AGA 0316
A vida no contexto cósmico

Amancio Friaça
2024

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 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

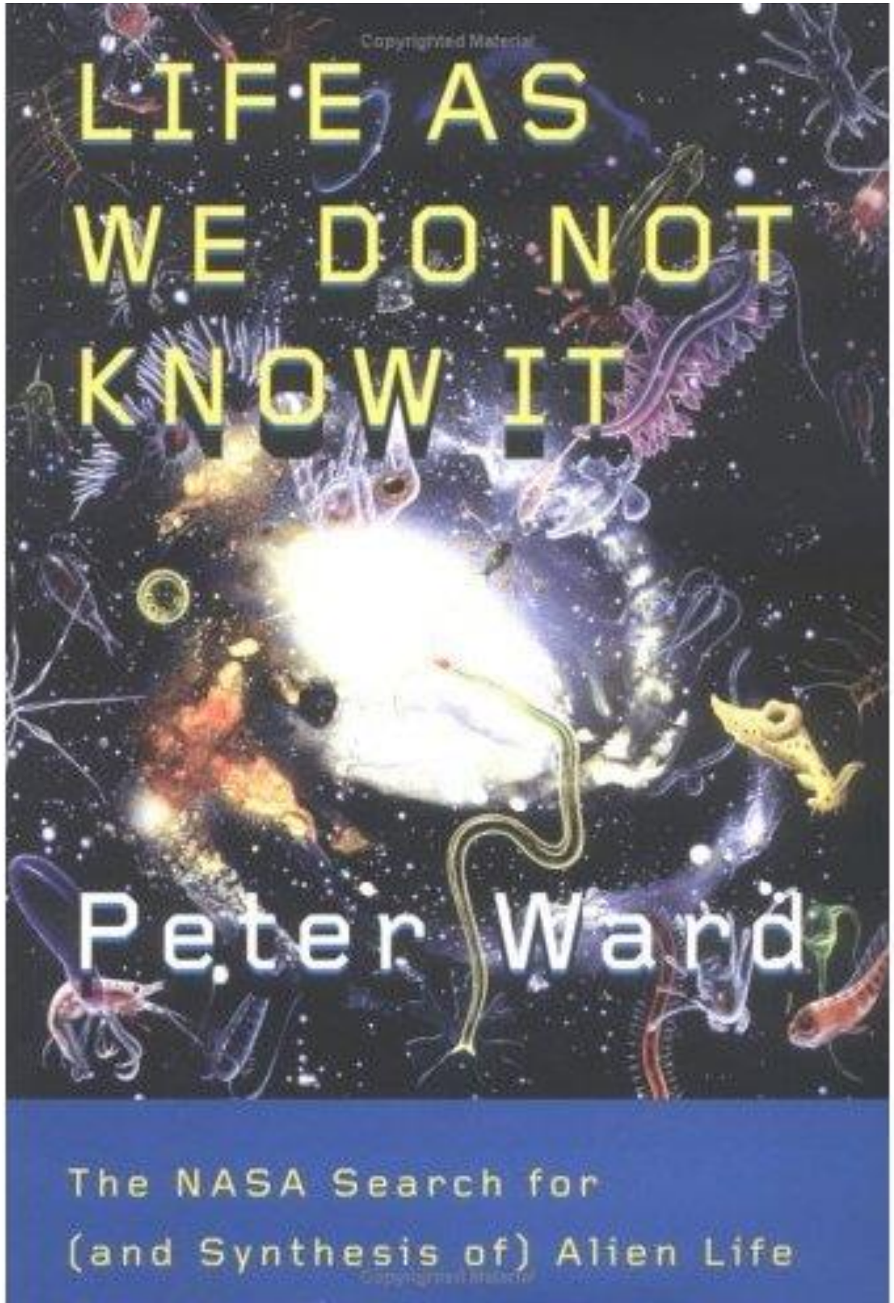
Questões Fundamentais (NAI Roadmap)

1. Como a vida se originou e evoluiu?

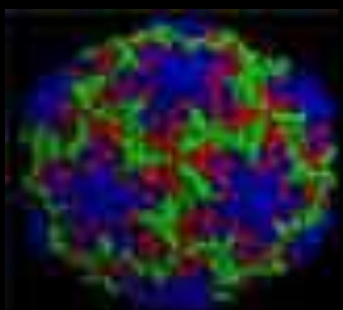
2. Existe vida em outras partes do Universo?

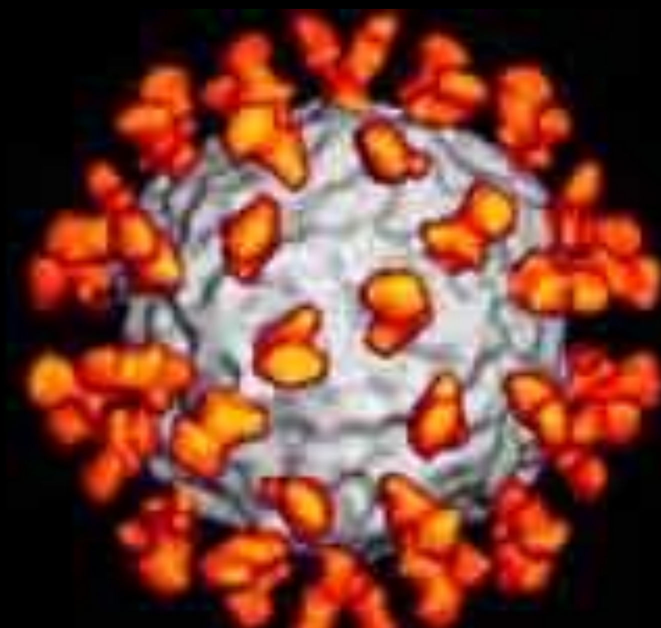
3. Qual será o futuro da vida na Terra e além?

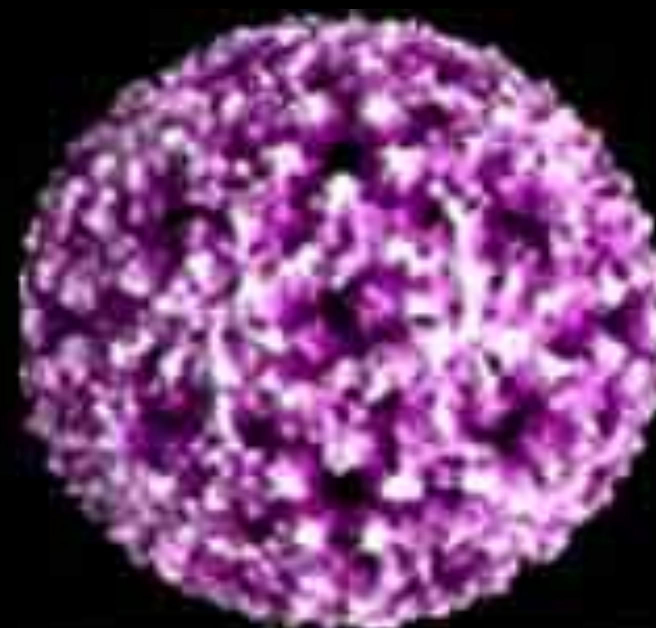
O que é a vida?


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

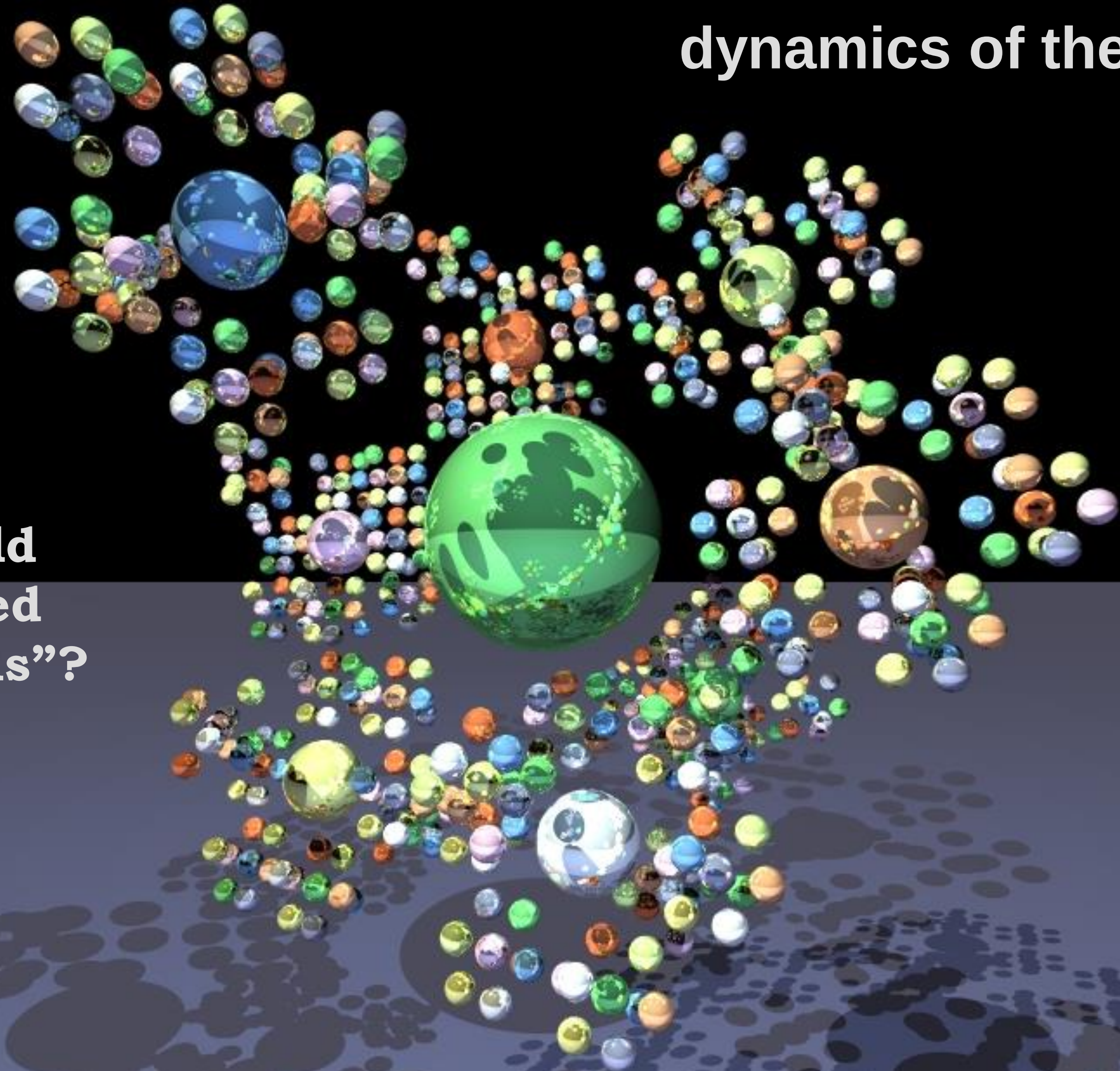
É vivo ou não?





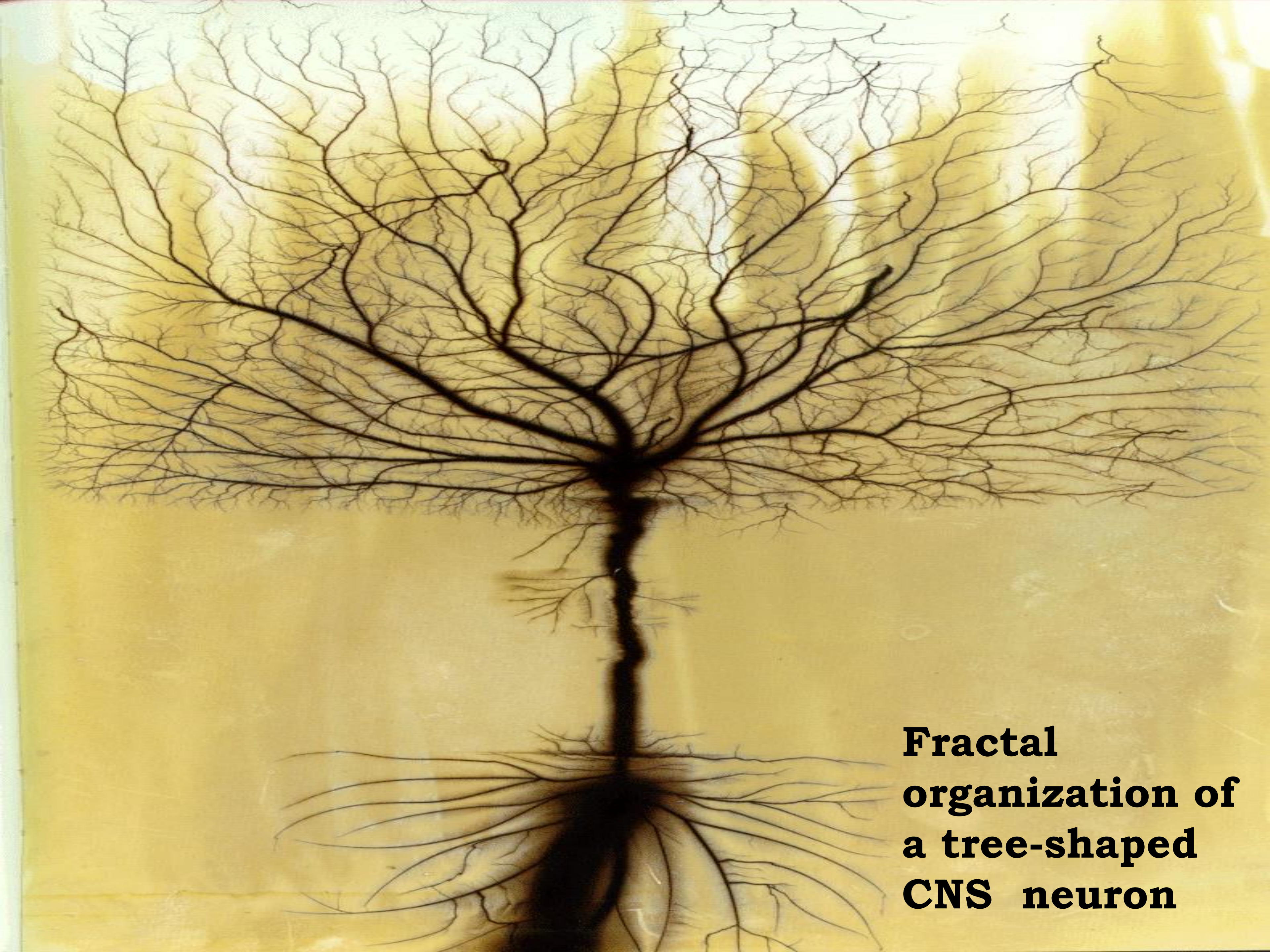


If we cannot follow up the dynamics of the process...



so...

fractals could be considered as “life forms”?



Fractal organization of a tree-shaped CNS neuron

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

Eric D. Schneider & Dorion Sagan

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 extraterrestrial 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

Origins of Life and Evolution of the Biosphere 32: 387–393, 2002.

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.

Origins of Life and Evolution of the Biosphere **28:** 613–622, 1998.

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)

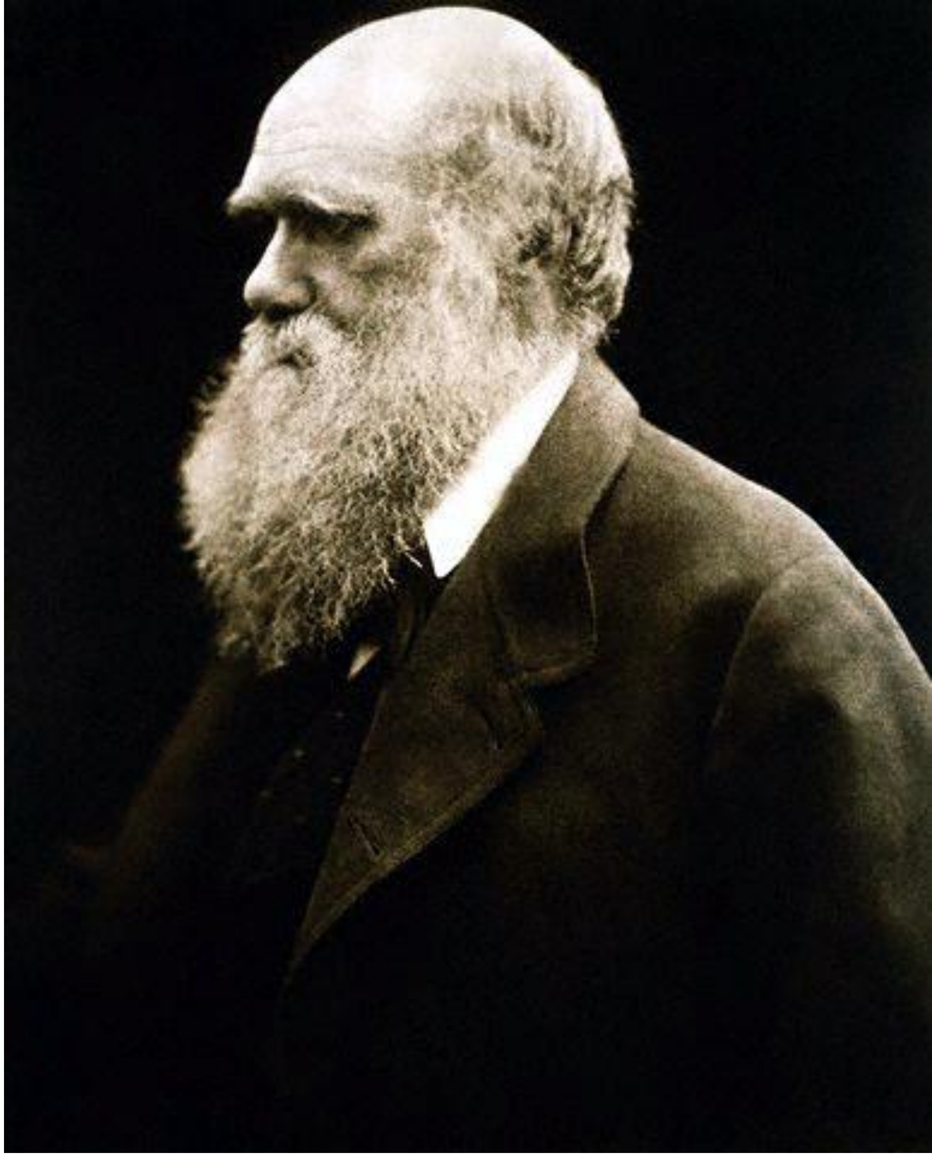
1) Any population of a species has the potential to produce **far more** offspring than the environment can support with resources.

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**.

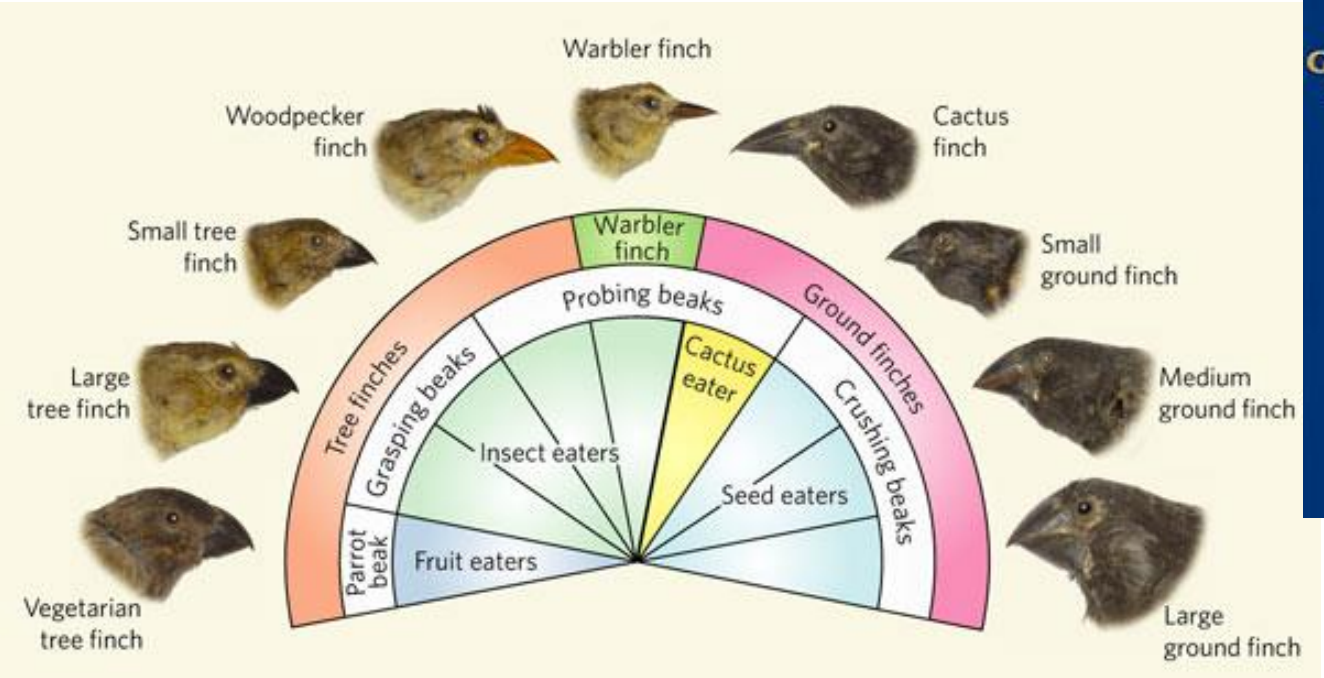
4) Some individuals possess traits that make them **better** able **to compete** for resources.

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

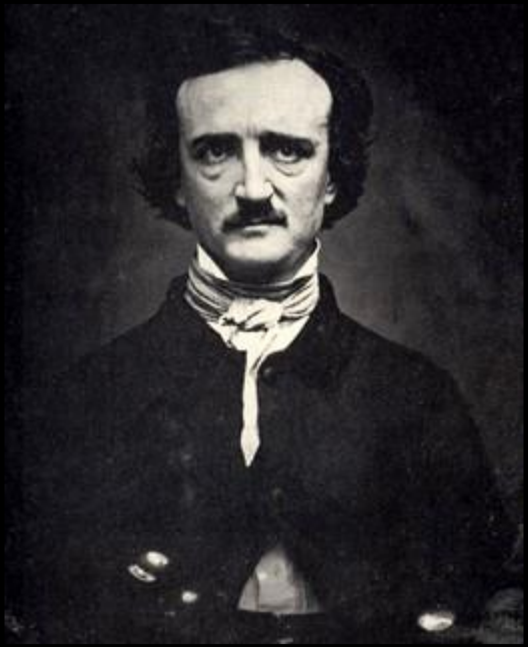
Algumas características da vida

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

FRONTEIRAS

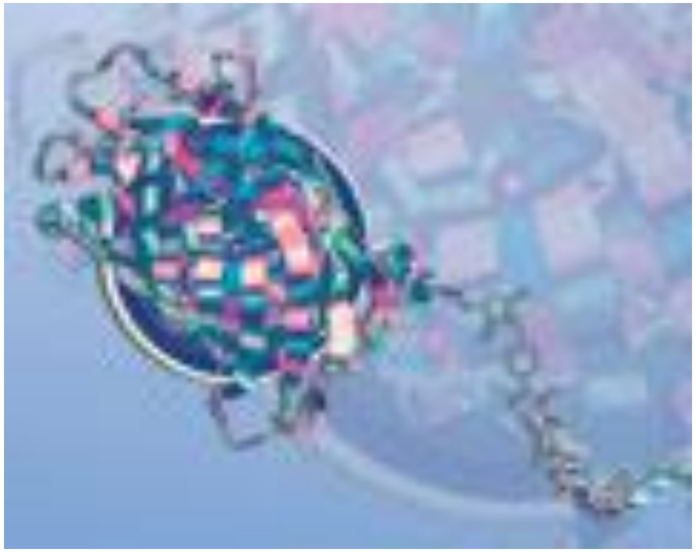
- Vivo/Morto
- Máquina/Organismo
- Química/Biologia

Edgar Allan Poe (1809-1849)



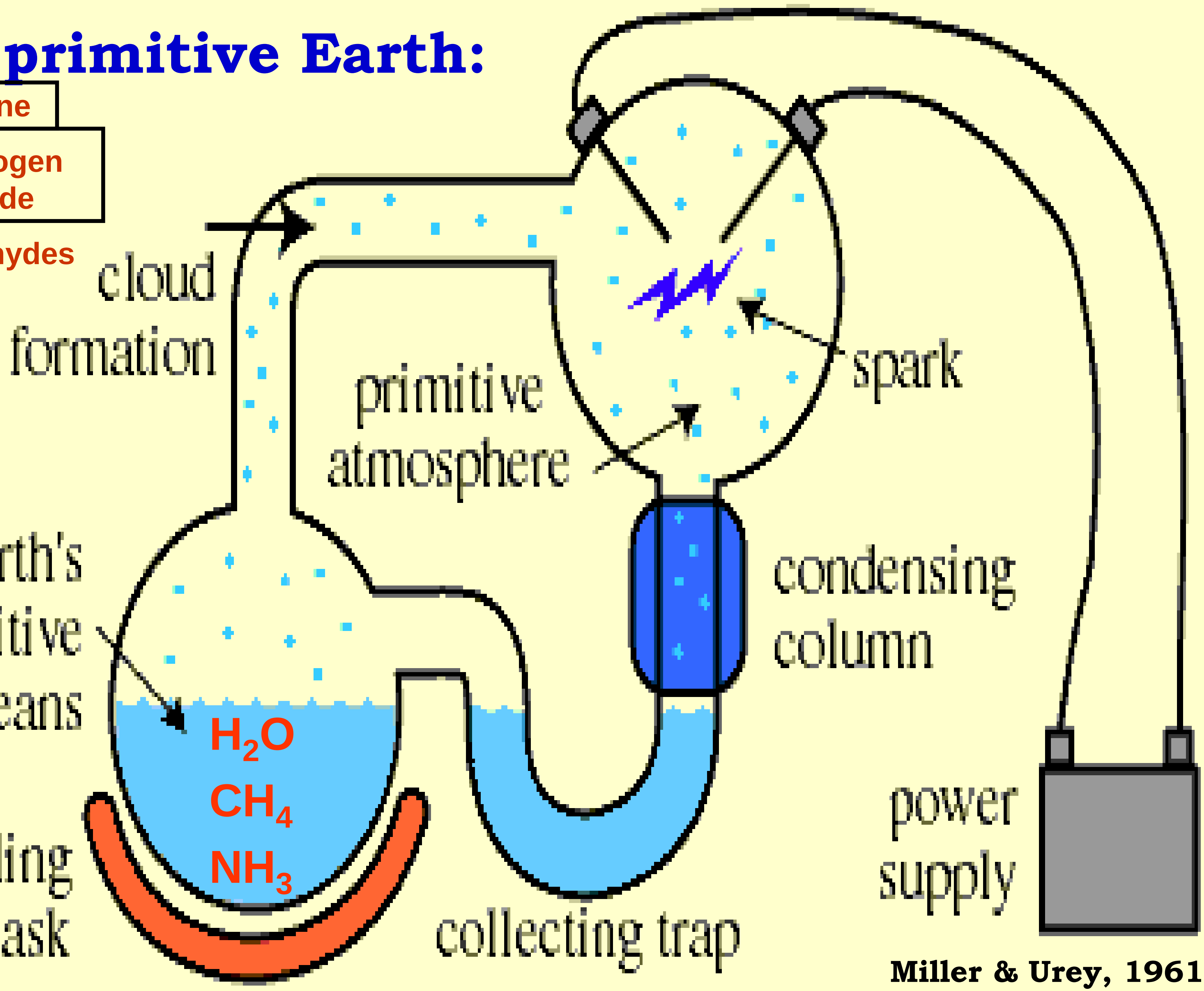
Chemistry in the New World of Bioengineering and Synthetic Biology

22 - 24 September 2008
Oxford, United Kingdom



In primitive Earth:

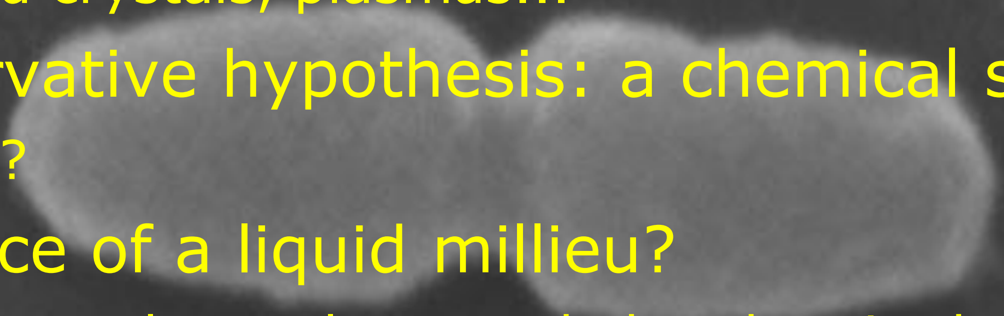
- Glycine
- Hydrogen cyanide
- Aldehydes



Miller & Urey, 1961

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?
  - H_2O: 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?

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

FOLLOW THE LIFE

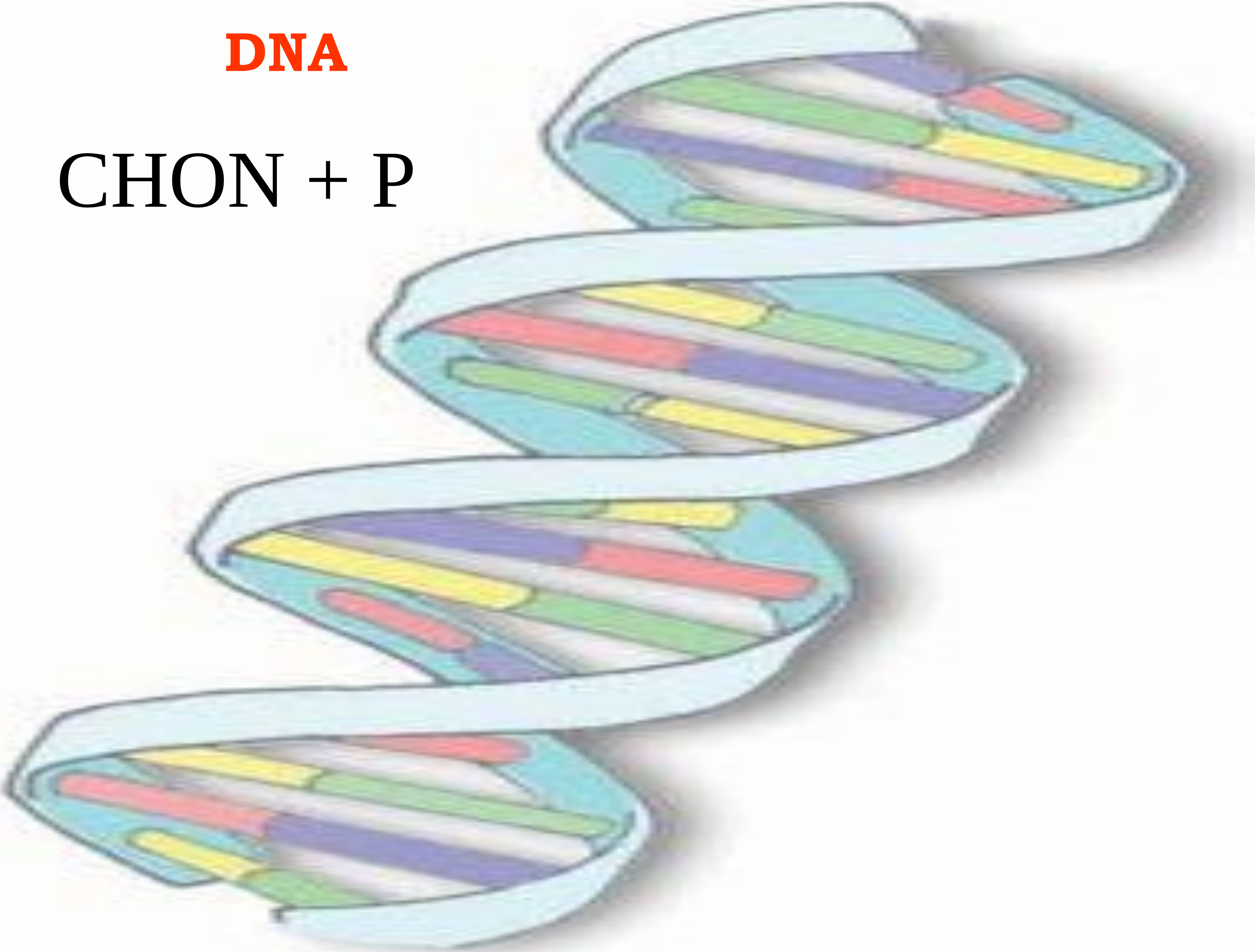
- Solvent
- Biogenic elements
- Source of Free Energy

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)

DNA

CHON + P



PERIODIC TABLE OF THE ELEMENTS

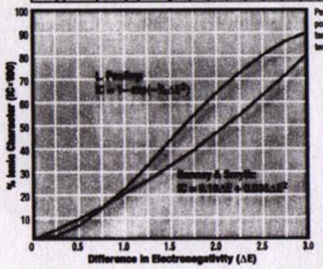
▼ Elementary Subatomic Particles

	Electron	Proton	Neutron	Photon	Neutrino
Symbol	e	p	n	γ	ν
Rest mass (kg)	$9.1093897(54) \times 10^{-31}$	$1.6726231(10) \times 10^{-27}$	$1.6749286(10) \times 10^{-27}$	0	≈0
Molar mass (kg/mol)	$5.48579903(13) \times 10^{-7}$	$1.007276470(12) \times 10^{-3}$	$1.008664904(14) \times 10^{-3}$	0	≈0
Particle-electron mass ratio	1	1836.152701(37)	1838.683662(40)	0	≈0
Particle-proton mass ratio	$5.44617013(11) \times 10^{-4}$	1	1.001378404(9)	0	≈0
Particle-neutron mass ratio	5.438673×10^{-4}	0.998624	1	0	≈0
Specific charge (C/kg)	$-1.75881962(53) \times 10^{+11}$	$9.5788309(29) \times 10^{+7}$	0	0	0
Radius (m)	$<1 \times 10^{-18}$	8×10^{-16}	8×10^{-16}	0	≈0
Spin quantum number	1/2	1/2	1/2	1	1/2
Compton wavelength (m)	$2.42631058(22) \times 10^{-12}$	$1.32141002(12) \times 10^{-15}$	$1.31959110(12) \times 10^{-5}$	–	–
Magnetic moment (J/T); μ	$928.47701(31) \times 10^{-26}$	$1.41060761(47) \times 10^{-26}$	$0.96623707(40) \times 10^{-26}$	0	0
In Bohr magnetons; μ/μ_B	1.001159652193(10)	$1.521032202(15) \times 10^{-3}$	$1.04187563(25) \times 10^{-3}$	0	0
In nuclear magnetons; μ/μ_N	1838.282000(37)	2.792847386(63)	1.91304275(45)	0	0

Elementary particles are the fundamental constituents of energy and matter. The positron (e^+) is a positive-energy particle which has the same mass as an ordinary electron. The antineutrino ($\bar{\nu}$) has similar properties as that of a neutrino (ν) except its spin is directed along its direction of motion, whereas the neutrino's spin is always opposite to the direction of motion. Negative beta decay is the transformation of a neutron into a proton, a beta particle (negative electron) and a antineutrino ($n \rightarrow p + e^- + \bar{\nu}$). Positive beta decay involves the transformation of a proton into a neutron, a positron and a neutrino ($p \rightarrow n + \beta^+ + \nu$). The magnetic moment (μ) of a particle can also be expressed as a dimensionless quantity by dividing it with either the Bohr magneton ($\mu_B = 9.2740154(31) \times 10^{-24}$ J/T) or the nuclear magneton ($\mu_N = 5.0507866(17) \times 10^{-27}$ J/T).

▼ % Ionic Character of a Single Chemical Bond

Difference in Electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
%IC (by L. Pauling)	0.2	1.0	2.2	3.9	6.1	8.6	12	15	18	22	26	30	34	39	43	47	51	56	59	63	67	70	73	76	79	82	84	86	88	89	91	92
%IC (by Hanney & Smyth)	1.6	3.3	5.1	7.0	8.9	11	13	15	17	20	22	24	27	29	32	35	37	40	43	46	49	52	55	59	62	65	69	72	76	80	83	87



Percent ionic character describes the nature of a bond. Bonds possessing 50% or greater ionic character are commonly termed ionic; bonds with less than 50% ionic character are termed covalent. Pauling's equation was modified by Hanney & Smyth in order to achieve better agreement between experimental and calculated values. Transition from ionic to covalent binding is usually accompanied by a reduction in electrical conductance, melting point and boiling point.

Elements

Atomic Number	Symbol	Name	Atomic Weight
1	H	Hydrogen	1.00794
2	He	Helium	4.002602
3	Li	Lithium	6.941
4	Be	Beryllium	9.012182
5	B	Boron	10.811
6	C	Carbon	12.011
7	N	Nitrogen	14.00674
8	O	Oxygen	15.9994
9	F	Fluorine	18.9984032
10	Ne	Neon	20.1797
11	Na	Sodium	22.989768
12	Mg	Magnesium	24.3050
13	Al	Aluminum	26.981539
14	Si	Silicon	28.0855
15	P	Phosphorus	30.973762
16	S	Sulfur	32.066
17	Cl	Chlorine	35.4527
18	Ar	Argon	39.948
19	K	Potassium	39.0983
20	Ca	Calcium	40.078
21	Sc	Scandium	44.955910
22	Ti	Titanium	47.88
23	V	Vanadium	50.9415
24	Cr	Chromium	51.9961
25	Mn	Manganese	54.93805
26	Fe	Iron	55.847
27	Co	Cobalt	58.93320
28	Ni	Nickel	58.6934
29	Cu	Copper	63.546
30	Zn	Zinc	65.39
31	Ga	Gallium	69.723
32	Ge	Germanium	72.61
33	As	Arsenic	74.92159
34	Se	Selenium	78.96
35	Br	Bromine	79.904
36	Kr	Krypton	83.80
37	Rb	Rubidium	85.4678
38	Sr	Strontium	87.62
39	Y	Yttrium	88.90585
40	Zr	Zirconium	91.224
41	Nb	Niobium	92.90638
42	Mo	Molybdenum	95.94
43	Tc	Technetium	(97.9072)
44	Ru	Ruthenium	101.07
45	Rh	Rhodium	102.90550
46	Pd	Palladium	106.42
47	Ag	Silver	107.8682
48	Cd	Cadmium	112.411
49	In	Indium	114.818
50	Sn	Tin	118.710
51	Sb	Antimony	121.757
52	Te	Tellurium	127.60
53	I	Iodine	126.90447
54	Xe	Xenon	131.29
55	Cs	Cesium	132.90543
56	Ba	Barium	137.327
57	La	Lanthanum	138.9055
72	Hf	Hafnium	178.49
73	Ta	Tantalum	180.9479
74	W	Tungsten	183.84
75	Re	Rhenium	186.207
76	Os	Osmium	190.23
77	Ir	Iridium	192.22
78	Pt	Platinum	195.08
79	Au	Gold	196.96654
80	Hg	Mercury	200.59
81	Tl	Thallium	204.3833
82	Pb	Lead	207.2
83	Bi	Bismuth	208.98037
84	Po	Polonium	(208.9824)
85	At	Astatine	(209.9871)
86	Rn	Radon	(222.0176)
87	Fr	Francium	(223.0197)
88	Ra	Radium	(226.0254)
89	Ac	Actinium	(227.0278)
104	Unq	Unnilquadium	(261.11)
105	Unp	Unnilpentium	(262.114)
106	Unh	Unnilhexium	(263.118)
107	Uns	Unnilseptium	(262.12)
108	Uno	Unniloctium	(265)
109	Une	Unnilennium	(266)
110	Uun	Ununnilium	(272)
58	Ce	Cerium	140.115
59	Pr	Praseodymium	140.90765
60	Nd	Neodymium	144.24
61	Pm	Promethium	(144.9127)
62	Sm	Samarium	150.36
63	Eu	Europium	151.965
64	Gd	Gadolinium	157.25
65	Tb	Terbium	158.92534
66	Dy	Dysprosium	162.50
67	Ho	Holmium	164.93032
68	Er	Erbium	167.26
69	Tm	Thulium	168.93421
70	Yb	Ytterbium	173.04
71	Lu	Lutetium	174.967
90	Th	Thorium	232.0381
91	Pa	Protactinium	231.03588
92	U	Uranium	238.0289
93	Np	Neptunium	(237.0482)
94	Pu	Plutonium	(244.0642)
95	Am	Americium	(243.0614)
96	Cm	Curium	(247.0703)
97	Bk	Berkelium	(247.0703)
98	Cf	Californium	(251.0796)
99	Es	Einsteinium	(252.083)
100	Fm	Fermium	(257.0951)
101	Md	Mendelevium	(258.10)
102	No	Nobelium	(259.1009)
103	Lr	Lawrencium	(262.11)

*indicates approximate values and/or inconsistent literature data.

Key

7 VIIA VIIB — 54.93805, 25, 1246, 2061, 2,3,4,6,7, 7.47, 1.55, 7.435, Mn, $[Ar]3d^5 4s^2$, Manganese

- Atomic Weight[1] ( ) indicates most stable or best known isotope
- Melting Point[7], °C
- Boiling Point[7], °C
- Density[8], g/cm³ (gases: g/L at 0°C, 1 atm)
- Electronegativity[9]
- First Ionization Potential[10], eV
- Group Classifications[6]
- Atomic Number[2]
- Oxidation States[3] bold indicates most stable state
- Symbol[4] black = solid, red = gas, blue = liquid, outline = synthetically prepared
- Electronic Configuration[5]
- Name[4]

The data for this reference guide were obtained from the latest scientific and government sources (IUPAC, CODATA, National Bureau of Standards, etc.). Estimated values and/or inconsistent data are marked with an asterisk (*). 1. Ratio of the average mass per atom of the element to 1/12 of the mass of an atom of ^{12}C. Round brackets indicate atomic weight of the most stable or best known isotope. 2. Number of protons in the nucleus of each atom of an element. 3. Number of charges an atom would have in a molecule (or an ionic compound) if electrons were transferred completely. 4. Names and symbols of elements 104-110 are those recommended by the International Union of Pure and Applied Chemistry (IUPAC)—alternative names have been proposed by other groups. 5. Distribution of electrons among the various atomic orbitals. 6. Two older group classifications systems still in use today rely on an A/B coding scheme to categorize periodic properties. Because of the potential for confusion between these two systems (i.e., VIIA in one scheme is equal to VIIB in the other), IUPAC recommends the use of an unambiguous 1-18 group classification system. 7. Melting point: temperature at which solid and liquid phases coexist in equilibrium. Boiling point: temperature at which the vapor pressure of a liquid is equal to the external atmospheric pressure. Unless otherwise stated values are at 1 atm; SP = sublimation point at 1 atm; TP = triple point. 8. Mass of the substance divided by its volume (g/cm³ at 20°C; for gases: g/L at 0°C, 1 atm). 9. Relative measure of the attraction of an atom in a chemical bond for the shared electrons. 10. Minimum energy to remove an electron from an isolated atom in its ground state (1eV = 96.487 kJ/mol).

PAPERTECH

Editors: T. K. Varga, M.A.Sc. & C. Bello, M.A.Sc.
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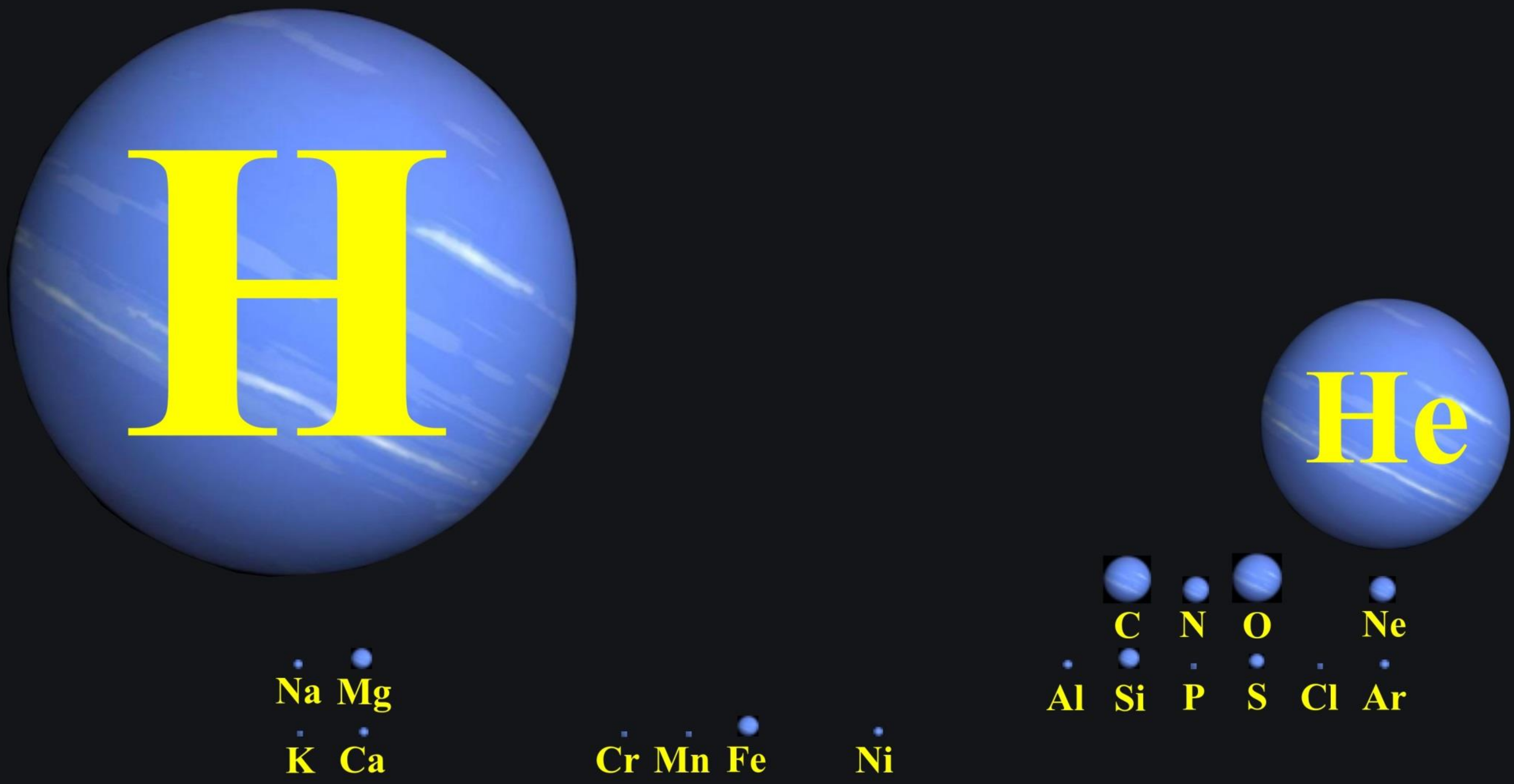
A Tabela Periódica dos Astrônomos

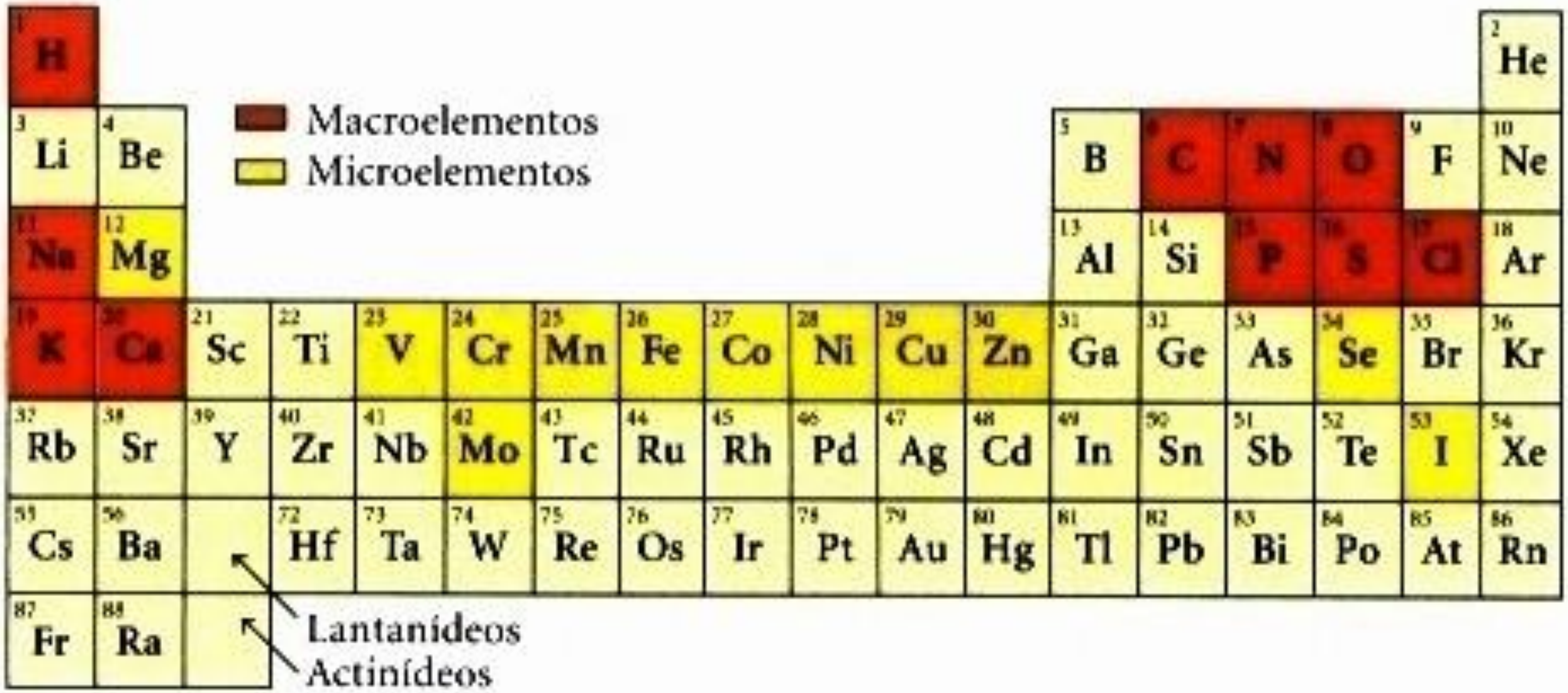


Água

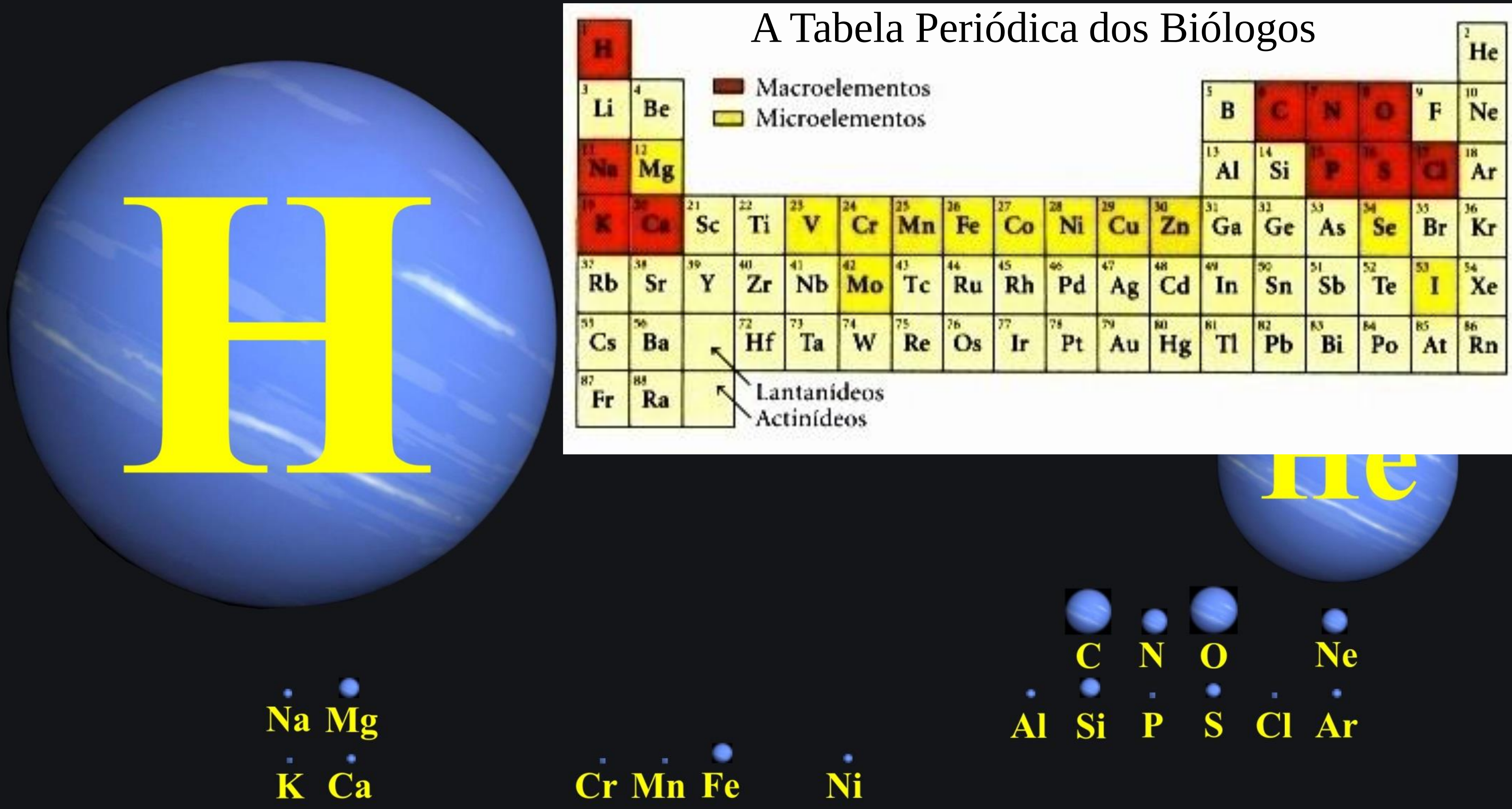
Principal componente dos cometas e dos seres vivos

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.

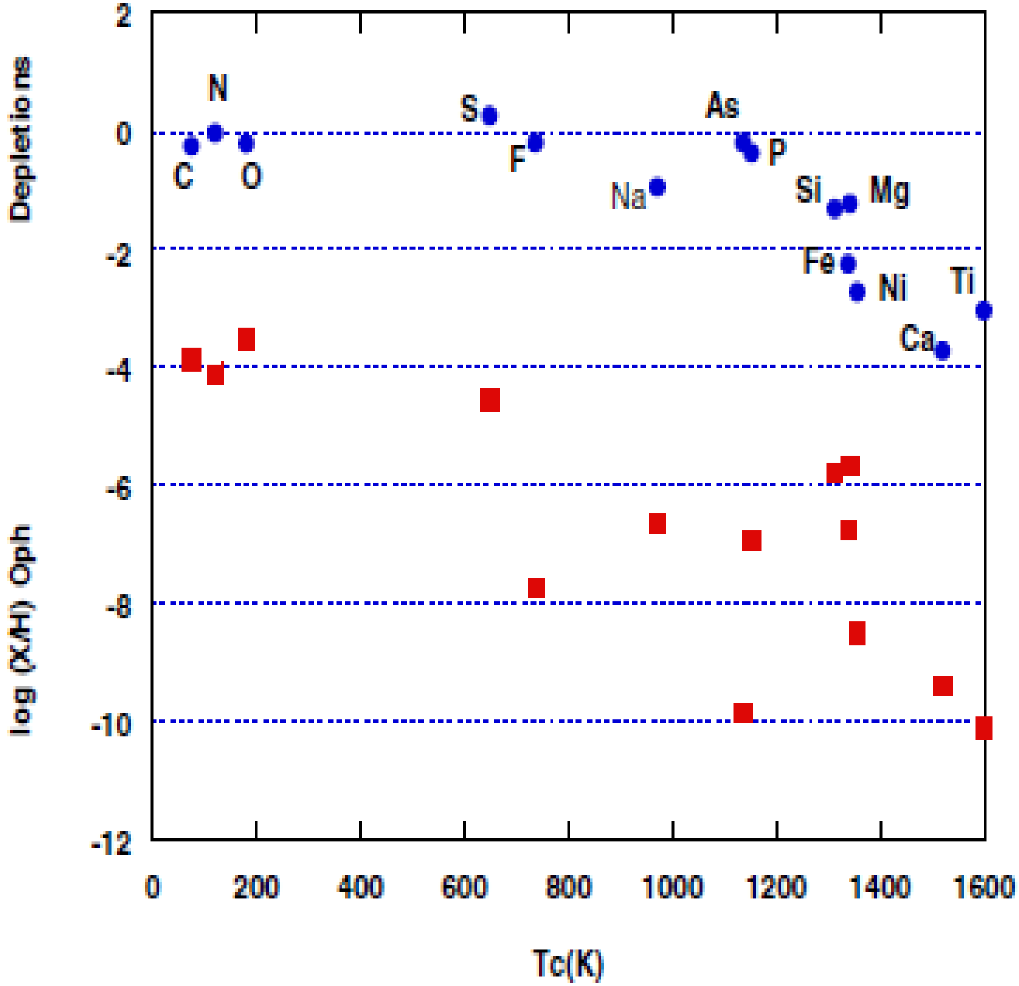

Macroelementos
Microelementos
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra
Lantanídeos
Actinídeos

A Tabela Periódica dos Astrônomos

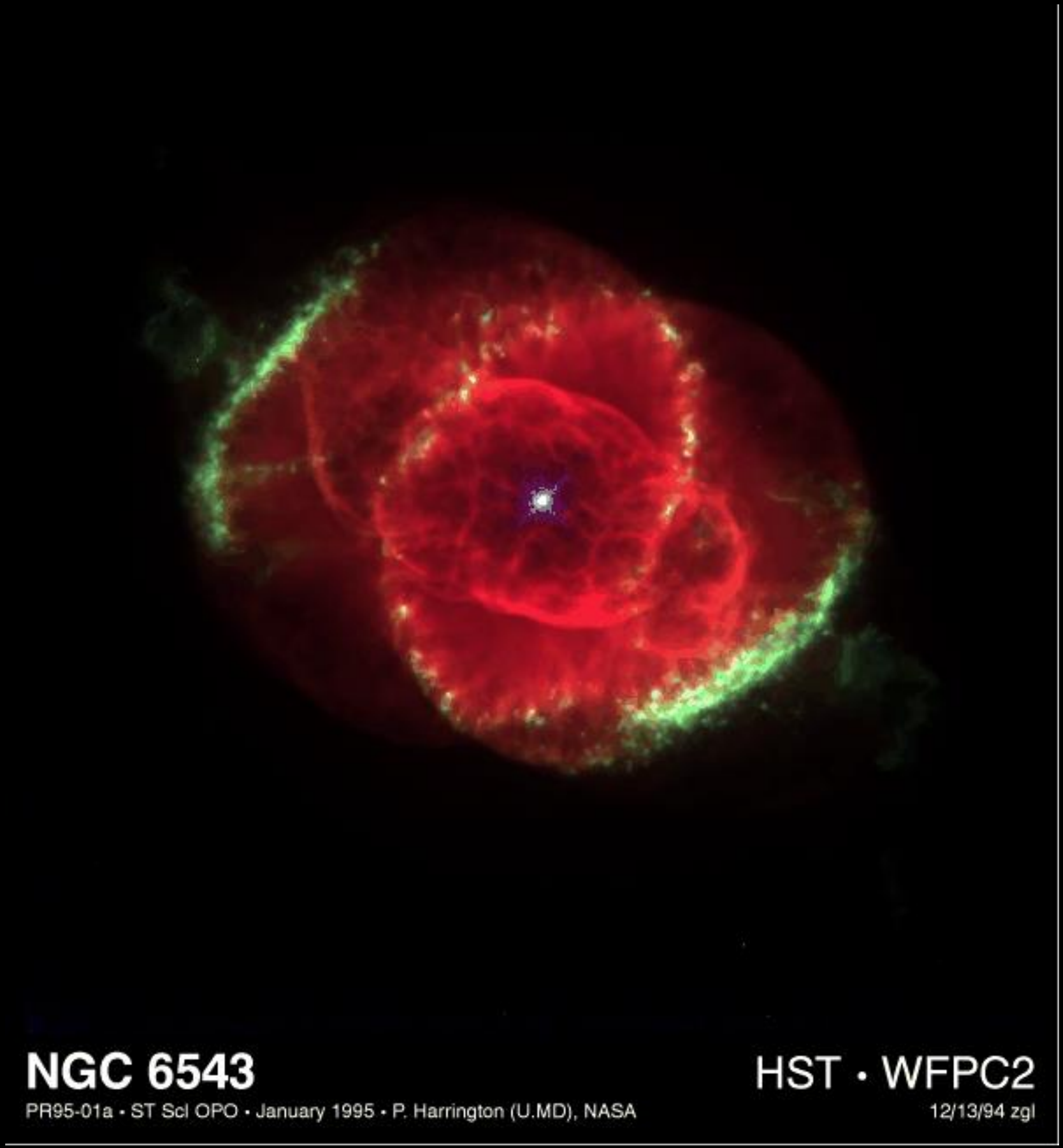


Abundâncias relativas dos elementos químicos

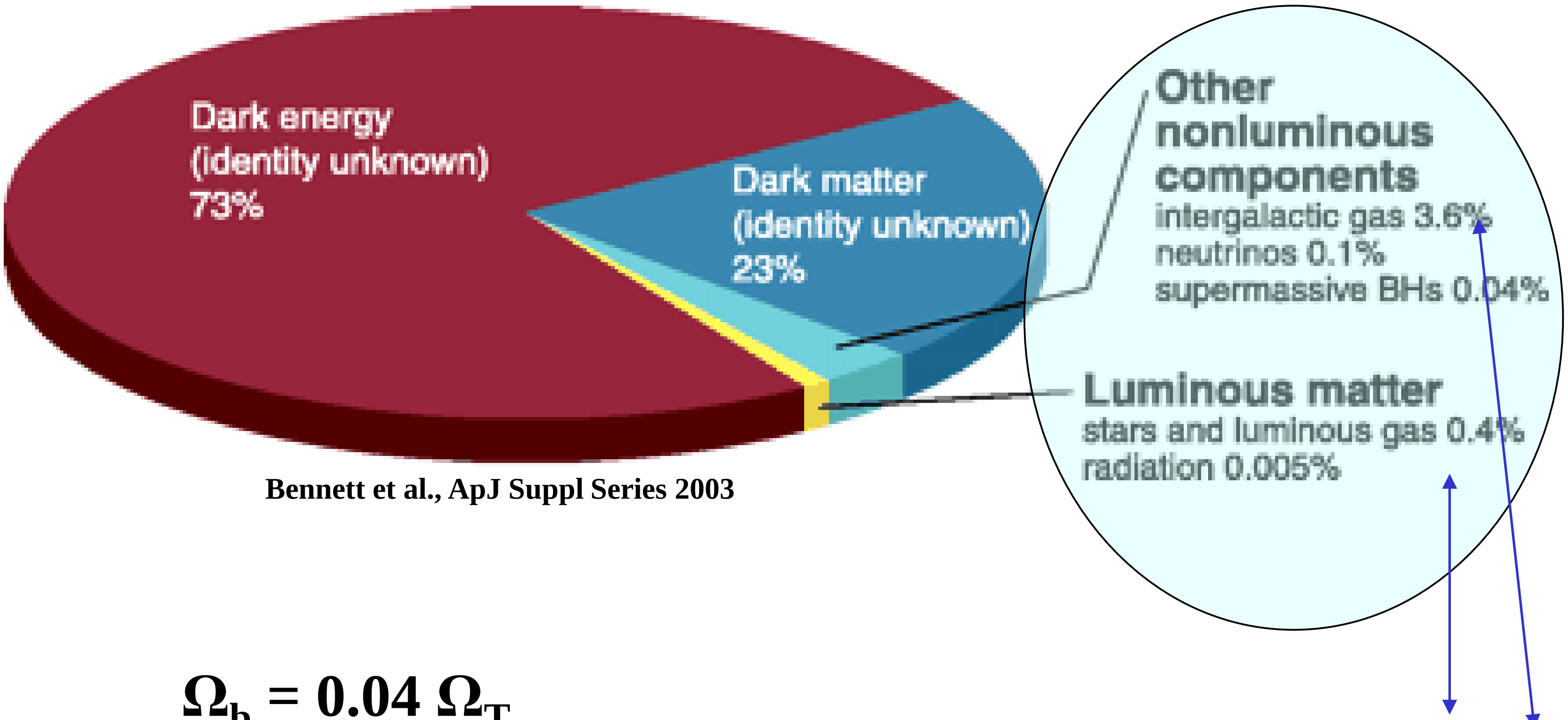
Relative number abundances of chemical elements (O=100) The abundances are in number (decreasing order) Sources: Lehninger 2000 (human body and Earth crust abundances); Asplund, Grevesse & Sauval 2004 (C, N, and O are solar photospheric values; the other elements are Solar System meteoritic values)		
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
Cl 0.31	K 5.3	Fe 6.17
K 0.24	Mg 4.7	S 3.16
S 0.20	Ti 1.1	Al 0.58
Na 0.12	H 0.4	Ca 0.43
Mg 0.04	C 0.4	Na 0.41



Depletions
log (X/H) Oph
Tc(K)
C
N
O
S
F
Na
As
P
Si
Mg
Fe
Ni
Ti
Ca
2
0
-2
-4
-6
-8
-10
-12
0
200
400
600
800
1000
1200
1400
1600


NGC 6543
HST • WFPC2
PR95-01a • ST ScI OPO • January 1995 • P. Harrington (U.MD), NASA
12/13/94 zgl

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



Bennett et al., ApJ Suppl Series 2003

$\Omega_b = 0.04\ \Omega_T$

Life building blocks come from these components...

Molecules in Space

331 Molecules

as if March 2024

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†	N_2^+†	CN^+†
3 atoms	C_3	C_2H	C_2O	C_2S	CH_2	HCN
	HCO	HCO^+	HCS^+	HOC^+	H_2O	H_2S
	HNC	HNO	MgCN	MgNC	N_2H^+	N_2O
	NaCN	OCS	SO_2	$c-SiC_2$	CO_2	NH_2
	H_3^+	H_2D^+	HD_2^+	SiCN	AlNC	SiNC
	HCP	CCP	AlOH	H_2O^+	H_2Cl^+	KCN
	FeCN	OCN^-	CO_2^+	H_2S^+	CN_2	HDO
	CS_2†					
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	C_5H	$l-H_2C_4$	C_2H_4	CH_3CN	CH_3NC	CH_3OH
	CH_3SH	HC_3NH^+	HC_2CHO	NH_2CHO	C_5N	$l-HC_4H$
	$l-HC_4N$	$c-H_2C_3O$	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_2OHCHO
	$l-HC_6H$	CH_2CHCHO(?)	CH_2CCHCN	H_2NCH_2CN	C_2H_6†	$(NH_2)_2CO$(??)
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(??)†	
11 atoms	HC_9N	CH_3C_6H	C_2H_5OCHO			
12 atoms	C_6H_6	$C_2H_5OCH_3$?	$n-C_3H_7CN$	$CO(CH_2OH)_2$(??)		
> 12 atoms	$HC_{11}N$	$C_{10}H_8^+$	$C_{14}H_{10}^+$(??)	C_{24}(??)	C_{60}	C_{70}

LOOKING AT OTHER PLANETARY SYSTEMS:

SEARCHING FOR KEY PREBIOTIC COMPOUNDS:

H_2O

NH_3

CH_4

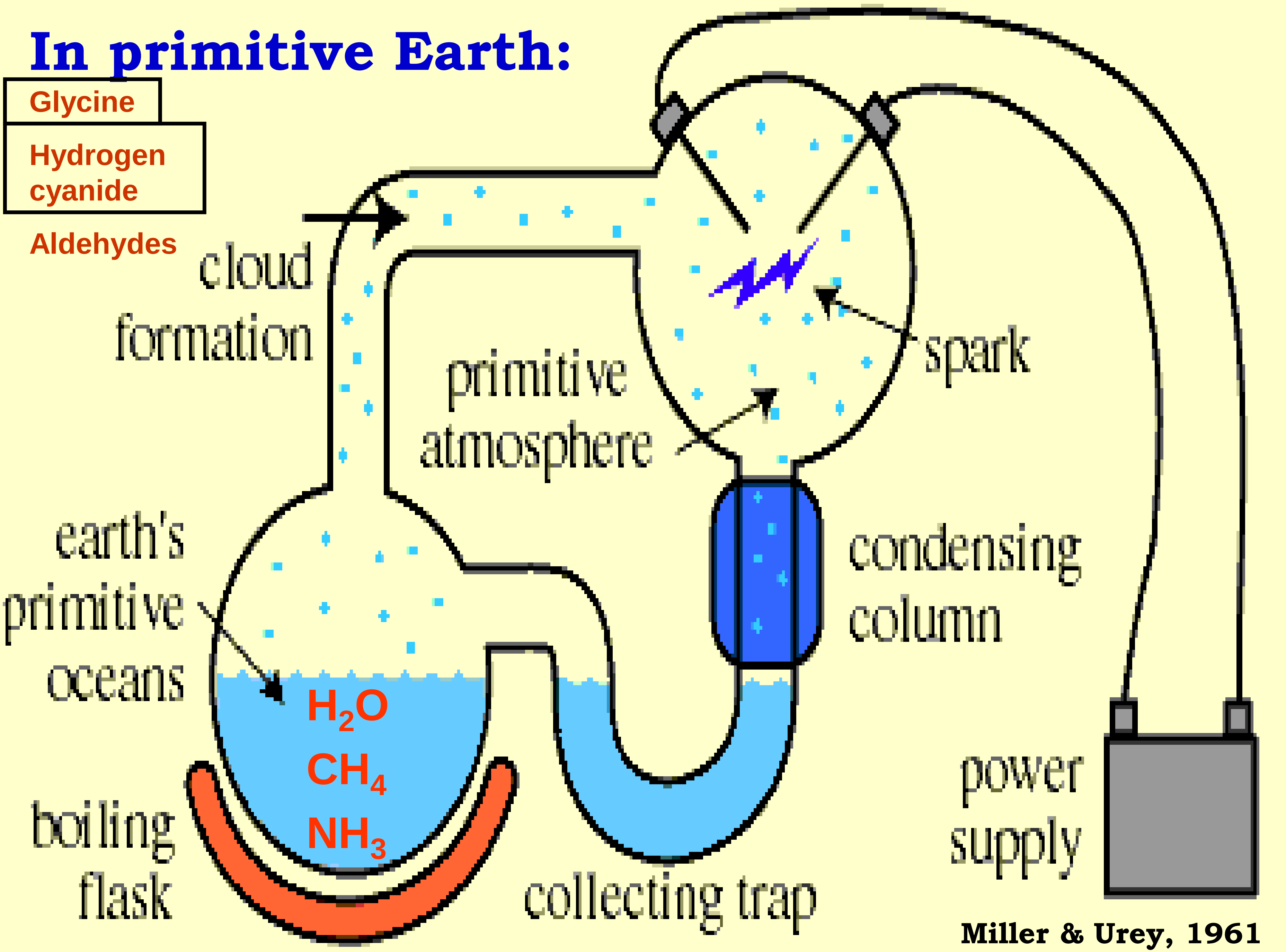
THOSE ARE FOUND UNDER RELATIVELY HIGH ABUNDANCES

In primitive Earth:

Glycine

Hydrogen cyanide

Aldehydes



Miller & Urey, 1961

Química de Sistemas

ORIGINS OF LIFE

Systems chemistry on early Earth

Nature 559, 171 (2009)

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 catalysis[1] — 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 ribose[3] (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.

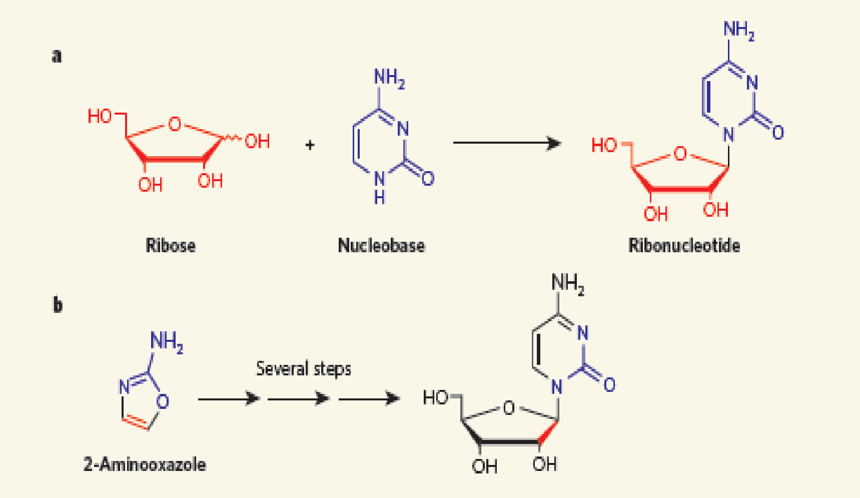


Figure 1 | Theories of prebiotic syntheses of pyrimidine ribonucleotides. The idea that RNA might have formed spontaneously on early Earth has inspired a search for feasible prebiotic syntheses of ribonucleotides, the building blocks of RNA. **a**, The traditional view is that the ribose sugar and nucleobase 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

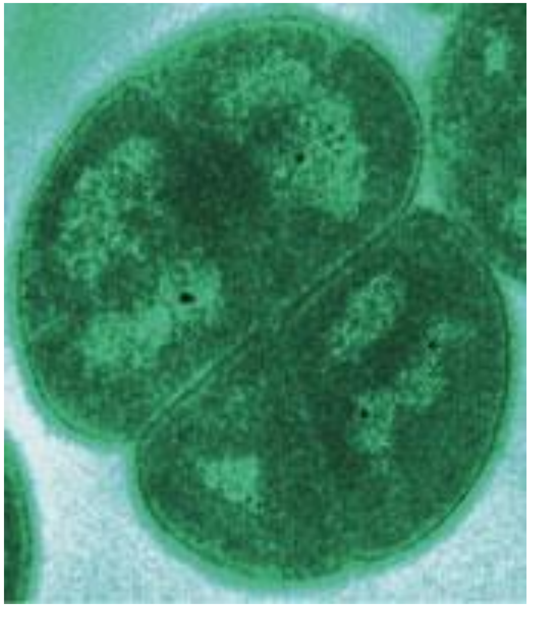
mixture of undesired compounds is formed. But Powner *et al.* add a third ingredient — phosphate — to the mix. In their reaction, phos-

Qual vida?

Extremófilos

Que tipo de vida esperamos encontrar fora da Terra?

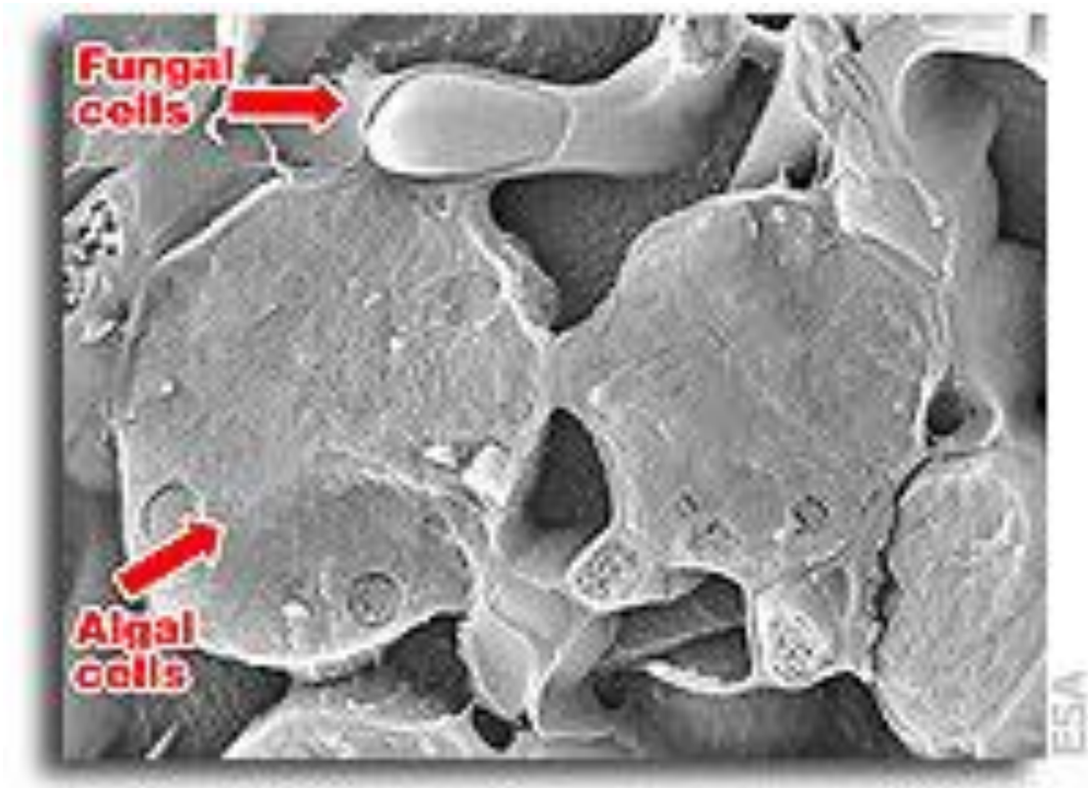
- O que é a vida?
- Um bom começo: Vida difícil de morrer!!!



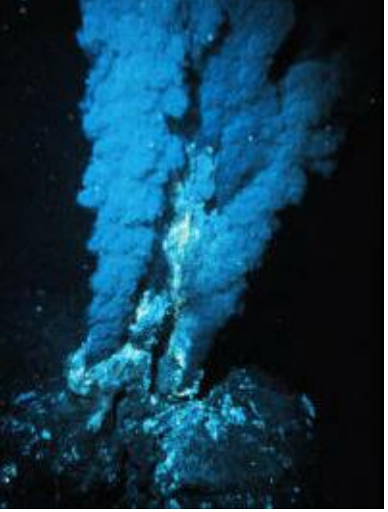
Deinococcus radiodurans – prospera com 5 000 Gy

(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)



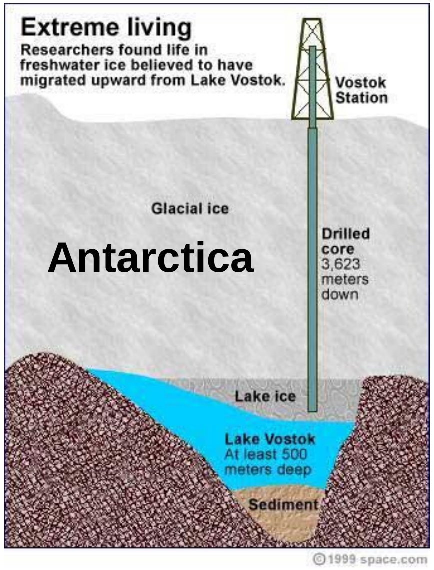
Extremophiles survival chart

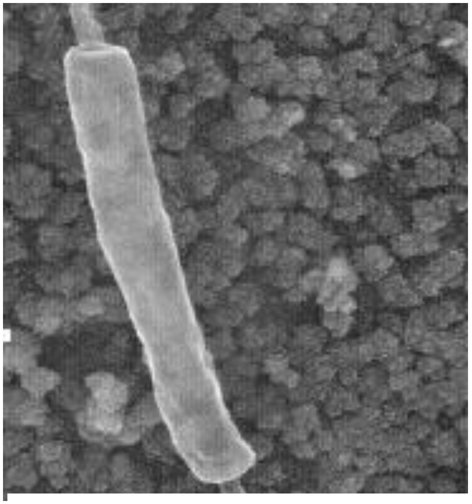


Hydrothermal vents

- 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)*

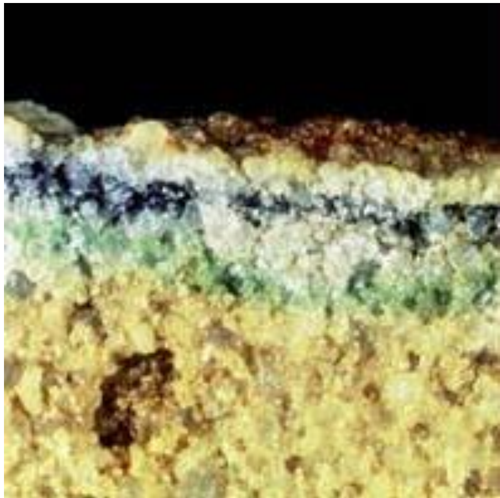




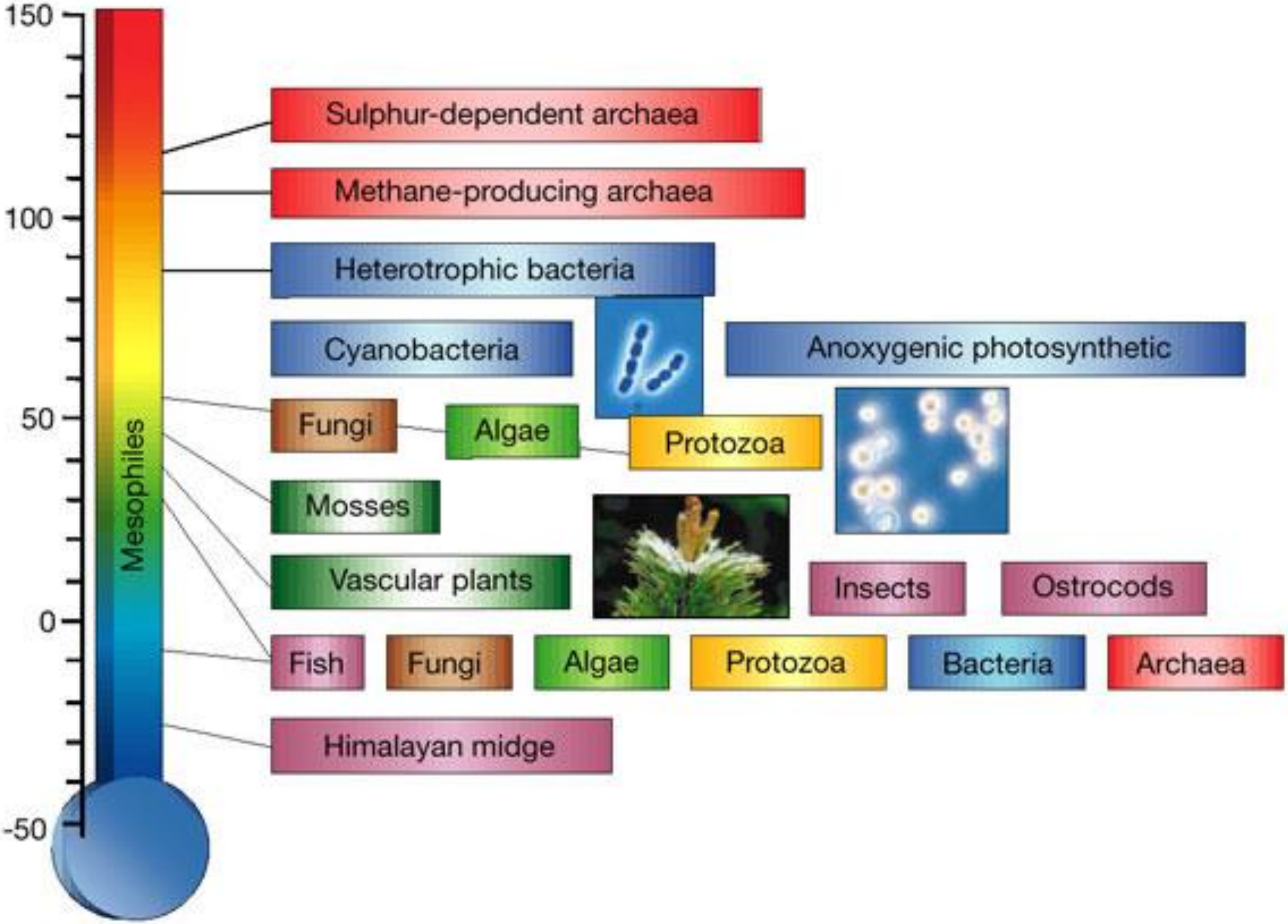
Thermophile bacteria

Hot geisers and volcanos

Cryptoendoliths



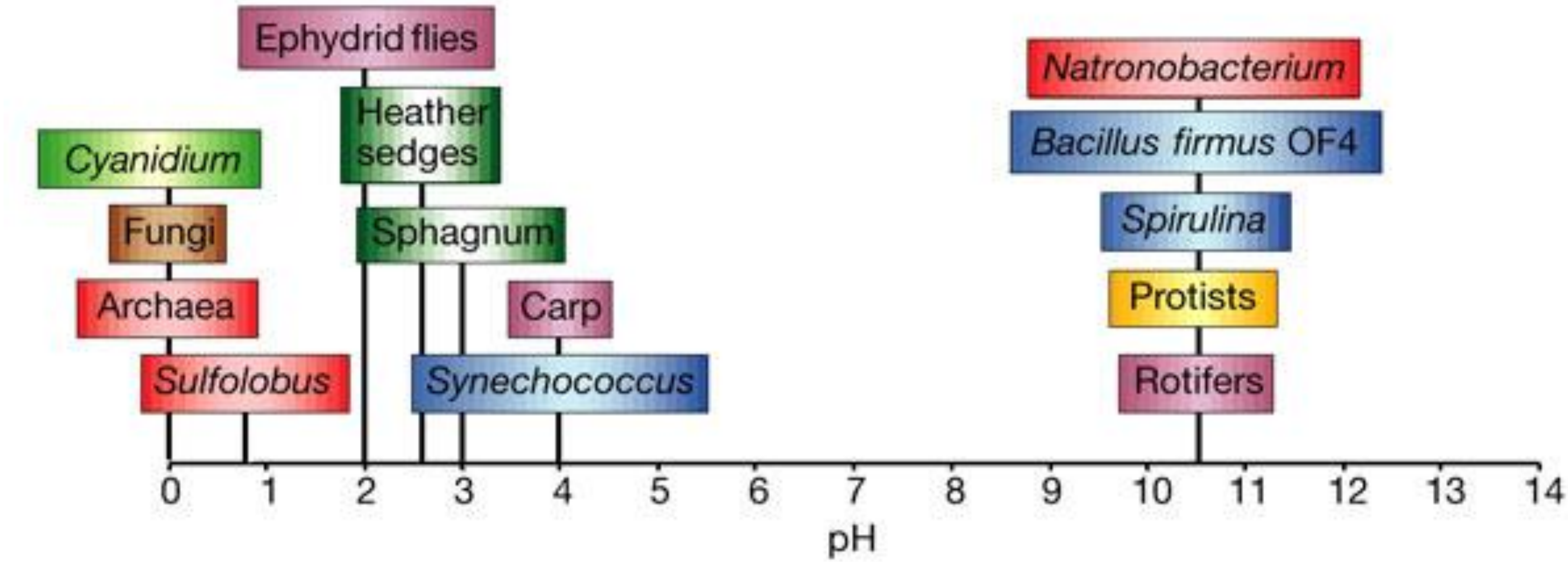
Temperature limits for life



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.

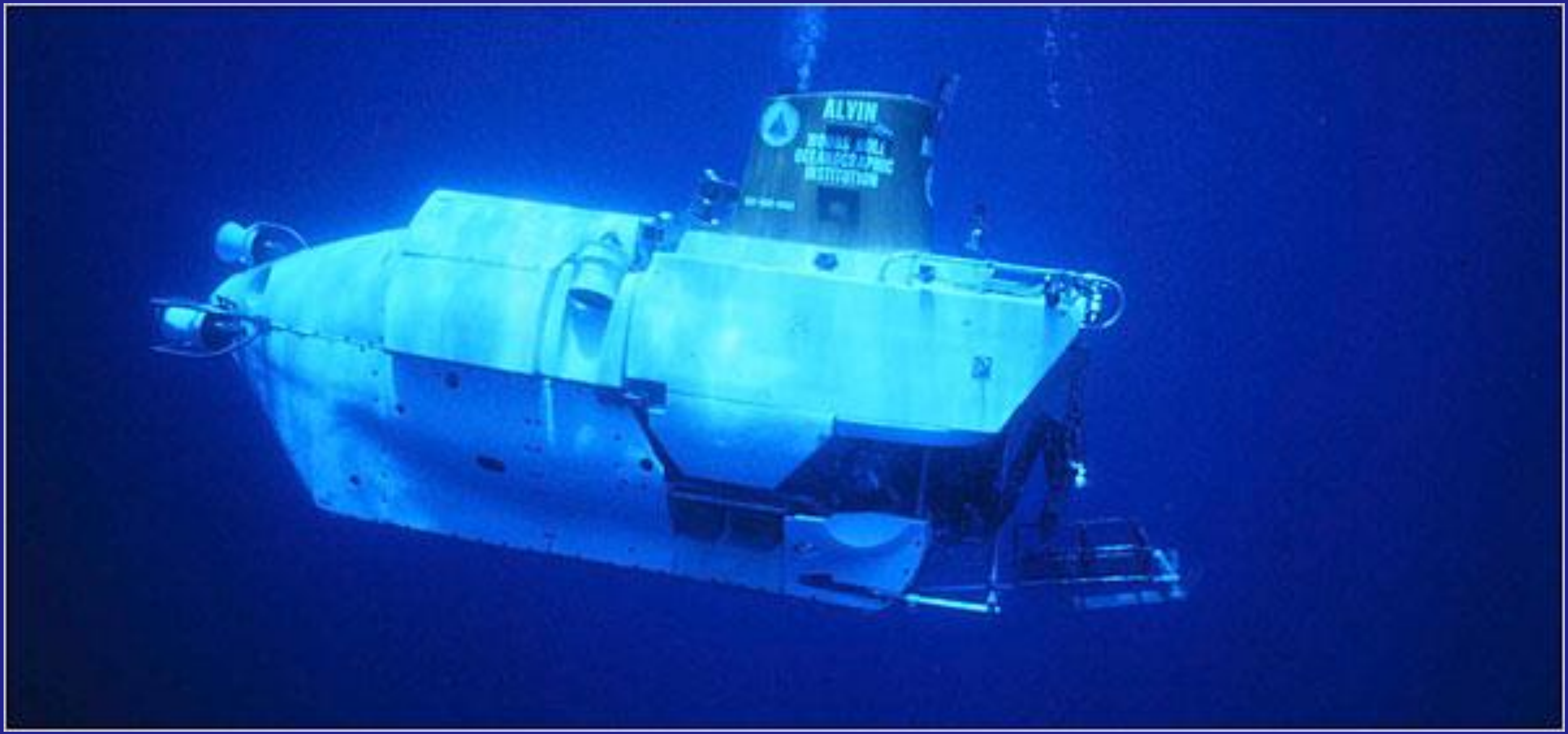
Life in extreme environments, LJ Rothschild & RL Mancinelli, Nature 409, 1092-1101 (22 February 2001)

pH limits for life

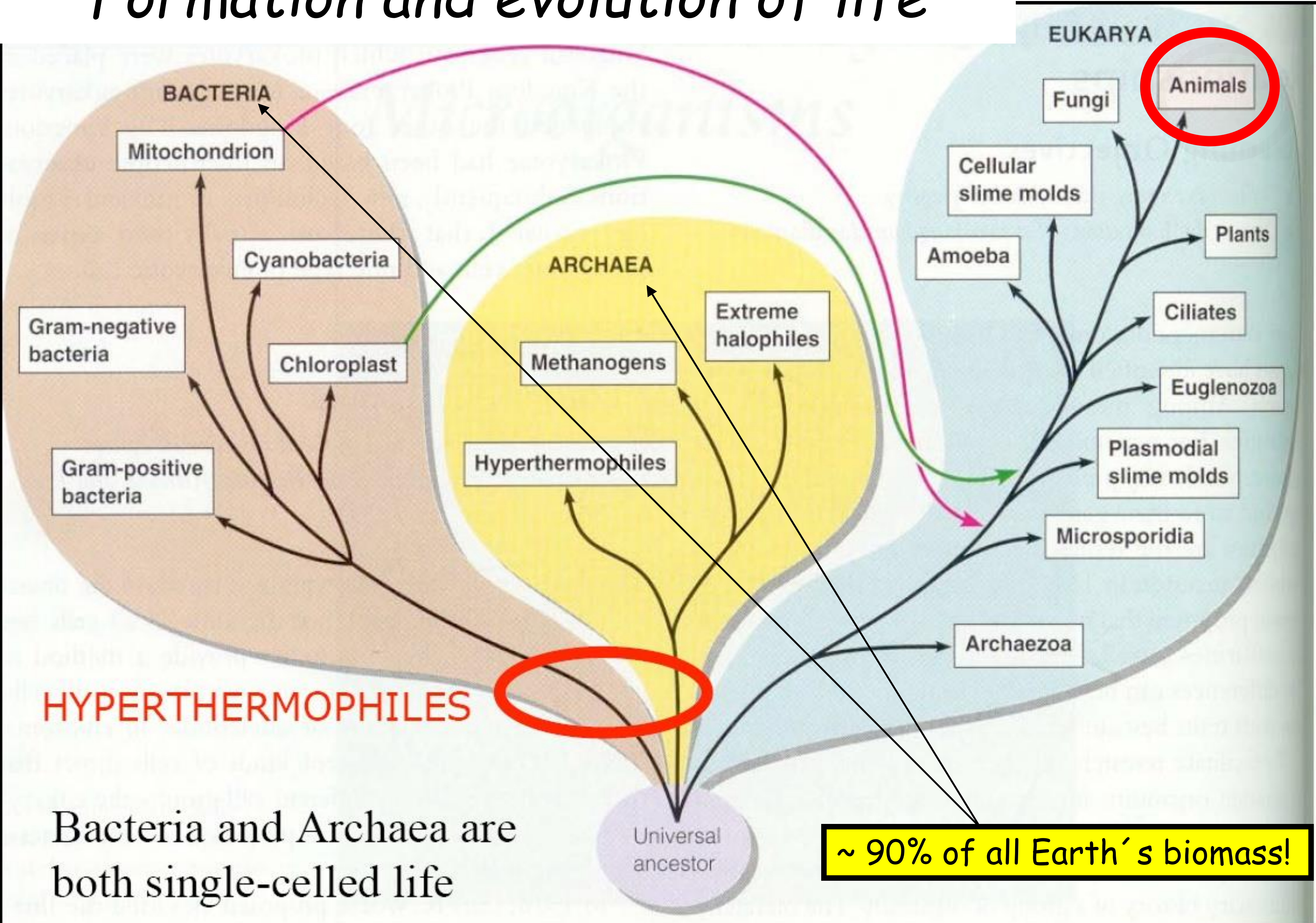


Examples of known pH limits for life are shown. Archaea are in red, bacteria in blue, algae in light green, assorted protists in yellow, fungi in brown, plants in dark green and animals in purple.

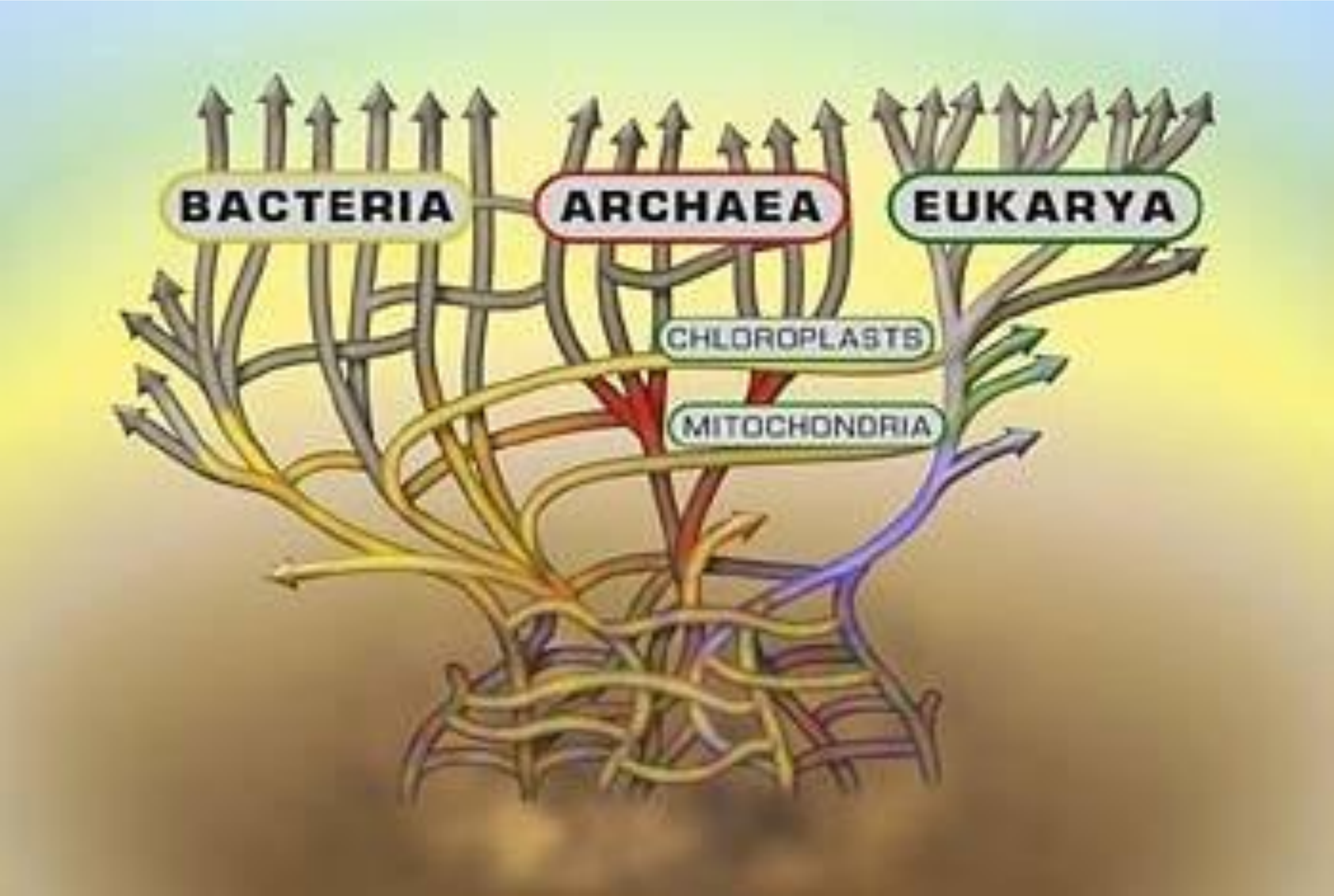
Fontes hidrotérmicas

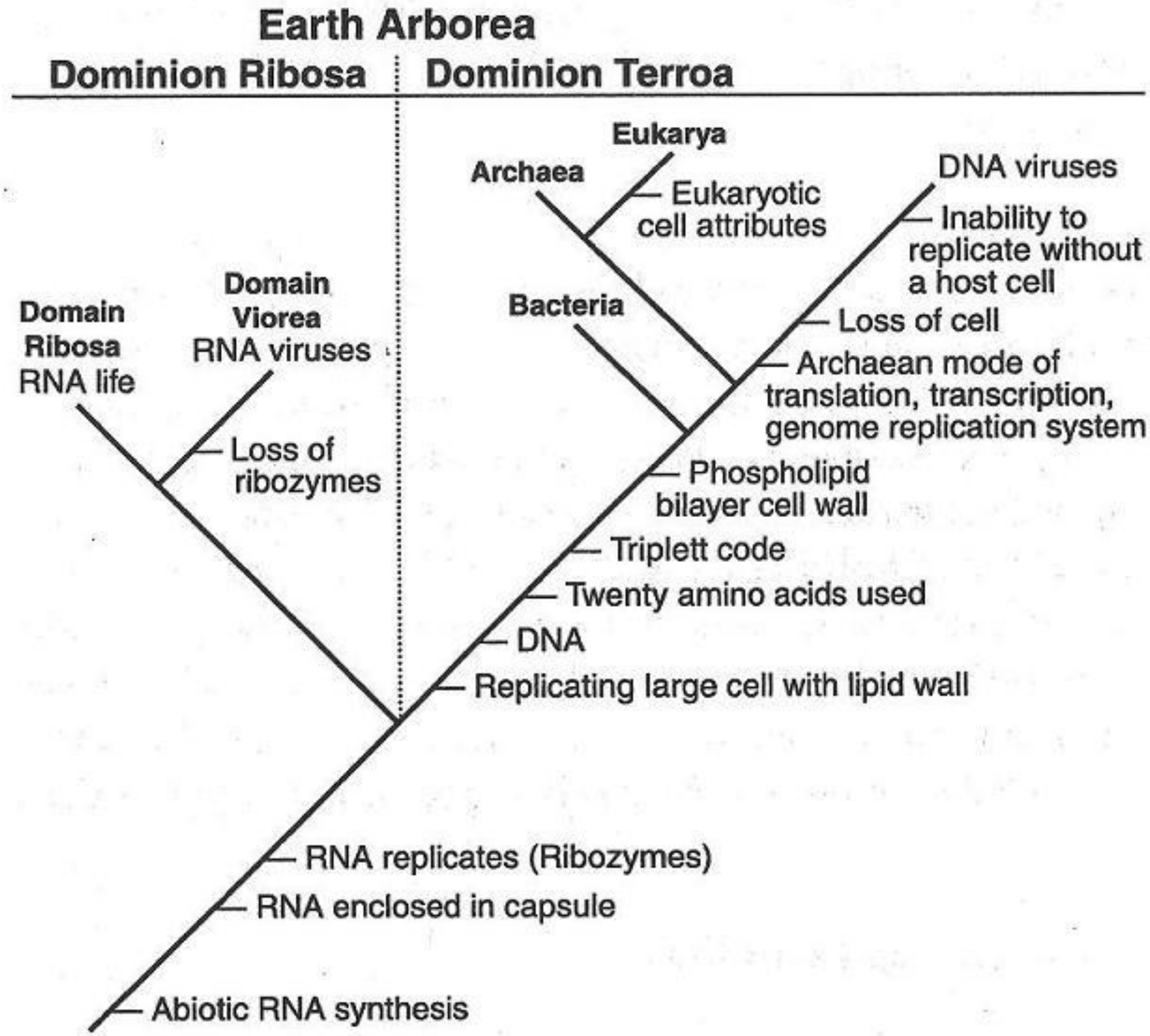

ALVIN

Formation and evolution of life



Bacteria and Archaea are both single-celled life


BACTERIA
ARCHAEA
EUKARYA
CHLOROPLASTS
MITOCHONDRIA


Earth Arborea
Dominion Ribosa
Dominion Terroa
Eukarya
Archaea
Eukaryotic cell attributes
DNA viruses
Inability to replicate without a host cell
Domain Viorea RNA viruses
Domain Ribosa RNA life
Bacteria
Loss of cell
Archaean mode of translation, transcription, genome replication system
Loss of ribozymes
Phospholipid bilayer cell wall
Triplett code
Twenty amino acids used
DNA
Replicating large cell with lipid wall
RNA replicates (Ribozymes)
RNA enclosed in capsule
Abiotic RNA synthesis

SIGNATURES OF A SHADOW BIOSPHERE

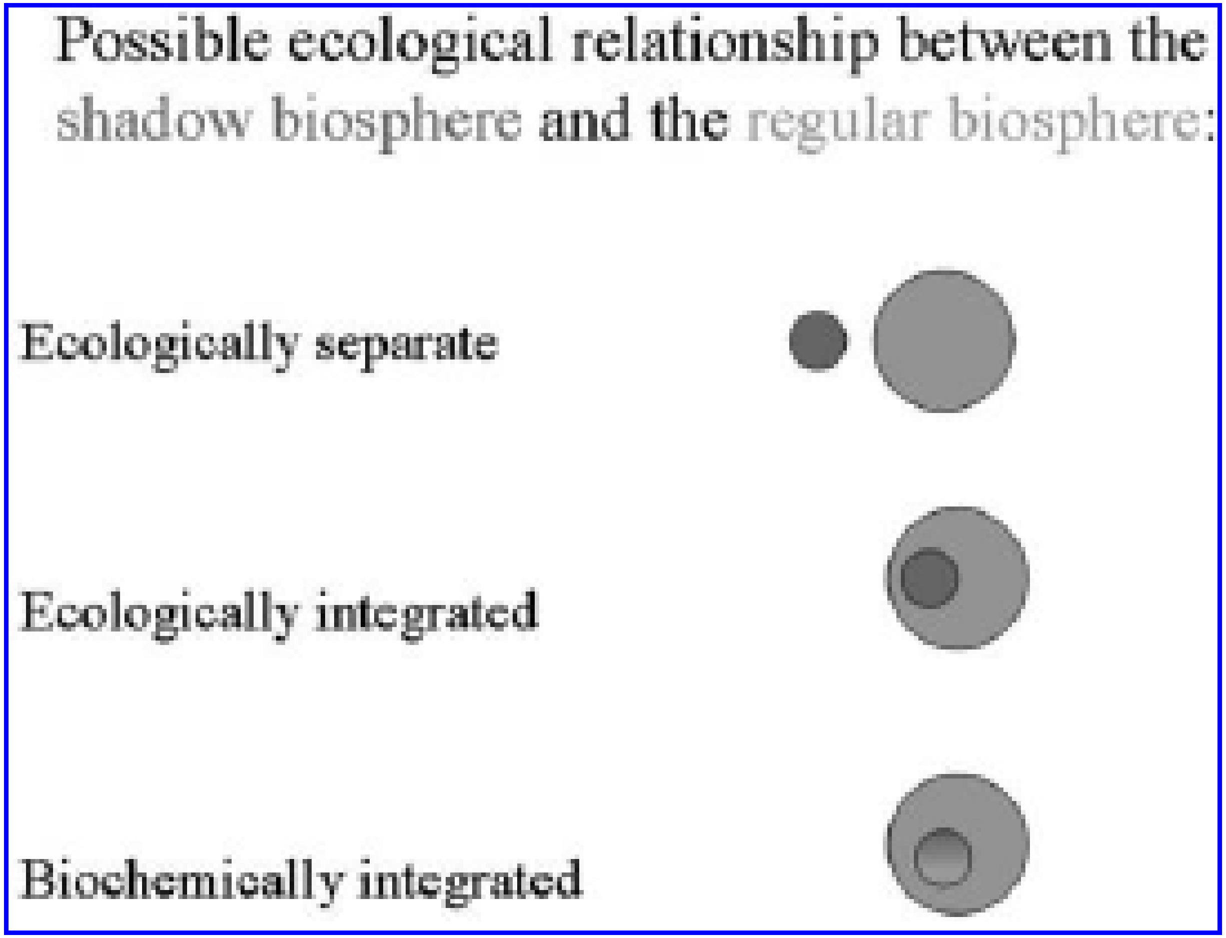
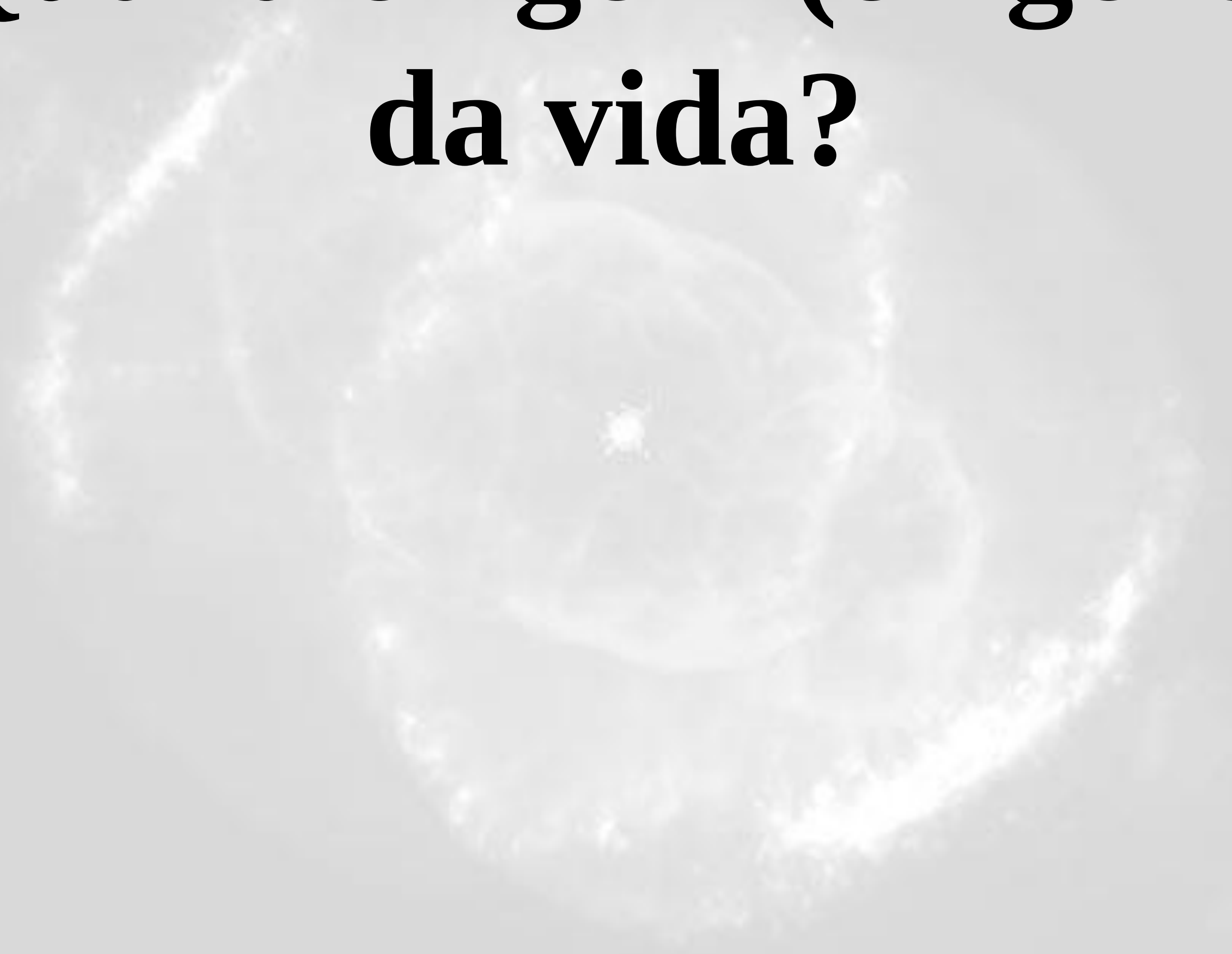


FIG. 1. Schematic representation of various possible relationships between known and weird life.

Qual a origem (origens) da vida?

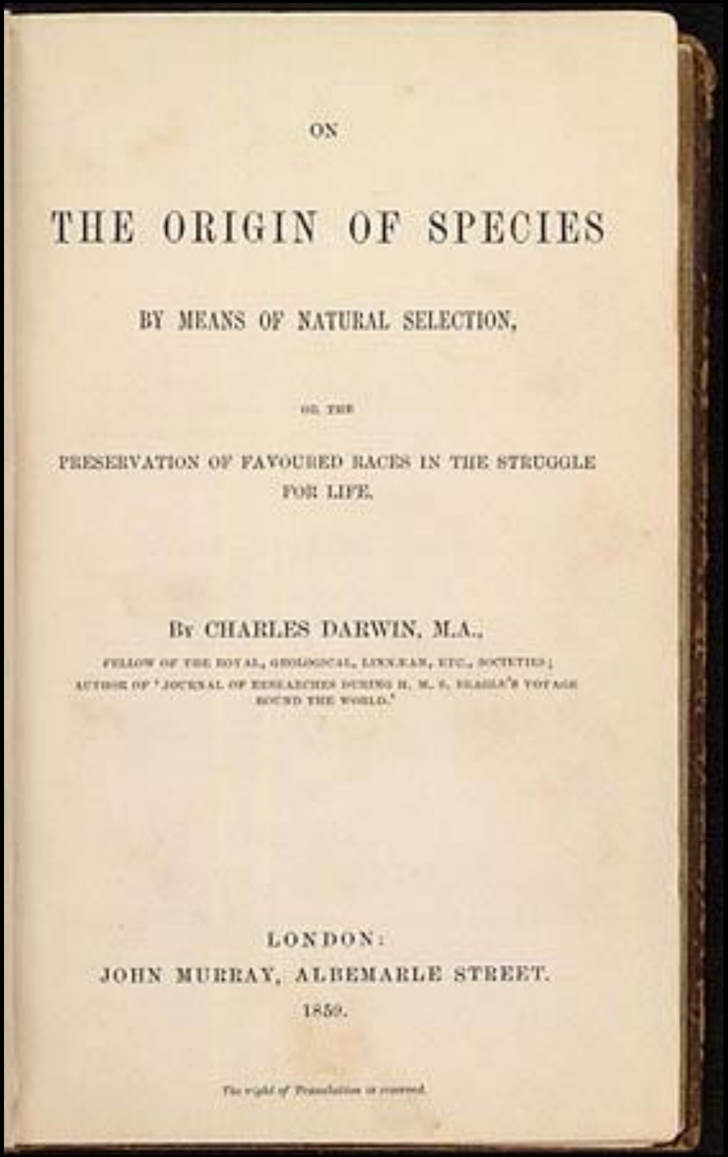


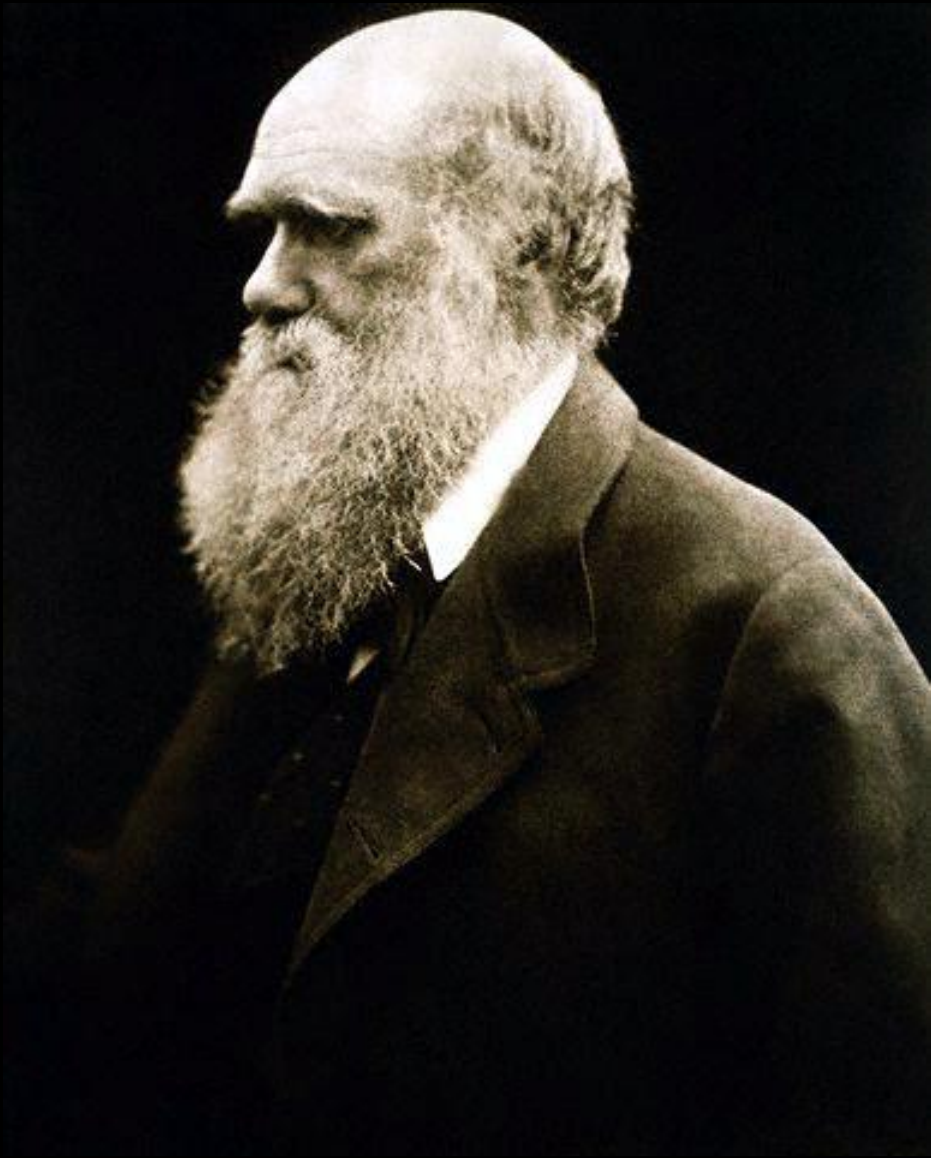
Some Warm Little Pond

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)





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.

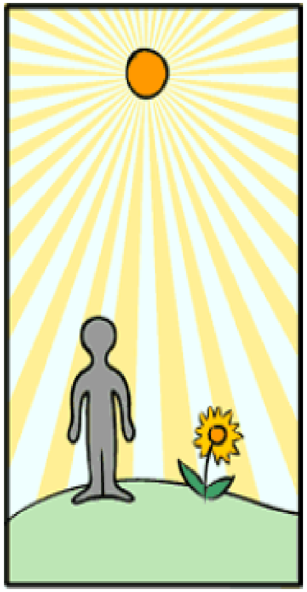
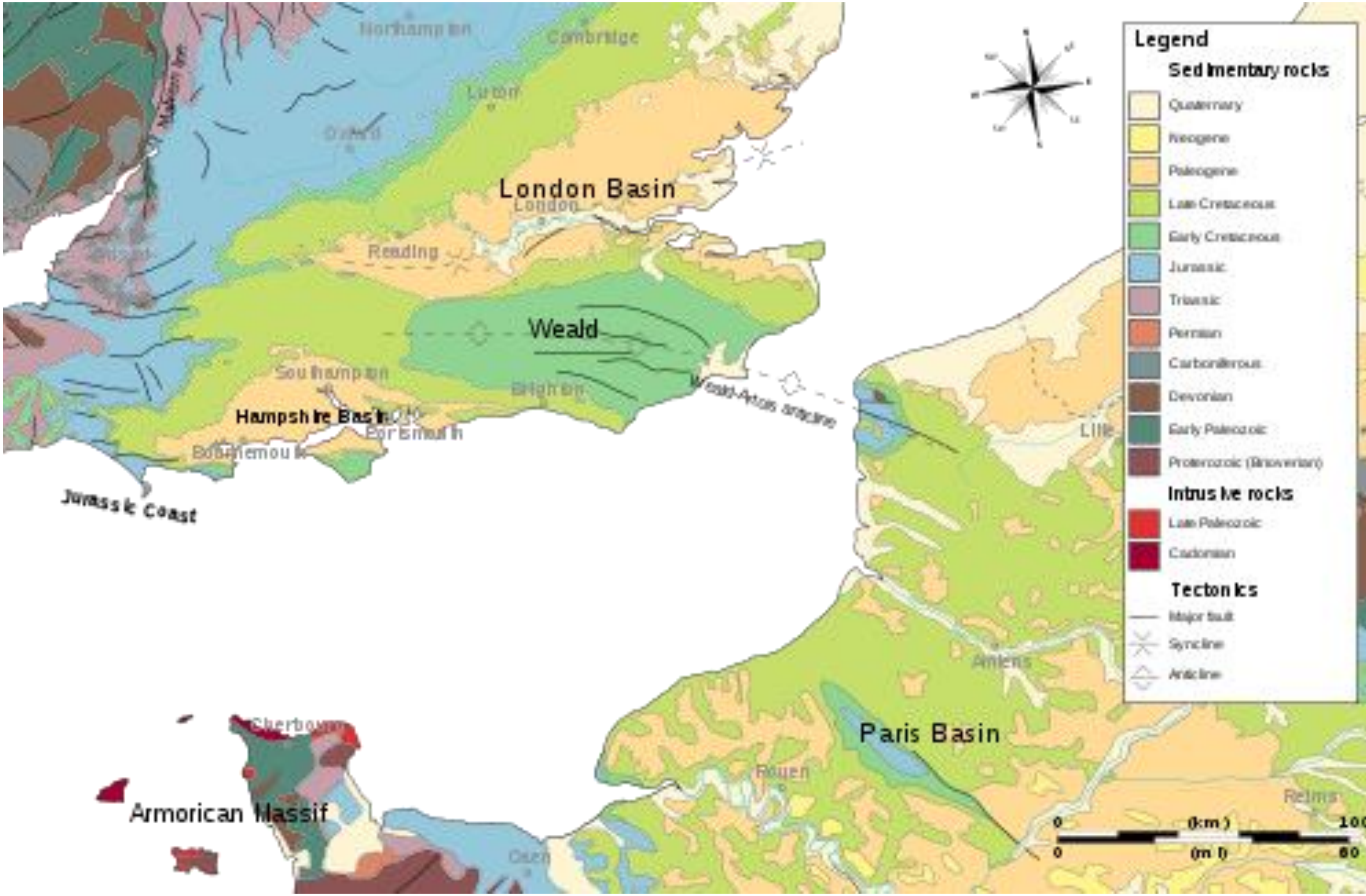
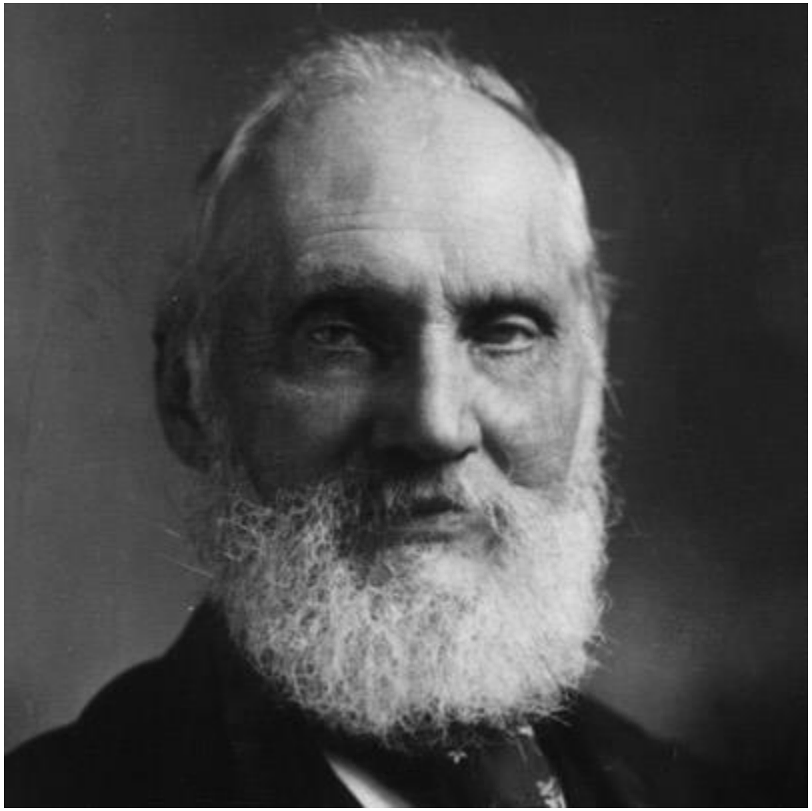


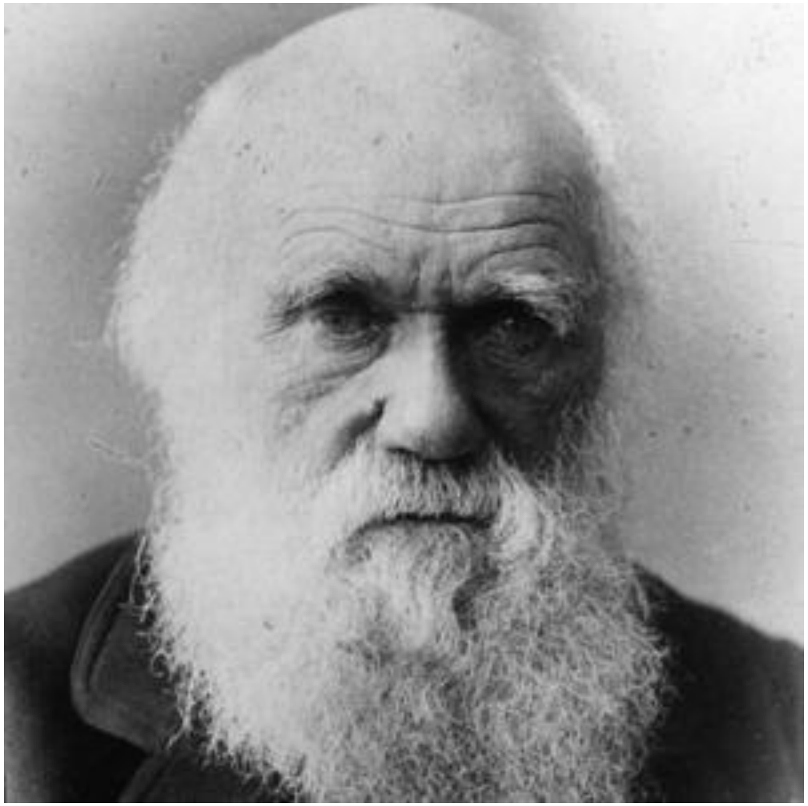
FIG. 1. Sunshine makes life possible on earth.



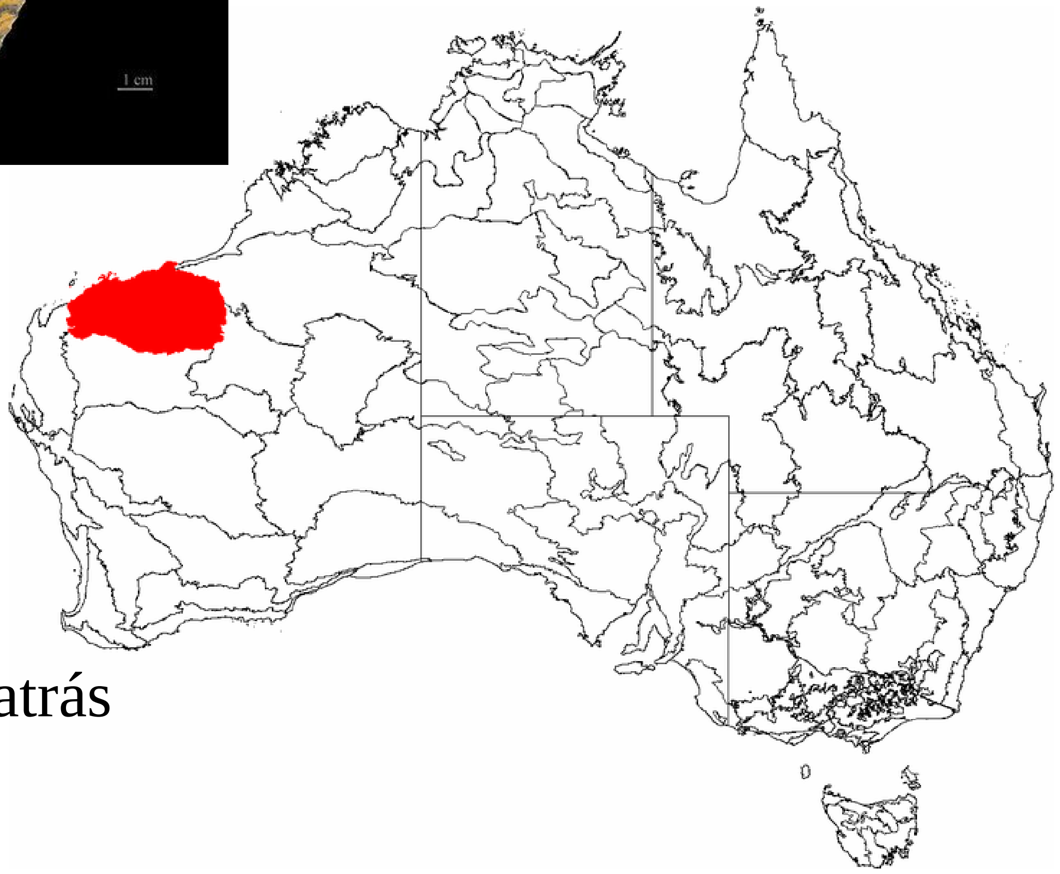
Denudation of the Weald

⇒ 300 milhões de anos





Kelvin X Darwin



Pilbara, 3,55 bilhões de anos atrás

CYANOBACTERIAL MICROFOSSILS

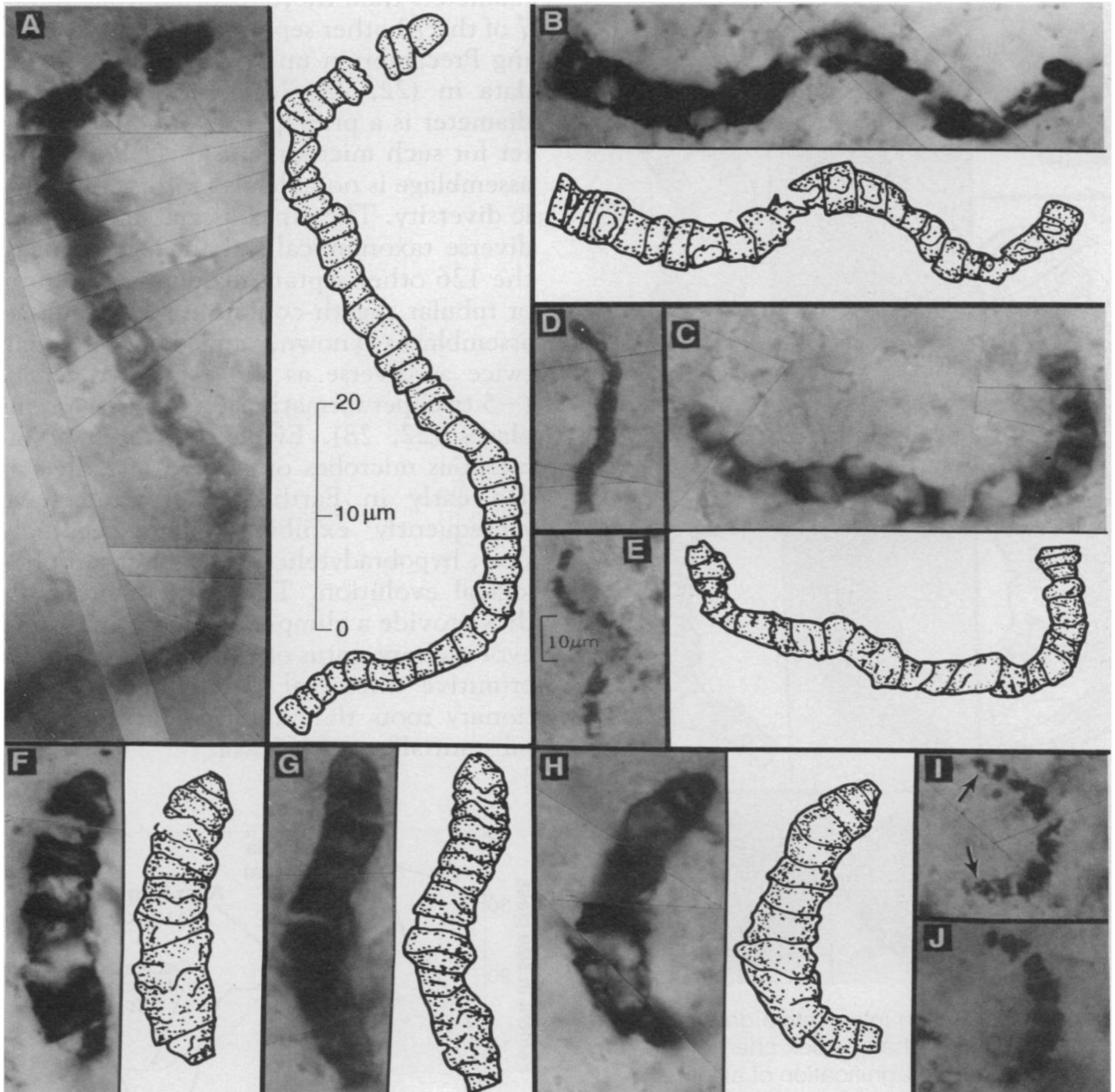


Fig. 4. Carbonaceous microfossils (with interpretive drawings) shown in thin sections of the Early Archean Apex chert of Western Australia. Magnification of (D, E, I, and J) denoted by scale in (E);magnification of all other parts shown by scale in (A). (A, B, C, and D) and (F, G, H, and 1) show photomontages of the sinuous three-dimensional microfossils. (A, B, C, D, and E) Primaevifilum amoenum Schopf, 1992 (A, holotype) (3). (F, G, H, I, and J) P. conicoterminatum Schopf, 1992 (H, holotype) (3); arrows in (I) point to conical terminal cells.

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SIDE BY SIDE: FOSSIL IMAGE AND MODERN CYANOBACTERIA

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

Oscillatoria, modern filamentous cyanobacteria

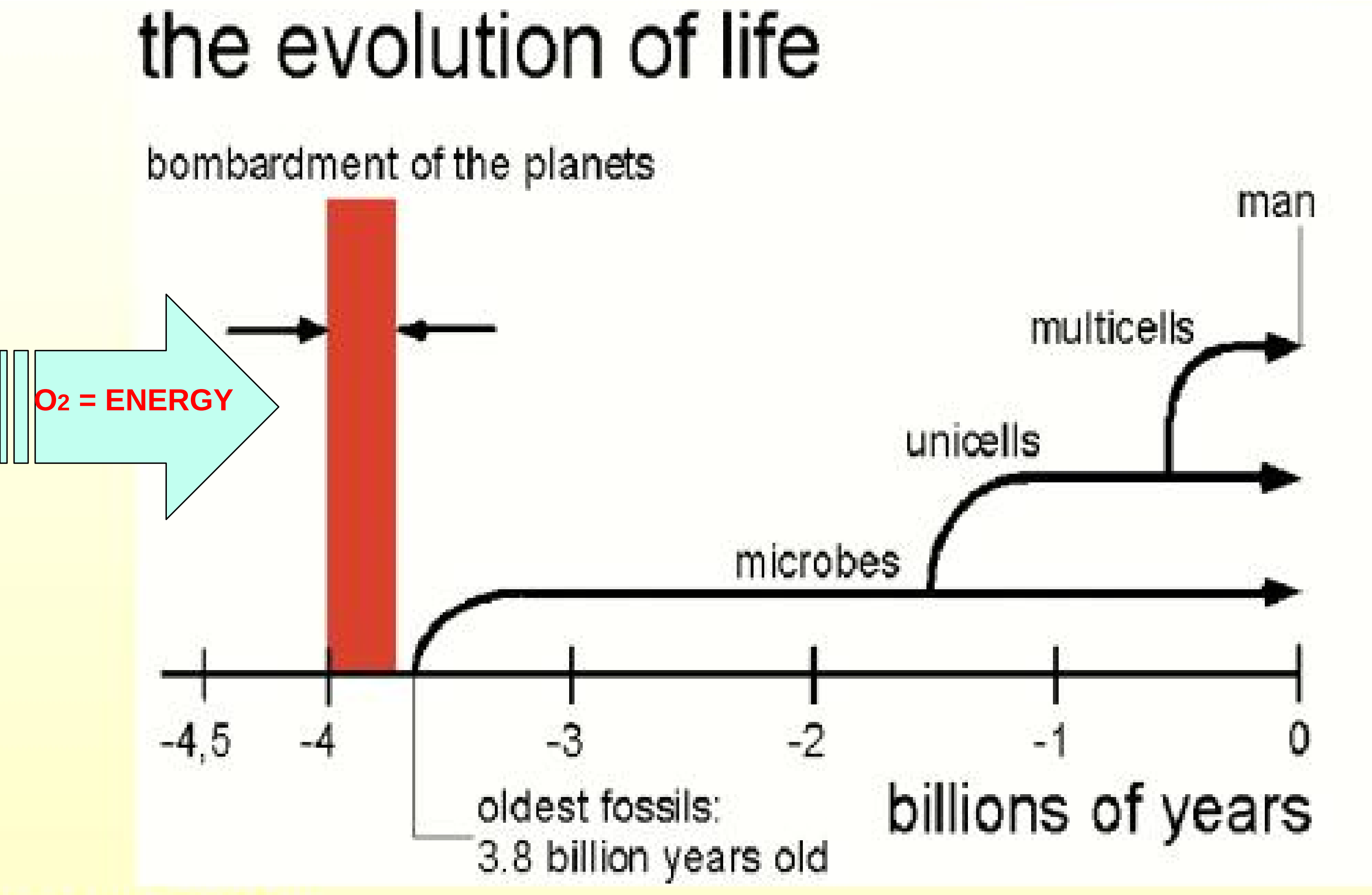
Evidence for life on Earth before 3,800 million years ago

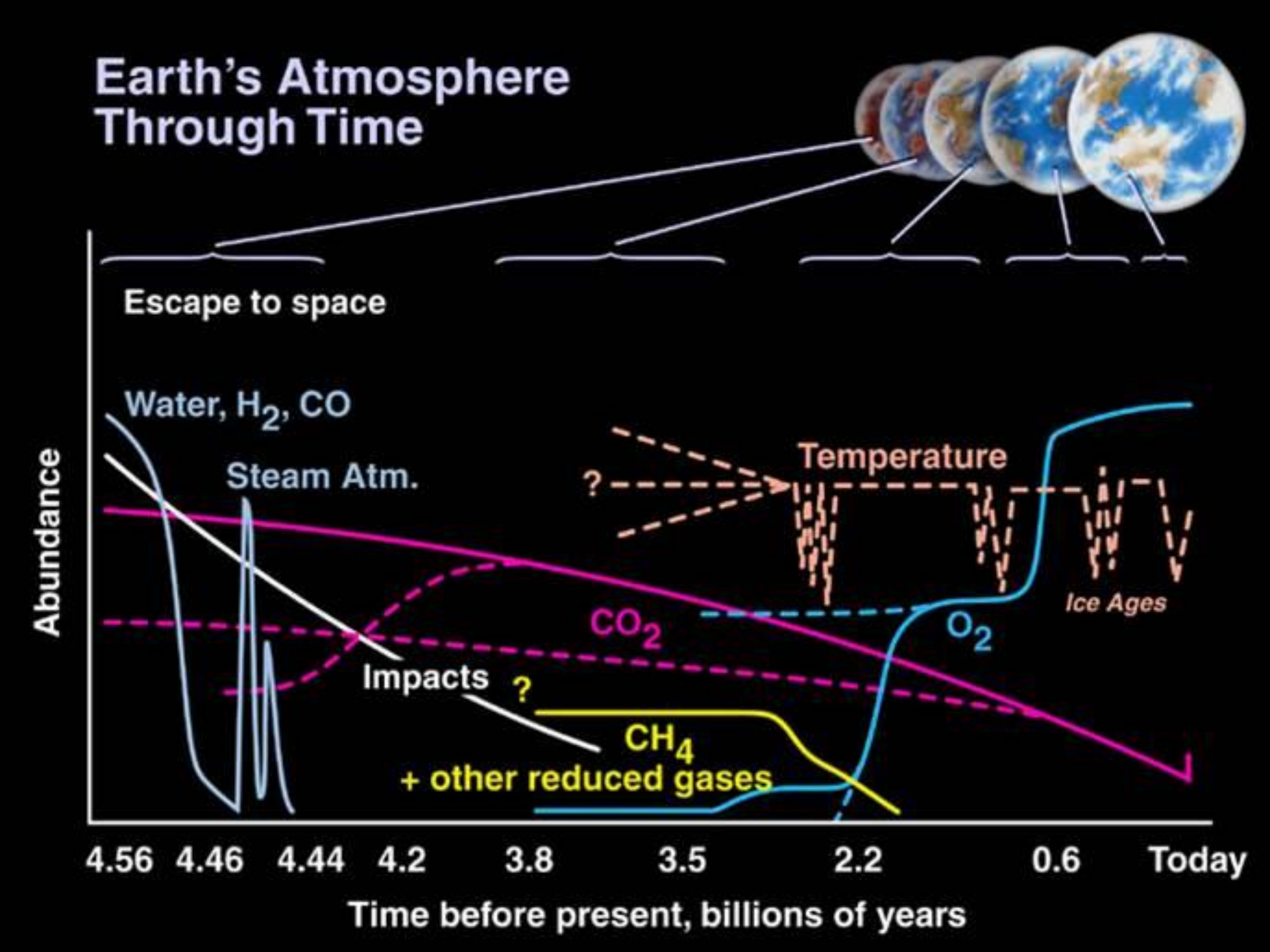
S. J. Mojzsis*, G. Arrhenius*, K. D. McKeegan†, T. M. Harrison†, A. P. Nutman‡ & C. R. L. Friend§

* Scripps Institution of Oceanography, University of California San Diego, La Jolla, California 92093-0220, USA
† W.M. Keck Foundation Center for Isotope Geochemistry, Department of Earth and Space Sciences, University of California Los Angeles, Los Angeles, California 90095-1567, USA
‡ Research School of Earth Sciences, The Australian National University, Canberra, A.C.T. 0200, Australia
§ Department of Geology and Cartography, Oxford Brookes University, Headington, Oxford OX3 0BP, UK

It is unknown when life first appeared on Earth. The earliest known microfossils (~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 ~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 Greenland[3-5], and a similar formation from the nearby Akilia island that is possibly older than 3,850 Myr (ref. 3). The carbon in

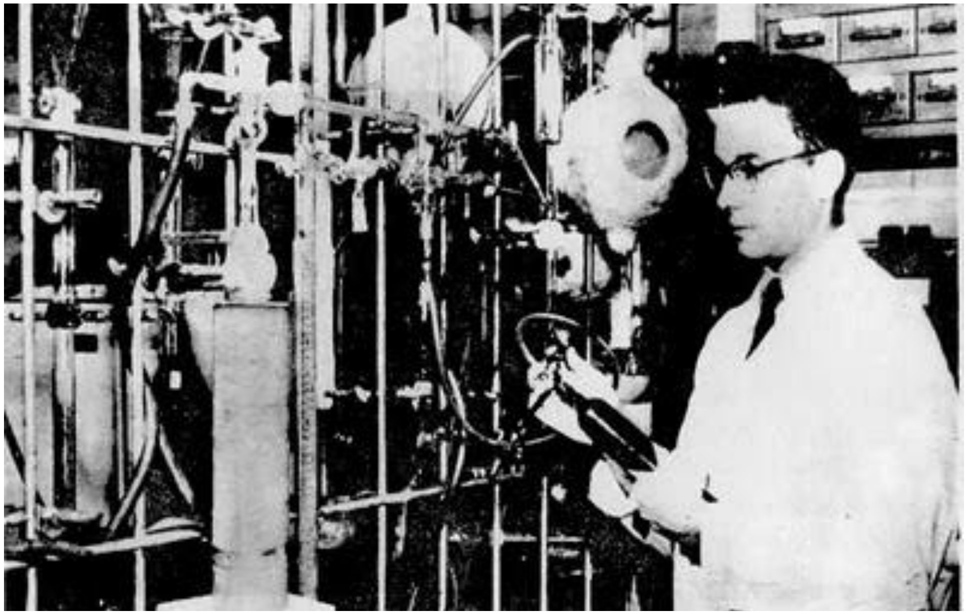
ORIGINS OF LIFE ON EARTH





Earth's Atmosphere Through Time
Escape to space
Water, H2, CO
Steam Atm.
Temperature
?
Ice Ages
CO2
O2
Impacts
?
CH4
+ other reduced gases
Abundance
4.56
4.46
4.44
4.2
3.8
3.5
2.2
0.6
Today
Time before present, billions of years

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

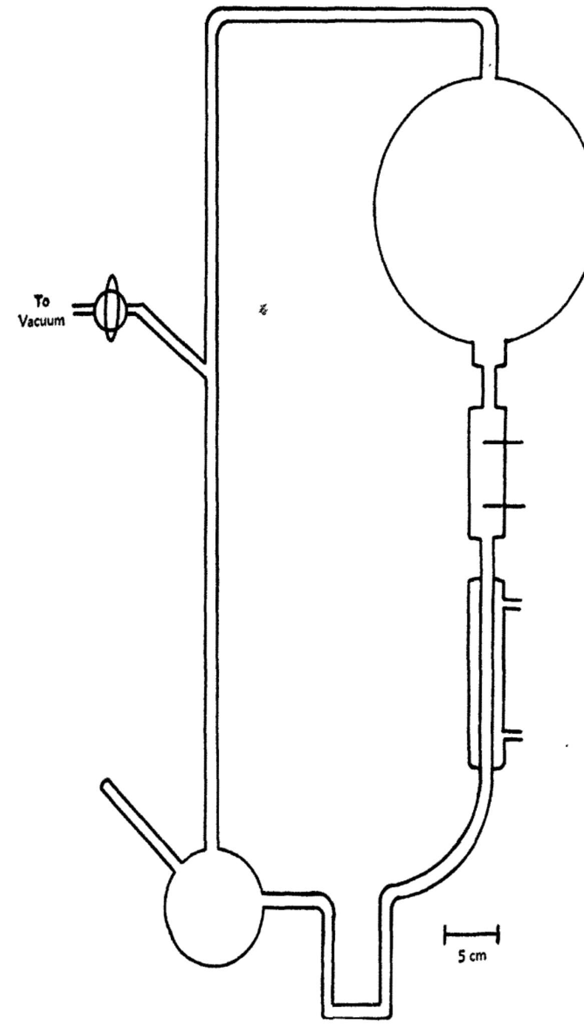


FIG. 1.

A descoberta da estrutura do DNA (1953)

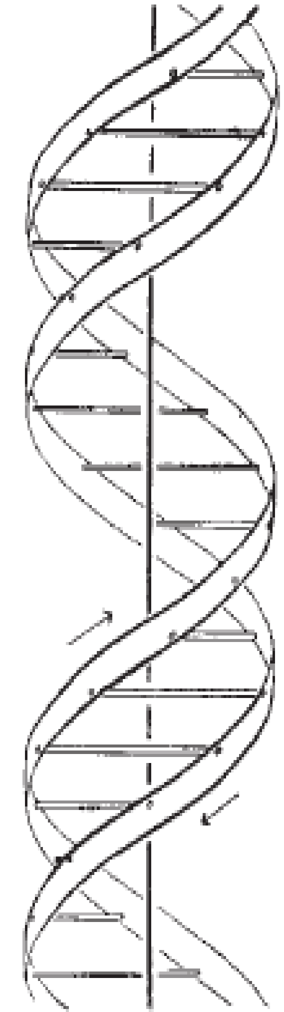
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

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 737



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

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

Clarice Lispector, *A Hora da Estrela*