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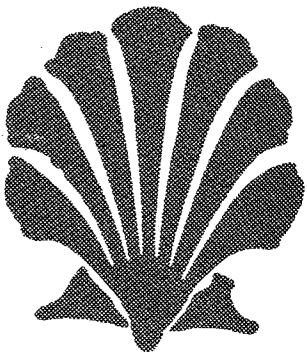
THE DEATH OF NATURE

WOMEN, ECOLOGY, AND THE SCIENTIFIC REVOLUTION

Harper & Row, Publishers, San Francisco

New York, Grand Rapids, Philadelphia, St. Louis
London, Singapore, Sydney, Tokyo, Toronto

CHAPTER 1



Nature as Female

The world we have lost was organic. From the obscure origins of our species, human beings have lived in daily, immediate, organic relation with the natural order for their sustenance. In 1500, the daily interaction with nature was still structured for most Europeans, as it was for other peoples, by close-knit, cooperative, organic communities.

Thus it is not surprising that for sixteenth-century Europeans the root metaphor binding together the self, society, and the cosmos was that of an organism. As a projection of the way people experienced daily life, organismic theory emphasized interdependence among the parts of the human body, subordination of individual to communal purposes in family, community, and state, and vital life permeating the cosmos to the lowliest stone.

The idea of nature as a living organism had philosophical antecedents in ancient systems of thought, variations of which formed the prevailing ideological framework of the sixteenth century. The organismic metaphor, however, was immensely flexible and adapt-

able to varying contexts, depending on which of its presuppositions was emphasized. A spectrum of philosophical and political possibilities existed, all of which could be subsumed under the general rubric of *organic*.

NATURE AS NURTURE: CONTROLLING IMAGERY. Central to the organic theory was the identification of nature, especially the earth, with a nurturing mother: a kindly beneficent female who provided for the needs of mankind in an ordered, planned universe. But another opposing image of nature as female was also prevalent: wild and uncontrollable nature that could render violence, storms, droughts, and general chaos. Both were identified with the female sex and were projections of human perceptions onto the external world. The metaphor of the earth as a nurturing mother was gradually to vanish as a dominant image as the Scientific Revolution proceeded to mechanize and to rationalize the world view. The second image, nature as disorder, called forth an important modern idea, that of power over nature. Two new ideas, those of mechanism and of the domination and mastery of nature, became core concepts of the modern world. An organically oriented mentality in which female principles played an important role was undermined and replaced by a mechanically oriented mentality that either eliminated or used female principles in an exploitative manner. As Western culture became increasingly mechanized in the 1600s, the female earth and virgin earth spirit were subdued by the machine.[1]

The change in controlling imagery was directly related to changes in human attitudes and behavior toward the earth. Whereas the nurturing earth image can be viewed as a cultural constraint restricting the types of socially and morally sanctioned human actions allowable with respect to the earth, the new images of mastery and domination functioned as cultural sanctions for the denudation of nature. Society needed these new images as it continued the processes of commercialism and industrialization, which depended on activities directly altering the earth—mining, drainage, deforestation, and assarting (grubbing up stumps to clear fields). The new activities utilized new technologies—lift and force pumps, cranes, windmills, geared wheels, flap valves, chains, pistons, treadmills, under- and overshot watermills, fulling mills, flywheels, bellows, ex-

cavators, bucket chains, rollers, geared and wheeled bridges, cranks, elaborate block and tackle systems, worm, spur, crown, and lantern gears, cams and eccentrics, ratchets, wrenches, presses, and screws in magnificent variation and combination.

These technological and commercial changes did not take place quickly; they developed gradually over the ancient and medieval eras, as did the accompanying environmental deterioration. Slowly over many centuries early Mediterranean and Greek civilization had mined and quarried the mountainsides, altered the forested landscape, and overgrazed the hills. Nevertheless, technologies were low level, people considered themselves parts of a finite cosmos, and animism and fertility cults that treated nature as sacred were numerous. Roman civilization was more pragmatic, secular, and commercial and its environmental impact more intense. Yet Roman writers such as Ovid, Seneca, Pliny, and the Stoic philosophers openly deplored mining as an abuse of their mother, the earth. With the disintegration of feudalism and the expansion of Europeans into new worlds and markets, commercial society began to have an accelerated impact on the natural environment. By the sixteenth and seventeenth centuries, the tension between technological development in the world of action and the controlling organic images in the world of the mind had become too great. The old structures were incompatible with the new activities.

Both the nurturing and domination metaphors had existed in philosophy, religion, and literature. The idea of dominion over the earth existed in Greek philosophy and Christian religion; that of the nurturing earth, in Greek and other pagan philosophies. But, as the economy became modernized and the Scientific Revolution proceeded, the dominion metaphor spread beyond the religious sphere and assumed ascendancy in the social and political spheres as well. These two competing images and their normative associations can be found in sixteenth-century literature, art, philosophy, and science.

The image of the earth as a living organism and nurturing mother had served as a cultural constraint restricting the actions of human beings. One does not readily slay a mother, dig into her entrails for gold or mutilate her body, although commercial mining would soon require that. As long as the earth was considered to be alive and sensitive, it could be considered a breach of human ethical behavior to carry out destructive acts against it. For most tradition-

al cultures, minerals and metals ripened in the uterus of the Earth Mother, mines were compared to her vagina, and metallurgy was the human hastening of the birth of the living metal in the artificial womb of the furnace—an abortion of the metal's natural growth cycle before its time. Miners offered propitiation to the deities of the soil and subterranean world, performed ceremonial sacrifices, and observed strict cleanliness, sexual abstinence, and fasting before violating the sacredness of the living earth by sinking a mine. Smiths assumed an awesome responsibility in precipitating the metal's birth through smelting, fusing, and beating it with hammer and anvil; they were often accorded the status of shaman in tribal rituals and their tools were thought to hold special powers.

The Renaissance image of the nurturing earth still carried with it subtle ethical controls and restraints. Such imagery found in a culture's literature can play a normative role within the culture. Controlling images operate as ethical restraints or as ethical sanctions—as subtle "oughts" or "ought-nots." Thus as the descriptive metaphors and images of nature change, a behavioral restraint can be changed into a sanction. Such a change in the image and description of nature was occurring during the course of the Scientific Revolution.

It is important to recognize the normative import of descriptive statements about nature. Contemporary philosophers of language have critically reassessed the earlier positivist distinction between the "is" of science and the "ought" of society, arguing that descriptions and norms are not opposed to one another by linguistic separation into separate "is" and "ought" statements, but are contained within each other. Descriptive statements about the world can presuppose the normative; they are then ethic-laden. A statement's normative function lies in the use itself as description. The norms may be tacit assumptions hidden within the descriptions in such a way as to act as invisible restraints or moral ought-nots. The writer or culture may not be conscious of the ethical import yet may act in accordance with its dictates. The hidden norms may become conscious or explicit when an alternative or contradiction presents itself. Because language contains a culture within itself, when language changes, a culture is also changing in important ways. By examining changes in descriptions of nature, we can then perceive something of the changes in cultural values. To be aware of the in-

terconnectedness of descriptive and normative statements is to be able to evaluate changes in the latter by observing changes in the former.[2]

Not only did the image of nature as a nurturing mother contain ethical implications but the organic framework itself, as a conceptual system, also carried with it an associated value system. Contemporary philosophers have argued that a given normative theory is linked with certain conceptual frameworks and not with others. The framework contains within itself certain dimensions of structural and normative variation, while denying others belonging to an alternative or rival framework.

We cannot accept a framework of explanation and yet reject its associated value judgments, because the connections to the values associated with the structure are not fortuitous. New commercial and technological innovations, however, can upset and undermine an established conceptual structure. New human and social needs can threaten associated normative constraints, thereby demanding new ones.

While the organic framework was for many centuries sufficiently integrative to override commercial development and technological innovation, the acceleration of such changes throughout western Europe during the sixteenth and seventeenth centuries began to undermine the organic unity of the cosmos and society. Because the needs and purposes of society as a whole were changing with the commercial revolution, the values associated with the organic view of nature were no longer applicable; hence the plausibility of the conceptual framework itself was slowly, but continuously, being threatened.

In order to make this interpretation of cultural change convincing, it will be advantageous to examine the variations of the organic framework, focusing on its associated female imagery and pointing out the values linked to each of the variants. It will then be possible to show how, in the context of commercial and technological change, the elements of the organic framework—its assumptions and values about nature—could be either absorbed into the emerging mechanical framework or rejected as irrelevant.

The Renaissance view of nature and society was based on the organic analogy between the human body, or microcosm, and the larger world, or macrocosm. Within this larger framework, how-

ever, a number of variants on the organic theme were possible. The primary view of nature was the idea that a designed hierarchical order existed in the cosmos and society corresponding to the organic integration of the parts of the body—a projection of the human being onto the cosmos. The term nature comprehended both the innate character and disposition of people and animals and the inherent creative power operating within material objects and phenomena. A second image was based on nature as an active unity of opposites in a dialectical tension. A third was the Arcadian image of nature as benevolent, peaceful, and rustic, deriving from Arcadia, the pastoral interior of the Greek Peloponnesus. Each of these interpretations had different social implications: the first image could be used as a justification for maintaining the existing social order, the second for changing society toward a new ideal, the third for escaping from the emerging problems of urban life. Drawing on the work of literary critics and historians of science and art, we can construct a spectrum of images of nature and delineate their associated value systems.

LITERARY IMAGES. The Chaucerian and typically Elizabethan view of nature was that of a kindly and caring motherly provider, a manifestation of the God who had imprinted a designed, planned order on the world.[3] This order imposed ethical norms of behavior on the human being, the central feature of which was behavioral self-restraint in conformity with the pattern of the natural order. Each organic creature was responsible for maintaining its own place and expressing itself within the natural order and was a necessary part of the whole, but was not the whole itself. The Elizabethan first had to understand his or her own place dictated by the cosmic and social order and then to act in accordance with the traditional reason and restraint that would maintain the balance and harmony of the whole. This reverence for nature's law was expressed by Richard Hooker (1593): "See we not plainly that obedience of creatures unto the law of nature is the stay of the whole world." Nature operated "without capacity or knowledge," solely on the basis of "her dexterity and skill," as the instrument of God's expression in the mundane world. Whatever was known of God was taught by nature, "God being the author of Nature, her voice is but

ORGANIC UTOPIAS. A third variation of the organic model expressed the needs of peasants and artisans for social revolution. The utopian millenarian tradition called for the complete overthrow of the established social order and its replacement by an egalitarian communal society and state of nature like that anticipated during the millennium—a thousand-year period when Christ would reign on earth and Satan would be banished. The millenarian movements had a historical continuity dating from the medieval crusades of the poor, Joachim of Fiore, the Brethren of the Free Spirit, the Amaurians, Thomas Munster, and the Anabaptists, to the religious sects of the English Civil War—Seekers, Ranters, Levelers, Antinomians, and Muggeltonians. These groups, along with the intellectuals who identified with them, shared a belief in the emergence of a new age of liberty and love in which God would appear from within and there would be equal sharing of food, clothing, and property among all people. At various times and places, leaders and groups emerged who tried to hasten the arrival of the millenarian age and to create communities based on an egalitarian state of nature and communal ownership of wealth. The reasons for failure ranged from military defeat by the forces of the church or state to betrayal by the leaders of rebellion.[13]

Millenarianism represented a preindustrial form of social revolution. It differed from the movements of the industrial revolution by preparing people, through revelation, to accept revolutionary change, as opposed to politicizing the working class. Signs in the heavens, prophets, and saviors would appear predicting the arrival of the millennium. For example, persisting since the Middle Ages was the prophecy that Frederick I (Barbaroso), King of Germany, would be resurrected; he had died in 1190 on the third crusade and was idealized as a savior of the poor who would bring with him a communal state. He would banish the Pope as Antichrist, and destroy his cohorts—the clergy, the wicked, and the rich, well-fed laity. Throughout the Middle Ages, prophets and written manifestos sustained revolutionary influences and the real hopes of the poor for a new social order.

In the early seventeenth century, two utopian plans, Tommaso Campanella's *City of the Sun* (1602) and Johann Valentin Andreä's *Christianopolis* (1619), articulated a philosophy of commu-

nal sharing that responded to the interests of artisans and the poor for a more egalitarian distribution of wealth based on an original harmony between people and nature.[14] They contrast markedly with a third utopia, *The New Atlantis* of Francis Bacon (1627), which undermined and transformed the concept of an organic utopian community. Yet historians have largely emphasized the similarity of the three works for the emergence of modern science and educational theory. As we shall see later, Bacon's ideas were rooted in an emerging market economy that tended to widen the gap between upper and lower social classes by concentrating more wealth in the hands of merchants, clothiers, entrepreneurial adventurers, and yeomen farmers through the exploitation and alteration of nature for the sake of progress. Andreä's and Campanella's utopian communities postulated a more egalitarian view of woman and man, artisan and master, than Bacon's more hierarchical and patriarchal community. But Bacon's inductive methodology, which helped to establish a precedent by which all persons could verify the truth for themselves, was also fundamental to the growth of egalitarianism.

From the perspective of today, there are both positive and negative aspects to Campanella's and Andreä's utopias. Some of their ideas are basic to subsequent "back to the land" utopian movements that have rejected the division of labor and the alienation of people from productive work brought about by capitalist modes of economic organization. Yet Campanella advocated a program of eugenics considered repressive in the wake of Hitler's genetically based holocaust, while Andreä's ideal society was based on a rigid Calvinist moralism.

Tommaso Campanella (1568–1639) followed the Renaissance naturalist philosopher, Bernardino Telesio (1509–1588), in his belief that God was immanent within nature and that all matter was alive. Change was explained by the dialectical warring of the opposites, heat and cold, as source of the dynamic motion of matter (see Chapter 4). In his attempt to establish an ideal society based on holistic presuppostions about nature, Campanella, in 1599, led a revolutionary movement to overthrow Spanish rule in Naples and the entire province of Calabria, in southern Italy. Portents in the heavens predicting the advent of the millennium indicated to him the necessity of immediate political overthrow and the fusion of all religious sects as the world returned to the golden age of simple, natu-

ral, primitive faith. The new society would liberate the people from the tyrannical slavery of political and religious usurpers and establish communal property and rule by brotherhood. A new, unique God, immanent in nature, would be revealed, coupled with a true spiritual religion, which, rather than debasing nature, would exalt it as a divine artisan. Under a new social rule, body and spirit would function in harmony.[15]

Signs in the heavens indicated that the millennium was near, and it was important to prepare the people of Calabria for a new city of God in which all of humanity would live in health and sainthood. In anticipation, the community had to be freed from Spanish domination. Inspired by Campanella's words, people and nobles would unite in armed rebellion.

Conditions in Naples were ripe for revolt. All classes of society were fraught with internal dissension. The people were angry about inequalities in social conditions and fiscal measures. The lords were unhappy with the government of the viceroy. Papacy and bishops were overwhelmed with juridical questions. Of the 70,000 people in Naples, 10,000 to 15,000 laborers were worn and driven by toil.

In preparation for the revolt, Campanella began preaching to large audiences and describing in eloquent terms the meaning of the signs in the heavens. His objective was to convert the people to a true spiritual religion which would lie at the foundation of his ideal republic. Aided by the voice of his friend Dionisio Ponzio and the energy of the nobleman Maurizio de Rinalis, the conspirators prepared to deliver the country from the tyranny of Spain by an uprising in Catanzaro, near the tip of Italy, and an armed attack on the Chateau d'Arena.

By the end of August 1599, everything was ready for the revolt. In a fiery speech to his companions on the mountain of Stilo, Campanella proclaimed victory to be near and described the happiness that would belong to all in the perfect city built by their communal effort. But the plans were shattered by the arrival of the troops of the Spanish viceroy, who arrested Campanella and his coconspirators on September 6, 1599. Campanella was captured and taken to Naples in chains, charged with heresy and conspiracy, and thrown into prison. He was retained there for twenty-seven years, during which time he was tortured four times.

Most of his voluminous works, including the utopian *City of the*

Sun, were written while in prison without access to books and under deplorable physical conditions. In the early years of his life, Campanella was a revolutionary who developed concrete plans for a better society and actively attempted to carry them out. After years of imprisonment by the Spanish Inquisition, he was released for a short time in 1626 but within a month was arrested and held prisoner in the Vatican until 1629. He spent the end of his life in France (1633–1639), where he received protection from Cardinal Richelieu, in whom he had by then placed his hope for a unified world. His final allegiance to Pope Urban VIII (pope from 1623 until 1644) and the French monarchy, in which he exchanged rebellion for protection and the freedom to publish and lecture, represented a conservative end to his revolutionary career.

Valentin Andreä (1586–1650) must be categorized as a reformer rather than a revolutionary, yet his reforms, like those of Campanella, were directed toward the creation of an egalitarian society. His *Christianopolis* (1619) described a utopian society in which the labor of all people was equalized and educational training existed for both sexes.

Like Campanella, Andreä was serious about making his utopian *Christianopolis* a social reality. In 1620, he moved to Calw, in the Black Forest, where as a Lutheran pastor he formed a social system that expanded from a congregational core into a larger community. At the basis of his society was a union of textile and dye workers in the Calw textile industry, consisting initially of thirteen families. The families, known as the Färberstift, all contributed money toward the education of the young, especially for orphans and the children of the poor, the operation of a library, care of the sick, elderly, and widowed, and support for the community church and its services. The emphasis on educational advancement by reformers such as Andreä and the Czech Jan Amos Comenius (1592–1670) soon spread to England, where it influenced the circle known as the Invisible College which included such seventeenth-century scientists and educators as Samuel Hartlib, John Dury, Theodore Haak, and Robert Boyle, preparing the way for England's first scientific society, The Royal Society of London, founded in 1660.[16]

The social context within which Campanella and Andreä initially proposed their utopian communities suggests that these societies were responses to the real needs of seventeenth-century people for

change and that both authors put forward these ideals as serious alternatives to existing social conditions. These communal societies are representative of an organic philosophy that placed people within rather than above nature. They represent ideals in many ways as inspiring to us today—as we search for antidotes to the problems of urbanization and industrialism—as they were to sixteenth-century reformers trying to alter the power relations of hierarchical society.

Holism. The people of Campanella's City of the Sun were to dwell in an organic holistic cosmos. Their earth was like an animal, drawing its source of motion from within, and was alive with blood from its bowels. As in the Hermetic *Emerald Tablet*, the earth was considered to be a mother and the sun a father:

> They assert two principles of the physics of things below, namely that the sun is the father and the earth the mother; the air is an impure part of the heavens; all fire is derived from the sun. The sea is the sweat of the earth, or the fluid of earth combusted, and fused within its bowels, but is the bond of union between air and earth, as the blood is of the spirit and flesh of animals. The world is a great animal, and we live within it as worms live within us.[17]

Recognized today as keys to viable ecosystems in nature are the interrelationships and organic unity among a system's parts, and the maintenance of ecological diversity. In native and traditional cultures which sustain equilibrium with their environments, rules, rituals, and religious practices have the latent function of preventing overuse of resources and overpopulation. In the City of the Sun, such principles subtly guided community norms and practices. Nature was an organic whole in which both natural and human cycles were integrated. Agricultural practices and animal breeding were performed in harmony with the seasonal cycles—a marked contrast, as we shall see, with Bacon's *New Atlantis*. Only land necessary for survival was cultivated; groves and woods were retained for wild animals. The breeding of oxen, sheep, hens, ducks, and geese took place in harmony with natural cycles of the winds and the seasonal rising of certain propitious stars and constellations. The holistic principles on which the community based its life also operated on an individual human scale. Diversity in diet was considered es-

sential to the maintenance of a healthy body. Food alternated from flesh to fish in order that the food stocks might not be depleted and nature might "never [be] incommoded nor weakened."[18] The number of meals per day varied with age in order that nature might be satisfied:

> Their food consists of flesh, butter, honey, cheese, garden herbs, and vegetables of various kinds. They were unwilling at first to slay animals, because it seemed cruel; but thinking afterward that it was also cruel to destroy herbs which have a share of sensitive feeling, they saw that they would perish from hunger unless they did an unjustifiable action for the sake of justifiable ones, and so now they all eat meat. Nevertheless they do not willingly kill useful animals, such as oxen and horses.[19]

Like the holistic health movements of today, which draw on ancient and Renaissance organismic principles, the natural harmonies of the body were maintained through nature's medicines. Herbs were used as mild natural cures for illness, harsh purgatives being advocated only rarely. The body itself was treated as a whole rather than a sum of separate parts. It was kept in tune through a program of regular gymnastics. Health, a delicate balance of the four humors, could be strengthened through the use of natural teas made from wild thyme, mint, basil, crushed garlic, or vinegar. Pleasant baths, removal to the country, and mild exercise were recommended for the curing of fevers.

People ate only according to the requirements of their own bodies, as determined by age and activity. Thus the general community took meals twice a day while the aged ate three times, consuming more easily digestible foods. Boys, while young and active, required four meals a day. Proper diet, sufficient exercise, and cleanliness formed the basis of a program of health care based on preventive medicine.

The stress on organic unity in agriculture, the community, and the human body was also manifested in the relation between cosmos and city. City planning and environmental design formed an important aspect of the holistic character of the City of the Sun. The city itself was a miniature replica of the larger macrocosm. The Temple of the Sun on a hill in the center of the city was surrounded by seven circular walls representing the seven circular

planets and named for them. Four streets and four gates oriented the community to the four points of the compass. The circular temple in the center was a small model of the plan of the heavens.

Science, often viewed today as a separate and isolated discipline, was an integral part of the daily lives and education of the Solarians. Both sides of the city walls were painted with representations and diagrams from the natural sciences. Thus the mechanical arts, their uses, and inventors were depicted on the innermost wall, with mathematical propositions and definitions on the outermost. On the walls between were paintings of all the known precious metals and stones, trees and herbs, fresh- and salt-water fishes, birds, mammals, insects, worms, and serpents. Accompanying the picture of each specimen was a description of its properties, locations, habits, methods of production or breeding, medical uses, and value to the human race.

The harmonies and influences of the macrocosm could be absorbed by each person, not only during worship in the temple but also in daily life within the city itself. Renaissance Neoplatonic theory held that pictorial and symbolic representations of the heavenly bodies, infused by the influences of the stars through the *spiritus mundi* (or spirit of the world) could transmit their powers to the beholder.[20] In this way, the soul of each individual could be made more consonant with the cosmos and integrated with the larger universe. The plan of the city was thus consciously designed to bring people into greater harmony with their larger organic environment.

These same holistic principles integrated Valentin Andreä's ideal city, Christianopolis. Christianopolis was located on a triangular island that, like the City of the Sun, was a "world in miniature" and was inhabited by people with common ideals and principles. The island was ". . . rich in grain and pasture fields, watered with rivers and brooks, adorned with woods and vineyards, full of animals, just as if it were a whole world in miniature. One might think that here the heavens and the earth had been married and were living together in everlasting peace."[21]

In contrast to the circular plan of the City of the Sun, Christianopolis was set out in the form of a square oriented to the four corners of the world. Fresh air and ventilation, flowing water and springs contributed to its healthy atmosphere. Moats were stocked

with fish, and open, unused spaces for wild animals were maintained. The city itself was a compact unit, each part serving a specific function necessary for the good of the whole. Fresh, clear water flowed through the town and supplied the houses. Underground canals removed daily wastes from the house for the sake of public health and pleasant surroundings.

Andreä believed that people were not beasts sent to "merely devour the pastures of the earth."[22] They were admonished to use it moderately, with gratitude, and with exact observation. The science laboratory therefore taught the details of natural history through a visual memory system. Painted on the walls of the hall of physics were detailed pictures of animals, plants, rocks and gems, the human races, and natural regions of the earth. Children learned the names, classes, and uses of herbs through play so that through exact observation they would be able to recognize them in nature.

Other pictures on the walls of the pictorial art shop showed the various regions of the earth, sketches of machines and statistics, perspective, and engineering fortifications. Astronomical instruments like those developed by Tycho Brahe were used for observations of the stars. Diagrams of the heavens illustrated their motions, harmonies, and the locations and shapes of individual planets and stars. In the chemical science laboratory, the properties of metals, minerals, and vegetables were studied that they might be used for the improvement of health and for the human race. Around the college were gardens containing the "living herbarium" of a thousand kinds of plants used for medicines, cooking, and decoration, as well as extensive gardens outside the walls for food crops.

In Andreä's community, nature was "aped" in order that her principles might be emulated and the earth and sky married together. Science served the human interest in Christianopolis because it was taught to all people in the community and because it was used in conjunction with natural harmonies rather than for exploitative purposes. Nature was not altered and tortured, as it would be in the laboratories of Bacon's *New Atlantis*, but observed and emulated. Natural science and the mechanical arts in the City of the Sun and in Christianopolis served the artisans and peasants because of the high status accorded them in the community and because of the great regard paid to the crafts and manual arts.

pressed for increased growth and development: entrepreneurs, military engineers, humanist academics, and scientists and technicians. Sixteenth-century master craftsmen and technicians who embraced the idea of progress in written works included: Kaspar Brunner (1547), master of ordnance, locksmith, and clockmaker; Robert Norman (1581), instrument maker; Peter Apian (1532), mechanic, globe and instrument maker, and mathematics professor; Ambroise Paré (1575) master of the guild of barber surgeons and surgeon to the king and military; and Gerard Mercator (1595), instrument maker, map maker, and surveyor. Military engineers included William Bourne (1578), gunner and military engineer, who addressed his treatise to "all generals and captains"; Niccolò Tartaglia (1537), mathematical advisor to gunners and merchants; Simon Stevin (1608), military engineer and bookkeeper; and Bonaiuto Lorini (1597), military technician to the Medicis. Humanists and academics included Abraham Ortelius (1570), classical scholar and mapmaker; François Rabelais (1535), writer; Jean Bodin (1566), political philosopher; and Loys Leroy (1568). Humanist concerns are not only fully compatible with the improvement of the human condition through technological advance, but imply an environment filled with humans at the expense of nature.

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."[37]

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 sci-

entists 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."[38] 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 Della 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."[39] "Serpents," wrote Della 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.

Della 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."[40]

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.[41]

Della 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."[42]

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 constrants 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.[43]

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."[44]

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."[45] 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.

THE BACONIAN PROGRAM. The development of science as a methodology for manipulating nature, and the interest of scientists in the mechanical arts, became a significant program during the latter half of the seventeenth century. Bacon's followers realized even more clearly than Bacon himself the connections between me-