Lorraine Daston

Fear & loathing of the imagination in science

Recently a reader responded with dismay to a *New Yorker* article by historian Daniel J. Kevles about the charge of scientific fraud brought by Margot O'Toole against Thereza Imanishi-Kari. What distressed this reader was not so much the issue of fraud itself as Kevles's argument that the exercise of judgment and imagination in science was essential and should not be conflated with fraud:

> …I am troubled by Kevles's acceptance of a need for scientists to be imaginative in analyzing research results. What might the public's realization that this practice exists do to its confidence in the hard sciences? Will we next be expected to believe that accountants require imagination in their work?[1]

Such expressions of uneasiness about the role of the imagination in science are not new. When the physicist John Tyndall delivered a "Discourse on the Scientific Use of the Imagination" to the British Association for the Advancement of Science in 1870, he too drew shocked reactions from the press. The London *Times* was severe:

> The glory of a Natural Philosopher appears to depend less on the power of his imagination to explore minute recesses or immeasurable space than on the skill and patience with which, by observation and experiment, he assures us of the certainty of these invisible operations…. [Tyndall] confesses that Mr. Darwin "has drawn heavily upon time and adventurously upon matter." We ask ourselves whether we are listening to one experimental philosopher describing the achievement of another experimental philosopher. We had been under the impression that Natural Philosophers drew no bills.[2]

The echo of fiscal analogies reverberates over the space of more than a century: scientists should be as methodical (and as plodding) as accountants ("Natural Philosophers draw no bills"). To permit the imagination to infiltrate science is to tamper with the books, to betray a public trust.

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1 Aaron Fischbach, "In the Mail," *New Yorker*, July 22, 1996, 6. Kevles's article appeared in the May 27, 1996 issue of the *New Yorker*.

2 *London Times*, September 19, 1870; reprinted in John Tyndall, *Essays on the Use and Limit of the Imagination in Science* (London: Longmans, Green, & Co., 1870), 1–2.

My aim here is not to show that first-rate science requires imagination; others have already pleaded this point with vigor and eloquence.[3] Rather, I would like to explore how and why large portions of the educated public – and many working scientists – came to think otherwise, systematically opposing imagination to science. I shall argue that the critical period was the mid-nineteenth century, when new ideals and practices of scientific objectivity transformed the persona of the scientist and the sources of scientific authority. More specifically, I shall focus on the apparent paradox, also first framed in the early decades of the nineteenth century, that the more scientists insisted upon the obduracy and intransigence of facts, the more they feared the power of their own imaginations to subvert those facts. Why would scientists convinced of the power of ugly facts to murder beautiful theories, as Thomas Henry Huxley famously put it, nonetheless take heroic precautions to protect those burly facts from gossamer-spun imagination?

The key to this paradox lies buried within the histories of the scientific fact, on the one hand, and of the faculty of the imagination, on the other. In order to dramatize the novelty of the mid-nineteenth-century developments, I shall begin with a brief account of how eighteenth-century natural philosophers and natural historians understood the relationship between scientific facts and the scientific imagination. The pivot of my story is the polarization of the personae of artist and scientist, and the migration of imagination to the artistic pole. At roughly the same time that artists working in a romanticist vein emphasized creativity over mimesis, scientists troubled by the overthrow of one time-honored theory after another in quick succession sought more durable achievements. This early nineteenth-century confrontation of individualistic, brashly subjective art with collective, staunchly objective science was not simply the collision of some timeless faith in the imagination with an equally timeless faith in facts. Rather, it signaled a mutation in the meanings both of imagination and of facts that still shapes the moral economy of science.

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Experience we have always had with us, but facts as a way of parsing experience in natural history and natural philosophy are of seventeenth-century coinage. Aristotelian experience had been woven of smooth-textured universals about "what happens always or most of the time"; early modern facts were historical particulars about an observation or an experiment performed at a specific time and place by named persons.[4] What made the new-style facts granular was not only their specificity but also their alleged detachment from inference and conjecture. Ideally, at least, "matters of fact" were nuggets of pure experience, strictly segregated from any interpretation or hypothesis that might enlist them as evidence. Some seventeenth-century philosophers were as skeptical as their twentieth-century successors about the bare existence of what we now (redundantly) call theory-free facts. René Descartes, for example, trusted only those experiments per-

3 Gerald Holton, "Imagination in Science," in his *Einstein, History, and Other Passions: The Rebellion against Science at the End of the Twentieth Century* (Reading, Mass.: Addison-Wesley, 1996), 78–102.

4 For an account of the transformation of scientific experience in the early modern period, see Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995).

formed under his own supervision, because those reported by others distorted the results to "conform to their principles."[5] Even the most vigorous promoters of "matters of fact" acknowledged that these nuggets of pure experience were hard won: Francis Bacon thought only the strict discipline of method could counteract the inborn tendency of the human understanding to infuse observation with theory.[6] The 1699 *Histoire* of the Paris Académie Royale des Sciences confessed that the "detached pieces" of experience the academicians offered in lieu of coherent theories or systems had been wrenched apart by a "kind of violence."[7] Chiseling out "matters of fact" from the matrix of interpretation and conjecture was hard work.

But it was the hard work of smelting and purifying, not that of building and constructing. One of the most striking features of the new-style scientific facts of the seventeenth century is how swiftly and radically they broke with the etymology that connected them to words like "factory" and other sites of making and doing. In Latin and the major European vernaculars the word "fact" and its cognates derives from the verb "to do" or "to make," and originally referred to a deed or action, especially one remarkable for either valor or malevolence: *facere/factum*, *faire/fait*, *fare/fatto*, *tun/Tatsache*.[8] English still bears traces of this earlier usage in words like "feat" and, especially, in legal phrases like "after the fact." When the word "fact" acquired something like its familiar sense in the early seventeenth century as "a particular truth known by actual observation or authentic testimony, as opposed to what is merely inferred, or to a conjecture or fiction," to quote from its entry in the *Oxford English Dictionary*, it snapped the philological bonds that had tied it to words like "factitious" and "manufacture." Conversely, by the mid-eighteenth century, once-neutral words like "fabricate" (originally, to form or construct anything requiring skill) or "fabulist" (teller of legends or fables) had acquired an evil odor of forgery and deception in addition to their root senses of construction. For most Enlightenment thinkers, facts *par excellence* were those given by nature, not made by human art. "Facts" and "artifacts" had become antonyms, in defiance of their common etymology.

In keeping with the opposition of natural facts to human artifacts, the errors that most terrified Enlightenment savants in theory and practice were the errors of construction, of a world not reflected in sensation but made up by the imagination. Sensory infirmities worried Enlightenment epistemologists of science relatively little, prejudices and misconceptions instilled by bad education rather more so, the distortions wrought by strong passions still more, and the unruly creations of the imagination most of all. These latter seemed so pervasive as to make the simplest factual narrative a triumph of vigilance, discipline, and civilization in the minds of some Enlightenment writers. Bernard de Fontenelle, Perpetual Secretary of the Académie Royale des Sciences in Paris, thought the inclination to embellish the facts of the matter in any re-

5 René Descartes, *Discours de la méthode* [1637], pt. VI. Unless otherwise specified, all translations are my own.

6 Francis Bacon, *Novum organum* [1620], pt. I.46.

7 *Histoire de l'Académie Royale des Sciences. Année 1699*, 2nd ed. (Paris, 1718), "Préface."

8 See relevant entries in the *Oxford English Dictionary*, *Grimms Wörterbuch*, and the *Dictionnaire historique de la langue française*.

telling so irresistible that "one needs a particular kind of effort and attention in order to say only the exact truth." It took centuries before society advanced to the point of being able to "preserve in memory the facts just as they happened," before which time "the facts kept in [collective] memory were no more than visions and reveries."[9]

The chronic inability to hold fast to fact, to keep the inventive imagination in check, was a midpoint along a continuum to madness. Scientists were as much at risk as poets from the diseases of the imagination. In Samuel Johnson's allegorical novel *The History of Rasselas, Prince of Abissinia*, the philosopher Imlac meets a learned astronomer "who has spent forty years in unwearied attention to the motions and appearances of the celestial bodies, and has drawn out his soul in endless calculations." Upon further acquaintance the astronomer proves as virtuous as he is learned, "sublime without haughtiness, courteous without formality, and communicative without ostentation." Surely the astronomer is the long-sought-after happy man, content in his science and virtue? Alas, no; the astronomer is stark raving mad. He discloses to Imlac his delusion that he alone can control the world's weather and that he therefore bears the crushing responsibility for the welfare of the world's population on his shoulders. Imlac reflects that no one is immune from the depredations of the imagination: "There is no man whose imagination does not sometimes predominate over his reason, . . . All power of fancy over reason is a degree of insanity; . . . By degrees the reign of fancy is confirmed; she grows first imperious, and in time despotic. Then fictions begin to operate as realities, false opinions fasten upon the mind, and life passes in dreams of rapture or anguish."[10]

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It was not only novelists and philosophers who worried about "fictions [that] begin to operate as realities," about the fragility of facts in the face of overweening imagination. Practicing naturalists also fretted openly. In his monumental *Mémoires pour servir à l'histoire des insectes* (1734 – 1742) the French naturalist and experimental physicist René Antoine Réaumur warned that "although facts were assuredly the solid and true foundations of all parts of physics," including natural history, not all reported facts in science could be trusted. It was not simply a matter of weeding out hearsay or dubious sources; even sincere, well-trained naturalists could adulterate observations with imaginings. Citing the example of Godaert's observation that some insects could spawn insects of a different species, Réaumur preached caution: "Too often the observer has the disposition to see objects quite otherwise than they [actually] are. The extravagant love of the marvelous, a too strong attachment to a system fascinates his eyes."[11] An errant imagination was also Georges Cuvier's diagnosis of how Jean-Baptiste Lamarck had gone astray in natural history: for all of his scientific gifts, Lamarck was one of those minds that "cannot prevent themselves from mixing [true discoveries, *découverts véritables*] with fantastic conceptions . . . . [T]hey laboriously

9 Bernard de Fontenelle, *De l'origine des fables* [1724], ed. J.-R. Carré (Paris: Librairie Félix Alcan, 1932), 14, 33.

10 Samuel Johnson, *The History of Rasselas, Prince of Abissinia* [1759], ed. J. P. Hardy (Oxford: Oxford University Press, 1968), 98 – 99, 104 – 105.

11 René François Ferchault de Réaumur, *Mémoires pour servir à l'histoire des insectes*, vol. 2 (Paris: Imprimerie Royale, 1736), xxxiv – v.

construct vast edifices on imaginary bases, similar to the enchanted palaces in our old romances which disappear when the talisman upon which their existence depends is broken."[12]

Cuvier's opposition of "true discoveries" to "romances," of fact to fiction, was at least as old as Bacon and was echoed countless times before, during, and after the Enlightenment. Equally banal and enduring was the parallel opposition of the faculties of reason and imagination. What was striking about eighteenth-century views of the imagination in light of later developments is their firm insistence that the imagination, despite its perils, was as essential to philosophy and science – the pursuits of reason – as to the arts. Moreover, both art and science drew on the same kind of healthy imagination – and both were at risk from the same pathologies of the imagination. Both science and art were, in the view of most of their eighteenth-century practitioners, dedicated to revealing the truths of nature; imagination enlisted to this aim was a sound, sane one, that is to say, an imagination subject to rules. Even the most inventive genius should, Enlightenment critics insisted, bow to the authority of nature and its rules. John Dryden, for example, wondered whether Shakespeare might not have gone too far in creating the monstrous character of Caliban in *The Tempest*, "a person which was not in Nature," and Goya explained the famous epigram of his *Caprichos* – "The sleep of reason produces monsters" – as a call to the union of reason and imagination: "Imagination deserted by reason produces impossible monsters. United with reason, imagination is the mother of the arts and the source of their wonders."[13]

Images of the monstrous pervaded Enlightenment accounts of the diseased imagination in the arts and sciences. Voltaire distinguished between the "active imagination," which inspired the finest works of mechanics, mathematics, poetry, and the fine arts, and the "passive imagination," which caused violent passions, fanaticism, delusions, and monsters both figurative and literal. The passive imagination in the arts and sciences welded together "incompatible objects" into chimeras; in the womb of a pregnant woman it could impress the soft embryo with the form of some hideous perception – for example, of a convicted criminal broken on the wheel – received by the mother.[14] The French critic Jean-François Marmontel acknowledged that fiction was no servile imitation of nature, but even fiction that perfected nature still kept the imagination on a short leash. What was variously called the "marvelous," "monstrous," or "fantastic" imagination in the arts led to the "debauchery of genius."[15] Poets and artists were instead directed to obey the cardinal rule of verisimilitude: "A verisimilar fact is a fact possible in the circumstances where one lays the scene.

12 Georges Cuvier, *Recueil des éloges historiques lus dans les séances publiques de l'Institut de France* [1819 – 1827], vol. 3 (Paris: Firmin Didot Frères Fils, 1861), 180.

13 Quoted in Rudolf Wittkower, "Genius: Individualism in Art and Artists," in Philip P. Wiener, ed., *Dictionary of the History of Ideas*, vol. 2 (New York: Charles Scribner's Sons, 1973), 307, 308.

14 [Voltaire], "Imagination," in Jean d'Alembert and Denis Diderot, eds., *Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers*, vol. 8 (Paris/Neuchâtel, 1751 – 1780), 560 – 563. See also Wendy Doniger and Gregory Spinner, "Misconceptions: Female Imaginations and Male Fantasies in Parental Imprinting," in *Daedalus* 127 (1) (Winter 1998).

15 [Marmontel], "Fiction," in *Encyclopédie*, vol. 6, 679 – 683.

Fictions without verisimilitude, and events prodigious to excess, disgust readers whose judgment is formed."[16] Enlightenment good taste demanded that even fictions be decked out as possible facts and that art as well as science follow nature. Both art and science required imagination, but in neither should the imagination be allowed to invent at will.

Or rather, *against* will, for in the view of Enlightenment writers like Voltaire and Marmontel the pathological imagination overthrew the reasonable sovereignty of the will. Whereas the healthy, active imagination always partakes of judgment and "raises all of its edifices with order," the diseased, passive imagination acts imperiously, so that its victims are no longer "master" of themselves.[17] Here the distinction between the healthy and the diseased imagination took on moral as well as epistemological (and aesthetic) undertones. The consequences of submitting weakly to the domineering imagination could be dramatic, as the members of the French scientific commission formed in 1784 to investigate alleged phenomena of animal magnetism emphasized. After observing the remarkable convulsions and cures displayed by mesmerized patients, the commission – which included the astronomer Jean-Sylvain Bailly, the chemist Antoine Lavoisier, and the electrician Benjamin Franklin – decided to undergo animal magnetism themselves. Seated in the great mesmeric tubs, under the magnetizer's wand, the commissioners contrasted their own calm impassivity with the spectacular crises of the *convulsionnaires*:

> The Commissioners could not help but be struck by the difference between the public treatment and their own particular treatment in the tubs. The calm and silence of the one, the motion and agitation of the other; there, the multiple effects of violent crises, the habitual state of mind and body interrupted and troubled, nature exalted; here, the body without pain, the mind untroubled, nature preserving both its equilibrium and its ordinary course, in a word the absence of all effects.[18]

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Tranquil and self-controlled savants versus shaking and shrieking patients: for the commissioners there could be no clearer contrast between the sound and the diseased imaginations. They concluded that the cures wrought by animal magnetism were often genuine, and the convulsions mostly sincere, but that all were the work of the imagination, "that active and terrible power that produces the great effects that one observes with astonishment at the public treatment."[19] Although gender and class played some role in how the commissioners gauged degrees of susceptibility to the imagination, the ultimate defense against "that active and terrible power" was enlightenment (*lumières*), a combination of intelligence and self-mastery. Despite their palpable disapproval of such excesses of the imagination, the savants of the Royal Commission paid tribute to its extraordinary power over mind and body. No roman-

16 [Chevalier de Jaucourt], "Vraisemblance," in ibid., vol. 17, 484.

17 Voltaire, "Imagination," 561.

18 [J. S. Bailly], *Rapport des commissaires chargés par le Roi, de l'examen du magnétisme animal* (Paris: Imprimerie Royale, 1784), 18–19. On animal magnetism in late eighteenth-century France and the background to the Royal Commission, see Robert Darnton, *Mesmerism and the End of the Enlightenment in France* (Cambridge, Mass.: Harvard University Press, 1968).

19 Bailly, *Rapport*, 59.

tic poet was ever more firmly convinced of the force of the unfettered imagination than the Parisian savants.

In Enlightenment art and science, the imagination was Janus-faced: on the one hand, it was essential to creative work in both realms; but on the other, it could betray the natural and the verisimilar by breeding monsters. Its power verged on the supernatural. It could drive brilliant artists and scientists mad, it could trigger violent seizures, it could cure the hopelessly ill, it could distort and obliterate facts. So long as art and science shared a common goal of truth to nature, they also shared a code of aesthetic, epistemological, and moral values that praised one face of the imagination and deplored the other. Genius – be it in poetry, sculpture, or natural philosophy – was the expression of heightened imagination. Whether the genius in question was Milton or Leibniz, Michelangelo or Descartes, the natural endowment that made their achievements possible was in essence the same: a soaring imagination that "produces more than it discovers . . . [that] hatches brilliant systems or discovers great truths."[20] Imagination was not yet immiscible with science, and it was arguably more robust than facts.

Between about 1780 and 1820 this configuration changed dramatically. Put in the briefest terms, facts hardened, the imagination ran riot, and art and science diverged in their aims and their collective personae. Within the narrow confines of this essay, it is only possible to offer emblematic episodes to illustrate the nature and extent of these major transformations in the self-images of artists and scientists. Immanuel Kant's account of genius in his *Kritik der Urteilskraft* heralded things to come. Kant took it for granted that originality was the *sine qua non* of genius and that "[e]veryone is agreed on the point of the complete opposition between genius and the *spirit of imitation*." But that which can be learned, reasoned Kant, can also be in a sense imitated. Hence even the greatest triumphs of the natural sciences could no longer count as true works of genius:

> So all that Newton has set forth in his immortal work on the *Principles of Natural Philosophy* may well be learned, however great a mind it took to find it all out, but we cannot learn to write in a true poetic vein, no matter how complete all the precepts of the poetic art may be, or however excellent its models. The reason is that all the steps that Newton had to take from the first elements of geometry to his greatest and most profound discoveries were such as he could make intuitively evident and plain to follow, not only for himself but for every one else.[21]

Kant was second to none in his admiration for Newton and the revelations of the natural sciences, but he nonetheless denied even Newton the title of genius. For Kant, the very transparency and communicability of mathematics and the natural sciences removed them from the realm of profound, ineffable originality inhabited by Homer or even Christoph Wieland. Kant's emphasis on communicability linked the natural sciences to an emergent opposition between objectivity and subjectivity that Kant himself pioneered. Kant employed these terms in several distinct senses in his critical philosophy; I wish to draw attention here only to the sense that res-

20 Denis Diderot, "Génie," in *Encyclopédie*, vol. 7, 583.

21 Immanuel Kant, *The Critique of Judgment* [1790], trans. James Creed Meredith (Oxford: Oxford University Press, 1952), 168 – 170.

onated most loudly for nineteenth-century scientists and that meshed most tightly with Kant's rejection of the bare possibility of scientific genius. In the closing pages of the *Kritik der reinen Vernunft*, Kant offered a rough-and-ready test for distinguishing objectively valid convictions from merely subjectively valid persuasions:

> If the judgment is valid for everyone, provided only he is in possession of reason, its ground is objectively sufficient [*objektiv gültig*], and the holding of it to be true is entitled conviction. If it has its ground only in the special character of the subject, it is entitled persuasion . . . . The touchstone whereby we decide whether our holding a thing to be true is conviction or mere persuasion is therefore external, namely, the possibility of communicating it and of finding it to be valid for all human reason.[22]

In the middle decades of the nineteenth century this ideal of objectivity as communicability, shorn of every idiosyncrasy and particular perspective, was realized in the emergence of international, long-term scientific collaborations like the Internationale Gradmessung or the Carte du Ciel, which committed participants around the globe and across generations to instruments, procedures, and research agendas standardized in the name of commensurability and solidarity. Charles Sanders Peirce, who himself participated in some of these far-flung collaborations as an experimental physicist, drew the philosophical moral that scientific objectivity depended on the existence of a vast scientific community, extended over time and space, "beyond this geological epoch, beyond all bounds."[23] Or as the experimental physiologist Claude Bernard put it with lapidary concision: "L'art c'est moi, la science c'est nous."[24]

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But if science – and with it, objectivity – had come to be identified with the communal and the communicable, how did art wander to the pole of solitude and the individual? Within the Enlightenment framework, both savants and artists, especially those touched by genius, were often idealized as solitary seekers of deep truths on the model of hermetic saints, whatever the biographical realities might have been.[25] One might therefore argue that there is nothing to be explained on the side of art: artists, at least in their idealized personae, simply remained lonely geniuses while their scientific brethren became clubby, and thereby ungenial. So simple a conclusion would, however, overlook the impact of far-reaching changes in aesthetics and in views of the artistic imagination that occurred in the early decades of the nineteenth century. Again, I can offer only a small sampling over the many possible examples to make my point vivid.

The ramifications of post-Kantian theories of the imagination fan out into a broad and branching tree, from Johann Gottlieb Fichte to Friedrich Schelling to Samuel Taylor Coleridge to Jules Miche-

22 Immanuel Kant, *Critique of Pure Reason* [1781, 1787], trans. Norman Kemp Smith (New York: St. Martin's Press, 1965), A820 – 821/B848 – 849, 645.

23 Charles Sanders Pierce, "Three Logical Sentiments," in Charles Hartshorne and Paul Weiss, eds., *Collected Papers of Charles Sanders Pierce*, vol. 2 (Cambridge, Mass.: Harvard University Press, 1932), 398.

24 Claude Bernard, *Introduction à l'étude de la médecine expérimentale* [1865], ed. François Dagognet (Paris: Garnier-Flammarion, 1966), 77.

25 Dorinda Outram, "The Language of Natural Power: The 'Eloges' of Georges Cuvier and the Public Language of Nineteenth-Century Science," *History of Science* 16 (1978): 153 – 178.

let and beyond.[26] There is probably no generalization that holds for all of these developments, but tendencies can be discerned. For my purposes, the most significant are, first, the heavy emphasis upon the almost mystical originality of the imagination, independent or even in defiance of reason and will; and, second, the allied cult of individual subjectivity, what the art historian Rudolf Wittkower once called the "egomania" of romanticism. Each element had distinguished antecedents – Plato's poetic furor or the Renaissance master as *Deus artifex* – but the combination of the two was novel to the early nineteenth century. Quasi-divine inspiration overwhelming will and judgment had not been traditionally paired with towering individualism: for example, the pythian priestesses through whom the godhead spoke at the oracle of Delphi were inspired but interchangeable. The intertwining of these two elements – originality and subjectivity – effectively rehabilitated what Enlightenment theorists had regarded as the pathological imagination. For the romantics, it was the unbidden, darkling force of the so-called passive imagination that was the wellspring of genial creativity, not the well-regulated active imagination subservient to will and reason. As William Blake retorted to Sir Joshua Reynolds, "What has Reasoning to do with the Art of Painting? …One power alone makes a poet; Imagination, the Divine Vision."[27] Hence the strong association in nineteenth-century psychological studies of genius – which restricted their subjects almost exclusively to artists and poets – between extraordinary creativity and the unconscious, or even insanity.[28]

In conjunction with the elevation of the passive imagination aesthetic norms shifted away from verisimilitude. A genuinely productive, as opposed to reproductive, imagination could be bound neither by the rules of decorum nor those of the natural order. Strict mimesis had never been the avowed ideal of Enlightenment critics, but they had subscribed to a standard of truth to nature, if not truth to fact. Romantic poets and artists attacked this aesthetic openly, under the twin banners of originality and individual subjectivity. Charles Baudelaire parodied what he called the credo of nature – "I believe in nature, and only in nature" – and called for art infused with imagination, for landscapes in which "human egotism replaces nature," for works to which the artist or poet "adds his soul." It was idolatry for art to prostrate itself before nature; any photograph could surpass the most faithful artistic replica in "absolute material exactitude." Deploring the public infatuation with photographic landscapes and portraits, Baudelaire insisted that ideals of truth and beauty not only did not coincide, they were inalterably opposed to one another: "With us the natural painter, like the natural poet, is almost a monster. The exclusive taste for the True (noble though it may be when limited to its true applications) here oppresses and suffocates the taste for the Beautiful." For Baudelaire, imitation of nature shaded imperceptibly into imitation of other artists: "The

26 For general overviews of these developments, see Karl Homann, "Zum Begriff Einbildungskraft nach Kant," *Archiv für Begriffgeschichte* 14 (1970): 266 – 302; Mary Warnock, *Imagination* (London: Faber and Faber, 1976); Eva T. H. Brann, *The World of the Imagination: Sum and Substance* (Savage, Md.: Rowman and Littlefield, 1991).

27 Quoted in Wittkower, "Genius," 306.

28 Most famously in Cesare Lombroso, *Genio e follia. Prelezione ai corsi di antropologia e clinica psichiatrica* (Milan: G. Chiusi, 1864).

artist, the true artist, the true poet . . . must be really faithful to his own nature. He must avoid like death borrowing the eyes and the sentiments of another man, however great," just as he must avoid depicting "the universe without man," without the intervention of the imagination.[29]

It is customary to classify such views as "romantic," a term Baudelaire himself occasionally used. However, this label covers over fault lines that opened up within romanticism between subjective art and objective science, between the acolytes of beauty and those of truth. Although early nineteenth-century science had its own avowed romantics, such as Johann Wolfgang Goethe, Johann Ritter, Sir Humphrey Davy, or Alexander von Humboldt, they were notably wary of the exalted imagination and individualism of the new aesthetics. The experimental physicist Ritter, who discovered ultraviolet radiation in his search for polarities in nature and who was given to utterances such as "Light is the external intuition of gravity, love the internal," nevertheless balked at allowing the imagination free rein in science: "The most beautiful thoughts are often no more than soap bubbles: filled with the hydrogen of our fantasy they rise quickly, and one does not realize that all the delightful play of their colors is nothing more than the reflection of their deceptive interiors."[30] Goethe warned the experimentalist against "the imagination [*Einbildungskraft*], which raises him to heights on its wings while he still believes his feet to be firmly planted on the ground";[31] Alexander von Humboldt scrupulously divided his monumental survey of nature into a first part containing "the main results of observation, which, stripped of all the extraneous charms of fancy, belong to the purely objective domain of a scientific delineation of nature," and a second part on "impressions reflected by the external senses on the feelings, and on the poetic imagination of mankind."[32] The wild imagination and individualism now held to be the birthright of true artists frightened even romantic scientists.

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The point is that the newly erected divide between the objective and the subjective – the very words first enter dictionaries as a pair in German, French, and English in the 1820s and 1830s[33] – ran deeper than any opposition between neoclassicism and romanticism. My claim is not that there ceased to be fastidious realists among artists or daring speculators among scientists. Baudelaire found plenty of nature-worshipers to criticize among the paintings on display at the Paris Salon of 1859; Tyndall did not want for examples of scientists guided by their sense of beauty. But the new polarity of the objective and subjective

29 Charles Baudelaire, "Salon de 1846," "Salon de 1859," in *Curiosités esthétiques. L'art romantique et autres oeuvres critiques*, ed. Henri Lemaitre (Paris: Editions Garnier, 1962), 97 – 200, 305 – 396.

30 Johann Ritter, *Fragmente aus dem Nachlasse eines jungen Physikers*, ed. Steffen and Brigit Dietzsch (Leipzig/Weimar: Gustav Kiepenhauer, 1984), 96, 260.

31 Johann Wolfgang Goethe, "Der Versuch als Vermittler von Objekt und Subjekt" [1792, publ. 1823], in *Goethes Werke*, vol. 13, *Naturwissenschaftliche Schriften I*, ed. Dorothea Kuhn und Rike Wankmüller (München: C. H. Beck, 1994), 14 – 15.

32 Alexander von Humboldt, *Cosmos* [1844], vol. 2, trans. E. C. Otté and W. S. Dallas (New York: Harper and Brothers, 1850 – 1859), 19.

33 For a brief account of the history of the words, see Lorraine Daston, "How Probabilities Came to Be Objective and Subjective," *Historia Mathematica* 21 (1994): 330 – 344.

structured how such boundary-straddling was perceived. When the novelist Gustav Flaubert attempted in *Madame Bovary* (1856) to depict a provincial adultery with clinical, impartial accuracy, both he and his critics seized upon the word "objective" to describe a style in which "subjects are seen as God sees them, in their true essence."[34] When embryologist Wilhelm His described the advantages of scientific drawings, he called the result "subjective."[35] Successful art could and did emulate scientific standards of truth to nature, and successful science could emulate artistic standards of imaginative beauty. But whereas in the eighteenth century both artists and scientists had seen no conflict in embracing both standards simultaneously, the chasm that had opened up between the categories of objectivity and subjectivity in the middle decades of the nineteenth century – words that, as Thomas De Quincey wrote in 1856, had once sounded pedantic and yet had so quickly become "indispensable to accurate thinking and to *wide* thinking"[36] – forced an either/or choice.

Hence a figure like Goethe, who combined artistic and scientific interests, became an uncomfortable paradox, especially for German scientists who could hardly escape the long shadow cast by the official national genius. The obligatory addresses delivered by leading German scientists on Goethe's scientific work provide a sensitive indicator of how entrenched the divide between objective and subjective had become. The physicist Hermann von Helmholtz gave two such addresses, in 1853 and 1862, and both turned on what Helmholtz took to be the opposition between scientific and artistic ways of thinking. Goethe's regrettable (in Helmholtz's view) attack on Newtonian optics could be explained, if not excused, by the impossibility of mingling the ineffable, almost divinatory intuitions of the artist with the crystalline concepts of the scientist. As in Kant's touchstone for distinguishing the objective from the subjective, communicability was central to Helmholtz's analysis of the distinction between artistic and scientific thinking: "Since artistic intuitions are not found by way of conceptual thinking, they cannot be defined in words . . . ."[37]

At the crossroads of the choice between objective and subjective modes stood the imagination. Very few nineteenth-century writers went so far as to deny scientists any imagination. Baudelaire, for example, acknowledged that imagination was as essential to the great scientist – or for that matter, the great diplomat or soldier – as to the artist. But in the next breath he relegated photography, whose exact rendering of what is seen he took to be diametrically opposed to the artistic imagination, to the sphere of science, where it might serve without corrupting.[38] By the last quarter of the nineteenth century, psychologists who investigated creativity routinely distin-

34 Quoted in Erich Auerbach, *Mimesis. The Representation of Reality in Western Literature* [1946], trans. Willard R. Trask (Princeton, N.J.: Princeton University Press, 1953), 487.

35 Wilhelm His, *Anatomie menschlicher Embryonen* (Leipzig: F. C. W. Vogel, 1880), 6. I am grateful to Robert J. Richards for this reference.

36 Thomas De Quincey, *The Confessions of an English Opium Eater* [1821], in *The Works of Thomas De Quincey*, 2nd ed., vol. 2 (Edinburgh: Adam and Charles Black, 1863), 265.

37 Hermann von Helmholtz, "Über Goethes naturwissenschaftlichen Arbeiten" [1853], and "Goethes Vorahnungen kommender naturwissenschaftlichen Ideen," in *Vorträge und Reden*, 4th ed., vol. 2 (Braunschweig: Friederich Viewig und Sohn, 1896), 344.

38 Baudelaire, "Salon de 1859," 319 – 322.

guished between different species of imagination, including the artistic and the scientific. In what was perhaps the most exhaustive treatment of the subject, the French psychologist Théodore Ribot defended science against the charges that it "sometimes extinguished the imagination" but nonetheless insisted that the "plastic imagination" of artists and poets and the "scientific" imagination belonged to different species (and further distinguished varieties within each species). Whereas the plastic imagination was free to invent and to grant its inventions a degree of emotional reality, the scientific imagination was constrained by "rational necessities that regulate the development of the creative faculty; it cannot wander aimlessly; in each case its end is determined, and, in order to exist, that is to say, in order to be accepted, the invention must be subjected to predetermined conditions."[39] For all his insistence on the existence and fecundity of the scientific imagination, Ribot could not free himself from a certain suspicion that imagination was linked to scientific error: the "false sciences" of astrology, alchemy, and magic represented for Ribot "the golden age of the creative imagination" in the history of science. In its 1902 survey of the psychology of creative mathematicians, the journal *Enseignement Mathématique* asked respondents, inter alia, whether "artistic, literary, musical, or, in particular, poetic occupations or relaxations seem to you of a nature to hinder mathematical invention, or to favor it, by the momentary rest they offer the mind?" It was apparently inconceivable that the exercise of the artistic imagination could promote the work of the mathematical imagination, except as a distraction in the same category as "physical exercises" and "vacations."[40]

39 Théodore Ribot, *Essai sur l'imagination créatrice* (Paris: Félix Alcan, 1900), 198.

Fear & loathing of the imagination in science

It is against this historical background that we must read distrust of the imagination in science. The power of the imagination had long awakened fear among scientists – and theologians, poets, artists, and doctors, to boot – because it could make up a world of its own that was livelier, lovelier, or more logical than the real world. In extreme cases the imagination could conquer the body as well as the mind, leading not only to madness but also to violent somatic crises. But Enlightenment theorists of the imagination had been confident in the right and competence of reason to discipline the imagination. Geniuses of art and science exercised the same brand of controlled imagination, in contrast to the wild imaginations that tyrannized pregnant women, religious fanatics, or mesmerized *convulsionnaires*. Only in the early nineteenth century was fear of the imagination in science compounded with loathing. The causes lay in new views of the artistic imagination as freed from all constraints of reason and nature, and in a new polarity between objectivity and subjectivity. Wild, ineffable imagination became the driving force of creativity in art – and the bogey of objectivity in science. In their ideals, practices, and personae both art and science had mutated, and drifted apart.

What kind of objectivity bans the imagination from science? I have mentioned one moment of objectivity, the communitarian impulse that urges sci-

40 "Enquête sur la méthode de travail des mathématiciens," *Enseignement Mathématique* 4 (1902): 208 – 211, Questions 19, 26, 28. Jacques Hadamard, *The Psychology of Invention in the Mathematical Field* [1945] (New York: Dover, 1949), reports on some results of the survey.

entists to standardize their instruments, clarify their concepts, and depersonalize their writing styles to achieve communicability and commensurability across continents and centuries, perhaps even across planets. Max Planck spoke in the name of this form of communitarian objectivity when he yearned for a physics that would be accessible "to physicists in all places, all times, all peoples, all cultures. Yes, the system of theoretical physics lays claim to validity not merely for the inhabitants of this earth, but also for the inhabitants of other heavenly bodies."[41] Communitarian objectivity could not coexist with the artistic cultivation of individualism, which enshrined personal perspectives and identified the ineffable with originality.

There was, however, a second moment of scientific objectivity that emerged alongside communitarian objectivity in the mid-nineteenth century. In an earlier article, Peter Galison and I have called this second moment "mechanical objectivity"; it replaces judgment with data-reduction techniques, observers with self-registering instruments, hand-drawn illustrations with photographs.[42] Mechanical objectivity strives to eliminate human intervention in the phenomena, to "let nature speak for itself." The free imagination celebrated by Baudelaire and other romantics threatened mechanical objectivity by projecting its own creations onto the facts of nature. Yet the facts envisioned by nineteenth-century scientists were not the fragile, pliable facts so carefully protected by their eighteenth-century predecessors from the distortions of system-builders. It was a byword that facts were angular, even truculent entities, sturdily resisting all attempts to ignore them or bend them to fit the Procrustean bed of theory. Huxley insisted that "a world of facts lies outside and beyond the world of words."[43] In part, this change in scientific perception corresponded to a very concrete change in scientific practice: in the last quarter of the eighteenth century a new generation of instruments and measuring techniques made it possible to stabilize and replicate results with a success undreamed of fifty years earlier.[44] In some real sense, scientific facts had become more robust. Why, then, were the automated ideals and practices of mechanical objectivity necessary at all? Why couldn't hard facts defend themselves against wild imagination?

The answer lies in a very different kind of fear that began to haunt scientists in the 1830s – the fear of vertiginous, open-ended progress. When Kant denied scientists genius, he had consoled them with progress: "The talent for science is formed for the continued advances of greater perfection in knowledge, with all its dependent practical advantages, as also for imparting the same to others. Hence scientists can boast a ground of considerable superiority over those who merit the honor of being called geniuses, since genius reaches a point at which art makes a halt, as there is a limit imposed upon it which it cannot transcend."[45] In

41 Max Planck, *Acht Vorlesungen über theoretische Physik* (Leipzig: S. Hirzel, 1910), 6.

42 Lorraine Daston and Peter Galison, "The Image of Objectivity," *Representations* 40 (Fall 1992): 81 – 128.

43 Thomas Henry Huxley, "Scientific Education: Notes of an After-Dinner Speech" [1869], *Science and Education. Essays* (New York: Appleton, 1894), 115.

44 Christian Licoppe, *La formation de la pratique scientifique: Le discours de l'expérience en France et en Angleterre (1630 – 1820)* (Paris: Editions de la Découverte, 1996), 243 – 317.

45 Kant, *Critique of Judgment*, 170.

the late eighteenth century, the sciences did indeed seem destined for smooth, steady, unlimited progress. Between 1750 and 1840, a stream of histories of various sciences poured from the press, all purporting to demonstrate the existence and extent of progress in those disciplines.[46] But the progress envisioned in these optimistic histories was of change without transformation. Once the foundations for the new science had been laid in the seventeenth century, as the standard story went, the edifice could be expanded but not remodeled. In the 1830s this placid view of scientific progress received a rude shock when the wave theory unseated the Newtonian emission theory of light, most notably as a result of the research of French physicist Augustin Fresnel.[47] How could a tested theory of impeccable scientific credentials, its luster burnished by the name of Newton, be so thoroughly routed – not merely generalized or simplified? Was scientific progress so inexorable, so durable after all?

The response of scientists was to retreat to the level of the description of facts, in order to salvage a stable core of knowledge from the ebb and flow of theories. As Ernst Mach put it in 1872, history of science taught the Heraclitean lesson of *panta rhei*, for revolutions in science had become perpetual: "The attempts to hold fast to the beautiful moment through textbooks have always been futile. One gradually accustoms oneself [to the fact] that science is incomplete, mutable."[48] Mach held up Joseph Fourier's heat theory as a "model theory" in science because it wasn't really a theory at all, being founded only on "observable fact."[49] The expectations for scientific progress voiced by Kant and others had not been disappointed; rather, they had been fulfilled with a vengeance. Never before had science bustled and flourished as it did in the latter half of the nineteenth century. Scientists multiplied in number, and with them, new theories, observations, and experiments. With these efforts, however, science not only grew; it also changed, and changed at a rate that could be measured in months rather than generations. No theory was safe from this breakneck progress, not even Newtonian celestial mechanics. By the 1890s Henri Poincaré was calling for ever more precise techniques of approximation in order to test whether Newton's law alone could explain all observed astronomical phenomena."[50]

Fear & loathing of the imagination in science

Within this maelstrom of change, only facts seemed to hold out the hope of definitive achievement in science. Like diamonds, scientific facts not only hardened but grew more precious to scientists in the nineteenth century – hence the fervor of proponents of mechanical objectivity in fending off all possible adulterations and distortions of facts by judgment or, especially, imagination. Eighteenth-century savants had revered facts but had believed them to be the alpha, not the omega, of scientific achieve-

46 Rachel Laudan, "Histories of Sciences and Their Uses: A Review to 1913," *History of Science* 31 (1993): 5 – 12.

47 For a detailed account of this episode, see Jed Z. Buchwald, *The Rise of the Wave Theory of Light. Optical Theory and Experiment in the Early Nineteenth Century* (Chicago: University of Chicago Press, 1989).

48 Ernst Mach, *Die Geschichte und die Wurzel des Satzes von der Erhaltung der Arbeit* [1872], 2nd ed. (Leipzig: Johann Ambrosius Barth, 1879), 1.

49 Ernst Mach, *Die Principien der Wärmelehre* (Leipzig: Johann Ambrosius Barth, 1896), 115.

50 Henri Poincaré, *Les Méthodes nouvelles de la mécanique céleste*, vol. 1 (Paris: Gauthier-Villars, 1892 – 1899), 3 – 4.

ment. (It should be noted that in eighteenth-century classifications of knowledge the custodians of fact were not natural scientists, per se, but rather civil and natural historians.) Moreover, they were confident that facts mangled by the *esprit de système* or an errant imagination would ultimately be corrected by theory. Their nineteenth-century successors, caught up in the gallop of progress, had lost this innocent trust in the corrective power of theories that came and went like mayflies. Pure facts, severed from theory and sheltered from the imagination, were the last, best hope for permanence in scientific achievement. As anthropologists teach us, loathing stems from some breach of purity, some sacred boundary transgressed. The wild imagination potentially contaminated the purity of facts, and this is why it came not only to be feared but also loathed.

There is a rusting irony in the reversed fortunes of art and science, already visible in the mid-nineteenth-century writings of scientists. Alexander von Humboldt sadly reflected in 1844 on the contrast between ephemeral science and enduring literature, saying, "It has often been a discouraging consideration, that while purely literary products of the mind are rooted in the depth of feelings and creative imagination, all that is connected with empiricism and with fathoming of phenomena and physical law takes on a new aspect in a few decades, …so that, as one commonly says, outdated scientific writings fall into oblivion as [no longer] readable."[51] By 1917 Max Weber could regard the opposition of transitory science to stable art to be a platitude, one that made it difficult to understand what sense it made to pursue science as a career. Near the end of World War I, addressing an audience of Munich students who desperately wanted him to explain how science illuminated the meaning of life, Weber flatly asserted that science provided no such answers; science could hardly answer the question of what the meaning of a scientific career was. Why should one devote a lifetime of labor to producing a result that "in 10, 20, 50 years is outdated"? Subjective art endured, but objective science evaporated. Weber's own answer crowned this irony with yet one more. The spiritual motivation and reward for a lifetime devoted to science was exactly the same as for a lifetime devoted to art: science for science's sake, art for art's sake, the immolation of the personality in the service of "the pure object alone."[52] Having disavowed the artistic imagination and having lost the permanence of artistic achievement, science nonetheless aspired to the ascetic single-mindedness of art.

51 Humboldt, *Cosmos*, vol. 1, xxiv.

52 Max Weber, "Wissenschaft als Beruf" [1917], in *Max Weber Gesamtausgabe*, vol. 17, ed. Wolfgang J. Mommsen and Wolfgang Schluchter with Birgitt Morgenbrod (Tübingen: J.C.B. Mohr, 1992), 84 – 87.