

CRITIQUES AND CONTENTIONS

“The Violence of Impediments”

Francis Bacon and the Origins of Experimentation

*By Carolyn Merchant**

ABSTRACT

Francis Bacon’s use of metaphors to characterize his nascent concept of experimentation must be interpreted within the historical context of his time. His approach to experimentation is one in which nature is constrained by the “violence of impediments” and is made new by “art and the hand of man.” His language about nature should be placed in the context of the history of the contained, controlled experiment, a concept that emerges from juridical practice, from the idea of nature in bonds, and from the tradition of the secrets of nature in settings such as the courtroom, the anatomy theater, and the laboratory.

FRANCIS BACON (1561–1626) played a formative role in the emergence of the contained, controlled experiment. From his early writings in the 1590s to his mature concept of the experiment in the 1620s, he struggled by means of vivid metaphor to define a new method of gaining truth about the natural world.¹ The efforts of classical and

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¹ I have used and compared a number of editions and translations of Francis Bacon’s texts in this article. Unless otherwise noted, “*Works*” refers to Francis Bacon, *Works*, ed. James Spedding, Robert Leslie Ellis, and Douglas Devon Heath, 14 vols. (London: Longmans Green, 1875); reference to these volumes will often appear in parentheses following mention of a specific title. Other translations—subsequently cited by editor—include Bacon, *The Philosophical Works . . . Methodized and made English, from the Originals, with Occasional Notes, to explain what is obscure . . .*, by Peter Shaw, 3 vols. (London: J. J. and P. Knapton, D. Midwinter and A. Ward, and others, 1733); Bacon, *Works*, ed. and trans. Basil Montagu, 3 vols. (Philadelphia: Parry & MacMillan, 1857);

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medieval writers that led merely to individualistic and arcane insights became a foil against which he developed a new mode of extracting secrets from nature. His vast knowledge of ancient and contemporary writers, in combination with his judicial life in the service of Elizabeth I and James I of England, contributed elements to the language he used to describe his new method. Of equal importance to his metaphorical style, however, was his immersion in the cultural, social, and economic fabric of *fin-de-siècle* Europe and the physical settings of his everyday life.

To appreciate the significance of Bacon's achievement, one must go beyond a textual analysis of the words he used in his published writings. It is necessary to examine the emergence of his nascent concept of the contained, controlled experiment. The ingredients of his idea included an active inquisitor (scientist) who posed a question, a subject/object that held the answer as a veiled secret, witnesses who could verify and if necessary replicate the experience, and a practical outcome that would improve the life of humankind. Although ambiguity may exist about the meanings of some of Bacon's terms, their relevance becomes clear if they are placed in the context of his times.

Here I explicate Bacon's movement toward the concept of the contained, controlled experiment in ways not heretofore discussed by historians (who have mainly focused on his inductive method) and respond to critics such as Peter Pesic who have debated his metaphors and objectives.² I respect and appreciate Pesic's research arguing that Bacon did not use the words "nature on the rack" or "torturing nature to reveal her secrets," although later authors have attributed those sayings to him.³ I argue, however, that

Benjamin Farrington, *The Philosophy of Francis Bacon* (Liverpool: Liverpool Univ. Press, 1964); Bacon, *Novum Organum*, trans. Michel Malherbe and Jean-Marie Pousseur (Paris: Presses Univ. France, 1986); Bacon, *The New Organon*, ed. and trans. Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge Univ. Press, 2000); and Bacon, *The Instauration magna, Pt. 2: Novum organum and Associated Texts*, ed. Graham Rees with Maria Wakely (Oxford Francis Bacon, 11) (Oxford: Clarendon, 2004). For a comprehensive list of editions and translations of Bacon's works to 1750 see R. W. Gibson, *Francis Bacon: A Bibliography of His Works and of Baconiana to the Year 1750* (Oxford: Scrivener, 1950).

² Peter Pesic, "Proteus Rebound: Reconsidering the Torture of Nature," *Isis*, 2008, 98:304–317 (hereafter cited as **Pesic, "Proteus Rebound"**); Pesic, "Wrestling with Proteus: Francis Bacon and the 'Torture of Nature,'" *ibid.*, 1999, 90:81–94 (hereafter cited as **Pesic, "Wrestling with Proteus"**); Pesic, "Nature on the Rack: Leibniz's Attitude towards Judicial Torture and the 'Torture' of Nature," *Studia Leibnitiana*, 1997, 29:189–197; Carolyn Merchant, "The Scientific Revolution and *The Death of Nature*," *Isis*, 2006, 97:513–533 (part of a special Focus section entitled "Getting Back to *The Death of Nature*: Rereading Carolyn Merchant") (hereafter cited as **Merchant, "The Scientific Revolution and *The Death of Nature*"**); Merchant, "Secrets of Nature: The Bacon Debates Revisited," *Journal of the History of Ideas*, 2008, 69:147–162; Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: HarperCollins, 1980) (hereafter cited as **Merchant, *Death of Nature***); and Merchant, *Reinventing Eden: The Fate of Nature in Western Culture* (New York: Routledge, 2003).

³ Pesic states that "works like Carolyn Merchant's *The Death of Nature* rely on such imagery"—i.e., "the torture of nature" (Pesic, "Proteus Rebound," p. 305). My argument in the book does not "rely" on the "torture of nature," and to make such a claim is a serious misrepresentation of the argument there. I did *not* claim "that Francis Bacon *advocated* that nature should be 'tortured' or 'put on the rack'" in order to reveal her secrets (*ibid.* [emphasis added]). I *did* use the term "torture" in my chapter on Bacon. I stated that Bacon's imagery "*treats nature as a female to be tortured through mechanical inventions*" and "*strongly suggests the interrogations of the witch trials and the mechanical devices used to torture witches*" (Merchant, *Death of Nature*, p. 168 [emphasis added]). I stated that "*the interrogation of witches as symbol for the interrogation of nature, the courtroom as model for its inquisition, and torture through mechanical devices as a tool for the subjugation of disorder were fundamental to the scientific method as power*" (*ibid.*, p. 172 [emphasis added]). To say that the fact that the inquisition and the torture of witches were prevalent in Bacon's cultural milieu and subtly influenced his language (e.g., "the inquisition of nature") is not the same as stating that Bacon *advocated* torture. Moreover, agreeing with Pesic that Leibniz may have been the first to attribute to Bacon the idea of putting nature on the rack does not mean (as he claims) that I believe that Leibniz himself *advocated* those views (Pesic, "Proteus Rebound," p. 314). Similarly, quoting a paragraph from Thomas Kuhn in which he (erroneously) attributes the phrase "twisting the lion's tail" to Bacon does not mean that I agree with Kuhn that Bacon used that particular

Bacon's concept of experiment entailed a nature constrained by the "violence of impediments" and transformed by "art and the hand of man."⁴ I disagree with Pestic that the dominant assessment of Bacon's approach to science historically was or should be that of a "heroic struggle" with nature,⁵ in which he confronts "her inherent greatness"⁶ and in which both "the scientist and nature . . . are tested and purified" (i.e., "wrestling with Proteus").⁷ I show instead how the contained, controlled experiment emerges from

phrase (*ibid.*, pp. 313–314). Moreover, to imply that I "blame Bacon and science for abusive experiments and ecological disaster" (*ibid.*, p. 308) contradicts my statements in *The Death of Nature* that "Bacon was not responsible for subsequent uses of his philosophy" (Merchant, *Death of Nature*, p. 165) and in "The Scientific Revolution and *The Death of Nature*" that "obviously Bacon cannot be held individually responsible for the positive or negative implications or applications of his ideas" (Merchant, "Scientific Revolution and *The Death of Nature*", p. 533). To claim that I hold the view that because "science and experiment *have* been abused, they *must* be intrinsically abusive" is a serious distortion of my argument (Pestic, "Proteus Rebound," p. 308). In my 2006 *Isis* Focus paper, "The Scientific Revolution and *The Death of Nature*," I argued that "witch trials served as models of interrogation to reveal hidden secrets that could be used to convict the accused and levy the death sentence" (p. 525) and that "to [later philosophers], the rack *exemplified* the constraint of nature in a closed, controlled system, responding to questions posed by an inquisitor before witnesses—the very core of experimentation itself" (p. 528 [emphasis added]). It was in this sense that I rather brashly concluded that "Bacon's efforts to define the experimental method were buttressed by his rhetoric" and that "the very essence of the experimental method arose out of techniques of human torture transferred onto nature" (*ibid.*, p. 532), and Pestic and Alan Sokal are right to question that last phrase (the latter in a private communication). There are indeed other contexts out of which the idea of the contained, controlled experiment emerged in the seventeenth century, three of which I discuss later in this essay.

⁴ Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 295); and Bacon, *Parasceve*, Aphorism 1 (*Works*, Vol. 4, p. 253). See Tables 1, 2, and 3 and ensuing discussion. Because of ambiguities in the meanings associated with the Latin word "*vexare*" ("vex"), some early (as well as recent) Bacon scholars have interpreted Bacon's Latin to mean the "torture" of nature. (See notes 30, 39, 47, 58, and 77, below, and Table 3.)

⁵ Pestic, "Wrestling with Proteus," pp. 81, 93. There are many possible readings of Bacon, and I suspect that Pestic and I will have to agree to disagree on the meanings and interpretations of many of Bacon's metaphors and their historical impact. Even if Bacon could be shown to have thought of his own work as a "heroic struggle that will ennoble humanity," that was not his primary message to the world or why his work was of such fundamental importance for history. Pestic, of course, is entitled to his own opinion, based on his own selection of texts and his own reading of them; nor do I believe that his opinion will change based on other interpretations, other readings, or my arguments herein; but perhaps a truce can be called. Pestic assigns benign meanings to words such as "force," "vex," and "hound" and does not discuss terms such as "power," "empire," and "dominion" that were at the crux of Bacon's program for the improvement of humankind; nor does he place Bacon's work in the larger political and economic context of his times. Certainly some of Bacon's metaphors, terms, and examples are indeed benign and nonviolent (see the ensuing discussion), as is appropriate to his overall goal of mimicking and speeding up nature's processes through art and experiment, but the vast majority of them implied some form of violence toward nature.

⁶ I disagree with Pestic that Bacon held that "man cannot enter nature's 'inner courts' without confronting *her inherent greatness*" (here Pestic himself represents nature as female) (Pestic, "Wrestling with Proteus," p. 93 [emphasis added]). In the preface to *The New Organon*, Bacon joins the conquering of nature with the penetration of its inner chambers and does not use the phrase "her inherent greatness." He states: "But any man whose care and concern is not merely to be content with what has been discovered and make use of it, but to *penetrate* further; and not to defeat an opponent in argument but to *conquer* nature by action; and not to have nice, plausible opinions about things but sure, demonstrable knowledge; let such men (if they please), as true sons of the sciences, join with me, so that we may pass the ante-chambers of nature which innumerable others have trod, and eventually open up access to the inner rooms" (Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, p. 30 [emphasis added]).

⁷ Many of Pestic's points are efforts to assign benign meanings to everything Bacon said and to science itself. Thus to claim in "Proteus Rebound" that Bacon opposed the rape of nature because he wrote derisively about the excessive use of fire as exemplified in "Vulcan's attempt to rape Minerva" strains credibility (Pestic, "Proteus Rebound," p. 308; see also Pestic, "Wrestling with Proteus," p. 93, and note 73, below). To equate the phrase "you may deceive nature sooner than force her" with "a robust basis for ecological concern" is likewise illogical (Pestic, "Proteus Rebound," p. 309). To claim that "entering into these holes and corners" refers to the "vast *antrum* where Aeneas met the Sibyl and found the way to the underworld" again badly stretches credulity (Pestic, "Proteus Rebound," pp. 309–310); and neither Pestic nor William Waterhouse ("Letter to the Editor," *Isis*, 1999, 90:770–771, on p. 771), on whom he relies, has presented any evidence that, for Bacon, "*antra*" (in the Latin phrase "penetratione intra hujusmodi antra et recessus" [*De Augmentis (Works)*, Vol. 1, p. 498]), which means

Bacon's early interest in the practical and mechanical arts; the role of his 1609 *Wisdom of the Ancients* in developing his tripartite division of nature as free, erring, and in bonds; and how particular settings in Bacon's cultural milieu contribute to and illustrate experimentation. Bacon's ultimate objective was to recover the "dominion over creation" lost in the Fall from Eden in order to benefit humanity in material terms.⁸ That dominion, however, was achieved by the constraint of nature through technology, a process that exacted heavy costs from nature itself.

Interpretations of Bacon and his role in the rise of experimental science have a long history and have been discussed in numerous books and articles. At one end of the spectrum is the view of the Frankfurt School philosophers, who see Bacon as initiating a tradition of human power and dominion over nature.⁹ Thus mechanistic science itself, as it emerged in the seventeenth century, may be seen as complicit in some of humanity's current ecological, medical, and human survival problems.¹⁰ At the other end of the scale are those who view Bacon as the humble servant of nature who gave humanity new tools to uncover the truths of nature.¹¹ A modicum of middle ground, however, may exist

a cavity (especially in the body), implies any such thing. Furthermore, to argue that Bacon was implying that "those who believe in witchcraft are fools" (Pescic, "Proteus Rebound," p. 311) contradicts Bacon's own claim that "superstitious narrations of sorceries, witchcrafts, dreams, divinations, and the like" are not to "be altogether excluded" (Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 [Works, Vol. 4, p. 296]).

⁸ Francis Bacon, *Novum Organum*, Bk. 2, Aphorism 52 (Works, Vol. 4, pp. 247–248); Bacon, *Novum Organum*, in Works, ed. and trans. Montagu, Vol. 3, p. 425; and Bacon, *Novum Organum*, ed. and trans. Jardine and Silverthorne, p. 221. See also Merchant, *Reinventing Eden* (cit. n. 2), Ch. 4 and pp. 74–75.

⁹ Max Horkheimer and Theodor Adorno, *Dialectic of Enlightenment*, trans. John Cumming (New York: Herder & Herder, 1972); William Leiss, *The Domination of Nature* (New York: Braziller, 1972); David Kubrin, "How Sir Isaac Newton Restored Law and Order to the West," *Liberation*, 1972, pp. 32–41; Brian Easlea, *Witch-hunting, Magic, and the New Philosophy: An Introduction to Debates of the Scientific Revolution, 1450–1750* (Sussex: Harvester, 1980); Michel Foucault, *Power/Knowledge: Selected Interviews and Other Writings, 1972–1977*, ed. Colin Gordon (New York: Pantheon, 1980); Morris Berman, *The Reenchantment of the World* (Ithaca, N.Y.: Cornell Univ. Press, 1981); Peter Linebaugh and Marcus Rediker, *The Many-Headed Hydra: Sailors, Slaves, Commoners, and the Hidden History of the Revolutionary Atlantic* (Boston: Beacon, 2000), Ch. 2; and José María Rodríguez-García, "Scientia Potestas Est—Knowledge Is Power: Francis Bacon to Michel Foucault," *Neohelicon*, 2001, 28:109–122.

¹⁰ In *The Death of Nature*, I argued that "the mechanistic style of problem solving" (as opposed to ecological science) "pays little regard to the whole ecosystem of which people are only one part. The antithesis of holistic thinking, mechanism neglects the environmental consequences of synthetic products and the human consequences of artificial environments" (p. 186). For Pescic to claim that my "arguments too sweepingly condemn all the interventions of science, as if all of them equally acted to despoil the environment" (Pescic, "Proteus Rebound," p. 316), is a misreading of the argument of both my book and my chapter on Bacon. Throughout "Proteus Rebound" he treats my work as being opposed to all science, stating that in my "distress over Bacon's project of dominion over nature" I "ignore the pressing need to relieve human suffering" (*ibid.*, p. 317). To the contrary, I in fact agree with the quotation he cites (in opposition) from Perez Zagorin to the effect that "should the world succeed in coping with its present environmental problems, it will do so, not by opposition to or rejection of science, but by the intelligent and humane use of science coupled with the existence of a public and governments capable of making sensible decisions about the application of science and its limits" (*ibid.*). Where I disagree is with the claim that science must be accomplished through the domination of nature. For more detail, see my work on chaos and complexity theories in science and on partnership with nature in Merchant, *Reinventing Eden* (cit. n. 2), Chs. 9, 10.

¹¹ On this side of the debate is Nieves Mathews, "Francis Bacon: Slave Driver or Servant of Nature," <http://www.sirbacon.org/mathewssessay.htm>. Mathews's objections are intensely political. She writes: "In 1942 Herbert Marcuse, the patron saint of a generation of leftist extremists, described Bacon as the 'evil animus' of modern science, while Martin Heidegger, who was still celebrating in 1953 what he called 'the inner truth and greatness of Nazism,' denounced in Bacon the symbol of a nefarious identification of science with technology. During those same decades Bacon's reputation as a scientist was also at its lowest ebb." See also Mathews, *Francis Bacon: The History of a Character Assassination* (New Haven, Conn.: Yale Univ. Press, 1996). Other defenders of Bacon include Alan Soble, "In Defense of Bacon," *Philosophy of the Social Sciences*, 1995, 25:192–215, rpt. with additions and corrections in *A House Built on Sand: Exposing Postmodernist Myths about Science*, ed. Noretta Koertge (New York: Oxford Univ. Press, 1998), pp. 195–215; Iddo Landau, "Feminist

between the two perspectives when larger political and social issues underlying his concept of power are taken into consideration.

“THE DOMINION OF MAN OVER THE UNIVERSE”

Francis Bacon lived on the cusp between the Renaissance and the Enlightenment, during the expansion of preindustrial capitalism. All over Europe a new flurry of activities that transformed nature through machines and inventions was taking place. Tunneling into the earth for coal and metals, building forges for refining ores and hammering metals, constructing mills powered by wind and water, and erecting machines for lifting and boring provided humanity with a new sense of power over nature. The development of the coal and iron industries, the enclosure of the commons for wool production for the textile industry, the cutting of enormous tracts of timber for shipbuilding, and the expansion of trade changed the natural landscape. Knowledge of crafts, mechanics, inventions, and the properties of matter was essential to creating a storehouse of reliable, replicable information about the practical arts that would be available not just to the few, but to the many.¹²

A number of works of the late sixteenth century provided Bacon with ample illustration of the constraint of nature by technology and the arts that would undergird his emerging concept of experiment. From Hugh Platt, author of the *Jewell House of Art and Nature: Conteyning divers rare and profitable inventions, together with sundry new experiments in the art of husbandry, distillation, and moulding* (1594), Bacon learned of numerous practical inventions that would benefit the common good. From Bernard Palissy, author of the *Discours Admirable* (1580), he knew of the techniques and economic impact of the craft traditions. From Georg Agricola’s *De Re Metallica* (1546), he recognized the enormous importance of the techniques of mining and metallurgy for extracting ores and metals from the earth and applying them to the advancement of civilization. These works contained numerous illustrations showing men operating alembics, crucibles, ovens, and distillation equipment, digging tunnels into the earth and extracting ores, operating forges and fires, pounding metals and stone, and constructing and operating waterwheels and windlasses—all examples of the constraint of nature under technology. One of Bacon’s earliest (though posthumously published) works, “The Masculine Birth of Time” (written in 1602–1603), already contained the subtitle that would characterize his mature program of the 1620s: “The Great Instauration of the Dominion of Man over the Universe.” Out of this early interest in the mechanical and practical arts, Bacon began to develop an experimental method by which nature could be studied and altered by “art and the hand

Criticisms of Metaphors in Bacon’s Philosophy of Science,” *Philosophy*, 1998, 73:47–61; and Perez Zagorin, *Francis Bacon* (Princeton, N.J.: Princeton Univ. Press, 1998), pp. 121–122. See also Peter Pestic, *Labyrinth: A Search for the Hidden Meaning of Science* (Cambridge, Mass.: MIT Press, 2000); Pestic, “Proteus Unbound: Francis Bacon’s Successors and the Defense of Experiment,” *Studies in Philology*, 2001, 98:428–456; and Pestic, “Clue to the Labyrinth: Francis Bacon and the Decryption of Nature,” *Cryptologia*, 2000, 24(3), <http://www.sirbacon.org/pestic.htm>. Graham Rees, “Introduction: The *Novum Organum* in Context,” in Bacon, *The Instauration magna, Pt. 2: Novum organum and Associated Texts*, ed. Rees and Wakely, pp. xxii–xxxviii, discusses the fluctuating responses to Bacon since the early seventeenth century and recent efforts to rehabilitate his reputation.

¹² Walter E. Houghton, Jr., “The History of Trades: Its Relation to Seventeenth Century Thought,” in *Roots of Scientific Thought*, ed. Philip P. Wiener and Aaron Noland (New York: Basic, 1953), pp. 355–360; Edgar Zilsel, “The Genesis of the Concept of Scientific Progress,” *ibid.*, pp. 251–255; and John U. Nef, *The Rise of the British Coal Industry* (New York: Routledge & Kegan Paul, 1932), Vol. 1.

of man" in the vast project of extending "the power and dominion of the human race itself over the universe."¹³

In 1878, during the height of the English Industrial Revolution, Friedrich Engels praised Bacon as the founder of English materialism and the experimental method. But he criticized both Bacon and John Locke for an approach that removed science and philosophy from its external context:

The analysis of Nature into its individual parts, the grouping of the different natural processes and natural objects in definite classes, the study of the internal anatomy of organic bodies in their manifold forms—these were the fundamental conditions of the gigantic strides in our knowledge of Nature which have been made during the last four hundred years. But this method of investigation has also left us as a legacy the habit of observing natural objects and natural processes in their isolation, detached from the whole vast interconnection of things; and therefore not in their motion, but in their repose; not as essentially changing, but as fixed constants; not in their life, but in their death.¹⁴

The result of the mechanistic revolution was to break down nature into parts—atoms and molecules—that could be manipulated by external forces. Nature itself was viewed as a machine that could be repaired and reconstructed from outside by a human mechanic. Treating nature as a machine removed it from its external, environmental context, isolating it in a confined, controlled space. The fundamental characteristic of the experimental method is isolation from outside factors so that variables can be controlled. Parts can be removed and interchanged; one atom can be substituted for another; one organism can be introduced and another removed. Nature becomes an instrument and the human mind itself an instrument operating on nature.

In *Dialectic of Enlightenment*, Max Horkheimer and Theodor Adorno castigated Bacon for the disaster of instrumental reason that they saw as the downfall of the Enlightenment, a program that sought to dominate nature: "The 'many things' which, according to Bacon, 'are reserved,' are themselves no more than instrumental," they wrote. "What men want to learn from nature is how to use it in order wholly to dominate it and other men." The result, they stated, was that "the fully enlightened earth radiates disaster triumphant. The program of the Enlightenment was the disenchantment of the world, the dissolution of myths, and the substitution of knowledge for fancy. Bacon, the 'father of experimental philosophy,' had defined its motives."¹⁵

The disenchantment of the world was "the extirpation of animism"—the removal of animistic and spiritual features from all things and the reduction of nature to mere matter. Instrumental reason separated morality from rationality, leaving individuals free to act so as to maximize power over other people and nature itself. Horkheimer and Adorno were especially strident in their critique of the concept of power over humans and nature that

¹³ Farrington, *Philosophy of Francis Bacon*, pp. 14–15, 18, 33, 53, 59; Bacon, *De Augmentis Scientiarum*, "Plan of the Work" (*Works*, Vol. 4, p. 29), Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 294 [quotation]); and Bacon, *Novum Organum*, Bk. 1, Aphorism 129 (*Works*, Vol. 4, p. 114 [quotation]).

¹⁴ Friedrich Engels, *Herr Eugen Dühring's Revolution in Science (Anti-Dühring)* (1878), ed. C. P. Dutt, trans. Emile Burns (1939; New York: International Publishers, 1966), pp. 26–29, as quoted in Howard L. Parsons, ed., *Marx and Engels on Ecology* (Westport, Conn.: Greenwood, 1972), p. 130. See also Karl Marx and Engels, *The Holy Family* (1844) (Los Angeles: Progress Publishers, 1956), p. 172: "The real founder of *English materialism* and all *modern experimental science* was *Bacon*. For him natural science was true science and *physics* based on perception was the most excellent part of natural science" (quoted in Parsons, ed., *Marx and Engels on Ecology*, p. 136).

¹⁵ Horkheimer and Adorno, *Dialectic of Enlightenment* (cit. n. 9), pp. 3–4.

they saw as the root problem of the Enlightenment. They wrote: “The concordance between the mind of man and the nature of things that [Bacon] had in mind is patriarchal: the human mind, which overcomes superstition, is to hold sway over a disenchanting nature. Knowledge, which is power, knows no obstacles.”¹⁶

This skeptical analysis of Bacon’s ultimate contribution to science and philosophy arises in part from Bacon’s insights into how knowledge of the world intersects with power over it. One must understand the causes of nature in order to understand and use its effects. One cannot command (dominate) nature without first understanding its laws. In Aphorism 3 of the *Novum Organum* (literally, the “New Instrument”), he joined the two ideas of knowledge and power into one concept: “Human knowledge and human power meet in one; for where the cause is not known the effect cannot be produced. Nature to be commanded must be obeyed.”¹⁷

The problem of domination becomes the problem of the Scientific Revolution. Does humanity remain the victim of nature, fatalistically accepting the hand that nature deals in the form of failed harvests and deaths from unknown diseases, droughts, and fires? Or can humanity, by understanding those causes through science and manipulating them through technology, gain the upper hand? As William Leiss pointed out in *The Domination of Nature*, “the consequence of this view is to set the relationship of man and the world inescapably in the context of domination: man must either meekly submit to these natural laws (physical and economic) or attempt to master them.” For Bacon, the path was clear. Through the arts and sciences, “the human race [could] recover that right over nature which belongs to it by divine bequest.”¹⁸

It is therefore only through understanding the laws of nature that humanity has a chance of controlling its own destiny. The scholastics, alchemists, and mechanics of the Middle Ages could not achieve those ends. What they knew, argued Bacon, had been arrived at by chance and arranged in a “nice” order. What they had not done was find a new method.

¹⁶ *Ibid.*, pp. 3–4. See also p. 42: “Today, when Bacon’s utopian vision that we should ‘command nature by action’—that is, in practice—has been realized on a tellurian scale, the nature of the thralldom that he ascribed to unsubjected nature is clear. It was domination itself.”

¹⁷ Francis Bacon, “Aphorisms Concerning the Interpretation of Nature and the Kingdom of Man,” in *Novum Organum*, Bk. 1, Aphorism 3 (*Works*, Vol. 4, p. 47). Shaw’s 1733 translation of *Novum Organum Scientiarum: A New Machine for Rebuilding the Sciences*, in Bacon, *Philosophical Works*, ed. Shaw, Vol. 2, p. 344, renders Aphorism 3 as “The Knowledge and Power of Man are coincident: for whilst ignorant of the Causes, he can produce no Effects: Nor is Nature to be conquer’d but by Submission.” Shaw explains that “the only method by which Men can rule Nature, must depend upon learning her Ways” (*ibid.*, Vol. 2, p. 344, note c), and “Man himself being necessarily subject to the laws of nature; tho’ within the compass of these laws he has a very extensive Power, that will always be commensurate to knowledge” (*ibid.*, Vol. 1, p. 564, note a). Montagu’s translation uses “subdued by submission”: “Knowledge and human power are synonymous, since the ignorance of the cause frustrates the effect. For nature is only subdued by submission, and that which in contemplative philosophy corresponds with the cause, in practical science becomes the rule” (Bacon, *Works*, ed. and trans. Montagu, Vol. 3, p. 345). Jardine and Silverthorne’s translation uses “conquered only by obedience”: “Human knowledge and human power come to the same thing, because ignorance of cause frustrates effect. For Nature is conquered only by obedience; and that which in thought is a cause, is like a rule in practice” (Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, Bk. 1, Aphorism 3, p. 33). Malherbe and Pousseur’s French translation is “Science et puissance humaines aboutissent au même, car l’ignorance de la cause prive de l’effet. On ne triomphe de la nature qu’en lui obéissant; et ce qui dans la spéculation vaut comme cause, vaut comme règle dans l’opération” (Bacon, *Novum Organum*, trans. Malherbe and Pousseur, Bk. 1, Aphorism 3, p. 101). Rees and Wakely translate it as “Human knowledge and power come to the same thing, for ignorance of the cause puts the effect beyond reach. For nature is not conquered save by obeying it; and that which in thought is equivalent to a cause, is in operation equivalent to a rule” (Bacon, *The Instauration magna*, Pt. 2: *Novum organum and Associated Texts*, ed. Rees and Wakely, Bk. 1, Aphorism 3, p. 65).

¹⁸ Leiss, *Domination of Nature* (cit. n. 9), pp. 150–151; and Bacon, *Novum Organum*, Bk. 1, Aphorism 124 (*Works*, Vol. 4, p. 115).

It was that new method that Bacon sought; he found it in the experimental method, a method grounded in observations, particulars, and facts. The instruments of the mind guided the instruments of the hand. Only what had been observed could lead to an understanding of nature. It is in this sense that Bacon stated, in Aphorism 1 of the *Novum Organum* (1620), that "Man, being the servant [*minister*] and interpreter of Nature, can do and understand so much and so much only as he has observed in fact or in thought of the course of nature."¹⁹ By understanding and obeying nature, mankind can command nature. There is thus no daylight between servant and commander. They are one and the same, for (as he stated in Aphorism 3) "nature to be commanded must be obeyed." As servant, humanity achieves knowledge; as commander, it achieves power. The two meet as one.²⁰

If power and knowledge meet as one, the issue dividing the critics and defenders of Bacon is how power/knowledge is used and toward what ends. The ways in which both capitalist culture and the state use scientific knowledge to enhance power is the issue raised by the conjunction of power/knowledge. Michel Foucault states, "There is no power relation without the correlative constitution of a field of knowledge, nor any knowledge that does not presuppose and constitute at the same time power relations."²¹

The domination of nature may be set in a liberatory or a repressive framework. In some cases those uses may be benign, in other cases neutral or malign. The confined, controlled experiment may result in violence toward nature or in the liberation of nature and human society. As I stated in *The Death of Nature*, "Bacon himself was not responsible for subsequent uses of his philosophy," but "because he was in an extremely influential social position and in touch with the important developments of his time, his language, style, nuance, and metaphor become a mirror reflecting his class perspective."²² In that mirror

¹⁹ Bacon, *Novum Organum*, Bk. 1, Aphorism 1 (*Works*, Vol. 4, p. 47). The Montagu translation reads "Aphorisms on the Interpretation of Nature and the Empire of Man. Aphorism 1: Man, as the minister and interpreter of nature, does and understands as much as his observations on the order of nature, either with regard to things or the mind, permit him, and neither knows nor is capable of more" (Bacon, *Works*, ed. and trans. Montagu, Vol. 3, p. 345). Michèle Le Doeuff writes, "What can be the meaning of a statement such as the one that opens the *Novum Organum*: 'Homo naturae minister et interpres?' . . . Supposing that Bacon's Latin had entirely reverted to the language of Cicero, the phrase must be translated by 'man, servant of nature,' . . . consequently minister is the opposite of a master. On the other hand, if one has doubts as to the perfect success of the reCiceronization of modern Latin . . . and if one ventures to refer then to medieval Latin, *minister* must be translated by 'administrator' or even by 'artisan,' the term being synonymous with *artifex*, and the French word for 'craft,' *metier* being derived from it. 'Man, the craftsman of Nature . . .' might be the right translation" (Michèle Le Doeuff, "Man and Nature in the Gardens of Science," in *Francis Bacon's Legacy of Texts*, ed. William A. Sessions [New York: AMS Press, 1990], pp. 119–138, on pp. 120–121). Following this line of reasoning, the phrase could also be translated as "Man, the administrator of Nature." Both "craftsman" and "administrator" convey a sense of control over nature and hence are closer to the idea of commanding nature. Other possible translations are "Man, the agent," "Man, the assistant," or "Man, the helper" of Nature—all of which convey a more active or managerial role than does "servant." Jardine and Silverthorne translate the phrase as "Man is Nature's agent and interpreter" (Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, Bk. 1, Aphorism 1, p. 33). Malherbe and Pousseur's French translation is "Homme, ministre et interprète de la nature" (Bacon, *Novum Organum*, trans. Malherbe and Pousseur, Bk. 1, Aphorism 1, p. 101). Rees and Wakely retain Spedding's rendering of "*minister*" as "servant": "Man, the servant and interpreter of nature" (Bacon, *The Instauration magna, Pt. 2: Novum organum and Associated Texts*, ed. Rees and Wakely, Bk. 1, Aphorism 1, p. 65).

²⁰ Bacon, *Novum Organum*, Bk. 1, Aphorism 3 (*Works*, Vol. 4, p. 47).

²¹ Michel Foucault, *Discipline and Punish: The Birth of the Prison*, trans. Alan Sheridan (New York: Pantheon, 1978), p. 27, quoted in Rodríguez-García, "Scientia Potestas Est—Knowledge Is Power" (cit. n. 9), p. 113. In his analysis of Foucault's conflation of power/knowledge, Rodríguez-García argues that Bacon's position(s) as the king's representative in the judiciary influenced his view of nature as a prisoner who must be forced to reveal its secrets (p. 120).

²² Merchant, *Death of Nature*, p. 165. Bacon's own vision of the contained, controlled experiment occurs in *The New Atlantis* (see below). Other examples, from the seventeenth century to the present (which Bacon did

was the image of nature as female—source of secrets to be extracted for economic advancement and revealed through experiment.

NATURE AS FEMALE

Nature for Francis Bacon and nearly everyone else in the Renaissance and Scientific Revolution was female. More than a metaphor, Nature was the servant of God in the mundane world—the bringer and reproducer of life and the meter of rewards and punishments. Accepted as both reality and metaphor by the lower, as well as the upper classes, Nature represented a fusion of ancient, Renaissance, and Christian symbols. Depicted as female by a host of artists, writers, philosophers, and ordinary people, Nature was a personification of the cosmos, the earth, and the human writ large.²³

Like the human and the cosmos, Nature as a living being had a body, soul, and spirit. Nature personified had breasts, a bosom, and a womb, as well as circulatory, reproductive, and elimination systems. For Neoplatonists, nature was the lower part of the world soul. For alchemists and natural magicians, matter was to be manipulated and transformed into higher metals, cures, potions, and pharmacopoeia. For Christians, nature was the dispenser of God's displeasure at mankind's disobedience—retribution for human sins. Failed harvests, drought, storms, diseases, and plagues resulted from human failure to obey the strictures of moral life. Nature was the substance of the body—a fusion of the elements, the base instincts, and human bodily and moral weakness. All aspects of the body were symbolized by the female, the weaker and more vulnerable sex. Matter, too, as female, represented the lower order of nature. Matter, like the female, was inconstant, changing, and corruptible. Matter, the body, and the reproductive organs were sites of potential corruption by the devil. To deny this reality of daily and moral life is to discount history itself.

The widely held belief that nature itself was female underlies Bacon's use of language and metaphor on which much of his program for a new experimental science rests. Bacon himself wrote of nature in the female gender in his 1605 English version of *The Advancement of Learning*: "For it is no more but by following and as it were hounding Nature in her wanderings, to be able to lead her afterwards to the same place again."²⁴ Not only the Latin texts that use the feminine "*natura*" for "nature," but also the nineteenth-century translations in which nature and matter are designated as "she," were truer to the beliefs and assumptions of the texts of the time than current translations that attempt to modernize Bacon's language.²⁵ Thus phrases such as "when by art and the hand of man

not envision), range from the study of reptiles, birds, and dogs in evacuated bell jars to creating new species through genetic engineering; the study of caged monkeys deprived of their mothers; the Tuskegee syphilis experiments; Depo-Provera trials on fertile women; underground nuclear tests; DDT tests conducted on whole ecosystems; the act of laying out transects and counting species within grids; testing the responses of dogs, birds, and plants to spaceflight; abstracting away friction and air resistance in inclined-plane experiments; and calculating momentum/energy transfers among colliding balls. Although not all of these experiments administer pain to a living thing, all reflect the confinement of nature by technology. Although not all raise equal moral issues, all reflect human "power over nature."

²³ Merchant, *Death of Nature*, Ch. 1. See also Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone, 1998), p. 261 ("the personification of nature was traditionally and invariably feminine"); and Park, "Nature in Person: Medieval and Renaissance Allegories and Emblems," in *The Moral Authority of Nature*, ed. Daston and Fernando Vidal (Chicago: Univ. Chicago Press, 1994), pp. 50–73.

²⁴ Francis Bacon, *The Advancement of Learning* (1605) (*Works*, Vol. 3, p. 331).

²⁵ See, e.g., the nineteenth-century translations of Bacon's texts in Bacon, *Works*, ed. and trans. Montagu (1857); and Bacon, *Works*, ed. Spedding *et al.* (1875). The twentieth-century translations by Farrington (1964)

she is forced out of her natural state, and squeezed and moulded," "to examine nature herself and the arts upon interrogatories," and "nature exhibits herself more clearly under the trials and vexations of art than when left to herself" more accurately reflect the cultural assumptions of the Renaissance and early modern period within which Bacon and other natural philosophers worked than do later, "more modern" translations.²⁶ I agree that today nature should not be gendered as female and that translations of "nature" as "it" rather than "she" more accurately reflect current understandings. But this was not the view of the Renaissance or of Bacon.²⁷

PAN, PROTEUS, AND PROMETHEUS

In addition to the underlying assumption that nature was female, Bacon drew on a number of allegories to characterize nature, most notably in *The Wisdom of the Ancients* (*De Sapientia Veterum*), written in Latin in 1609, early in the course of Bacon's published works. Following the Greek pattern of investing male and female gods with human as well as superhuman characteristics, Bacon drew on ancient allegories to develop an approach to nature that would eventually underlie his emerging concept of experiment. He used the Greek god Pan to symbolize nature, Proteus to symbolize matter, and Prometheus to symbolize "the state of man." Other relevant figures include Daedalus (mechanic), Orpheus (philosophy), Proserpina (spirit), and Sphynx (science).²⁸ Of the thirty-one deities of the ancient world described by Bacon in this early work, Pestic seizes on Proteus as the deity on which to hang his main argument. What underlies this choice?

The gods described by Bacon in *The Wisdom of the Ancients* were not just symbols, but moral forces and powers that organized the world. He drew on a number of sixteenth-century handbooks of mythology, interpreting them as they advanced his own philosophy. Such works included Lilio Gregorio Giraldi's *History of the Gods* (1548), Natale Conti's *Mythology* (1551), and Vincenzo Cartari's *Images of the Gods* (1556). In particular, Bacon drew heavily on Conti's *Mythology* in framing his arguments. In *The Veil of Isis* Pierre Hadot writes, "In Bacon, besides the moral explanation, we find an allegorical exegesis that makes a physical phenomenon correspond to mythical figures: the fight for sovereignty between Ouranos, Kronos, and Zeus represents the birth of the world; Eros is prime

and Jardine and Silverthorne's translation of the *Novum Organum* (2000) translate "nature" in the female gender, whereas that of Rees and Wakely (2004) translates "nature" as "it."

²⁶ Bacon, *De Augmentis Scientiarum*, "Plan of the Work" (*Works*, Vol. 4, p. 29); Bacon, *Parasceve*, Aphorism 10 (*Works*, Vol. 4, p. 263); and Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 298).

²⁷ The fact that nature was gendered as female in the past is part of a pervasive patriarchal framework that assumes that men are rational and women are emotional. Feminist history and science over the past four decades have challenged those assumptions in many fields and social practices. Despite such efforts, men as prominent as Harvard's recent president Lawrence Summers still assume that women are not as adept at science as men, and popular media still use the phrase "mother nature" to depict nature's "wrath" against humanity, expressed in the form of natural disasters (hurricanes, tornados, droughts, earthquake, etc.). I agree with Pestic, "Proteus Rebound," p. 308 n 14, when he quotes Susan Haack, *Defending Science—Within Reason: Between Scientism and Cynicism* (Amherst, N.Y.: Prometheus, 2003), p. 316, to advise that, "rather than disparaging a stereotyped science misperceived as embodying stereotypically masculine values, we need to rid ourselves of stereotypes, both of women and of science." But the comment that immediately follows this quotation seriously demeans the intelligence of "young women." Pestic writes: "Would it not be unfortunate if young women, told that science learned from the torture of female witches to abuse Mother Nature herself, concluded that they should have nothing to do with science?"

²⁸ Francis Bacon, *The Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, pp. 285–313; see the topics entitled "Pan," "Proteus," "Prometheus," "Daedalus," "Orpheus," "Proserpina," and "Sphynx." See also Bacon, *Works*, Vol. 6, pp. 617–686 (Latin), 687–764 (English).

matter, Pan is nature, Proserpina the earth's creative energy, and Proteus matter in the multiplicity of its forms."²⁹

I will argue that the allegorical figures of Pan, Proteus, and Prometheus, as described in *The Wisdom of the Ancients*, characterize Bacon's early ideas of the three major states exhibited by nature, set out in tentative form in the 1605 *Advancement of Learning* and presented in developed form in the 1620s.

Nature, Bacon states in his 1623 Latin revision of *The Advancement of Learning* (*De Dignitate et Augmentis Scientiarum*), exists in three states—at liberty, in error, and in bonds:

She is either free and follows her own course of development as in the heavens, in the animal and vegetable creation, and in the general array of the universe; or she is driven out of her ordinary course by the perverseness (*pravitatibus*), insolence (*insolentiis*), and forwardness of matter (*materiae contumacies*) and violence of impediments (*impedimentorum violentia*), as in the case of monsters (*monstris*); or lastly she is put in constraint (*constringitur*), molded (*fingitur*), and made as it were new by art and the hand of man (*arte et opera humana*); as in things artificial.³⁰

(For textual comparisons of the three states see Tables 1, 2, and 3.) For Bacon, however, nature erring (or the wonders of nature) and nature in bonds (or the wonders of art) were

²⁹ Pierre Hadot, *The Veil of Isis: An Essay on the History of the Idea of Nature*, trans. Michael Chase (Cambridge, Mass.: Harvard Univ. Press, 2006) (hereafter cited as **Hadot, *Veil of Isis***), p. 80; see also p. 79 on sixteenth-century handbooks of mythology.

³⁰ Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 294). Bacon organized his discussion of nature into three states—free, erring, and in bonds—in several places in his published work. His threefold *schema* initially appeared in the 1605 English edition of *The Advancement of Learning* and was further elaborated in the 1623 Latin edition, *De Dignitate et Augmentis Scientiarum* (see Table 1). (Bacon also presented the three states of nature in his "Description of the Intellectual Globe" [1612], published posthumously by Isaac Gruter in *Scripta in Naturali et Universali Philosophia* [Amsterdam: Ludovicum Elzevirium, 1653]; see *Works*, ed. and trans. Montagu, Vol. 2, pp. 571–589.) A second major discussion was in the *Parasceve*, or *Preparative towards a Natural and Experimental History*, "Aphorisms on the Primary History," published in 1620 with and immediately following the *Novum Organum* (see Table 2). Additionally, the history of "nature free" and "nature under constraint" (the first and third states) was discussed in the "Plan of the Work" for the *Instauratio Magna*, or *Great Instauration*, also published in 1620 immediately preceding the *Novum Organum* (see Table 3). Of these discussions, Pestic quotes only that in the "Plan of the Work," using the Spedding translation with Latin inserts for the words "under constraint and vexed [*naturae constrictae et vexatae*]" and "under the vexations [*vexationes*] of art" (Pestic, "Wrestling with Proteus," p. 88; see also Pestic, "Proteus Rebound," p. 306). But, contrary to Pestic's argument that for Bacon "vexare" ("vex") had only mild meanings, such as "shaking" or "harassing," some early scholars read Bacon's Latin more harshly. Peter Shaw, a chemist and Physician in Ordinary to Kings George II and George III, translates "vexare" in this and other passages as "torture": Bacon, *Philosophical Works*, ed. Shaw (see Table 3 and notes 39 and 58, below). Thomas Tennison, Archbishop of Canterbury, also interpreted Bacon's Latin as meaning "torture" in his 1679 "Account of the Philosophy, Mechanic Inventions, and Writings of Sir Francis Bacon" that introduced the *Baconiana*, writing as follows: "The seventh and greatest Branch of the third part of the Instauration, is his Sylva Sylvarum, or Natural History; which containeth many Materials for the building of Philosophy, as the Organon doth Directions for the work. It is an History not only of Nature freely moving in her Course (as in the production of meteors, plants, minerals); but also of Nature in constraint, and vexed and *tortur'd* by humane [human] Art and Experiment." See Francis Bacon, *Baconiana, or Certain genuine remains of Sr. Francis Bacon, Baron of Verulam, and Viscount of St. Albans in arguments civil and moral, natural, medical, theological, and bibliographical* (London: Printed by J.D. for Richard Chiswell, 1679), p. 41 (emphasis added); Tennison is also quoted in Bacon, *Works*, ed. and trans. Montagu, Vol. 2, p. 4 n 7. Tennison's statement followed several pages of text that outlined Bacon's framework for *The Great Instauration*, including "The Preface: The Distribution of the Work of the Great Instauration; Aphorisms guiding to the Interpretation of Nature" (*Baconiana*, p. 32). It seems likely that Tennison is referring to the first and third states of nature (i.e., at liberty and in bonds), as set out by Bacon in his "Distribution of the Work," suggesting that they might be applied to the materials in the *Sylva Sylvarum*. Tennison's characterization closely approximates the quotations in Table 3.

Table 1. Francis Bacon's Three States of Nature, 1605–1623

<i>Advancement of Learning</i> , 1605 (English) (Spedding <i>et al.</i> , 1875) ¹	"Description of the Intellectual Globe," 1612 (Montagu, 1857) ²	"Description of the Intellectual Globe," 1612 (Rees, 1996) ³	<i>De Dignitate et Augmentis Scientiarum</i> , 1623 (Latin) (Spedding <i>et al.</i> , 1875) ⁴	<i>De Augmentis Scientiarum</i> , 1623 (Shaw, 1733) ⁵	<i>(De Augmentis) Of the Dignity and Advancement of Learning</i> , 1623 (Spedding <i>et al.</i> , 1875) ⁶
History of Nature is of three sorts; of nature in course, of nature erring or varying, and of nature altered or wrought; that is, history of Creatures, history of Marveles, and history of Arts.	But we attempt a partition of natural history, derived from the tendency and condition of nature herself, which is found placed in three several states, and subject as it were, to three modes of government. For nature is either free, spontaneously diffusing and developing itself in its wonted course, that is, when nature depends upon itself, in no way obstructed and subdued, as in the heavens, animals, plants, and all the natural productions; <i>or, again</i> , it is evidently torn down and precipitated from its proper state by the pravity and erratic tendency of obdurate and resisting matter, or by violence of obstacles, as in the case of monsters and unnatural productions; <i>or, finally</i> , it is coerced by the art and industry of man, fashioned, altered, and as it were made anew, as in things artificial. For in things artificial nature seems as it were, new made, and there is seen a new face of things, or second universe. Wherefore natural history [is] either the <i>liberty</i> of nature, or its <i>errors into bonds</i> . We shall therefore divide natural history into the history of generations, the history of pretergenerations, and the history of arts, which we are accustomed to call <i>mechanical</i> and experimental history.	But I shall set up the partitions of natural history on the basis of the force and condition of nature itself, which we find existing in a triple condition and subject, as it were, to three kinds of government. For nature is either <i>free</i> and left to go its own way and unfold itself in its usual course, that is, nature advances by itself without being interfered with or worked on in any way, as in the heavens, animals, plants and the whole order of nature; <i>or again</i> it is quite forced and ripped from its state by the crookedness and arrogance of defiant and rebellious matter, and by the violence of impediments, as in the monsters and heterocites of nature; <i>or, finally</i> , it is restrained, moulded, completely transformed and as it were made new by art and human agency, as in artificial things. For in artificial things nature seems as it were made up, and we see bodies in an entirely new guise and a kind of alternative universe of things. Therefore natural history deals with either the <i>liberty</i> of nature, or its <i>errors or bonds</i> . Thus I shall divide natural history into the history of <i>Generations</i> , history of <i>Pretergenerations</i> , and history of <i>Arts</i> , the last of which I usually call <i>Mechanical</i> and <i>Experimental</i> .	Partitionem <i>Historiae Naturalis</i> molietur ex statu et conditione ipsius Naturae, quae in triplici statu posita invenitur, et tanquam regimen trinum subit. Aut enim libera est natura et cursu suo consueto se explicans, ut in coelis, animalibus, plantis, et universo naturae apparat; aut a pravitatebus et insolentis materiae contumaciae ab impedimentorum violentia de statu suo detruditur, ut in monstris; aut denique ab arte et opera humana constringitur et fingitur, et tanquam novatur, ut in artificialibus. Sit itaque partitio <i>Historiae Naturalis</i> in <i>Historiam Generationum</i> , <i>Praeier- Generationum</i> , et <i>Artium</i> ; quam postremam etiam <i>Mechanicam et Experimentalem</i> appellare consuevimus. Harum prima <i>Libertatem Naturae</i> tractat; <i>secunda Errores</i> ; tertia <i>Vincula</i> . Libenter autem <i>Historiam Artium</i> , ut <i>Historiae Naturalis</i> speciem constituimus; quia inveteravit consensus opinio, ac si aliquid quippiam esset ars, a natura, artificialia a naturalibus; unde illud malum, quod peritque illud naturae, quod peritque naturae, se putant, si historiam animalium aut plantarum aut mineralium conferentur, omisissimum mechanicarum experimentum.	5. We form our Division of <i>Natural History</i> upon the threefold state and <i>condition of Nature</i> ; which is (1.) either free, and proceeding in her ordinary course, without molestation; or (2.) obstructed by some stubborn and less common Matters, and thence put out of her course, as in the production of <i>Monsters</i> ; or (3.) bound and wrought upon by human means, for the production of Things artificial. Let all <i>Natural History</i> , therefore, be divided in the <i>History of Generations</i> , <i>Prætergenerations</i> , and <i>Arts</i> ; the first to consider <i>Nature at Liberty</i> ; and the <i>second, Nature in her errors</i> ; and the <i>third, Nature in constraint</i> . 6. The History of Arts should the rather make a Species of <i>Natural History</i> , because of that prevalent opinion as if <i>Art Nature</i> , and Things natural were a different thing from whence many Writers of <i>Natural History</i> think they perform notably, if they give us the <i>History of Animals, Plants, or Minerals</i> without a word of the <i>mechanic Arts</i> .	The division which I will make of Natural History is founded upon the state and condition of nature herself. For I find nature in three different states, and subject to three different conditions of existence. She is either free and follows her own course of development as in the heavens, in the animal and vegetable creation, and in the general array of the universe; or she is driven out of her ordinary course by the perversion, insolence, and forwardness of matter and violence of impediments, as in the case of monsters; or lastly she is put in constraint, moulded, and made as it were new by art and artificial. Let Natural History therefore be divided into the <i>History of Generations</i> , of <i>Pretergenerations</i> , and of <i>Arts</i> ; which last I also call <i>Mechanical</i> and <i>Experimental History</i> . Of these the first treats of the Freedom of Nature, the second of her Errors, the third of her Bonds. And I am the more induced to set down the History of the Arts as a species of Natural History, because an opinion has long been prevalent that art is something different from nature, and things artificial different from things natural; whence this evil has arisen—that most writers of Natural History think they have done enough when they have given an account of animals or plants or minerals, omitting all mention of the experiments of mechanical arts.

¹ Francis Bacon, *The Advancement of Learning*, in *Works*, ed. James Spedding, Robert Leslie Ellis, and Douglas Devon Heath, 14 vols. (London: Longmans Green, 1875), Vol. 3, p. 330. ² Francis Bacon, "Description of the Intellectual Globe," in *Works*, ed. and trans. Basil Montagu, 3 vols. (Philadelphia: Parry & MacMillan, 1857), Vol. 2, p. 572. Regarding the ellipses, see the discussion of the Proteus quotation at note 46, above. ³ Francis Bacon, "Description of the Intellectual Globe," in *Philosophical Studies*, c. 1611–c. 1619, ed. Graham Rees (Oxford: Clarendon, 1996), Ch. 2, pp. 101, 103. Regarding the ellipses, see the discussion of the Proteus quotation at note 46, above. ⁴ Francis Bacon, *De Dignitate et Augmentis Scientiarum*, in *Works*, ed. Spedding *et al.*, Vol. 1, p. 496. ⁵ Francis Bacon, *De Augmentis Scientiarum*, in *The Philosophical Works Methodized and made English, from the Originals, with Occasional Notes, to explain what is obscure*, by Peter Shaw, 3 vols. (London: J. J. and P. Knapton, D. Midwinter and A. Ward, and others, 1733), Vol. 1, p. 44. ⁶ Francis Bacon, *Of the Dignity and Advancement of Learning*, in *Works*, ed. Spedding *et al.*, Vol. 4, Bk. 1.

Table 2. Francis Bacon's Three States of Nature, *Parasceve*, 1620

<i>Parasceve</i> , Aphorisms de Confiencia Historia Prima, 1620 (Latin) (Spedding et al., 1875) ¹	<i>Parasceve</i>) Aphorisms of the Formation of the First History, 1620 (Montagu, 1857) ²	<i>Parasceve</i>) Aphorisms on the Primary History, 1620 (Spedding, 1875) ³	<i>Parasceve</i>) Aphorisms on Compiling a Primary History, 1620 (Jardine and Silverthorne, 2000) ⁴	<i>Parasceve</i>) Aphorisms on the Construction of a Primary History, 1620 (Rees and Wakely, 2004) ⁵
<p>Aphorismus I. Natura in triplici statu ponitur et tanquam regimen subit trinum. Aut enim libera est et cursu suo ordinato se explicat, aut a pravitibus et insolentibus materiae, aique ab impedimentorum violentia de statu suo detrahitur, aut ab arte et ministerio humano constringitur et fingitur. Atque primus ille status ad <i>species rerum</i> refertur, secundus ad <i>monstra</i>, tertius ad <i>artificialia</i>. Etenim in artificialibus natura jugum recipit ab imperio hominis; nunquam enim illa facta fuissent absque homine. At per operam et ministerium hominis conspiciuntur prorsus nova corporum facies, et veluti rerum universitates altera, sive theatrum alterum. Triplex itaque est historia naturalis. Tractat enim aut naturae <i>Libertatem</i>, aut <i>Errores</i> aut <i>Vincula</i>; ut non male eam partiri possimus in historiam <i>Generatiorum</i>, <i>Proaeteregenerationum</i>, et <i>Artium</i>; quarum postremae etiam <i>Mechanicam</i> et <i>Experimentalem</i> appellare consuevimus. Neque tamen id praecipuum, ut haec tria separatim tractentur. Quidni enim possint historiae monstrorum in singulis speciebus cum historia ipsarum specierum coniungi? Etiam artificialia quandoque cum speciebus recte coniunguntur, quandoque melius separantur. Quamobrem e re nata de his consilium capere optimum est. Methodus enim iterationes et prohibentem gignit, aequae ubi nimia est, ac ubi nulla.</p>	<p>Aphorism I. Nature is placed in three situations, and subject to a threefold government. For she is either free, and left to unfold herself in a regular course, or she is driven from her position by the obstinacy and resistance of matter, and the violence of obstacles, or she is constrained and moulded by human art and labour. The first state applies to specific nature of bodies; the second to monsters; the third to artificial productions, in which she submits to the yoke imposed on her by man, for without the hand of man they would not have been produced. But from the labour and contrivance of man an entirely new appearance of bodies takes its rise, forming, as it were, another universe or theatre. Natural history, then, is threefold, and treats either of the liberty, the wanderings, or the fetters of nature; so that we may apply divide it into the histories of generation, proaeteregeneration, and arts; the latter of which divisions we are also wont to call mechanic or experimental. Yet would we not direct these three to be carried on separately, for why should not the history of monstrosities in every species be combined with that of the species itself? So, also, artificial subjects may sometimes properly enough be treated of together with certain natural species, though, at other times, it is better to separate them. Circumstances, therefore, must guide us, for too rigid a method admits of repetitions and prolixity as much as no method.</p>	<p>Aphorism I. Nature exists in three states, and is subject as it were to three kinds of regimen. Either she is free, and develops herself in her own ordinary course; or she is forced out of her proper state by the perverseness and insubordination of matter and the violence of impediments; or she is constrained and moulded by art and human ministry (<i>Ministerio</i>). The first state refers to the spectra of things; the second to monsters; the third to things artificial. For in things artificial nature takes orders from man and works under his authority; without man such things would never have been made. But by the help and ministry (<i>ministerium</i>) of man a new face of bodies, another universe or theatre of things, comes into view. Natural History therefore is threefold. It treats of the liberty of nature, or the errors (<i>errors</i>) of nature, or the bonds (<i>vinctula</i>) of nature; so that we may fairly distribute it into history of Generations, of Proaeteregeneration, and of Arts; which last I also call Mechanical or Experimental history. And yet I do not make it a rule that these three should be kept apart and separately treated. For why should not the history of the monsters in the several species be joined with the history of the species themselves? And things artificial again may sometimes be rightly joined with the species, though sometimes they will be better kept separate.</p>	<p>Aphorism I. Nature exists in three states and accepts three kinds of regime. She is either free and unfolding in her own ordinary course, or driven from her state by the vicious and insolent assaults of matter and by the force of obstructions, or constrained and shaped by human art and agency. The first state refers to the species of things, the second to prodigies, the third to artificial things. For in artificial things nature accepts the yoke from the empire of man; for these things would never have been done without man. A completely new face is given to bodies by human effort and agency, a different universe of things, a different theatre. There are, consequently, three forms of natural history. It deals either with the <i>Freedom</i> of nature or with the <i>Errors</i> of nature or with the <i>Bonds</i> of nature; so that a good division we might make would be a history of <i>Births</i>, a history of <i>Prodigious Births</i>, and a history of <i>Arts</i>; the last of which we have also often called the <i>Mechanical</i> and the <i>Experimental Art</i>. But we are not prescribing that the three should be treated separately. Why may not the histories of prodigies in particular species be rightly joined with the history of the species themselves? Artificial things too are sometimes rightly joined with species, and sometimes better separated.</p>	<p>Aphorism I. Nature exists in a triple condition and is subject, as it were, to three kinds of government. For it is either free and unfolds itself in its ordinary course; or it is torn from its course by the crookedness and arrogance of matter and by the violence of impediments; or it is restrained and moulded by art and human agency. And the first condition relates to the <i>Species</i> of things, the second to <i>Monsters</i>; and the third to <i>artificial things</i>. For in artificial things nature is held in subjugation by the empire of man, for without man these things would never have been made. But through the effort and agency of man we see bodies in an entirely new guise and as a kind of alternative universe or theatre of things. Therefore natural history is threefold. For it deals either with the <i>liberty</i> of nature, or <i>its errors</i> or <i>its bonds</i>; so that we can fairly divide it into <i>History of Generations</i>, of <i>Proaeteregeneration</i> and of <i>Arts</i>, the last of which I have also got used to calling <i>Mechanical</i> and <i>Experimental</i>. Nevertheless I do not advise that these three be dealt with separately. For there is no reason why history of Monsters in particular Species cannot be joined with the History of Species themselves. Artificial things too are sometimes rightly taken with Species, but at others better kept apart from them. So it is best to take these things as they come. For methodical discourse breeds repetition and prolixity, alike where there is too much of it and where there is none at all.</p>

¹ Francis Bacon, *Parasceve ad Historiam Naturalem et Experimentalem*, in *Works*, ed. James Spedding, Robert Leslie Ellis, and Douglas Devon Heath, 14 vols. (London: Longmans Green, 1875), Vol. 1, p. 395. ² Francis Bacon, *Preparation for a Natural and Experimental History*, in Bacon, *Works*, ed. and trans. Basil Montagu, 3 vols. (Philadelphia: Parry & MacMillan, 1857), Vol. 3, p. 426. ³ Francis Bacon, *Preparative towards a Natural and Experimental History* [*Parasceve*], in *The New Organon*, ed. Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge Univ. Press, 2000), pp. 223–224. ⁴ Francis Bacon, *A Preparative to a Natural and Experimental History* [*Parasceve*], in *The Instauration magna, Pt. 2: Novum organum and Associated Texts*, ed. Graham Rees with Maria Wakely (Oxford: Francis Bacon, 11) (Oxford: Clarendon, 2004), p. 455.

Table 3. Francis Bacon’s History of Nature, “Plan of the Work,” 1620

<p>“Distributio operis,” 1620 (Lain) (Spedding <i>et al.</i>, 1875)¹</p>	<p>“Preliminaries,” 1620 (Shaw, 1733)²</p>	<p>“Distribution of the Work,” 1620 (Montagu, 1857)³</p>	<p>“Plan of the Work,” 1620 (Spedding <i>et al.</i>, 1875)⁴</p>	<p>“Distribution de l’Oeuvre,” 1620 (French) (Malherbe and Pousseur, 1986)⁵</p>	<p>“Plan of the Work,” 1620 (Jardine and Silverthorne, 2000)⁷</p>	<p>“Plan of the Work,” 1620 (Rees and Wakely, 2004)⁷</p>
<p>Quoad congeriem vero, conficimus historiam non solum naturae liberae ac solutae (cum scilicet illa sponte fluit et opus suum peragat, qualis est historia coelestium, meteororum, terrae, et maris, mineralium, plantarum, animalium); sed multo magis naturae constrictae et vexatae; nempe, cum per artem et ministerium humanum de statu suo detruditur, atque premittitur fingitur, laeque omnia artium mechanicarum, omnia operativaque partis liberalium, omnia practicum complurium, quae in artem program non coalescunt, experientia, quantum inquirere licuit, et quantum ad finem nostrum faciunt) perscribimus. Quin etiam (ut quod res est, eloquamur) nil morati, multo plus et operae et praesidii in hac parte, quam in illa altera, posuimus: quandoquidem natura rerum magis se prodit per vexationes artis, quam in libertate propria.</p>	<p>With regard to its collection, we propose to shew <i>Nature</i> not only in a <i>free state</i>, as in the <i>History of Meteors, Minerals, Plants, and Animals</i>, but more particularly as she is bound, and tortur’d, press’d, form’d, and turn’d out of her course by <i>Art and human Industry</i>. Hence we would set down all opposite experiments of the mechanic and liberal Arts; with many others not yet formed into Arts: for the nature of things is better discover’d by the torturings of Art, than when they are left to themselves.</p>	<p>With regard to its compilation, we intend not to form a history of natural ac liberty and in her usual course, when she proceeds willingly and acs of her own accord, (as for instance the history of the heavenly bodies, meteors, the earth and sea, minerals, plants, and animals,) but much rather a history of nature constrained and nature constrained and perplexed, as she is seen when thrust down from her proper rank and harassed and modelled by the art and contrivance of man. We will therefore go through all the experiments of the mechanical and the operative part of the liberal arts, and all those of different practical schemes which have not yet been put together so as to form a peculiar art: as far as we have been able to investigate them and, it will suit our purpose. Besides, (to speak the truth) without paying any attention to the pride of man, or to appearances, we consider this branch of much more assistance and support than the other: since the nature of things betrays itself more by means of the operations of art than when at perfect liberty.</p>	<p>I mean it to be a history not only of nature free and at large (when she is left to her own course and does her work her own way)—such as that of the heavenly bodies, meteors, earth and sea, minerals, plants, animals,) but much more of nature under constraint and vexed, that is to say, when by art and the hand of man she is forced out of her natural state and squeezed and moulded. Therefore I set down at length all experiments of the mechanical arts, of the operative part of the liberal arts, of the many crafts which have not yet grown into arts properly so called, so far as I have been able to examine them and as they exanude to the end in view. Nay (to say the plain truth) I do in fact (low and vulgar as men may think it) count more upon this part both for helps and safeguards than upon the other, seeing that the nature of things betrays itself more readily under the vexations of art than in its natural freedom.</p>	<p>Pour ce qui est de la masse à rassembler, nous ne nous bornons pas à constituer une histoire de la nature libre et déliée (telle qu’elle se manifeste dans son cours spontané et dans l’accomplissement de son oeuvre propre), et qui comprend: l’histoire des cieux, des météores, de la terre et de la mer, des animaux, des plantes, des minéraux, mais, avant tout, une histoire de la nature contrainte et tourmentée, telle qu’elle se manifeste quand l’art et l’assistance de l’homme l’arrachent à son état, la pressent et la façonnent. C’est pourquoi toutes les expériences des arts mécaniques, toutes celles qui relevant de la partie opérative des arts libéraux, toutes les nombreuses activités pratiques auxquelles manque encore le lien d’un art défini s’y trouvent consignées (dans la mesure où nous avons pu les rechercher et où elles servent à notre fin). Bien plus, pour dire les choses comme elles sont: il n’y ayt cure de la fierté des hommes ou du prestige des matières, nous consacrons beaucoup plus de travail et de moyens à cette partie qu’à la première: car la nature des choses se livre davantage à travers les tourments de l’art que dans sa liberté propre.</p>	<p>And as for its composition, we are making a history not only of nature free and unconstrained (when nature goes its own way and does its own work), such as a history of the bodies of heaven and the sky, of land and sea, of minerals, plants and animals; but much more of nature restrained and harassed, when it is forced from its own condition by human agency, and squeezed and moulded. Therefore I record in detail (as far as I have been able to investigate them, and as far as they contribute to my aim) all the experiments of the mechanical arts, all the experiments of the operative department of the liberal arts, and of the many practical arts which have not yet formed a specific art of their own (so far as we have had an opportunity to investigate and they are relevant to our purpose). Moreover (but place more pat much more effort and many more resources into this part than into the other, and pay no attention to men’s digests or what they find attractive, since nature reveals herself more through the harassment of art than in her own proper freedom.</p>	<p>But for its mass, I do not just put together a history of nature free and unconstrained (when, that is, it goes its own way and does its own work—as in the history of the heavenly bodies, meteors, the Earth and sea, minerals, plants and animals) but much more of nature restrained and vexed, namely when it is forced from its own condition by human agency; and squeezed and moulded. Therefore I record in detail (as far as I have been able to investigate them, and as far as they contribute to my aim) all the experiments of the mechanical arts, of the operative department of the liberal arts, and of the many practices which have not yet coalesced into a proper art. In fact (to tell it as it is) I am not put off by men’s arrogant superiority or by outward appearances but place more effort and resources into this part than into the history of nature free, seeing that the nature of things shows itself more openly under the vexations of art than in its natural freedom.</p>

¹ Francis Bacon, “Distributio operis,” in *Works*, ed. James Spedding, Robert Leslie Ellis, and Douglas Devon Heath, 14 vols. (London: Longmans Green, 1875), Vol. 1, p. 141. ² Francis Bacon, “Preliminaries,” in *The Philosophical Works Methodized and made English, from the Originals, with Occasional Notes, to explain what is obscure*, by Peter Shaw, 3 vols. (London: J. and P. Knapton, D. Midwinter and A. Ward, and others, 1733), Vol. 1, p. 14. ³ Francis Bacon, “Distribution of the Work,” in *Works*, ed. and trans. Basil Montagu, 3 vols. (Philadelphia: Parry & MacMillan, 1857), Vol. 3, p. 341. ⁴ Francis Bacon, “Plan of the Work,” in *Works*, ed. Spedding *et al.*, Vol. 4, p. 29. ⁵ Francis Bacon, “Distribution de l’Oeuvre” in *Novum Organum*, trans. Michel Malherbe and Jean-Marie Pousseur (Paris: Presses Univ. France, 1986), p. 83. ⁶ Francis Bacon, “Plan of The Great Renewal,” in *The New Organum*, ed. Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge Univ. Press, 2000), pp. 20–21. ⁷ Francis Bacon, “Plan of the Work,” in *The Instauration magna, Pt. 2: Novum organum and Associated Texts*, ed. Graham Rees with Maria Wakely (Oxford Francis Bacon, 11) (Oxford: Clarendon, 2004), p. 39.

not separate and exclusive categories; rather, they crossed over into each other and could be studied in ways that illuminated each other and nature itself. "I do not make it a rule," he wrote, "that these three should be kept apart and separately treated. For why should not the history of the monsters in the several species be joined with the history of the species themselves? And things artificial again may sometimes be rightly joined with the species, though sometimes they will be better kept separate."³¹

Pan symbolizes the first state, nature at liberty. "The ancients," states Bacon, "have exquisitely described Nature under the person of Pan." Pan, as the figure of a man with a goat's body, mediates between higher and lower forms of nature. The upper part, or man, symbolizes "equitability of motion, and constancy and dominion over the earth and earthly things"; the lower part, or brute beast, symbolizes "perturbations and unconstant motions" that need to be moderated by the upper part. As hunter, Pan is the human effort to uncover knowledge through observation and experience. He "lays open all the things of nature."³²

As in Bacon's first state of nature (in which "she is . . . free and follows her own course of development as in the heavens, in the animal and vegetable creation, and in the general array of the universe"³³), Pan represents nature's harmonious activity and continual development. His marriage to Echo means that the world is an image or reflection of itself. The matter of the world, however, is recalcitrant and disruptive. It has an "inclination and desire to the relapsing and dissolution of the world into the old chaos." Fortunately for humanity, however, matter's "malice and violence" are "restrained and kept in order by the prepotent unity and agreement of things, signified by Cupid or the god of love." When Pan audaciously challenges Cupid in wrestling, the latter overcomes and restrains him. The order and harmony of nature are thus maintained in the face of the recalcitrant tendency of matter to dissolve the world and return it to chaos.

Proteus, or matter, symbolizes Bacon's second state, or nature in error. This second state was necessary to account for the great variety of shapes, wonders, and strange forms of nature that resulted when "she is driven out of her ordinary course by the perverseness, insolence, and forwardness of matter and violence of impediments, as in the case of monsters."³⁴ In *The Wisdom of the Ancients*, Proteus represents matter, which when acting freely and at liberty produces the species of the world, but when restrained and confined by handcuffs (i.e., "the violence of impediments") turns "himself into all manner of forms and wonders of nature: sometimes into fire, sometimes into water, sometimes into the shape of beasts, and the like, till at length he was restored to his own form again."³⁵ In their book *Wonders and the Order of Nature, 1150–1750*, Lorraine Daston and Katharine Park draw on Bacon's second state of nature to describe the books or "cabinets" of wonders and curiosities of nature that were so common in the Renaissance. As Bacon stated, it was by understanding the "wonders of nature" that one could proceed to an understanding of the

³¹ Bacon, *Parasceve*, Aphorism 1 (*Works*, Vol. 4, p. 253). See also Bacon, "Description of the Intellectual Globe," in *Works*, ed. and trans. Montagu, Vol. 2, p. 572. In his outline for "The New World of Sciences," Bacon planned that Bk. 2 would contain chapters entitled "The Errors of Nature, or the History of Praetergenerations," and "The Bonds of Nature, or Mechanical History" (Bacon, *Works*, Vol. 5, p. 121).

³² Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, on pp. 290–292; see also Hadot, *Veil of Isis*, p. 296.

³³ Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 294). (See Table 1.)

³⁴ *Ibid.* See also Merchant, *Death of Nature*, p. 170.

³⁵ Francis Bacon, "Proteus, or Matter," in *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, p. 297. For Pestic's interpretation of the Proteus allegory see "Wrestling with Proteus," "Proteus Rebound," "Proteus Unbound" (cit. n. 11), and *Labyrinth* (cit. n. 11).

third state of nature, or "the wonders of art."³⁶ For Bacon, the curiosities, wonders, and strange shapes that nature sometimes produced when acting perversely were explained by the myth of Proteus.

The myth of Proteus illustrates the differences between Bacon's first and second states of nature. Proteus (Neptune's herdsman) slept every noon after counting his flock of sea-calves. His flock or herd, states Bacon, "seems to be nothing but the ordinary species of sensible creatures, plants, and metals." When free and unconstrained, Proteus existed with his flock completed. By analogy, matter, "after the forming and perfecting of these kinds, having ended as it were her task, . . . seems to sleep and take her rest, not attempting the composition of any more species. And this may be the moral of Proteus counting of his flock, and of his sleeping."³⁷

But when subjected to "manacles" or "bonds and handcuffs" (i.e., "the violence of impediments"), Proteus struggles and changes shape in an effort to free himself.³⁸ Under duress, matter, likewise, assumes "divers strange forms and shapes of things" that are wonders or monstrous freaks of nature, not the living things that are produced when nature acts freely and at liberty. But matter can never be annihilated, even if an "expert minister of nature" tries to reduce it to nothing.³⁹ For Bacon, the allegory of Proteus thus

³⁶ Daston and Park, *Wonders and the Order of Nature* (cit. n. 23), pp. 220–231. They quote Bacon as follows: "from the wonders of nature is the nearest intelligence and passage towards the wonders of art: for it is no more by following and as it were hounding Nature in her wanderings, to be able to lead her afterwards to the same place again" (p. 223). Also: "Bacon invoked the 'wonders of nature' to bridge the natural and the artificial" (p. 260). For citations see Bacon, *Advancement of Learning* (1605) (*Works*, Vol. 3, p. 331); and Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 296). On Bacon's interpretation of monsters see Katharine Park and Lorraine J. Daston, "Unnatural Conceptions: The Study of Monsters in Sixteenth- and Seventeenth-Century France and England," *Past and Present*, Aug. 1981, no. 92, pp. 20–54, on p. 44: "As nature struggled to overcome the recalcitrance of matter or the fetters of art, she assumed the novel forms of 'pretergeneration,' monsters, which served as models for the novelties of art." See also Park, "Nature in Person" (cit. n. 23), pp. 50–73.

³⁷ Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, p. 297.

³⁸ *Ibid.* The main feature of the allegory is that Proteus, as matter, can escape his handcuffs by assuming different shapes, but if caught could be made to tell all he knew. To understand the hidden mysteries of nature, Bacon states, a person needed to catch Proteus "in manacles, and holding him fast therewith: who, nevertheless, to be at liberty, would turn himself into all manner of forms and wonders of nature." See also Bacon, *Parasceve*, Aphorism 5 (*Works*, Vol. 4, p. 257).

³⁹ Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, p. 297: "Nevertheless, if any expert minister of nature shall encounter matter by main force, vexing and urging her with intent and purpose to reduce her to nothing, she contrariwise, seeing annihilation and absolute destruction cannot be effected by the omnipotency of God, being thus caught in the straits of necessity, doth change and turn herself into divers strange forms and shapes of things, so that at length, by fetching a circuit as it were, she comes to a period, and if the force continue, betakes herself to her former being." In the *De Augmentis Scientiarum* Bacon states, "For like as a man's disposition is never well known or proved till he be crossed, nor Proteus ever changed shapes till he was straitened and held fast, so nature exhibits herself more clearly under the trials and vexations of art than when left to herself" (Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 [*Works*, Vol. 4, p. 298]). Shaw's 1733 translation of these passages uses the word "torture" (three times) to describe the handcuffing of Proteus. In "Physical Mythology," Shaw translates the Proteus allegory as follows: "And thus far the Fable reaches of Proteus, and his Flock, at liberty and unrestrained. For the Universe, with the common Structures and Fabricks of the Creatures, is the Face of Matter, not under constraint; or as the Flock wrought upon, and tortured, by human means. But if any skillful Minister of Nature shall apply force to Matter; and by design torture and vex it, in order to its Annihilation; it, on the contrary, being brought under this Necessity, changes and transforms it self into a strange Variety of Shapes and Appearances; for nothing but the Power of the Creator can annihilate, or truly destroy it: so that at length running thro' the whole Circle of Transformations, and compleating its Period, it in some degree restores itself if the Force be continued. And that method of binding, torturing, or detaining, will prove the most effectual and expeditious, which makes use of Manacles and Fetters; that is, lays hold and works upon Matter in extremest Degrees" (Bacon, *Philosophical Works*, ed. Shaw, Vol. 1, p. 567 [emphasis added on the word "torture" and its variants]). Shaw likewise uses "torture" in his translation of the passage in *De Augmentis Scientiarum* quoted above (omitting the phrase about Proteus): "For as a man's Temper

reveals the perversity, insolence, and elusiveness of matter under “constraint or binding.”⁴⁰

The third state of nature, or nature in bonds, is symbolized by Prometheus, or the state of man. He is “the nature of man . . . capable of a mind and understanding,” “human nature,” “man in nature,” and man “mixed and compounded” of all things.⁴¹ As bringer of technology, Prometheus likewise represents nature transformed by art. To assist humanity, Prometheus stole fire from the sun, “which [in] infinite ways affords aid and assistance to all labors and mechanical arts, and to the sciences themselves.” After a number of other crimes, Jupiter “cast him into chains, and doomed him to perpetual torment.” Every day an eagle feasted on his liver, “but as much as was eaten in the day grew again in the night, that matter for torment to work upon might never decay.” But Hercules crossed the ocean in a cup, shot the eagle, and set Prometheus free.⁴²

The myth of Prometheus illustrates the liberation of humanity from torment. “The meaning of the allegory is this,” states Bacon: “that men’s outcries upon the defects of nature and art, proceed from an excellent disposition of the mind.” Those who complain that Prometheus’s gift of fire is not enough are “ever in action, seeking always to find out new inventions.” Scholars who accept the philosophy of the Peripatetics, Bacon insists, are slaves to ancient ideas. On the other hand, those who angrily complain that humanity knows nothing acknowledge “the imperfection of nature and art.” By setting Prometheus free, Hercules frees him (and with him humankind) from perpetual torment and slavery. Bacon concludes: “The sailing of Hercules in a cup to set Prometheus at liberty . . . redeem[s] man from the slavery of hell.” Putting nature (Prometheus) in bonds will thus be followed by human freedom and redemption.⁴³

The frontispiece of Bacon’s *Novum Organum* (1620) draws on this analogy, showing a ship sailing through the pillars of Hercules. The image invokes Hercules’s voyage to free Prometheus and, with him, liberate mankind to pursue knowledge of the arts and sciences.

is never well known till he is cross’d; in like manner, the Turns and Changes of Nature cannot appear so fully, when she is left at her liberty, as in the Trials and Tortures of Art” (Bacon, *Philosophical Works*, ed. Shaw, Vol. 1, p. 46 [emphasis added]; Bacon’s Latin is “*irritata et vexata*” [cf. *Works*, Vol. 1, p. 500]). The 1624 French translation of the Latin in *De Augmentis Scientiarum* reads: “Car de même qu’on ne connaît jamais bien la disposition d’un homme, jusqu’à ce qu’il soit tourmenté, ni Protée ne changea jamais de formes, jusqu’à ce qu’il fût lié et retenu, aussi les passages et diversités de la nature, ne peuvent pas apparaître si pleinement dans la liberté de la nature, comme dans les essais et travaux de l’art” (“for like a man’s disposition is never revealed until it be crossed, and Proteus’s essence is always changed until it be constrained, so nature never reveals herself more clearly than when tortured”) (Francis Bacon, *Le progresz et avancement aus sciences diuines & humaines*, trans. A. Mavgars [Paris: Pierre Billaine, 1624], pp. 105–106; see also “la nature alteree et travaillée,” on the three states of nature [p. 197]). I thank Roger Hahn for modernizing and translating the French. “*Travaux*”/“*travailler*”/“*travail*” stems from “*tripalium*,” an instrument of torture. See *Webster’s New Twentieth Century Dictionary of the English Language Unabridged*, 2nd ed. (New York: Simon & Schuster, 1979), s.v. “*travail*.” The *Oxford English Dictionary* (*OED*) shows “*travail*” as evolving from “an instrument or engine of torture. . . . The etymological sense was thus ‘to put to torture, torment’”: s.v. “*travail*.”

⁴⁰ Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, p. 297. Matter, Bacon states elsewhere, “is not devoid of an appetite and inclination to dissolve the world and fall back into the old chaos, but that its force and malice is restrained and kept in order by the prevailing concord of things (which is signified by Love or Cupid)” (Bacon, *De Augmentis Scientiarum* [*Works*, Vol. 4, p. 325]). As in Plato’s *Timaeus*, matter was recalcitrant and had to be forcefully shaped by the demiurge.

⁴¹ Francis Bacon, “Prometheus, or, the State of Man,” in *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, pp. 308, 306. See also Bacon, “Physical Mythology,” in *Philosophical Works*, ed. Shaw, Vol. 1, pp. 552–560.

⁴² Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, pp. 305–307. See also Hadot, *Veil of Isis*, p. 95: “In Francis Bacon, at the dawn of modern science, Prometheus was to appear as the founder of experimental science.” On the history of the Prometheus myth Hadot cites Raymond Trousson, *Le thème de Prométhée dans la littérature européenne*, 2 vols., 2nd ed. (1964; Geneva: Librairie Droz, 1976).

⁴³ Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, pp. 306, 308–309.

In this work, Bacon states that "man can recover that right over nature that belongs to it by divine bequest." The goal is "to establish the power and dominion of the human race over the entire universe."⁴⁴

Pesic does not embrace the tradition of Prometheus as the bound hero who assists humanity through science and technology. To do so would be to admit to the daily torment (torture) of the chained Prometheus by the eagle. Instead, he sets up Proteus as the bound hero, exemplar of the heroic (male) scientist—Bacon's humble "servant of nature"—who gains truth through constant struggle with nature. He sees Proteus not as tortured, but merely vexed. Instead of having his liver devoured, like the suffering Prometheus, the handcuffed Proteus turns himself into strange forms and shapes. That these "wonders of nature" might be monsters or even freaks of nature is not acknowledged by Pesic. He insists that even though Proteus is in handcuffs and chains, "it is not a scene of torture."⁴⁵ He exonerates Bacon from violence toward nature by quoting the following passage:

But if anyone gets annoyed because I call the arts the bonds of nature when they ought rather to be considered its liberators and champions in that in some cases they allow nature to achieve its ends by reducing obstacles to order, then I reply that I do not much care for such fancy ideas and pretty words; I intend and mean only that nature, like *Proteus*, is forced by art to do what would not have been done without it: and it does not matter whether you call this forcing and enchaining, or assisting and perfecting.⁴⁶

But, contrary to Pesic, what Bacon is saying here is that he himself does not care to use pretty words such as "liberators" and "champions" in order to mollify others when all that is actually being achieved is to "reduce obstacles to order." The real meaning, Bacon states, is that nature (like Proteus) must be *forced* by art to do what it would not have done on its own. Merely "assisting and perfecting" nature as the alchemist does will not force it to yield its secrets.

Pesic has made a major distinction between the words "torture" and "vex," arguing that Bacon used only the milder term "vex" in relation to nature. Nevertheless, Bacon was striving toward the idea of the contained, controlled experiment in which a natural object is forced by art or technology to yield its secrets. The mechanical and practical arts out of which his concept of experiment emerged depended on hammering, molding, squeezing, and shaping nature under the constraint of tools and technological impediments. When it comes to the contained, controlled experiment, we can find a spectrum of meanings in terms such as "torment," "transmute," "torture," "vex," "hound," "alter," "constrain," "confine," "constrict," "change," "capture," "conquer," "disclose," "extract," "mold,"

⁴⁴ Bacon, *Novum Organum*, frontispiece; the quotations are from Bk. 1, Aphorism 129 (*Works*, Vol. 4, pp. 114, 115).

⁴⁵ Pesic, "Wrestling with Proteus," p. 84. Pesic and I disagree on the interpretation of this passage. Where Pesic sees a "heroic struggle," I see the "violence of impediments" and Shaw sees "torture" (Bacon, *Philosophical Works*, ed. Shaw, Vol. 1, p. 567; see note 39, above).

⁴⁶ Francis Bacon, "Description of the Intellectual Globe," in Bacon, *Philosophical Studies, c. 1611–c. 1619*, ed. Graham Rees (Oxford Francis Bacon, 6) (Oxford: Clarendon, 1996), pp. 100–101 (quoted in Pesic, "Wrestling with Proteus," p. 86; and Pesic, "Proteus Rebound," p. 307). See also Bacon, *Works*, Vol. 3, p. 729 (Latin), Vol. 5, p. 506 (English); and Bacon, *Works*, ed. and trans. Montagu, Vol. 2, p. 572. The tract, unpublished by Bacon, appeared in Gruter, *Scripta in Naturali et Universali Philosophia* (cit. n. 30). This paragraph is another instance of Bacon's denunciation of the alchemical and natural magic traditions, which sought only to perfect the base metals and to assist nature in bringing about new medicines, potions, metals, and products, rather than, as he advocated, fundamentally transforming and transmuting nature.

“penetrate,” “shake,” “shape,” “squeeze,” “straiten,” “struggle,” “subdue,” “wrest,” and “wrestle.”⁴⁷

Distributed among many of Bacon’s works and often reappearing in slightly altered phraseology, these terms all connote some degree of violence toward nature (the “violence of impediments”).⁴⁸ Simply annoying and pestering nature, or “assisting and perfecting” it, was not enough. The new method required a far more fundamental transmutation. As Bacon stated in *De Augmentis Scientiarum* (1623), “a more subtle error . . . has crept into the human mind; namely, that of considering art as merely an assistant to nature, having the power indeed to finish what nature has begun, to correct her when lapsing into error, or to set her free when in bondage, but by no means to change, transmute, or fundamentally alter nature.”⁴⁹ The new technologies, he wrote elsewhere, “do not like the old, merely exert a gentle guidance over nature’s course, they have the power to conquer and subdue her, to shake her to her foundations.”⁵⁰

⁴⁷ At least forty different phrases using these verbs, many of which are repeated or paraphrased, appear in different works throughout Bacon’s literary career. Among these many possibilities, Pestic focuses on the meanings of “vex,” “hound,” and “torture.” He insists that Bacon’s term “vex” (“*vexare*”) connotes only harassment, not violence, abuse, or torture (Pestic, “Wrestling with Proteus,” p. 88; and Pestic, “Proteus Rebound,” p. 306). Yet a spectrum of meanings exists. In Latin, “*vexatio*” is defined both as “jolting, jostling, shaking, and tossing” and as “ill-treatment or abuse,” while “*vexo*” also means “to distress, harass, trouble, maltreat”: William Smith, *A Smaller Latin–English Dictionary*, 3rd ed. (New York: Barnes & Noble, 1933), p. 803. Charlton T. Lewis and Charles Short, *A Latin Dictionary* (1879; Oxford: Clarendon, 1975), p. 1984, defines “*vexo*” to include “torment,” listing “*crucio*” as a synonym, as well as “to maltreat, abuse, harass” and “to move violently, to shake, to agitate.” The *King James Version Dictionary* of “definitions of words from the King James Bible” defines “vex” as “1. ‘to irritate,’ 2. ‘to plague; to torment; to harass; to afflict,’ . . . 5. ‘to persecute’”: *KJV Dictionary*, <http://av1611.com/kjbp/kjv-dictionary/vex.html>. English dictionaries define “vex” as “1. ‘to irritate; annoy; provoke’; 2. ‘to torment’; . . . 5. ‘to afflict with physical pain’”: *Random House Unabridged Dictionary* (New York: Random House, 2006). Under the verb “to torment,” the *OED* gives “2. To afflict or vex with great suffering or misery.” Under the verb “to rack,” the *OED* includes “vex” and “torture.” In Latin dictionaries, “*vexare*” is given as a translation of the verb “to torment”: *Cassell’s New Latin Dictionary* (New York: Funk & Wagnall, 1959), p. 855. The verb “to rack,” meaning “to torment,” is likewise translated as “*vexare*,” as well as “*torquere*” and “*(ex)cruciare*”: *ibid.*, p. 806. The noun “rack,” defined as “the instrument of torture,” is rendered in Latin as “*eculeus, tormentum, quaestio* (= examination under torture)”: *ibid.*, p. 806. The spectrum of meanings associated with “*vexare*” may account for the fact that later writers, whose main source was Bacon’s Latin texts, attributed terms such as “torture” and “rack” to him. See Merchant, “Scientific Revolution and *The Death of Nature*,” pp. 526–529; and Pestic, “Wrestling with Proteus.”

⁴⁸ For Bacon’s uses of these terms see Merchant, *Death of Nature*, Ch. 7, pp. 168–172. I have discussed the range of meanings associated with many of them in Merchant, “Scientific Revolution and *The Death of Nature*,” pp. 526–529 and note 34. Violence toward living nature results in pain (physical or psychological). Violence toward nonliving nature may, in turn, result in pain to living nature. In the Renaissance, however, everything was alive.

⁴⁹ Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 294). See also Bacon, “Description of the Intellectual Globe,” in *Works*, ed. and trans. Montagu, Vol. 2, p. 572: “there has insinuated itself into mens’ minds a still subtler error, namely, this, that art is conceived to be a sort of addition to nature, the proper effect of which is to perfect what nature has begun, or to correct her where she has deviated; but by no means to work radical changes in her, and shake her at the roots.” For the Spedding translation see *Works*, Vol. 3, p. 730 (Latin), Vol. 5, p. 506 (English).

⁵⁰ Francis Bacon, “Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works” (*Cogitata et Visa*) (written 1607), in Farrington, *Philosophy of Francis Bacon*, p. 93; see also pp. 96, 99. Although Pestic himself draws freely on Bacon’s posthumously published “Description of the Intellectual Globe,” he nevertheless argues that ideas expressed by Bacon in the posthumously published works translated by Farrington do not represent his true thoughts. On the contrary, these works may well reveal Bacon’s innermost ideas and the evolution of his thinking about nature, while some of his published works were designed to curry favor, especially with James I. Pestic states that “Merchant also does not seem to be aware of the context of a passage she cites in which Bacon supposedly comes ‘leading to you Nature with all her children to bind her to your service and make her your slave,’ for she does not notice that this comes from an early and unpublished writing of Bacon, who never wrote of ‘enslaving’ Nature in any of his published works” (Pestic, “Proteus Rebound,” p. 307). But Pestic does not point out the context of that passage or that, immediately following it,

Against this background, Bacon's concept of the contained, controlled experiment arose out of three influences: the juridical tradition, the idea of nature in bonds (Prometheus), and the idea of extracting the secrets of nature.

THE JURIDICAL TRADITION

The first influence on Bacon's nascent concept of experiment was the juridical tradition. Bacon was an experienced practitioner of the law, rising to ever higher offices during the reigns of Queen Elizabeth I and James I. He became a barrister in 1582, was made Queen's Counsel to Queen Elizabeth, and in 1589 became Clerk of the Star Chamber (unsalaried). Under James I he was appointed Learned Council (1603), Solicitor General (1607), Clerk of the Star Chamber (salaried, 1608), Attorney General (1613), member of the Privy Council (1616), Lord Keeper of the Great Seal (1617), and Lord Chancellor and Baron Verulam (1618). But Bacon was himself painfully subjected to the judicial process and prison in 1621, when the High Court of Parliament convicted him of accepting bribes and sentenced him to the Tower of London, where he spent one day before being released.

Initially, English courts were known for fairness, flexibility, and speed. Common law judges heard cases of ordinary people as well as the nobility. Under the Tudors (Henry VII, Henry VIII, Elizabeth I), Star Chamber trials were public. But under the Stuarts, James I and Charles I, court sessions became secret and there were no witnesses, juries, or appeals. They used the Star Chamber to try cases of sedition and to try nobles. The court could order prison, fines, and even torture. The verdict was handed down in writing. (The Star Chamber was abolished by the Long Parliament in 1641.)

A number of scholars have written on the relationship between the courtroom and the rise of experimental science. The judicial process as it emerged in England and Bacon's life within that process converge to provide a setting for his concept of experiment. In *The Veil of Isis* Hadot writes,

It has been said of Francis Bacon, the founder of modern experimental science, that he "submits the natural process to juridical categories, in the same way as a civil or penal matter." It is true that Bacon uses the vocabulary of violence, constraint, and even torture as he sketches the

Bacon again reiterates the primary goal of all his work: "so may I succeed in my only earthly wish, namely to stretch the deplorably narrow limits of man's dominion over the universe to their promised bounds" (Farrington, *Philosophy of Francis Bacon*, p. 62). The passage about nature as a slave is a translation from the Latin: "sed revera naturam cum fetibus suis tibi addicturus et mancipaturus" (Bacon, *Works*, Vol. 3, p. 528). Neither Pestic nor Waterhouse, on whom he again relies, has provided any evidence that the phrase "addicturus et mancipaturus" (which means "bound and acquired as a slave"), as Bacon used it, has anything to do with purchasing land or cattle or that "*fetibus*" ("fetuses") refers to "calves and crops" rather than "human children" (see Waterhouse, "Letter to the Editor" [cit. n. 7], p. 771; and Pestic, "Proteus Rebound," p. 307 n 11). Moreover, by quoting Bacon (in the above passage), who as speaker "comes to his 'dear, dear son,'" Pestic implies that harsh phrases are not really intended by Bacon and that—despite what it actually says—the passage really refers only to service and not to slavery (Pestic, "Wrestling with Proteus," p. 92; and Pestic, "Proteus Rebound," p. 307). Bacon's "Masculine Birth of Time," written in 1602–1603, is addressed by Bacon "as an older man in authority to a younger man whom he calls 'son'" (Farrington, *Philosophy of Francis Bacon*, p. 61 n 2). (It was not until May 1606 that Bacon, at age forty-one, married fourteen-year-old Alice Barnham, daughter of a rich London alderman. There were no children from the marriage.) Bacon's "Masculine Birth of Time" (*Temporis Partus Masculus*) (1602–1603) and "Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works" (*Cogitata et Visa*) (1607) were published posthumously during the seventeenth century by Isaac Gruter in *Scripta in Naturali et Universali Philosophia* (cit. n. 30). Many of Bacon's "harsher" phrases that appear in the Farrington translations would therefore have been available to Bacon's followers.

program of modern experimental science: “the secrets of nature are better revealed under the torture of experiments than when they follow their natural course.”⁵¹

The judicial process distinguished between physical torture and judicial torture, and Pesic has usefully differentiated between them.⁵² Physical torture was the subjection of an individual to intense physical agony. In England, judicial torture was the process of torture used to extract a confession from a witness in cases of high treason before proceeding to trial. A witness who confessed under torture, however, might recant in court when put on the witness stand. Thus the tortured witness might not be a reliable witness. In the case of nature, however, a reliable experiment could be repeated with the same results. Nature put on the witness stand does not lie but hides the truth, revealing her secrets only when questioned under controlled conditions. The scientist asks the question and nature, held in a confined, controlled space that could be replicated at different places and times, repeats the same answers. Through the judicial process of interrogatories, humanity could recover the state of nature lost by Adam and Eve in the Fall from Eden. Bacon wrote, “I mean (according to the practice in civil causes) in this great plea or suit granted by the divine favor and providence (whereby the human race seeks to recover its right over nature), to examine nature herself and the arts upon interrogatories.”⁵³

NATURE IN BONDS

The second influence on Bacon’s idea of the experiment, that of nature in bonds, has roots in the allegory of Prometheus. Hadot identifies three themes—Heraclitus’s aphorism “Nature loves to hide,” the veiled Isis (nature), and the idea of the secrets of nature—that

⁵¹ Hadot, *Veil of Isis*, p. 93; see also p. 340 n 6, citing Bacon, *Novum Organum*, Bk. 1, Aphorism 98: “de même les opérations cachées de la nature se livrent mieux sous le *tourment* des arts que dans leur cours ordinaire” (Bacon, *Novum Organum*, trans. Malherbe and Pousseur, p. 159 [emphasis added]). On p. 120 Hadot quotes the same aphorism: “so the secrets [*occulta*] of nature are better discovered under the torture of the [mechanical] arts than when it proceeds in its natural course” (I incorrectly cited this aphorism as no. 109 in Merchant, “Scientific Revolution and *The Death of Nature*,” note 45). See also Bacon, “Distribution de l’Oeuvre,” in *Novum Organum*: “une historie de la nature contrainte et *tourmentée*” and “car la nature de choses se livre davantage à travers les *tourments* de l’art que dans sa liberté propre” (Bacon, *Novum Organum*, trans. Malherbe and Pousseur, p. 83; for the full quotation see Table 3). Malherbe and Pousseur provide a glossary of terms that define French meanings of the Latin; see *ibid.*, p. 348: “Tourment: *vexatio*. La nature se livre mieux *per vexationes artis* (83, 27; 159, 19); *Natura vexata* (83, 17).” The French “*tourment*” translates into English as “torment, torture, anguish, pain, . . . vexation.” “*Tourmenter*” translates as “to torment, to torture, to rack, . . . to vex, . . . to harass, to annoy, to pester.” The French “*torture*” translates as “torture, rack, pain *Mettre à la . . .* to put to the rack”; “*torturer*”: “to torture, to put to the rack.” The English “vex” translates as “(to harass) *affliger, tourmenter, vexer, fâcher*”: James Boïelle, *A New French and English Dictionary* (New York: Funk & Wagnall, 1903), pp. 550–551, 577. The *Nouveau Petit Larousse illustré* (Paris: Librairie Larousse, 1929) states: “*Tourmenter: Soumettre à des tortures: tourmenter des prisonniers. Soumettre à de violentes tortures physiques: la goutte le tourmente*” (p. 1041).

⁵² Pesic, “Wrestling with Proteus,” pp. 90–92; and Pesic, “Nature on the Rack” (cit. n. 2), pp. 189–190.

⁵³ On the “inquisition of truth” see Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 296). On the “inquisition of nature” see Francis Bacon, “Preface,” in *The Great Instauration* (*Works*, Vol. 4, p. 20); on the examination of “nature herself and the arts upon interrogatories” see Bacon, *Parasceve* (*Works*, Vol. 4, p. 263): “(according to the practice in civil causes) in this great plea or suit granted by the divine favor and providence (whereby the human race seeks to recover its right over nature), to examine nature herself and the arts upon interrogatories [*super articulos*].” On the latter phrase with the Latin insert see Pesic, “Wrestling with Proteus,” p. 91. Jardine and Silverthorne translate the passage as “Or rather (to use the language of civil procedure) we intend, in this *Great Suit* or *Trial*, given and granted by the goodness and providence of God (by which the human race seeks to recover its right over nature), to cross-examine nature herself and the arts on the articles of the case” (Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, p. 232).

come together in the seventeenth century to produce a Promethean tradition of extracting nature's secrets through experimentation.

Both in the Middle Ages and during the mechanistic revolution, mechanics, magicians, and scientists worked within the Promethean tradition that "sought to do violence to nature by artificial means." Prometheus himself was subjected to eternal torture after having stolen the secret of fire from the gods. For Bacon, Prometheus symbolized the efforts of humanity to dominate nature.⁵⁴

Hadot sets Goethe in the opposite, or Orphic, tradition that sees nature as a mystery or poem. "Mysterious in broad daylight, never/Will Nature be defrauded of her veil./What to your spirit she reveal not, that you fail/to torture out of her with screw or lever." Goethe, Hadot writes, "thus contradicts Francis Bacon, who sought to force Nature to talk under the torture of experimentation. For Goethe, rather than talk, 'Nature keeps silent under torture.'" ⁵⁵

THE SECRETS OF NATURE

The third influence, intimately related to the first two, is Bacon's immersion in the tradition of the secrets of nature. A major theme within his philosophy is the transformation of the ancient and medieval tradition of the secrets of nature. In *Science and the Secrets of Nature*, William Eamon has written in detail about books of secrets in the Middle Ages and the early modern era as emblematic of a new approach to seeking knowledge of nature.⁵⁶ Bacon framed his approach within the tradition of natural magic, the goal of which was to extract the secrets of nature. In the *New Atlantis* he transformed the natural magic tradition of Giambattista Della Porta and Henry Cornelius Agrippa into an experimental methodology that would benefit the whole of humanity.

Hadot explicates Bacon's use of the secrets of nature. Nature in the Renaissance, he argues, is a fusion of the classical multibreasted Artemis and the Egyptian Isis, who says of herself, "I am all that is and will be. No mortal has lifted my veil."⁵⁷ "Modern science, as the heir in this sense to the occult sciences and magic, was to assign itself precisely the goal of unveiling the secrets of nature. . . . They were to become in this way the object of the new physics, mathematics, and mechanics. Francis Bacon, for instance, declared that Nature unveils her secrets only under the torture of experimentation."⁵⁸

⁵⁴ Hadot, *Veil of Isis*, p. 138.

⁵⁵ *Ibid.*, pp. 148–149. Hadot himself identifies with the Orphic rather than the Promethean method (see pp. 317, 319).

⁵⁶ William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J.: Princeton Univ. Press, 1994). See also Katharine Park, *Secrets of Women: Gender, Generation, and the Origins of Human Dissection* (New York: Zone, 2006); and Merchant, "Secrets of Nature" (cit. n. 2).

⁵⁷ Hadot, *Veil of Isis*, p. 265. See also Carolyn Merchant: "For [George] Sarton, Isis is symbolic of nature and her robe conceals nature's secrets. She says of herself, he wrote, quoting a passage from Plutarch on Isis and Osiris: 'I am everything which existed, which is now and will ever be, no mortal has ever disclosed my robe'" (Carolyn Merchant, "Isis: Science and History," in *Earthcare: Women and the Environment* [New York: Routledge, 1996], pp. 57–72, on p. 57; portions originally published as Merchant, "Isis' Consciousness Raised," *Isis*, 1982, 73:398–409).

⁵⁸ Hadot, *Veil of Isis*, p. 35. See Bacon, *Novum Organum*, trans. Malherbe and Pousseur, Bk. 1, Aphorism 98, p. 159 (quoted and discussed at note 51, above). Shaw translates the passage as "so the Secrets of Nature are better gotten out by the *Torturing* of Arts, than when suffer'd to take their own course" (Bacon, *Novum Organum Scientiarum: A New Machine for Rebuilding the Sciences*, Bk. 1, Aphorism 98, in *Works*, ed. Shaw, p. 394 [emphasis added]). Montagu translates the passage as "the secrets of nature reveal themselves more readily when *tormented* by art than when left to their own course" (Bacon, *Works*, ed. and trans. Montagu, Vol. 3, p. 363 [emphasis added]). In his Latin edition of the *Novum Organum*, Thomas Fowler provides a footnote in which

Bacon drew on the secrets tradition and used the language of nature as female to articulate an experimental philosophy. He states that not only were the secrets of nature hidden “in certain deep mines and caves,” but they could be wrested from nature’s grasp by miners and smiths, “the one searching into the bowels of nature, the other shaping nature as on an anvil.” The technologies of gunpowder, printing, and the magnet “help us to think about the secrets still locked in nature’s bosom.” Under the mechanical arts, Bacon wrote, “nature betrays her secrets more fully when in the grip and under the pressure of art than when in the enjoyment of her natural liberty.” He thus sought to secularize and make available that which was of use in the *arcana* of the ancients, transforming it into a body of knowledge accessible to all. “There is therefore much ground for hoping that there are still laid up in the womb of nature many secrets of excellent use having no affinity or parallelism with anything that is now known.”⁵⁹

EMERGENCE OF THE CONTAINED, CONTROLLED EXPERIMENT

Much has been written about the rise of experimental science in the seventeenth century and its role in the formation of a repeatable, verifiable methodology accessible to all observers in all places and at all times. The fusion of the twin pillars of mathematics and experimentation was an important contribution to the Scientific Revolution, later becoming positivism, or the acceptance as truth only what is verifiable either mathematically or empirically via observation or experimentation. Cited as exemplars of the experimental method are such notable moments as Galileo’s purported dropping of balls of unequal weight from a tower (alleged to be the leaning tower of Pisa) in 1590, Harvey’s dissections of animals and human hearts (published in 1628), the Torricellian barometer carried to the top of the Puy-de-Dôme in 1648 by Pascal’s brother, Otto van Guericke’s 1654 Magdeburg hemispheres experiment, and Boyle’s subjection of living things to the evacuated bell jar in the 1670s. Ancient and medieval mechanics, celestial observations, natural magic, and corporeal dissections all contributed to the rise of experimental science.

The contained, controlled experiment depends on several factors: first, a controlled environment in which characteristics and quantities such as moisture, temperature, pressure, and space itself are all prescribed; second, a question that is to be put to nature and that can be answered by the experiment; third, an object or set of objects that are to be manipulated and that will yield an answer to the question; fourth, an experimenter outside the space who dictates the conditions under which the experiment proceeds; fifth, observ-

he translates the passage as “Nature best discovers her secrets when *tortured* by Art”; and in his introduction he states that “nature like a witness, when put to the *torture*, would reveal her secrets” (*Bacon’s Novum Organum*, ed. with introduction and notes by Thomas Fowler, 2nd ed. [Oxford: Clarendon, 1889], Bk. 1, pp. 304 n 82, 127 [emphasis added]). The Spedding translation is “so likewise the secrets of nature reveal themselves more readily under the vexations of art than when they go their own way” (*Works*, Vol. 4, p. 95); Bacon’s Latin is “simili modo, et occulta naturae magis se produnt per vexationes artium, quam cum cursu suo meant” (*Works*, Vol. 1, p. 203). It would seem, therefore, that many scholars and translators have read Bacon’s Latin phrase “*vexationes artium*” as implying torture or torment and that Aphorism 98 in Book 1 of the *Novum Organum* is one place that has led many to the idea that Bacon believed that nature should be tortured to reveal her secrets.

⁵⁹ Bacon, *De Augmentis Scientiarum*, Bk. 3, Ch. 3 (*Works*, Vol. 4, p. 343); and Bacon, “Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works,” in Farrington, *Philosophy of Francis Bacon*, pp. 96, 99 (the Latin is “ab arte tenetur et urgetur, quam in libertate propria”; see Bacon, *Cogitata et Visa* [*Works*, Vol. 3, pp. 615, 617–618]). On secrets laid up in the womb of nature see Bacon, *Novum Organum*, Bk. 1, Aphorism 109 (*Works*, Vol. 4, p. 100). The Latin is “Itaque sperandum omnino est, esse adhuc in naturae sinu multa excellentis usus recondita, quae nullam cum jam inventis cognationem habent aut parallelismum, sed omnino sita sunt extra vias phantasiae; quae tamen adhuc inventa non sunt” (*Works*, Vol. 1, p. 208).

ers or witnesses who can verify the answers to the question; sixth, the recording of data; and seventh, the possibility of repeating the initial conditions in other places and times and hence obtaining the same answers.

Three early modern settings—the courtroom, the anatomy theater, and the laboratory—illustrate the structural characteristics of the contained, controlled experiment.⁶⁰

The trial courtroom is a room enclosed and set off from the external environment, including the influence of the public, the crowd, and the natural environment (trees, breezes, mountains, etc.). On one side of a dividing bar is the judge's bench, the lawyers' tables, the witness stand, and the jury box. On the other side of the bar is the public gallery for the spectators, who are also witnesses to the trial. A question or set of questions is put by a lawyer to a subject on the witness stand. The defendant, if called as a witness, may be in bonds—manacled in handcuffs and subjected to mental agony. (In "The Masculine Birth of Time," Bacon successively summons Aristotle, Plato, Galen, and other "sham philosophers" to the bar to face prosecution for "false coinage, "vague inductions," and "bogus cures.") The questions put to a witness are designed to elicit answers that will prove the prosecutor's point. They reveal the secrets held within the witness's mind. Layers of data are peeled away, revealing the inner truths. The judge and jury hear the evidence. They are finders of facts; their verdict is, literally, a statement of truth. The testimony (evidence, facts, data) is recorded by a court reporter. If the witness is reliable, the same answers will be elicited at a future time. "It is by the witness of works," Bacon stated, "that truth is revealed and established."⁶¹

Bacon used the term "trial" to characterize an experiment. The interrogation of nature is analogous to a judicial trial, in which the subject on the witness stand is forced to answer questions in order to extract the truth ("the inquisition of truth"). In the quest for understanding, the scientist must not think that "the inquisition of nature is in any part interdicted or forbidden." In the case of *Science v. Nature*, the scientist/inquisitor/judge/examiner faces the witness/examinee/nature on the stand. Nature *per se* cannot speak but is privy to the facts and knowledge (secrets) to be extracted. Nature must recognize the words of the questions put by the human examiner as written in its/her own language and must in turn give reliable, repeatable answers in that language.⁶² By analogy, the scientist designs an experiment in which nature is "put to the question" in a confined, controlled space where the correct answers can be extracted through inquisition.⁶³ That confined,

⁶⁰ I have elaborated on the anatomy theater in Merchant, "Secrets of Nature" (cit. n. 2). In Merchant, "Scientific Revolution and *The Death of Nature*," I used the rack as symbol for the interrogation of witches, citing examples from James VI of Scotland (James I of England), *Daemonologie* (1597) (New York: Dutton, 1924). Although the vast majority of witches interrogated and executed by the Inquisition and accused in England under James I were women, the idea of interrogation in a confined, controlled space before witnesses as an exemplar of the emerging idea of the experiment is gender neutral. Pesic's claim that the existence of male witches undercuts the argument is not relevant. In *The Death of Nature*, I argued that witches were one of many symbols of the disorder of nature; see Merchant, *Death of Nature*, p. 172 and Ch. 5, "Nature as Disorder: Women and Witches."

⁶¹ Bacon, "Masculine Birth of Time," in Farrington, *Philosophy of Francis Bacon*, pp. 63, 64, 65; and Bacon, "Thoughts and Conclusions on the Interpretation of Nature or a Science of Productive Works," *ibid.*, p. 93.

⁶² Kenneth William Cardwell, "Francis Bacon, Inquisitor," in *Francis Bacon's Legacy of Texts*, ed. Sessions (cit. n. 19), pp. 269–289, esp. pp. 277, 280–284. In his discussion of Bacon's experimental method, Immanuel Kant wrote, "Reason . . . must approach nature in order to be taught by it. It must not, however, do so in the character of a pupil who listens to everything that the teacher chooses to say, but of an appointed judge who compels the witnesses to answer questions which he has himself formulated" (Immanuel Kant, *Critique of Pure Reason*, trans. Norman Kemp Smith [London: Macmillan, 1956], p. 20).

⁶³ Michèle Le Doeuff states: "Nature can be *put to the question*, through procedures of inquiry that can be described, this very description and the application of these procedures comprising what Bacon means by

controlled space is Bacon's third state of nature—that is, nature in bonds, or nature “in constraint, molded, and made as it were new by art and the hand of man.”

The anatomy theater, as it emerged in the sixteenth and seventeenth centuries in Padua, Leiden, and other European universities, is a second contained, controlled environment. The theater, with its rows of descending seats centered on a dissecting table, is a self-contained amphitheater cut off from the outside environment. The corpse lying prone on the central table is subjected to a series of questions—surgical cuts that reveal the secrets contained within it. The body is that of an executed criminal who (symbolically) lies in bonds on the table. The anatomy professor standing above the prone body either does the dissection himself or directs the barber surgeon. The answers to the questions reveal the parts of the body, peeling back layers of truth as the innermost structures are laid open for all to see. Laboratory assistants record the data. The professors, students, and privileged members of the public, arrayed in ever-widening concentric rows around the central corpse, are witnesses to the truths uncovered. If the dissection is done carefully and reliably, the same truths, data, and secrets will be revealed in subsequent “trials.” Those trials repeat the truths already learned and instruct subsequent observers. They are public demonstrations of the truths (verdicts) of nature.

In 1604, Bacon drew on the concept of anatomy and the corpse of nature in his criticism of the ancients for continually using dead principles rather than actively investigating the forces of nature. “Speculation has been principally concerned with the investigation of these dead principles, as if a man should make it his business to anatomize the corpse of nature without enquiring into her living faculties and powers.” In 1608, Bacon proposed a plan to head up a school or college in which he could install vaults, furnaces, and laboratories and “a collection of phenomena concerning surgery, distillations, mineral trials,” and he named several physicians who could assist in the instruction.⁶⁴

In the *Novum Organum* (1620), Bacon proclaimed the need to create an “anatomy of the world” through “diligent dissection.” He wrote, “For I am building in the human understanding a true model of the world, such as it is in fact, not such as man’s own reason would have it to be; a thing which cannot be done without a very diligent dissection and anatomy of the world.”⁶⁵ By analogy, a body (the corpse of nature) flayed open on the dissecting table comprised a series of cavities that contained secrets to be uncovered through scientific inquiry. The new method of interrogating nature was to instruct the understanding so that it “may in very truth dissect nature.”⁶⁶

experimental science” (Le Doeuff, “Man and Nature in the Gardens of Science” [cit. n. 19], p. 124 [emphasis added]).

⁶⁴ Farrington, *Philosophy of Francis Bacon*, pp. 41 (quotation), 47.

⁶⁵ Bacon, *Novum Organum*, Bk. 1, Aphorism 124 (*Works*, Vol. 4, p. 110). Contrary to Pescic’s claim that Bacon would have rejected dissections on live animals (citing Sprat’s “accounts of some animal experimentation that Bacon would have found too cruel” [Pescic, “Proteus Rebound,” p. 315]), Bacon himself argued in *De Augmentis Scientiarum* that human dissections were limited in value since they were performed only on dead bodies, but that that deficiency could be overcome by dissections on live animals: “Of that other defect in anatomy (that it has not been practiced on live bodies) what need to speak? For it is a thing hateful and inhuman, and has been justly reprov’d by Celsus. But yet it is no less true (as was anciently noted) that many of the more subtle passages, pores, and pertusions appear in dead bodies, though they be open and manifest in live. Wherefore that utility may be considered as well as humanity, the anatomy of the living subject is not to be relinquish’d altogether, nor referred (as it was by Celsus) to the casual practices of surgery; since it may be well discharged by the dissection of beasts alive, which, notwithstanding the dissimilitude of their parts to human, may, with the help of a little judgment, sufficiently satisfy this inquiry” (Bacon, *De Augmentis Scientiarum*, Bk. 4, Ch. 2 [*Works*, Vol. 4, p. 386]).

⁶⁶ Bacon, *Novum Organum*, Bk. 2, Aphorism 52 (*Works*, Vol. 4, p. 246); Bacon, *Advancement of Learning* (*Works*, Vol. 3, p. 374); and Bacon, *De Augmentis Scientiarum*, Bk. 4, Ch. 2 (*Works*, Vol. 4, pp. 385–386).

The laboratory, as a third example of the contained, controlled environment, replicates the structural features of the courtroom and the anatomy theater. It is an enclosed space in which environmental variables such as temperature, air pressure, dust, and moisture can be controlled. A question is posed by the experimenter. He or she designs an apparatus that will answer the questions around which the laboratory is itself organized (equipment, assistants, recordation). The apparatus is subjected to a sequence of forces, impulses, or tests that will elicit answers. The data are recorded by witnesses and reduced by mathematical equations that will reveal the truths (secrets) of nature. If reliable results are found, they can be repeated at a future time and place by other experimenters and viewed by other witnesses.

The "laboratory" as a self-contained space for conducting practical investigations in the natural sciences and chemistry derived from the alchemist's workhouse. The term was introduced by Ben Jonson in a masque performed at the court of James I in 1610, in which Mercury drives twelve alchemists from an alchemical laboratory and welcomes in Prometheus, Nature, and twelve "sons of nature."⁶⁷ The alchemist's laboratory typically comprised an array of furnaces, bellows, cauldrons, crucibles, presses, alembics, stills (distillation equipment), jars, flasks, and mortars and pestles, along with animal skeletons, herbs, powders, metals, and a variety of symbols, books, and recipes. In it, the alchemist searched for transmutations that would produce cures, potions, gold, and the philosopher's stone. Bacon's ultimate goal was to transform the individualistic efforts of the alchemist and the magus into a method of obtaining knowledge that would serve all of humanity.⁶⁸

By 1594, Bacon had already envisioned the need for "laboratories," zoos, botanical gardens, and museums that would bring together the "mind of man" with "the nature of things" for the advancement of humankind. He proposed a new philosophy in which he recommended to Queen Elizabeth four principal works—a research library, a botanical garden and zoo, a museum (or "cabinet") of inventions made by the "hand of man," and a laboratory (or "still-house") with "mills, instruments, furnaces, and vessels."⁶⁹ Although Bacon did not use the term "laboratory," his vision for still-houses with furnaces, distillation equipment, and various types of instruments and vessels drew inspiration from the alchemist's workhouse.

In his writings of the 1620s, Bacon moved toward the concept of the contained, controlled experiment. In Book 2 of the *Novum Organum* (1620) he presented a number of "instances" that exemplified the constraint of nature in a confined space altered by "art and the hand of man." Here he organized numerous observations and descriptions of experiments done on nature (several of which he stated that he himself had conducted) into a series of "privileged instances." His work reveals a knowledge of Copernicus's idea of the motion of the earth, of Galileo's discoveries with the telescope, of the use of the

⁶⁷ The word "laboratory" was used by Jonson in a masque, published in 1610, entitled "Mercury Vindicated from the Alchemists at Court." It began: "After the loud music, the scene discovered, being a laboratory, or alchemist's workhouse; Vulcan looking to the registers, while a Cyclope, tending the fire, to the cornets began to sing." Mercury forces out twelve alchemists from an alchemical laboratory and proceeds to admit Prometheus, Nature, and twelve "sons of nature." Ben Jonson, *Works*, 11 vols. (Oxford: Clarendon, 1954–1965), Vol. 7, pp. 407–417; see also *Oxford English Dictionary*, s.v. "laboratory."

⁶⁸ Paolo Rossi, *Francis Bacon: From Magic to Science* (Chicago: Univ. Chicago Press, 1968), pp. 32–33. Rossi writes, "According to Bacon, magic endeavours to dominate and to improve nature; and for this it should be imitated. Where it needs revising is in its claim to use one man's inspiration instead of the organized efforts of the human race, and to make science serve individual ends rather than mankind" (p. 32).

⁶⁹ Farrington, *Philosophy of Francis Bacon*, p. 15; Daston and Park, *Wonders and the Order of Nature* (cit. n. 23), p. 290; and Francis Bacon, "Gesta Grayorum" (*Works*, Vol. 8, p. 335).

microscope, of Gilbert's experiments with the magnet, and of the variation of the tides in the Atlantic, Florida, Panama, and Peru. While his organizational *schemata* (mainly vast catalogues of observations) were ultimately fruitless as a method of presenting data, many of his "instances" were inspirational to his followers. Among several "instances of power" are "man's contrivances or tools," in which the "noblest and most perfect works, the finished products of every art," show that "nature should contribute to human affairs and human advantage." The best materials wrought by art are those that "most closely imitate nature, or on the other hand masterfully rule her and change her completely." The machines of the ancients and the invention of the cannon operating by means of gunpowder, as well as instances of art such as paper and silk, are all "instances of power."⁷⁰

Bacon also described other "instances" that exemplified the use of force and "the violence of impediments" to reveal the properties of matter and shape it into new forms. Instances of "struggle and dominance," he wrote, expose the indestructibility of matter in which fire, pressure, or violence cannot reduce matter to nothing, but instead cause it to change shape or position; of struggle in the bonding of bodies together, in which they refuse to be torn apart by contact with another body; and of violent (mechanical) compression, in which a body ultimately liberates itself from an impellent and flies through the air. But the compression of air in a bladder, the pressure created by covering a ball in water with a bell filled with air, and the hammering of a sealed lead ball filled with wine are examples of the *limit* of violent instances.⁷¹ Violent forces and compressions are extremely powerful, Bacon noted, especially in such cases as machines and missiles that are capable of destroying organic life itself. In cases where violent forces do not result in new stable forms, however, additional experiments should be tried, because "it is of considerable use if fixed, stable natures can be imposed on bodies by violent forces. . . . For man is more the master of forceful movements than of the others."⁷²

But in other cases—the ultimate goal being to increase "man's" authority by finding ways to mimic, perfect, and speed up nature's operations—violence would not obtain useful results. "Violent, sudden, or inconsistent heat" is counterproductive in investigating the "orderly inequality" of heat in the warmth of vegetables, the wombs of animals, or "the earth's own wombs, the wombs in which metals and fossils are formed."⁷³ In the *Advancement of Learning (De Augmentis Scientiarum* [1623]), in his discussion of the "Chances of Experiment," Bacon noted that when fire was used to experiment on bodies,

⁷⁰ Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, Bk. 2, Aphorism 36, pp. 162, 164, 160; Aphorism 31, p. 150; Aphorism 43, p. 182; Aphorism 45, p. 185.

⁷¹ *Ibid.*, Bk. 2, Aphorism 48, pp. 191, 193; Aphorism 45, pp. 185–186. See also Bacon, *Works*, ed. and trans. Montagu, Vol. 3, pp. 411–418. Montagu translates these instances as "wrestling instances" (Bk. 2, Aphorism 48, p. 411).

⁷² Bacon, *New Organon*, ed. and trans. Jardine and Silverthorne, Bk. 2, Aphorism 50, pp. 210–211, on p. 211.

⁷³ *Ibid.*, Bk. 2, Aphorism 50, pp. 214–215. Bacon stated: "Man would truly be seen to increase his authority if by heat and artificial forces, operations of nature could be copied in kind, perfected in power and varied in number; to which should be added that they could be speeded up" (p. 214). That fire (Vulcan) could be too violent a force resulting in monstrous shapes was a concern expressed by Bacon in his allegory of Erichthonius in *The Wisdom of the Ancients*. Here Minerva, representing Nature, is violently assaulted by Vulcan, producing the misshapen Erichthonius. Art, in the form of fire (as used by impostors) can therefore go too far; instead, nature should be obsequiously embraced (Bacon, *Works*, ed. and trans. Montagu, Vol. 1, p. 301; for Shaw's translation see *Philosophical Works*, ed. Shaw, Vol. 1, pp. 564–565). In "The Masculine Birth of Time" Bacon stated that humanity should be united "with things themselves in a chaste, holy, and legal wedlock" (Farrington, *Philosophy of Francis Bacon*, p. 72), an image that Mark Breitenberg sees as consistent with "nature as a chaste wife over which man possesses 'natural' dominion" and of "the new science as the 'penetration' of a 'chaste nature'" (Mark Breitenberg, *Anxious Masculinity in Early Modern England* [Cambridge: Cambridge Univ. Press, 1996], pp. 90, 9).

the parts were separated and lost in combustion; similarly, in distillations the dregs were separated from the vapors. If, however, someone could try what he called a "close distillation," in which the matter was confined in a vessel and the heat regulated so that the vessel did not crack, then the matter might be transformed into new and useful shapes. Here the matter was like Proteus, the vessel was like the handcuffs, and the heat caused Proteus to change into new shapes. A violent force such as fire would defeat the desired outcome, whereas an operation like the heat of the womb would preserve the body intact.⁷⁴

The *New Atlantis* (written in 1624 and published posthumously in 1627) epitomized Bacon's most mature conception of the contained, controlled experiment. Here, in the visionary experiments conducted in Salomon's House, the workers all contributed to setting up "trials" and recording data. Separate "laboratories" (termed "preparations and instruments," including "perspective houses," "engine houses," "furnaces," "sound houses," "mathematical houses," "parks and inclosures," "chambers," and "orchards and gardens") existed for the study, speeding up, and modification of the activities of plants and animals, aquatic life, the metals, and the weather—all for the benefit of humankind. The parks, gardens, caves, deep mines, wells, pools, streams, and fountains were strategically sited to facilitate the conduction of investigations; likewise, "laboratories" were specifically organized for dissections and surgeries, experiments with medicines and poisons, and the creation of new species of plants and animals. The research and the recording of the results were undertaken by apprentices, novices, and scientists. "The end of our foundation," Bacon stated, "is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible."⁷⁵

⁷⁴ Bacon, *De Augmentis Scientiarum*, Bk. 5, Ch. 2 (*Works*, Vol. 4, pp. 420–421): "then it is one of the best ways, and plainly shakes out the folds of nature. . . . But what I may call *close distillation* no man has yet made trial. Yet it seems probable that the force of heat, if it can perform its exploits of alteration within the enclosure of the body, where there is neither loss of the body nor yet means of escape, will succeed at last in handcuffing this Proteus of matter, and driving it to many transformations; only the heat must be so regulated and varied, that there be no fracture of the vessels. For this operation is like that of the womb, where the heat works, and yet no part of the body is either emitted or separated." See also Bacon, *De Augmentis Scientiarum*, in *Works*, ed. Shaw, Vol. 1, p. 124: "this becomes an excellent instrument, and really enters the Bosom of Nature. . . . But no Man has hitherto tried *close Distillation*. Yet it seems probable, that if the Force of Heat may have its Action confined in the Cavities of a Body, without any possibility of loss or escape, this *Proteus* of Matter will be manacled, as it were, and forced to undergo numerous Transformations; provided only the Heat be so moderated and changed, as not to break the containing Vessel. For this is a kind of *natural Matrix*, where the Heat has its Effect without separating or throwing off the Parts of a Body." In an explanatory note, Shaw states: "The thing meant here is . . . a *new Digestion*, practiced by means of the Digestor, or hollow metalline *Engine*, made so strong and firm, as to endure a great Violence of *Fire*: which is an Operation that had not, perhaps, been practiced at the time our Author wrote" (p. 124, note a). Pesic argues that this passage shows that Bacon's image of experimental procedures is "feminine and maternal" (Pesic, "Proteus Rebound," pp. 308, 309 n 17; and Pesic, "Wrestling with Proteus," p. 93). Yet Bacon's ultimate rationale for experimentation was to understand the way that nature works, the goal being to extend "the power and dominion of the human race itself over the universe" (Bacon, *Novum Organum*, Bk. 1, Aphorism 129 [*Works*, Vol. 4, p. 114]).

⁷⁵ Bacon, *New Atlantis* (*Works*, Vol. 3, pp. 129–166, on p. 156). Of the *New Atlantis*, Michèle Le Doeuff writes, "The gardens where new species are produced, the workshops where new sorts of heat are fabricated are presented in the *New Atlantis* before the description of the division of tasks proper to the process of knowledge, and under the following title: 'The Preparations and Instruments' are these. . . . The proliferation of artifacts creates things that procure greater well-being, of course, but these things are also necessary as instruments in the acquiring of knowledge concerning nature. Being 'instruments of science,' they are not just like the telescope or the microscope. They must be conceived of as objects which contain a phenomenon under a *tortured form*" (Le Doeuff, "Man and Nature in the Gardens of Science" [cit. n. 19], p. 132 [emphasis added in the last sentence]). The *New Atlantis* (written in 1624) and the *Sylva Sylvarum*; or, *A Natural History* (written in 1626, just before Bacon's death) were published together posthumously in 1627 by William Rawley. The *Sylva Sylvarum* is an inventory of natural phenomena presented in ten centuries (or chapters) under which are listed

In *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Steven Shapin and Simon Schaffer analyze the important role of witnessing in the rise of experimentation. They investigate the problem of the reliability of knowledge. Robert Boyle's experiments with the air-pump, in which living things were subjected to the vacuum produced by the evacuation of air from a bell jar, could be viewed by witnesses. The resulting truths were agreed upon by all witnesses and were replicable in other times and places. A reliable form of knowledge resulted, one that helped to reestablish the social and political order left in disarray by the English Civil War. The results exemplify the concept of the laboratory experiment toward which Bacon was tending. The bell jar is a confined, controlled space. The experimenter designs the "trials" to be made on nature in an effort to extract its secrets. Here living things are subjected to "the violence of impediments." Nature is in bonds. In Bacon's terms, "She is put in constraint, moulded, and made as it were new by art and the hand of man; as in things artificial." The new method was needed, stated Boyle (echoing Bacon), because "some men care only to know nature, others to command her."⁷⁶

The confined, controlled experiment depends on the isolation of the factors under investigation from any environmental conditions that might interfere with the results, so that the question being asked of nature can actually be answered. Similarly, the mathematical method depends on the description of bodies in motion under closed, idealized conditions in which environmental factors (such as air resistance, friction, etc.) are abstracted away, so that the mathematical equation holds. Together, the experimental method and the mathematical method helped to define the mechanistic revolution as it evolved in the seventeenth century.

Bacon's concept of science that emerges from the contained, controlled experiment is explicated by his allegory of the Sphynx. The Sphynx represents science. It receives difficult questions and riddles that are to be solved freely by study and meditation, with knowledge as the end result. But if practice and action are the goals, then the enigmas are "troublesome and raging," the understanding is "racked and imprisoned," and the riddles "wonderfully torment and vex the minds of men." Bacon states, "Of Sphynx's riddles, they are generally two kinds; some concerning the nature of things, others touching the nature of man. So also there are two kinds of empires, as rewards to those that resolve them. The one over nature, the other over men; for the proper and chief end of the true natural philosophy is to command and sway over natural beings; as bodies, medicines, mechanical works, and infinite other things."⁷⁷

"experiments" that set out a vast and loose collection of observations, speculations, teachings, and experiments. It was apparently intended for Pt. 3 of the *Instauratio magna* but does not exemplify the concept of "laboratories" for experimentation under constrained conditions as envisioned in the *New Atlantis*, which immediately followed it in the printed volume.

⁷⁶ Bacon, *De Augmentis Scientiarum*, Bk. 2, Ch. 2 (*Works*, Vol. 4, p. 294); and Robert Boyle, *Works*, ed. Thomas Birch (Hildesheim: Olms, 1965), Vol. 1, p. 310. On the role of witnessing see Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J.: Princeton Univ. Press, 1985). On the role of Newtonian science in helping to reestablish social order after the English Civil War see Kubrin, "How Sir Isaac Newton Helped to Restore Law and Order to the West" (cit. n. 9).

⁷⁷ Bacon, *Wisdom of the Ancients*, in *Works*, ed. and trans. Montagu, Vol. 1, p. 310. Shaw's translation is "But after the Muses have given over their Riddle to *Sphinx*; that is, to *Practice*, which urges and impels to Action, Choice and Determination; then it is that they become *torturing*, severe, and trying; and unless solved and interpreted, strangely perplex and harass the human Mind; rend it every way, and perfectly tear it to pieces" (Bacon, *Philosophical Works*, ed. Shaw, Vol. 1, p. 572 [emphasis added to "torturing"]).

CONCLUSION

Francis Bacon stood on the cusp between the Renaissance and the Enlightenment. He sought a reliable method for extracting knowledge (secrets) from nature. In so doing, he was groping toward the concept of the experiment. His historical context provided sources that both directly and subtly influenced his language and metaphors. He drew on ancient allegorical figures such as Pan, Proteus, and Prometheus to frame his idea of the three states of nature (free, erring, and in bonds). The traditions of the law, bondage, and the secrets of nature lent metaphors that helped to describe his *New Organon*. Settings such as the courtroom, the anatomy theater, and the laboratory provided background for the experiment as a trial, a dissection, and the altering of nature by "art and the hand of man." Humanity is thus both servant and commander of nature, for "human knowledge and human power meet in one."