Origins of Artificial Life

Life itself is a highly evolved complex system, which makes it difficult to disentangle its necessary properties (eg, its information processing needs) from its contingent properties (eg, its embodiment in a specific physico-chemical substrate). The field of *Artificial Life* (ALife) has been developed to understand "life as it could be", to distinguish the necessary from the contingent, and to build alternative forms, including computer-based forms. One interest of ALife is the study of the Origin of Life: how the "phase transition" between non-living matter, and living systems, can be bridged.

One approach to this question is via *Artificial Chemistries* (AChems), computational systems inspired by (but not constrained by) properties of natural chemistry. AChems are designed to implement generative processes that exploit the power of constrained combinatorics to build complex systems. As the systems generated become more complex, they may be used as a vehicle to understand how to bridge the gap between mere static components and "living" self-sustaining systems.

We have an approach called "sub-symbolic artificial chemistry", with multiple exemplar systems, that allows a rich set of behaviours to be developed as emergent properties of underlying structure and dynamics. We have recently augmented this with "MetaChem", a graph-based language that can be used to capture and define the structure of a range of specific AChems, and combine them in novel ways. However, MetaChem can also be considered a higher-level AChem in its own right, and hence potentially be used to *generate* novel AChems.

The aim of this PhD research is to use the principles of MetaChem as a foundation for designing and building a series of increasingly complex computational AChems, at different levels of structure, in order to generate a more "life-like" artificial system, and to analyse the requirements and properties needed to bridge the gap between AChem and ALife.

This PhD research will be cosupervised by
Prof Susan Stepney (Dept Computer Science; YCCSA)
Dr Angelika Sebald (Dept Chemistry; YCCSA)