Grasping the Technical Image

BY EVAN HEPLER-SMITH*

HORST BREDEKAMP, VERA DÜNKEL, and BIRGIT SCHNEIDER, Eds. *The Technical Image: A History of Styles in Scientific Imagery*. Chicago: University of Chicago Press, published in association with the Bard Graduate Center, 2015. x + 198 pp., illus., index. ISBN 978-0-226-25884-3. $50.00 (hardcover).

KLAUS HENTSCHEL. *Visual Cultures in Science and Technology: A Comparative History*. Oxford: Oxford University Press, 2014. x + 496 pp., illus., index. ISBN 978-0-19-871787-4. $99.95 (hardcover).

JANET VERTESI. *Seeing like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars*. Chicago: University of Chicago Press, 2015. xi + 318 pp., illus., index. ISBN 978-0-226-15596-8. $35.00 (hardcover).

NATASHA MYERS. *Rendering Life Molecular: Models, Modelers, and Excitable Matter*. Durham: Duke University Press, 2015. xvi + 308 pp., illus., index. ISBN 978-0-8223-5878-7. $26.95 (paper).

Once upon a time, in the 1970s, there was no "strong intellectual tradition in which visual modes of communication are accepted as essential for the historical analysis and understanding of scientific knowledge." The idea of visual thinking in science was "apt to seem strange and even incomprehensible." "Acceptance of the conceptual importance of *visual* modes of discourse," it appeared, would "require a rather fundamental change of intellectual values within the history of science."[1]

*Harvard University Center for the Environment, 1 Oxford St. SC371, Cambridge, MA 02138, hepler@fas.harvard.edu

1. Martin J. S. Rudwick, "The Emergence of a Visual Language for Geological Science 1760–1840," *History of Science* 14, no. 3 (1976): 149, 150, 182 n4.

Things have changed. Over the past four decades, historians of science have developed a rich and varied analytical language for the study of scientific visuality. The 1976 essay lamenting the lack of such a historiographic tradition, Martin Rudwick's "The Emergence of a Visual Language for Geological Science," is now often cited as its founding document.[2] The verdict is in: technical images are worthy objects of study. What methods for studying them can we distill from this mass of scholarship? How can we use the study of scientific imagery to answer other sorts of historical questions?

One might start with the images themselves. This is the approach of *The Technical Image: A History of Styles in Scientific Imagery*, a collection that aims to "serve as a textbook of methodology" for the study of visual representation (3). First published as *Das Technische Bild* (2008), the beautifully produced English translation includes much new and revised material, but retains the distinctive organization of the original German edition. Three introductory essays are followed by ten historical case studies, arranged in reverse chronological order from the contemporary to the early modern period, addressing subjects familiar (x-rays, natural historical illustrations) and less so (weavers' notation, industrial photoessays). Interspersed among these chapters are short bibliographic essays on key concepts in the study of technical images, drawing together theoretical discourses of art history ("Arranging Images as Tableaux") and science studies ("Chains of Representations"). The book concludes with a substantial bibliography of "essential contributions to the scholarship on scientific imagery," grouped into a dozen subject areas.

The contributors to *The Technical Image* approach the study of technical images from a perspective "firmly rooted in the methods of art history" (1). Their objects of inquiry are the characteristic forms of visual representation in science; this is, as the book's subtitle announces, a history of *styles*. Style, writes Horst Bredekamp, coeditor of the volume and founder of the research project from which it emerged, denotes "recognizably shared traits of created forms that transcend the individual producer" (18). To study images in this way tends to blur or elide the historical specificity of individual images, the editors acknowledge. On the other hand, the study of styles affords access to the creative as well as the created aspects of scientific imagery. "An image not only displays the symptoms and results of a thought style," they write, citing

2. Sachiko Kusukawa, "Classics from This Journal: Martin Rudwick's 'The Emergence of a Visual Language for Geological Science 1760–1840'," *History of Science* 54, no. 1 (2016): 98–104.

Ludwik Fleck, "but also constitutes that style with a quasi-objective power that seems to transcend the work of any individual" (3).

The bibliographic essays and case studies respectively outline and exemplify particular methods for stylistic analysis. For example, the essay on "iconological analysis" describes a three-stage model of formal description, iconographic analysis, and ascription of historical meaning, as developed in the work of the art historians Aby Warburg and Erwin Panofsky (32–35). Reinhard Wendler puts the method to work in a chapter addressing the graphic design of James Watson's textbook *The Molecular Biology of the Gene*. Wendler's vivid description of the design of virus illustrations demonstrates the effectiveness of iconological analysis for mobilizing visual evidence (74–76).

There is a danger in this approach. In adopting formal description as a starting point, the history of styles trades on the rhetorical power of a view from nowhere. As Bredekamp writes, "we stake our endeavor on a naïveté that, needless to say, we no longer possess and that we nonetheless need to invoke in order to begin afresh time and again" (23). Yet an analysis that takes images as transcending the particulars of their production leaves room for the analyst's own particulars to come into play. The historian Nick Wilding has argued that this aspect of stylistic analysis led Bredekamp to judge as authentic a Galileo text that Wilding later showed to have been forged.[3]

Several contributors to *The Technical Image* productively explore the limits of the method. In her study of apparatuses for producing evanescent optical phenomena, Franziska Brons seeks "to avoid mistaking the contingencies of a tradition handed down to us in the form of physical pictures for the many facets and factors of the history of the image" (103). An essay on "Image Noise" advocates attending not only to images selected as right representations but also to "the forms of technically impaired images" (139). The history of styles offers analytical resources for sounding its own methodological borders and, perhaps, for broadening them.

3. Nick Wilding, "Review: Irene Brückle, Oliver Hahn, and Horst Bredekamp, eds., *Galileo's Sidereus Nuncius: A Comparison of the Proof Copy (New York) with Other Paradigmatic Copies*; Paul Needham and Horst Bredekamp, eds., *Galileo Makes a Book: The First Edition of Sidereus Nuncius, Venice 1610*," *Renaissance Quarterly* 65, no. 1 (2012): 217–218; Horst Bredekamp, Irene Brückle, and Paul Needham, eds., *A Galileo Forgery: Unmasking the New York Sidereus Nuncius* (Berlin: Walter De Gruyter, 2014); Nick Wilding, "Review: Horst Bredekamp, Irene Brückle, and Paul Needham, eds., *A Galileo Forgery: Unmasking the New York Sidereus Nuncius*," *Renaissance Quarterly* 67, no. 4 (2014): 1337–1340.

A complementary historiographic approach focuses on image-making and image-makers. Where do conventions of visual representation in science come from? Who or what perpetuates them? When and why do they change? Klaus Hentschel addresses these questions in *Visual Cultures in Science and Technology: A Comparative History*. "Comparative" is an understatement. In pursuit of "an integrative view on recurrently noted general features of visual cultures in science and technology" (1), Hentschel delves into about two thousand sources (most of them secondary) spanning a wide range of subjects and disciplines.

The introduction begins with a five-page history of the concept of "culture," and indeed, culture is Hentschel's quarry. The book draws together accounts of the creation and perpetuation of conventions for making and interpreting scientific images. Hentschel alternates between discussion of "visual cultures" and more fine-grained analogs, "visual domains," which he defines, with a nod to Fleck, as "joint predilections for certain types of images, patterns, or recording techniques" (27, 83). In the introduction, Hentschel explores a host of insights that members of various disciplines—art history and gestalt psychology, along with history, sociology, and philosophy of science—have contributed to the study of visual cultures of science. (Hentschel's condensed list of two dozen of these "important and lasting insights" [70–72] is quite useful.) In a brief second chapter, he lays out a set of nine superimposed layers that he takes to comprise visual culture: pattern recognition, practical training in the arts, and other features "present in very many case studies in science and technology" (84). Three subsequent chapters trace the formation of visual cultures of science, drawing upon numerous examples from the historiography of science. The remaining half of the book explores Hentschel's nine layers of visual culture, again by means of examples gleaned from a wide range of secondary literature. (Like the contributors to *The Technical Image*, Hentschel draws the vast majority of his examples from early modern through contemporary Europe and America; historians interested in the visual cultures of premodern and non-Western science will need to look elsewhere.)

Hentschel argues that visual domains come into being when "pioneers"—individuals trained within artisanal traditions or practical fields such as architecture—import modes of visuality from these fields into the natural sciences (159). Often, these visual domains are soon swept away by newly imported visual techniques. Occasionally, however, they take hold within a field of science, achieving "long-term stability by slow adaptation and amalgamation in everyday practices" (167).

As a corollary to this argument, Hentschel advocates paying special attention to the social and educational background of pioneers of visual culture, and to the artisans who carry out the slow work of adaptation and amalgamation in the everyday labor of crafting scientific images. The spotlight that Hentschel casts on members of the latter group, a diverse cast of woodcutters, illustrators, illuminators, and other technicians, is a particular strength of the book. (Hentschel has developed an invaluable online database of such figures, containing entries for more than 10,000 illustrators active from the mid-fifteenth to the mid-twentieth century.[4])

Inter alia, Hentschel touches upon geology, spectroscopy, thermodynamics, CT scans, gravitation, paleontology, the kangaroo, the English balance of trade, Dürer, Martian canals, an instrument for measuring the color of the sky, and appropriately enough, cabinets of curiosities. There is something here for everyone and enough to leave anyone with historical whiplash. A bit of patient browsing, however, yields unexpected treasures: decades-old scholarship on "drawing after models" in German technical education, for example, an intriguing intersection of the histories of modeling, visual reasoning, and pedagogy (274).

If *The Technical Image* constitutes a morphological study of scientific imagery, *Visual Cultures in Science and Technology* outlines a kind of evolutionary natural history of visual culture, attending to mechanisms of variation (the social background of "pioneers" and their movement into new fields) and of reproduction (pedagogy, the work of illustrators). These complementary paths through the visual historiography of science share the underlying premise that scientific imagery has a life of its own.

Ethnographies by the sociologist Janet Vertesi and the anthropologist Natasha Myers take the study of scientific imagery in a different direction. Attending to visual practices alongside other aspects of science in action, they use specific, concrete stories about images and image-work to account for the formation of scientific collectives and scientific selves. In the process, by heeding what lies behind and beside visual representations, they call attention to the essential role of the non-visual—mathematics, affect, kinesthetic embodiment—in the making and use of scientific images.

In *Seeing Like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars*, Vertesi delves into the work of an interdisciplinary team of planetary

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4. *Database of Scientific Illustrators, 1450–1950*, http://www.uni-stuttgart.de/hi/gnt/dsi/ (accessed 29 Sep 2016).

scientists studying the surface of Mars. Trained in different disciplines, employing different methods, seeking to answer different research questions, these scientists shared two precious instruments: robot Rovers, equipped with digital cameras, traversing the Martian surface. For the members of the Rover project, "'doing science' on another planet," was a matter of sophisticated digital image processing and just as sophisticated teamwork.

Vertesi shows that these signal features of Mars Rover science are intimately linked: "images in interaction are central to the production of the team's social order" (15). Drawing on fieldwork conducted from 2006–2008, Vertesi aims to "shift analytical attention from the images themselves to *the work of scientific representation*" (8, author's italics). Operating in an ethnomethodological mode, Vertesi considered images and their production and reception in the thick of the interactions through which they took on meaning for her subjects. "[I]t is only through constant interaction—with image-processing software suites, with teammates, and with robots—that team members can conduct their science, operate their robots, and produce knowledge about the Red Planet" (14).

Her book is organized according to the life cycle of these images. Successive chapters (all of them filled with color plates) address planning the acquisition of photographs, making transmissions from Mars into research data and research data into meaningful images, and employing images to make a case for what Mars is like, where the Rovers should go next, and why the public ought to keep funding the whole enterprise.

Interwoven throughout is the story of "Susan," "Tyrone," and *Spirit*: respectively, a mission scientist, a treacherous tract of Martian soil, and a rover whose faulty wheel dug a furrow through this soil and whose cameras captured an image of it. While training in the use of the project's image-processing software, Susan noticed that amplifying certain spectra produced a two-toned version of this image. To Susan, a soil chemist, this suggested a material difference between two strata of soil, possible evidence of an ancient Martian hot spring—an environment hospitable to life.

Such argument by image manipulation, Vertesi shows, is a ubiquitous feature of the Rover project. Vertesi calls it "drawing as," on analogy with the experience of *seeing* a static gestalt image *as* its various forms—as a duck or as a rabbit, in the iconic example. One of Vertesi's informants describes the duality thus: "The image never changes, but you can manipulate the image, and everyone sees something different" (80–81). In drawing the soil in Tyrone *as* two distinct substances, Susan formulated and supported a claim for the existence of a geological feature of the Martian past.

Internal debates over Susan's hypothesis mixed epistemology and equity. Was Susan's claim credible, and should the team reallocate the precious resource of Rover time to follow up on it? The Rover scientists worked toward consensus by means of countless images—"the visual equivalent of drinking from a fire hose," one of Vertesi's informants called it (5). Using images to persuade and train each other to draw and see Mars in new ways, the project scientists produced a common point of view, literally and figuratively. As Vertesi puts it, "seeing like a Rover binds these scientists, engineers, and robots into a single collective team" (7).

The connection between visual epistemology and social order is no surprise. Vertesi's achievement lies in illuminating the particular images and interactions by which her subjects constituted knowledge and their scientific collective. As Hentschel's survey demonstrates, histories of scientific visuality tend to account for both images and image-making as social achievements; Vertesi reverses this explanatory move. For the Rover collective, she shows, "social work is also largely achieved through image work" (244).

If the work of image-making can produce a scientific collective, it can also form the scientific self. In *Rendering Life Molecular*, Natasha Myers follows protein modelers in training as they crystallize proteins and subject them to x-rays, build diverse three-dimensional models from crystallographic data, evaluate the reliability of both models and modelers, and animate biochemical objects as molecular machines with minds of their own.

"The visual cultures of science must be understood simultaneously as performance cultures," Myers insists (5). Working her way through the making of protein science and protein scientists, Myers addresses each stage of this process as a kind of "rendering," a term that she adopts to capture modeling as a constructive, embodied enterprise. Crystallographers "do not 'see' molecules or produce 'images' of biological phenomena; rather, they *make* models to *render* the molecular world visible, tangible, and workable" (18).

One strand of this argument is ontological. Renderings of proteins are "performative," Myers contends; they "make the world molecular" (19). Here, we are on similar ground to the practice of "drawing as" that, as Vertesi puts it, makes "epistemology look like ontology" (87). However, Myers shows that protein modelers are individually responsible for establishing the conditions under which novel scientific objects can be made.

A more provocative argument lies here, in Myers' account of the painstaking fashioning of both models and modelers. The path from impure materials to crystal structure is long and challenging, requiring "modelers to get fully

entangled with their instruments and materials as they rend imperceptible substances into visible and palpable forms" (71). Such intimate entanglements can last years. Attending to the experiences of students in the midst of this painstaking procedure, Myers shows that modeling entails affective labor as well as visual reasoning. The crystallographer Max Perutz described model-building as "falling in love"; one of Myers' informants compares the completion of a model to the birth of a child (113–114). A disinterested relationship between modelers and molecules, on the other hand, begot an error so notorious that it became known as "The Great Pentaretraction" (136–140). Objective modeling, Myers argues, is a matter of caring for and caring about the object. For protein modelers, "objectivity names the peculiar ecology of moral and affective entanglements that tether modelers to the substances they aim to model" (142).

Scientists relate to their molecules in bodily ways as well. Myers describes modelers contorting their arms, legs, and torsos to channel the "pain" of an awkwardly folded protein and to think through how it might fold more comfortably (99–101). In this way, scientists test hypothetical models for three-dimensional protein folding by means of what Myers calls "body experiments" and "kinesthetic imagination": embodied forms of visual reasoning. In both physical and emotional senses, the image-making work of protein modelers entails *feeling*.

This is not so much a matter of anthropomorphizing molecules, Myers argues, as "molecularizing" scientists. Vertesi notes an analogous phenomenon among her Rover team. In planning and making sense of Rover photographs, team members tended not to treat the robots as extensions of their human bodies and senses. Rather, they contorted themselves to approximate Rover physiognomy, "adopt[ing] the rover's bodily apparatus with its unique bodily sensitivities in order to understand and interact with Mars" (176). Situated in the space between contextual "visual cultures" and images themselves, such moments give specific, concrete force to Bredekamp's claim that style is "co-generative of the mentality whose emanation it later appears to be" (21).

Both studies also illustrate the key role of non-visual supports in the persistence of visual cultures. Explaining their faith in their images "as evidence of anything" to Vertesi, Rover scientists cited the discrete counts of photons striking Rover cameras and the mathematical formulas with which their software represents and stores image manipulations (196). These are the quantitative underpinnings of their creative image-work; supple images are also static numbers. Similarly, Myers notes that an online database, the Protein Data Bank, has

supported the renewed prominence of three-dimensional modeling in the study of the molecules of life (10–13). It is not quite that Martian science and protein modeling are epistemic hybrids marrying image and logic.[5] Rather, the visual traditions of these fields are maintained and perpetuated through non-visual infrastructure. In the contemporary cases that Vertesi and Myers address, this is a matter of digital data and computers, but such infrastructure has other forms and a deeper history to explore.[6]

Back in 1976, as Rudwick sought to call specific historical attention to scientific images, he also contended that geology ultimately had to be accounted for as "an integrated visual-and-verbal mode of communication" (152). As the work of Vertesi and Myers demonstrates, methods drawn from the history of styles and the history of visual culture can mobilize scientific imagery for arguments that cut across the varieties of scientific practice. There are integrated stories to tell.

5. Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997).

6. Lorraine Daston, "The Sciences of the Archive," *Osiris* 27 (2012): 156–187; Elena Aronova, Christine von Oertzen, and David Sepkoski, eds. "Data Histories," *Osiris* 32 (2017). I have traced one such history in the field of organic chemistry: Evan Hepler-Smith, "'Just as the Structural Formula Does': Names, Diagrams, and the Structure of Organic Chemistry at the 1892 Geneva Nomenclature Congress," *Ambix* 62, no. 1 (2015): 1–28.