

Origins of Life

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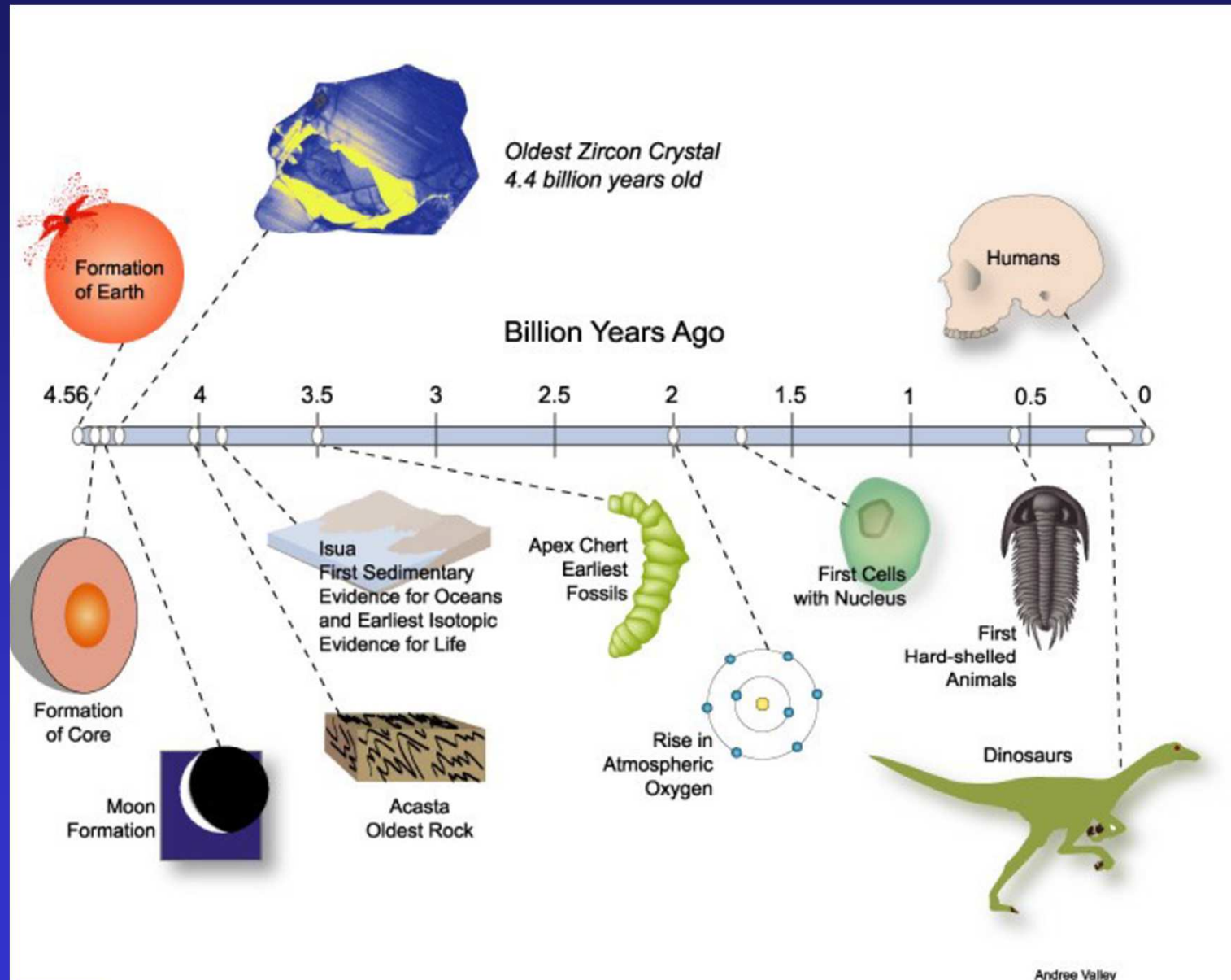


Earth – „Pale Blue Dot“
(0.12 pixel in size)

Voyager 1 @
6.4 billions km
distance @
February 14th, 1990

Heidelberg – December 2019

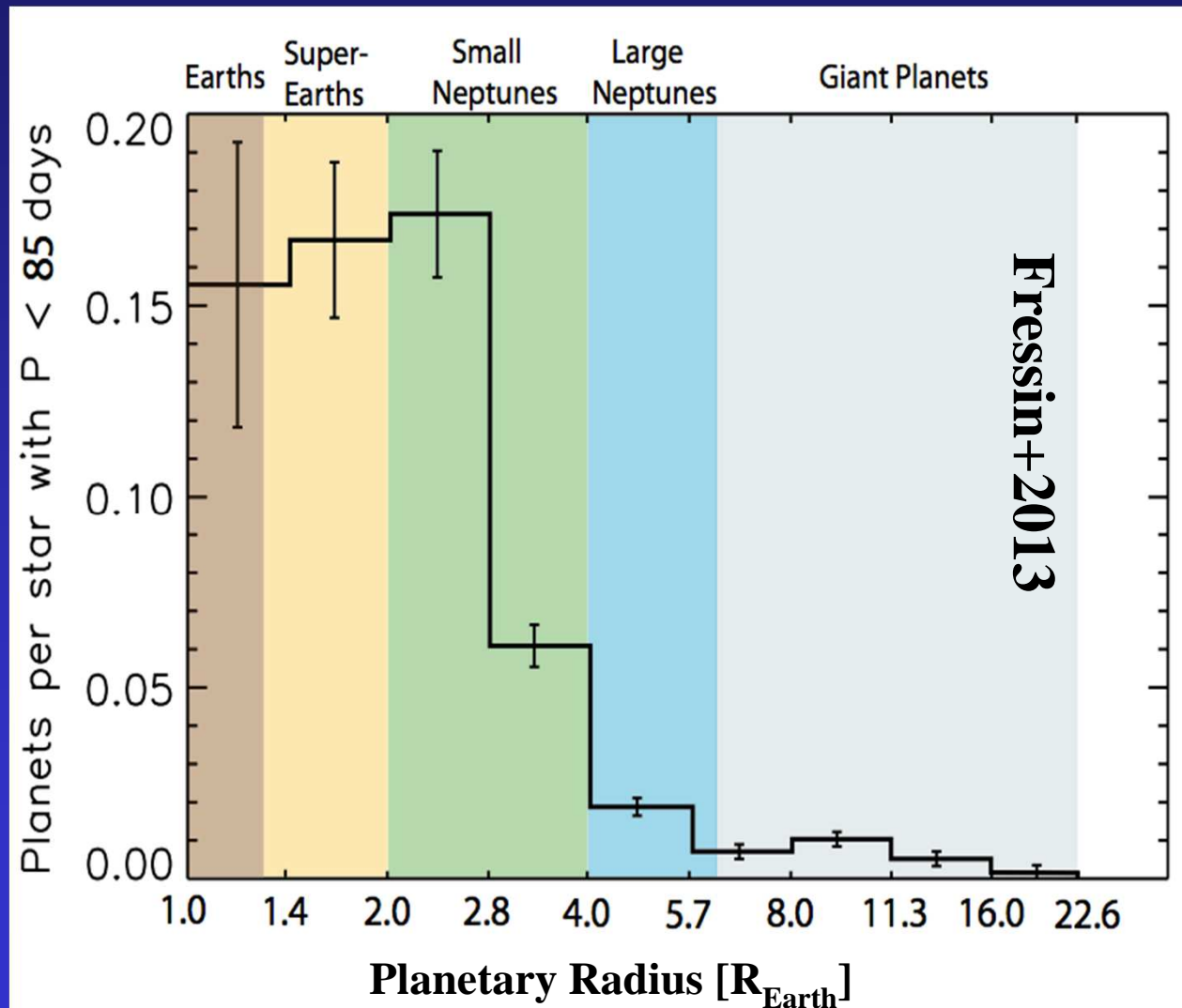
Origin of Life – A Special Event in Earth's History



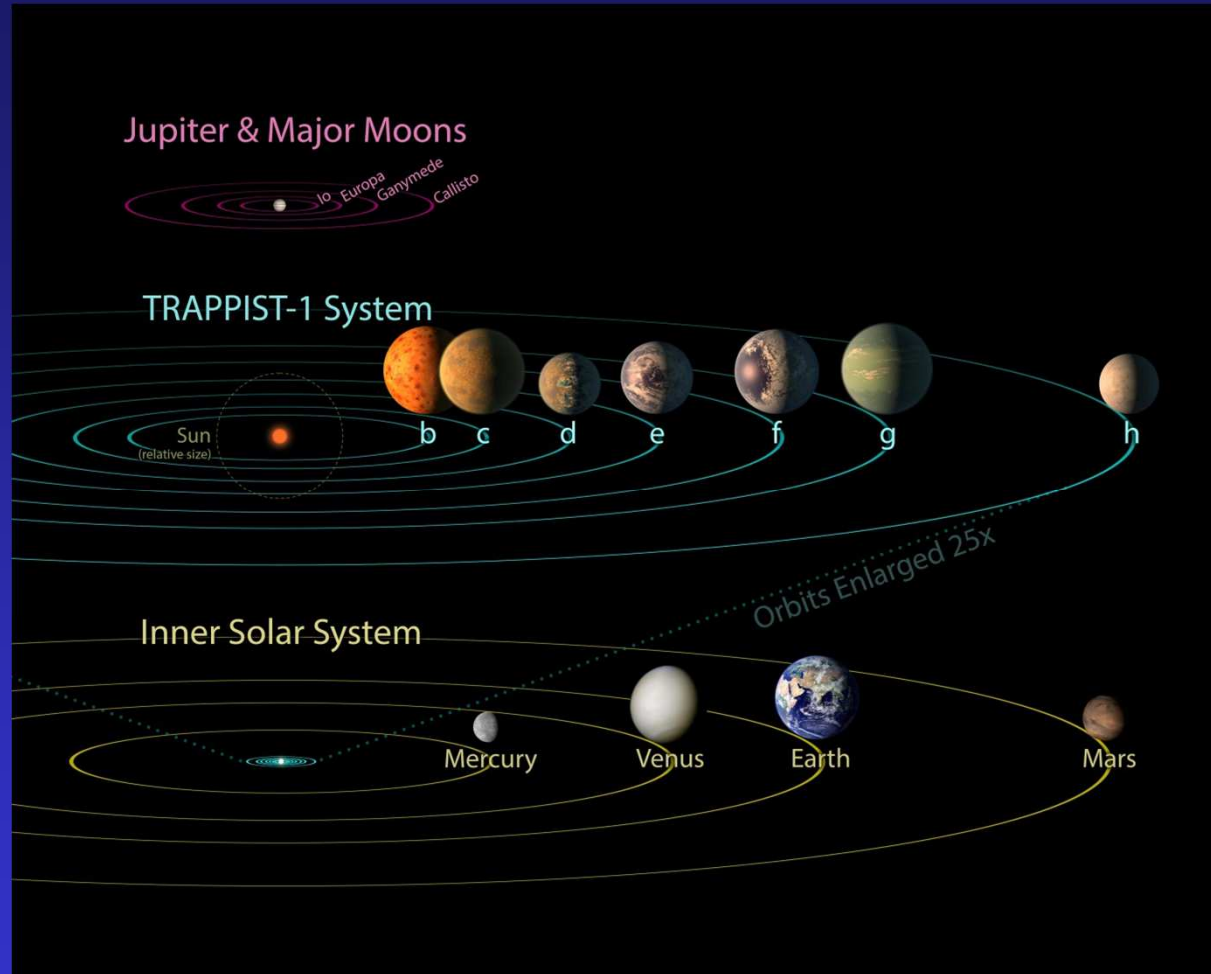
An Important Discovery: Earth-like planets and Superearths are abundant!

2 planets/
M star

1 planet/
G star



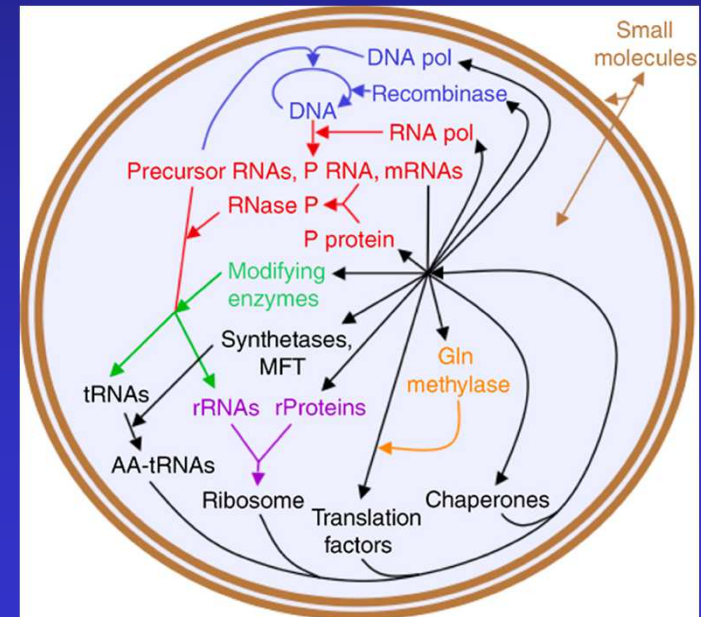
7 Planets in one go – Trappist-1



- 7 planets with masses between 0.5 and 1 Earth mass
- Red dwarf star (M8) in 40 light years distance
- Planets d and e are located in habitable zone

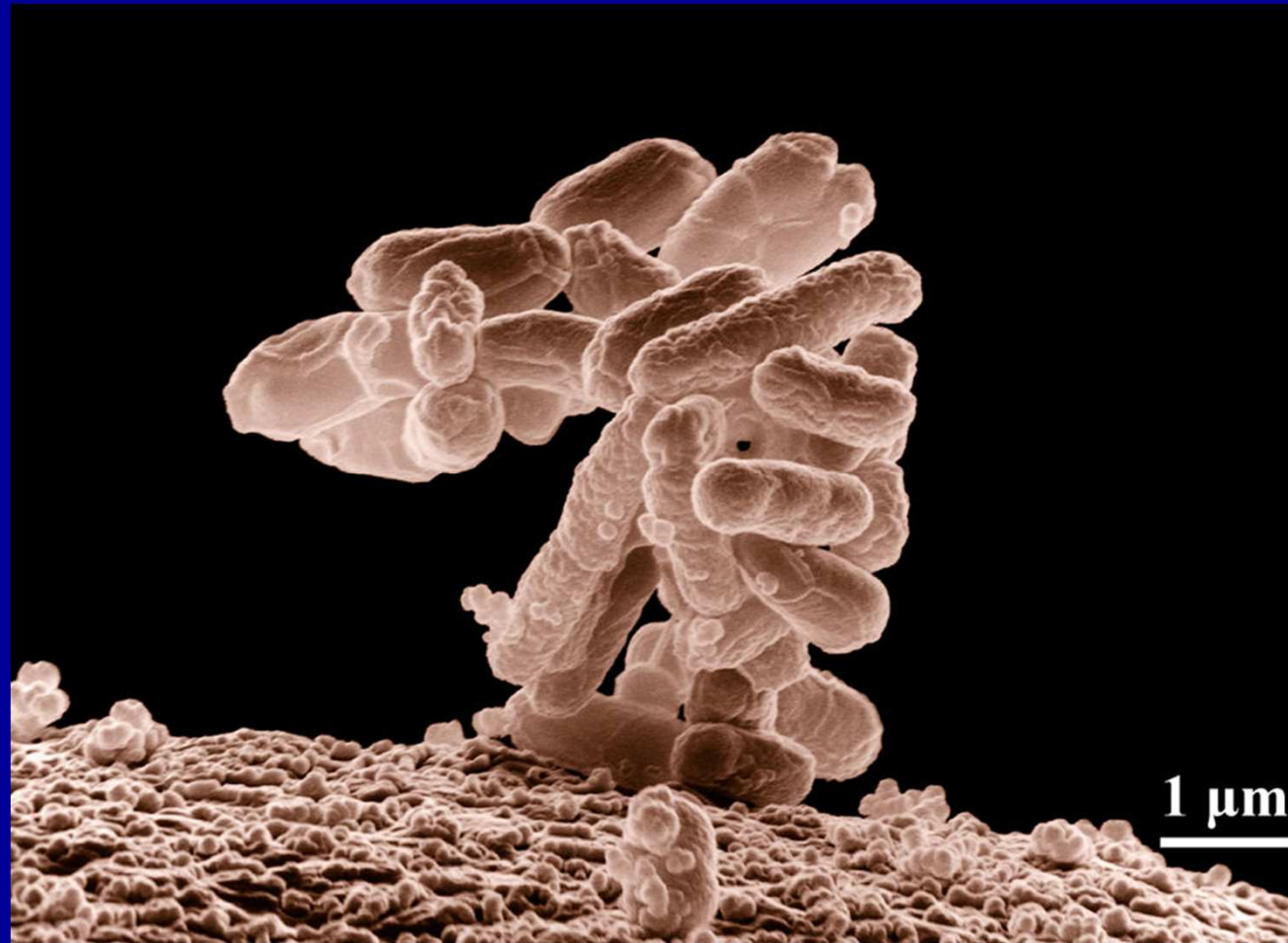
Origins of Life ...

- What is Life?
- Information or Metabolism?
- Origin of symmetry breaking
(Chirality of amino acids– L-configuration)
- Experimental System:
Informationen genom + cell walls
- Synthesis of RNA
(Ribose, Nucleobases, Phosphate)



Forster & Church (2006)

Mikrobiologists would be excited by extraterrestrial life like this ...



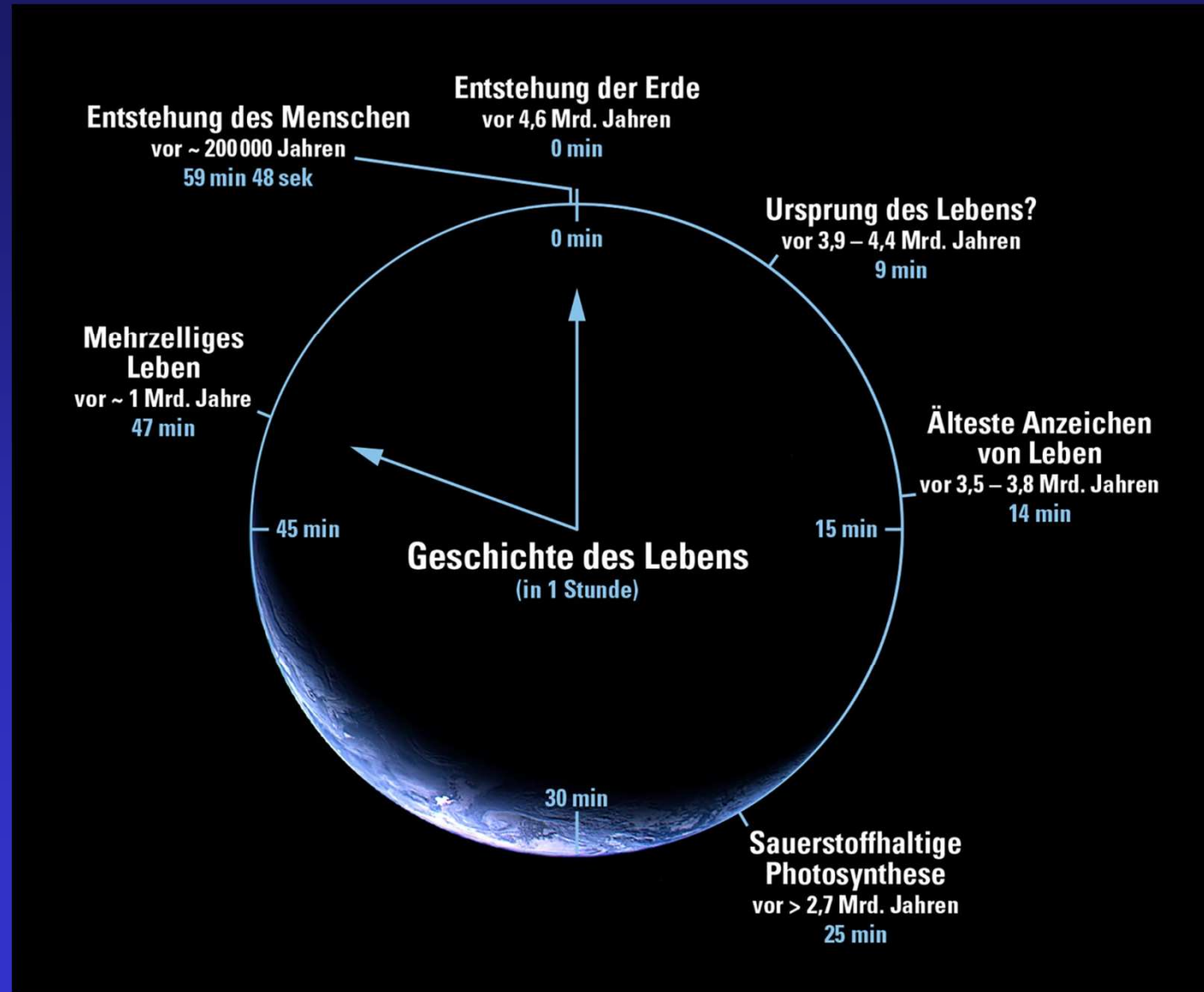
Escherichia coli - Bakteria: Eric Erbe (Agricultural Research Service)

**Maybe you like this animal better:
Aye-Aye-Lemur**



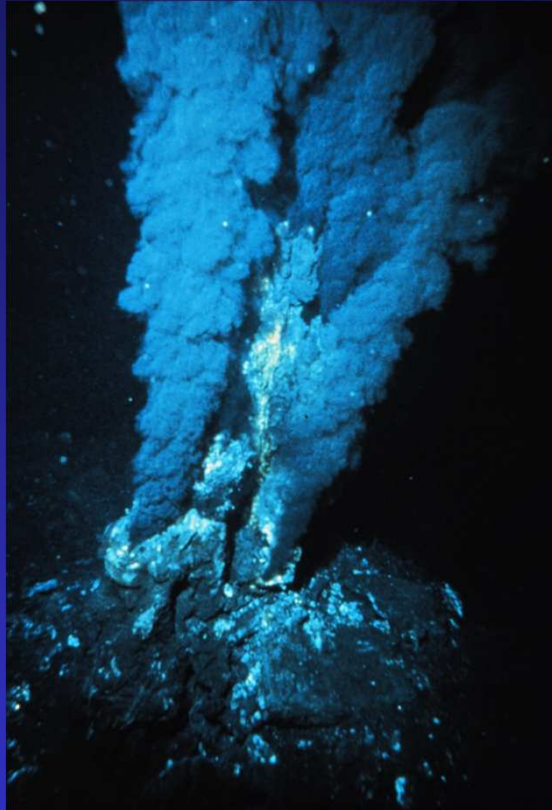
Credit: Bristol Zoo, England

Origins of Life – When?



Stromatolites
(3.5 Gyr)

Origins of Life – Where?



R. Rona - NOAA

**Black (White) Smoker
(Hydrothermal Sources)**

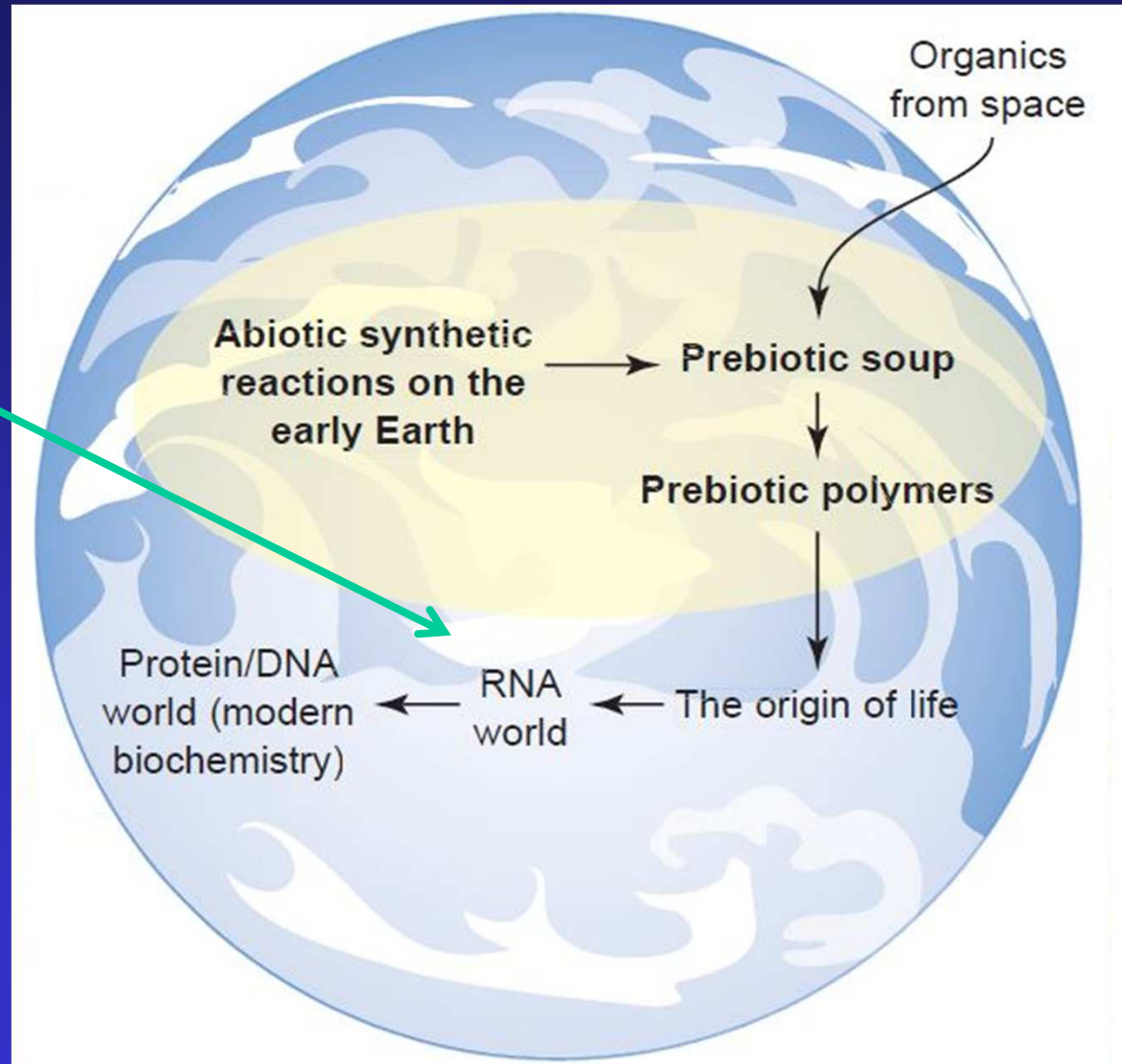


B. Pearce – Mc Master

**Geothermal Fields
„Darwin: Warm little ponds“**

Formation of Life – How?

RNA



Bada & Lazcano (2002)

1953 – Annus mirabilis

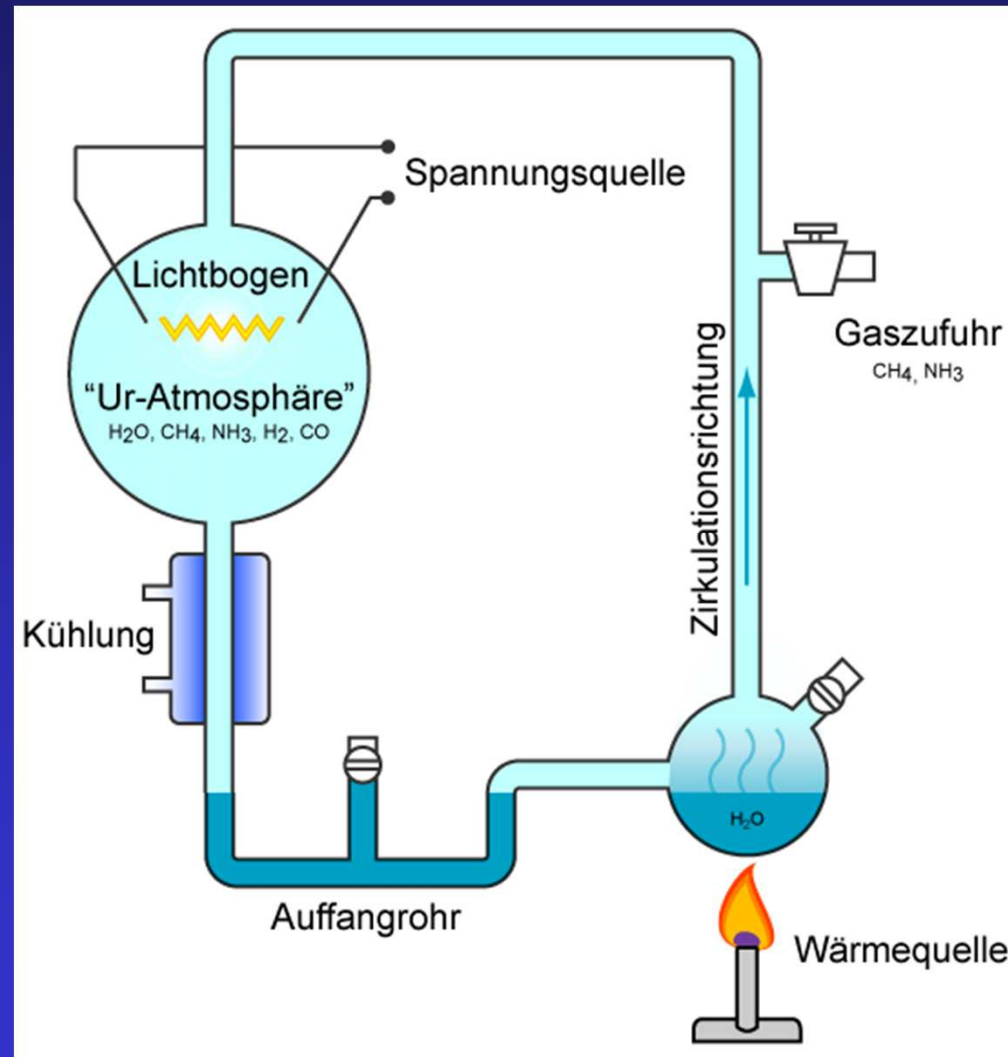


Miller–Urey Experiment



**Watson & Crick: Double helix-
DNA-Modell**

A Key Experiment: Miller-Urey Experiment (1953)

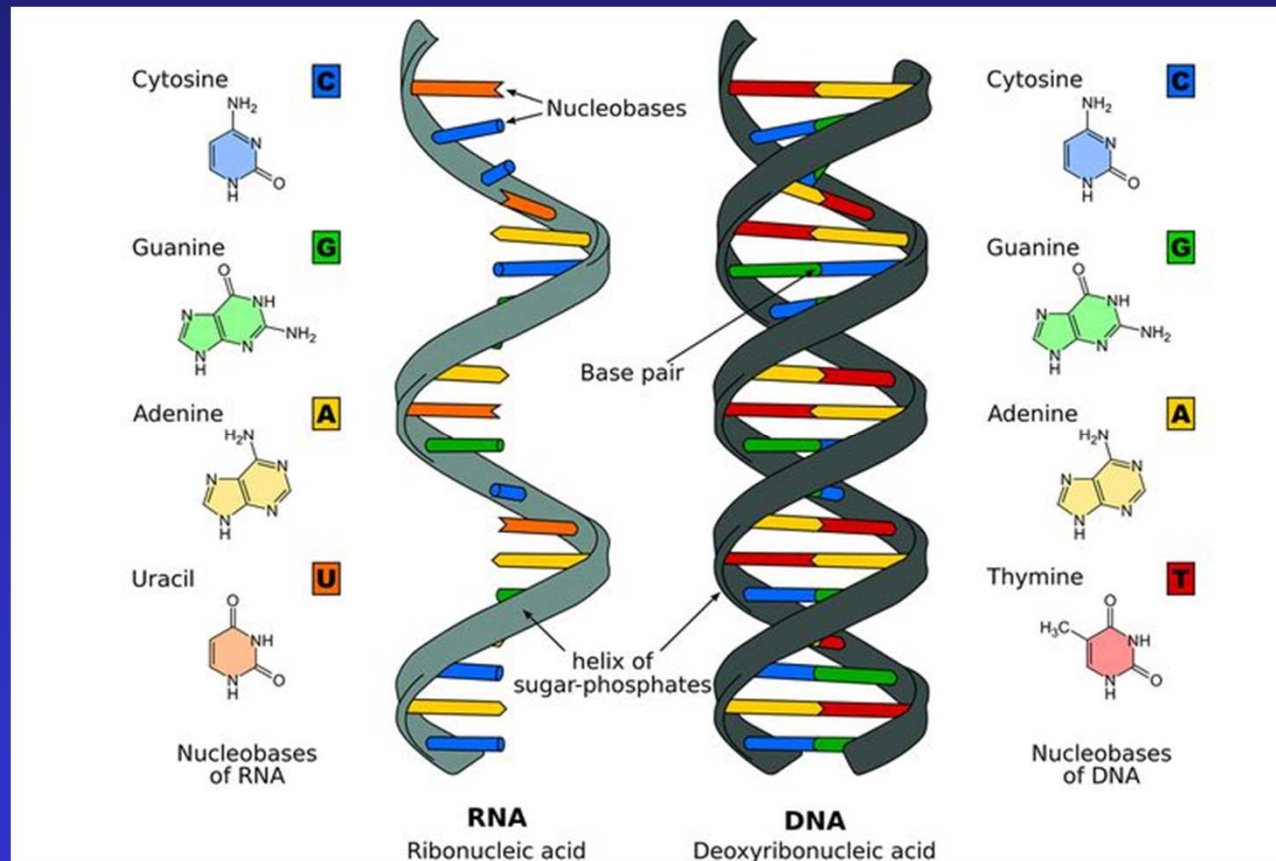


In addition: Discovery of amino acids in meteorites and comets

An Idea – RNA-World

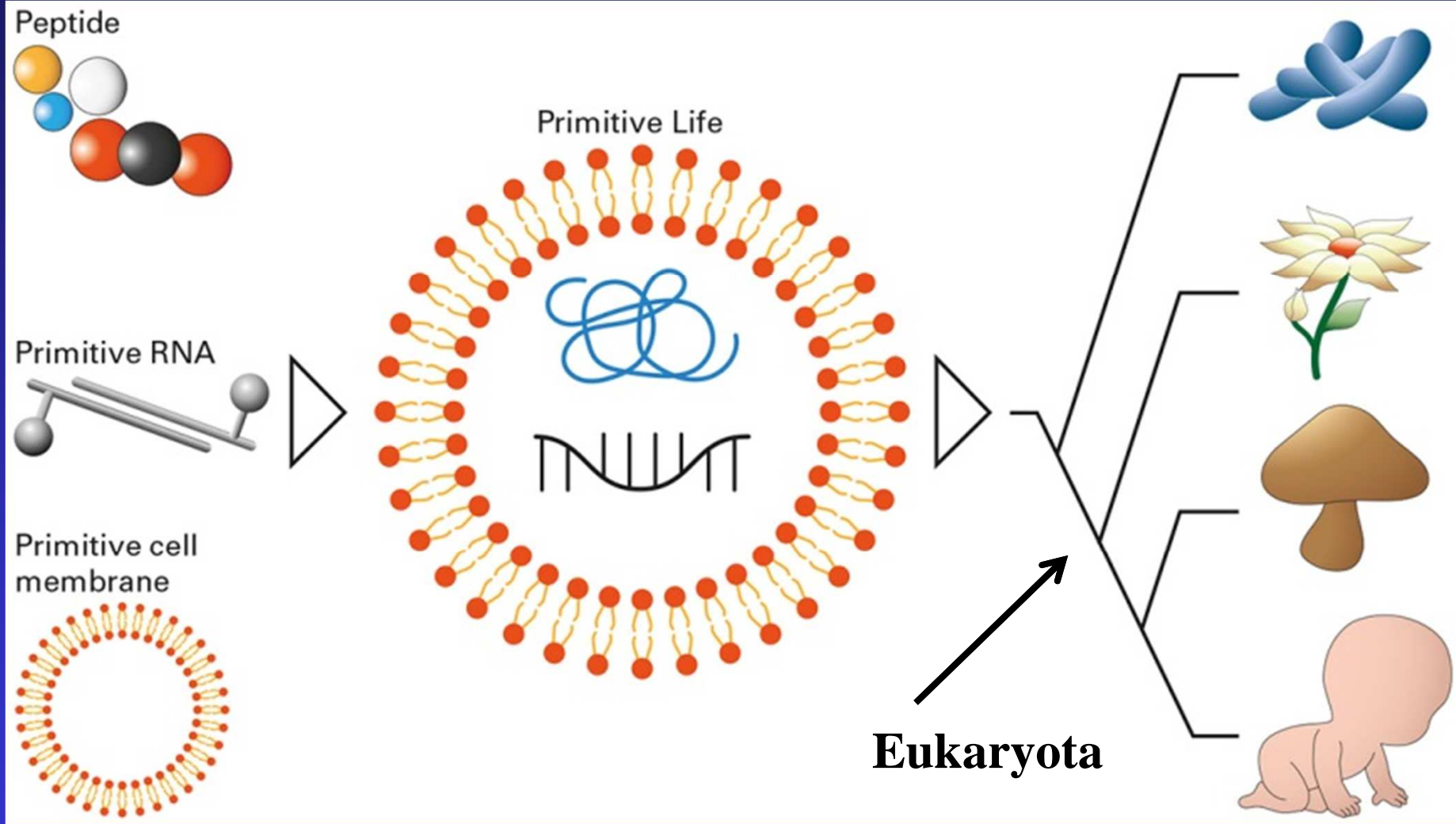
Synthesis of RNA

(Nucleobases + Ribose: Nucleoside + Phosphate: Nucleotide)



Formation of a self-replicating molecule (RNA – W. Gilbert)

The Entire System



Earth between 4 and 4.5 Gyr ago

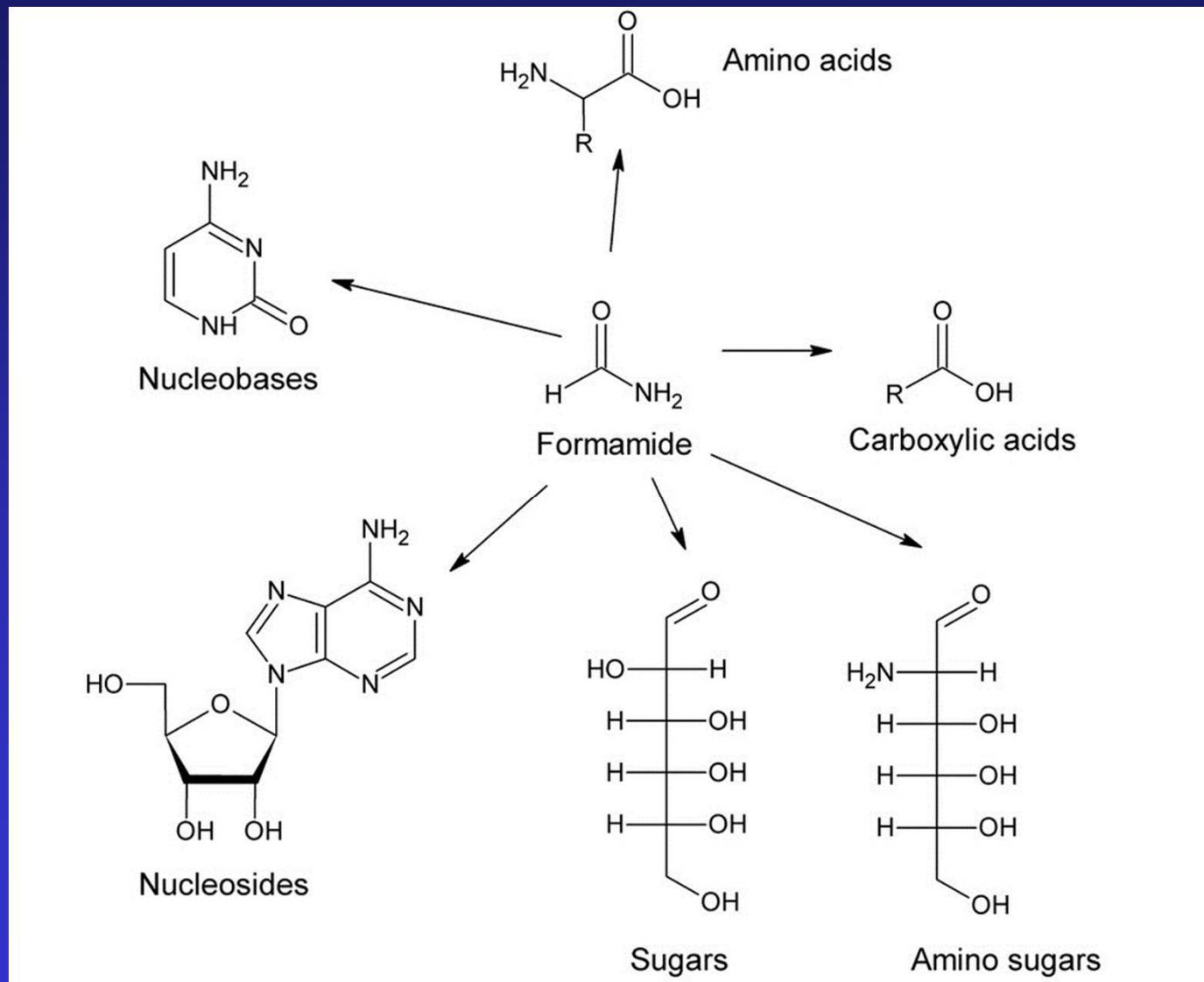
Substantial continuous supply of complex prebiotic molecules
(comets, asteroids, pebbles, ...)

Carbonaceous chondrites:

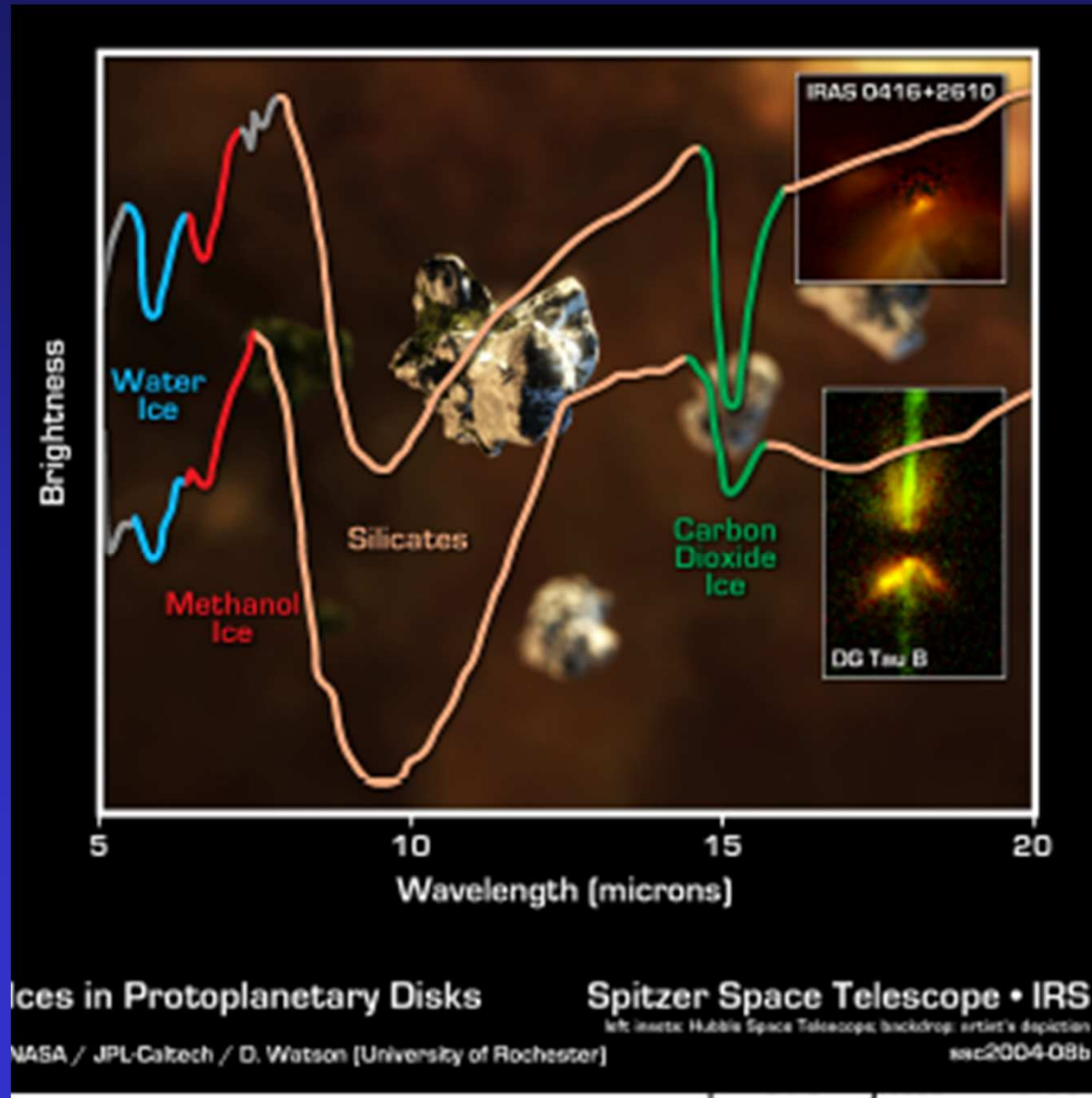
- Porous and water-rich parent bodies with low-T hydrothermal systems
- Phyllosilicates and clay minerals
- Variety of sulfides (FeS, Fe-Ni sulfides, ...)
- 0.1% P
- Amino acids, bases, sugars



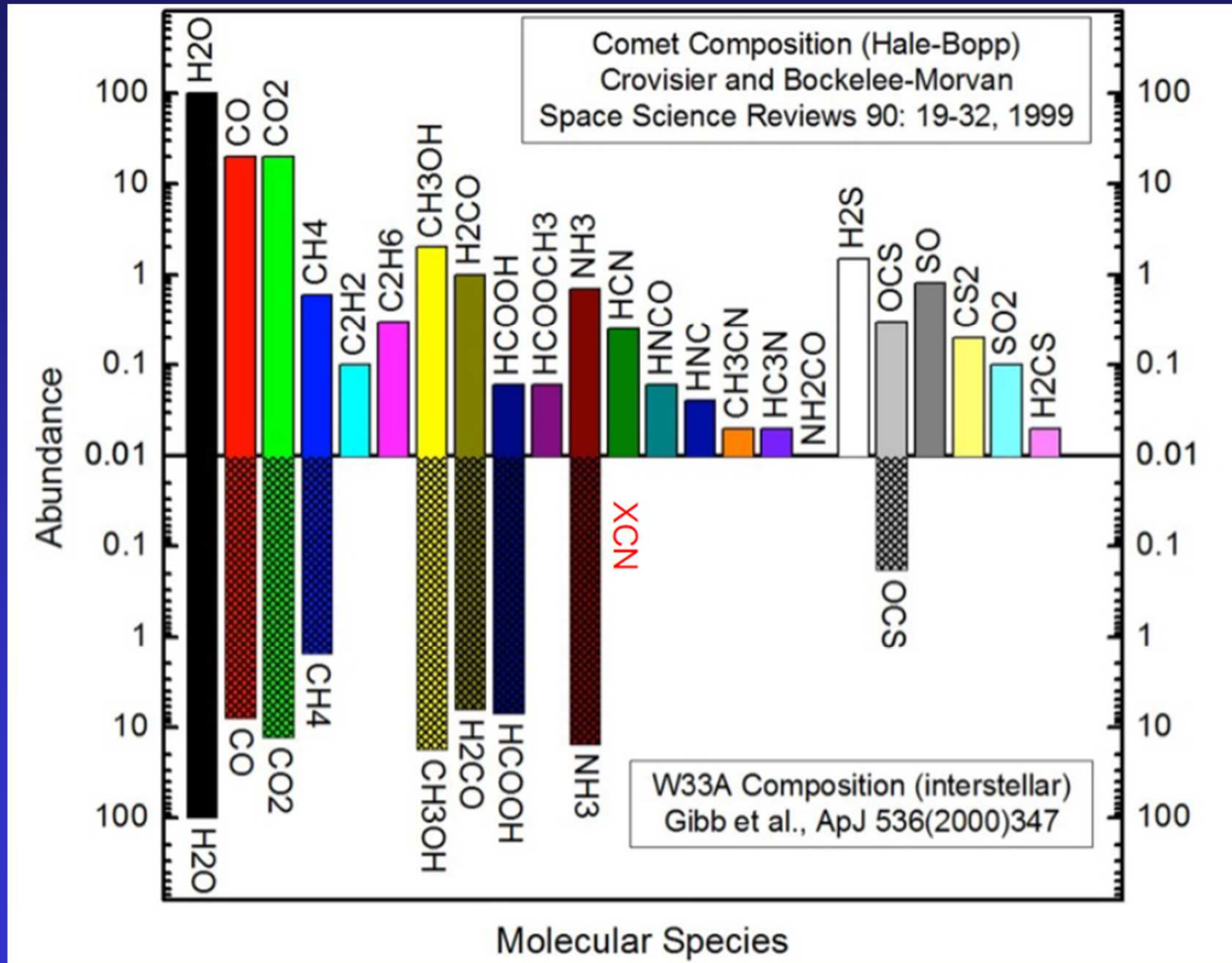
Formamide – A Key Molecule?



Ice Experiments



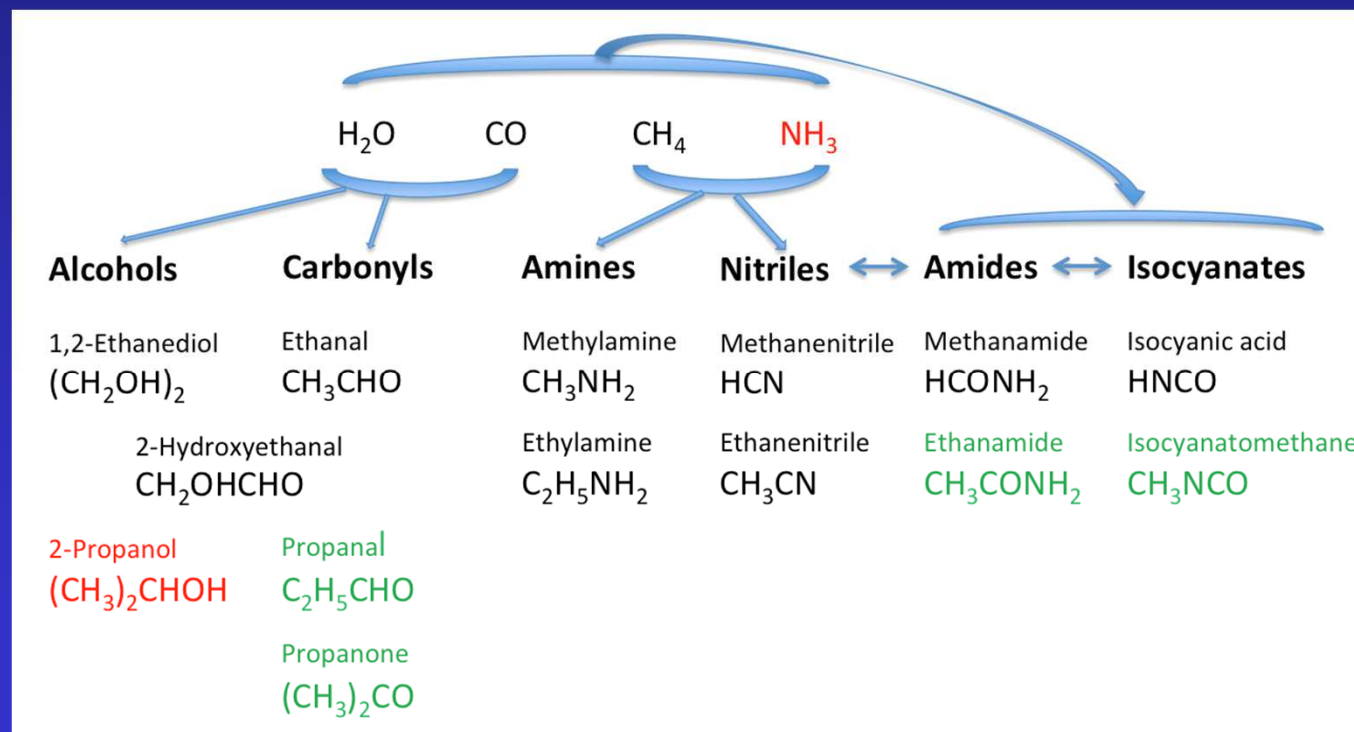
Comets and Interstellar Ices



Rosetta – Complex Molecules

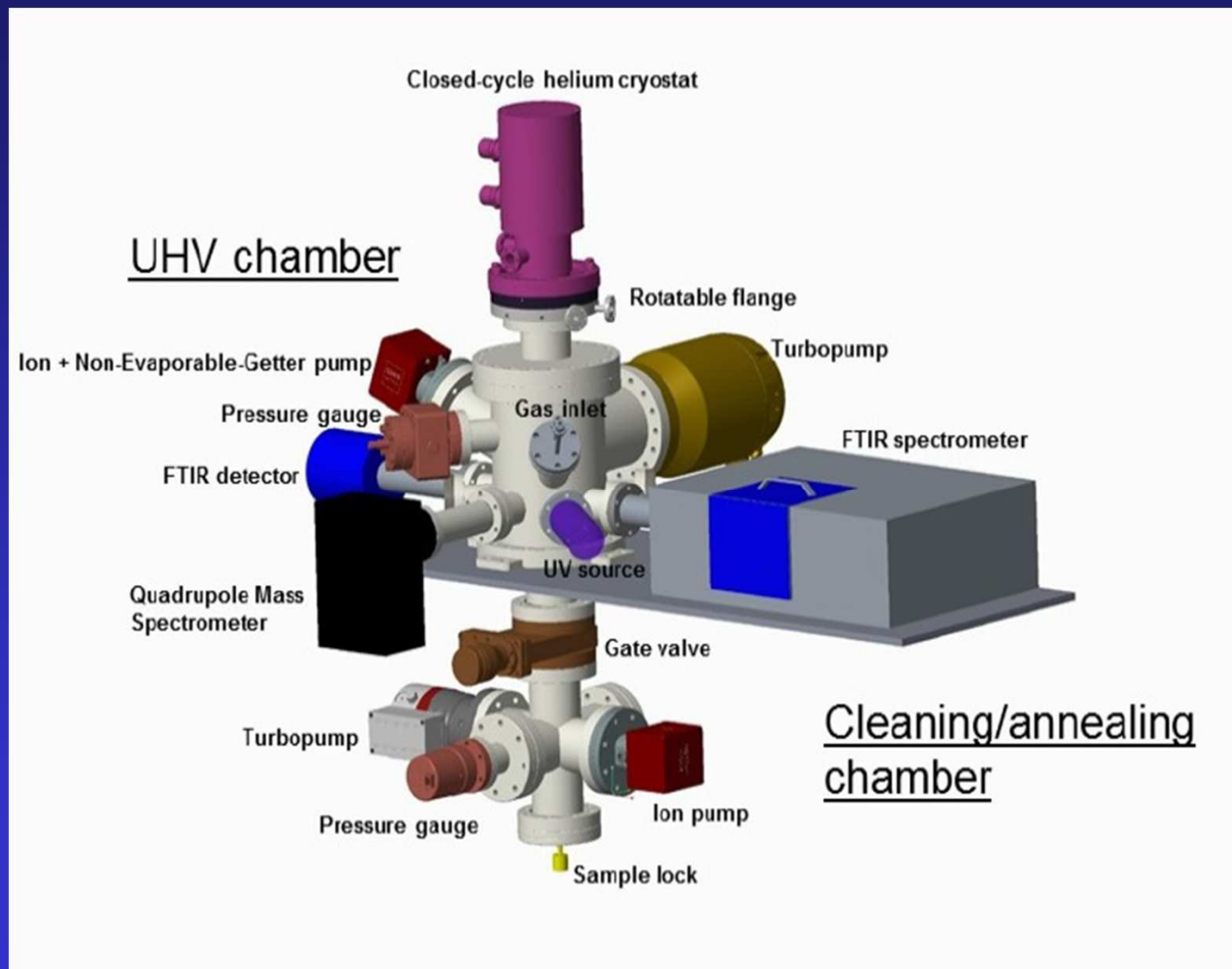


Primitive ISM Material
(strongly deuterated organic material)

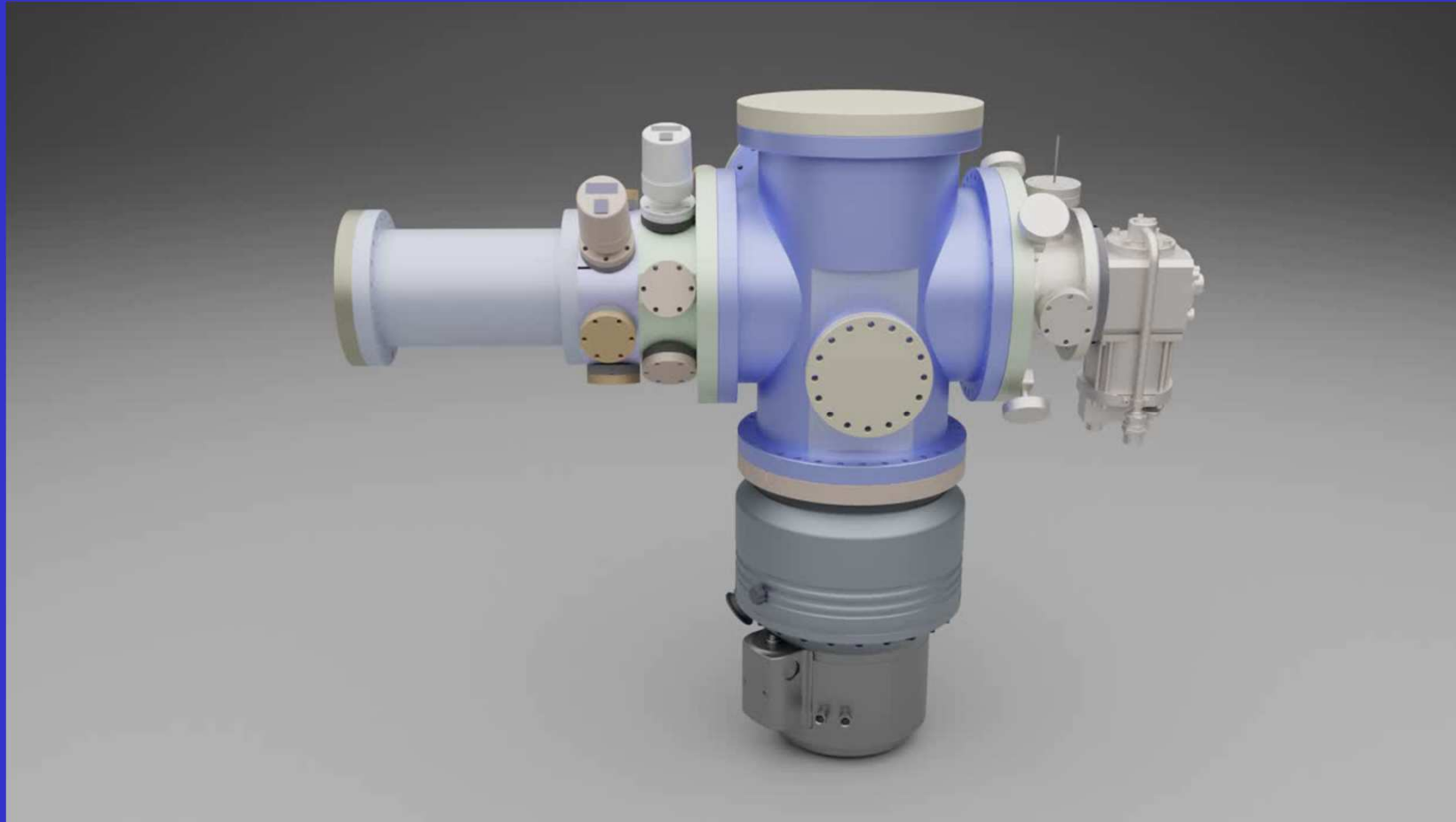


Goesmann et al. (2015)

Ice Experiments



Organics: Energetics of Low-T Surface Reactions

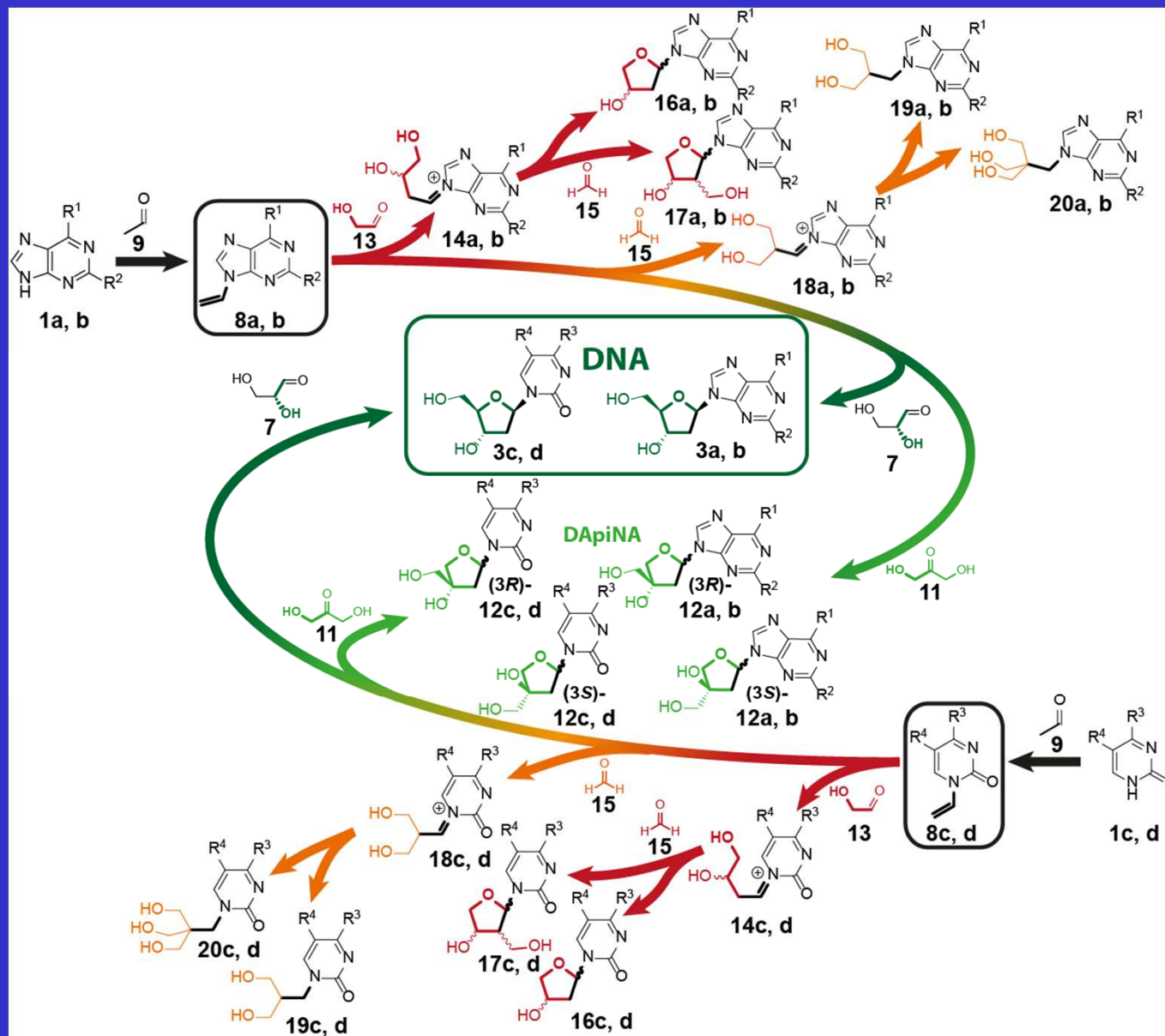


Reactions between C and H_2 , O_2 , C_2H_2 lead to HCH, $\text{CO}+\text{O}$, and cyclic C_3H_2 (no barriers)

Henning & Krasnokutski
(Nature Astr., 2018)

Origins of Life - The Helix of Life

Trapp Fellow Group



J. S. Teichert, F. M. Kruse, O. Trapp, *Angew. Chem. Int. Ed.* **2019**, *58*, 9944-9947.

Origins of Life – Initiatives in Germany

