AGA 0316
A vida no contexto cósmico

Amancio Friaça

2025

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?

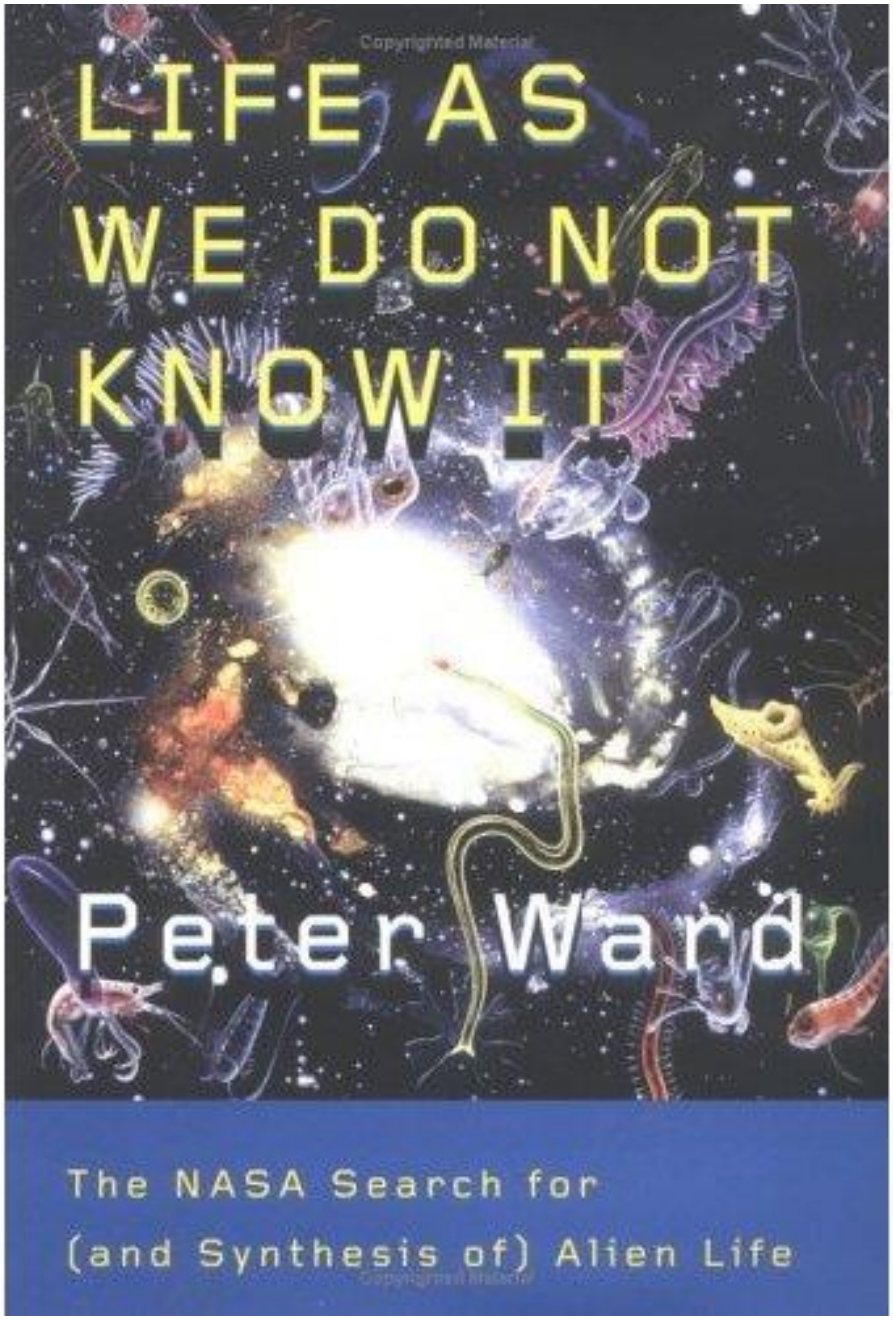
Questões vetores

- 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

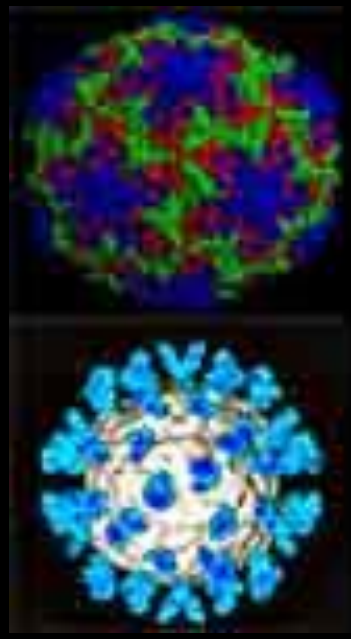
Questões Fundamentais (NAI Roadmap)

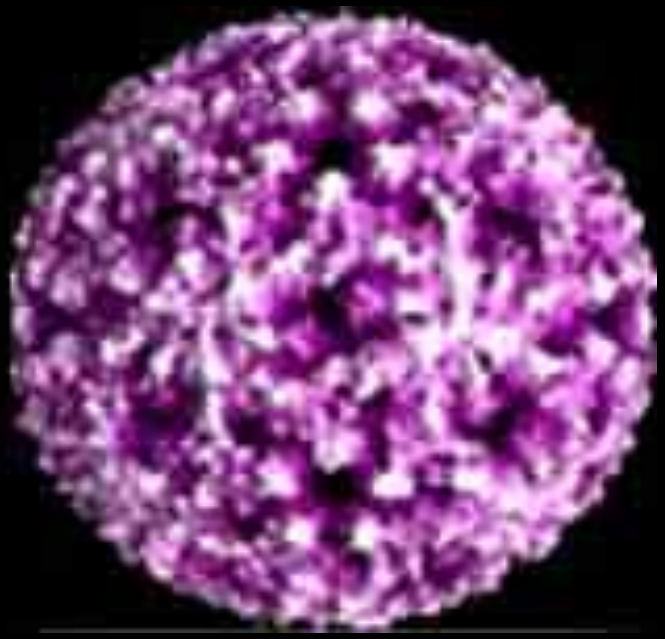
1. Como a vida se originou e evoluiu?
2. Existe vida em outras partes do Universo?
3. Qual será o futuro da vida na Terra e além?

O que é a vida?

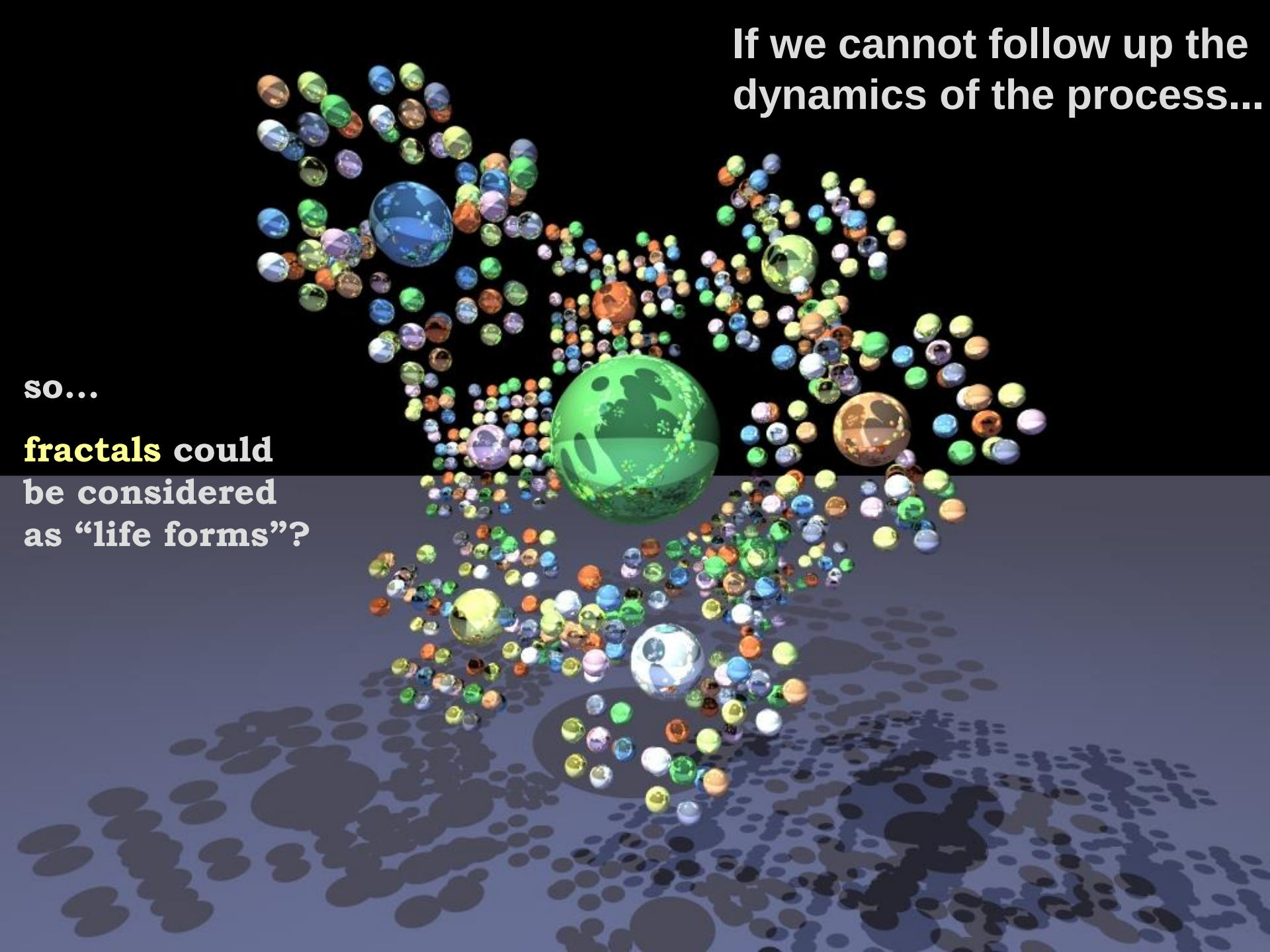

Copyrighted Material
LIFE AS WE DO NOT KNOW IT
Peter Ward
The NASA Search for (and Synthesis of) Alien Life
Copyrighted Material

É vivo ou não?



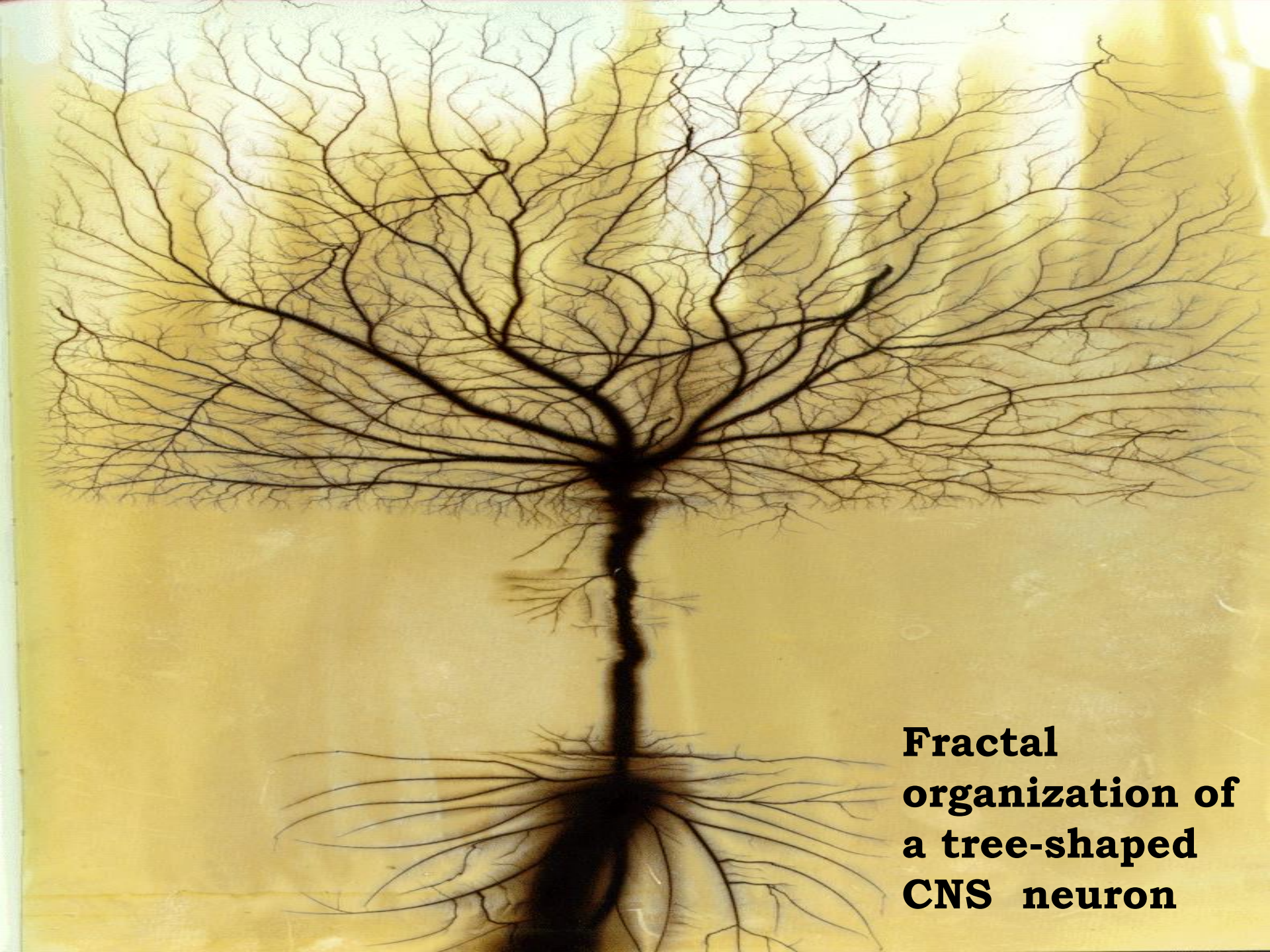


If we cannot follow up the dynamics of the process...



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).

© Shirley Owens and Catherine McGowan, 1996

INTO THE COOL

ENERGY FLOW THERMODYNAMICS AND LIFE

Eric D. Schneider & Dorion Sagan

Lynn Margulis & Dorion Sagan

DEFINING 'LIFE'

CAROL E. CLELAND[1] and CHRISTOPHER F. CHYBA[2]
[1] *Department of Philosophy and the Center for Astrobiology, University of Colorado, Boulder, CO 80309 USA;* [2] *Center for the Study of Life in the Universe, SETI Institute, 2035 Landings Drive, Mountain View, CA 94043 and Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94404 USA*

(Received 2 March 2002; accepted in revised form 12 June 2002)

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.
© 2002 *Kluwer Academic Publishers. Printed in the Netherlands.*

ABOUT VARIOUS DEFINITIONS OF LIFE

PIER LUIGI LUISI
Inst. für Polymere, ETH-Z, 8092-Zurich, CH, Switzerland

(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.
© 1998 *Kluwer Academic Publishers. Printed in the Netherlands.*

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)

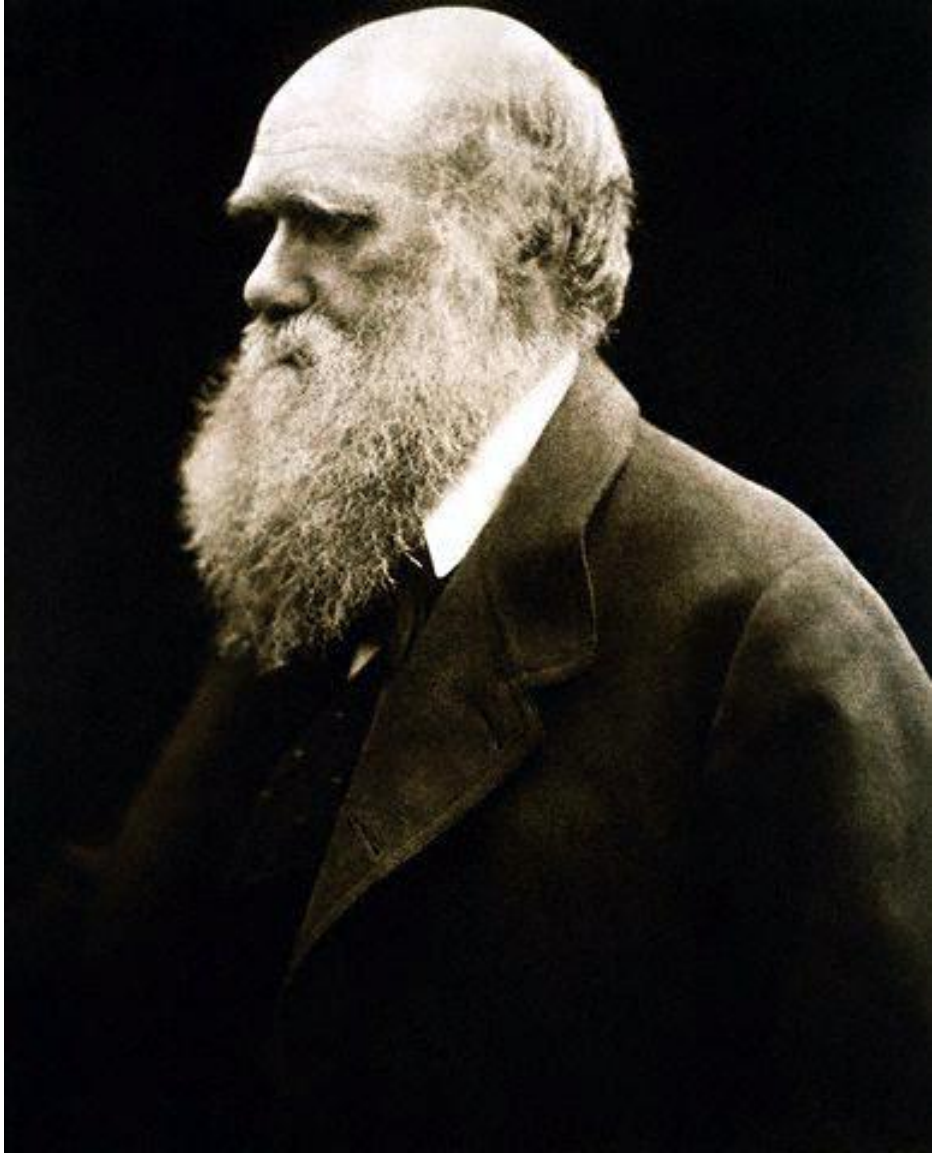
1) Any population of a species has the potential to produce **far more** offspring than the environment can support with resources.

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**.

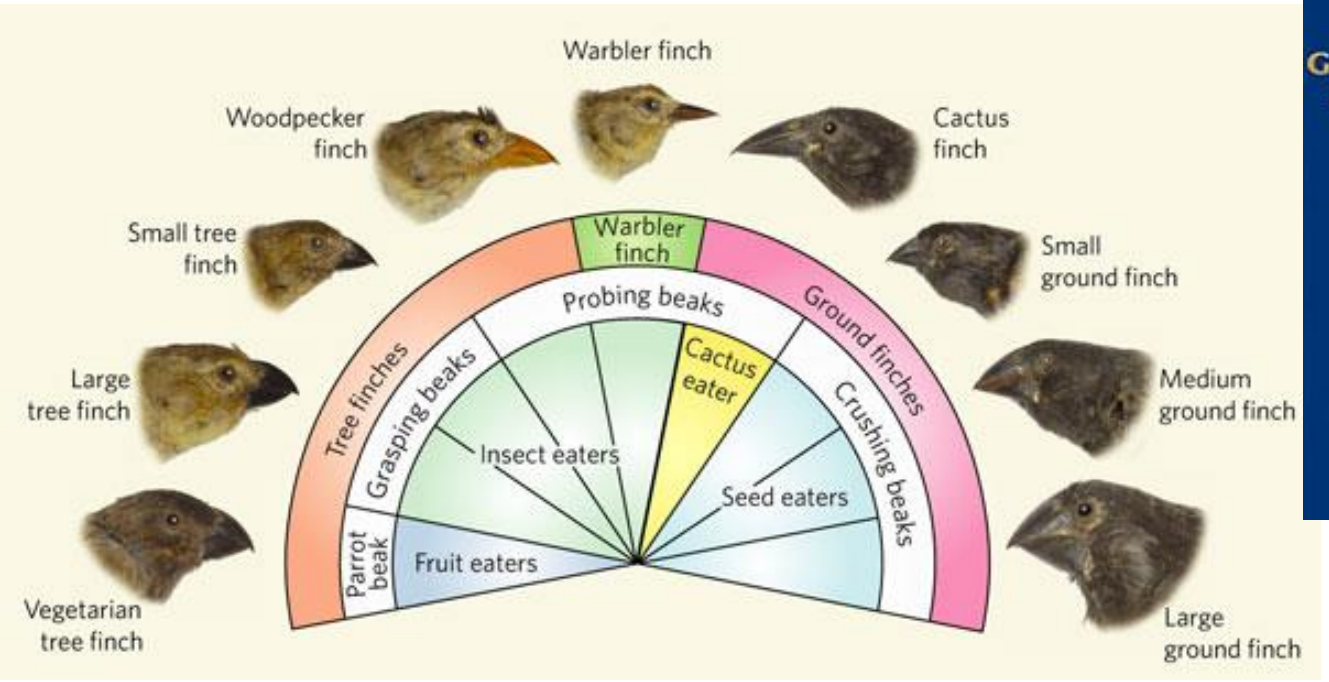
4) Some individuals possess traits that make them **better** able **to compete** for resources.

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)

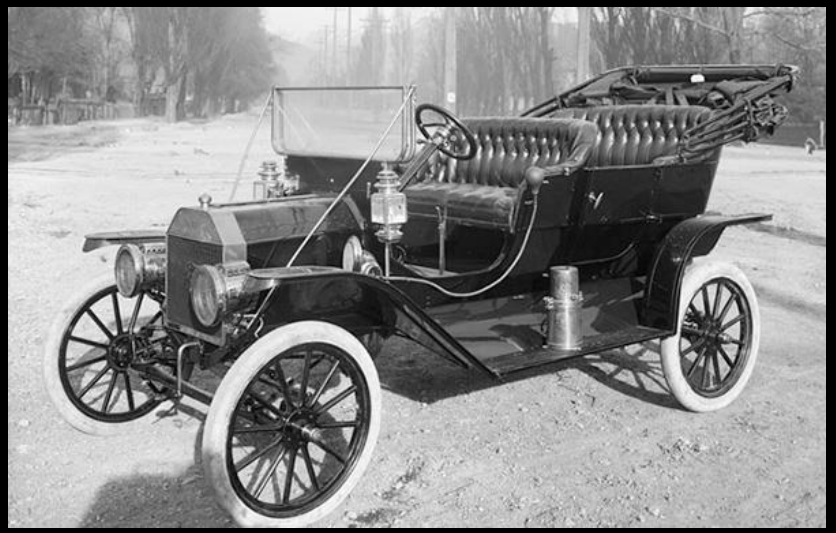


Todos os tendilhões das Ilhas Galápagos tinham um ancestral comum proveniente da América do Sul. Mas todas a espécies se adaptaram a microambientes particulares.

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

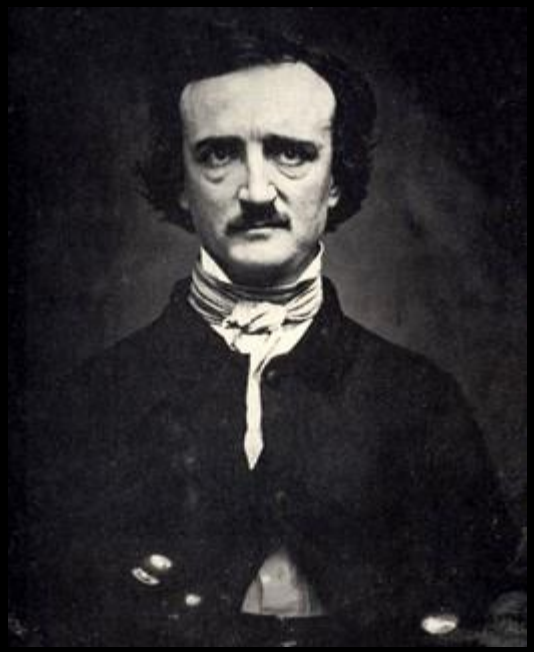
Algumas características da vida

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

FRONTEIRAS

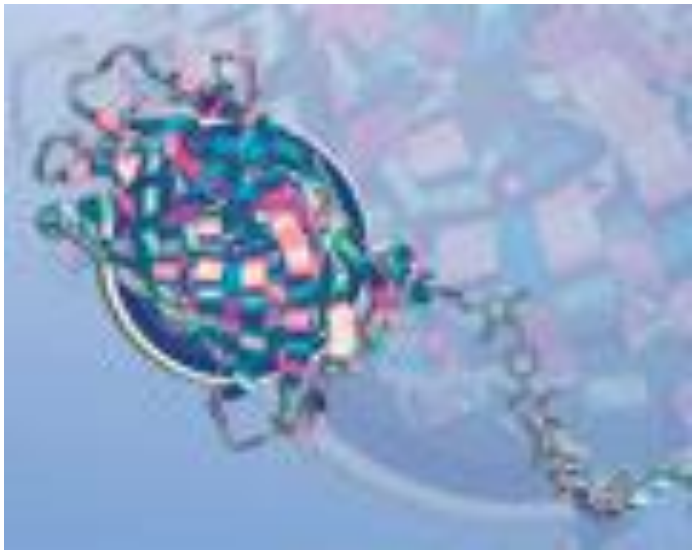
- Vivo/Morto
- Máquina/Organismo
- Química/Biologia

Edgar Allan Poe (1809-1849)



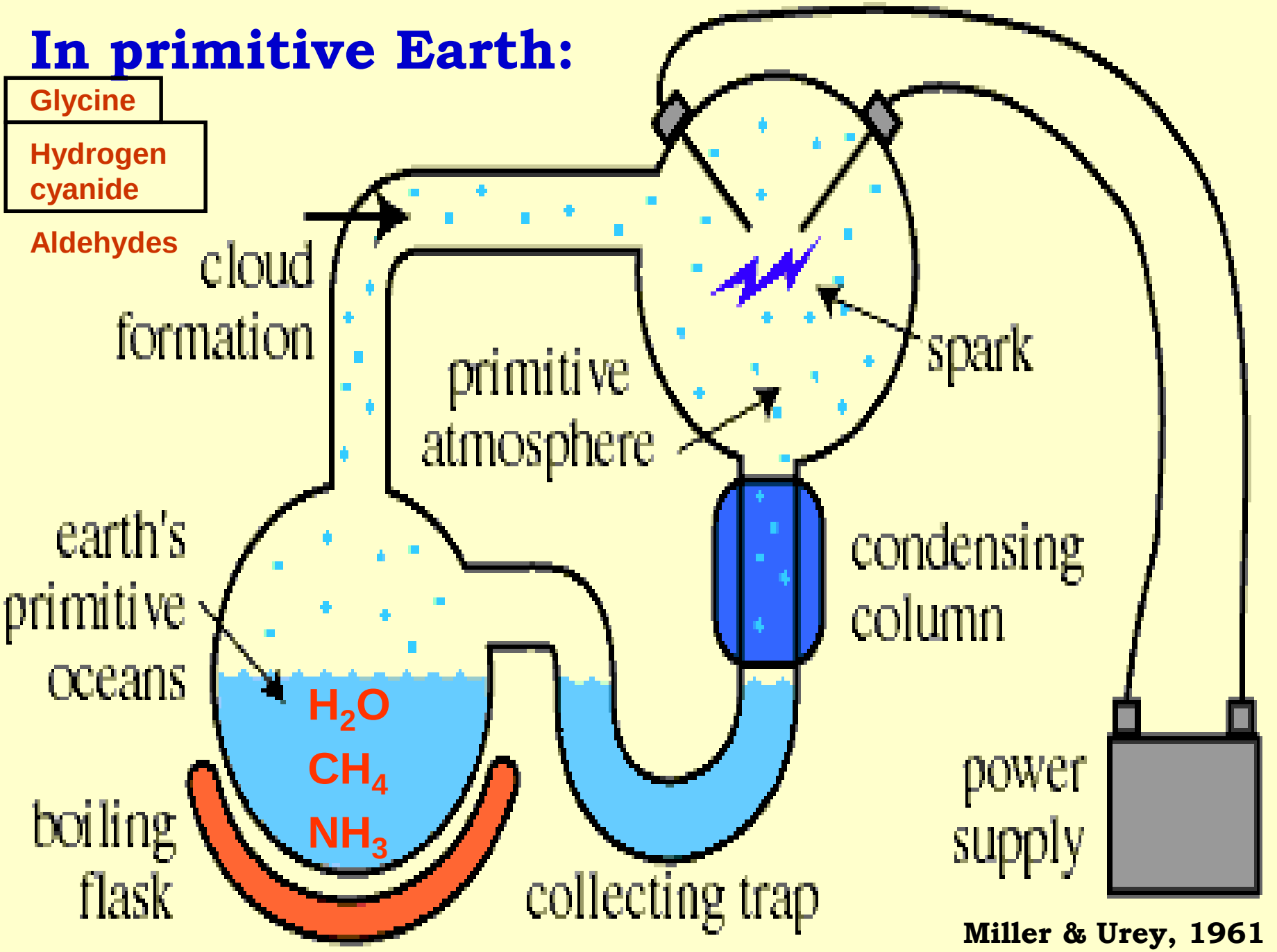
Chemistry in the New World of Bioengineering and Synthetic Biology

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?

© Shirley Owens and Catherine McGowan, 1996

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

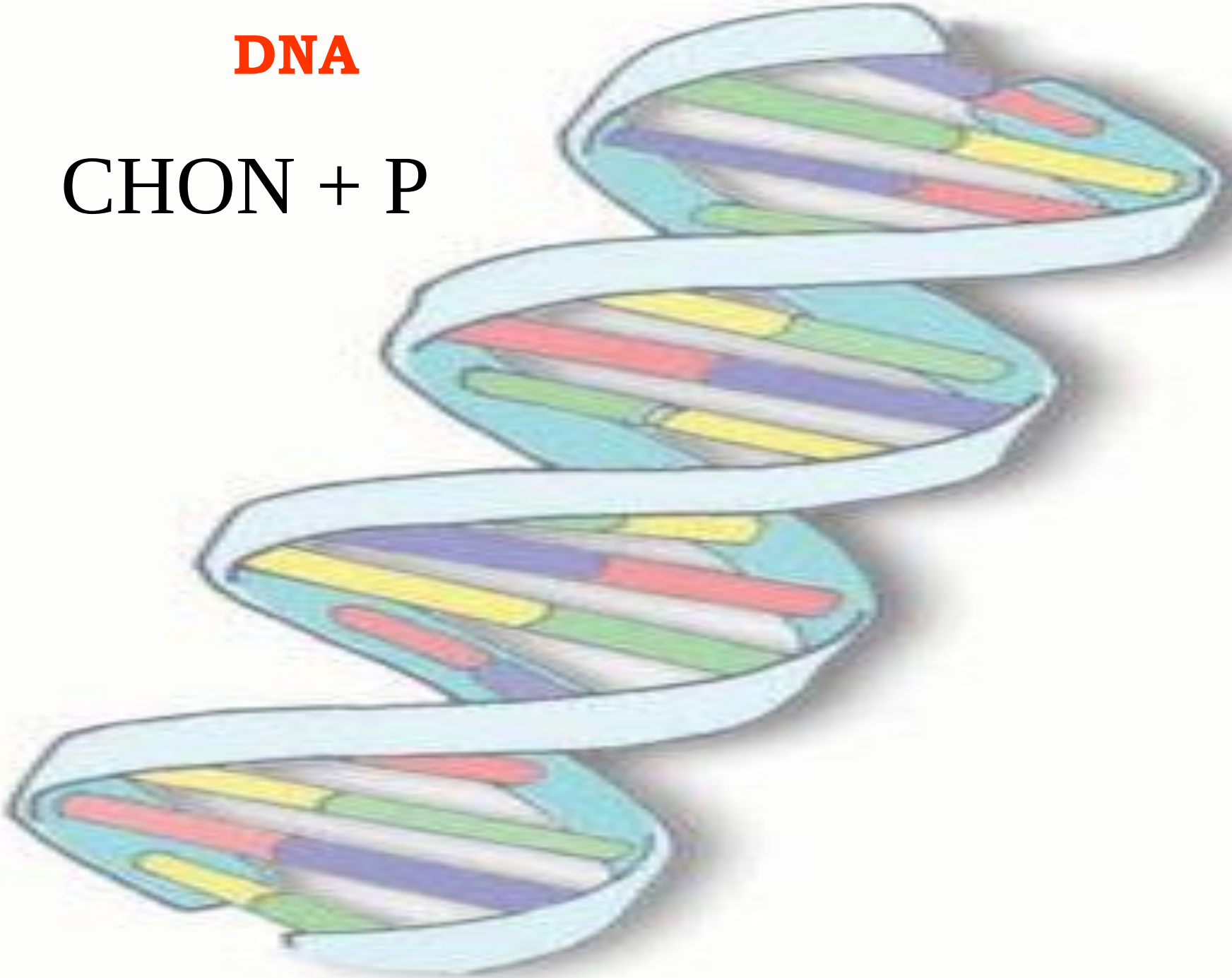
FOLLOW THE LIFE

- 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

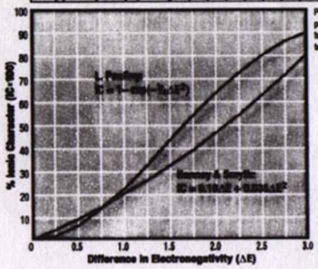
▼ Elementary Subatomic Particles

	Electron	Proton	Neutron	Photon	Neutrino
Symbol	e	p	n	γ	ν
Rest mass (kg)	9.1093897(54) x 10^{-31}	1.6726231(10) x 10^{-27}	1.6749286(10) x 10^{-27}	0	≈0
Molar mass (kg/mol)	5.48579903(13) x 10^{-7}	1.007276470(12) x 10^{-3}	1.008664904(14) x 10^{-3}	0	≈0
Particle-electron mass ratio	1	1836.152701(37)	1838.683662(40)	0	≈0
Particle-proton mass ratio	5.44617013(11) x 10^{-4}	1	1.001378404(9)	0	≈0
Particle-neutron mass ratio	5.438673x10^{-4}	0.998624	1	0	≈0
Specific charge (C/kg)	−1.75881962(53) x 10^{+11}	9.5788309(29) x 10^{+7}	0	0	0
Radius (m)	<1 x 10^{-18}	8 x 10^{-16}	8 x 10^{-16}	0	≈0
Spin quantum number	1/2	1/2	1/2	1	1/2
Compton wavelength (m)	2.42631058(22) x 10^{-12}	1.32141002(12) x 10^{-15}	1.31959110(12) x 10^{-5}	–	–
Magnetic moment (J/T); μ	928.47701(31) x 10^{-26}	1.41060761(47) x 10^{-26}	0.96623707(40) x 10^{-26}	0	0
In Bohr magnetons; μ/μ_B	1.001159652193(10)	1.521032202(15) x 10^{-3}	1.04187563(25) x 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 (μ_B = 9.2740154(31) x 10^{-24} J/T) or the nuclear magneton (μ_N = 5.0507866(17) x 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 Hannay & 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 Hannay & 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

Group classifications: 1 IA IA; 2 IIA IIA; 3 IIIA IIIB; 4 IVA IVB; 5 VA VB; 6 VIA VIB; 7 VIIA VIIB; 8 VIIIA VIII; 9 VIIIA VIII; 10 VIIIA VIII; 11 IB IB; 12 IIB IIB; 13 IIIB IIIA; 14 IVB IVA; 15 VB VA; 16 VIB VIA; 17 VIIB VIIA; 18 VIII 0

Atomic No.	Symbol	Name	Atomic Weight	Melting Point, °C	Boiling Point, °C	Density	Electronegativity	First Ionization Potential, eV	Oxidation States	Electronic Configuration
1	H	Hydrogen	1.00794	-259.34	-252.87	0.0899	2.20	13.598	1	1s1
2	He	Helium	4.002602	-272.2 (26 atm)	-268.93	0.1785	–	24.587		1s2
3	Li	Lithium	6.941	180.5	1342	0.534	0.98	5.392	1	[He]2s1
4	Be	Beryllium	9.012182	1287	2471	1.8477	1.57	9.322	2	[He]2s2
5	B	Boron	10.811	2075	4000	2.31	2.04	8.298	3	[He]2s2 2p1
6	C	Carbon	12.011	4492*	3825*	2.25	2.55	11.260	2,±4	[He]2s2 2p2
7	N	Nitrogen	14.00674	-210.00	-195.79	1.2506	3.04	14.534	2,±3,4,5	[He]2s2 2p3
8	O	Oxygen	15.9994	-218.79	-182.95	1.429	3.44	13.618	-2	[He]2s2 2p4
9	F	Fluorine	18.9984032	-219.62	-188.12	1.69	3.98	17.422	-1	[He]2s2 2p5
10	Ne	Neon	20.1797	-248.59	-246.08	0.9002	–	21.564		[He]2s2 2p6
11	Na	Sodium	22.989768	97.72	883	0.97	0.93	5.139	1	[Ne]3s1
12	Mg	Magnesium	24.3050	650	1090	1.74	1.31	7.646	2	[Ne]3s2
13	Al	Aluminum	26.981539	660.32	2519	2.702	1.61	5.986	3	[Ne]3s2 3p1
14	Si	Silicon	28.0855	1414	3265	2.33	1.90	8.151	4	[Ne]3s2 3p2
15	P	Phosphorus	30.973762	44.15	277	1.82	2.19	10.486	±3,4,5	[Ne]3s2 3p3
16	S	Sulfur	32.066	115.21	444.60	2.07	2.58	10.360	±2,4,6	[Ne]3s2 3p4
17	Cl	Chlorine	35.4527	-101.5	-34.04	3.214	3.16	12.967	±1,3,5,7	[Ne]3s2 3p5
18	Ar	Argon	39.948	-189.35	-185.85	1.784	–	15.759		[Ne]3s2 3p6
19	K	Potassium	39.0983	63.38	759	0.86	0.82	4.341	1	[Ar]4s1
20	Ca	Calcium	40.078	842	1484	1.54	1.00	6.113	2	[Ar]4s2
21	Sc	Scandium	44.955910	1541	2830	2.989	1.36	6.54	3	[Ar]3d1 4s2
22	Ti	Titanium	47.88	1668	3287	4.5	1.54	6.82	3,4	[Ar]3d2 4s2
23	V	Vanadium	50.9415	1910	3407	5.96	1.63	6.74	2,3,4,5	[Ar]3d3 4s2
24	Cr	Chromium	51.9961	1907	2671	7.20	1.66	6.766	2,3,6	[Ar]3d5 4s1
25	Mn	Manganese	54.93805	1246	2061	7.47	1.55	7.435	2,3,4,6,7	[Ar]3d5 4s2
26	Fe	Iron	55.847	1538	2861	7.86	1.83	7.870	2,3	[Ar]3d6 4s2
27	Co	Cobalt	58.93320	1495	2927	8.92	1.88	7.86	2,3	[Ar]3d7 4s2
28	Ni	Nickel	58.6934	1455	2913	8.90	1.91	7.635	2,3	[Ar]3d8 4s2
29	Cu	Copper	63.546	1084.62	2562	8.94	1.90	7.726	1,2	[Ar]3d10 4s1
30	Zn	Zinc	65.39	419.53	907	7.14 (20°C)	1.65	9.394	2	[Ar]3d10 4s2
31	Ga	Gallium	69.723	29.76	2204	6.095	1.81	5.999	3	[Ar]3d10 4s2 4p1
32	Ge	Germanium	72.61	938.25	2833	5.35	2.01	7.899	4	[Ar]3d10 4s2 4p2
33	As	Arsenic	74.92159	817*	614*	5.727 (25°C)	2.18	9.81	±3,5	[Ar]3d10 4s2 4p3
34	Se	Selenium	78.96	221	685	4.81	2.55	9.752	-2,4,6	[Ar]3d10 4s2 4p4
35	Br	Bromine	79.904	-7.2	58.8	3.119	2.96	11.814	±1,5	[Ar]3d10 4s2 4p5
36	Kr	Krypton	83.80	-157.36	-153.22	3.74	–	13.999		[Ar]3d10 4s2 4p6
37	Rb	Rubidium	85.4678	39.31	688	1.532	0.82	4.177	1	[Kr]5s1
38	Sr	Strontium	87.62	777	1382	2.6	0.95	5.695	2	[Kr]5s2
39	Y	Yttrium	88.90585	1526	3336	4.469	1.22	6.38	3	[Kr]4d1 5s2
40	Zr	Zirconium	91.224	1855	4409	6.49	1.33	6.84	4	[Kr]4d2 5s2
41	Nb	Niobium	92.90638	2477	4744	8.57	1.6	6.9	3,5	[Kr]4d4 5s1
42	Mo	Molybdenum	95.94	2623	4639	10.2	2.16	7.099	2,3,4,5,6	[Kr]4d5 5s1
43	Tc	Technetium	(97.9072)	2157	4265	11.5	1.9	7.28	7	[Kr]4d5 5s2
44	Ru	Ruthenium	101.07	2334	4150	12.3	2.2	7.37	2,3,4,6,8	[Kr]4d7 5s1
45	Rh	Rhodium	102.90550	1964	3695	12.4	2.28	7.46	2,3,4	[Kr]4d8 5s1
46	Pd	Palladium	106.42	1554.9	2963	12.02	2.20	8.34	2,4	[Kr]4d10
47	Ag	Silver	107.8682	961.78	2162	10.5	1.93	7.576	1	[Kr]4d10 5s1
48	Cd	Cadmium	112.411	321.07	767	8.642	1.69	8.993	2	[Kr]4d10 5s2
49	In	Indium	114.818	156.60	2072	7.30	1.78	5.786	3	[Kr]4d10 5s2 5p1
50	Sn	Tin	118.710	231.93	2602	7.28	1.96	7.344	2,4	[Kr]4d10 5s2 5p2
51	Sb	Antimony	121.757	630.63	1587	6.684 (25°C)	2.05	8.641	±3,5	[Kr]4d10 5s2 5p3
52	Te	Tellurium	127.60	449.51	988	6.25	2.1	9.009	-2,4,6	[Kr]4d10 5s2 5p4
53	I	Iodine	126.90447	113.7	184.4	4.93	2.66	10.451	±1,5,7	[Kr]4d10 5s2 5p5
54	Xe	Xenon	131.29	-111.75	-108.04	5.89	–	12.130		[Kr]4d10 5s2 5p6
55	Cs	Cesium	132.90543	28.44	671	1.879	0.79	3.894	1	[Xe]6s1
56	Ba	Barium	137.327	727	1897	3.594	0.89	5.212	2	[Xe]6s2
57	La	Lanthanum	138.9055	920	3455	6.146	1.10	5.577	3	[Xe]5d1 6s2
72	Hf	Hafnium	178.49	2233	4603	13.31	1.3	7.0	4	[Xe]4f14 5d2 6s2
73	Ta	Tantalum	180.9479	3017	5458	16.6	1.5	7.89	5	[Xe]4f14 5d3 6s2
74	W	Tungsten	183.84	3422	5555	19.35	2.36	7.98	2,3,4,5,6	[Xe]4f14 5d4 6s2
75	Re	Rhenium	186.207	3186	5596	20.5	1.9	7.88	-1,2,4,6,7	[Xe]4f14 5d5 6s2
76	Os	Osmium	190.23	3033	5012	22.61	2.2	8.7	2,3,4,6,8	[Xe]4f14 5d6 6s2
77	Ir	Iridium	192.22	2446	4428	22.65	2.20	9.1	2,3,4,6	[Xe]4f14 5d7 6s2
78	Pt	Platinum	195.08	1768.4	3825	21.45	2.28	9.0	2,4	[Xe]4f14 5d9 6s1
79	Au	Gold	196.96654	1064.18	2856	19.31	2.54	9.225	1,3	[Xe]4f14 5d10 6s1
80	Hg	Mercury	200.59	-38.83	356.73	13.546	2.00	10.437	1,2	[Xe]4f14 5d10 6s2
81	Tl	Thallium	204.3833	304	1473	11.85	2.04	6.108	1,3	[Xe]4f14 5d10 6s2 6p1
82	Pb	Lead	207.2	327.46	1749	11.34	2.33	7.416	2,4	[Xe]4f14 5d10 6s2 6p2
83	Bi	Bismuth	208.98037	271.40	1564	9.78	2.02	7.289	3,5	[Xe]4f14 5d10 6s2 6p3
84	Po	Polonium	(208.9824)	254	962	9.196	2.0	8.42	2,4	[Xe]4f14 5d10 6s2 6p4
85	At	Astatine	(209.9871)	302	337	–	2.2	–	±1,3,5,7	[Xe]4f14 5d10 6s2 6p5
86	Rn	Radon	(222.0176)	-71	-61.7	9.73	–	10.748		[Xe]4f14 5d10 6s2 6p6
87	Fr	Francium	(223.0197)	27	677	–	0.7	–	1	[Rn]7s1
88	Ra	Radium	(226.0254)	700	<1140	5.8	0.9	5.279	2	[Rn]7s2
89	Ac	Actinium	(227.0278)	1051	3198	10.07	1.1	6.9	3	[Rn]6d1 7s2
104	Unq	Unnilquadium	(261.11)	–	–	–	–	–		[Rn]5f14 6d2 7s2
105	Unp	Unnilpentium	(262.114)	–	–	–	–	–		[Rn]5f14 6d3 7s2
106	Unh	Unnilhexium	(263.118)	–	–	–	–	–		[Rn]5f14 6d4 7s2
107	Uns	Unnilseptium	(262.12)	–	–	–	–	–		[Rn]5f14 6d5 7s2
108	Uno	Unniloctium	(265)	–	–	–	–	–		[Rn]5f14 6d6 7s2
109	Une	Unnilennium	(266)	–	–	–	–	–		[Rn]5f14 6d7 7s2
110	Uun	Ununnilium	(272)	–	–	–	–	–		

*indicates approximate values and/or inconsistent literature data.

• Lanthanides

Atomic No.	Symbol	Name	Atomic Weight	Melting Point, °C	Boiling Point, °C	Density	Electronegativity	First Ionization Potential, eV	Oxidation States	Electronic Configuration
58	Ce	Cerium	140.115	799	3424	6.770	1.12	5.466	3,4	[Xe]4f1 5d1 6s2
59	Pr	Praseodymium	140.90765	931	3510	6.773	1.13	5.422	3,4	[Xe]4f3 6s2
60	Nd	Neodymium	144.24	1016	3066	7.00	1.14	5.489	3	[Xe]4f4 6s2
61	Pm	Promethium	(144.9127)	1042	3000	7.264	1.13	5.554	3	[Xe]4f5 6s2
62	Sm	Samarium	150.36	1072	1790	7.536	1.17	5.631	2,3	[Xe]4f6 6s2
63	Eu	Europium	151.965	822	1596	5.244	1.2	5.666	2,3	[Xe]4f7 6s2
64	Gd	Gadolinium	157.25	1314	3264	7.901	1.20	6.141	3	[Xe]4f7 5d1 6s2
65	Tb	Terbium	158.92534	1359	3221	8.230	1.2	5.842	3,4	[Xe]4f9 6s2
66	Dy	Dysprosium	162.50	1411	2561	8.551	1.22	5.927	3	[Xe]4f10 6s2
67	Ho	Holmium	164.93032	1472	2694	8.80	1.23	6.018	3	[Xe]4f11 6s2
68	Er	Erbium	167.26	1529	2862	9.066	1.24	6.101	3	[Xe]4f12 6s2
69	Tm	Thulium	168.93421	1545	1946	9.321	1.25	6.18436	2,3	[Xe]4f13 6s2
70	Yb	Ytterbium	173.04	824	1194	6.966	1.1	6.25394	2,3	[Xe]4f14 6s2
71	Lu	Lutetium	174.967	1663	3393	9.84	1.27	5.42589	3	[Xe]4f14 5d1 6s2

•• Actinides

Atomic No.	Symbol	Name	Atomic Weight	Melting Point, °C	Boiling Point, °C	Density	Electronegativity	First Ionization Potential, eV	Oxidation States	Electronic Configuration
90	Th	Thorium	232.0381	1750	4788	11.72	1.3	6.08	4	[Rn]6d2 7s2
91	Pa	Protactinium	231.03588	1572	–	15.37	1.5	5.89	4,5	[Rn]5f2 6d1 7s2
92	U	Uranium	238.0289	1135	4131	19.05±0.02	1.38	6.05	3,4,5,6	[Rn]5f3 6d1 7s2
93	Np	Neptunium	(237.0482)	644	–	20.45	1.36	6.19	3,4,5,6	[Rn]5f4 6d1 7s2
94	Pu	Plutonium	(244.0642)	640	3228	19.816	1.28	5.8	3,4,5,6	[Rn]5f6 7s2
95	Am	Americium	(243.0614)	1176	2607	13.67	1.3	5.993	3,4,5,6	[Rn]5f7 7s2
96	Cm	Curium	(247.0703)	1345	–	13.51	1.3	6.02	3	[Rn]5f7 6d1 7s2
97	Bk	Berkelium	(247.0703)	1050	–	14.78	1.3	6.23	3,4	[Rn]5f9 7s2
98	Cf	Californium	(251.0796)	900	–	–	1.3	6.30	3	[Rn]5f10 7s2
99	Es	Einsteinium	(252.083)	860	–	–	1.3	6.42	3	[Rn]5f11 7s2
100	Fm	Fermium	(257.0951)	1527	–	–	1.3	6.50	3	[Rn]5f12 7s2
101	Md	Mendelevium	(258.10)	827	–	–	1.3	6.58	2,3	[Rn]5f13 7s2
102	No	Nobelium	(259.1009)	827	–	–	1.3	6.65	2,3	[Rn]5f14 7s2
103	Lr	Lawrencium	(262.11)	1627	–	–	–	–	3	[Rn]5f14 6d1 7s2

Key

7 VIIA VIIB — example box: 54.93805 | 25 | 1246 | 2061 | 7.47 | 1.55 | 7.435 | 2,3,4,6,7 | Mn | [Ar]3d5 4s2 | 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[5] Configuration
- 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).

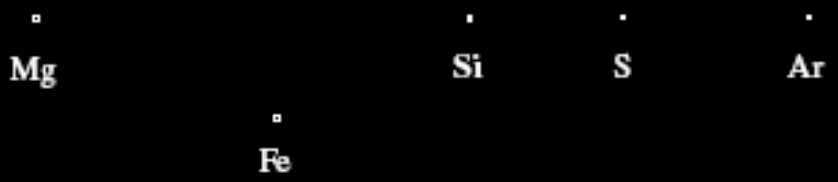
PAPERTECH

Editors: T. K. Varga, M.A.Sc. & C. Bello, M.A.Sc.
Product No. LCH-04F **ISBN** 1-55080-073-6

© Papertech Marketing Group Inc., 1994. All Rights Reserved. PERMA-CHARTS® come with a LIFETIME WARRANTY against peeling and delamination. For more information and a complete list of PERMA-CHART® titles see your dealer or write to: Papertech Marketing Group Inc., 163 Buttermill Ave., Unit 12, Concord, Ontario, CANADA L4K 3X8. 1-800-387-3826 (Continental U.S. & Canada). Printed in Canada.

The Astronomer's Periodic Table

(Ben McCall)



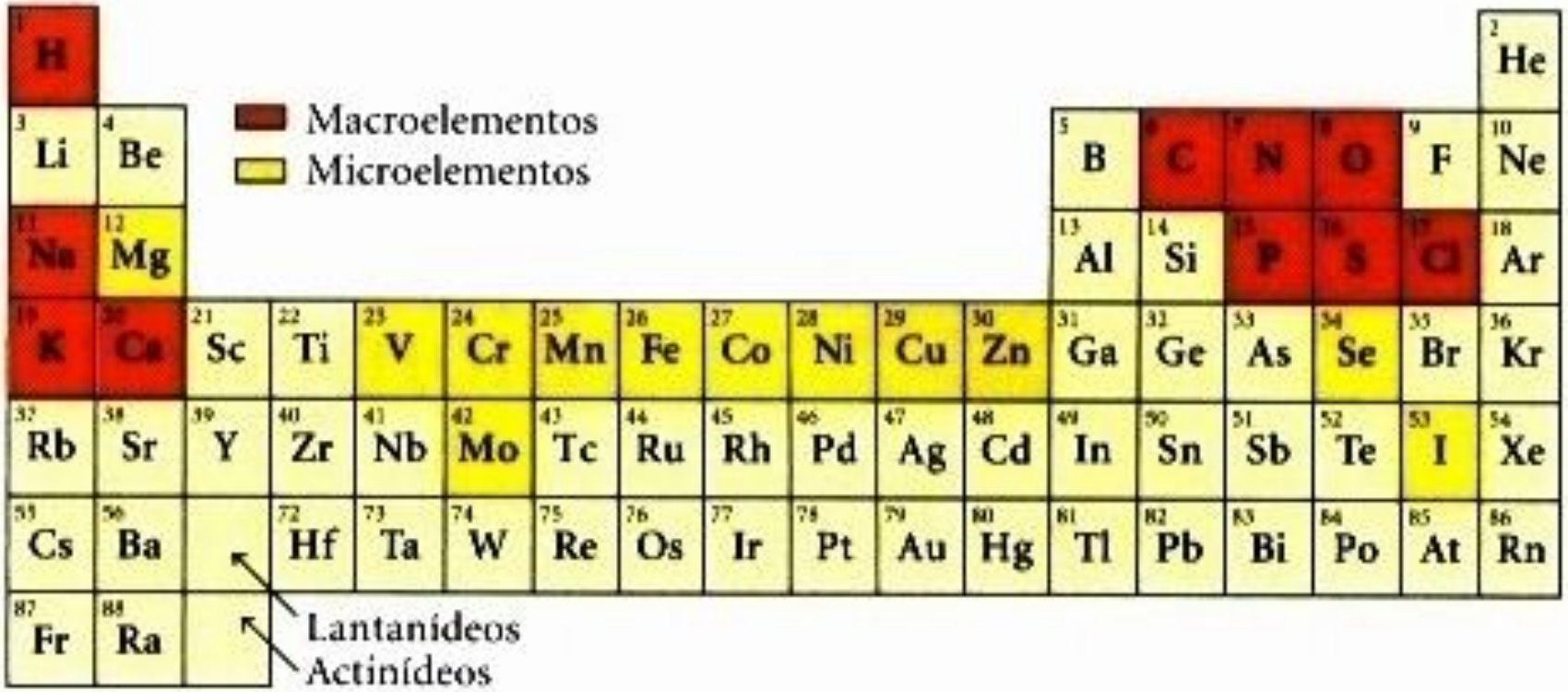
Courtesy Ben Mc Call

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

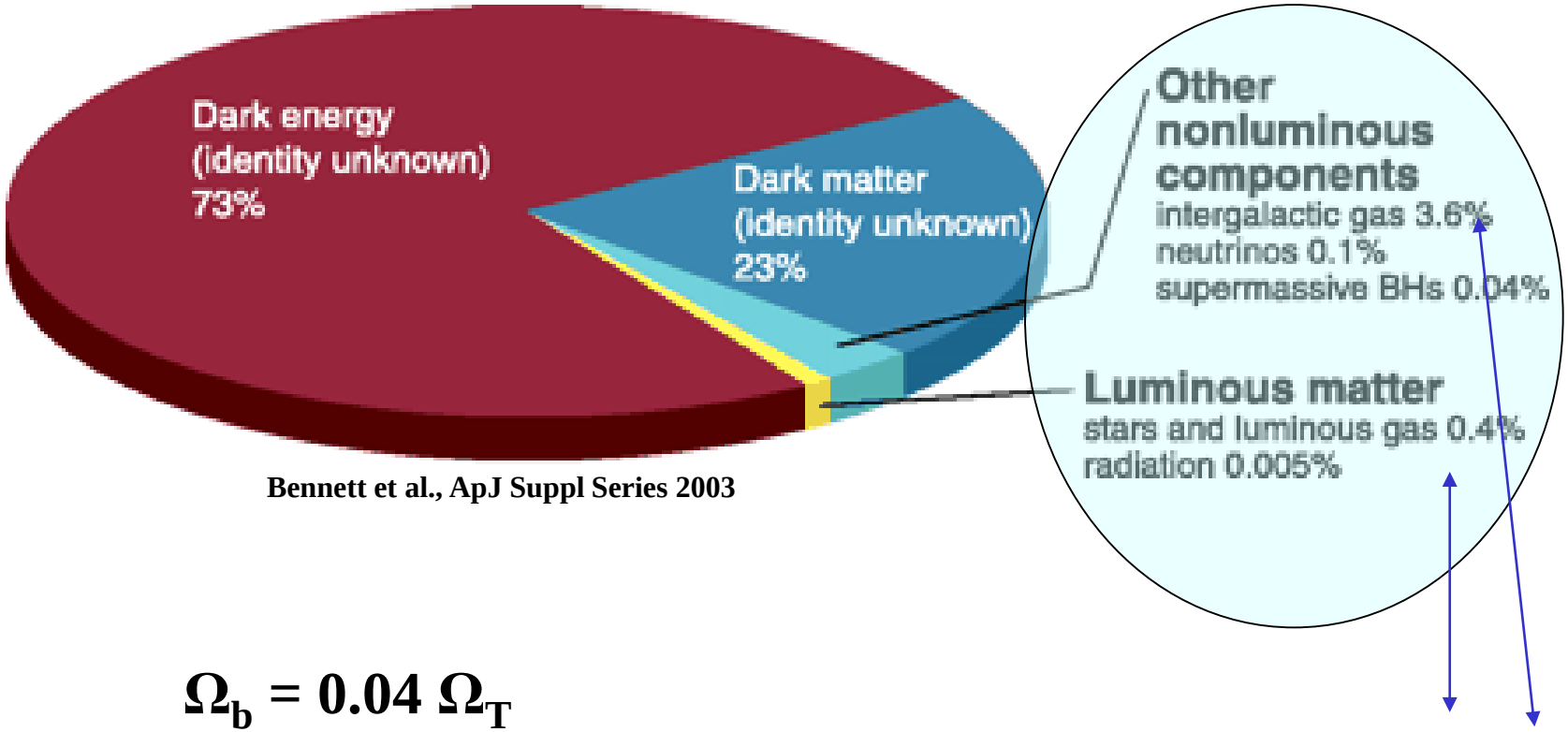
NGC 6543

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

HST • WFPC2

12/13/94 zgl

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



Bennett et al., ApJ Suppl Series 2003

$\Omega_b = 0.04\ \Omega_T$

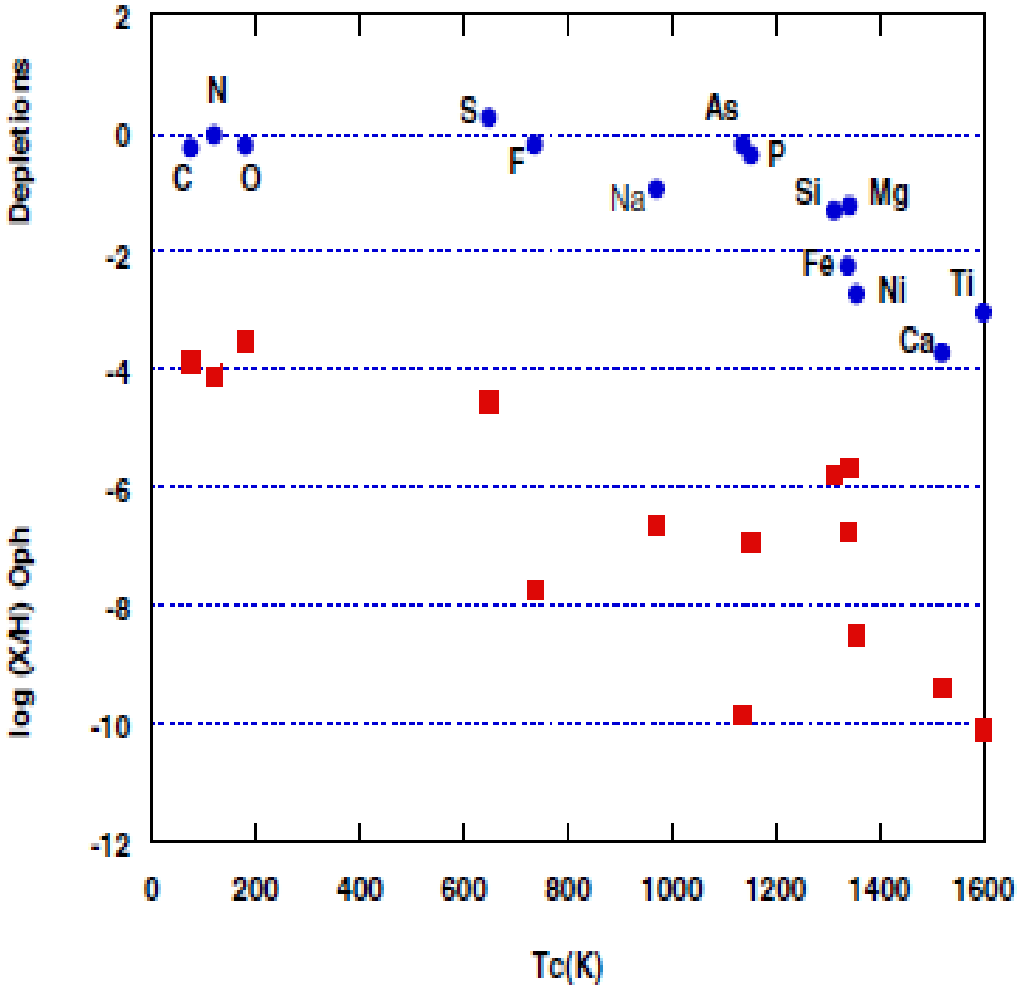
Life building blocks come from these components...

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}

Molecules in Space

318 Molecules

as if March 2023


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

LOOKING AT OTHER PLANETARY SYSTEMS:

SEARCHING FOR KEY PREBIOTIC COMPOUNDS:

H_2O

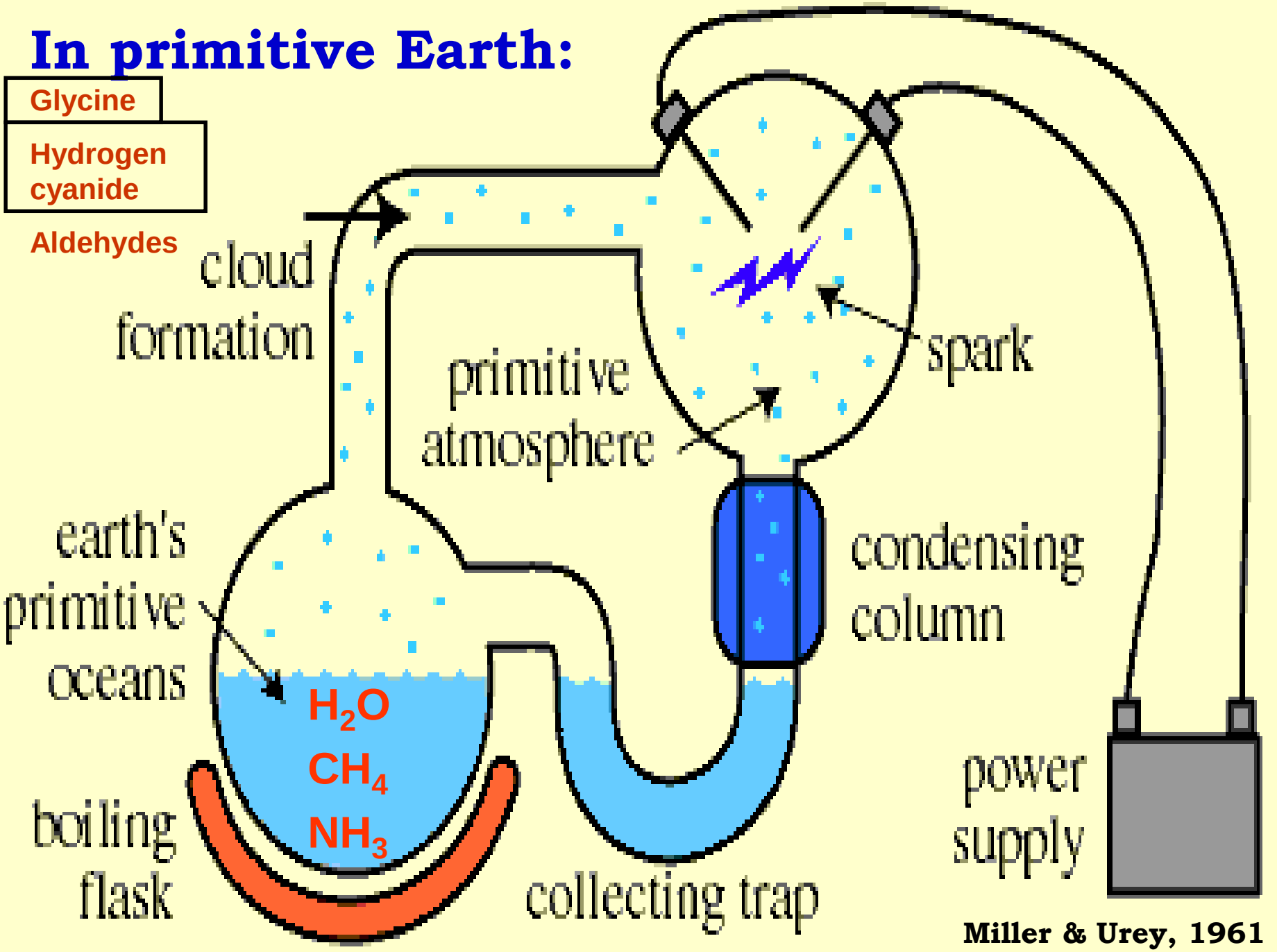
NH_3

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.

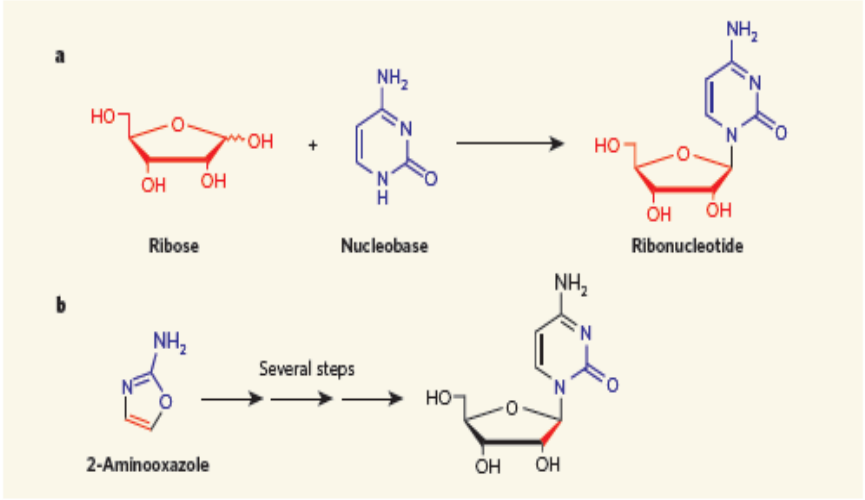


Figure 1 | Theories of prebiotic syntheses of pyrimidine ribonucleotides. The idea that RNA might have formed spontaneously on early Earth has inspired a search for feasible prebiotic syntheses of ribonucleotides, the building blocks of RNA. **a**, The traditional view is that the ribose sugar and nucleobase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

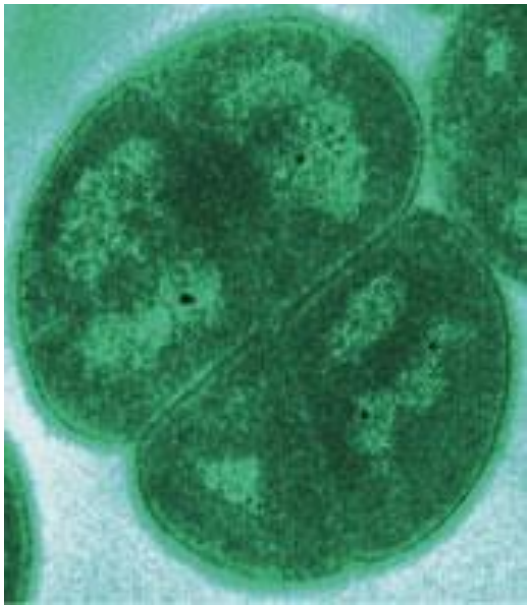
mixture of undesired compounds is formed. But Powner *et al.* add a third ingredient — phosphate — to the mix. In their reaction, phos-

Qual vida?

Extremófilos

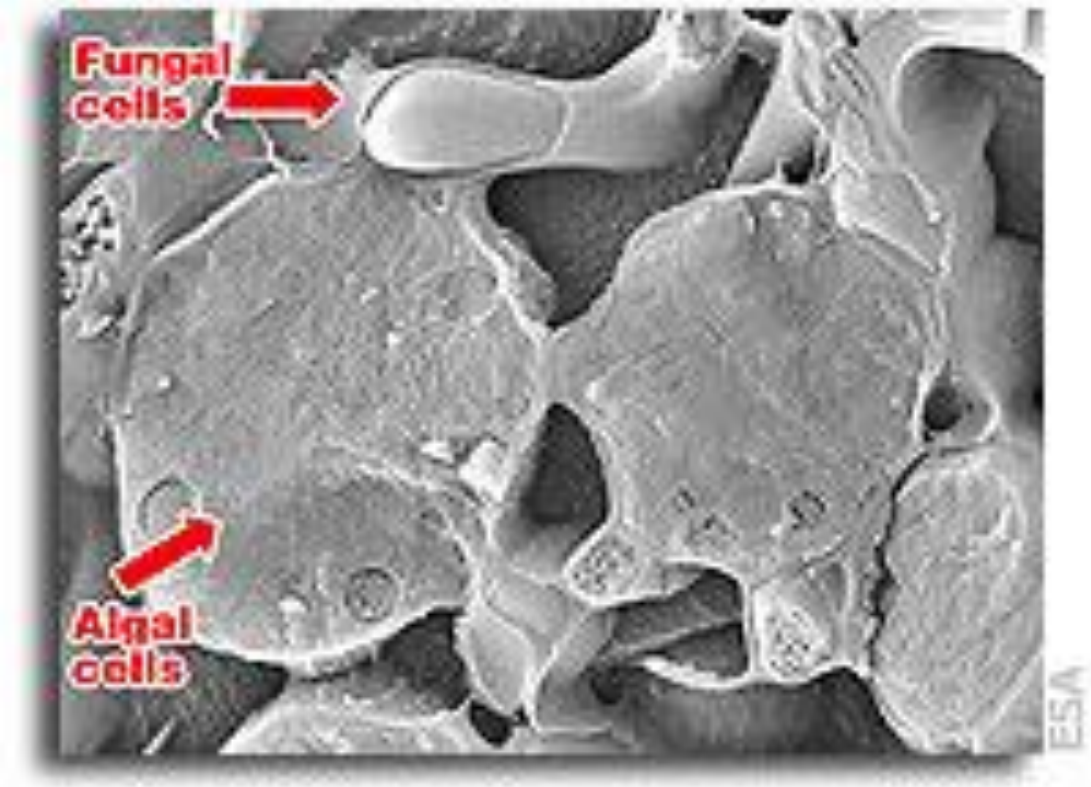
Que tipo de vida esperamos encontrar fora da Terra?

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

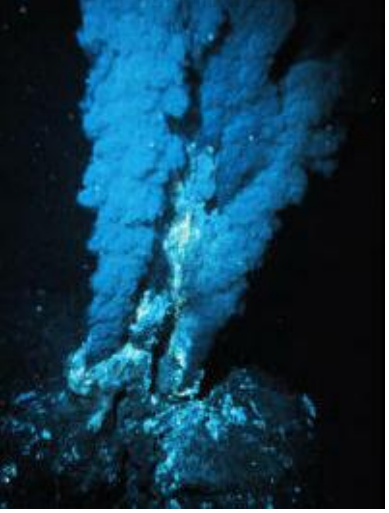


Deinococcus radiodurans – prospera com 5 000 Gy
(10 Gy mata o ser humano, 60 Gy a Escherichia Coli)

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

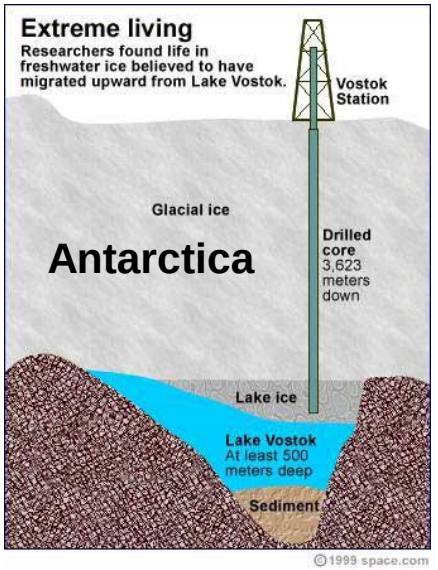


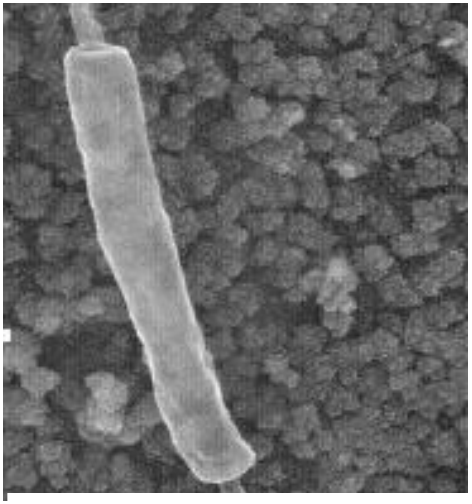
Extremophiles survival chart



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)*

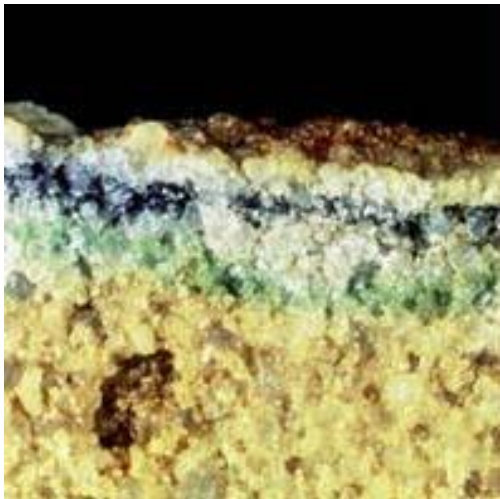




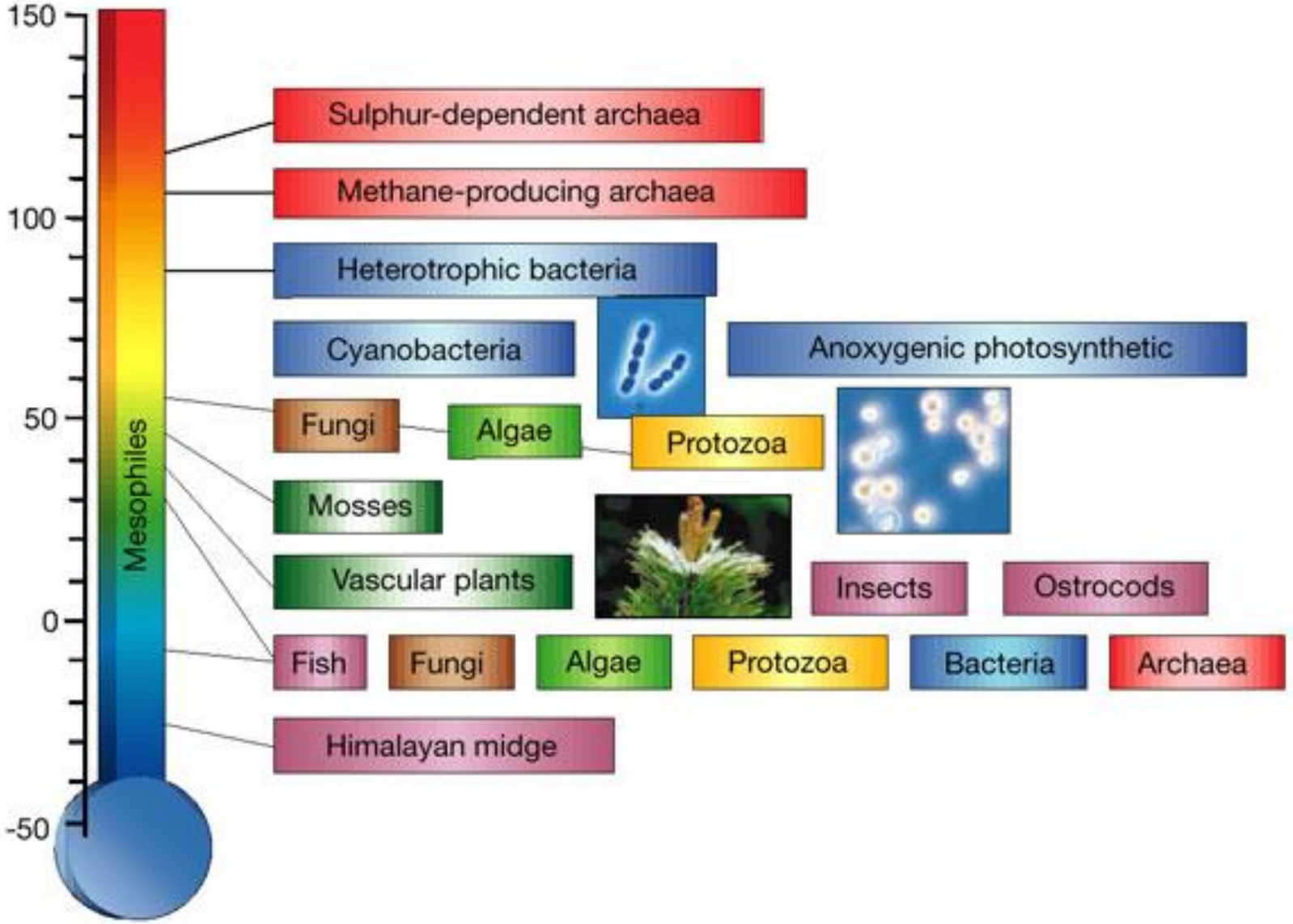
Thermophile bacteria

Hot geisers and volcanos

Cryptoendoliths



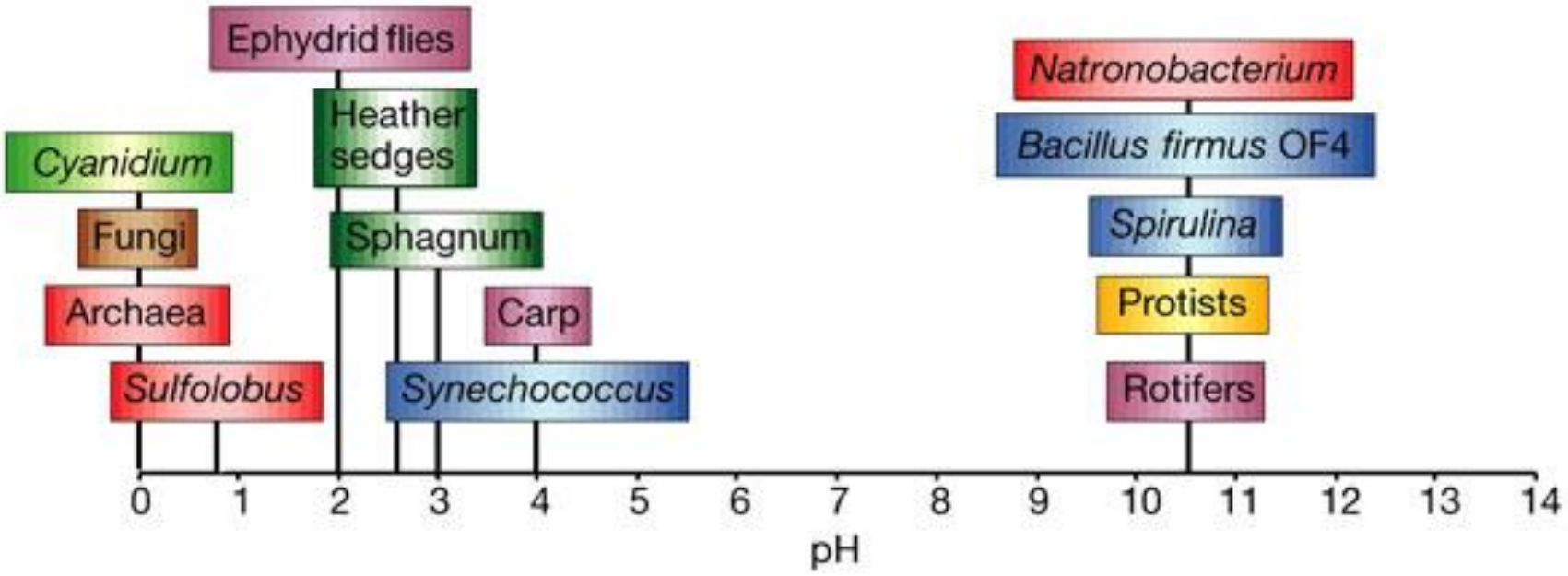
Temperature limits for life



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.

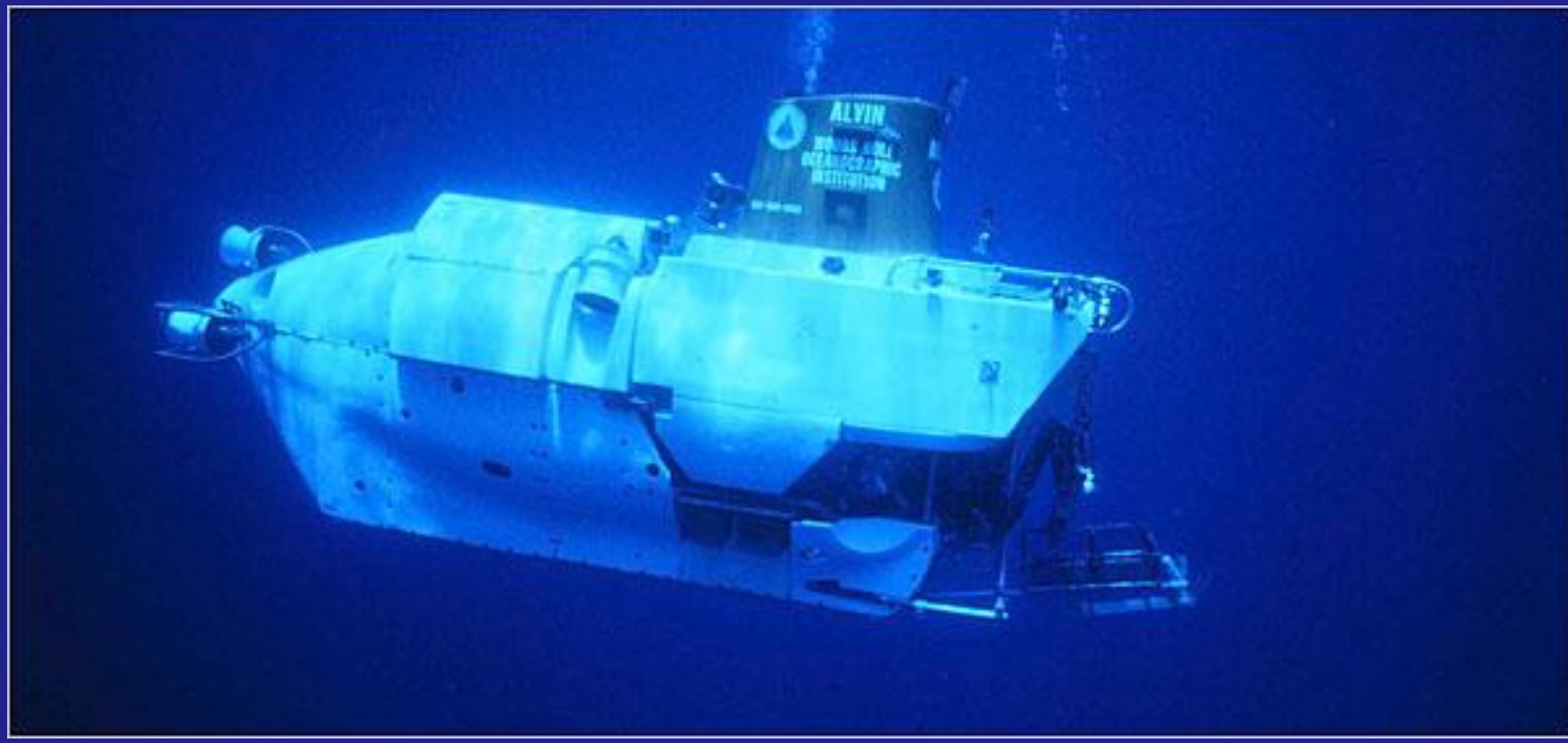
Life in extreme environments, LJ Rothschild & RL Mancinelli, Nature 409, 1092-1101 (22 February 2001)

pH limits for life

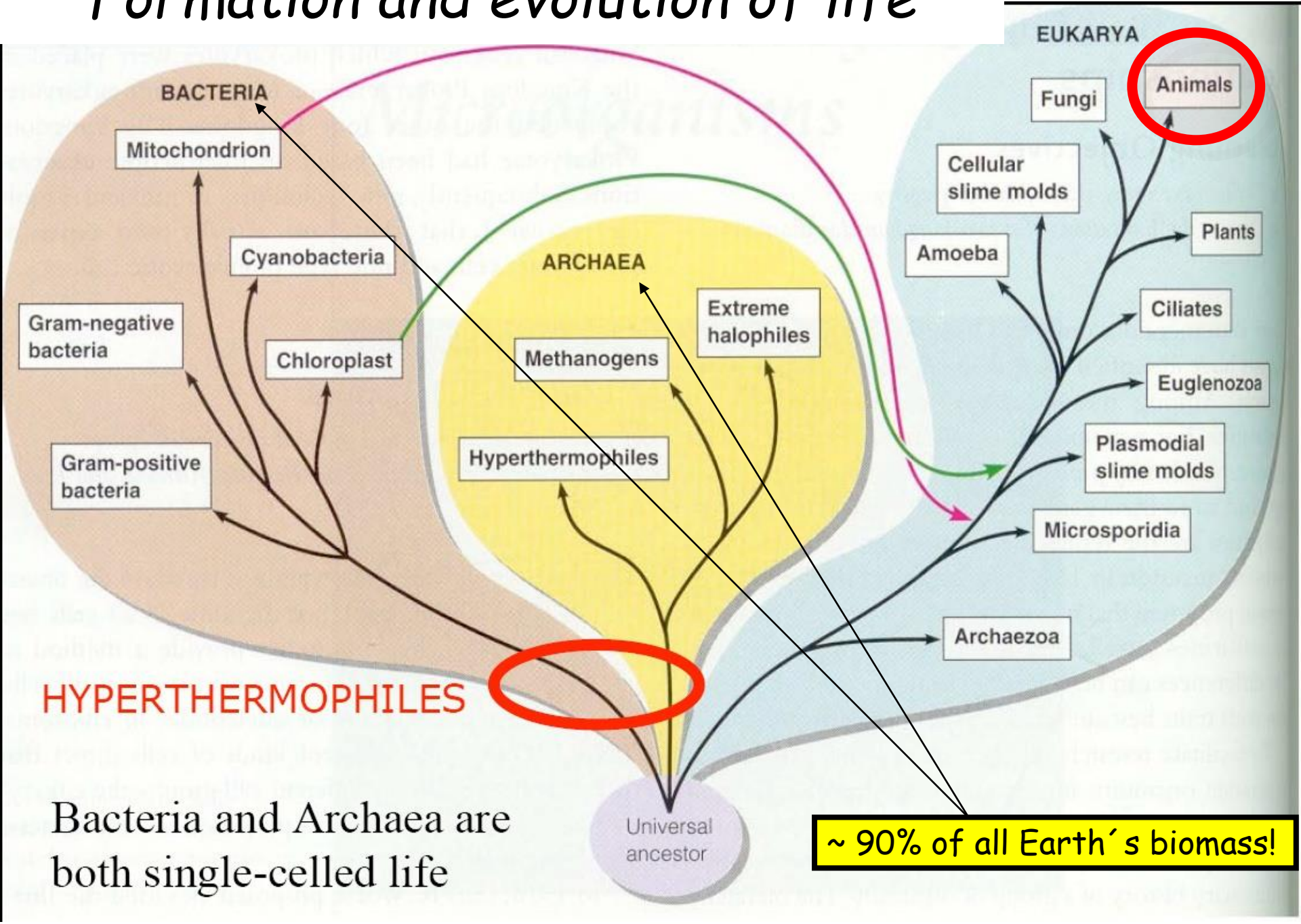


Examples of known pH limits for life are shown. Archaea are in red, bacteria in blue, algae in light green, assorted protists in yellow, fungi in brown, plants in dark green and animals in purple.

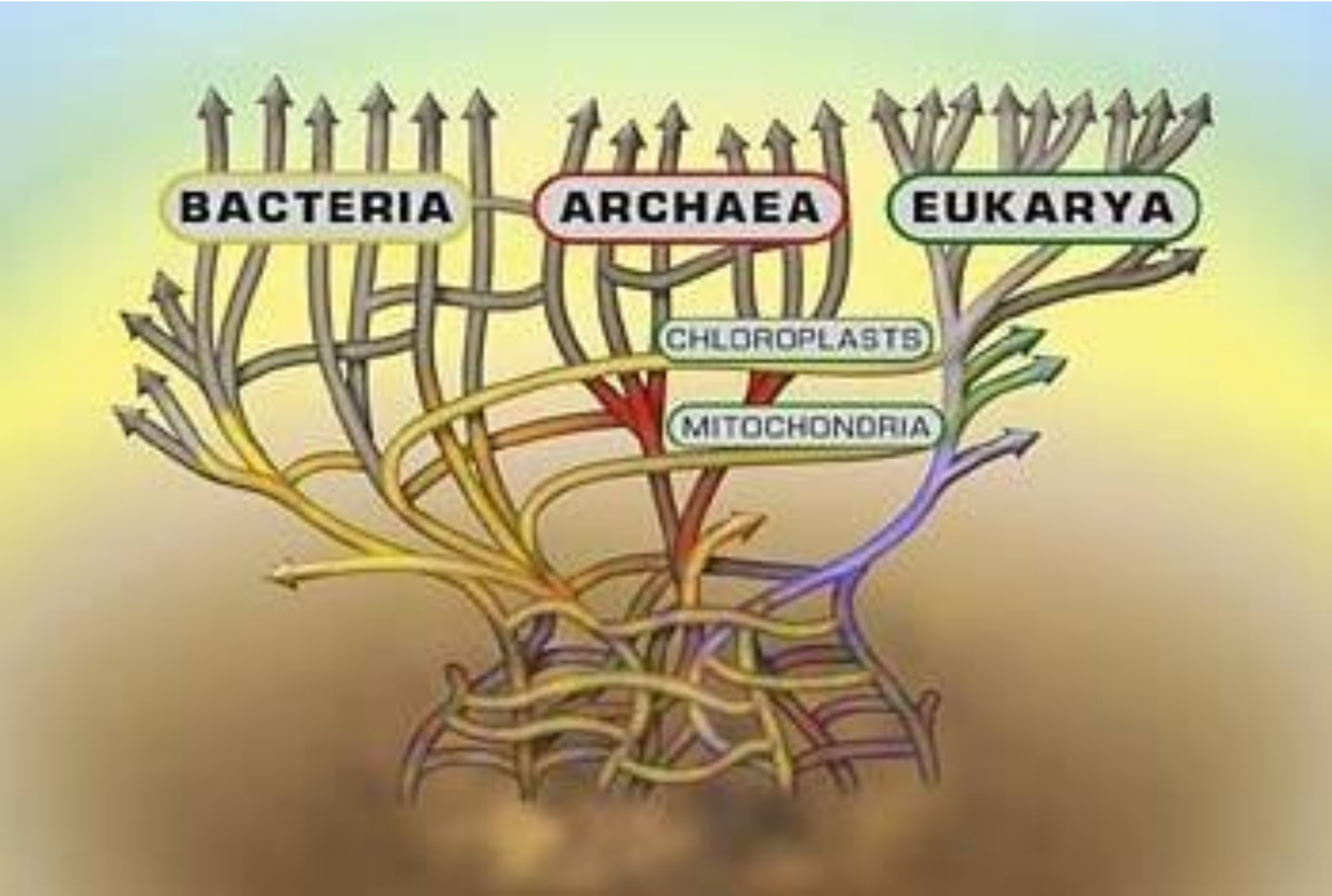
Fontes hidrotérmicas

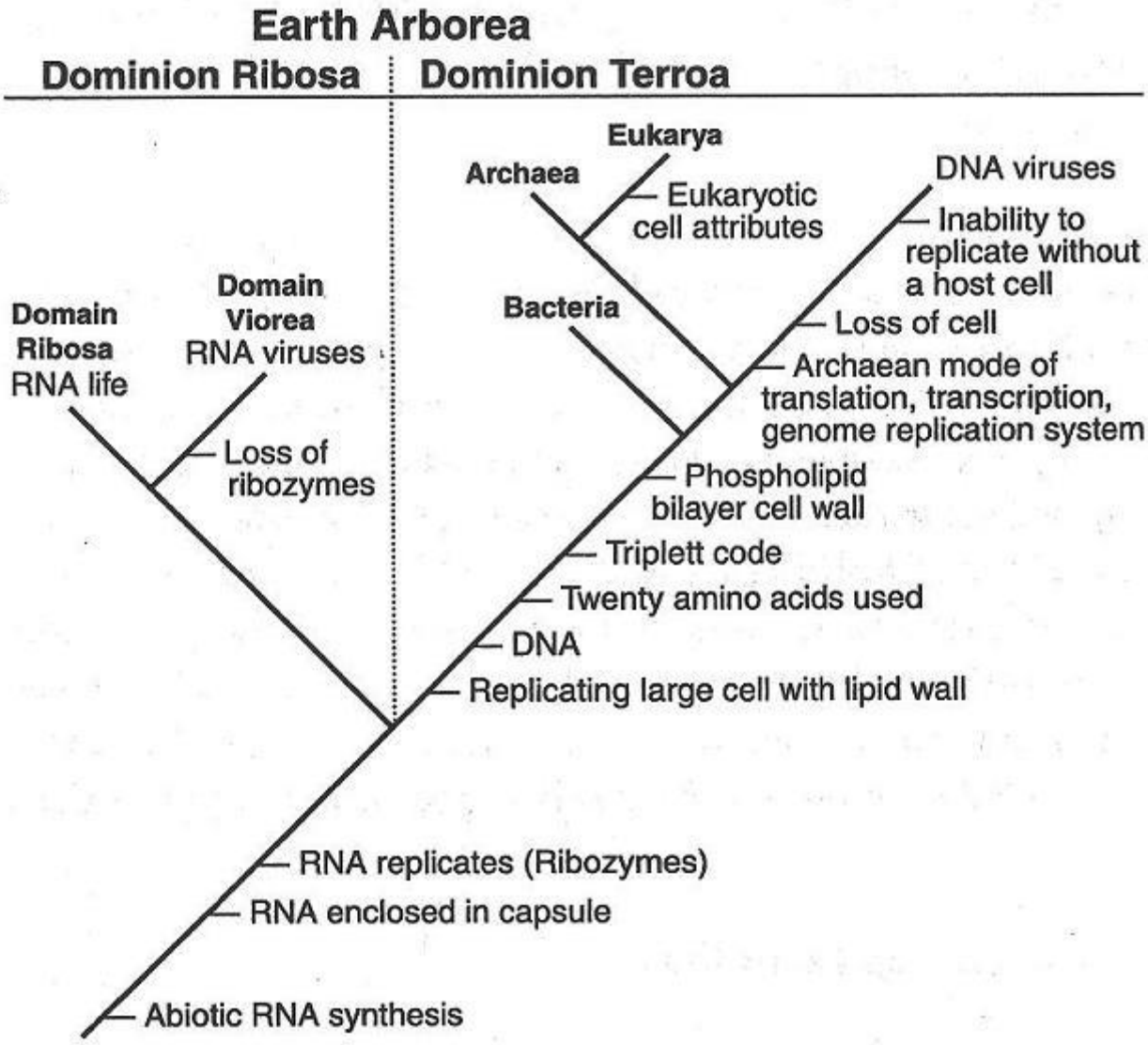

ALVIN

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
Bacteria
Loss of cell
Archaean mode of translation, transcription, genome replication system
Domain Ribosa
RNA life
Domain Viorea
RNA viruses
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

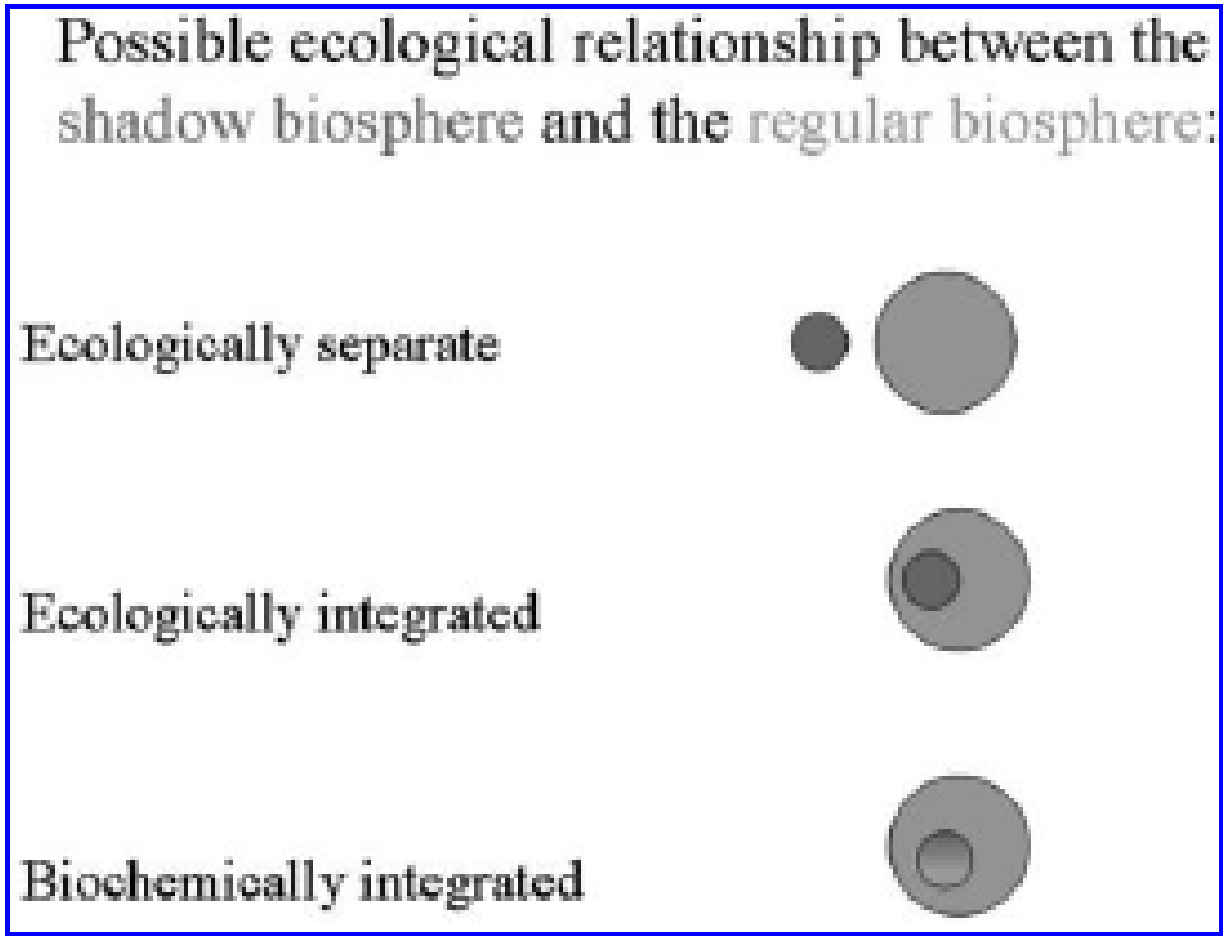


FIG. 1. Schematic representation of various possible relationships between known and weird life.

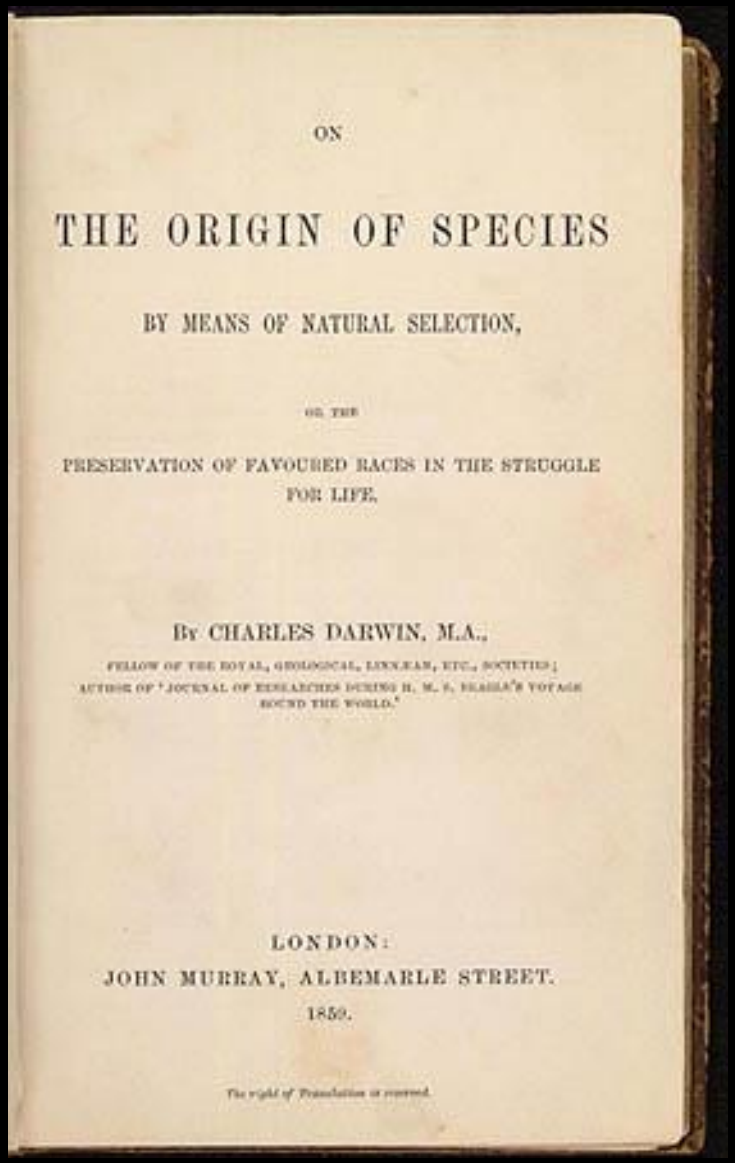
Qual a origem (origens) da vida?

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)



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

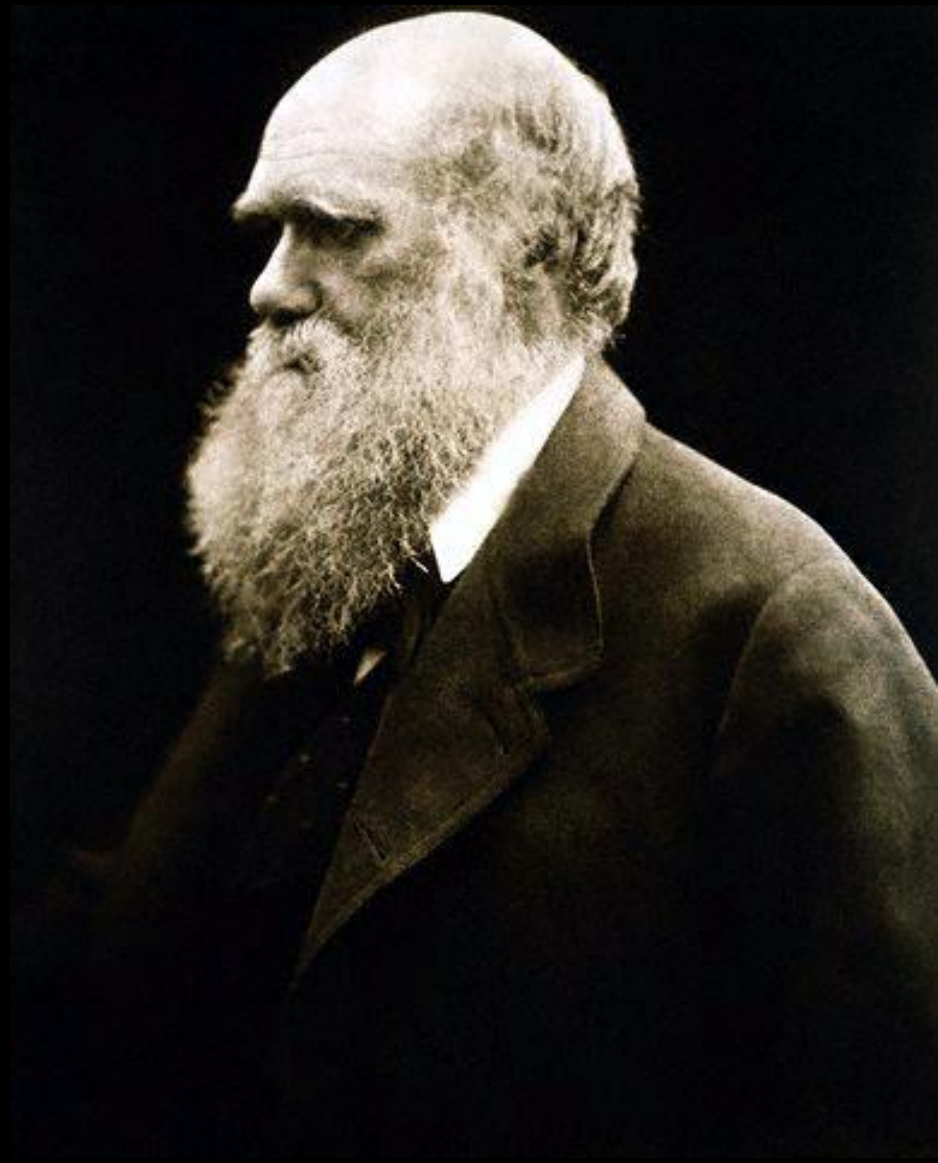
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.



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.

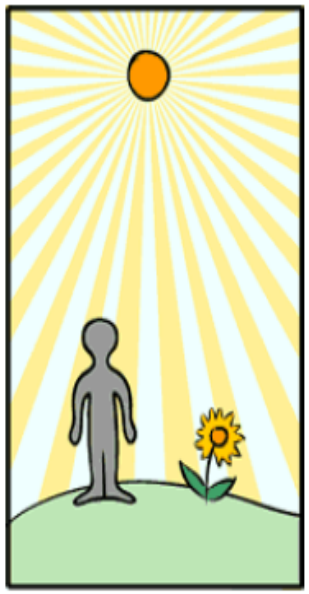
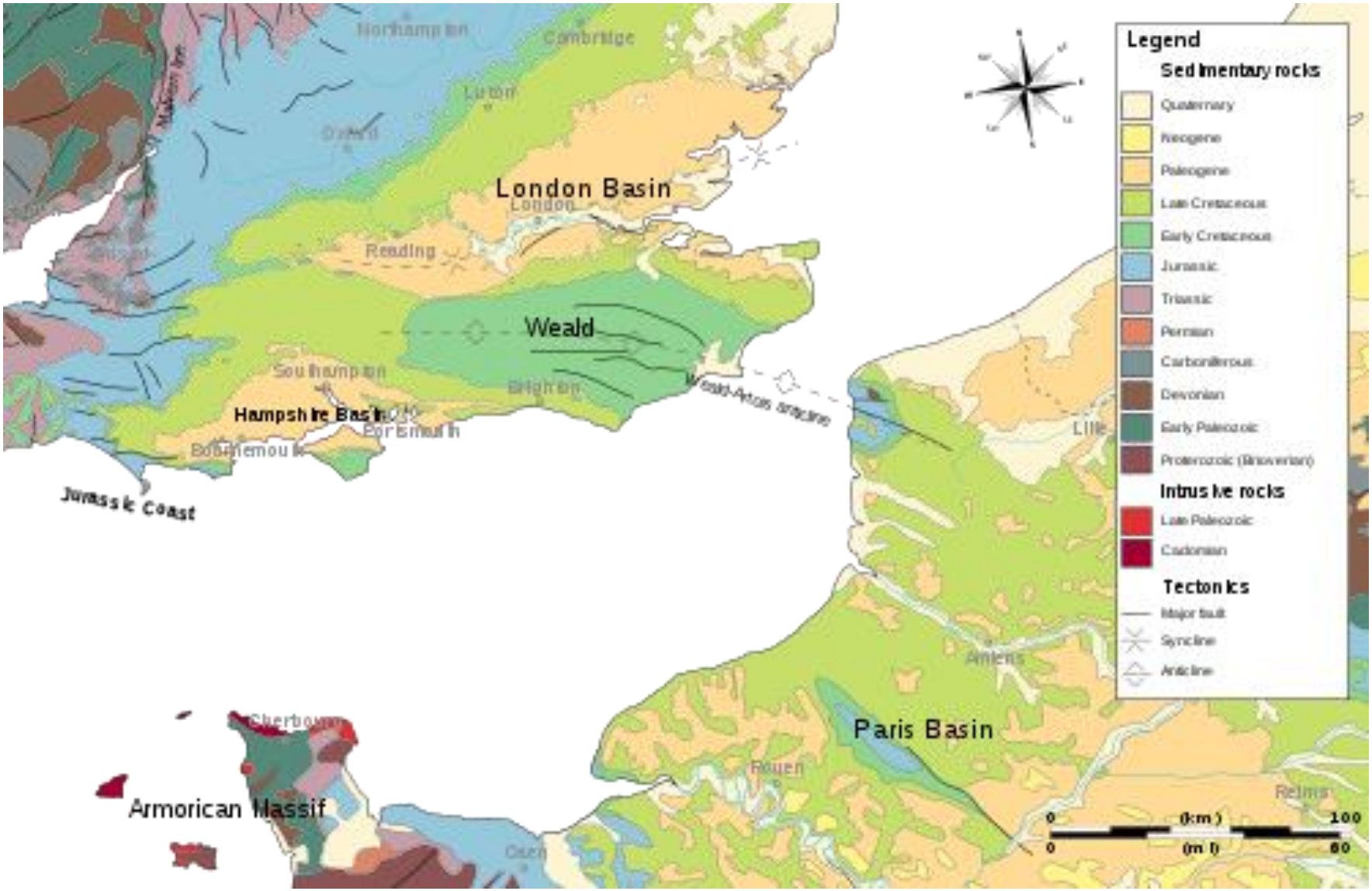
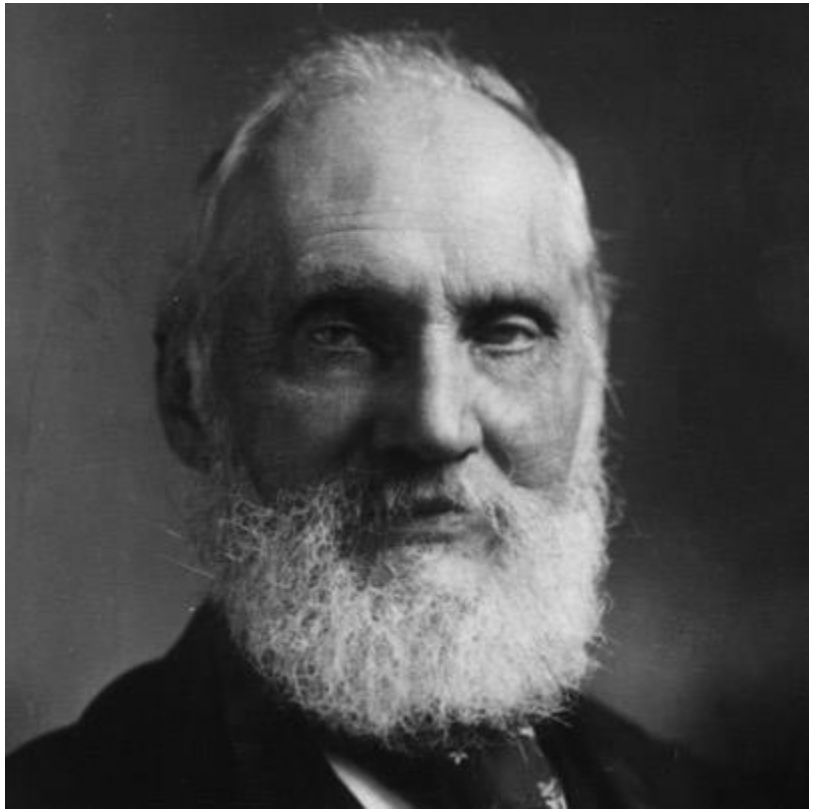


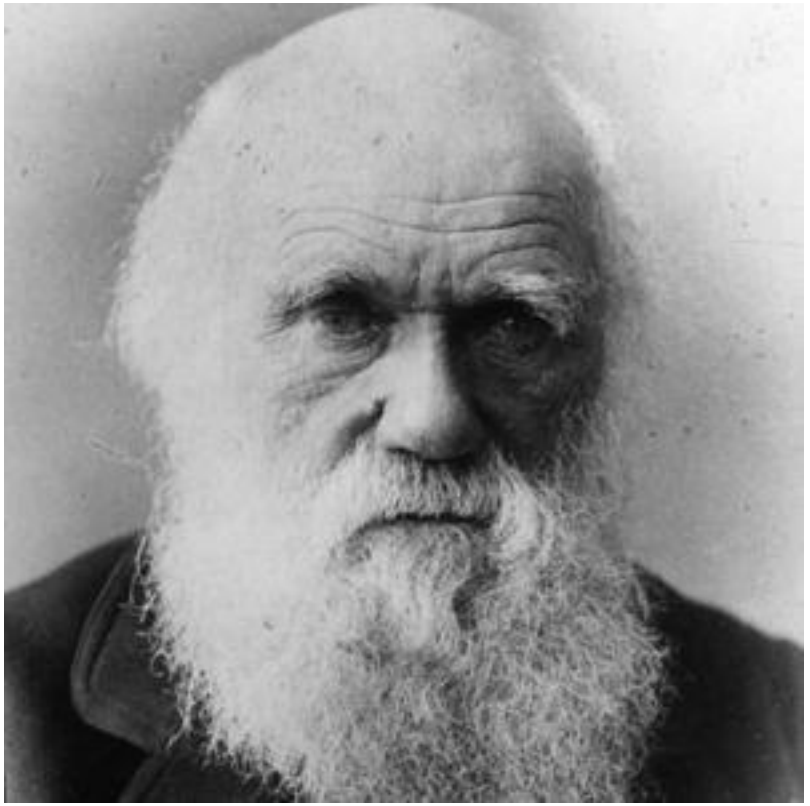
FIG. 1. Sunshine makes life possible on earth.



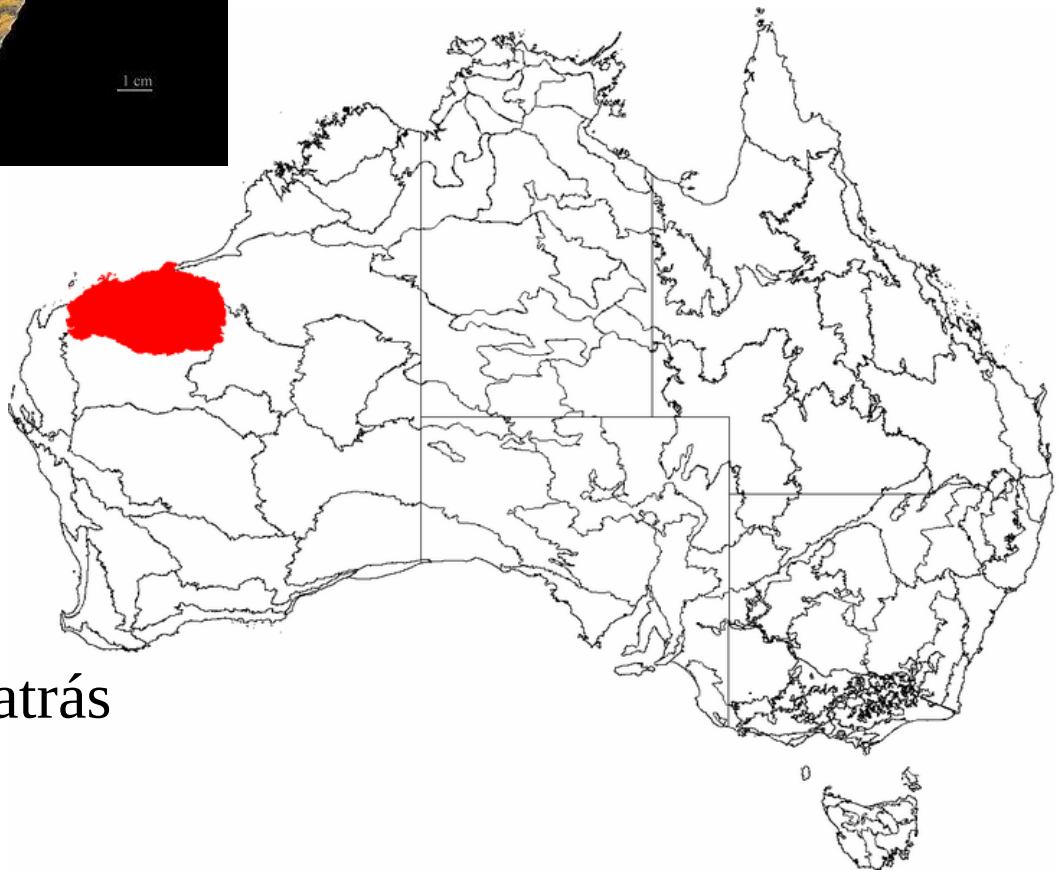
Denudation of the Weald

$\Rightarrow$ 300 milhões de anos





Kelvin X Darwin



Pilbara, 3,55 bilhões de anos atrás

CYANOBACTERIAL MICROFOSSILS

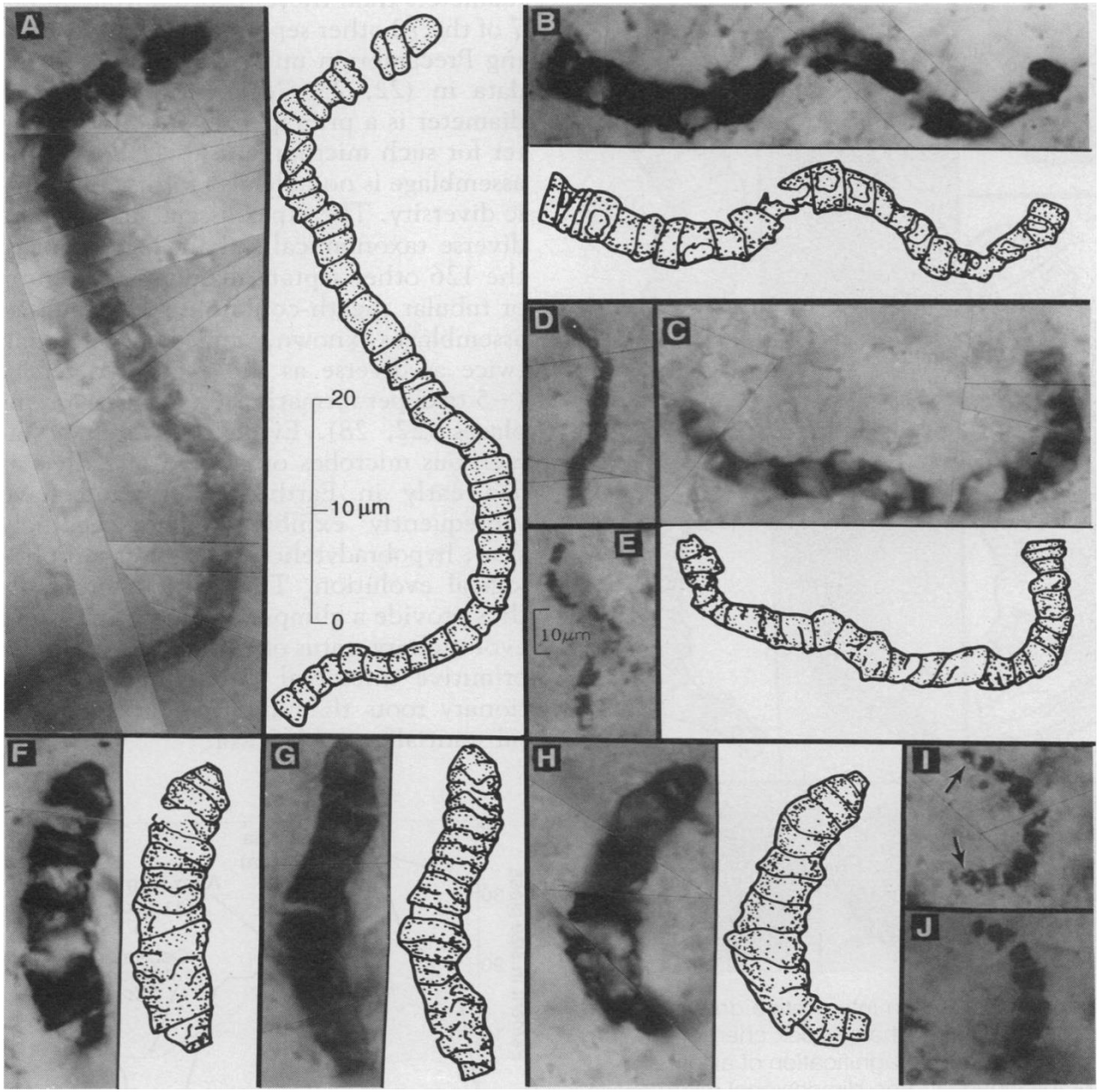


Fig. 4. Carbonaceous microfossils (with interpretive drawings) shown in thin sections of the Early Archean Apex chert of Western Australia. Magnification of (D, E, I, and J) denoted by scale in (E); magnification of all other parts shown by scale in (A). (A, B, C, and D) and (F, G, H, and 1) show photomontages 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.

SIDE BY SIDE: FOSSIL IMAGE AND MODERN CYANOBACTERIA

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

Oscillatoria, modern filamentous cyanobacteria

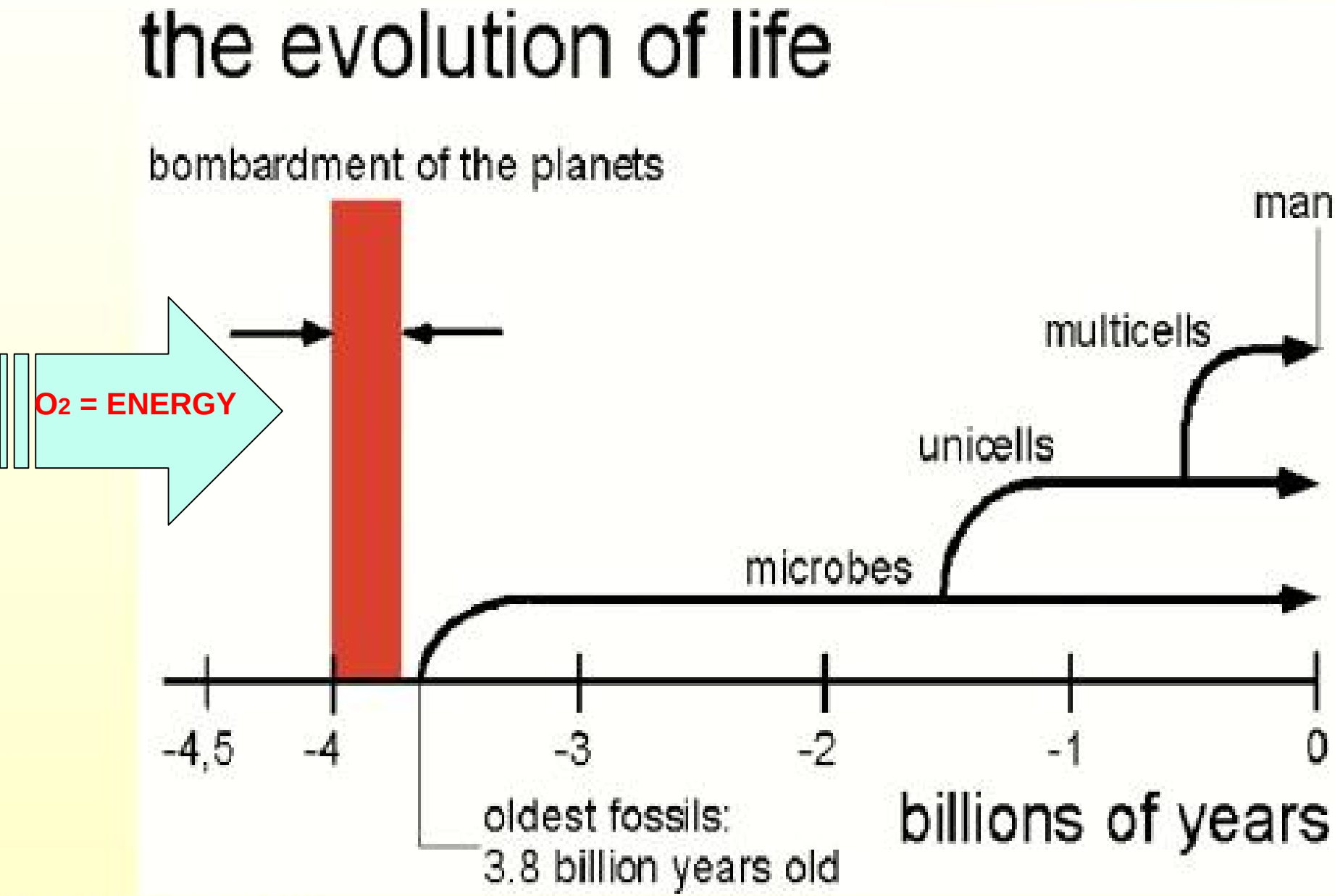
Evidence for life on Earth before 3,800 million years ago

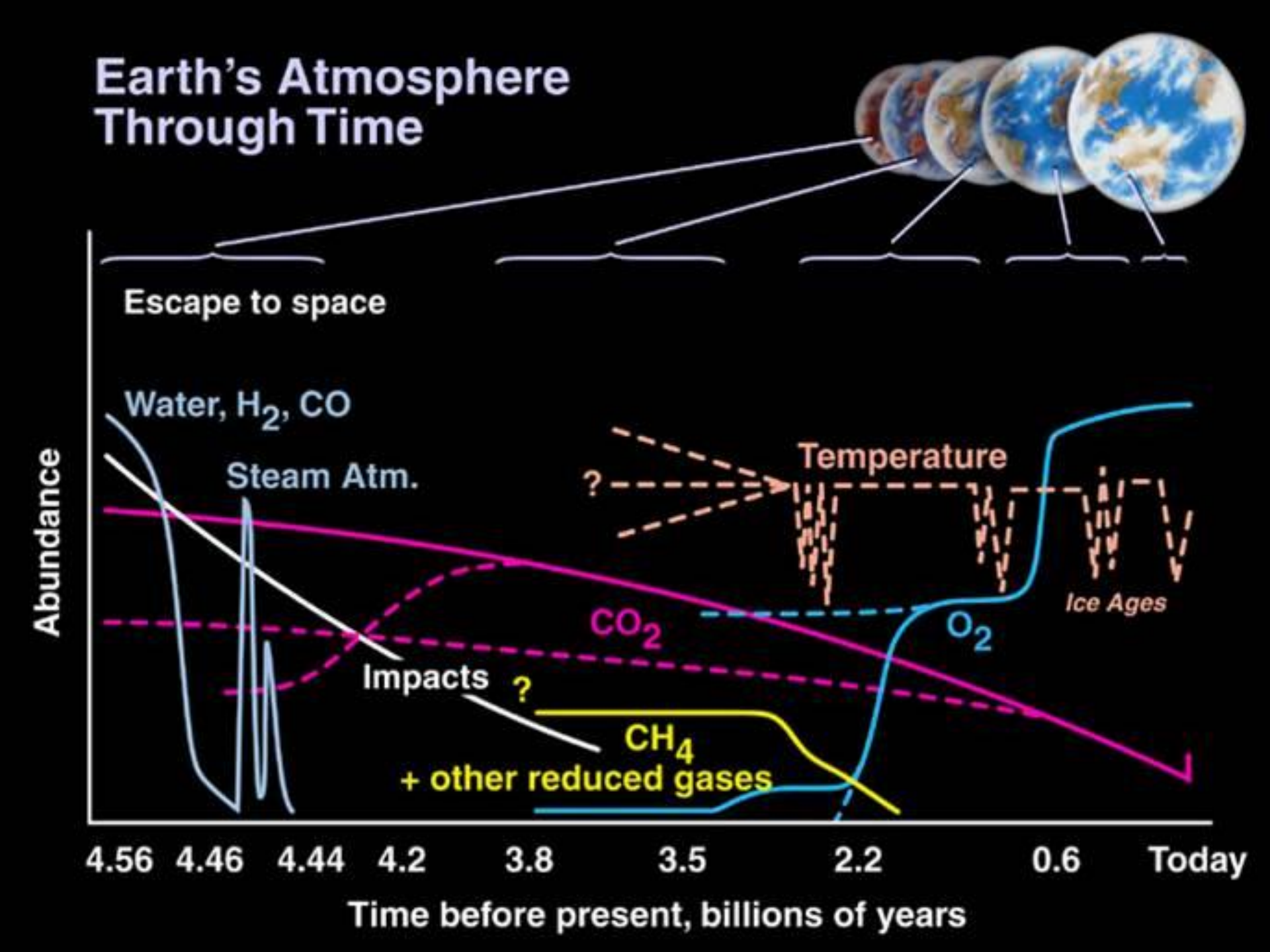
S. J. Mojzsis*, G. Arrhenius*, K. D. McKeegan†, T. M. Harrison†, A. P. Nutman‡ & C. R. L. Friend§

* 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

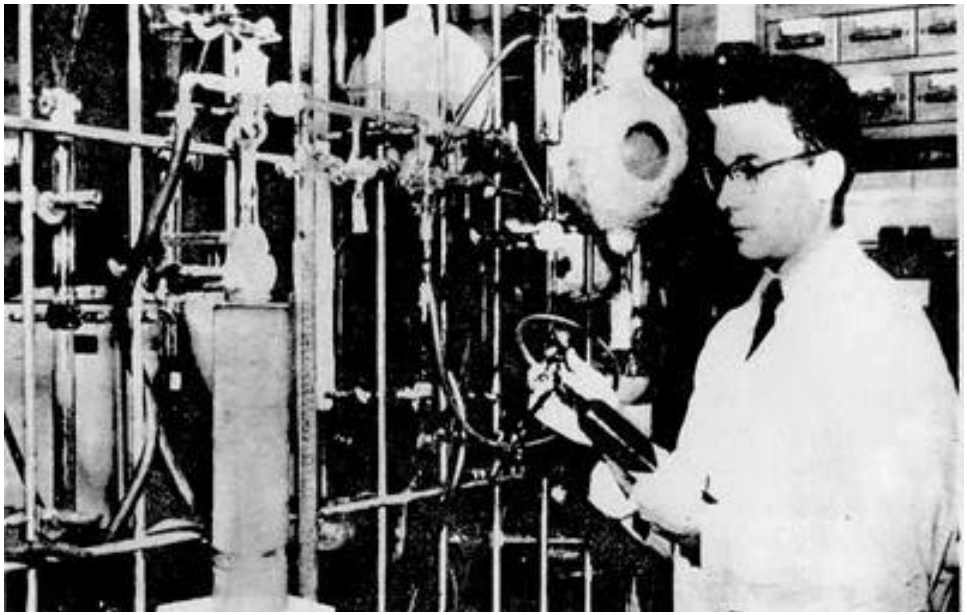
It is unknown when life first appeared on Earth. The earliest known microfossils (~3,500 Myr before present) are structurally complex, and if it is assumed that the associated organisms required a long time to develop this degree of complexity, then the existence of life much earlier than this can be 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, H_2, CO
Steam Atm.
?
Temperature
Ice Ages
CO_2
O_2
Impacts
?
CH_4
+ other reduced gases
Abundance
4.56
4.46
4.44
4.2
3.8
3.5
2.2
0.6
Today
Time before present, billions of years

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

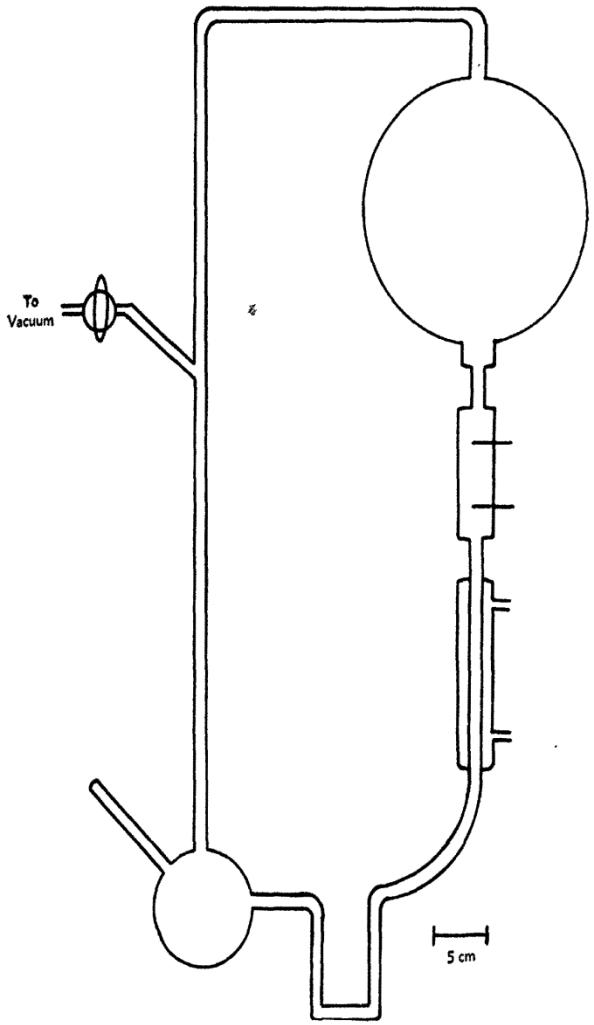


FIG. 1.

A descoberta da estrutura do DNA (1953)

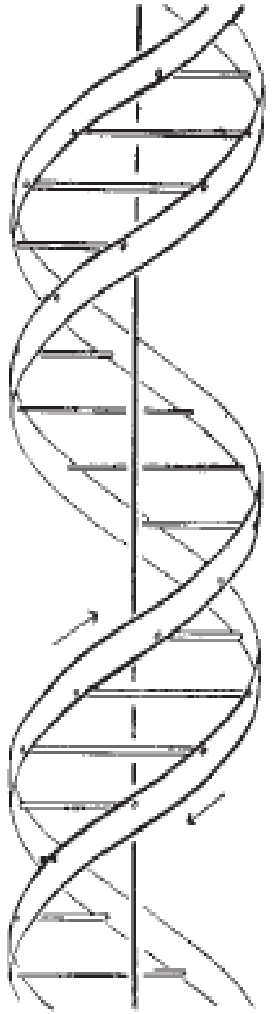
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

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*