
WE DO NOT
KNOW IT
Peter Ward
The NASA Search for
(and Synthesis of) Alien Life
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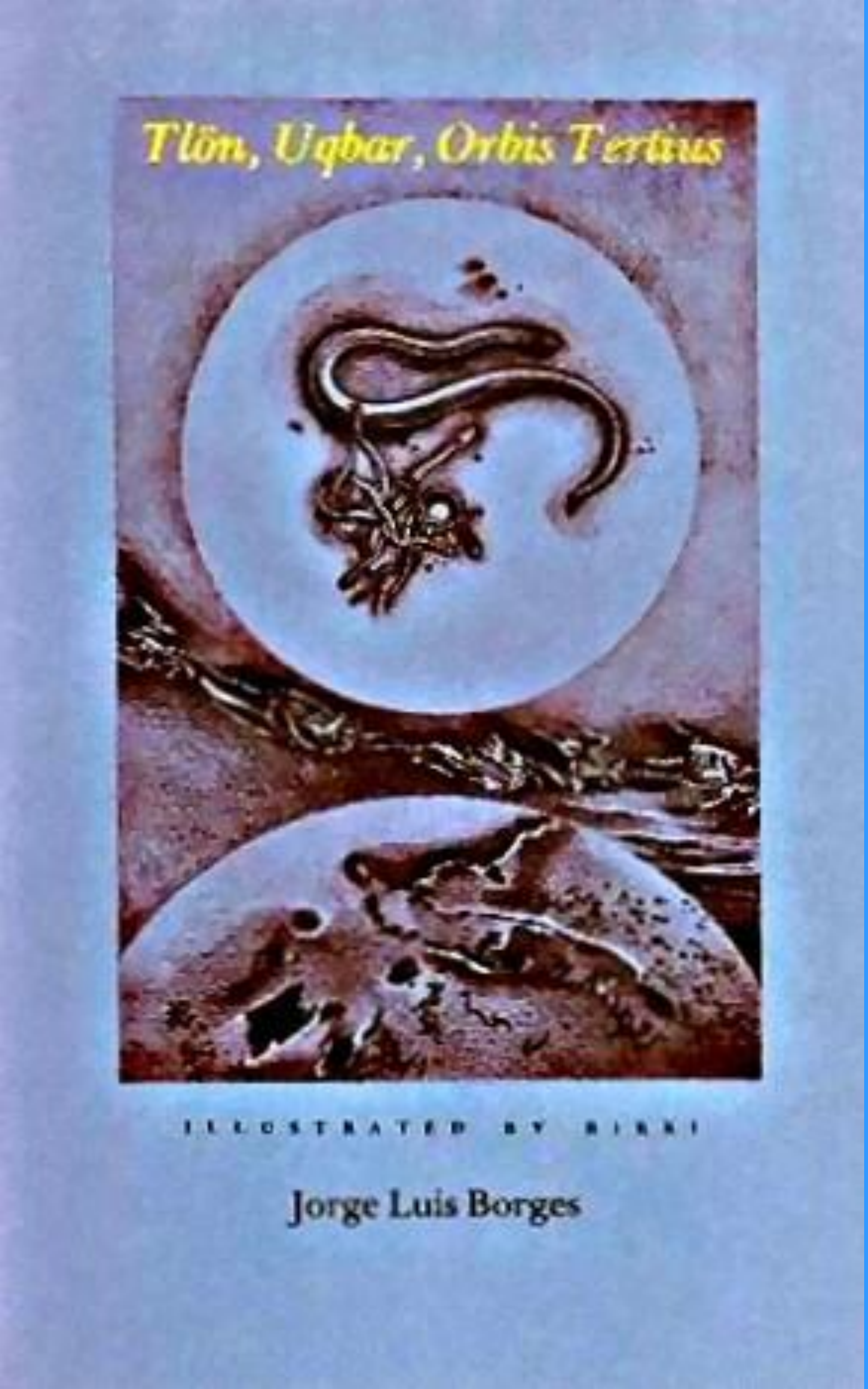
Tlön, Uqbar, Orbis Tertius



Quase imediatamente a realidade cedeu em mais de um ponto.

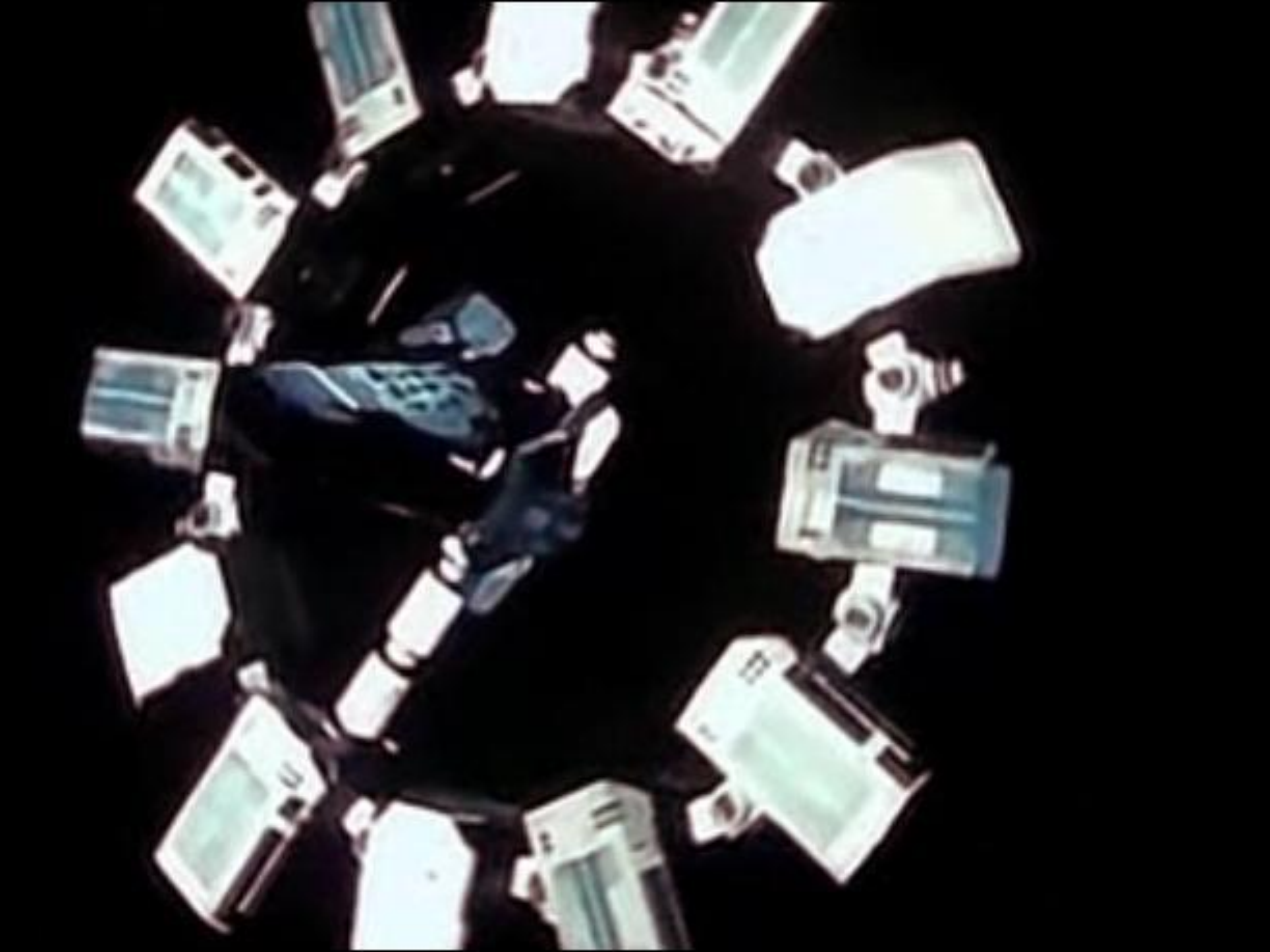
Como não submeter-se à Tlön,à minuciosa evidencia de um planeta tão ordenado?

O contato e hálito de Tlön desintegraram este mundo.

O mundo será Tlön.

A Exploração Espacial

Exploração Espacial
Algumas Reflexões



Do not go gentle into that good night,
Old age should burn and rave at close of day;
Rage, rage against the dying of the light.

Though wise men at their end know dark is right,
Because their words had forked no lightning they
Do not go gentle into that good night.

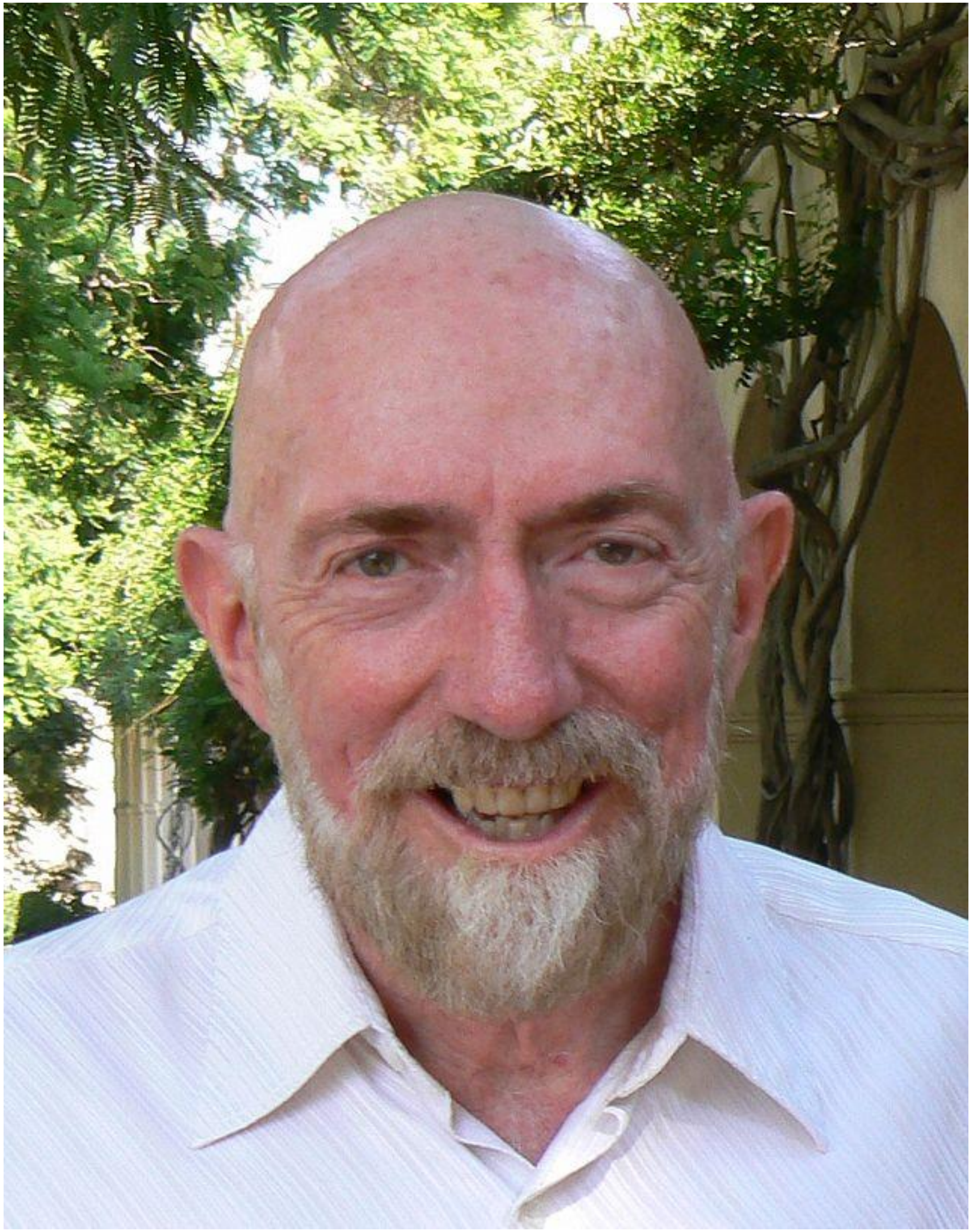
Good men, the last wave by, crying how bright
Their frail deeds might have danced in a green bay,
Rage, rage against the dying of the light.

Wild men who caught and sang the sun in flight,
And learn, too late, they grieved it on its way,
Do not go gentle into that good night.

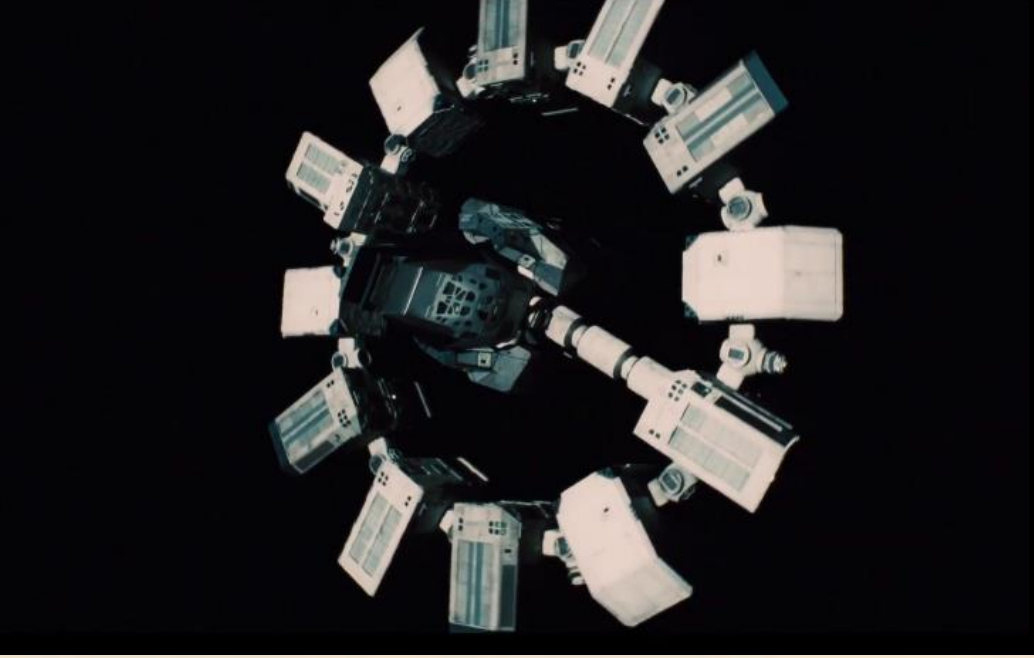
Grave men, near death, who see with blinding sight
Blind eyes could blaze like meteors and be gay,
Rage, rage against the dying of the light.

And you, my father, there on the sad height,
Curse, bless, me now with your fierce tears, I pray.
Do not go gentle into that good night.
Rage, rage against the dying of the light.

Do not go gentle into that good night
(Dylan Thomas, 1914 – 1953)



Kip Thorne

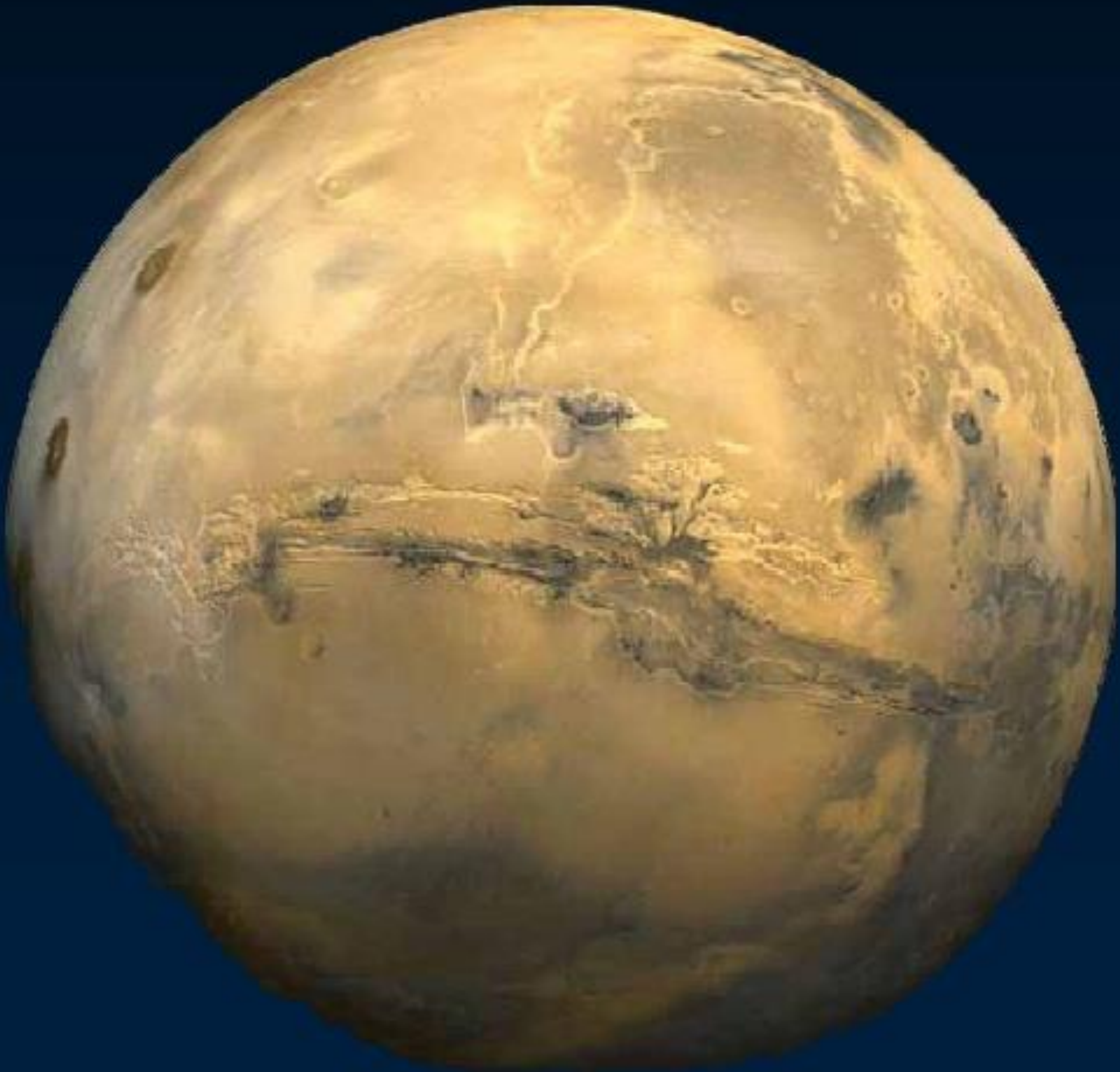


Sistema Solar

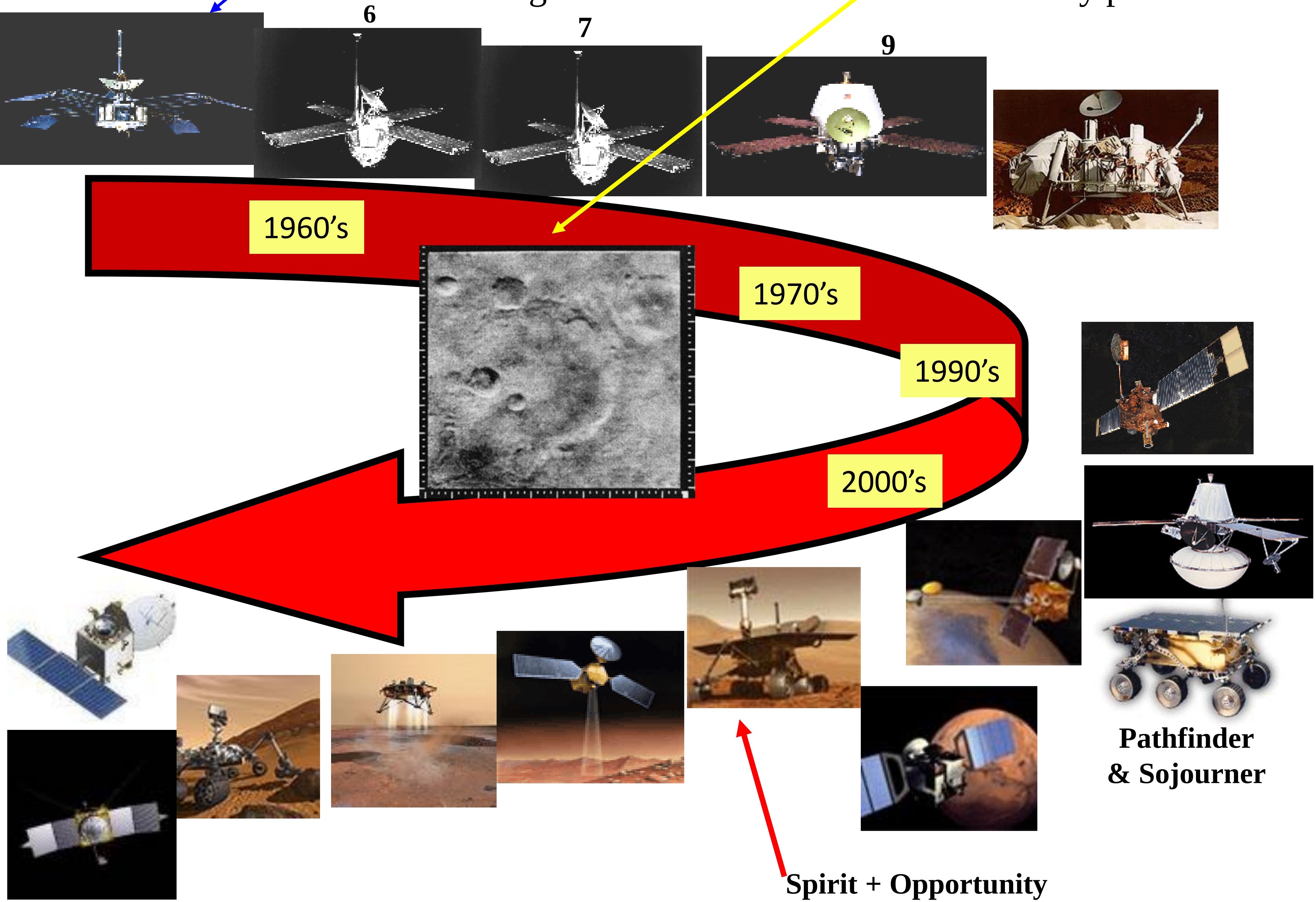
Exploração Espacial: Esterilidade vs. Diversidade no Sistema Solar

Sistema Solar
Pessimismo vs. Otimismo

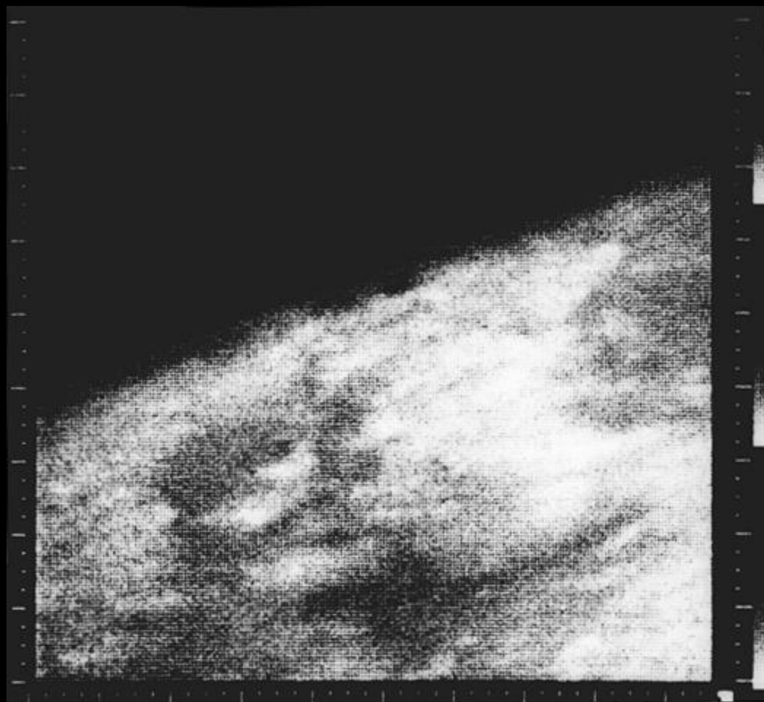
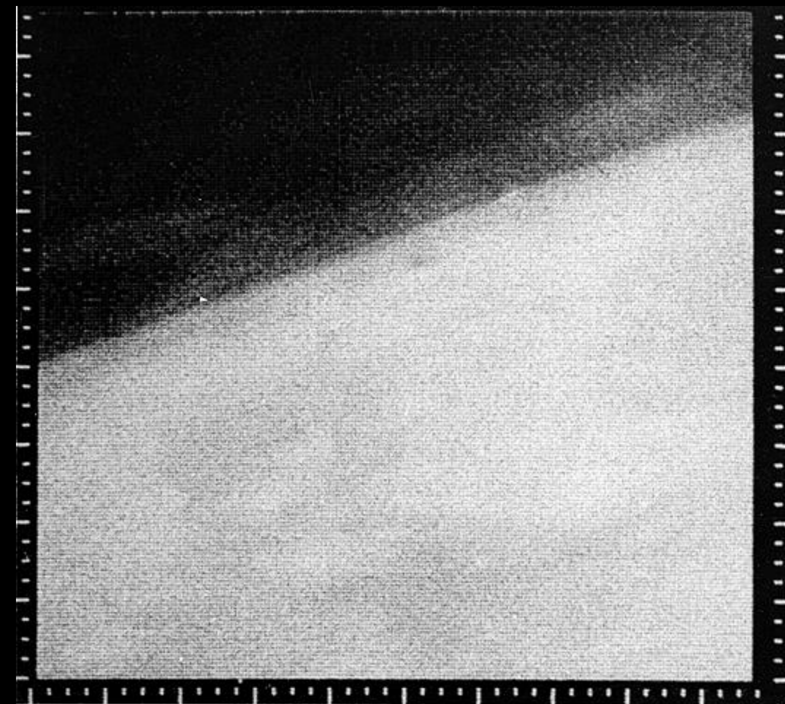
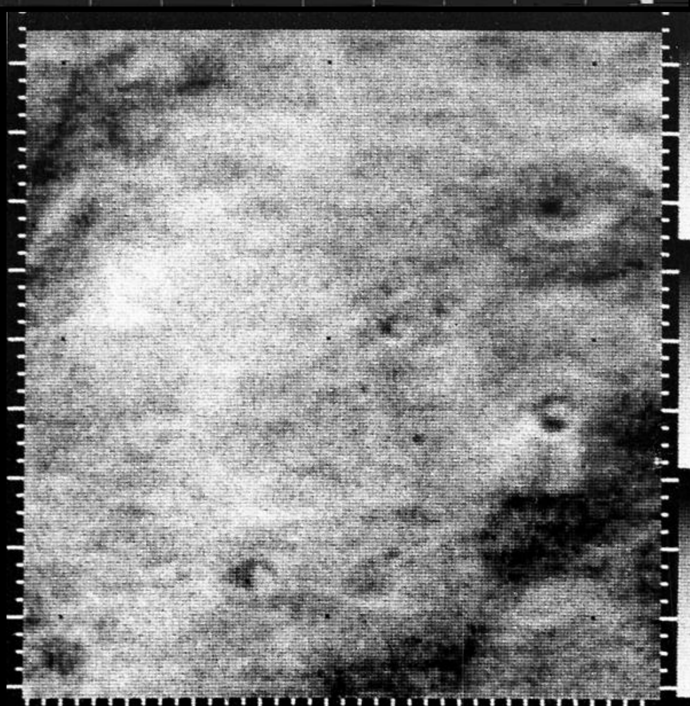
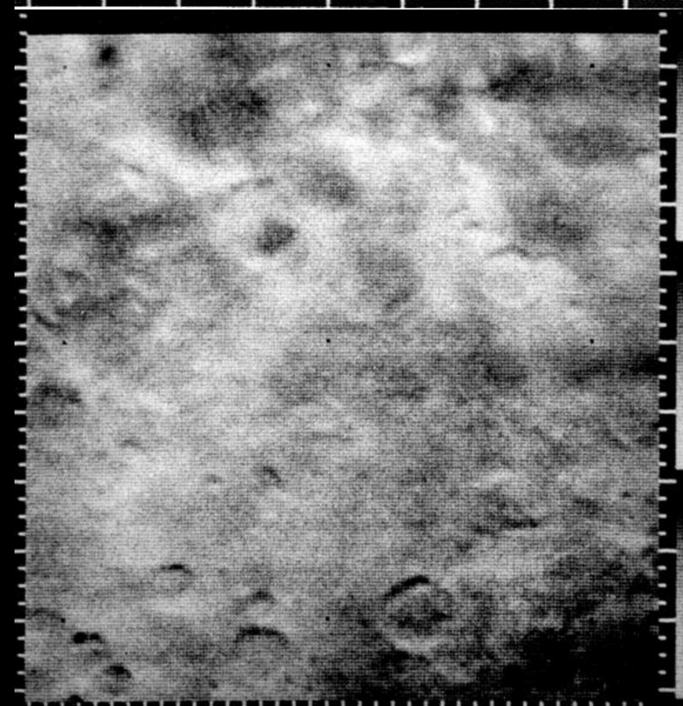
MARTE

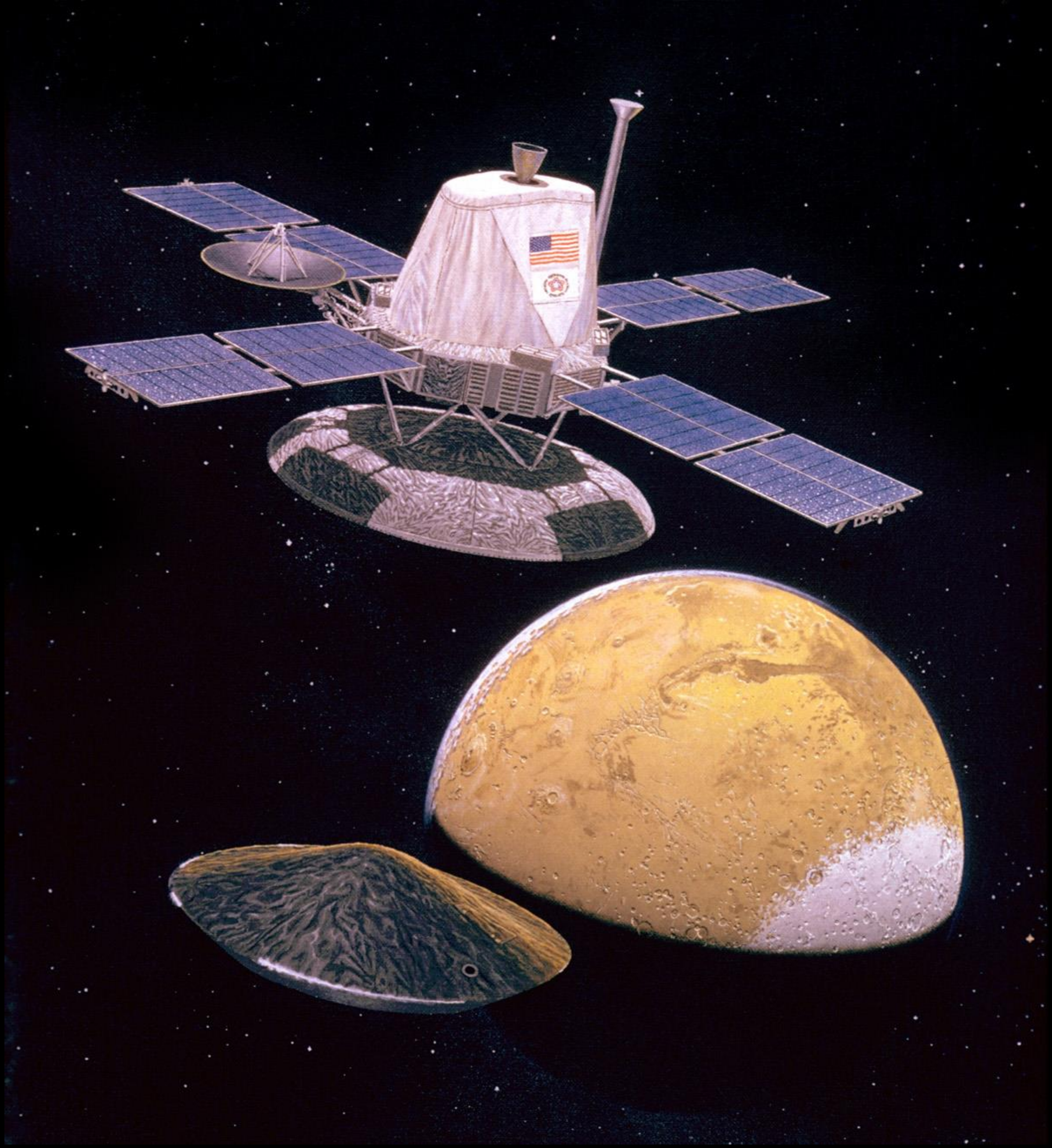


- In 1965 “Mariner 4” spacecraft send a few dozen good pictures of the Martian surface – no evidence for intelligent life. Mars is in fact a cold and dry planet!

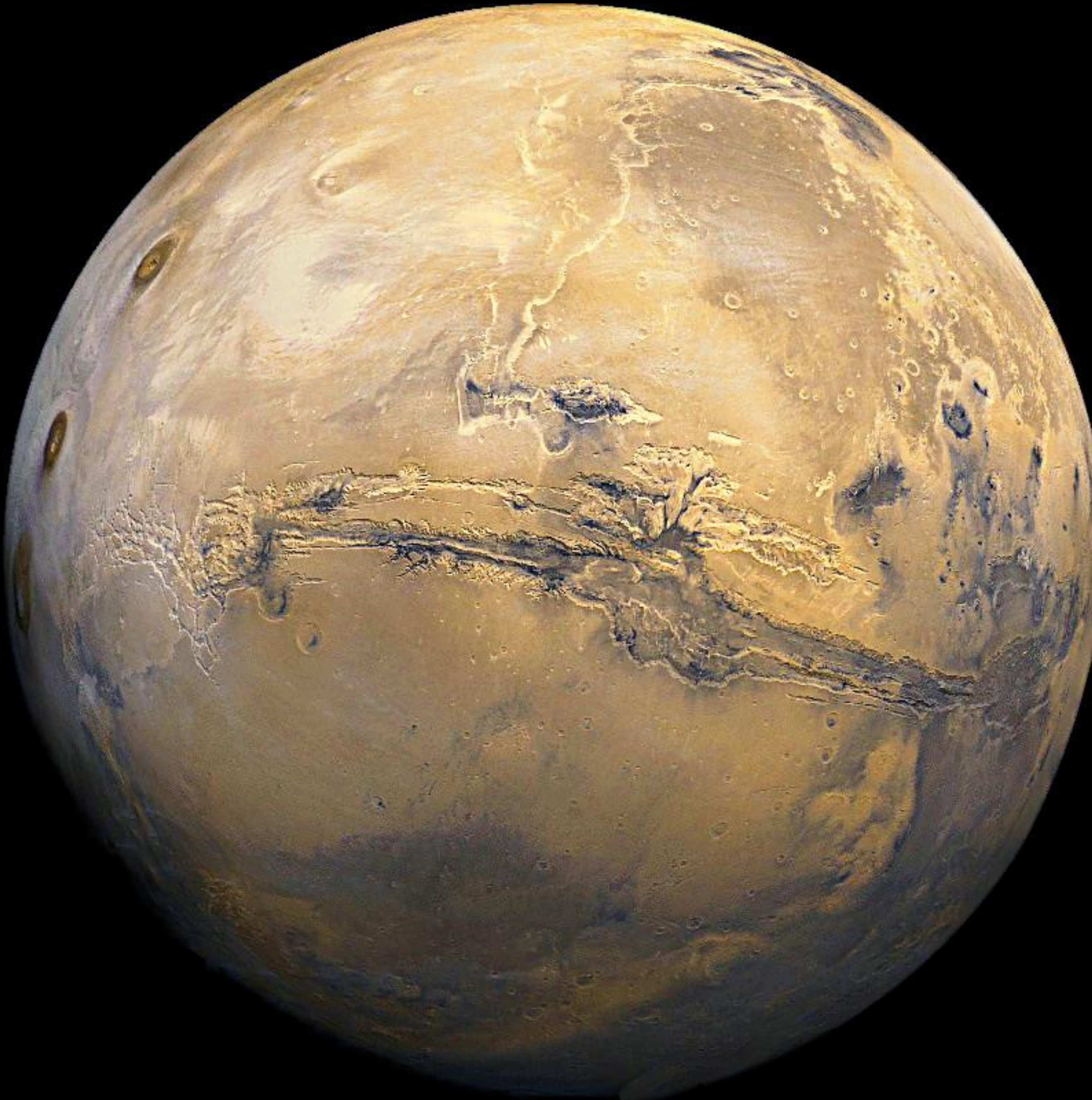


Mariner 4 flyby of Mars (14 July 1965)

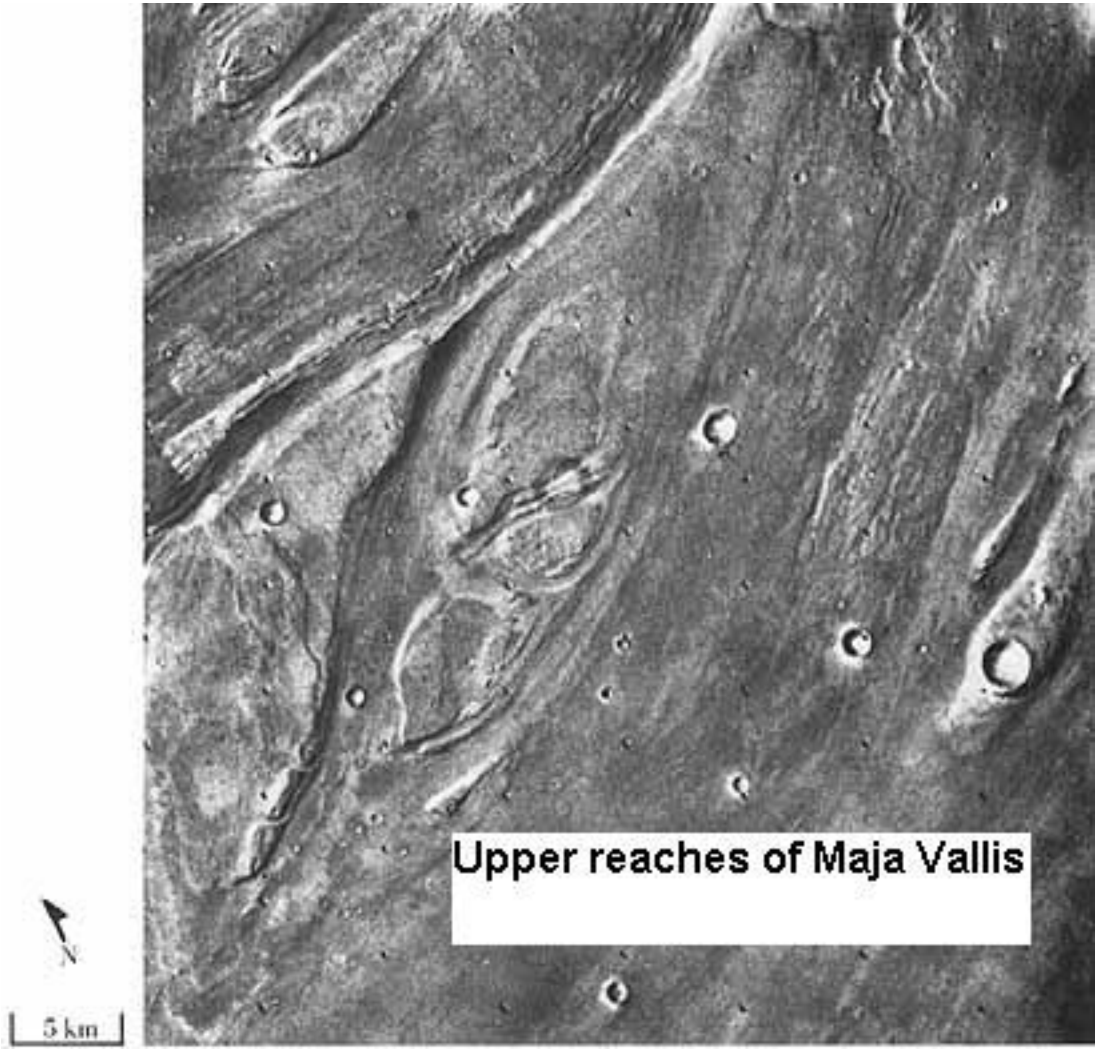







Viking 1 & 2 (1976)



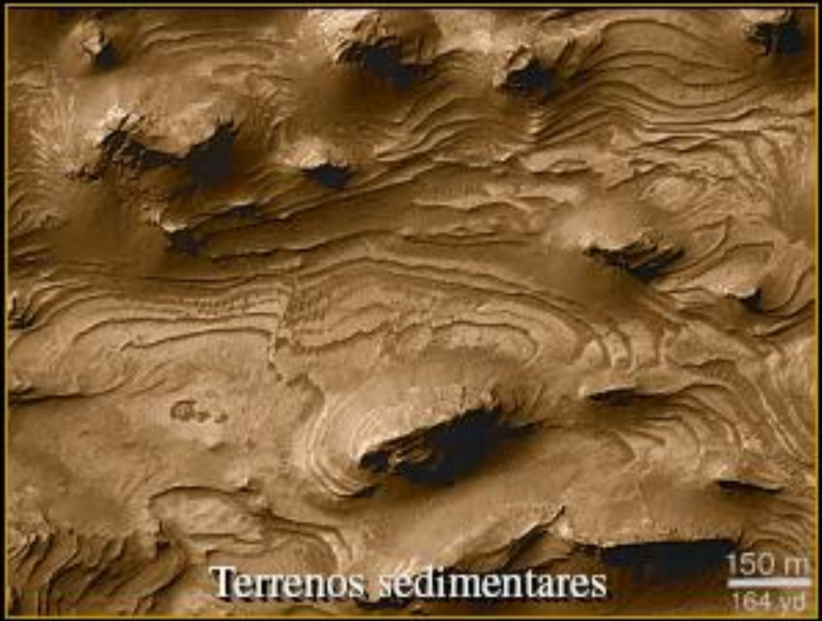
O Sistema Solar
é úmido



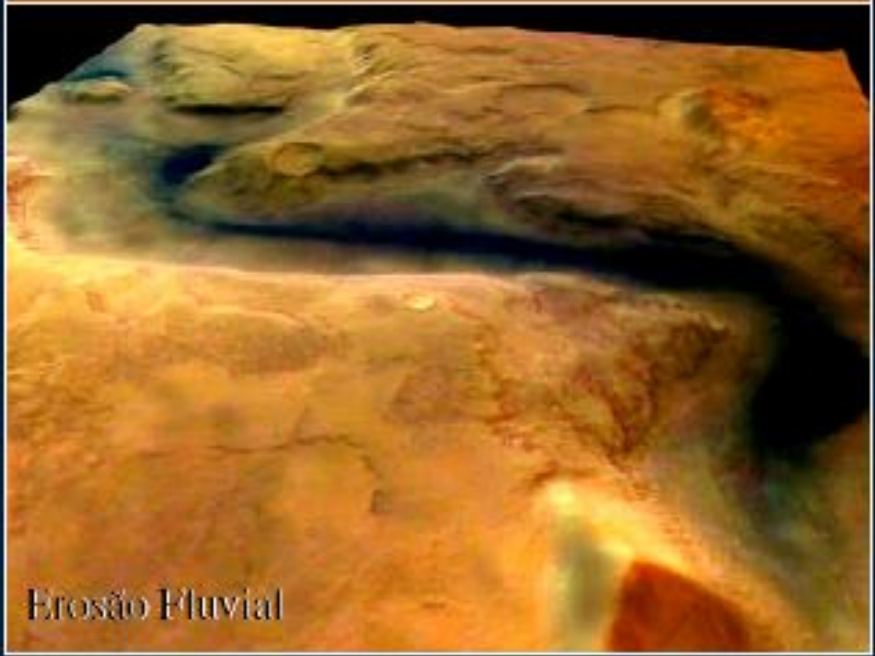
N
5 km
Upper reaches of Maja Vallis

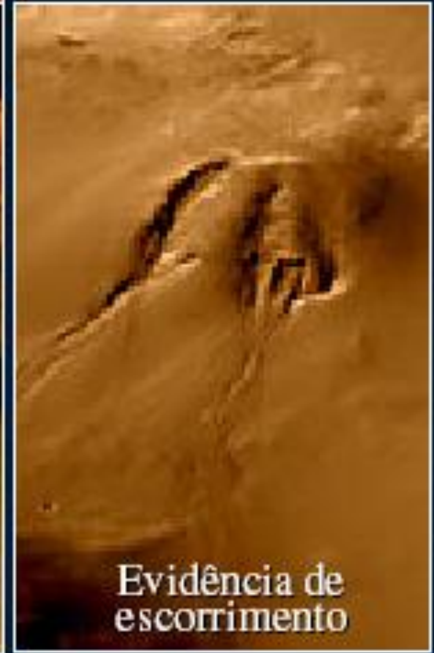
Vestígios de água em Marte

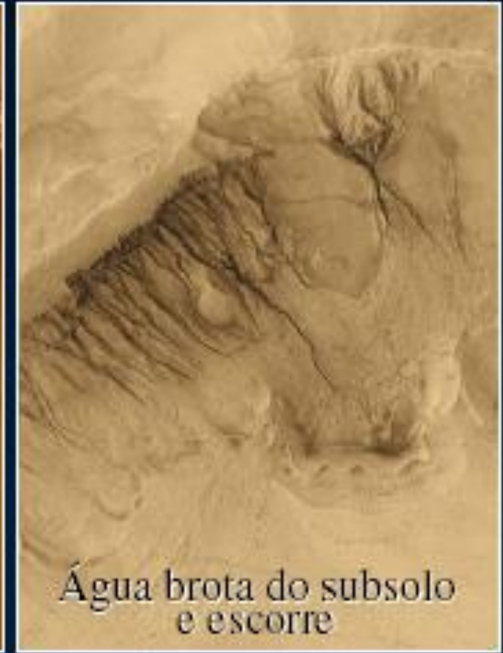
Já houve clima favorável à existência de água líquida na superfície. Eis algumas evidências:

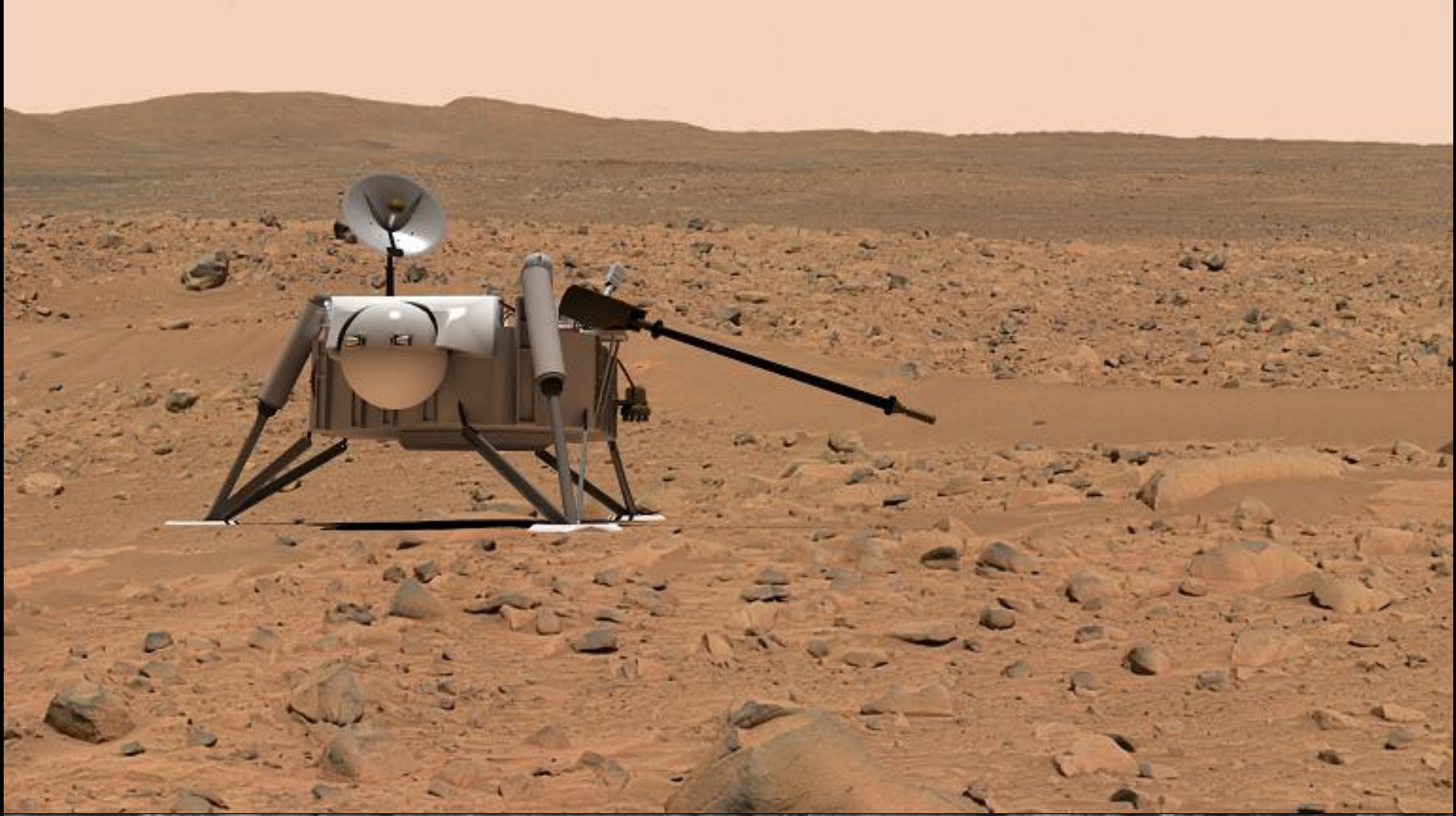


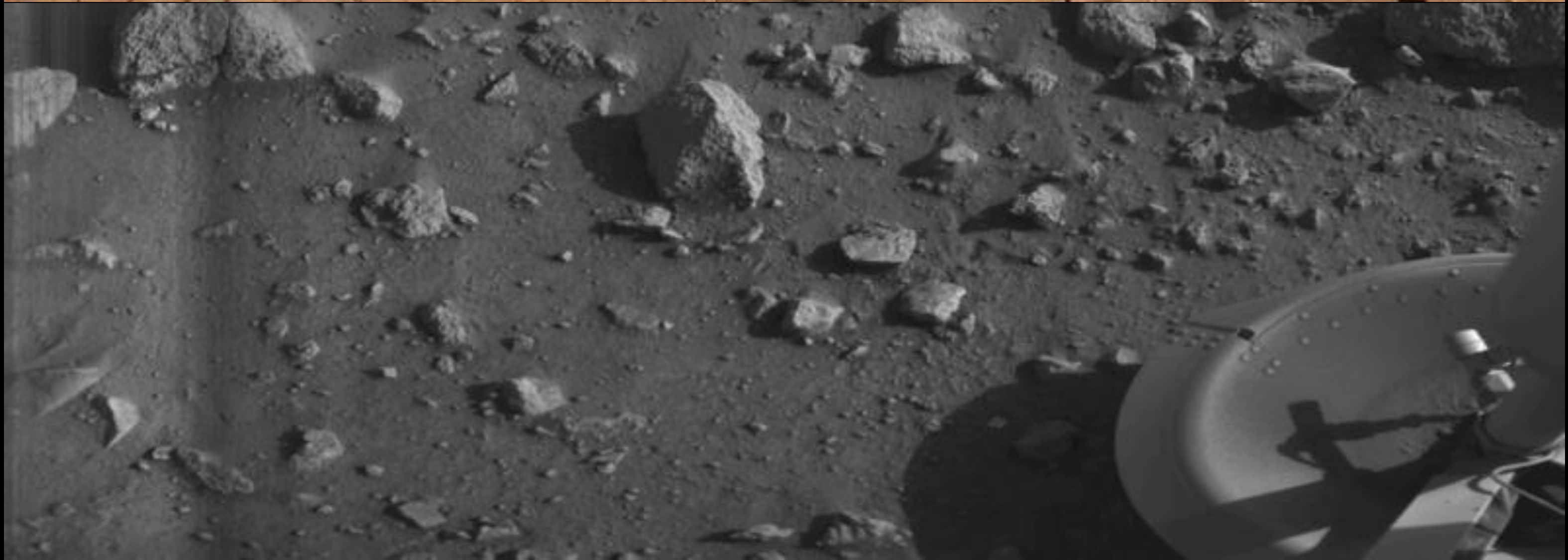
Vale Reull (41° S, 101° L), visto de 273 km acima do solo. Canal formado no passado por água corrente

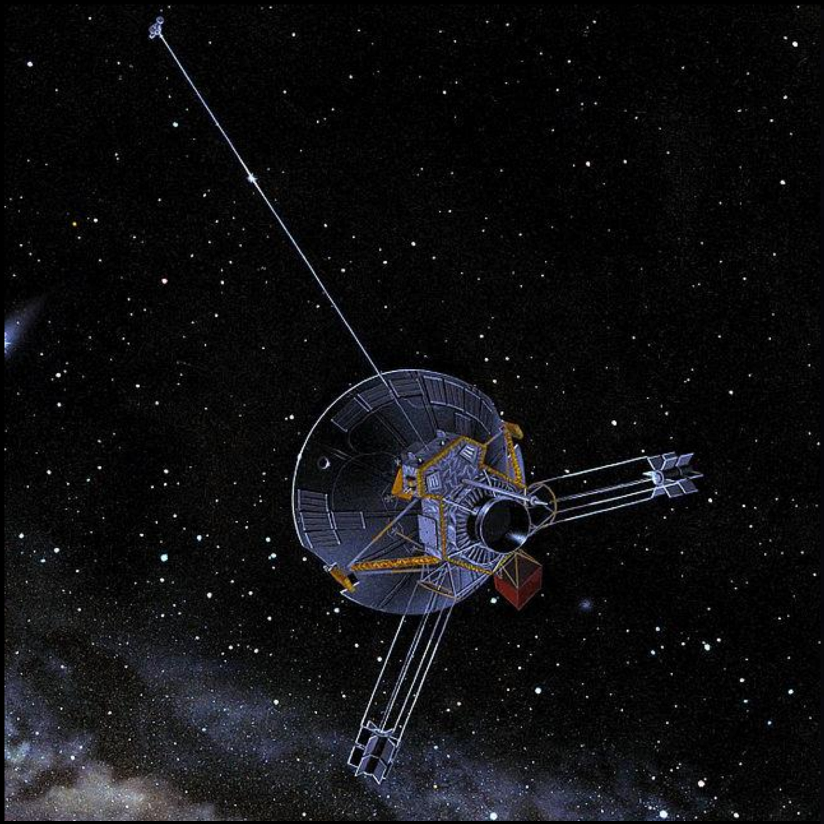













Pioneer 10 Júpiter 3/12/1973

Pioneer 11 Júpiter 2/12/1974; Saturno 29/8/1979

Voyager 1 Júpiter 5/3/1979; Saturno 12/11/1980

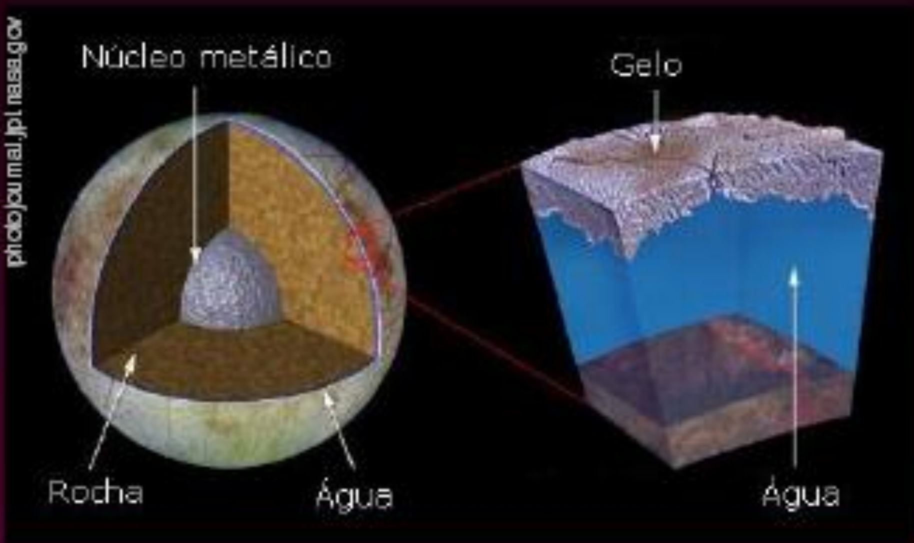
Voyager 2 Júpiter 8/7/1979; Saturno 22/8/1981; Urano 24/1/198; Netuno 25/8/1989

Galileo Júpiter 8/12/1995
sonda atmosférica 7/12/1995

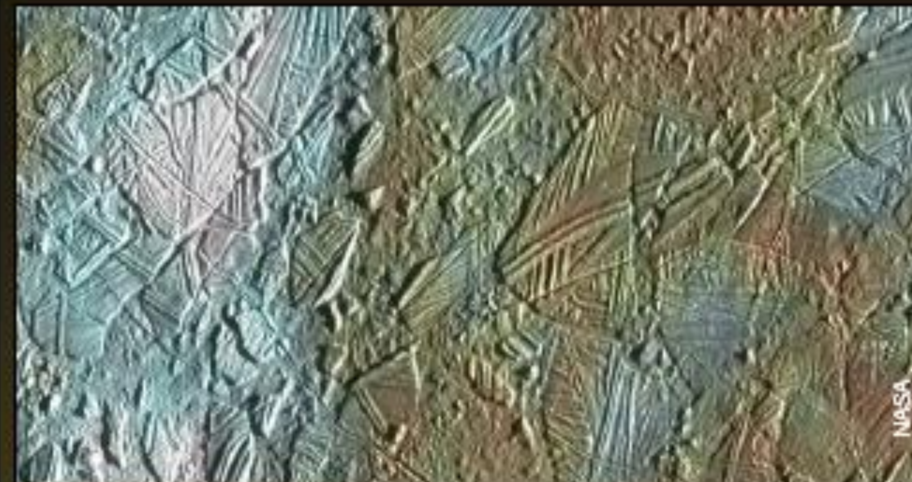
Luas de Júpiter

Io, Europa, Ganimedes Calisto

Europa



Europa, um dos maiores satélites de Júpiter, é um oceano cósmico. Abaixo de sua superfície congelada jaz um oceano de água líquida.

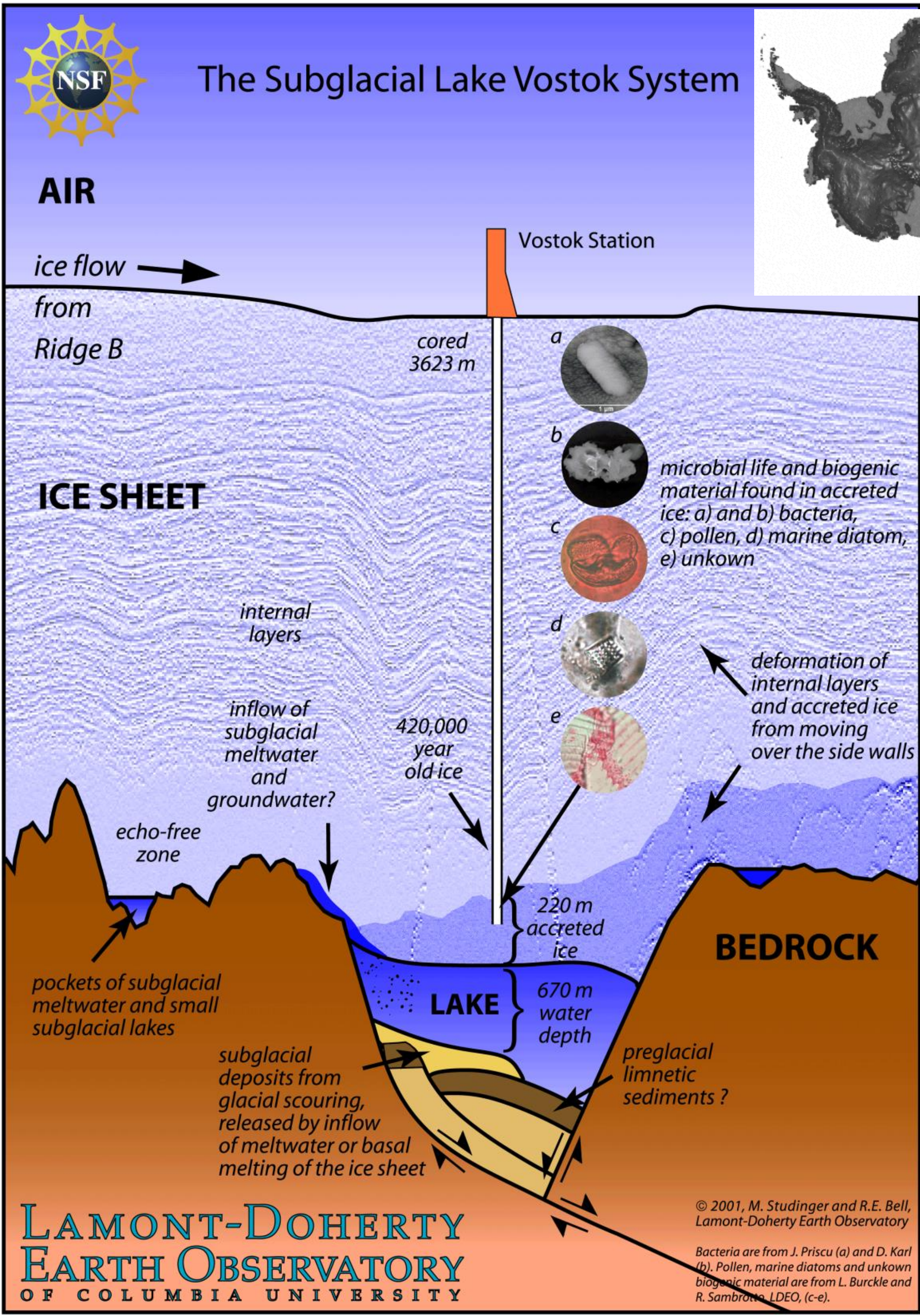


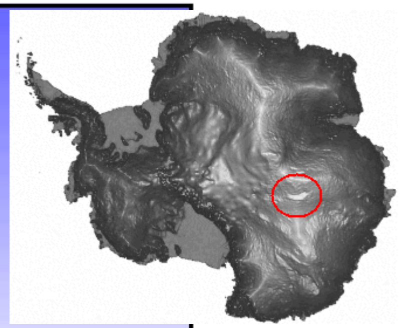
A crosta se fragmenta, os blocos de gelo flutuam na água, movem-se, e são fundidos em posições diferentes após o congelamento da água. Este fenômeno também se observa nas regiões polares da Terra.

Em futuro próximo uma sonda visitará Europa.

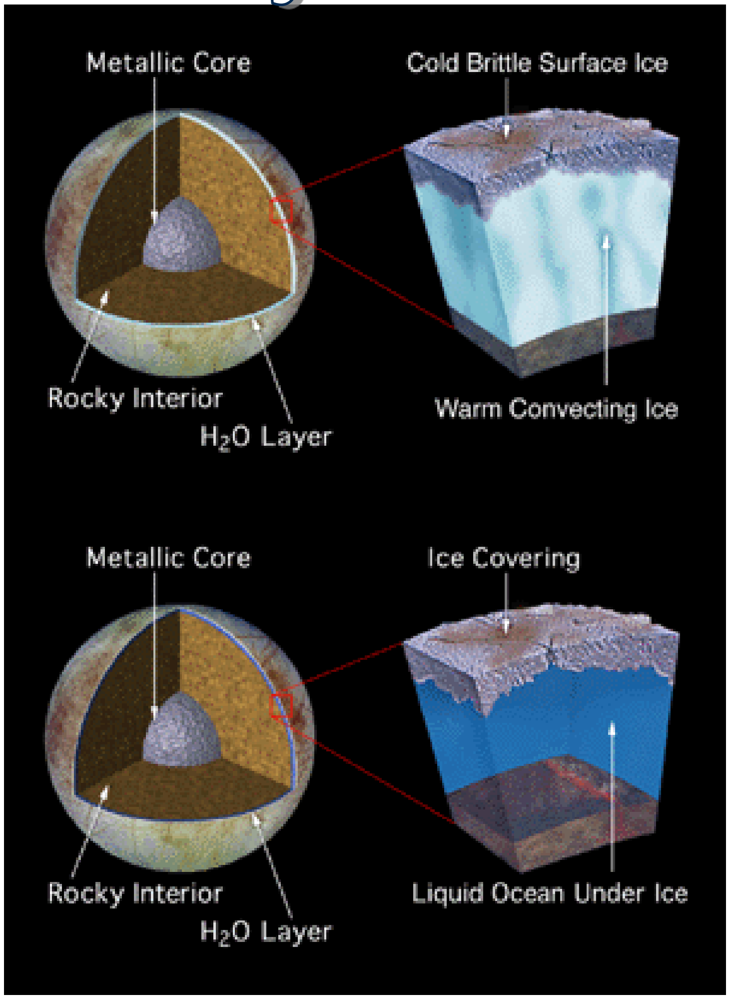
Um explorador aquático deverá mapear o interior e procurar por alguma forma de vida.

Life in subglacial systems

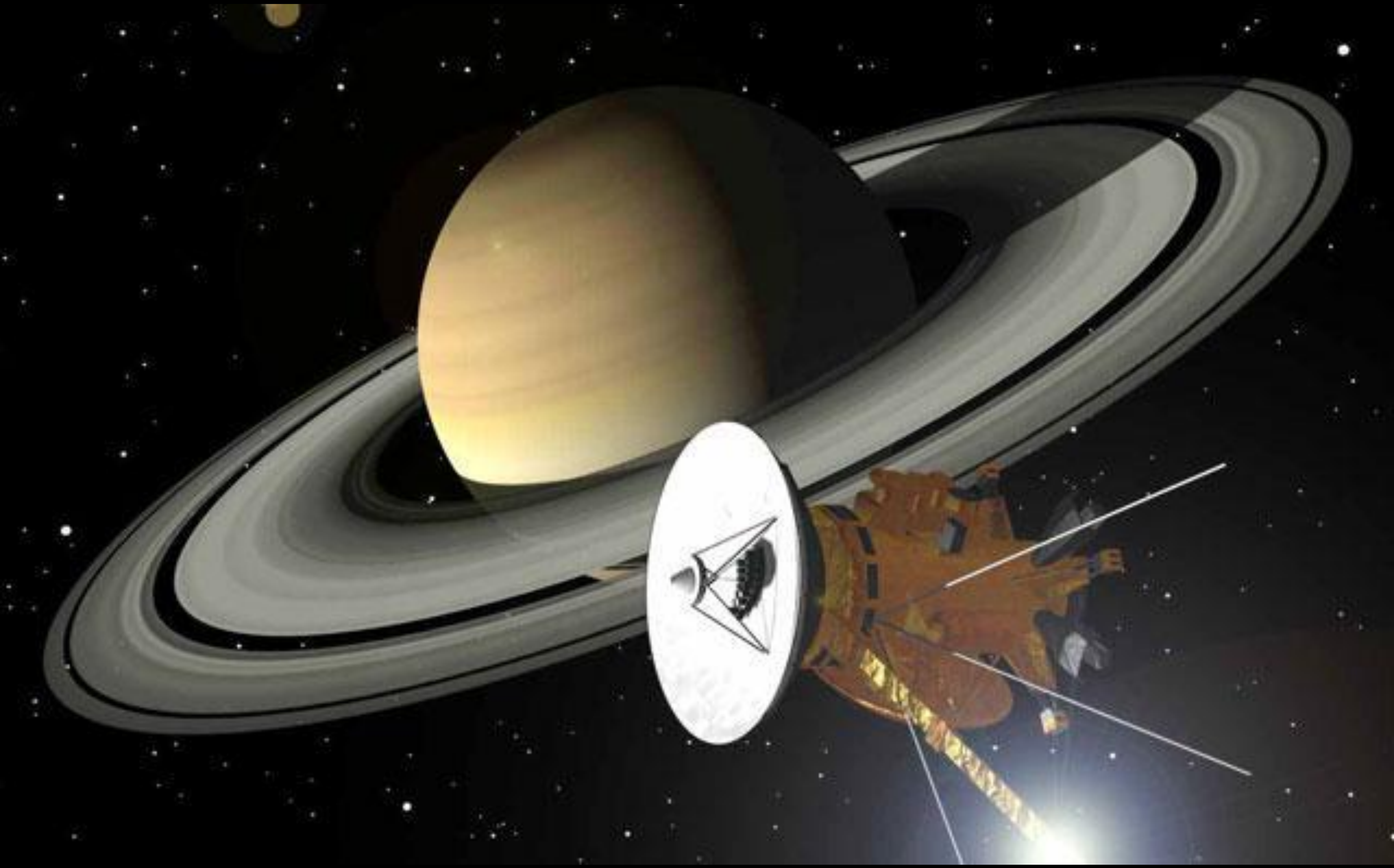




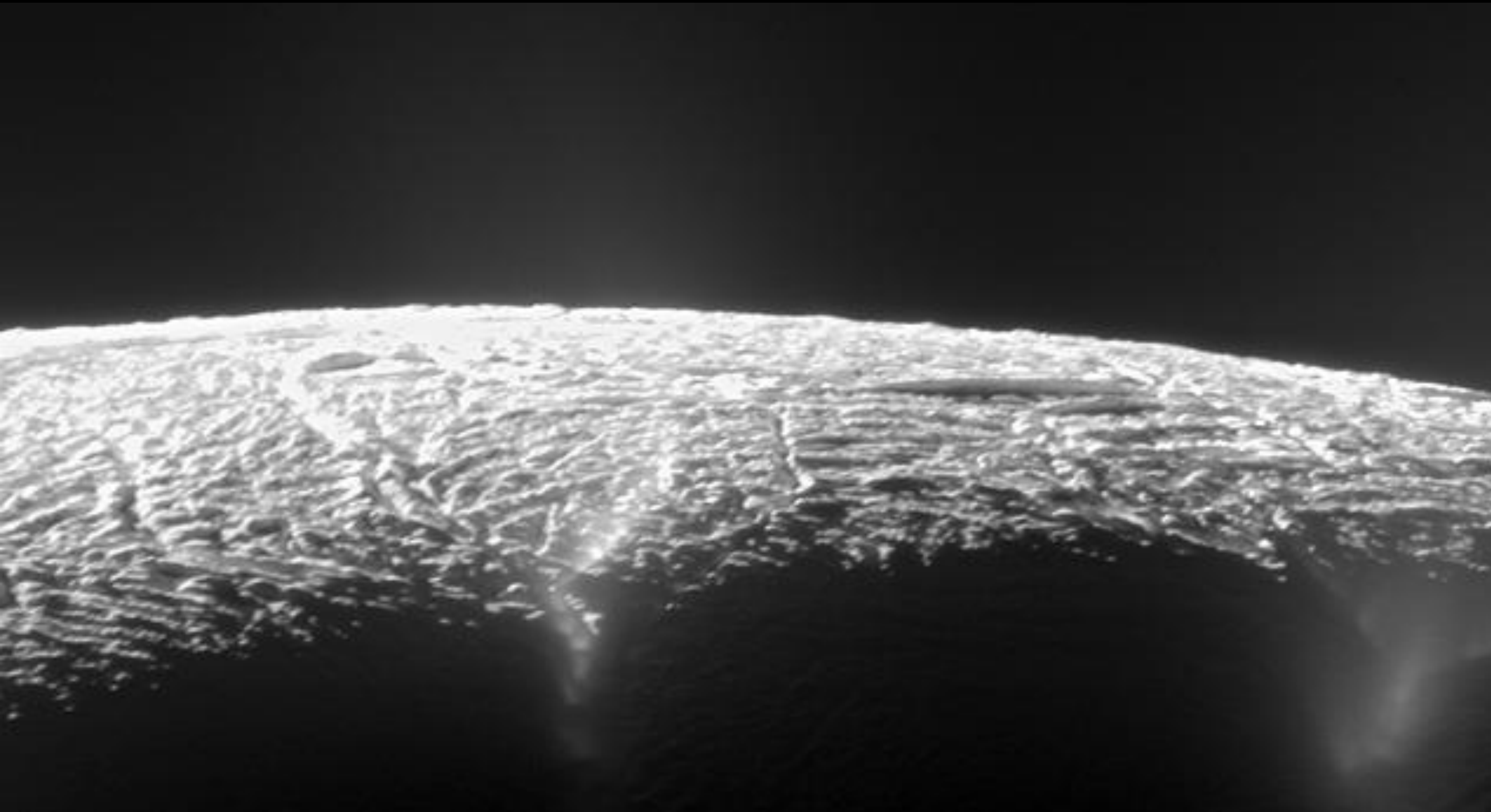
Europa



Kuhn



Enceladus



Os cometas são feitos praticamente de água

Composição química básica:

80% de H_2O,

16% de CO,

4% de CO_2

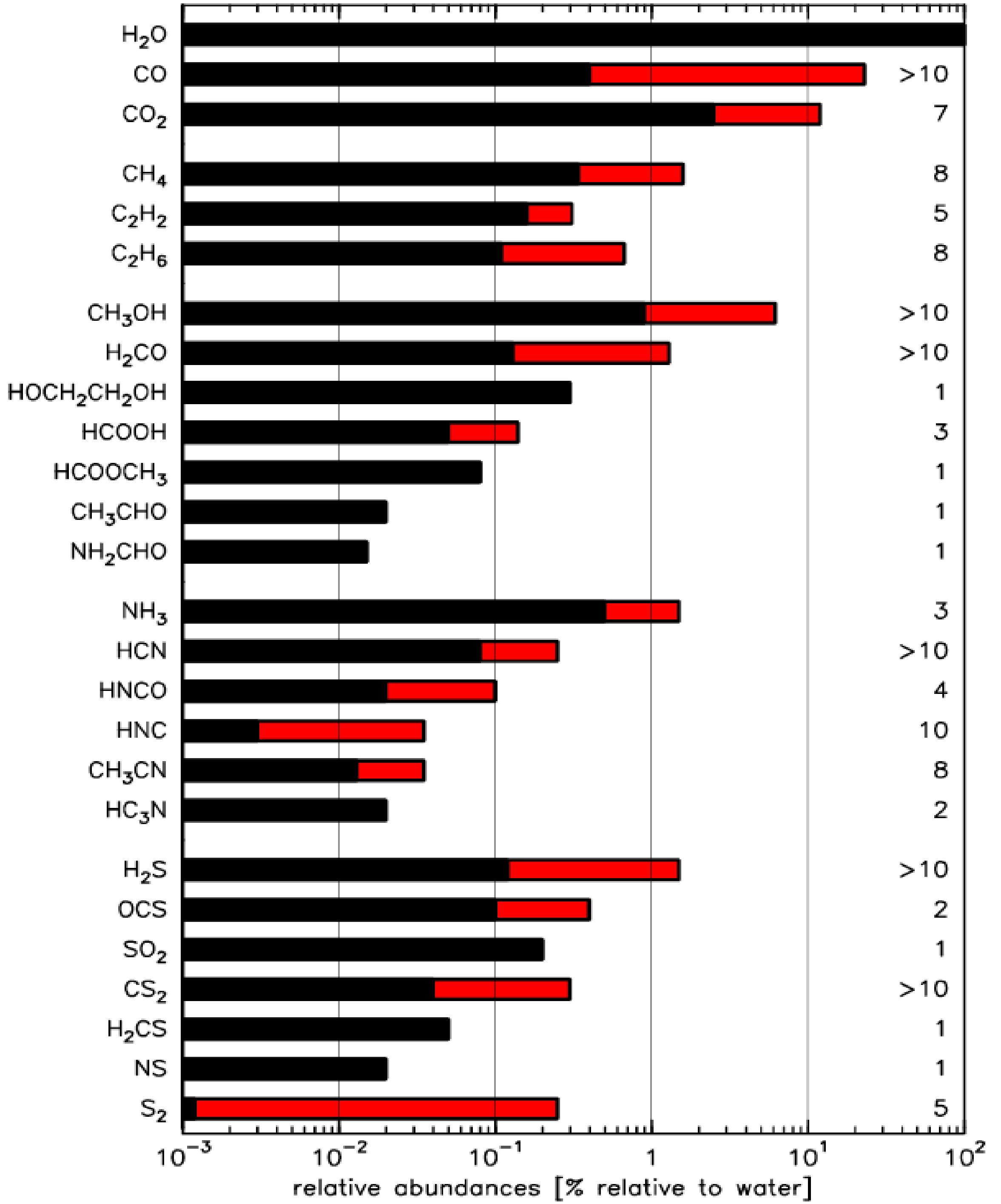
e traços de

NH_3 e CH_4

Evidence for chemical diversity

Diversity among Oort cloud comets

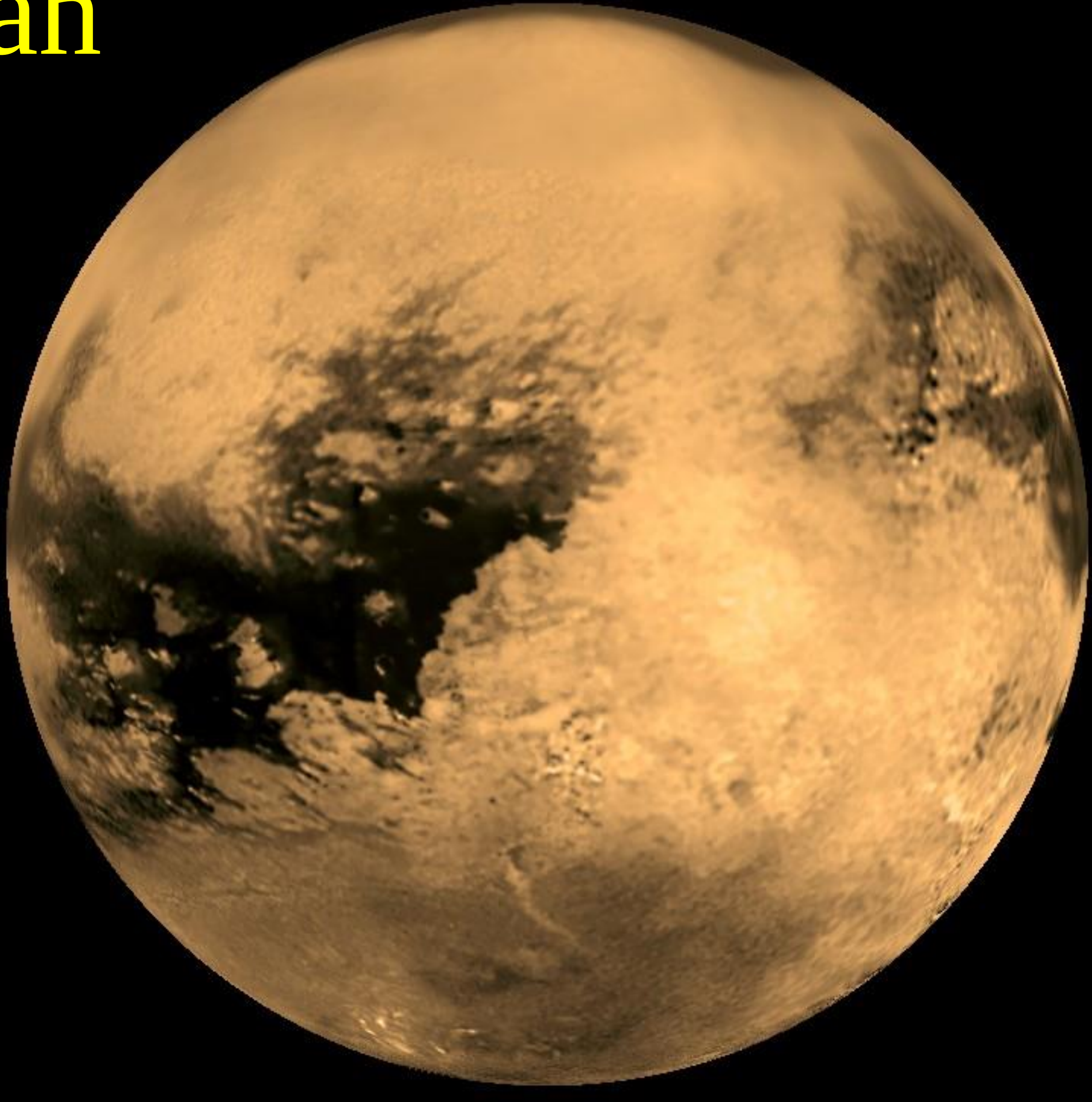
No systematic differences between Oort cloud and « Kuiper belt » comets

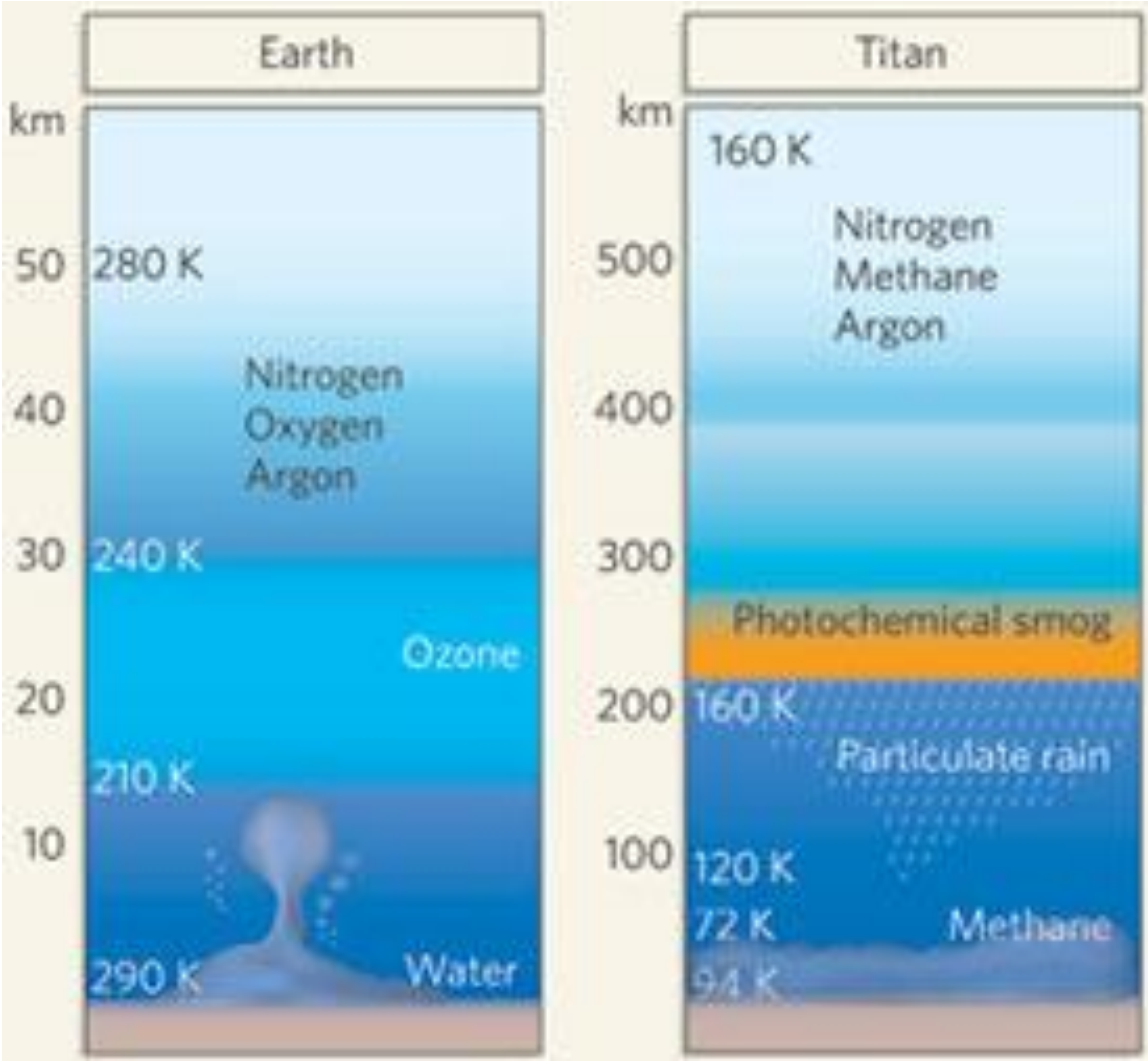


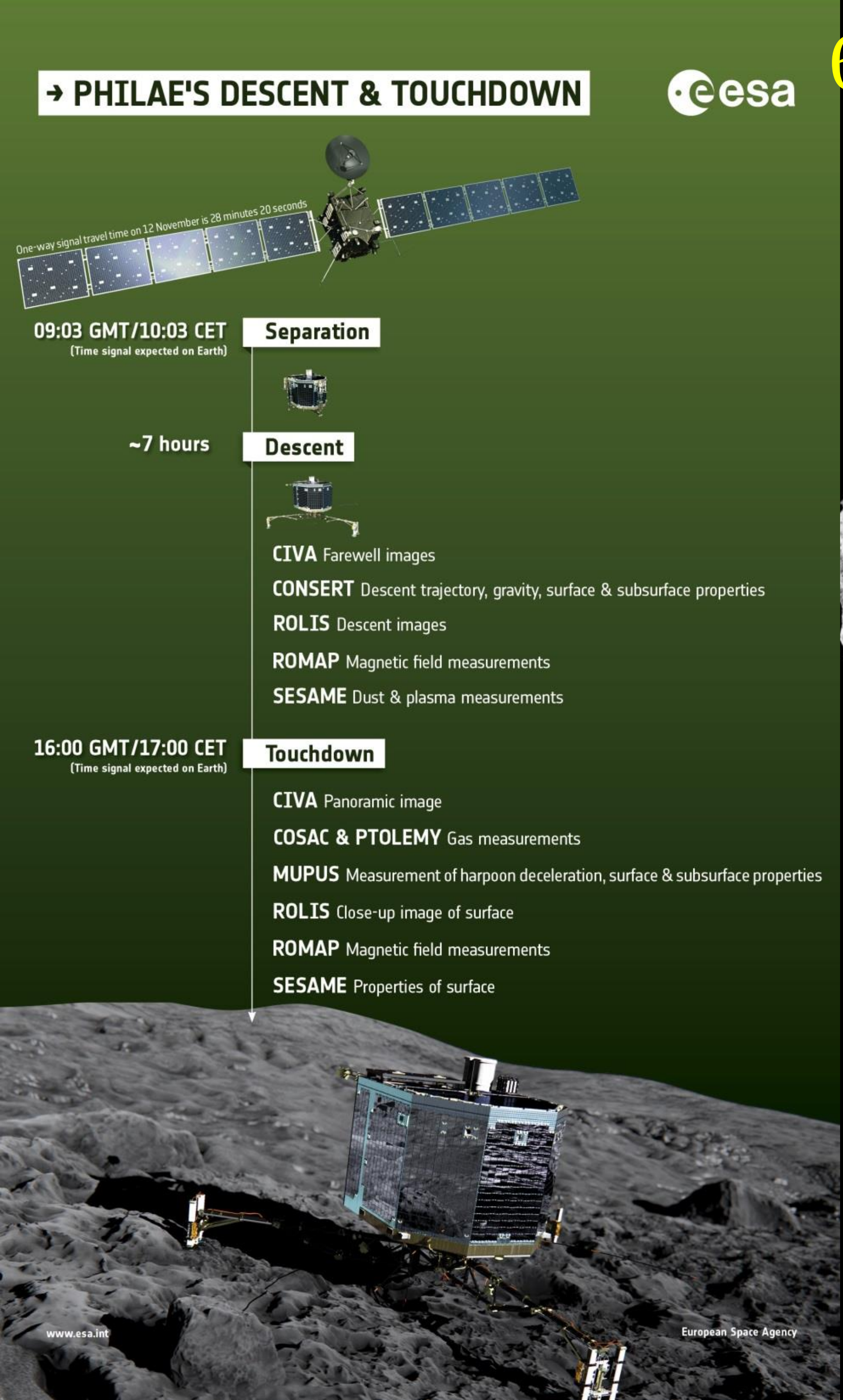
Crovisier 2005

O Sistema Solar
é orgânico

Titan

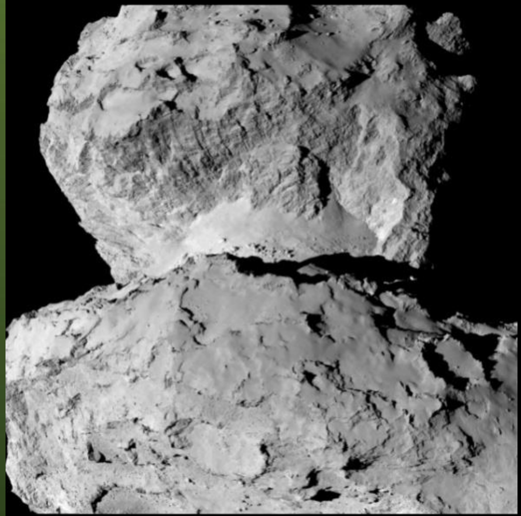



Earth
km
50
40
30
20
10
280 K
Nitrogen
Oxygen
Argon
240 K
Ozone
210 K
290 K
Water
Titan
km
500
400
300
200
100
160 K
Nitrogen
Methane
Argon
Photochemical smog
160 K
Particulate rain
120 K
72 K
Methane
94 K



67P/Churyumov-Gerasimenko

Rosseta/Philae



TOUCHDOWN

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esa
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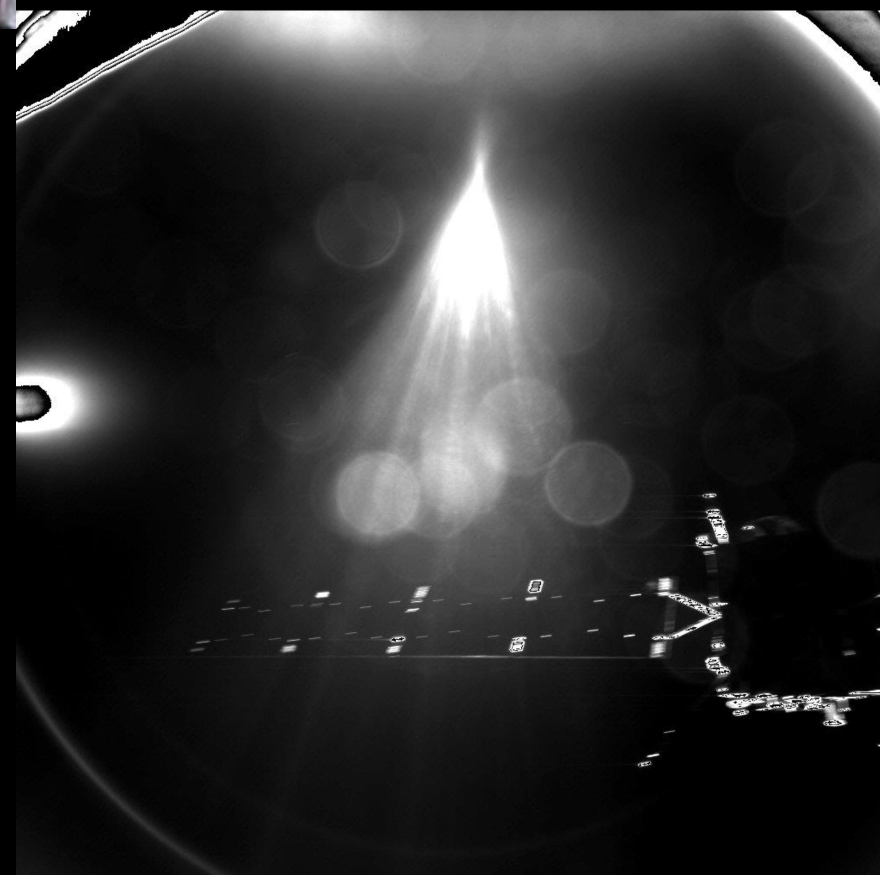
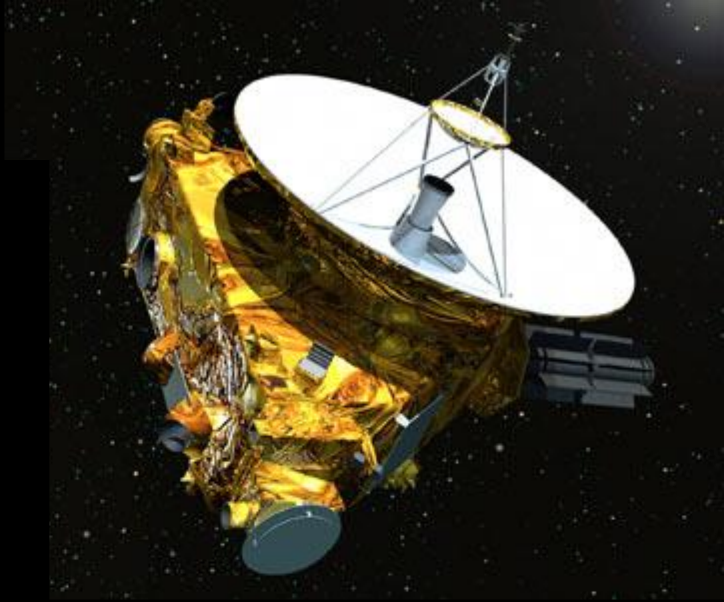
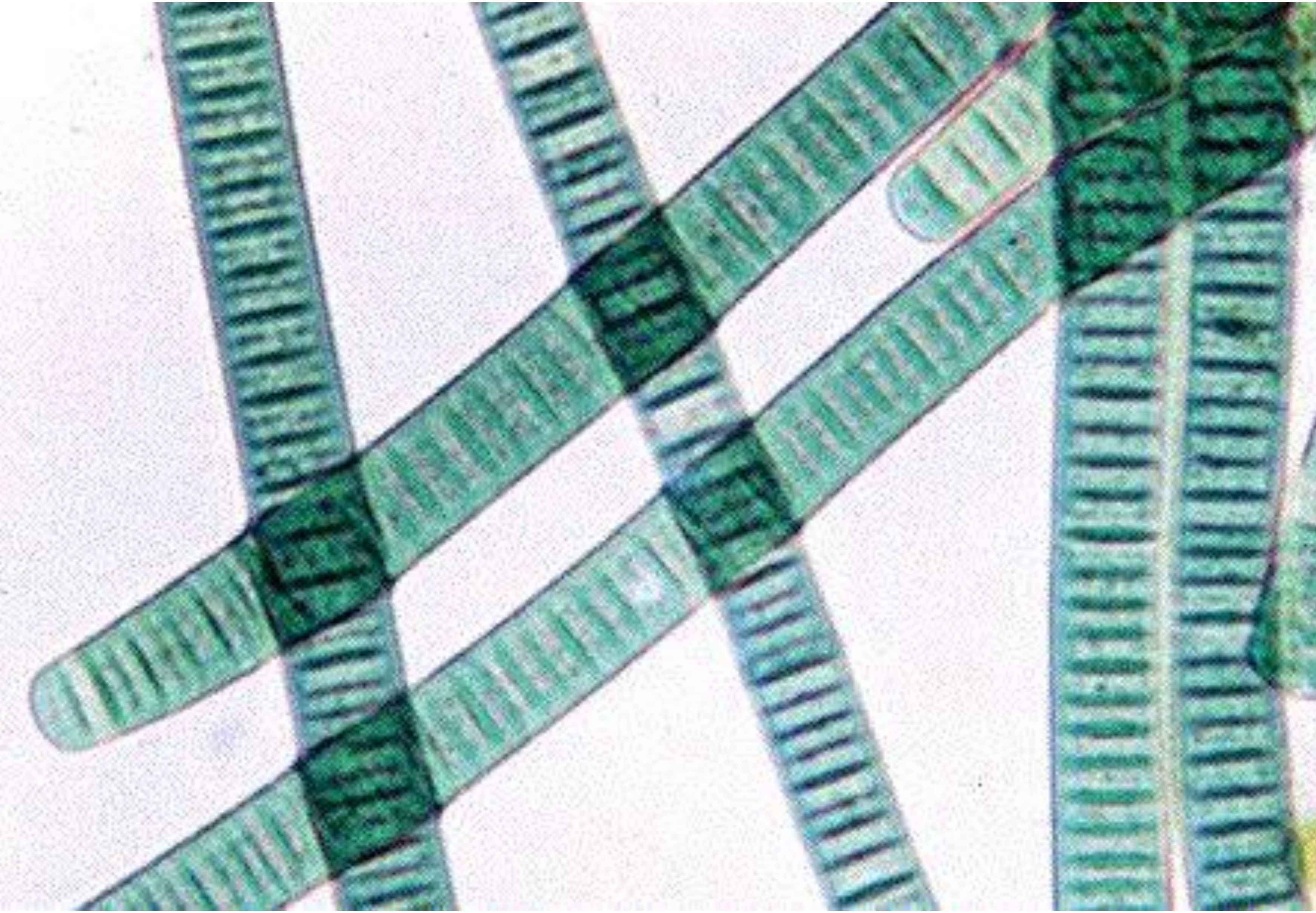


PLUTÃO
New Horizons



CLOSEST APROXIMATION
12.500 km
2015/07/15 00:52 GMT

Ação humana
na Terra e além



Ação Humana na Terra e além

Antropoceno
Poluição e Contaminação extraterrestes
Geoengenharia
Terraformação
Astroengenharia (Macroengenharia)

Geology of mankind

Paul J. Crutzen

The Anthropocene

The Anthropocene could be said to have started in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane.

For the past three centuries, the effects of humans on the global environment have escalated. Because of these anthropogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to come. It seems appropriate to assign the term 'Anthropocene' to the present, in many ways human-dominated, geological epoch, supplementing the Holocene — the warm period of the past 10–12 millennia. The Anthropocene could be said to have started in the latter part of the eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane. This date also happens to coincide with James Watt's design of the steam engine in 1784.

referring to the "anthropozoic era". And in 1926, V. I. Vernadsky acknowledged the increasing impact of mankind: "The direction in which the processes of evolution must proceed, namely towards increasing consciousness and thought, and forms having greater and greater influence on their surroundings." Teilhard de Chardin and Vernadsky used the term 'noösphere' — the 'world of thought' — to mark the growing role of human brain-power in shaping its own future and environment.

The rapid expansion of mankind in numbers and per capita exploitation of Earth's resources has continued apace. During the past three centuries, the human population has increased tenfold to more than 6 billion and is expected to reach 10 billion in this century. The methane-producing cattle population has risen to 1.4 billion. About 30–50% of the planet's land surface

ozone-destroying properties of the halogens have been studied since the mid-1970s. If it had turned out that chlorine behaved chemically like bromine, the ozone hole would by then have been a global, year-round phenomenon, not just an event of the Antarctic spring. More by luck than by wisdom, this catastrophic situation did not develop.

Unless there is a global catastrophe — a meteorite impact, a world war or a pandemic — mankind will remain a major environmental force for many millennia. A

The anthropocene: the current human-dominated geological era: Human impacts on climate and the environment

Figure 1 shows me more than 70 years ago in the lap of my grandmother.

I have changed a lot, but so has much on planet Earth. Human population has increased three-fold during my lifetime, reaching about six thousand million, with the largest rise, 1.8% per year, after the 2nd World War. As shown in the partial listing of Table 1, many human activities impact on earth's environment, often surpassing nature with ecological, atmospheric chemical and climatic consequences.

Figure 1

FEATURE

A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.

Although Earth has undergone many periods of significant environmental change, the planet's environment has been unusually stable for the past 10,000 years[1–3]. This period of stability — known to geologists as the Holocene — has seen human civilizations arise, develop and thrive. Such stability may now be under threat. Since the Industrial Revolution, a new era has arisen, the Anthropocene[4], in which human actions

SUMMARY

- New approach proposed for defining preconditions for human development
- Crossing certain biophysical thresholds could have disastrous consequences for humanity
- Three of nine interlinked planetary boundaries have already been overstepped

Authors

Johan Rockström[1,2], Will Steffen[1,3], Kevin Noone[1,4], Åsa Persson[1,2], F. Stuart Chapin, III[5], Eric F. Lambin[6], Timothy M. Lenton[7], Marten Scheffer[8], Carl Folke[1,9], Hans Joachim Schellnhuber[10,11], Björn Nykvist[1,2], Cynthia A. de Wit[4], Terry Hughes[12], Sander van der Leeuw[13], Henning Rodhe[14], Sverker Sörlin[1,15], Peter K. Snyder[16], Robert Costanza[1,17], Uno Svedin[1], Malin Falkenmark[1,18], Louise Karlberg[1,2], Robert W. Corell[19], Victoria J. Fabry[20], James Hansen[21], Brian Walker[1,22], Diana Liverman[23,24], Katherine Richardson[25], Paul Crutzen[26], Jonathan A. Foley[27]

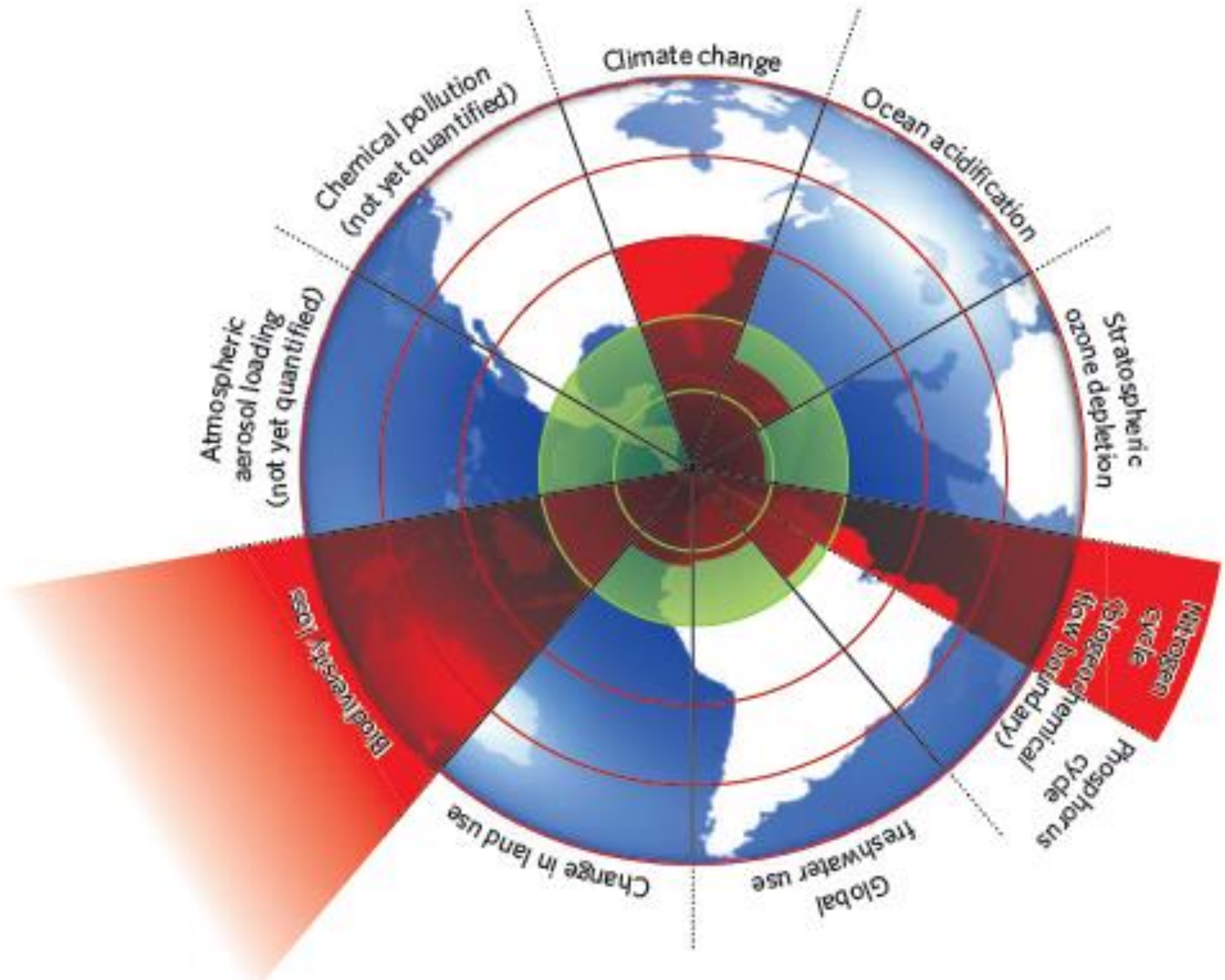
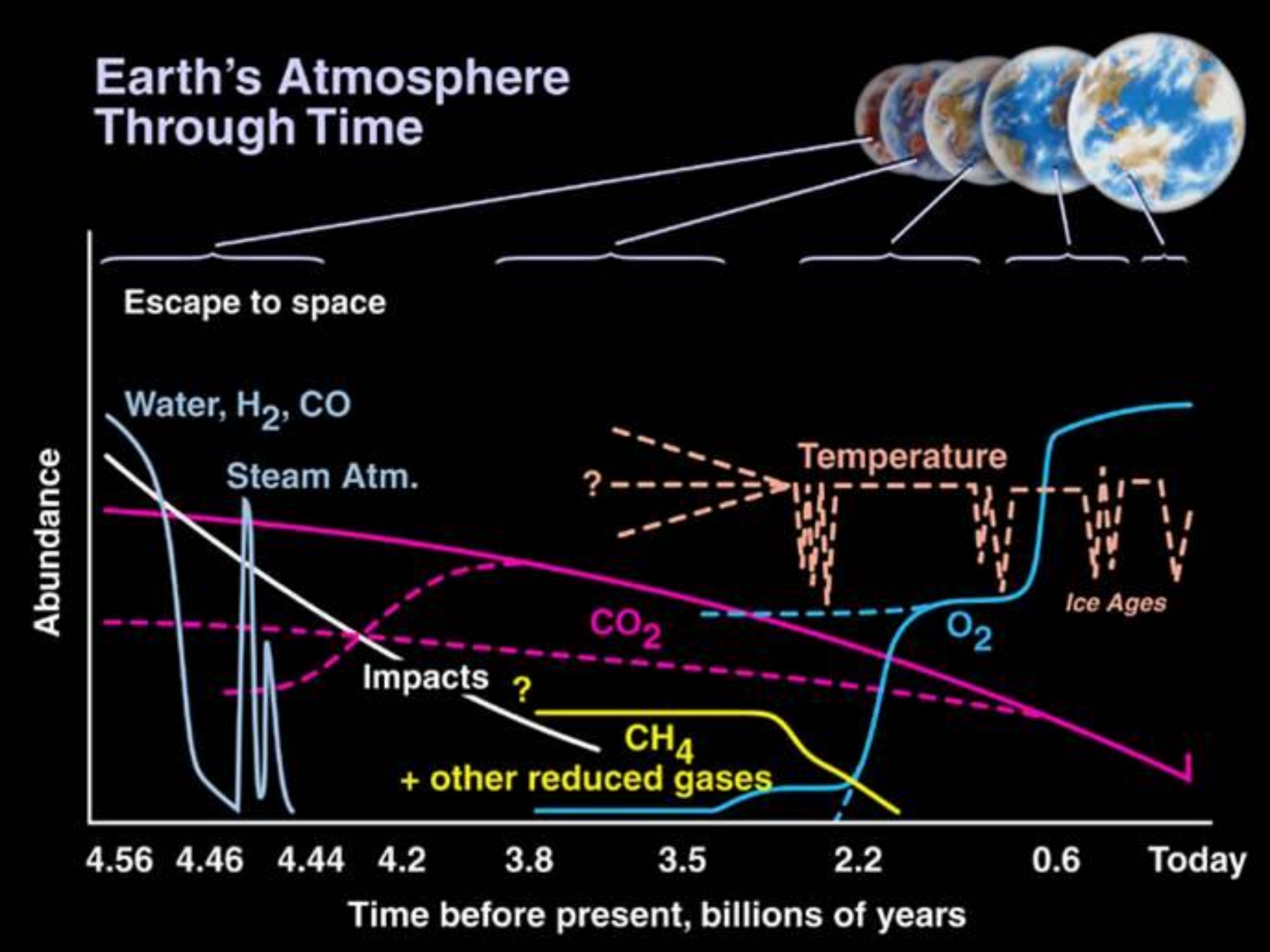


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.


Earth's Atmosphere
Through Time
Escape to space
Water, H_2, CO
Steam Atm.
Temperature
?
Ice Ages
CO_2
O_2
Impacts
?
CH_4
+ other reduced gases
Abundance
4.56 4.46 4.44 4.2 3.8 3.5 2.2 0.6 Today
Time before present, billions of years

Teoria de Gaia

Proc. R. Soc. Lond. B. **189**, 167–181 (1975)
Printed in Great Britain

Thermodynamics and the recognition of alien biospheres

By J. E. Lovelock, F.R.S.
Department of Applied Physical Sciences, University of Reading, Reading, RG1 2AL

The presence of a mature biosphere is likely to change surface and atmospheric composition and the energy balance of a planet away from that of the abiotic state. Is it possible that such a change might be detected from afar by astronomical techniques and so form the basis of a test for the presence of a planetary biosphere? A distant view of the Earth in this context shows that certain of its thermodynamic properties are recognizably different from those of the other terrestrial planets, which presumably are lifeless. The general application of this test for the remote detection of other biospheres will be discussed, as will some implications of this way of viewing biospheres on the nature and organizations of life on Earth.

Introduction

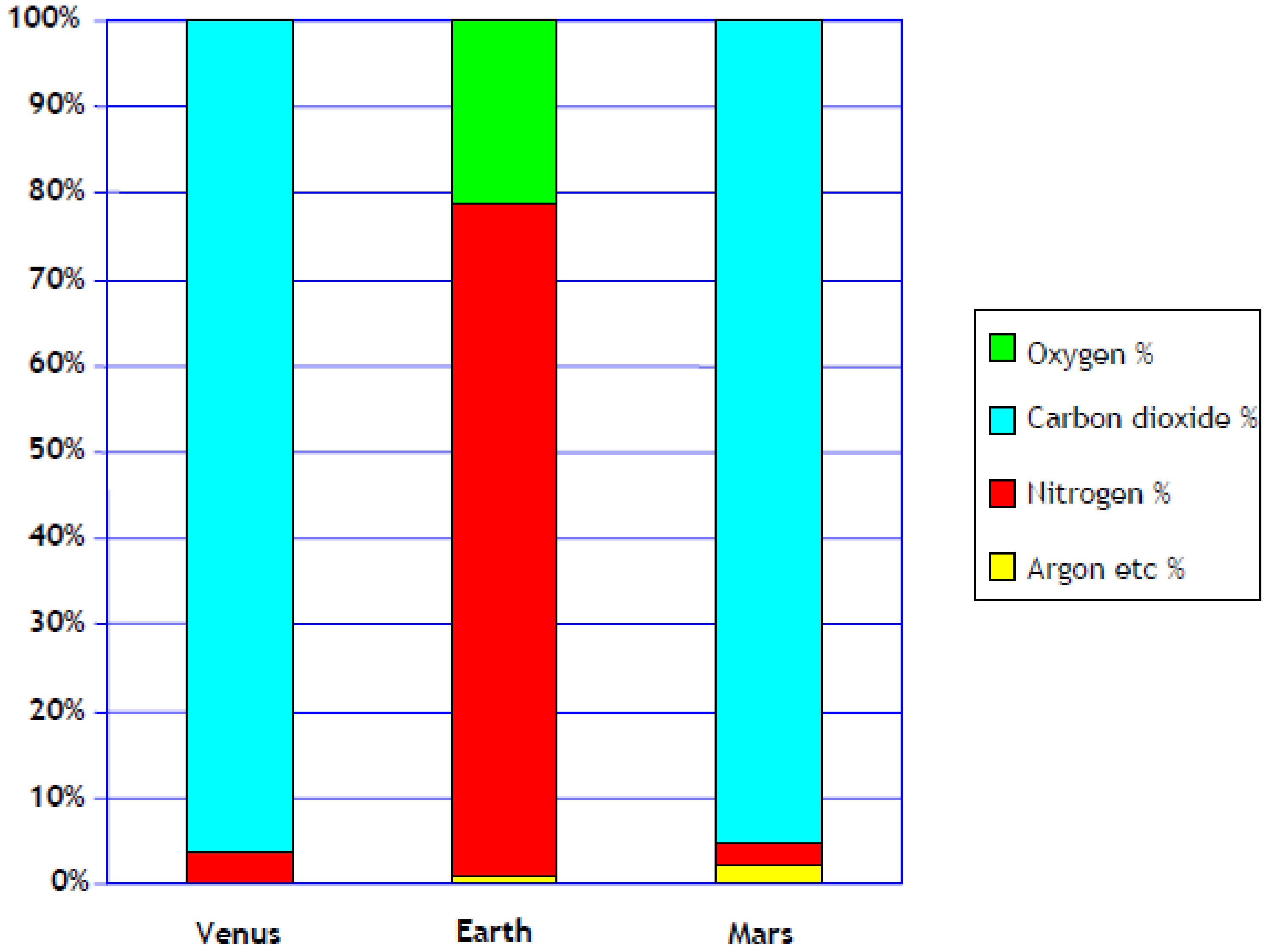
It is a cliché of science fiction for the captain of a space craft when approaching a new planetary system to call his exobiological officer and ask 'do any of those planets bear life?'. The operation by this officer of a remote sensing device soon provides a confident answer, yes or no. One purpose of this paper is to consider the possible basis of such a device.

To operate at planetary orbital distances the device would need to observe and to measure physical rather than biological properties. Guidance for the choice of the specific properties to measure comes from a consideration of the process of life and the act of recognition within a context which includes also instrument design. A branch of science large enough to encompass these three different subjects is thermodynamics. From the early technology of the steam engine to the intricacies of the present technosphere, engineers have used thermodynamics as a source of inspiration and of recipes; so it may be for instruments and procedures for the detection of life.

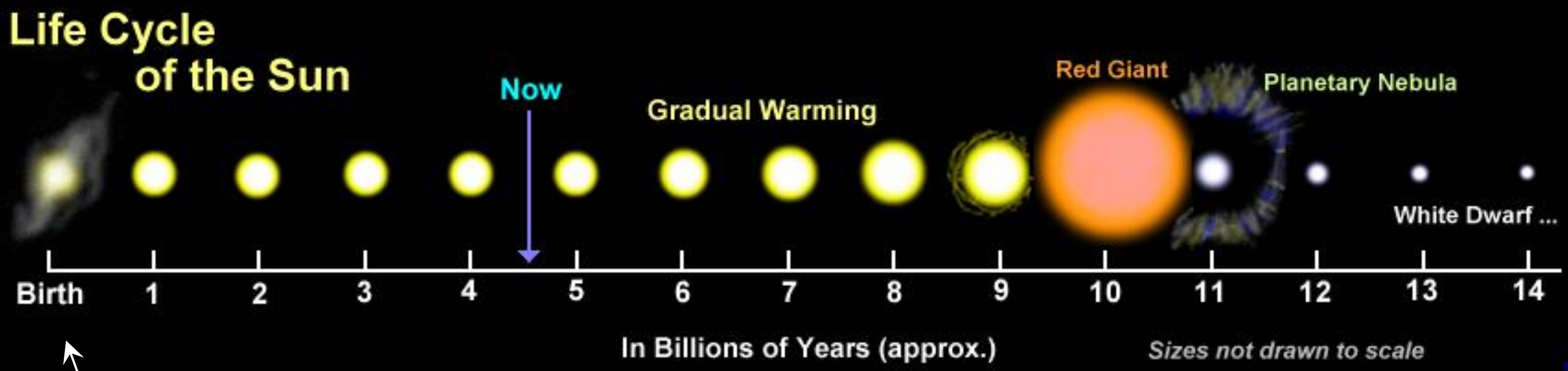
There are several reasons for choosing to seek a biosphere rather than any of its component parts; with a telescope it is easier to see an elephant than a virus and where a planetary system is viewed from afar it seems prudent to go for the largest unit of all, namely, the biosphere itself. A physical, in contrast to a biological, approach to planetary life detection was suggested (Lovelock 1965) and later Hitchcock & Lovelock (1967) proposed that the knowledge of the chemical composition of a planetary atmosphere itself constituted a life detection experiment. It was further suggested that sufficient information for these purposes might be gathered by astronomical measurements in the infrared.

At that time it was generally believed that the abundance of the atmospheric

The composition of planetary atmospheres



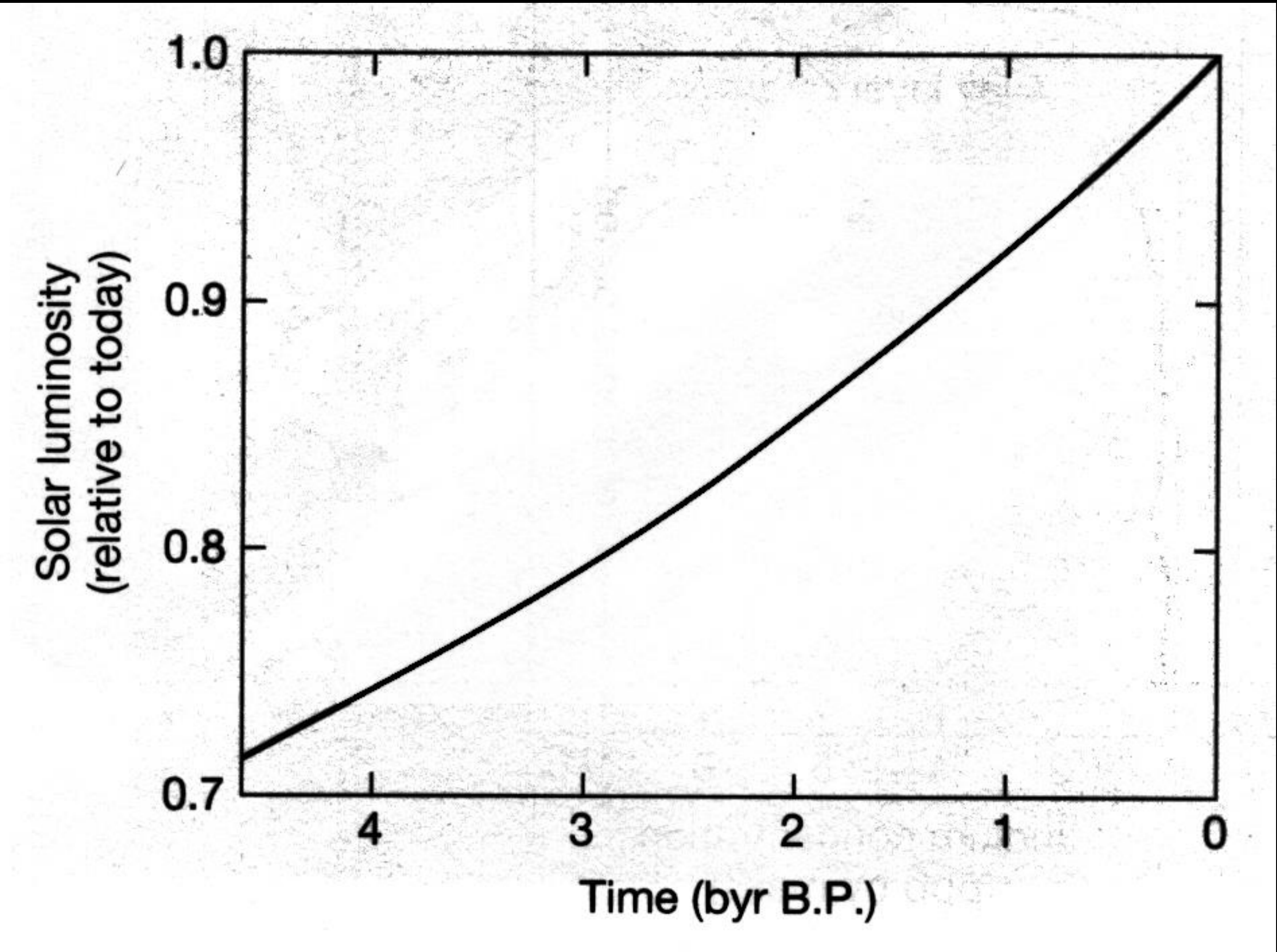
Evolução do Sol



Colapso da nuvem molecular

A Terra provavelmente será destruída

Solar Luminosity versus Time



Faint Young Sun is important for climate. Not so critical for photosynthesis.

Razões para a habitabilidade da Terra

1) Sistema solar com órbitas estáveis e quase circulares
2) Júpiter absorve cometas, minimizando “killing events”
3) A Lua evita o caos do eixo de rotação da Terra
4) A tectônica de placas recicla o CO_2 necessário para a vida
5) A magnetosfera terrestre protege contra o vento solar
6) A heliosfera protege contra raios cósmicos
7) Um longo interglacial começa há 10.500 anos
8) Evolução da Atmosfera:
    - Micróbios produzem O_2, CH_4 ⇨ CH_4 com efeito estufa e após, O domina
    - Camada de ozônio se forma há ~ 2.3 Ganos, protegendo contra UV
    - Desenvolvem-se algas simples e fungos
    - Mais O_2 e animais em 0.6 Ganos
    - Humanos em 2 Manos (1/3 do O_2 vai para o cérebro)
    - A humanidade retorna CO_2 e aumenta o efeito estufa

James Lovelock

Nature, 426, 770-771 (2003)

The living Earth

James Lovelock

Imagine a science-based civilization far distant in the Galaxy that had built an interferometer of such resolving power that it could analyse the chemical composition of our atmosphere. Simply from this analysis, they could confidently conclude that Earth, alone among the planets of the Solar System, had a carbon-based life and an industrial civilization. They would have seen methane and oxygen coexisting in the upper atmosphere, and their chemists would have known that these gases are continually consumed and replaced. The odds of this happening by chance inorganic chemistry are very long indeed. Such persistent deep atmospheric disequilibrium reveals the low entropy characteristic of life. They would conclude that ours was a live planet — and the presence of CFCs in the atmosphere would suggest an industry unwise enough to have allowed their escape.

As part of NASA's planetary exploration team in 1965, thoughts such as these led me to propose atmospheric analysis for detecting life on Mars. I also wondered what could be keeping Earth's chemically unstable atmosphere constant and so appropriate for life, and what kept the climate tolerable despite a 30% increase in solar luminosity since the Earth formed. Together, these thoughts led me to the hypothesis that living organisms regulate the atmosphere in their own interest, and the novelist William Golding suggested Gaia as its name. Although the concept of a live Earth is ancient, Newton was the first scientist to compare the Earth to an animal or a vegetable. Hutton, Huxley and Vernadsky expressed similar views but, lacking quantitative evidence, these earlier ideas remained anecdotal. In 1925 Alfred Lotka conjectured that it would be easier to model the evolution of organisms and their material environment coupled as a single entity than either of them separately. Gaia had its origins in these earlier thoughts, from the evidence gathered by the biogeochemists Alfred Redfield and Evelyn Hutchinson and from the mind-wrenching top-down view provided by NASA.

Although welcomed by atmospheric scientists, Earth scientists were cautious. Biologists, especially Ford Doolittle and Richard Dawkins, argued strongly that global self-regulation could never have evolved, as the organism was the unit of selection, not the biosphere. In time I realized that they were right — but still I thought, something keeps the Earth habitable. In 1981 I composed a model of dark- and light-coloured plants that competed for growth on a planet in progressively increasing sunlight. My intention was not to make a blueprint for the Earth, but a model to show that Gaia is consistent with natural selection. This 'Daisyworld' regulated its temperature close to that fittest for plant growth and — unusually for an evolutionary model made from coupled differential equations — it was stable, insensitive to initial conditions and resistant to perturbation. Daisyworld is darwinian, but the evolution of the organisms and the evolution of temperature proceed as a single, coupled process. The model was much criticized, but so far has resisted falsification. It was easy to show that Daisyworld tolerates 'cheats' — daisies that grow but offer nothing towards self-regulation. Other critics claimed that daisies would adapt to changing temperature and therefore simply track temperature change, not regulate it. But the restraining function connecting growth with temperature is not negotiable; chemistry, not biology, sets its constants.

NASA/BETTMANN/CORBIS

Our planet in perspective: Gaia theory explains the constancy of our unstable atmosphere.

Gaia

Organisms and their environment evolve as a single, self-regulating system.

At this stage, the Gaia theory was missing plausible control mechanisms. The first discovered was a biological process that redressed the imbalance of the nutritious elements sulphur and iodine — these are abundant in the oceans, but deficient on the land surface. It was widely assumed that hydrogen sulphide and sea salt aerosol drifted from the ocean to the land. In 1971 I discovered that methyl iodide and dimethyl sulphide were ubiquitous in the Atlantic surface waters, and from my measurements Peter Liss calculated their fluxes in 1974. He argued that these biogenic gases were the main carriers of the natural elemental cycles of sulphur and iodine.

Then in 1982, the geochemists James Walker, P. B. Hayes and Jim Kasting suggested that the weathering of calcium silicate rock could regulate carbon dioxide and climate. Greater warmth leads to more rainfall and a faster removal of carbon dioxide from the atmosphere by rock weathering, which provides a negative feedback on temperature. This plausible mechanism is by itself too small to account for the observed rate of weathering. Organisms on the rocks and in the soil bring it to life as a Gaian mechanism; their growth varies with temperature and their presence amplifies the rate of weathering.

In 1986, there was the awesome discovery by Robert Charlson, James Lovelock, Meinrat Andreae and Steven Warren of a connection between biogenic dimethyl sulphide gas — the product of ocean algae — its oxidation in the atmosphere to form cloud condensation nuclei, and the subsequent effect of the clouds formed on climate. We wondered whether this could be a Gaian regulatory mechanism through the feedback between climate change and algal growth.

By the end of the 1980s there was sufficient evidence, models and mechanisms, to justify a provisional Gaia theory. Briefly, it states that organisms and their material environment evolve as a single coupled system, from which emerges the sustained self-regulation of climate and chemistry at a habitable state for whatever is the current biota.

Like life, Gaia is an emergent phenomenon, comprehensible intuitively, but difficult or impossible to analyse by reduction — not surprisingly it is often misunderstood. A simple automatic mechanism, like a

Gaia

Organisms and their environment evolve as a single, self-regulating system.

A Ética da Teoria de Gaia

A metáfora de uma “Terra viva”:

ela nos lembra que somos parte dela e que os direitos humanos devem levar em conta as necessidades dos nossos parceiros planetários.

James Lovelock (Nature, 2003)

O Templo da Natureza

Lao Tze

Seneca

São Francisco

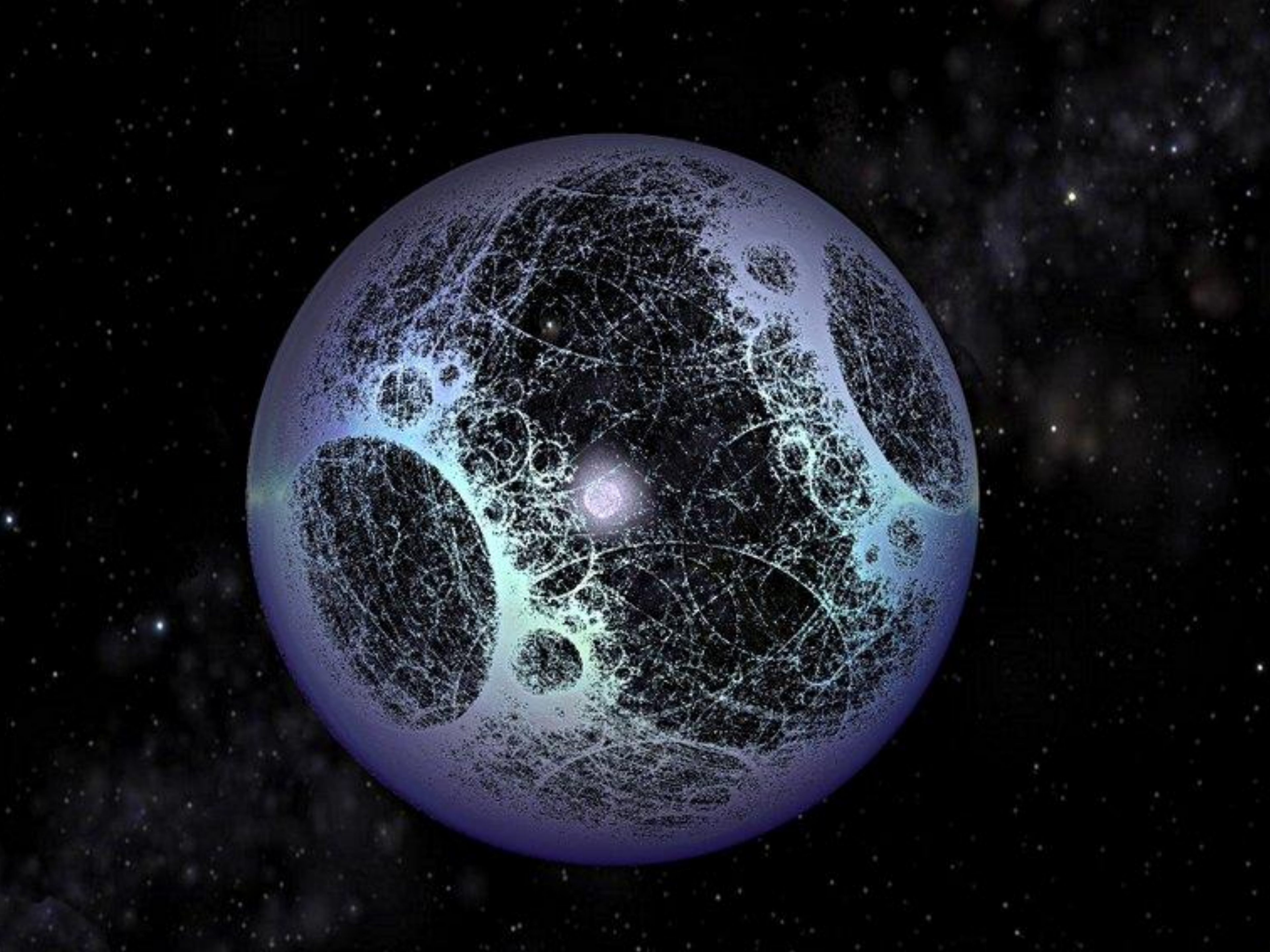
Erasmus Darwin

John Muir

Aldo Leopold

Arne Naess

James Lovelock



Onde está todo mundo?

O Paradoxo de Fermi (1950)

International Journal of Astrobiology 10 (4): 341–347 (2011)
doi:10.1017/S147355041100019X

Spatio-temporal constraints on the zoo hypothesis, and the breakdown of total hegemony

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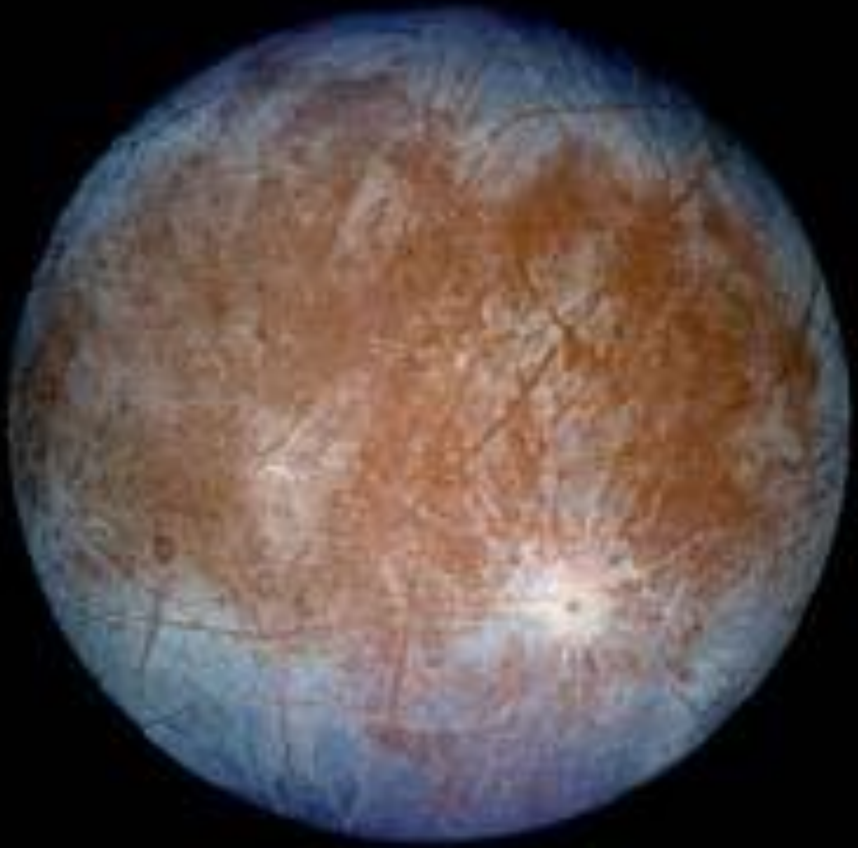
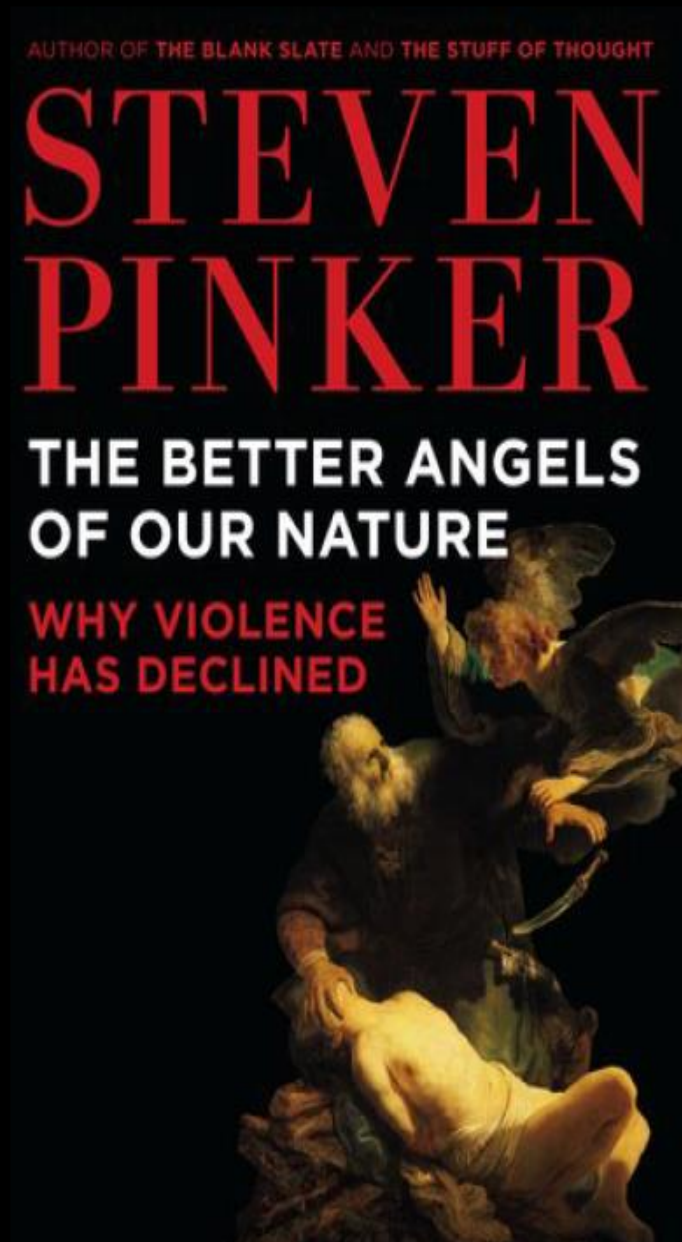
e-mail: dhf@roe.ac.uk

Abstract: The Zoo Hypothesis posits that we have not detected extraterrestrial intelligences (ETIs) because they deliberately prevent us from detecting them. While a valid solution to Fermi's Paradox, it is not particularly amenable to rigorous scientific analysis, as it implicitly assumes a great deal about the sociological structure of a plurality of civilizations. Any attempt to assess its worth must begin with its most basic assumption – that ETIs share a uniformity of motive in shielding Earth from extraterrestrial contact. This motive is often presumed to be generated by the influence of the first civilization to arrive in the Galaxy. I show that recent work on inter-arrival time analysis, while necessary, is insufficient to assess the validity of the Zoo Hypothesis (and its related variants). The finite speed of light prevents an early civilization from exerting immediate cultural influence over a later civilization if they are sufficiently distant. I show that if civilization arrival times and spatial locations are completely uncorrelated, this strictly prevents the establishment of total hegemony throughout the Galaxy. I finish by presenting similar results derived from more realistic Monte Carlo Realization (MCR) simulations (where arrival time and spatial locations are partially correlated). These also show that total hegemony is typically broken, even when the total population of civilizations remains low. The Zoo Hypothesis is therefore only justifiable on weak anthropic grounds, as it demands total hegemony established by a long-lived early civilization, which is a low probability event. In the terminology of previous studies of solutions to Fermi's Paradox, this confirms the Zoo Hypothesis as a 'soft' solution. However, an important question to be resolved by future work is the extent to which many separate hegemonies are established, and to what extent this affects the Zoo Hypothesis.

A Ética do Cosmos

Europa



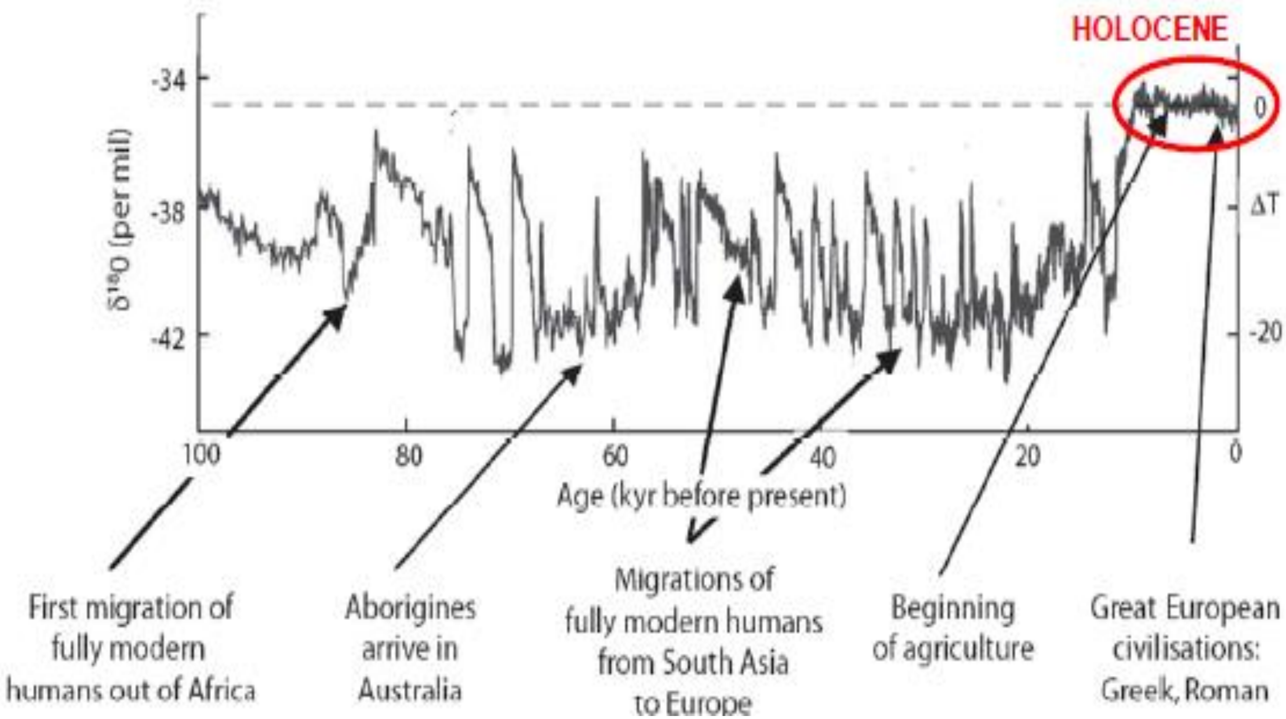

AUTHOR OF THE BLANK SLATE AND THE STUFF OF THOUGHT
STEVEN
PINKER
THE BETTER ANGELS
OF OUR NATURE
WHY VIOLENCE
HAS DECLINED

Six Trends

The Better Angels of Our Nature, Steven Pinker

- Pacification Process (~3.000 B.C-)
- Civilizing Process (13rd century-)
- Humanitarian Revolution (17th century-)
- Long Peace (1945- 1989)
- New Peace (1989-)
- Rights Revolutions (1948-)

Uma Coincidência Cósmica



HOLOCENE
-34
-38
-42
δ18O (per mil)
0
ΔT
-20
100
80
60
40
20
0
Age (kyr before present)
First migration of fully modern humans out of Africa
Aborigines arrive in Australia
Migrations of fully modern humans from South Asia to Europe
Beginning of agriculture
Great European civilisations: Greek, Roman

An Exceptionally Long Interglacial Ahead?

A. Berger and M. F. Loutre

When paleoclimatologists gathered in 1972 to discuss how and when the present warm period would end (*1*), a slide into the next glacial seemed imminent. But more recent studies point toward a different future: a long interglacial that may last another 50,000 years.

An interglacial is an uninterrupted warm interval during which global climate reaches at least the preindustrial level of warmth. Based on geological records available in 1972, the last two interglacials (including the Eemian, ~125,000 years ago) were believed to have lasted about 10,000 years. This is about the length of the current warm interval—the Holocene—to date. Assuming a similar duration for all interglacials, the scientists concluded that "it is likely that the present-day warm epoch will terminate relatively soon if man does not intervene" (*1*, p. 267).

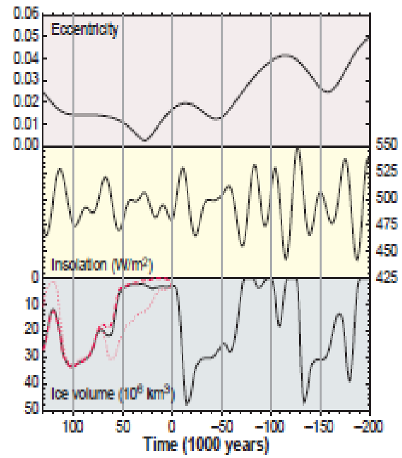
Some assumptions made 30 years ago have since been questioned. Past interglacials may have been longer than originally assumed (*2*). Some, including marine isotope stage 11 (MIS-11, 400,000 years ago), may have been warmer than at present (*3*). We are also increasingly aware of the intensification of the greenhouse effect by human activities (*4*). But even without human perturbation, future climate may not develop as in past interglacials (*5*) because the forcings and mechanisms that produced these earlier warm periods may have been quite different from today's.

Most early attempts to predict future climate at the geological time scale (*6*, *7*) prolonged the cooling that started at the peak of the Holocene some 6000 years ago, predicting a cold interval in about 25,000 years and a glaciation in about 55,000 years. These projections were based on statistical rules or simple models that did not include any CO_2 forcing. They thus implicitly assumed a value equal to the average of the last glacial-interglacial cycles [~225 parts per million by volume (ppmv) (*8*)].

But some studies disagreed with these projections. With a simple ice-sheet model, Oerlemans and Van der Veen (*9*) predicted a long interglacial lasting another 50,000 years, followed by a first glacial maximum in about 65,000 years. Ledley also stated that an ice age is unlikely to begin in the next 70,000 years (*10*), based on the relation between the observed rate of change of ice volume and the summer solstice radiation.

Other studies were more oriented toward modeling, including the possible effects of namics of the ice-age cycles. For example, according to Saltzman *et al.* (*11*) an increase in atmospheric CO_2, if maintained over a long period of time, could trigger the climatic system into a stable regime with small ice sheets, if any, in the Northern Hemisphere. Loutre (*12*) also showed that a CO_2 concentration of 710 ppmv, returning to a present-day value within 5000 years, could lead to a collapse of the Greenland Ice Sheet in a few thousand years.

On a geological time scale, climate cycles are believed to be driven by changes in insolation (solar radiation received at the top of the atmosphere) as a result of variations in Earth's orbit around the Sun. Over the next 100,000 years, the amplitude of insolation variations will be small (see the figure), much smaller than during the Eemian. For example, at 65°N in June, insolation will vary by less than 25 Wm^{-2} over the next 25,000 years, compared with 110 Wm^{-2} between 125,000 and 115,000 years ago. From the standpoint of insolation, the Eemian can hardly be taken as an analog for the next millennia, as is often assumed.

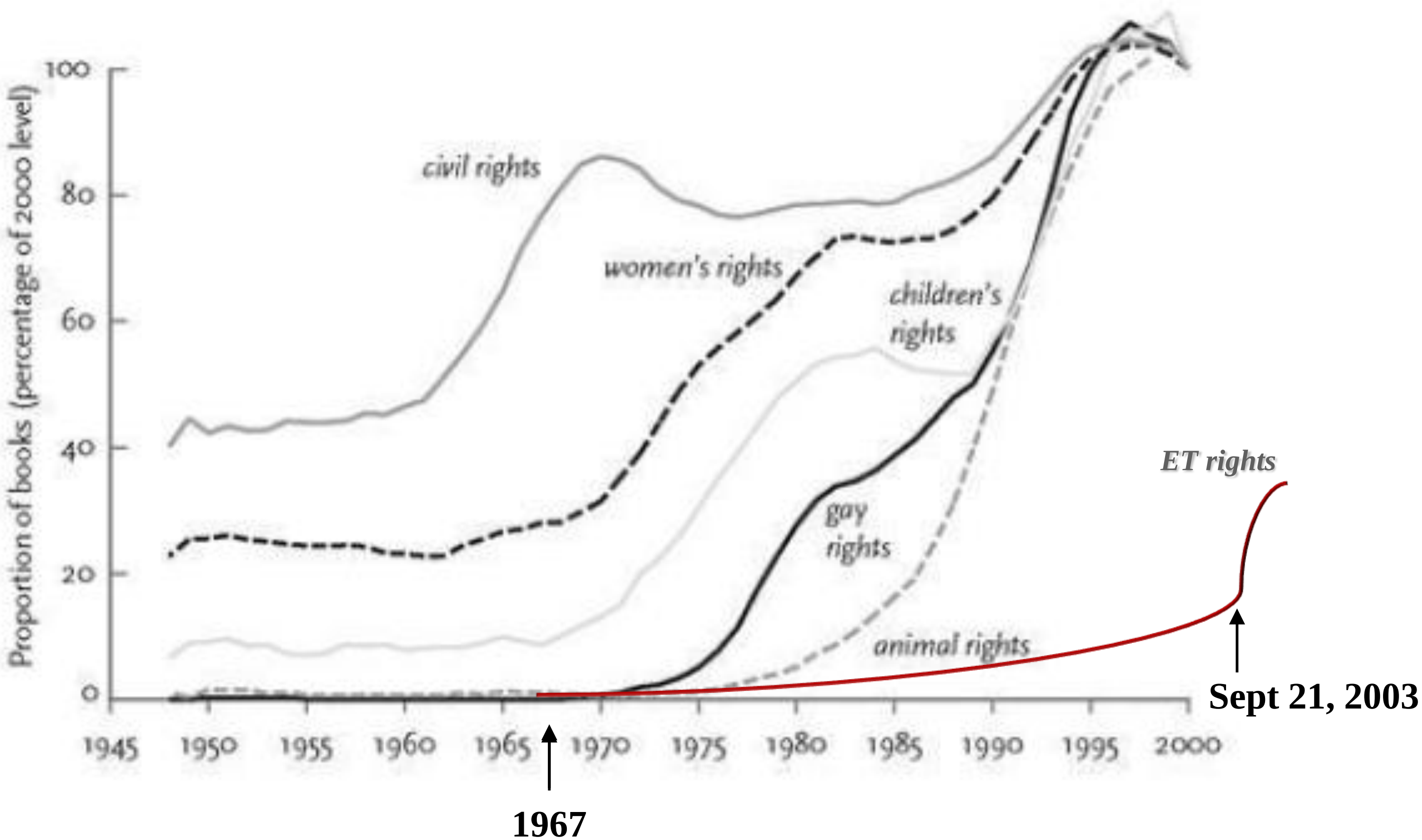


Orbiting the Sun. Long-term variations of eccentricity (**top**), June insolation at 65°N (**middle**), and simulated Northern Hemisphere ice volume (increasing downward) (**bottom**) for 200,000 years before the present to 130,000 from now. Time is negative in the past and positive in the future. For the future, three CO_2 scenarios were used: last glacial-interglacial values (solid line), a human-induced concentration of 750 ppmv (dashed line), and a constant concentration of 210 ppmv (dotted line). Simulation results from (*13*, *15*); eccentricity and insolation from (*19*).

The small amplitude of future insolation variations is exceptional. One of the few past analogs (*13*) occurred at about 400,000 years before the present, overlapping part of MIS-11. Then and now, very low eccentricity values coincided with the minima of the 400,000-year eccentricity cycle. Eccentricity will reach almost zero within the next 25,000 years, damping the variations of precession considerably.

Simulations with a two-dimensional climate model (*14*), forced with insolation and CO_2 variations over the next 100,000 years, provide an insight into the possible consequences of this rare phenomenon. Most CO_2 scenarios (*15*) led to an exceptionally long interglacial from 5000 years before the present to 50,000 years from now (see the bottom panel of the figure), with the next glacial maximum

The authors are at the Université catholique de Louvain, Institut d'Astronomie et de Géophysique G. Lemaître, 2 Chemin du Cyclotron, B-1348 Louvain-la-Neuve, Belgium. E-mail: berger@astr.ucl.ac.be

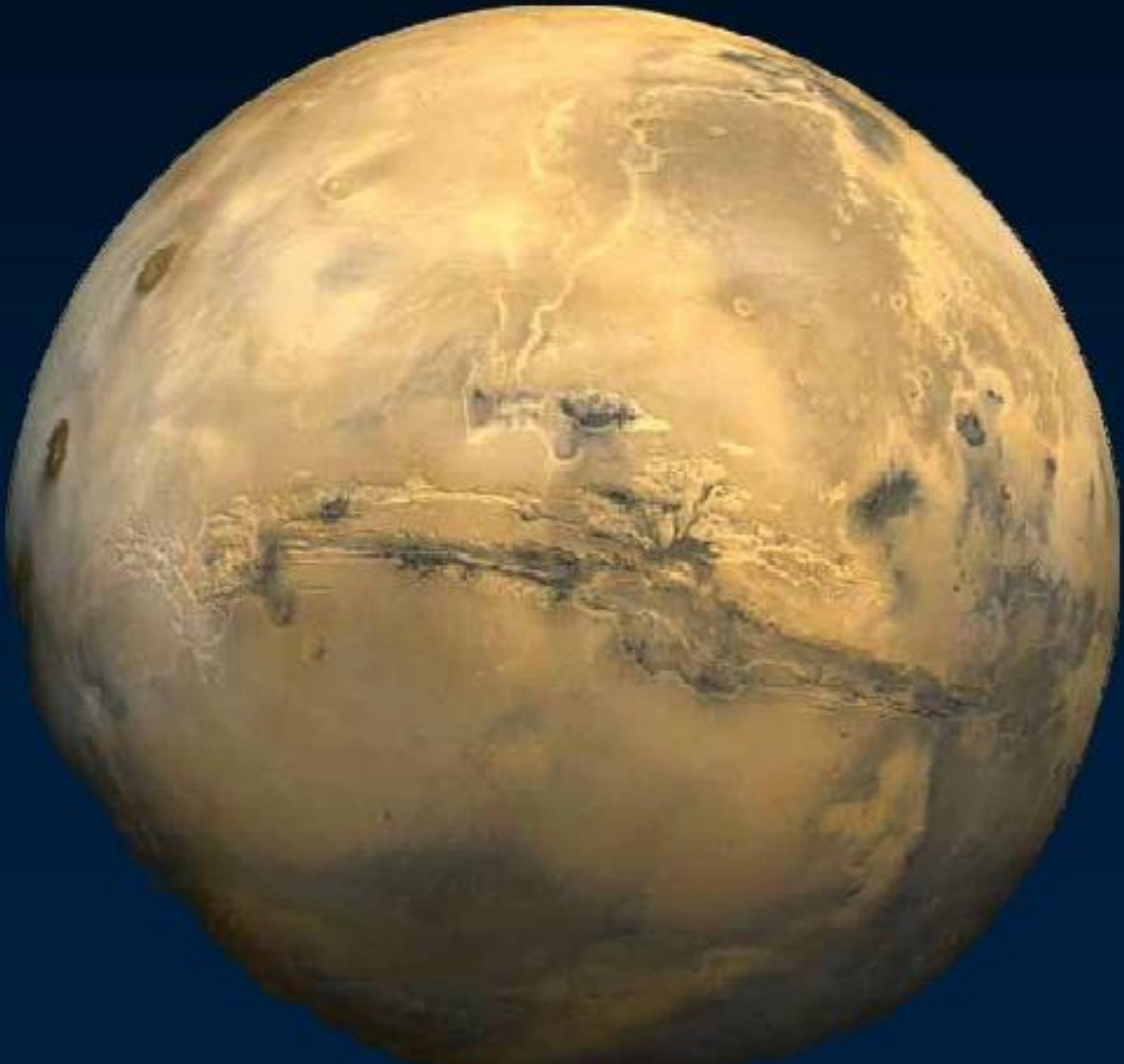


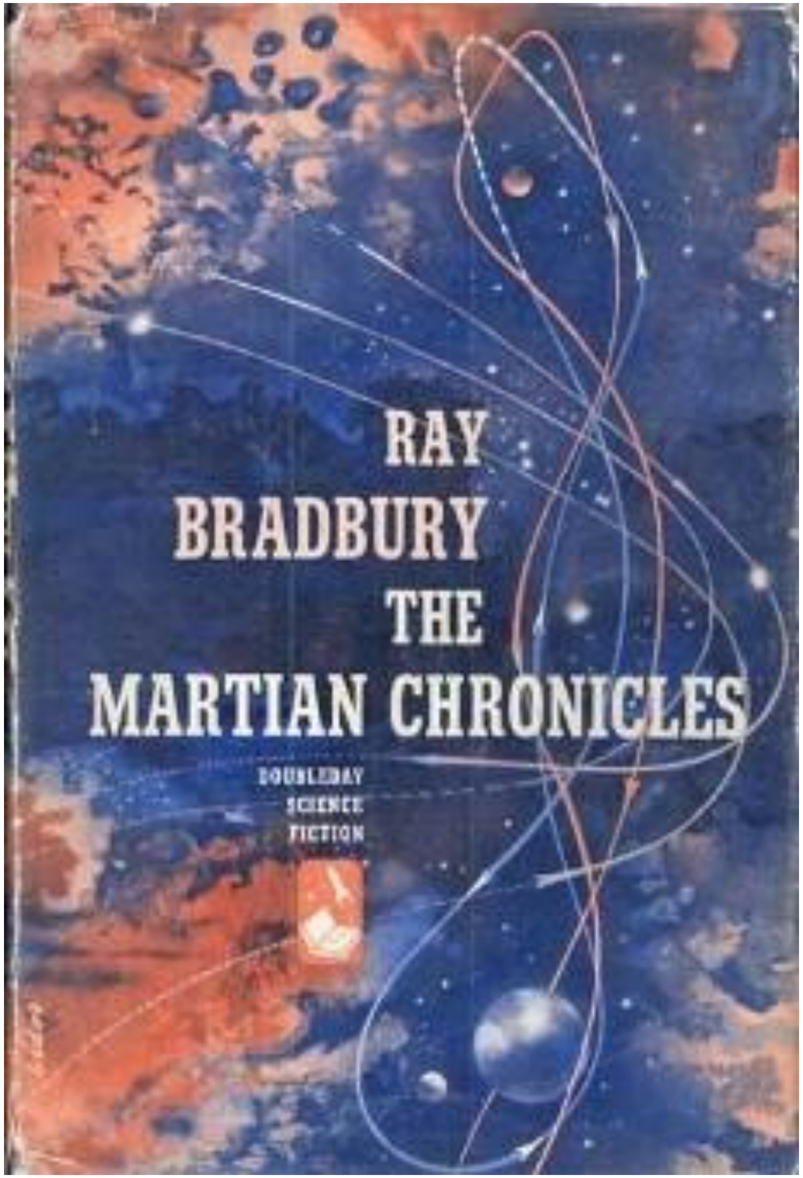
UN. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*

Mergulho da Galileo em Júpiter
21 de setembro de 2003

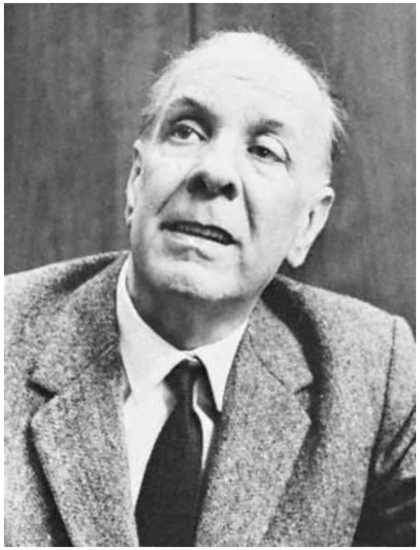

Mergulho da Cassini em Saturno
15 de setembro de 2017

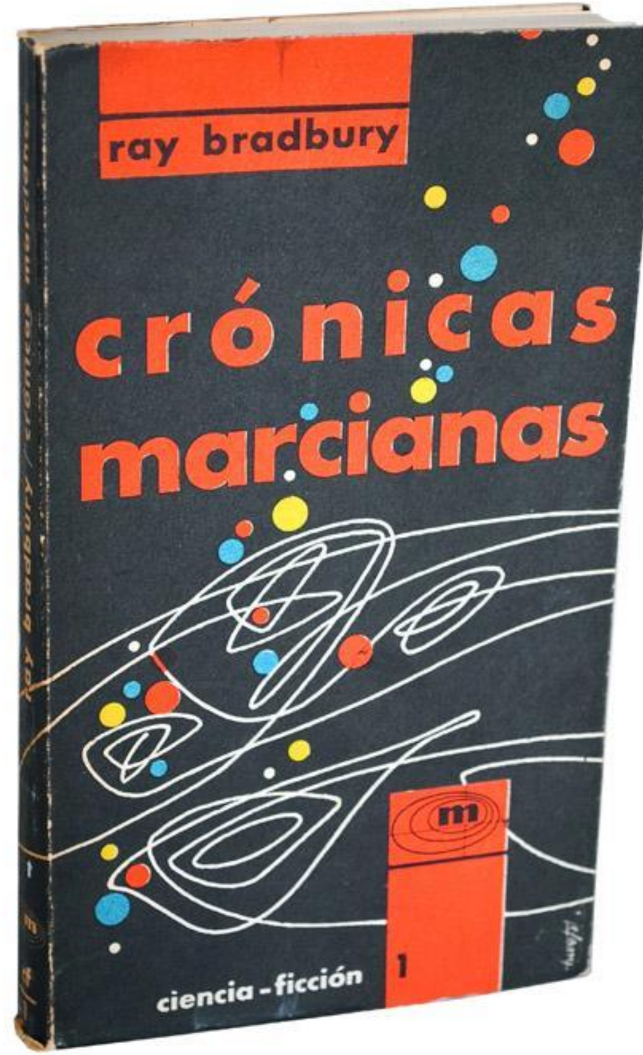
MARTE





The Martian Chronicles (1950)
Ray Bradbury





Como podem me tocar estas fantasias de maneira tão íntima?

Prólogo a *Crónicas Marcianas* de Ray Bradbury
Jorge Luis Borges (outono de 1954)

Acaso *La tercera expedición* es la historia más alarmante de este volumen. Su horror (sospecho) es metafisico: la incertidumbre sobre la identidad de los huéspedes del capitán John Black insinua incómodamente que tampoco sabemos quiénes somos ni cómo es, para Dios, nuestra cara. Quiero asimismo destacar el episodio titulado *El marciano*, que encierra uma patética variación del mito de Proteo.

Los marcianos, que al principio del libro son espantosos, merecen su piedade cuando la aniquilación los alcanza. Vencen los hombres y el autor no se alegra de su victoria. Anuncia com tristeza y com desengaño la futura expansíon del linaje humano sobre el planeta rojo...

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Research Paper

The Physics, Biology, and Environmental Ethics of Making Mars Habitable

CHRISTOPHER P. MCKAY[1] and MARGARITA M. MARINOVA[1,2]


ROBERT WAS CRYING LOUDLY, AND DAD PICKED HIM UP AND CARRIED HIM, AND THEY WALKED DOWN THROUGH THE RUINS TO THE CANAL...
...THE CANAL, WHERE TOMORROW OR THE NEXT DAY THE BOYS' FUTURE WIVES WOULD COME UP IN A BOAT... SMALL LAUGHING GIRLS NOW, WITH THEIR FATHER AND MOTHER...
THE NIGHT CAME DOWN AROUND THEM AND THERE WERE STARS. BUT TIMOTHY COULDN'T FIND EARTH. IT HAD ALREADY SET...
THAT WAS SOMETHING TO THINK ABOUT. IT HAD ALREADY SET!
A COOL NIGHT WIND BLEW AROUND THEM... AND AS THEY WALKED, DAD SAID...
YOUR MOTHER AND I WILL TEACH YOU. PERHAPS WE'LL FAIL. I THINK NOT. WE'VE HAD EXPERIENCE. WE'VE SEEN. WE PLANNED THIS TRIP YEARS AGO, EVEN BEFORE YOU WERE BORN. EVEN IF THERE HADN'T BEEN A WAR, WE'D HAVE COME TO MARS TO LIVE AND FORM OUR OWN STANDARD OF LIVING. IT WOULD HAVE BEEN ANOTHER HUNDRED YEARS BEFORE MARS WOULD HAVE BEEN POISONED BY EARTH CIVILIZATION. NOW, OF COURSE...
THEY REACHED THE CANAL. IT WAS LONG AND STRAIGHT AND COOL AND WET AND REFLECTIVE IN THE NIGHT...
I'VE ALWAYS WANTED TO SEE A MARTIAN, DAD. WHERE ARE THEY? YOU PROMISED...
THERE THEY ARE, MICHAEL...
DAD POINTED STRAIGHT DOWN. THE MARTIANS WERE THERE, ALL RIGHT. IT SENT A THRILL CHASING THROUGH TIMOTHY...
THE MARTIANS WERE THERE... IN THE CANAL... REFLECTED IN THE WATER. TIMOTHY AND MICHAEL AND ROBERT AND MOM AND DAD. THE MARTIANS STARED BACK AT THEM FOR A LONG, LONG SILENT TIME FROM THE RIPPLING WATER...

O PIQUINIQUE DE UM MILHÃO DE ANOS

“Eu sempre quis ver um Marciano”, disse Michael. “Onde eles estão, Pai? Você prometeu.”

“Eles estão ali”, disse Papai, e ele tirou Michael do seu ombro e apontou para baixo.

Os Marcianos estavam ali. Timothy começou a tremer.

Os Marcianos estavam ali – no canal – refletidos na água. Timothy e Michael e Mamãe e Papai.

Os Marcianos olharam-se a si mesmos por longo, longo silencioso tempo na água ondulante...

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NA ESQUINA DO COSMOS COM A VIDA

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