Reviews

M. Norton Wise (ed.), *Growing Explanations. Historical Perspectives on Recent Science* (Durham: Duke University Press, 2005). 346 pp. pb. £18.95. ISBN 0-8223-3319-8.

What counts as a scientific explanation? Which phenomena or facts about the world need to be explained? These questions have received very different answers in different eras. For instance, Aristotelian natural philosophy favored teleological explanations. In the 17th century, however, teleological accounts of natural phenomena were discredited and replaced by mechanical explanations in terms of matter in motion. The demand for mechanical explanations reached a peak toward the end of the 19th century when Lord Kelvin famously proclaimed that all understanding derives from mechanical model building. Other scientists and philosophers questioned the pertinence of mechanical models or even doubted that explanation was among the aims of science. Pierre Duhem, for instance, argued that explanation belonged to metaphysics and viewed scientific theories as concise descriptions of phenomena, rather than explanatory representations of a hidden reality.

Thus, scientific explanation has been an evolving and often contested meta-scientific category. Its form has also varied considerably across disciplines. One could contrast the law-based explanations given by the physical sciences with the functional explanations offered in the life sciences or with the intentional explanations that play a prominent role in the human sciences. As it happens, we lack a systematic historical study of the varieties of scientific explanation. *Growing Explanations* fills partly this gap, with respect to contemporary science, by narrating some significant recent developments in the saga of explanation. According to Norton Wise, the book's editor, the nature of explanation has changed in many areas of post-World War II science, moving away from reductionism and toward an organismic conception.

In reductionist explanations, complex phenomena are reduced to the properties and behavior of a few simple entities lying in a deeper level of reality. For much of the 20th century, reductionism was rampant in physics and chemistry. Purified phenomena, created in the laboratory under controlled conditions, were explained, at least in principle, in terms of the fundamental laws governing their submicroscopic causes. Thus, reductionism has been an attempt to come to terms with, or perhaps evade, the diversity and complexity of the natural world.

This style of explanation reached its limits when it had to tackle complex quotidian phenomena, such as the form of a snowflake or the 'froth on a pint of beer' (p. 7). The advent of the computer after World War II has made possible to simulate complex systems, which are the outcome of many-body and/or nonlinear interactions. Understanding is not achieved by decomposing a system into its elementary constituents. Rather, one understands a complex system as one would understand an organism, that is by 'growing' it. Growing in this case means producing a computer simulation that reveals the, often unexpected, development of a system and its emergent properties, that is those properties that are not deducible from the properties of its constituents. The simulation comprises a 'growing explanation' of the system's behavior. As the creator of catastrophe theory, René Thom put it, 'to understand reality... [is] to *simulate nature*' (p. 95). The intuition behind this new explanatory style is that 'What we can construct we are also able to explain' (p. 303).

These issues are lucidly laid out in Wise's illuminating introduction. The papers that comprise *Growing Explanations* are interesting and well crafted. Some of them, however, do not engage directly the book's main theme, the character of explanation in contemporary science. The first three chapters are about mathematical physics. Peter Galison examines recent developments in string theory and their implications for the uneasy relationship between mathematics and physics. Amy Dahan Dalmedico discusses chaos theory, a field that exemplifies antireductionism, nonlinearity, and emergent phenomena. David Aubin gives an account of catastrophe theory and René Thom's qualitative mathematical explanations of everyday phenomena. The next two chapters focus on technology. Ann Johnson reconstructs the origins of finite element analysis, a method that was developed to handle complexity in engineering design, and Claude Rosental discusses the legitimization of fuzzy logic as a new academic and industrial field. In a chapter on cybernetics and molecular biology, Evelyn Fox Keller examines the impact of computers on biology and the conceptualization of life as an emergent phenomenon. The following two chapters concern immunology. Alfred Tauber reads the history of immunology as a problematic attempt to disambiguate the concept of the self, and Ilana Löwy traces the changing conception of AIDS from the early 1980s to the 21st century. Finally, there are three chapters on the intriguing subject of artificial life. Richard Doyle, Stefan Helmreich, and Claus Emmeche contrast, from various perspectives, the question of life in biology with the related question whether the computer-created objects of artificial life constitute living systems.

Growing explanations, as Wise points out, have encountered resistance in the scientific community. Reductionism persists as an explanatory strategy, not only in its traditional stronghold, elementary particle physics, but also in other areas of science, such as immunology. This is hardly surprising. Arguably, explanatory styles never die out.

A brief review cannot do justice to the richness of this volume. I highly recommend it to historians and philosophers of science alike.

Theodore Arabatzis

Karen H. Parshall and Adrian C. Rice (eds.), *Mathematics Unbound: The Evolution of an International Mathematical Research Community, 1800–1945* (Providence, Rl: American Mathematical Society; London Mathematical Society, 2002). 406 pp. hc. ISBN 0-8218-2124-5.

The volume under review represents a milestone in research into a particular aspect of the history of mathematics: that of internationalisation of mathematics during a period when nation states and nationalism were emerging. The editors' introduction sets the stage by discussing various ways of conceptualising the emergence of mathematics as an international venture. They choose 'internationalisation' as the term most appropriately emphasising the efforts involved in the evolution of international research 1800–1945. Focusing on the actions and ambitions of individuals or groups shifts the attention from 'internationalism' as an ideology towards the process of internationalisation and leads to an abundance of interesting historical questions. As such, the introduction and the 16 papers open up an agenda for further research and present impressive insights gained from such a perspective that only recently has found its way into the history of mathematics.

Because of the many facets of the process of internationalisation, the authors' analyses are multidimensional and strongly intertwined. Perhaps, as a consequence, the individual papers are only implicitly organised by theme. Classical themes such as chronology and geography are intermingled with professionalisation, with international cooperation and conferences, or with the spread and translation of knowledge. Many thorough studies highlight aspects of mathematics at the 'centres' in France and Germany, whereas others address the transmissions of modern Western mathematics to either parts of the European periphery (the case of Spain is discussed by Ausebo and Hormigón and a particular case of import of Galois theory into Italy is described by Martini) or abroad—to USA (where the role of Dickson is discussed by Fenster) and Asia (the modernisation of Japanese mathematics is interestingly analysed by Sasaki, and China is examined in fascinating papers by Dauben and Xu). Even within Europe, the balance between France and Germany was a complicated one that shifted in