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Introduction

This Special Issue is based on presentations made at the W. Ross Ashby Centenary Conference at the University of Illinois in Urbana on 4–6 March 2004. The purpose of the conference was to use the occasion of the 100-year anniversary of Ashby's birth for reflecting on his lasting intellectual legacy. Being organised at the University of Illinois, where Ashby spent the most productive years of his professional career, the conference turned out to be a wonderful celebration of this great scholar of impeccable integrity.

The story of how this conference and its participants came together, is interesting enough to bear recounting. In the late 1990s, the guest co-editor of this special issue, Peter Asaro, was conducting research in the archives of the Biological Computer Laboratory (BCL), which was directed by Heinz von Foerster at the University of Illinois from 1958–1976. In reading the correspondence of von Foerster, Asaro came across several references to the scientific notebooks of W. Ross Ashby. Among these references was an anecdote, or rumor, that Ashby had, on his deathbed, ordered his wife Rosebud to destroy the notebooks. This seemed quite out of character for Ashby and so Asaro began a world-wide search for information on the whereabouts of these notebooks. In 1998, he began contacting many of Ashby's surviving students and colleagues, the librarians and archivists at the institutions Ross Ashby had worked at and even numerous individuals (unrelated, as it turned out) with the Ashby name, yet was unable to discover any official archive of Ashby's personal or professional papers. With the assistance of the head archivist at the University of Illinois, William Maher, Asaro did manage to get many papers, including lecture notes and course materials, from some former students of Ashby's, including Roger Conant, into the archives where they now reside beside the papers of Heinz von Foerster, the BCL and the American Cybernetics Society. But there was no trace of Ashby's scientific notebooks or personal papers.

Then, in 1999, the website *Principia Cybernetica* published a PDF version of *An Introduction to Cybernetics*. The editor of that website, Francis Heylighen, was able to put Asaro in contact with Ross's grandsons, Mick and John Ashby, and he was excited to learn that the family did in fact still have Ross's scientific notebooks. He was even more excited to learn of their immense size and scope, and that they had been meticulously indexed by Ross himself. The trustees of Ross's notebooks, his daughters Jill, Sally and Ruth, had been unsure of what to do with the notebooks, though they recognised their potential significance and had kept them safe for many years. After several years of meetings with Mick and John, and discussions amongst the family members, Ross's scientific notebooks were eventually scanned and indexed in a laborious and painstaking process, described in the article in this issue by Mick Ashby. The original physical notebooks themselves were then deposited in the British Library in 2003.

In 2004, with support from the Program in Science, Technology, Information and Medicine (STIM), a conference was organised by Peter Asaro, John Wedge and Andy Pickering to celebrate the intellectual legacy of W. Ross Ashby. In addition to former colleagues and students, and scholars influenced by his work, the organisers of the conference also invited the Ashby family to participate. Everyone was delighted when the family arrived from England, including all three of his daughters, a son-in-law and two grandsons. In addition to several

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formal presentations on various aspects of Ashby's work, most of which are covered in this Special Issue, there were ample opportunities during the conference for informal discussions among the participants. In this respect, members of the Ashby family added something unique to the conference. They shared with the other conference participants their personal reminiscences about W. Ross Ashby and brought to the conference some unique photographs, personal letters, and various other documents.

Among the documents brought to the conference by the Ashby family, the most remarked upon were samples from the extensive handwritten notebooks in which Ross Ashby recorded the evolution of his scientific ideas from 1928 until he passed away in 1972. The existence of this intellectual treasure, consisting of 25 books with the total of about 7400 pages, was announced publicly for the first time at the conference, together with a plan for making the notebooks available on the Internet.

The W. Ross Ashby Digital Archive, which Mick Ashby developed and describes in his article, contains not only the notebooks, but also other relevant information. One item in the archive is a biography of Ross Ashby written by his oldest daughter, Jill Ashby. A shortened and slightly modified version of this biography is presented in this Special Issue as the second paper. The remaining nine papers discuss various aspects of Ross Ashby's scholarly contributions and their lasting legacy. Together, they capture well the overall thrust of his work. They are fairly complementary and the overlap between them is rather small. For convenience, they are ordered alphabetically by the authors' names, not by their contents.

Peter Asaro addresses in his paper Ashby's legacy to future research in artificial intelligence and cognitive neuroscience. His primary focus is on Ashby's late work in the period 1967–1972, where he develops a conception of an 'embodied mind' that has figured prominently in theories of situated robotics, ecological perception and the mechanisms of consciousness. He concludes that Ashby's view of information theory as an essential tool for dealing with complex systems and his preliminary ideas of how to further apply it to developing an embodied conception of the brain remains one of the principal challenges for future artificial intelligence and cognitive neuroscience.

Geoffrey Bowker and Ray-Shyng Chou introduce and discuss Ashby's unorthodox view of memory as a learning machine that can derive required information about the past by interacting with its environment and examine the various implications of this view.

Peter Cariani first explains why Ross Ashby is rightly regarded as a founder of both general systems theory and cybernetics. He then examines in detail Ashby's homeostat, which was conceived and developed by Ashby in the 1940s, to demonstrate a brain-like capability of sophisticated adaptive control by which stability is maintained in the face of unpredictable disturbances. A special attention in the paper is given to one feature of the homeostat – its use of both analog and digital techniques.

Michael Geoghegan and Paul Pangaro argue in their paper that Ashby's formulation of the necessary and sufficient conditions for a system to learn in order to remain viable in a varying environment is applicable to human organisations. The argument is pursued by identifying plausible analogies between biological organisms, which were of interest to Ashby and social organisations, which are of interest to the authors.

George Klir explains how some of Ashby's ideas were instrumental in the emergence of systems science. He discusses in more detail three of these ideas, which influenced his own work in systems science: (1) Ashby's clear distinction between an object of interest and systems defined on the object for various purposes; (2) Ashby's ideas about the relationship between overall systems (wholes) and their various subsystems (parts); and (3) Ashby's recognition of the central role of information theory in dealing with systems.

In his paper, Klaus Krippendorff first presents some of his personal recollections as a former student of W. Ross Ashby, with a particular focus on Ashby's efforts to make information theory useful for dealing with systems. He then examines various global aspects of cyberspace and makes some connections to Ashby's way of thinking, in particular his use of the Bremermann computational limit.

A unique feature of the paper by Andrew Pickering is that it focuses on the development of Ashby's ideas during the early stages of his professional career, when he worked in a psychiatric milieu. His work during this period (1930–1960) is much less visible than his later work in cybernetics and general systems research at the BCL of the University of Illinois in 1961–1972. Pickering shows quite convincingly how Ashby's later work had evolved quite naturally from his earlier work in psychiatry.

Stuart Umpleby reviews some general and cross-disciplinary theories developed by Ashby, such as the theory of complex adaptive systems. He discusses why these theories are not known in many areas of science and what this situation reveals about science. He then speculates about the prospective broader role of these theories in the future.

Kevin Warwick argues in his fascinating paper that the science fiction film *The Matrix*, in which an intelligent machine network challenges the supremacy of humans on the earth, is perfectly realistic when examined from the standpoint of logical extensions of Ashby's cybernetic ideas.

We hope that this Special Issue will renew interest in the many brilliant ideas left to us by W. Ross Ashby. These ideas do not seem to lose their relevance with time. Some are even more relevant now than during Ashby's lifetime and some are still waiting for further development. In this regard, we would like to express, on behalf of the whole academic community, our gratitude to the Ashby family for making the remarkable Ashby Notebooks available and easily accessible by scientists and historians.

Peter M. Asaro and George J. Klir