

SOE 4: Plenary Talk Stuart Kauffman

Time: Monday 14:00–14:45

Location: HSZ 02

Plenary Talk

SOE 4.1 Mon 14:00 HSZ 02

The Emergence and Evolution of Life Beyond Physics —
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The emergence and evolution of life is based on physics but is beyond physics. Evolution is an historical process arising from the non-ergodicity of the universe above the level of atoms. Most complex things will never exist. Human hearts exist. Prebiotic chemistry saw the evolution of many organic molecules in complex reaction networks, and the formation of low energy structures such as membranes. Theory and experiments suggest that from this, the spontaneous emergence of self reproducing molecular systems could arise and evolve. Such *collectively autocatalytic systems* cyclically link non-equilibrium processes whose constrained release of energy constitutes *work*, to construct the

same constraints on those non-equilibrium processes. Cells do work to construct the boundary conditions that give the constrained releases of energy by which work they construct themselves.

Such systems are living, and can propagate their organization with heritable variations, so can be subject to natural selection. In this evolution, these proto-organisms emerge unprestatably, and afford novel niches enabling, not causing, further types of proto-organisms to emerge. With this, unprestatable new functions arise. The ever-changing phase space of evolution includes these functionalities. Since we cannot prestate these ever new functionalities, we can write no laws of motion for this evolution, which is therefore entailed by no laws at all, and thus not reducible to physics. Beyond entailing law, the evolving biosphere literally constructs itself and is the most complex system we know in the universe.