

stories and objects are interesting, but there are simply too many to make this a casual read. The risk of overwhelming the reader is compounded by intermittent signposting, in particular the lack of real introduction or conclusion to any of the chapters. The net result feels like reading a peculiarly themed build-your-own-adventure story from cover to cover, rather than following any of the singular plot paths offered.

This is a shame, because many of these narratives are of great interest in their own right. Some, such as the formation of cosmology as an observational discipline, have been told in more detail elsewhere (in particular in the work of Helge Kragh). However, others are greatly enhanced by the personal narration of Graham-Smith. Anecdotal mentions only appear infrequently, but still serve to convey the unpredictability and excitement which clearly permeated the field. His description of the tracking of Cygnus A by observatories in Cambridge, Jodrell Bank and Australia – ‘the moment when radio astronomy showed its potential in observational cosmology’ – points to a time of continual trying-and-finding, and shows the importance of multi-location collaboration while subtly hinting at the drive of competition (pp. 85–90). Equally, many interesting segments arise from the author’s expertise in the factors which set radio astronomy apart from other techniques of astronomical surveillance. In particular, there are fascinating technical challenges around the size required of the apertures, leading to the international development of kilometre-sized connected arrays (pp. 187–223). These could, if arranged more clearly, prove excellent grist to an internalist historian’s mill.

But these criticisms are perhaps unfair given that this is a work intended as popular physics – which brings us back to the problem of audience. In a work of this subject matter, it is perhaps difficult to know whether readers are looking for personal stories to flesh out the physics bones, or for a focused account of a particular scientific field. But in order to include all those narratives, this book would have benefited from an alternative format – perhaps some way of distinguishing discussions of natural and technical objects, or separating different levels of detail, or a way of visually tracing the recurrent stories. As it is, I suspect that only a select proportion of readers could really engage with all the material; personally speaking, even degree-level physics knowledge was not sufficient equipment. If the only reader who can mentally catalogue the oncoming stream of information is an already astronomy-literate one looking to broaden their knowledge, then we must ask the question of what the book adds over a series of Wikipedia searches. One answer to this question is the charming glimpses into Graham-Smith’s personal enthusiasm. But in this case enthusiasm needs to be balanced with control of the subject matter, tighter editing and much greater awareness of the recipient. It is a cliché that too much expertise can inhibit the ability to teach, but this work seems to be a case in point.

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CATELIJNE COOPMANS, JANET VERTESI, MICHAEL LYNCH and STEVE WOOLGAR (eds.), **Representation in Scientific Practice Revisited**. Cambridge, MA: MIT Press, 2014. Pp. ix + 366. ISBN 978-0-262-52538-1. £24.95 (paperback).

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Entangled hybrids, material and corporeal enactment, ephemeral instruments, qualitative versus quantitative negotiation, dynamic simulation, incorporated measurement and the ethics of digitization – these are just a handful of the themes that emerge in *Representation in Scientific Practice Revisited*. The volume, edited by Cateelijne Coopmans, Janet Vertesi, Michael Lynch and Steve Woolgar, takes stock of the manifold approaches to scientific imaging that have emerged in the twenty-five years since Lynch and Woolgar published *Representation in Scientific Practice* (1990). If the earlier volume awakened a consciousness about graphic intervention, this collection of essays lays bare two important vectors along which such study has expanded: first, the profusion

of visualization techniques that complicate the production of contemporary scientific knowledge; second, the multiplicity of ethnographic, sociological, phenomenological and descriptive hermeneutics with which to examine those techniques. In thirteen chapters and eight responses, the volume's authors cut paths through contemporary fields as varied as nanotechnology, mathematics, space exploration, computational biology, economics, neuroscience and law. As a result, all of *Revisited's* readers will find themselves on a number of interdisciplinary excursions, learning manifold ways of approaching the images that comprise so much of scientific practice.

A number of authors do this with particular insight. Janet Vertesi examines how Mars Rover scientists process the same photograph in myriad ways. She lands on a new conceptual approach – 'drawing as' – which finds theory in imaging as each practitioner enacts a 'purposeful visual construal' (p. 17) of his or her objects of analysis (whether Galileo drawing a telescoped moon, or the teams working on the Rover's 'pancams'). Via Merleau-Ponty's 'habit-body', Rachel Prentice observes that delicate shifts of embodied skill and mediating technologies make for a 'taking place' (p. 91) in which surgeons can now perform minimally invasive cuts into their patients. Michael Barany and Donald MacKenzie's account of chalk, blackboards and scrap paper in contemporary mathematics probes how analytical rigour and atypical co-understanding are constituted by the mundane, the short-lived and even a 'self-effacing materiality' (p. 107). In stressing the difference between representing according to convention and representing in order to break convention altogether, Cyrus Mody offers a revelatory window onto imaging disputes in the earliest days of nanotechnology. And most provocative is a set of illustrations in Morana Alac's article on teaching student workers to extract meaningful data from fMRI machines for cognitive neuroscience. Produced by the author herself, these pictures distill real-time conversations between Alac's ethnographic subjects into contour drawings, lines of dialogue and descriptions of gestures akin to stage directions. Whether the effect was intended or not, those five figures invite scholars to work reflexively with graphic representation. That is, they pose a cogent question: might visualization present yet another medium for scholarly analysis – one that those who write about the scientific image have explored little of as yet?

What all *Revisited's* contributors do explore is the vexed question of representation. Taken to be synonymous with mimesis and reference, the word remains a bogeyman, assumed to be a pale adjunct to a world 'out there'. Many of this book's contributors – Vertesi's, Mody's, and Barany and MacKenzie's contributions being notable exceptions – dispense with the term altogether, and subscribe to an alternative view. Sometimes refined through Donna Haraway's term 'worlding' or Jakob von Uexküll's *Umwelt*, this alternative sees virtual realities and digital models as consequential things that meaningfully, and even physically, construct the world. Lorraine Daston echoes these sentiments, and, in calling for representation's retirement, also encourages a pivot away from epistemology and towards ontology. Steve Woolgar then stands back and asks, 'To what extent are epistemology and ontology distinct?' (p. 331). And Lucy Suchman completes the deed by assessing the dialectic at play: 'Knowing subjects and objects known, in other words – the distinction that underwrites the classic Western philosophical differentiation of epistemology from ontology – are mutually constituted, including in their enactment as separate things' (p. 333). Could it be, then, that representation is itself a kind of 'worlding' – just one of ontology's many epistemic forms?

To this gauntlet we might also add the question of history. The intricacies of producing scientific knowledge – a result, paradoxically, of both academic specialization and interdisciplinarity – also leave one wondering about the contemporary cultural pressures exerted on these fields. What does the Mars Rover team's switching between visualizations – and extracting different information from varying pictures of the terrain – say about the premium placed on manipulability in our digital age? Is there an epistemic difference between chalk on a blackboard and markers on a whiteboard? Why have microbiologists become dependent on analogizing cells as machines –

and even erasing the boundary between the two? Is there anything particular about the twenty-first century's obsessions with engineering that can explain this? Are computational biologists coopting any procedures of filmmaking when they turn to their microscopic camera to observe the spatio-temporal mechanisms of the heart? That such questions can be raised not only throws light on the ample opportunities for inquiry that remain, but also reveals the great distance travelled beyond initial approaches to scientific imaging, such as Bruno Latour's 'immutable mobiles'. Indeed, as *Revisited* demonstrates so well, change, alterity, variety and the mobility they entail guide today's most vital engagement with science and its pictures.

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