# Vida no universo

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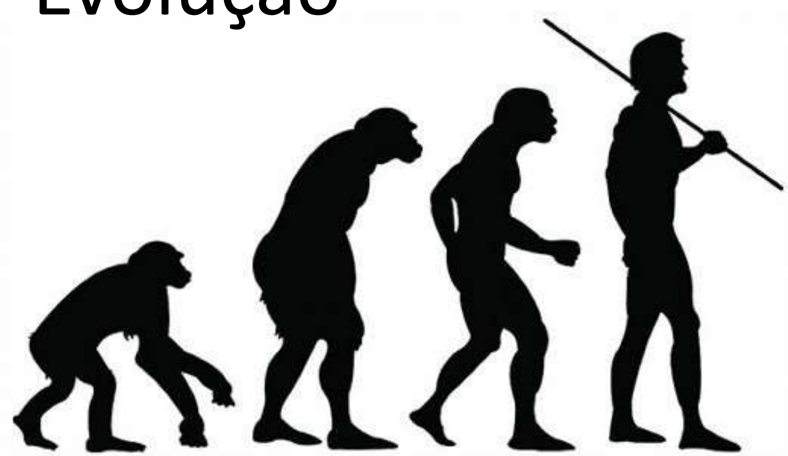
AGA 0205 – Elementos de Astronomia
2013-B

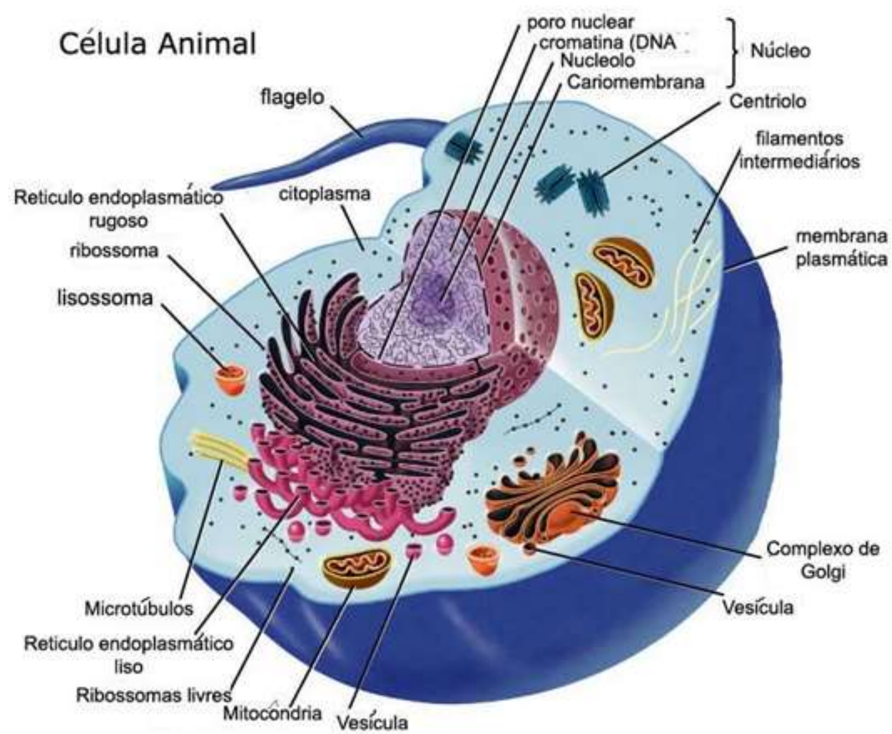
# Vida, o que É?

## Não existe definição perfeita

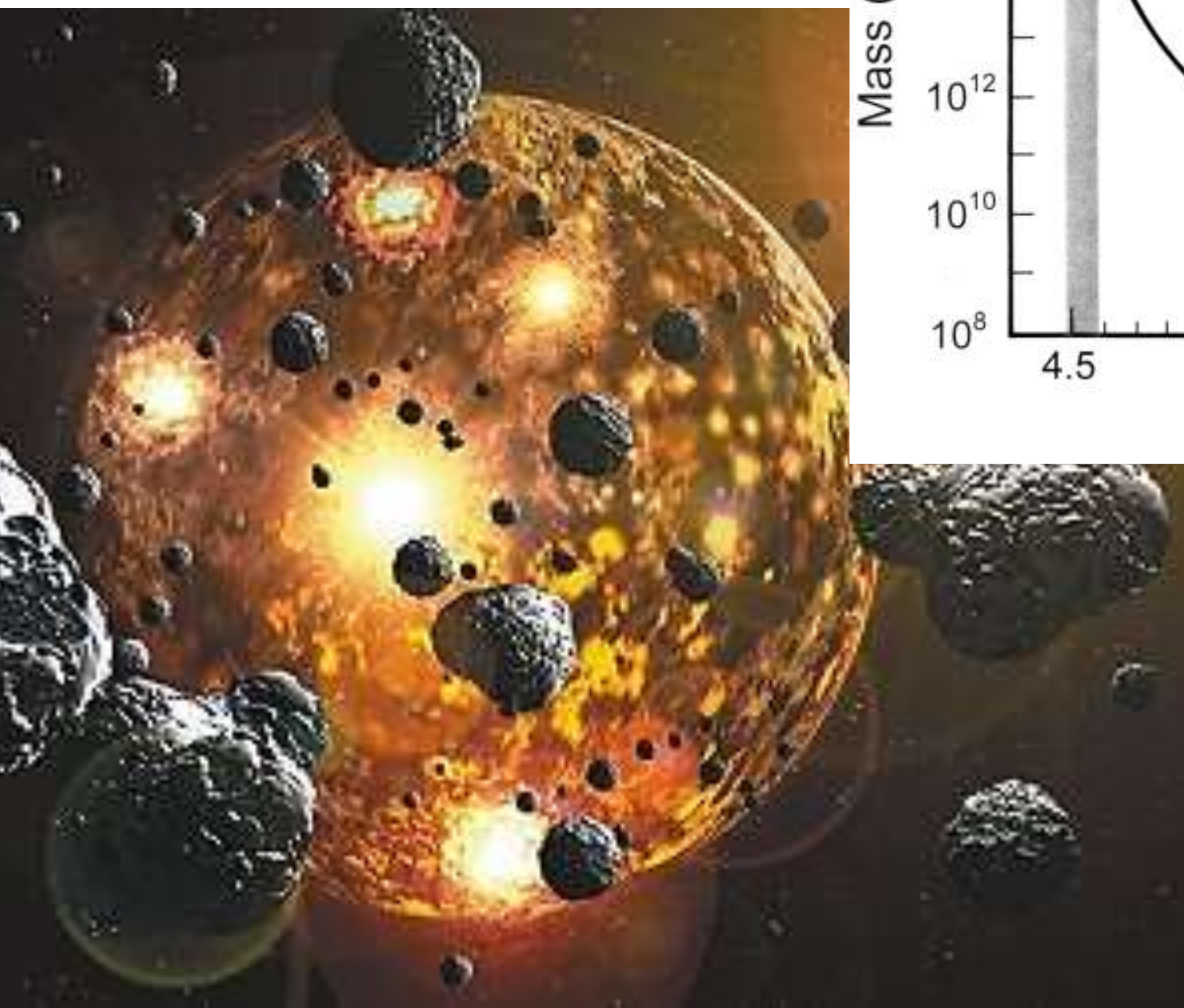
- Reprodução
- Crescimento e desenvolvimento
- Organização e complexidade
- Utilização de energia
- Resposta ao ambiente
- Evolução

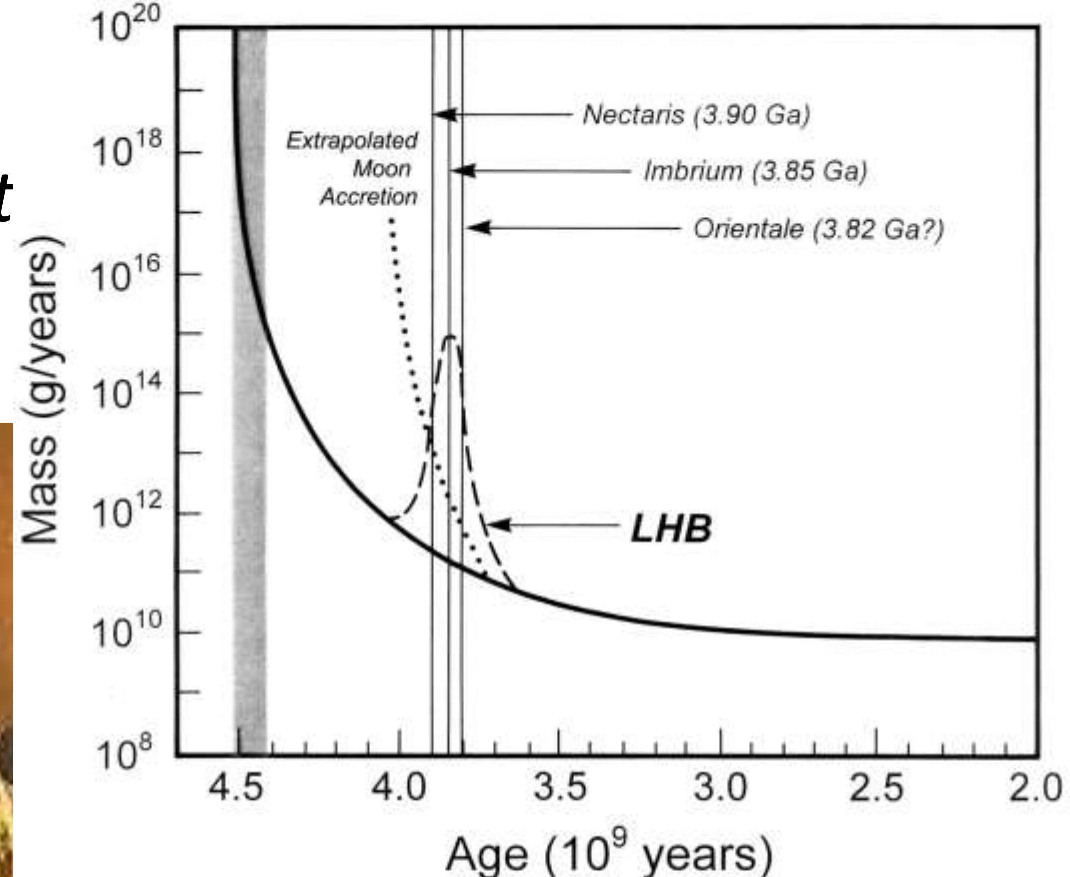
Jumento+Egua = Mula ou Burro
Robôs?
Virus?



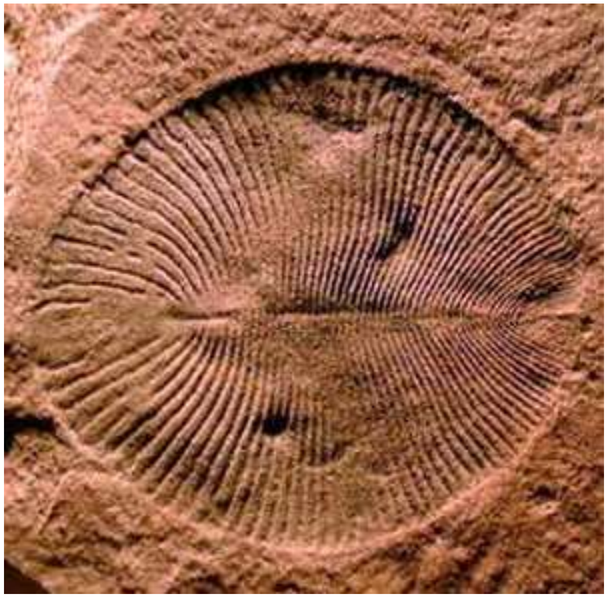


# Inicio da Vida na Terra após o *late bombardment* ~ há 3,9 bilhões de anos)

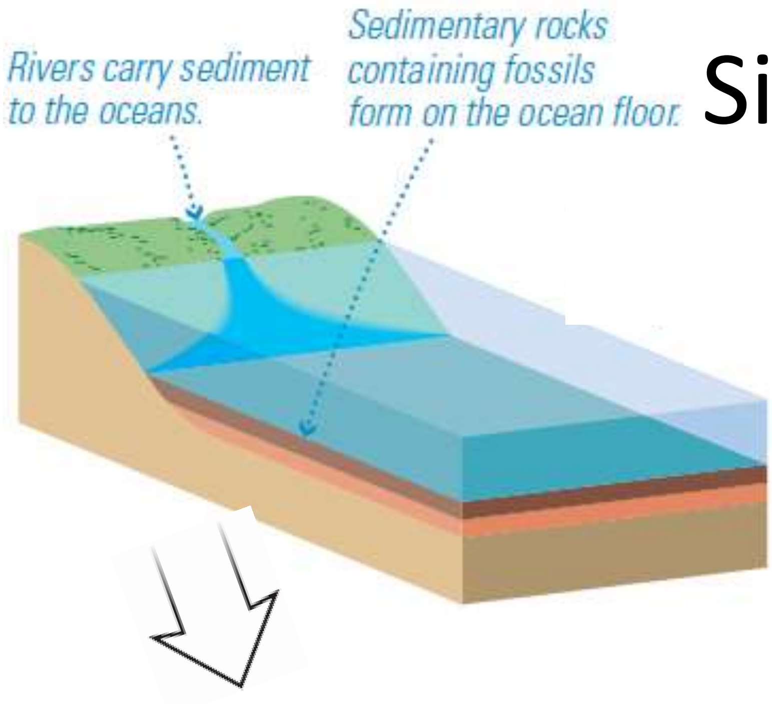


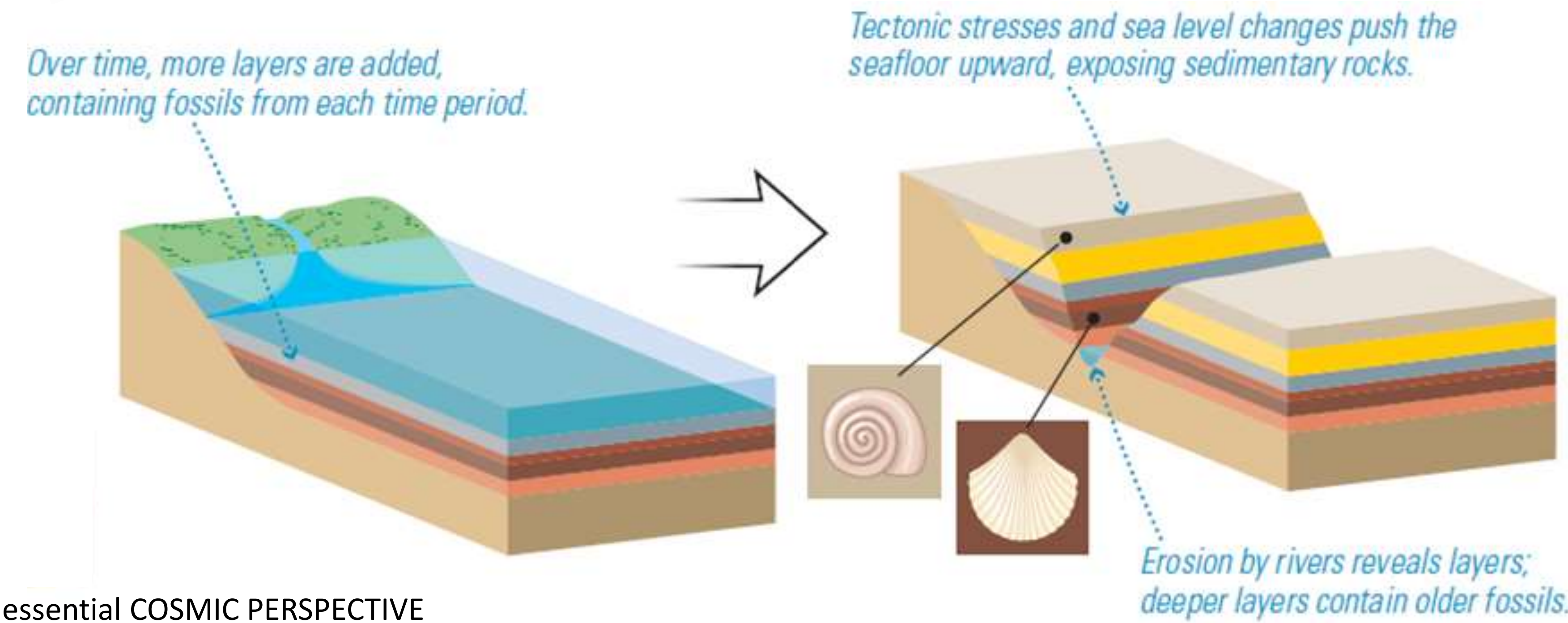


# Registros da vida primitiva em nosso planeta



# Sinais mais antigos de vida: estudo de rochas sedimentarias

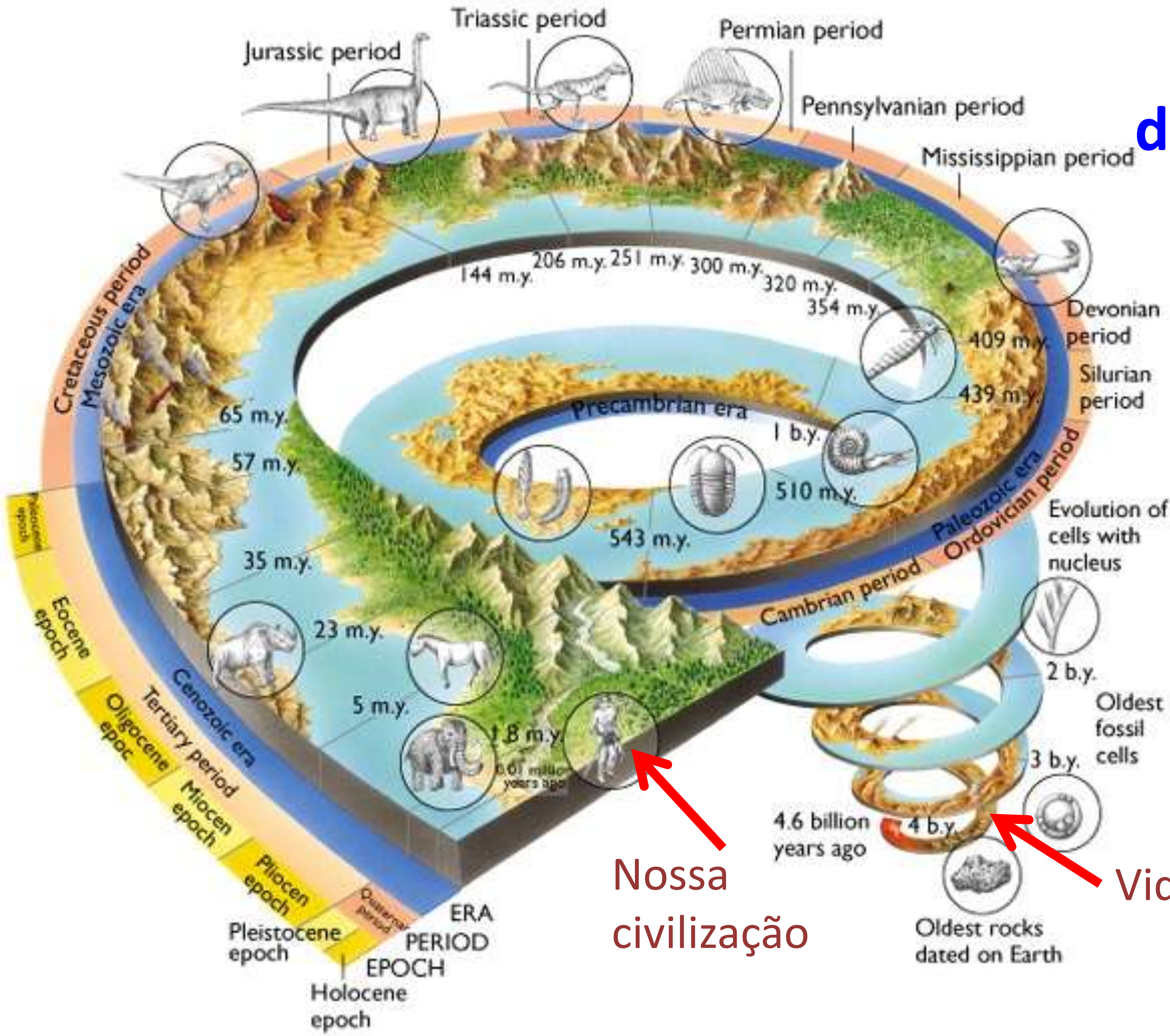


# Grand Canyon: mais de 500 milhões de anos de história

The rock layers of the Grand Canyon record more than 500 million years of Earth's history.

# Escalas de tempo desde a origem da Terra



# Estromatólitos: fósseis mais antigos, evidencias de vida bacteriana

## Controls on development and diversity of Early Archean stromatolites

9548–9555 | PNAS | June 16, 2009 | vol. 106 | no. 24
www.pnas.org/cgi/doi/10.1073/pnas.0903323106

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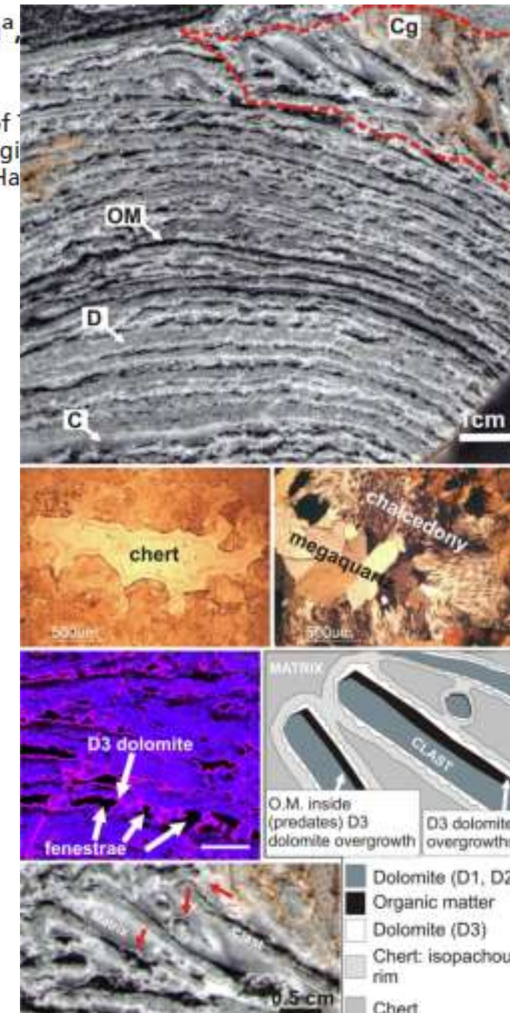
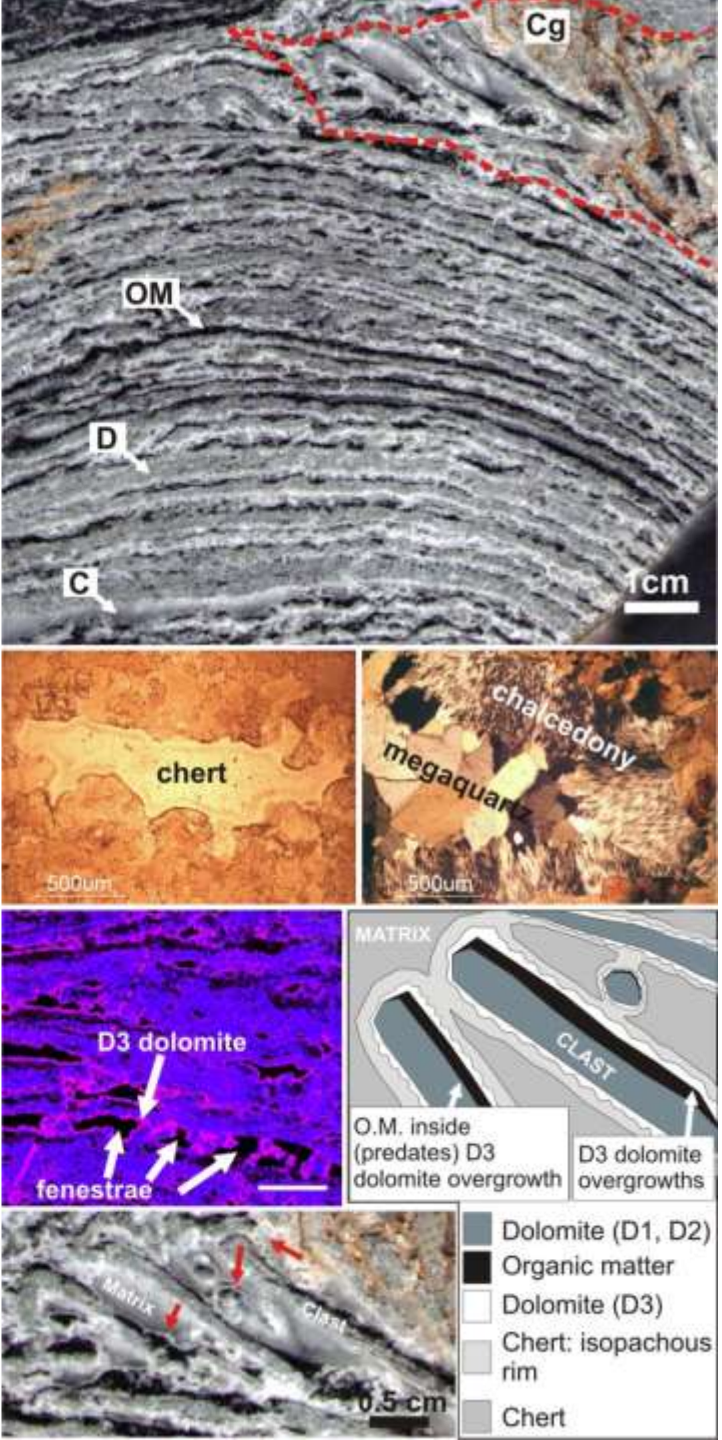
[a]National Aeronautics and Space Administration Astrobiology Institute at the Jet Propulsion Laboratory, California Institute of T
…2, Australia; [c]Department of Geologi…
…anismic and Evolutionary Biology, Ha…

The ≈3,450-million-year-old Strelley Pool Formation in Western Australia contains a reef-like assembly of laminated sedimentary accretion structures (stromatolites) that have macroscale characteristics suggestive of biological influence. However, direct microscale evidence of biology—namely, organic microbial remains or biosedimentary fabrics—has to date eluded discovery in the extensively-recrystallized rocks. Recently-identified outcrops with relatively good textural preservation record microscale evidence of primary sedimentary processes, including some that indicate probable microbial mat formation. Furthermore, we find relict fabrics and organic layers that covary with stromatolite morphology, linking morphologic diversity to changes in sedimentation, seafloor mineral precipitation, and inferred microbial mat development. Thus, the most direct and compelling signatures of life in the Strelley Pool Formation are those observed at the microscopic scale. By examining spatiotemporal changes in microscale characteristics it is possible not only to recognize the presence of probable microbial mats during stromatolite development, but also to infer aspects of the biological inputs to stromatolite morphogenesis. The persistence of an inferred biological signal through changing environmental circumstances and stromatolite types indicates that benthic microbial populations adapted to shifting environmental conditions in early oceans.



# Estromatólitos

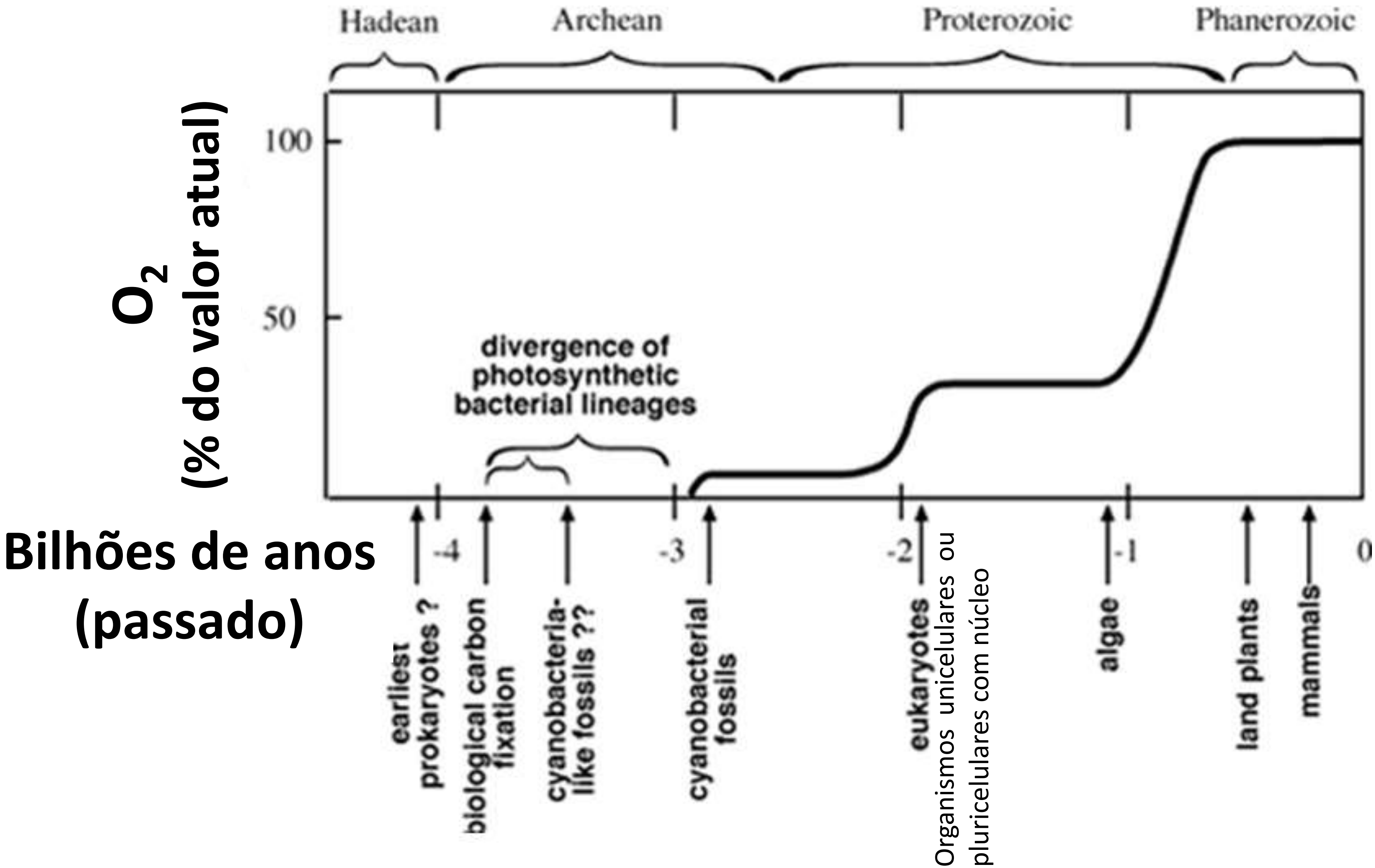
## Fósseis mais antigos, evidencias de vida bacteriana




**3450-million-year-old Strelley Pool Formation in Western Australia**

Fosseis estromatólitos em secções transversais de 1,8 bilhões de anos em Great Slave Lake, Canada

# Cianobactérias produziram o oxigênio da atmosfera terrestre



# Estromatólitos modernos

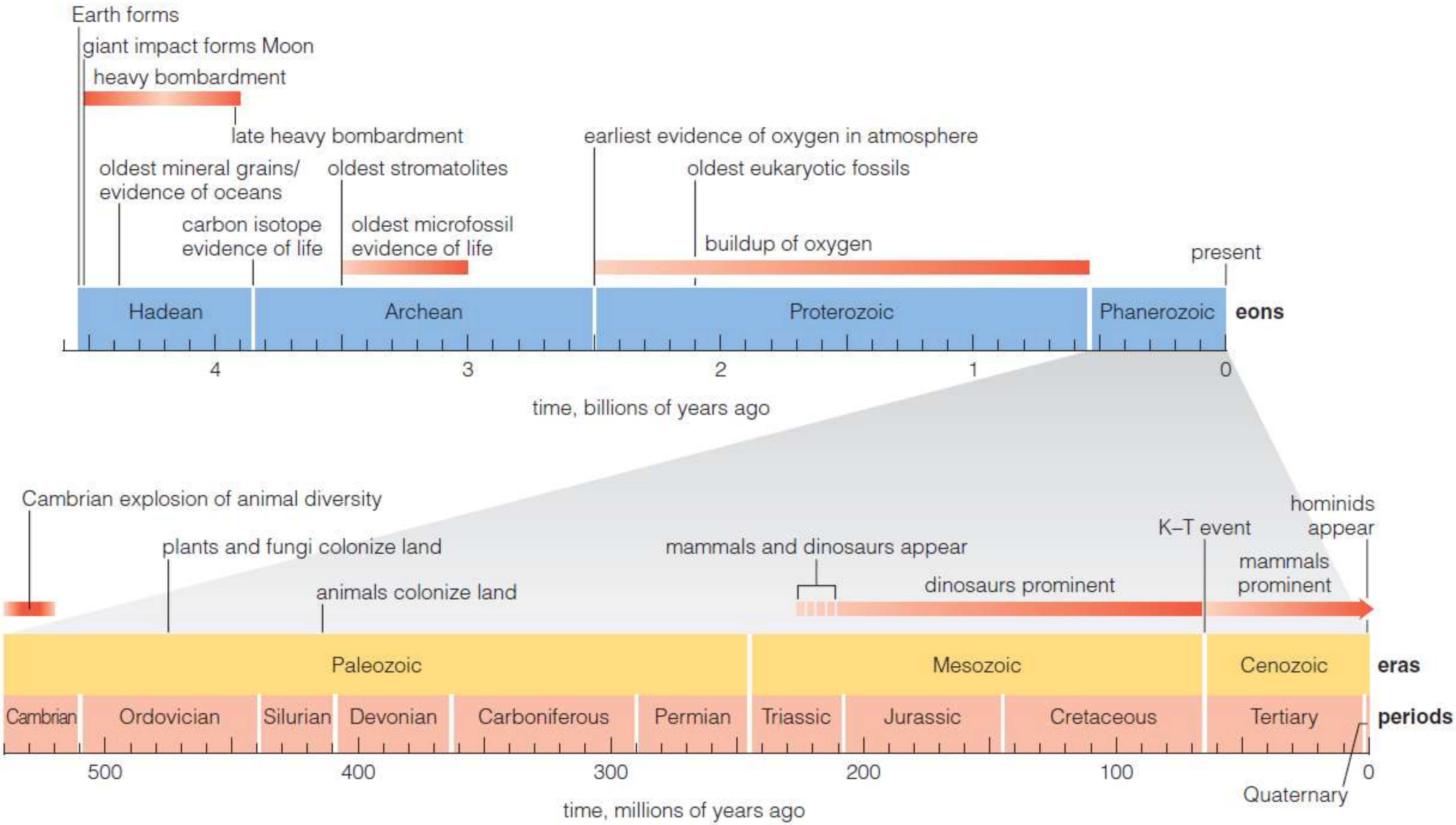
Hamelin Pool , Shark bay, Austrália

Cyanobacteria living in Hamelin Pool are direct descendants of the oldest form of photosynthetic life on earth

# Estromatólitos modernos

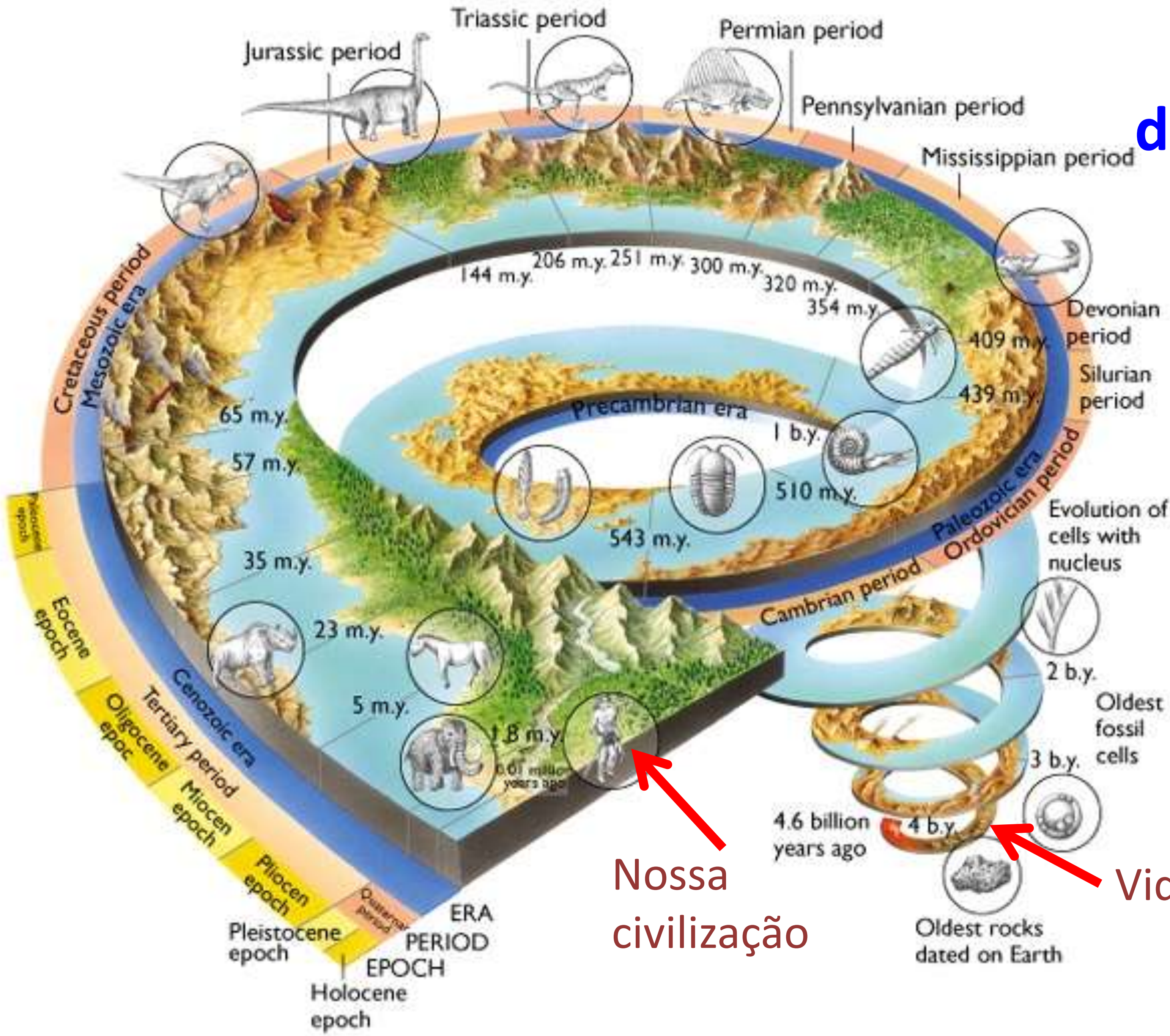
Lagoa salgada, RJ, Brasil

# Escala de tempo geológico




The geological time scale. Notice that the lower timeline is an expanded view of the last portion of the upper timeline. The eons, eras, and periods are defined by changes observed in the fossil record. The absolute ages come from radiometric dating. (The *K–T event* is the geological term for the impact linked to the mass extinction of the dinosaurs [Section 9.4].)

# Escalas de tempo desde a origem da Terra



# Se a idade do Universo fosse de 1 ano ...

**Vida complexa ~ há 1h**

**Modern humans ~ há 6 min**

**Agricultura ~ há 23 segundos**

**Civilizações ~ há 10 segundos**

**Descoberta do Brasil ~ há 1 segundo**

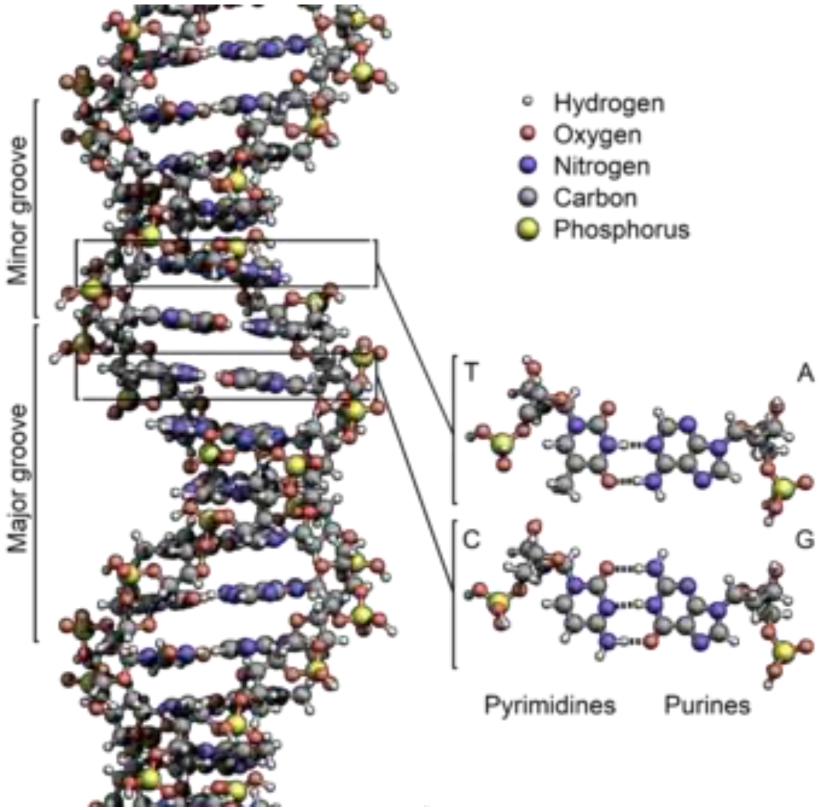
**Lei da gravitação universal ~ há 0,7 segundos**

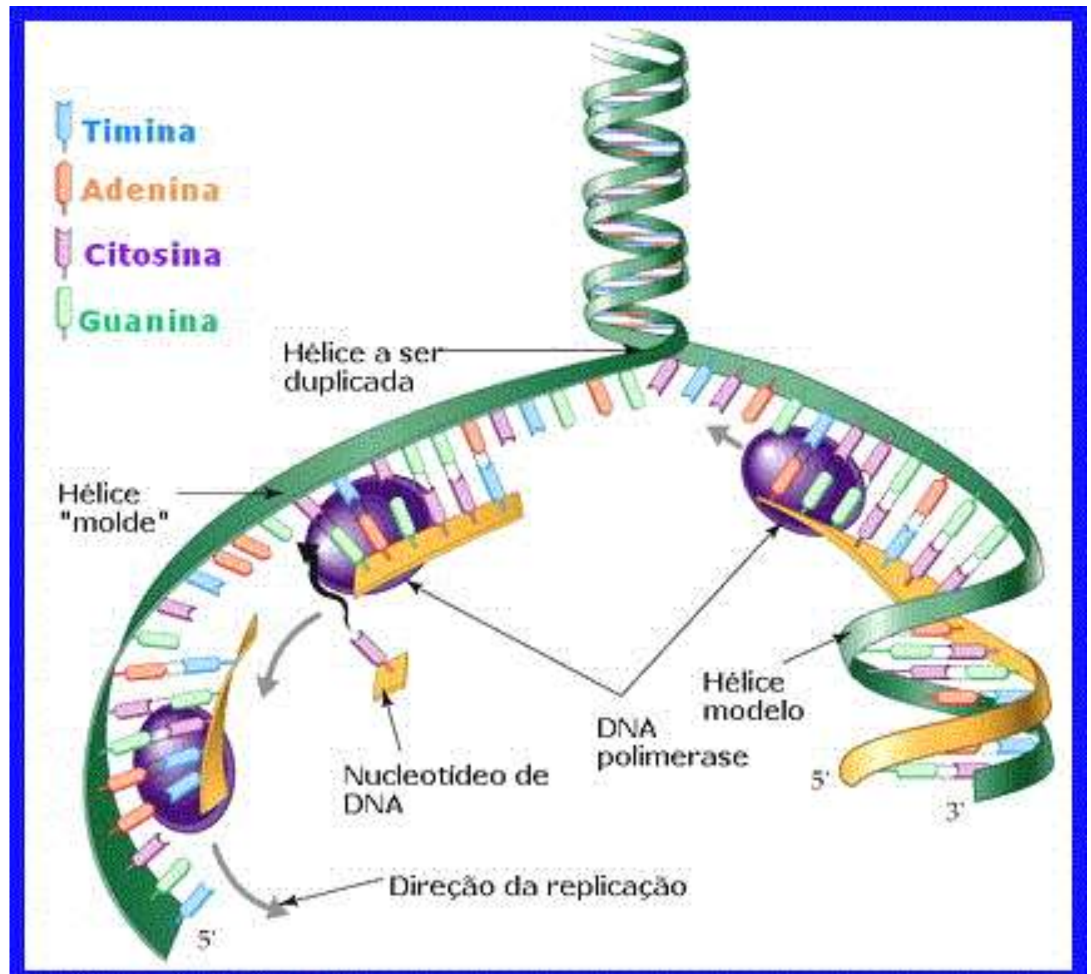
**Computadores pessoais ~ há 0,07 segundos**

**Internet ~ há 0,05 segundos**

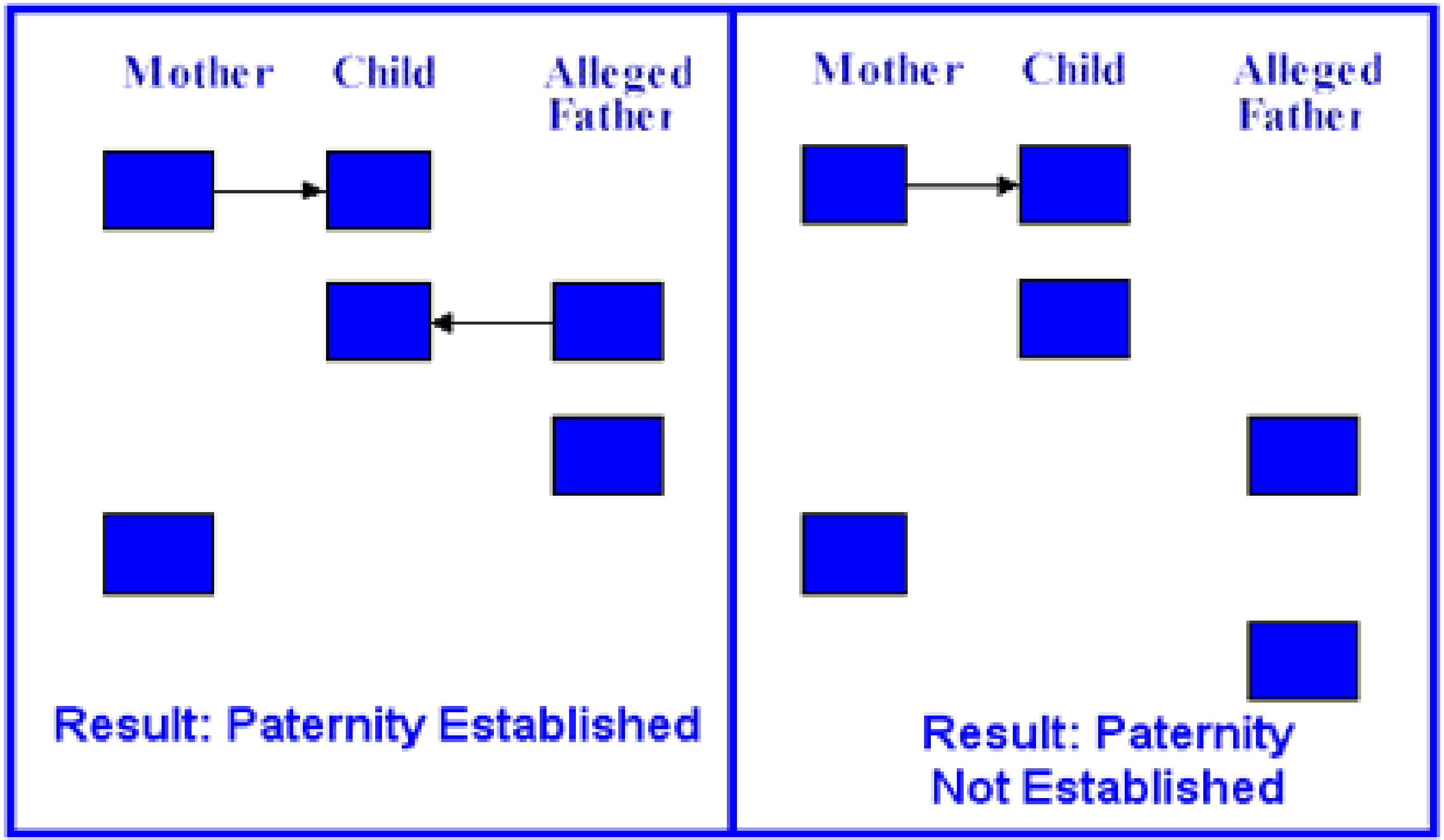
**Twitter ~ há 0,01 segundos**

# DNA: a base da vida

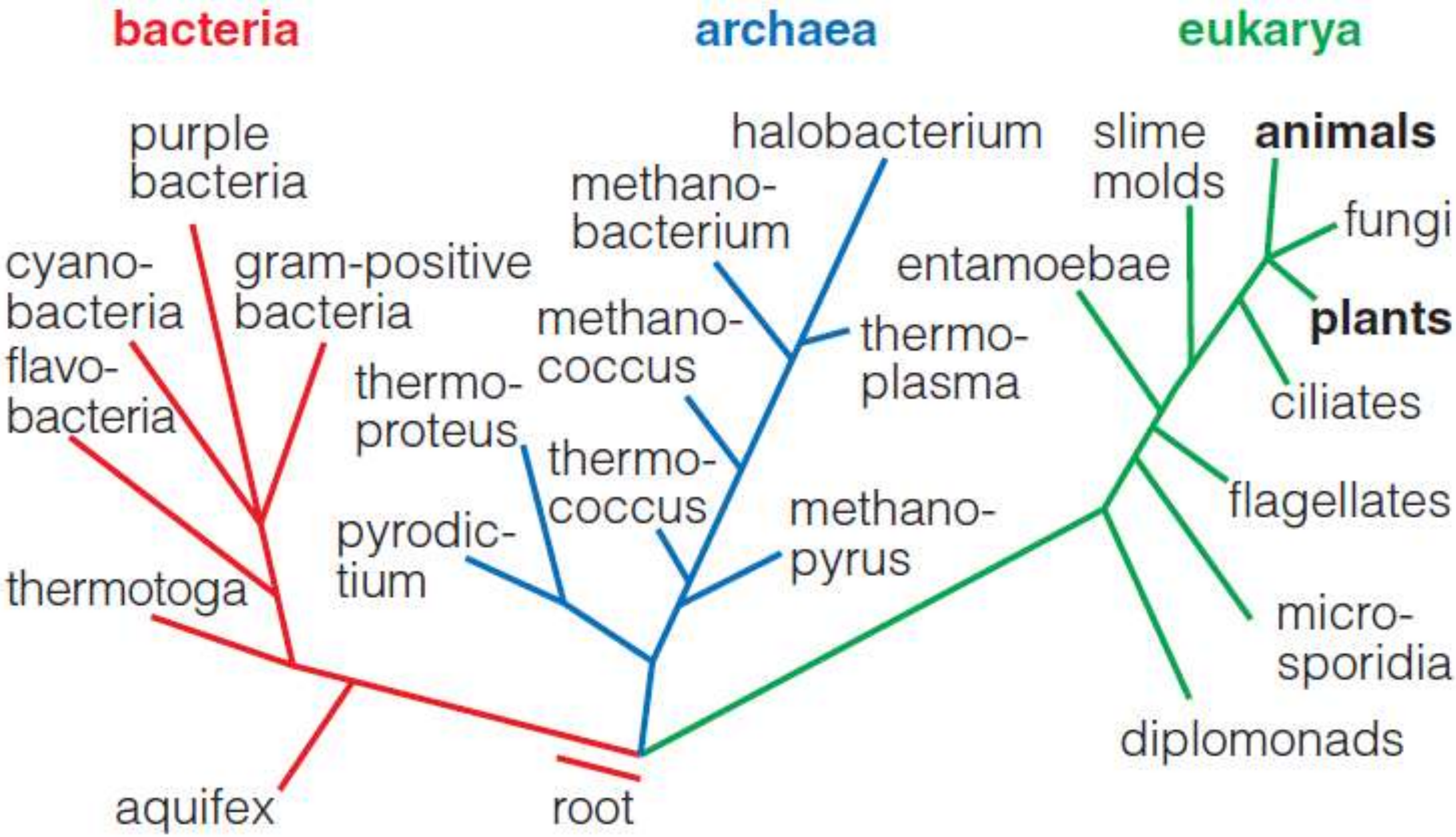


# DNA paternity test



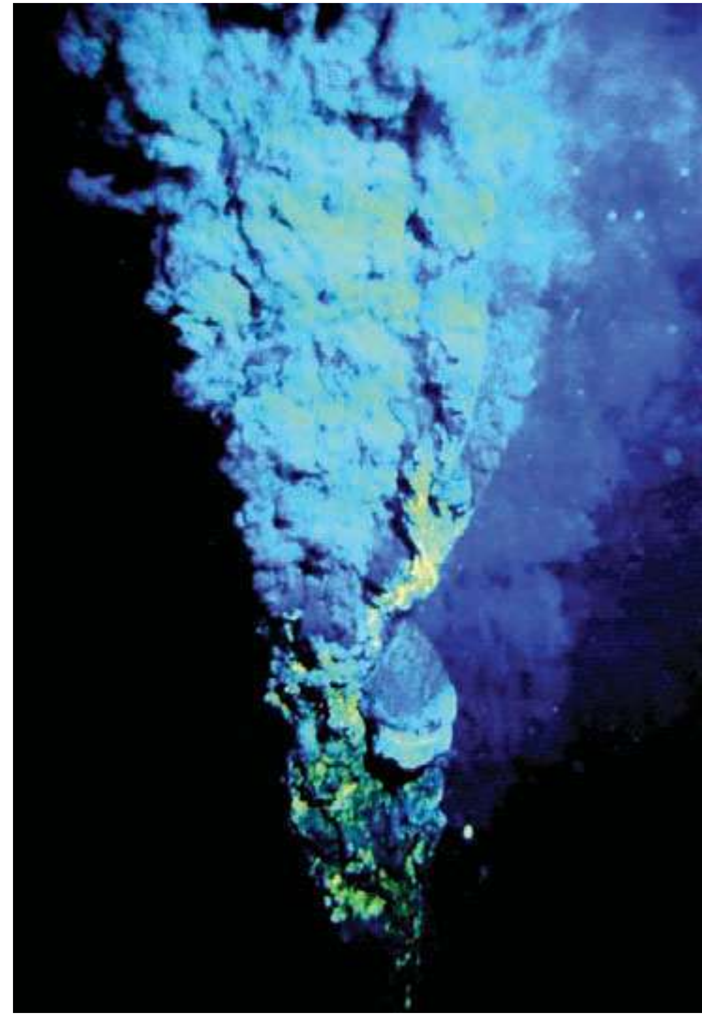
# Arvore da vida




The tree of life, showing evolutionary relationships determined by comparison of DNA sequences in different organisms. Just two small branches represent *all* plant and animal species.

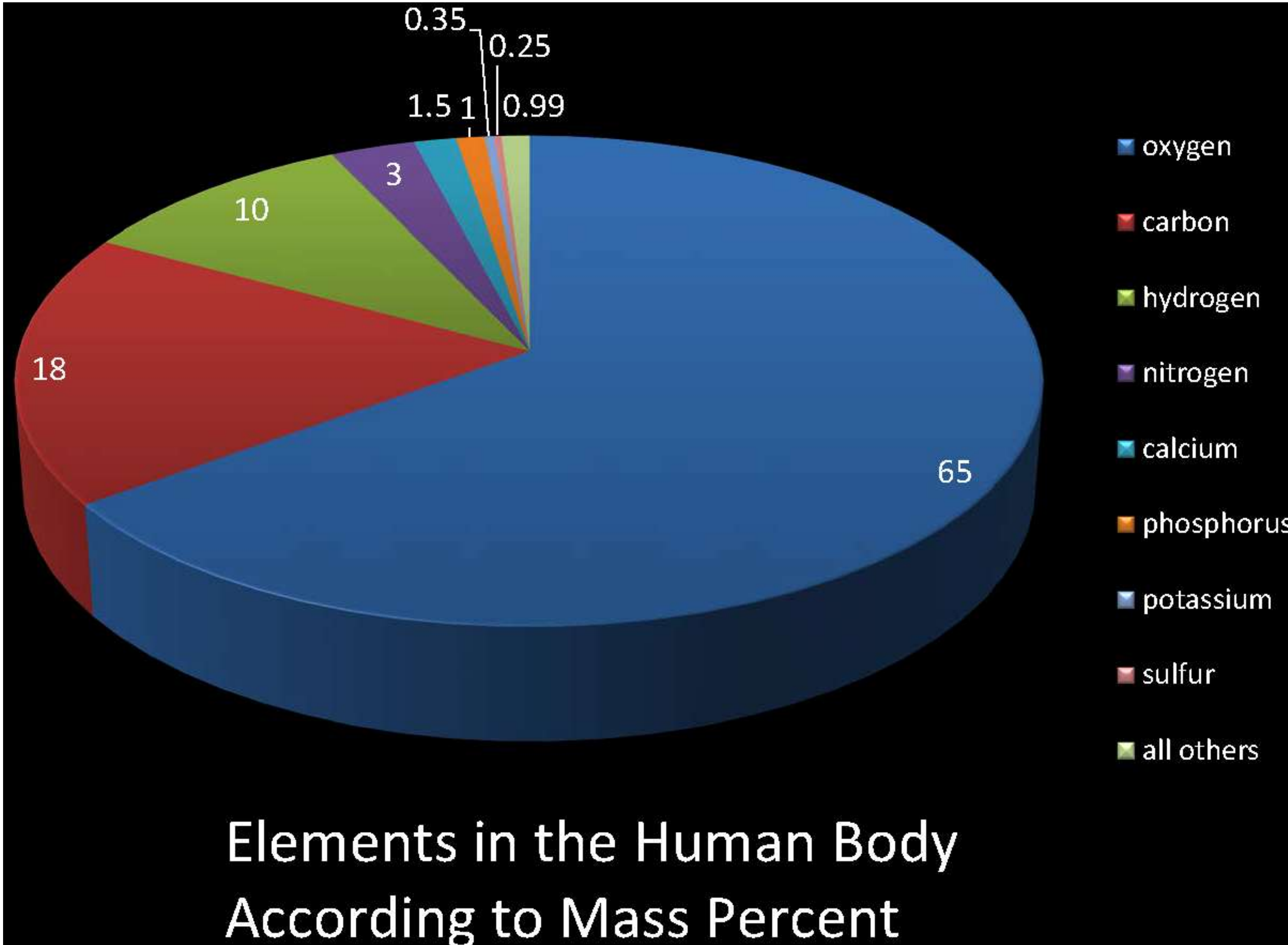
# Organismos mais antigos: extremófilos?

Termófilo, produz algumas das mais brilhantes cores do Grand Prismatic Spring, Yellowstone



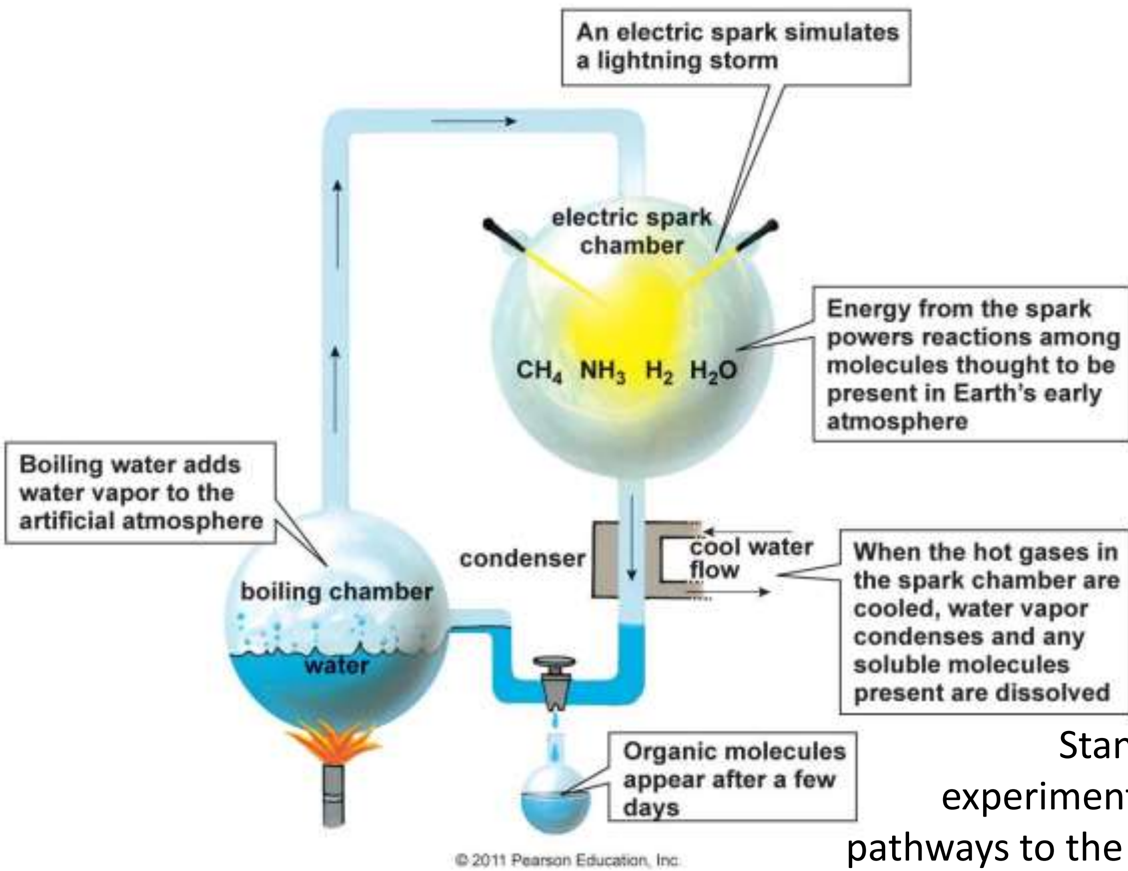
This photograph shows a black smoker—a volcanic vent on the ocean floor that spews out hot, mineral-rich water. DNA studies indicate that the microbes living near these vents are evolutionarily older than most other living organisms, hinting that early life may have arisen in similar environments.

# Mas como começou a vida?



# Mas como começou a vida?

A teoria da evolução explica a diversidade de vida mas não explica como a vida começou.



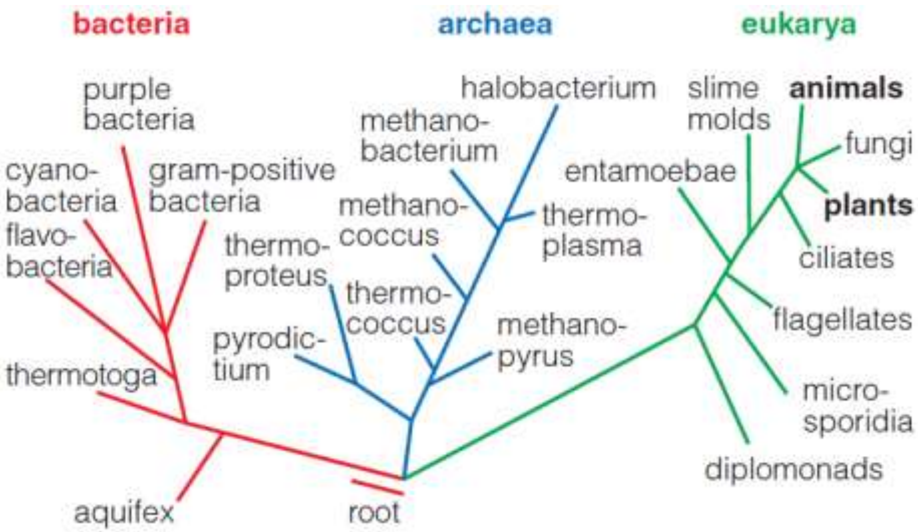

Stanley Miller poses with a reproduction of the experimental setup he first used in the 1950s to study pathways to the origin of life. (He worked with Harold Urey, so the experiment is called the Miller-Urey experiment.)

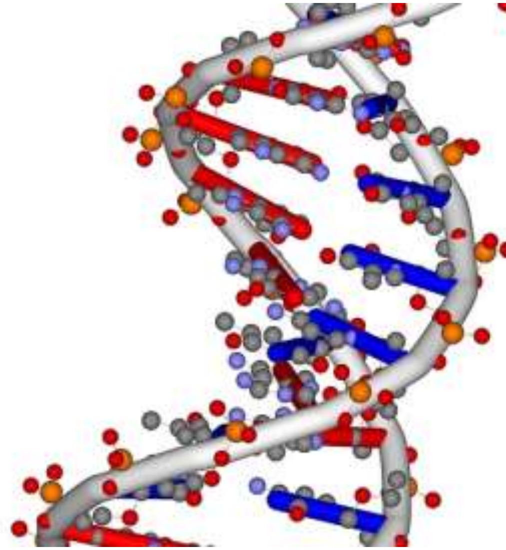
# Moléculas orgânicas em meteoritos: fonte primária da vida na Terra?

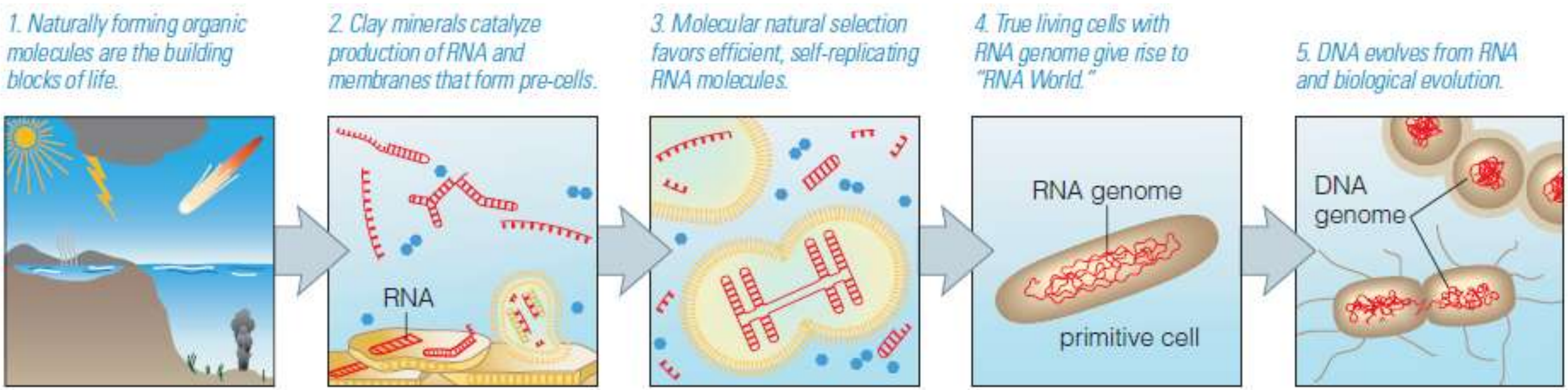
The Murchison meteorite contains complex organic molecules – including carbon, hydrogen, oxygen, nitrogen and sulphur.

Yoshihiro Furukawa, of Tohoku University:
Impactos poderiam ter sintetizado moléculas orgânicas

# Mas como passar de moléculas orgânicas à vida?





# XV International Conference on the Origin of Life

24-29 August 2008, Florence, Italy

ISSOL

The International Society for the Study of the Origin of Life
The International Astrobiology Society

http://www.astrobiobrasil.org/IIwapbr/

# II Workshop on Astro and Paleobiology

## *Extreme Environments in Modern and Ancient Times*

**18 e 19 de Novembro de 2013**

**Auditório do Bloco G**

**Instituto de Astronomia, Geofísica e Ciências Atmosféricas – USP**

A Astrobiologia se dedica ao estudo da vida e suas conexões com o ambiente espacial, englobando sua origem, evolução, distribuição e futuro. A Paleobiologia, por sua vez, estuda formas de vida pregressa na Terra como modelo para o entendimento da evolução dos organismos e do planeta. São duas áreas afins e que cada vez mais se relacionam. Em sua segunda edição, este workshop terá como tema central ambientes extremos, tanto atuais como antigos, sua influência na vida, estratégias de sobrevivência e analogias com ambientes extraterrestres.

**ASSISTA AO VIVO ONLINE**

*(as palestras serão transmitidas ao vivo, durante o evento, pelo sistema IPTV da USP)*

# Life elsewhere
# Marte?

The *Spirit* rover studies a rock on Mars (the photograph was taken by a camera aboard the rover). Such studies help scientists learn if and when Mars may have been habitable.

# Mars Rover Curiosity

*11.nov.2012*

**Five Bites Into Mars**

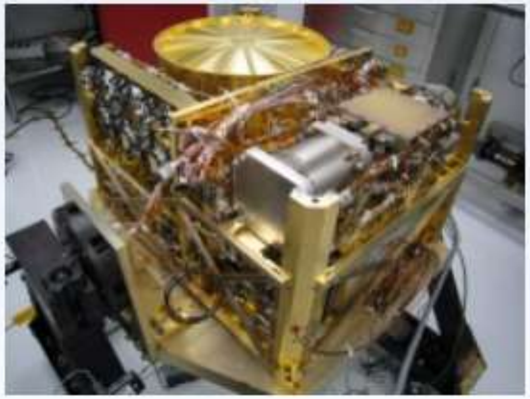
# Curiosity's SAM Instrument Finds Water and More in Surface Sample Sept 26, 2013

The first scoop of soil analyzed by the analytical suite in the belly of NASA's Curiosity rover reveals that fine materials on the surface of the planet contain several percent water by weight. The results were published today in Science as one article in a five-paper special section on the Curiosity mission.

"One of the most exciting results from this very first solid sample ingested by Curiosity is the high percentage of water in the soil," said Laurie Leshin, lead author of one paper and dean of the School Science at Rensselaer Polytechnic Institute. "About 2 percent of the soil on the surface of Mars is made up of water, which is a great resource, and interesting scientifically." The sample also released significant carbon dioxide, oxygen and sulfur compounds when heated.

Curiosity landed in Gale Crater on the surface of Mars on Aug. 6, 2012, charged with answering the question: "Could Mars have once harbored life?" To do that, Curiosity is the first rover on Mars to carry equipment for gathering and processing samples of rock and soil. One of those instruments was employed in the current research: the Sample Analysis at Mars (SAM) instrument suite, which includes a gas chromatograph, a mass spectrometer and a tunable laser spectrometer. These tools enable SAM to identify a wide range of chemical compounds and determine the ratios of different isotopes of key elements.

"This work not only demonstrates that SAM is working beautifully on Mars, but also shows how SAM fits into Curiosity's powerful and comprehensive suite of scientific instruments," said Paul Mahaffy, principal investigator for SAM at NASA's Goddard Space Flight Center in Greenbelt, Md. "By combining analyses of water and other volatiles from SAM with mineralogical, chemical and geological data from Curiosity's other instruments, we have the most comprehensive information ever obtained on



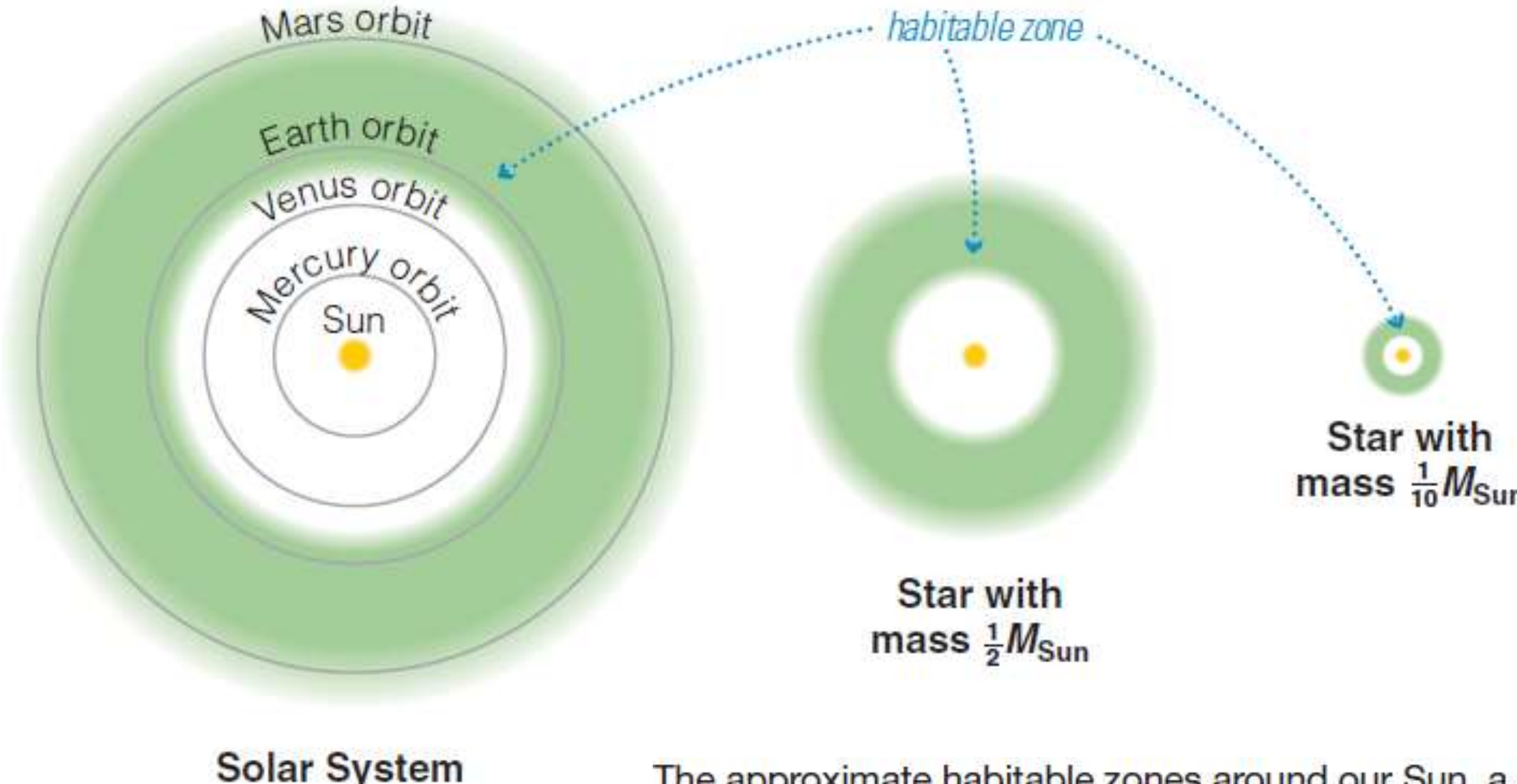
The Sample Analysis at Mars instrument suite, prior to its installation on the Curiosity rover.

***Image Credit: NASA Goddard***

The Sample Analysis at Mars instrument suite found water in the dust, dirt and fine soil from the Rocknest site on Mars. (This file photo shows trenches Curiosity dug in October 2012.)

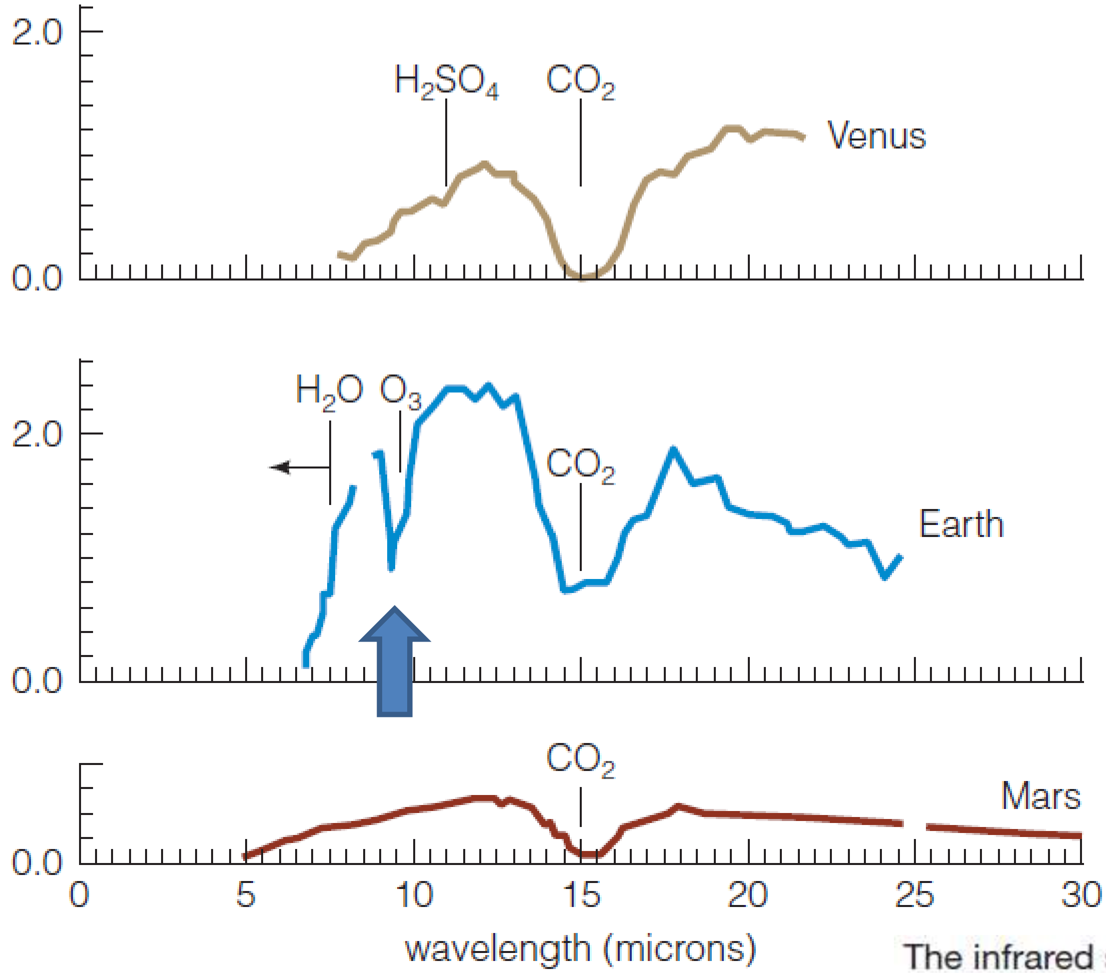
***Image Credit: NASA/JPL-Caltech/MSSS***

# Vida fora do sistema solar: zonas habitáveis em outras estrelas




The approximate habitable zones around our Sun, a star with one half the mass of our Sun (spectral type K), and a star with one tenth the mass of our Sun (spectral type M), shown to scale. The habitable zone becomes increasingly smaller and closer in for stars of lower mass and luminosity.

# Signatures of life



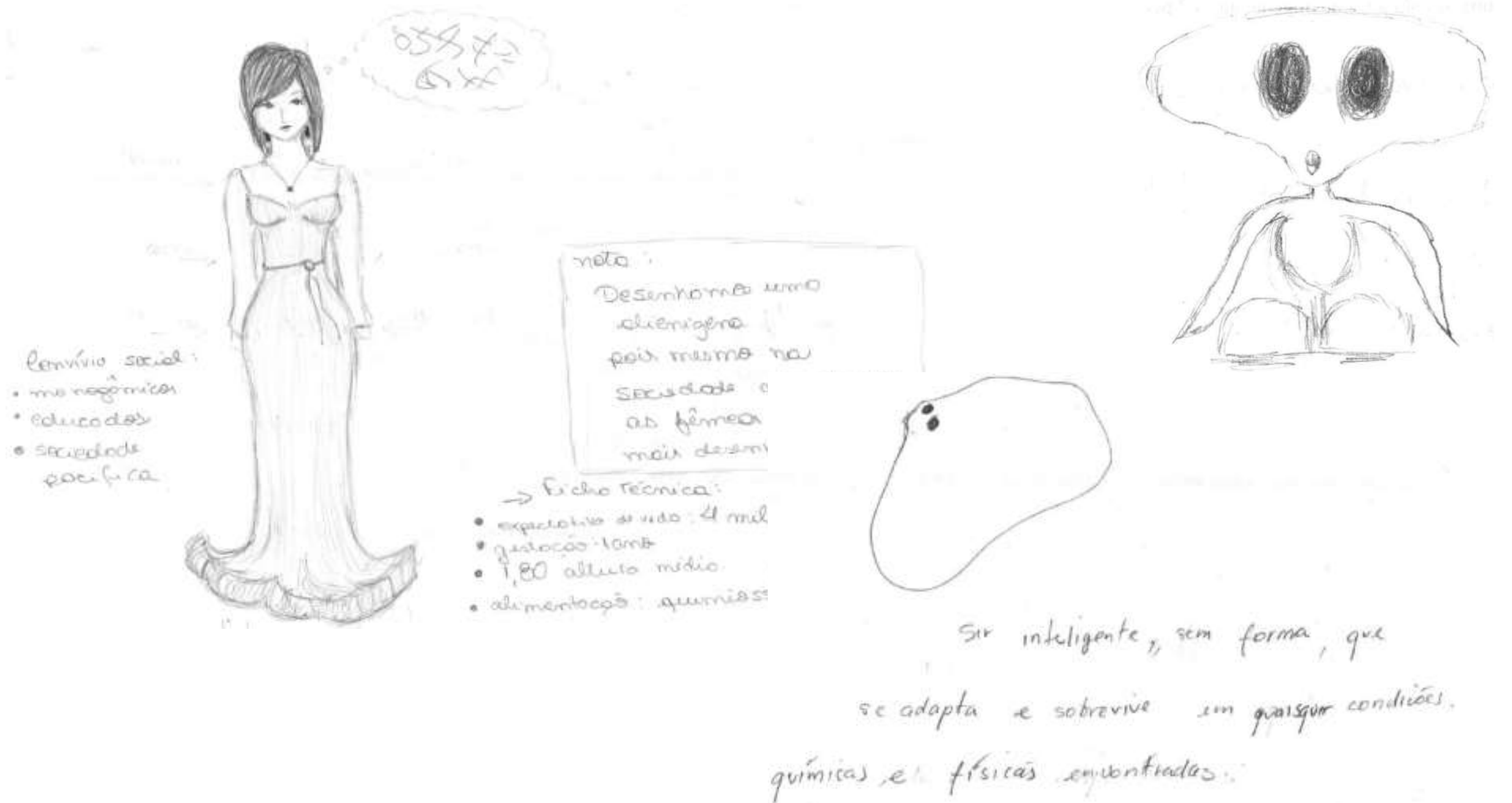

$O_3$: indicador de vida?

The infrared spectra of Venus, Earth, and Mars, as they might be seen from afar, showing absorption features that point to the presence of carbon dioxide ($CO_2$), ozone ($O_3$), and sulfuric acid ($H_2SO_4$) in their atmospheres. While carbon dioxide is present in all three spectra, only our own planet has appreciable oxygen (and hence ozone)—a product of photosynthesis. If we could make similar spectral analyses of distant planets, we might detect atmospheric gases that would indicate life.

# Zona habitável na Galáxia

The highlighted green ring in this painting of the Milky Way Galaxy represents what some scientists suspect to be a galactic habitable zone—the only region of the galaxy in which Earth-like planets are likely to be found. However, other scientists think that Earth-like planets could be far more widespread.

# Talvez existam outras civilizações, mas o contato direto é difícil devido às enormes distâncias



# S E T I

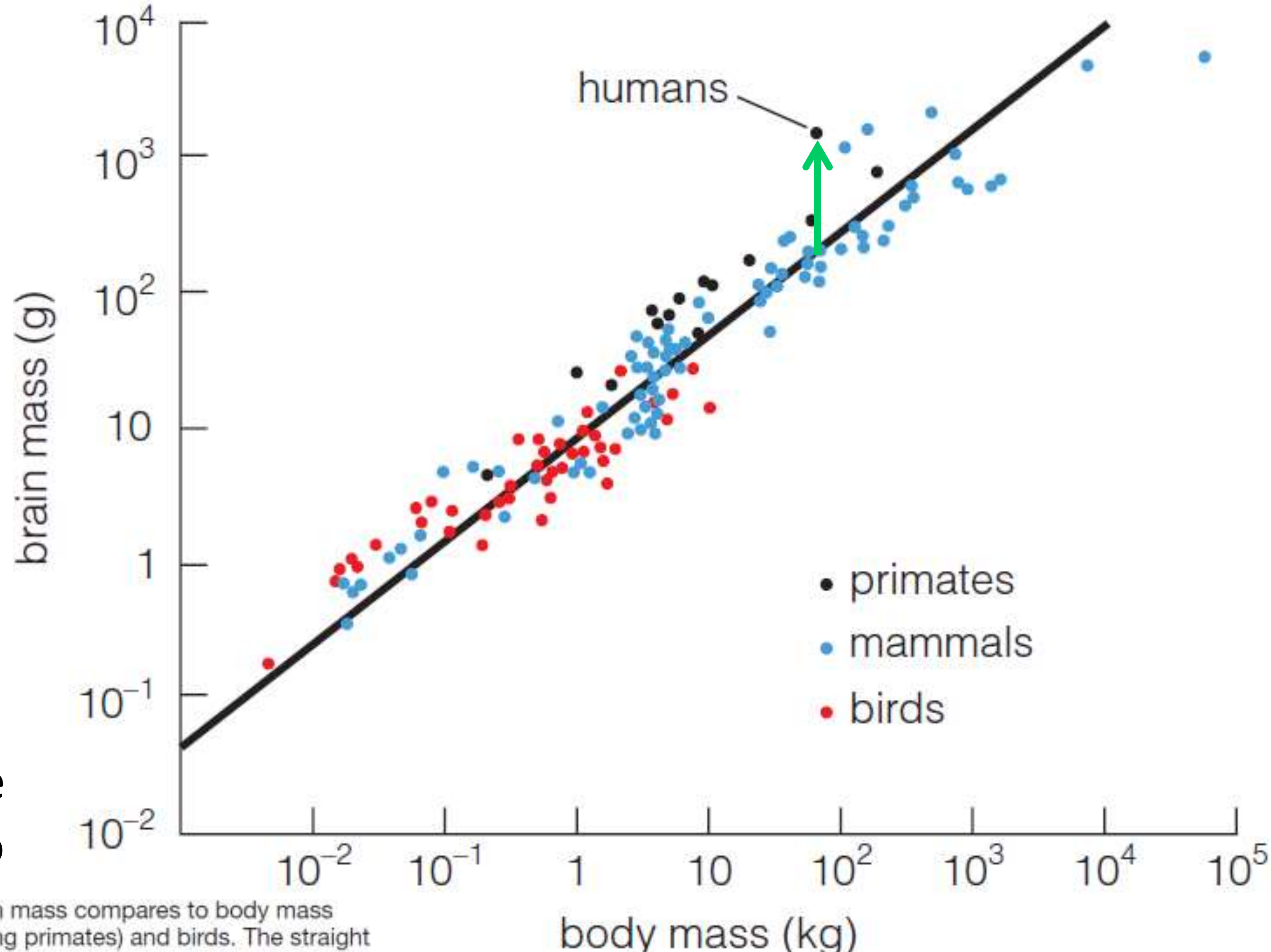
# Search for Extraterrestrial Intelligence

- SETI passivo: detetar sinais (por ex. rádio mensagens) enviadas por outras civilizações

- SETI ativo: enviar mensagens a outras civilizações

- Mas, o SETI faz sentido? existem outras civilizações? Existe inteligência ET?

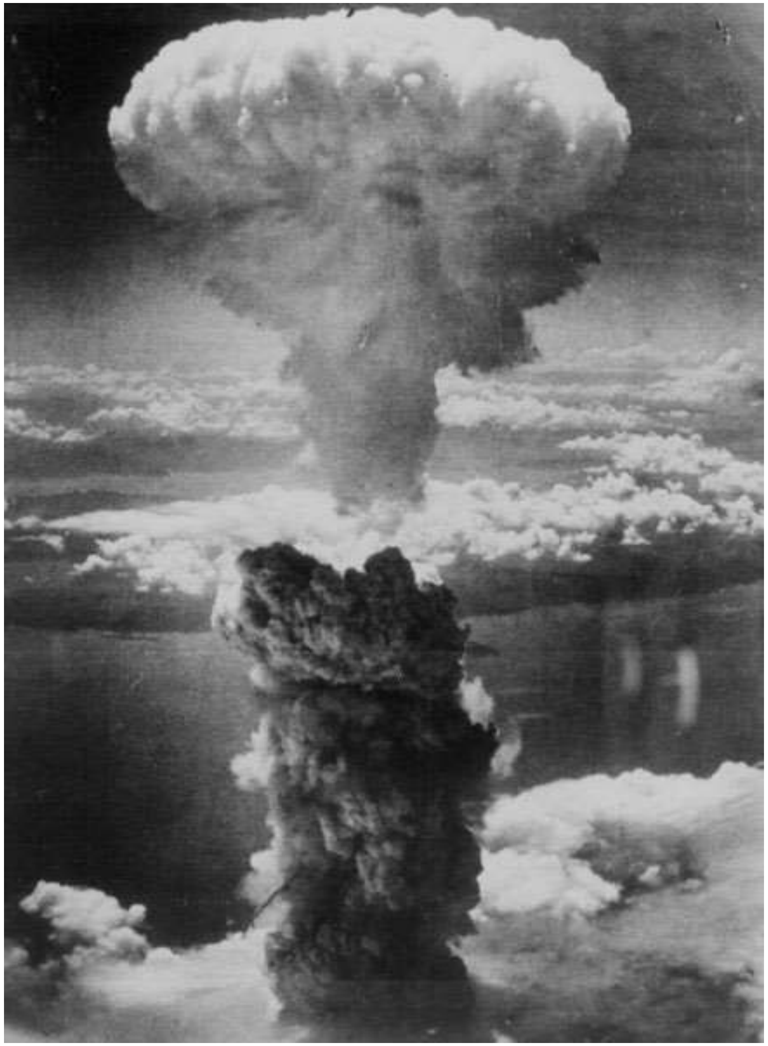
# Inteligência



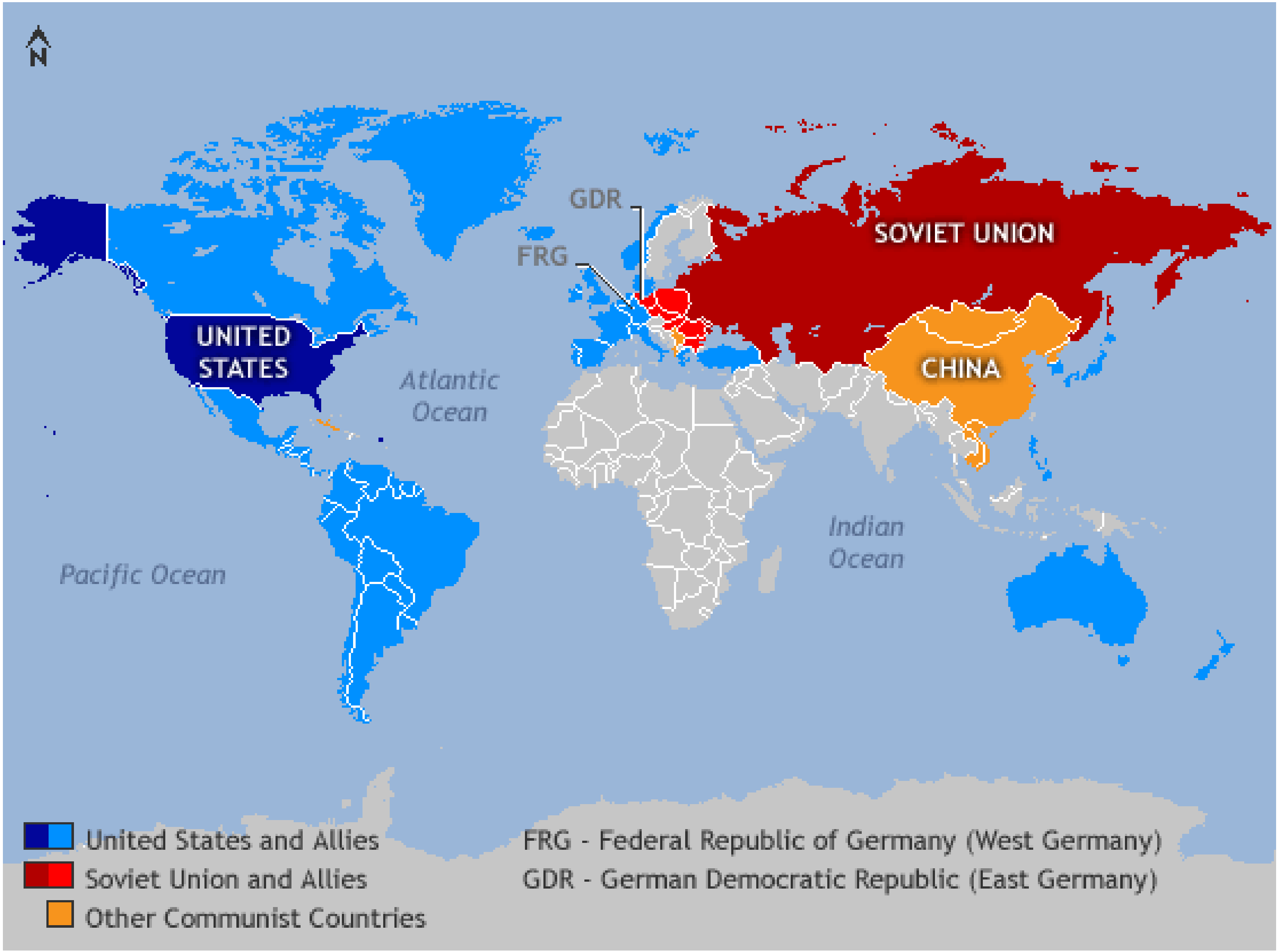

Quociente de encefalização

This graph shows how brain mass compares to body mass for some mammals (including primates) and birds. The straight line represents an average of the ratio of brain mass to body mass, so animals that fall above the line are smarter than average and animals that fall below the line are less smart. Note that the scale uses powers of 10 on both axes. (Data from Harry J. Jerison, 1973.)


# How long can last a civilization?



# Cold war


N
GDR
FRG
SOVIET UNION
UNITED STATES
CHINA
Atlantic Ocean
Indian Ocean
Pacific Ocean
United States and Allies
Soviet Union and Allies
Other Communist Countries
FRG - Federal Republic of Germany (West Germany)
GDR - German Democratic Republic (East Germany)

# Cuban missile crisis

13-day confrontation between the Soviet Union and Cuba on one side, and the U.S.A, in October 1962


USA: It shall be the policy of this nation to regard any nuclear missile launched from Cuba against any nation in the Western Hemisphere as an attack by the Soviet Union on the United States, requiring a full retaliatory response upon the Soviet Union.

To halt this offensive buildup, a strict quarantine on all offensive military equipment under shipment to Cuba is being initiated. All ships of any kind bound for Cuba, from whatever nation or port, will, if found to contain cargoes of offensive weapons, be turned back. This quarantine will be extended, if needed, to other types of cargo and carriers.

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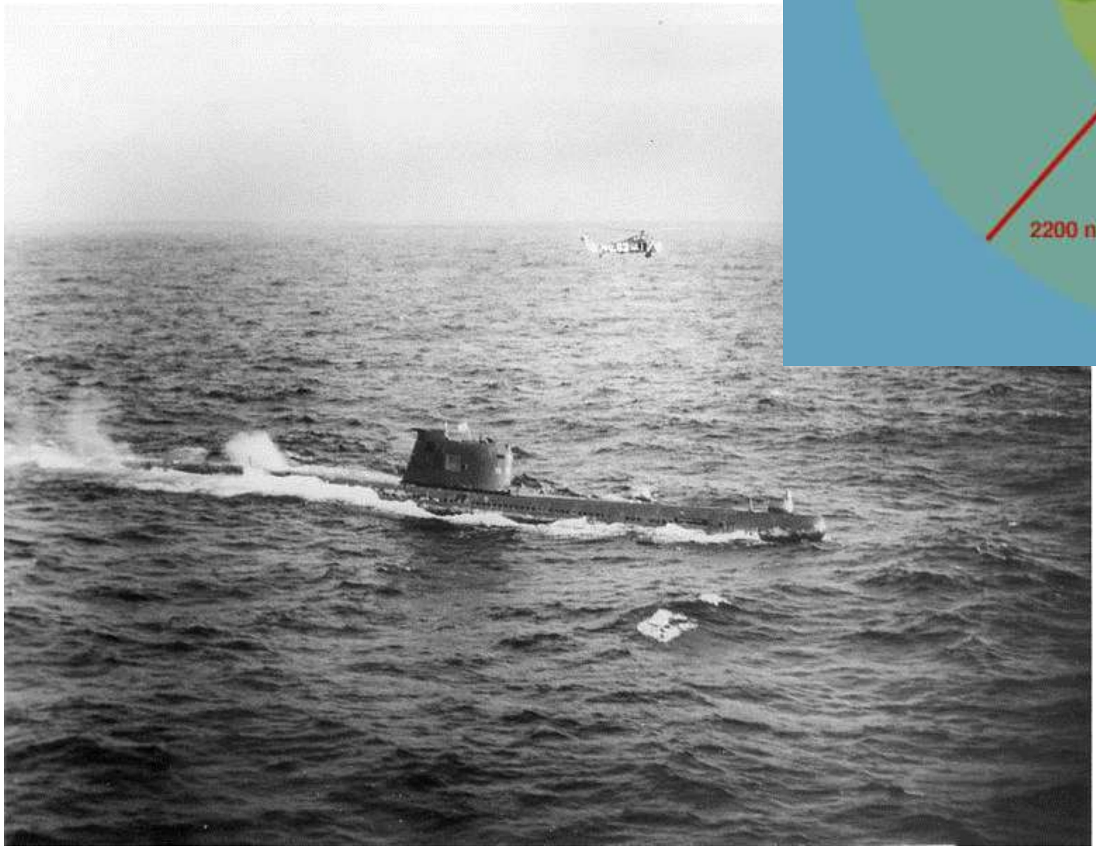


Soviet submarine B-59 (carrying nuclear torpedo), forced to the surface by U.S. Naval forces in the Caribbean near Cuba, October 26, 1962

Vasili Alexandrovich Arkhipov

# Fim da guerra fria


November 1989: queda do muro de Berlim

The USSR was declared officially dissolved on December 25, 1991

1: Russian
2: Ukrainian
3: Belorussian
4: Uzbek
5: Kazakh
6: Georgian
8: Lithuanian
13: Armenian
15: Estonian

# Bio war: germs

- Smallpox (**Varíola)**, entered the Andes in 1524 (trazida pelos espanhois)
- Milhões de nativos morreram

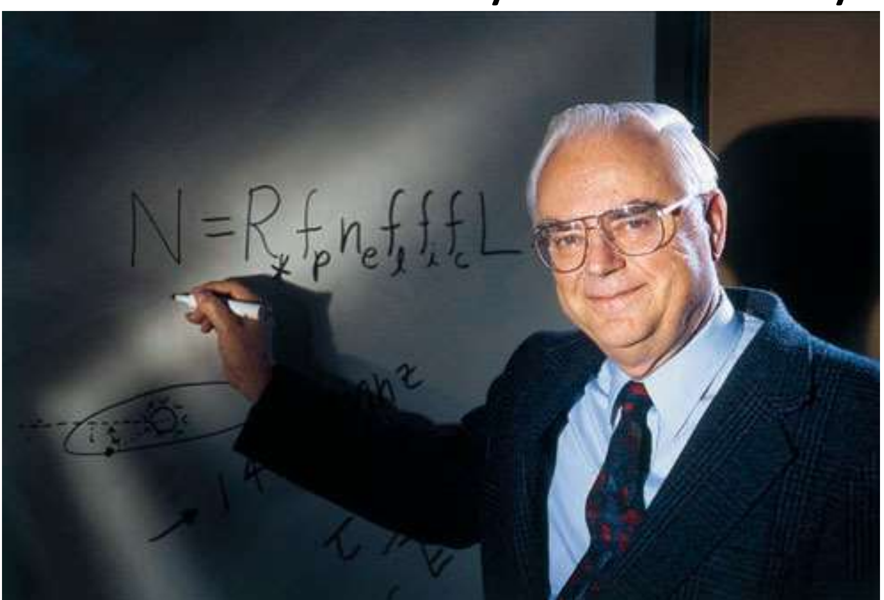


**Huayna Capac** (1464/1468–1525/1527)

# How many civilizations are out there?
# Equação de Drake

$$N_c = N_* \cdot f_P \cdot n_{HZ} \cdot f_L \cdot f_I \cdot f_S$$

***N****** is the number of stars in our galaxy,
$f_P$ represents the fraction of stars that have planets.
$n_{HZ}$ is the average number of planets in each planetary system suitably located in the habitable zone




Astronomer Frank Drake, with the equation he first wrote in 1961.

$f_L$ is the fraction of suitable planets on which life begins
$f_I$ is the fraction of those planets where life evolves to intelligence
$f_S$ is the fraction of a star's life during which an intelligent species is communicative

# How many civilizations are out there? Equação de Drake

$$N_c = N_* \cdot f_P \cdot n_{HZ} \cdot f_L \cdot f_I \cdot f_S$$

| Estim | Variables | Pessimistic | | Optimistic |
|---|---|---|---|---|
| $N_*$ | Number of stars per galaxy | $2 \times 10^{11}$ | | $2 \times 10^{11}$ |
| $f_P$ | Fraction of stars with planets | 0.1 | 0,7 | 0.5 |
| $n_{HZ}$ | Number of planets per star that lie in habitable zone for longer than 4 billion years | 0.01 | 0,2 | 1 |
| $f_L$ | Fraction of suitable planets on which life begins | 0.01 | 0,1 | 1 |
| $f_I$ | Fraction of planets with life where life evolves to intelligence | 0.01 | 0,1 | 1 |
| $f_S$ | Fraction of star's existence during which a technological society survives | $10^{-8}$ | $10^{-6}$ | $10^{-4}$ |
| $N_c$ | Number of communicative civilizations per galaxy | $2 \times 10^{-4}$ | | $1 \times 10^{7}$ |

10 000 anos / 10 bilhões de anos

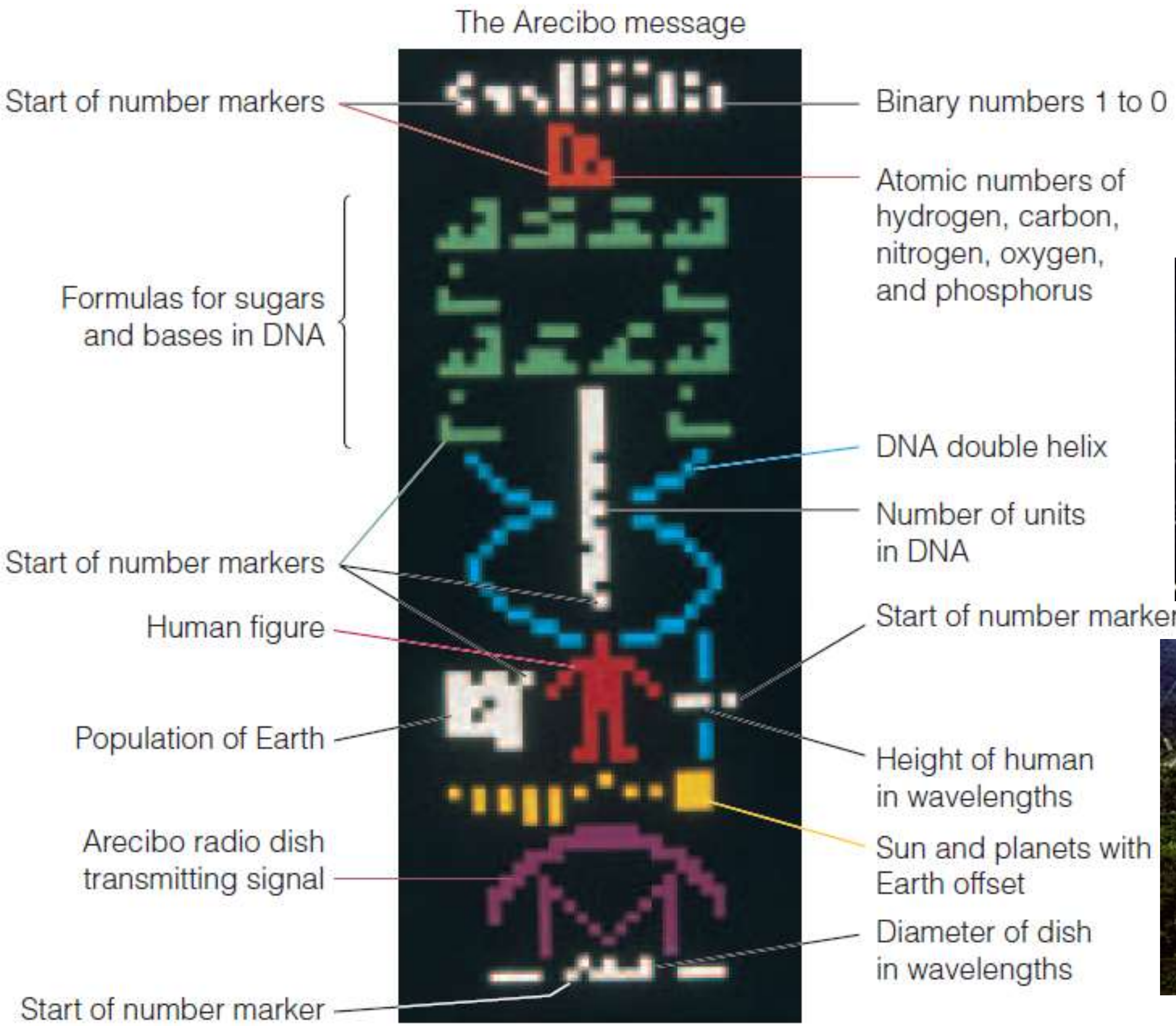
## 280 civilizações?

# Allen telescope array

## Observações astronômicas e busca de inteligência extraterrestre

- 6 m dishes
- Goal: 350 antennas
- Completed: 42 antennas
- wide field of view (2.45° at λ = 21 cm)
- instantaneous frequency coverage from 0.5 to 11.2 GHz

# Active SETI



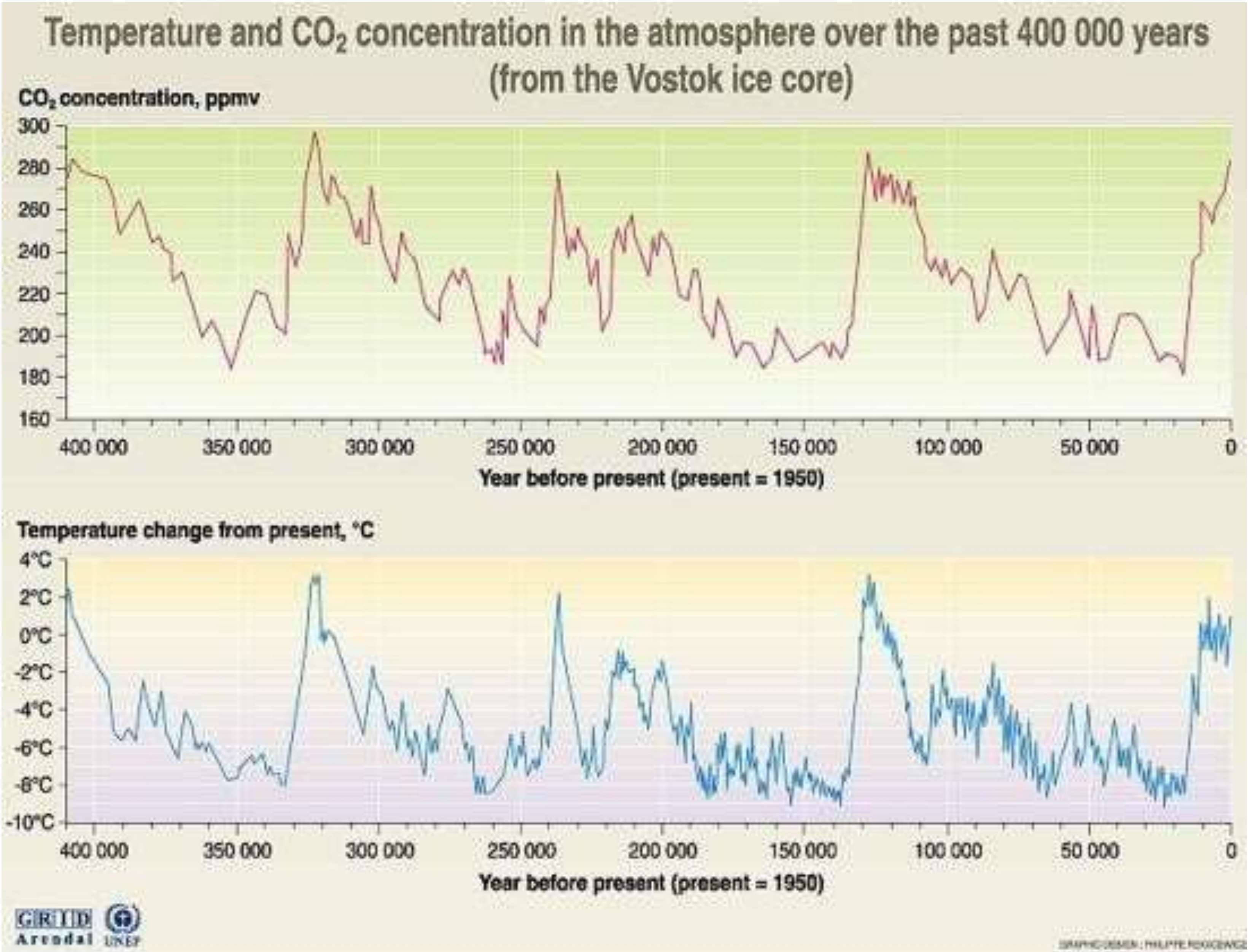

In 1974, a short message was broadcast to the globular cluster M13 using the Arecibo radio telescope.

# O fim da Vida na Terra

# Quando será a próxima idade de gelo?

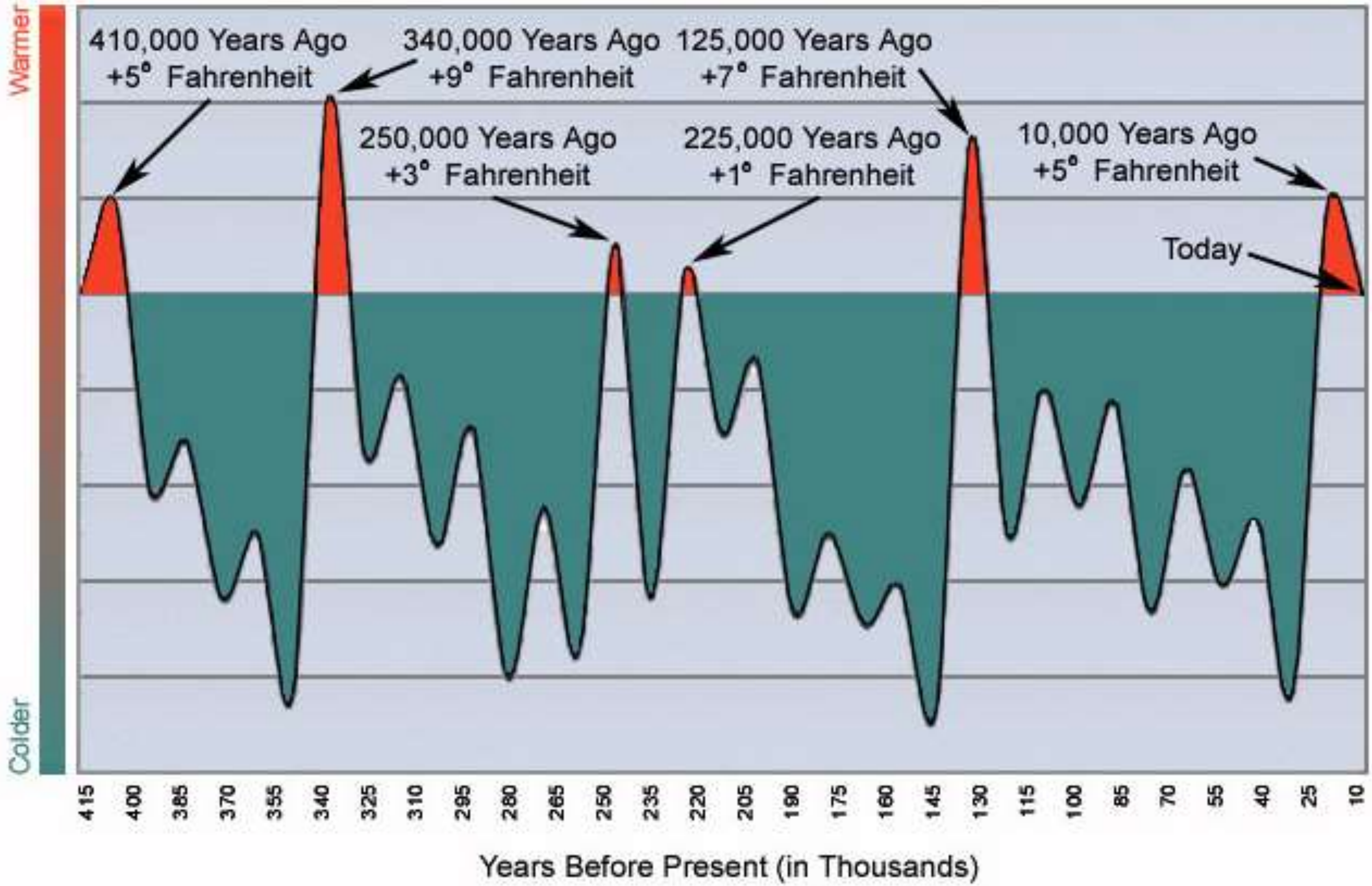
## Evidencias do Lago Vostok

# Are we enjoying a “summer”?

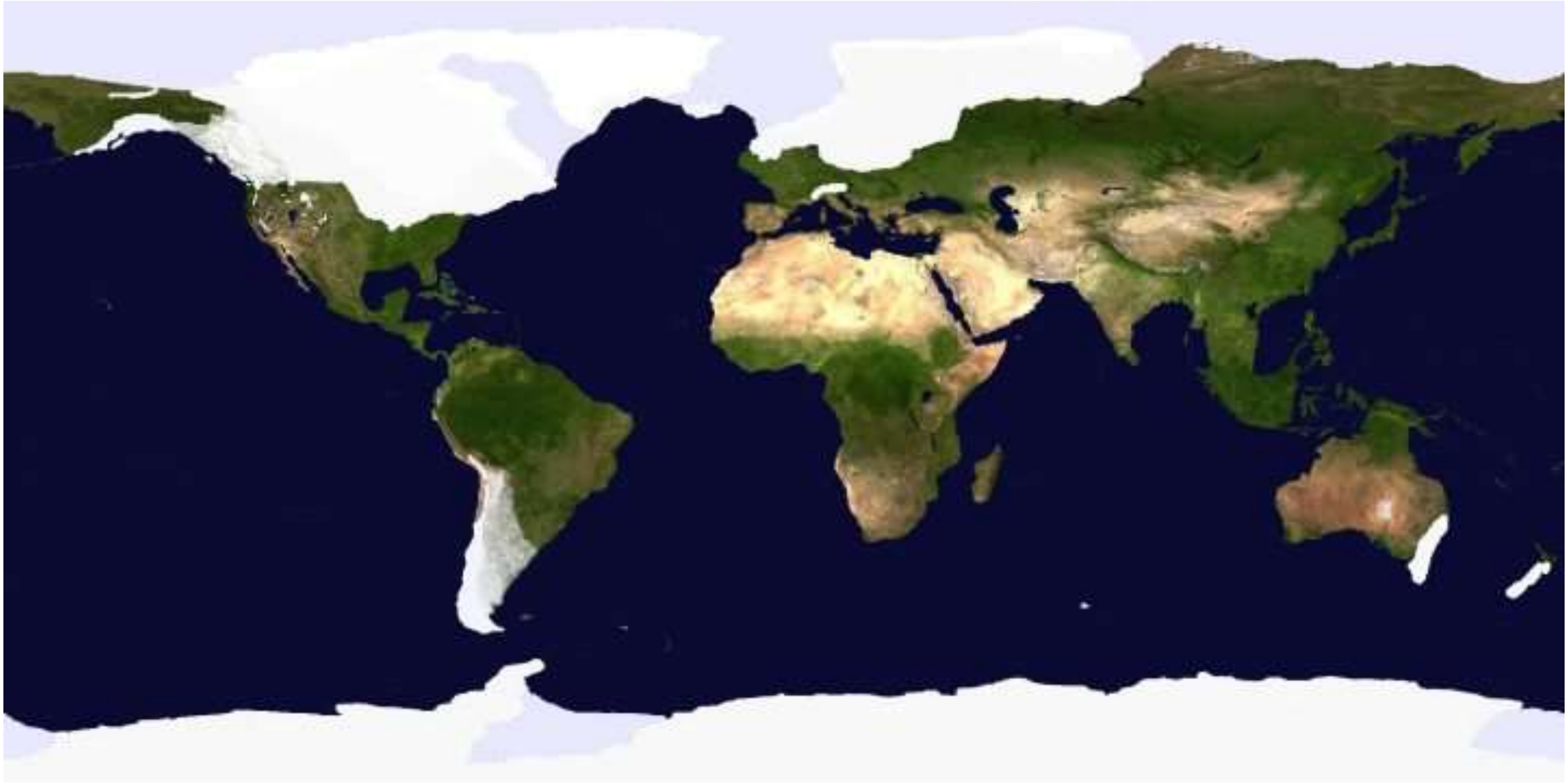



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3June), pp 429-436, 1999.

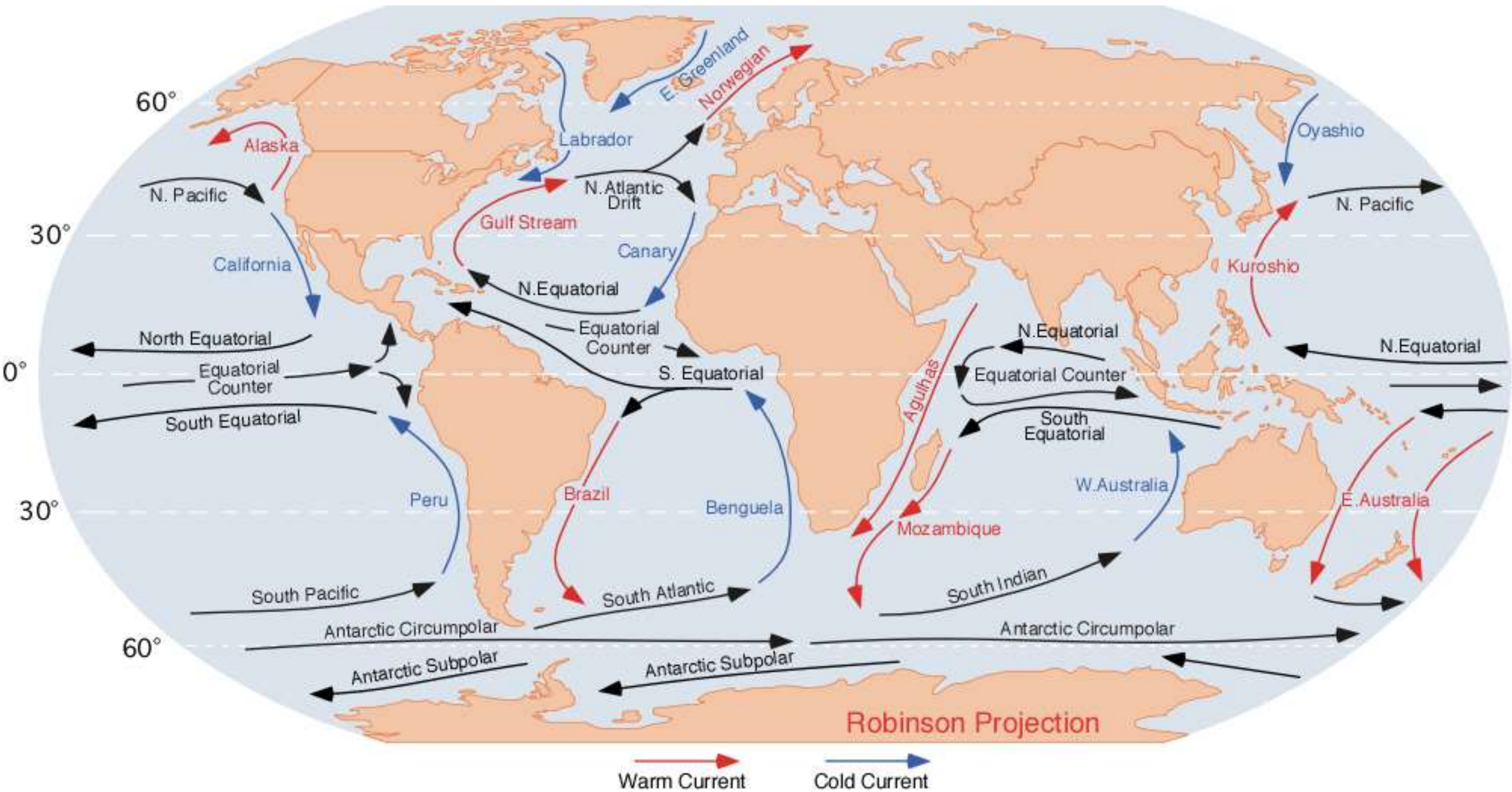
# 415,000 Years of Global Temperature Change



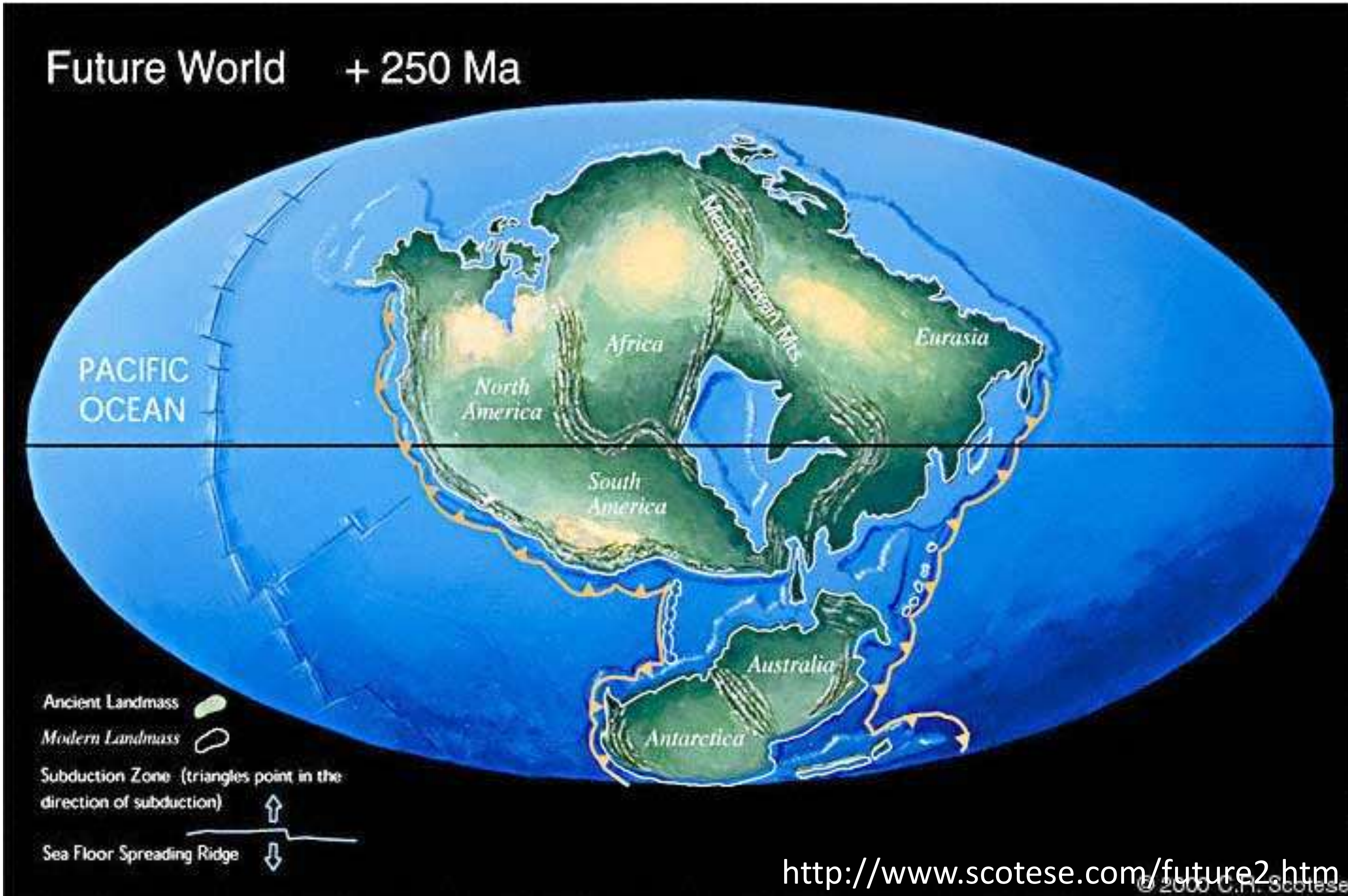
# Ice Age: war?



# Map of Ocean currents

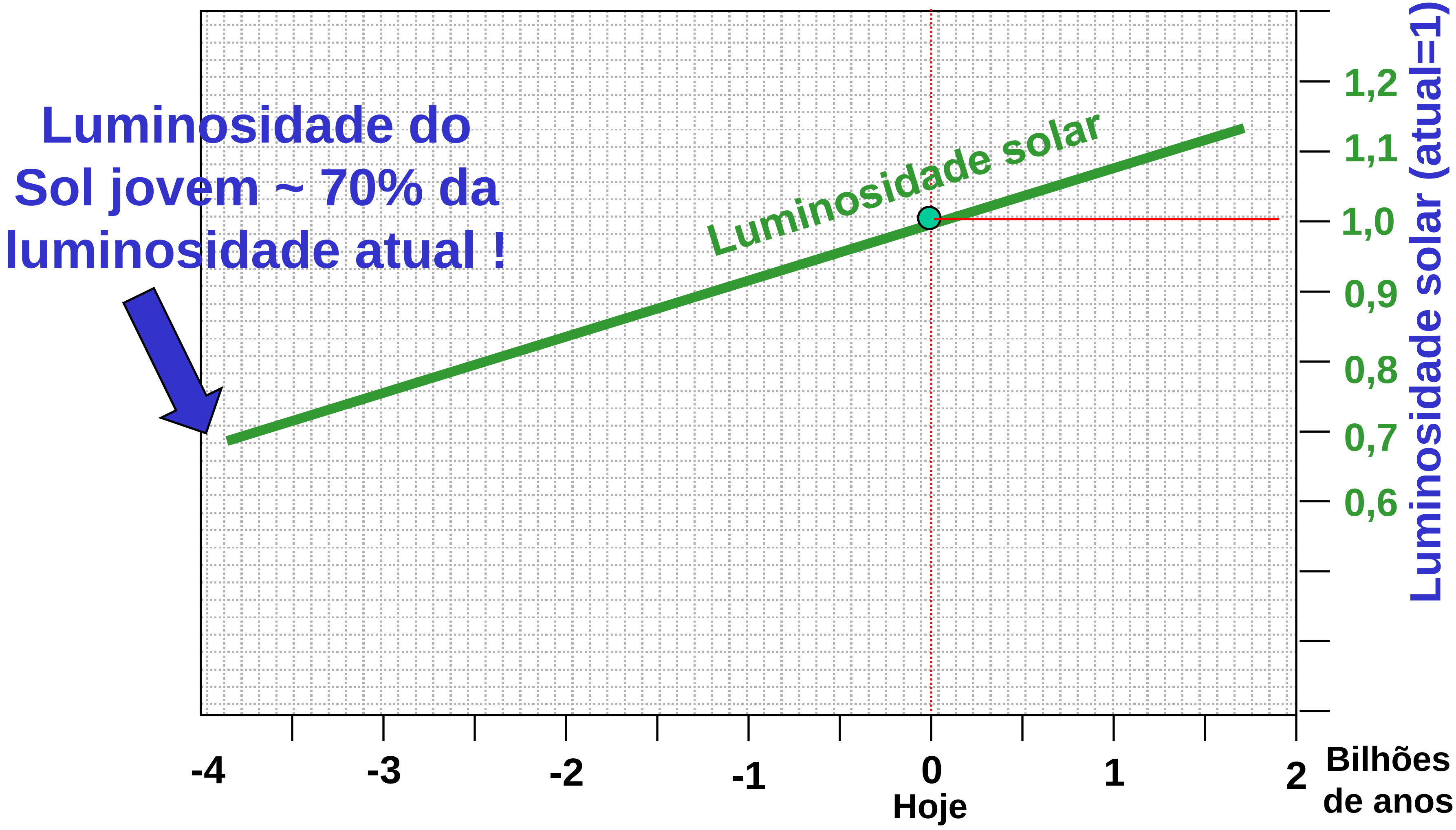


# Mapa da Terra daqui a 250 Milhões de anos




http://www.scotese.com/future2.htm

# Variação da Luminosidade vinda do Sol



# $CO_2$ cycle

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

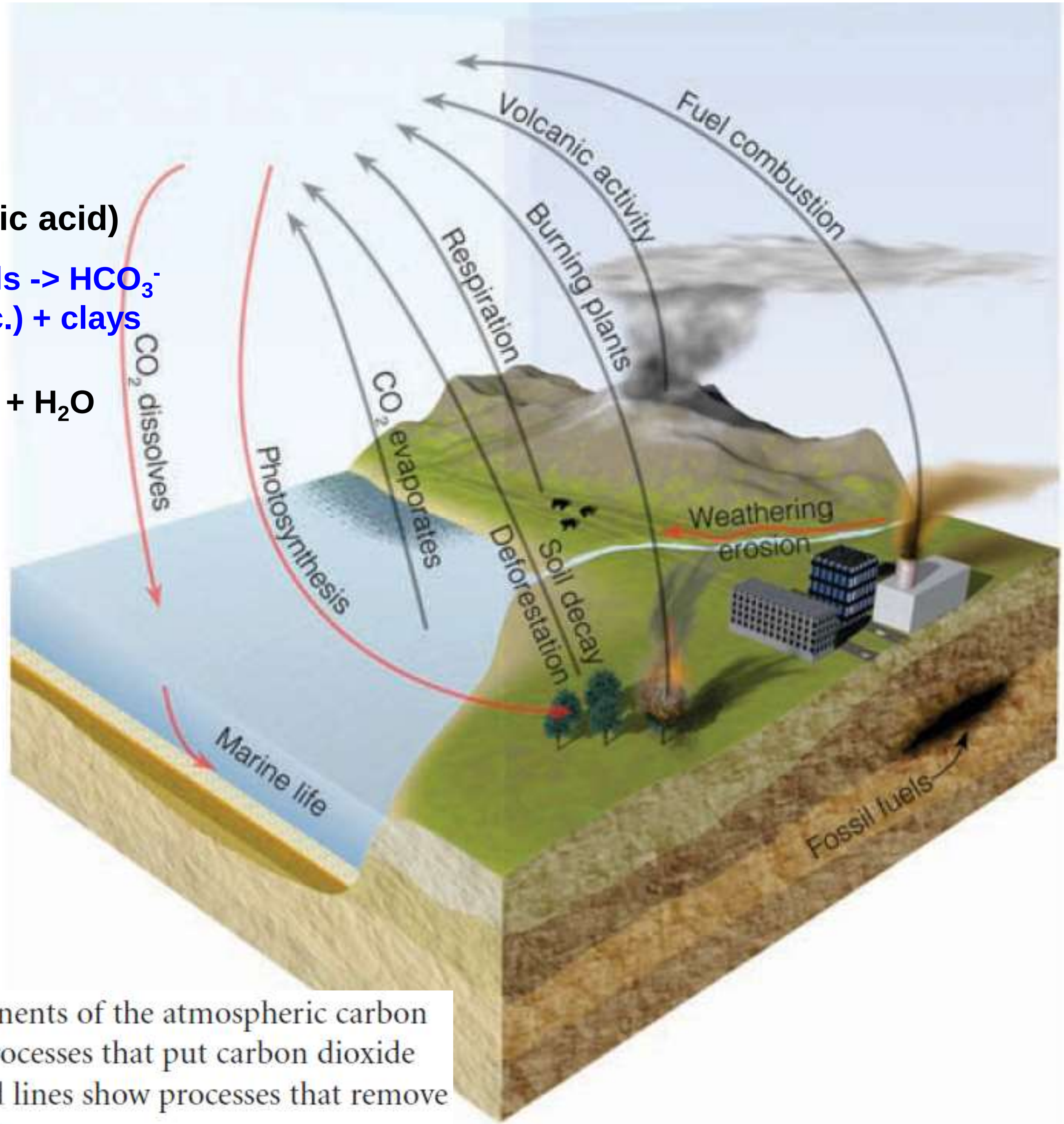
$H_2CO_3 + H_2O$ + silicate minerals $\rightarrow HCO_3^-$ + cations ($Ca^{++}$, $Fe^{++}$, $Na^+$, etc.) + clays

$Ca^{++} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O$

Calcita
e calcáreos

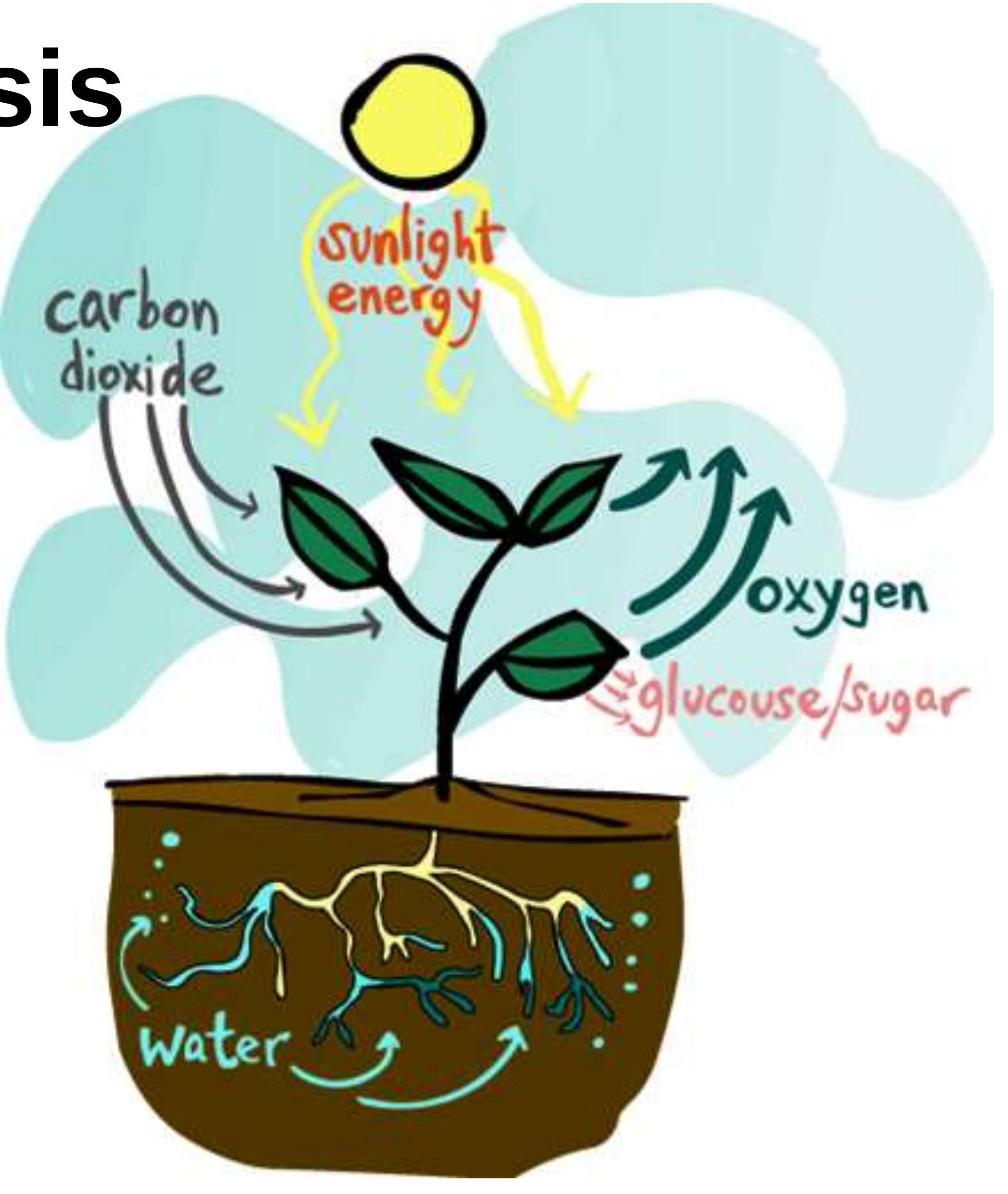
Parte do $CO_2$ é retornado:

$CaCO_3 + SiO_2 \rightarrow CO_2 + CaSiO_3$




● FIGURE 1.4 The main components of the atmospheric carbon dioxide cycle. The gray lines show processes that put carbon dioxide into the atmosphere, whereas the red lines show processes that remove carbon dioxide from the atmosphere.

# Photosynthesis



# Influencia de evolução do Sol na vida na Terra

## temos só 1500 milhões de anos?

LETTERS TO NATURE

Biogeosciences Discussions, 2, 1665–1679, 2005
www.biogeosciences.net/bgd/2/1665/
SRef-ID: 1810-6285/bgd/2005-2-1665
European Geosciences Union

Biogeosciences Discussions

# Causes and timing of future biosphere extinction

S. Franck, C. Bounama, and W. von Bloh

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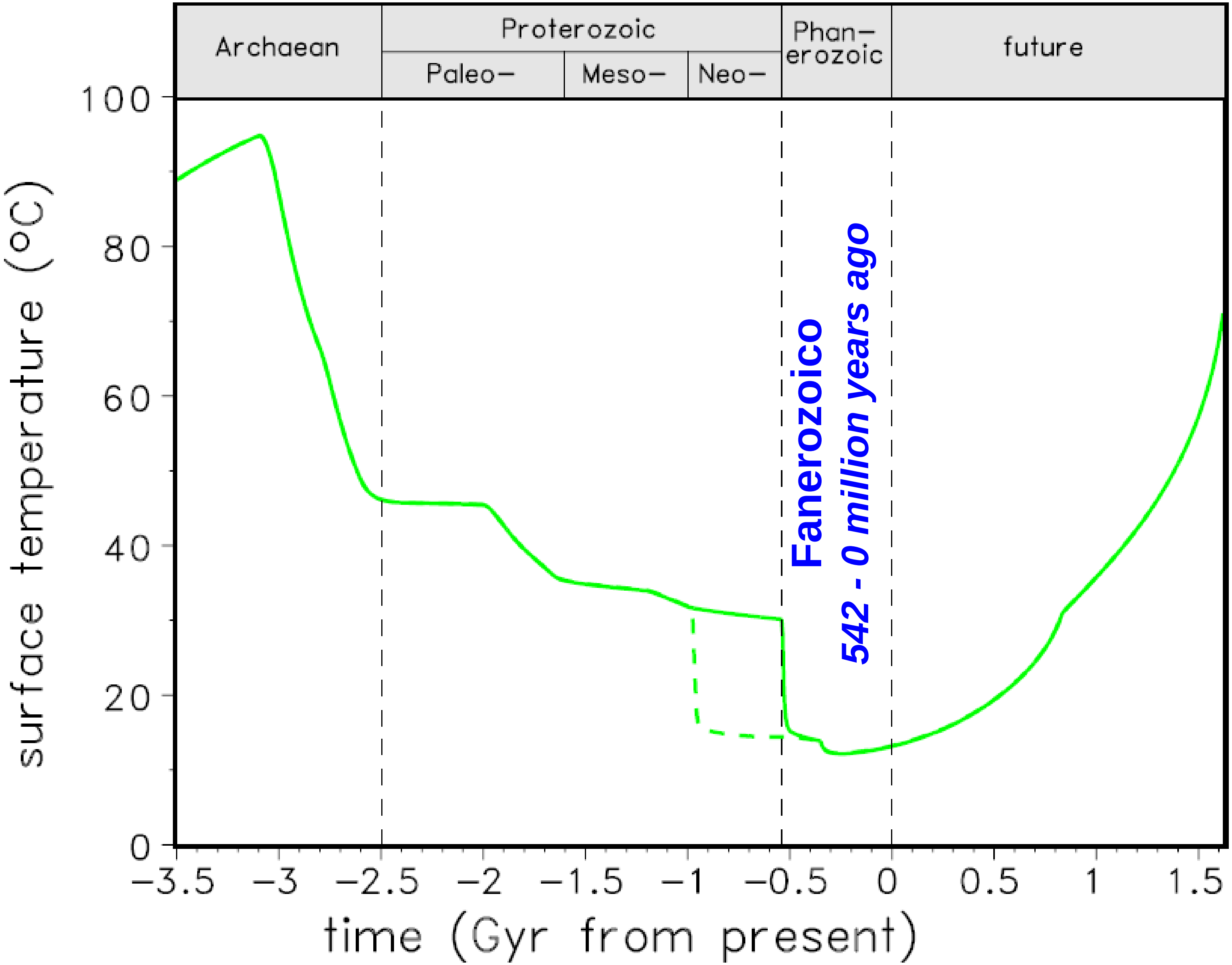
Potsdam Institute for Climate Impact Research, Potsdam, Germany

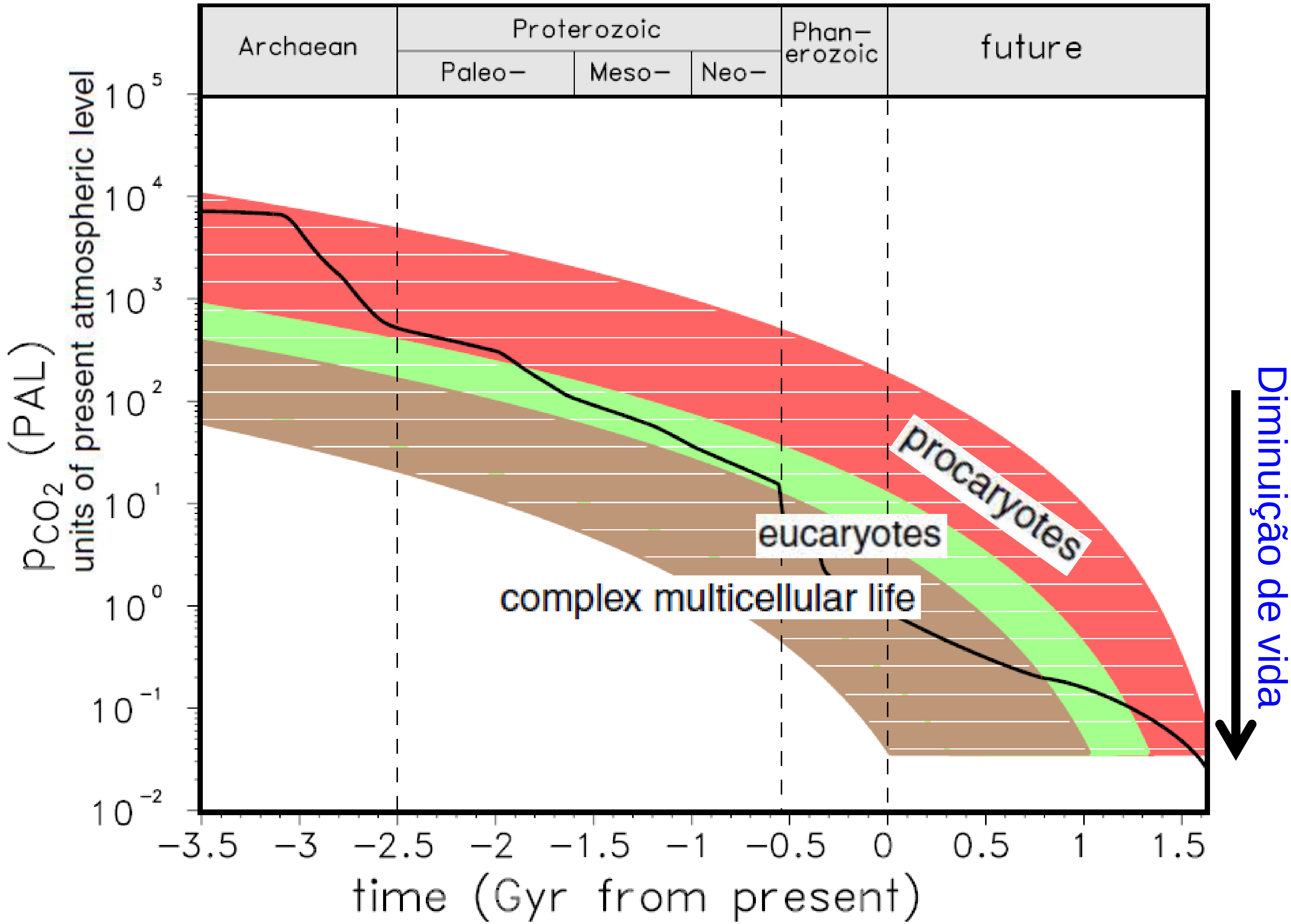
We present a minimal model for the global carbon cycle of the Earth containing the reservoirs mantle, ocean floor, continental crust, biosphere, and the kerogen, as well as the aggregated reservoir ocean and atmosphere. The model is specified by introducing three different types of biosphere: procaryotes, eucaryotes, and complex multicellular life. We find that from the Archaean to the future a procaryotic biosphere always exists. 2 Gyr ago eucaryotic life first appears. The emergence of complex multicellular life is connected with an explosive increase in biomass and a strong decrease in Cambrian global surface temperature at about 0.54 Gyr ago. In the long-term future the three types of biosphere will die out in reverse sequence of their appearance. We show that there is no evidence for an implosion-like extinction in contrast to the Cambrian explosion. The ultimate life span of the biosphere is defined by the extinction of procaryotes in about 1.6 Gyr.

# Earth surface temperature



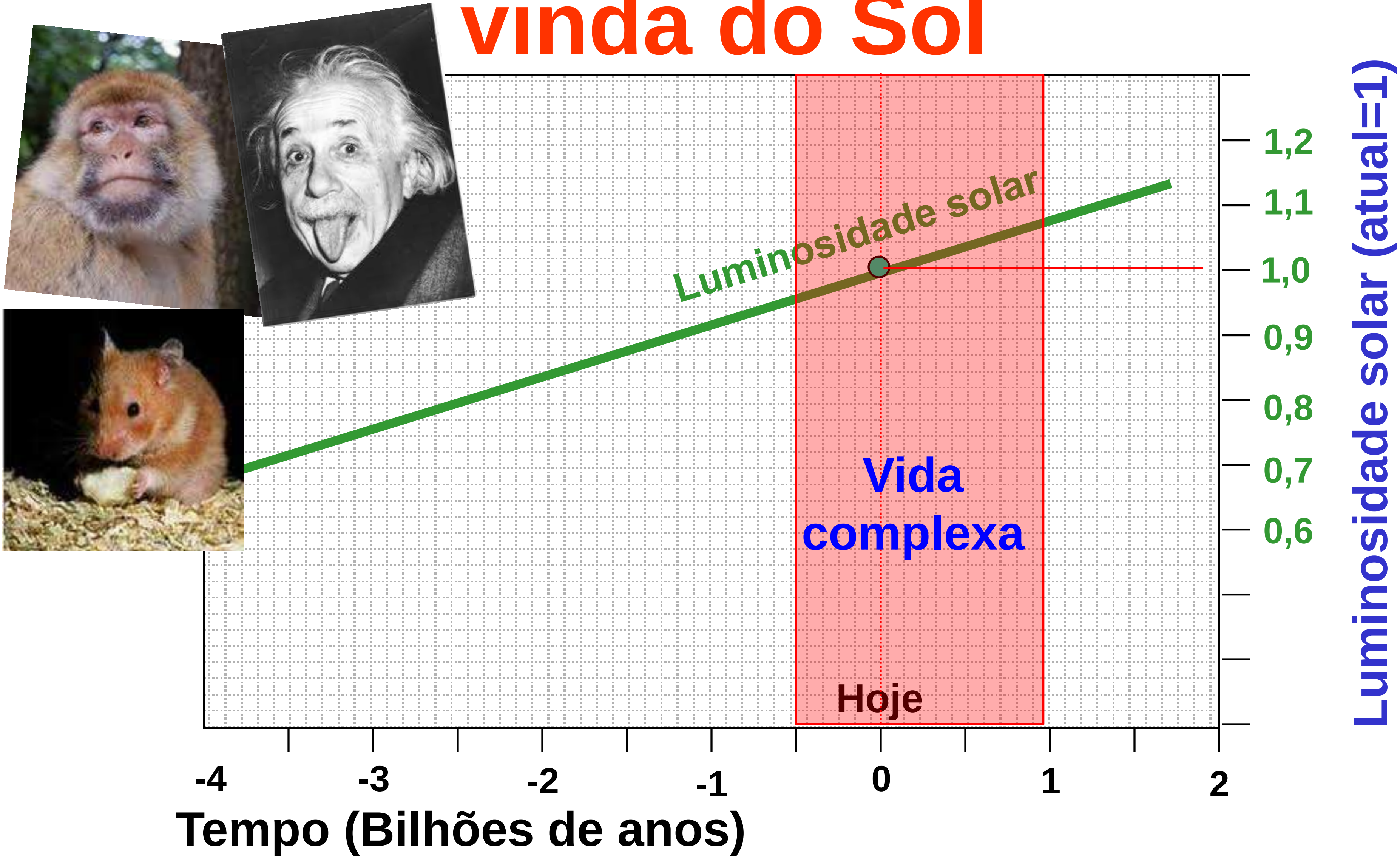

S. Franck, C. Bounama, and W. von Bloh

# The evolution of atmospheric $CO_2$ concentration




S. Franck, C. Bounama, and W. von Bloh

# Variação da Luminosidade vinda do Sol



# Fim dos oceanos (começa daqui a 1 bilhão de anos)

Fim dos oceanos será em aprox. 1,5 – 3 bilhões de anos

Fim dos oceanos será em aprox. 1,5 – 3 bilhões de anos

# Em ~ 5 bilhões de anos o Sol será uma gigante vermelha: fim da Terra