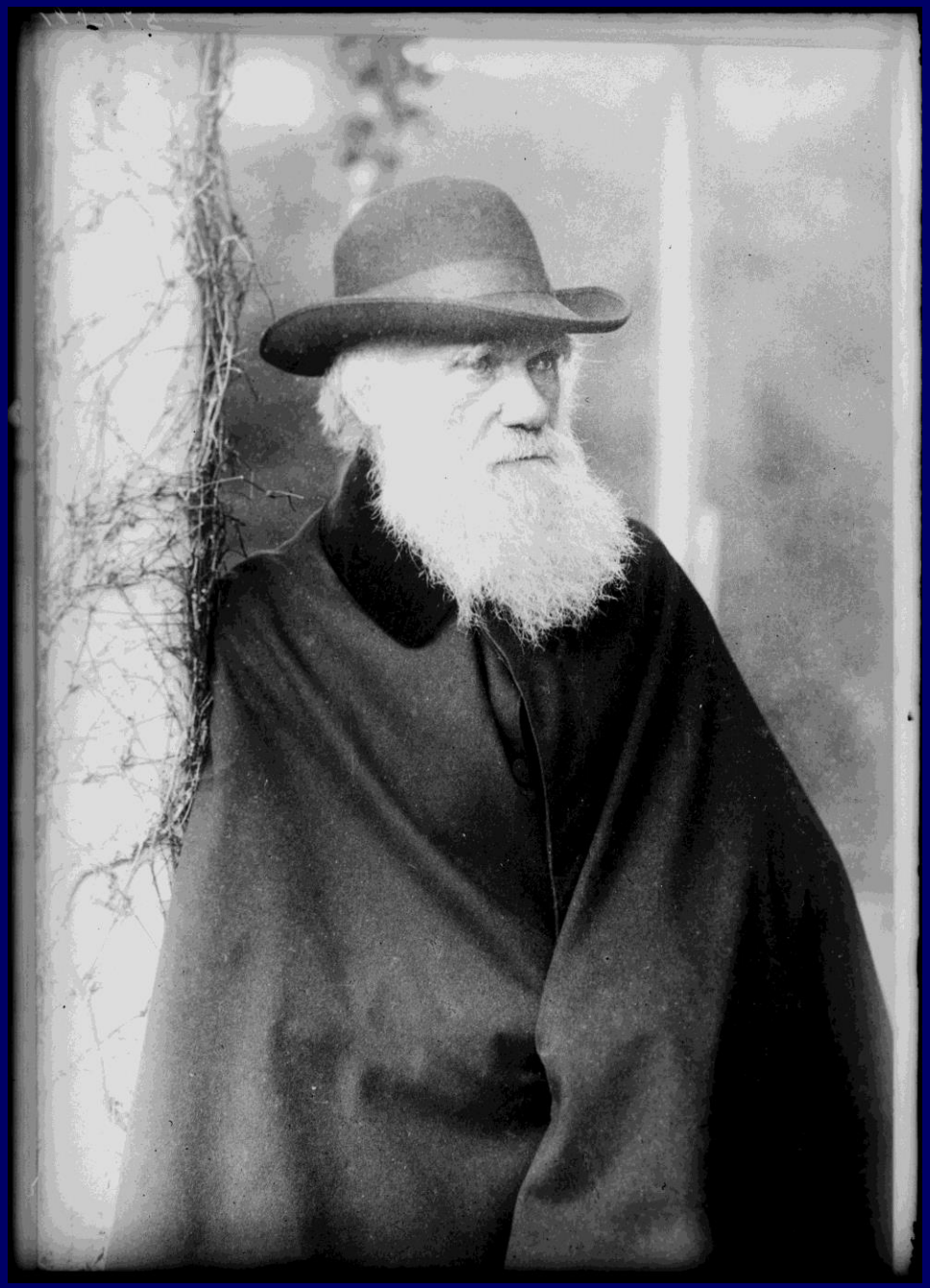
UPPSALA UNIVERSITET

The origin and evolution of life

Malgorzata Moczydlowska-Vidal



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.'

Theory of evolution is developing and criticized, as the current synthesis is not final.
Mechanisms are debated and new proposed, but the process of evolution is the fact of the past and present life!

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1859.

- Successive appearance of new species
- Different rates of change
- Species once lost do not reappear
- On the affinities of extinct species to each other and to living species

(Darwin, chapter 11) Laws of biology not changed

”Laws acting around us …growth with reproduction, inheritance, variability from the conditions of life, struggle for life, divergence, extinction, ….as a consequence to Natural Selection”

(Darwin, last page) Laws correctly formulated, selection on every level and additional mechanisms

Origination – adaptation – extinction

“Life...having been originally breathed by the Creator”

(Darwin, last line) Believe (prior to 3.8 Ga) or not (natural phenomena on Earth and in the Universe)

•H, C, N, O – most common elements in our solar system and 96% of living organisms

•Basic chemistry predicts that these components are likely to have formed in the early atmosphere – H_2, H_2S, CH_4, NH_3, H_2O (Urey, 1952)

•Energy: solar radiation, UV, electric discharges, cosmic rays

Life arose from reactions between matter and energy

Miller, 1953 experiment to simulate primitive atmosphere and to study whether pre-biotic synthesis of organic molecules could have taken place in such environment

Juan Oró, 1960 synthesized adenine from HCN (5 HCN, base in nucleic acids)

Bada, Chalmers, Cleaves, Lazcano & Miller, Ferris & Orgel, Arhenius, Mojzis and others……

The chemical syntheses of organic compounds on the pre-biotic Earth probably yielded a mixture of many molecules, including many of those found in contemporary cells

All living beings consist of molecules of

- Nucleic acids
- Proteins

RNA, DNA
are composed of 5 bases
Adenine **A**
Guanine **G**
Cytosine **C**
Thymine **T**
Uracil **U**
2 sugars: ribose and deoxyribose
phosphate – chiral, R enantiomers

Contain 20 amino acids
– chiral, L enantiomers

All life must have a common chemical origin

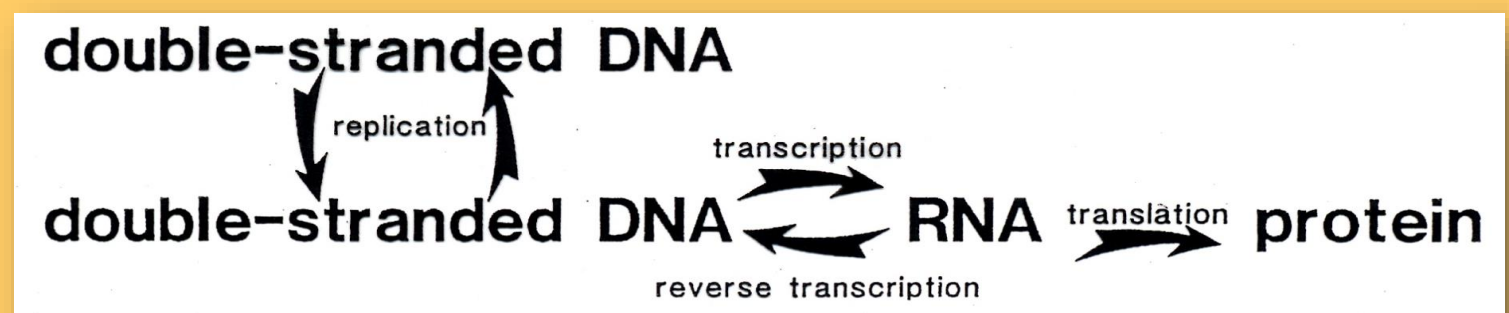
LUCA Last universal common ancestor

Living systems: autopoiesis and reproduction

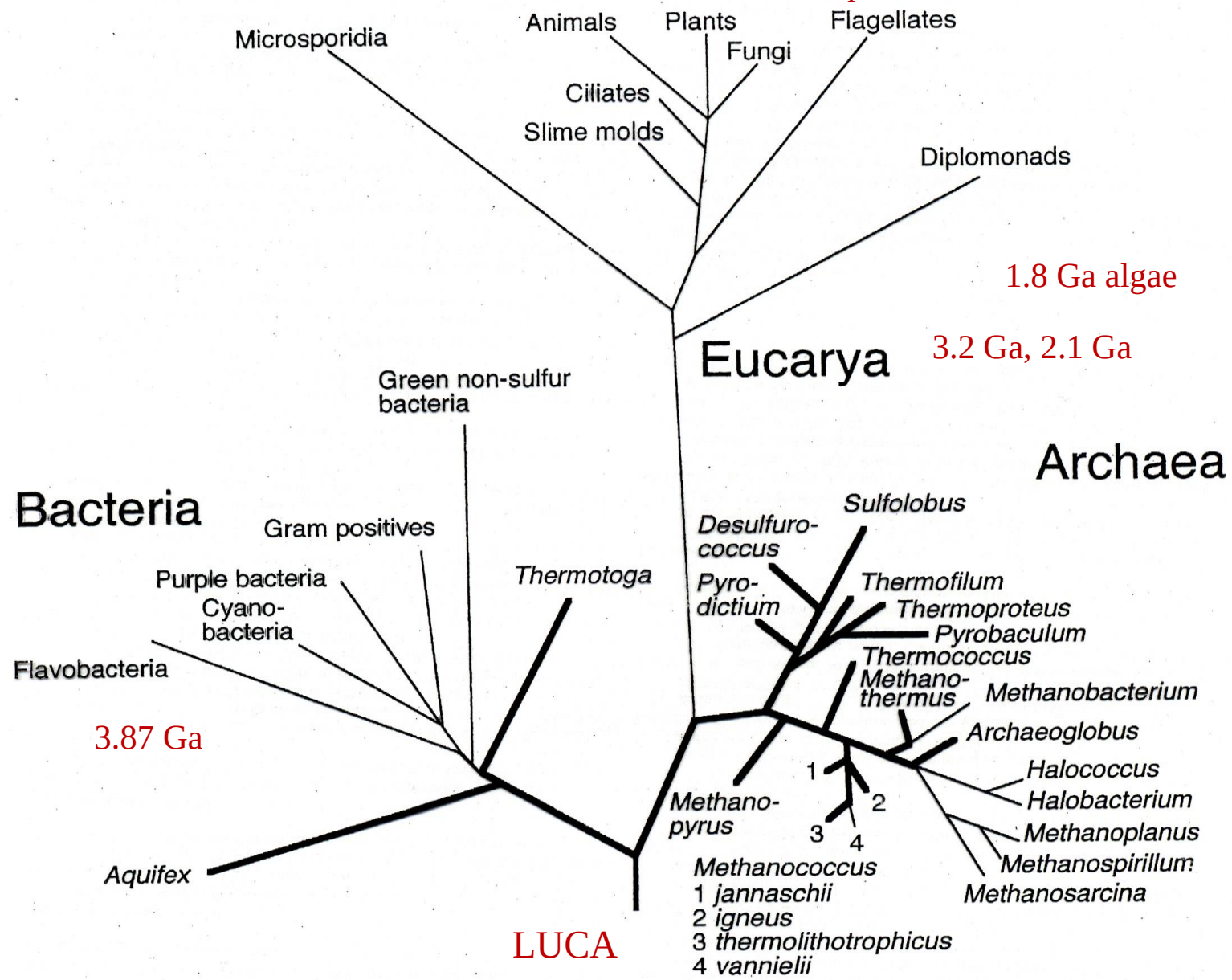
All contemporary cells: DNA, RNA, stringing amino acids into proteins in ribosomes

DNA → RNA → protein
transcription translation

RNA world



630 Ma metazoa, 200 000 *Homo sapiens*



LUCA

Universal phylogenetic tree. Bold lines: Hyperthermophiles.

3.87 Ga

1.8 Ga algae

3.2 Ga, 2.1 Ga

4.2 Ga

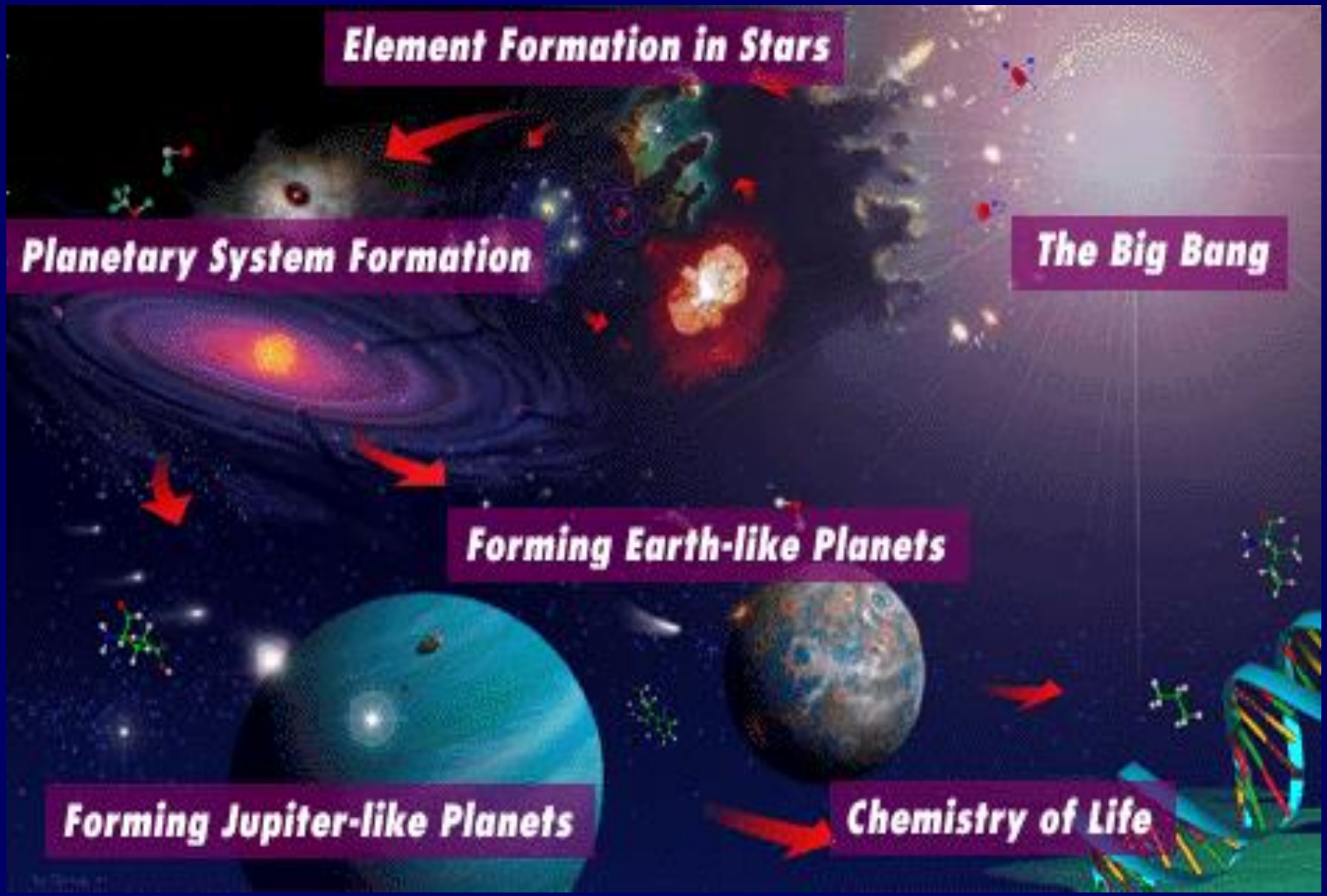
Archaeobacterium – ancestor to nucleus

Proteobacterium = purple bacterium – ancestor to mitochondrion

Cyanobacterium – ancestor to plastid

SET
confirmed by genomics

From speculations to science – cosmology, astrophysics, cosmochemistry, 14.6 Ga



The habitable Earth and its life

Habitable conditions: H_2O, oxygenic atmosphere, UV, global mean T, organic elements CHONSP

Geochemistry, clay minerals

Biomolecular synthesis, membranes, protocells, *ca*. 4.2 Ga

Bacteria, archaea, cyanobacteria,
Single- to multicellular eukaryotes
Metazoans to *Homo* (radiation *ca*. 200 000 years ago, 4 species

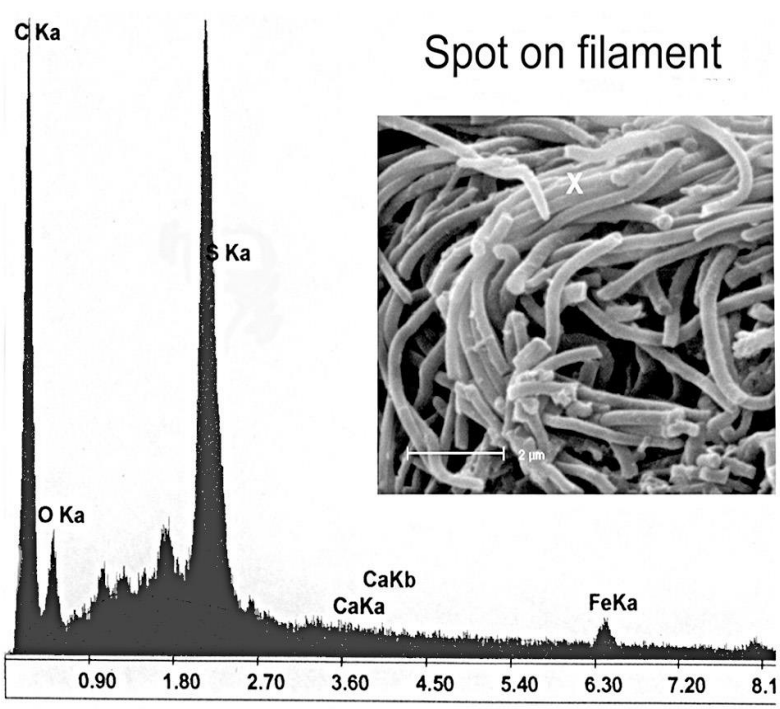
Records:
Fossils (micro-macro, organic-walled, soft-bodied, skeletal)

Bio-sedimentary structures – stromatolites
Biomarkers (fossil molecules, steranes, hopanes)
Biominerals
Carbon fractionation $\partial^{13}C$, photosynthetic fixation of CO_2 by the Calvin cycle

$\delta\ ^{13}C = [(^{13}C/^{12}C)_{sa} / {}^{13}C/^{12}C)_{st} - 1] \times 10^3$ [‰ PDB]

SEM-EDAX, energy dispersive X-ray analyses

Spot on filament

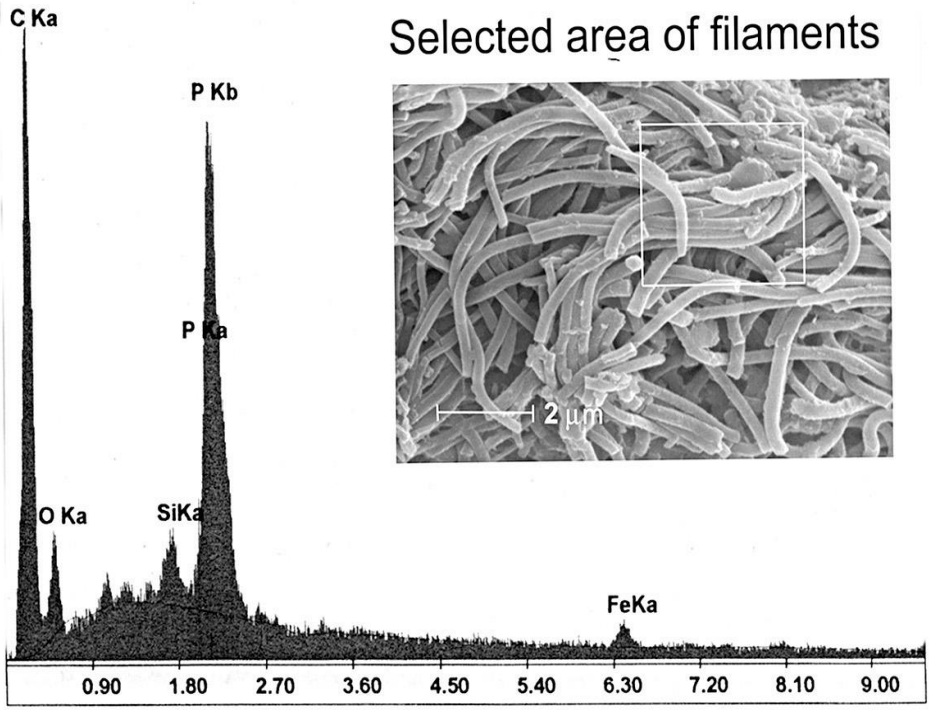


Element	Wt %	At %
C K	79.08	86.47
O K	13.15	10.79
S K	5.11	2.09
CaK	0.19	0.06
FeK	2.47	0.58
Total	100.00	100.00

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	179.73	2.14	0.85	83.98
O K	28.06	9.12	2.45	3.08
S K	76.52	21.39	1.46	3.58
CaK	2.06	14.09	21.98	0.15
FeK	11.25	8.80	4.49	1.28

1

Selected area of filaments



Element	Wt %	At %
C K	78.58	85.86
O K	13.86	11.37
SiK	1.64	0.77
P K	3.27	1.39
FeK	2.65	0.62
Total	100.00	100.00

Element	Net Inte.	Bkgd Inte.	Inte. Error	P/B
C K	137.87	1.52	0.93	90.48
O K	20.79	7.32	2.78	2.84
SiK	17.68	16.19	3.59	1.09
P K	32.31	16.18	2.35	2.00
FeK	8.27	5.17	4.83	1.60

2

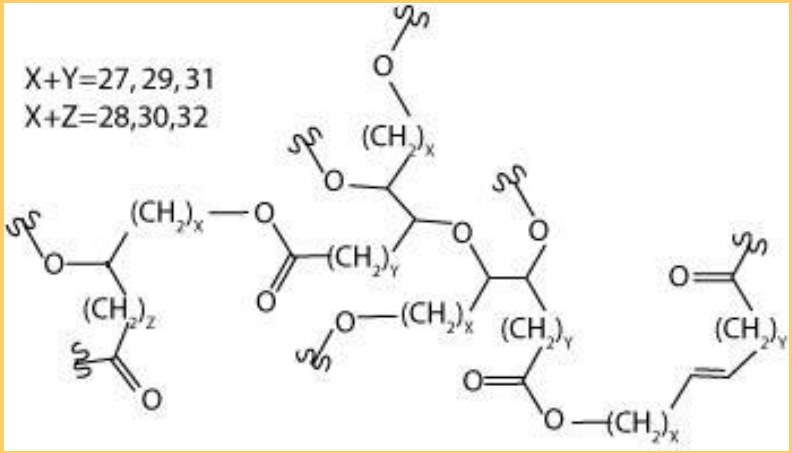
Biomarkers

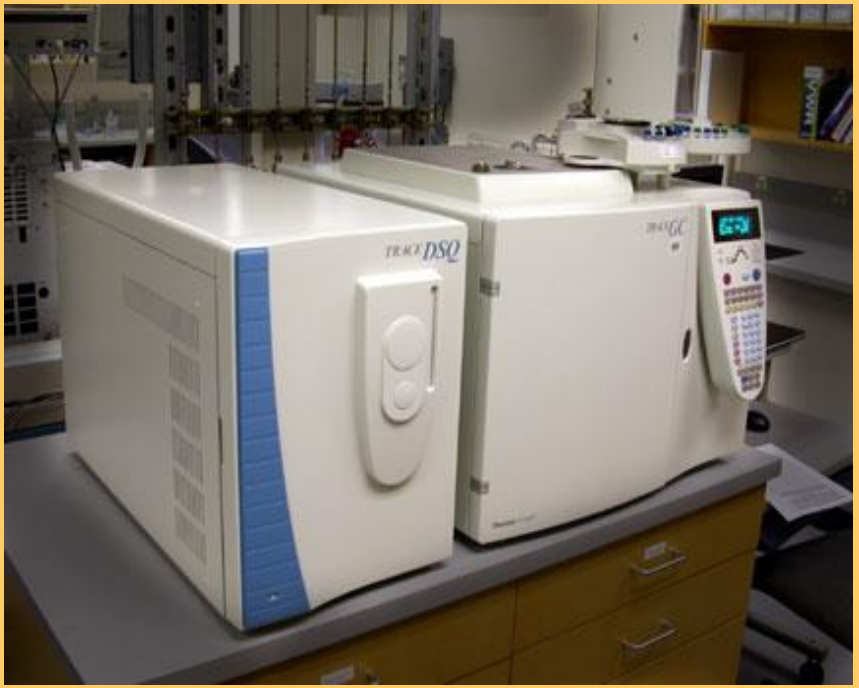
Gas chromatograph/Mass spectrometer

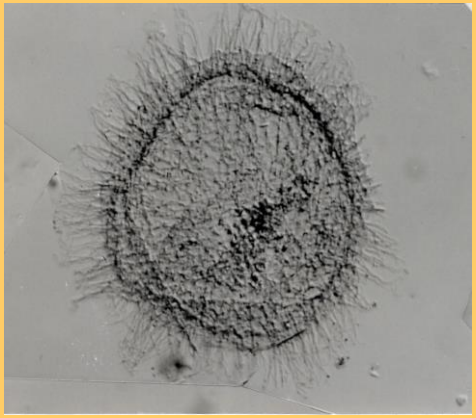
Characteristics of original molecular structure

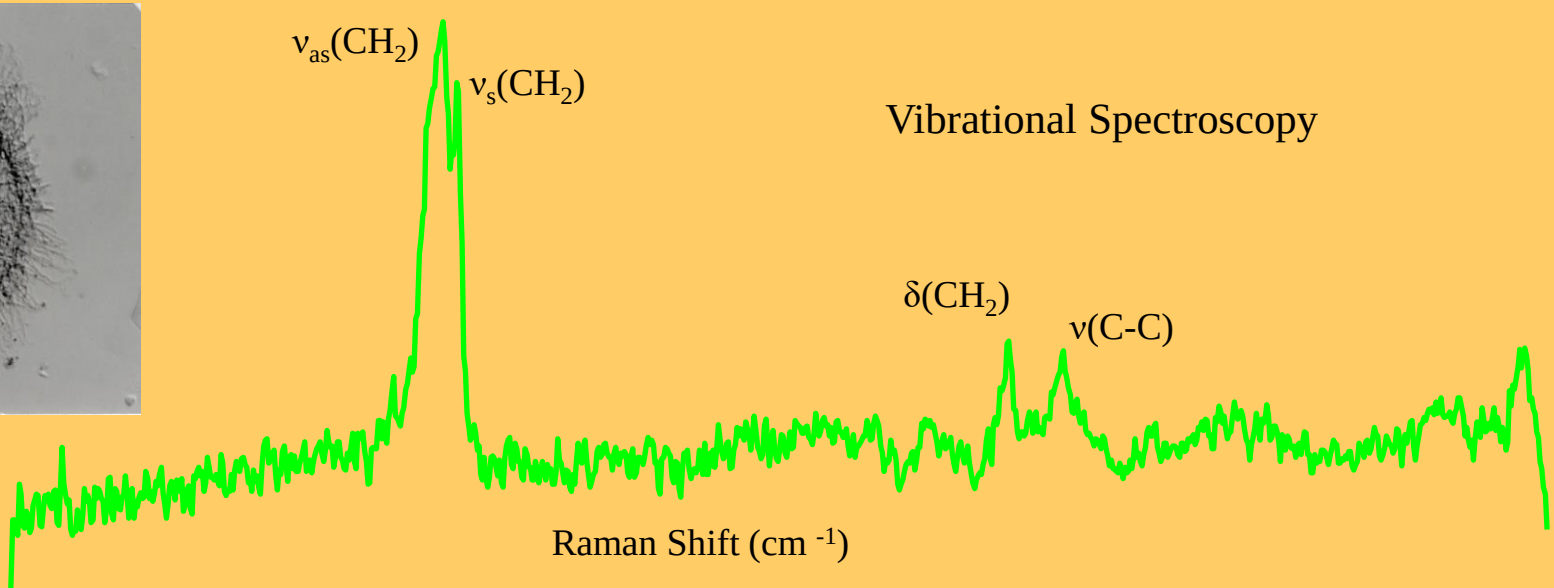
Algaenan

e.g. chlorophyte



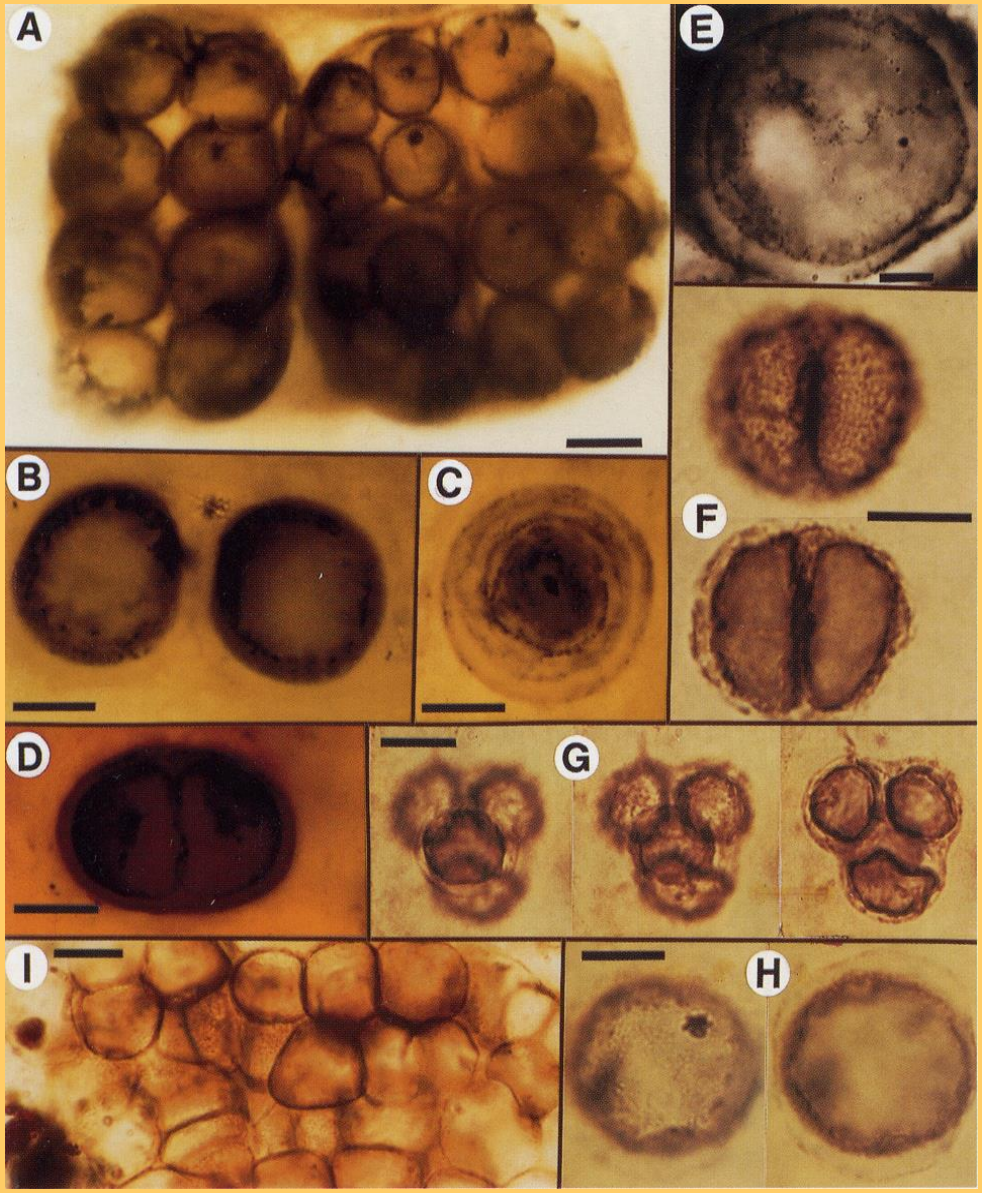






Vibrational Spectroscopy

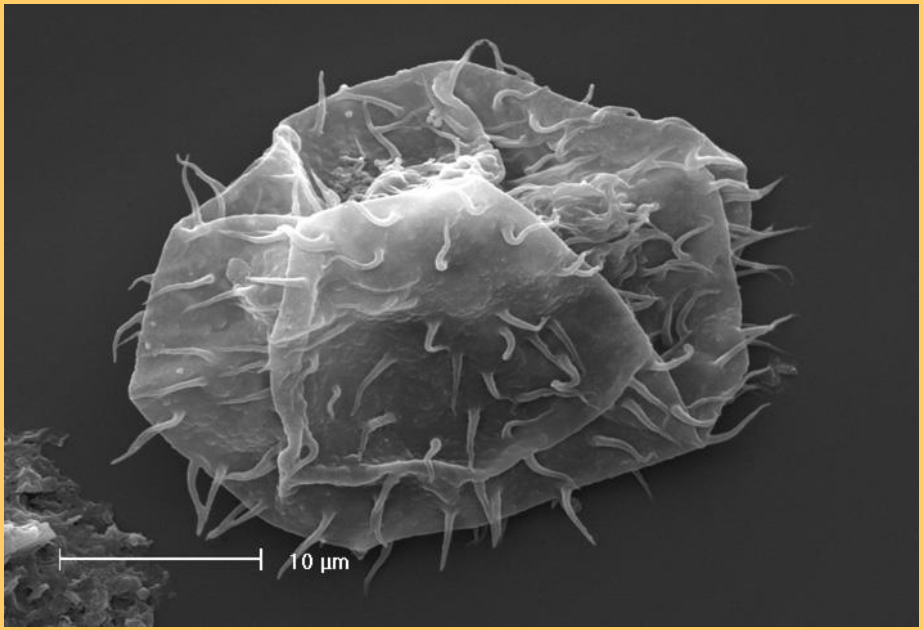
Spheroidal cyanobacteria, 1 Ga–650 Ma

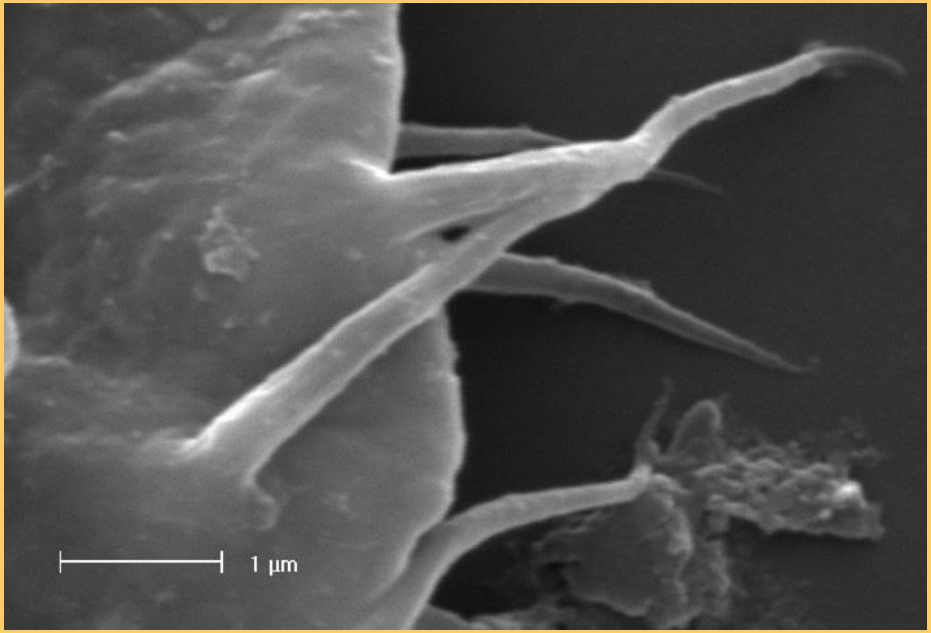


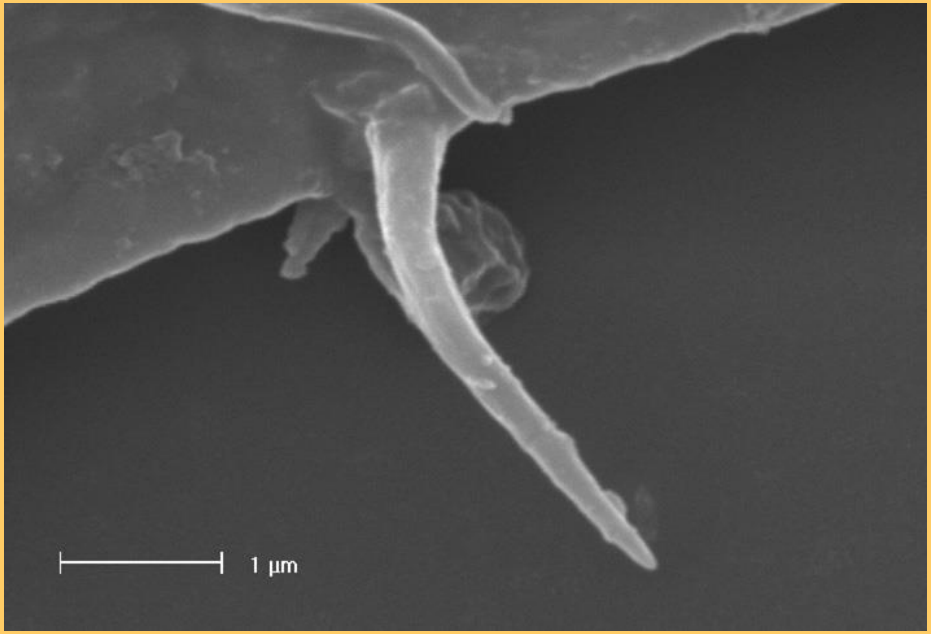
Oscillatoriopsis, *ca.* 850 Ma

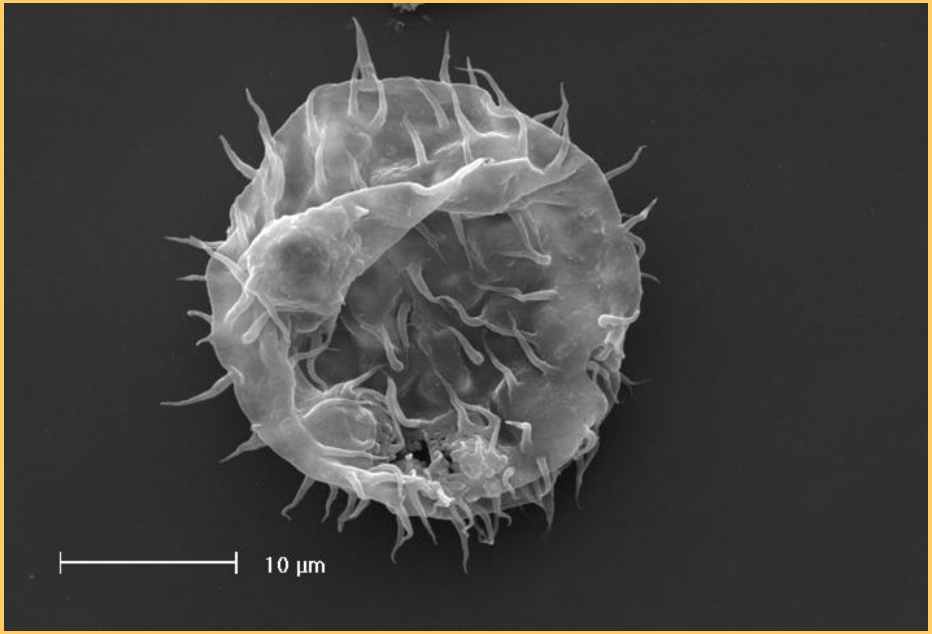
(Schopf, 1999)

Globosphaeridium cerinum, *ca.* 540 Ma









Digermulen, Arctic Norway

Si-biomineralized exoskeletons (CT imaging, STEM EDS energy dispersive spectroscopy, Laser-Raman spectroscopy, field emission electrone probe microanalyzer with EDS, X-ray diffraction)

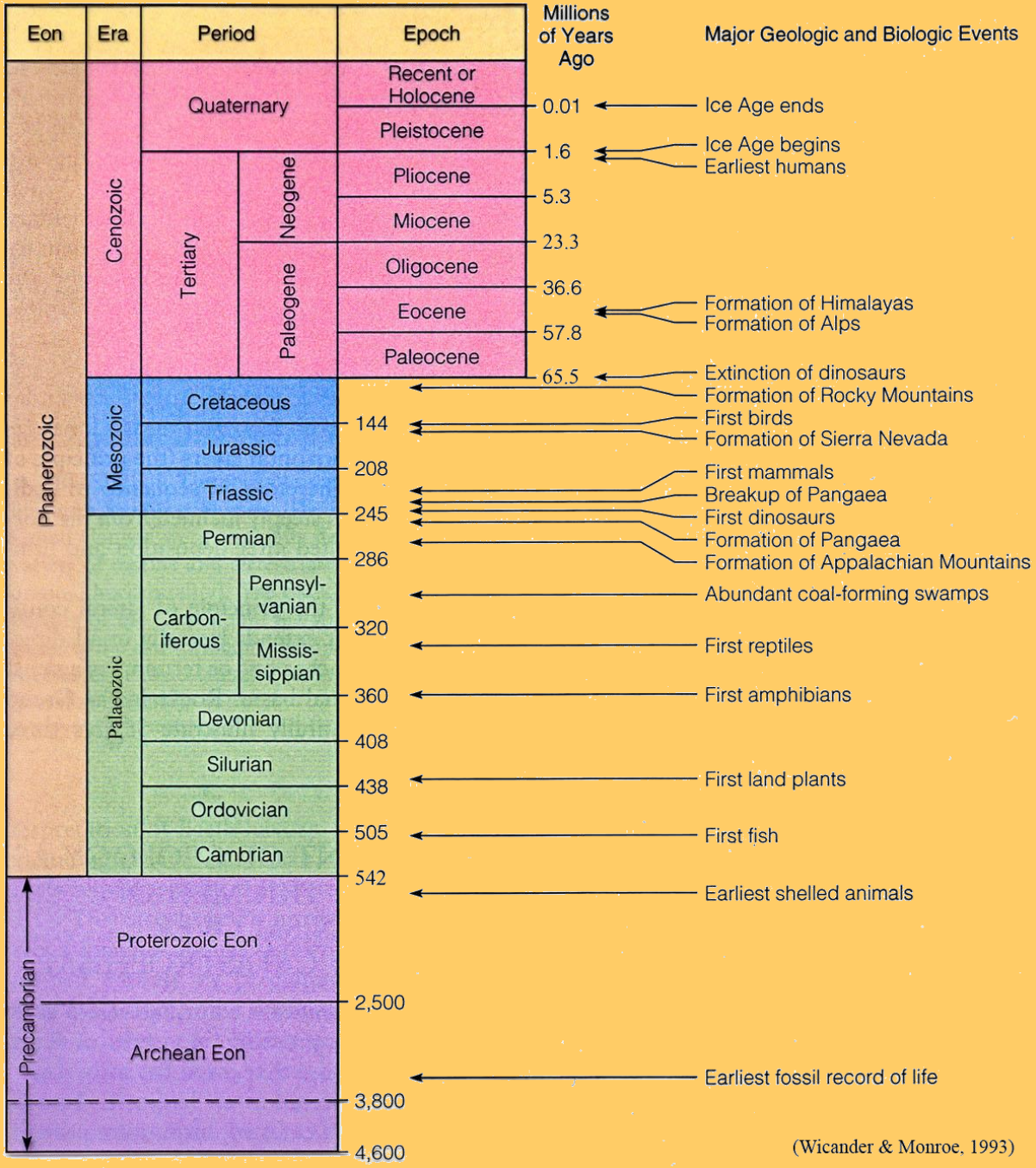
3-D preserved, radial symmetry, polarity, segmentation

Ediacaran *ca*. 630 Ma

The oldest metazoans (90 Ma prior to the Cambrian explosion, 60 Ma prior to the Ediacaran soft-bodied fauna)

(Small scale bar 1 mm
Long 1 cm)

(Moczydlowska *et al*., 2021, JoP)



Isotopic datings by Mass-spectrometry:

U ^{238} to Pb ^{206}
U ^{235} to Pb ^{207}

Th ^{235} to Pb ^{208}

Rb ^{87} to Sr ^{87}

K ^{40} to Ar ^{40}

C ^{14} to N ^{15}

Long way since Darwin

Mechanisms – Biological laws by Darwin and newly revealed

Polypeptide chains – Self-Assemble
RNA – autopoiesis and replication, catalyst; DNA – transcription and reverse
Mutations transferred by inheritance, but also occur by lateral gene transfer and viruses

Laws of physics and chemistry – constrain the reactions, also biological (black matter and energy ????)
Autonomous transformation of elements from H, He,…; radioactive isotopes decay to stable isotopes
Particles, atoms, molecules – force of attraction, electron charge and exchange, elemental atom bonds, their properties, symmetry and assymetry in crystalographic net in minerals and organic molecules – All constrained by laws, chanalized, selected
Electrons can only move in permited orbits – Selection
Neutrinos are chiral, L enantiomers in nature – Selection
Elementary particles to assemble into other particles, atoms, molecules – Self-Assemble
Autoevolution of form and function to form molecules (RNA, DNA) – physico-chemical constraints – Selection
Chemoselectivity in the Kolbe reaction C–C bond formation – Selection
Chiral L- amino acids in proteins, R- sugars in RNA, DNA – Selection in organisms
Organic carbon fractionation in photosynthesis – Selection of lighter stable isotopes of C ($^{12}C/^{13}C$)
Recalcitrant biomolecules (algaenans, sporopollenins, chitin) in reproductive/resting cysts in cyanobacteria, algae, plant spores and pollen, fungi, carapaces of metazoans – Selected by reproduction and inheritance
Genes for heredity – Selected active (recessive)

Environmental, food-web, population dynamics, sociobiology, kin- group selection – Selection
Human spirituality is natural selection of conscious minds (Lightman, 2023) – Selection
……to be continued with new research and discoveries……..

Evolution involves the “selection of particular traits and this arise during embryonic development” – Evo-devo methods

- Genomic changes occurred in evolutionaty time (mutations)
- Genome reorganization and regulatory variation (signalling gradients) – molecular origin of the trait novelty (example of cartilaginous fish skate and shark fins) – mutation and selection in life environment
- Developmental transcription factors, such as *hox* genes
- “Evolutionary innovations by genomic reorganizations caused by two rounds of whole-genome duplication (chromosomes were duplicated and re-arranged to give rise to the diversity of existing karyotypes in vertebrates” – mutation and selection (Marlétaz *et al*., 2023, Nature 616)

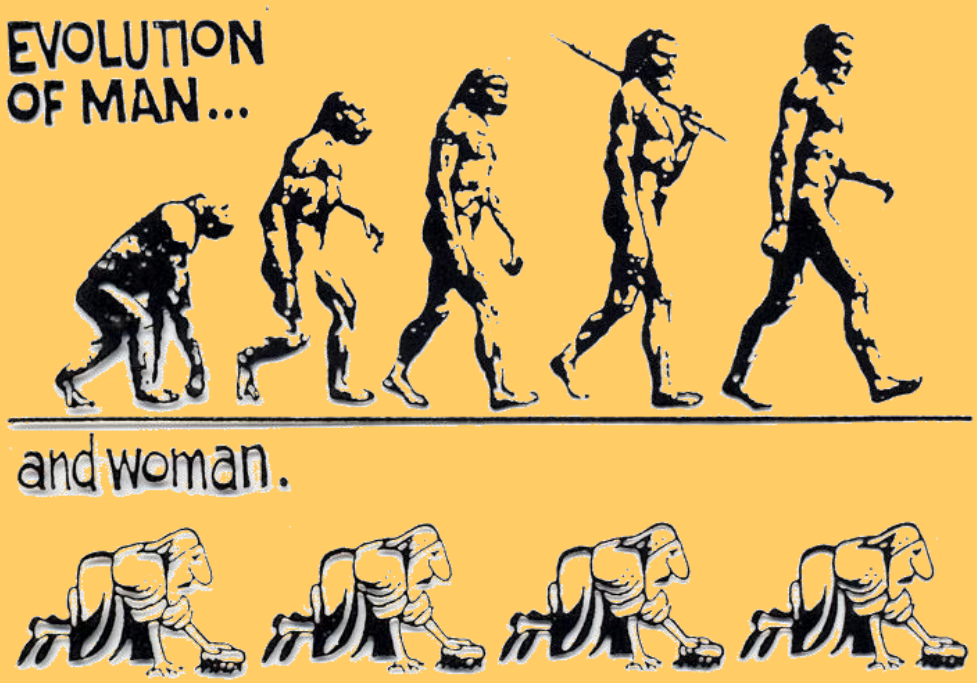
“Interactions between biomolecules in cell processes control cell fate, and perturbations of these interactions lead to mutations” (cancer, mutations are also bad, extinction; Seath *et al*., 2023, Nature 616)

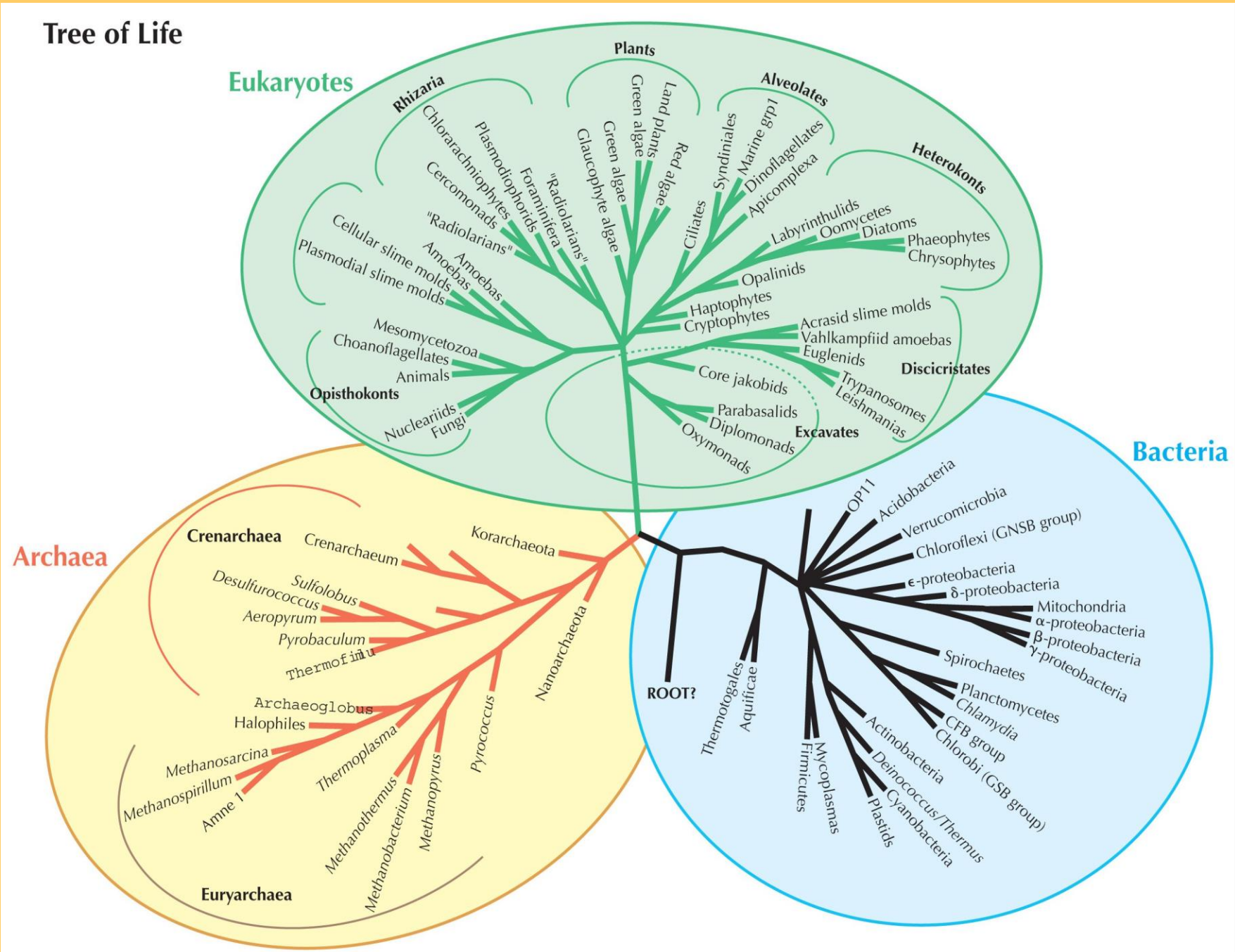
“Abiotic synthesis of amino acids in the Mid-Atlantic Ridge demonstrating fluid-rock interactions to generate amino acids abiotically and giving credence to the hydrothermal theory for the origin of life” (Ménez *et al*., 2018, Nature 564)

The (random and constrained) mutations and selection exist and play a role in the evolution

Evolution has no evidence for design

That's all folks!




Tree of Life
Eukaryotes
Rhizaria
Chlorarachniophytes
Plasmodiophorids
Foraminifera
"Radiolarians"
Cercomonads
"Radiolarians"
Amoebas
Cellular slime molds
Amoebas
Plasmodial slime molds
Plants
Green algae
Land plants
Green algae
Red algae
Glaucophyte algae
Alveolates
Syndiniales
Marine grp1
Dinoflagellates
Apicomplexa
Ciliates
Heterokonts
Labyrinthulids
Oomycetes
Diatoms
Phaeophytes
Chrysophytes
Opalinids
Haptophytes
Cryptophytes
Acrasid slime molds
Vahlkampfiid amoebas
Euglenids
Trypanosomes
Leishmanias
Discicristates
Core jakobids
Parabasalids
Diplomonads
Oxymonads
Excavates
Mesomycetozoa
Choanoflagellates
Animals
Opisthokonts
Nucleariids
Fungi
Archaea
Crenarchaea
Crenarchaeum
Sulfolobus
Desulfurococcus
Aeropyrum
Pyrobaculum
Thermofilu
Korarchaeota
Nanoarchaeota
Archaeoglobus
Halophiles
Methanosarcina
Methanospirillum
Amne 1
Thermoplasma
Methanothermus
Methanobacterium
Methanopyrus
Pyrococcus
Euryarchaea
Bacteria
ROOT?
Thermotogales
Aquificae
OP11
Acidobacteria
Verrucomicrobia
Chloroflexi (GNSB group)
ϵ-proteobacteria
δ-proteobacteria
Mitochondria
α-proteobacteria
β-proteobacteria
γ-proteobacteria
Spirochaetes
Planctomycetes
Chlamydia
CFB group
Chlorobi (GSB group)
Deinococcus/Thermus
Cyanobacteria
Plastids
Mycoplasmas
Firmicutes
Actinobacteria