Ação humana na Terra e além

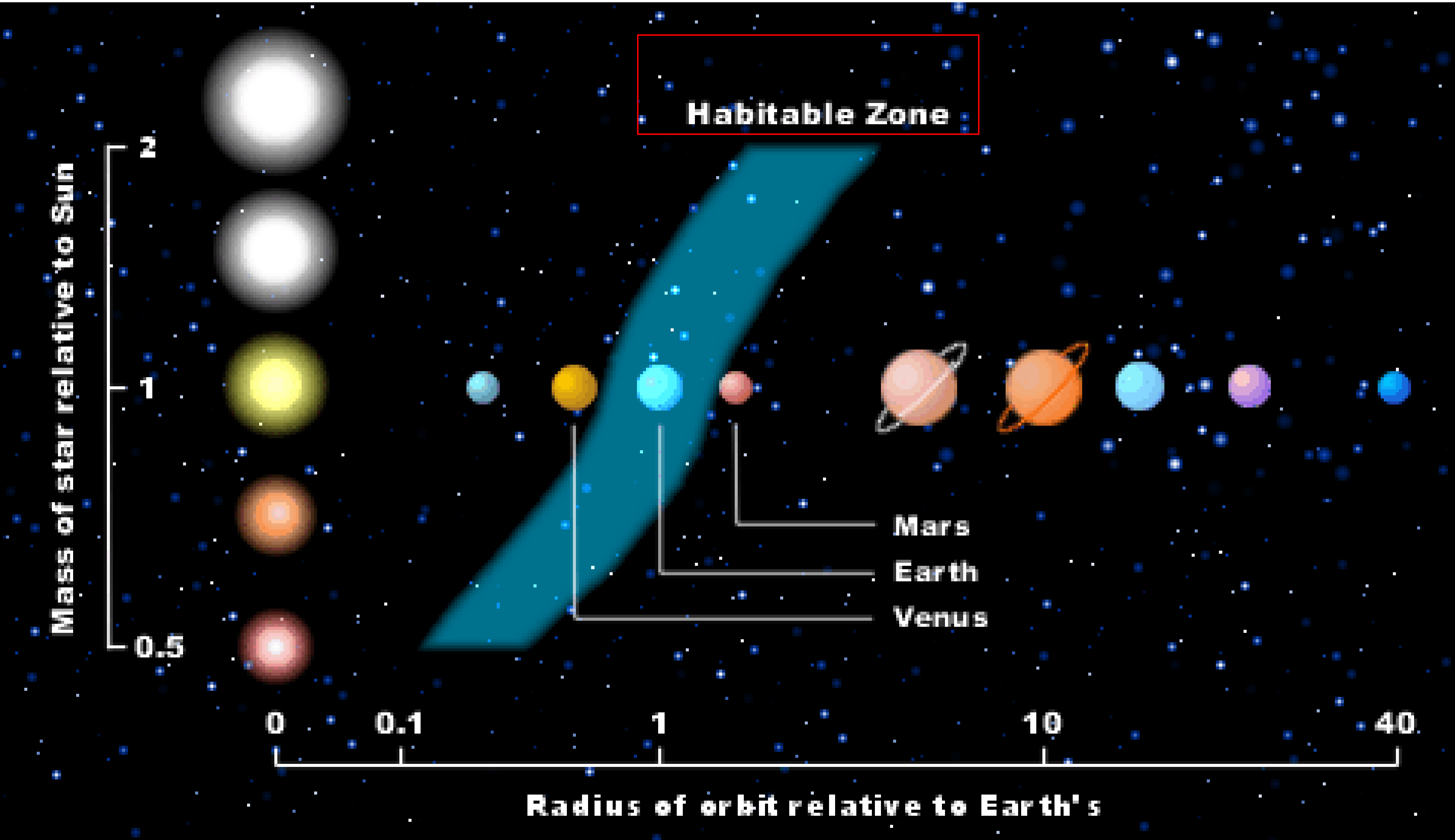
Eixos de pesquisa astrobiológica

- História da complexidade cósmica
- Universo molecular
- Habitabilidade
- Sistema Solar
- Exoplanetas
- Extremófilos
- Origens da vida
- Bioassinaturas
- Evolução das biosferas
- Ação humana na Terra e além

Habitabilidade

Stellar habitable zone

Main assumptions: Surface H_2O for ~ Gyear, geological activity, CO_2-H_2O-N_2 atmosphere, B-field, climate stability, resistance to catastrophes for ~ Gyear



Annu. Rev. Astron. Astrophys. 1994. 32: 83–114

THE GOLDILOCKS PROBLEM: Climatic Evolution and Long-Term Habitability of Terrestrial Planets

Michael R. Rampino

Department of Earth System Science, New York University, New York, New York 10003

Ken Caldeira

Global Climate Research Division, Lawrence Livermore National Laboratory, Livermore, California 94551

KEY WORDS: atmospheric evolution, greenhouse effect, Mars, Venus

INTRODUCTION

Why is Venus too hot, Mars too cold, and Earth "just right" for life? (The allusion to the fairy tale involves the three bowls of porridge belonging to Papa Bear, Mama Bear, and Baby Bear—one too hot, one too cold, and one just right—tested by a hungry Goldilocks.) A simplistic answer might be that a planet's surface temperature is to a large extent a function of its distance from the Sun, and Earth just happens to be at the "right" distance for comfortable temperatures and liquid water. However, this is far from the whole story.

The Goldilocks Problem involves the early history of the planets and the evolution of their atmospheres. Its solution must also take into consideration the long-term evolution of the Sun, and hence the so-called faint young Sun problem, that is, the fact that the early Earth was apparently warm enough for liquid water despite the 25–30% lower luminosity of the early Sun (Newman & Rood 1977; Gough 1981). Had Earth been too cold initially for liquid water to exist on its surface, the resulting icy planet would have had a high albedo or reflectivity, lowering temperatures further, and might have become irreversibly ice-covered—the "white Earth catastrophe" (Caldeira & Kasting 1992a). Yet evidence exists that liquid water has been abundant on Earth for at least the last 3.8 billion years.

The white Earth catastrophe might be averted through geologic activity that provides continued outgassing of CO_2, thereby warming the planet, and eventually melting the ice. But could too much CO_2 produce surface conditions too hot for liquid water, arresting the rock weathering reactions that act to remove CO_2 from the atmosphere, and creating a dense, hot CO_2-rich atmosphere, such as present on Venus today?

Many scientists have stressed the importance of the origin and evolution of life on Earth in biogeochemical cycling of carbon and in causing important changes in atmospheric composition over the last 4 billion years. Proponents of the Gaia hypothesis (Lovelock & Margulis 1974; Lovelock 1979, 1989) go further in claiming that life itself has managed to maintain surface conditions on Earth within a fairly narrow window through a series of negative feedbacks involving greenhouse gases, cloud albedo, and other factors.

Razões para a habitabilidade da Terra

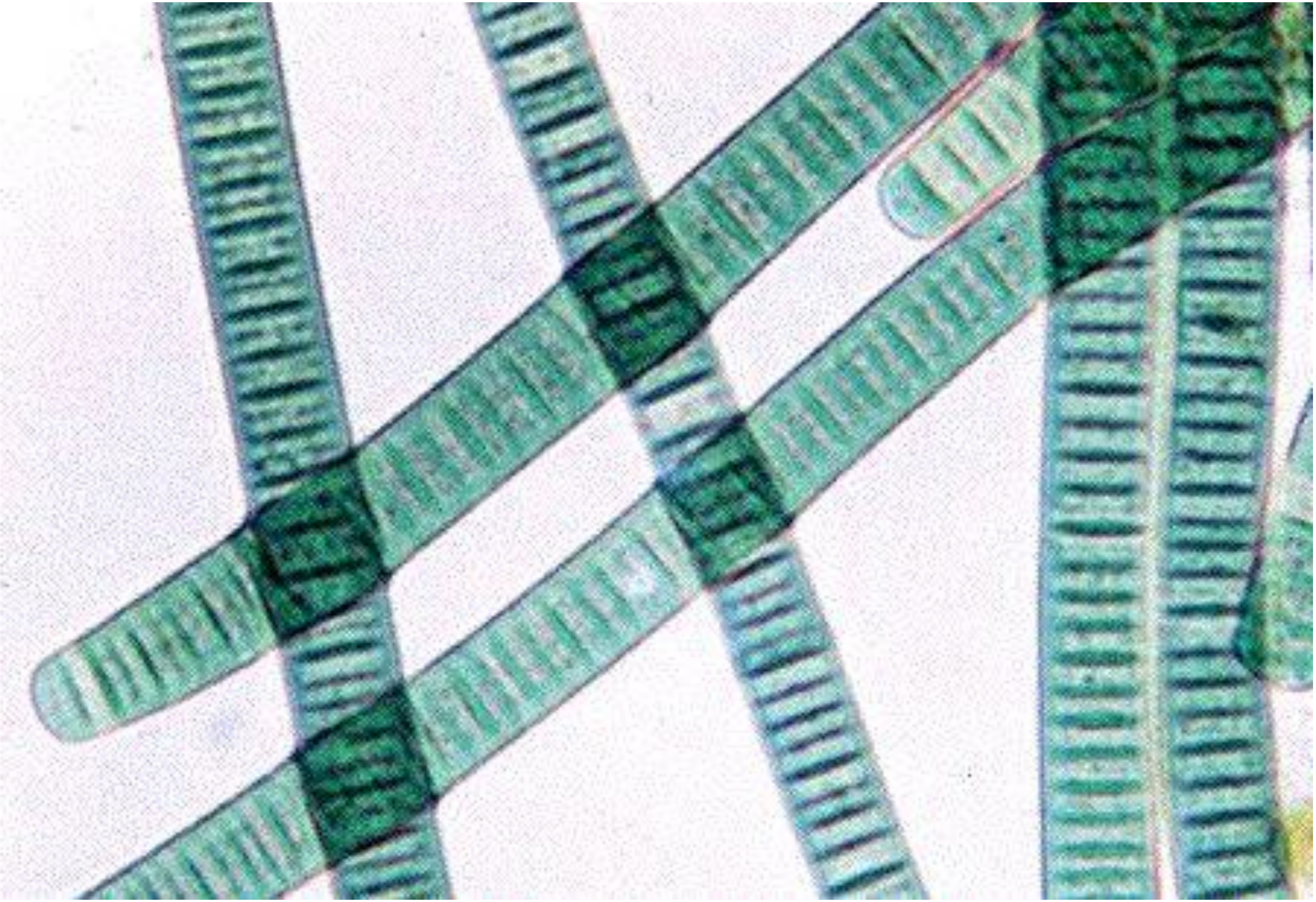
1) Sistema solar com órbitas estáveis e quase circulares
2) Júpiter absorve cometas, minimizando “killing events”
3) A Lua evita o caos do eixo de rotação da Terra
4) A tectônica de placas recicla o CO_2 necessário para a vida
5) A magnetosfera terrestre protege contra o vento solar
6) A heliosfera protege 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

Ação humana
na Terra e além

Ação Humana na Terra e além

Antropoceno
Poluição e Contaminação extraterrestes
Geoengenharia
Terraformação
Astroengenharia (Macroengenharia)

Os Dois Grandes Atores: I- Cianobactérias



Os Dois Grandes Atores: II- Homo Sapiens

A Grande Muralha

Geology of mankind

Paul J. Crutzen

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

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.

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.

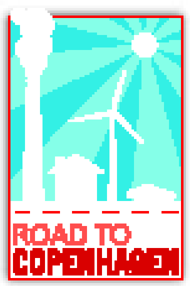
I have changed a lot, but so has much on planet Earth. Human population has increased three-fold during my lifetime, reaching about six thousand million, with the largest rise, 1.8% per year, after the 2nd World War. As shown in the partial listing of Table 1, many human activities impact on earth's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



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

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

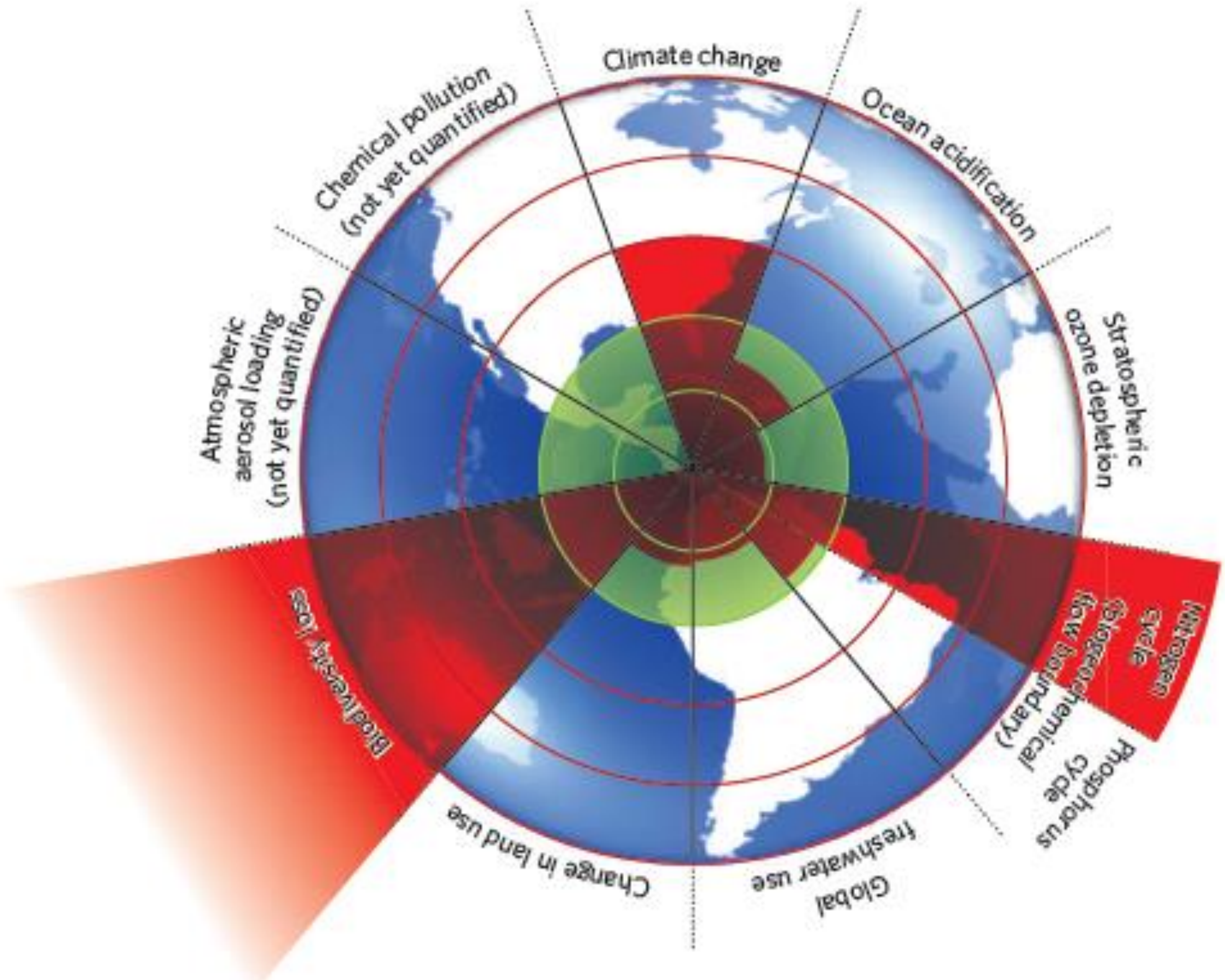


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference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

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atmosphere, on a regional basis		To be determined	
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of Earth system thereof		To be determined	

Boundaries for processes in red have been crossed. Data sources: ref. 10 and supplementary information

Teoria de Gaia

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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.

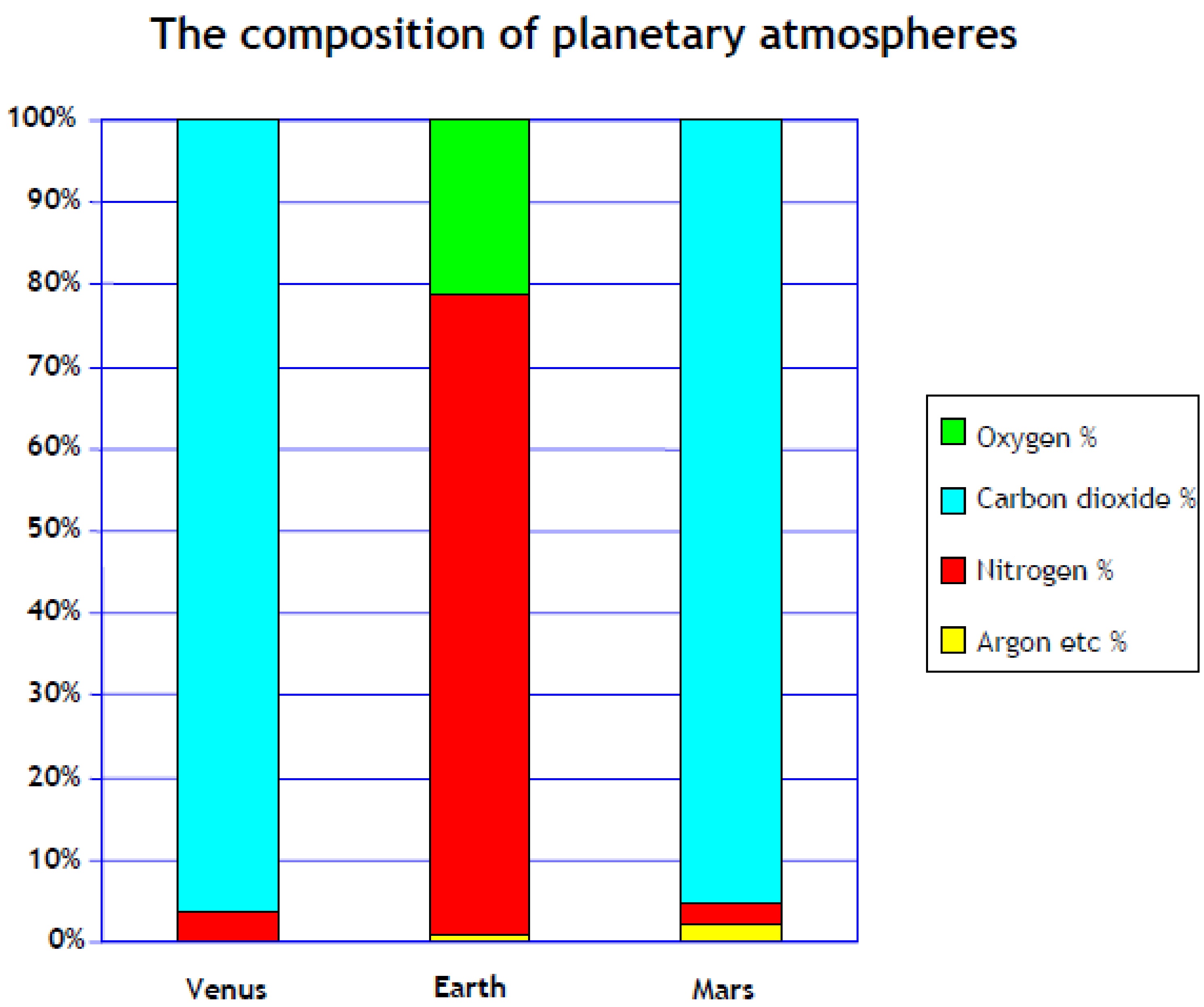
Introduction

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
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Venus
Earth
Mars
Oxygen %
Carbon dioxide %
Nitrogen %
Argon etc %

James Lovelock

Nature, 426, 770-771 (2003)

Gaia

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

The living Earth

Gaia

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

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.

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.

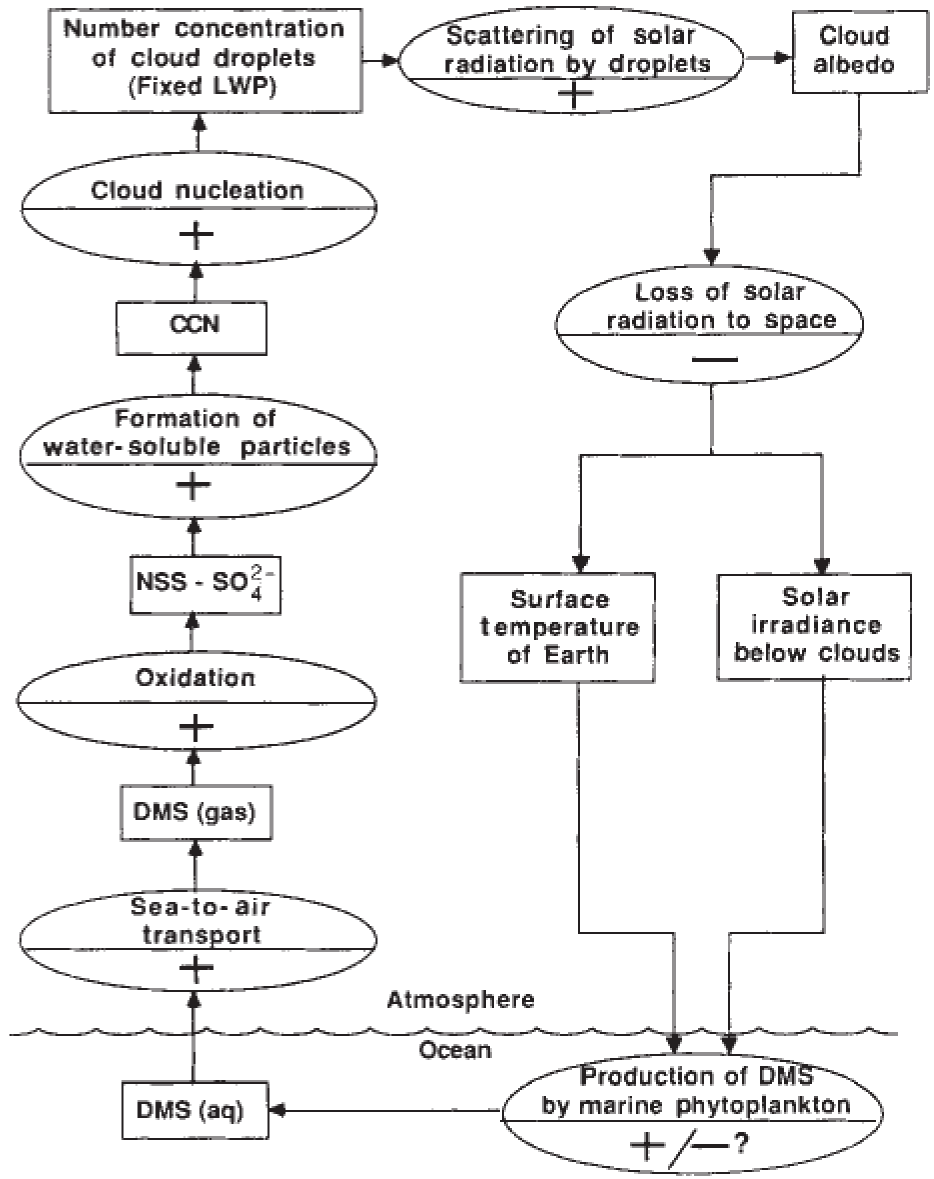
By the end of the 1980s there was sufficient evidence, models and mechanisms, to justify a provisional Gaia theory. Briefly, it states that organisms and their material environment evolve as a single coupled system, from which emerges the sustained self-regulation of climate and chemistry at a habitable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

NASA/BETTMANN/CORBIS

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

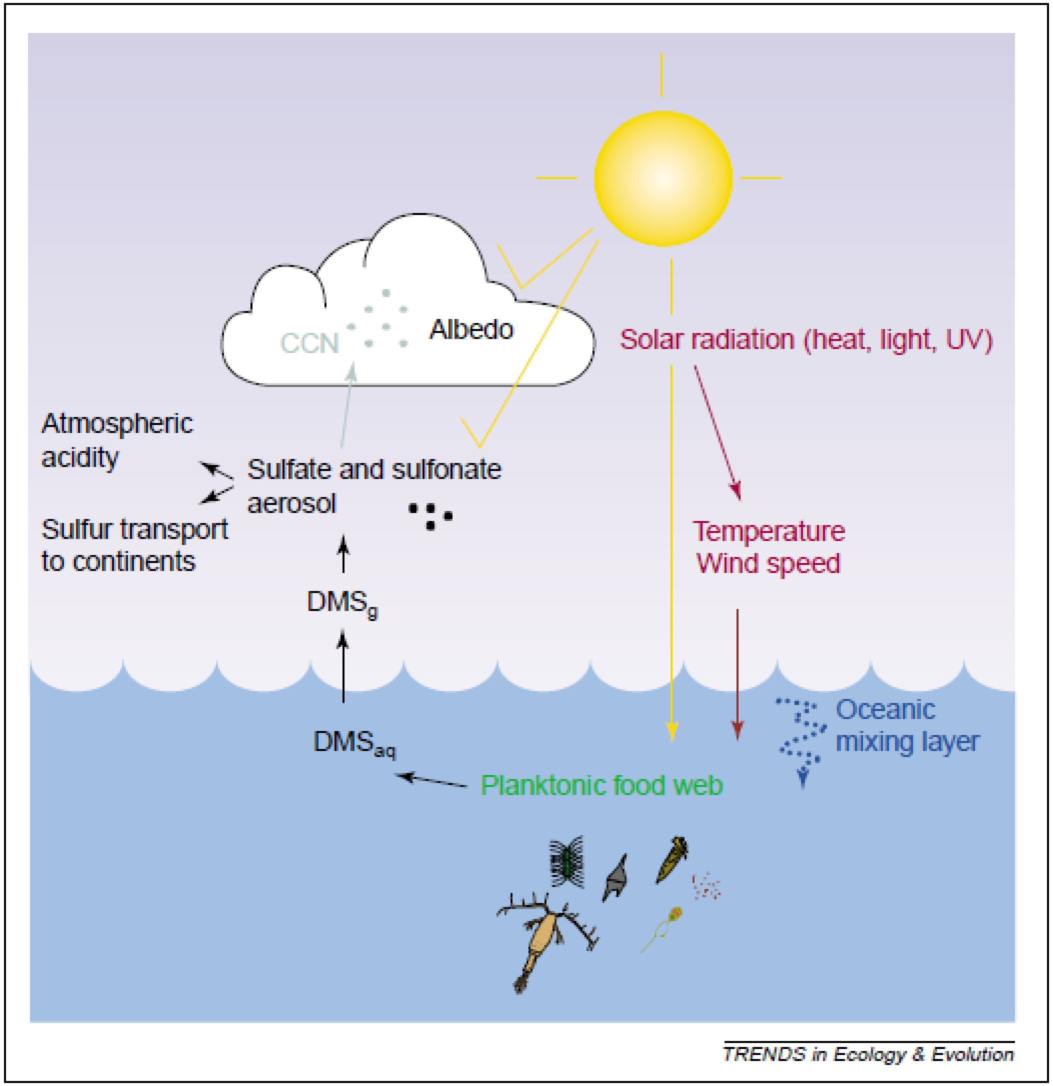
CLAW



NATURE VOL. 326 16 APRIL 1987

Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate

Robert J. Charlson*, James E. Lovelock†, Meinrat O. Andreae‡ & Stephen G. Warren*

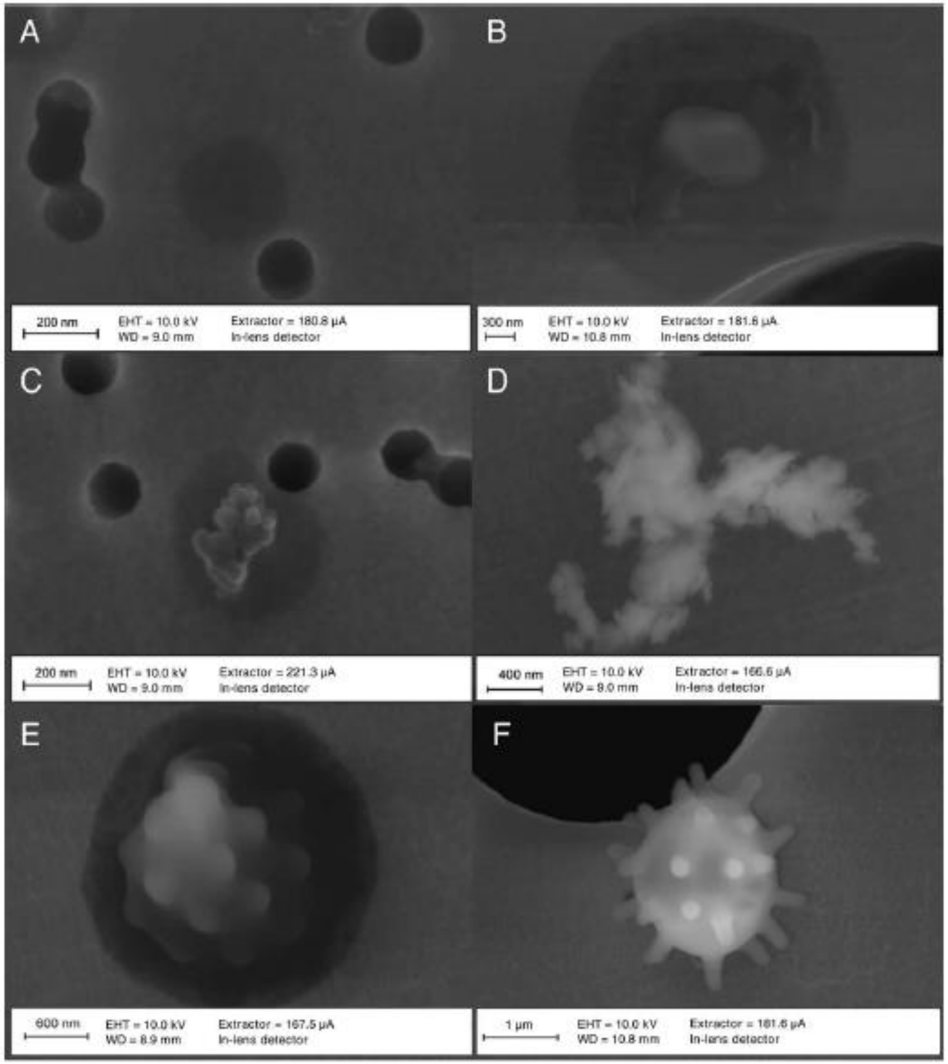

Albedo
CCN
Solar radiation (heat, light, UV)
Atmospheric acidity
Sulfate and sulfonate aerosol
Sulfur transport to continents
Temperature
Wind speed
DMS_g
DMS_{aq}
Oceanic mixing layer
Planktonic food web
TRENDS in Ecology & Evolution

Rainforest Aerosols as Biogenic Nuclei of Clouds and Precipitation in the Amazon

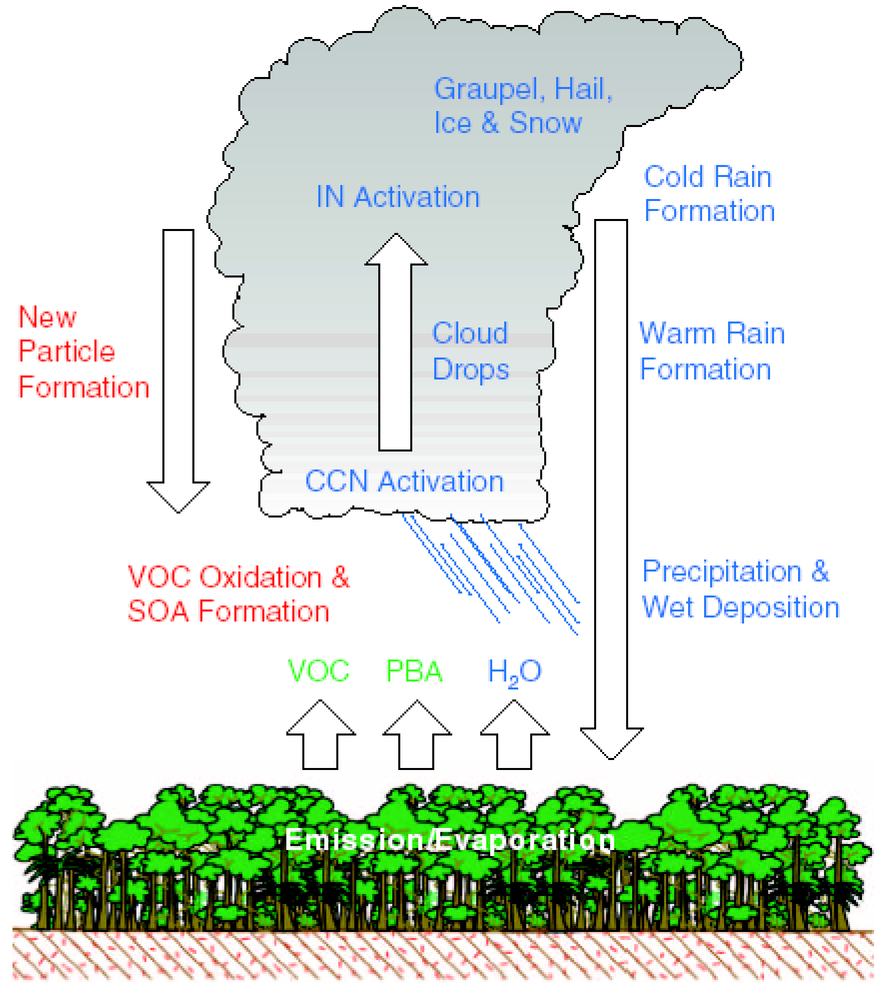
U. Pöschl,[1*] S. T. Martin,[2*] B. Sinha,[1] Q. Chen,[2] S. S. Gunthe,[1] J. A. Huffman,[1] S. Borrmann,[1] D. K. Farmer,[3] R. M. Garland,[1] G. Helas,[1] J. L. Jimenez,[3] S. M. King,[2] A. Manzi,[4] E. Mikhailov,[1,5] T. Pauliquevis,[6,7] M. D. Petters,[8,9] A. J. Prenni,[8] P. Roldin,[10] D. Rose,[1] J. Schneider,[1] H. Su,[1] S. R. Zorn,[1,2] P. Artaxo,[6] M. O. Andreae[1]

The Amazon is one of the few continental regions where atmospheric aerosol particles and their effects on climate are not dominated by anthropogenic sources. During the wet season, the ambient conditions approach those of the pristine pre-industrial era. We show that the fine submicrometer particles accounting for most cloud condensation nuclei are predominantly composed of secondary organic material formed by oxidation of gaseous biogenic precursors. Supermicrometer particles, which are relevant as ice nuclei, consist mostly of primary biological material directly released from rainforest biota. The Amazon Basin appears to be a biogeochemical reactor, in which the biosphere and atmospheric photochemistry produce nuclei for clouds and precipitation sustaining the hydrological cycle. The prevailing regime of aerosol-cloud interactions in this natural environment is distinctly different from polluted regions.

SCIENCE VOL 329 17 SEPTEMBER 2010



A
B
C
D
E
F
200 nm
300 nm
200 nm
400 nm
600 nm
1 µm



Graupel, Hail,
Ice & Snow
IN Activation
Cold Rain
Formation
New
Particle
Formation
Cloud
Drops
Warm Rain
Formation
CCN Activation
VOC Oxidation &
SOA Formation
Precipitation &
Wet Deposition
VOC
PBA
H_2O
Emission/Evaporation

Aquecimento Global

Future CO_2 Emissions and Climate Change from Existing Energy Infrastructure

Steven J. Davis,[1]* Ken Caldeira,[1] H. Damon Matthews[2]

Slowing climate change requires overcoming inertia in political, technological, and geophysical systems. Of these, only geophysical warming commitment has been quantified. We estimated the commitment to future emissions and warming represented by existing carbon dioxide–emitting devices. We calculated cumulative future emissions of 496 (282 to 701 in lower- and upper-bounding scenarios) gigatonnes of CO_2 from combustion of fossil fuels by existing infrastructure between 2010 and 2060, forcing mean warming of 1.3°C (1.1° to 1.4°C) above the pre-industrial era and atmospheric concentrations of CO_2 less than 430 parts per million. Because these conditions would likely avoid many key impacts of climate change, we conclude that sources of the most threatening emissions have yet to be built. However, CO_2-emitting infrastructure will expand unless extraordinary efforts are undertaken to develop alternatives.

If current greenhouse gas (GHG) concentrations remain constant, the world would be committed to several centuries of increasing global mean temperatures and sea level rise (*1*–*3*). By contrast, near-elimination of anthropogenic CO_2 emissions would be required to produce diminishing GHG concentrations consistent with stabilization of mean temperatures (*4*–*6*). Yet long-lived energy and transportation infrastructure now operating can be expected to contribute substantial CO_2 emissions over the next 50 years [e.g., (*7*)]. Barring widespread retrofitting of existing power plants with carbon capture and storage (CCS) technologies or the early decommissioning of serviceable infrastructure, these "committed emissions" represent infrastructural inertia, which may be the primary contributor to total future warming commitment.

[1]Department of Global Ecology, Carnegie Institution of Washington, 260 Panama Street, Stanford, CA 94305, USA. [2]Department of Geography, Planning and Environment, Concordia University, 1455 de Maisonneuve Boulevard West, H 1255-26 (Hall Building), Montreal, Quebec H3G 1M8, Canada.

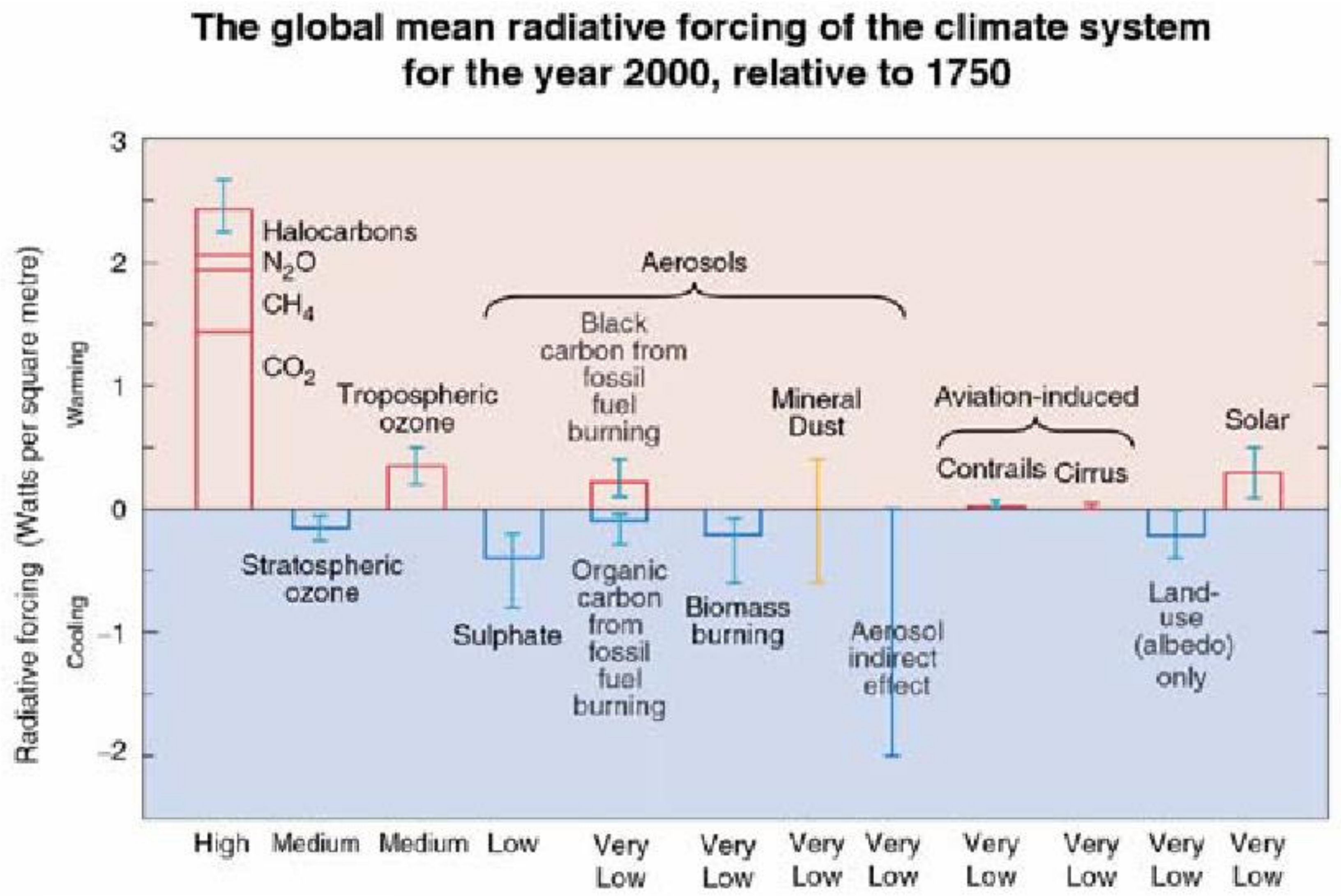
*To whom correspondence should be addressed. E-mail: sjdavis@carnegie.stanford.edu

Emissions scenarios such as those produced by the Intergovernmental Panel on Climate Change (IPCC) rely on projected changes in population, economic growth, energy demand, and the carbon intensity of energy over time (*8*). Although these scenarios represent plausible future emissions trends, the infrastructural inertia of emissions at any point in time is not explicitly quantified. Here, we present scenarios reflecting direct emissions from existing energy and transportation infrastructure, along with climate model results showing the warming commitment of these emissions.

With respect to GHG emissions, infrastructural inertia may be thought of as having two important and overlapping components: (i) infrastructure that directly releases GHGs to the atmosphere, and (ii) infrastructure that contributes to the continued production of devices that emit GHGs to the atmosphere. For example, the interstate highway and refueling infrastructure in the United States facilitates continued production of gasoline-powered automobiles. Here, we focus only on the warming commitment from infrastructure that directly releases CO_2 to the atmosphere. Essentially, we answer the following question: What if no additional CO_2-emitting devices (e.g., power plants, motor vehicles) were built, but all the existing CO_2-emitting devices were allowed to live out their normal lifetimes? What CO_2 levels and global mean temperatures would we attain? Of course, the actual lifetime of devices may be strongly influenced by economic and policy constraints. For instance, a ban on new CO_2-emitting devices would create tremendous incentive to prolong the lifetime of existing devices. Thus, our scenarios are not realistic, but they offer a means of gauging the threat of climate change from existing devices relative to those devices that have yet to be built.

The details of our analytic approach are described in (*9*). In summary, we developed scenarios of global CO_2 emissions from the energy sector (*10*) using data sets of power plants (*11*, *12*) and motor vehicles (*13*) worldwide, as well as estimates of fossil fuel emissions produced directly by industry, households, businesses, and other forms of transport (*14*). We estimated lifetimes and annual emissions of infrastructure from historical data. Non-energy emissions (e.g., from industrial processes, land use change, agriculture, and waste) were taken from the IPCC's Special Report on Emissions Scenarios (*8*). We projected changes in CO_2 and temperature in response to our calculated emissions with the use of an intermediate-complexity coupled climate-carbon model, the University of Victoria Earth System Climate Model (*9*).

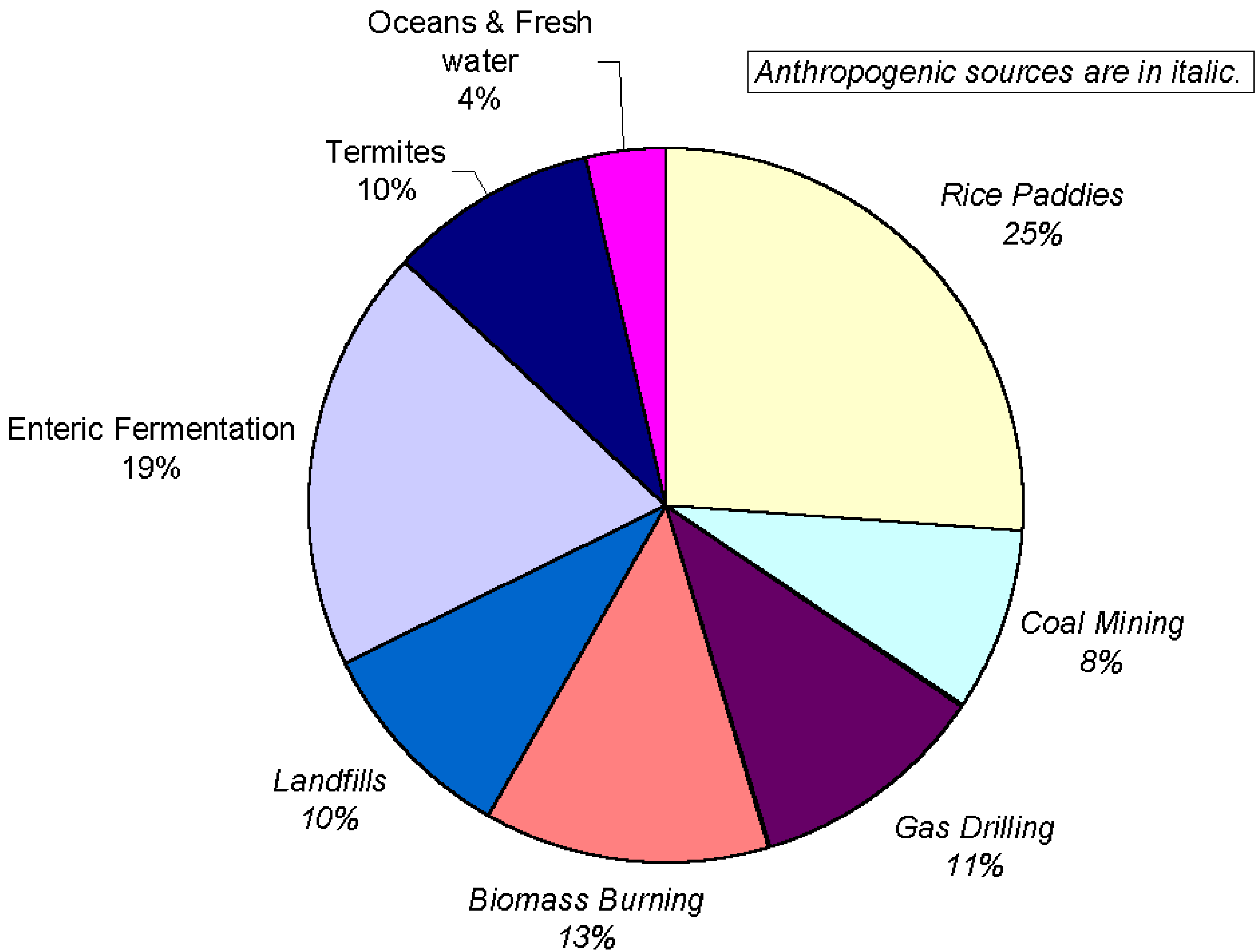
Cumulatively, we estimate that 496 (282 to 701 in lower- and upper-bounding scenarios) gigatonnes of CO_2 (Gt CO_2; 1 Gt = 10^{12} kg) (*9*) will be emitted from the combustion of fossil fuels by existing infrastructure between 2010 and 2060 (Fig. 1, A and B). Adding emissions from non-energy sources, climate model results indicate that these emissions would allow the atmospheric concentration of CO_2 to stabilize below 430 parts per million (ppm), with mean warming of 1.3°C (1.1° to 1.4°C) above the pre-industrial era (or 0.3° to 0.7°C greater than at present; Fig. 1, C and D). Excluding emissions from non-energy sources, atmospheric CO_2 emissions would


The global mean radiative forcing of the climate system
for the year 2000, relative to 1750
Radiative forcing (Watts per square metre)
Warming
Cooling
3
2
1
0
-1
-2
Halocarbons
N_2O
CH_4
CO_2
Tropospheric ozone
Stratospheric ozone
Aerosols
Black carbon from fossil fuel burning
Sulphate
Organic carbon from fossil fuel burning
Biomass burning
Mineral Dust
Aerosol indirect effect
Aviation-induced
Contrails
Cirrus
Land-use (albedo) only
Solar
High
Medium
Medium
Low
Very Low
Very Low
Very Low
Very Low
Very Low
Very Low
Very Low
Very Low

Composição da Atmosfera

Gas	concentração (%)	
N_2	78	
O_2	21	
Ar	0.9	
H_2O	variável	
CO_2	0.037	370 ppm
CH_4		1.7
N_2O		0.3
O_3		1.0 to 0.01 (superfície-estratosfera)

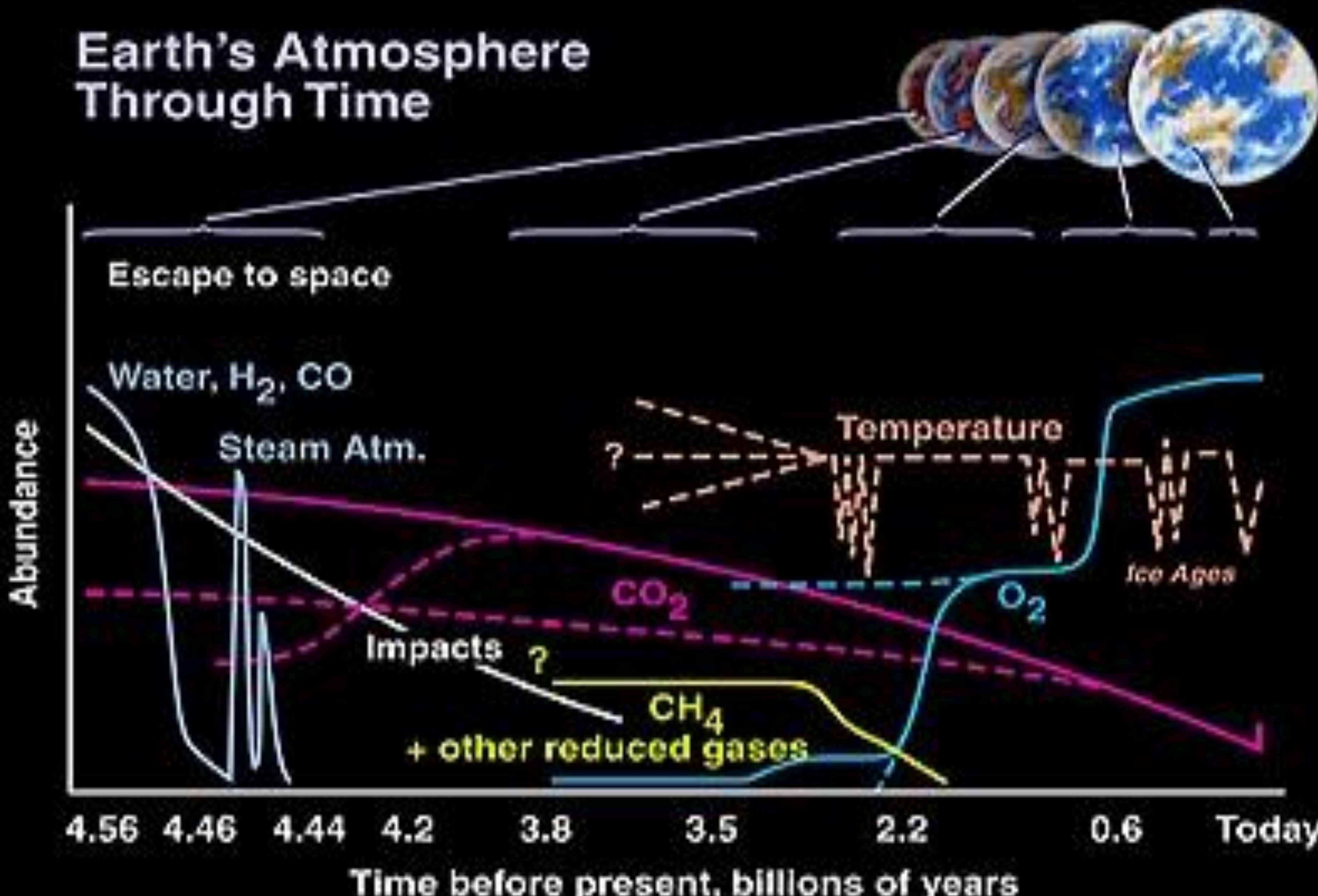
Gases do Efeito Estufa (H_2O, CO_2, CH_4, N_2O, O_3)

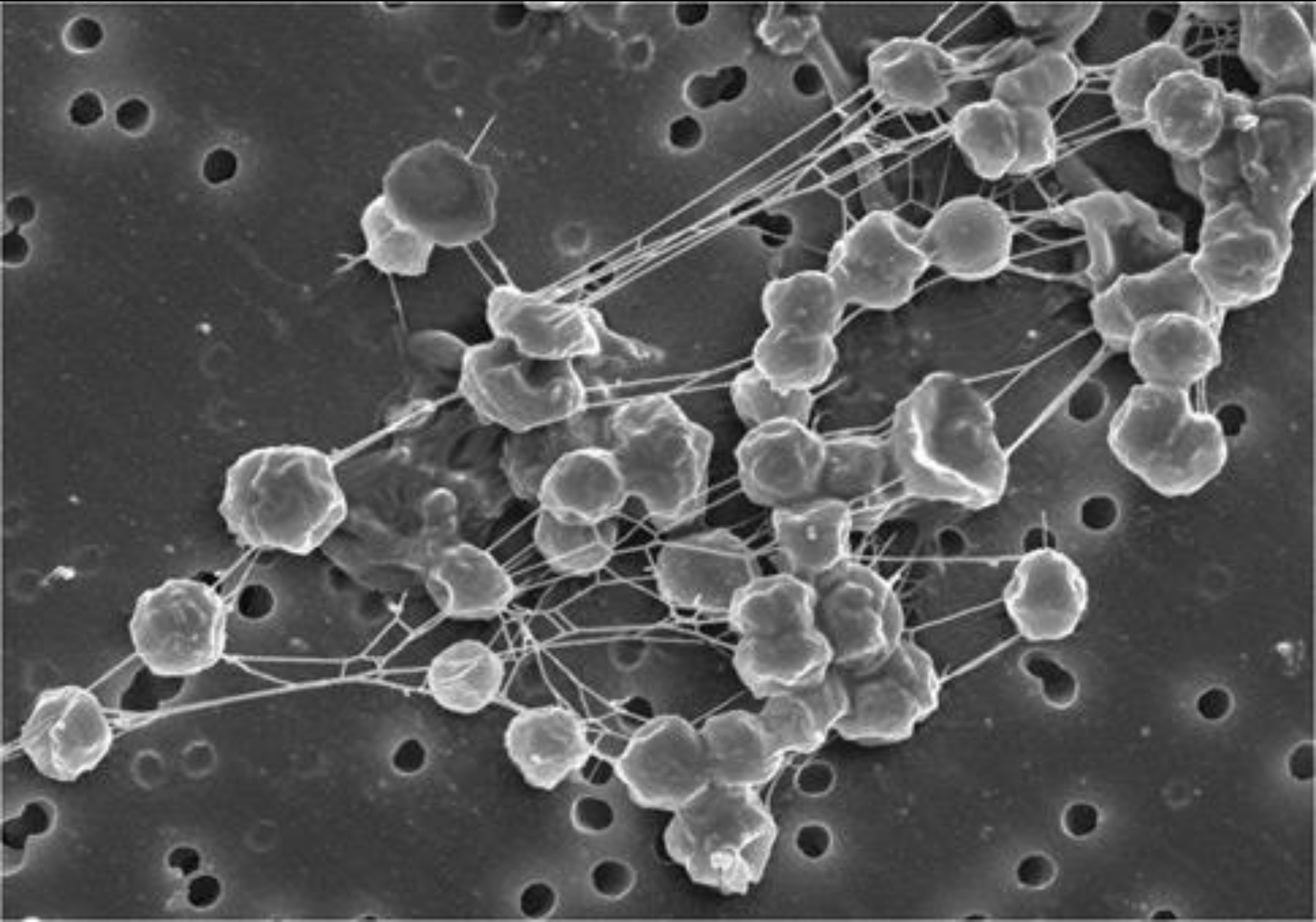


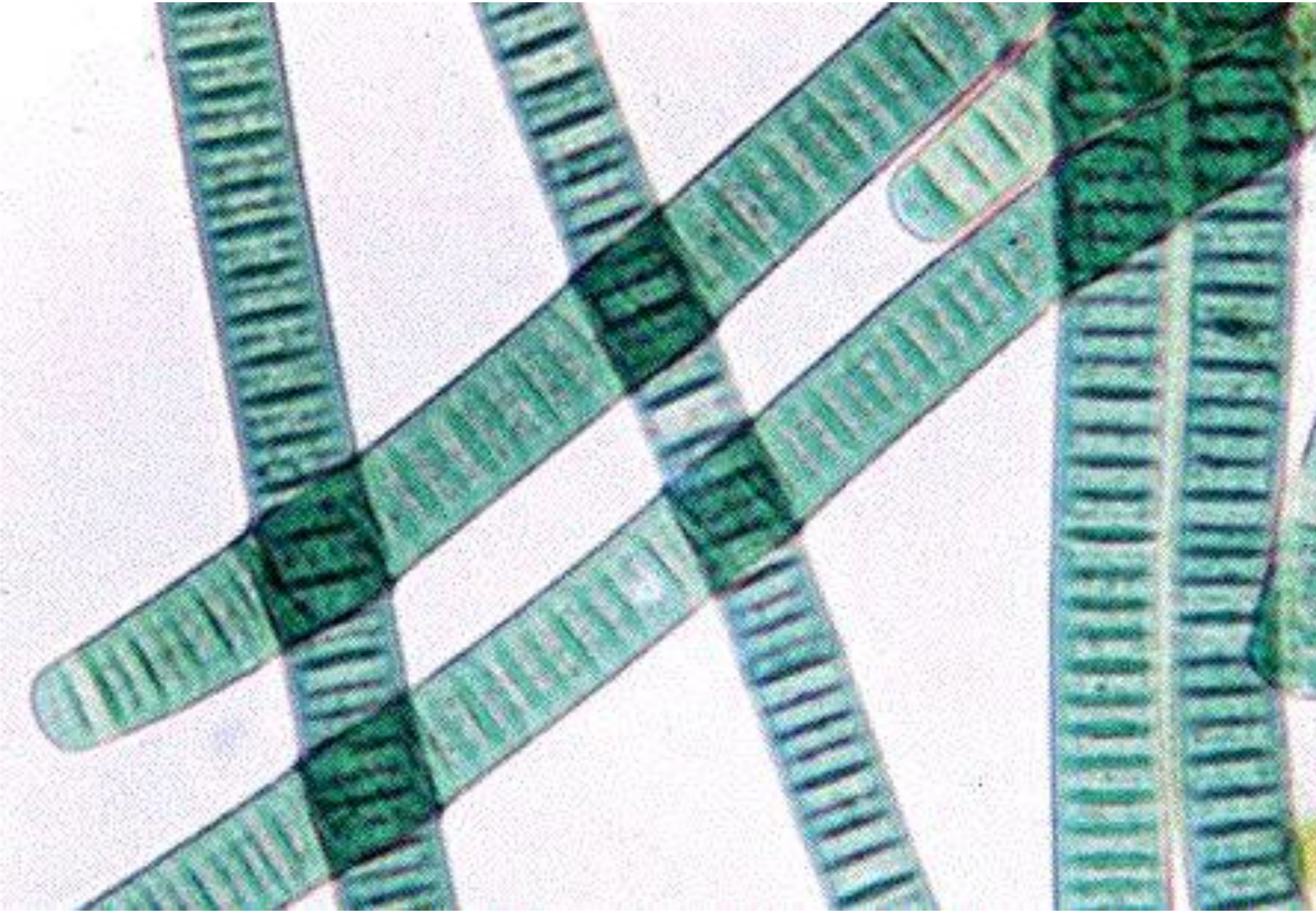
Fontes de Metano na Terra

(University of Toronto, Dept. Atmospheric Physics)

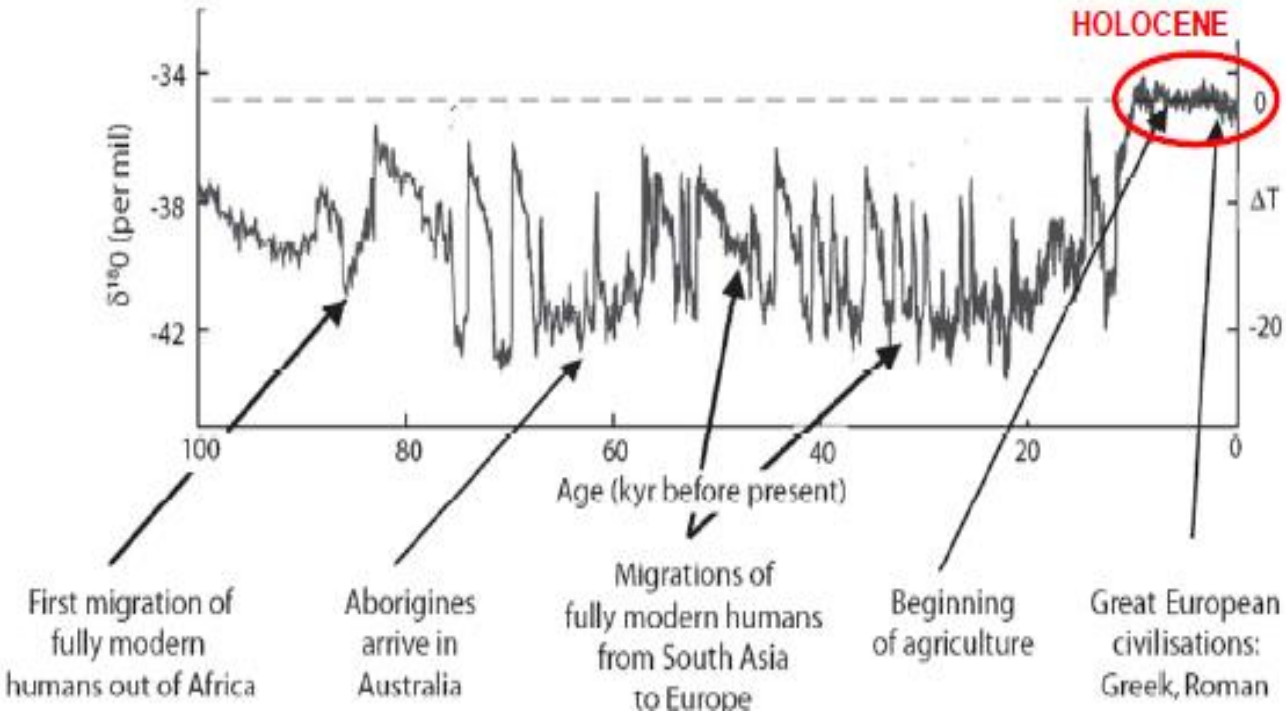
Evolução das Biosferas


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





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).

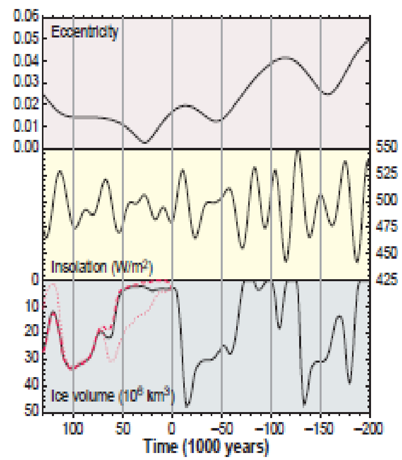
Some assumptions made 30 years ago have since been questioned. Past interglacials may have been longer than originally assumed (*2*). Some, including marine isotope stage 11 (MIS-11, 400,000 years ago), may have been warmer than at present (*3*). We are also increasingly aware of the intensification 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

<table>
<tr><th colspan="2">Eón</th><th>Era</th><th colspan="2">Período</th><th>Epoca</th></tr>
<tr><td rowspan="16" colspan="2">Fanerozoico
(544 ma a hoy)</td><td rowspan="7">Cenozoica
(65 ma a hoy)</td><td rowspan="2" colspan="2">Cuaternario
(1.8 ma a hoy)</td><td>Holoceno
(11,000 años a hoy)</td></tr>
<tr><td>Pleistoceno
(1.8 ma a 11,000 años)</td></tr>
<tr><td rowspan="5">Terciario
(65 a 1.8 ma)</td><td rowspan="2">Neógeno
(23 a 1.8 ma)</td><td>Plioceno
(5 a 1.8 ma)</td></tr>
<tr><td>Mioceno
(23 a 5 ma)</td></tr>
<tr><td rowspan="3">Paleógeno
(65 a 23 ma)</td><td>Eoceno
(54 a 38 ma)</td></tr>
<tr><td>Oligoceno
(38 a 23 ma)</td></tr>
<tr><td>Paleoceno
(65 a 54 ma)</td></tr>
<tr><td rowspan="3">Mesozoica
(245 a 65 ma)</td><td colspan="2">Cretácico
(146 a 65 ma)</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Jurásico
(208 a 146 ma)</td></tr>
<tr><td colspan="2">Triásico
(245 a 208 ma)</td></tr>
<tr><td rowspan="6">Paleozoica
(544 a 245 ma)</td><td colspan="2">Pérmico
(286 a 245 ma)</td><td rowspan="6"></td></tr>
<tr><td colspan="2">Carbonífero
(360 a 286 ma)</td></tr>
<tr><td colspan="2">Devónico
(410 a 360 ma)</td></tr>
<tr><td colspan="2">Silúrico
(440 a 410 ma)</td></tr>
<tr><td colspan="2">Ordovícico
(505 a 440 ma)</td></tr>
<tr><td colspan="2">Cámbrico
(544 a 505 ma)</td></tr>
<tr><td rowspan="3">Tiempo Precámbrico
(4,500 a 544 ma)</td><td>Proterozoico
(2500 a 544 ma)</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Arcaico
(3800 a 2500 ma)</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Hádico
(4500 a 3800 ma)</td><td></td><td colspan="2"></td><td></td></tr>
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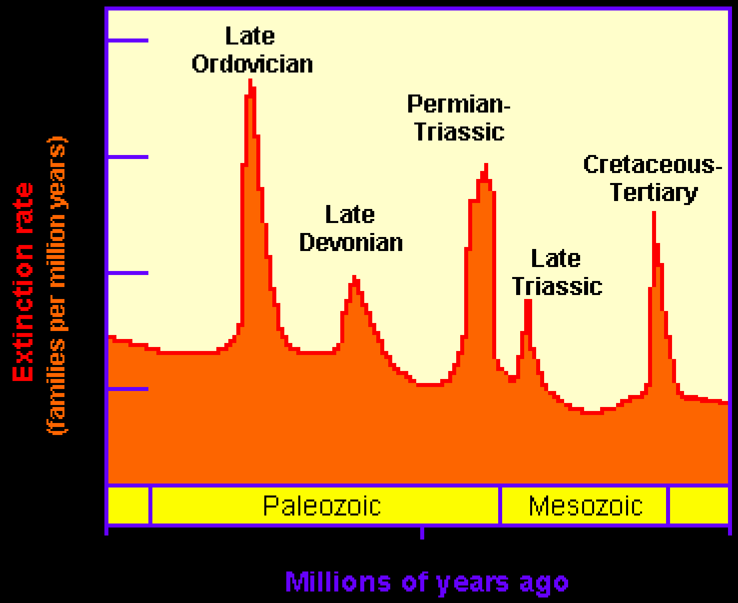
Evolução das Biosferas

- Evolução da Complexidade
- Sistemas de auto-regulação
  - papel da biodiversidade
- Diversificação latitudinal e altitudinal
- Estados Estáveis
- Transições abruptas
  - extinções em massa
- Impacto humano na biosfera

Evolução da Complexidade na Terra

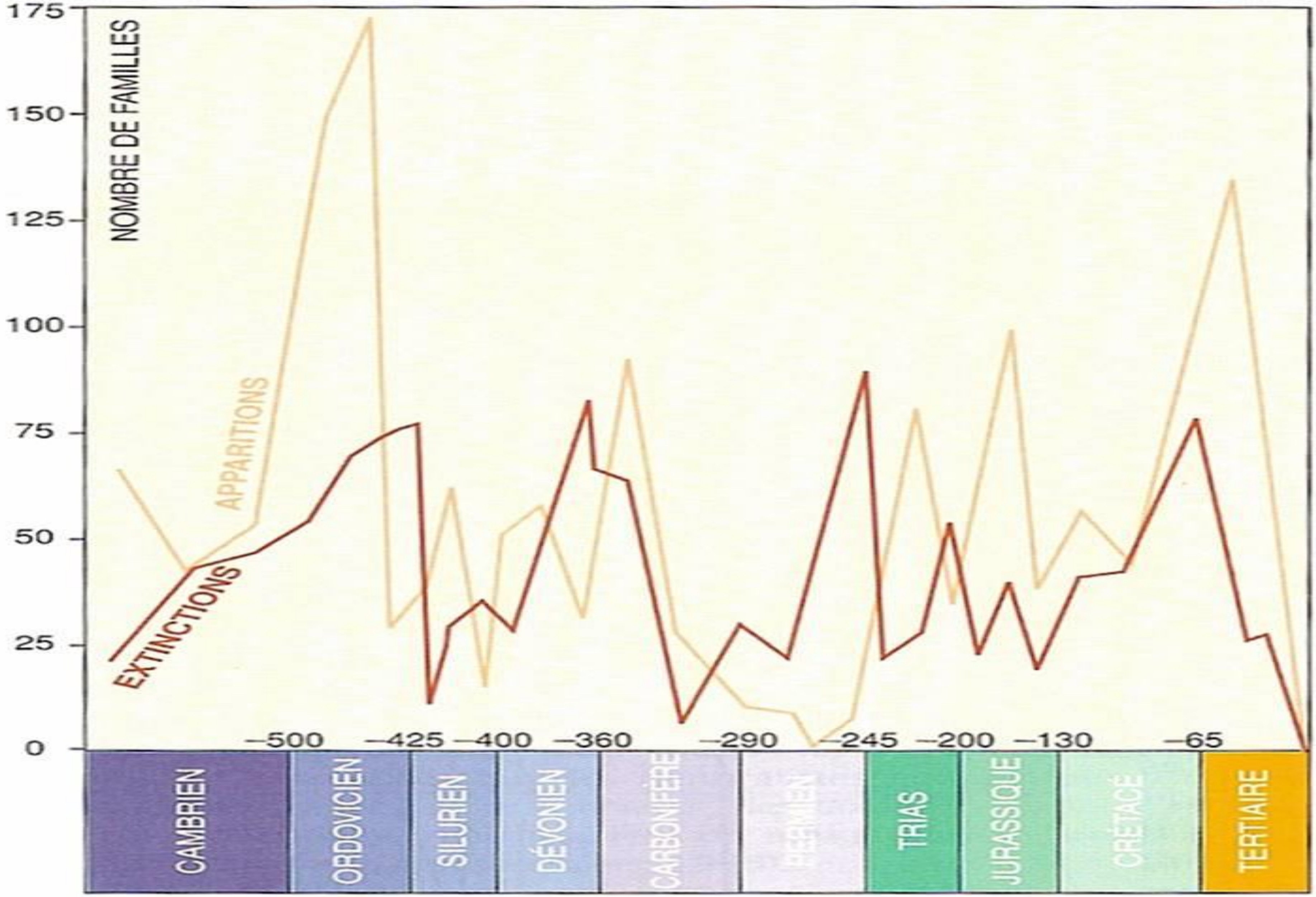
Evento de Tunguska *(30 de Junho de 1908)*

Extinções em Massa
Causas Astronômicas
(L. & W. Alvarez 1980)



SCIENCE 6 June 1980:
Vol. 208. no. 4448, pp. 1095 - 1108
DOI: 10.1126/SCIENCE.208.4448.1095
Articles
Extraterrestrial Cause for the Cretaceous-Tertiary Extinction
Luis W. ALVAREZ **1, Walter** ALVAREZ **2, Frank Asaro 3, and Helen V. Michel 4** 1
Professor emeritus of physics at Lawrence Berkeley Laboratory, University of California, Berkeley 94720
2 Associate professor in the Department of Geology and Geophysics, University of California, Berkeley
3 Senior scientist in the Energy and Environment Division of Lawrence Berkeley Laboratory
4 Staff scientist in the Energy and Environment Division of Lawrence Berkeley Laboratory

Platinum metals are depleted in the earth's crust relative to their cosmic abundance; concentrations of these elements in deep-sea sediments may thus indicate influxes of extraterrestrial material. Deep-sea limestones exposed in Italy, Denmark, and New Zealand show iridium increases of about 30, 160, and 20 times, respectively, above the background level at precisely the time of the Cretaceous-Tertiary extinctions, 65 million years ago. Reasons are given to indicate that this iridium is of extraterrestrial origin, but did not come from a nearby supernova. A hypothesis is suggested which accounts for the extinctions and the iridium observations. Impact of a large earth-crossing asteroid would inject about 60 times the object's mass into the atmosphere as pulverized rock; a fraction of this dust would stay in the stratosphere for several years and be distributed worldwide. The resulting darkness would suppress photosynthesis, and the expected biological consequences match quite closely the extinctions observed in the paleontological record. One prediction of this hypothesis has been verified: the chemical composition of the boundary clay, which is thought to come from the stratospheric dust, is markedly different from that of clay mixed with the Cretaceous and Tertiary limestones, which are chemically similar to each other. Four different independent estimates of the diameter of the asteroid give values that lie in the range 10 ± 4 kilometers.



9. Extinctions et radiations adaptatives. Après les pics de radiation initiaux du Cambrien et de l'Ordovicien inférieur, chacun des cinq pics majeurs d'extinction a été suivi d'un nouveau pic de diversification.

A ação humana tem sido no sentido de apagar as bioassinaturas:

- Aumentando o CO_2
- Destruindo o O_3
- Esgotando a água doce
- Desestabilizando ciclos de feedback negativo que mantêm estados fora do equilíbrio termodinâmico
- Liquidando a biodiversidade

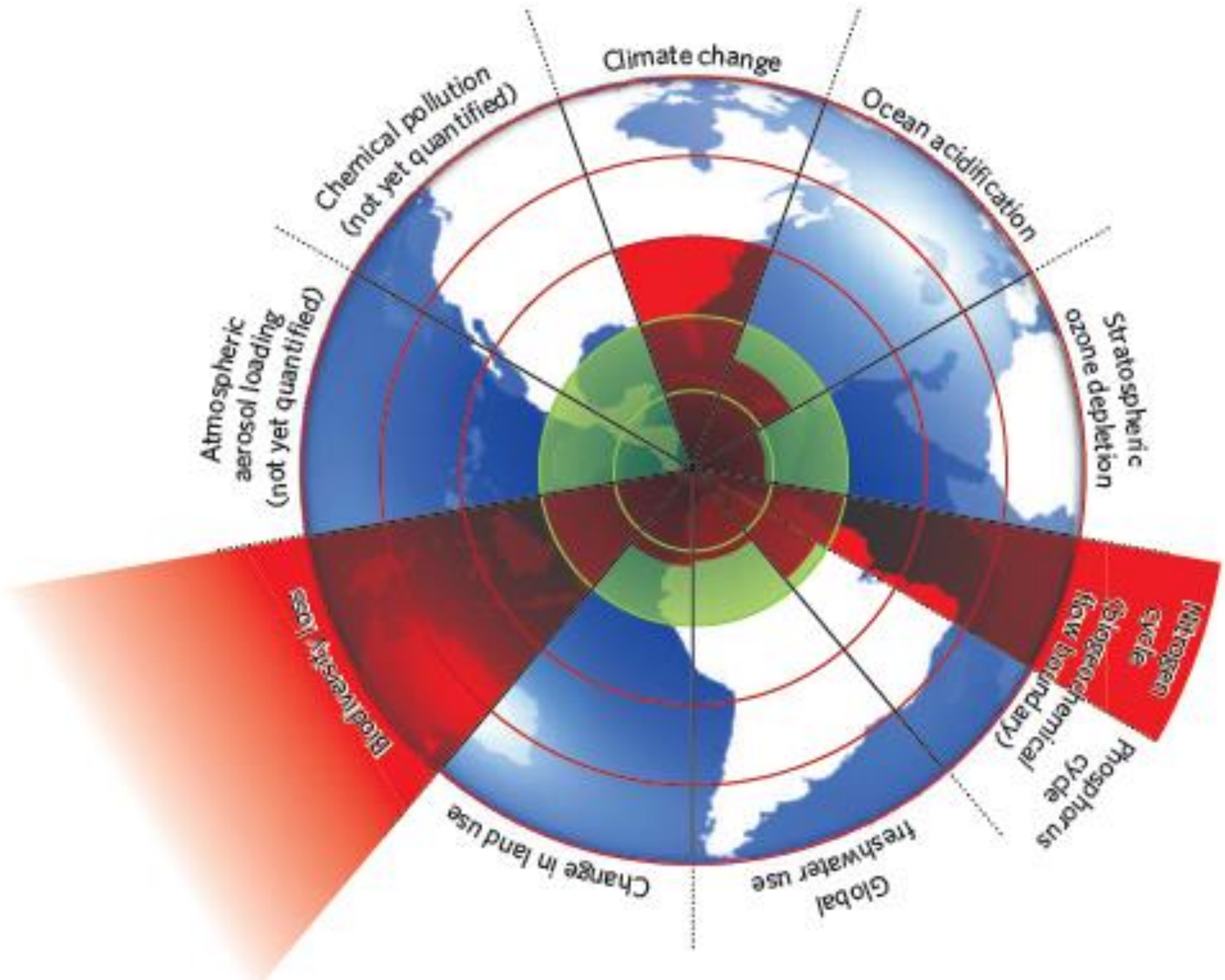


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference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

2010 International Year of Biodiversity

Biodiversity is life
Biodiversity is our life

Welcome!

The United Nations declared 2010 to be the International Year of Biodiversity. It is a celebration of life on earth and of the value of biodiversity for our lives. The world is invited to take action in 2010 to safeguard the variety of life on earth: biodiversity

UNITED NATIONS
International Year of Biodiversity

STATEMENT BY AHMED DJOGHLAF
EXECUTIVE SECRETARY OF THE CONVENTION ON BIOLOGICAL DIVERSITY AT THE OPENING SESSION OF THE TENTH MEETING OF THE CONFERENCE OF THE PARTIES TO THE CONVENTION ON BIOLOGICAL DIVERSITY
Nagoya, 18 October 2010

Mr. President
Ladies and gentlemen,

From Curitiba to Bonn, and from Bonn to Nagoya, here we are gathered as a community of nations representing the family of the people of the world at this largest, biggest biodiversity conference in the history of the United Nations Convention on Biological Diversity.

Here we are as a community of nations not for just another United Nations meeting, but for the most important meeting on biodiversity in the history of the United Nations. This is indeed a defining moment in the history of mankind.

As Daisetz Teitaro Suzuki stated "The problem of Nature is the problem of human life". However, today human life is a problem for Nature.

Assembled at this historical Aichi-Nagoya biodiversity summit, we the 16,000 participants assembled today from all over the world, representing the 193 Parties and their partners, are called upon to address the unprecedented loss of biodiversity seriously compounded by global warming.

Biodiversity Conservation: Challenges Beyond 2010

Michael R. W. Rands,[1*] William M. Adams,[2] Leon Bennun,[3] Stuart H. M. Butchart,[3] Andrew Clements,[4] David Coomes,[5] Abigail Entwistle,[6] Ian Hodge,[7] Valerie Kapos,[8,9,10] Jörn P. W. Scharlemann,[8] William J. Sutherland,[10] Bhaskar Vira[2]

The continued growth of human populations and of per capita consumption have resulted in unsustainable exploitation of Earth's biological diversity, exacerbated by climate change, ocean acidification, and other anthropogenic environmental impacts. We argue that effective conservation of biodiversity is essential for human survival and the maintenance of ecosystem processes. Despite some conservation successes (especially at local scales) and increasing public and government interest in living sustainably, biodiversity continues to decline. Moving beyond 2010, successful conservation approaches need to be reinforced and adequately financed. In addition, however, more radical changes are required that recognize biodiversity as a global public good, that integrate biodiversity conservation into policies and decision frameworks for resource production and consumption, and that focus on wider institutional and societal changes to enable more effective implementation of policy.

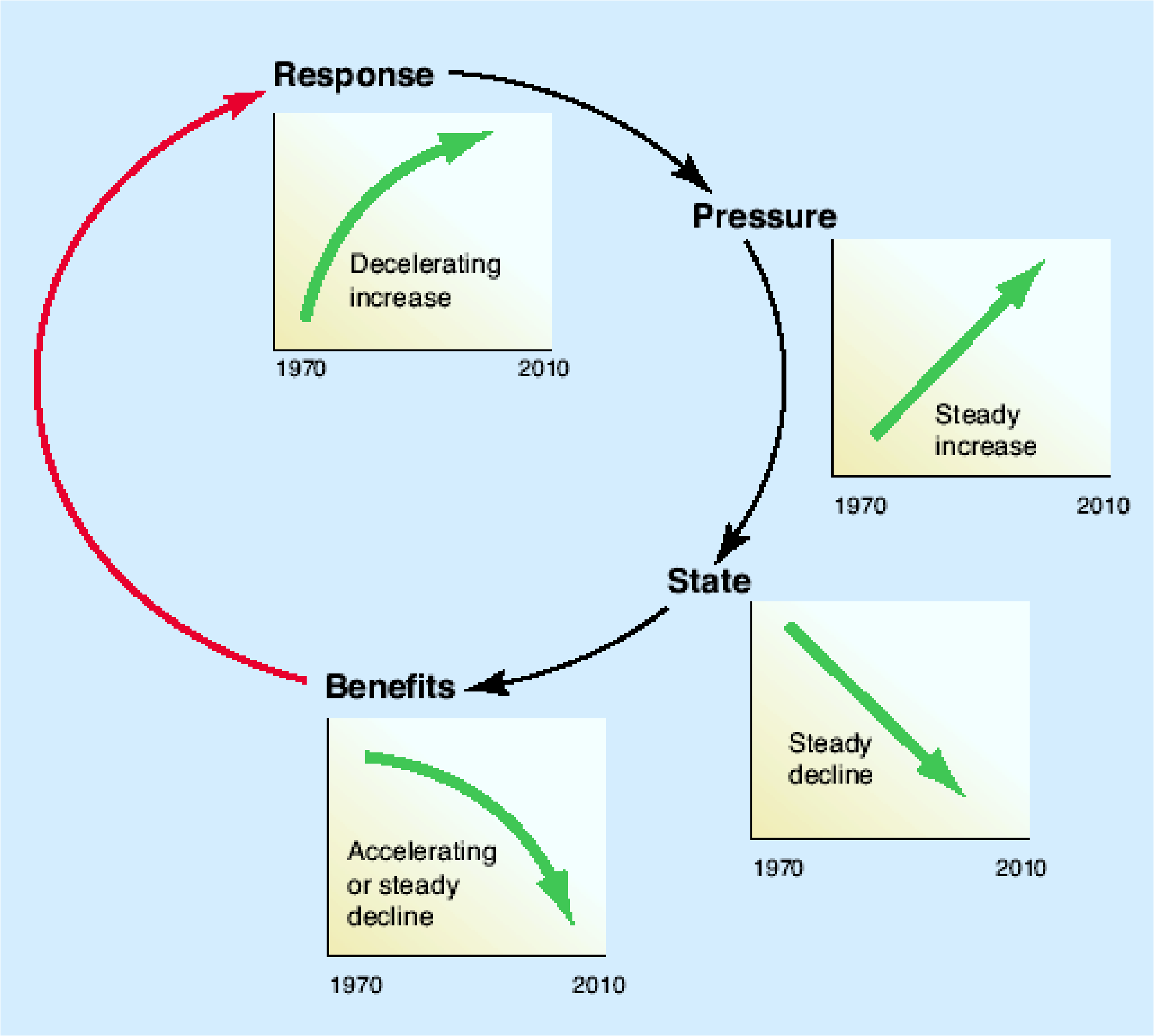
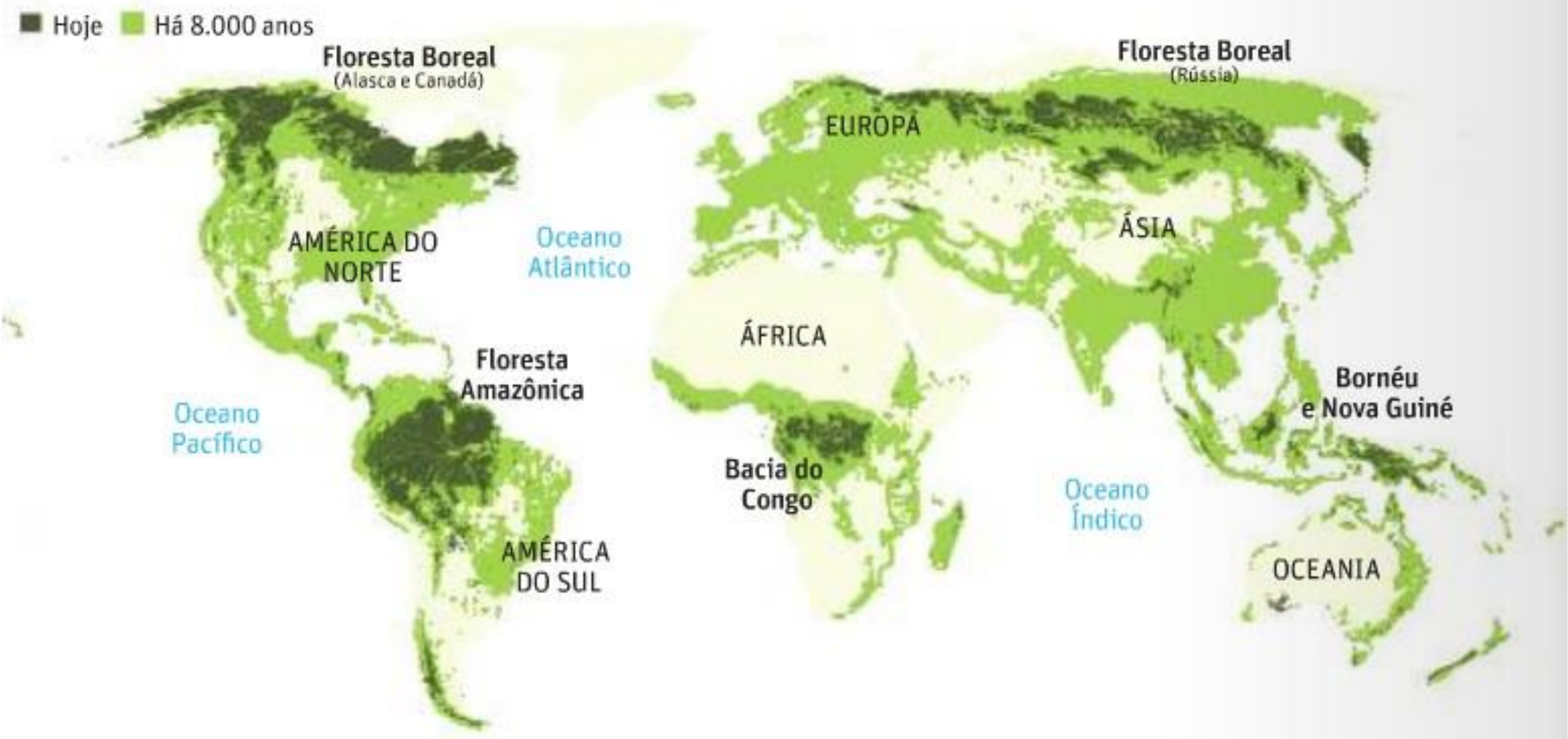


Fig. 3. The feedback loop between responses to biodiversity loss, the pressures on biodiversity, the state of biodiversity, and the benefits it provides. The arrow linking benefits to responses is highlighted because of its particular importance: Responses are put in place in relation to how far the maintenance of biodiversity is valued as a benefit to society and individuals. Thumbnail graphs show the overall trend in each of these aspects over the past 4 decades [simplified from (*7*)]. Although responses continue to grow, the rate of increase is slowing and not keeping pace with the steady rise in pressures. A corresponding steady decline in state is linked to a steady or possibly accelerating decline in benefits.

TERRA SOB CERCO O estado atual da biodiversidade



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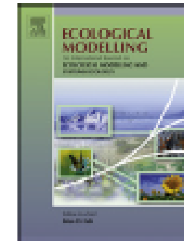


Harvesting the sun: New estimations of the maximum population of planet Earth

Siegfried Franck[a,*], Werner von Bloh[a], Christoph Müller[a], Alberte Bondeau[a], B. Sakschewski[b]

[a] *Potsdam Institute for Climate Impact Research (PIK), Research Domains Earth System Analysis and Climate Impacts & Vulnerabilities, Telegraphenberg, P.O. Box 601203, D-14412 Potsdam, Germany*

[b] *Universität Potsdam, Institut für Biochemie und Biologie, Karl-Liebknecht-Str. 24-25, D-14476 Potsdam, Germany*

Table 3

Comparing) estimates of the Earth's maximum human population to the results of LPJmL.

North latitude (°)	m² per person to support life									
	No allowance for urban and recreational needs Number of people (billions)					750 m² per person for urban and recreational needs Number of people (billions)				
	D.W.	LPJmL – Genghis K.	LPJmL – save-forests	LPJmL – Burger	LPJmL – wmr[a]	D.W.	LPJmL – Genghis K.	LPJmL – save-forests	LPJmL – Burger	LPJmL – wmr[a]
70	10	1.7	0.4	0.2	1.7	5	0.7	0.2	0.2	0.7
60	30	14.5	2.6	3.4	13.4	11	6.2	1.1	2.6	6.0
50	95	37.9	17.6	9.6	29.2	17	13.0	5.7	6.4	11.9
40	136	35.8	27.8	8.9	30.5	18	12.1	9.6	5.7	11.5
30	151	22.3	21.2	6.2	21.4	20	8.5	8.1	3.7	8.4
20	105	13.4	7.9	6.6	11.8	16	4.6	3.0	3.5	4.3
10	77	28.1	11.1	12.1	26.1	11	7.8	3.8	5.9	7.7
0	121	40.1	6.1	17.4	37.0	17	10.0	1.6	7.5	9.7
−10	87	37.3	15.2	14.3	32.1	9	9.4	3.7	6.6	9.0
−20	112	27.1	17.6	10.8	22.7	11	8.5	6.0	5.4	8.1
−30	88	15.8	15.4	4.9	12.3	9	5.6	5.5	2.7	5.0
−40	9	6.0	6.0	1.7	4.6	1	1.7	1.7	1.0	1.6
−50	1	1.5	1.5	0.3	1.4	1	0.5	0.5	0.2	0.5
Total	1022	281.5	150.4	96.4	244.2	146	88.6	50.5	51.4	84.4
				1500 m² per person		79	53.8	31.1	36.1	52.2

[a] LPJmL-wmr is a Genghis-Khan-scenario, but only with the three currently most important crop types (wheat, maize and rice) plus pasture.

James Lovelock

Nature, 426, 770-771 (2003)

Gaia

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

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

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

O Ponto de Vista Arquimediano

Três Eventos Determinantes da Era Moderna

A Condição Humana

- A descoberta da América
- A Reforma
- A invenção do telescópio

HANNAH ARENDT
A CONDIÇÃO HUMANA (PRÓLOGO) (1958)

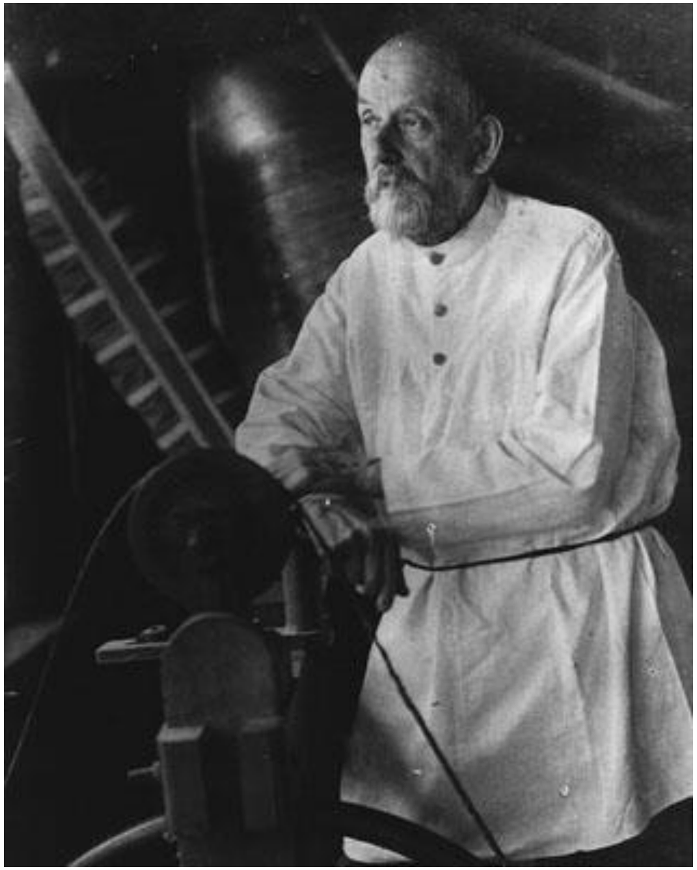
Hannah Arendt (1906-1975)

Sputink (lançado em 4/10/1957)

Em 1957, um objeto terrestre, feito pela mão do homem, foi lançado ao universo, onde durante algumas semanas girou em torno da Terra segundo as mesmas leis de gravitação que governam o movimento dos corpos celestes - o Sol, a Lua e as estrelas. É verdade que o satélite artificial não era lua nem estrela; não era um corpo celeste que pudesse prosseguir em sua órbita circular por um período de tempo que para nós, mortais limitados ao tempo da Terra, durasse uma eternidade. Ainda assim, pode permanecer nos céus durante algum tempo; e lá ficou, movendo-se no convívio dos astros como se estes o houvessem provisoriamente admitido em sua sublime companhia.

Este evento, que em importância ultrapassa todos os outros, até mesmo a desintegração do átomo, teria sido saudado com a mais pura alegria não fossem as suas incômodas circunstâncias militares e políticas. O curioso, porém, é que essa alegria não foi triunfal; o que encheu o coração dos homens que, agora, ao erguer os olhos para os céus, podiam contemplar uma de suas obras, não foi orgulho nem assombro ante a enormidade da força e da proficiência humanas. A reação imediata, expressa espontaneamente, foi alívio ante o primeiro "passo para libertar o homem de sua prisão na terra". E essa estranha declaração, longe de ter sido o lapso acidental de algum repórter norte-americano, refletia, sem o saber, as extraordinárias palavras gravadas há mais de vinte anos no obelisco fúnebre de um dos grandes cientistas da Rússia: "A humanidade não permanecerá para sempre presa à terra".

Há já algum tempo este tipo de sentimento vem-se tornando comum; e mostra que, em toda parte, os homens não tardam a adaptar-se às descobertas da ciência e aos feitos da técnica, mas, ao contrário, estão décadas à sua frente. Neste caso, como em outros, a ciência apenas realizou e afirmou aquilo que os homens haviam antecipado em sonhos - sonhos que não eram loucos nem ociosos.



Konstantin Tsiolkovsky (1857-1935)

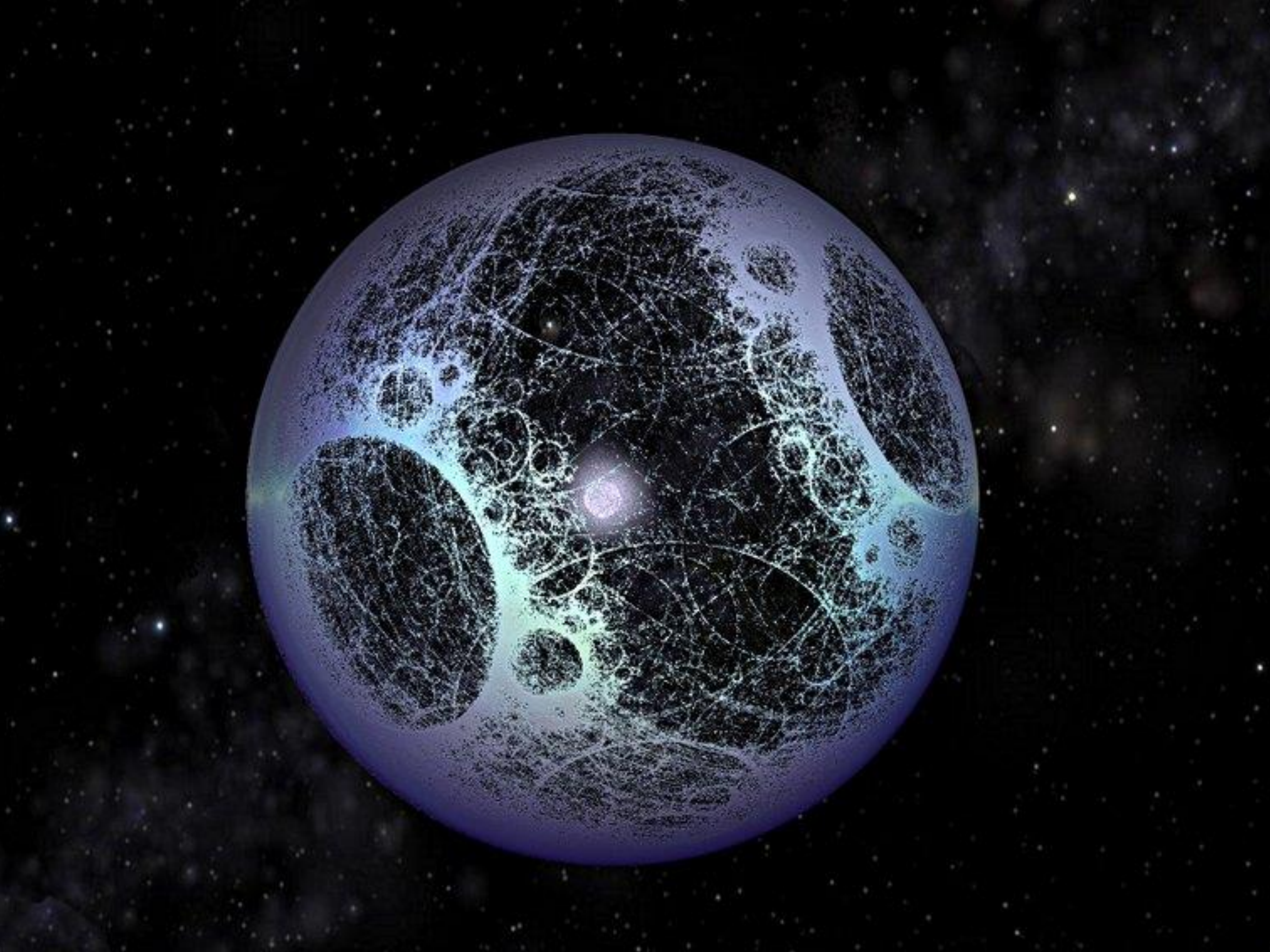
Estátua de K. Tsiolkovsky no
Planetário de Brisbane, Austrália

A Terra é o berço da humanidade, mas ninguem vive para sempre no seu berço

Gagarin no espaço (12/04/1961)

A Terra é Azul

E a Ação dos *Outros*?

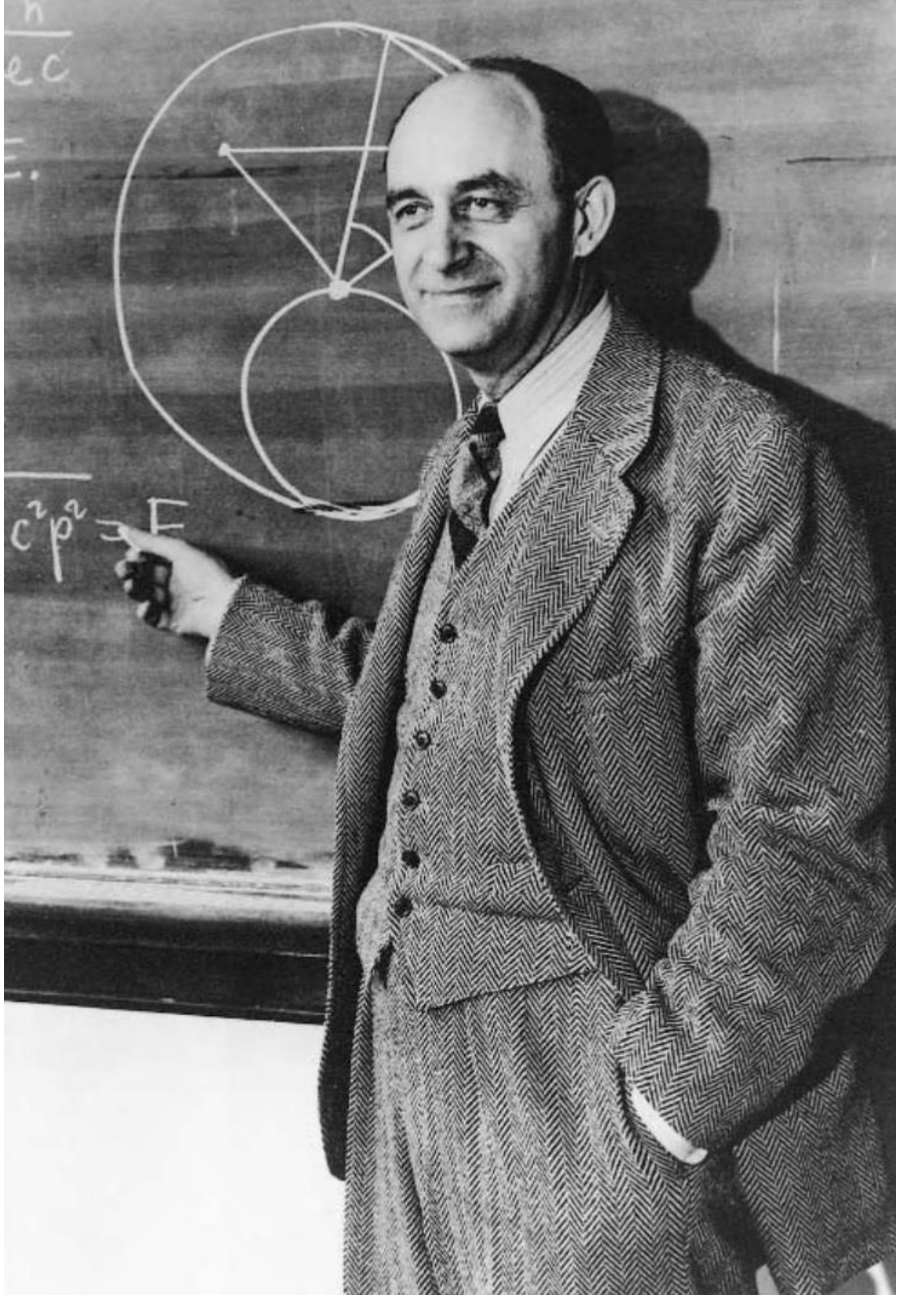


SIGA A VIDA

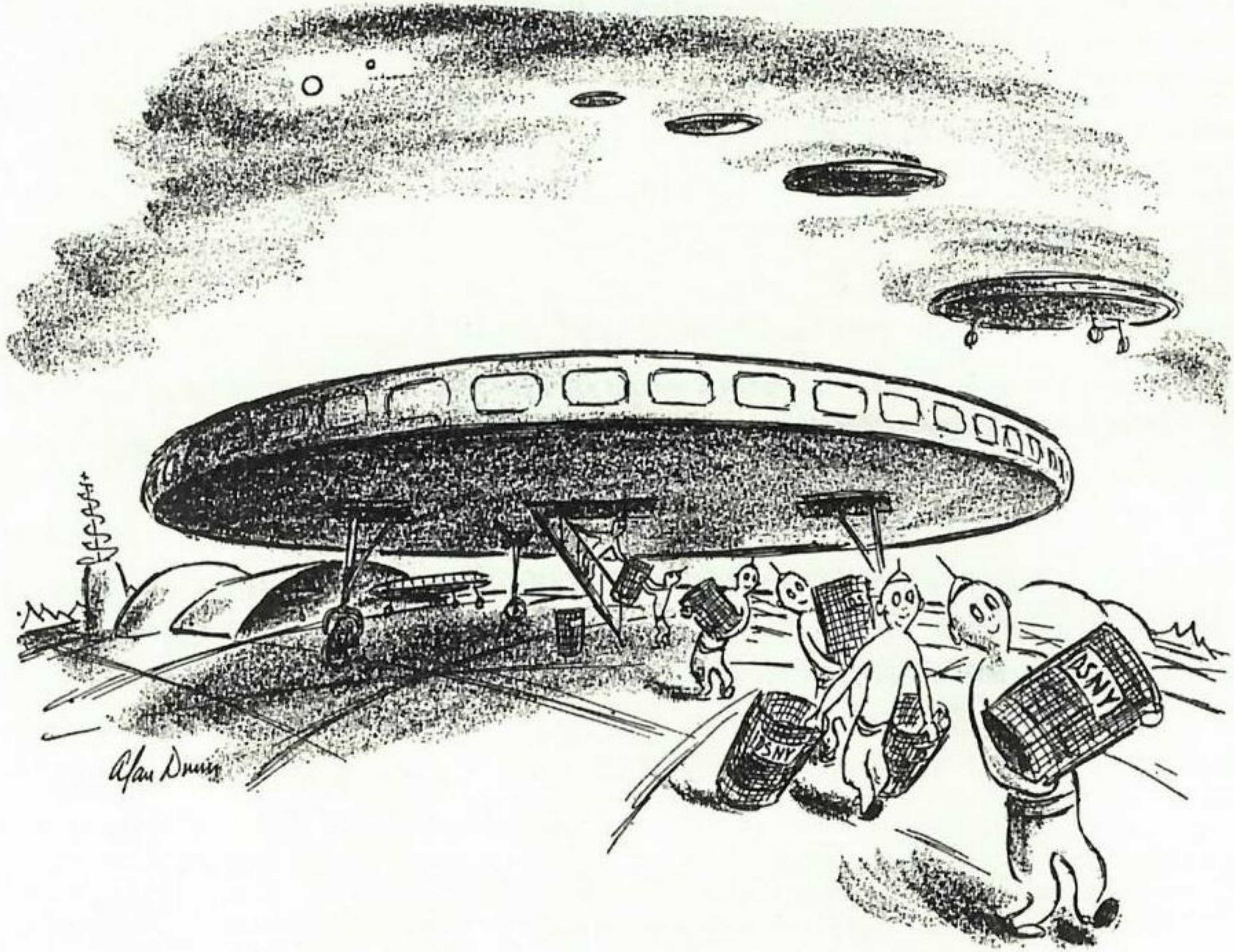
- Siga a água (Follow the water)
- Siga o carbono
- Siga o nitrogênio
- Siga o fósforo
- Siga a energia
- Siga a entropia
- ⇒ Siga a informação
- ⇒ Siga o significado

Onde está todo mundo?

O Paradoxo de Fermi (1950)



Enrico Fermi (1901-1954)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IF THE UNIVERSE IS TEEMING WITH ALIENS…

WHERE IS EVERYBODY?

FIFTY SOLUTIONS TO THE FERMI PARADOX
AND THE PROBLEM OF EXTRATERRESTRIAL LIFE

Stephen Webb

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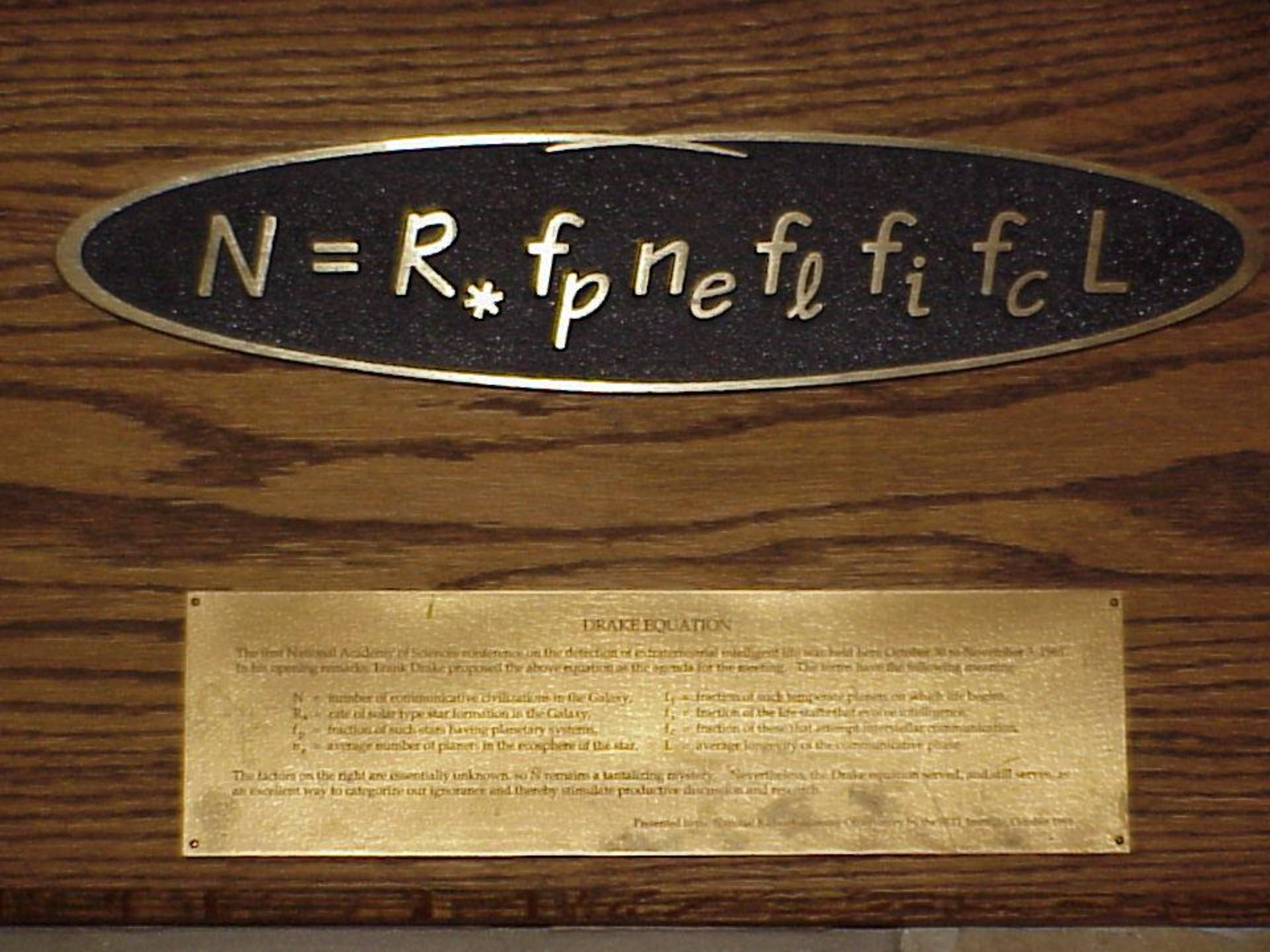
Equação de Drake

Frank Drake (1961)


N = R* fp ne fl fi fc L
DRAKE EQUATION
The first National Academy of Sciences conference on the detection of extraterrestrial intelligent life was held here October 31 to November 1, 1961.
In his opening remarks, Frank Drake proposed the above equation as the agenda for the meeting. The terms have the following meaning:
N = number of communicative civilizations in the Galaxy,
R* = rate of solar type star formation in the Galaxy,
fp = fraction of such stars having planetary systems,
ne = average number of planets in the ecosphere of the star,
fl = fraction of such temperate planets on which life begins,
fi = fraction of the life starts that evolve intelligence,
fc = fraction of these that attempt interstellar communication,
L = average longevity of the communicative phase
The factors on the right are essentially unknown, so N remains a tantalizing mystery. Nevertheless, the Drake equation served, and still serves, as an excellent way to categorize our ignorance and thereby stimulate productive discussion and research.

Equação de Drake

Primeiro encontro do projeto SETI (Search for Extra Terrestrial Intelligence), Green Bank, Virginia, 1961

$$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

- N é o número de civilizações extraterrestres em nossa galáxia com as quais poderíamos ter chances de estabelecer comunicação.
- R^* é a taxa de formação de estrelas em nossa galáxia.
- f_p é a fração de tais estrelas que possuem planetas em órbita.
- n_e é o número médio de planetas que potencialmente permitem o desenvolvimento de vida por estrela que tem planetas.
- f_l é a fração dos planetas com potencial para vida que realmente desenvolvem vida.
- f_i é a fração dos planetas que desenvolvem vida inteligente.
- f_c é a fração dos planetas que desenvolvem vida inteligente e que têm o desejo e os meios necessários para estabelecer comunicação.
- L é o tempo esperado de vida de tal civilização

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doi:10.1017/S1473550413000207

Preface

Reflections on the Equation

Frank Drake
SETI Institute Mountain View CA

The Equation first appeared 51 years ago on a blackboard in a cozy residence hall at the new radio observatory at Green Bank, West Virginia. I had based it on the known history of our galaxy and the Earth, and the factors affecting the existence of intelligent, technology-using life on Earth and similar planets. It predicts the number of civilizations N like ours that we might detect with our instruments. The goal was to produce an estimate of the number of detectable civilizations, and thereby reveal the challenge to be faced by serious searchers. Twelve scientists from many disciplines were present, in response to a request from the National Academy of Scientists to convene a workshop on the possibilities of detecting extraterrestrial intelligent life, a potential discovery that had been made plausible by the recent development of high sensitivity radio telescopes. These, for the first time in history, could detect radio signals no stronger than we were then radiating, sent from the distance of nearby stars. One such telescope was only a few hundred feet away, and had actually been used in the first modern search about a year previously. The Equation served as a convenient and succinct agenda for the workshop – seven topics, seven sessions.

Quem é o outro cósmico?

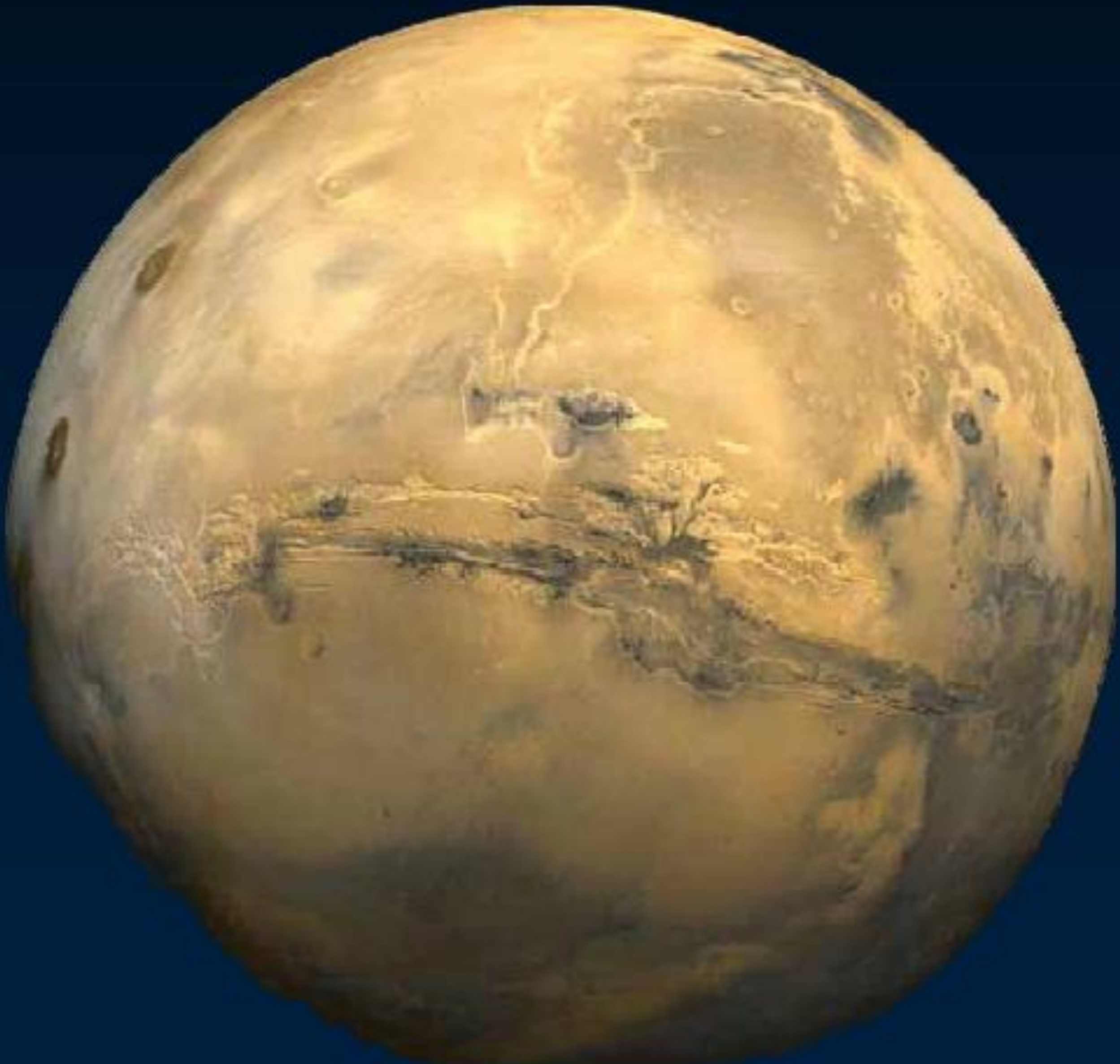
- Uma super-inteligência
- Um longevo senil
- Um anjo cósmico
- Um predador high-tech

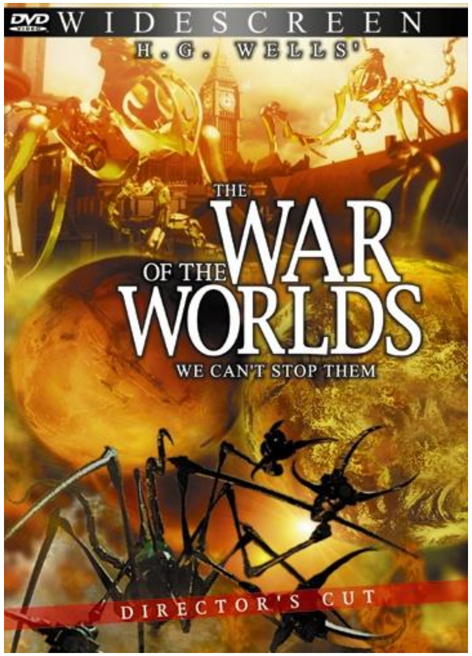
Luciano de Samósata

(c. 125-depois de 180 d.C)

História Verdadeira

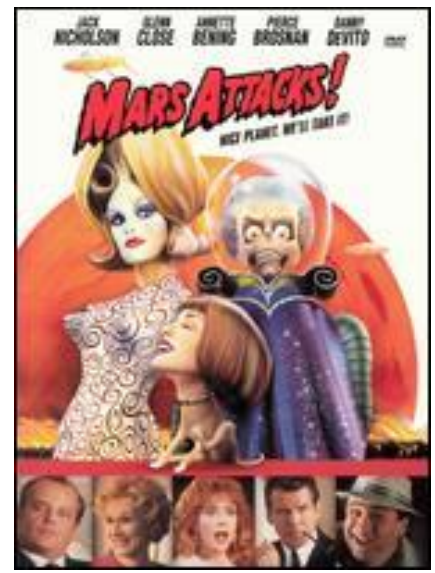
MARTE





The War of the Worlds (1898)

The Red Angry Planet (1959)



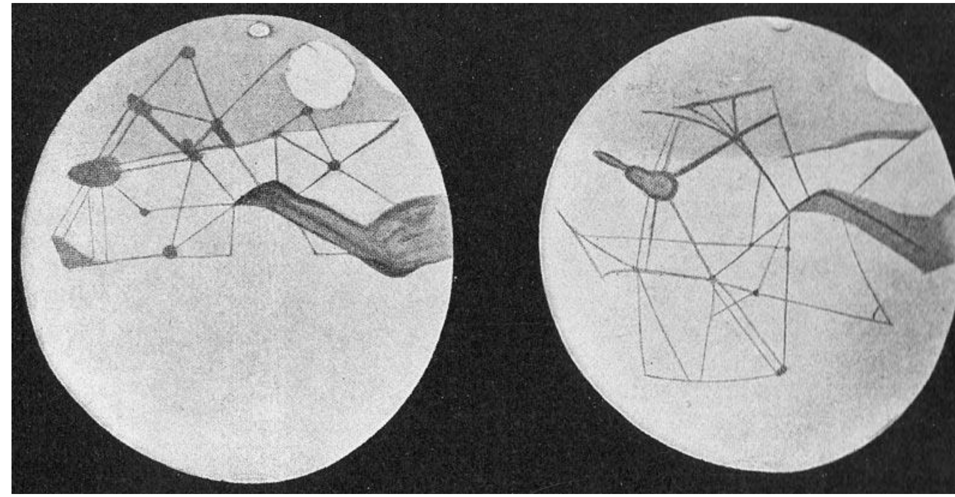
Marte Ataca! (1996)

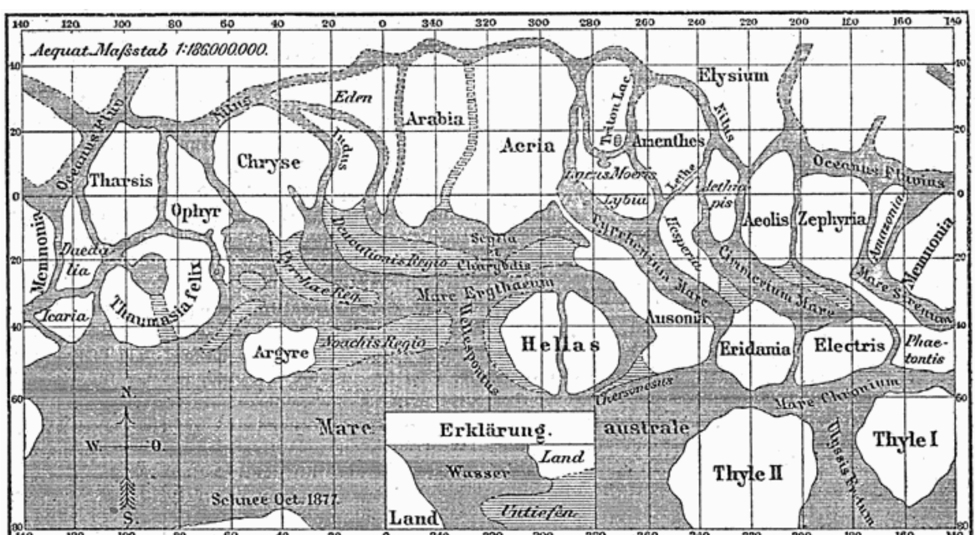
History of Martian “Civilization”

- In 1784 William Herschel (famous for the discovery of Uranus) claimed that Mars has an atmosphere and is therefore probably inhabited.
- Giovanni Schiaparelli claimed to see a network of 79 linear channels (canali) in 1877
- Percival Lowell opened Lowell Observatory in Flagstaff, Arizona in 1894. (claimed to see 200 canals)
- Lowell suggested that canals were built by an ancient martian civilization.

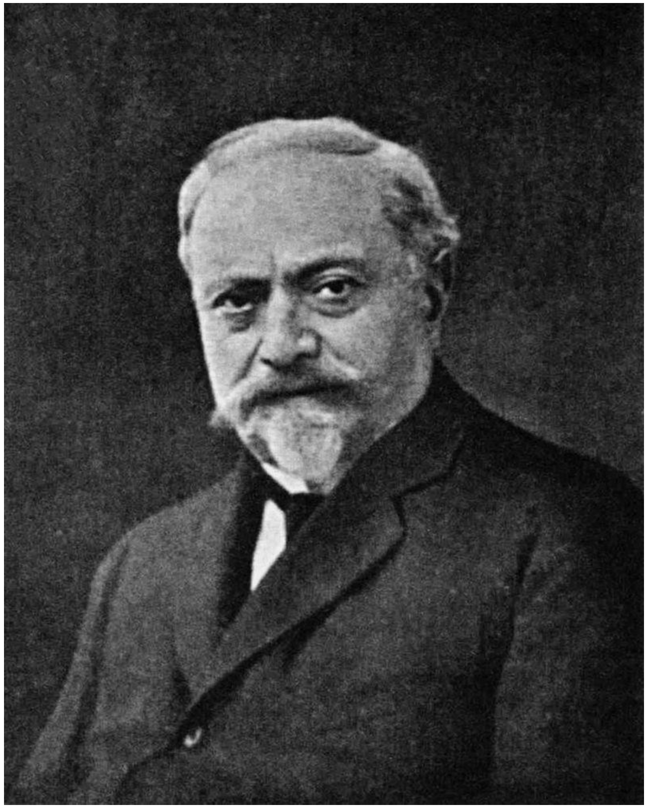
William Herschel
(1738 -1822)

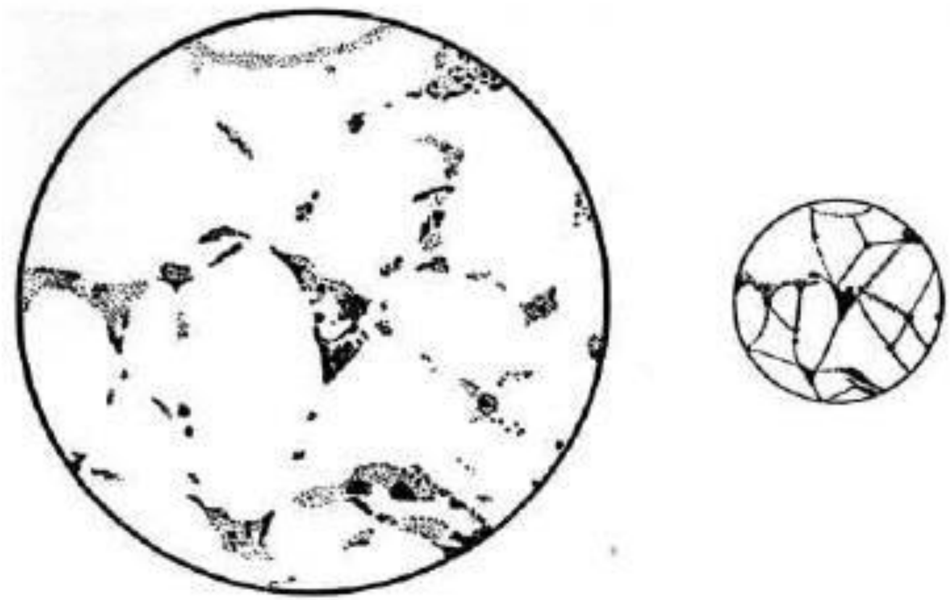
Giovanni Schiaparelli
(1835-1910)





Percival Lowell
(1855-1916)



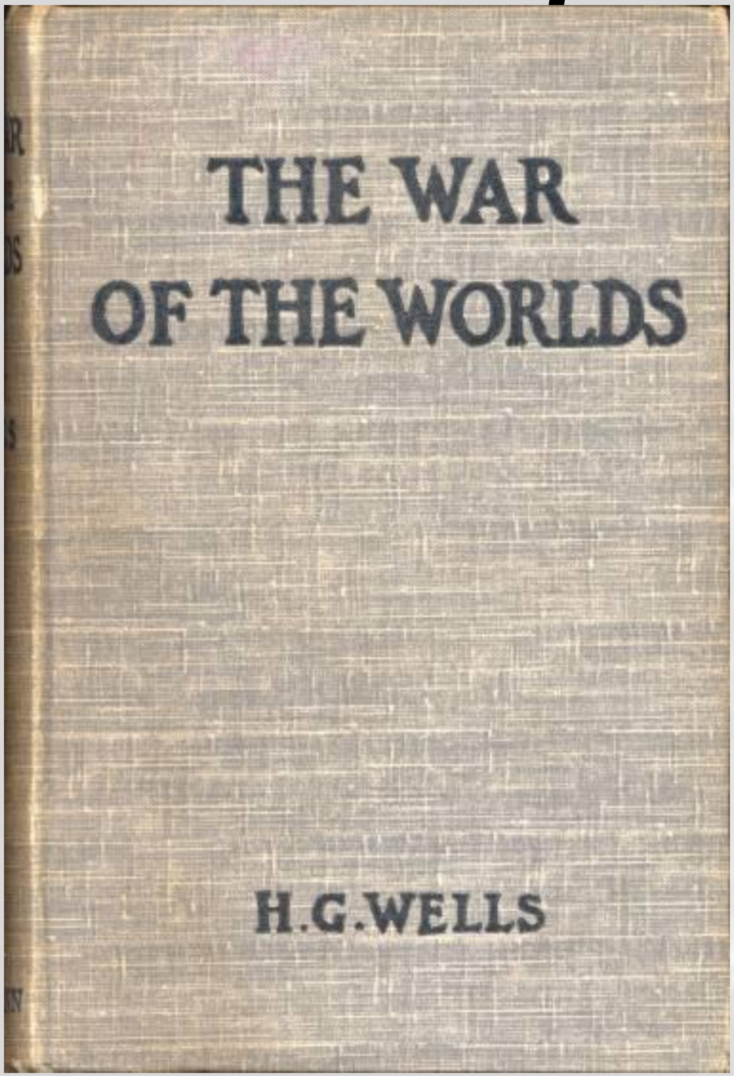


"Os canais são ilusões de óptica."

Vincenzo Cerulli (1859-1927)

Os ETs são expulsos de Marte

The War of the Worlds (1898)



H.G. Wells (1866-1946)

SIGNATURES OF A SHADOW BIOSPHERE

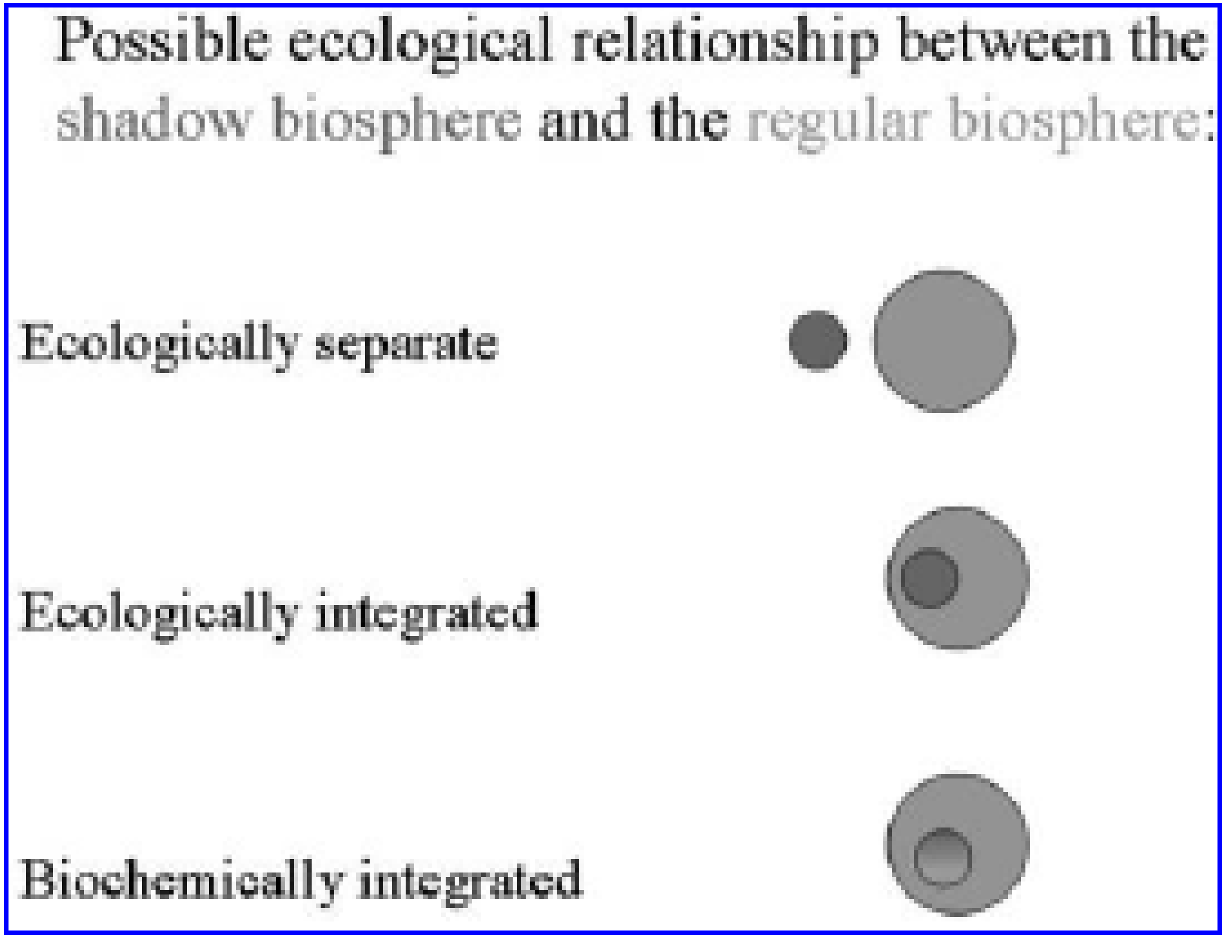
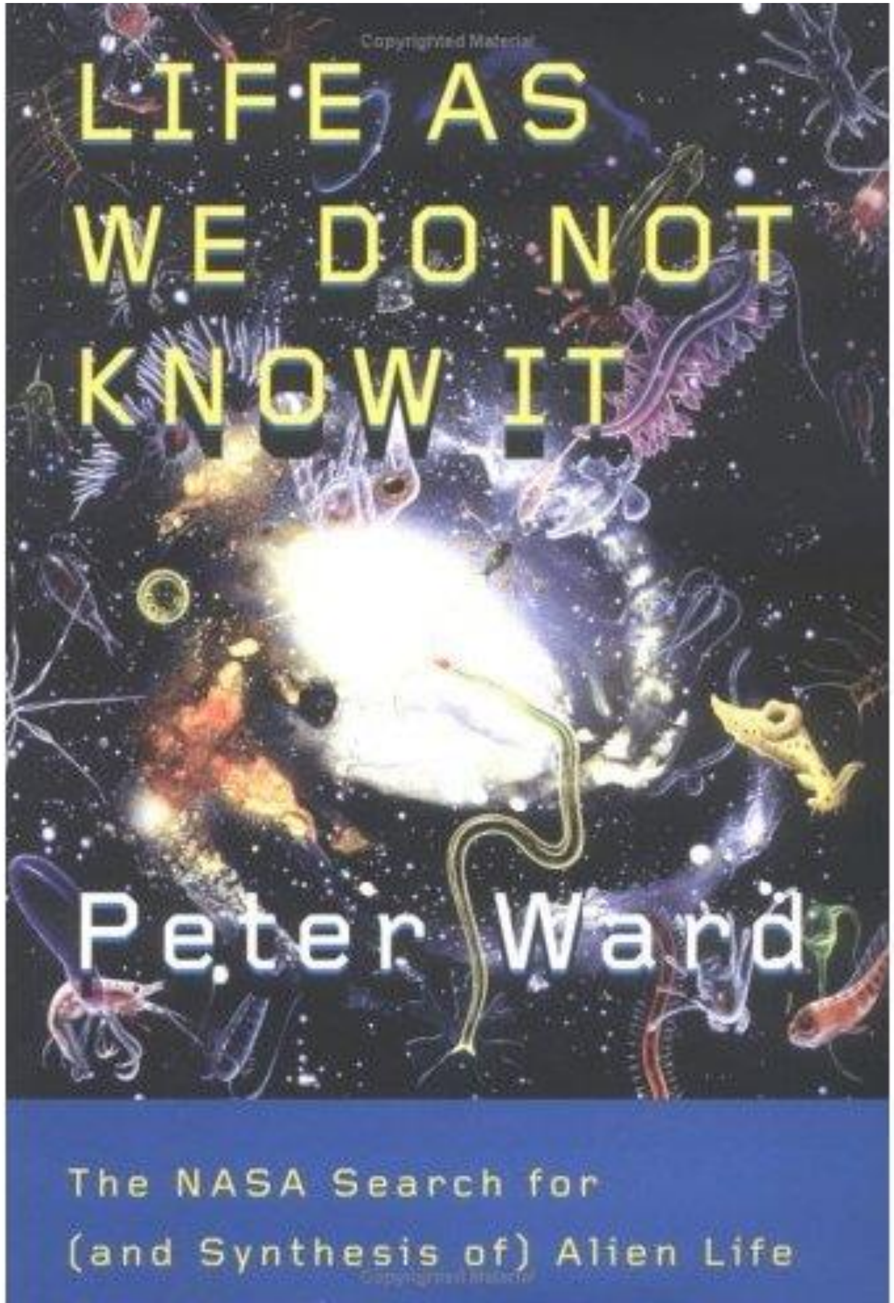
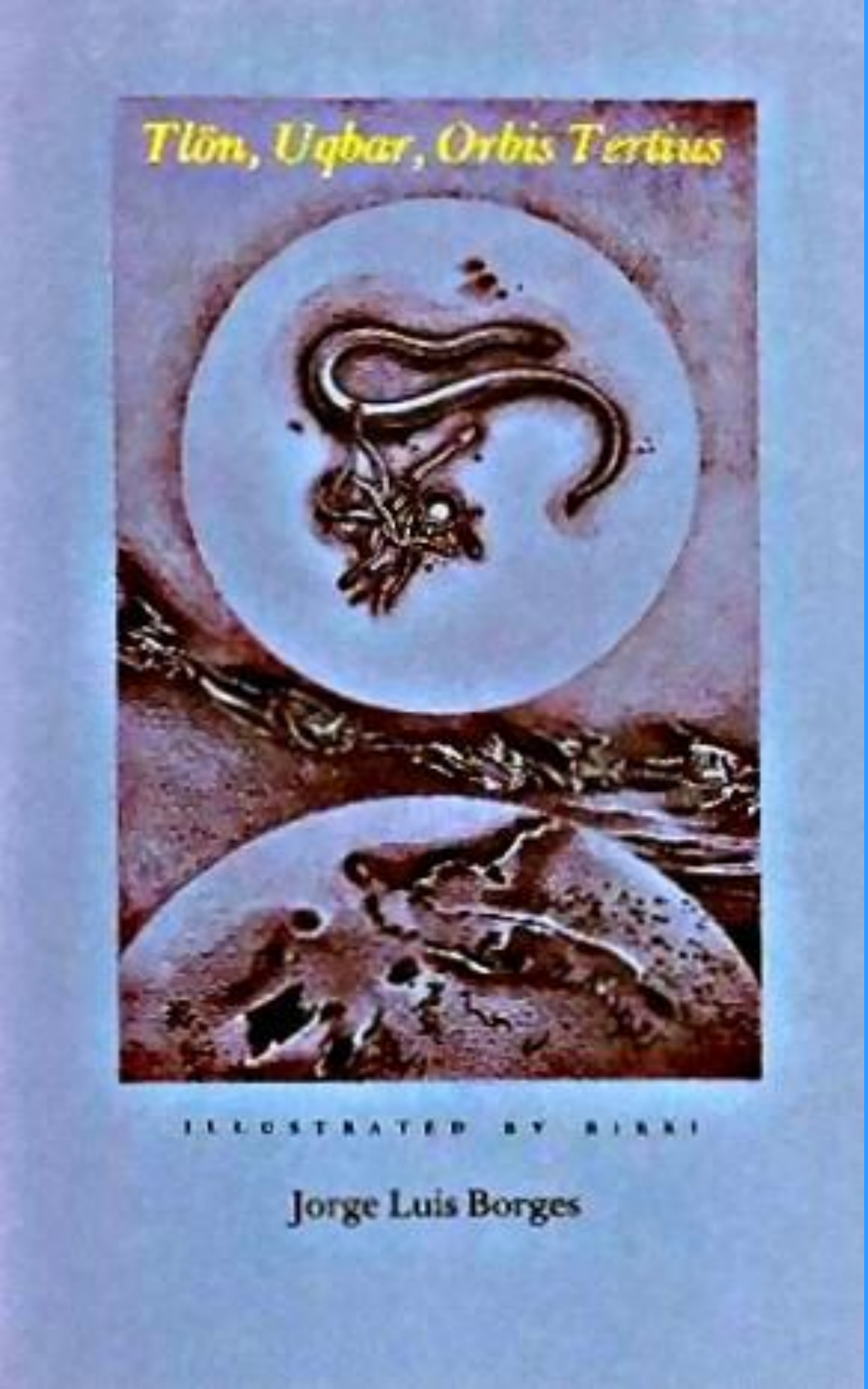


FIG. 1. Schematic representation of various possible relationships between known and weird life.


Copyrighted Material
LIFE AS
WE DO NOT
KNOW IT
Peter Ward
The NASA Search for
(and Synthesis of) Alien Life
Copyrighted Material

O mundo será Tlön.



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.

Marte Ataca!

Orson Welles (CBS Radio, 30/10/1938)

my eyes go looking for flying saucers in the sky

PAGE 2 THE CHICAGO UN. THURSDAY, JUNE 26, 1947

In These United States

Supersonic Flying Saucers Sighted by Idaho Pilot

Speed Estimated at 1,200 Miles an Hour When Seen 10,000 Feet Up Near Mt. Rainier

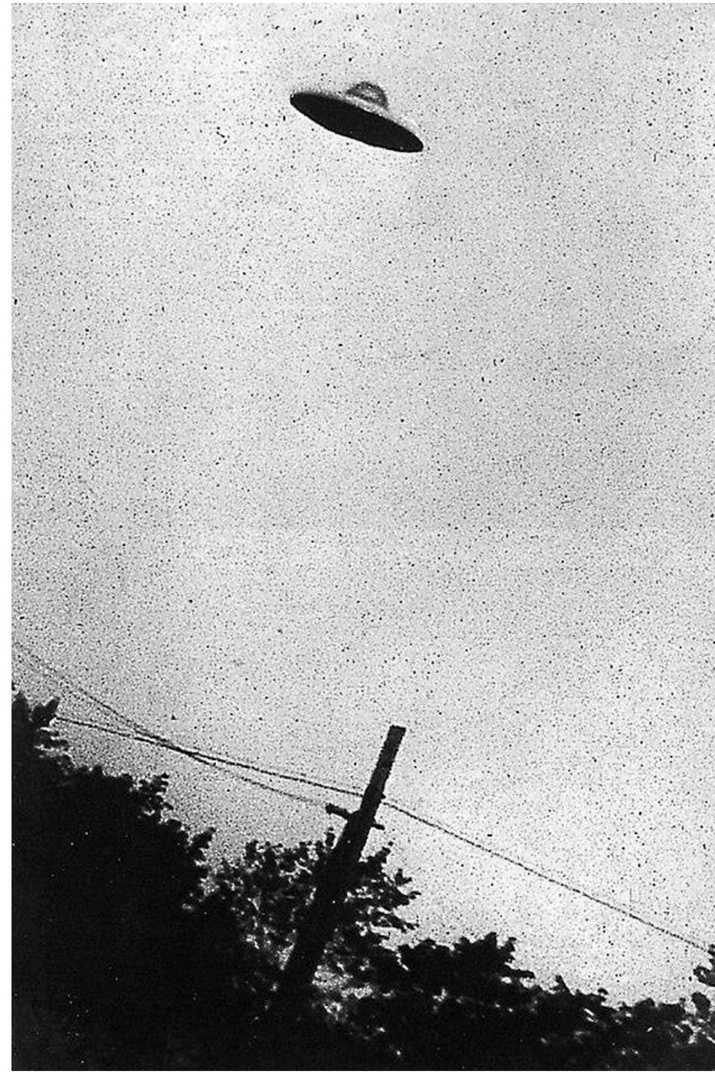
PENDLETON, Ore., June 25—(AP)

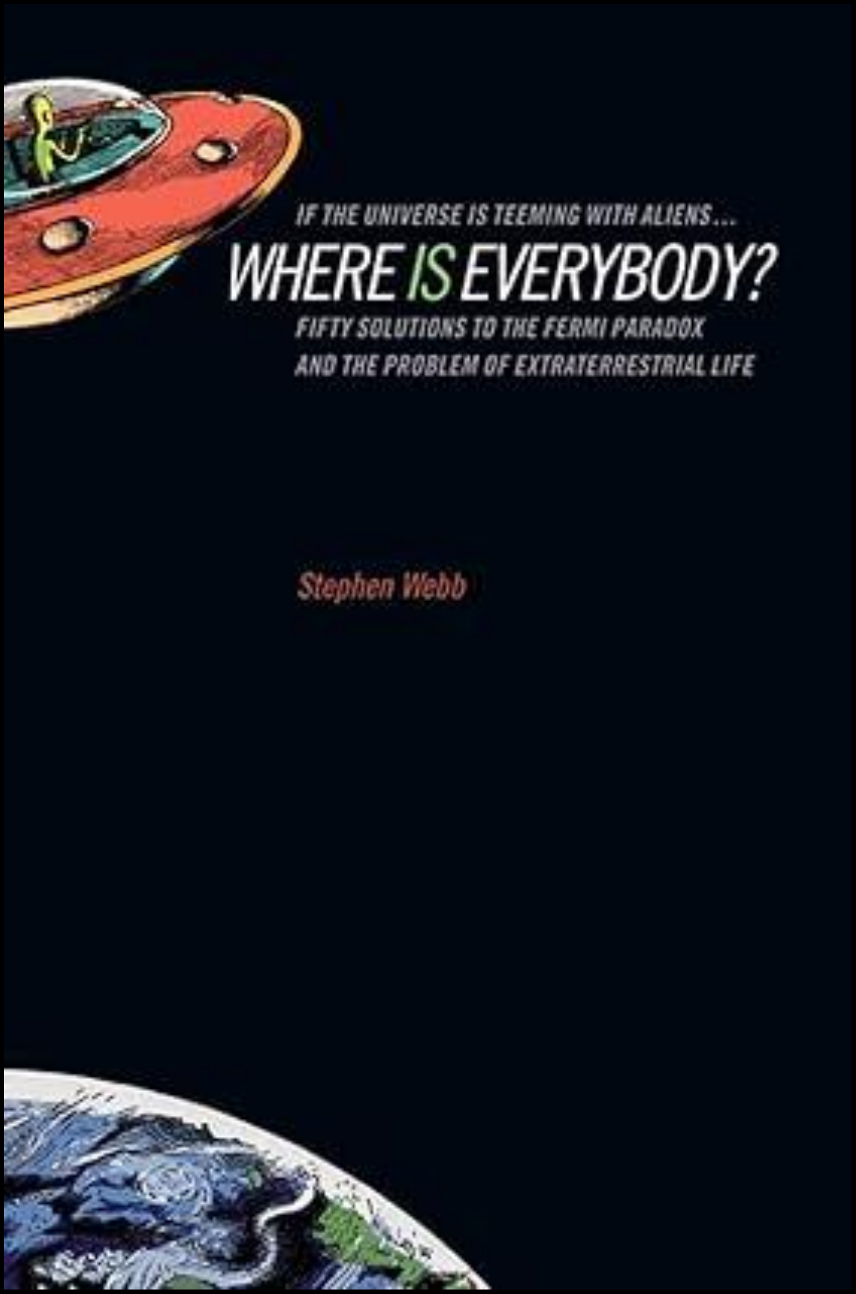
NINE bright, saucer-like objects flying at "incredible" speed at 10,000 feet altitude were reported here today by Kenneth Arnold, Boise (Idaho), pilot, who said he could not hazard a guess as to what they were.

Arnold, a U.S. Forest Service employee searching for a missing plane, said he sighted the mystery craft yesterday at 3 p.m. They were flying between Mount Rainier and Mount Adams, in Washington state, he said, and appeared to weave in and out of formation. Arnold said he clocked them and estimated their speed at 1,200 miles an hour.

Inquiries at Yakima last night brought only blank stares, he said, but he added he talked today with an unidentified man from Ukiah, south of here, who said he had seen similar objects over the mountains near Ukiah yesterday.

"It seems impossible," Arnold said, "but there it is."

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

Duncan H. Forgan

Scottish Universities Physics Alliance (SUPA), Institute for Astronomy, University of Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK
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.

O Templo da Natureza

Lao Tze

Seneca

São Francisco

Erasmus Darwin

John Muir

Aldo Leopold

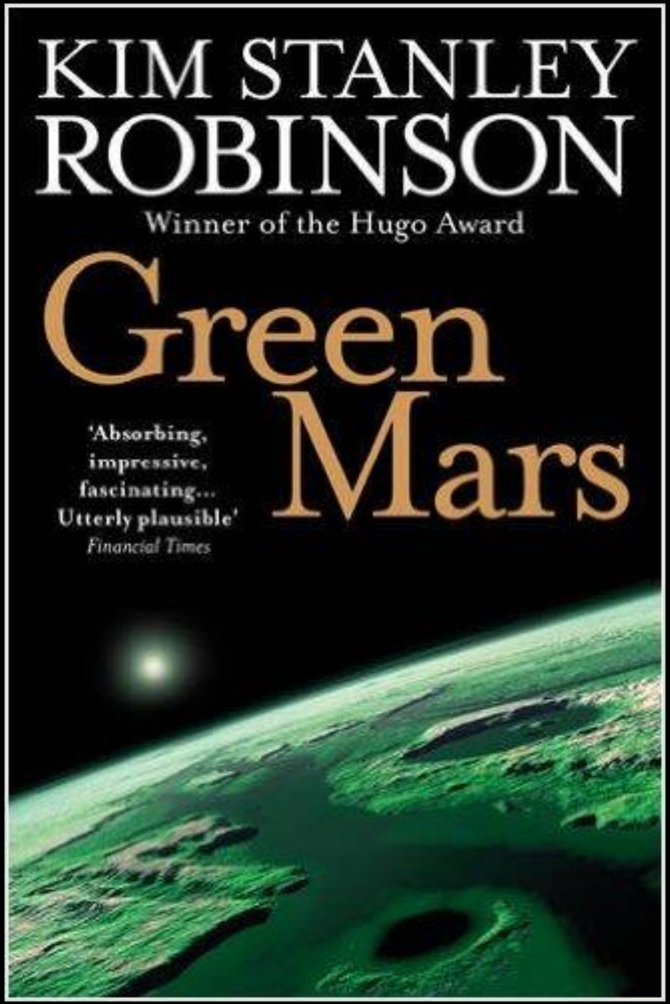
Arne Naess

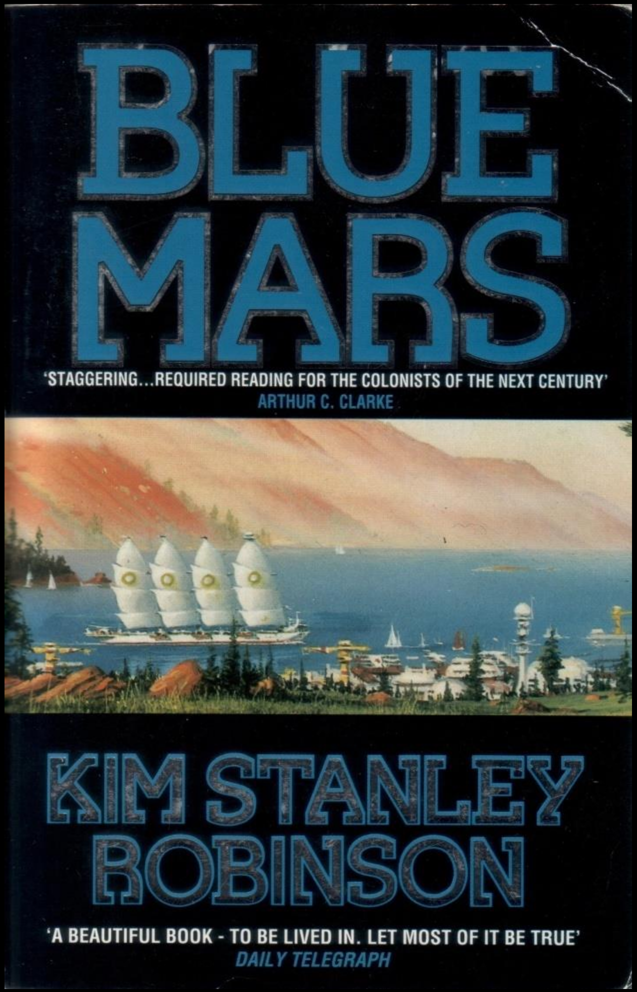
James Lovelock

RED MARS

'A staggering book... The best novel on the colonization of Mars that has ever been written'
ARTHUR C. CLARKE

KIM STANLEY ROBINSON


KIM STANLEY
ROBINSON
Winner of the Hugo Award
Green
Mars
'Absorbing,
impressive,
fascinating...
Utterly plausible'
Financial Times

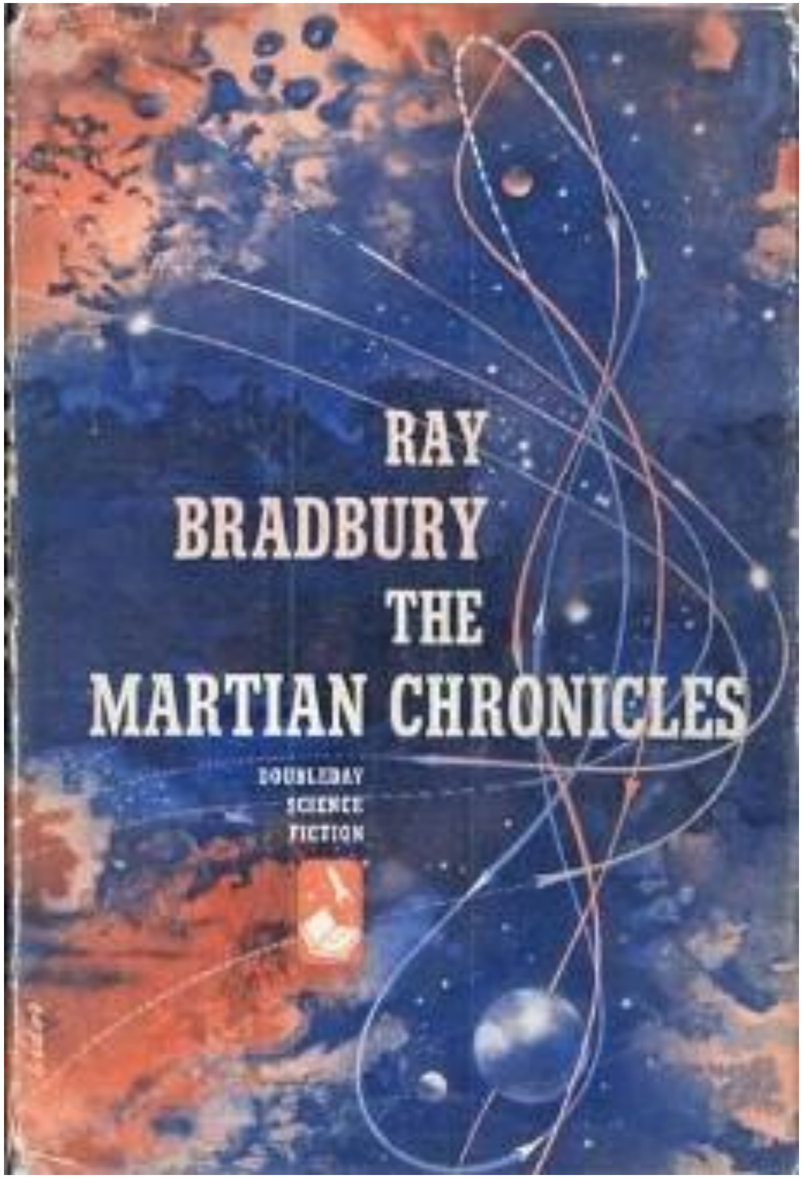

BLUE
MARS
'STAGGERING...REQUIRED READING FOR THE COLONISTS OF THE NEXT CENTURY'
ARTHUR C. CLARKE
KIM STANLEY
ROBINSON
'A BEAUTIFUL BOOK - TO BE LIVED IN. LET MOST OF IT BE TRUE'
DAILY TELEGRAPH

ASTROBIOLOGY
Volume 1, Number 1, 2001
Mary Ann Liebert, Inc.

Research Paper

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

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



The Martian Chronicles (1950)
Ray Bradbury

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...


THE MILLION YEAR PICNIC
SOMEHOW THE IDEA WAS BROUGHT UP BY MOM THAT PERHAPS THE WHOLE FAMILY WOULD ENJOY A FISHING TRIP. BUT THEY WEREN'T MOM'S WORDS; TIMOTHY KNEW THAT. THEY WERE DAD'S WORDS, AND MOM USED THEM FOR HIM, SOMEHOW. IMMEDIATELY, THERE WAS A TUMULT AND A SHOUTING, AND QUICK AS JETS, THE CAMP WAS TUCKED INTO CAPSULES AND CONTAINERS. MOM SLIPPED INTO TRAVELING JUMPERS AND BLOUSE, DAD STUFFED HIS PIPE... HIS EYES ON THE MARTIAN SKY, AND THE THREE BOYS PILED... YELLING... INTO THE MOTOR BOAT...
HURRAH!
A PICNIC-FISHING-TRIP!
CAREFUL, MIKE... ROBERT...
C'MON, TIMMY...
SEVERIN AND ELDER
ADAPTED FROM A STORY BY
RAY BRADBURY
DAD PUSHED A STUD. THE MOTOR BOAT SENT A HUMMING SOUND UP INTO THE SKY. THE WATER SHOOK BACK AND THE BOAT NOSED AHEAD. TIMOTHY SAT BESIDE DAD, HIS SMALL FINGERS ON TOP OF DAD'S HAIRY ONES. DAD HAD A FUNNY LOOK IN HIS EYES AS THE BOAT WENT UP-CANAL... A LOOK THAT TIMOTHY COULDN'T FIGURE...
HOW FAR ARE WE GOING, DAD?
A MILLION YEARS.
GEE...
YEAH...
MOTHER POINTED ONE SOFT LONG ARM...
LOOK, CHILDREN! THERE'S A DEAD CITY.
WOW!
GOLLY!
THE DEAD CITY LAY DEAD FOR THEM AND THEM ALONE, DROWSING IN THE HOT SILENCE OF THE MARTIAN SUMMER. AND DAD LOOKED AS IF HE WAS PLEASED THAT IT WAS DEAD...
1


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...

Vede, senhor Nicetas – disse Baudolino-, quando eu não era presa das tentações deste mundo, dedicava noites a imaginar outros mundos. Um tanto com ajuda do vinho e outro tanto com a do mel verde. Não há nada melhor que imaginar outros mundos – disse – para esquecer como é doloroso este em que vivemos. Pelo menos era o que eu pensava na altura. Ainda não tinha percebido que a imaginar outros mundos se acaba por mudar até este.

Umberto Eco, Baudolino