

**Joan Steigerwald 2019: *Experimenting at the Boundaries of Life: Organic Vitality in Germany around 1800*, Pittsburgh: University of Pittsburgh Press, geb., ix+460 S., 55,00 US\$, ISBN-13: 978-0822945536.**

**Andrew Reynolds 2018: *The Third Lens. Metaphor and the Creation of Modern Cell Biology*, Chicago: University of Chicago Press, brosch., 272 S., 17 Abb., 30,00 US\$, ISBN: 9780226563268.**

**Grote, Mathias (2019): *Membranes to Molecular Machines: Active Matter and the Remaking of Life*, geb., 296 S., 27 Abb., 45 US\$, Chicago: University of Chicago Press, ISBN: 9780226625157.**

If we took these three books as a snapshot, we would have to admit that the history and philosophy of science in general, and of biology in particular, is in embarrassingly good shape. Broad in historical and philosophical scope, dealing with interdisciplinary questions in appropriately interdisciplinary ways, deeply engaged with the critical literatures that inform them, it has been an absolute pleasure to think with each of them.

Joan Steigerwald has written an amazing book, which will attract a wide and ready readership. Its goal is to radically reform mainstream historical understanding of biological science's intertwined origins with eighteenth century German philosophy. While of course giving due credit to the historiographical footsteps in which she is therefore walking, Steigerwald has nevertheless gone further than earlier historians to animate the cross-cutting philosophical and experimental discussions which these actors engaged in, and to such a degree that they become too useful to ignore. Her core notion of 'boundaries of life' offers a novel and powerful means by which to organise much of the history of biology.

An introductory chapter articulates the historiographical ambition, to give back to late eighteenth century reasoning about life much of its epistemological depth, its direct interconnection with the material investigation of living stuff (and reasoning about those means of investigation), alongside novel schemes of experimentation. The overall effect is—hopefully—to demonstrate how boundary concepts (more on these shortly) were productive not only at boundaries between a nascent biology and idealist philosophy, but also played a role within that biology, helping to justify and create space for its independent investigation. Chapter 1 establishes our historical context, tracing some of the ways in which organic vitality was made a subject of concerted attention in the second half of the century. Chapter 2 creates broad grounds for revisionism by taking an in-depth look at Kant's reasoning about reasoning, demonstrating how biology—a subject which otherwise defied his schemes—required novel solutions. Both of the key aspects of his argument—the need to understand organisms as means and ends, and the need for subjective judgement in addressing them—became a highly influential analytical scheme for researchers of organic vitality (118–120).

In Chapter 3 we get to grips with those titular boundaries of life. Particular attention is given to instrumentation and experimentation, finding examples in the work of Humboldt, Ritter, Johann Christian Reil, and Carl Friedrich Kielmeyer, while also recognising the influence of figures such as Galvani and Volta. The boundaries discussed are multiple, including those between the living and non-living, between instrumentation and phenomena, between the terrestrial and subterranean (mining and mine inspection is a persistent feature throughout

the book), and between organism and environment. In Chapter 4 the intertwining of philosophical reflection on life with investigation of organic materials is deepened through attention to cultures of scholarship converging on the University of Jena. Chapter 5 addresses boundaries in the hands of Friedrich Wilhelm Joseph Schelling. This chapter more than the others speaks first to philosophers and historians of philosophy. It's most generally important function is to add layers to what boundaries might be conceptually, therefore what their presence might indicate to investigators, and so how the historian can think with them. The final substantive chapter, Chapter 6, synthesises what has been argued throughout in order to provide a comprehensive picture of organic theorising in the early nineteenth century.

Steigerwald's boundaries also help to explain why biologists, and the historian and philosopher of biology, might find cells and membranes so stimulating. Her book offers a platform for the overall history of biology within which we can interpret Reynolds' and Grote's books as exploring in greater depth two of its core themes, respectively the metaphorical and the material.

As with Steigerwald, Reynolds well knows the historiographical and philosophical pioneers whose footsteps he is treading in when it comes to the topic of his research, in his case concerning the presence of metaphor in biological science. The great strength of *The Third Lens* is the systematicity with which it finds and collects metaphors, and the author's ability to connect examples to the context of debate in which they either originally mattered or have since ceased to matter.

An introductory chapter provides an overview of the status of metaphor in histories and philosophies of science, with particular attention to biology. He also briefly establishes a framework, a form of pragmatism particularly alert to realist concerns, which apparently guided his research. This framework however is used lightly, only returned to and further fleshed out in the final two chapters. Chapter 1 provides an overall historical landscape in which to situate the book's subsequent case studies, beginning in the seventeenth century and ending in the mid-twentieth century. This chapter is remarkable for its economy and deftness. Chapter 2 pursues our first cases, concerning physiological researchers who cast the cell or its components variously as a "laboratory, factory, battery or an electric motor" (60). Reynolds' key argument is that metaphors have prescriptive as well as descriptive qualities. Chapter 3 discusses the times in which cells have been composed as societies. The chapter's primary message is that the same scientist can hold onto wildly different metaphors depending on their immediate concerns, even when those metaphors appear incompatible (111). Chapter 4 picks up on a briefly discussed element of Chapter 3, the emergence of cell signalling as a research field, one replete with engineering metaphors. This chapter argues that finding new metaphors, and pushing them to their very limits (that is, beyond the immediate ways in which they might be thought appropriate) not only helps to organise science, but is also one way in which sciences are developed. Chapter 5 is the first of two chapters not directed at particular cases, but offering more of an analytical framework. Here he discusses the kinds of metaphor which are typically used to explain the function of metaphor within science, his own preferred metaphor being that of a cognitive 'tool'. This of course loops back to the monograph's pragmatist beginnings. The final chapter then pursues a discussion of metaphors in relation to realism, one that is eclectic and relies on a distinction between literal truth and objective truth.

In terms of restating the case for metaphors as playing an epistemic role in science, one amenable to historical and philosophical analysis, *The Third Lens* is a most helpful resource, updating the discussion and reviving possible lines of future analysis. However, an aspect of this book's framing raises an important issue. I think Reynolds' sets himself an unhelpful challenge, by measuring metaphor's importance against older, normative, philosophical criteria. I interpret Reynolds as assuming that metaphor must do something peculiar, independent, and which could be redescribed as essentially cognitive or logical, in order for it to be incorporated as a functional component of scientific epistemology. This assumption forces Reynolds into some unnecessarily strong claims, such that metaphors might play a constraining role in scientific research all on their own. They might. But, following seminal work in the 1960s by Mary Hesse and others, we do not need this claim to know that we should attend to their role in specific cases, each of which might produce different results. Reynolds recognises this at numerous points throughout the book, after all, he is not discussing the way scientists use metaphor entirely in isolation of parallel developments. Ultimately then, we do not need the strong claim when we might instead tie metaphor together with further features of scientific life, practice, and context. With metaphor we also need the material, and both are stronger for it.

Grote blends insights and interests across the history, philosophy, and social study of twentieth century biology, with the additional explicit intention that these can also inform understanding of biological science in the present. As with *The Third Lens*, Grote recognises a plethora of metaphors within molecular and cell biology, but treats these as requiring parallel historical analysis and explanation to those which Reynolds adopts. Here we focus on the history of methods, instruments, and experimental materials which have inspired, or been inspired by, metaphors and analogies with machines, mechanisms, and pumps. While in general this approach might sound very familiar to historians and philosophers of science, the specific way in which Grote achieves this study is quite novel. Rather than looking for a particular question, technique, or puzzle which organised research in his communities of interest, c.1970s-1990s, he instead pursues a 'genealogy of practices' (145). For sure, these practices are recovered through a linear focal point, with Angela Creager's multi-angled history of Tobacco Mosaic Virus (TMV) acting as a direct model for Grote's multi-angled history of the protein-membrane bacteriorhodopsin (BR), but what the practices surrounding BR ultimately amount to become much more lateral and layered.

"This book's leading question will be to find out precisely how, in the last quarter of the twentieth century, the life sciences came to consider cells and their substructures as such 'molecular landscapes,' i.e., as ordered arrangements of molecular machinery" (6) The additional benefits that arise include the finding of alternative paths through twentieth century biology, which do not keep genes at their centre, and a means of preparing oneself to receive the variety of machine, engineering, and mechanistic terms present in twenty-first century biology without assigning them all too readily to rhetoric, language, or metaphor alone. This first chapter also introduces us to the particular proton 'pump' BR, which the book follows into different contexts. From the outset Grote's agenda gains support from both Reynolds' and Steigerwald's books, the former for recognising the importance and productivity of metaphor, the latter for wanting to deconstruct simplistic antagonisms between 'mechanism' and 'vitalism'.

Chapter 1 first sets out why the historian and philosopher of science might attend to membranes. We could very well be in Steigerwald's eighteenth century, "stories from membrane research challenge distinctions such as those between the living and the unenlivened, or the "natural" and the "synthetic" (32). Chapter 2 introduces *Halobacterium*, the purple microorganism whose membrane, thanks to being particularly visible in the electron microscope, suggested a number of lines of research for structural and biochemical studies. Chapter 3 considers some of the wider effects of these developments, for how researchers understood living things to work at molecular scales, and with the array of instruments and novel chemical techniques which both inspired and made possible what he calls a 'plug-and-play' approach to *Stoff* throughout the remainder of the twentieth century. *Stoff* is Grote's preferred term for the material biological and non-biological things in question, a choice of terminology intended to capture blurred living/non-living materials, but which (having read Steigerwald) I could not extract for myself from the long history of terms used to describe living matter. Of course, in addition, Grote is well aware that aspects of this plug-and-play culture have either remained in, or been rediscovered within, biology, in the form of synthetic biology. Chapter 4 looks through membranes from another perspective, demonstrating how a world of functioning molecular machines simultaneously inspired new visions for biology as technology, in particular the possibility of creating 'biochips'. A fifth and final chapter summarises Grote's arguments at methodological and historiographical levels.

In the wild we might expect Steigerwald, Reynolds, and Grote to run free and thrive in quite different habitats. Nevertheless, I hope to have demonstrated that putting them together in captivity (even if only for a short while) can be very rewarding.

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