

## Picturing Science, Producing Art

Caroline A. Jones and Peter Galison

**A**nalytic attempts to distinguish “art” and “science” often founder at the boundaries drawn between them. Do the alligators that hang from the ceiling in the late Renaissance cabinet of wonders at Wurms form part of the history of scientific classification, or part of the history of aesthetics? Are theories of female reproduction in Cinquecento Italy marked more by discourses of medicine, or by contemporaneous casting techniques? Did early photographs of mammals in motion serve primarily to educate the eye, or to provide raw data for physiologists? To bring such questions into a late-twentieth-century frame, is entering an artist’s website an artistic or a technological experience? As the chapters in this book demonstrate, the much-vexed inquiry as to whether science and art are incommensurable realms of knowledge is misplaced. What promises more is a view of history that asks: What are the conditions under which objects become visible in culture, and in what manner are such visibilities characterized as “science” or “art?” We are after precisely these boundary conditions.

There are moments in the nineteenth and twentieth centuries when such categorization (as *either* science or art) was itself the point. Coincident with the rise of modernism, and in part constitutive of modernism as a form of knowledge, scientists and artists contrasted their two domains. Each defined the other by a near absolute opposition. Science, the anatomists of the 1860s insisted, began when artistic license was canceled. Art, Baudelaire maintained, began when the deadening industrial-mechanical ethos of science could be forcibly set aside. In the production within laboratories and

studios, in the power and ambition of art and science to capture the world, in the variegated and evolving audiences that art and science demanded (or even created), the two realms have been separated, and their resulting relations described variously as markers of the premodern, signposts of the modern, and charged conduits into the postmodern. What much of this focus on “art” and “science” as discrete *products* ignores are the commonalities in the *practices* that produce them. Both are regimes of knowledge, embedded in, but also constitutive of, the broader cultures they inhabit.

Over the last twenty years, scholars have increasingly probed scientific and artistic objects to get at these practices, seeking the historical conditions of possibility that have made them meaningful. Using the resources of history, philosophy, and sociology (as well as art history and the history of science), what are the most current ways and places in which we can think through these two domains? That is the query motivating the essays in this collection.

## ART AND SCIENCE AS BINARY ECONOMY

There is a history to the perception of difference between science and art, and a parallel history to the attempt to unify the two. Although “art” is the older term, its emergence as a humanist enterprise in the Renaissance is coeval with the birth of talk about “scientific method.” From this point on, each defined and legitimated itself in relation to its shadow term, and the continuing strength of the dyad is reflected in the very structure of a late-twentieth-century undergraduate education featuring “arts and sciences.”<sup>1</sup> A peculiar feature of this polar linkage during the twentieth century, as revealed in C. P. Snow’s famous inauguration of the “two cultures” debate in 1959, was its unstated assumption of what might be called an economy of the binary. Like all binaries, art and science needed to be yoked together (yet held apart) in order to accrue the strengths of their polar positions: soft versus hard, intuitive versus analytical, inductive versus deductive, visual versus logical, random versus systematic, autonomous versus collaborative, and, like all binaries, at some level, female versus male.<sup>2</sup> The binary production of knowledge (the bifurcation of practices) was equally simple: art invented, science discovered.

Rather than address science and art as if these “opposites” were permanent features of the world, this book aims to explore the intersection of their histories, and to do so in a way that positions methodological and philosophical issues front and center. Though differing in many respects, the essays in this volume do hold certain strategies in common. They are not aimed at identifying universal demarcation criteria that separate science from art, nor are they after a description that might conjoin the two activities under a single broad and unifying rubric. Instead, the effort here is to explore how historians of art, historians of science, philosophers, and cultural historians can learn from one another’s methods at the boundaries between their fields, and how the

historical inquiry into conditions of artistic and scientific image production can shed light on multiple philosophical and historical issues. The essays are grouped under rubrics formulated as both topics and queries into the productive force of scientific and artistic representations. From a variety of angles, they emphasize the central theme of this book: namely, that art, science, and the hermeneutical concepts that we bring to them are historically and culturally embedded. Neither practice has unique and absolute purchase on “reality,” and neither is as alienated from history as its rhetoric might imply.

Although we seek to frustrate the standard binary economy, it is inevitable that as soon as “art” and “science” are mentioned, a host of other projects will come to mind. For clarity it is worth characterizing at least a few of these enterprises, if only to distinguish them from the direction of the present volume.

We begin, not coincidentally, with the late nineteenth century, when the Industrial Revolution was at its peak. It was at this moment, particularly in the most rapidly industrializing nations (e.g., England), that a rich controversy developed over whether art and science had (or should have) distinguishable goals. From John Ruskin and Charles Baudelaire to T. H. Huxley and Thomas Carlyle, the encroaching dominance of industrial technology made it imperative that the energies of an instrumental science be understood (and, possibly, contained).<sup>3</sup> Two things seemed clear: art occupied the domain of the creative, intervening mind, and the scientific ethos seemed to demand precisely the suppression of such impulses. (This was, of course, an intervention specific to its time. As many of the essays in this volume relate, both earlier and later bifurcations were very different.) Particularly in this largely British frame of reference (which C. P. Snow would inherit some decades later), the scientific method became linked inextricably with technology, industrial progress, and class mobility, while institutionalized art and literature came to be associated with the preservation of tradition, social order, and the conservation of rustic values. The special case of the modernist avant-garde defined itself, in one sense, precisely through its opposition to this particular binary. Confronting institutions of art and canonical literature, self-described modernists manifested their opposition to the academy through a pronounced tropism for advanced scientific and technological ideas—from X rays and relativity to radio and airplanes.<sup>4</sup> The perceived difference between the two domains would be mobilized precisely to destabilize the cultural category of “art,” through the newly powerful realm called “science.”

Along more explicitly psychological lines, various authors of the mid-twentieth century argued for parallels between creativity in art and science. One thinks here of the Gestalt-era psychologists of the 1950s and 1960s, such as Rudolf Arnheim on visual thinking, or Anton Ehrenzweig on the link between abstraction in visual art and science.<sup>5</sup> Along with this Gestalt-psychological tradition, which paid particular attention to the perceptual, there was also the work of practicing physicists such as

Ernst Mach and Harvard physicist-philosopher Percy Bridgman. For these scientists, an interest in sense perception was closely coupled to broader epistemological concerns. It is into this psycho-philosophical tradition that physicist Gerald Holton's influential work on "themata" and scientific creativity in scientific thinking belongs.<sup>6</sup> It is suggestive that many of these theorists (Bridgman is an exception) had emigrated from Europe to the United States during or after the Second World War. They were forced to leave behind their roots in a Central European *wissenschaftlich* approach to learning, where all fields of inquiry had been unified as one systematic investigation into various products of the human mind.<sup>7</sup> They took up influential positions in a pragmatic country in which highly specialized autonomous branches of inquiry were rapidly becoming the norm.

For all their continuities with prior literature, such postwar discussions of art and science had a new vocabulary after 1959 with C. P. Snow's widely discussed and immensely controversial lecture and publication, *The Two Cultures*.<sup>8</sup> Snow's intervention (and the responses to it) had implications that may well be more revealing historically than theoretically. For Snow, the two cultures were not only different, they were unequal: the scientific ethos stood for all that was hopeful, progressive, vigorously heterosexual, and future oriented, while the artistic-literary tradition embodied the profoundly hidebound culture of a decaying elite.<sup>9</sup> Some scholars took aim at the dichotomy, others at the ascendancy of the scientific. Whether in appreciation or condemnation, the sudden currency of Snow's phrase revealed how completely and deeply divided the domains of art and science were held to be—at least by some.<sup>10</sup>

Perhaps in response to this sense of a division, a new body of work emerged in the 1960s that sought explicitly to explore the similarities (and admitted differences) between the practices of art and science. These thinkers constructed, in a way, the "anthropology" of the two cultures that Snow had presupposed but never fully explained.<sup>11</sup> When historian and philosopher of science Thomas Kuhn wrote his *Structure of Scientific Revolutions* (1962) and its follow-on essays, he deliberately treated the production of science in a "sociological" way that made both science and art the "products of human behavior," demanding a more ethological approach. Indeed, the widespread popularity of Kuhn's book drew in large measure from the seeming universality of its story of normal-crisis-revolutionary developments and paradigm shifts that could be viewed across the arts and sciences. But when E. M. Hafner pursued such similarity relations between pictures in art and in science, Kuhn drew the line, arguing that pictures were, on the one hand, essential for artists, whereas, "The scientific illustrations, on the other hand, are at best by-products of scientific activity. . . . In Hafner's striking parallels, an end product of art is juxtaposed with a tool of science."<sup>12</sup> For Kuhn and the scientists with whom he identified, pictures and aesthetic criteria in general were mere means to an end, whereas for artists they were ends in themselves.<sup>13</sup> The binary

economy rules Kuhn's argument, with the artist an active agent recording a passive nature, and the scientist a passive recorder of natural flux.

Time and again during the 1960s, this tension between alliance and antagonism emerged. Just as Hafner had grounded his art-historical claims in Kuhn's depiction of science, art historian Ernst Gombrich drew his methodology explicitly from the theory of the scientific method offered by Karl Popper. Popper had aimed to separate the productive domain of true science from the cultural noise of "pseudo-science," and generated his set of "demarcation criteria" toward that end. Was the experimental premise testable, and, through testing, falsifiable? If so (and only so, Popper contended), could scientific explanations participate in the progressivist march of science. Ignoring the obvious—that art could never be "falsifiable" in the strict sense Popper had intended—Gombrich adapted the Popperian program to his theory of schemata, or "making and matching," in which the artist (like the scientist) renders an approximation of the natural world that can be tested, corrected, amended, and improved. Gombrich's *wissenschaftlich* unification of all human activity proved productive, but carried in its wake a problematic exclusion of much of twentieth-century abstraction, from Cubism to Abstract Expressionism and beyond.<sup>14</sup>

These sympathetic endeavors to locate similarities between art and science (while preserving philosophical distinctions between the two) formed as vigorous a tradition as the efforts to map the differences between them. At the present late-twentieth-century moment, anxieties about the divide have diminished. There is little attention paid by the authors in this book to the structural inquiries of previous decades that mapped the parallels and antiparallels perceived between the two types of activity. This is not even to speak of the difficulty seen presently in defending the notion that there are (or ever were) only *two* "activities" in the domains marked "science" and "art." Neither are the issues addressed here reducible to questions of "influence" by one autonomous sphere on another (although clearly the active appropriation and use of various prevailing discourses *can* be found). This distinguishes the present volume from much of the existing scholarship, which presumes the binary economy in order to chart its differential forces.

When presumptions of that binary economy have been at work, the results can be profound—as is best exemplified in the classic essay by Erwin Panofsky establishing Galileo's debt to artistic traditions of *chiaroscuro* for his interpretation of the craters of the moon.<sup>15</sup> Looking in the other direction (from science to art) Linda Dalrymple Henderson has provided sweeping chronicles of artists' reworkings and creative misreadings of non-Euclidean geometry, and Martin Kemp has charted artistic investigations of optics "from Brunelleschi to Seurat."<sup>16</sup> Kemp goes further than Henderson in claiming a deep congruence between "the central intellectual and observational concerns in the visual arts and the sciences in Europe from the Renaissance to the nineteenth

century,” and does so largely by looking at those moments in which artists seem to him to have “consciously aspired towards goals that we would now regard as scientific.”<sup>17</sup>

This anchoring of artistic to scientific practices is mirrored by a large, interesting, and growing body of literature by those who seek to interpret images that remain “unclaimed” by the institutions of art, but are readable as constructions of visual knowledge. James Elkins and Barbara Maria Stafford are among the art historians who have begun to open up this terrain. Elkins’s term for this new activity is not art history but “image studies,”<sup>18</sup> a term redolent of other late-twentieth-century academic discourses from “cultural studies” to “visual studies,” many of which tap post-structuralist and literary theories of the text. The scientific or other non-art images studied by Elkins and others play a myriad of conceptual roles, from aiding calculation to summarizing data, from the documentation of priority to the conceptualization of models only awkwardly put into analytic or mathematical form. In the study of such problems, art historians join science studies scholars in examining such diverse topics as Feynman graphs and Minkowskian space-time diagrams, images from electron microscopes, X rays, CAT and PET scans, digitalized computer visualizations of data, patent sketches, and the transformation of images from one medium into another.<sup>19</sup> The evident variety and depth of these concerns about the links, interfaces, or gray areas between “art” and “science” (ever more loosely construed) emphasizes the intellectual intensity of current debates over their relations. But rather than searching for brackets to join or wedges to split the vexed dyad, or mining some *terra incognita* between its two (always unequal) halves, we want to set this binary economy aside. The authors here address questions of viewing and knowing in which both artistic and scientific practices are brought into consideration, among many other kinds of cultural practices and productions.

There is nothing monolithic in this assembly; these are variable slices into histories that are themselves characterized by their heterogeneity. Yet there are themes within this diversity, assembled here as a cluster of “sites” for examining the productive work that both scientific and artistic images do, as well as the practices and institutions through which those images are embedded in culture. The representations at issue here are not just the canonical end products of artistic processes (oil on canvas or sculpted stone) or the end products of scientific ones (perfected equations or “golden events”), although these can be found. As authors, we want more broadly to include the iconography of cartoons, scientific images of DNA, particle tracks, anatomical photographs, artists’ printed diagrams and poems, instrumental motion studies, fossils, enameled birth trays, concrete factory buildings, illustrated panegyrics, botanical broadsheets, and attempted resolutions of astronomical “monsters.” We want, singly and collectively, to ask what work these images do, and what historically specific conditions make it possible for them to count as part of culture.

The “sites” at which we gather to address such images pose five thematic questions,

headed by the rubrics **Styles**, **The Body**, **Seeing Wonders**, **Objectivity/Subjectivity**, and **Cultures of Vision**. Each site is opened by an image from electronic-media artist Perry Hoberman's material meditation on the human-machine interface, *Faraday's Islands*; Hoberman's motley aggregates of consumer appliances are themselves representations of the problems posed.

In the first site, **Styles**, we ask: *How are images and practices aggregated, and to whose benefit?* Style is the presumptive tool for such aggregation and disaggregation, and from its common usage in art history, the term has been appropriated to characterize shifts, breaks, or modes of production in the history of science as well. (The view of blenders from Hoberman's installation [page 25] reminds us that "style" is also embedded in the commodity fetish). Yet the authors here would like to "make strange" this common tool, and they question with clarity and precision its unproblematic usage and narrowed definition. In full knowledge of its troubling past, the scholars in **Styles** would propose that we use this framing device only after its outlines have been radically redrawn.

Next, we turn to the implications of specific pictures in **The Body**, asking: *How do images shape body knowledge, and for whom?* What, for example, coexists with the depicted body—how are its divine, mechanical, productive aspects displayed or suppressed? In what sense is the body a "technoscientific" amalgam, as Hoberman's piece might suggest (page 99)? As with the **Styles** section, **The Body** spans a broad historical area to investigate varieties of body knowledge available at different historical moments, from the early codification of Christian dogma to the discourse of cyberspace.

A more narrow historical focus can also be useful. For the sake of such specificity, the **Seeing Wonders** site brings together several essays that focus on the Renaissance and early modern period (with Hoberman's spectacle standing as a later variant of the traditional, highly staged *Wunderkammer* [page 209]). Here, we take aim at a specific epistemological question: *What do we know when we see?* The more "wondrous" the image, the more loaded the question becomes. While their objects ranged from rocks to saints and from bees to peasants, the artists and natural philosophers of the early modern period linked seeing to knowing in revealing ways. The wonders examined here presuppose (and enforce) specific worldviews—located in particular knowledges of the thing seen.

Turning to the later modern period, a parallel site emerges in the historicized binary **Objectivity/Subjectivity** (a binary that Hoberman's installed and projected machinery [page 325] is meant to question). The query here is: *What do images presuppose about (human) nature?* What do discourses of "objectivity" and "subjectivity" produce in the way of images, and how do those images in turn produce knowledge? What types of statements must be marshaled to support their interpretations?

In direct correspondence with the **Objectivity/Subjectivity** site, **Cultures of Vision**

calls forth a final epistemological problem, suggested by the forest of projection screens in Hoberman's installation (page 399): *What viewers and processes does the image presuppose?* Not as general as questions of "(human) nature," this site harbors issues of location, mediation, politics, physiology, and attention, all of which enter into the objects and practices that designate science and art.

Looking in some detail at the various essays constituting these sites, we will identify the network of overlapping concerns that animate our contemporary narratives of picturing science and producing art. There can be no doubt that in attempting to locate the conditions of possibility for various historical regimens of seeing and knowing, we reveal something of our own desires to trouble the bifurcation of what are still institutionalized as separate domains.

## SITES

*Styles: How are images and practices aggregated, and to whose benefit?*

In the essay by Carlo Ginzburg that opens this site, there are two notions of the work of art (or product of science). The one is relational (embedded in a specific historical moment), the other absolute (a fixed attribute of form). While the absolute can be understood through the relational (history), the converse is not so. (That is to say, one cannot derive history from form.) Style, *mutatis mutandis*, is both absolute and relative, but only the relative (historicity) of style can explain the other (local production of the absolute). Ginzburg's essay and the others in this section are ultimately about the deployment of "style" as a heuristic device for aggregating production. But each author critiques the felicity of that heuristic, showing that there is always something prior about style—some assumption governing its use—residing, perhaps, in authorial uniqueness, or (more typically) in purely formal relations, theories about ethnic origins, or absolutes of other types.<sup>20</sup> Ginzburg, in interrogating style, shows how the notion can serve both to split and to lump. He concludes with a sharp critique of the very category itself as ideologically laden—"an instrument of exclusion"—and calls for both an acknowledgment of the utter uniqueness of a particular work in its isolation, and for a nonsimultaneous *translation* of the work's singularity into a relationship with history.

Irene Winter is similarly critical of the heuristic of style, but only as it has been reified as distinct from "meaning" through the peculiar divagations of art-historical theory. She makes the useful distinction between "stylistic analysis" as an operation that is clearly located in the viewer, while the more problematic concept of style is positioned as something inherent and identifiable in the work itself. Refusing to relinquish stylistic analysis, her real target is the development within art history of two paths, where style was reserved for form alone, while "iconology" was given to be the bearer of meaning. Through a close reading of objects identified geographically as roughly



contemporaneous products of “Syrian” versus “Phoenician” cultures, Winter seeks a composite model of style as containing both elements that are “not-necessarily-conscious” and those that are “consciously deployed”—a historically bounded set of possibilities that are winnowed down in the work itself for reasons that have everything to do with meaning. In Winter’s analysis, the ruler’s strong arm is inevitably both formal (creating structural and decorative patterns) and meaningful (conveying specific information about power)—yet, crucially, “the potential use and value of style as a concept depends entirely upon the nature of the analytical operation(s) in which it performs.”

For Ginzburg, the possibility of the individual object’s resistance to aggregation must be held in tension with our (not always progressive) need to make social sense of it. For Winter, who is working with objects that are both divorced from individual makers and unknowable outside social systems, the problem is a different one, a more delicate negotiation in which “reading in” is balanced with a sensitive appreciation for the obdurate peculiarities of historically situated cultural forms. This dialectic between individual (makers, readers, objects) and social (modes of meaning, contextually embedded producers of objects) is intrinsic to the heuristic of style itself. Elsewhere Svetlana Alpers has commented upon the fact that scholars outside art history have been drawn to the discrimination of styles “because it is scientific”—more empirical “than the critical appreciation of and interpretation of individual works.”<sup>21</sup> This sense of the “scientific” use of style as erasing or subsuming the individual occurs too in Amy Slaton’s essay on technological styles.

Slaton shows how technicians’ factory forms, as read by art historians, have been used to suggest stylistic aggregations that work precisely through the *absence* of imagery (in this case, through the absence of “the decorative”). This is a notion of style that no longer depends on links forged between essential qualities of the works themselves, but upon shared modes of providing them with cultural significance.<sup>22</sup> Clearly Slaton’s is the same “modal” heuristic that Ginzburg and Winter deploy. She argues that it is important to extend style beyond innovators (Henry Ford, for example, as the “author” of the automobile) and to identify it with the taste of consumers, and the existence of technical practices together with the institutions that enforce them. “Technological style” thus becomes more than a borrowed metaphor, more than an analogue of style in the artistic-architectural sense. Conjoint practices issue in both style-as-technique and style-as-formal-relations. The concrete factory aesthetic emerges from engineering concerns, but its forms inaugurate their own history of signification.

For Slaton, Ginzburg, and Winter, style is a culturally loaded term that brings powerful forces of nationalism, politics, and racism into play in the fields of aesthetics and social interaction. Science is pictured here as actively wielding style (Ginzburg) rather than distantly reflecting or unconsciously manifesting it; style in art and architecture

is dismantled to reveal the processes of professional identity formation (Slaton) or the production of national cultural identity by interpretive history itself (Winter). Gudea and Assurnasirpal, Augustine and Feyerabend, cement technicians and architects—all are shown to picture science or produce art in insistently stylized ways. But far from the mysterious attribute of a cultural *Zeitgeist*, in this book style is viewed as strategically constructed, both in the act of making culture and in the process of interpreting it.

*The Body: How do images shape body knowledge, and for whom?*

Processes of doing science and making art involve the body, but the book's authors argue that "the body" is most often figured as an *object* of these cultural inquiries, constructed through the parallel and intertwining discursive regimes of (natural) science and (figurative) art. Where interpretation and identity are key issues for the *Styles* section of the book, here the central theme is the *power* of images to instantiate and produce knowledges of, and by, the body. Arnold Davidson begins the section with a minutely historicized account of the iconography of the stigmata, demonstrating that notions of evidence and theological dogma regarding this bodily miracle were fixed in panel paintings and frescoes before they ever appeared in the putatively authorizing Vatican texts. Simultaneously, he shows how the visual iconography of the stigmata itself becomes a parallel tradition that never fully converges with the textual accounts. St. Francis's markings cannot be visualized as the higher "imaginative vision" (identified by post-Augustinian philosophy) that the textual accounts want to emphasize; the fresco paintings of Giotto and his followers inevitably *embody* the miraculous in particularly concrete ways. We suggest that the very materiality of paint (that is, the transformation of the narrative's iron-red blood to iron-red pigment), instantiates a baser "corporeal vision" that was, in Davidson's words, "meant to stabilize the status of the stigmata [as] a singular miracle." "Official" possibilities for the religious body were enlarged in this visual tradition, and subsequent miraculous bodily transformations were experienced—one might say indelibly marked—by the body knowledge such images produced.

Moving from the late medieval period to the eighteenth century, Londa Schiebinger also explores the ways in which verbal and visual discourses construct body knowledge. But by focusing on gender divisions in scientific practices, she also locates the production of what we might call "body ignorance." Like the oral and internal traditions of women's body knowledge that Barbara Duden describes as eliminated by scientific knowledge,<sup>23</sup> Schiebinger posits a variety of "counter-bodies" that Enlightenment science ignores—individual human bodies obscured by racist, sexist, and colonial programs; polymorphously sexual plant bodies gendered and socialized; "native" bodies (and indigenous knowledge) overrun by the expanding discourse of colonial natural philosophy. In Schiebinger's most salient example of such "body ignorance," she examines how the cartographic and classificatory gaze of Enlightenment

science erased the experiential knowledge of the Surinamese women whose views had been presented by female naturalist Maria Sibylla Merian. Merian's complex descriptions of the plants of Surinam included political critiques and medicinal lore—specifically, the local knowledge that the seeds of a certain tree worked as an abortifacient (knowledge that worked to confound the plans of Dutch colonial slave traders along the way). The production of ignorance from this matrix of knowledges took place as Merian's descriptions were taken over by British naturalists, who had their own nativist objectives. The indigenous body knowledge of the plant's medicinal use was suppressed. While Davidson shows the way in which visual imagery can serve to “corporealize” knowledge of natural wonders (which we see as parallel to Augustine's lowest category of “corporeal vision”), Schiebinger shows the ways in which the visual and verbal discourses of colonial botany worked precisely to erase such corporeal knowledge (in favor of a type of knowledge we might categorize as analogous to Augustine's third and highest category of “intellectual vision”).

With a view of the early decades of the twentieth century, Caroline Jones examines a realm that might be identified with the intermediate Augustinian realm of “imaginative vision.” Here, in the practices of a single modernist artist (Francis Picabia), Jones locates the modern body-machine complex, analogous to what Donna Haraway terms the “technoscientific body” (already suggested by the image of Hoberman's installation). Picabia's evocative line drawings navigated certain normative modes of knowing the sexed body and explored the psychological states that were then held to enforce sexual difference. These were modes (conveyed by his own neurologists) that theorized his persistent neurasthenia as a sexual disorder, reparable only through the proper channeling of procreative and electrical energies. The standard model of “influence” that might be used to explain Picabia's work (in which a concept moves from scientific discourse to artistic imagery) is confounded by a closer reading of the images, particularly those dedicated to the very neurologists formulating the psychologized sexual body Picabia inhabited. Picabia's machinic images produce their own renegade forms of knowledge, some appropriate to the neurasthenic subject, and some frankly out of that subject's domain. The newly *visceral* presence of technology in the Picabian body allowed hybrid, hermaphroditic, and synoecious couplings that (like Davidson's visualized stigmata) present an instantaneous visual “tradition” at odds with the dogmas established by textual culture—even the textual culture that might be constructed by Picabia's own accompanying poems.

In her expansive voyage over the terrain mapped by the scientists of “Life Itself,” Donna Haraway observes their visual culture—generated by game designers, molecular geneticists, microbiologists, and commercial advertisers—with a mordant yet curiously sympathetic eye. Haraway traces, as does Schiebinger, exclusionary (and largely unconscious) tropes of cartographic delineation and their origin in systems of colonial control. She, too, examines the production of ignorance—in this case accomplished

by the reductive “mapping” of the Human Genome Project. Empowered by the rigid yet fragile operation of what she calls “gene fetishism,” the technoscientific body of the genome is produced through a variety of discourses. The most visual of these is that “official art of capitalism” (as David Harvey has termed it), the advertisement. The cartoons used to market genetic research technologies constitute Haraway’s most powerful object, for here the operation of the fetish becomes an anxious negotiation between the production of ignorance and the body knowledges it would erase. The advertisements’ jokes, their very comedic structure, attempts to resolve these negotiations in favor of “Man<sub>TM</sub>,” the parthenogenic substitute for diverse lived bodies’ narratives, experiences, and subjectivities. As Haraway’s analysis shows, the links between these anxious comedic structures and the more official stories of science are profound: the metaphor of the map ensures the systematics of colonial control; the construction of human bodies as husks for “replicators” and “selfish genes” fuels the cultural unconscious that produces the fetish; the lie of the “master molecule” empowers the fetishists in their disavowal of the living in favor of the replicant and the undead.

The implications of Haraway’s larger argument connect, as well, with artist Perry Hoberman’s contribution to this volume. Hoberman and Haraway would both agree that the gene fetish is related (one is tempted to say “genetically related”) to the ideology of cyberspace. Each has argued that cyberspace is falsely theorized (and popularized) as a disembodied realm that leaves the “meat” of the body behind, in exchange for the map-like manipulations of various electronic simulation games (in Haraway’s account, primarily the Maxis Corporation’s “Sim” games—*SimLife*, *SimCity*, *SimEarth*). Such “deanimations” (as Haraway terms them) are experienced by Hoberman in his role as a sometime producer of virtual-reality technologies (known in the industry as “location-based entertainments,” but perhaps more aptly described as “location-erasing entertainments”). The *disembodiment* of such visual and verbal discourses is always strategic, as Haraway shows (even if it may be the unconscious strategy of the fetish). Hoberman, too, works to materialize the systematics (the marketing ploys and electrical grids) and links to the body (hair dryers, food blenders and mixers, foot massagers) that make technology as cathected as it is. As the work of both Hoberman and Haraway reveals, the cyberbabble cycling around “virtual” reality serves above all to erase other realities, from distant yet specific worlds of colonialist empires, to the more proximate “meat” of migrant workers in the computer-chip industry in Silicon Valley, to the narrowed choices that the rhetoric of “interactive” technology serves to mask. As *Faraday’s Islands* and other works by Hoberman emphasize, technology always operates in an embodied world, where, at the most, we might aspire to inhabit what Haraway calls the “carbon-silicon fused flesh of technoscientific bodies”—hybrids, once again, as the neurasthenic Picabia already imagined us to be.

*Seeing Wonders: What do we know when we see?*

In the most historically focused and largest of the book's sites, five authors address objects from an age before the production of colonial and cartographic certainty, when boundaries between the natural and the artificial, the seen and the known, the monstrous and the wondrous, were fixed at points far from the contemporary compass. Krzysztof Pomian's essay magisterially tracks a shift from ancient epistemes of equivalence between vision and cognition (seeing as knowing, and, in parallel, "to know is to see"), to Enlightenment models of cognition as production, in which seeing (as mediated by "scopes," both tele- and micro-), is productive of a Cartesian "intellectual intuition" only later challenged by Hume. Pomian concludes with a third model, characteristic of the contemporary moment, which he identifies as "indirect cognition," a mode in which "seeing" is knowing-through-technology. Sight in Pomian's ultimate moment has become distant from "mere" ocular vision. Unlike the boundaries that will be traced by the other authors in this section (between nature and art, true and false reproduction, the panegyric and the scientific, the premodern and the modern), all of which involve modes of *visual* representation, Pomian's final regime of knowledge (which could also be called "instrumental cognition") suggests a potentially postmodern frame. Highly mediated, eliding into unbounded, less visual zones in which "nature" is produced purely discursively, such "indirect cognition" produces all the wonders of the universe that we no longer need to "see" to believe.

Pomian's philosophical and historical sweep is focused in subsequent essays on more narrow spans of Renaissance and early modern European natural philosophy (practices conducted by those whom we identify today as "artists" as well as by those now categorized as "scientists"). These other essays illustrate how different the sight-knowledge relation can be from contemporary models (even from those just beginning to evolve). As Lorraine Daston argues, the relation between seeing and knowing often begins with the cognitive side of the equation, and the supposed self-evidence of the seen dissolves with the historically shifting boundaries of belief about the powers of nature set against those of humankind. What is it, Daston asks, that makes a thirteenth-century observer decide that an image-bearing stone (a cameo) is imprinted by nature rather than cleverly carved, while four centuries later another image-bearing stone (a fossil) provokes questions as to whether it is naturally deposited or artificially formed? As Daston insists, these distinctions were not fuzzy at the time—they were fixed firmly and definitively in the thirteenth century, to be redrawn in the seventeenth just as firmly and definitively. The kinds of indirect, postmodern knowledges to which Pomian alludes resonate intriguingly with Daston's analysis: What kind of boundaries are being drawn today between "nature" and "artifice," as postmodern theorists simulate carbon-silicate hybrids and invent ways to store knowledge in a manipulated biomass?

Introducing the theme of “wonder” that threads through this site, Daston explores the ambivalence that greets these unstable objects—the figured fossils, carved cameos, crystal-studded bibelots, and nature-machine amalgams that are seen as marvels in some epochs, kitsch in others. It is precisely ambivalence that fuels Katharine Park’s chosen historical moment, as well, but her fifteenth-century Italians experienced an ambivalence tinged with horror—a profound fear of the unchecked power of reproduction in both nature and art. Park pursues the nature/art boundary into the crannies of medical and juridical debate, and chases the “wonder/horror” dichotomy into the anxious terrain already set forth by the earlier section, **The Body**. Relating to both Haraway’s examinations of the gene fetish and Jones’s look at machinic sex, Park analyzes late-Medieval theories of reproduction in which the visible is, paradoxically, both proof of secure knowledge and product of false knowing. Park’s historical subjects harbor anxieties: about the vulnerability of females’ reproductive apparatus, and the skills of counterfeiters in altering a newly impressionable Nature. There were strong connections between cuckoldry and counterfeit in the thoughts of Park’s Italian clerical elite. Early efforts to dissect the female corpse were linked, she argues, to these anxieties about female and monetary reproduction. The membrane of the female body was held to be permeable and “impressionable,” and potent images were uniquely capable of influencing the more fluid female form. The power of the sign in Park’s history thus oscillates between passive symbol of prior knowledge, and potent stimulator of new knowledge that may be false, or true. The sign’s capacity to shift from miraculous wonder to counterfeit horror has everything to do with the status of representation itself in fifteenth-century Tuscan culture.

The oscillatory relation Park traces between the image as that which registers knowledge and that which produces it also obtains in David Freedberg’s analysis. Freedberg’s chronicle of the destabilizing power of natural imagery in the sign systems of the later Italian Renaissance is a progressivist narrative (as the Renaissance patrons, panegyrists, and members of the “Lynx-eyed” academy themselves believed). In his specific focus on the iconology of the bee, Freedberg traces a tense, taut line between the knowledge produced by the new technologies of vision (e.g., the microscope) and the symbolic knowledge necessitated by the Medicean reign. The more that “bees” become the subjects of specific natural-historical inquiries, the less they can function as transparent vehicles of Papal flattery. *The more they “know,” the less they “represent.”* Freedberg celebrates the microscopic accuracy of the engravings prepared for the Barberini Pope (whose escutcheon sported three bees), but argues that such a celebration of optical technology was dangerous at a time when Galileo was being targeted as a heretic. Such micrographical accuracy did not extend, of course, to a correct identification of the head of the hive as the *queen* bee; for the papal panegyrists, the fecund and benign monarch of bee-dom could only be a king, explicitly analogized to the pope himself. Between classical tales of sweet honey and smooth governance, and new

microscopic visions of black, hairy, bug-eyed creatures with multiply jointed legs and inhuman sexual practices, an uneasy gap began to open. In a real sense, these bee-studded images promulgated knowledge that their authors became anxious to constrain.

In Joseph Koerner's richly allusive essay, such visually implicated knowledges shift differently. If Freedberg defines an opposition between representing and reporting (or praising and knowing), Koerner shows how such a conscious opposition must itself be seen as a moment in the development of modernism. While imagery may be a maker of knowledge, it is also, for Koerner, a manifestation of a worldview. The image plays a crucial historical role in visually demarcating (for present-day viewers) a premodern ("unknowing") universe of Bosch from an already modern ("knowing") frame of Breughel. The premodern is incapable of referencing itself as a representation, while the modern is powerless to avoid it. Citing Lévi-Strauss's inability to penetrate the savage world he would understand without thereby destroying its very "savagery," Koerner theorizes the historicity of framing itself: Bosch's refusal to "frame," to bracket the wondrous from the horrific or the monstrous from the sacred, stands in contrast to Breughel's consciously framed tableaux. Koerner finds in Bosch and Breughel closely linked yet crucially disparate pictures that "stand at our disposal for apprehending the threshold to an alternative historical reality." His distinctions between "representing" and "knowing" return us again to distinctions among the categories of modernism, its precursor, and its potentially postmodern sequel. These artworks, for Koerner, register the crucial juncture at which the world splits among conflicting worldviews. As in Haraway's discussion of the postmodern "pov" or point-of-view, Koerner traces the move from world as plenum, to "the" world as contingent and discursively framed.

*Objectivity/Subjectivity: What do images presuppose about (human) nature?*

"Objectivity," in its widespread usage, is one of the most vaunted attributes of science in both popular and scholarly accounts. Some notion of objectivity motivates most analyses of what separates the production of science from the production of art, with "subjectivity" the shadow term that is held to separate art from science. And yet, as the authors of this section demonstrate, neither category is stable or sufficient—not for artists and not for scientists. Peter Galison, building on joint work published elsewhere with Daston, argues that the scientist's pictorial objectivity is, fundamentally, a nineteenth-century concept, exemplified in the discourse of the scientific atlas. Long before the term "objectivity" itself appears, these atlases served as visual compilations and repositories of the basic objects of science—the best and truest depictions of bodies (for example) that could be produced. But in the first of these "true to nature" tomes (which appeared in the eighteenth century), the atlas image was anything *but* a depiction of some specific bit of nature—the very idea was anathema. *True* images at this point were held to be precisely those in which the artist/scientist was able to part the curtains of appearances, and in so doing reveal an inner or hidden reality obscured

from sight. Distinct from Pomian's first epoch of "vision as cognition," these Enlightenment thinkers found much to mistrust in that which was merely seen. Genius was needed to discern the true from the fleeting. By contrast, Galison contends, the goal of the nineteenth-century natural philosopher became increasingly to *restrain* this individual "genius," and to harness the image-making process to appearances so "mechanically" that it would preclude the possibility—indeed, even the *suspicion*—of any human intervention whatsoever. Not coincidentally (as we have argued), it was also at this moment that the roles of scientist and artist began to congeal into their binary domains. Scientists and their defenders claimed the new automaticity of depiction as objectivity, which itself became a newly valued term. But as Galison reveals, the fate of objectivity did not rest here. In the twentieth century, subjective judgment (which had long been a term of opprobrium for nineteenth-century scientists) became a term of approbation for atlas makers, who chose to celebrate their roles as expert interpreters rather than advertise how closely they confined and policed their artist-collaborators.

Galison's account of the nineteenth-century production of pictorial scientific objectivity as self-effacement and externalization stands in stark contrast to the interiority suggested by Jan Goldstein in her depiction of the simultaneous rise of Cousinian psychology among upper-middle-class Frenchmen. Constructed as a hodgepodge of neo-German Idealist philosophy, Victor Cousin's teachings were taught throughout the Lycée and university systems, coming close to an official philosophy of the (male) bourgeoisie. Front and center stood everything that was subjective, everything associated with a forceful will; Cousinianism was a celebration of the individualistic, morally independent, highly sensible and sensitive *moi*. Because Cousin's hierarchies so privileged the subjective, they might at first appear to be at loggerheads with the nineteenth-century atlas makers Galison describes, whose rallying cry was self-abnegation. But as Goldstein makes clear, the Cousinians saw their task of self-inquiry as one in which, paradoxically, self-sacrifice and asceticism were central moral characteristics. Perhaps one should put it this way: the subjectivism associated with Cousinian individualism, creativity, and force of male character involves the supervaluation of the *moi* (subjectivity), while a different but related type of individual fortitude came to be supervalued in the sciences. The moral profile of the Cousinian ascetic (called "subjectivity") jibes precisely with the willful suppression of the scientist's desire to see a theory confirmed or an expectation realized (termed "objectivity"). The scientist's receptivity to the world is, by the light of the atlas makers, not born of passivity but of triumphant self-restraint.

The notion of objectivity-as-self-restraint produces an intriguing disagreement between historian of photography Joel Snyder, on the one side, and Galison and Daston, on the other. For Galison, the salient feature of objectivity as captured in the



nineteenth-century atlas-making tradition is that it is both procedural and moral; it is an attempt by the picture-making scientist to abolish the idealizing, “artistic” interventions of earlier observers. For Snyder, the point of the physiologist-photographer Etienne-Jules Marey’s work lies precisely in the fact that it does away with the central role of the “observer” altogether. Snyder argues that (for Marey) it is insignificant whether the process under consideration could be observed accurately by humans, or even at all. Put differently, Marey’s instruments construct images entirely unavailable to unmediated human vision (arriving once again at Pomian’s category of “indirect cognition”). As with all images, ultimately even the instruments fall away, and only chronophotographic tracings remain. These tracings, not the original photographic subjects (trotting horse, running man) then become the true “subject of investigation.” Marey’s staccato images do not “freeze” perceptual time, they schematize temporal progression. As Snyder is at pains to emphasize, even before Marey the long-exposures of early photography did *not* show what a human observer saw. Boats passing on the river vanished in virtue of their movement, and streets were voided of their carriages and their *flâneurs*. From considerations such as these, Snyder concludes that whatever else they do, photographs are not aimed uniquely at enhancing sense impressions. At times they create a new domain of the visual, producing at the same time new viewing subjects to make sense of that domain.

The three essays of this section can be structured as follows. For Galison, there is no stake in claiming for the mechanical-objectivists any kind of sense-data impressionism. None of the nineteenth-century atlas makers (nor their eighteenth-century predecessors) grounded their images on what we might see with the unaided eye. In this sense, Snyder’s Marey is functioning as a research physiologist, doing precisely what astronomers or anatomists were also doing in *their* laboratories and observatories: correcting the senses with mechanical aids, teaching us just where our senses can lead us astray, and, indeed, constructing entirely new modes of vision through which the world would subsequently be perceived. What is striking in the Marey story, and what connects it back to Goldstein’s culture of Cousinianism, is what Marey held to be necessary in replacing the senses: *the imagination*.<sup>24</sup> For most German, British, or American atlas makers of the mid- to late nineteenth century, “imagination” suggested the vagaries of artistic license, a freedom from the constraints of mechanical reproduction; we might recall also that the “imaginative” was only the middle register of Augustine’s hierarchy of religious visions, between the corporeal (Marey’s senses) and the intellectual. One might speculate, building on Goldstein’s work, that the long tradition of Cousinian psychology (with its emphasis on the conciliation of art and science) left a positive valence to the imagination in French physico-physiological research that was absent in the Anglo-Saxon world. The imaginative elided with the intellectual in the French hierarchy of representations. But however one considers the particularities of

these instances, the broader lesson is clear: the objectivity/subjectivity axis that has so characterized debates over the domains of art and science was itself a historical entity coeval with those debates. It took its defining form in the nineteenth century, and its history forms the backdrop to our own.

*Cultures of Vision: What viewers and processes does the image presuppose?*

This final site deals with the logic of “visual culture” and the issue of visibility itself, which together form the subject of inquiry within much of science studies and art history. From her perspective as an art historian, Svetlana Alpers performs a complex reading of representations of the artist’s workplace, including genres such as still life and landscape that are not usually read as indexical studio signs. Alpers seeks both to reflect on the relation of artist to reality, and to analogize artists’ efforts to those of scientists participating in the mimetic and analytic traditions of experimentation described elsewhere by Galison and Alexi Assmus. As the subsequent essay by sociologist of science Bruno Latour also does, Alpers’s contribution underscores the double action that follows from linking art and science. The comparison grants a “seriousness” to artists, rendering them skillful rather than merely moral; at the same time, it brings experimenters out of their isolation in a separate “culture,” and in so doing, redefines the epistemic status of what they do. At first pass, one might model the studio on the laboratory, focusing attention on the role of technician-assistant. But Alpers is after the painting’s self-promoting status as an indicator of individual experience in general, experience in which the individual’s presence in the world is not tangential, but rather central to the activity of making art.<sup>25</sup> And in this respect, the artist in the studio is manifestly *unlike* the scientist in the early modern laboratory. Withdrawing (elsewhere she calls it “retreating”) into the studio is a regressive act, one that returns us to a prior experience. As regressive, the view from the studio is colored either as originary (how the child sees) or as precursor to philosophy (how we come to experience through vision). The explorations of the artist are in this sense philosophical and psychological quite as much as aesthetic.

The personal, philosophical, and psychological also enter into Bruno Latour’s paper, which thematizes the plurality of “cultures” in this section’s title by posing a question that is pressing for science studies, for art history, and for our theories of religious faith. What, he asks, can we learn from the way these vastly different regimes of knowledge use visual techniques to point toward “remote phenomena and absent features?” At this level of abstraction, the painter employs iconology, the scientist symbolic representations, and the theologian one realm of reality to stand in for another. But most importantly, Latour insists, the dynamic of this set of symbols (and symbols of symbols) does not function by directly invoking the final referent, but rather by a complex process of mediation that is itself the bearer of meaning. In the articulation of these systems of mediations, both the historian of art and the historian of science end

up showing how complicated it is to put together the elements of a finished piece of work. Varnishes, dealers, assistants, patrons; maps, measuring devices, graphs, charts; angels, saints, monks, worshipers—these chains of mediators constitute the circumstances under which the work of art, science, (or religion) is produced. Here (Latour insists) an asymmetry arises. Constructivism *flatters* the arts because exhibiting mediations works “in the same direction” as the art’s own ambition, but the same multiplication of mediators *threatens* a popular construal of science that holds it to be an infinitely direct and immediate reference to the world.

A more sophisticated view, Latour argues, would take science to be that which is held constant through transformations; instead of trying to get at *things* and *mind* directly, he wants to bracket those categories in and of themselves, and get at them through the dynamical transformation of one mediator into another. In the end, Latour wants a language of visual culture rich enough to include many types of mediators, but one in which no type is subsumed by any other. He asks that we bracket out the extremes of *res* and *cogito*, and focus on the “cooking steps” that mediate between.

Simon Schaffer has a similar aim, but his kitchen proffers less heavenly fare. Schaffer wants an understanding of the widely distributed features of popular culture, and the central role they play in defining scientific knowledge. More specifically, he aims to show that the nebular hypothesis in astronomy—the notion that stars and planetary systems formed through the coalescence of clouds of gas in space—was tied root and branch to nineteenth-century battles over evolution, the progress of civilization, and the Irish Question. For both friends and enemies of the nebular hypothesis, progress in the heavens (from chaos to brilliant stars) vouchsafed the idea that there could be progress below (in politics and society).

Schaffer’s story, however, is not purely a narrative of abstract ideas. The contest over “progress” in deep space was fought, among other places, in the famed observatory of the Earl of Rosse in Ireland. Rosse (William Parsons) and his second in command, Ulsterman Thomas Romney Robinson, inveighed against papism, materialism, and evolution. Their aims oscillated between process and product. Process encompassed the astronomical display of a factory-like laboratory in which production was explicit, workmanlike, and British (in explicit distinction to the rural Irish surround). Product centered on the content of the observatory’s pictures, produced through exquisite draftsmanship and always aiming at the “resolution” of the so-called nebulae into stars. For if such a resolution could be completed, it would (so Rosse and his allies contended) not only refute the nebular hypothesis, but also the broader promise of evolutionary progress (and social responsibility) that it seemed to imply.

The stakes of debates in visual culture are also at issue in art historian Jonathan Crary’s essay. Crary, too, is after the dynamics of visual culture and, like Alpers (and Galison, and Pomian), registers a nineteenth-century shift. Crary, however, looks not to changes from mimesis to analysis (Alpers), nor from genial to mechanical to

judgment-based objectivity (Galison), nor from “vision-as-cognition” to “vision-as-production” (Pomian). Although these histories can all be linked with his account, he focuses instead on a single thread within the epistemic shifts of modernism. He charts the deep reconceptualizations of *attention* (involving perception, cognition, and aesthetics) that he sees as constitutive of the late-nineteenth-century subject. Put starkly, Crary’s account identifies a transformation from classical theories of vision as something mechanical and capable of abstraction from the body (exemplified by the camera obscura), to modernist notions of perception as a process characterized by temporal flux and embedded in a physical body. The newly felt fragility of perception made attention and attentiveness new problems—problems of pressing urgency within both the modernizing workplace and modernist art. No longer was it possible to think of vision as fundamentally passive, a system in which the mind was imprinted by an external world. Crary joins those in science studies who argue against continuity with prior theories of mind: late-nineteenth-century epistemologies foreground the observer and the integrative, *active* observing process; the eye becomes “thick” and the viewing process fundamentally unstable.<sup>26</sup> Conceptually this marked a shift, from representation as a simple trajectory between equals to a relation of inherently unequal forces, from a semiology of perception to a physics of perception. For Crary, the modernist obsession with an aesthetics of “presence” and raptness takes place within this new epistemological field. Our histories of nineteenth-century visual culture must be read against such scientific understandings of perception and attention. They register the fault lines of an emerging modernist episteme, and set the stage for our own late-twentieth-century theories of the spectacular.

In its overarching analysis of the way that representations function in scientific and artistic discourses, *Picturing Science, Producing Art* attempts to present a broader analysis of knowledge production as a whole. By denaturalizing the categories “science” and “art,” and by attempting simultaneously to historicize and locate the mechanisms that enable their binary economy to function, we seek to provide more than just a belated corrective to the “two-culture debate” (lingering still in the late twentieth century). The cultural frames and positions available to scientists and artists as producers, and the equally constrained yet movable locations of those who interpret their work, have been our objects of study. By historicizing notions that see science as revealed Truth and art as mere individual statement, we take both realms of knowing more seriously. For the interdisciplinary scholars of this book, science and art are deeply important sources of knowledge, neither transcending the social (as “pure scientific knowledge”) nor propelling society from without (as “art of genius”). We have blurred the boundaries in order to demonstrate the ways that both domains *make* culture, revealing how they mark both mind and matter in the process.

## Notes

1. For a helpful summary, see Stefan Collini, introduction to C. P. Snow, *The Two Cultures* (Cambridge: Cambridge University Press, 1993), particularly p. xii. Here Collini notes that the term “scientist” was proposed only in the mid-nineteenth century, explicitly by analogy with the word “artist”:
 

an article of 1834 [reported] on how the lack of a single term to describe “students of the knowledge of the material world” had bothered meetings of the British Association for the Advancement of Science in the early 1830s, at one of which “some ingenious gentleman proposed that, by analogy with *artist*, they might form *scientist*,” though the same report records that “this was not generally palatable.”

Collini’s internal quotations are from William Whewell, who may himself have been the “ingenious gentleman” he referenced. See Sydney Ross, “Scientist: the Story of a Word,” *Annals of Science* 18 (1962): 65–85.

A search on the Internet with the limiters “Art and Science” brings up thousands of websites that turn out to be orientation maps for undergraduate college curricula. Interestingly enough, the formerly capacious label “College of Liberal Arts,” expanded to include the natural and social sciences, has often experienced a (sem)-meiotic division into its shadow binaries, “College of Arts and Sciences.” This conversion was adopted at Boston University in the spring of 1996.
2. As collaborators, we may be accused of exemplifying these binaries, but we also enjoy switching between them and multiplying the terms.
3. Charles Baudelaire, “The Modern Public and Photography,” in “The Salon of 1859,” *Baudelaire: Selected Writings on Art and Artists*, trans. P. E. Charvet (Cambridge: Cambridge University Press, 1972), pp. 291–98. John Ruskin, *The Eagle’s Nest* (New York: J. Wiley and Son, 1873). Also see citations by Collini, introduction, pp. xiv–xv; T. H. Huxley, “Science and Culture” (1880), reprinted in Huxley, *Science and Education: Essays* (London, 1893), pp. 134–59; Matthew Arnold, “Literature and Science” (1882), reprinted in *The Complete Prose Works of Matthew Arnold*, ed. R. H. Super, vol. x (Ann Arbor: University of Michigan Press, 1974), pp. 52–73.
4. The literature on both avant-gardism and technologism is vast. For a good introduction see Renato Poggioli, *Theory of the Avant-Garde*, trans. Gerald Fitzgerald (Cambridge, Mass.: Belknap Press of Harvard University Press, 1968); Peter Bürger, *Theory of the Avant-Garde* (Minneapolis: University of Minnesota Press, 1984); Reyner Banham, *Concrete Atlantis* (Cambridge, Mass.: MIT Press, 1986) and *Theory and Design in the First Machine Age* (Cambridge, Mass.: MIT Press, 1960); Richard Guy Wilson et al., *The Machine Age in America, 1918–1941* (New York: Brooklyn Museum and Harry N. Abrams, 1986); *The Great Utopia: The Russian and Soviet Avant-Garde, 1915–1932* (New York: Solomon R. Guggenheim Museum, 1992). For a view of the conjunction of fascism with avant-gardism and modernism, see also Jeffrey Herf, *Reactionary Modernism* (Cambridge: Cambridge University Press, 1984), and forthcoming studies by Jeffrey Schnapp and Hal Foster. A more optimistic view is reflected in the work of Linda Dalrymple Henderson, for which see below.
5. Rudolf Arnheim, *Art and Visual Perception* (Berkeley and Los Angeles: University of California Press, 1954); Anton Ehrenzweig, *The Hidden Order of Art: A Study in the Psychology of Artistic Imagination* (Berkeley and Los Angeles: University of California Press, 1967): “Psychologically, abstraction in modern scientific thought is not merely reminiscent of abstraction in modern art, but is due to the same phenomenon of dedifferentiation. . . . The need for seeing incompatibles ‘together’ is more easily discerned in periods of transition when science is still groping for new models to accommodate still existing contradictions and inconsistencies.” Ehrenzweig uses here the wave/particle duality as such an “incompatibility” that requires the suspension of secondary Gestalt types of vision in favor of his “dedifferentiated” primary vision (pp. 131, 133).
6. Gerald Holton, *Thematic Origins of Scientific Thought* (Cambridge: Harvard University Press, 1973) and *The Scientific Imagination* (Cambridge: Cambridge University Press, 1978).
7. See Fritz Ringer, *The Decline of the German Mandarins* (Cambridge: Harvard University Press, 1969).

8. For commentary, one might begin with F. R. Leavis's withering critique in *Two Cultures? The Significance of C. P. Snow* (London: Chatto and Windus, 1962). See also John de la Mothe, *C. P. Snow and the Struggle of Modernity* (Austin: University of Texas Press, 1992).
9. For the deep gendering of Snow's account, see, in particular, his comment that the nature of scientific culture is "steadily heterosexual," without literary culture's emphasis on "the feline and oblique." C. P. Snow, "The Two Cultures," *New Statesman* (October 6, 1956): 413. For this and other insights into Snow and his milieu we are indebted to Stefan Collini, our colleague at the Institute for Advanced Study in Princeton during the 1994–95 academic year. See Collini, introduction, p. xxvi.
10. Historian of literature and technology Leo Marx continues to plumb the vitality of the two cultures debate, seeing it as instrumental in isolating discussions regarding the environment to a small group of natural scientists. See his "The Environment and the Two Cultures Divide," in *Science, Technology, and the Environment*, ed. James Fleming and Henry Gemery (Akron, OH: University of Akron Press, 1994).
11. See Leavis's critique in *Two Cultures?*; essay also anthologized in Leavis, *Nor Shall My Sword: Discourses on Pluralism, Compassion and Social Hope* (London: Chatto and Windus, 1972), anthropological issue discussed on p. 50.
12. T. S. Kuhn, *The Essential Tension* (Chicago: University of Chicago Press, 1977), p. 342. Kuhn is responding to E. M. Hafner, "The New Reality in Art and Science," *Comparative Studies in Society and History* 11 (1969): 385–97. Note that Kuhn's title encodes the "tension" between two other binary poles, philosophy and history, but also perhaps implicitly art and science.
13. Kuhn, *Essential Tension*, pp. 342–43.
14. On links between the Vienna Circle and the Dessau Bauhaus, see Peter Galison, "Aufbau/Bauhaus: Logical Positivism and Architectural Modernism," *Critical Inquiry* 16, 4 (1990):709–52. On the implications and impact of Gombrich's account of abstract art, see Caroline A. Jones, "Abstraction and the Leaven of Criticism," in *Eyesight Alone: Clement Greenberg and American Art* (forthcoming).
15. Erwin Panofsky, "Galileo as a Critic of the Arts," *Isis* 47, part 1, no. 147 (March 1956): 3–15; see also Samuel Edgerton, "Galileo, Florentine 'Disegno,' and the 'Strange Spottedness of the Moon,'" *Art Journal* (Fall 1984): 225–32.
16. Linda Dalrymple Henderson, *The Fourth Dimension and Non-Euclidean Geometry in Modern Art* (Princeton: Princeton University Press, 1983); also see her forthcoming book on Marcel Duchamp. Martin Kemp, *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat* (New Haven: Yale University Press, 1990). See also Samuel Y. Edgerton, Jr., *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution* (Ithaca: Cornell University Press, 1991), and J. V. Field, *The Invention of Infinity, Mathematics and Art in the Renaissance* (Oxford: Oxford University Press, 1997).
17. Kemp, *The Science of Art*, p. 1.
18. James Elkins, "Art History and Images that Are Not Art," *Art Bulletin* 77, 4 (1995): 551–71. See also Elkins, *The Object Stares Back: On the Nature of Seeing* (New York: Simon & Schuster, 1996). Barbara Maria Stafford's books on these subjects include: *Body Criticism: Imaging the Unseen in Enlightenment Art and Medicine* (Cambridge, Mass.: MIT Press, 1991) and *Artful Science* (Cambridge, Mass.: MIT Press, 1994).
19. This literature is so vast, one can only indicate some key starting points. On diagrams, see S. S. Schweber, *QED and the Men Who Made It* (Princeton: Princeton University Press, 1994), especially chapter 8: "Feynman and Space-Time Processes"; also, Schweber, "Feynman and the Visualization of Space-Time Processes," *Reviews of Modern Physics* 58, 2 (1986): 449–509. Galison, "Minkowski's Space-Time: From Visual Thinking to the Absolute World," *HSPS* 10 (1979): 85–121. On indicator diagrams, see Robert Michael Brain, *The Graphic Method: Inscription, Visualization, and Measurement in Nineteenth-Century Science and Culture* (Ph.D. dissertation, University of California at Los Angeles, 1996), and M. Norton Wise, "Fleeming Jenkin Measures Energy and Utility: Indicator Diagrams and Supply-Demand Curves," paper delivered at the Second Annual Harvard-MIT-Princeton Grad-

- uate Workshop in the History of the Physical Sciences (Princeton University, May 1997); Robert Brain and M. Norton Wise, "Muscles and Engines: Indicator Diagrams in Helmholtz's Physiology," in *Universalgenie Helmholtz: Ruckblick Nash 100 Jahren*, ed. Lorenz Krüger (Akademie Verlag, 1994), 124–45. See also Michael Lynch and Steve Woolgar, ed., *Representation in Scientific Practice* (Cambridge, Mass.: MIT Press, 1990); Bruno Latour's discussion of "immutable mobiles" in *Science in Action* (Cambridge: Harvard University Press, 1987), pp. 227, 236–37 (found also in Latour, "Drawing Things Together," in *Representation in Scientific Practice*, ed. Lynch and Woolgar). Bernard Carlson and Michael E. Gorman, "Interpreting Invention as a Cognitive Process: Thomas Edison, Alexander Graham Bell, and the Telephone," *Science, Technology, and Human Values* 15 (Spring 1990): 131–64. See also Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997) on instrument-produced images.
20. For further thinking on the subject, see Arnold Davidson, "Styles of Reasoning, Conceptual History, and the Emergence of Psychiatry," in *The Disunity of Science*, ed. Peter Galison and David Stump (Stanford: Stanford University Press, 1996).
  21. Svetlana Alpers, "Style is What You Make It: The Visual Arts Once Again," in *The Concept of Style*, ed. Berel Lang (Ithaca: Cornell University Press, rev. ed., 1987): pp. 137–62, quote, p. 138.
  22. This resonates with Alpers's call for a turn "from style as historical ordering to the mode of making." (in *ibid.*, p. 162.)
  23. Barbara Duden, *The Woman Beneath the Skin: A Doctor's Patient in Eighteenth-Century Germany*, trans. Thomas Dunlap (Cambridge: Harvard University Press, 1991).
  24. As Snyder relates, Marey emphasizes the role of the imagination in the final chapter of his last book: "The images . . . appeal rather to the imagination than to the senses." E.-J. Marey, *Movement*, trans. Eric Pritchard (London, 1895), p. 304.
  25. For a discussion of the ideology of this construct, see Caroline A. Jones, *Machine in the Studio: Constructing the Postwar American Artist* (Chicago: University of Chicago Press, 1996).
  26. See, for example, Tim Lenoir, "The Eye as Mathematician: Clinical Practice, Instrumentation, and Helmholtz's Construction of an Empiricist Theory of Vision," in *Hermann von Helmholtz and the Foundations of Nineteenth-Century Science*, ed. David Cahan, California Studies in the History of Science, 12 (Berkeley and Los Angeles: University of California Press, 1993).