between the desire to align the history of computing with the historiographic trends of its parent discipline, and a manifest excitement about the exceptional nature of the first electronic computers developed in the mid-1940s, which Mahoney described as the result of a 'convergence' between the agendas of mathematical logic on the one hand and the development of mechanical calculation on the other.

Mahoney's substantive writings on the history of computing, which in this volume are grouped into two sections dealing with the history of software and software engineering and with the early history of theoretical computer science, paint on a similarly broad canvas. Working largely from the published technical literature, his approach is highly synoptic: a typical essay covers a lot of ground lightly, sketching a big picture and including many telling details and provocative observations, but leaving the reader with much to do to put flesh on the bones of the story.

One of Mahoney's most original and valuable observations was his recognition that the central artefacts in the history of computing are not the computers themselves, but rather the programs, both systems software and applications, written to run on them. After considering the practical problems of how to preserve and understand such artefacts, Mahoney turned to the emergence of software engineering, a development driven by the perception of a 'software crisis' in the 1960s and the ensuing desire to find predictable and manageable ways of producing software. He usefully relates this enterprise to other events in the history of American industry, such as Henry Ford's introduction of mass-production techniques in the automobile industry, analysing the way that various proponents of software engineering drew upon different aspects of the history of industrialization to provide models for the disciplining of the programming process.

The largest section of the book consists of a number of writings recounting the emergence of a mathematical theory of computing and software, from the development of theories of automata and formal languages in the mid-1950s through to the development of mathematical foundations for programming-language semantics in the early 1980s. Here Mahoney tells a story of scientific progress and developments in response to largely internal processes and problems that will mostly be familiar to workers in the field, and somewhat challenging to those without such background. An interesting theme in this section describes the reciprocal influence of computing on the development of mathematics, where it provided a new field of practical application for some of the most rarefied areas of twentieth-century mathematics such as universal algebra, formal logic and category theory.

These two histories, of software engineering and of theoretical computer science, occupied much of Mahoney's attention, and the reader can observe him revisiting key events and quotations, setting them in different perspectives as his understanding matures. They did not exhaust his interests, however, and this volume also includes essays on feminist approaches to computing, and the emergence of a computational science of nature, for example in the work of Stephen Wolfram.

One leaves this volume with something of the sense of having read a summary of a history that has yet to be written in detail. Mahoney provides useful guides to the territories he covers, however, and this book provides a valuable overview of the work of an influential pioneer in the field.

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EDEN MEDINA, **Cybernetic Revolutionaries: Technology and Politics in Allende's Chile**. Cambridge, MA and London: MIT Press, 2011. Pp. xv + 326. ISBN 978-0-262-01649-0. £22.95 (hardback).
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When the Popular Unity's candidate Salvador Allende came to power in 1971, he nationalized Chile's banks and industries, and the international corporate-political community responded, with US President Richard Nixon ordering the CIA to 'make the [Chilean] economy scream' (p. 45).

Foreign aid plummeted and foreign credit shrivelled, but Allende pressed on. Seeing science and technology as political instruments to shape Chile's socialist future, President Allende authorized his technical director of companies and trade, Fernando Flores, to commission British cybernetician Stafford Beer to design a computerized network linking factories and government management to monitor production and distribution, identify problems from the bottom up, and respond to needs in 'real time'. This became Project Cybersyn (Proyecto Synco). The Chilean and British designers are Eden Medina's 'cybernetic revolutionaries'.

Medina begins her technological, political, economic and cultural study of Project Cybersyn by providing context and a fuller history of the computerization of Chile, beginning in the 1960s. She then pieces together the story of what may be cybernetics' most ambitious endeavour, using it to explore if and how political goals might be embedded in a technological design, in this case the creation of a high-tech 'people's science' that would strengthen communication between labour and management. 'At stake', she writes, 'was the design of a computer system that would not only facilitate production in an economy in crisis but instantiate the Chilean vision of socialist democracy' (p. 69).

As for Stafford Beer, we learn, he ecstatically took on this task. Having spent years as a business management consultant, here was an opportunity to apply his ideas of the corporation as a nervous system to a national economy. (Beer published *Brain of the Firm* in 1972.) Beer based Project Cybersyn on his viable system model (VSM), or liberty machine, with the first level being the sensory input (the workers), then moving up to the cerebral cortex – that is, the highest-level management teams who would resolve the most complex problems from the capital, Santiago. After providing a history of Beer's career and a detailed description of VSM, Medina turns to Project Cybersyn's four major components: Cyberstride, CHECO, Cybernet and the Opsroom.

With her analysis of Cyberstride, the program software, and the Chilean Economic simulator (CHECO), the systems for building models and predicting trends, Medina delves into the story of cross-cultural tech transfer between British programmers and Chilean designers. Medina's analysis of Cybernet, the hardware 'internet', continues to explore technological, political and trans-national aspects affecting Cybersyn's full realization. The government owned only four mainframes and expansion would be difficult since manufacturers – IBM and Burroughs – had abandoned Chile upon Allende's election. Beer was given time on only one of these machines for Project Cybersyn. As for the Cybernet's nodes, the designers made do with what was available: a few hundred outdated telex machines connected factories up and down the coast to the computer in Santiago.

Medina's description of the high-tech Opsroom (operations room), where information was to be gathered and analysed and decisions were to be made, provides a valuable historical example of how industrial and graphic design can be engaged to articulate technological and political values; that is, to provide the 'image'. The hexagonal Opsroom, imagined as cybernetic socialist modernism, was to have a wall for electronic panels showing algedonic signals, Beer's homeostatic device for tracking production trends and the level of a problem's urgency. There were to be screens displaying data as modern graphs and flow diagrams. Control panels were to be built into the armrests of fibreglass swivel chairs and participants would have sat in a non-hierarchial circle. Yet this futuristic plan lacked access to the latest electronics and up-to-date information. Plus, women seemed left out of the design.

Pointing to how certain traditional ideas of class and gender were retained, Medina notes that large buttons on the Opsroom consoles were intended to accommodate workers' hands, while Beer forbade keyboards so as to 'eliminate the girl [typist] between themselves and the machinery' (p. 127). Cybersyn intended to establish worker–supervisor–government overseer communication, but even at the research stages, Medina reports, information-gathering engineers dispatched to factories ignored workers, interacting only with supervisors. Beer intended the communication

system to allow for more decision-making input by labour, yet the Chilean right claimed that 'Popular Unity Controls Us by Computer' (p. 185) and Beer's leftist colleagues (the British Society for Social Responsibility in Science) snidely reported, 'Chile: Everything under Control' (p. 191). Cold War pressures made socialism a wide target and Project Cybersyn was seen as 'Big Brother', exploiting the oppressive potential of cybernetic 'command and control'. Medina's detailed attention to internal and external stresses and judgements of the project is impressive. She also covers complex relationships between key figures, such as Flores's distancing himself from the project, as he took on the burden of the expanding threats of counterrevolution.

Project Cybersyn was never fully implemented. In 1972, however, it effectively helped to put down a crisis when a strike by truck owners and most of the professional class nearly paralysed the country and toppled Allende's regime. Medina offers a fascinating chapter on how the internet of telexes successfully transmitted information (reportedly two thousand messages a day) in near real time, allowing the government to keep goods and fuel moving. Here was evidence of Project Cybersyn's potential. But we know how the story ends. On 11 September 1973 General Augusto Pinochet's military forces storm the presidential palace. Allende dies. Project Cybersyn is abandoned.

In the epilogue, Medina tracks the whereabouts over the last thirty-five years of Project Cybersyn's main actors caught initially in Pinochet's dictatorship. Flores was imprisoned, would later lose interest in cybernetics, and then settled in Silicon Valley. Others end up in the UK, at Imperial College, for example. Beer, we read, 'worked tirelessly to get his friends out of Chile' and 'kept up these efforts until 1976, when the Pinochet government finally released Fernando Flores into exile (p. 225). The epigraph Medina chose for her prologue is taken from Beer's own assessment of Project Cybersyn in 1972: 'One day this will make quite a story' (p. 1). Indeed. With *Cybernetic Revolutionaries*, Eden Medina has provided a compelling analysis of an important chapter in the global history of cybernetics, one linking northern and southern hemispheres, and one that coincided with great political hope, then tragedy.

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Sally Smith Hughes, **Genentech: The Beginnings of Biotech**. Chicago and London: The University of Chicago Press, 2011. Pp. xv + 215. ISBN 978-0-226-35918-2. $25.00 (hardback).
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Sally Smith Hughes's *Genentech: The Beginnings of Biotech* is a history of the first academic–industrial 'start-up' firm dedicated to genetic engineering. Over six chapters, Hughes charts how Genentech quickly progressed from a decidedly small-scale enterprise in the late 1970s, with no dedicated location or facilities, to a multimillion-dollar company that enjoyed the fastest first-day gain in Wall Street history when its shares were publicly offered in 1980. Her approach throughout is largely biographical: drawing on oral histories to examine how Genentech's founders and early recruits determined which compounds to synthesize, negotiated federal guidelines on genetic techniques, and tried to combine academic and entrepreneurial values.

Chapter 1 looks at the prehistory of Genentech, detailing how the young biologists Herb Boyer and Stan Cohen were instrumental in the development of recombinant DNA techniques that allowed scientists to isolate, clone and express specific genes in microorganisms. The second chapter looks at Genentech's creation, as Boyer and the venture capitalist Robert Swanson explored ways to commercially exploit these new techniques. Hughes argues here that some younger biologists like Boyer were attracted to industrial collaborations during the 1970s, thanks to declining federal funding for basic research (although she acknowledges that others remained sceptical about 'selling out' to industry). Chapter 3 then outlines how a small