

O que é a vida?

Questões vetores

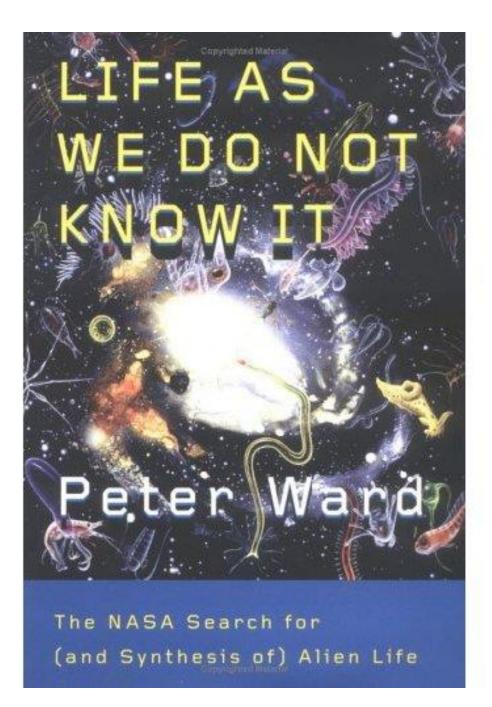
- O que é a vida?
 - uma questão além da biologia comum
 - subjetividade e definibilidade
- Como seria a vida fora da Terra?
 - a vida como nós não conhecemos
- Como detectar a vida fora da Terra?
 - Explorações in situ
 - Criptoecosistemas
 - Exomicropaleontologia
 - Bioassinaturas
 - Ecocatástrofes
 - Síndrome Gaia

Algumas Questões em Astrobiologia

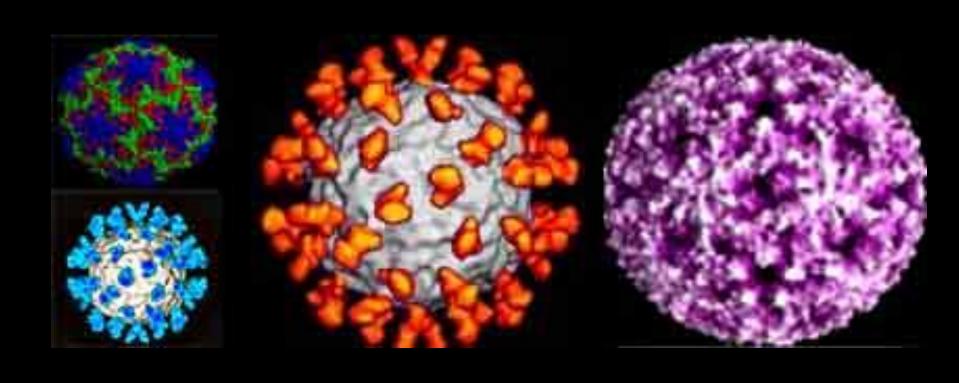
- Como a vida começou na Terra e como ela evolui?
- Quais são os princípios que regem a organização da matéria que resultou nos seres vivos?
- Como a biosfera de nosso planeta evoluiu?
- Existem outros planetas como a Terra?
- Como reconhecer a assinatura de vida em outros corpos celestes?
- O que torna um planeta habitável?
- Será a vida um fenômeno comum no Universo?
- Qual será o futuro da espécie humana, na medida em que a vida terrestre se expanda para além de seu planeta de origem?

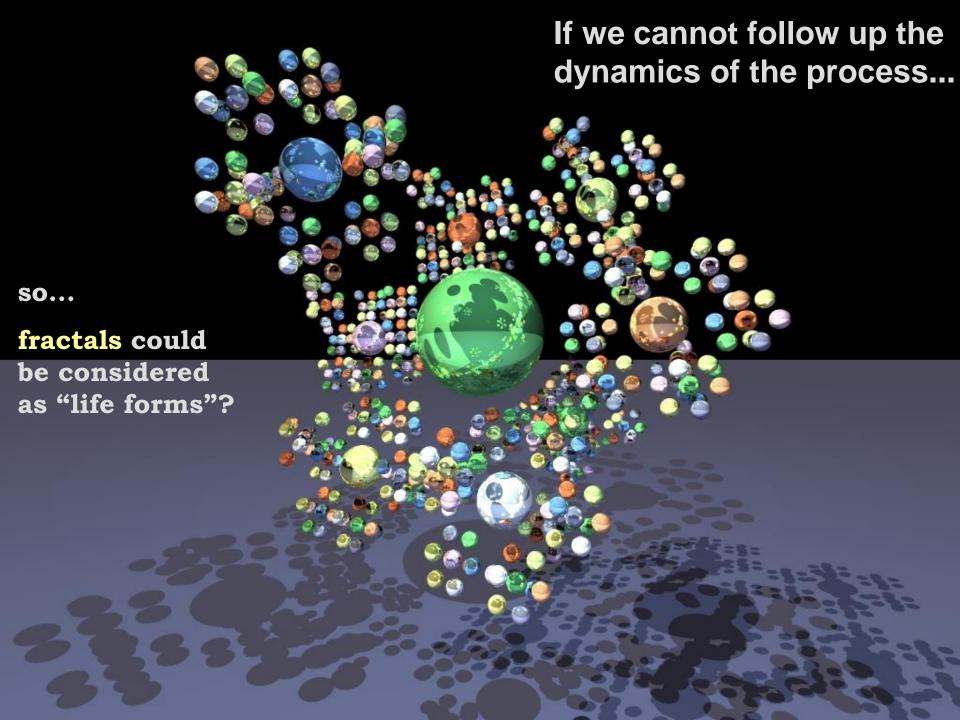
Questões Fundamentais (NAI Roadmap)

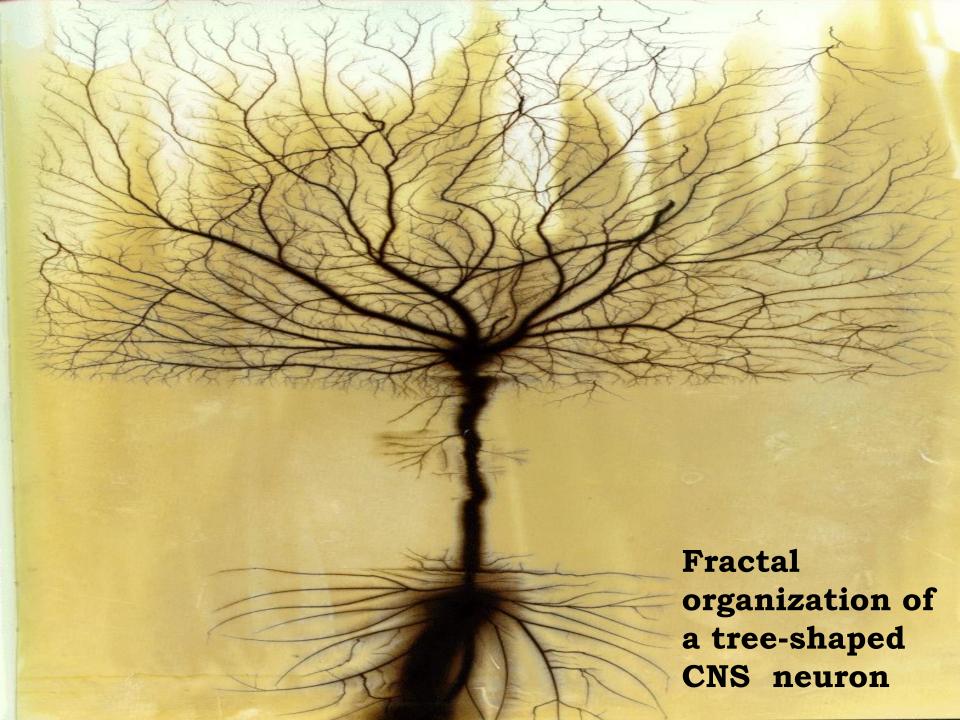
- 1. Como a vida se originou e evoluiu?
- 2. Existe vida em outras partes do Universo?
- 3. Qual será o futuro da vida na Terra e além?



É vivo ou não?







How can we define life?

- First of all, its essence is subjective
- In second place, we can list a number of characteristics (Schneider, astro-ph/9604131, 1996; Szostak et al., Nature, 2001; Bains, Astrobiology, 2005; Lunine 2005)
 - Complex and diversified interaction with the environment
 - System out of thermodynamical equilibrium
 - High information content
 - Memory + reading/recovering mechanism
 - Self-replication

Life is a self-sustained chemical system, capable of evolution in a Darwinian sense (Joyce 1994).





INTO

ENERGY FLOW

THE

THERMODYNAMICS

COOL

AND LIFE





Lynn Margulis & Dorion Sagan



DEFINING 'LIFE'

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Abstract. There is no broadly accepted definition of 'life.' Suggested definitions face problems, often in the form of robust counter-examples. Here we use insights from philosophical investigations into language to argue that defining 'life' currently poses a dilemma analogous to that faced by those hoping to define 'water' before the existence of molecular theory. In the absence of an analogous theory of the nature of living systems, interminable controversy over the definition of life is inescapable.

Keywords: definition of life, astrobiology, Viking, Europa, natural kinds

1. Definitions of Life

The philosophical question of the definition of 'life' has increasing practical importance. As science makes progress towards understanding the origin of life on Earth, as laboratory experiments approach the synthesis of life (as measured by the criteria of some definitions), and as greater attention is focused on astrobiology and the search for life on Mars and Jupiter's moon Europa, the utility of a general definition grows. In particular, definitions of 'life' are explicit or implicit in any remote in situ search for extratemental life. The design of life-detection experiments to be performed on Europa (Chyba and Phillips, 2001) or Mars (Conrad and Nealson, 2001) by spacecraft landers depends on assumptions about what life is, and what observations will count as evidence for its detection.

The Viking missions' searches for life on Mars in 1976 remain the only dedicated in situ searches for extraterrestrial life to date. The Viking biology package experiments looked for signs of microbial metabolism (Ezell and Ezell, 1984). Reviewing the results of one of the experiments in the package, the Labeled Release experiment, the head of the Viking biology team wrote in 1978 that, '... if information from other experiments on board the two Viking landers had not been available, this set of data would almost certainly have been interpreted as presumptive evidence of biology' (Klein, 1978).

However, such an interpretation was widely rejected for a number of reasons, including proposed chemical explanations for the observations in terms of oxidizing

ABOUT VARIOUS DEFINITIONS OF LIFE

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(Received 25 March 1997)

Abstract. The old question of a definition of minimal life is taken up again at the aim of providing a forum for an updated discussion. Briefly discussed are the reasons why such an attempt has previously encountered scepticism, and why such an attempt should be renewed at this stage of the inquiry on the origin of life. Then some of the definitions of life presently used are cited and briefly discussed, starting with the definition adopted by NASA as a general working definition. It is shown that this is too limited if one wishes to provide a broad encompassing definition, and some extensions of it are presented and discussed. Finally it is shown how the different definitions of life reflect the main schools of thought that presently dominate the field on the origin of life.

Dedicated to Prof. Dieter Seebach for his 60th birthday

1. Introduction

One might think that among the many people working in fields of prebiotic life, artificial life, cell models and the like, one finds many references to a definition of life in the literature. These researchers should know what they are researching or what they are trying to reproduce in their laboratories. This is not the case: actually definitions of life are rare (some definitions are cited in Chyba and McDonald (1995)**, by Folsome (1979), or in the recent book edited by Rizzotti (Rizzotti, 1996)), and those which are given are not very popular. The reason why this is so would already be 'per se' an interesting argument of discussion. It would also be interesting to follow how these few definitions have changed in the course of the years, as these changes automatically reflect how science values have moved with time (e.g. proteins versus nucleic acids, metabolism versus self-replication, etc.)***.

An analysis of the various definitions of life given in history is, however, out of the framework of the present short article. Some old definitions of life, which are relevant for the arguments presented here, will be given without further comments as footnotes.

One interesting and often forgotten definition I would like to add without further comment goes back to M. Perret in the early fifties (Perret, 1952). This definition was later taken up by J. D. Bernal (1965). It reads: 'Life is a potentially self-perpetuating system of linked organic reactions, catalyzed stepwise and almost isothermally by complex and specific organic catalysts which are themselves produced by the system'.

I find particularly fascinating the definition of life given 1894 by Engels (yes! Friedrich Engels of Karl Marx' memory) and particularly what he says about life and chemistry (Engels, 1894). His definition reads: 'Life is the existence form of proteic structures, and this existence form consists essentially in the constant self-renewal of the chemical components of these structures' (Engels knew about Haeckel's work, who in turn knew about Rolle's ideas – none of them at that time had a clear notion of what proteins really were.

Requisitos de uma definição de vida

- ser universal e coerente com a compreensão dos sistemas vivos na ciência moderna
- ser estruturada de modo a proporcionar uma compreensão clara e uma transmissão fácil de seu conteúdo no meio científico
- estar inserida em paradigma específico, de modo a apresentar uma sólida base teórica

Emmeche (1997, 1998)

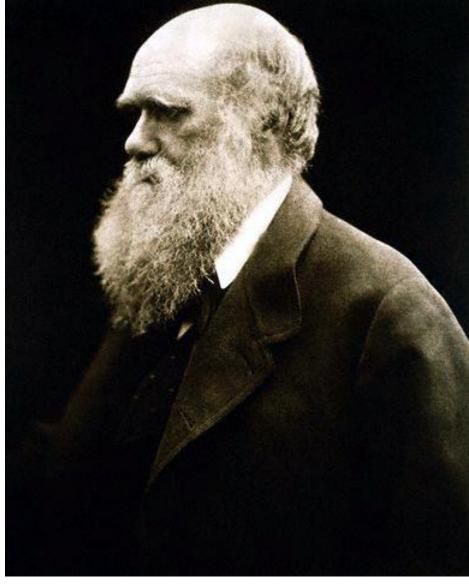
CORPOS PARADIGMÁTICOS

- Evolução Darwiniana
- Fenômenos Emergentes
- Autopoiesis
- Biossemiótica

"The origin of species by means of natural selection" (1858)

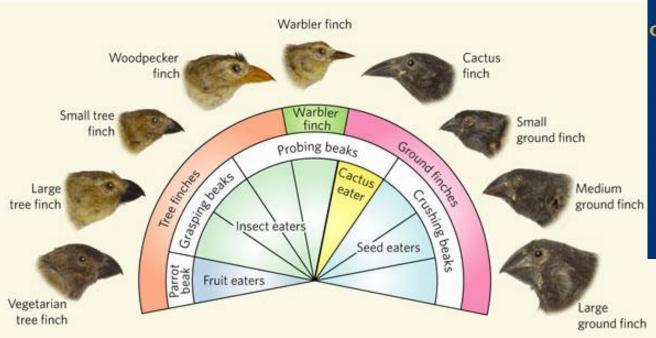
- 1) Any population of a species has the potential to produce **far more** offspring than the environment can support with resources.
- 2) The overproduction leads to **a struggle for survival** among the individuals.
- 3) Population consists of individuals that are slightly different from one another in **many heritable traits**.
- 4) Some individuals possess traits that make them **better** able **to compete** for resources.

Conclusion: In any local environment, heritable traits that enhance survival and successful reproduction will become progressively more common in succeeding generations.



Charles Darwin (1809-1882)

Seleção Natural (Evolução Darwiniana)





Todos os tendilhões das Ilhas Galápagos tinham um ancestral comum proveniente da América do Sul. Mas todas a espécies se adaptaram a microambientes particulares.

Seleção Artificial

Descendentes do lobo cinzento





- O que é a vida?
- Como se distinguir entre "vivo" e "não vivo"?





Objetos não-vivos não estão sujeitos à Evolução Darwiniana





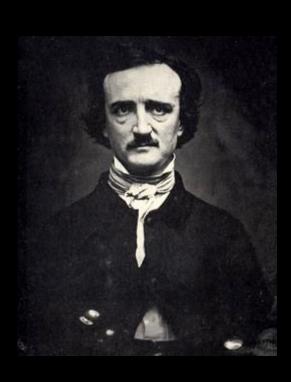
Algumas características da vida

- 1. Ordem/estrutura
- 2. Reprodução
- 3. Crescimento/desenvolvimento
- 4. Utilização de Energia
- 5. Resposta ao Ambiente
- 6. Adaptação evolutiva

FRONTEIRAS

- Vivo/Morto
- Máquina/Organismo
- Química/Biologia

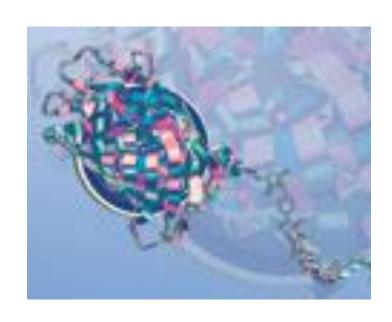
Edgar Allan Poe (1809-1849)

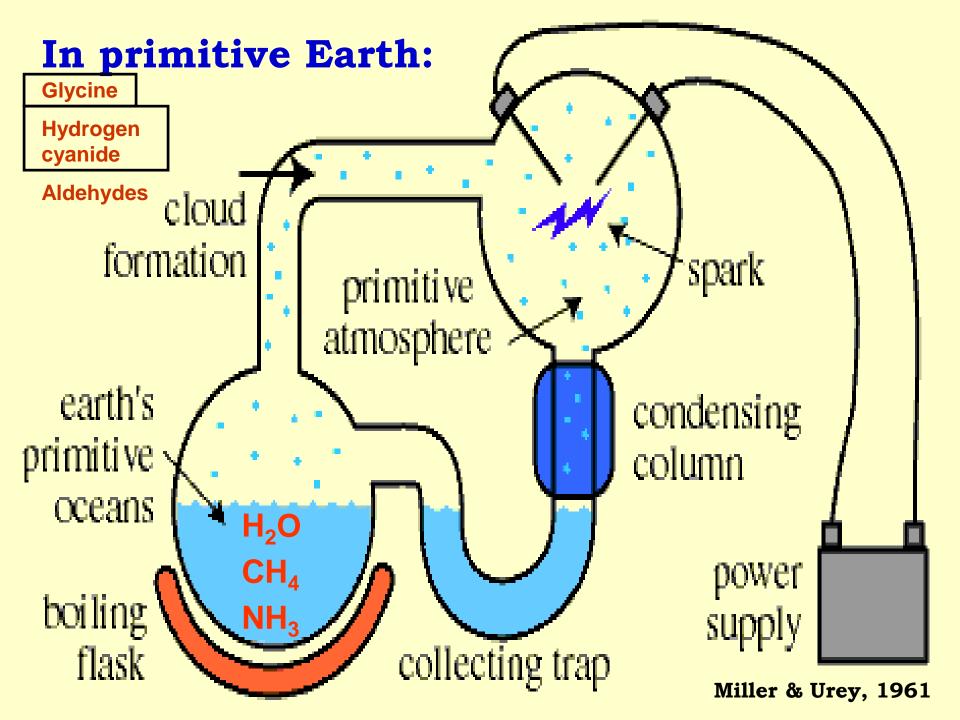




Chemistry in the New World of Bioengineering and Synthetic Biology

22 - 24 September 2008 Oxford, United Kingdom





For a practical search, restrictive hipothesis...

- What kind of complex systems?
 - Liquid crystals, plasmas...
- Conservative hypothesis: a chemical system
 - C, Si?
- Presence of a liquid millieu?
 - H₂O: excelent solvant and abundant in the Universe
- Existence of a solid/liquid interface?
 - Favours molecular interactions...

Questions

- 1) Does life need, necessarily, such atoms and physical-chemical conditions?
- 2) Can life develop, in another planet, under totally different conditions?

 © Shirley Owens and Catherine McGowan, 1996

FOLLOW THE LIFE

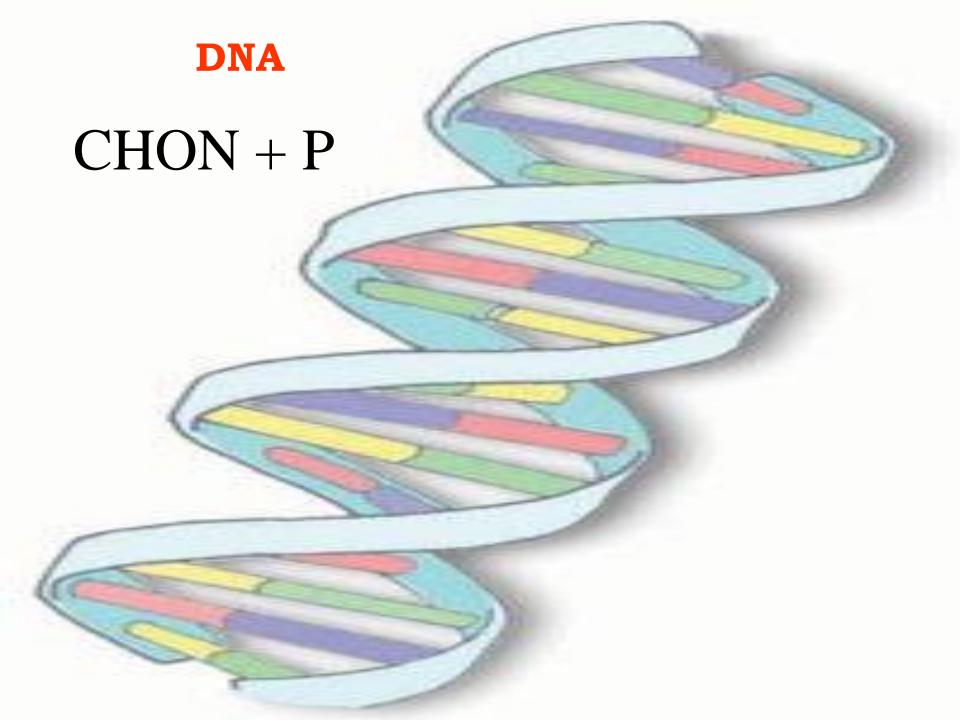
- Solvent
- Biogenic elements
- Source of Free Energy

searches for life within our solar system commonly retreat from a search for life to a search for "life as we know it," meaning life based on liquid water, a suite of so-called "biogenic" elements (most famously carbon), and a usable source of free energy.

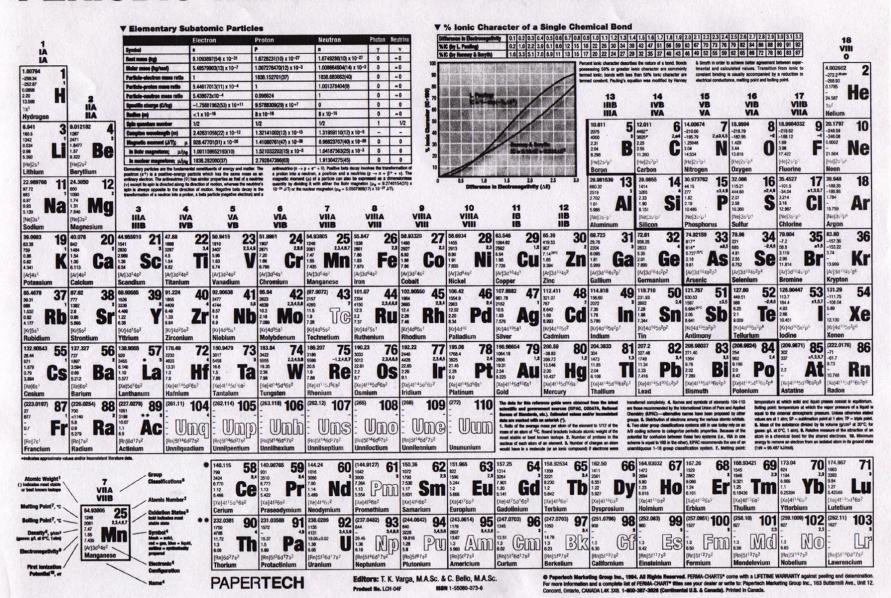
(Chyba & Hand, 2005, p. 34)

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



PERIODIC TABLE OF THE ELEMENTS



A Tabela Periódica dos Astrônomos











Água

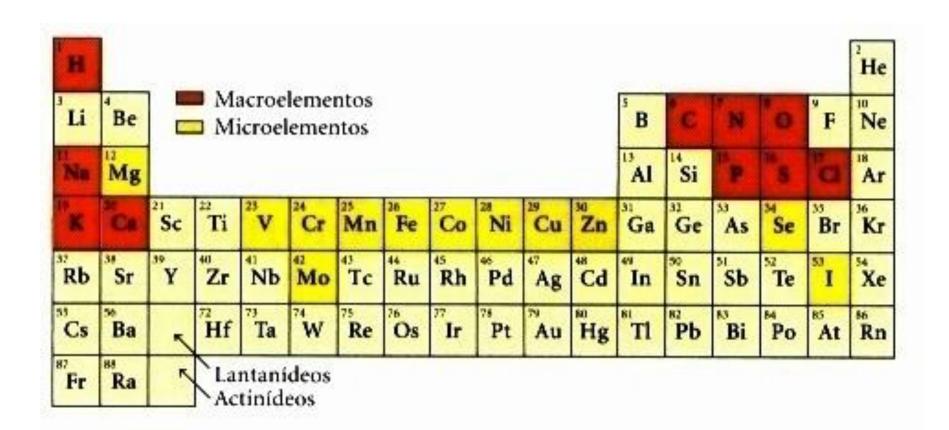
Principal componente dos cometas e dos seres vivos





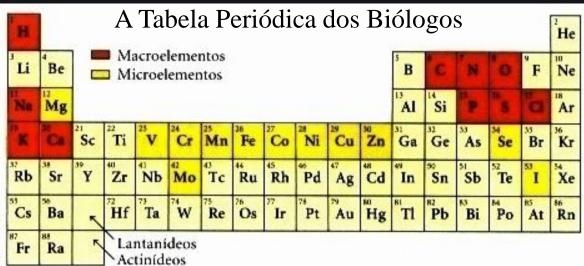
Assim, o Oxigênio e o Hidrogênio são os elementos principais de seres vivos terrestres e do Universo

Logo atrás vem o Carbono e o Nitrogênio.



A Tabela Periódica dos Astrônomos













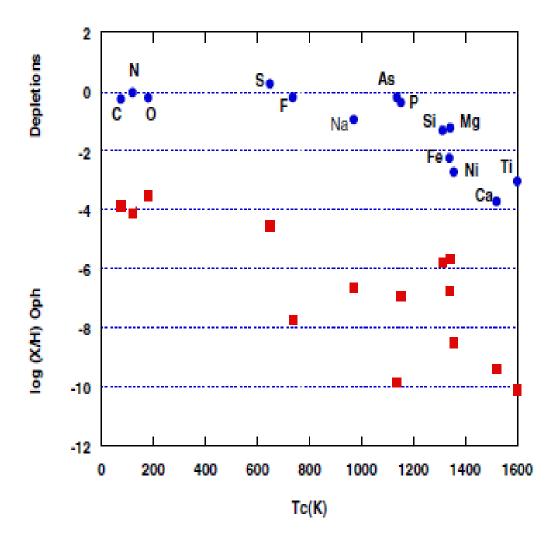
Abundâncias relativas dos elementos químicos

Relative number abundances of chemical elements (O=100)

The abundances are in number (decreasing order)

Sources: Lehninger 2000 (human body and Earth crust abundances); Asplund, Grevesse & Sauval 2004 (C, N, and O are solar photospheric values; the other elements are Solar System meteoritic values)

Human Body	Earth Crust	Cosmic	
H 247	O 100	H 21 900	
O 100	Si 59.6	O 100	
C 37.3	Al 16.8	C 53.7	
N 5.49	Fe 9.6	N 13.2	
Ca 1.22	Ca 7.5	Mg 7.41	
P 0.86	Na 5.3	Si 7.10	
CI 0.31	K 5.3	Fe 6.17	
K 0.24	Mg 4.7	S 3.16	
S 0.20	Ti 1.1	AI 0.58	
Na 0.12	H 0.4	Ca 0.43	
Mg 0.04	C 0.4	Na 0.41	



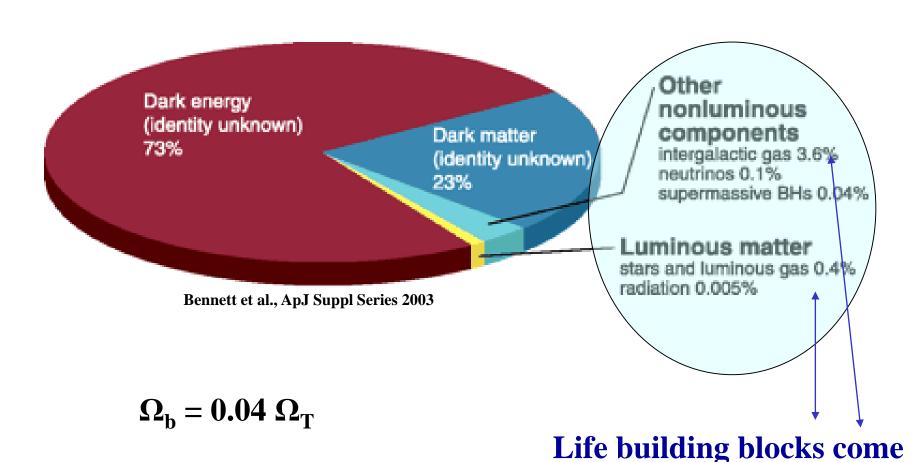


NGC 6543

HST • WFPC2
12/13/94 zgl

PR95-01a • ST Scl OPO • January 1995 • P. Harrington (U.MD), NASA

A cosmological perspective to search of life in the Universe...



from these components...

2 atoms	H_2	AlF	AlCl	C_2	CH	CH^+
	CN	CO	CO^+	CP	SiC	HCl
	KCl	NH	NO	NS	NaCl	OH
	PN	SO	SO^+	SiN	SiO	SiS
	CS	HF	HD	FeO (?)	O_2	CF^+
	SiH (?)	PO	AlO	OH^+	CN-	SH^+
	LiH	SH	N_2	$S_2\dagger$	$N_2^+\dagger$	$CN^{+\dagger}$
HNC NaCl H_3^+ HCP FeCN	C_3	C_2H	C_2O	C_2S	CH_2	HCN
	HCO	HCO^{+}	HCS^+	HOC^+	H_2O	H_2S
	HNC	HNO	MgCN	$_{ m MgNC}$	N_2H^+	N_2O
	NaCN	OCS	SO_2	$c - SiC_2$	CO_2	NH_2
	H_3^+	H_2D^+	HD_2^+	SiCN	AINC	SiNC
	HCP	CCP	AlOH	H_2O^+	H_2Cl^+	KCN
	FeCN	OCN^-	CO_2^+	H_2S^+	CN_2	HDO
	$CS_2\dagger$					
4 atoms	$c - C_3H$	$l-C_3H$	C_3N	C_3O	C_3S	C_2H_2
	NH_3	HCCN	$HCNH^+$	HNCO	HNCS	$HOCO^+$
	H_2CO	H_2CN	H_2CS	H_3O+	$c-SiC_3$	CH_3
	C_3N^-	$PH_3(?)$	HCNO	HOCN	HSCN	H_2O_2
	C_4 (??)					
5 atoms	C_{5}	C_4H	C_4Si	$l-C_3H_2$	$c-C_3H_2$	H_2CCN
	CH_4	HC_3N	HC_2NC	HCOOH	H_2CNH	H_2C_2O
	H_2NCN	HNC_3	SiH_4	H_2COH^+	C_4H^-	HC(O)CN
6 atoms	Cg H	$l-H_2C_4$	C_2H_4	CH_3CN	CH_3NC	CH_3OH
	CH_3SH	HC_3NH^+	HC_2CHO	NH_2CHO	Cg N	$l-HC_4H$
	$l-HC_4N$	$c-H_2C_3O$	$H_2CCNH(?)$	C_5N-		
7 atoms	C_6H	CH_2CHCN	CH_3C_2H	HC_5N	CH_3CHO	CH_3NH_2
	$c-C_2H_4O$	H_2CCHOH	C_6H –			
8 atoms	CH_3C_3N	$HC(O)OCH_3$	CH_3COOH	C_7H	H_2C_6	CH ₂ OHCHO
	$l-HC_6H$	$CH_2CHCHO(?)$	CH_2CCHCN	H_2NCH_2CN	$C_2H_6\dagger$	$(NH_2)_2CO(??$
9 atoms	CH_3C_4H	CH_3CH_2CN	$(CH_3)_2O$	CH_3CH_2OH	HC_7N	C_8H
	$CH_3C(O)NH_2$	C_8H^-	C_3H_6			
10 atoms	CH_3C_5N	$(CH_3)_2CO$	$(CH_2OH)_2$	CH_3CH_2CHO	$NH_2CH_2COOH(??)\dagger$	
11 atoms	HC_9N	CH_3C_6H	C_2H_5OCHO			
12 atoms	C_6H_6	$C_2H_5OCH_3$?	$n-C_3H_7CN$	$CO(CH_2OH)_2(??)$		
			$C_{14}H_{10}^{+}(??)$			

Molecules in Space

331 Molecules as if March 2024

LOOKING AT OTHER PLANETARY SYSTEMS:

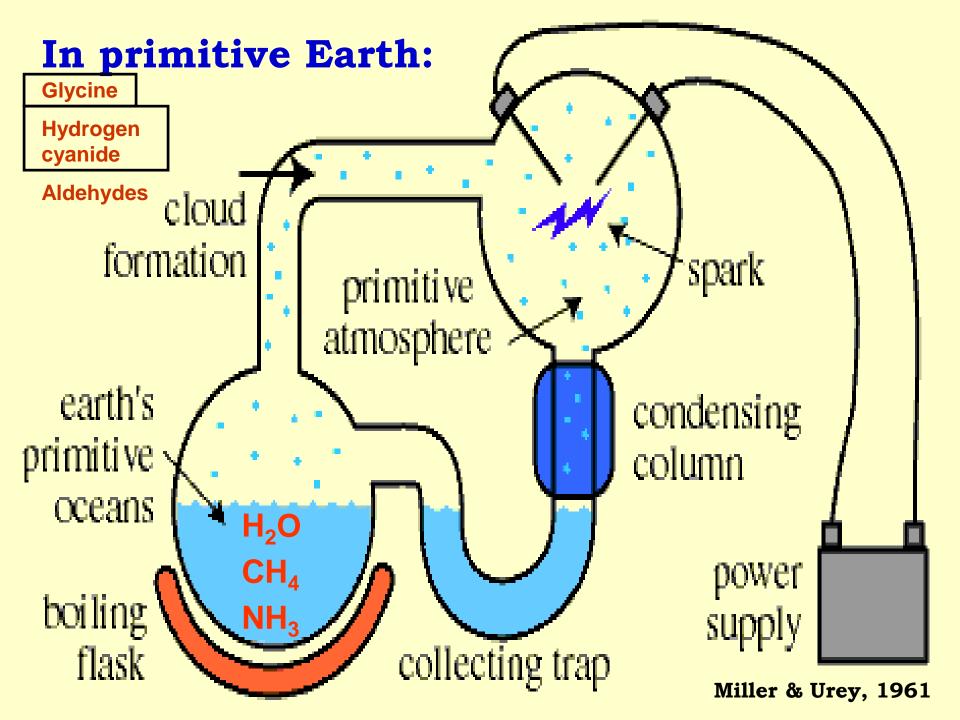
SEARCHING FOR KEY PREBIOTIC COMPOUNDS:

 H_2O

NH₃

CH₄

THOSE ARE FOUND UNDER RELATIVELY HIGH ABUNDANCES



Química de Sistemas

ORIGINS OF LIFE

Systems chemistry on early Earth

Jack W. Szostak

Understanding how life emerged on Earth is one of the greatest challenges facing modern chemistry. A new way of looking at the synthesis of RNA sidesteps a thorny problem in the field.

It is well established that the evolution of life passed through an early stage in which RNA played central roles in both inheritance and catalysis¹ — roles that are currently played by DNA and protein enzymes, respectively. But where did the RNA come from?

Experiments reported by Powner et al.² (page 239 of this issue) provide fresh insight into the chemical processes that might have led to the emergence of information-coding nucleic acids on early Earth.

For 40 years, efforts to understand the prebiotic synthesis of the ribonucleotide building blocks of RNA have been based on the assumption that they must have assembled from their three molecular components: a nucleobase (which can be adenine, guanine, cytosine or uracil), a ribose sugar and phosphate. Of the many difficulties encountered by those in the field, the most frustrating has been the failure to find any way of properly joining the pyrimidine nucleobases — cytosine and uracil — to ribose3 (Fig. 1a). The idea that a molecule as complex as RNA could have assembled spontaneously has therefore been viewed with increasing scepticism. This has led to a search for alternative, simpler genetic polymers that might have preceded RNA in the early history of life.

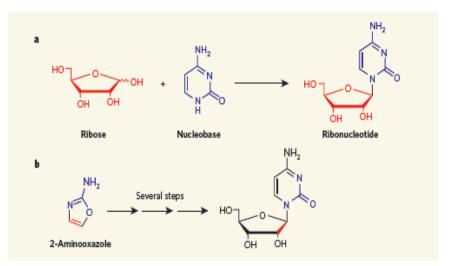


Figure 1 | Theories of prebiotic syntheses of pyrimidine ribonucleotides. The idea that RNA might have formed spontaneously on early Earth has inspired a search for feasible prebiotic syntheses of ribonucleotides, the building blocks of RNA. a, The traditional view is that the ribose sugar and nucleobase components of ribonucleotides formed separately, and then combined. But no plausible reactions have been found in which the two components could have joined together. b, Powner et al.² show that a single 2-aminooxazole intermediate could have contributed atoms to both the sugar and nucleobase portions of pyrimidine ribonucleotides, so that components did not have to form separately. For a more detailed overview of the pathways depicted here, see Figure 1 on page 239.

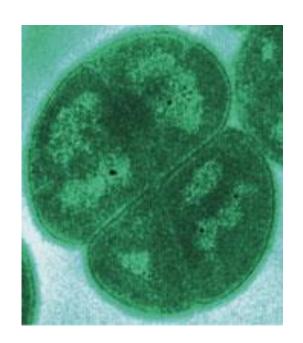
intractable tar of insoluble products. Similarly, simple carbon-nitrogen compounds, derived from cyanide and ammonia, react with each mixture of undesired compounds is formed. But Powner et al. add a third ingredient phosphate — to the mix. In their reaction, phosNature 559, 171 (2009)

Qual vida?

Extremófilos

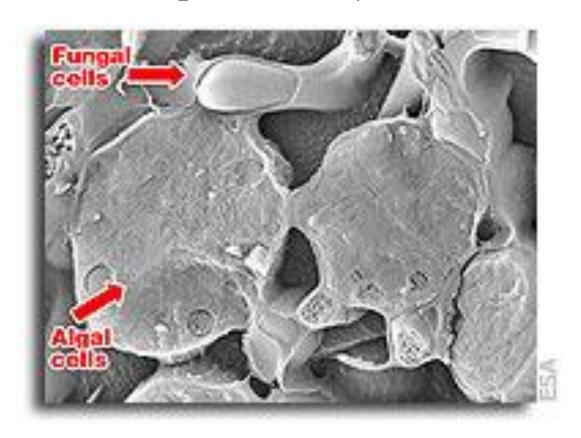
Que tipo de vida esperamos encontrar fora da Terra?

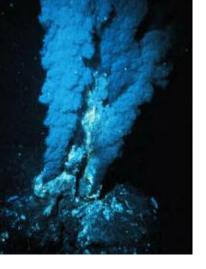
- O que é a vida?
- Um bom começo: Vida difícil de morrer!!!



Deinococcus radiodurans – prospera com 5 000 Gy (10 Gy mata o ser humano, 60 Gy a Escherichia Coli)

LICHEN CAN SURVIVE IN SPACE (http://www.astrobiology.com/news/viewpr.html?pid=18232)

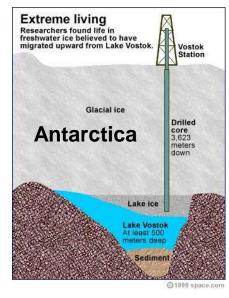


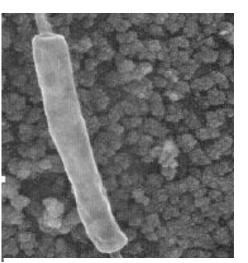


Hydrothermal vents

Extremophiles survival chart

- Temperature: -15° C < T < 230° C
- 0 < pH < 12
- 0 < Pressure < 1200 atm
- No mandatory oxygen-based metabolism
- 20-40 Myears of dormancy
- 2 ½ years in space, at 20 K, with no nutrients, water and exposed to radiation (*Strep. Mitis*)





Thermophile bacteria

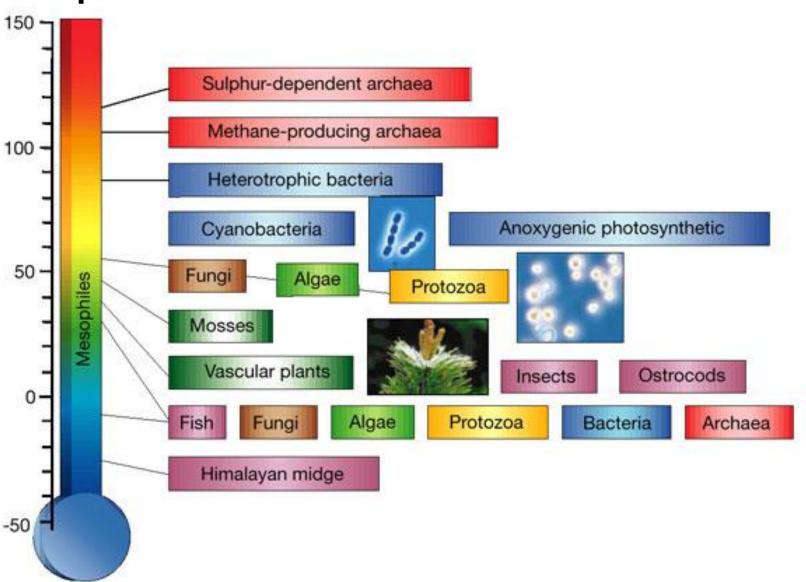
Hot geisers and volcanos



Cryptoendoliths

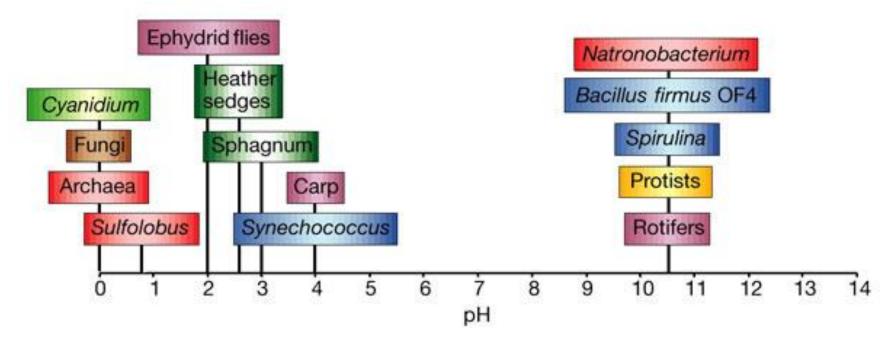


Temperature limits for life



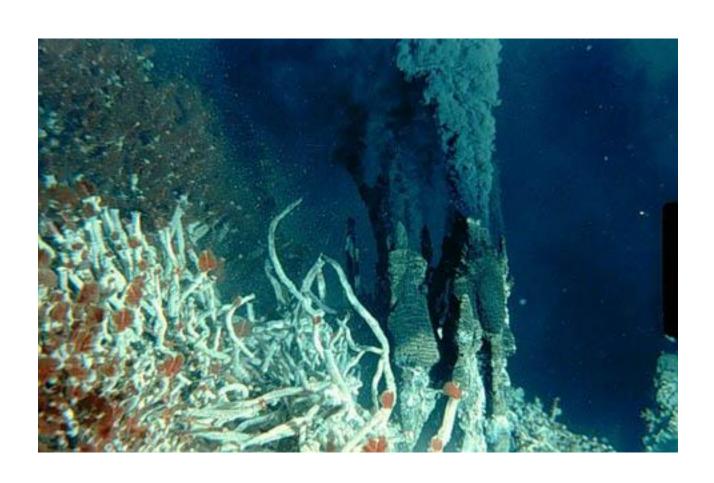
The highest and lowest temperature for each major taxon is given. Archaea are in red, bacteria in blue, algae in light green, fungi in brown, protozoa in yellow, plants in dark green and animals in purple.

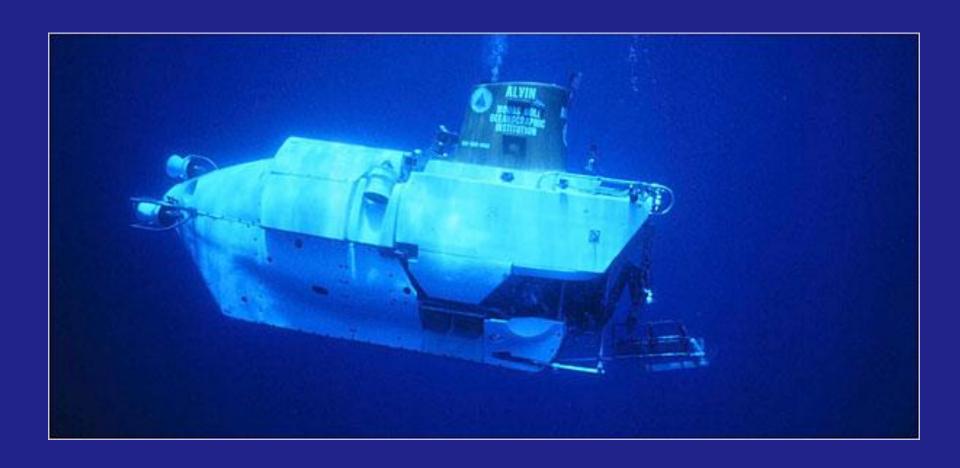
pH limits for life

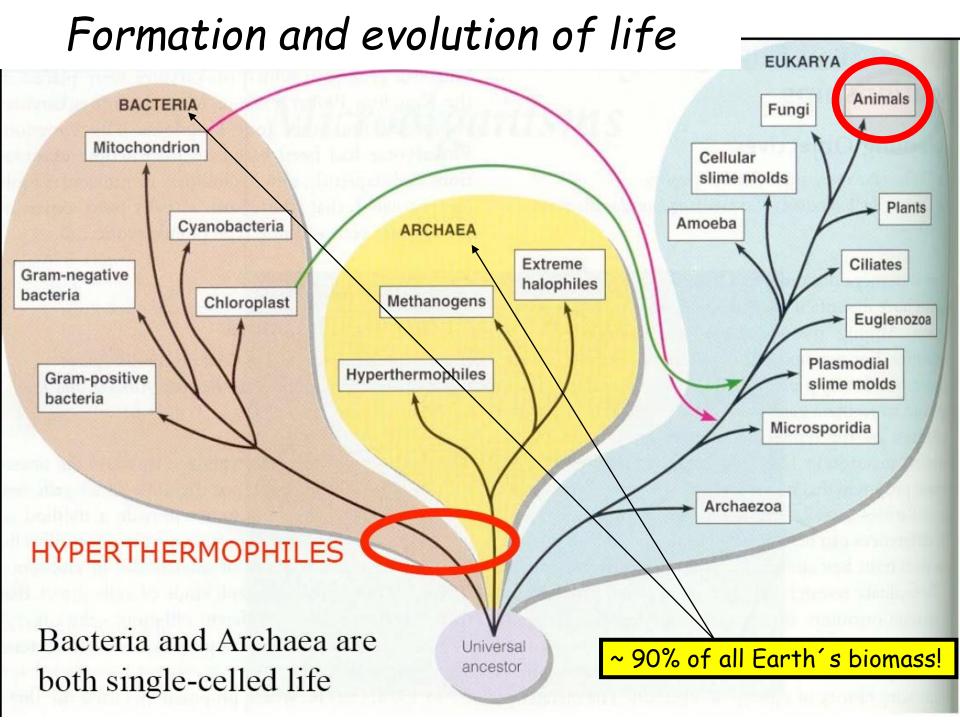


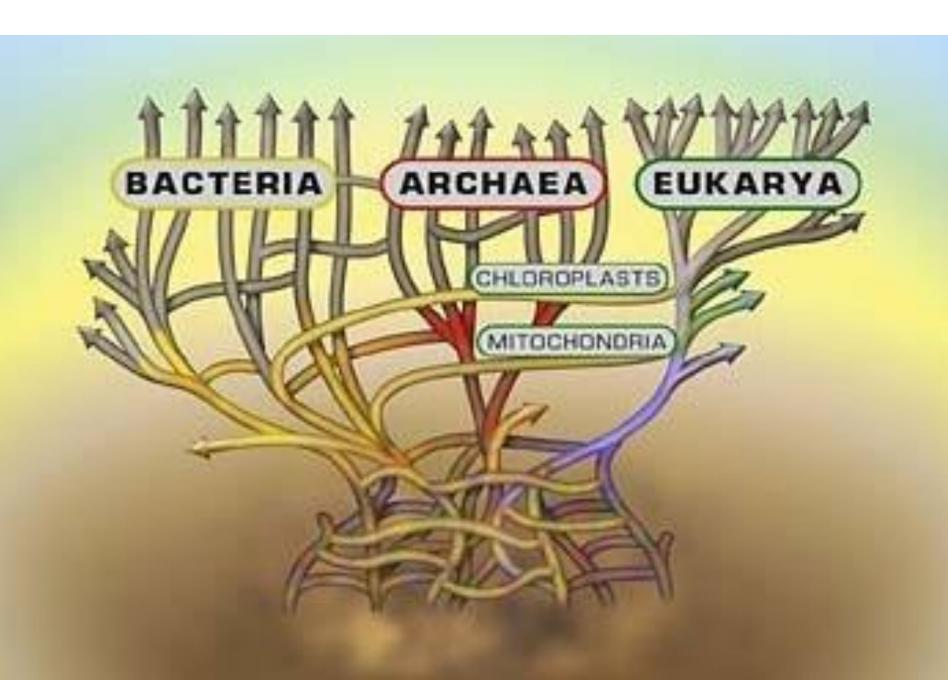
Examples of known pH limits for life are shown. Archaea are in red, bacteria in blue, algae in light green, assorted protists in yellow, fungi in brown, plants in dark green and animals in purple.

Fontes hidrotérmicas

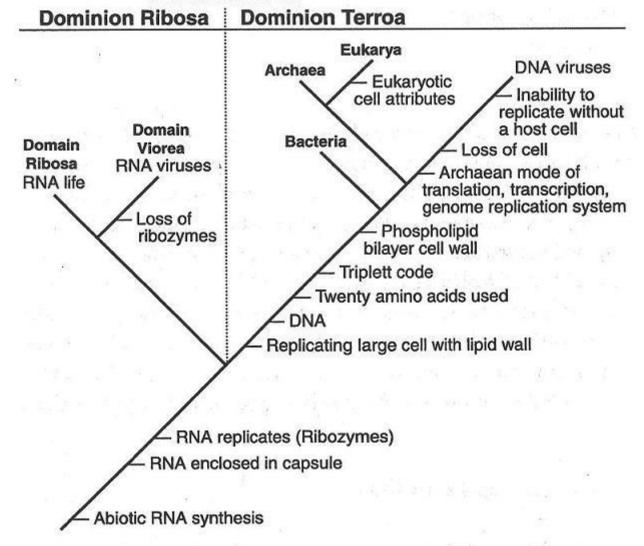








Earth Arborea



SIGNATURES OF A SHADOW BIOSPHERE

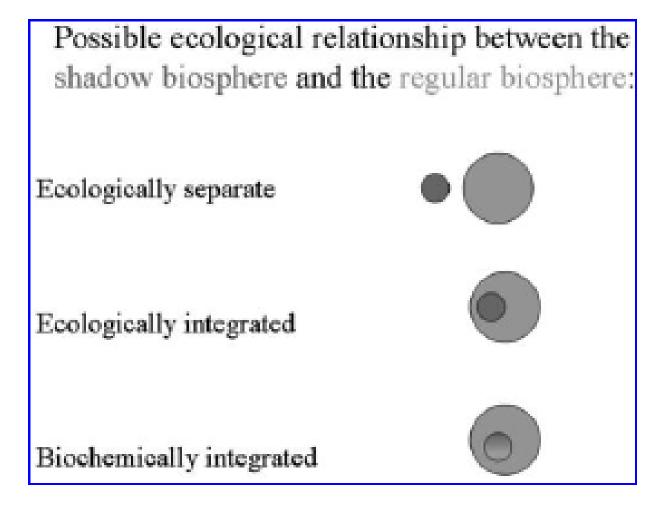


FIG. 1. Schematic representation of various possible relationships between known and weird life.

Qual a origem (origens) da vida?

Some Warm Little Pond

It is often said that all the conditions for the first production of a living organism are now present, which could ever have been present.—But if (& oh what a big if) we could conceive in some warm little pond with all sorts of ammonia & phosphoric salts,—light, heat, electricity &c present, that a protein compound was chemically formed, ready to undergo still more complex changes, at the present day such matter wd be instantly devoured, or absorbed, which would not have been the case before living creatures were formed.

Letter to J. D. Hooker, 1 Feb [1871]

"Origem das Espécies" (1859)

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION.

OR THE

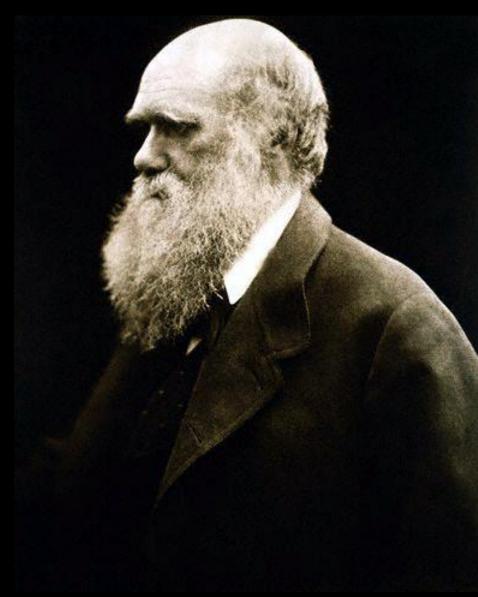
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIPE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GROUNDSCAL, LINXXEAN, ETC., SOCIETIES; ACTURE OF *JOCKNAL OF EXSEALECTES POLITICS I. M. S. SLAMA'S VOTAGE ROCKY THE WORLD.

LONDON: JOHN MURRAY, ALBEMARLE STREET. 1859.

The right of Pranchation or represent.



How the Sun Shines*

John N. Bahcall

What makes the sun shine? How does the sun produce the vast amount of energy necessary to support life on earth? These questions challenged scientists for a hundred and fifty years, beginning in the middle of the nineteenth century. Theoretical physicists battled geologists and evolutionary biologists in a heated controversy over who had the correct answer.

Why was there so much fuss about this scientific puzzle? The nineteenth-century astronomer John Herschel described eloquently the fundamental role of sunshine in all of human life in his 1833 Treatise on Astronomy.

The sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth. By its heat are produced all winds,...By their vivifying action vegetables are elaborated from inorganic matter, and become, in their turn, the support of animals and of man, and the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata.

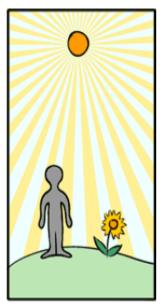
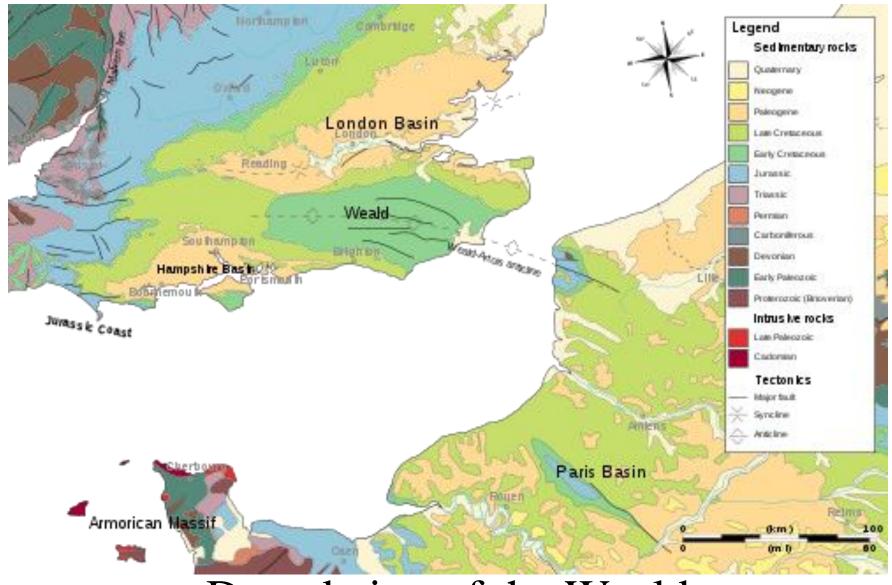
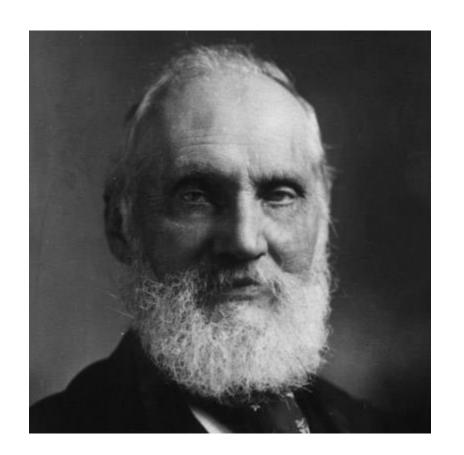
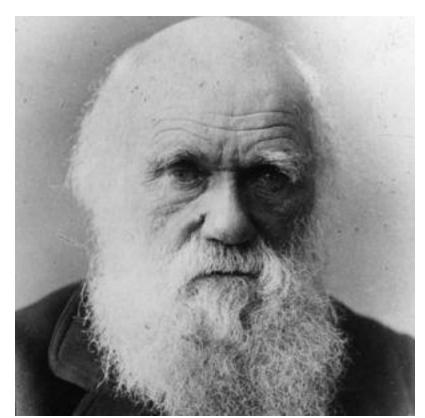


FIG. 1. Sunshine makes life possible on earth.

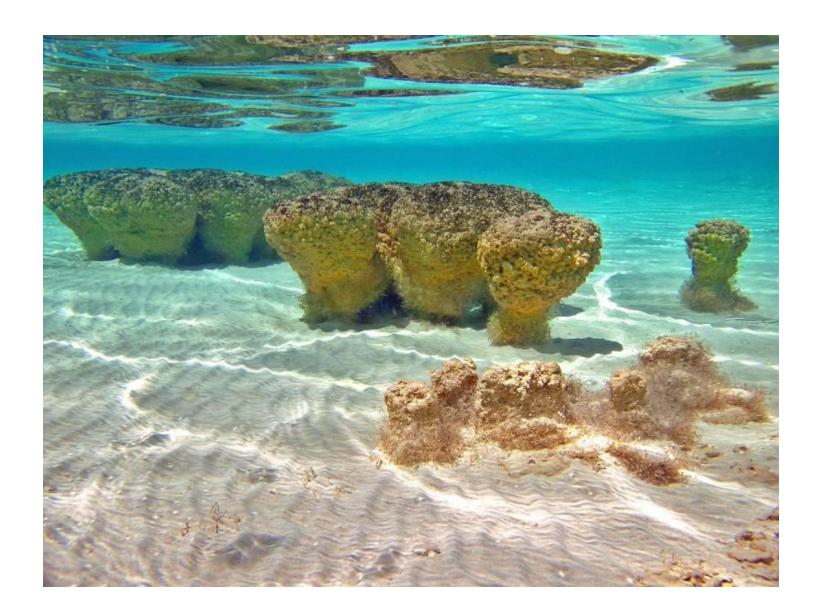


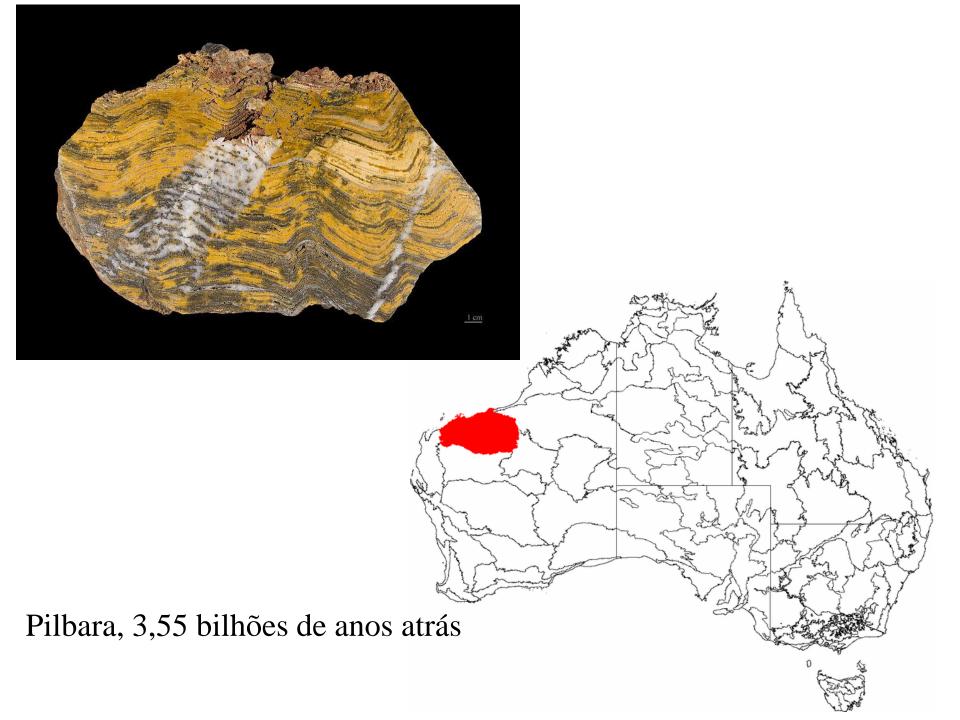
Denudation of the Weald ⇒ 300 milhões de anos





Kelvin X Darwin





CYANOBACTERIAL MICROFOSSILS

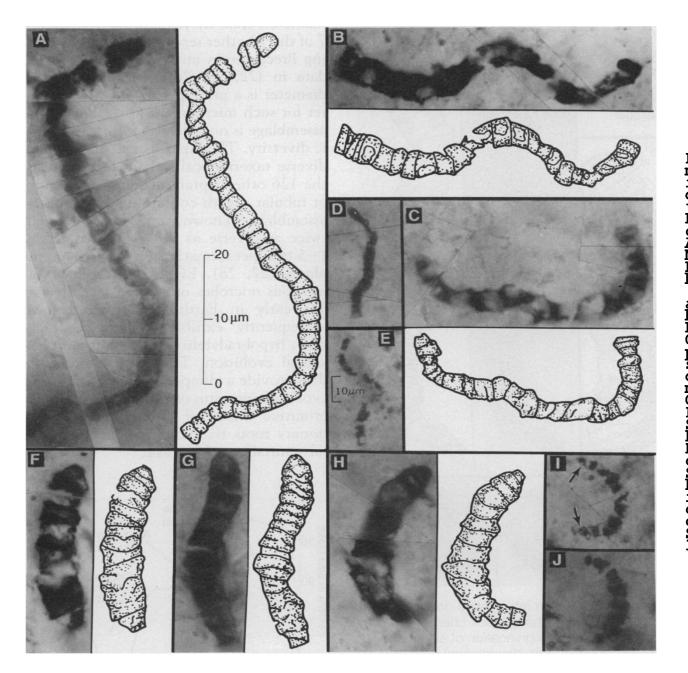
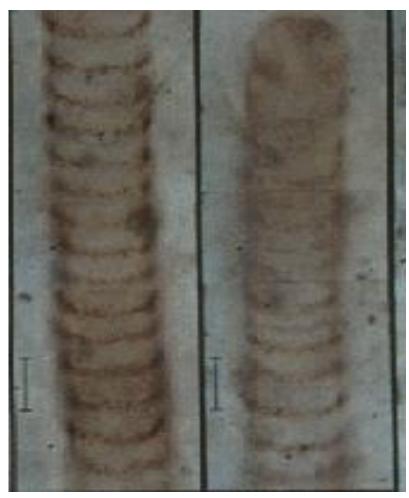
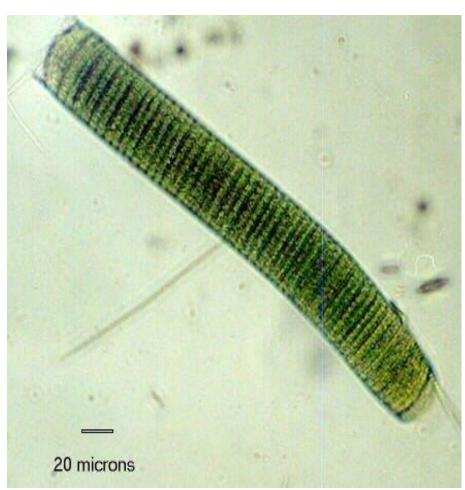


Fig. 4. Carbonaceous microfossils (with interpretive drawings) shown in thin sections of the Early Archean Apex chert of Western Australia. Magnification E, I, and J) of (D, denoted scale; magnification other parts shown scale in C, and D H, and and D and photomontages sinuous dimensional microfossils. C, D, a Primaevifilum Schopf, 199 holotype) (3) and amoenum H, I, and J conicoterminatum Schopf, 1992 holotype) (3); point to terminal conical cells. ŠČĪĒŇĊE * VOL. 30 APRIL 1993 260 *

SIDE BY SIDE: FOSSIL IMAGE AND MODERN CYANOBACTERIA



http://webs.wichita.edu/mschneegurt/biol103/lecture08/lecture8.html



Oscillatoria, modern filamentous cyanobacteria

Evidence for life on Earth before 3,800 million years ago

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† W.M. Keck Foundation Center for Isotope Geochemistry, Department of Earth and Space Sciences, University of California

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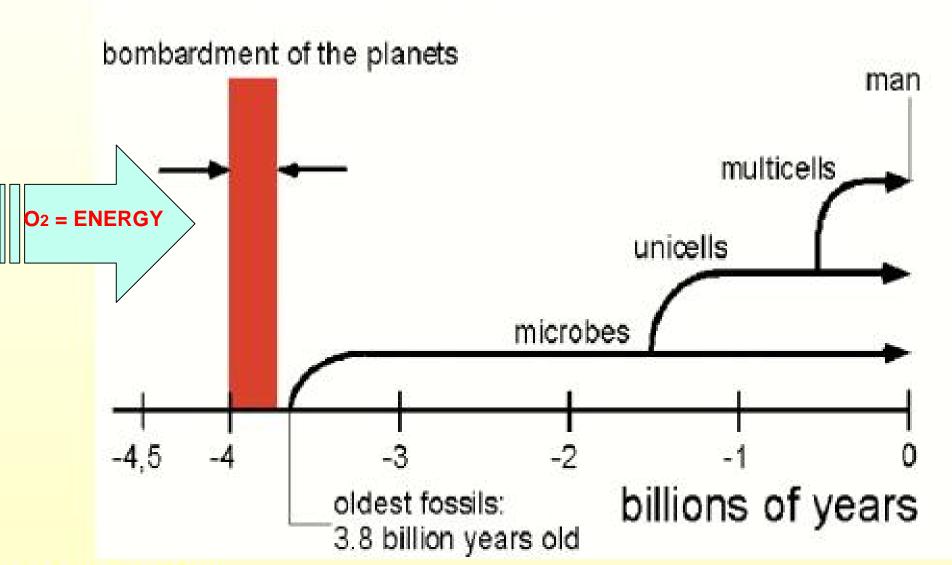
‡ Research School of Earth Sciences, The Australian National University, Canberra, A.C.T. 0200, Australia

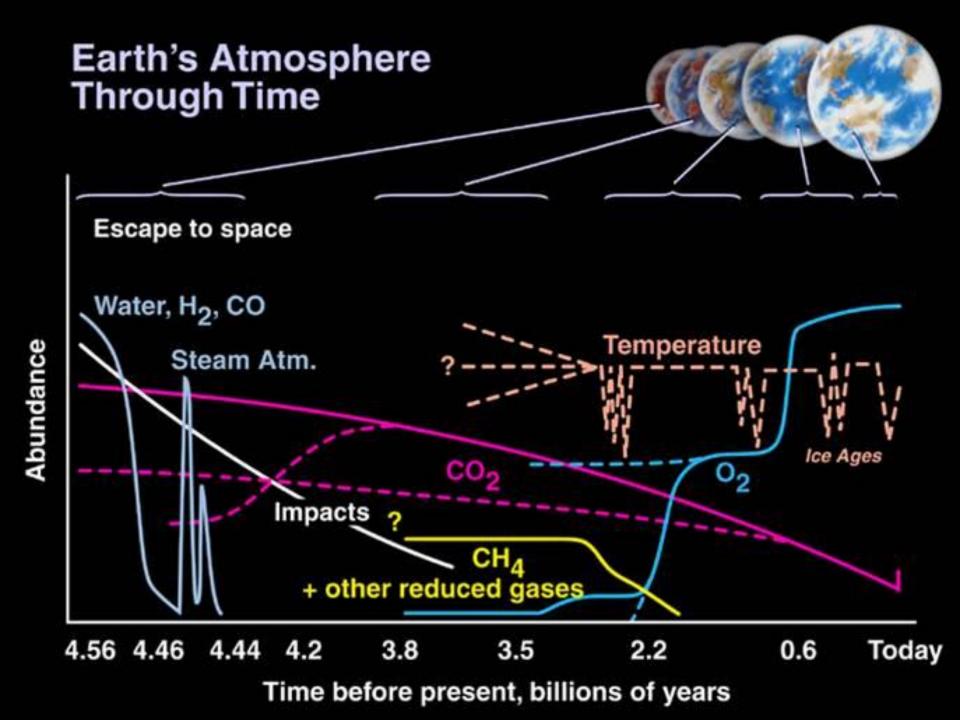
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It is unknown when life first appeared on Earth. The earliest known microfossils (\sim 3,500 Myr before present) are structurally complex, and if it is assumed that the associated organisms required a long time to develop this degree of complexity, then the existence of life much earlier than this can be argued^{1,2}. But the known examples of crustal rocks older than \sim 3,500 Myr have experienced intense metamorphism, which would have obliterated any fragile microfossils contained therein. It is therefore necessary to search for geochemical evidence of past biotic activity that has been preserved within minerals that are resistant to metamorphism. Here we report ion-microprobe measurements of the carbon-isotope composition of carbonaceous inclusions within grains of apatite (basic calcium phosphate) from the oldest known sediment sequences—a ~3,800-Myr-old banded iron formation from the Isua supracrustal belt, West Greenland35, and a similar formation from the nearby Akilia island that is possibly older than 3,850 Myr (ref. 3). The carbon in

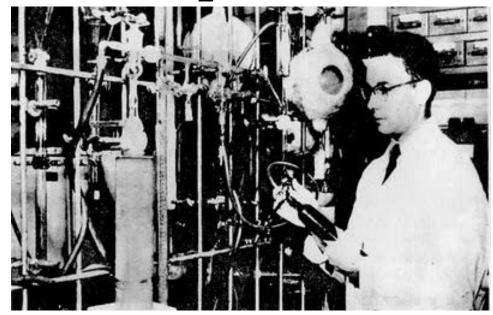
ORIGINS OF LIFE ON EARTH







O experimento de Miller (1953)



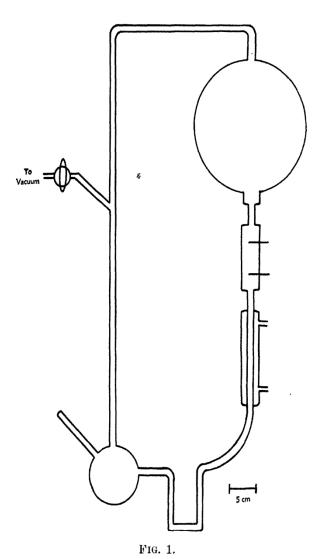
A Production of Amino Acids Under Possible Primitive Earth Conditions

Stanley L. Miller^{1, 2}

G. H. Jones Chemical Laboratory, University of Chicago, Chicago, Illinois

Science 117, 528-529 (1953)

May 15, 1953



A descoberta da estrutura do DNA (1953)

MOLECULAR STRUCTURE OF NUCLEIC ACIDS

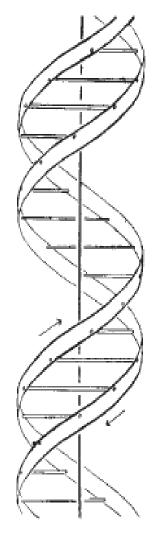
A Structure for Deoxyribose Nucleic Acid

J. D. WATSON F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems, Cavendish Laboratory, Cambridge.

April 25, 1953

NATURE



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

737



Tudo começou com um sim. Uma molécula disse sim a outra molécula e nasceu a vida.

Clarice Lispector, A Hora da Estrela