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A HISTORICAL ATLAS OF OBJECTIVITY

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Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007)

On the stone steps of the Main Medical, two minutes later, appeared beneath the arc-light a tall figure, ascetic, self-contained, apart. His swart cheeks were gaunt, his nose high-bridged and thin. He did not hurry, like the belated homebodies. He was unconscious of the world. He looked at Martin and through him; he moved away, muttering to himself, his shoulders stooped, his long hands clasped behind him. He was lost in the shadows, himself a shadow

Sinclair Lewis, *Arrowsmith*[1]

The mythical scientist in early twentieth-century America cut a lone figure, "impersonal as the chill northeast wind" and "oblivious of everything save his experiment." He toiled through the night in his laboratory, "a place unimpressive and unmagical save for the constant-temperature bath with its tricky thermometer and electric bulbs," as if working in the lab were a prayer that promised illumination—"alone, absorbed, [and] contemptuous of academic success and of popular classes," he knew all about material forces, but he was blind to the vital force that created all others. Accustomed to the "beautiful dullness of long labors," he remained "illimitably ignorant" of literature, art, and music. He believed that unerring techniques in experimentation, impartial observations, and exquisitely minute calculations would bring progress—a steady march toward the truth. He chose the highest calling in the world because he was "intensely religious—so religious that he will not accept quarter-truths, because they are an insult to his faith." He was "so devoted to Pure Science . . . that he would rather have people die by the right therapy than be cured by the wrong. Having built a shrine for humanity, he wanted to kick out of it all mere human beings." This

[1] Peter Dear argues that the Popperian notion of objectivity invokes "a kind of shadow-world that only exists by virtue of those things that it is *not*" or by the negation of subjectivity. P. Dear, "From Truth to Disinterestedness in the Seventeenth Century," *Social Studies of Science* 22 (1992), 619–31; original emphasis.

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autocratic figure, brilliantly insane and tyrannically honest, embodied the cult of science and objectivity.[2]

In *Objectivity*, Daston and Galison take us back to the historical moment when scientific objectivity was "a desire, a passionate commitment to suppress the will, a drive to let the visible world emerge on the page without intervention" or to achieve a "pure reproduction" (143). In this eloquently written book, the authors propose that although the articulation of scientific or mechanical objectivity as suppression of subjectivity dates back to Kant, it first emerged in the European scientific community only in the mid-nineteenth century and became in a few decades an "epistemic norm" that regulated scientific practitioners. In other words, the institutionalization of mechanical objectivity roughly coincided with what historians have identified as the neo-Kantian turn in German academia.[3] Trained to develop "a stern and vigilant conscience" that demanded a "fierce self-regulation" (122), the ideal "post-Kantian" scientist in late nineteenth-century Europe became a moral virtuoso immersed in a special kind of asceticism: to embrace objectivity meant "not only to practice a science but also to pattern a self" (10). Disciplined to see nature through machines in all her particularities and to represent them without idealization or interpretation, the scientific self "aimed to be a machine—to see as if his inner eye of reasoned sight were deliberately blinded" (140). To see without subjective interference required not only a technical mastery but also a moral determination. Blind sight and self-elimination characterized the scientific worker/machine devoted to the ideal of objectivity at the turn of the twentieth century.

Objectivity maps the dominant "kinds of sight" or the collective "ways of seeing" before, during and after the reign of mechanical objectivity. The authors trace the history of objectivity (and of epistemology) by focusing on images, or, more specifically, scientific atlases that make visible the dominant epistemic virtue specific to each historical period: truth-to-nature, mechanical objectivity, and trained judgment. They offer three representative images from the three periods postulated—an eighteenth-century flora, a late nineteenth-century image of a snowflake, and a mid-twentieth-century image of solar magnetogram. Each image illustrates a different technology of sight, scientific self, and conventionalized image: the four-eyed sight of a sage that produced reasoned

[2] S. Lewis, *Arrowsmith*, first published in 1925.

[3] According to Thomas E. Willey, "Neo-Kantianism emerged in the late 1850s and early 1860s [as a response to "naive scientism" and materialism], achieved academic supremacy in the 1890s, and rapidly lost its academic preeminence (but not its entire following) after 1914." T. E. Willey, *Back to Kant: The Revival of Kantianism in German Social and Historical Thought, 1860–1914* (Detroit, 1978), 21. The authors do not use the term "neo-Kantian" or engage with Kant's epistemology.

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images, the blind sight of a disciplined worker that produced mechanical images, and the physiognomic sight of a trained expert that produced interpreted images. As the "select collections of images that identify a discipline's most significant objects of inquiry" (17), scientific atlases map an observational science's territory by systematically compiling the working objects, provide a pictorial taxonomy for the discipline, and calibrate the collective eye (or "disciplinary eye") by setting definitive standards for "how to describe, how to depict, [and] how to see." Through constant use over distance and generations, atlases "enroll practitioners as well as phenomena" to make "collective empiricism in the sciences possible" (25–6). In short, the atlases facilitated the long-distance and intergenerational transmission, integration, and standardization of scientific knowledge. They united isolated observers into disciplinary communities in observational sciences by supplying shared objects of inquiry, similar to the way in the physical sciences textbooks helped the formation and maintenance of disciplines.[4]

Scientific objectivity is not, the authors assert, a "transhistoric honorific" (34) coextensive with science itself. Their schematic history challenges the philosophers' myth that objectivity, defined as "an ideal that subjects all scientific statements to the test of independent and impartial criteria; recognizing no authority of persons in the realm of cognition,"[5] is an intrinsic or essential facet of science. If the authors are cognizant of the "anti-representational" and feminist critique of objectivity as the Eurocentric–masculine gaze,[6] they nevertheless wish to inject a strong dose of reality check to the polemical attack on objectivity. When did the word "objectivity" come into general use? What exactly did it mean for practicing scientists? How did it become an important epistemic norm or ethos in scientific practice? By asking these historical questions, the authors seek on the one hand to dismantle the familiar, supposedly timeless and universal, epistemology—scientific knowledge as a faithful re-presentation of nature produced by a transparent process of cognition between the value-neutral subject and the subject-independent object. On the other hand, they wish to temper down the rhetorical/polemical reification of this (reputedly) Enlightenment epistemology that erases the trace of the knower. To accomplish this compromise, they redefine the basic elements of epistemology—the subject, the object, and true knowledge (re-presented nature)—as the "scientific self,"

4 O. Hannaway, *The Chemists and the Word: The Didactic Origins of Chemistry* (Baltimore, 1975).

5 I. Scheffler, *Science and Subjectivity* (Indianapolis, 1967), 1.

6 E. F. Keller, *Reflections on Gender and Science* (New Haven, 1985); R. Rorty, *Objectivity, Relativism, and Truth* (Cambridge, 1991); D. Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," *Feminist Studies* 14 (1988), 575–99.

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the "working object," and standardized or conventionalized knowledge. The production of knowledge is not a context-free process between the subject and the object, but a culturally mediated process regulated by collective epistemological norms. Although these norms or "regulative ideals" are often bundled together under the timeless ideal of objectivity that we ascribe to modern science, they originated in different, particular historical periods.

It might come as a surprise to those familiar with Daston's earlier works that the authors' tripartite scheme consciously excludes "Baconian" facts—"strange facts" and "contrived experiments" that defined seventeenth-century objectivity (*avant la lettre*).[7] It was this singularity of Baconian facts (as opposed to Aristotelian universal experience)[8] that engendered the rhetoric of impartiality as a means of acquiring public trust and consensual knowledge. Not only did the particular objects or facts compromise the Aristotelian metaphysics of truth, but also they undermined the authority of the knowing subject. Bacon's four idols brought to the surface the obstacles, prejudices, biases, and limitations of human perspective and experience, according to Mary and Jim Tiles's case study in "historical epistemology," to initiate a turn to the material world for an alternative foundation of authoritative knowledge.[9] Julie Robin Solomon has further argued that Bacon forged his philosophical "regime of disinterestedness"—impartial subjects and authoritative objects—specifically to negotiate the systematic tensions and fissures he faced in Jacobean England and to institute social consensus and control in the commonwealth by appropriating "the intellectual riches produced by subordinate subjects."[10] Bacon's "self-effacing cognitive strategies" deliberately displaced authority from the knowing subject to the observed material world, she contends, to negotiate the competing systems of political, judicial, and commercial power in his favor. Baconian objectivity contained, it seems, at least three features of our commonsense notion of objectivity—the impartiality of the subject, the independent reality of material objects, and the intersubjectivity of knowledge.[11] Historians might

7 L. Daston, "Baconian Facts, Academic Civility, and the Prehistory of Objectivity," in A. Megill, ed., *Rethinking Objectivity* (Durham, NC., 1994), 37–63; *idem*, "Preternatural Philosophy," in L. Daston, ed., *Biographies of Scientific Objects* (Chicago, 2000), 15–41.

8 P. Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago, 1995).

9 M. Tiles and J. Tiles, *An Introduction to Historical Epistemology: The Authority of Knowledge* (Oxford, 1993).

10 J. R. Solomon, *Objectivity in the Making: Francis Bacon and the Politics of Inquiry* (Baltimore, 1998), xiv; D. E. Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution* (New Haven, 2007), 211–53.

11 Megill, *Rethinking Objectivity*, 1–20; P. Zagorin, "Francis Bacon's Concept of Objectivity and the Idols of the Mind," *British Journal for the History of Science* 34 (2001), 379–93.

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legitimately ask, then, why not acknowledge Baconian elements in the history of objectivity, or more contextually, what happened to Baconian objectivity during the Enlightenment? By characterizing the early modern epistemological culture of singular, yet authentic, facts as the "prehistory" of objectivity, Daston and Galison obviate the need to take stock of the rhetorical context that shaped several facets of our commonsense notion of objectivity.[12] They also leave unexplained the conspicuous presence of Bacon and the rhetorical purchase of his name in what they regard as the history of objectivity proper.

Before mechanical objectivity, the "epistemic virtue" of truth-to-nature governed Enlightenment observational sciences. The authors designate by truth-to-nature not a faithful description of nature-as-is but a disciplined quest imbued with a moral/metaphysical attitude to discern the hidden reality. The quest for God's laws as prescribed in natural theology shaped, for example, the judgments of truth and beauty to reveal "the elegance and harmony of the natural object" (75). The ideal naturalist (exemplified by Carolus Linnaeus) had to possess "sharp senses, capacious memory and the ability to analyze and synthesize impressions to extract the typical from the natural particulars" or to "fix the empirically variable, exclude the accidental, eliminate the impure, unravel the tangled, [and] discover the unknown." Steeped in nature, but refusing to be enslaved by her variegated appearances, scientific atlas-makers created "a way of seeing . . . past the surface of plants, bones or crystals to underlying forms" to depict what Goethe termed the "pure phenomenon" (58–60). Not only nature's variability, but also the "layers of art and artifice, convention and conception" surrounding artists' production process threatened the ideal image "drawn from nature" (104). The "reasoned images" or "lofty abstractions," produced in collaboration with the artists (hence the term four-eyed sight), tamed nature's variability by eliminating the idiosyncrasies of both the subjects and the objects to express the minds' idea in typical specimens such as Goethe's *Urpflanze*, Albinus's meticulously prepared ideal skeleton, and paleontologists' perfect fossil specimens.

The model of historical causality the authors have chosen invites a closer scrutiny, if we wish to understand this sudden transition in the "epistemic way of life" (67). Even if Enlightenment atlas-makers reacted against the Baconian preoccupation with "strange and monstrous objects," one might ask, is such a purely cognitive rebellion sufficient cause for the radical turn toward the normative conception of nature? In proposing the subsequent rise of mechanical objectivity in the mid-nineteenth century, the authors explicitly reject both the "telescopic" and the "microscopic" causality in historical

[12] Particularly influential works in this regard are Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Chicago, 1985); Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago, 1994).

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explanation. The telescopic approach would call for the relevance of major political, economic, social, technological, and intellectual forces—the French Revolution, the Industrial Revolution, and so on—to the epistemological changes under consideration. They discard these as "only remotely relevant" events in favor of "proximate links" that would provide an explanation "on the same scale and of the same nature as the explanandum itself" in which "cause and effect meshed seamlessly." The microscopic approach would require a dense configuration of micro-contexts, but the authors contend that "local causes can obscure rather than clarify the kind of wide-ranging effect . . . like viewing an image pixel by pixel" (36). While these reservations are understandable in light of the crude politicization of scientific culture and/or the proliferating microhistories that tend to trivialize science's place in history, the call for an "intrinsic explanation" remains unspecified and unsatisfactory, especially when their "history of objectivity becomes, *ipso facto*, part of the history of the self" (37), a rich hermeneutic field that has not yet produced a generally applicable model of historical causality.[13] Mediations between broad sociopolitical contexts and specific scientific practices require layers of things, actors, languages, and institutions that spin complicated, overlapping webs of interaction.[14]

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Daston and Galison attribute the rise of scientific or mechanical objectivity to the "ethos" of self-elimination among the "post-Kantian" scientists, which forced them to pursue an exquisite reproduction of individual objects in all their particularities and singularities: the representation of types/ideals or the "stripping away of the accidental to find the essential became a scientific vice" (11–16). The language of "ethos" brings to mind Robert K. Merton's "affectively toned complex of values and [binding] norms" that fashioned scientists' conscience through institutional legitimation and subsequent internalization of the communal moral consensus.[15] The authors' intention is, however, to dissolve the internal–external divide in Mertonian sociology of knowledge by paying attention to the "technologies of the self" (*à la* Michel Foucault)—"the keeping

[13] M. Foucault, *The Hermeneutics of the Subject* (New York, 2005); J. Goldstein, *The Postrevolutionary Self: Politics and Psyche in France, 1750–1850* (Cambridge, MA, 2005).

[14] C. Smith and M. N. Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge, 1989); Mary Terrall, *The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment* (Chicago, 2002).

[15] R. K. Merton, "The Normative Structure of Science (1942)," in N. W. Storer, ed., *The Sociology of Science: Theoretical and Empirical Investigations* (Chicago, 1973), 267–78; L. J. Prelli, "The Rhetorical Construction of Scientific Ethos," in H. W. Simons, ed., *Rhetoric in the Human Sciences* (London, 1989), 48–68.

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of a lab notebook with real-time entries, the discipline of grid-guided drawing, the artificial division of the self into active experimenter and passive observer, the introspective sorting of one's own sensations into objective and subjective by sensory physiologists, the training of voluntary attention" (38), and so on. These technologies produced a different kind of scientist, "long on diligence and self-restraint, [and] scant on genial interpretation" (121). The scientific self was articulated "through concrete acts, repeated thousands of times in a myriad of fields in which observers struggled to act, record, draw, trace and photograph their way to minimize the impact of their will" (38). Machines disciplined both the subject and the object to constitute the "working objects" or scientific atlases. In particular, photography's ability "to render each and every tiny detail effortlessly," to save artistic labor, and to produce "objective images" (free of human interpretation) was instrumental to an interactive altering of the process and the products of cognition. In contrast to the Enlightenment naturalist who actively selected, sifted, and synthesized numerous sensations, the authors contend, the post-Kantian scientist practiced extreme restraint and discipline to abnegate or annihilate the self.[16] Objectivity became intimately intertwined with (the suppression of) subjectivity—*yang* and *yin*, in the authors' metaphor—in nineteenth-century scientists' adaptation of Kant's philosophy.

The focus on atlases to discern the reigning epistemic norm in observational sciences brings about the semantic irony that "mechanical" objectivity aimed at producing nonstandardized images of nature-as-is, which "truth-to-nature" did not. More importantly, the focus justifies a chronological leap from the early Enlightenment to the late nineteenth century. This leaves a large gap in the implicit narrative of *Objectivity* particularly around Kant's own era when philosophical inquiry came to focus on epistemology.[17] Pointed attacks on speculative metaphysics preceded the emergence of epistemology as the central project of philosophy, which foreshadowed the need for objectivity in philosophical inquiry. In his *Essay on the Origin of Human Knowledge* (1746), for example, Condillac sought to rescue metaphysics from the "vain and ambitious" philosophers who thrived on superficial "extravagances" and "airy speculations" by introducing the method of geometry, "the only and sure way of arriving at the truth." If one reasoned in metaphysics and moral science with "as great

[16] Simon Schaffer, "Astronomers Mark Time: Discipline and the Personal Equation," *Science in Context* 2 (1988), 115–45.

[17] For Kant's role in forging "philosophy-as-epistemology" see R. Rorty, *Philosophy and the Mirror of Nature* (Princeton, 1979), 131–64. The words *Erkenntnislehre* and *Erkenntnistheorie* were invented in 1808 and 1832 respectively, the latter only after the Hegelian system was discredited by empirical research. H.-G. Gadamer, *Truth and Method* (New York, 1993) (Translation of *Wahrheit und Methode* (1960)), 220.

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exactness as in geometry," framed "as accurate ideas as the geometricians," and determined "the meaning of words in a precise and invariable manner," one could prescribe "a plain and easy order for the attainment of demonstration." This new kind of metaphysics, "*desirous only of seeing things as they really are*," Condillac concluded, "is as simple as truth itself."[18] Such a methodical search for truth, divested of ingenious systems and based on the Baconian/Lockean emphasis on the senses, defined the fundamental aim of his refurbished metaphysics (or epistemology in our terms):

> Our first aim, which we ought never to lose sight of, is the study of the human understanding; not to discover its nature, but to know its operations; to observe with what art they are combined, and how we ought to conduct them, in order to acquire all the knowledge of which we are capable. We must ascend to the origin of our ideas, we must unfold their formation, and trace them to the limits which nature has prescribed, to the end that we may fix the extent and boundaries of our knowledge, and new model as it were the whole frame of the human understanding.[19]

In probing the "operations" (rather than the "nature") of human understanding, mathematics became a "great art" to render nature's truth self-evident, thereby forging a close alliance between science and metaphysics. If "by the word natural we are to understand nature exempt from blemish," Condillac observed, "it is evident that we ought not to pretend to imitate her by a careless irregularity, not to throw off the appearance of art till we have learnt to avoid so unpardonable a defect."[20] The idea of perfect nature required a representational technique that made invisible the intermediary human art and artifice. The authority of "natural" objects, expressed in mathematical precision, would guarantee the appearance of truth in Enlightenment epistemology, or "true metaphysics" in the contemporary translator's term. We might ask, then, how did this suppression of human artifice and idiosyncrasy through mathematical language in philosophy relate to the active selection and synthesis by botanists in the same period, both geared toward a transparent (seemingly artless) representation of perfect nature? Did the emergent epistemological concerns in philosophy play any role in the contemporary practice of science? The answers to these questions would help alleviate the "antirepresentationalist" and feminist critique of objectivity focused on *the* Enlightenment epistemology. The instrumental use of mathematical

[18] E. B. de Condillac, *An Essay on the Origin of Human Knowledge* (New York, 1974) (translation of *Essai sur l'origine des connaissances humaines* (1746)), 2–3; added emphasis; cf. *idem*, "A Treatise on Systems," in *Philosophical Writings of Etienne Bonnot, Abbé de Condillac* (London, 1982), 1–153.

[19] Condillac, *Essay*, 5–6.

[20] Ibid., 333.

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reasoning in French philosophy and sciences could also help explain German philosophers' quest for a moral foundation of sciences and Enlightenment.

The figure most conspicuous by his absence from *Objectivity* is Kant. The authors do not ask, that is, what might have prompted Kant to stipulate how the "objects" of philosophy and science ought to be constituted and why "objectivity" became a necessary feature of his epistemology that was modeled on exact sciences. Kant's quest for a "science" (*Wissenschaft*) of metaphysics began with a question "whether such a thing as metaphysics be at all possible?" He thought it "almost ridiculous" that metaphysics, "which pretends to be wisdom incarnate, for whose oracle every one inquires," should "move round the same spot, without ever gaining a single step," while every other science was continually advancing. Professedly awoken from a "dogmatic slumber" in speculative (Leibnizian–Wolffian) philosophy by Hume's question of whether the concept of cause could be thought "by reason, *a priori*, and consequently whether it possessed an inner truth, independent of all experience," Kant came to conclude that "metaphysics consists altogether of such [a priori] concepts." For metaphysics to become a science, however, he deemed it necessary to "determine the whole sphere of pure reason completely and from universal principles." The critique of pure reason had to exist "as a science, systematic and complete as to its smallest parts" before he could "think of letting metaphysics appear on the scene, or even have the most distant hope of so doing."[21] In contrast to the traditional metaphysics that pursued the knowledge of "things in themselves" through the use of speculative reason, the "science" of metaphysics sought the knowledge of "things as objects of experience" in the process of human understanding. In contrast to Locke and Hume, who made metaphysics a mere "delusion," Kant's "objects" of experience were not simply a collection of the sensations or impressions of material objects to which our knowledge should conform through analysis. Instead, these objects had to conform to the synthetic, a priori "concepts," or the "knowledge absolutely independent of all experience," constituted by our faculty of pure reason. Kant's vision of an "intellectual revolution" that would place metaphysics on "the secure path of a science" (in the manner of geometry and Newtonian physics) hinged on the capacity of pure reason to "attain to certainty whether we know or do not know the *objects* of metaphysics." The objects of metaphysics or a priori "concepts" attain "objective validity," that is, only when we acknowledge their dual constitution as "things in themselves" (which cannot be known, but can be thought) and as "things as objects of experience" (which can be known and are subject to natural laws or the principle of causality). This critical

[21] I. Kant, *Prolegomena* (1783), in J. W. Ellington, ed., *Immanuel Kant: Philosophy of Material Nature* (Indianapolis, 1985), 1–7; Eric Watkins, *Kant and the Metaphysics of Causality* (Cambridge, 2005).

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distinction between the "intellectual" and the "sensible" modes of representation granted pure reason its positive, practical use in simultaneously configuring the doctrine of morality as well as that of nature.[22] In other words, the science of human understanding had to scrutinize the capacity of pure reason to stabilize legitimate "objects" of metaphysical inquiry and their objective reality.[23] Kantian "objectivity" not only was irreducible to material objects and their multifarious manifestations but also involved the self in constructing the moral sphere that would serve the "interests of humanity." The reform or rebirth of metaphysics occupied Kant most of his life because he thought it essential to the welfare of the human race to articulate a moral choice based on human freedom.[24] One has to wonder, then, why the "post-Kantian" self would be enslaved to mindlessly reproducing the minute appearances of nature.

It seems possible in this light that objectivity served as an indispensable "rhetoric of inquiry"[25] in forging philosophy as a modern ("scientific") discipline centered on epistemology or "theory of knowledge" (*Erkenntnistheorie*), one closely modeled on mathematical sciences, yet with an eye toward a more comprehensive terrain of empirical sciences. In offering a synthesis of celestial and terrestrial mechanics through the notion of gravity in his *Mathematical Principles of Natural Philosophy* (1687), Newton had wished to "derive the rest of the phenomena of Nature by the same kind of reasoning from mechanical principles," suspecting that "they may all depend upon certain forces by which the particles of bodies . . . are either mutually impelled towards one another, and cohere in regular figures, or are repelled and recede from one another." Newton's vision of the unity in nature was encapsulated in a set of "attractions"—gravitational, electrical, magnetic, and chemical—which would explain all physical changes in nature.[26] Kant philosophized Newton, setting up new parameters for conceiving "science."[27] To this end, he sought to cleanse metaphysics of the futile, stagnant

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22 I. Kant, *The Critique of Pure Reason* (New York, 1965), Preface and Introduction. Many thanks to Professor John Zammito for pointing out the importance of understanding in Kant's *Critique*.

23 A. B. Dickerson, *Kant on Representation and Objectivity* (Cambridge, 2004); P. Mittelstaedt, "The Constitution of Objects in Kant's Philosophy and in Modern Physics," in P. Parrini, ed., *Kant and Contemporary Epistemology* (Dordrecht, 1994), 115–29.

24 F. C. Beiser, "Kant's Intellectual Development: 1746–1781," in P. Guyer, ed., *The Cambridge Companion to Kant* (Cambridge, 1992), 26–61.

25 H. W. Simons, ed., *The Rhetorical Turn: Invention and Persuasion in the Conduct of Inquiry* (Chicago, 1990); J. S. Nelson *et al.*, eds., *The Rhetoric of the Human Sciences: Language and Argument in Scholarship and Public Affairs* (Madison, WI, 1987).

26 I. Newton, *Principia* (1687), Preface; *idem*, *Opticks* (1704), Query 31.

27 R. Calinger, "Kant and Newtonian Science: The Pre-critical Period," *Isis* 70 (1977), 349–62; M. Friedman, *Kant and the Exact Sciences* (Cambridge, MA, 1992).

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"mock-combats" in speculative reasoning and to transform it into a rigorous exercise in human understanding that combined world-knowledge and self-knowledge.[28] While identifying the suppression of subjectivity as the Kantian ethos, the authors do not provide an intellectual or institutional rationale for this collective mood. Instead, they use three major scientists—Hermann von Helmholtz in Germany, Claude Bernard in France, and Thomas Henry Huxley in Britain—to delineate the Kantian turn in mid-nineteenth-century visual practice in science. They argue that these scientists adopted the epistemological goal of objectivity and discarded the metaphysical aim of truth to pursue reliable, progressive knowledge despite their diverse philosophical traditions, disciplinary preoccupations, individual interests, and variegated and protean uses of Kant. By characterizing the neo-Kantian turn in natural sciences as a pan-European phenomenon, the authors stress its philosophical origin rather than its intellectual, institutional, or sociopolitical context.[29] The tenuous Kantian qualities of these scientists' visual practices should make us wonder, though, if their ritual invocation of objectivity had more to do with Kant's academic authority and symbolic capital than with his philosophical ideals.[30] The authors' emphasis on the disciplined suppression of the self that resulted in mere fidelity to nature's whims is fundamentally at odds with Kant's own struggle to lay the objective foundation for science through a systematic reflection on the scientist's cognitive duty. Nor does it alert us to the historical contingency that prompted Kant to articulate objectivity as the main facet of epistemology.

Why Kant came to provide a shared philosophical idiom for the ambitious, institution-building European scientists of the mid-nineteenth century would also require a situated probe, a task the authors explicitly delegate to other scholars. Thomas E. Willey has argued that the rise of neo-Kantianism in German academia was closely tied to the failed revolution of 1848. Its maturation and institutionalization ran in tandem with the liberal accommodation of Bismarck's unification and the bourgeois aspirations for and visions of democracy in the Wilhelmian era. Rapid industrialization brought pressure on the traditional curriculum at high schools (*Gymnasien*) and universities, as evidenced in the proliferation of institutes initially in physiology and chemistry, inducing

[28] For the "homology between the world and the rational subject" which fashioned the autonomy of the Kantian self see J. Seigel, *The Idea of the Self* (Cambridge, 2005), 295–331.

[29] M. Friedman and A. Nordmann, eds., *The Kantian Legacy in Nineteenth-Century Science* (Cambridge, MA, 2006). K. C. Köhnke, *The Rise of Neo-Kantianism: German Academic Philosophy between Idealism and Positivism* (Cambridge, 1991).

[30] Rhetoric as a "ritual use of words" to indicate political commitments, thereby engendering or constituting political practice and culture, is analyzed in L. Hunt, *Politics, Culture and Class in the French Revolution* (Berkeley, CA, 1984).

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a sense of impending crisis in humanistic disciplines by the 1880s. Inspired by the success of the natural sciences, a thorough examination of the logic of human and social sciences broadened German liberalism's ethical, social, and political reach.[31] The transnational migration of neo-Kantianism rode on the success of German sciences (*Wissenschaften*). According to Peter Novick, American students of history in Germany absorbed the ideal of technical, specialized, and rigorous scholarship as a "sacred vocation." Misrecognizing Leopold von Ranke's professed abstention from moral judgment and attention to details as an insistence on the strict presentation of facts,[32] they recast him as the "mythic hero" who incarnated empirical science in history to forge their scholarly–professional identity. If the historian conscientiously mastered the critical analysis of documents (*Quellenkritik*) and avoided the "phantoms" of hypothesis, he could produce a body of reliable, atomistic facts which interpreted themselves "when justly arranged." Much like scientific hypotheses, historical interpretations had to be evaluated by their power to explain, and conformity to, the facts. By wedding Ranke's fastidious scholarship to the late-nineteenth-century cult of science, American historians fashioned a "scientific history" that enshrined a rigidly factual and empirical inquiry. Their conception of scientific objectivity (*wissenschaftliche Objektivität*) prescribed that the historian be a neutral, disinterested judge unaffected by social pressure or political influence in his pursuit of the historical truth. The shared professional habit of rigid self-elimination would ensure progress toward writing the "ultimate" history—the definitive and objective re-creation of the historical past. The objectivist creed that constituted the American historical profession comprised "a commitment to the reality of the past, and to truth as correspondence to that reality; a sharp separation between knower and known, between fact and value, and, above all, between history and fiction." In other words, the American historians' ideal of objectivity fused the Baconian/Lockean emphasis on the objectivity of the external (historical) world with the post-Kantian suppression of subjectivity to define progress in historical scholarship—"moving ever closer to the objective truth about the past."[33] The historians' ideal was nearly indistinguishable, it seems, from the scientists' commonsense notion of objectivity which provided a rhetorical focus of Ludwik Fleck's and Thomas S. Kuhn's critique.[34]

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31 Willey, *Back to Kant*.

32 Novick points out how strongly idealistic Ranke in fact was. For the poetic dimension of European historical writing see Hayden White, *Metahistory: The Historical Imagination in Nineteenth-Century Europe* (Baltimore, 1973), 163–90.

33 P. Novick, *That Noble Dream: The "Objectivity Question" and the American Historical Profession* (Cambridge, 1988), 1–60.

34 L. Fleck, *Genesis and Development of a Scientific Fact* (Chicago, 1979) (translation of *Entstehung und Entwicklung einer wissenschaftlichen Tatsache: Einführung in die Lehre vom*

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Although Daston and Galison do not deal with the uses of objectivity in historical scholarship, we should observe that historians shared the scientific atlas-makers' desire to replicate the "real" objects in minute, vivid details. American historians attributed their "objectivity" to Bacon rather than to Kant, however. The strength of "Baconian" objectivity in the neo-Kantian period could pose a problem for the authors' story, if they wished to develop a coherent history of objectivity across disciplines. Their model of historical development may provide a possible justification for this mix. They observe that "epistemic virtues, once entrenched, seem to endure—albeit to differing degrees in different disciplines" (41) and with modification. While they argue that the invention of the three epistemic norms belonged to particular historical periods, they do not advocate the Kuhnian, "catastrophist" model of history that would require clear-cut cognitive revolutions or gestalt switches. Neither do they endorse a cumulative, uniformitarian model of history in the neopositivist fashion. Instead of "a smooth slope or an abrupt precipice," they use the analogy of an avalanche to describe the emergence of scientific objectivity and other epistemic virtues—"at first, a few tumbling rocks, falling branches, and minor snow slides amount to nothing much, but then, when conditions are ripe, individual events, even small ones, can trigger a massive, downward rush" (49). The history of successively dominant epistemic virtues is not one of monarchic succession that triumphs on the ruins of its predecessor, but that of "innovation and proliferation" as if new stars winked into existence, "not replacing old ones, but changing the geography of the heavens" (18). As a non-teleological history of epistemology, *Objectivity* allows for a "quietly compatible" (28) existence of multiple epistemological norms in a given period.

* * *

The plurality of operative epistemic norms ensued not just from the leftovers that blended into the newly dominant one, we should infer, but also from divergent scientific/disciplinary practices and concomitant philosophical justifications in any given period. Only when we consider the possibility of discipline-specific practice and epistemology can we understand the authors' digression in chapter 5 to structural objectivity which spurned all images as well as the cloistered self. Communicability "beyond all bounds," or a unified and complete system of knowledge that would hold sway in the entire universe, was the aim of structural objectivity that stipulated invariable, enduring relations or structures "that survive translation, transmission, theory change,

Denkstil und Denkkollektiv (Basel, 1935)); T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, 1962).

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and differences among thinking beings due to physiology, psychology, history, culture, language and species" (in Max Planck's fantasy, 256). The initial claim to structural objectivity in Germany began, according to the authors, as a response to the radical empiricism of psychophysiology (Helmholtz) and psychophysics (Wundt), or an experimental turn to the "objective science of mind" which attempted to ground mathematics and logic in the "observable facts of experience." Fearing that psychology would swallow up all sciences, the mathematician Frege relocated objectivity in the realm of pure symbols or concept-writing (*Begriffsschrift*). The intense debate between the "idealists" and the "empiricists" in the 1880s only strengthened objectivity's status as "the *sine qua non* of science," fueling the debate on the subjectivity of color experience spearheaded by Poincaré at the Sorbonne. In defending the "objective value of science," Poincaré opposed the metaphysics of truth as well as the radical empiricism of Ernst Mach, William James, and Henri Bergson.

If the "fear" of subjectivity fostered divergent ideals of objectivity in mathematics, theoretical physics, the observational and experimental sciences, history, and the social sciences, it would indicate that objectivity functioned less as a Kantian ideal than as a shared rhetoric of legitimation for a variety of ascendant or marginal sciences in the changing institutional, social, and political context of unified and imperial Germany. Experimental psychology struggled to take root in German universities, despite Helmholtz's towering stature and the promising start of Wundt's Leipzig institute in 1870.[35] The idealized norms of disinterestedness and autonomy camouflaged the institution-building activities of ambitious scientists in pursuit of distinction, prestige, recognition, and resources.[36] In marked contrast, no organic chemist had to argue for the objectivity or scientificity of their specialty, which was the most successful scientific discipline in nineteenth-century Germany in terms of institutional build-up and proven utility in agriculture and industry. Just at the time when chemistry became entrenched as the core field in the natural sciences, chemical philosophy and philosophical chemistry, which had nurtured its transformation from a sooty art into a public science in previous centuries, disappeared as a genre of writing altogether.[37] Modern philosophy of science began in the 1830s as the philosophy of physics, a discipline that aimed at the intellectual domination of

[35] M. G. Ash, *Gestalt Psychology in German Culture, 1890–1967: Holism and the Quest for Objectivity* (Cambridge, 1995).

[36] T. Lenoir, *Instituting Science: The Cultural Production of Scientific Disciplines* (Stanford, 1997).

[37] M. G. Kim, "Labor and Mirage: Writing the History of Chemistry," *Studies in History and Philosophy of Science* 26 (1995), 155–65.

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the natural sciences.[38] The impressive roster of mathematicians and theoretical physicists who rose to defend the non-empirical objectivity or scientificity of their fields attests to this institutional need to augment the small number of institutes for theoretical physics (in comparison with experimental physics) or even for physical chemistry (in comparison with organic chemistry). When Wilhelm Ostwald was called in 1887 to the first chair of physical chemistry in Germany, he sought to legitimize his young discipline by presenting it as a boundary discipline that would remedy the "atomistic" fragmentation of scientific disciplines by dealing with the most general problems—the transformations of matter and energy, the two "realities" that supposedly constituted the objects of all scientific investigations. He visualized the underlying unity of science through a suggestive image of an archipelago that would reveal the connected landmass underneath when the water receded.[39]

The quest for institutional legitimacy or power enshrined objectivity as the most important criterion of scientificity not just in the natural sciences but more urgently in other traditional "sciences" that faced an uphill battle to maintain their autonomy from the encroachment of the natural sciences.[40] Scientificity in all forms became an important rhetorical topos in these demarcation debates for which Helmholtz as a leading physicist set a conciliatory, yet imperialist, tone in 1862.[41] In response, Wilhelm Dilthey employed the term "human sciences" (*Geisteswissenschaften*) in 1883 to group together all "sciences which take socio-historical reality as their subject matter" as "a unity distinct from the natural sciences" (*Naturwissenschaften*). He wished to overcome the opposition and incommensurability between the two groups of sciences by demonstrating the "objective reality of inner experience" and the "existence of the external world . . . that contains human facts and spiritual meaning." An objective science of historical experience was possible only through self-knowledge.[42] German classical sociology emerged in this context to negotiate the tension

[38] R. R. Yeo, *Defining Science: William Whewell, Natural Knowledge, and Public Debate in Early Victorian Britain* (Cambridge, 1993); C. Jungnickel and R. McCormmach, *Intellectual Mastery of Nature: Theoretical Physics from Ohm to Einstein*, 2 vols. (Chicago, 1986).

[39] W. Ostwald, *Abhandlungen und Vorträge* (Leipzig, 1916), 185–206.

[40] Gadamer, *Truth and Method*, 3–9.

[41] H. von Helmholtz, "On the Relation of Natural Science to Science in General," in David Cahan, ed., *Science and Culture: Popular and Philosophical Essays* (Chicago, 1995), 76–95 (translation of "Ueber das Verhältnis der Naturwissenschaften zur Gesamtheit der Wissenschaften (1862)").

[42] W. Dilthey, *Introduction to the Human Sciences* (Princeton, 1989), 56–8 (*Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte* (1883), in *Gesammelte Schriften*, vol. 1 (Stuttgart, 1923)); Gadamer, *Truth and Method*, 218–42.

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between the traditional (Humboldtian) ideal of *Bildung* and the increasingly specialized sciences dealing with material and practical concerns. The "mandarin" modernists such as Ferdinand Tönnies, Georg Simmel, and Max Weber tried to curb the unreflective application of (natural-)scientific methods to human sciences.[43] The Wilhelmian era saw intense debates on the status of scientific methods in humanistic and social disciplines, which also produced competing efforts at reenvisioning the university disciplinary map.[44] Karl Lamprecht's history of "German culture" sparked a strenuous *Methodenstreit* in the 1890s not simply because of its reliance on the "scientific" (Wundt's psychological) method, but more seriously because of the way he constituted the object of historical inquiry around the unspecified notion of "economic life" that grew to encompass all facets of culture.[45] The Leipzig circle's effort to envision a unified field of natural and cultural sciences found its clearest expression in Wilhelm Ostwald's "radical" or monistic energetics that granted the status of reality only to energy not as a reductionist scheme, but as a vision of unification through systematization. In his new journal, *Annalen der Naturphilosophie*, Ostwald promoted a new "system of sciences" that modified Auguste Comte's pyramid to install energetical sciences as the current stage in the historical development of sciences. He denigrated philology as a paper science (*Papierwissenschaft*) for its lack of predictive power, the hallmark of scientificity.[46] Who or what defined the standards of scientificity mattered in drawing the university disciplinary map and in distributing resources.

Max Weber's manifesto on objectivity in social (including cultural) sciences came on the heels of these *Kulturkämpfe* within and across disciplines grappling with the fragmentation of knowledge, society, and politics in imperial Germany. As an editor of the *Archiv für Sozialwissenschaft und Sozialpolitik*, a journal expressly aimed at "the education of judgment about practical social problems," he asked what the standards governing these judgments should be and how the *Archiv* could adhere at the same time to "its intention to be an exclusively scientific journal." In representing an empirical specialty (*Fachdisziplin*), the *Archiv* had to strive for "scientific objectivity" and "objectively valid truths" that could be acknowledged as such "even by a Chinese." Social "science"

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43 F. Ringer, *The Decline of the German Mandarins: The German Academic Community, 1890–1933* (Cambridge, MA, 1969); *idem*, *Max Weber's Methodology: The Unification of the Cultural and Social Sciences* (Cambridge, MA, 1997); *idem*, *Max Weber: An Intellectual Biography* (Chicago, 2004).

44 W. Windelband, "History and Natural Science," *History and Theory* 19 (1980), 165–8 (translation by G. Oakes of "Geschichte und Naturwissenschaft," rectoral address at Strasbourg, 1894).

45 K. Lamprecht, *Deutsche Geschichte*, 12 vols. (Berlin, 1891–1909); R. Chickering, *Karl Lamprecht: A German Academic Life (1856–1915)* (Atlantic Highlands, NJ, 1993).

46 M. G. Kim, "Wilhelm Ostwald (1853–1932)," *Hyle* 12 (2006), 141–8.

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was limited to the "systematically correct" analysis of facts (means, ends, and consequences), which would allow political antagonists to discuss social policy on neutral grounds, but it could never assume the task of providing "binding norms and ideals . . . for immediate practical activity." Even the "self-evident" value of certain philanthropic goals (social hygiene, poor relief, protective labor legislation, and so on) was a mere "illusion" at the level of social policy. According to Weber, "an empirical science cannot tell everyone what he *should* do—but rather what he *can* do":[47]

> Nowhere are the interests of science more poorly served in the long run than in those situations where one refuses to see uncomfortable facts and the realities of life in all their starkness. The *Archiv* will struggle relentlessly against the severe self-deception which asserts that through the synthesis of several party points of view, or by following a line between them, practical norms of scientific validity can be arrived at . . . The capacity to distinguish between empirical knowledge [*Erkennen*] and value judgments [*Beurteilen*], and the fulfillment of the scientific duty to see the factual truth, as well as the practical duty to stand up for our own ideals, constitute the program to which we wish to adhere with ever-increasing firmness.[48]

Weber's strong endorsement of interest-neutral facts did not mean that he disregarded value-orientation in the social sciences. Nor did he take the natural sciences as a model of inquiry. Critical of both mechanistic laws and the "monistic" ethical imperative (derived from the evolutionary principle), he set out to articulate an alternative scientific method that took stock of the "infinite multitude" of social reality and its cultural significance related to value judgment. As a "science of actuality" (*Wirklichkeitswissenschaft*), social science had to "understand the surrounding reality [*Wirklichkeit*] of life . . . in its *uniqueness*—on the one hand the relationships and the cultural significance of individual appearances in their present manifestations, and on the other hand the basis of their having become historically so and not otherwise."[49] Although the infinite multiplicity of reality forced the scientist to select a finite portion as the "object" of investigation, he had the obligation to examine carefully this process

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47 M. Weber, "'Objectivity' in Social Science and Social Policy," in *Max Weber on the Methodology of the Social Sciences*, trans. E. A. Shils and H. A. Finch (The Free Press, 1949), 49–112; original emphasis ("Die 'Objectivität' sozialwissenschaftlicher und sozial politischer Erkenntnis (1904)," in *idem*, *Gesammelte Aufsätze zur Wissenschaftslehre* (Tübingen, 1922), 146–214).

48 Weber, "Objectivity," 57–8; "Objektivität," 154–5. In this first part of the essay, Weber is articulating the editorial policy more than his personal view.

49 Weber, "Objectivity," 72–3; original emphasis; "Objectivität," 170–71. L. A. Scaff, *Fleeing the Iron Cage: Culture, Politics, and Modernity in the Thought of Max Weber* (Berkeley, 1989), 83–7.

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of selection to ensure the cultural significance of the selected configuration of socioeconomic reality. Weber's careful scrutiny of concept formation to establish the "objectivity" of social science culminated in his notion of the "ideal type"—a pure, "utopian" mental construct (*Gedankenbild*) that subsumed a range of individual phenomena under a particular, value-laden viewpoint. The social scientist could thereby relate empirical reality to evaluative ideas in a systematic manner without insisting on a monolithic ethical imperative or on suppositionless laws. The "objectivity" of the social sciences depended not on the "hypothetical" universality of (and an uncritical belief in) abstract laws that reduced empirical reality to a unilateral causal relationship, but on reflexive idealization that coordinated the rich diversity of empirical reality with the relevant value judgment. The scientist had to appreciate the diversity and particularity of social reality not to take sides in partisan interests, but to discern objectively their historically (and culturally) conditioned relationship with a particular value judgment.

Weber's ideal social scientist shared with historians and image-producing natural scientists, we should observe, the obsession with an infinitely variable reality. Nonetheless, he differed from them in constructing ideal types, somewhat reminiscent of Kant's synthetic a priori and more in tune with the advocates of structural objectivity. The diversity of methodological responses despite their shared enchantment with infinite realities among the practitioners of various "sciences" should make us wonder if we can attribute their ritual invocation of objectivity solely to Kantian inclinations.[50] Disciplinary autonomy weighed heavily on Weber's mind as he struggled to elaborate an objective method of social sciences that could handle such current sociopolitical problems as industrial labor[51] and interest politics without reducing them to the quantitative or "monistic" (and hypothetical) laws of the natural sciences, as can be seen in his blistering critique of Ostwald's *Energetische Grundlagen der Kulturwissenschaften* (1909).[52] While praising Ostwald for his art of presentation that simplified technical "thought objects" with "astonishing" efficiency (*Kraftersparnis*) in Ernst Mach's fashion of "thought economy," Weber accused Ostwald of disciplinary patriotism (*ressortpatriotischer Wertmaßstäbe*) in turning the world picture (*Weltbild*) of a single discipline into a general world view (*Weltanschauung*),

[50] G. E. McCarthy, "Max Weber and the Kantians: Epistemology and Method in the *Wissenschaftslehre*," in *idem*, *Objectivity and the Silence of Reason: Weber, Habermas, and the Methodological Disputes in German Sociology* (New Brunswick, NJ, 2001), 127–212.

[51] R. M. Brain, "The Ontology of the Questionnaire: Max Weber on Measurement and Mass Investigation," *Studies in History and Philosophy of Science* 32 (2001), 647–84; M. Weber, "Zur Psychophysik der Industriellen Arbeit (1908–09)" in *idem*, *Gesammelte Aufsätze zur Soziologie und Sozialpolitik* (Tübingen, 1924), 61–255.

[52] M. Weber, "Energetische Kulturtheorien," *Archiv für Sozialwissenschaft und Sozialpolitik* 29 (1909), 575–98; reprinted in *idem*, *Gesammelte Aufsätze zur Wissenschaftslehre*, 376–402.

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as Ernst Haeckel's popular exposition of Darwinism had done.[53] Even more inflammatory was Weber's rhetoric against Ernest Solvay, dubbed a pure technologist schooled only in the natural sciences who "raped" sociology with the pretense of an "exact" sociological method.

The intensifying rhetoric of objectivity at the turn of the twentieth century owed much to the perceived triumph of the natural sciences, which not only threatened the traditional humanistic/scholarly disciplines within the university hierarchy but also delivered materialism and false prophecy to the mass public.[54] World War I and its destructive technological spectacle made the situation only more complicated for Weber, who participated actively in the political turmoil ensuing from the humiliating defeat.[55] Facing "an extremely negative" view of the "intellectual aristocracy" produced by rigorous training for specialized sciences to seek "an unreal realm of artificial abstractions," Weber nevertheless defended the autonomy of sciences against the political current that increasingly called for an ideological leader (*Führer*). He cited a "widespread notion" among the youth that science had become "a problem in calculation . . . involving only the cool intellect" that barred the scientist from developing a personality or from personally experiencing genuine, pulsating reality with heart and soul. He countered not only that scientific progress required an idea, an intuition, or an inspiration, but also that a scientist could acquire personality only by devoting himself "*solely* to the work at hand." The "scientific worker" could gain recognition only by putting on the "blinders" that limited his soul to a strictly specialized field, even to a particular passage of a selected manuscript. Such an "inner devotion to the task" alone could lift the scientist to the height and dignity of the subject he pretended to serve:

> Without this strange intoxication, ridiculed by every outsider; without this passion this "thousands of years must pass before you enter into life and thousands more wait in silence"—according to whether or not you succeed in making this conjecture; without this, you have *no* calling for science and you should do something else. For nothing is worthy of man as man unless he can pursue it with passionate devotion.[56]

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53 Haeckel's *The Riddle of the Universe* (New York, 1900) (*Welträthsel, gemeinverständliche Studien über monistische Philosophie* (Bonn, 1899)) was a smashing success that saw seven editions within the first two years of its publication and sold 400,000 copies by World War I in Germany alone. The people's edition that cost just one mark appeared in 1903. R. J. Richards, *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought* (Chicago, 2008), 398–403.

54 W. Ostwald, *Monistische Sonntagspredigten* (Leipzig, 1911).

55 W. J. Mommsen, *Max Weber and German Politics, 1890–1920* (Chicago, 1984).

56 M. Weber, "Science as a Vocation" (1918), in *From Max Weber: Essays in Sociology*, ed. H. H. Gerth and C. Wright Mills (New York, 1946), 128–56, 135; original emphasis ("*Wissenschaft als Beruf*," in *Gesammelte Aufsätze zur Wissenschaftslehre*, 524–55).

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The "strange intoxication" that bound Weber's social scientist to the minute details of scholarship with "passionate devotion" resonates with the spell of mechanical objectivity in the observational sciences that prefigured the mythical scientist in *Arrowsmith*. If the scientist shared this "inner calling" with the artist, Weber argued, the scientist differed from the artist in his commitment to progress, the awareness that his work would be outdated and surpassed in the near future. Even if the modern scientist had to put aside former illusions about science as the way to true being, true art, true nature, true God, or true happiness, science contributed to the total life of humanity through its technology of controlling life, methods of thinking, tools and training for thought, and pursuit of clarity. Instead of asking the scientist or teacher to use scientific facts in the service of practical interests as an ideological leader, one had to accept that science was a "vocation" organized in special disciplines in the service of self-clarification and the knowledge of interrelated facts. The scientist may not be a prophet dispensing sacred values and revelations, or a sage who divined the meaning of the universe, yet as an intellectual destined to live in a godless and prophetless time he had to maintain his intellectual integrity in the classroom: "The task of the teacher is to serve the students with his knowledge and scientific experience and not to imprint upon them his personal political views." Weber issued a dire warning: academic prophecy will only create fanatical sects but never a genuine community.[57]

Weber's tenacity in defending scientific objectivity as an interest-neutral (not value-neutral) and intersubjective (transcultural) norm seems to have been shared by the advocates of structural objectivity running from Frege and Poincaré to Carnap and the Vienna Circle after World War I. To be sure, the Kantian origins of analytic philosophy have been discerned not only in the continuity of philosophical issues but also in setting the broader agenda of "rational anthropology"—"the philosophical study of human persons—as embodied minds embedded in the larger natural world."[58] The authors trace this development through the articulation of the interpersonal self. Despite the perspectival diversity in sciences, philosophy, and life experiences (that included the trenches of World War I), Rudolf Carnap "adamantly" held to his "neutral attitude," an ontological, political, and moral "principle of tolerance" that would lead to "an intersubjective, objective world" through a collective building up (*Aufbau*) of knowledge (290–91). Moritz Schlick, who assumed the Vienna chair in philosophy of the inductive sciences (originally held by Ernst Mach) in 1922, preserved the "longing for a common [international and cosmic] world, and one that can be communicated, not just experienced." The authors

[57] Ibid., 146–55.

[58] R. Hanna, *Kant and the Foundations of Analytic Philosophy* (Oxford, 2001); *idem*, *Kant, Science, and Human Nature* (Oxford, 2006).

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detect in the subsequent articulation of structural objectivity a "curious parallel between self and world" wherein each shaped the other, both "stripped down to skeletal relations, nodes in a network" (301–2). Hermann Weyl captured this parallelism in the metaphor of "invariants under transformation." For him and others, Einstein's special theory of relativity served as an affirmation of structural objectivity, although Einstein's own position proved far more delicate and difficult to fit in the framework of analytic philosophy. The emigration of various members of the Vienna Circle in the 1930s established logical empiricism as a dominant philosophical tradition in the United States, where it metamorphosed into an academic philosophy cleansed of its previous social and political ambitions.[59]

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The intellectual/institutional genealogy of logical empiricism, threaded through the notion of structural objectivity, would seem out of place in a book dealing with images and centered on mechanical objectivity. Although Daston and Galison do not spell out why they chose to include this chapter, the intellectual prominence of structural objectivity and the utopian ideal of interpersonal self at the turn of the twentieth century can help us understand the divergence between academic philosophy and scientific practice in mid-twentieth-century America. Academic philosophy in the United States continued to build on the insights and accomplishments of the mathematicians, physicists, and philosophers who articulated structural objectivity. With secure institutionalization by the mid-twentieth century, one that fostered professional training and a newfound confidence, however, the authors observe that scientists endeavored to overcome the limits of mechanical objectivity by trained judgment in establishing the boundary between the normal and the pathological, in classifying the observed phenomena, in generating hypotheses and insights, and even in recognizing scientific novelty. In the era of collective and standardized training, the number of people involved in scientific education and research raised a serious concern about ensuring some kind of uniformity on the objects of scientific inquiry despite the divergence of results. Judgment "as an act of cultivated perception and cognition" (331) was acquired through a sophisticated apprenticeship that taught "unconscious act of holistic recognition" combining a variety of unarticulated considerations for similarity or novelty. Instead of the four-eyed sight of truth-to-nature or the blind sight of mechanical objectivity, they needed a kind of physiognomic sight—"a capacity of both maker and user of atlas images to synthesize, highlight, and grasp relationships in ways that were not reducible

[59] G. A. Reisch, *How the Cold War Transformed Philosophy of Science: To the Icy Slopes of Logic* (Cambridge, 2005).

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to mechanical procedure, as in the recognition of family resemblance" (314). This subconscious (identified as Freudian) epistemological strategy relied on the new scientific self as an expert who often commanded the most sophisticated instruments, yet could not confer self-evident generality to the images produced by them. An overarching "intellectual" approach as seen in the magisterial review articles required the "practiced eye" to discern the patterns even without conscious efforts. The insistence on trained judgment as a necessary supplement to objectivity became the new regulative ideal in this "regime of the interpreted image" (324).

The "judging, unconscious-intuitive scientific self" (359) that confidently molded the twentieth-century practice of science without close interaction with the mainstream academic philosophy can also make intelligible to us the challenge to the positivist philosophy that intensified in the 1960s. In *Personal Knowledge*, Michael Polanyi declared that objectivity was not "a counsel of self-effacement, but the very reverse—a call to the Pygmalion in the mind of man." He further insisted that

> the discovery of objective truth in science consists in the apprehension of a rationality which commands our respect and arouses our contemplative admiration; that such discovery, while using the experience of our senses as clues, transcends this experience by embracing the vision of a reality beyond the impressions of our senses, a vision which speaks for itself in guiding us to an ever deeper understanding of reality.

The power of science to make contact with this deeper reality in nature required the participation of the knower "striving passionately to fulfill his *personal* obligations to *universal* standards." He pursued this "true sense of objectivity in science," a personal responsibility we cannot avoid through "objective criteria of verifiability—or falsifiability," by an analysis of the "structure of skills" that cultivated and transmitted the "tacit" components of scientific knowledge.[60]

More famously, Thomas S. Kuhn criticized the "textbook image" of science as a constellation of facts, theories and methods collected in current texts and scientific development as an ever-growing stockpile to which these items have been added. Textbooks helped institute the philosophical attitude that portrayed science as an objective and rational study of the "things" out there in the pursuit of permanent, universal truth, scientific facts as the "true" representation of nature and scientific development as the accumulation of such immutable facts. He portrayed the historical integrity of science in its own time rather than identifying the permanent contributions of an older science to our present vantage. In studying Galileo, for example, Kuhn advised not to ask about "the relation of

[60] M. Polanyi, *Personal Knowledge: Towards a Post-critical Philosophy* (Chicago, 1958), 5–17 and 64; added emphasis.

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Galileo's views to those of modern science, but rather about the relationship between his views and those of his group . . . from the viewpoint that gives those opinions the maximum internal coherence and the closest possible fit to nature."[61] This historical and holistic understanding of science became a rallying cry to reformulate the basic agenda for the history, philosophy, and sociology of science. If one understood science as a tradition-bound activity and an integral part of culture, the cognitive authority of science should reside not in the rules, but in the scientific community or tradition. The antithesis between tradition and science, the irrational and the rational, the social and the natural has to be reformulated. Concomitantly, cognition is constrained not only by the natural world but also by the social and the cultural. Scientific development then consists of the successive reconstructions of this tradition. A historicized image of science left little room, that is, for a universal epistemology or an unfettered notion of scientific progress.

Much ink has been spilt in the past several decades on working out the consequences of Kuhn's challenge.[62] By and large, philosophers and historians of science have gone their separate ways, which has made obsolete the Kuhnian agenda of modeling scientific epistemology and progress.[63] Daston and Galison retain a hint of nostalgia for this bygone era when history and philosophy of science were engaged in mutually reinforcing projects. They pursue an alternative history of objectivity (and epistemology) by examining "practices of seeing, rather than theories of vision" (368), to reinvigorate the cross-fertilization between the two fields. The focus on the scientific atlas is meant to diffuse the conventional privilege accorded to mathematical concepts and theoretical physics, to define a different disciplinary foundation for observational sciences, to broaden the range of practitioners involved in making science, and to discern more sharply the epistemic norms that regulate the practitioners through sociocultural mediation. To accomplish these ends, historians might call for a more fine-grained analysis with an ethnographic attention to the actors' actions, categories, and perceptions, as Svetlana Alpers has advocated in art history.[64] To configure the "artisanal epistemology," one has to dig deeper than the surface of representation and discern the processes that shape the multifaceted and multilayered interactions

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61 Kuhn, *The Structure of Scientific Revolutions*, 1.

62 J. Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge, 1998); J. H. Zammito, *A Nice Derangement of Epistemes: Post-positivism in the Study of Science from Quine to Latour* (Chicago, 2004). Many thanks to Professor Robert S. Westman for this reference.

63 T. S. Kuhn, "The Relations between the History and the Philosophy of Science," in *idem*, *Essential Tension* (Chicago, 1977), 3–20; *idem*, "The Trouble with the Historical Philosophy of Science" (Cambridge, MA, 1992).

64 S. Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago, 1983).

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between the subject and the object mediated by instruments and cultures.[65] Instruments do not determine the process of cognition by themselves, but perform a complex set of mediations to negotiate the boundaries between disciplines, institutions, nations, and cultures.[66] *Objectivity* can perhaps be regarded as a historical atlas (rather than a history) of objectivity, something like a primary grid or a contour in a mapmaking process, designed to chart the terrain, to identify initial barriers and landmarks, and to encourage further exploration. The utility of *Objectivity* for philosophers and historians of science would depend on whether they can "operationalize" the atlas effectively to produce more detailed maps. As in fractal geometry, the coastline could get infinitely longer with each successive zooming in on a smaller range of the terrain. The authors provide a rich vocabulary to entice further exploration. They have also begun sketching out strategies for such excursions.

Objectivity defines a crossroads in the changing relationship between history and philosophy of science.[67] A theme the authors intend to pursue further seems to be the fabricated nature or hybrid "ontology" of scientific objects. Daston suspects in dealing with pre-Kantian observational sciences that ontology is not about the "real" objects that exist independently of the subjects, but about "how scientists furnish the universe with objects that are amenable to sustained and probing investigation."[68] As Galison puts it, "fabricated objects" are emerging increasingly as the "primary objects of study in the traditionally designated 'pure' parts of physics, chemistry and biology." Once we begin to think through these "new objects—objects that may range from the virtual objects of computer simulation to the carbon-fiber composites"—he suggests, "it may well be that the artificial/natural break *never* worked too well."[69] The moment of reckoning in *Objectivity* thus comes in the last chapter on the current use of digital images in nanotechnology. In contrast to the atlas-makers, who "aimed to fix nature . . . as faithfully as possible" (382), nanoscientists manipulate images to produce new kinds of devices. The authors maintain that this shift from

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65 P. H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago, 2004).

66 M. N. Wise, "Mediating Machines," *Science in Context* 2 (1988), 77–113; *idem*, "Architectures for Steam," in P. Galison and E. Thompson, eds., *Architecture of Science* (1999), 107–40; *idem*, "Staging an Empire," in L. Daston, ed., *Things that Talk* (Cambridge, MA, 2004), 101–46.

67 For this resurgent concern see "Changing Directions in History and Philosophy of Science," *Isis* 99 (2008), 88–134.

68 L. Daston, "On Scientific Observation," *Isis* 99 (2008), 97–110; *idem*, *Biographies of Scientific Objects*.

69 P. Galison, "Ten Problems in History and Philosophy of Science," *Isis* 99 (2008), 111–24; original emphasis.

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"image-as-representation" to "image-as-process" or "tool to make and change things" completely transformed the epistemological and ontological function of images in scientific practice. Operating under a combination of previous epistemic virtues, this "presentational approach" produces a reality that straddles the natural and the artificial.

The hybrid (natural–artificial) reality of investigative objects is not a new problem in chemistry, a disciplined material practice that cultivated laboratory culture much earlier than did physics and constituted the institutional/material core of nineteenth-century European sciences. Instead of *talking* about objectivity, chemists have been *making* stable objects in their laboratories. Their progress is measured not by a better approximation of true nature, but by their ability to make a more stable material world that can be sustained over geographical and temporal distance. If we can trace the history of chemical ontology with an ethnographic sensitivity, it should offer the philosophers of "thing knowledge" and "materialist epistemology"[70] rich material to probe the *built* (and therefore historical) nature of scientific objects, the culturally and materially disciplined identity of scientific investigators, and the *evolving* totality of the material world constructed by our scientific knowledge.[71] Admittedly, this would be a tall order: chemistry did not play an important role in the twentieth-century philosophy of science precisely because chemists did not pretend to deal with nature-as-is, but stabilized artificial objects through a set of instrumental and linguistic practices.[72] Nevertheless, it is not clear why a shift toward an epistemology of "fabricated objects" would focus on visual images and especially on atlases. One could object that interpreting visual images is a notoriously subjective enterprise, as is well known in art history. In addition, atlases were by design highly stylized artifacts that aimed at representing nature. Their integrative function as a kind of proto-textbook should give us a pause after decades of intensive research to undo the "textbook image" of science and to cultivate a new terrain of cognitive/professional interaction between history and philosophy of science by closely examining the material culture of science in its dynamic detail.[73] The use of atlases would then be a strangely retroactive move in conducting an archeology of scientific ontology.

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70 Hans Radder, ed., *The Philosophy of Scientific Experimentation* (Pittsburgh, PA, 2003); D. Baird, *Thing Knowledge: A Philosophy of Scientific Instruments* (Berkeley, CA, 2004).

71 M. G. Kim, "The 'Instrumental' Reality of Phlogiston," *Hyle* 14 (2008), 27–51; *idem*, "From Phlogiston to Caloric: Chemical Ontologies," forthcoming in S. Mauskopf and T. Schmaltz, eds., *Integrating History and Philosophy of Science* (Durham, NC, 2010).

72 M. G. Kim, "The Layers of Chemical Language," *History of Science* 30 (1992), 69–96 and 397–437.

73 A. Pickering, *Constructing Quarks* (Edinburgh, 1984); M. Rudwick, *The Great Devonian Controversy: The Shaping of Scientific Knowledge among Gentlemanly Specialists* (Chicago, 1985).

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The most troubling question in *Objectivity* remains, then, what the status of scientific atlases as objects of historical/philosophical inquiry would be if modern science has never been about the truth of nature or representing it, or discovering and representing nature-as-is, but about making new worlds. What if the very modernity of Western science is indissolubly tied to its manipulative capacity to forge or stabilize new material worlds, rather than to its efficacy in presenting the external world to our view? If we were to trace chemistry instead of natural history, physics, and physiology (all interested mostly in deciphering nature-as-is) through history, would we have the same set of problems in philosophy of science? Visual images have not always been the most significant objects of scientific or scholarly investigation. The focus on scientific atlases would in fact exclude the imagined, malleable, yet most productive objects of science that helped create and sustain modern sciences and worlds, such as the imponderable fluids of electricity, magnetism, and fire or heat. Phlogiston, the invisible principle of inflammability, was once regarded as a real, "most interesting object of human knowledge"[74] that allowed the philosophical chemist to bridge the material and the spiritual.[75] In order to guard ourselves against an "overvaluation of the visual," an "implicit, unthought undercurrent" of Western modernity and an active component of current global culture, we need to at least distinguish among "different modalities and conceptions of vision, among different visual practices and visual regimes," as Gary Shapiro has argued.[76] We also have to acknowledge our cultivated/naturalized preference for the visual in constructing new objects of investigation, as in the case of nanoscientists. Casting a look backward from our vantage point in history when new visual technologies have equipped us with an unprecedented capacity to chart, manipulate and create virtual reality would be an ultimate form of Whiggish history.

Despite these reservations about privileging the visual, we should welcome a new round of reflexive discussions on how we constitute the "objects" of our scholarly or scientific inquiry, which necessarily involves self-knowledge.[77] Daston and Galison move away from the *social* (historically conditioned) *construction* of scientific knowledge toward the *collective* (morally responsible) *constitution* of scientific objects that are "more explicitly and forcefully" (196) detected in the realm of the visual. The important question for us becomes,

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74 De La Folie, *Le Philosophe sans Prétention ou L'Homme rare* (Paris, 1775), 88.

75 J. Priestley, *Disquisitions Relating to Matter and Spirit and the Doctrine of Philosophical Necessity Illustrated* (London, 1777).

76 G. Shapiro, *Archeologies of Vision: Foucault and Nietzsche on Seeing and Saying* (Chicago, 2003), 6.

77 T. Nagel, *The View from Nowhere* (Oxford, 1986); A. N. H. Creager *et al.*, eds., *Science without Laws: Model Systems, Cases, Exemplary Narratives* (Durham, NC, 2007).

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then, why the intense periodic anxiety about the "objects" of scientific or scholarly endeavor? What we choose to investigate has always been a source of anxiety because this choice prefigures not only our individual success and our chosen discipline's respectability but also our intellectual responsibility to the larger society. Kant and Weber rehabilitated the "objects" of their respective disciplines in a manner that brought the empirical into the realm of personal (but not subjective) judgment to refurbish or create their disciplines: objectivity served as the constitutive rhetoric for their "sciences" while preserving what mattered to them as morally responsible scientists. In other words, we could regard *Objectivity* as a continuation of the Kantian dialogue on what Heidegger termed "fundamental ontology" (or perhaps meta-ontology), which puts the spotlight on the "internal possibility of ontology" to provide the foundation for philosophy and sciences.[78] What if we stand in the new century at the edge of manipulability, rather than at the "edge of objectivity,"[79] as the decisive criterion for what we regard as science? What if the *Brave New World*, Francis Bacon's dream and Aldous Huxley's nightmare, is upon us?[80] How would we then reconcile our technological capacity and moral obligations in doing science? Philosophers might respond that "historical ontology" as a reflexive study of how we constitute the objects of inquiry[81] is meant to support the project of "historical epistemology" or the "discussion of matters of contemporary concern using the resources of history."[82] Historical ontology and epistemology as socially relevant intellectual pursuits cannot simply be a more detailed study of past scientific practices and their products. Only by probing the moral obligation and social relevance of scientific pursuits, as Kant and Weber did, can we develop historical ontology and epistemology as a transdisciplinary concern for all sciences, one that reaches beyond a mere description of objects and objectivity in natural sciences.

We must ask, then, what should be the socially (now globally) relevant aim of rehabilitating objectivity as a historically variable, rather than a timeless, "virtue" in knowledge-making? What are the "matters of concern" that should motivate us to examine not just the "things" of our daily lives but also our

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78 M. Heidegger, *Kant and the Problem of Metaphysics* (Bloomington, IN, 1962), 17.

79 C. C. Gillispie, *The Edge of Objectivity: An Essay in the History of Scientific Ideas* (Princeton, NJ, 1960); K. R. Popper, *Objective Knowledge: An Evolutionary Approach* (Oxford, 1972); D. Bloor, "Popper's Mystification of Objective Knowledge," *Science Studies* 4 (1974), 65–76.

80 F. Bacon, *New Atlantis* (1626); A. Huxley, *Brave New World* (1932).

81 I. Hacking, *Historical Ontology* (Cambridge, MA, 2002); H. O. Sibum, ed., "Science and the Changing Senses of Reality circa 1900," special issue, *Studies in History and Philosophy of Science* 39 (2008), 295–458.

82 Tiles and Tiles, *An Introduction to Historical Epistemology*, 5; B. Latour, "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern," *Critical Inquiry* 30 (2004), 225–48.

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scholarly or scientific selves with an enhanced reflexivity?[83] In more concrete terms, why do we wish to restore a working relationship between history and philosophy of science through images rather than concepts? The rhetoric of objectivity captured in previous centuries the concern with the "objects" of "science" and their relevance to historically conditioned values and norms, as we have seen with Kant and Weber. Our capacity to produce and manipulate images to constitute the objects of scholarly or scientific investigation (such as digital humanities and molecular modeling) raises anew the question of how to balance scholarly or scientific standards and (geo)political concerns. Would a selective mixture of epistemic virtues from the previous centuries suffice? Should we invest our major research effort in manipulating images? We cannot forget that the epistemic "virtue" of truth-to-nature embedded in Linnaean classification and atlases carried the "imperial design" to the "four corners" of the world during the European "Enlightenment." The truth of nature was not simply discovered but artfully drawn to ensure the European dominance of the world.[84] The chemical empire is present in and expanding through the "things" of our daily lives long after the European territorial empires have disappeared, sustaining Western philosophical projects.[85] Whether the "hegemony of computers" in the global circulation of images and information would serve merely to enhance the performativity of this material empire or to empower marginalized constituents of the emergent global order is a matter of pressing concern.[86] While advocating an inclusive and cooperative map of university disciplines in 1862, Helmholtz urged

> each of us to think of himself, not as a man seeking to gratify his own thirst for knowledge, or to promote his own private advantage, or to shine by his own abilities, but rather as a fellow-labourer in one great common work bearing upon the highest interests of humanity.[87]

Objectivity or not, this is our scholarly duty to the global community.

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[83] B. Latour, "When Things Strike back: A Possible Contribution of 'Science Studies' to the Social Sciences," *British Journal of Sociology* 51 (2000), 107–23; B. Brown, *A Sense of Things: The Object Matter of American Literature* (Chicago, 2003).

[84] B. F. Tobin, "Imperial Designs: Botanical Illustration and the British Botanic Empire," *Studies in Eighteenth-Century Culture* 25 (1996), 265–92; M. L. Pratt, *Imperial Eyes: Travel Writing and Transculturation* (London, 1992).

[85] E. Domanska, "The Material Presence of the Past," *History and Theory* 45 (2006), 337–48.

[86] Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge* (Minneapolis, 1984).

[87] Helmholtz, "On the Relation of Natural Science to Science in General," 95.

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