

Introduction:

Methodological Premises of This Book

This book has two purposes. The first is to bring together images made in the last quarter-century that work at the limits of representation. The second is methodological: this book is my contribution to the problem that is still occasionally called the two cultures—the gulf of misunderstanding that has opened between the sciences and the humanities.ⁱ I hope the interpretive method I practice here will contribute to the difficult goal of speaking at once to both the sciences and humanities.

It seems to me that it would be hard to find a more difficult subject as far as university and intellectual life is concerned. The mutual alienation of natural scientists and humanists runs very deep, though it tends to be papered over by the ecumenical atmosphere that universities foster—the many committees, social relations, interdepartmental initiatives, and more-or-less successful interdisciplinary conferences—which can easily give the impression that there is a healthy ongoing dialogue between the humanities and the sciences. Certainly there is no lack of casual or non-technical conversation between humanists and scientists: but there is precious little overlap in courses or reading lists, and virtually no detailed, substantive discussion.

Graduate students in the sciences generally take no humanities courses, and it is nearly universal for humanities students to avoid sciences after the basic first- and second-year college distribution requirements. (In other university systems, such as those in England, the division is even more stark, and humanities students may take no science courses at all.) Those proclivities

extend into professional life. In my experience professors in the humanities often depend on chance social relations (relatives, friends) for their expertise in science, and scientists are apt to assume that help from specialists isn't necessary to appreciate the arts. The idea that there is a gap between the humanities and the sciences seems to be contradicted by the ease with which faculty members can communicate the generalities of their disciplines, and the very idea that there are two cultures seems to be moot, simply because it was raised so long ago (in 1962): a polemic that old, so the reasoning seems to go, must be inherently false, or poorly put. On the contrary, it seems to me that the abyss between the faculties, to use the administrative term, is immense: it has reached the point where I do not think it is unfair to say that contemporary universities are unified in name only.ⁱⁱ

For all his quirks, C.P. Snow was largely right when he named the two cultures and pointed to the disparity between them.ⁱⁱⁱ His famous test was to ask writers to define the Second Law of Thermodynamics; when they couldn't, he compared the importance of the Second Law to Shakespeare's *Hamlet*. The question, "Can you describe the Second Law of Thermodynamics?" is, he said, equivalent to the question, "Have you read a work of Shakespeare's?"^{iv} Snow's test was annoying and belligerent, and also brilliant. It remains the case that virtually no one outside the sciences reads unpopularized science, and hardly anyone in the sciences reads the professional literature of the humanities. "I now believe," Snow wrote in 1963, "that if I had asked an even simpler question—such as, What do you mean by mass, or acceleration, which is the equivalent of saying, *Can you read?*—not more than one in ten of the highly educated would have felt that I was speaking the same language."^v Snow's rude questions continue to be unanswerable. I am especially interested in the fact that they bother so few people: to a degree that continues to surprise me, the two cultures do not find their mutual lack of interest to be a problem. One reason for that insouciance appears to be collegiality of university life.

Another reason may be the assumption on the part of those in the humanities that the philosophy and sociology of science provide an adequate description of science, and the reciprocal assumption on the part of scientists that the philosophic self-descriptions of the humanities are epiphenomenal on art and culture, and therefore dispensable. Neither assumption, it seems to me, survives Snow's rude questions unless it seems those questions are themselves without consequences.

In the mid-1990s some of Snow's concerns were revived by Alan Sokal's critique of humanists' misuses of science. In one essay Sokal proposes his own variant on Snow's questions. He imagines asking an "average undergraduate" student, "Is matter composed of atoms?"—and then when the student says "Yes," he proposes asking, "Why do you think so?"^{vi} That second question is trickier than either of Snow's questions, because it leads into a number of further problems. Would it be reasonable to reply, "Because a consensus of scientists think so?"^{vii} Should everyone be armed with a demonstration of the atomic nature of matter? Sokal's test is not as sharp-edged as Snow's, but it is just as telling.

The literature on Snow's lecture and Sokal's writings is huge. By the late 1970s, when the interest in Snow's lecture was dying down, there were over 800 essays, reviews, and books on "The Two Cultures."^{viii} Sokal's book *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science* has been translated into Catalan, Dutch, German, Italian, Japanese, Korean, Polish, Portuguese, Spanish, and Turkish, with Russian, Hungarian, and Chinese translations forthcoming.^{ix} From the sheer size of the bibliographies on Sokal and Snow it might seem that there is an ongoing dialogue between the humanities and sciences. Unfortunately the literature is often schematic, marred by polemical intent, and conceptually impoverished.^x This is not the place to describe the two bibliographies or the other recent encounters between science and art. Instead I just want to register my general impression of the kind and quality of the debates by

citing^{xi} a single example: a letter written by the physicist Jonathan Katz, which appeared in 1999 in *Physics Today*, an official publication of the major American association of physicists. Katz claims that “postmodernism is nothing more than a scheme to obtain cushy university jobs for its practitioners.” He wonders why humanities departments don’t consider themselves guilty for not recognizing the “scheme” for the “transparent scam it is.” “Don’t they have a nose for cowpatties at all?” he asks.^{xii} Katz’s letter is curt, but his thoughts are in line with the discussion in *Physics Today*, which was mainly on Sokal and the sociologist of science Bruno Latour. I take it as a sign of the level of exchanges between the sciences and humanities that the editors of *Physics Today* thought Katz’s letter was an appropriate contribution—whether or not they agreed with it, they did not consider it irrelevant, inappropriate, or irresponsible.^{xiii} (I assume the editors thought it was funny, but it would not have been published unless it was worth reading.)

Opinions like Katz’s can be taken as evidence that science studies in the humanities have not diffused throughout the sciences. It is now possible to get a PhD degree in a number of science-related fields within the humanities, including the sociology, history, and philosophy of science, and even the anthropology and literature of science. Each has contributed to the discussion about science, but it remains an open question whether the emerging disciplines have diminished the distance between the sciences and humanities.

It is true that there are a number of admirable texts on the subject of science and the humanities by writers such as Michel Serres, Barbara Stafford, Jacques Bouveresse, Paul Feyerabend, Kurt Hübner, Bruno Latour, Ian Hacking, Andrew Pickering, E.O. Wilson, and Abraham Pais. Books like theirs can be well argued, well informed, and ecumenical—certainly good qualities for writing, whether the subject is the sciences or the humanities. But as reflective as such books can be, they raise a further problem. As far as I can see these authors speak principally either to audiences in the humanities or in the sciences, rather than to mixtures of the

two.^{xiv} Pais, for instance, is read by scientists, even though he has written on subjects of general interest. Most of the other authors are read principally by people in the humanities. At the center there is a void: with the partial exception of E.O. Wilson, no writer I know is read, and few are trusted, by readers on both sides. (I am not talking here about popularized science, but books that address the links between science and the humanities. Otherwise writers such as Stephen Hawking, Stephen Kay Gould, and Bill Bryson would be counter-examples.)

Sokal's book *Fashionable Nonsense*, which he co-authored a book with Jean Bricmont, would seem to sit squarely between science and the humanities, because it is a review of scientific and mathematical errors committed by various poststructuralist French thinkers. Just in terms of content, it would be reasonable to expect that it would attract readers from both "cultures." When it first appeared in French, and then later in English, it attracted a wide range of readers. Yet I wonder how many of those readers work in the humanities. Reviewing the book, the philosopher Thomas Nagel asks how many admirers of postmodern thought might actually read *Fashionable Nonsense*: will "teachers of cultural studies and feminist theory," he asks, "go through these patient explanations of total confusion about topology, set theory, complex numbers, relativity, chaos theory, and Gödel's theorem?"^{xv}

Even scholars such as Serres who have spent their lives writing back and forth between science and art find few readers outside the humanities. Serres escapes censure in *Fashionable Nonsense*; Sokal and Bricmont say his work is "replete with more-or-less poetic allusions to science and its history; but his assertions, though extremely vague, are in general neither completely meaningless nor completely false."^{xvi} It appears they do not consider Serres to be an interesting writer on the art-science border, as for example Bruno Latour does.^{xvii} Like Jacques Lacan, who also left some texts on science, Serres is judged to be neither obviously wrong nor

importantly right, and so he gets passed by—even in a book explicitly dedicated to comparing sciences and arts.^{xviii}

Another example of a writer with unequal readership in the arts and sciences is the historian Peter Galison, who writes some of the best-informed historical accounts of modern physics. His book *Image and Logic: A Material Culture of Microphysics*, which I discuss in the last chapters of this book, was reviewed by two physicists in the journal *Isis*; they wonder what it means that “even Galison, who understands so much about high energy physics and has thought so seriously about its power structures, fails to persuade one of the great doers, [W.H.K.] Panofsky, of the relevance of his postmodern discourse.”^{xix} It is necessary, the reviewers say, to stop and ask who reads “postmodern” history of science if the scientists don’t.

It goes without saying that Bricmont and Sokal have readers in the humanities, and that Serres and Galison have scientists among their readers: but I am aiming at an important general question here. I want to introduce the methodology of this book by proposing that scholars who cross between science and the humanities should take as one of their goals that their work be read *equally* by people on both sides. I do not mean that a scholar should aim to have exactly the same numbers of readers from the two “cultures”: rather that potential readers could come with equal probability from either side. The polemics that mar the literature on Sokal and Snow are mostly one-sided: the contributors identify themselves as apologists for one side or the other. The more balanced literature, such as Serres’s or Galison’s, comes closer to being acceptable to readers from either side. When the writing reaches a certain level the problem named by the *Isis* reviewers comes to the fore: if an author’s readers are mostly from one side or the other, in what sense is the work a bridge?

The central question, I think, is how to write in such a way as to create something that is meaningful both to working scientists and to humanists. Let me try to answer this question, and

introduce the methodology of this book, by describing three fundamental problems that occur in writing that mixes the humanities and sciences.

1. *The sciences are different from the humanities because scientific writing includes equations: hence humanist accounts of science that are set in prose risk omitting a central feature of scientific writing.*

Any interpretation opens a distance from the thing that is interpreted, but that difference is specially marked in writing about science because—at an elementary, evidentiary level—scientists work with equations, and interpreters respond with words. When people write about the sciences, they are obliged to substitute “literary” prose for what the classicist Wesley Trimpi calls “geometric” prose—mathematics.^{xx} As Trimpi stresses, literary and geometric discourses have been separate since the Hellenic period, and that makes the interpretation of science importantly different from the narrative interpretation exemplified by literary texts.^{xxi}

I stress this simple fact to suggest that part of what inflames misunderstandings between the two “cultures,” and prevents them from talking to one another in a fuller sense, may be a deep dissimilarity between modes of writing. The very word *writing* means something different when it includes symbolic configurations as well as the Roman alphabet. Reading, too, is very different in the humanities and the sciences, and for an equally basic reason: science textbooks usually have problem sets at the end of each section or chapter. Both students and professionals are expected to stop when they get to the problems and—in the telling phrase—*work* some of them. That means a scientific text cannot normally be read straight through. It involves stops and starts, and long pauses for calculation as well as cogitation. The same may be said of scientific and mathematical papers, which routinely truncate their lines of reasoning so that the reader has to work a little to reconstruct the full argument. It is appropriate at all levels of scientific writing

to say something like, “I leave the full demonstration to the reader,” or to proceed in such a way that the reader knows where that phrase might have been inserted.

That is not to say that I don’t read Montaigne or Foucault with a pencil in hand: I do, and my copies of books are often filled with marginal arguments. But all that is *optional*, in the sense that Montaigne and Foucault both wrote in a manner that can loosely be identified with the speed of a speaking or silently reading voice. Like most everyone since St. Jerome, I read silently, which means I normally read faster than I would if I read out loud, and without the cadences that are typical of the spoken word. Yet there is an underlying similarity between reading Montaigne out loud, and reading him to myself: the speed of his thought, his choice of words, his changes of pace and direction all appeal to an experience that is *continuous*, that moves through his ideas and words at a varying but ongoing rate. Things are different when the flow of words is periodically interrupted by numbered problems, propositions, and theorems. It is no more possible to read Newton’s *Principia* without stopping on each page than it is to read any freshman biology textbook in one gulp as if it were a paperback novel. Accounts of reading that gloss over this point, and propose a generalized reading or writing, tend to be written by authors who have not read books like the *Principia*: for those who have, I think the difference is clear, deep, and fairly consistent across different scientific disciplines and literary forms.

It is not irrelevant to the subject of this book that the same can be said about the *images* in scientific texts. Images in humanities texts tend to have minimal impact on the rates of reading: I can glance at an illustration in an art history monograph in order to verify something the author says, but I am not often expected to interrupt my reading altogether to make a concerted study of the image. (The notion is that ideally, I will go and see the original.) A typical image in a science text, on the other hand, comes with its own caption, which instructs me how to read it: the caption tells me what the symbols mean, what is measured on the x and y axes, and

so forth. Reading science, I often find I have to stop reading the text altogether and spend some time with the image in order to learn to interpret it; and the same process recurs repeatedly in the course of reading an illustrated science essay or textbook.

Writers in the humanities don't tend to stop their readers short with each new picture. Commonly the captions in humanities texts are minimal, because the continuous narrative in the body of the text does the work of interpretation. Paragraph-long captions are the exception, but they prove the rule because they make use of extended narratives (called, in the publishing trade, *discursive captions*), which are an attempt to repeat, in miniature, the continuously legible text that surrounds the image. In the sciences, on the other hand, it is often thought appropriate and even necessary to provide images with long non-discursive, densely technical captions. A problem arises when scientific images are placed in literary contexts, or vice versa, disturbing the normative relation between image and the flow of narrative.^{xxii}

Assumptions about the appropriate explanation of images, and about numbered problems and equations, can be summed up in a phrase: they constitute what I will call the *problem of the pencil*. I can read Montaigne without a pencil if I choose, but I absolutely cannot read an *Introduction to Quantum Mechanics* without a pencil and lots of extra paper. If I try to read an *Introduction to Quantum Mechanics* without stopping, as if it were a humanist narrative, most of it will go in one ear and out the other. I will not really understand the text: I will get its flavor, but unfortunately flavor does not count when it comes to quantum mechanics, at least not in the way I might claim such things as flavor, gist, or tone can matter when it comes to Montaigne. Hence an initial challenge for interdisciplinary work that tries to bridge the sciences and humanities is what to do with the problem of the pencil: the assumption that the reader will have a pencil in hand, and that reading will be interrupted, without warning and repeatedly, by equations, technical illustrations, and unsolved problems. The fact that theories of reading and

writing in the humanities continue to assume that equations, pictures with discursive captions, and problem sets are simple *additions* to “literary” narrative is a sign, perhaps the most fundamental, of the distance between the sciences and the humanities.

2. *Contemporary interdisciplinary scholarship, including work that links the arts and sciences, does not always specify which of disciplines under study is being used to illuminate which others.*

Writing about Sokal, the critic Teri Reynolds observes that “the point of any interdisciplinary endeavor is that work done in one field may be used to elucidate material in another.”^{xiii} The question is then a matter of deciding *which* field is to serve as the one that can “help us see new things about the other.” For Sokal, the illuminating discipline is physics (or some other branch of science), and the unilluminated discipline is some poststructuralist theory. In work such as Serres’s, a third discipline serves to illuminate two or more other disciplines that are themselves being compared to one another: again it is a matter of choosing which discipline sheds light on which others.

In the history of art, interdisciplinary research that includes science typically focuses on the scientific sources for particular movements and methods in Western art. In that case science helps explain the art: so for example notions of the fourth dimension shed light on ideas in Duchamp’s *Large Glass*, or Chevreul’s color theories reveal how Seurat constructed *La Grande jatte*. Let me label this operation, in which science helps explain art, as the first of several possible configurations in art history.

Other art historians prefer to go in the opposite direction and let the art explain the science—as it can in the history of anatomical illustration, which was intermittently influenced by contemporary painting, sculpting, printmaking, and even architecture. Call that the second

configuration. It is also possible—the third configuration—to explain both the art and science in terms of some other discipline. Among the many candidates, by far the most common is philosophy. There are several limit cases, which do not often appear as such, but are helpful in thinking about the forms philosophy has taken when it is utilized in this way. Scholarship that depends on the reception of Hegel need not specify causal links between disciplines that are being studied, because the final purpose of such scholarship is to demonstrate the natural affinities between the parts of a culture. A Marxist scholar, on the other hand, might want to make explicit links between the elements of culture and the conditions of the society: the latter would always cause the former, whether the subject is art or science. The vicissitudes of the Hegelian and Marxist approaches could account for a large percentage of writing on cultural history; what matters in this context is that they both introduce philosophic or theoretical discourse as the third discipline, taking a relevant philosophic practice as the ultimate ground of explanation and adjudication.^{xxiv}

This third configuration helps elucidate the fourth, which is the preferred one in much contemporary historical writing: to let explanation itself become evanescent. In that practice science and art may be put side by side, but without drawing a direct link between a particular scientific idea and a particular artistic work. Jonathan Crary's work, for example, juxtaposes paintings, photographs, labor conditions, theories of government and capitalism, advances in physiological optics, Kantian philosophy, contemporaneous psychology, and leisure technologies such as panoramas, dioramas, and stereoscopes.^{xxv} Crary makes sure that his examples fit narrow geographic and temporal bounds—mainly western Europe in the late nineteenth century—but he does not normally attempt to prove that a particular painter looked at a particular kind of optical device, or read a particular text. For example, in one chapter of a book on later nineteenth-century vision and visibility he discusses several paintings by Manet, the Kaiserpanorama (an

optical diversion popular in Berlin in the 1880s), photographs by Muybridge, and theories of optical perception and attention. Michael Baxandall has called that kind of historical writing “inferential criticism”: it is important for such work that influences existed, but it is not important to find direct links.^{xxvi} Manet might have been interested in popular optical diversions like the Kaiserpanorama, or he might not—but they pertain in the same decade, and are symptoms of the same culture.

In one sense inferential criticism is sensible, because causal links can’t always be found. In another sense it avoids larger questions: in general terms Crary belongs to the wider tradition of Marxist criticism, although his Marxism is tempered by readings of late twentieth-century writers such as Michel Foucault and Guy Debord. In that matrix, the ultimate cause of cultural phenomena—if the word “cause” still has purchase—is the configuration of class, labor, and society that comprised bourgeois culture. That culture was a complex and evolving whole, making it unnecessary or unrewarding to spell out causal connections. In the most fundamental sense, Hegel’s model of history gives this kind of historical writing its meaning: the very concept of a *Zeitgeist* implies that late nineteenth-century European bourgeois culture was a web of associated phenomena, making the search for cause and effect links inadvisable or unrewarding, and the reliance on any single direction of explanation (from social class to taste, for example) misguided.^{xxvii} Thus explanation can be evanescent. In some passages Crary juxtaposes technology and art; in others, he practices inferential criticism; and in others, he implies that his larger project is an inquiry into the workings of nineteenth-century bourgeois culture. That flexibility can be an asset, because it avoids the narrow search for direct causes that can be so vexing to historians in search of crucial pieces of evidence, and also because it avoids an unproductive adherence to theoretical models that can become incompatible with the material at hand. Some of the richest and most evocative texts on science and the humanities remain

uncommitted to any specific explanatory model. In other cases the same strategy can seem evasive, for example when it seems that the reason Crary declines to explain an image directly in terms of some technology, or vice versa, is because avoiding a causal narrative might make the overall account denser and harder to critique.

These are four configurations for the relation between disciplines: where the scientific discipline explains the nonscientific one; where the roles are reversed; where a third discipline, ultimately philosophy, guides the interpretation of both the scientific and non-scientific material; and where various disciplines are put in ambiguous conjunction. The four possibilities quickly lead into formidably complex problems, and interdisciplinarity itself is the subject of a growing literature.^{xxviii} It is seductive to create “unexpected associations that reorganize a familiar conceptual field and allow us to behave differently within it,” as Reynolds says, but it matters how that is done: by using science to explain art or vice versa; by shifting the onus of explanation back and forth; or by proposing an underlying conceptual problem that is illuminated by both. Reading an interdisciplinary text, it is usually not difficult to tell which discipline is doing the explaining, or if the author is moving back and forth between different explanatory systems. Sometimes—and this is especially true in some of the most sophisticated and influential texts—it is difficult to be sure what configuration, or set of configurations, is at work, and in that case the entire concept of interdisciplinarity becomes conceptually unclear. The result can be rich and evocative, but it can also be impressionistic and ill-structured, so that readers in the sciences especially may not feel that their disciplines are adequately represented.

3. Interpretation operates by metaphors and models that are themselves not necessarily part of the originating discourse.

Interpretation can be put as an abstract question of representation, because an interpretation is a discourse that re-presents something—a concept, text, image, process, or act—that has already been presented. In linguistic terms, the engine of that re-presentation is metaphor. For a sociologist of science, the illuminating metaphor might be power relations among scientific institutions, so that an account of the activity of a particular laboratory might be told in terms of grant proposals, rank, gender, or relations with other departments and laboratories. For a philosopher of science, the leading interpretive metaphor might be epistemology, resulting in narratives about the ways that experience is gathered and segmented into data, and how that data is assumed to be related to phenomena. For a popular-science writer, the interpretive metaphor might be biography, so that Einstein’s life might become the story of his friendships, family, politics, and professional appointments. I take the word *metaphor* very capaciously here: it might be a heuristic concept, an extended model, a thought experiment, an analogy, an image, or even a fully articulated metaphysical program. What I mean to suggest is that an interpretation cannot work—it cannot be perceived *as* an interpretation—unless it can be understood as a *particular* way of projecting a discourse that is already present onto a new discourse. The particularity of the re-presentation is then perceived as a metaphor or model.

Why put things so abstractly? Because seeing interpretation as an engine constructed of metaphors makes it clearer why scientists can find it unrewarding to read humanists’ accounts of their work. For a reader who knows the actual science, sooner or later the metaphors, models, or analogies proposed by sociologists or philosophers of science will begin to sound like something other than science. A scientist may read patiently on, mentally translating the various metaphors back into their original contexts, until he or she reaches the point where the interpretation seems to lose touch with its subject—where the metaphor engine appears to break down. Even if nothing in the account is overtly wrong, the interpretation may seem increasingly and finally

irreparably irrelevant. The metaphors or models, which seemed so fruitful and illuminating to the scholar who wrote the account, will appear to lose their grip on the subject at hand—on the actual practice or whatever is construed as part of the original presentation of the science, before its interpretation. At that point, the scientist may give up reading and go back to doing science, or—if the interpretation seems pernicious or egregiously misinformed—write a text like Sokal’s or Snow’s.

This problem of the failure of metaphor pertains as much to detailed studies like Pickering’s or Galison’s as it does to popularizations like Stephen Hawking’s *Brief History of Time*.^{xxix} It has no simple solution: any writer who sets out to interpret another discipline proposes and remains within a program of interpretation, whether it is spelled out or just implied. The issue is not the power of the metaphor or its flexibility or nuance: it is more a matter of the inherent structure of interpretation itself.

I mention these three issues in order to set up the approach I am taking in this book. It strikes me that to move forward with the project of talking about the humanities and sciences together, it is necessary to take a radical position in regard to narrative, explanation, and interpretation. The methodology I have in mind can be put as three answers to these three problems. In order, they are:

1. Regarding narrative: let geometric discourse remain geometric.

The historian Kevin Mulligan, reviewing Sokal and Bricmont’s book *Fashionable Nonsense*, pointed to two texts by Robert Musil, who was following writers such as Wilhelm Dilthey in worrying the distinction between the *Naturwissenschaften* and the *Kulturwissenschaften*. Mulligan comments: “Where Sokal and Bricmont betray their exasperation with

writers who simply could not be bothered even to consult scientific popularizations, Musil [in 1921] suggests that the important thing is to ‘go to the end of the trampoline of science before jumping off.’”^{xxx} To me Musil’s answer is optimal, even though he never wrote the kind of text that his argument implies.^{xxxi} The problem of the pencil certainly cannot be solved by adding problem sets to books in the humanities, but it does not follow that it is a good idea to minimize the number of equations in books on the history, sociology, or philosophy of science. (In particular it does not appear that omitting equations widens the audience for books in the history and philosophy of science. Hawking’s publisher supposedly told him that every equation in *A Brief History of Time* would halve his readership: but that problem only affects genuinely popular books.)

In this book I have tried to resist the inevitable slide toward what Trimpi calls literary discourse by keeping as close as possible to the specific textures of writing in the different sciences. There is no way to include *all* the equations, graphs, and technical arguments of the source texts: that would not be interpretation, but repetition. Nor is there any such thing as pure geometric discourse, excepting perhaps *Principia Mathematica*. Yet it seems to me that as far as possible, equations and even problems should be included in accounts of scientific texts simply to address the damage caused by changing geometric writing into literary writing.

Some scholarship on science tries for a middle ground, for example by inventing very simple problems that are still quantitative, or by adopting new kinds of qualitative schematics. Humanities-style illustrations—that is, without technical captions or quantitative content—can also help re-present quantitative “geometric” discourse. Popular books on string theory and topology, for example, tend to have more illustrations than the primary texts. But given that Western writing has been divided between two discourses for so long—effectively, in Trimpi’s argument, since the inception of Greek philosophy, mathematics, and rhetoric—it does not

necessarily make sense to invent a third kind of writing between the arts and sciences. In particular I have avoided writing a semi-technical pidgin that might mediate between the scientists' writing and a literary discourse.^{xxxii}

Because there is no such thing as full literary fidelity to geometric discourse, it is essential to continuously work to break down the illusion that geometry can be melted into literary discourse. (That illusion drives popular science, making periodicals like *Scientific American* seem adequate to their subjects. But in what sense does an article in *Scientific American*, with no equations, represent a discipline that can only represent truth *through* equations?) The best choice, I think, is an *uneven* form of writing that occasionally breaks the flow of narrative to make a place for equations, technical illustrations, and problems. It does no harm if the reader occasionally needs to grab a pencil, or linger over an incomprehensible illustration, or ponder the sudden intrusion of an equation bristling with new symbols.

2. *Regarding explanation: avoid making one discipline dependent on others, by abjuring cause and effect relations between disciplines.*

I suggested that humanistic writing about science comes in four configurations: texts in which art explains science, those where science explains art, those in which a third discipline, normally philosophy, is called upon to provide the explanation of both science and art; and those in which science and art explain one another in an evanescent or inconsistent fashion, with ambiguous implications. There is a fifth and final possibility: it is possible to imagine a kind of scholarship in which explanation itself is avoided. I call that kind of narrative *non-causal*, and it is the one I follow in this book.

The painter Giorgio De Chirico provides a ready example. He talked about some of his own early metaphysical canvases as if they were inspired by a concept he called "the enigma."

As far it is possible to tell, “enigma” for De Chirico was a personal mixture of his memories of the city of Turin, mingled with his thoughts about Nietzsche (who had lived there) and De Chirico’s own feelings of solitude and romantic oblivion, which he got partly from Giacomo Leopardi. Art historians have noted De Chirico’s idea, but they have tried to interpret his canvases in other terms. Some scholars have concentrated on his biography; others have written on the sociology and politics of art in his time and place, on the breakdown of perspectival painting, and on the Freudian elements of his pictorial fantasies. There is a sense in which *all* such interpretations miss the mark, because De Chirico’s main concern was a specific kind of conceptual opacity. “Enigma” was an apotropaic magic word, meant to ward off interpretations that would dissect his allusions. In a case like De Chirico’s, it seems to me that it might be interesting to re-conjure the word, and to leave it intact so it can repel psychoanalytic, social, and formal interpretations. That does not mean De Chirico’s early paintings should be proof against art historical scholarship: it means that the scholarship could focus on understanding how the concept of “enigma” was built, and exactly what kinds of clarity it was meant to repel. Writing of that sort would be non-causal in the sense I mean it here: it would decline to explain De Chirico’s paintings in terms of *any other discipline*.^{xxxiii}

Non-causal narrative is not always called for. Most studies of art-science links have clear causal direction: Galileo influenced the depiction of the moon in paintings by Velázquez, Rubens, and others; and at least two art historians have claimed that Galileo’s counter-Reformation tastes in art influenced the direction of his science.^{xxxiv} It is also possible to study the early seventeenth century culture of art and science by switching back and forth between cases where art influenced science and vice versa.^{xxxv} In such cases there is no particular reason to avoid causal connections. Non-causal writing starts to make sense when it becomes apparent that cause-and-effect links are not doing full justice to the material. Moons and other celestial

phenomena are minor elements of late Renaissance paintings, even those specifically influenced by Galileo's discoveries: so an account such as Eileen Reeves's *Painting the Heavens*, which studies the moons in several paintings of Galileo's generation, works more as a footnote to the history of astronomy than an adequate account of the paintings.^{xxxvi} Instead of saying that Galileo's discovery of mountains on the moon prompted Velázquez to paint ambiguously translucent and solid mountains on a moon in his *Assumption of the Virgin*, it might be better to look at how the painting presents translucency and opacity, in order to discover meanings that are independent of scientific causes.

Most of the images I study in this book were either made by artists who were largely uninterested in science, or by scientists unaware of the relevant art. That in itself would not preclude a causal analysis—historical scholarship does not need to be restricted to *conscious* emulation—but it means that if I tried to present the scientific images as products of late modernism my argument would quickly become counter-intuitive. I would have to emphasize, for example, the few examples of scientists who are actually influenced by art. Several of the scientists I discuss in this book are interested in modern art, and a few also paint or make artworks by manipulating scientific or mathematical images. But even in those cases, it would not help much to list the artistic influences, because they account for so little of what goes into the scientific images. The converse is also true: if I were to describe the paintings and fine-art photographs in chapters 1 and 2 as part of a larger culture informed by scientific illustration, I might succeed in finding a few interesting links: but I would end up explaining only a little of the paintings and photographs in question, and I would go against the grain of artists', critics', and historians' understanding of the images.

Presenting each of the six fields in this book as an independent discipline has the advantage of letting each speak its own language, using its own concepts and interests. If I do not

say that a kind of scientific image was made possible by the scientists' awareness of abstract painting, then I avoid explaining away the science as an *effect* of some non-scientific practice.

That is why each chapter of this book concerns a separate subject: the idea is that the form of the book supports its non-causal agenda. The images are contemporaneous (they were all made in the last quarter of the twentieth century and the beginning of the twenty-first) and I think they are part of the same phenomenon, which I will describe, differently in each context, as a growing fascination with the last moments of ordinary representation. But I do not offer a unifying account of the phenomenon: no philosophic frame, no common ground in visual culture, no shared aesthetic or artistic qualities.

At one point, writing this book, it seemed that the images *could* be united if I made use of the aesthetic concept of the sublime. The same period that produced the images in this book also saw a renaissance in studies of the sublime in psychoanalysis, Continental philosophy, and postmodern literary theory. The coincidence seemed irresistible, especially because sublimity is the quality many historians and critics would assign to images of deep space or of elementary particles. The first draft of this book was an extended study of the postmodern sublime, taking the images as examples. Essentially that version was a philosophic discourse on visual forms of the postmodern sublime. The book was tightly organized, because it is not difficult to find images that illustrate many of the critiques of the Kantian sublime, or enact the epistemological disappointment that characterizes recent attempts to fashion a postmodern sublime. Yet I paid a high price for philosophic unity: the sublime is virtually unknown outside the humanities, and so I lost a lot of the detail of what was happening in the scientific images. Eventually I decided the book had to be entirely rewritten, excising the sublime from the chapters on scientific images, and sequestering it in the discussions of painting and photography where it is already part of the critical conversation. The first draft was a philosophic and art critical text that would have

worked to bring several sciences into the fold of humanist discourse on postmodern images. As it stands, this book is a contribution to no particular discipline, and I hope it entirely fails to bring any image-making practice into the domain of any other.

It might be said that this book is still basically philosophy because it is about representation, which is itself a philosophic concept. Philosophy is sophophagic—it eats other disciplines—and inevitably what I have to say has taken on a philosophic or analytic cast. But I have not introduced any of the philosophic vocabulary of representation (*Vorstellung*, *Darstellung*, *Idea*, *simulacrum*, *eidolon*, *imago*). I hope the book is only philosophic in a weaker sense: the title announces a common theme that could be philosophic, except that I have not pursued it *as* philosophy. The first draft of this book depended on a philosophic theme at the expense of most of the non-art images. In a non-causal narrative, it is the reader's task to decide what threads might tie the images together, and just how tightly they should be pulled.

3. Regarding interpretation: defer the problem of inappropriate metaphors by avoiding metaphors that are not found in the original discourse.

To the extent that interpretation is metaphor, it will always drag a discourse off in the direction of some other discourse. Again there is no definitive solution, only strategies to avoid. Part of the point of not introducing the philosophy of representation is to avoid placing the various practices I describe under the sign of some foreign metaphor before they have had a chance to speak in their own voices. I do not want to claim scientists work on “the limits of representation” when they are really working on the calculation of blur circles, Fourier transforms, or pixel thresholds. On the other hand I have not tried for some pristine interpretation that would somehow speak in the exact language it is meant to interpret, without metaphors—and therefore without interpretive power. The two methodological principles that have guided

me here are not to rely on metaphors that are not found in the primary texts, and to mark the places where metaphors begin to guide the inquiry, so that they can at least become objects of discussion and self-criticism.

I believe that the clearest, most fruitful response to the abyss between the humanities and the sciences is to just set out the disciplines, in detail, side by side, and let them tell their stories in their own languages. As far as I can see that is the only way to produce a book that can be read by scientists and humanists without the creeping feeling that their disciplines are being explained—or explained away—by someone who does not really understand them.

Needless to say, this methodology has its limitations. The theme of the book has to be discovered and rediscovered by the reader in each new context, and there is no conclusion in which the whole is neatly packaged as a thesis about representation at the beginning of the twenty-first century. (I indulged in some talk of that kind in the Preface, because it is true to the genesis of the book. In that respect the book is an extended criticism of the synthetic ideas in the Preface.) I hope the open-ended quality of this book can be experienced as a gift, because it allows each reader to discover what counts as commonality and difference. As a reader in any of these disciplines, or in none of them, you can decide which are the best ways of describing the limits of representation. It is possible that you may conclude that I have written six separate stories, not linked by any particular theme, problem, trope, analogy, or common history. I am willing to risk fragmentation or incoherence in the hope of writing something potentially acceptable to people working in different disciplines. What could be more important, in this age of specialization—in this age overrun by messy popularizations of all sorts—than a text that could serve as a meeting place of disciplines?

And finally, it is worth saying that this is not a programmatic book. The images came first, then the naïve overarching theory of the sublime, and finally the thought that it is better to risk fragmentation than to write yet another theory of the humanist meaning of science or yet another popular-science exposition of a partly incomprehensible scientific discipline. This Introduction was written last, and these lines last of all. That is as it should be: after all, starting from first principles and writing a book to fit would have been yet another capitulation to philosophy.

Notes to the Introduction

ⁱ I am not interested here in the “science wars,” the question of whether science is culturally relative, so that its results are socially constructed. The arguments I will be making, especially in chapter 6, concerning the undependability of physics images, are not intended to raise doubts about the images’ degree of independence from social constructions of truth or reality. For social construction see Ian Hacking, *The Social Construction of What?* (Cambridge, MA: Harvard University Press, 1999). [Another source for the “two cultures” debate in the same period, which I am not considering here because it is too idiosyncratic \(both in terms of science and contemporaneous art\) is Paavo Pylkkänen, ed., *Bohm-Biederman Correspondence: Creativity and Science* \(London: Routledge, 1999\). I thank Melanie Bollman for drawing this to my attention. Her Master’s thesis on the correspondence, “Art and Science: Examining the ‘Two Cultures’ Debate” \(2006\) is on file in the John Flaxman Library at the School of the Art Institute of Chicago.](#)

ⁱⁱ It is pertinent here that theorizing about the unity of the university—from Cardinal Newman to Jaroslav Pelikan, Jacques Derrida, and Bill Reading—has taken place in the humanities, with very little attention paid to science. This is explored in the Introduction to *Visual Practices Across the University*, edited by James Elkins (Paderborn: Wilhelm Fink Verlag, 2007), forthcoming. The gap is exemplified by the essays in another book I have edited, *Visual Literacy* (New York: Routledge, 2007, forthcoming); its contributors are almost exclusively theorists in the humanities.

ⁱⁱⁱ I will not be addressing the question of whether “cultures” is the right word here: it is sufficiently clear as a way of naming the faculty who teach in the relevant departments. On the one side: art history, history of science, philosophy, and sometimes art practice; on the other, physics, chemistry, microbiology, biology, and astrophysics.

^{iv} Snow, *The Two Cultures: And a Second Look* (Cambridge: Cambridge University Press, 1963), 20.

^v Snow, *The Two Cultures*, 21. It is interesting that Sokal notes an exact parallel—an instance—of Snow’s unasked question, in Paul Virilio’s “The Third Interval: A Critical Transition,” in *Rethinking Technologies*, edited by Verena Conley (Minneapolis: University of Minnesota Press, 1993), 5: “it now seems appropriate to reconsider the notions of acceleration and deceleration (what physicists call positive and negative speeds).” Sokal and Bricmont comment: “The reader who does not find this uproariously funny (as well as depressing) is invited to sit in on the first two weeks of Physics I.” Sokal and Bricmont, Sokal, “Transgressing the Boundaries: An Afterword,” *Dissent* 43 no. 4 (1996): 93-99, quotation in n. 15.

^{vi} Sokal, “Transgressing the Boundaries,” 93.

^{vii} The literary critic Stanley Fish, who wrote on the Sokal hoax, would say that it is. See Fish, “Professor Sokal’s Bad Joke,” *The New York Times*, May 21, 1996, available on Sokal’s website, www.physics.nyu.edu/faculty/sokal/fish.html.

^{viii} Paul Boytinck, *C.P. Snow: A Reference Guide* (Boston, MA: G.K. Hall and Co., 1980).

^{ix} See Sokal’s website, www.physics.nyu.edu/faculty/sokal, accessed 15 September 2004. The essential texts are: Sokal and Bricmont, *Fashionable Nonsense: Postmodern Intellectuals’ Abuse of Science* (New York: Picador, 1999), which reprints the original essay, “Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity,” along with a commentary on its intentional errors; and Sokal, “A Physicist Experiments With Cultural Studies,” *Lingua Franca* 6 no. 4 (1996), 62-64; *Fashionable Nonsense* originally appeared as *Impostures Intellectuelles* (Paris: Editions Odile Jacob, 1997). The book, *The Sokal Hoax: The Sham that Shook the Academy*, edited by the Editors of *Lingua Franca* (Lincoln, Nebraska: University of Nebraska Press, 2000), also contains Sokal’s original essay and *Lingua Franca* admission, but is marred by the inclusion of a large number of ephemeral essays by journalists, and the exclusion of responses in more scholarly journals.

^x I think Snow and Sokal would both agree, with qualifications. For Sokal's take on this see Jean Bricmont and Alan Sokal, "Reply to Turnbull, Krips, Dusek, and Fuller [reviewing *Fashionable Nonsense*]," *Metascience* 9 no. 3 (2000): 347-95. The rancor of the debate, and Sokal and Bricmont's earnestness, earned them Derrida's characterization as "pas sérieux." One of the unfortunate aspects of the Sokal debates is the distance Derrida decided to keep. Derrida's own long-standing critique of the ideology and effects of seriousness (beginning with the work on Husserl, and continuing through the exchange with Searle) would have made him an ideal interlocutor, but when he wrote a response to Sokal and Bricmont he decided to speak to those who already know his position, by simply—and nonsensically—accusing Sokal and Bricmont of being unserious. Of course, Sokal and Bricmont took his accusations entirely literally. See Sokal and Bricmont, "Les critiques de Derrida et de Dorra ratent leur cible," published as "Réponse à Jacques Derrida et Max Dorra," *Le Monde* (12 December 1997), 23. The question of seriousness and humor is the hardest and perhaps most essential subject in the debates. Another illuminating moment occurred when Bruno Latour's sociological intervention in relativity theory (ridiculed by Sokal and Bricmont) was defended by the physicist David Mermin; Mermin's defense was then attacked by other physicists, on the grounds that ambiguity and playfulness have no place in logic discourse. See *Physics Today* 52 no. 8 (1999): 82-83. The same question surfaces in Latour's response to Sokal and Bricmont, "Y a-t-il une science après la guerre froide?" *Le Monde* (31 January 1997), 15.

^{xi} Recent encounters are enumerated in my *Visual Practices Across the University*.

^{xii} Katz, letter in *Physics Today* 52 no. 10 (1999): 120. The letters continue in *ibid.*, 11-15, 120-22, in response to Mermin's review of *Fashionable Nonsense*, in *Physics Today* 52 no. 4 (1999): 70.

^{xiii} There are important exceptions in both debates. See for example Bricmont and Sokal's "Reply to Turnbull, Krips, Dusek, and Fuller."

^{xiv} There are exceptions. Latour has communicated some of his ideas directly to scientists; see for example Latour, “From the World of Science to That of Research,” *Science* 280 (10 April, 1998), 208. Some relevant books by the authors I have named are: Serres, *Hermes: Literature, Science, Philosophy*, edited by Josué Harari and David Bell (Baltimore, MD: Johns Hopkins Press, 1982); Stafford, *Visual Analogy: Consciousness As the Art of Connecting* (Cambridge, MA: MIT Press, 1999); Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1986); Galison, *How Experiments End* (Chicago: University of Chicago Press, 1987), and other texts cited in chapter 6; Hacking, *The Social Construction of What?* (Cambridge, MA: Harvard University Press, 1999), and other texts cited in chapter 4; Pais, *Niels Bohr’s Times: In Physics, Philosophy, and Polity* (New York: Oxford University Press, 1991); Hübner, *Critique of Scientific Reason*, translated by Paul Dixon (Chicago: University of Chicago Press, 1983), which was also translated into Russian; Feyerabend, *Conquest of Abundance: A Tale of Abstraction Versus the Richness of Being* (Chicago: University of Chicago Press, 1999); and Pickering, *Constructing Quarks: A Sociological History of Particle Physics* (Chicago: University of Chicago Press, 1984).

^{xv} Nagel, “The Sleep of Reason,” *The New Republic* (October 12, 1998), 32-38.

^{xvi} *Fashionable Nonsense*, 180.

^{xvii} Latour and Serres, *Conversations on Science, Culture, and Time*, translated by Roxanne Lapidus (Ann Arbor, MI: University of Michigan Press, 1995).

^{xviii} He is mentioned several times in passing, for example in Jean Bricmont and Alan Sokal, “Sokalratic Debate Continues, Fueled by Latour and Copenhagen Interpretations,” *Physics Today* 52 (August, 1999): 15, 82: “...the works of Jacques Lacan... and others... constitute a genre in their own right, characterized principally by name-dropping and the display of erudition” (quotation on p. 82).

^{xix} C.W.F. Everitt and Anna Muza, “History, Theory, and the Ziggurat of Physics,” review of Galison, *Image and Logic* (Chicago: University of Chicago Press, 1997), in *Isis* 91 (2000): 310-

13, quotation on p. 313. Wolfgang Kurt Hermann Panofsky is to be distinguished from the art historian Erwin Panofsky; the former is the author of, for example, *Classical Electricity and Magnetism* (Reading, MA: Addison-Wesley, 1962).

^{xx} Trimpi, *Muses of One Mind: The Literary Analysis of Experience and Its Continuity* (Princeton, NJ: Princeton University Press, 1983).

^{xxi} Trimpi could have extended his parallel, because the few Egyptian mathematical and geometric texts are clearly distinct from the other genres, and the same could be said of the ancient Near East in general. On the other hand, I am not proposing this as a sufficient model. Cynthia Pyle's work, especially "Historical and Philological Method in Angelo Poliziano and Method in Science: Practice and Theory," in *Poliziano nel suo tempo, Atti del VI Convegno internazionale (Chianciano-Montepulciano 18-21 luglio 1994)*, edited by Luisa Secchi Tarugi (Florence: Franco Cesati Editore, 1996), 371-86, is especially convincing on the connection between Renaissance philology and the development of science: she proposes that a set of hermeneutic rules carried over from the analysis of classical texts to the beginnings of modern natural science. It would also be possible to argue against the concept of disciplines as Stephen Toulmin does in *Return to Reason* (Cambridge, MA: Harvard University Press, 2001), but it remains unsaid, in Toulmin's account, how the *existing* discourses could be made to speak to one another.

^{xxii} This is further described in my *Domain of Images* (Ithaca NY: Cornell University Press, 1999), 46-51, 233.

^{xxiii} *The Sokal Hoax*, 61; thanks to Teri Reynolds.

^{xxiv} See, in this respect, the interesting distinction between philosophy and theory in Fredric Jameson's review of Slavoj Žižek's work, *London Review of Books* (2006): [].

^{xxv} Crary, *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (Cambridge, MA: MIT Press, 1999).

^{xxvi} Baxandall, “The Language of Art Criticism,” in *The Language of Art History*, edited by Salim Kemal and Ivan Gaskell (Cambridge: Cambridge University Press, 1991), 73-74, quoted in David Summers, review of Crary, *Suspensions of Perception*, in *The Art Bulletin* 83 no. 1 (March 2001): 158.

^{xxvii} Gombrich, *In Search of Cultural History* (Oxford: Clarendon Press, 1974 [1969]); my essay “Art History Without Theory,” *Critical Inquiry* 14 (1988): 354-78, and the reply to Gombrich, *Ibid.* 14 (1988): 893.

^{xxviii} I have tried to work out relations between art history and science in more detail in a review of Martin Kemp, *The Science of Art* (Yale, 1990), in the *Zeitschrift für Kunstgeschichte* 54 no. 4 (1991): 597-601. For interdisciplinarity in general see for example my “Nine Modes of Interdisciplinarity in Visual Studies,” which is reply to Mieke Bal’s essay “Visual Essentialism and the Object of Visual Culture,” *Journal of Visual Culture* 2 no. 2 (2003): 232-37.

^{xxix} For an interesting attempt to find “nonsense” in scientists’ writings to complement the “nonsense” Sokal finds in poststructuralist writers, see Mara Beller, “The Sokal Hoax: At Whom Are We Laughing?” *Physics Today* 51 no. 9 (1998): 29.

^{xxx} Mulligan, “The Symptoms of Gödel-Mania,” review of Sokal and Bricmont’s *Impostures intellectuelles* (the original French edition of *Fashionable Nonsense*), in *The London Times Literary Supplement* (1 May, 1998), available on naturalscience.com/ns/books/book04.html.

^{xxxi} His near-contemporary, Alfred Döblin, wrote such a book in *Berlin Alexanderplatz*, though the equations in that book do not need to be read.

^{xxxii} I am thinking of Peter Galison’s observation that physicists communicate with one another, across sub-specialties, by the use of simplified languages he calls creoles. Galison does not apply his account of pidgins and creoles to his own writing, but it seems to me the extension is inevitable, because his writing is also a kind of talk that hopefully takes places between theorists and experimentalists. Galison, *Image and Logic: A Material History of Twentieth-Century Microphysics* (Chicago: University of Chicago Press, 1997), 48-51.

^{xxxiii} This is explored in more detail in my review of Hal Foster, *Compulsive Beauty* (MIT, 1993), in *The Art Bulletin* 76 no. 3 (1994): 546–48.

^{xxxiv} For the suggestion that Galileo’s sense of art influenced his rejection of Keplerian elliptical orbits—made by Aby Warburg and later by Erwin Panofsky—see the excellent summary in Horst Bredekamp, “Gazing Hands and Blind Spots: Galileo as Draftsman,” *Science in Context* 13 no. 3-4 (2000): 423-62, especially pp. 454-57.

^{xxxv} For example, Thomas DaCosta Kaufmann’s work, such as *Court, Cloister, and City: The Art and Culture of Central Europe, 1450-1800* (Chicago: University of Chicago Press, 1995); and Kaufmann, *The Mastery of Nature: Aspects of Art, Science, and Humanism in the Renaissance* (Princeton: Princeton University Press, 1993).

^{xxxvi} See my review of Reeves, *Painting the Heavens: Art and Sciences in the Age of Galileo* (Princeton, 1997), in the *Zeitschrift für Kunstgeschichte* 62 (1999): 580-85.