

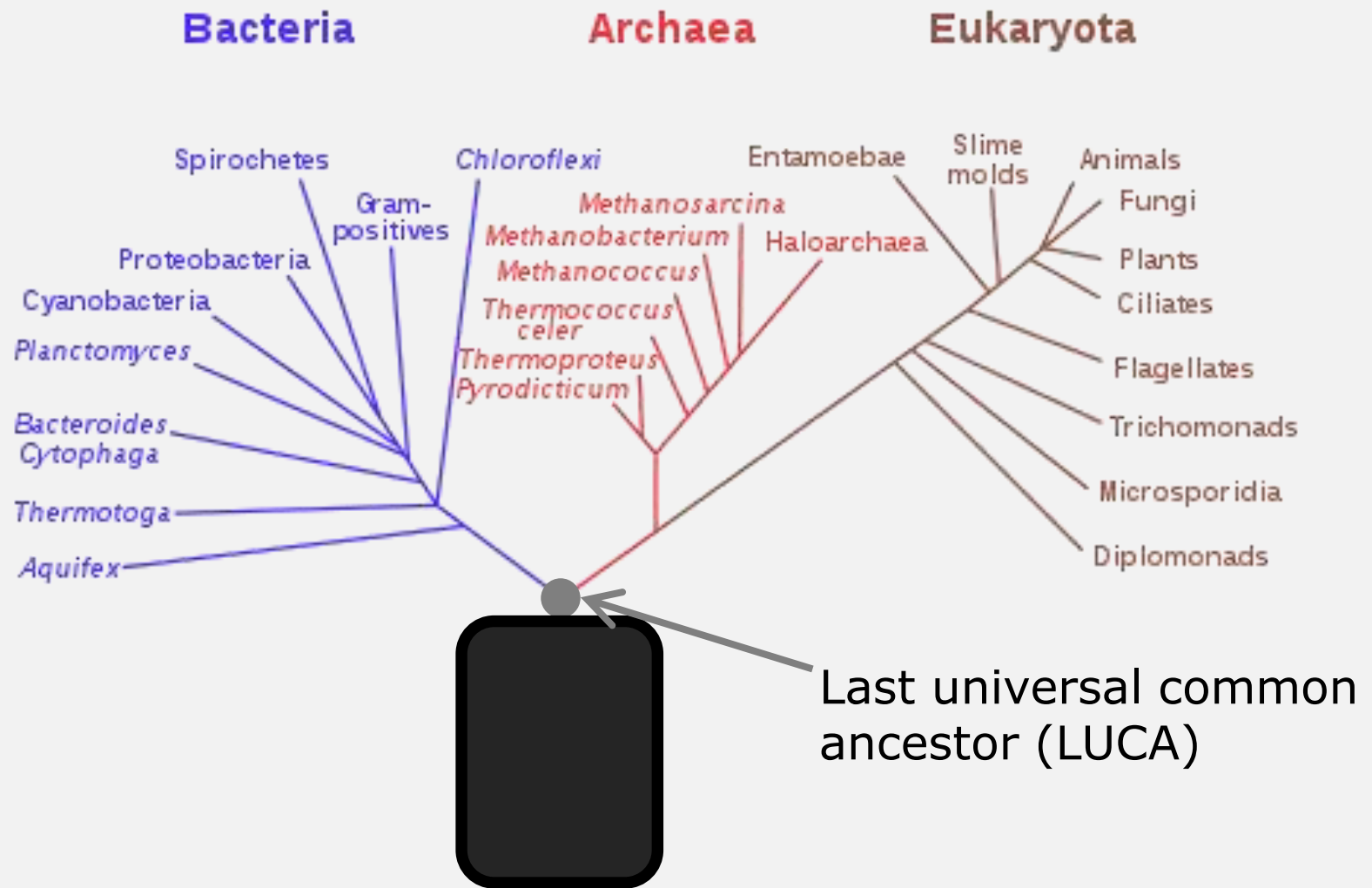


Blue Marble Space
Institute of Science

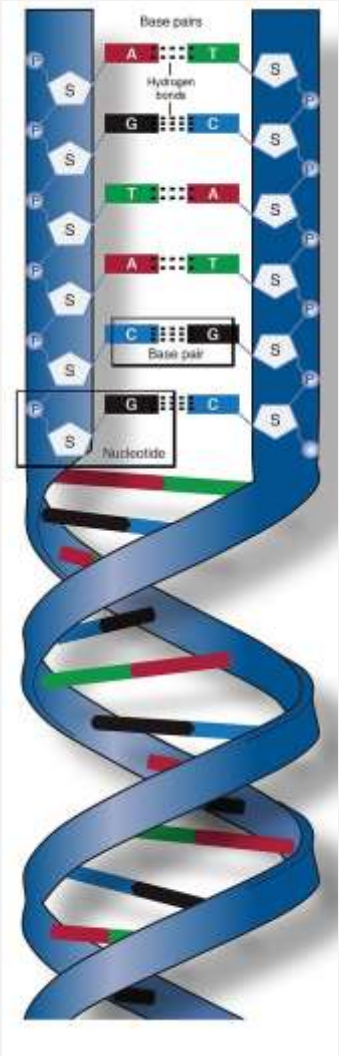
Origins of Life Can Chemistry be alive ?

Omer Markovitch

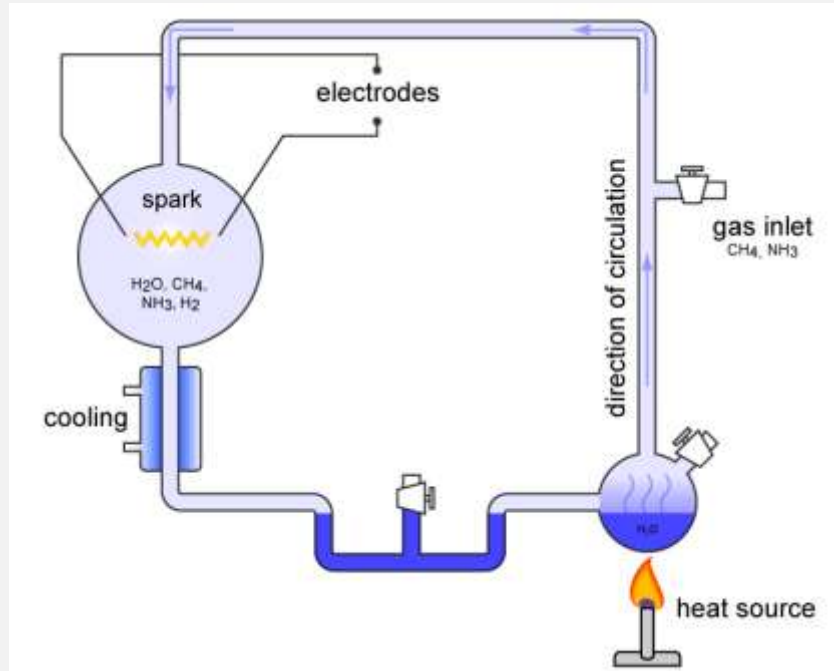
<http://www.Markovitch.me>



1953: DNA



1953: Miller-Urey experiment

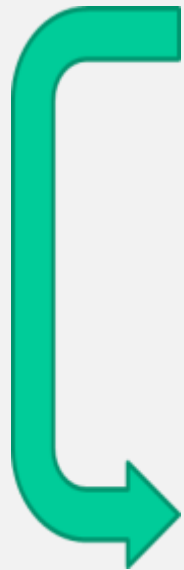
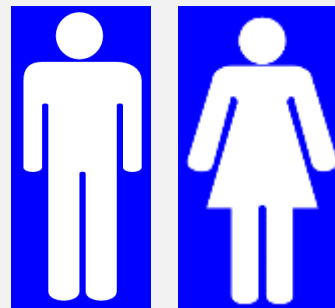
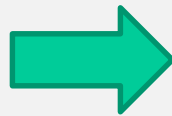
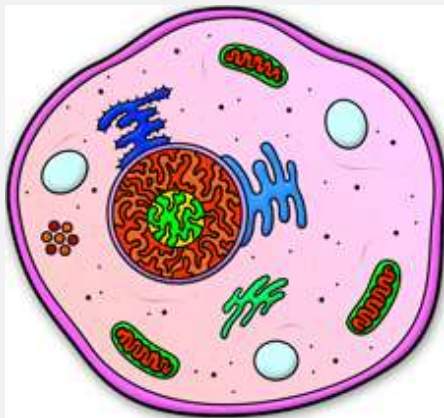
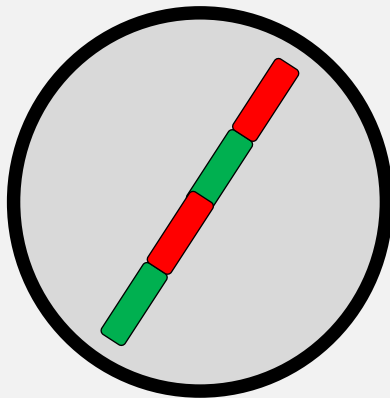
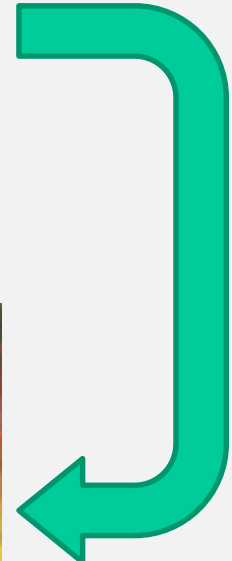
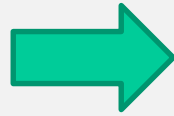


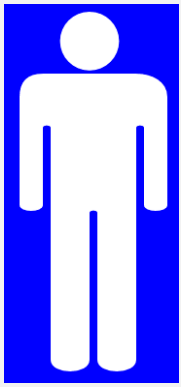
1950

1982:
Ribozyme (RNA)

Today

(1989
Nobel Prize)



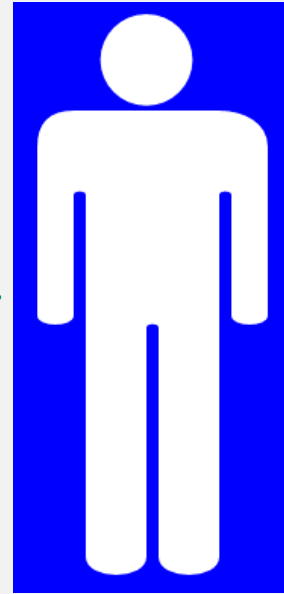
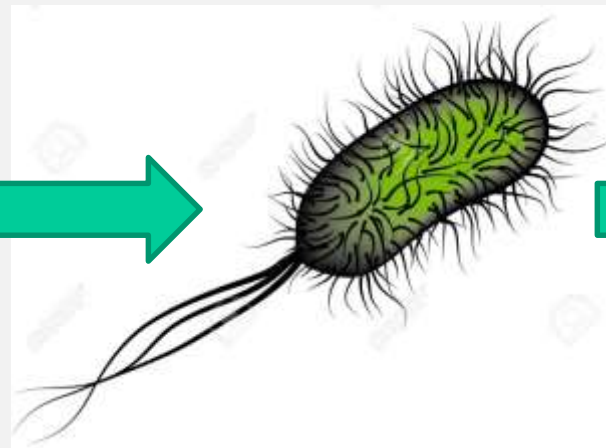
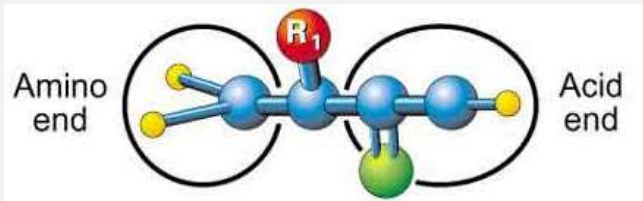




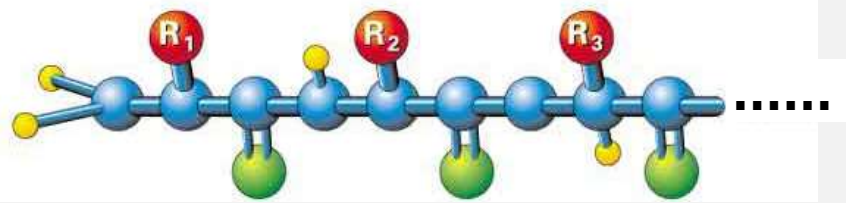
While there are data related to Darwinian evolution (fossils), there is no direct data for the origin of life.

Life is complex.

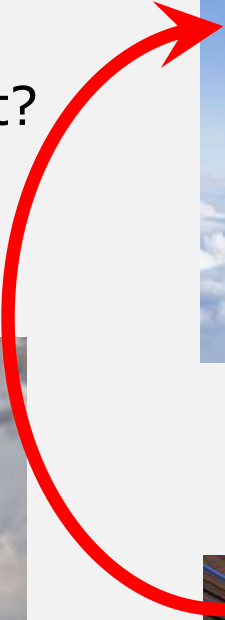
Pool of amino acids

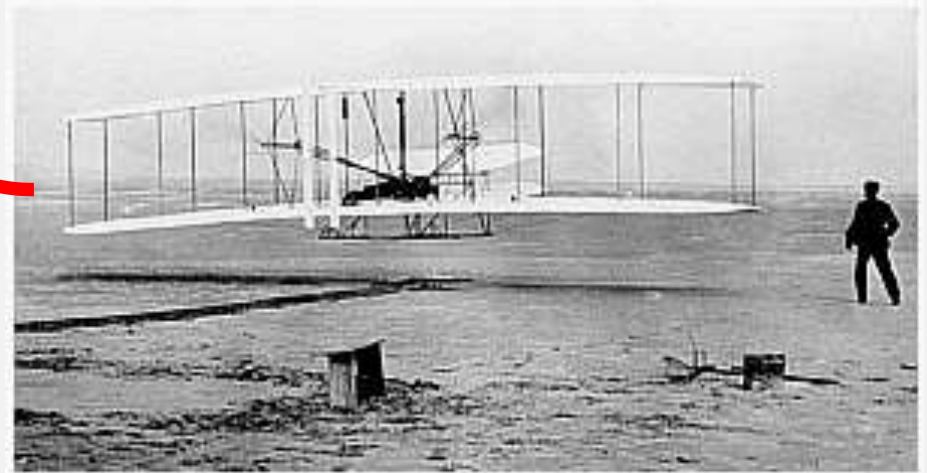
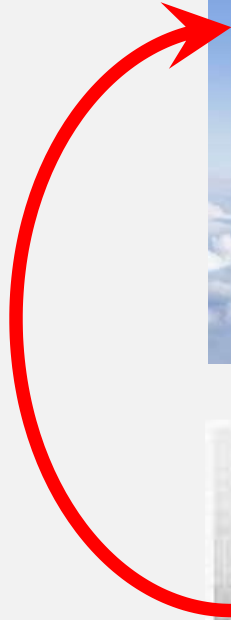


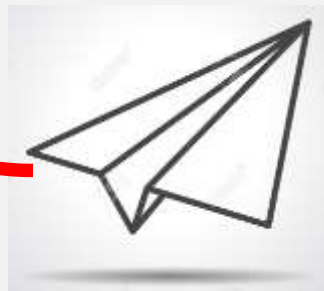
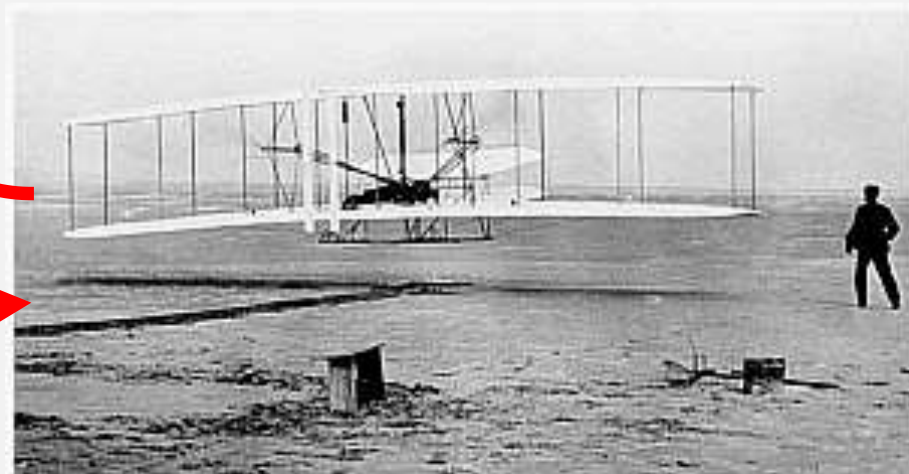
Amino Acid Chain (Protein)



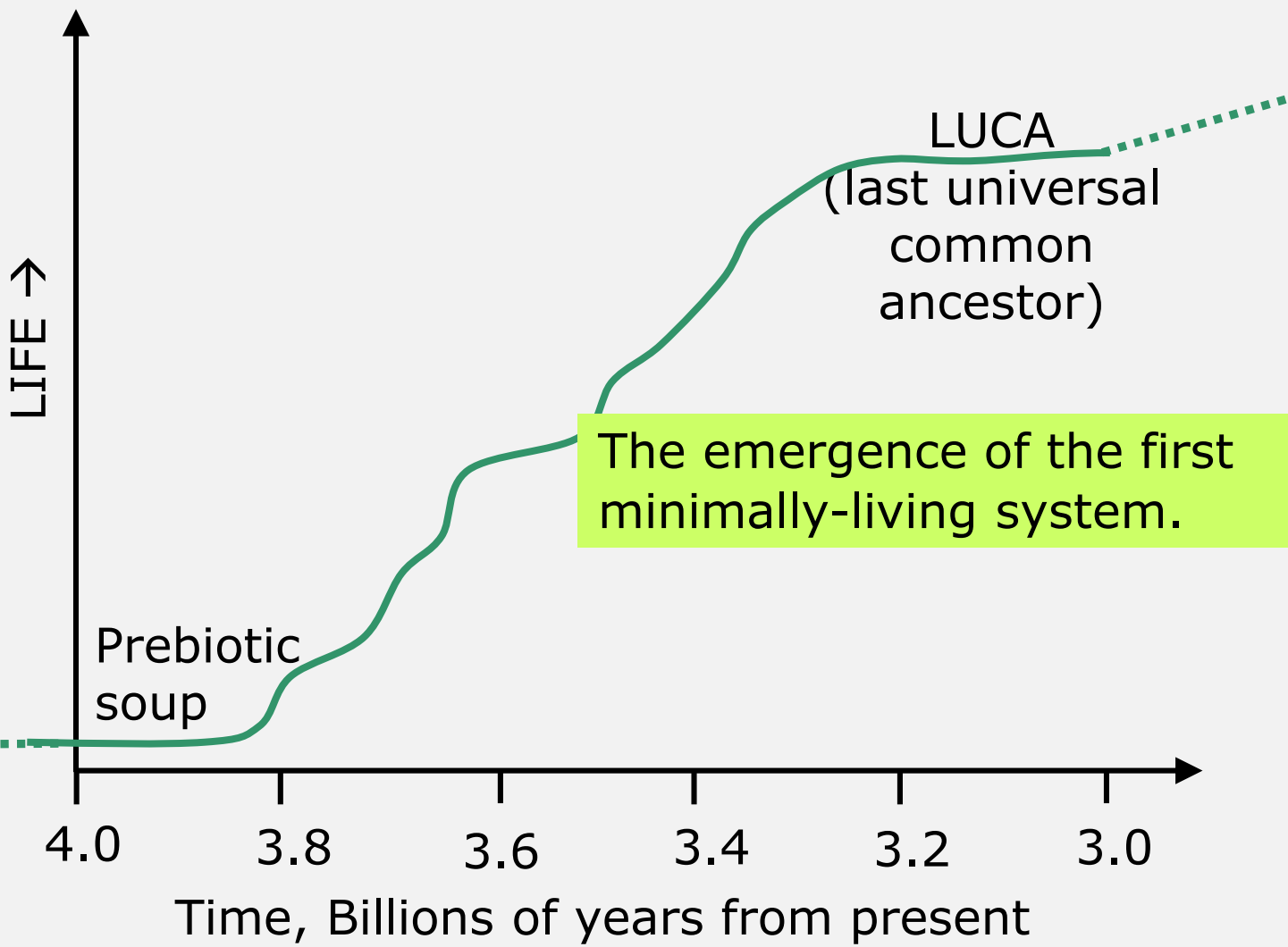
Is this a likely event?





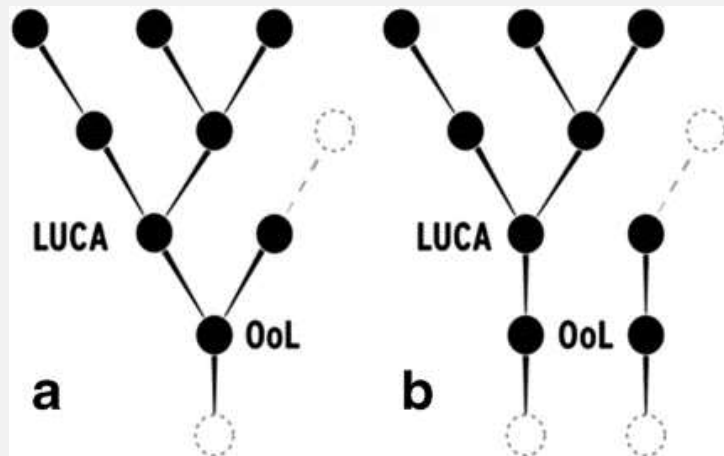
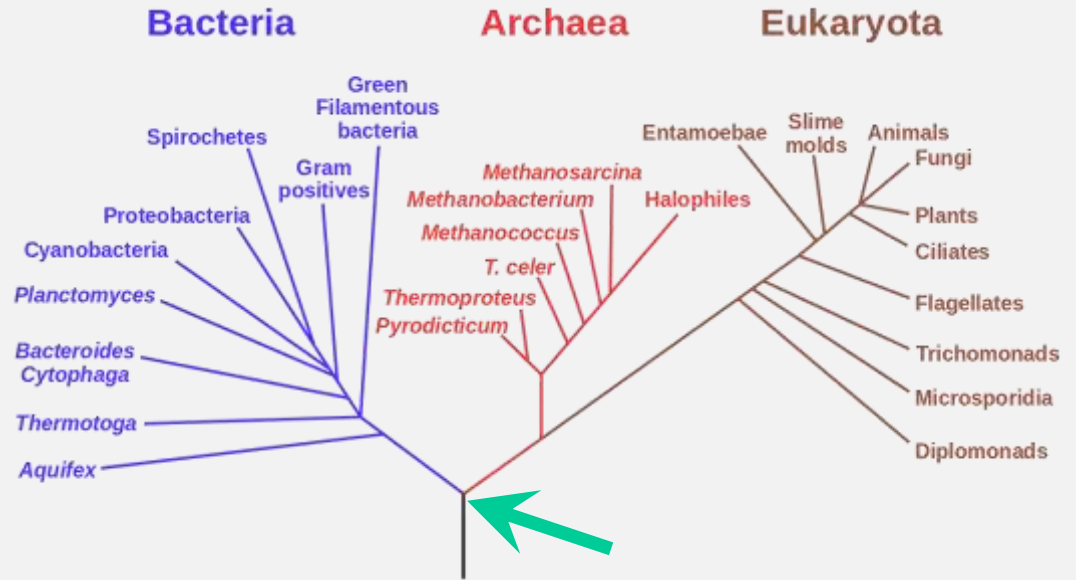


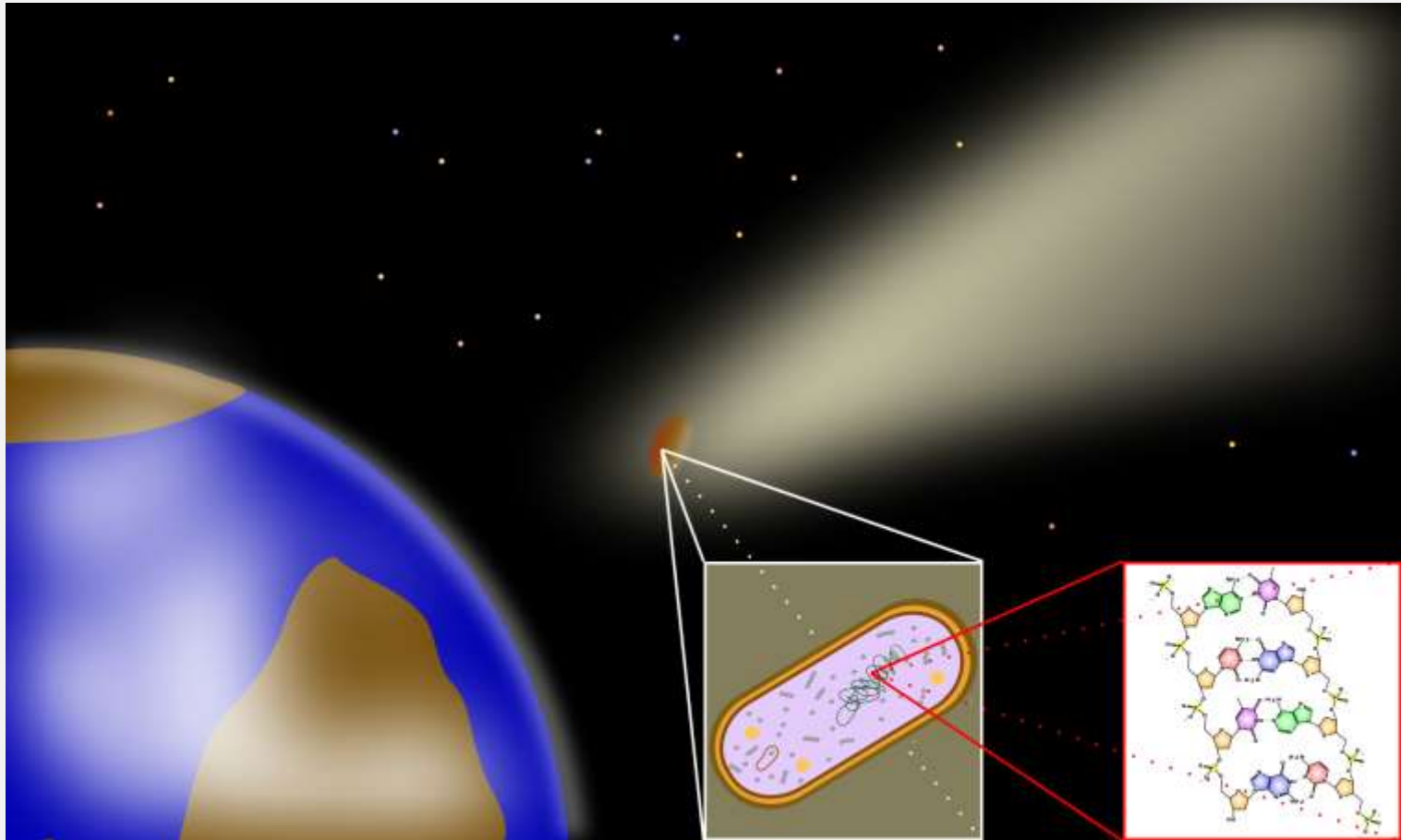
(Chemical system)



LUCA

(last universal common ancestor)





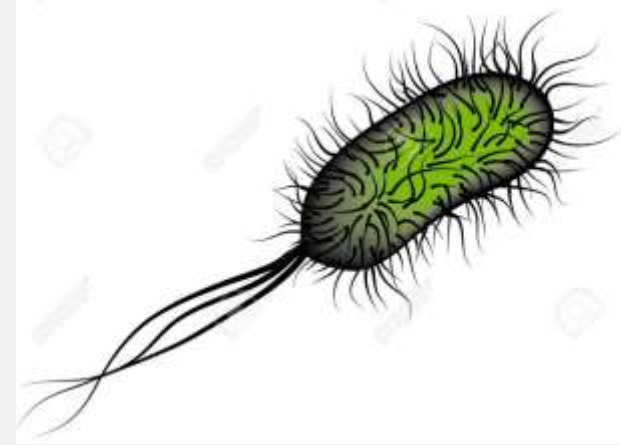
Panspermia ?

X Shifts the problem „outside“.

X Does not answer the question of how life started.

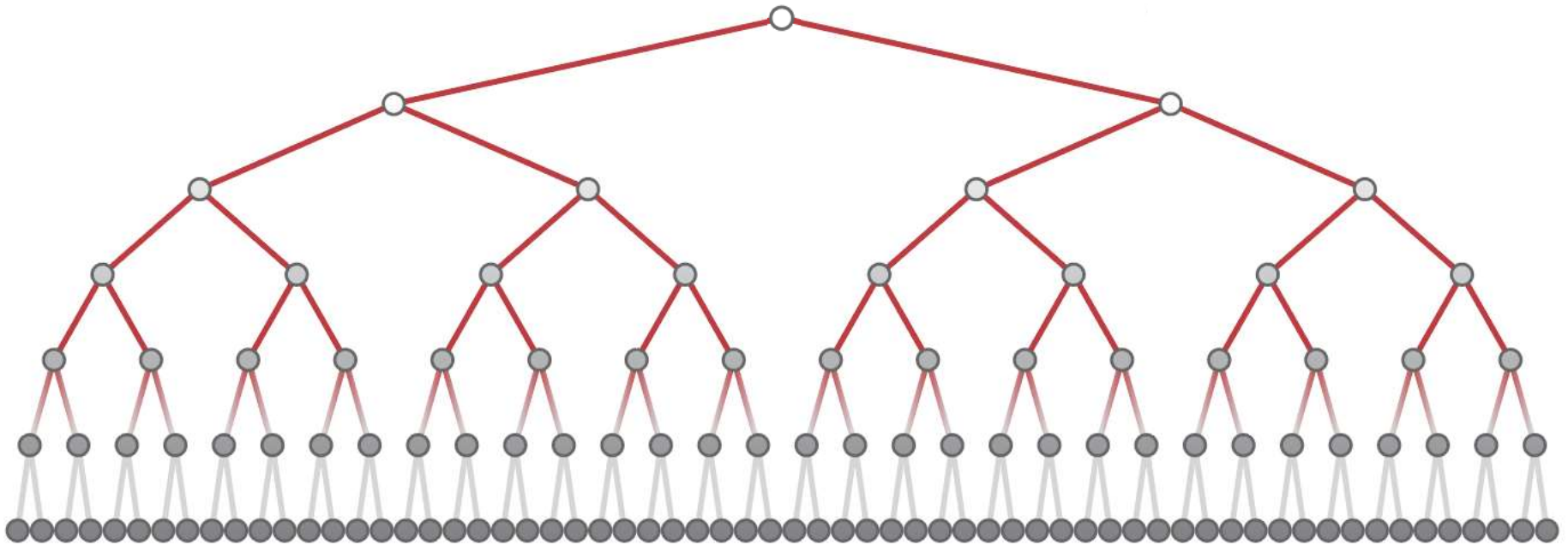
What are the basic ingredients of Life?

Can we come up with a definition for (minimal) Life?



Self-replication (self-sustaining)
& Darwinian evolution

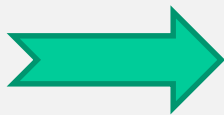
Self replication (exponential growth)



Darwinian Evolution = genetic variations are selected over generations.

The base for Darwinian Evolution is the random variations of progenies.

Parent



Child 1

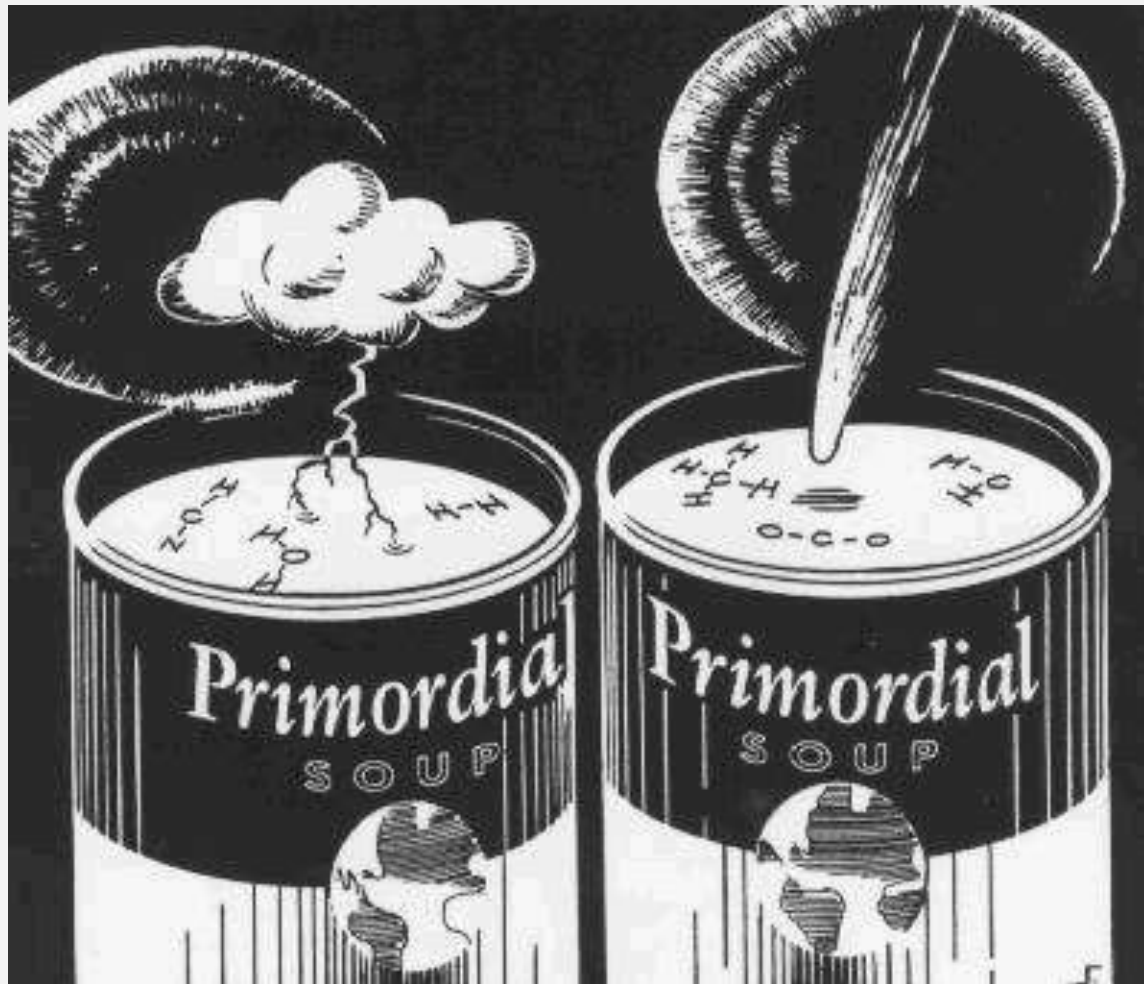


Child 2

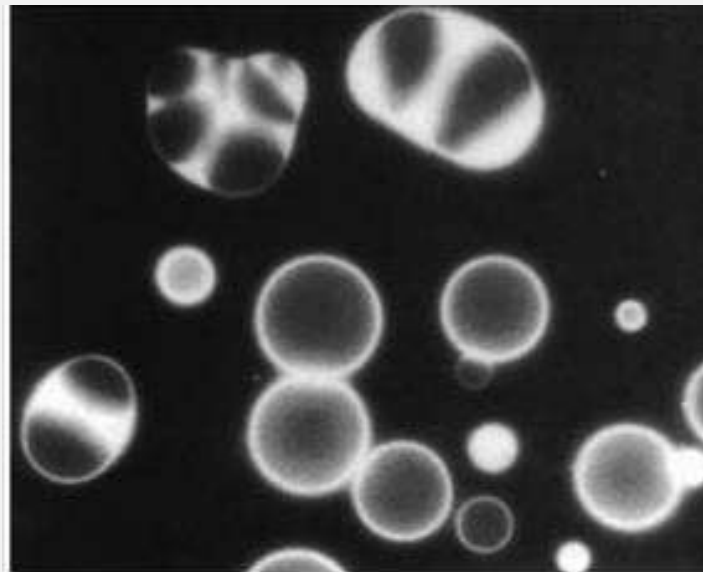


Child 3



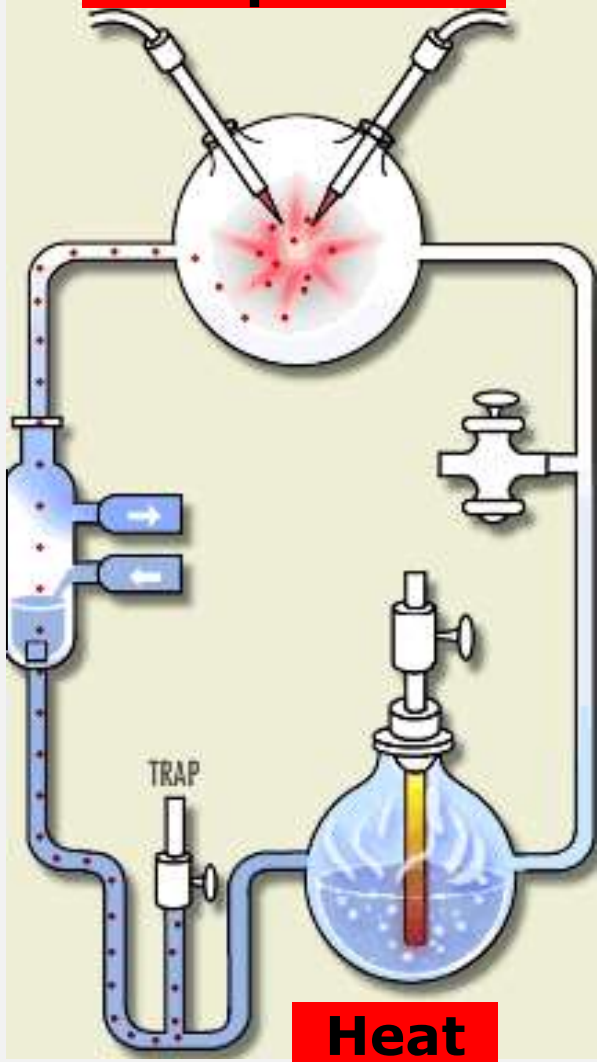


Murchison meteorite



Miller & Urey's experiment

Spark



Heat

Mixing according to early-Earth's atmosphere (ammonia, methane, water, hydrogen)
→ Simple chemical and biological molecules formed

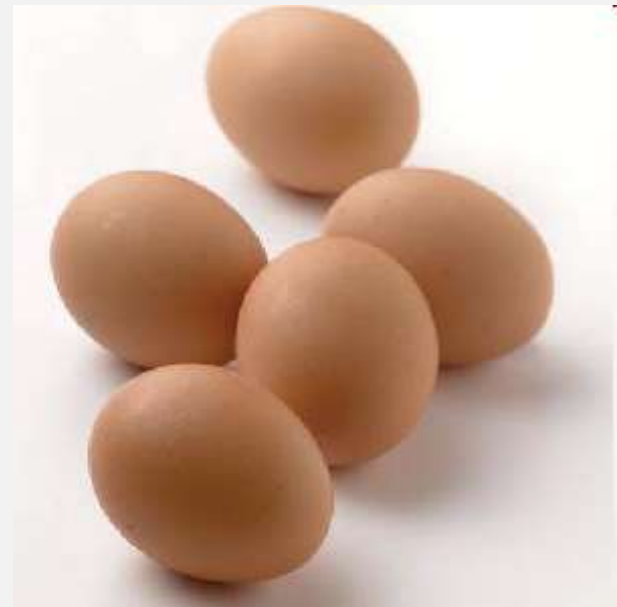
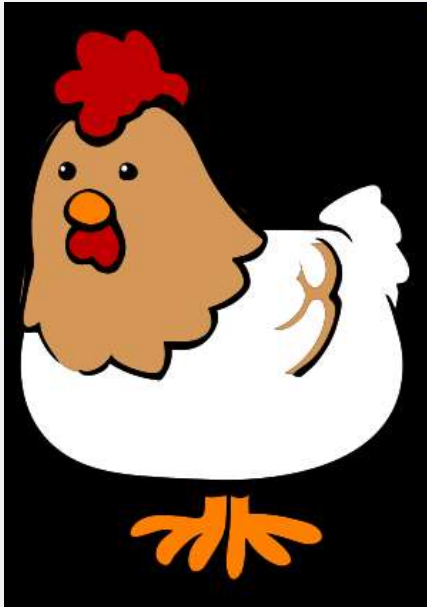
Sets the stage for the emergence of life on Earth, but
Does **NOT** answer the question of how life started.

Self-replication & Darwinian evolution

Chicken or Egg ?

Not one before the other, but they are coupled.

Chicken + Egg = Chegg 😊

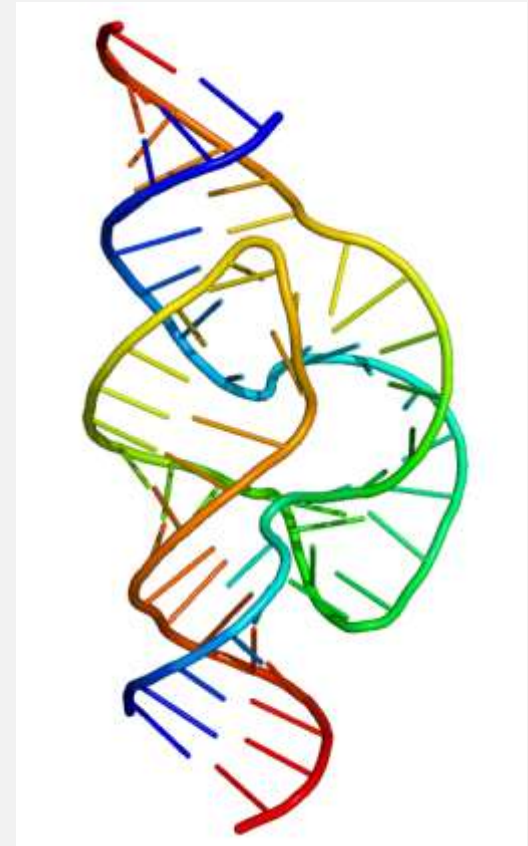


"RNA world" origins of life

Biology central dogma



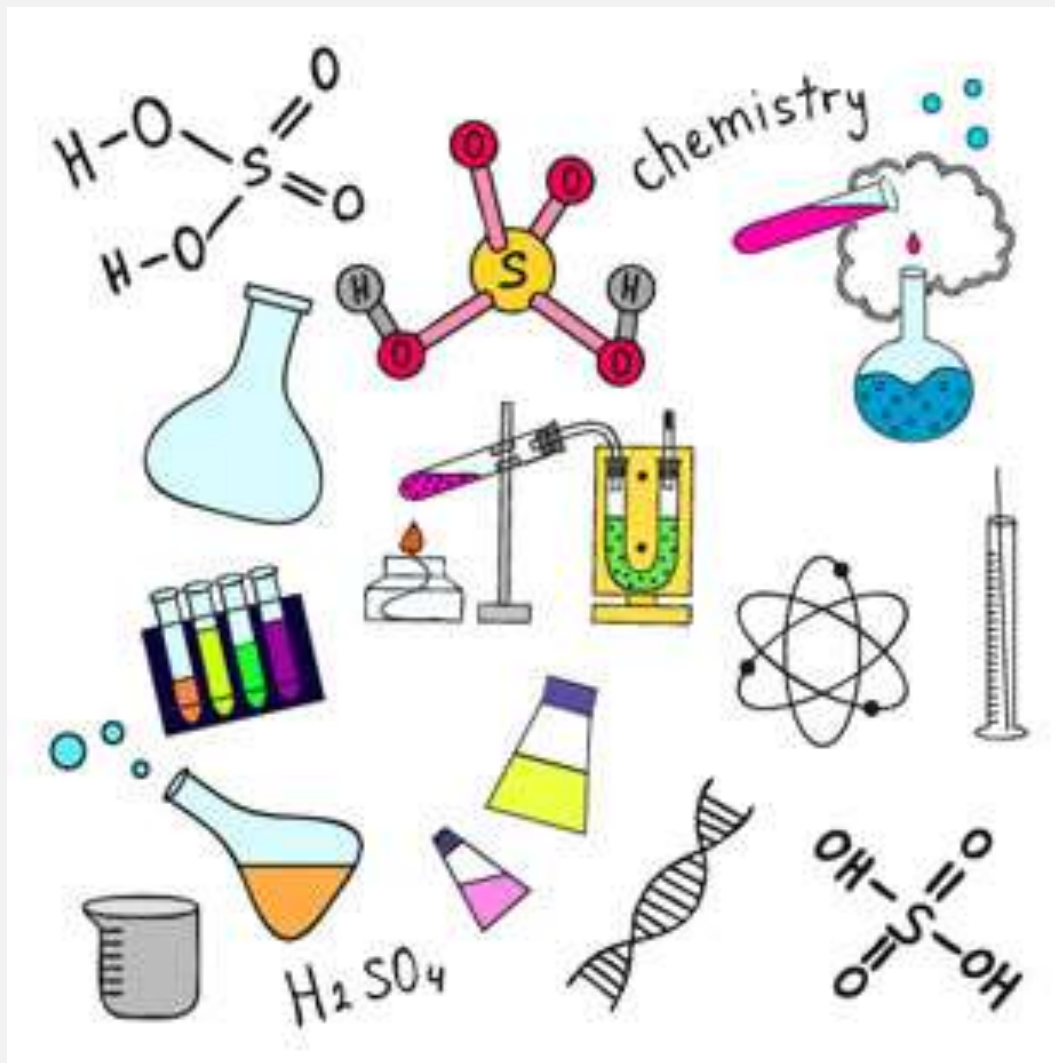
Ribozyme = Catalytic RNA
(folds like a protein)



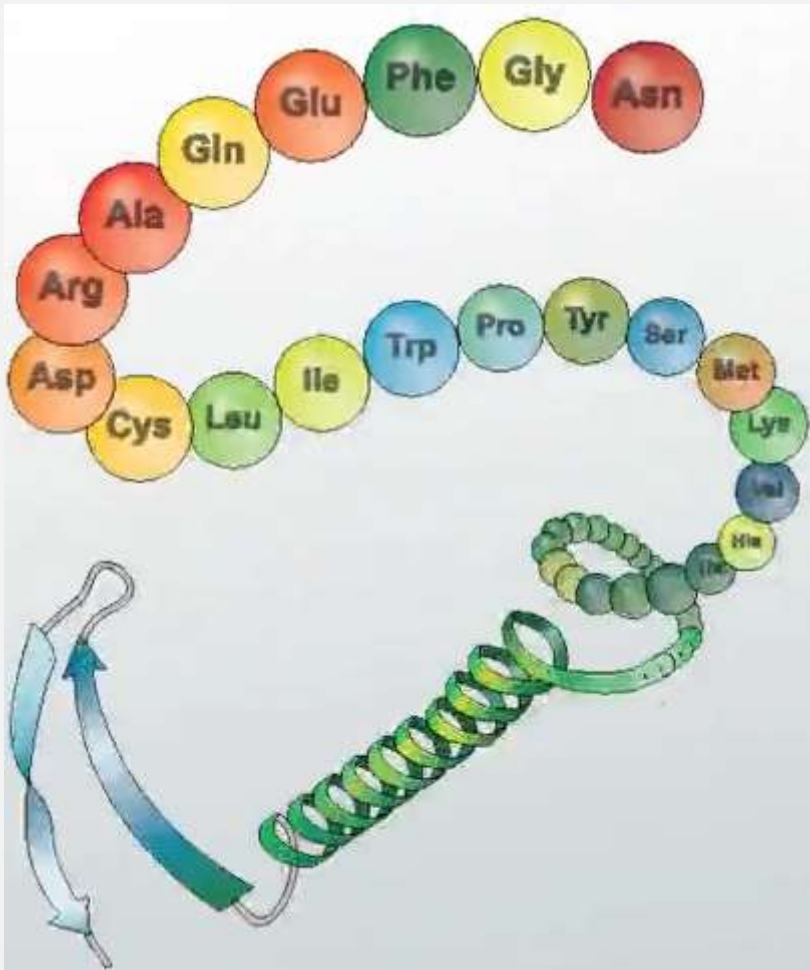
"RNA world" origins of life



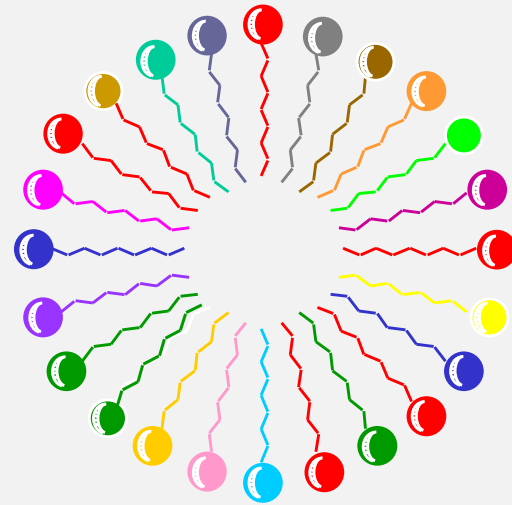
- ✓ Chegg
- X Immensely complex to start on its own
- X Need to be very long for function (fold)
- X Needs to be un-folded to replicate



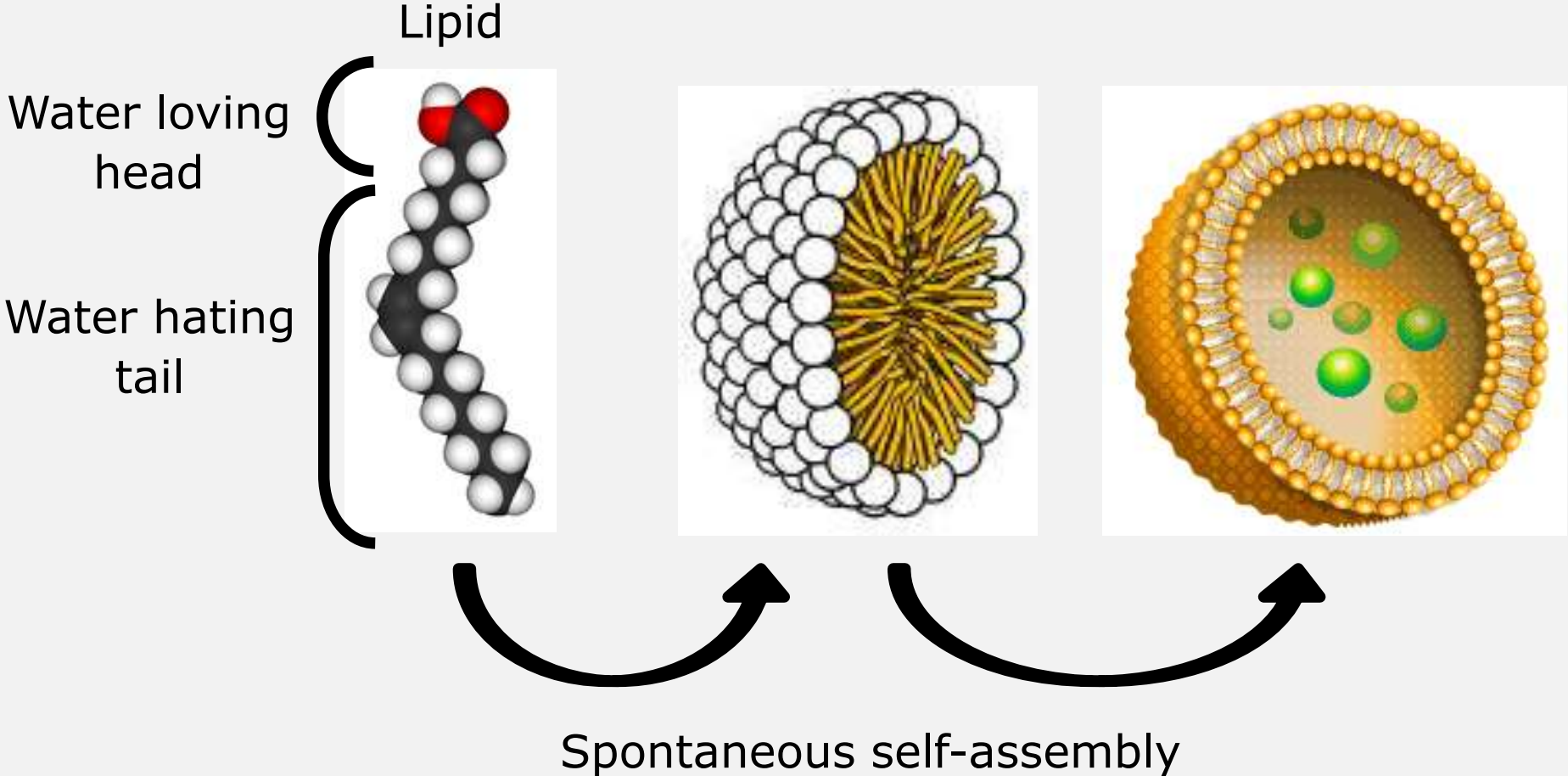
Biological polymers
(DNA / RNA / proteins)
Strong covalent bonds
Order matters



Chemistry
Self-assembly
Weak non-covalent bonds
"Random access"

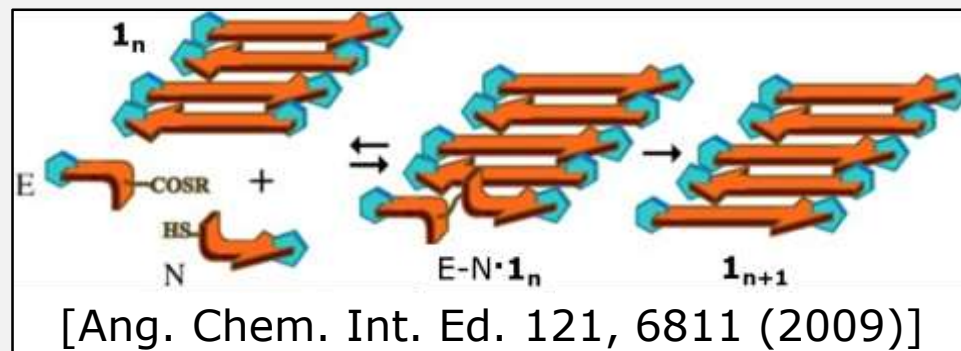
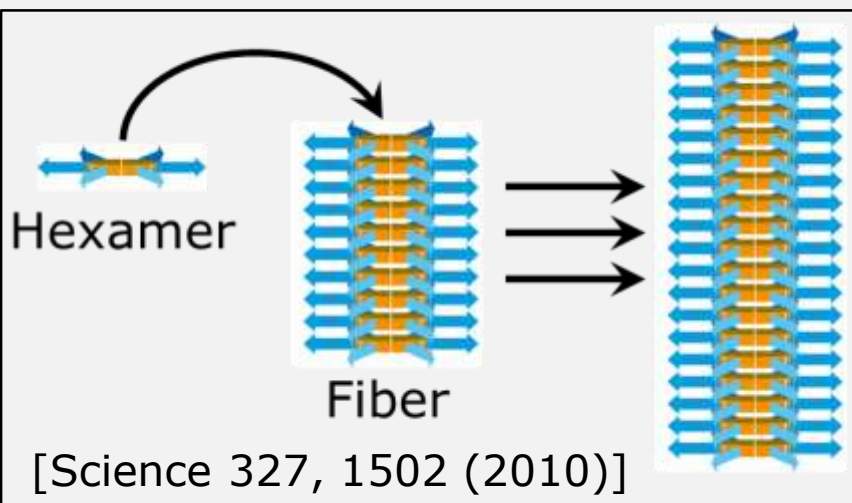
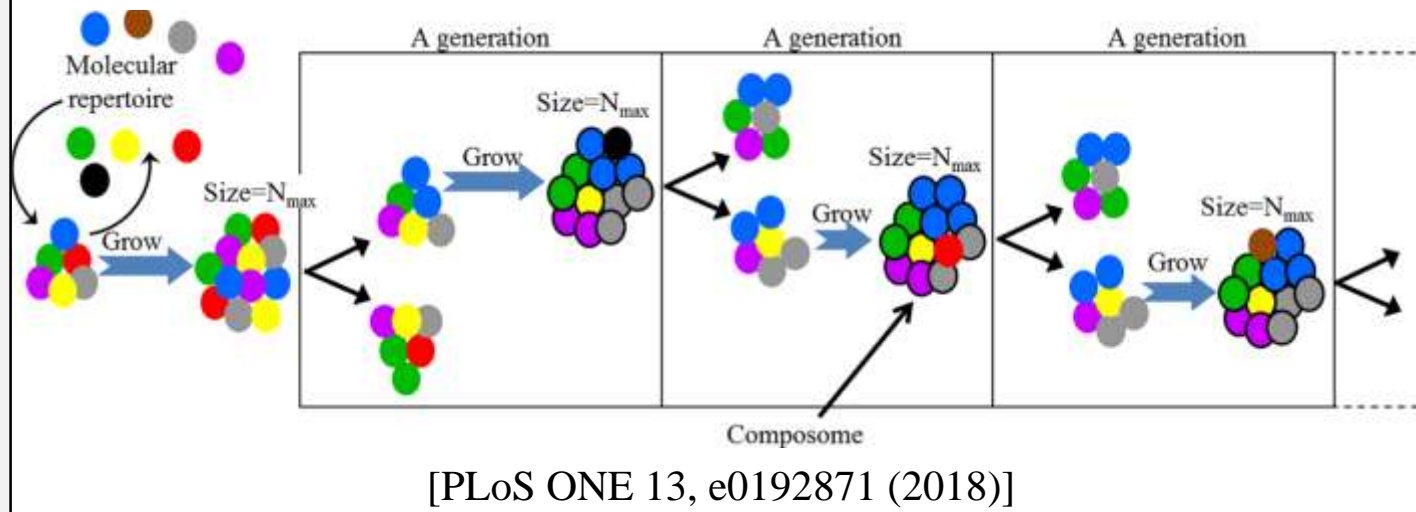


Self-assembly



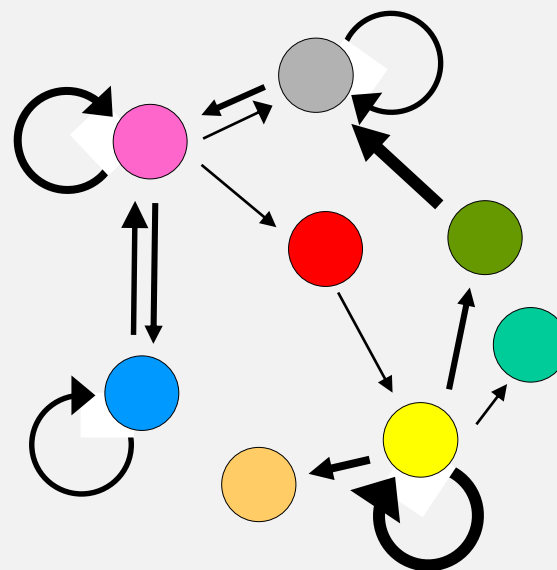
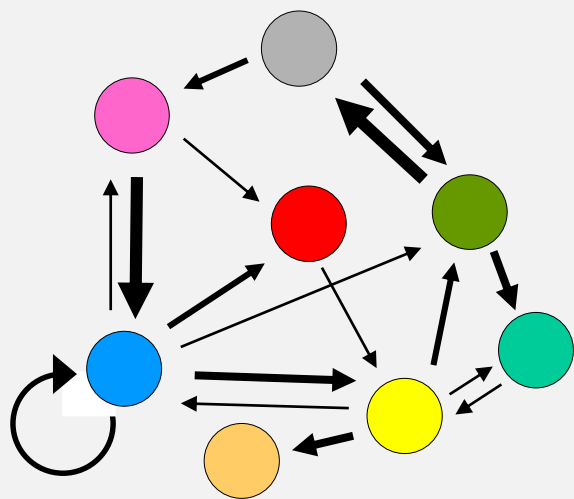
Chemistry: self-replication driven by self-assembly

GARD model for chemical evolution:

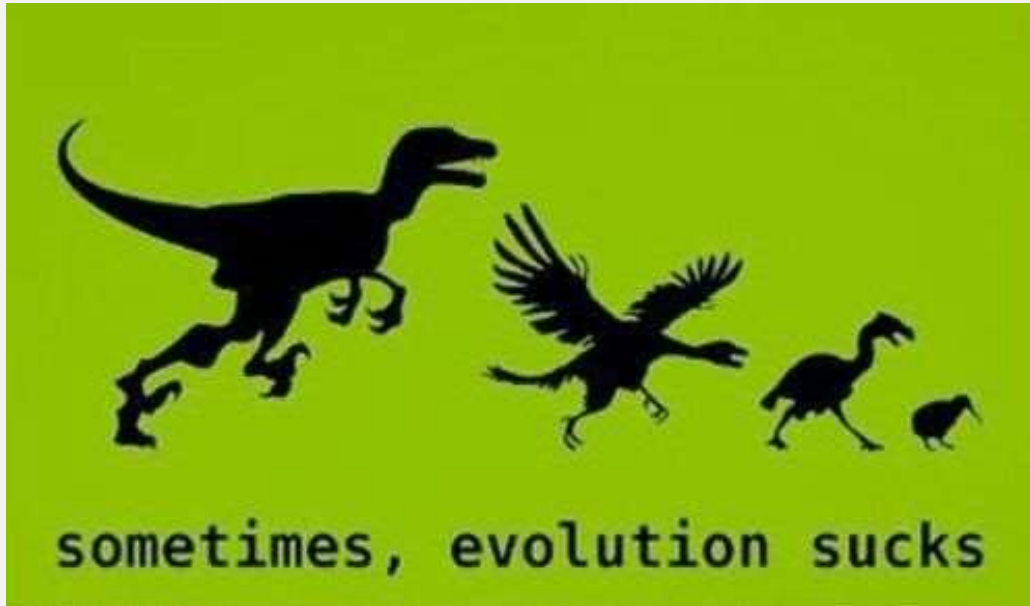




I am taking the networks perspective



- 1) What is "life"?
- 2) What is special about biology?
- 3) Can chemistry be "alive"?



The screenshot shows the top navigation bar of the Scientific American website. On the left, there are buttons for 'Subscribe' and 'Latest Issues'. In the center is the 'SCIENTIFIC AMERICAN' logo with a '175' anniversary badge. On the right, there are links for 'Cart', 'Sign In', and 'Stay Informed'. Below the navigation bar is a horizontal menu with categories: 'THE SCIENCES', 'MIND', 'HEALTH', 'TECH', 'SUSTAINABILITY', 'EDUCATION', 'VIDEO', 'PODCASTS', 'BLOGS', and 'PUBLICATIONS'. A search icon is on the far right. The main content area features a red banner that reads 'SCIENTIFIC AMERICAN JUNE 2007'. Below this is a large blue banner with the article title 'A Simpler Origin for Life' in white serif font. Underneath the title is a sub-headline: 'The sudden appearance of a large self-copying molecule such as RNA was exceedingly improbable. Energy-driven networks of small molecules afford better odds as the initiators of life'. At the bottom of the article preview, it says 'By Robert Shapiro'.

Shapiro, *Scientific American*, 296, 46 (2007)

More general about chemical evolution and chemical networks:

Lancet, Zidovetzki & Markovitch; *J. R. Soc. Interface*, 0159 (2018)

Thank You



Blue Marble Space
Institute of Science



@OmerMarkovitch





Blue Marble Space
Institute of Science

<https://bmsis.org/>

We are an international community engaged in building a sustainable future and nurturing scientific interest among the public.

Our mission is to explore life as a universal phenomenon and empower the next generation of scientists.

Young Scientist Program

Blue Marble Space
Institute of Science

