9/30/17

Origins of Life: A Chemist's Perspective

Andrew Sagadyn

Life - Evolution

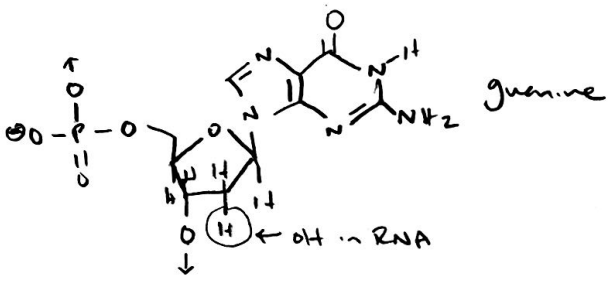
- Memory - what worked ⟷ DNA/RNA
- Adapt - rxt fast ⟷ proteins

⤴ ? → Single molecule origin of life

Life = Polymers (define)

Key: Simplicity (rxn run itself → statistics)

DNA



Coupd Polymer:
- Monomer - phosphate, sugar, base
- Polymer - phosphodiester bond

Source: ?

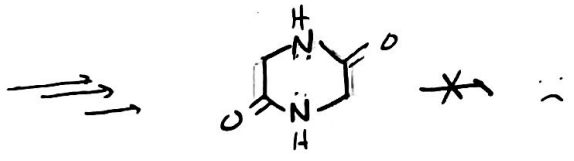
Rxn: Dehydration

$A + B \rightleftharpoons H_2O + C$ (Le Chatelier)

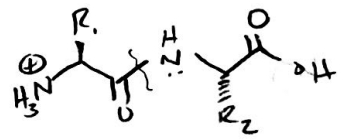
Pro: Still plays dual role

Con: Probability it was synthesized abiotically is low - very low

Bifunctionality Great for Polymer, but also means can self rxt



Peptides



Simple Polymer
- Monomer - amino acid
- Polymer - peptide bond

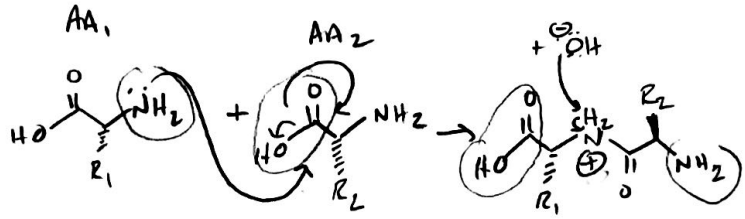
Source:
- space
- Bubbles near water (Miller-Urey)

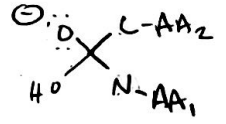
Rxn: Peptide Bond Formation
- dehydration (but hard to make)
- once made, locked in

Pro: Continuous path for life

Con: No longer plays dual role

Polymerization problems





tetrahedral intermediate

Paradoxes

Levinthal's

#bonds ↙ #ac

$3^{2\cdot50} = 10^{47}$ conformations ← #stable conformations

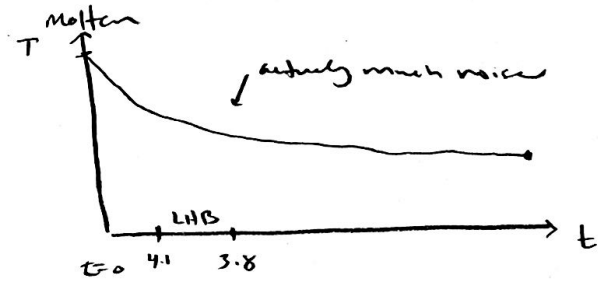
10^{-13} s ← time to rotate a bond

$\Rightarrow 10^{34}$ s $\cdot \frac{1\,h}{3600\,s} \cdot \frac{1\,day}{24\,h} \cdot \frac{1}{365\,d} \approx 10^{26}$ years (10^{16} · age of universe)

Resolution: local folding 1st

Faint Sun

70% of current output → T for origins of life (≈ current 15°C)



(4.5 by)

- Greenhouse effects
- LHB (late heavy bombardment)
  - 100-200°C
  - liver up until life's appearance

Thermodynamics/kinetics

$$A + A \rightleftharpoons A\text{-}A + A \rightleftharpoons A\text{-}A\text{-}A \ldots$$

$K_{eq} = \frac{[products]}{[reactants]}$ fixed by stability of molecules (tells where reaction reaches "end")

Ex: $A + B \rightleftharpoons C$

$K_{eq} = \frac{[C]}{[A][B]}$

But what do I put here?

→ dynamic equilibrium

- Solve steady state rates

$$\frac{d[X]}{dt} = 0 = k_{in} - k_{out}$$