technologies, and they train students to view things this way. Indeed, few disciplines in the life sciences have experienced such a frantic pace of technical achievement as molecular biology. Progress since 1953 has been such that the lack of major discovery between 1965 and 1972 was perceived as a phase of crisis (p. 439 n. 33); the main breakthrough that followed (DNA sequencing) was permitted by technical developments, the fashioning of the methods of recombinant DNA. Hence technological innovation permeates the way actors perceive the history of their field and its future. This rhetoric provides the main foil of the *Black Box of Biology*. A recurring theme in Morange's treatment is that striking developments such as polymerase chain reaction methods are usually the extension of older experimental lines, whose earlier history he duly charts (which is probably what he means by his claim to focus on 'normal science' on p. 9). Similarly, when discussing intellectual developments in evolutionary (Chapter 23) or developmental (Chapter 22) biology, he tends to highlight continuities. Overall, *The Black Box of Biology* is a healthy antidote to overstatement.

Morange wanted to provide an account 'that is as complete as possible' (p. 5). Considering the sheer breadth of topics, he has largely succeeded in this ambition of reaching textbook comprehensiveness. Of course, completeness depends upon how one delimits one's area of inquiry. He is not particularly interested in the institutional, social or economic contexts of the developments under consideration and he limits himself to mentioning them when they are documented by other historians. The focus is on laboratories and achievements made in the United States, the United Kingdom and France; the reader will learn little about the settings and the spread of molecular-biology methods in other countries or geographical areas. One cannot take issue with their absence; they would have required another book, and another author. Other omissions are more relevant to the author's focus on experimental work. The new sections chronicle experimental lines of research as documented by the publication of important (or neglected) papers, with general comments on their novelty or continuity with earlier practices. However, this history of molecular biology gives little information on the training of scientists and technicians, on the timescale and hidden work involved in the design of experiments or on other material aspects of this experimental science. I for one regretted that the author did not draw more upon his practical experience as a biochemist and as a teacher to illuminate the material and social settings of these laboratories, which, he claims, are the same everywhere (p. 88).

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Johan Alfredo Linthorst, *Research between Science, Society and Politics: The History and Scientific Development of Green Chemistry*

Utrecht: Eburon, 2023. Pp. 268. ISBN 978-9-4630-1434-2. €36.00 (paperback).

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Research between Science, Society and Politics examines the international rise of 'green chemistry'. First emerging in the early 1990s, green chemistry, in the words of one of

its advocates, sought to make chemistry 'benign by design' (p. 68): to find new ways to produce chemical compounds that did not damage the environment. Despite this seemingly noble ambition, however, the definition of green chemistry and its nature are 'a matter of dispute' (p. 20). Linthorst attempts to navigate the complexities of how green chemistry emerged in different national contexts, while questioning whether 'green chemistry' is a simple buzzword or an emerging scientific subfield.

The book (a published PhD thesis) expands upon Linthorst's 2010 article 'An overview: origins and development of green chemistry' in *Foundations of Chemistry*, which noted an explosive growth in the use of the term in the natural sciences (alongside related synonyms such as clean chemistry, environmental chemistry and benign chemistry) beginning in the late 1990s. This article provided the rationale for an in-depth historical contextualization of the increasingly popular term 'green chemistry', with elements of the article appearing in *Research between Science, Society and Politics* in Chapters 2 and 5.

Following an introductory discussion of the literature around green chemistry in science and technology studies (STS), Linthorst provides three national case studies of green chemistry in action. Chapter 2 focuses on the United States, where the 'birth' of green chemistry occurred (p. 47). The publication of Rachel Carson's *Silent Spring* in 1962, Linthorst argues, marked the beginning of a series of critiques of the synthetic organic chemical industry in the United States and its environmental impact (pp. 47–8). Green chemistry emerged from this environmentalist context, nurtured by the Environmental Protection Agency (EPA) and the field of environmental chemistry (charged with detecting chemical pollution in the environment). For the EPA, a body targeted and suppressed by a series of right-wing administrations, funding green chemistry offered the potential of 'pollution prevention' by devising ways of producing non-toxic chemicals without releasing 'toxic by-products' (p. 66).

Chapter 3 moves to the United Kingdom, where a similar rationale for green chemistry emerged. In the 1980s, under the loose environmental regulations of Margaret Thatcher's premiership, the polluted nation gained the unenviable title of 'the dirty man of Europe' (p. 89). Public pressure and the influence of the European Economic Community, however, forced a change in the Thatcher government's position. By 1990, 'promoting clean technologies' (including green chemistry) was seen as a way of improving environmental standards without upsetting the 'commercial forces' that supposedly spurred technological progress (p. 100). James Clark, a chemist at York University, was a central advocate of clean technology and lobbied the Royal Society of Chemistry to launch the journal *Green Chemistry* in 1999 (p. 108). In the Netherlands, the case study of Chapter 4, green chemistry emerged in a rather different form. Here, 'sustainable' and 'green' chemistry were used interchangeably and often referred to finding renewable 'feedstock' (the raw material used to produce chemical products). This could imply, for example, the substitution of petrochemicals with biomass (p. 134).

Research between Science, Society and Politics contains a significant range of sources, including interviews with leading advocates of green chemistry and sources from the archives and periodicals of chemistry societies. The book will likely be of interest to scholars of pollution, sustainability and environmental chemistry. However, it does not contain an index, making it impossible to look up specific information. Historians of science might also consider jumping ahead to Chapter 5, which discusses the intellectual and conceptual origins of green chemistry. It would have made more sense to bring this chapter forward, as the book currently assumes a level of knowledge of green chemistry that only specialized scholars would possess.

At the heart of *Research between Science, Society and Politics* is the question of what green chemistry is. Is it a buzzword, a subfield of chemistry or a scientific revolution in progress? Linthorst concludes that green chemistry has not followed the 'development path of a

traditional scientific speciality' and is certainly not a Kuhnian 'scientific revolution' (pp. 198, 200). 'Green chemistry' instead acts as an umbrella term which hosts many different scientists working on many different problems. Linthorst does recognize that STS scholars have argued that green chemistry is a form of 'greenwashing' (pp. 27–8). The promise of green chemistry has undeniably acted as a get-out-of-jail-free card for the chemical industry and national governments, enabling them to portray the future of commercial chemistry in a positive light without regulating it in the present. In the Anthropocene, when unregulated corporations threaten the very ecosystems on which the survival of our species (and of all others on Earth) depends, a more critical take on industry-funded sciences like green chemistry would not be untimely (p. 67). Yet Linthorst resists the label of greenwashing, insisting at one point that some green chemists are 'good-willing' and 'have been producing valuable chemical knowledge to tackle environmental problems' (p. 201). This may well be true, but does not exonerate chemists from the charge of greenwashing. As the old saying goes, the road to hell is paved with good intentions.

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Marco Tamborini, *The Architecture of Evolution: The Science of Form in Twentieth-Century Evolutionary Biology*

Pittsburgh: University of Pittsburgh Press, 2022. Pp. 283. ISBN: 978-0-8229-4735-6. $455.00 (hardcover).

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> Alternative approaches to evolutionary theory do exist, often with long pedigrees in largely continental traditions: evolution is not co-extensive with adaptationist preferences in explanation … D'Arcy Thompson kept the structuralist vision alive, with an explicitly anti-Darwinian evolutionary version, in the finest work of prose in English natural history.
>
> Stephen Gould, 'On growth and form', in *Evolution* (1998), pp. 23–4.

Marco Tamborini's *The Architecture of Evolution* explores, and attempts to identify, the contrasting recent historical developments in Continental and anglophone approaches to animal morphology – the science of form – particularly from a modern German perspective. Tamborini's goal is to stress 'the deep intersections between philosophical theories, morphological practices, and architectural design' (p. 205) in order to argue that 'what biologists eventually accepted and firmly defended was no longer Goethe's idea of grounding morphology as an independent science. Rather, '*morphology was reimagined as a transdisciplinary methodology at the boundary between biology, engineering, and literature*' (p. 208, emphasis added).

If there is one central concept it is 'constraint', although a number of others are invoked in the book – such as evolvability, modularity, burden and heterochrony. Such quasi-mechanistic terms took over from non-vitalistic concepts such as *Bauplan*, *Gestalt*, holism and organicism as explanatory factors in the evolution of the complexity of anatomical forms. Tamborini writes, 'The debate about the number and kind of mechanisms