

CPSH Seminar Series

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Beyond Miller–Urey: Pathways to Life in Prebiotically Relevant Environments using Plasmas

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Lightning storms – electrical discharges - are one of the initial sources of energy which could have driven chemical reactions on the primitive Earth. Our experiments model prebiotic lightning events under a neutral atmosphere (composed of N_2 and CO_2) in contact with bodies of water or land. We demonstrate how a combination of phases (i.e., solid catalysts, neutral atmospheres, and liquids) can couple in non-equilibrium environments to synthesize complex organic molecules. For example, we show how electrical discharges convert N_2 , CO_2 and H_2O into highly reactive intermediates ($N\cdot$, $C\cdot$, $CN\cdot$, $CH\cdot$, $H\cdot$, $O\cdot$, OH) in the gas phase. The aqueous phase (representing ocean, lakes, and ponds) acts as a reservoir, collecting stable products (NO_2^- , NO_3^- , NH_4^+ , CH_4 , and formate) that are important precursors of more complex and functional organic molecules. We demonstrate how free electrons in the plasma can penetrate into the aqueous phase, drive radical production, and contribute to the formation of organic molecules. Finally, we speculate how the addition of catalysts in hydrothermal vents could synergize with lightning to enable distinct reaction pathways toward life.

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