A mineral Origin of Life

life

MDPI

Essay

A Field Trip to the Archaean in Search of Darwin's Warm Little Pond

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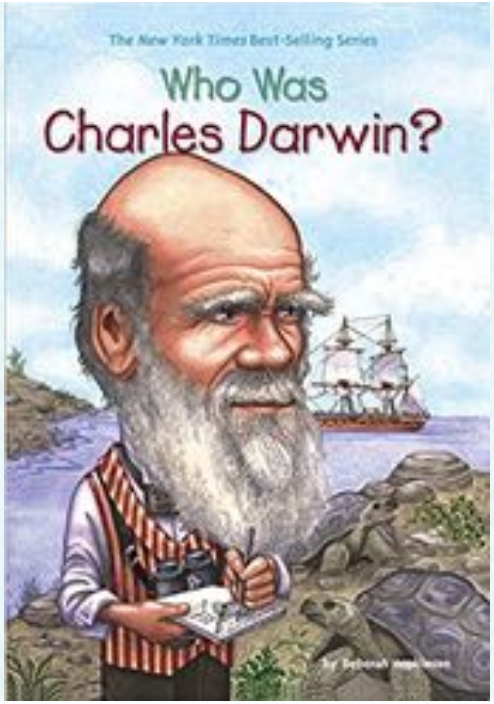


"It is often said that all the conditions for the first production of a living organism are present, which could ever have been present. But if (and oh what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts, light, heat, electricity etcetera present, that a protein compound was chemically formed, ready to undergo still more complex changes [...]" ~Charles Darwin, in an 1871 letter to Joseph Hooker [26].

A mineral Origin of Life

Astrochemistry

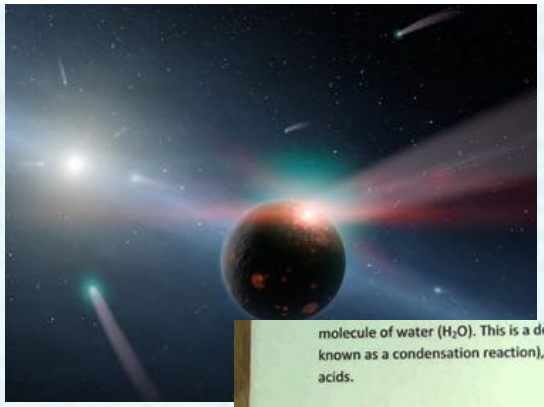
Geology/Geochemistry

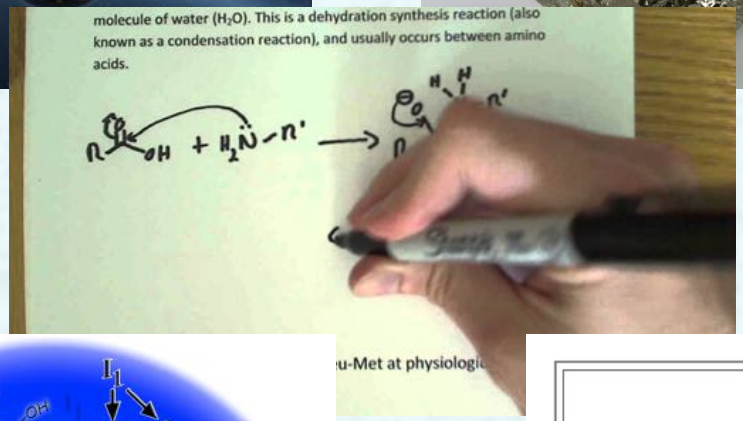
Mineral Chemistry

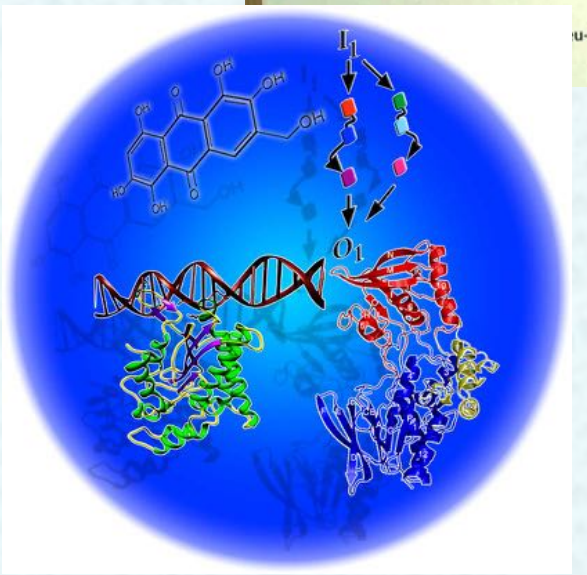
Organic Chemistry

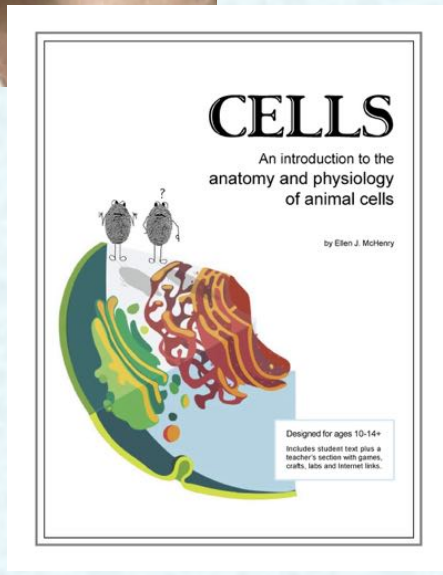
Biochemistry

Biology





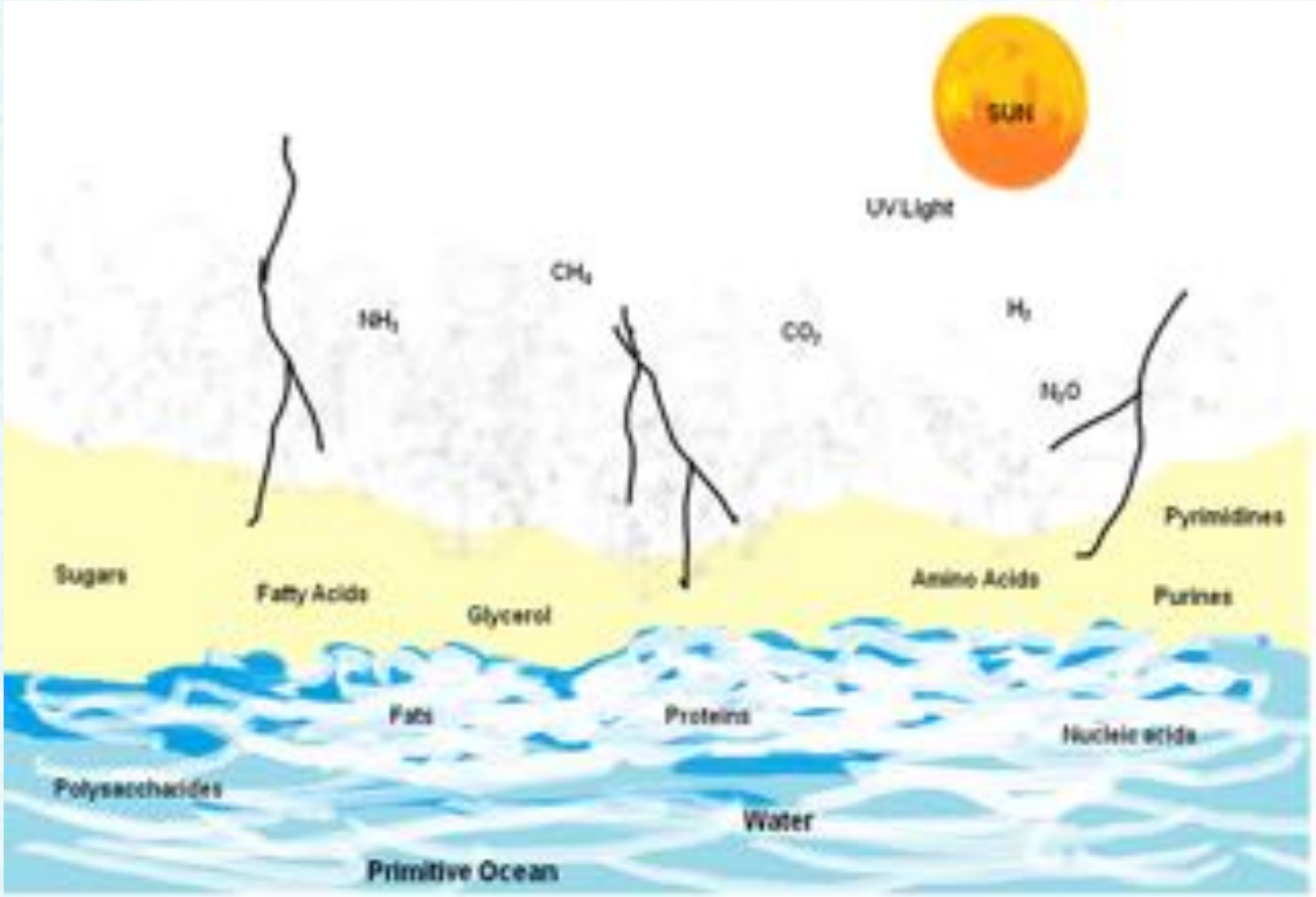




Geology/Geochemistry

Proto-continents
Shores
Ocean

More specific environments
Volcanoes …



Geology/Geochemistry

Geoscience Frontiers 8 (2017) 275–288

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journal homepage: www.elsevier.com/locate/gsf

Research paper

Nuclear geyser model of the origin of life: Driving force to promote the synthesis of building blocks of life

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[b] Earth-Life Science Institute, Tokyo Institute of Technology, 2-12-1 Ookayama, Tokyo, 152-8550, Japan

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Aqueous electron
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ABSTRACT

We propose the nuclear geyser model to elucidate an optimal site to bear the first life. Our model overcomes the difficulties that previously proposed models have encountered. Nuclear geyser is a geyser driven by a natural nuclear reactor, which was likely common in the Hadean Earth, because of a much higher abundance of ^{235}U as nuclear fuel. The nuclear geyser supplies the following: (1) high-density ionizing radiation to promote chemical chain reactions that even tar can be used for intermediate material to restart chemical reactions, (2) a system to maintain the circulation of material and energy, which includes cyclic environmental conditions (warm/cool, dry/wet, etc.) to enable to produce complex organic compounds, (3) a lower temperature than 100 °C as not to break down macromolecular organic compounds, (4) a locally reductive environment depending on rock types exposed along the geyser wall, and (5) a container to confine and accumulate volatile chemicals. These five factors are the necessary conditions that the birth place of life must satisfy. Only the nuclear geyser can meet all five, in contrast to the previously proposed birth sites, such as tidal flat, submarine hydrothermal vent, and outer space. The nuclear reactor and associated geyser, which maintain the circulations of material and energy with its surrounding environment, are regarded as the nuclear geyser system that enables numerous kinds of chemical reactions to synthesize complex organic compounds, and where the most primitive metabolism could be generated.

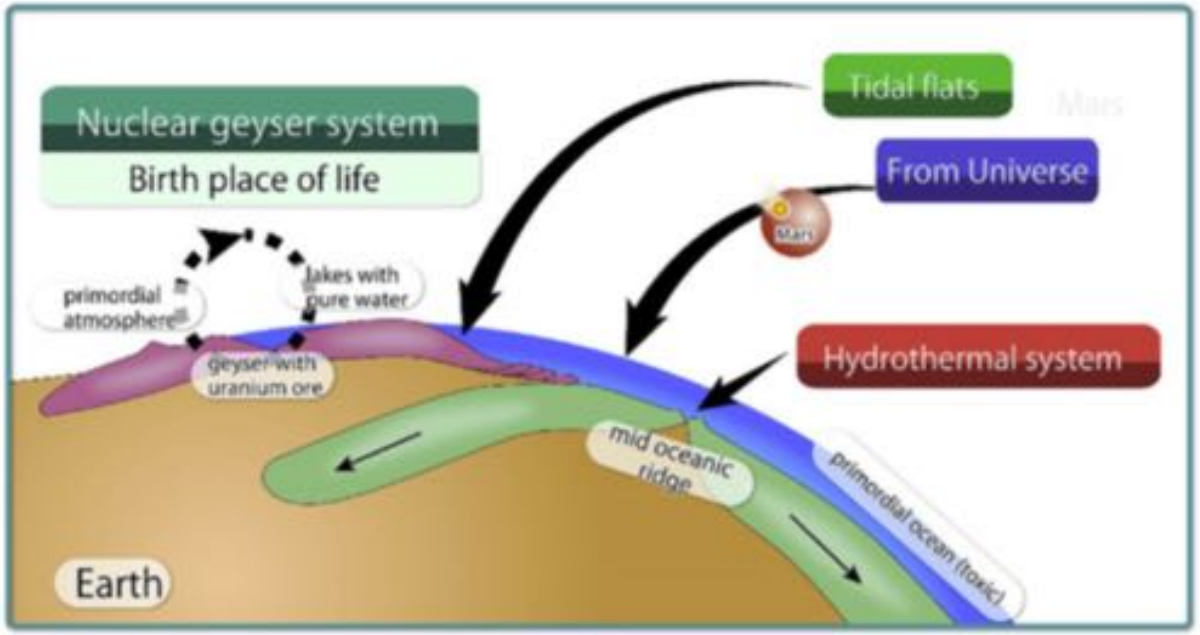


Figure 1. Proposed models for the birth place of life: tidal flats, submarine hydrothermal vents, outer space, and nuclear geyser system (the present work).

Mineral Chemistry

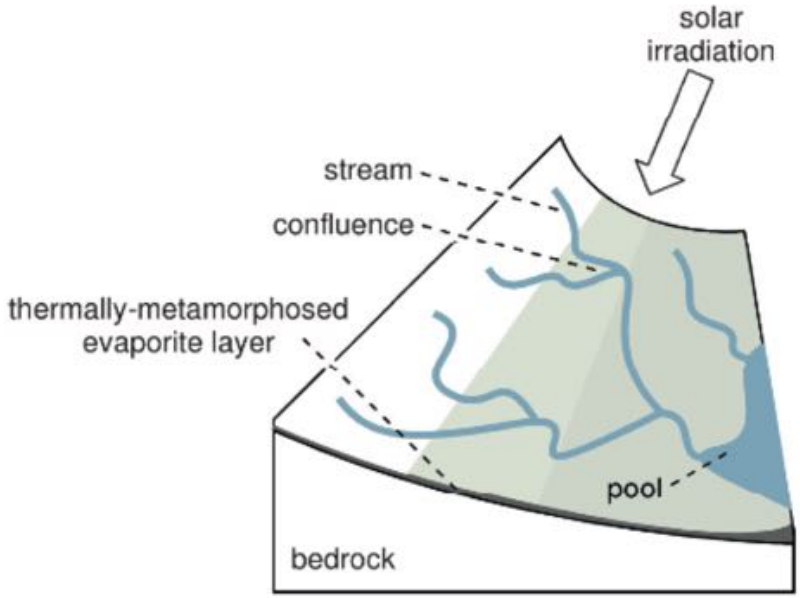


Figure 17. Late stage of the geochemical scenario.

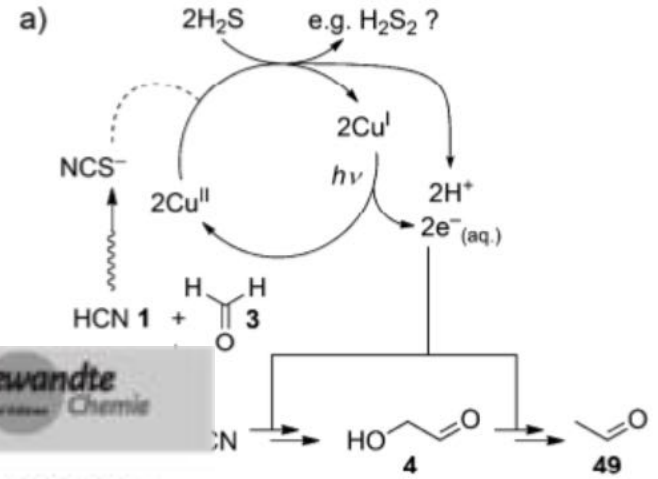
$$Ca_2[Fe(CN)_6] \xrightarrow{660^\circ C} 2Ca(CN)_2 + Fe(CN)_2$$

$$Ca(CN)_2 \xrightarrow{660^\circ C} \mathbf{CaNCN} + C \underset{}{\overset{1000^\circ C}{\rightleftharpoons}} \mathbf{CaC_2} + N_2$$

$$Mg_2[Fe(CN)_6] \xrightarrow{315^\circ C} 2Mg(CN)_2 + Fe(CN)_2$$

$$Mg(CN)_2 \xrightarrow{395^\circ C} MgCN_2 + C$$

$$3MgCN_2 \xrightarrow{420^\circ C} \mathbf{Mg_3N_2} + 3C + 2N_2$$



GDCh Reviews Angewandte International Edition Chemie

International Edition: DOI: 10.1002/anie.201506585
German Edition: DOI: 10.1002/ange.201506585

Prebiotic Systems Chemistry

The Origin of Life—Out of the Blue

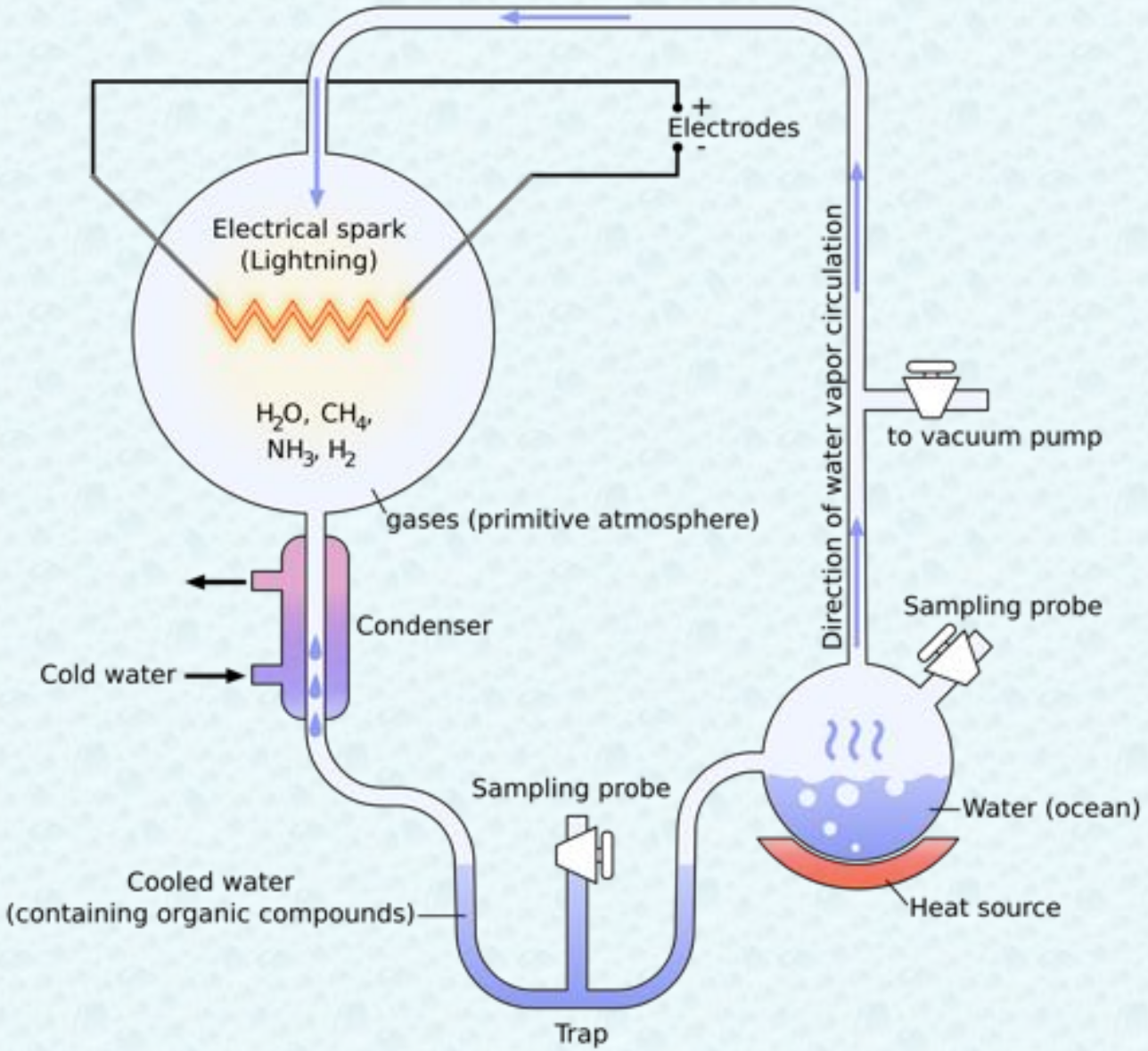
*John D. Sutherland**

Organic Chemistry

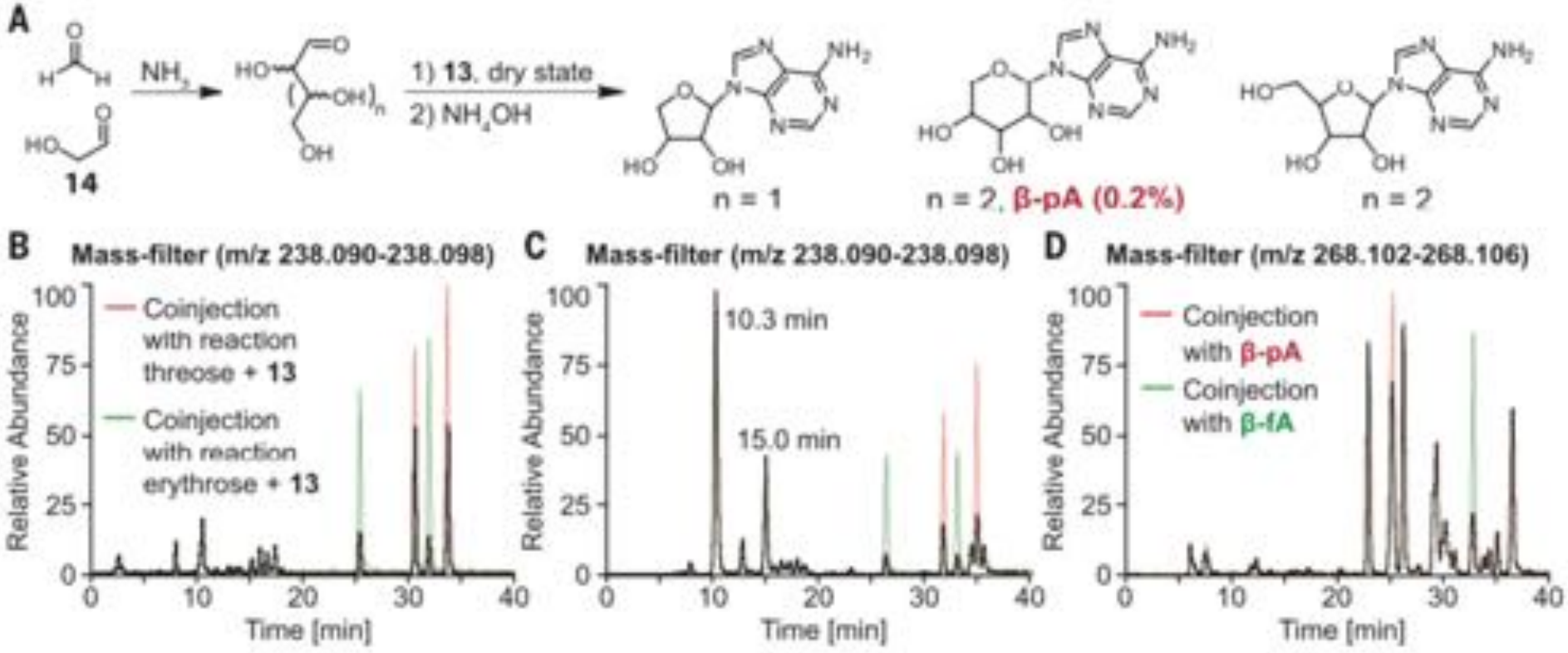
A Production of Amino Acids Under Possible Primitive Earth Conditions

Stanley L. Miller[1, 2]
G. H. Jones Chemical Laboratory, University of Chicago, Chicago, Illinois

Science (1953) 117: 528-529
DOI: 10.1126/science.117.3046.528



Organic Chemistry



Science

AAAS

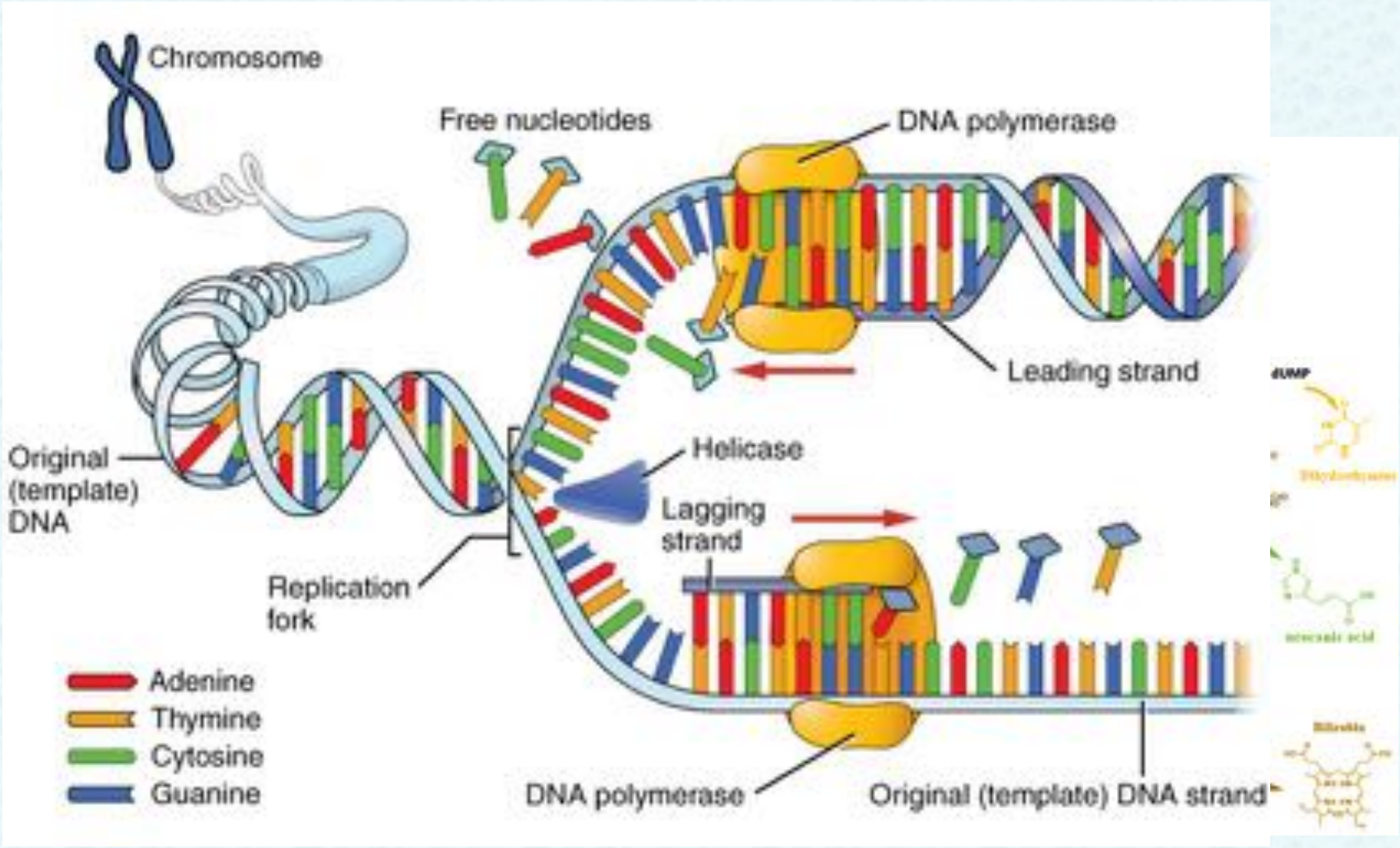
A high-yielding, strictly regioselective prebiotic purine nucleoside formation pathway

Sidney Becker, Ines Thoma, Amrei Deutsch, Tim Gehrke, Peter Mayer, Hendrik Zipse and Thomas Carell (May 12, 2016)

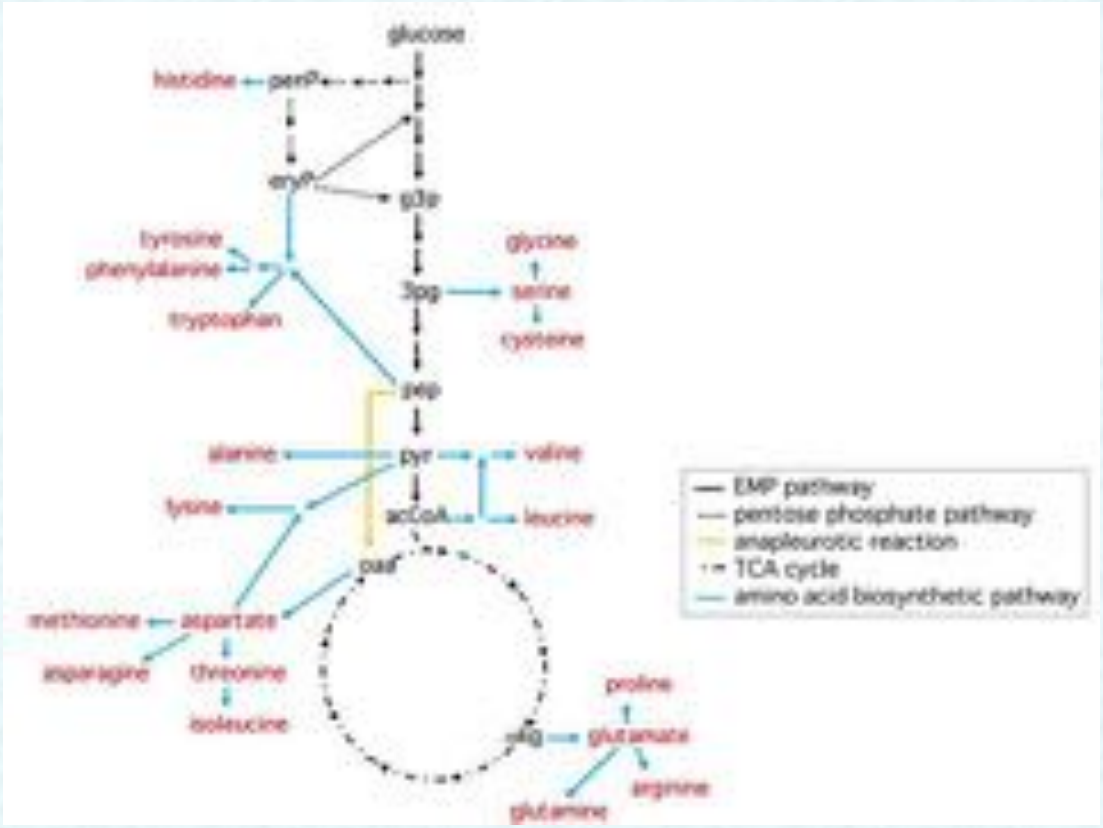
Science **352** (6287), 833-836. [doi: 10.1126/science.aad2808]

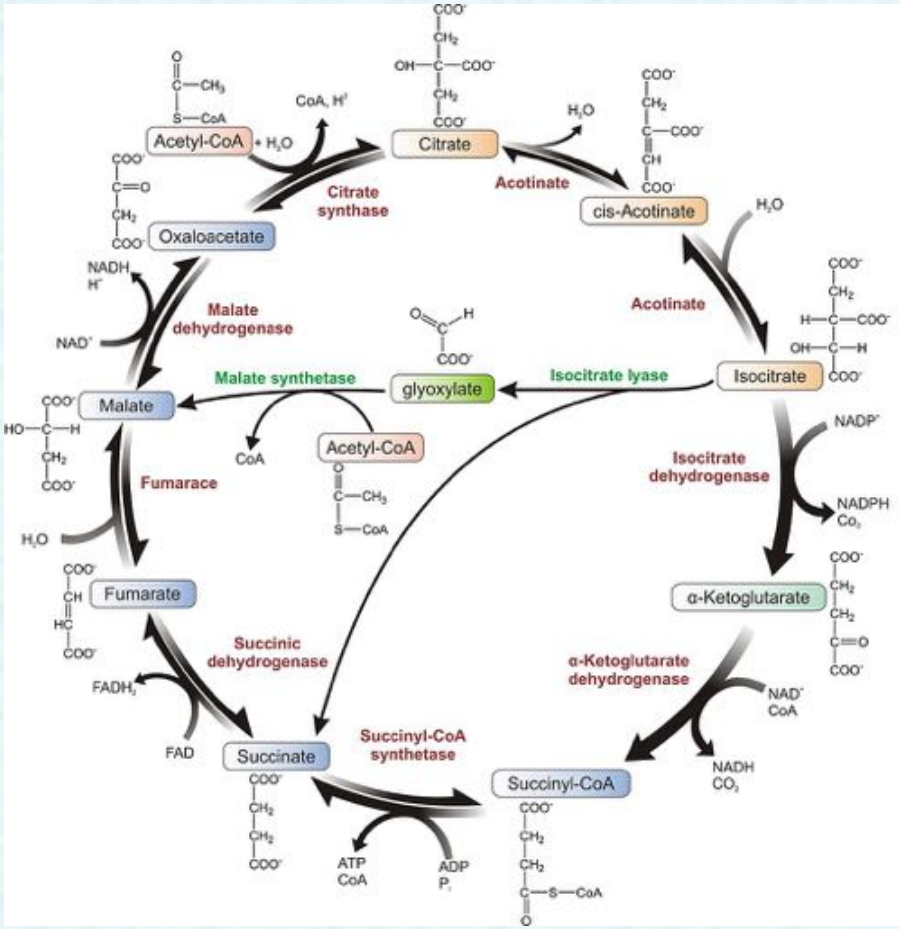
Biochemistry

- Information
- Metabolism

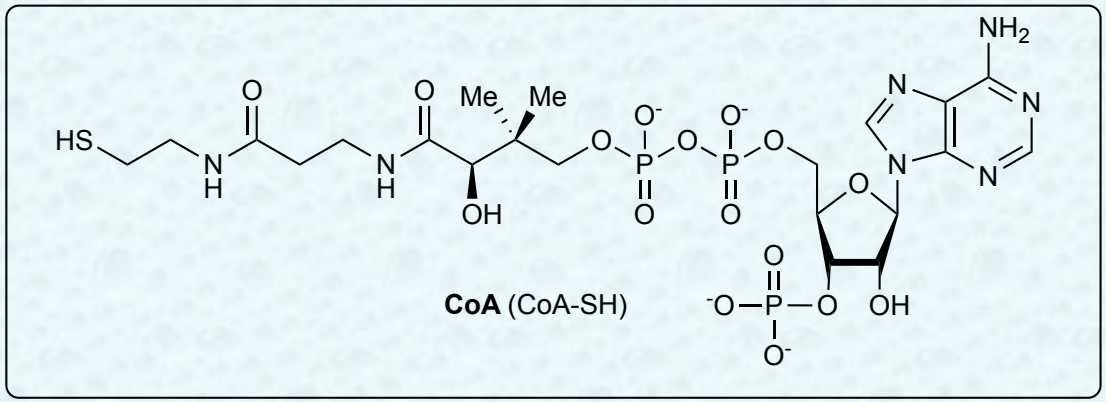


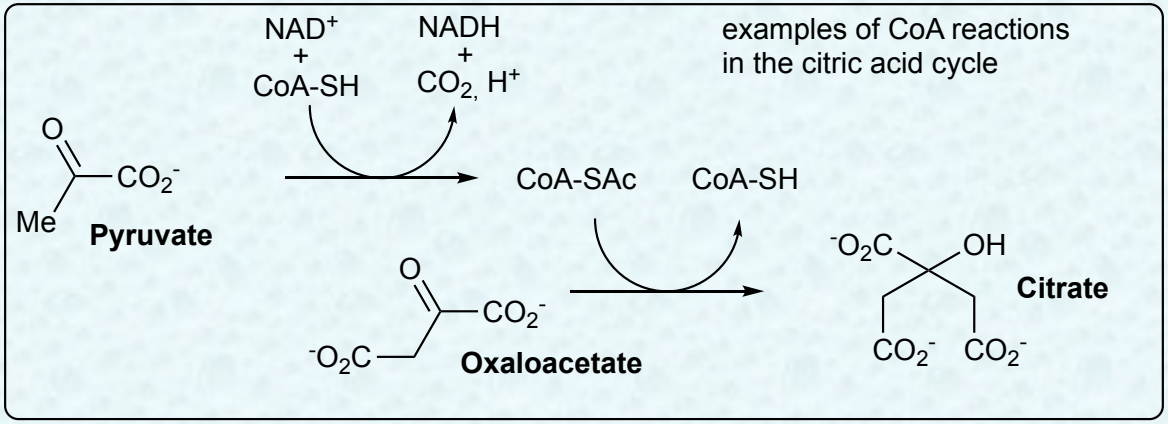
Biochemistry





Thesis project





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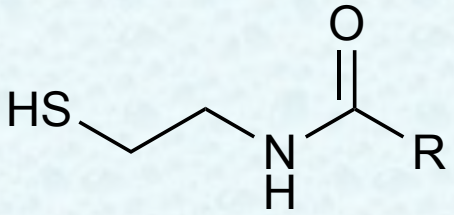
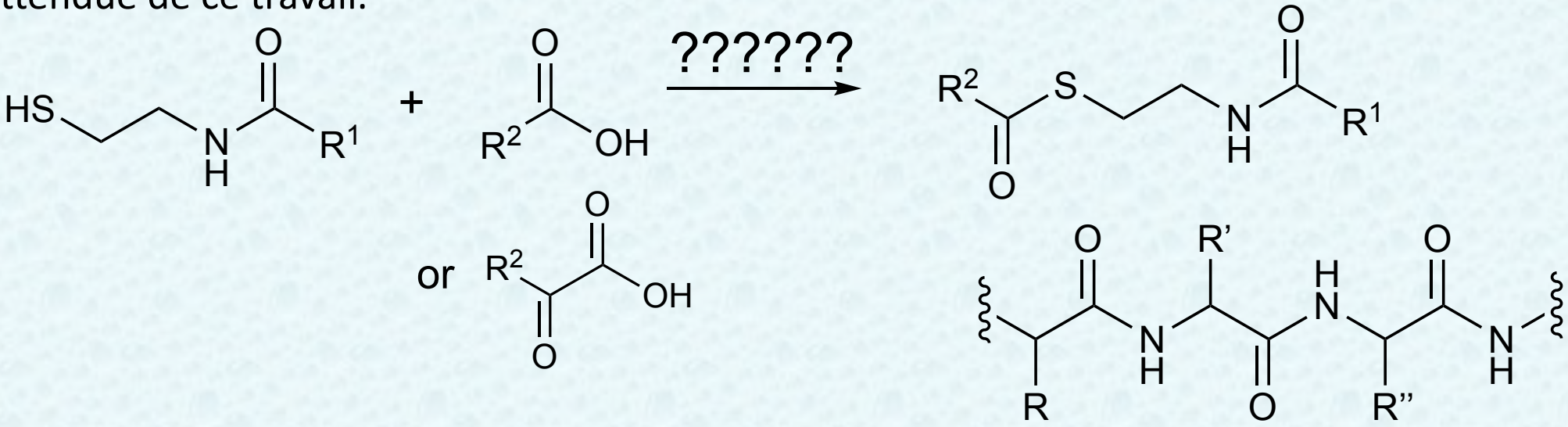


- Mimes synthétiques du coenzyme A
- Réactivité à des molécules simples : H_2, N_2, H_2O, H_2S, NH_3, CH_4, CO, CO_2, HCN, P_4O_{10} …
- Production des liaisons thioester (notamment dérivées du cycle de l'acide citrique)
- Systèmes d'activations (métaux de transition, polyphosphates) -> liaisons peptidiques
- Protocoles de détection adaptés
- Une meilleure compréhension des mécanismes biologiques d'évolution des thiols est attendue de ce travail.



Thesis project, backgrounds

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

Phil. Trans. R. Soc. B (2006) **361**, 1787–1808
doi:10.1098/rstb.2006.1904
Published online 7 September 2006

From volcanic origins of chemoautotrophic life to Bacteria, Archaea and Eukarya

Günter Wächtershäuser[1,2,*]

[1]*80333 Munich, Weinstrasse 8, Germany*
[2]*209 Mill Race Drive, Chapel Hill, NC 27514, USA*

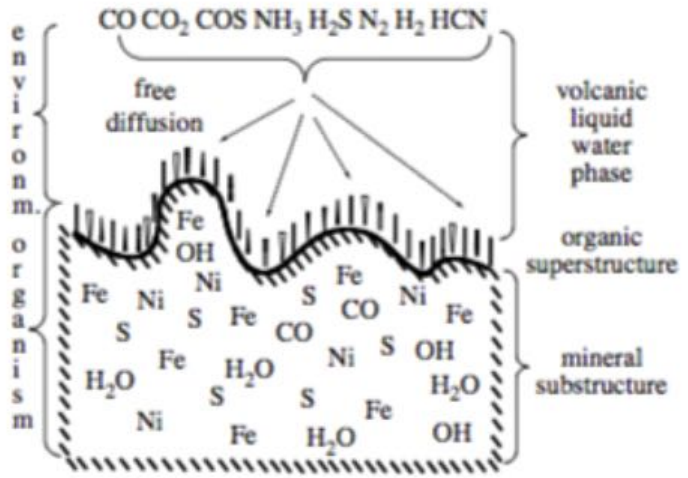


Figure 1. Cross-sectional representation of the minimal organization of the pioneer organism.

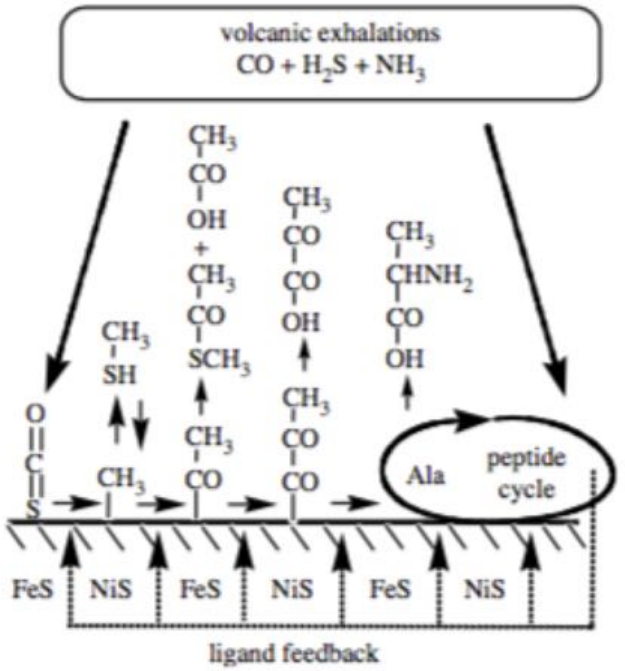
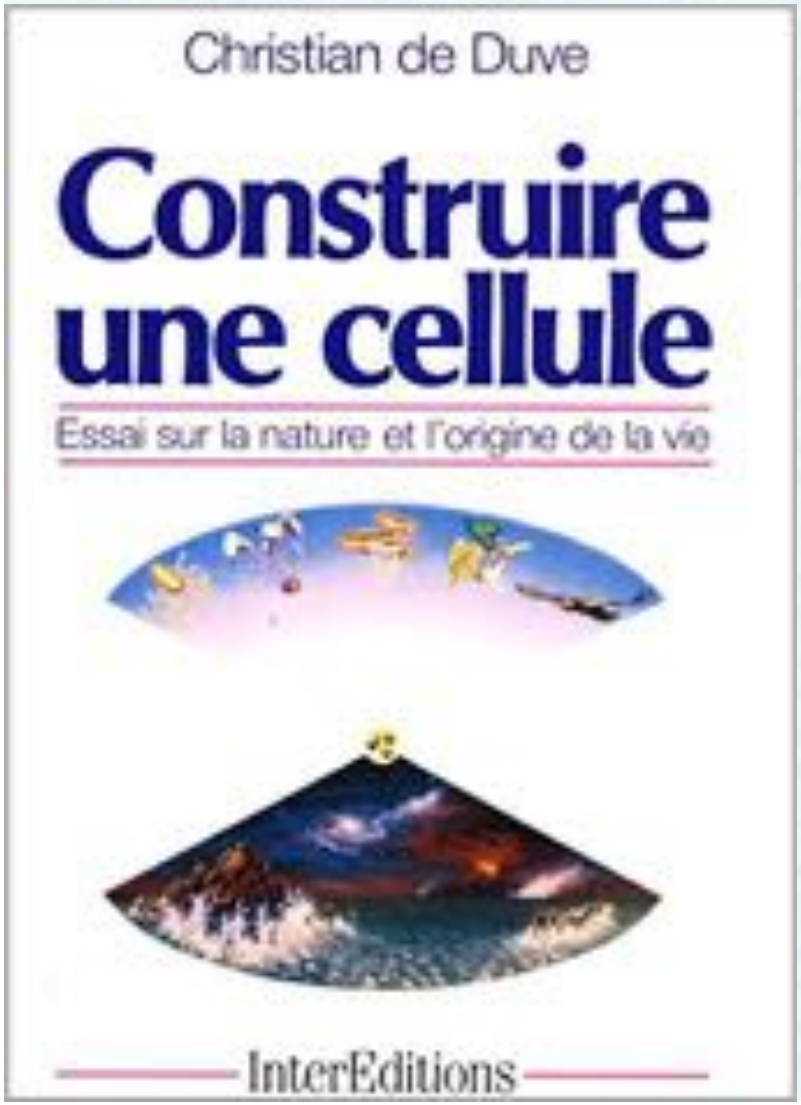
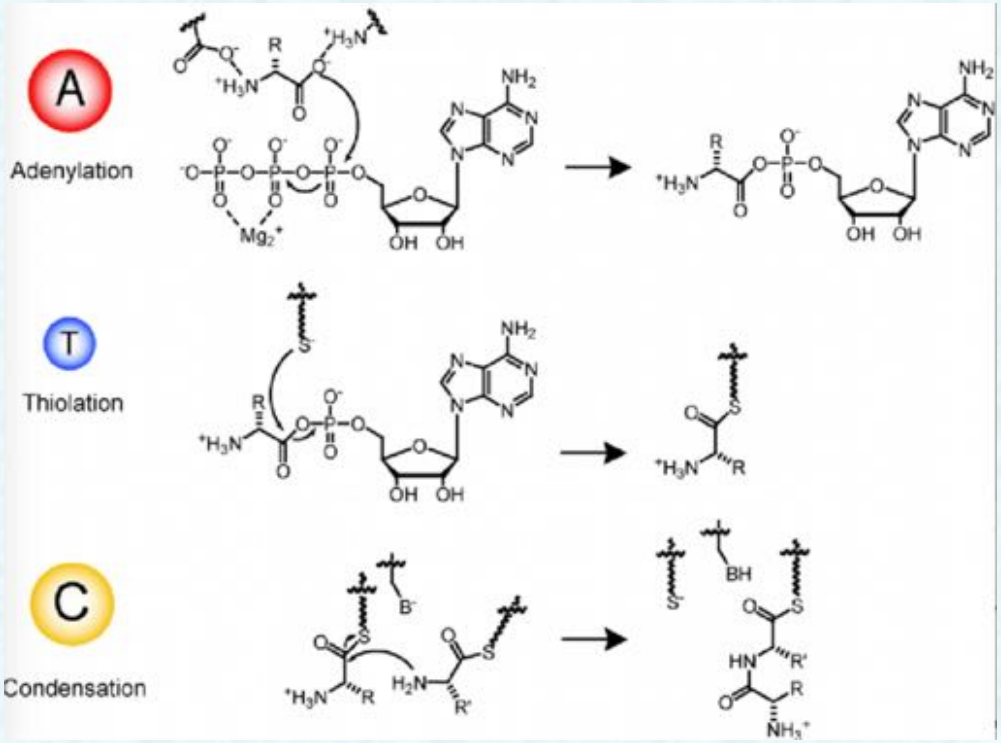


Figure 3. Integrated hypothetical reaction pathway with autocatalytic feedback (dotted arrows).

Thesis project, backgrounds

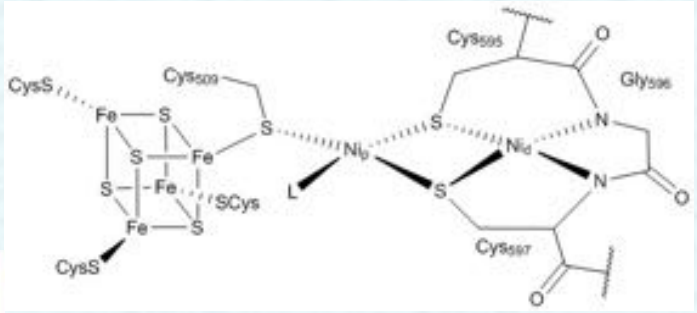


Thioester World



Thesis project, backgrounds

CO-methylating acetyl-CoA synthase



CHEMICAL REVIEWS

Review

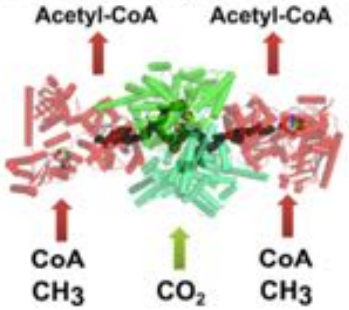
pubs.acs.org/CR

Structure, Function, and Mechanism of the Nickel Metalloenzymes, CO Dehydrogenase, and Acetyl-CoA Synthase

Mehmet Can,[†] Fraser A. Armstrong,[‡] and Stephen W. Ragsdale*[,†]

[†]Department of Biological Chemistry, University of Michigan, Ann Arbor, Michigan

[‡]Inorganic Chemistry Laboratory, University of Oxford Oxford, OX1 3QR, United K



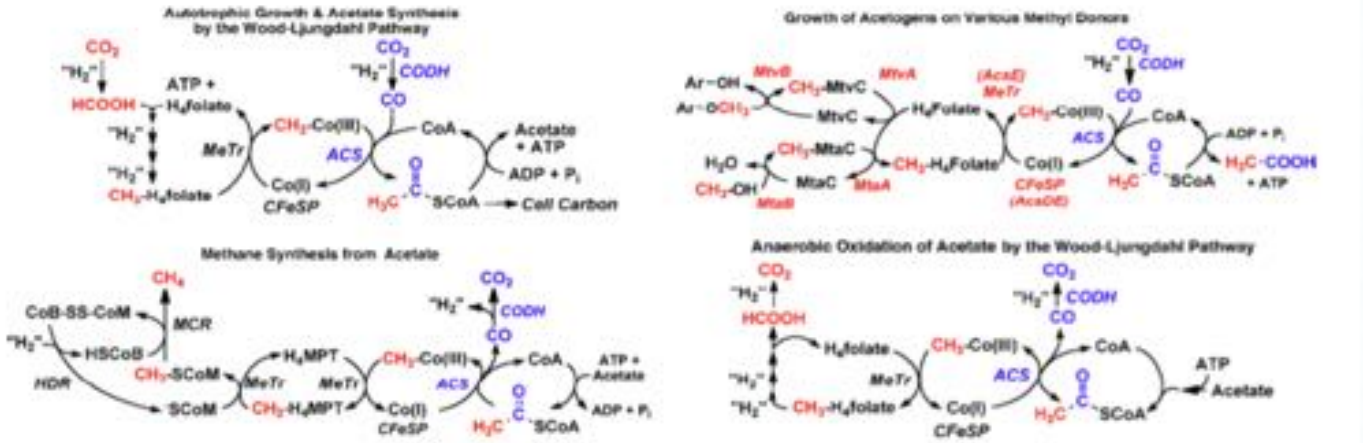


Figure 1. The Wood–Ljungdahl pathway of CO/CO_2 fixation and its involvement in acetogenesis and methyltrophy, as well as in the oxidation of acetate to methane. The methanogenic CODH/ACS is often called ACDS, acetyl-CoA synthase decarbonylase.

dx.doi.org/10.1021/cr400461p | Chem. Rev. 2014, 114, 4149−4174

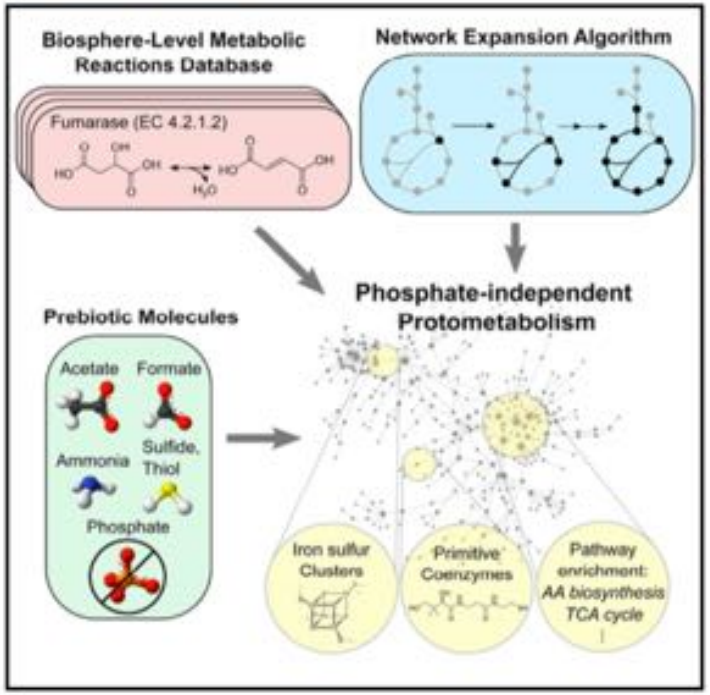
Thesis project, backgrounds

http://dx.doi.org/10.1016/j.cell.2017.02.001

Cell

Remnants of an Ancient Metabolism without Phosphate

Graphical Abstract



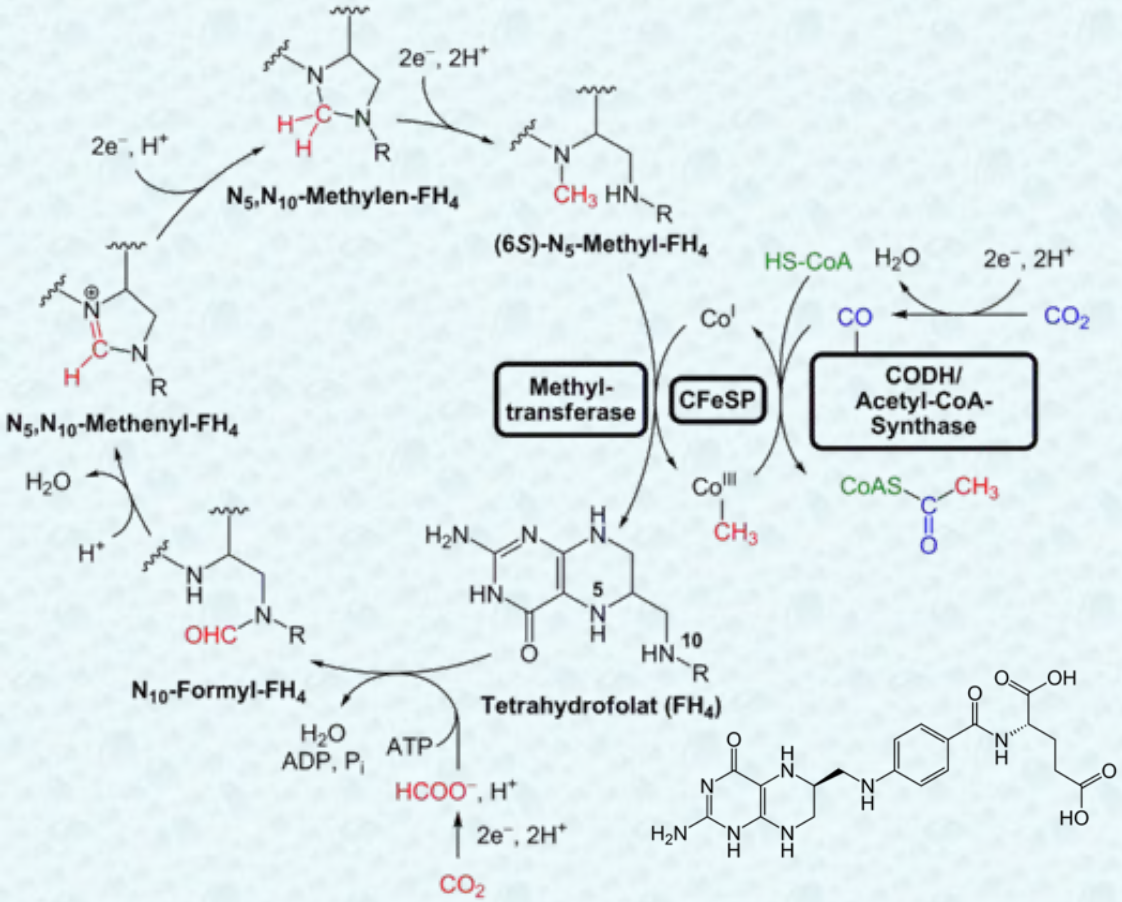
Authors

Joshua E. Goldford, Hyman Hartman, Temple F. Smith, Daniel Segrè

Highlights

- We computationally test the plausibility of an ancient metabolism without phosphate
- A phosphate-independent network exists within biosphere-level metabolism
- This network displays hallmarks of prebiotic chemistry, e.g., iron-sulfur cofactors
- This could represent a "metabolic fossil" of early thioester-driven biochemistry

Biology



Reductive acetyl-coenzyme A pathway (Wood-Ljungdahl pathway)