MAR15-2015-020937

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Self-Replication, Exponential Growth, Selection and Competition in Artificial Systems

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Self-replication and evolution under selective pressure are inherent phenomena in life, but few artificial systems exhibit these phenomena. We have designed a process and a system of DNA origami tiles that exponentially replicate a seed pattern, doubling the copies in each diurnal-like cycle of temperature and UV illumination, producing more than 7 million copies in 24 cycles. We use this system to demonstrate exponential selection: two similarly-growing sub-populations, one with a "red" dye incorporated, the other with a "green" dye, can be controlled by colored light. The light heats one species reducing its replication rate. The progeny of the non-absorbing species replicate preferentially and take over the system. The species selection is enhanced by competition for a resource, critical crosslinking strands required for replication. This addressable selectivity of different constituents in the same solution should be adaptable to the selection and evolution of multi-component nanoscopic-microscopic self-replicating materials. Materials that multiply exponentially and can be selected for specific properties may provide a new paradigm for design from the nanoscopic to the microscopic. Further such systems can provide insights into diverse problems ranging from the origin of life to information, computation and materials science.