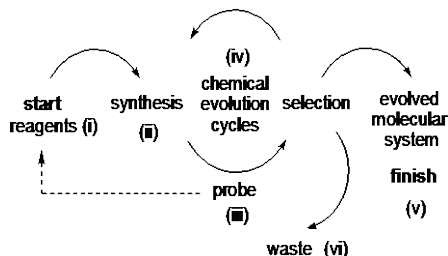


Hybrid Chemo-Robotic Systems for Environmental Programming of Functional Polymeric Systems

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Introduction: The development of inorganic systems capable of evolution as a fundamentally less complex ‘emergent’ model of prebiotic evolution is proposed as a solution to the information paradox that could pre date other more complex systems e.g. organic heteropolymers capable of catalysis and replication. In this approach we allow complexity and information transfer between systems to bootstrap the assembly of systems capable of exhibiting evolutionary dynamics. This experimental approach not only requires developments in information theory, but automation of experiments, robotics, and evolutionary programming. Thus this area defines an intrinsically multidisciplinary field requiring contributions from chemistry / chemical engineering, molecular biology / genetics, robotics and computing science.

Results: In our laboratory we have recently developed a programmable fluidic system comprising a series of linear flow systems, coupled network reactor arrays with a sensor array, and control actuation.[1-3] In this research, by coupling separate reactions in both space and time, we aim to control the assembly of kinetically unstable polymeric structures that are maintained away from thermodynamic equilibrium. In a nutshell we will use a fully automated semi-batch-semi-flow system to explore the non-equilibrium assembly of inorganic structures, combinatorial organic reactions combined with gradients of light, pH, redox, organic cations selecting for catalysis, emergence functionality and persistence of morphology, see Scheme 1.



Scheme 1: Description of the engineering process using fluidic automation.

Discussion: Using this system we are searching for the minimal evolvable inorganic chemical entities using a series of experimental platforms. This is because minimal self-assembling inorganic systems capable of catalysis and replication may provide a route to cross the information threshold where the number of evolvable bits (Evb) exceeds that required to start the process

(Ib). Ultimately this approach could allow us to (re)discover biology relevant to life on earth as it is today, or to develop a totally new ‘inorganic biology’.[4] We think that the evolvable pre-biotic inorganic systems could be considered to be minimal life forms where $E_{vb} > I_b$ and could therefore represent a testable approach to explore plausible inorganic ‘origins’ relevant to the emergence of life on Earth, as well as allowing the engineering of new biologies from the bottom up (expanding the possible chemistries capable of life).

In this context we consider life to be a replicative population-based ensemble of unstable entities, capable through evolution of giving a fitter population as a function of generations capable of survival. Such entities, through generational survival, naturally acquire information content with a measureable increase in functional ‘bit-content’ (at least initially). Our intention is that this will provide a roadmap to progress towards the complexity of contemporary biological systems whereby the key step is the transition to evolvability, and then ultimately to open ended evolution, see Figure 1.

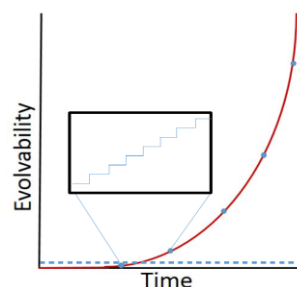


Figure 1: Graph depicting the emergence of evolution with graph of evolvability against time.

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