Technological Innovation as an Evolutionary Process

Technological artefacts and biological organisms 'evolve' by very similar processes of blind variation and selective retention. This analogy is explored systematically, for the first time, by a team of international experts from evolutionary biology, history and sociology of science and technology, cognitive and computer science, economics, psychology, education, cultural anthropology and research management. Do technological 'memes' play the role of genes? In what sense are novel inventions 'blind'? Does the element of design make inventions 'Lamarckian' rather than 'Darwinian'? Is the recombination of ideas the essence of technological creativity? Can invention be simulated computationally? What are the entities that actually evolve – artefacts, ideas or organizations? These are only some of the many questions stimulated and partially answered by this powerful metaphor. By its practical demonstration of the explanatory potential of 'evolutionary reasoning' in a well-defined context, this book is a ground-breaking contribution to every discipline concerned with cultural change.

JOHN ZIMAN is well-known internationally for his many scholarly and popular books on condensed-matter physics and on science, technology and society. He was born in 1925, and was brought up in New Zealand. He took his DPhil at the University of Oxford and lectured at the University of Cambridge before becoming Professor of Theoretical Physics at Bristol University in 1964. His research on the electrical properties of metals earned his election to the Royal Society in 1967. After voluntary early retirement from Bristol University in 1982 he devoted himself to the systematic analysis and public exposition of various aspects of the social relations of science and technology, on which he is a recognized world authority. In 1997, as Convenor of the Epistemology Group, which studies the evolution of knowledge and invention, he invited leading scholars from a number of disciplines to work together on this book.

Technological Innovation as an Evolutionary Process

Edited by JOHN ZIMAN

on behalf of *The Epistemology Group*

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In memory of

DONALD THOMAS CAMPBELL

1916 – 1996

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Preface

'Isn't technological innovation rather like biological evolution?' This was the question that Gerry Martin asked me, one day in the autumn of 1993. Like all his questions, it turned out to be more penetrating than it mildly suggested. It certainly seemed very plausible. People had asked it before – but why had so few stayed longer for an answer? After five years, many opinions, much talk, and several megabytes of text, here is a provisional reply.

Quite clearly, this enquiry could not be confined to a single academic discipline. Backed generously by the Renaissance Trust, we conjured up *The Epistemology Group*, a market-place for ideas about 'the Evolution of Knowledge and Invention'. Scholars from different intellectual traditions debated these in a series of informal seminars (1994–95, at the Royal Society of Arts in London), presented some of their findings in a public Forum (June 1996, at the London School of Economics), and hammered them out together at an International Workshop (January 1997, at Goring, Oxfordshire).

This volume, then, is not just a compilation of diverse opinions on a puzzling theoretical question. Whether they mutually agree or disagree, the authors of the various chapters speak for themselves. But they do so out of a shared experience, as conscientious participants in a collective intellectual enterprise, addressing the same set of problems, locating their responses in the same conceptual frame and yet remaining mindful of the issues on which they knew they were divided. This is why the production of this book has been such an agreeable task, to which all the authors have contributed harmoniously.

My editorial work has mostly been to cut out near-duplicate accounts of some of the general themes and then to tack the various chapters together with cross-references. These take the form '(Vincenti, ch.13)', or, more cryptically, '(§13.3)' to indicate that this theme is also dealt with at length by Walter Vincenti in

chapter 13, or more particularly in section 3 of that chapter. Superscript numbers (e.g. '[7]') indicate notes listed at the end of the book, in which literature citations are given in 'Harvard' form (e.g. 'Campbell 1964'). Full details for these references are set out in a comprehensive bibliography at the end of the book. This bibliography also operates as an author index, in that at the end of each reference there is a code in square brackets which indicates where that reference was cited in the text. For example [**13**, *7*] means that this work is cited as note 7 in chapter 13.

The shared framework of concepts, problems and controversies within which we worked is outlined in chapter 1. Let me emphasize, however, that this introductory chapter is not the usual artful synthesis of the multiplicity of perspectives actually presented in this volume: it represents the situation as we had already come to see it *before* the Goring meeting. This book thus owes a great deal to the many other participants in the Epistemology Group activities where these perceptions had evolved. In particular, let me thank the following:

Prof. Barry Barnes, Department of Sociology, University of Exeter; Dr Kerstin Berminge, Department of Theory of Science, University of Göteborg, Sweden; Sir James Black FRS, Prof. of Analytical Pharmacology, King's College Hospital Medical School, London; Prof. Margaret Boden FBA, School of Cognitive and Computer Science, University of Sussex; Prof. Werner Callebaut, Department of Philosophy, University of Limburg, Maastricht, Netherlands; Prof. Mihaly Csikszentmihalyi, Department of Psychology, University of Chicago, Chicago IL, USA; Dr Manuela Delpos, Konrad Lorenz Institut, Altenberg-Donau, Austria; Prof. Daniel Dennett, Centre for Cognitive Science and Philosophy, Tufts University, Medford MA, USA; Prof. Richard Gregory CBE FRS, Department of Psychology, University of Bristol; Dr Rob Iliffe, Department of Humanities, Imperial College, London; Prof. Peter Munz, Victoria University of Wellington, New Zealand: Prof. Keith Pavitt, Science Policy Research Unit, University of Sussex; Prof. Henry Plotkin, Department of Psychology, University College, London; Dr André Pomiankowski, Galton Laboratory, University College, London; Dr Emma Rothschild, King's College, Cambridge; Dr Simon Schaffer, Department of History and Philosophy of Science, University of Cambridge; Dr Elizabeth Van Meer, Department of Applied Philosophy, Wageningen Agricultural University, Wageningen, Netherlands; Dr Richard Webb, Centre for the Philosophy of the Natural and Social Sciences, London School of Economics.

As can be seen from our numerous references to his writings, we all owe a great deal to the work of Professor Donald Campbell of Lehigh University, who was a very active founding member of the Epistemology Group, and who was to have attended the Goring Workshop and contributed a chapter to this volume. His death on 6 May 1996 not only brought to an end a most distinguished and

creative scholarly career but took from us an inspiring and much loved colleague and friend.

In the end, however, our main debt of gratitude is to Gerry Martin. We have not really answered his question yet, but his stimulus and support has made us think about interesting things, which is what we all most enjoy. And we will go on searching.

John Ziman
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