Biology 590S. Origins of Cellular Life. Notes on special Skype sessions with experts.
Fall 2017

Dr. Nick Lane - UCL - Autotroph first hypothesis

- When asked to summarize the "metabolism-first" hypothesis, Dr. Lane mentioned that he was uncomfortable with that label. Rather, from his perspective, the field is divided between the competing hypotheses of "autotroph first" (i.e. simple metabolic systems functioning in a vent with an established pH gradient that can make their own building blocks) and "heterotroph first" (i.e. simple systems with a semipermeable lipid membrane in a primordial soup that can transport the energy, nucleotides, and other building blocks it needs).
- Autotrophs that generate CO2 from H2 were likely the earliest cells based on phylogenetic evidence.
- Although H2 and CO2 are relatively unreactive in lab, cell structures (e.g. earliest "leaky" membranes) were likely carrying a charge gradient. This reaction also becomes favorable given a pH gradient ($\approx$ $60mV$ per pH unit, Nernst equation).
- Ancient conditions in alkaline vents such as those in the Lost City would have had more ferrugenous iron with more acidic (higher CO2) and anoxic ocean water. These conditions are difficult to recapitulate in lab (which is one of the objectives of the Lane group), so they simulate at pH 5, titrate in some CO2 and add FeS.
- Dr. Lane's perspectives on "top-down" vs "bottom-up" approaches to origins research: he said he thought it would be a lot of fun to go do field work to collect samples to observe ancient samples directly ("top-down"), but he fears that these samples often do not reflect the ancient chemical conditions he ultimately seeks. Therefore, he takes an experimental approach to simulate these early chemical and thermodynamic conditions.
- When asked about the need to invoke a protein pump to allow "leaky"-membrane cells to leave the vent, he said the class had identified an "uncomfortable gap" in the autotroph-first hypothesis. He would like to demonstrate polymerization of nucleic acids by thermophoresis and convection within simulated vent environments and/or inside protocells. Experiments like these are needed to fill the gap in knowledge.
- When asked what the remaining challenges in the field were from his perspective, he said:
  - Need to make organic molecules using H2 and CO2 as starting materials in a microfluidic device that mimics early earth scenarios.
  - Prebiotic synthesis of chemicals such as oxaloacetate and other Kreb's cycle intermediates need to be demonstrated experimentally
  - The stability of nucleotides and lipids in the thermophilic vents such as the lost city needs to be demonstrated experimentally.

Disclaimer: these notes are the interpretation of Dr. Lane's words by Dr. Schmid