Editorial

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We are pleased to present this special issue of *Artificial Life*, which is dedicated to articles arising from a workshop held on September 6, 2012, as part of the Unconventional Computation and Natural Computation (UCNC) conference in Orléans, France. UCNC is now a well-established meeting in the portfolio of conferences dedicated to nonstandard computation, dating back to 1998. The 2012 conference was hosted by the Fundamental Computer Science Laboratory of the University of Orléans, and the Second Workshop on Biological and Chemical Information Technologies (BioChemIT) was organized by the COBRA project.

COBRA was a three-year initiative (2010–2013), supported by the European Commission to encourage and nurture research and training in the field of biological and chemical information technology. Fundamentally, the field seeks to harness the capabilities of natural and chemical systems. Rather than simply deriving *inspiration* from living systems, biological and chemical IT researchers seek to *directly use* or *construct* these systems for the purposes of engineering and computation. Over the past few years, technological advances in chemistry, molecular biology, functional materials, and engineering have brought biological and chemical information processing within our control. The ability to build, design, and grow ICT systems that can exploit these processes will lead to revolutionary advances in the future [1].

The five articles in this issue represent a broad swathe of work, mainly covering alternative computational substrates (such as droplet architectures, chemical media, and microbes) and novel theory (complexity measurement).

The first two articles concern chemistry-based computing. The one by Jones et al. considers how an architecture composed of interacting autonomous droplets might (in future) be applied to applications in robotics. They give their design for a single droplet (capable of rudimentary sensing of its environment, processing, and actuation), which is based on the well-known Braitenberg vehicle, before presenting preliminary experimental results on the processing and actuation phases, using multiple droplets.

Although the first two articles both use the Belousov-Zhabotinsky (BZ) reaction [4] as a basic underlying mechanism, the second one (by King et al.) takes a slightly different approach from the first, in that it considers the geometry of the *vessel* containing the reaction, and how this might be designed in order to obtain large networks of chemical oscillators. Coupled oscillators are fundamental to the study of complex systems, and their properties have been harnessed for the purposes of nonstandard computation in a variety of domains and substrates (e.g., [2]). This article presents

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detailed experimental investigations into the effect of channel geometry on BZ excitability, thus laying the ground for threshold-based chemical computing implemented by the combination of reactions and specific 3D reaction vessel structure.

The third article, by Ozasa et al., concerns the use of single-celled organisms; specifically, microbes from the genus *Euglena*, which are capable of self-directed movement. Previously, single colonies have been used to implement simply neurocomputing algorithms [3], but a useful extension, demonstrated here, would be to connect multiple colonies, for the purposes of distributed processing. *Euglena* cells are naturally averse to blue light, and this property is used to externally direct the swimming behavior of colonies of cells. In this way, the isolated colonies may be optically coupled, which allows studies of both cooperative and competitive control of behavior and colony distribution.

The fourth article, by Beneš et al., also concerns microbial computing, but in the context of synthetic biology. The engineering of genetic circuits within bacteria (and other simple organisms) is now well established, but there are inherent difficulties with the approach, due to the unpredictable nature of the biological substrate. The notion of evolving circuits in situ is therefore appealing, and here the authors present a scheme for using plasmids (short circular strands of DNA) to drive a population towards good solutions. Importantly, they present a dual selection mechanism, and simulation results suggest that this adds robustness to the process.

The final article in this issue, by Lui et al., considers issues of complexity, and introduces a new definition based on Kolmogorov complexity and Shannon entropy. The article shows some applications of this new measure, one using the familiar cellular automata classification scheme of Wolfram, and the other using the self-organization of porphyrin molecules. The utility of the method is illustrated by convincing demonstrations that the results of measuring existing well-understood structures (using the new metric) are consistent with previous theory.

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