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The Gender and Science Reader

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Muriel Lederman and Ingrid Bartsch

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Chapter 8

Carolyn Merchant

DOMINION OVER NATURE

Disorderly, active nature was soon forced to submit to the questions and experimental techniques of the new science. Francis Bacon (1561–1626), a celebrated "father of modern science," transformed tendencies already extant in his own society into a total program advocating the control of nature for human benefit. Melding together a new philosophy based on natural magic as a technique for manipulating nature, the technologies of mining and metallurgy, the emerging concept of progress and a patriarchal structure of family and state, Bacon fashioned a new ethic sanctioning the exploitation of nature.

Bacon has been eulogized as the originator of the concept of the modern research institute, a philosopher of industrial science, the inspiration behind the Royal Society (1660), and as the founder of the inductive method by which all people can verify for themselves the truths of science by the reading of nature's book.[1] But from the perspective of nature, women, and the lower orders of society emerges a less favorable image of Bacon and a critique of his program as ultimately benefitting the middle-class male entrepreneur. Bacon, of course, 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.

Sensitive to the same social transformations that had already begun to reduce women to psychic and reproductive resources, Bacon developed the power of language as political instrument in reducing female nature to a resource for economic production. Female imagery became a tool in adapting scientific knowledge and method to a new form of human power over nature. The "controversy over women" and the inquisition of witches – both present in Bacon's social milieu – permeated his description of nature and his metaphorical style and were instrumental in his transformation of the earth as a nurturing mother and womb of life into a source of secrets to be extracted for economic advance.

Bacon's roots can be found in middle-class economic development and its progressive interests and values. His father was a middle-class employee of the queen, his mother a Calvinist whose Protestant values permeated his early home life. Bacon took steps to gain the favor of James I soon after the latter's ascent to the throne in 1603. He moved from "learned counsel" in 1603 to attorney general in 1613, privy councillor in 1616, lord keeper in 1617, and, finally, lord chancellor and Baron Verulam in 1618. His political objectives were to gain support for his program of the advancement of science and human learning and to upgrade his own status through an ambitious public career.[2]

[. . .]

Bacon was also well aware of the witch trials taking place all over Europe and in particular in England during the early seventeenth century. His sovereign, while still James VI of Scotland, had written a book entitled *Daemonologie* (1597). In 1603, the first year of his English reign, James I replaced the milder witch laws of Elizabeth I, which evoked the death penalty only for killing by witchcraft, with a law that condemned to death all practitioners.[3]

It was in the 1612 trials of the Lancashire witches of the Pendle Forest that the sexual aspects of witch trials first appeared in England. The source of the women's confessions of fornication with the devil was a Roman Catholic priest who had emigrated from the Continent and planted the story in the mouths of accused women who had recently rejected Catholicism.

These social events influenced Bacon's philosophy and literary style. Much of the imagery he used in delineating his new scientific objectives and methods derives from the courtroom, and, because it treats nature as a female to be tortured through mechanical inventions, strongly suggests the interrogations of the witch trials and the mechanical devices used to torture witches. In a relevant passage, Bacon stated that the method by which nature's secrets might be discovered consisted in investigating the secrets of witchcraft by inquisition, referring to the example of James I:

> *For you have but to follow and as it were hound nature in her wanderings, and you will be able when you like to lead and drive her afterward to the same place again.* Neither am I of opinion in this history of marvels that superstitious narratives of *sorceries, witchcrafts, charms*, dreams, divinations, and the like, where there is an assurance and clear evidence of the fact, should be altogether excluded . . . howsoever the use and practice of such arts is to be condemned, yet from the speculation and consideration of them . . . a useful light may be gained, not only for a true judgment of the offenses of persons charged with such practices, *but likewise for the further disclosing of the secrets of nature. Neither ought a man to make scruple of entering and penetrating into these holes and corners, when the inquisition of truth is his whole object – as your majesty has shown in your own example.*[4]
>
> (italics added)

The strong sexual implications of the last sentence can be interpreted in the light of the investigation of the supposed sexual crimes and practices of witches. In another example, he compared the interrogation of courtroom witnesses to the inquisition of nature: "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."[5] Bacon pressed the idea further with an analogy to the torture chamber: "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 [mechanical devices] than when left to herself."[6]

The new man of science must not think that the "inquisition of nature is in any part interdicted or forbidden." Nature must be "bound into service" and made a "slave," put "in constraint" and "molded" by the mechanical arts. The "searchers and spies of nature" are to discover her plots and secrets.[7]

This method, so readily applicable when nature is denoted by the female gender, degraded and made possible the exploitation of the natural environment. As woman's womb had symbolically yielded to the forceps, so nature's womb harbored secrets that through technology could be wrested from her grasp for use in the improvement of the human condition:

> 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 . . . only by the method which we are now treating can they be speedily and suddenly and simultaneously presented and anticipated.[8]

Bacon transformed the magical tradition by calling on the need to dominate nature not for the sole benefit of the individual magician but for the good of the entire human race. Through vivid metaphor, he transformed the magus from nature's servant to its exploiter, and nature from a teacher to a slave. Bacon argued that it was the magician's error to consider art (technology) a mere "assistant to nature having the power to finish what nature has begun" and therefore to despair of ever "changing, transmuting, or fundamentally altering nature."[9]

The natural magician saw himself as operating within the organic order of nature – he was a manipulator of parts within that system, bringing down the heavenly powers to the earthly shrine. Agrippa, however, had begun to explore the possibility of ascending the hierarchy to the point of cohabiting with God. Bacon extended this idea to include the recovery of the power over nature lost when Adam and Eve were expelled from paradise.

Due to the Fall from the Garden of Eden (caused by the temptation of a woman), the human race lost its "dominion over creation." Before the Fall, there was no need for power or dominion, because Adam and Eve had been made sovereign over all other creatures. In this state of dominion, mankind was "like unto God." While some, accepting God's punishment, had obeyed the medieval strictures against searching too deeply into God's secrets, Bacon turned the constraints into sanctions. Only by "digging further and further into the mine of natural knowledge" could mankind recover that lost dominion. In this way, "the narrow limits of man's dominion over the universe" could be stretched "to their promised bounds."[10]

Although a female's inquisitiveness may have caused man's fall from his God-given dominion, the relentless interrogation of another female, nature, could be used to regain it. As he argued in *The Masculine Birth of Time*, "I am come in very truth leading to you nature with all her children to bind her to your service and make her your slave." "We have no right," he asserted, "to expect nature to come to us." Instead, "Nature must

be taken by the forelock, being bald behind." Delay and subtle argument "permit one only to clutch at nature, never to lay hold of her and capture her."[11]

Nature existed in three states – at liberty, in error, or in bondage:

> She is either free and follows her ordinary 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, insolence, and forwardness of matter and violence of impediments, as in the case of monsters; or lastly, she is put in constraint, molded, and made as it were new by art and the hand of man; as in things artificial.[12]

The first instance was the view of nature as immanent self development, the nature nututing herself of the Aristotelians. This was the organic view of nature as a living, growing, self-actualizing being. The second state was necessary to explain the malfunctions and monstrosities that frequently appeared and that could not have been caused by God or another higher power acting on his instruction. Since monstrosities could not be explained by the action of form or spirit, they had to be the result of matter acting perversely. Matter in Plato's Timaeus was recalcitrant and had to be forcefully shaped by the demiurge. Bacon frequently described matter in female imagery, as a "common harlot." "Matter is not devoid of an appetite and inclination to dissolve the world and fall back into the old Chaos." It therefore must be "restrained and kept in order by the prevailing concord of things." "The vexations of art are certainly as the bonds and handcuffs of Proteus, which betray the ultimate struggles and efforts of matter."[13]

The third instance was the case of art (techné), man operating on nature to create something new and artificial. Here "nature takes orders from man and works under his authority." Miners and smiths should become the model for the new class of natural philosophers who would interrogate and alter nature. They had developed the two most important methods of wresting nature's secrets from her, "the one searching into the bowels of nature, the other shaping nature as on an anvil." "Why should we not divide natural philosophy into two parts, the mine and the furnace?" For "the truth of nature lies hid in certain deep mines and caves," within the earth's bosom. Bacon, like some of the practically minded alchemists, would "advise the studious to sell their books and build furnaces" and, "forsaking Minerva and the Muses as barren virgins, to rely upon Vulcan."[14]

The new method of interrogation was not through abstract notions, but through the instruction of the understanding "that it may in very truth dissect nature." The instruments of the mind supply suggestions, those of the hand give motion and aid the work. "By art and the hand of man," nature can then be "forced out of her natural state and squeezed and molded." In this way, "human knowledge and human power meet as one."[15]

Here, in bold sexual imagery, is the key feature of the modern experimental method – constraint of nature in the laboratory, dissection by hand and mind, and the penetration of hidden secrets – language still used today in praising a scientist's "hard facts," "penetrating mind," or the "thrust of his argument." The constraints against penetration in Natura's lament over her torn garments of modesty have been turned into sanctions in language that legitimates the exploitation and "rape" of nature for human good. The seventeenth-century experimenters of the Accademia del Cimento

of Florence (i.e., the Academy of Experiment, 1657–1667) and the Royal Society of London who placed mice and plants in the artificial vacuum of the barometer or bell jar were vexing nature and forcing her out of her natural state in true Baconian fashion.[16]

Scientific method, combined with mechanical technology, would create a "new organon," a new system of investigation, that unified knowledge with material power. The technological discoveries of printing, gunpowder, and the magnet in the fields of learning, warfare, and navigation "help us to think about the secrets still locked in nature's bosom." "They 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." Under the mechanical arts, "nature betrays her secrets more fully . . . than when in enjoyment of her natural liberty."[17]

Mechanics, which gave man power over nature, consisted in motion; that is, in "the uniting or disuniting of natural bodies." Most useful were the arts that altered the materials of things – "agriculture, cookery, chemistry, dying, the manufacture of glass, enamel, sugar, gunpowder, artificial fires, paper, and the like." But in performing these operations, one was constrained to operate within the chain of causal connections; nature could "not be commanded except by being obeyed." Only by the study, interpretation, and observation of nature could these possibilities be uncovered; only by acting as the interpreter of nature could knowledge be turned into power. Of the three grades of human ambition, the most wholesome and noble was "to endeavor to establish and extend the power and dominion of the human race itself over the universe." In this way "the human race [could] recover that right over nature which belongs to it by divine bequest."[18]

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. For Bacon, as for Harvey, sexual politics helped to structure the nature of the empirical method that would produce a new form of knowledge and a new ideology of objectivity seemingly devoid of cultural and political assumptions.

[. . .]

Capitalism and scientific progress

Bacon's utopian *New Atlantis*, written in 1624, shortly before his death, postulated a program of scientific study that would be a foundation for the progress and advancement of "the whole of mankind."

By the time Bacon wrote his *New Atlantis*, a significant cleavage existed in English society between wage laborers and merchants. The rift between middle-class society and the poorer sectors was developing in the textile industry, mining industry, and the crafts.[19]

In seventeenth-century England, the rural poor became servants for the families of gentleman landlords, husbanders, and yeoman farmers. The cottager's son or daughter who became a servant in husbandry left home around the age of ten and was cared for, fed, clothed, and housed by the surrogate family for the next ten to twenty years. After marriage, probably to another servant, the cottage-laborer might well face the rest of his or her short life in poverty, earning small sums for daily labor contracts.

Cottagers supplied much of the labor for the rural putting-out systems, which combined large numbers of households in the production of textiles under the direction of a clothier capitalist. When not employed in planting, plowing, and harvesting operations, farmers and their families engaged in the sorting, carding, and spinning of wool. The subsequent weaving, dying, and dressing of cloth was performed by craftspeople, journeypeople, and artisans who only secondarily helped with harvesting in the late summer and fall. The clothier supplied the raw materials and marketed the textiles in domestic and international trade.

During the sixteenth century, the relationship of the artisan to the clothier capitalist had been changing. When the rural weaver could not afford a loom, the clothier offered one for rent. Most looms were operated in individual homes, but in some rural communities the clothier's enterprise became concentrated in a group of houses or in one building. A larger clothier might own dye houses where the work was supervised, and fulling mills and workshops where the cloth was stretched and pressed. In 1618, an English writer estimated that a clothier who made twenty broadcloths a week provided work for 500 persons, counting wool sorters, carders, spinners, weavers, burlers, fullers, cloth finishers, dyers, and loom and spinning wheel makers. In the West Country, the capital investments were larger and the number of operations directed by the clothier more extensive than in the Yorkshire country of the north.

The transition from craft production to preindustrial capitalism taking place throughout the century was more pronounced in the rural rather than the urban putting-out systems. A clothier in the rural putting-out system was freer than his urban counterpart from municipal taxes and regulations and from restrictions on the quality of his product, the number of his employees, and his methods of production. "The expansive years between 1460 and 1560 are particularly important because the balance of tradition and innovation shifted gradually but decisively. . . . But by 1560 the cleavage between capital and labor . . . was firmly and widely established in many parts of industrial Europe."[20] Rising prices widened the separation between wages and profits with a larger share of community wealth going to the capitalist.

A second industry that employed the poor as wage workers was mining.[21] Large-scale operations were rare, with only about 100 workers being employed in each of the larger mines. In England, the coal industries at Newcastle upon Tyne and Wear developed rapidly in the late sixteenth century, impelled by the increasing scarcity of timber.

In the British copper and brass industry that developed in the 1560s, large capital investments were necessary for opening and developing the mining shafts, smelting the ore, producing brass wire, and flattening ingots. Since neither the workers nor any single capitalist had the necessary funds, capital was supplied by English and German shareholders – members of the nobility, clergy, state officials, and merchants. Separation of worker and capitalist was thus a prerequisite for the start of this industry.[22] In the iron industry, foundry and forge were owned and products marketed by entrepreneurs. Free and independent miners and metal workers were a decreasing group.

A similar separation was taking place within the crafts, created by decreasing upward mobility for journeypeople. By hard and diligent work or by marrying the master's daughter, a journeyman might succeed.[23] But more and more masters tended to pass their craft to their sons, making the group hereditary. Masters became "small-scale industrial capitalists," and journeypeople became their paid workers, with less

chance for independence. The journeyman weaver, for example, owned neither the material, as did the clothier, nor the looms, as did the master weaver.

Within the craft guilds, some masters accumulated money and extended the markets beyond their own towns. Lower craftspersons became more dependent on them. The same phenomenon of market extension and dependence also took place between one craft and another.

Francis Bacon's early interest in writing a "History of Trades" was a manifestation of his desire to discover those secrets of the craft workshops that could be applied to the practical needs and interests of middle-class society. Growth and progress could be achieved from the study of the mechanical arts, "for these . . . are continually thriving and growing."[24]

The concept of scientific progress that Bacon developed as a program sanctioned the gap between journeyman and master craftsman. Much has been made of the concept of progress in Western society, through which standards of living for "all mankind" are presumably improved. But did the "public good" really include the cottager, journeyperson, and peasant, or did it function so as to benefit the master craftsman, clothier, and merchant?

The idea of scientific progress has been associated with the rise of technology and "the requirements of early capitalistic economy" by scholars who have argued that the idea of cooperation and the sharing of knowledge for both the construction of theory and the public good stemmed from the intellectual attitudes of sixteenth-century master craftsmen, mechanical engineers, and a few academic scholars and humanists. "The absence of slavery, the existence of machinery, the capitalistic spirit of enterprise and economic rationality seem to be prerequisites without which the ideal of scientific progress cannot unfold."[25]

The sixteenth-century groups that evolved the concept of progress are the same groups that right up until the present have pressed for increased growth and development: entrepreneurs, military engineers, humanist academics, and scientists and technicians.

[. . .]

What had been merely prefaces and statements advocating a utilitarian concept of progress in these sixteenth-century treatises became a whole program and ideology in the utopian thought of Francis Bacon. In the *New Atlantis*, progress was placed in the hands of a group of scientists and technicians who studied nature altered by "the mechanical arts" and "the hand of man" that her secrets might be utilized to benefit society.

Mechanism and the *New Atlantis*

The scientific research institute designed to bring progress to Bensalem, the community of the *New Atlantis*, was called Salomon's House. The patriarchal character of this utopian society was reinforced by designating the scientists as the "Fathers of Salomon's House." In the *New Atlantis*, politics was replaced by scientific administration. No real political process existed in Bensalem. Decisions were made for the good of the whole by the scientists, whose judgment was to be trusted implicitly, for they alone possessed the secrets of nature.

Scientists decided which secrets were to be revealed to the state as a whole and which were to remain the private property of the institute rather than becoming public knowledge: "And this we do also, we have consultations, which of the inventions and experiences which we have discovered shall be published, and which not: and all take an oath of secrecy for the concealing of those which we think fit to keep secret, though some of those we do reveal sometimes to the state, and some not."[26]

The cause of the visit to the governor by a scientist from the distant Salomon's House, which resulted in a conference with the visitors to Bensalem, was shrouded in secrecy. No father of the institute had been seen in "this dozen years. His coming [was] in state, but the cause of his coming [was] secret."

The scientist father was portrayed much like the high priest of the occult arts, the Neoplatonic magus whose interest in control and power over nature had strongly influenced Bacon. He was clothed in all the majesty of a priest, complete with a "robe of fine black cloth with wide sleeves and a cape," an "undergarment . . . of excellent white linen," and a girdle and a clerical scarf, also of linen. His gloves were set with stone, his shoes were of peach-colored velvet, and he wore a Spanish helmet.

The worship to be accorded to the scientist was further enhanced by his vehicle, a "rich chariot" of cedar and gilt carried like a litter between four richly velveted horses and two blue-velveted footmen. The chariot was decorated with gold, sapphires, a golden sun, and a small cherub of gold with wings outspread" and was followed by fifty richly dressed footmen. In front walked two bareheaded men carrying a pastoral staff and a bishop's crosier.

Bacon's scientist not only looked but behaved like a priest who had the power of absolving all human misery through science. He "had an aspect as if he pitied men"; "he held up his bare hand as he went, as blessing the people, but in silence." The street was lined with people who, it would seem, were happy, orderly, and completely passive: "The street was wonderfully well kept, so that there was never any army [which] had their men stand in better battle array than the people stood. The windows were not crowded, but everyone stood in them as if they had been placed."

Bacon's "man of science" would seem to be a harbinger of many modern research scientists. Critics of science today argue that scientists have become guardians of a body of scientific knowledge, shrouded in the mysteries of highly technical language that can be fully understood only by those who have had a dozen years of training. It is now possible for such scientists to reveal to the public only information they deem relevant. Depending on the scientist's ethics and political viewpoint, such information may or may not serve the public interest.

Salomon's House, long held to be the prototype of a modern research institute, was a forerunner of the mechanistic mode of scientific investigation. The mechanical method that evolved during the seventeenth century operated by breaking down a problem into its component parts, isolating it from its environment, and solving each portion independently. Bacon's research center maintained separate "laboratories" for the study of mining and metals, weather, fresh- and salt-water life, cultivated plants, insects, and so on.

The tasks of research were divided hierarchically among the various scientists, novices, and apprentices. Some abstracted patterns from other experiments, some did

preliminary book research, some collected experiments from other arts and sciences; others tried out new experiments, or compiled results or looked for applications. The interpreters of nature raised the discoveries into greater observations, axioms, and aphorisms. This differentiation of labor followed the outlines of Bacon's inductive methodology.

In the laboratories of Salomon's House, one of the goals was to recreate the natural environment artificially through applied technology. Large, deep caves called the Lower Region were used for "the imitation of natural mines and the producing of new artificial metals by compositions and materials."[27] In another region were "a number of artificial wells and fountains, made in imitation of the natural sources and baths." Salt water could be made fresh, for "we have also pools, of which some do strain fresh water out of salt, and others by art do turn fresh water into salt."

Not only was the manipulation of the environment part of Bacon's program for the improvement of mankind, but the manipulation of organic life to create artificial species of plants and animals was specifically outlined. Bacon transformed the natural magician as "servant of nature" into a manipulator of nature and changed art from the aping of nature into techniques for forcing nature into new forms and controlling reproduction for the sake of production: "We make a number of kinds of serpents, worms, flies, fishes of putrefaction, where of some are advanced (in effect) to be perfect creatures like beasts or birds, and have sexes, and do propagate. Neither do we this by chance, but we know beforehand of what matter and commixture what kind of those creatures will arise."

These examples were taken directly from Delia Porta's *Natural Magic* (1558), the second book of which dealt specifically with putrefaction and the generation of the living organisms mentioned by Bacon – worms, serpents, and fishes. The chapter dealing with putrefaction had discussed the generation of canker worms from mud, so that "we may also learn how to procreate new creatures."[28] "Serpents," wrote Delia Porta, "may be generated of man's marrow, of the hairs of a menstrous woman, and of a horsetail, or mane," while "certain fishes," such as groundlings, carp, and shellfish, "are generated out of putrefaction." New beasts and birds could be generated through knowledge and carefully controlled coupling.

Delia Porta also set down instructions as to how to produce a new organism in a series of trials. Such creatures "must be of equal pitch; they must have the same reproductive cycle, and one must be equally "as lustful as the other." Furthermore "if any creatures want appetite . . . we may make them eager in lust."

The *New Atlantis* had parks and enclosures for beasts and birds where just such experiments were performed: "By art likewise we make them greater or taller than their kind is, and contrariwise dwarf them, and stay their growth; we make them more fruitful and bearing than their kind is, and contrariwise barren and not generative. Also we make them differ in color, shape, activity, many ways."[29]

The scientists of Salomon's House not only produced new forms of birds and beasts, but they also altered and created new species of herbs and plants: "We have also means to make divers plants rise by mixtures of earths without seeds, and likewise to make divers new plants differing from the vulgar, and to make one tree or plant turn into another."

Rather than respecting the beauty of existing organisms, Bacon's *New Atlantis* advocated the creation of new ones:

> We have also large and various orchards and gardens, wherein we do not so much respect beauty as variety of ground and soil, proper for diverse trees and herbs. . . . And we make (by art) in the same orchards and gardens, trees and flowers to come earlier or later than their seasons, and to come up and bear more speedily than by their natural course they do. We make them by art greater much than their nature, and their fruit greater and sweeter and of differing taste, smell, color, and figure, from their nature.[30]

Delia Porta had, again, given numerous examples of changing the colors and tastes of plants: a white vine could be turned into a black one, purple roses and violets could become white, and sweet almonds and pomegranates sour.

That such experimentation on animals and the creation of new species was ultimately directed toward human beings was intimated by Bacon: "We have also parks and enclosures of all sorts of beasts and birds, which we use not only for view or rareness but likewise for dissections and trials, that thereby we may take light [i.e., enlightenment] what may be wrought upon the body of man. . . . We also try all poisons and other medicines upon them as well of chirurgery as physic."[31]

Much of Bacon's strategy in the *New Atlantis* was directed at removing ethical strictures against manipulative magic, of the sort found in Agrippa's *Vanity of Arts and Science* (1530), a polemic probably written for Agrippa's own self-protection, containing important arguments against transforming and altering nature. Just as Agricola had been obliged to refute Agrippa's views on mining in order to liberate that activity from the ethical constraints imposed by ancient writers, so Bacon was obliged to refute the constraints against the manipulation of nature. Agrippa had argued against tampering with nature and maiming living organisms:

> Those exercises appurtenant to agriculture . . . might in some measure deserve commendation, could it have retained itself within moderate bounds and not shown us so many devices to make strange plants, so many portentous graftings and metamorphoses of trees; how to make horses copulate with asses, wolves with dogs, and so to engender many wondrous monsters contrary to nature: and those creatures to whom nature has given leave to range the air, the seas and earth so freely, to captivate and confine in aviaries, cages, warrens, parks, and fish ponds, and to fat them in coops, having first put out their eyes, and maimed their limbs.[32]

Agrippa had further inveighed against the manipulators of nature who had tried to discover "how to prevent storms, make . . . seed fruitful, kill weeds, scare wild beasts, stop the flight of beasts and birds, the swimming of fishes, to charm away all manner of diseases; of all which those wise men before named have written very seriously and very cruelly."

Much of Bacon's program in the *New Atlantis* was meant to sanction just such manipulations, his whole objective being to recover man's right over nature, lost in the Fall. Agrippa had observed that after the Fall nature, once kind and beneficent, had become wild and uncontrollable: "For now the earth produces nothing without our labor and our sweat, but deadly and venomous . . . nor are the other elements less kind to us: many the seas destroy with raging tempests, and the horrid monsters devour the

air making war against us with thunder, lightning and storms; and with a crowd of pestilential diseases, the heavens conspire our ruin."

In order to control the ravages of wild tempestuous nature, Bacon set as one of the objectives of Salomon's House the artificial control of the weather and its concomitant monsters and pestilences: "We have also great and spacious houses, where we imitate and demonstrate meteors, as snow, hail, rain, some artificial rains of bodies and not of water, thunder, lightnings, also generation of bodies in air, as frogs, flies, and diverse others." Tempests (like that produced by Shakespeare's magician, Prospero) could also be created for study by using "engines for multiplying and enforcing of winds."[33]

The Baconian program, so important to the rise of Western science, contained within it a set of attitudes about nature and the scientist that reinforced the tendencies toward growth and progress inherent in early capitalism. While Bacon himself had no intimation as to where his goals might ultimately lead, nor was he responsible for modern attitudes, he was very sensitive to the trends and directions of his own time and voiced them eloquently. The expansive tendencies of his period have continued, and the possibility of their reversal is highly problematical.

Bacon's mechanistic utopia was fully compatible with the mechanical philosophy of nature that developed during the seventeenth century. Mechanism divided nature into atomic particles, which, like the civil citizens of Bensalem, were passive and inert. Motion and change were externally caused: in nature, the ultimate source was God, the seventeenth century's divine father, clockmaker, and engineer; in Bensalem, it was the patriarchal scientific administration of Salomon's House. The atomic parts of the mechanistic universe were ordered in a causal nexus such that by contact the motion of one part caused the motion of the next. The linear hierarchy of apprentices, novices, and scientists who passed along the observations, experimental results, and generalizations made the scientific method as mechanical as the operation of the universe itself. Although machine technology was relatively unadvanced in Bensalem, the model of nature and society in this utopia was consistent with the possibilities for increased technological and administrative growth.

In the *New Atlantis* lay the intellectual origins of the modern planned environments initiated by the technocratic movement of the late 1920s and 1930s, which envisioned totally artificial environments created by and for humans. Too often these have been created by the mechanistic style of problem solving, which 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. It would seem that the creation of artificial products was one result of the Baconian drive toward control and power over nature in which "The end of our foundation 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."[34] To this research program, modern genetic engineers have added new goals – the manipulation of genetic material to create human life in artificial wombs, the duplication of living organisms through cloning, and the breeding of new human beings adapted to highly technological environments.

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Notes

1 Treatment of Francis Bacon's contributions to science include Paolo Rossi, *Francis Bacon: From Magic to Science* (London: Routledge & Kegan Paul, 1968); Lisa Jardine, *Francis Bacon and the Art of Discourse* (Cambridge, England: Cambridge University Press, 1974); Benjamin Farrington, *Francis Bacon: Philosopher of Industrial Science* (New York: Schumann, 1949); Margery Purver, *The Royal Society Concept and Creation* (London: Routledge & Kegan Paul, 1967).

2 Farrington, *Francis Bacon*, p. 82. James Spedding, *The Letters and Life of Francis Bacon*, 7 vols. (London: Longmans, Green, Reader and Dyer, 1869), vol. 3, pp. 56–66.

3 James I, *Daemonologie* (New York: Barnes and Noble, 1966; first published 1597); Keith Thomas, *Religion and the Decline of Magic* (New York: Scribner's, 1971), p. 520; Wallace Notestein, *A History of Witchcraft in England from 1558 to 1718* (New York: Apollo Books, 1968), p. 101; Ronald Seth, *Stories of Great Witch Trials* (London: Baker, 1967), p. 83.

4 Bacon, "De Dignitate et Augmentis Scientiarum" (written 1623), *Works*, ed. James Spedding, Robert Leslie Ellis, Douglas Devon Heath, 14 vols. (London: Longmans Green, 1870), vol. 4, p. 296. The ensuing discussion was stimulated by William Leiss's *The Domination of Nature* (New York: Braziller, 1972), Chap. 3, pp. 45–71.

5 Bacon, "Preparative Towards a Natural and Experimental History," *Works*, vol. 4, p. 263. Italics added.

6 Bacon, "De Dignitate," *Works*, vol. 4, p. 298. Italics added.

7 Bacon, "The Great Instauration" (written 1620), *Works*, vol. 4, p. 20; "The Masculine Birth of Time," ed. and trans. Benjamin Farrington, in *The Philosophy of Francis Bacon* (Liverpool, England: Liverpool University Press, 1964), p. 62; "De Dignitate," *Works*, vol. 4, pp. 287, 294.

8 Quoted in Moody E. Prior, "Bacon's Man of Science," in Leonard M. Marsak, ed., *The Rise of Modern Science in Relation to Society* (London: Collier-Macmillan, 1964), p. 45.

9 Rossi, p. 21; Leiss, p. 56; Bacon, *Works*, vol. 4, p. 294; Henry Cornelius Agrippa, *De Occulta Philosophia Libri Tres* (Antwerp, 1531): "No one has such powers but he who has cohabited with the elements, vanquished nature, mounted higher than the heavens, elevating himself above the angels to the archetype itself, with whom he then becomes cooperator and can do all things," as quoted in Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (New York: Vintage Books, 1964), p. 136.

10 Bacon, "Novum Organum," Part 2, in *Works*, vol. 4, p. 247; "Valerius Terminus," *Works*, vol. 3, pp. 217, 219; "The Masculine Birth of Time," trans. Farrington, p. 62.

11 Bacon, "The Masculine Birth of Time," and "The Refutation of Philosophies," trans. Farrington, pp. 62, 129, 130.

12 Bacon, "De Augmentis," *Works*, vol. 4, p. 294; see also Bacon, "Aphorisms," *Works*, vol. 4.

13 "De Augmentis," *Works*, vol. 4, pp. 320, 325; Plato, "The Timaeus," in *The Dialogues of Plato*, trans. B. Jowett (New York: Random House, 1937), vol. 2, p. 17; Bacon, "Parasceve," *Works*, vol. 4, p. 257.

14 Bacon, "De Augmentis," *Works*, vol. 4, pp. 287, 343, 393.

15 Bacon, "Novum Organum," *Works*, vol. 4, p. 246; "The Great Instauration," *Works*, vol. 4, p. 29; "Novum Organum," Part 2, *Works*, vol. 4, p. 247.

16 Alain of Lille, *De Planctu Naturae*, in T. Wright, ed., *The Anglo-Latin Satirical Poets and Epigrammatists* (Wiesbaden: Kraus Reprint, 1964) vol. 2, pp. 441, 467; Thomas

Kuhn, "Mathemetical vs. Experimental Traditions in the Development of Physical Science," *Journal of Interdisciplinary History* 7, no. 1 (Summer, 1976): 1–31, see p. 13. On the Accademia del Cimento's experiments see Martha Ornstein [Bronfenbenner], *The Role of Scientific Societies in the Seventeenth Century* (reprint ed., New York: Arno Press, 1975, p. 86.

17 Bacon, "Thoughts and Conclusions on the Interpretation of Nature or A Science of Productive Works," trans. Farrington, *The Philosophy of Francis Bacon*, pp. 93, 96, 99.

18 Bacon, "De Augmentis," *Works*, vol. 4, p. 294; "Parasceve," *Works*, vol. 4, p. 257; "Plan of the Work," vol. 4, p. 32; "Novum Organun," *Works*, vol. 4, pp. 114, 115.

19 The following discussion of the effects of early capitalist organization in the textile industry draws on Laslett, pp. 15–17; Eugene F. Rice, Jr., *The Foundations of Early Modern Europe, 1460–1559* (New York: Norton, 1970), pp. 52–53; E. Lipson, *The Economic History of England* (London: Black, 1943) vol. 2, pp. 9, 11–15, 17, 31; E. Lipson, *A Short History of Wool and Its Manufacture (Mainly in England)* (Cambridge, Mass.: Harvard University Press, 1953); Henry Kamen, *The Iron Century: Social Change in Europe, 1550–1660* (London: Wiedenfeld and Nicolson, 1971), p. 114. For late sixteenth-century laws regulating the textile industry, see R.H. Tawney and Eileen Power, *Tudor Economic Documents* (London: Longmans Green, 1924), vol. 1, pp. 169–228; see also Thomas Deloney, "The Pleasant History of John Winchcomb, in his Younger Years Called Jack of Newburie," in F.O. Mann, ed., *The Works of Thomas Deloney* (Oxford, 1912).

20 Rice, pp. 53–54.

21 The discussion of capitalist organization in the mining industry draws on Lipson, *Economic History*, vol. 2, pp. 114, 162; John U. Nef, "Coal Mining and Utilization," in Charles Singer and others, eds., *A History of Technology* (New York: Oxford University Press, 1957), vol. 3, p. 77; J.U. Nef, *The Rise of the British Coal Industry* (London: Routledge & Kegan Paul, 1932), vol. 1. On laws regulating the mining industry see Tawney and Power, pp. 229–92.

22 Henry Hamilton, *The English Brass and Copper Industries to 1880* (London: Cass, 1967; first published 1926), pp. 70, 17, 76.

23 For example, see Deloney. On declining upward mobility for journeymen see J.U. Nef, *Industry and Government in France and England, 1540–1640* (Philadelphia: American Philosophical Society, 1940), pp. 17–19; Christopher R. Friedrichs, "Capitalism, Mobility, and Class Formation in the Early Modern German City," *Past and Present*, no. 69 (Nov. 1975): 24–49; E.F. Rice, *Foundations of Early Modern Europe*, pp. 48–49; Natalie Z. Davis, *Society and Culture in Early Modern France* (Stanford, Cal.: Stanford University Press, 1975), pp. 4–15. See also Lipsom, *Economic History*, vol. 2, p. 35; Hamilton, p. 71.

24 Walter E. Houghton, Jr., "The History of Trades: Its Relation to Seventeenth Century Thought," in Philip P. Wiener and Aaron Noland, eds., *Roots of Scientific Thought* (New York: Basic Books, 1953), pp. 355–60. Bacon, *Works*, vol. 4, pp. 74–75.

25 Edgar Zilsel, "The Genesis of the Concept of Scientific Progress," in *Roots of Scientific Thought*, pp. 251–55, quotation on p. 275. A.C. Keller, "Zilsel, the Artisans, and the Idea of Progress in the Renaissance," in *Roots of Scientific Thought*, pp. 281–86. Paolo Rossi, *Philosophy, Technology and the Arts in the Early Modern Era* (New York: Harper & Row, 1970), Chap. 1, 2, pp. 1–99. J.B. Bury, *The Idea of Progress* (New York: Dover, 1955). For a criticism of the scholar-craftsman theory and its relation to technological progress, see A. Rupert Hall, "The Scholar and the Craftsman in the Scientific Revolution," in Marshall Clagett, ed., *Critical Problems in*

the History of Science (Madison: University of Wisconsin Press, 1959), pp. 3–23. As cited in Zilsel, Keller, and Rossi, sixteenth-century treatises advocating cooperative sharing of knowledge for human progress included: Master craftsmen: Kaspar Brunner, "Grundlicher Bericht des Buchsengiessens" (1547); *Archive fur die Geschichte der Naturwissenschaften und Technik* 7 (1916), p. 171; Robert Norman, *The Newe Attractive* (London, 1581), preface and dedication; Peter Apianus, *Quadraus Astronomicus* (Ingolstadt, 1932), dedication; Ambroise Pare (1509–1590), *Oeuvres*, ed. J.F. Malgaigne (Paris, 1840; first published 1575), introduction; Gerard Mercator (1512–1594), *Atlas* (1595), 4th ed. (Antwerp, 1630), introduction to maps of France. Military engineers: William Bourne (d. 1583), *Inventions or Devices* (London, 1587), Preface to the Reader; Niccolo Tartaglia (1499–1557), *Questi et Inventoni* (Venice, 1546), dedication; S. Stevinus (1548–1620), *Hypomnemata Mathematica* (written 1605–1608) in *Oeuvres Mathematica*, ed. Girard (Leyden, 1634), vol. 2, p. 111 ff.; Bonaiuto Lorini, *Delle Fortificazioni* (Venice, 1597). Humanists and academics: Abraham Ortelius (1527–1598), *Theatrum Orbis Terrarum* (Antwerp, 1570); Francois Rebelais (1490–1553), *Gargantua and Pantagruel* (Paris, 1533), last chapter; Jean Bodin, *Methodus and Facilem Historiarum Cognitionem* (Paris, 1566), Chap. 7; Loys Leroy, *Les Politiques d'Aristotle* (Paris, 1568), argument to Book II. Political theorist J. Schaar has pointed out that the full humanization of life logically implies a human environment filled with humans at the expense of nature.

26 Bacon, "The New Atlantis," *Works*, vol. 3, subsequent quotations on pp. 165, 154, 155. On politics and science in "The New Atlantis," see Joseph Haberer, *Politics and the Community of Science* (New York: Van Nostrand Reinhold, 1969), pp. 46, 47; see M.E. Prior, "Bacon's Man of Science," in L.M. Marsak, ed., pp. 41–53; P. Rossi, *Francis Bacon*, Chap. 1. On critiques of technology, see John McDermott, "Technology: The Opiate of the Intellectuals," *New York Review of Books*, July 31, 1969; Theodore Roszak, *Where the Wasteland Ends* (Garden City, NY: Doubleday, 1963), Chap. 2.

27 Bacon, "The New Atlantis," *Works*, vol. 3, quotations on pp. 157, 158, 159.

28 G. Della Porta, *Natural Magic*, ed. D.J. Price (facsimile of 1658 ed., New York: Basic Books, 1957; first published 1558), pp. 27, 29, 31–40.

29 Bacon, *Works*, vol. 3, quotations on pp. 158, 159. Cf. Della Porta, pp. 59, 61, 62.

30 Bacon, *Works*, vol. 3, p. 158. Cf. Della Porta, pp. 61–62, 73, 74–75, 81, 95–99.

31 Bacon, *Works*, vol. 3, p. 159.

32 Henry Cornelius Agrippa, *The Vanity of Arts and Sciences* (London, 1694; first published 1530), pp. 252–53.

33 Bacon, *Works*, vol. 3, pp. 157, 158.

34 *Ibid.*, p. 156.