bilities: they could be blended in with astrological ethnology, they could be used simply by themselves, they could be subordinated to the idea of design, and finally they could embody the idea of adaptation imposed upon mankind as a consequence of its worldwide dispersion.

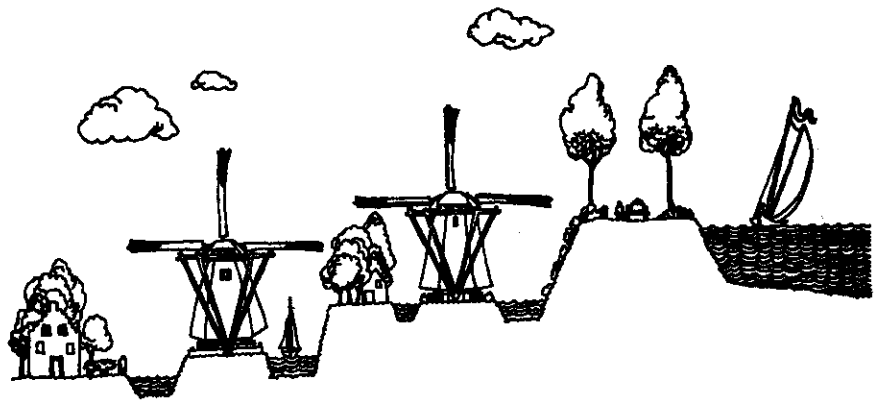
With the passage of time, astrological ethnology begins to slip away in the night, but the environmental correlations and generalizations live a hardy life all through the eighteenth century.

Respect for Hippocrates and Galen continues, but they seem now more and more like consultants than like fountainheads of knowledge because there is a great deal of contemporary observation and study of climate, health, mental and physical states, as one can see so well in *The Anatomy of Melancholy*. Opposed to them is the increasing awareness of other influences and an awareness that the distribution of mankind is evidence of creativity and adaptability of a high order, as François had hinted.

Fontenelle balks at applying the same environmental criteria to men as he applies to plants and animals. A clustering of ability or talent at certain periods is noticed, an observation which challenges by implication the uniformity of climatic influences through time. Abbé du Bos in the eighteenth century, as we shall see, considered this problem at length. There is an increasing interest in national character. Temple's ideas of the importance of borrowing, whether by individuals or by civilizations, suggest the role of imitation and copying, of the cultural milieu. Environmental theories become more secular, they are less tied to the design argument, and they are used as explanations of religious schism. Finally, with Alberti, Barclay, and Burton, the appreciation of the air of a place, of a change of air, of the effects of views, prospects, seascapes, hint at the study of the aspects of nature that is to come.

Ideas of environmental influence which appeared in our period were significant largely because of their volume and because of the variety of uses to which they were put; it is useless to claim that they contributed anything to understanding the relation of human cultures and their natural environment. It is very well to say that the climatic correlations, capricious and foolish as they were, stimulated study of regions and led to a realization of cultural differences. These differences had been understood, however, for a long time. The way to creative understanding did not lie through Bodin; a more open way was through the ideas of Acosta and François. The study of the classics, the reading of travels in the New World and in the Old failed to achieve a new departure which would make the most of the implications of the new discoveries: that traces of living men could be found almost everywhere in the world, that movement, migration, war, invasion, had been a large part of human history, that men lived and survived in a bewildering variety of conditions in widely different physical environments, and that they used their land, too, in widely different ways.

Chapter 10



Growing Consciousness of the Control of Nature

1. Introduction

Men have long been aware of their ability to change their physical environment, but only a few have regarded these changes as part of a broader philosophical, religious, or scientific attitude concerning man's place in nature. I am not referring to the theme of man's control over nature through the application of theoretical science to applied science and technology, nor to technical improvements and inventions made by artisans which lead to new and purposeful uses of and demands on natural resources. However, these general themes cannot be neglected, because of the newer philosophic outlook of the modern period toward the improvement of life and the importance of practical activity, especially in the philosophy of Francis Bacon. The theme of man's control over nature, flattering to man and his works, has, however, been concerned only casually with the theme of man as a geographic agent, in which changes have been apprehended from the point of view of their effects

on the earth and not as evidences of purposeful mastery over environmental obstacles.

The idea of man as a geologic or geographic agent is a modern one even though its sources lie in observations which differed little from those made frequently in the Middle Ages, of changes which could easily be made in a preindustrial age: the clearing of trees; the burning of forests or using them for grazing or for charcoal making; drainage of bogs and swamps; the heating of cities whose chimneys made the urban atmosphere warmer than that of the countryside; agriculture; and occupations in which the ax, the plow, or fire might be used. These activities had been going on from time immemorial, but one must look to the late seventeenth and eighteenth centuries for the beginnings of bolder syntheses. The stimulus for this came in part from successes in agriculture, drainage, engineering, and other occupations often directly concerned with the land, whose activities resulted either in change in the land itself or in its geographical relationship to another piece of land.[1] Scattered here and there in this period are isolated notices of subjects which today have become organized bodies of knowledge: air pollution, soil erosion, fertilizers, forestry, climatic change, ecology. It is possible that these observations, and many like them unrecorded, were so commonplace that they were common knowledge from which more philosophic generalizations could later emerge. In the eighteenth century, this was a significant achievement of Count Buffon.

2. Renaissance Philosophies of Technology

In the Renaissance and in writings of the seventeenth and eighteenth centuries there is a continuation of two different outlooks: one which comes out of theoretical science, theology, or philosophy and emphasizes man's role in changing or controlling nature as the expected function of his position in the scale of being and of his unique ability through his intelligence to interpret the significance of the creation. Examples of this type are in the writings of Ficino, Paracelsus, and Francis Bacon. The other outlook has a much less exalted origin, often being derived from everyday observations without philosophizing or moralizing. These often have been made almost as asides in discussions of techniques in mining, forestry, irrigation, or engineering; they may appear in law or legislative history, or from the practical needs of statecraft.

Let us examine some of these points of view in the Renaissance; they are indicative more of the possibility of making such observations than they are of any purposive scientific or philosophic inquiry into the relationship of human society to environmental change.

[1] See especially *A History of Technology*, Vol. 3, ed. Singer, *et al.*, pp. 12–13, chapters 2, 3, 12, 17, 25.

The third sign of immortality, says Marsilio Ficino in the *Platonic Theology*, is taken from the activities of the arts and of government. In this work the hymn to man may be too fervid, the belief in final causes too unyielding, but it also is a refreshing affirmation of the creativity of man after the baleful castigation that mars so much of Christian theology—that man is unworthy, cursed, full of sin.

Man, Ficino says, is much freer than are the animals which either lack art entirely or have only one and do what they do fatalistically. Men not only invent—they improve on their inventions. Man "imitates all the works of the divine nature, and perfects, corrects and improves the works of lower nature. Therefore the power of man is almost similar to that of the divine nature, for man acts in this way through himself."[2] Man is not only creative; he also binds the parts of nature together by his art. He is a transformer of materials, a user of all the elements. "Man not only makes use of the elements, but also adorns them, a thing which no animal ever does. How wonderful is the cultivation of the soil all over the earth, how marvelous the construction of buildings and cities, how skillful the control of the waterways!" It reminds one of Cicero and the lyrical passages of St. Augustine. "Man is really the vicar of God, since he inhabits and cultivates all elements and is present on earth without being absent from the ether." He uses and rules the animals, which despite their natural gifts of self-protection fight a losing battle with him. In a passage strongly reminiscent of Philo's remarks (*On the Creation*, 84–85) which already have been quoted, Ficino asks,

> Who has ever seen any human beings kept under the control of animals, in such a way as we see everywhere herds of both wild and domesticated animals obeying men throughout their lives? Man not only rules the animals by force, he also governs, keeps and teaches them. Universal providence belongs to God, who is the universal cause. Hence man who provides generally for all things, both living and lifeless, is a *kind* of god.[3]

The more one studies the early history of the idea of man as a controller of nature, the more one is struck with the depth of this awareness of power, particularly over the larger animals. Historically, these broader conclusions based on successes in plant and animal domestication have been of the utmost importance in shaping attitudes toward other forms of life. Ficino's interpretation of man's part in modifying the earth differs also from the religious interpretation which came from the monastic orders, especially in the Middle Ages. With the monks, clearing, the establishment of monasteries, and conversions are but different aspects of one activity, the founding of the kingdom of Christ on earth. Ficino's emphasis is different: those qualities which enable

[2] Marsilio Ficino, *Platonic Theology*, Bk. XIII, chap. 3, selections trans. Josephine L. Burroughs, *JHI*, Vol. 5 (1944), pp. 227–239.
[3] *Ibid.*, p. 234.

man to do what he does, to make the changes of the earth he is capable of making, and to force the lower orders of life to do his bidding are those qualities which bring him closest to the divine and which mark him off most decisively from all other kinds of life. The conclusion is irresistible that it is the uniqueness of man that enables him to perform the wonders he does perform.

Although it is difficult to see any marked change in the ideas being discussed from the Middle Ages to the Renaissance, nevertheless in the latter period, if one is to judge from the writings of men like Leonardo, Paracelsus, Agricola, and Palissy, there is a more self-conscious and self-confident attitude toward artisanship, invention, and technology. Basically this awareness is an enlargement of the observation that through human agency things existing in one form in nature are transformed into another form inconceivable without the intervention of man. Man is not a creator of raw materials—God is; but man is a powerful transformer; this, as we shall see, is a leading idea of Paracelsus.

There is little doubt of this growing self-consciousness in the Renaissance regarding the power of man to transform not only the elements but the landscape. The interest in the things of this world was greater than in the Middle Ages; the rediscovery of the literature of classical antiquity included the technical literature such as Vitruvius' work as well, and the technology of the Middle Ages could be improved and built upon. "Technical achievement received special stimulus during the Renaissance period from greater general preoccupation with active life and from the increased desire of many a far-seeing craftsman for intellectual enlightenment and a scientific foundation for his customary rule-of-thumb manual work."[4]

In technical writings on architecture, mining, canal building, and metallurgy one often finds comments concerned with the broader implications of transformations being made or of the planning that brings them about. Thus Leon Battista Alberti's broad conception of the nature of an architect's duties was based not only on science as he knew it, but on a philosophy of man, human aspirations stimulating activities which lead to planning and to changing the landscape. Alberti is quite conscious of human ability—it shows itself in the long history of artisanship and invention. He observes that one can beautify nature, including in the adornment the surviving relics of the Italian past. He is well aware too of the role of plant introductions in the aesthetic and economic life of a country.[5]

> Why should I insist on the great plenty of Waters brought from the most remote and hidden Places, and employed to so many different and useful Purposes? Upon Trophies, Tabernacles, sacred Edifices, Churches and the like, adapted to divine Worship and the Service of Posterity? Or lastly, why should I mention the Rocks cut, Mountains bored through, Vallies filled up, Lakes confined, Marshes discharged into the Sea, Ships built, Rivers turned, their Mouths cleared, Bridges laid over them, Harbours formed, not only serving to Men's immediate Conveniences, but also opening them a way to all Parts of the World.[6]

[4] Klemm, *A History of Western Technology*, p. 111.
[5] *Ten Books on Architecture*, trans. Leoni, Bk. VI, chap. 4.

Leonardo da Vinci was also interested in technology and planning and their relation to the physical environment. A man who could say, "Every large river may be led up the highest mountains on the principle of the siphon," showed that he understood the relationship of physical theory to applied technology through a middle term of resolute human activity.[7] In a country with a long tradition of land reclamation, river control, and canal construction, it is not surprising that Leonardo, a canal builder, would often see that the ability of man to change his environment was related to water and its control. Rivers, he said, deposit more soil when they are near populated districts. Because the mountains and hills are cultivated, the rains can wash away the loose soil much more easily than they can a hard ground covered with weeds. Leonardo observed the erosive power of water and its role as a leveling agent. "The water wears away the mountains and fills up the valleys, and if it had the power it would reduce the earth to a perfect sphere." Later, applying this principle, he proposes the purposeful use of running water to fill up the marshes with the soil of mountains, thus purifying the air as well.[8]

One finds in Leonardo what one finds also in Paracelsus, Palissy, Agricola, and Bacon, an admiration for the inventor and experimenter, the skilled of hand, and a contempt for the pretensions of authority: "If indeed I have no power to quote from authors as they have, it is a far bigger and more worthy thing to read by the light of experience, which is the instructress of their masters. They strut about puffed up and pompous, decked out and adorned not with their own labours but by those of others, and they will not even allow me my own."[9]

Another attempt, broad and philosophic in scope like Ficino's and Francis Bacon's, to interpret intelligent and creative man—in his ordinary daily activities, in health and illness, in the work with tools which changed his surroundings—as a vital part of the cosmos, was made by the celebrated physician and student of alchemy and natural history, Theophrastus Bombastus von Hohenheim (Paracelsus). Paracelsus considers a problem which Bacon, steeped in star lore and in the teaching of Romans 1:20, will also consider, of a unified conception of man, coming from three different strands of thought: The creation of man as an event in God's six days' work, the effects of the curse on man, and the relation of these two events to human creativity.

Paracelsus solves the first problem by using the ancient idea of the macrocosm, the whole universe, and the microcosm, man, who has the same elements

[6] *Ibid.*, p. x. Quoted in Klemm, *op. cit.*, pp. 112–113.
[7] *The Notebooks of Leonardo da Vinci*, ed. MacCurdy, p. 775.
[8] *Ibid.*, p. 310, quote on p. 317, and p. 322.
[9] *Ibid.*, p. 57.

within him but in different forms and who reflects, in a small way, the processes characteristic of the whole. In creating man, the microcosm, God plans that he shall collaborate in the creation, and alchemy becomes a technique, a method, a philosophy of change and transformation all in one, whose purpose it is to put the finishing touches on a nature uncompleted at the creation.

The solution to the second problem is breathtaking and bold, and quite out of keeping with the traditionally gloomy and pessimistic interpretations of the Fall. During the six days' work all matter was created, but art, that is, artisanship and craft and the "light of nature," was not. This celebrated phrase of Paracelsus, when applied to man, meant his creative faculty. Man did not possess this light of nature at the creation; it was bestowed upon him when Adam was driven from Paradise, man being commanded to work with his hands, woman to bring forth children in sorrow. Adam and Eve, who in Paradise resembled heavenly creatures, now become earthly. Since Paracelsus obviously believes that necessity is the mother of invention, "Eve was taught to bring up her children, and thus cradles and nursing came into being." As a creature of earth, man required a reason and an understanding of which he had no need as a heavenly creature living in Paradise. When man was expelled from Eden, he received from the angels their knowledge but not all knowledge. Henceforth man also had to ferret out the secrets of nature by craft. "For he and his children must learn one thing after another in the light of Nature, in order to bring to light that which lies hidden in all things. For although man was created whole as regards his body, he was not so created as regards his 'art.' All the arts have been given him, but not in an immediately recognizable form; he must discover them."[10]

Furthermore, it is God's will that we do more than accept nature as we find it. We must "investigate and learn why it has been created. Then we can explore and fathom the use of wool on the sheep and of the bristles on the sow's back; so we can place each thing where it belongeth, and can cook raw food so that it tasteth good in the mouth, and can build for ourselves winter apartments and roofs against the rain. . . ."[11]

All things on earth have been given into the hands of man "in order that he may bring them to the highest development, just as the earth does with all that it brings forth." This task means striving, exploration, and inquiry; man has the obligation to improve upon what has been given him. Consistent with his belief that necessity is the mother of invention and that created things exist to entice man into activity, Paracelsus says that because created things are made for man, he needs them and must explore everything in the creation. In Paracelsus' philosophy, man is restless, curious, active, his status in the world being determined by a God whose secrets are not visible but must be discovered. "It is not God's will that His secrets should be visible; it is His will that they become manifest and knowable through the works of man who has been created in order to make them visible." God is revealed in his works; so is man; hence, the need for man to work continually to discover God's gifts to him.[12]

[10] *Paracelsus, Selected Writings*, pp. 176–177. From "Das Buch Paragranum," in *Paracelsus Sämtliche Werke*, ed. Sudhoff and Matthiessen, Pt. I, Vol. 8, pp. 290–292. Quoted in Klemm, *op. cit.*, p. 144; I am indebted to this work for the references to P.

[11] "Die Bücher von den unsichtbaren Krankheiten," 1531–1532, Sudhoff, Vol. 9; Klemm, p. 144.

This introduces the third point and leads to an examination of the nature of human art and creativity, especially as they bear on technology and toolmaking, the means by which man can transform nature. Paracelsus' answers are reminiscent of the fire and the smoke of the foundry, the clank and the bustle of the mines, and redolent with the wood and the shavings of the carpenter's shop, with which he, in his journeys, was quite familiar. Paracelsus believed what was written in the Bible, that everything was created from nothing; but the creation, even if entirely accomplished, was not entirely completed. He believed that the earth was created for man, that it surrounded him as the flesh of the apple surrounds its core with its seeds. The completion of the creation is therefore envisaged anthropocentrically: everything was created *ex nihilo* but not in the form in which it is used by man. The necessary completion of the creation is accomplished by fire and its master, Vulcan. "God hath created iron, but not that which can be made from it, not rust or iron bars or sickles; only iron ore, and as ore he giveth it to us. The rest he commandeth to Fire, and to Vulcan, the master of Fire. It followeth that iron itself is subject to Vulcan, and so is the craft thereof." Fire is the powerful agent of change whether one is smelting ore or baking bread. Neither does God create medicines in completed form: it is fire which separates the medicine from the dross.

Thus alchemy, most frequently through the use of fire, is a human creation, an art, a means of completing the creation. The alchemist is identical with the artisan. "Thus there are alchemists of wood, such as carpenters who prepare the wood that it may become a house; also the woodcarvers who make of the wood something quite alien to it, and thus is a picture formed from it." God creates nothing to perfection, but he commands Vulcan to complete the process: "Bread is created and bestowed on us by God; but not as it cometh from the baker; but the three vulcans, the cultivator, the miller and the baker make of it bread."[13] He has in mind the Greek conception of Hephaestus as a craftsman's god, as a divine craftsman. In these lines Paracelsus not only expresses his philosophy of alchemy but shows his affinity with the age-old no-

[12] *Paracelsus*, pp. 182–184; *Lebendiges Erbe*, pp. 113–116; Sudhoff, Pt. I, Vol. 7, pp. 264–265; Vol. 14, pp. 116–117; Vol. 12, pp. 59–60.

[13] "Labyrinthus Medicorum errantium," 1537–38, in *The Hermetical and Alchemical Writings of Paracelsus*, trans. Waite; *Paracelsus. Selected Writings*, p. 185; Klemm, p. 145. See Jacobi, ed., Theophrastus Paracelsus *Lebendiges Erbe* (Zürich and Leipzig,

tions of man as a doer, maker, finisher, expressed, as we have seen, in the Stoic and Hermetical writings.

Like Paracelsus, Georgius Agricola (George Bauer) thought that manual work was more than ordinary daily activity, that it was embodied in a philosophy as well; he "was another of those truly versatile men of the Renaissance who combined with humanist learning a mind directed to the contemplation of Nature and also to practical technological activity."[14] Of special interest to our theme is Agricola's defense of mining, which, he insists, requires great skill not only in the craft itself but in prospecting for ores. It is an error to emphasize its temporary nature, he says, citing examples of mines whose ores are unexhausted after hundreds of years, in contrast with the permanence of agriculture. The real problems of health and safety in mines cannot be met by advocating the abolition of mining because it is dangerous. He is particularly severe on the opinion that mining is useless because metals perform no fundamental service either to the soul or to the body of man.

Agricola scarcely dignifies with a reply a teleological argument that if it had been nature's design to make the products of mines available to man, the ores would have been close to the surface. He scorns the notion that the earth hides nothing, keeps nothing, conceals nothing that is useful or necessary to man, but "like a beneficent and kindly mother she yields in large abundance from her bounty and brings into the light of day the herbs, vegetables, grains, and fruits, and the trees."[15] Because minerals, on the other hand, lie deeply buried it cannot be argued that they should not be sought after.

In another important passage Agricola denounces the belief—apparently widely held in his time—that mining is a destroyer of nature. The strongest argument

> of the detractors [of mining] is that the fields are devastated by mining operations, for which reason formerly Italians were warned by law that no one should dig the earth for metals and so injure their very fertile fields, their vineyards, and their olive groves. Also they argue that the woods and groves are cut down, for there is need of an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish a pleasant and agreeable food for man. Further, when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away. Therefore the inhabitants of these regions, on account of the devastation of their fields, woods, groves, brooks and rivers, find great difficulty in procuring the necessaries of life, and by reason of the destruction

1942), and *Paracelsus. Selected Writings*, Eng. trans. Guterman, for many selections from Paracelsus on a wide variety of topics; both have a valuable glossary of terms used by P.

[14] Klemm, *op. cit.*, p. 145.

[15] *De re metallica*, Bk. I, Hoover trans. p. 7.

> of the timber they are forced to greater expense in erecting buildings. Thus it is said, it is clear to all that there is greater detriment from mining than the value of the metals which the mining produces.[16]

To these arguments Agricola made two replies, one touching upon the specific abuses mentioned, the other raising the broader philosophical issue of the usefulness of metals to man.

Miners do slight damage if any to the fields, Agricola said, because they dig in otherwise unproductive mountains or in gloomy valleys. Cleared areas, with the roots of shrubs and trees removed, may be planted in grain, the bountiful crops of the new fields compensating for losses suffered because of higher timber prices. Birds, edible beasts, and fish furthermore can be purchased and stocked in these mountainous regions with the profits from the metal industry.

To all the more general objections to mining (including the one that metals, especially the nobler and the more valuable, are corrupters of mankind) Agricola replies simply that civilization cannot exist without metals. None of the arts is older than agriculture, but the metal arts "are at least equal or coeval, for no mortal man ever tilled a field without implements."[17] Even though he respects the honesty, innocence, and goodness of men who despise metals for the corruption and calamities they have brought upon the human race, to him they are putting the blame in the wrong place. War cannot be blamed on the metals; lacking iron or bronze, men would fight with their hands. Agricola insists on blaming human nature, not advances in metallurgy, for slaughter, robbery, and war. To speak ill of metals is to accuse and condemn as wicked the Creator himself, for by the condemnation of these, men assume that the Creator fashioned something in vain and without good cause. Pious and sensible men cannot conceive of the Creator being the author of evils.[18]

Metals are not concealed in the earth to prevent man from getting at them, "but because provident and sagacious Nature has appointed for each thing its place." He ridicules the argument that the metals were concealed because they were not intended for use by pointing out that man, a terrestrial animal, goes into the depths of the sea to fish and it is stranger for man to search the sea than to search the bowels of the earth. Moreover, birds live in the air, fish, in water, other creatures have the earth, particularly man, so that "he might cultivate it and draw out of its caverns metals and other mineral products." Agricola gives a lengthy list of the uses of metals in various occupations where they are needed directly, or indirectly through metal-made tools to perform the required tasks. "If we remove metals from the service of man, all methods of protecting and sustaining health and more carefully preserving the course of life are done away with." Without them Agricola thinks men could only

[16] *Ibid.*, p. 8.

[17] *Ibid.*, Pref., p. xxv.

[18] *Ibid.*, Bk. I, pp. 11–12.

live lives like those of wild beasts. Men should not try to degrade the metals; as a creation of nature they supply human needs of man, both adorning man and being useful to him.[19]

In *The Admirable Discourses* (1580), Bernard Palissy expressed a similar philosophy, that once the truth about nature has been discovered men should do what is necessary to profit from the discovery. Contemptuously disclaiming any knowledge of the classical languages, Palissy scorned also those who were more interested in written authority than in observation. His attitude toward authority was similar to Leonardo's.

> Once I knew without any doubt that the waters of natural fountains were caused and produced by rains, I have thought that it was stupid for those who possess lands barren of water not to learn ways of making fountains, seeing that God sends waters on sandy lands as well as on others, and that it takes very little science to know how to catch it. If the ancients had not otherwise studied the works of God, they would have lived on the pasturage of animals, they would only have taken the fruits of the fields as they came, without work: but they wisely decided to plant, sow and cultivate, to aid nature. That is why the first inventors of some good thing, to help nature, have been so honored by our predecessors, that they have thought them to be participants in the spirit of God. [God] wishes us to work to help nature. . . .[20]

Knowledge of the care of nature comes also through observation of its processes. In the *Dialogue on Waters and Fountains*, Theory asks if the trees along the mountain that he wishes to use for a park should be cut down.

> Good Lord, no! don't do that: for these trees will be very useful to you in this matter. There are in many parts of France, and particularly at Nantes, wooden bridges, where, to break the violence of water and ice against the pillars of these bridges, great quantities of upright posts have been placed in front of the pillars, for otherwise they would not last long. In the same way, trees planted along the mountain, where you wish to make your park, will serve much to reduce the violence of the waters, and far from advising you to cut them down, I would advise you to plant some if there were none: for they would serve to prevent the waters from excavating the ground, and by such means grass will be preserved, and along this grass the waters will flow quietly straight down to your reservoir.[21]

Alberti, Leonardo, Paracelsus, Agricola, and Palissy all lived during the fifteenth and sixteenth centuries, and they lived in widely scattered places. They were all unusual men; one of them, Leonardo, was a genius; the others

[19] *Ibid.*, pp. 12, 14, 18.

[20] *The Admirable Discourses*, pp. 58–59. Palissy here expounds his theory of the origin of springs and fountains in rainwater, but see p. 13 on the question of Palissy's originality. On his attitude toward authority see La Rocque's introduction to his trans. of the discourses.

[21] *Ibid.*, p. 63. See also his discussion of the multiple uses of land made possible by careful planning, p. 67, and of the importance of wood, pp. 71–72. "If I wanted to put in writing how great is the necessity of wood, and how impossible it is to do without it, I should never be finished" (p. 72).

were men of great talent. They all had in common an interest in technology, in artisanship, and in environmental change. They have, moreover, a kinship with the political theorist Giovanni Botero, who advised princes to concern themselves with improving their kingdoms through drainage or clearing; they also have a kinship with Albrecht Dürer, who, like Leonardo an artist, engineer, and artisan, was interested in improving artisanship by more exacting scientific and mathematical methods.[22]

3. Francis Bacon

Broadly speaking, there was a growing optimism throughout the seventeenth and eighteenth centuries that man's accumulating knowledge was increasing his control over nature. There were dissenters who still saw in classical antiquity an early apogee of human accomplishment, or who believed in a senescence in nature or that the curse on man was accompanied by a curse on nature as well. The optimistic trend, however, can be observed in Agricola, in Paracelsus, and in Francis Bacon whose name is associated with the early history of the scientific method, with speculation on the application of theoretical science to applied science and technology, and with the broad question of man's control over nature. Bacon has much of interest to say on this last theme, some that is reminiscent of medieval thought, some that resembles the thought of the eighteenth and nineteenth centuries.[23]

In his plea for an understanding of nature (he uses this word synonymously with the creation), Bacon warns that men should realize they are dealing with a creation of God, not a construct of the human mind.

> For we copy the sin of our first parents while we suffer for it. They wished to be like God, but their posterity wish to be even greater. For we create worlds, we direct and domineer over nature, we will have it that all things *are* as in our folly we think they should be, not as seems fittest to the Divine wisdom, or as they are found to be in fact; and I know not whether we more distort the facts of nature or our own wits; but we clearly impress the stamp of our own image on the creatures and works of God, instead of carefully examining and recognising in them the stamp of the Creator himself. Wherefore our dominion over creatures is a second time forfeited, not undeservedly; and whereas after the fall of man some power over the resistance of creatures was still left to him—the power of subduing and managing them by true and solid arts—yet this too through our insolence, and because we desire to be like God and to follow the dictates of our own reason, we in great part lose. If therefore there be any humility towards the Creator, any reverence for or disposition to magnify His works, any charity for man and anxiety to relieve his sorrows and necessities, any love of truth in nature, any hatred of darkness, any desire for the purification of the understanding, we must entreat men again and again to discard, or at least set

[22] See Klemm, *op. cit.*, p. 131.

[23] Francis Bacon, 1561–1626. *Advancement of Learning*, 1605; *Novum Organum*, 1620; *New Atlantis*, 1629.

> apart for a while, these volatile and preposterous philosophies, which have preferred theses to hypotheses, led experience captive, and triumphed over the works of God; and to approach with humility and veneration to unroll the volume of the Creation, to linger and meditate therein, and with minds washed clean from opinions to study it in purity and integrity.[24]

Human ignorance is like a second fall of man; it is, like the Fall, also a form of failure if the old philosophy can triumph even over the words of God. In the exhortation to "unroll the volume of the creation," Bacon makes good use of the old idea of learning in the book of nature.

Bacon's philosophy of man's attaining control over nature by cultivating the arts and sciences and encouraging invention is not divorced from religion; it is a vital part of religion, being closely related to the history of the creation and to the fall of man. Repeatedly he invokes the lesson of Genesis that the creation of light took place on the first day; when he says that experiments should imitate the creation of light, human science is exalted by the comparison with divine creation. ". . . We look for experiments that shall afford light rather than profit, imitating the divine creation, which, as we have often observed, only produced light on the first day, and assigned that whole day to its creation, without adding any material work."[25]

To Bacon, the fall of man, "the sin of our first parents," was of decisive importance in the subsequent history of both man and nature, as is apparent in the eloquent closing lines of the *Novum Organum*:

> For man, by the fall, lost at once his state of innocence, and his empire over creation, both of which can be partially recovered even in this life, the first by religion and faith, the second by the arts and sciences. For creation did not become entirely and utterly rebellious by the curse, but in consequence of the Divine decree, "in the sweat of thy brow shalt thou eat bread," she is compelled by our labors (not assuredly by our disputes or magical ceremonies), at length, to afford mankind in some degree his bread, that is to say, to supply man's daily wants.

Not only are separate roles assigned to religion and faith and to the arts and sciences, but the latter mitigate the physical consequences of the first fall and of the second fall (that is, the adoption of philosophies that prevent an investigation and understanding of nature.)

How does Bacon envisage human control over nature? For one thing, it is a lofty and objective position for man, as one would expect from the comparisons with the creation of light. This position is revealed in the famous passage on the three ambitions: men may want to enlarge their own power in

[24] "The Natural and Experimental History for the Foundation of Philosophy: or Phenomena of the Universe: Which is the Third part of the Instauratio Magna," *The Works of Francis Bacon*, ed. Spedding, Ellis, and Heath, Vol. 5 (Vol. 2 of the translations of *The Philosophical Works*), pp. 131–134. Quotation on p. 132.

[25] *Novum Organum*, Bk. I, Aph. 121.

their own country, an ambition which Bacon thinks vulgar and degenerate; men may strive to enlarge the power and empire of their native country over mankind, a more dignified ambition than the first, but still covetous; or they may strive for an enlargement of the power of man over the whole universe, a sounder and a nobler ambition. Bacon follows the passage on the three ambitions with one of the most quoted of his sentences: "Now the empire of man over things is founded on the arts and sciences alone, for nature is only to be commanded by obeying her."[26]

In the goal for the knowledge that will lead to mastery over nature, Bacon has little patience with those who think the ancient world superior. The present is a true antiquity. One expects more from an old than from a young man; similarly, since the world now is older, its stock has increased, and so have experiments and observations. Bacon is struck by the recent expansion of man's geographic vision; it must be matched by a comparable growth in his intellectual vision. The contrast between the fresh air of the voyages and discoveries and the stale adherence to authority and to classical knowledge is a fundamental observation in his philosophy. Men must rise to the opportunities afforded them by the age of discovery.

"It would, indeed, be dishonorable to mankind, if the regions of the material globe, the earth, the sea, and stars, should be so prodigiously developed and illustrated in our age, and yet the boundaries of the intellectual globe should be confined to the narrow discoveries of the ancients."[27]

The importance of voyages and travels to discovery and invention, in the interchange of ideas which lead to further mastery over nature, is clear when the governor of the *New Atlantis* describes the mission of the three fellows of Saloman's House, who set out in two ships "to give us knowledge of the affairs and state of those countries to which they were designed; and especially of the sciences, arts, manufactures, and inventions of all the world; and withal to bring unto us books, instruments, and patterns in every kind. . . ." The governor, remembering the creation of light on the first day, continues, "But thus you see we maintain a trade, not for gold, silver, or jewels, nor for silks, nor for spices, nor any other commodity of matter; but only for God's first creature, which was light; to have light, I say, of the growth of all parts of the world."[28]

In Bacon's thought the voyages of discovery, especially those of scientific travelers, become a standing rebuke to those who uncritically accept authority and precedent in an age conscious of the stimulus that comes from the broadening of its horizons. In fact there seems to be a parallel between the voyages of discovery and invention, for philosophies and sciences founded

[26] *Ibid.*, Aph. 129.

[27] *Ibid.*, Aph. 84.

[28] "New Atlantis," in *Ideal Commonwealths*, World's Greatest Literature ed., pp. 119–120.

on nature grow; those on opinion, neither change nor increase. Comparing the stationary sciences unfavorably with the mechanical arts, Bacon says that the latter "are founded on nature and the light of experience, for they (as long as they are popular) seem full of life, and uninterruptedly thrive and grow, being at first rude, then convenient, lastly polished, and perpetually improved."[29] Bacon hints here at an ideal series of stages in the development of technology.

Saloman's House, known also as Solomon's House and as the College of the Six Days' Works (the latter name showing Bacon's attraction to the symbolism of the hexaemeral creation, beginning with the creation of light), was named, says the governor, after the king of the Hebrews "famous with you, and no strangers to us"; here some of his works, lost elsewhere, have been preserved, including Solomon's "natural history which he wrote of all plants, from the cedar of Libanus to the moss that groweth out of the wall; and of all things that have life and motion." Saloman's House, as described by the governor, represents that active aspect of Christian thought which worships the workmanship of God in the creation, sees at the same time the usefulness of created things to man. Our king [he said] learned from the Hebrews that God created the world within six days, "and therefore he instituted that house, for the finding out of the true nature of all things, whereby God might have the more glory in the workmanship of them, and men the more fruit in their use of them, did give it also that second name."[30]

Since Saloman's House is such an important institution in New Atlantis, where the arts, science, ethics, and religion are intertwined to the strength and the glory of all, one would expect, in addition to more invention, more research in medicine, more inquiry in the fields of theoretical science, an active interest in transforming the environment in the service of mankind; in these proposals, moreover, there is no hint that environmental change by man might ever be undesirable. "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."[31]

In New Atlantis, a great variety of composts and soils make the earth fruitful. Salt- and fresh-water lakes are exploited for their fish and fowl; natural bodies are buried in them, too. Salt water is made into fresh, fresh water into salt. Streams, cataracts, and "engines for multiplying and enforcing of winds" are sources of power. In the orchards and gardens "we do not so much respect beauty as variety of ground and soil, proper for divers trees and herbs, and some very spacious, where trees and berries are set, whereof we make divers kinds of drinks, beside the vineyards." Grafting is much practiced. Gardens, trees, flowers, are made by art to ripen earlier or later than they would naturally. By art also they are larger, their fruit sweeter, their taste, smell, color, and figure different. Many are discovered to have medicinal value. "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."

Parks and enclosures for beasts and birds are used not only for view or rareness but likewise for dissections and trials, to discover through them "what may be wrought upon the body of man." Experiments of like kind are made on fish, and breeding places are set aside for worms and flies.[32]

In New Atlantis the human activities which affect the natural environment are primarily those concerned with agriculture and horticulture (soil fertilization, plant breeding and selection) and the use of the waters and the winds as energy to drive the machines of an industrial society in the service of God and man. "We have certain hymns and services, which we say daily, of laud and thanks to God for His marvellous works. And forms of prayers, imploring His aid and blessing for the illumination of our labors; and turning them into good and holy uses."[33]

4. Optimism of Seventeenth Century Writings

In the spirit of Bacon and Romans 1:20, Sir Thomas Browne says he will find evidences of Him in nature, "that universal and publick Manuscript," the servant of God. The world "was made to be inhabited by Beasts, but studied and contemplated by Man; 'tis the Debt of our Reason we owe unto God, and the homage we pay for not being Beasts; without this, the World is still as though it had not been, or as it was before the sixth day, when as yet there was not a Creature that could conceive, or say there was a World." Again we meet the thought that it is God-given reason possessed alone by man that gives meaning to the creation. And the higher man's endowment the better is this meaning understood. It is not "those vulgar Heads that rudely stare about, and with a gross rusticity admire his works" who honor the wisdom of God, but those "whose judicious inquiry into His Acts, and deliberate research into His Creatures, return the duty of a devout and learned admiration."[34]

Man is an "amphibious piece between a corporal and spiritual Essence"; indeed he is a microcosm, for he embodies in his own life all five kinds of existence. First he is a rude mass of dull being "not yet privileged with life,"

[29] *Novum Organum*, Bk. I, Aph. 74.
[30] *New Atlantis*, p. 119.
[31] *Ibid.*, p. 129.
[32] *Ibid.*, pp. 129–132.
[33] *Ibid.*, p. 137.
[34] *Religio Medici*, Gateway ed., Pt. I, sect. 16, p. 27; sect. 13, p. 24. Browne wrote the *RM* in 1635 and it was first published in 1643.

then successively he lives the lives of plants, animals, man, and finally spirits. In "one mysterious nature" man with these five kinds of existences comprehends the creatures of the world and of the universe; "thus is man that great and true Amphibium," a spanner of worlds. The embodiment of all five existences in his life uniquely qualifies him for his role on earth. God made the creation for His own glory and then made man as the only being able to do him homage.[25] His creation on the sixth day changes completely the meaning of the creative acts which preceded him. If we add (which Browne did not) the injunctions of Genesis 1:28, man becomes God's workman and governor of nature. The most highly gifted men through inquiry and research will accomplish these tasks the best. Sir Matthew Hale will expand eloquently on this theme. (See pp. 481–482.)

Like Bacon, Descartes had confidence in the power of knowledge to control the environment; in fact, the relevant passage in the *Discourse on Method* has become almost as famous as Bacon's statement that we can command nature only by obeying her. Perhaps his enthusiasm for technology as an ally in the struggle to better the lot of the human race may have been intensified by his studies and observations during his residence in the Netherlands, where dramatic transformations of the land by drainage and polder making were then taking place.

To digress for a moment, one could write an illuminating essay on the influence of Dutch hydraulic engineering on optimistic interpretations of modifications of the land by human agency. The first half of the seventeenth century was a golden age of accomplishment; even before this, the expert outside the dikes, Andries Vierlingh, wrote in old age his work on making dams, dikes, and sluices and "creating new land from sandbanks or sandy foreshores." Of the work Vierlingh wrote, "It is not really such a great art, a shepherd might be able to imitate it. But making new land belongs to God alone. For He gives to some people the intelligence and power to do it. It takes love and very much labour, and it is not everybody who can play that game." After the year 1600, windmills became active pumpers on a large scale. Jan Leeghwater (1575–1650), the expert inside the dikes, also writing in old age, had seen the face of the country change in his own lifetime. In the peninsula north of Amsterdam he had by 1640 counted twenty-seven lakes which had been pumped dry, and he himself proposed draining the Haarlemmermeer with the help of a hundred and sixty windmills. Finally Cornelius Vermuyden, commissioned by James I in 1621 to repair the Thames wall at Dagenham, remained to supervise the draining of the fens.[26]

When, Descartes says, he had acquired knowledge of "certain general notions in physics," when he realized how much these principles differed from those of the past which were still being honored, he could not withhold his knowledge "without greatly sinning against the law which enjoins upon us the duty of procuring, as well as we can, the general good of mankind." It is now possible to attain knowledge of "the utmost use" to men, a practical knowledge which can gain ascendancy over the speculative philosophy taught in the schools. By means of this practical knowledge, "by ascertaining the force and action of fire, water, the air, the heavenly bodies, and the skies, of all the physical things that surround us, as distinctly as we know the various trades of our artisans, we can apply them in the same way to all the uses for which they are fit, and thus make ourselves, as it were, the lords and masters of nature."[27]

Leibniz, also, saw the possibilities of the arts and sciences contributing to the advancement of mankind. He repeatedly made proposals for their promotion, including elaborate plans for exhibitions, museums, and academies. He was impressed with the vastness of human knowledge; it was difficult to ascertain how much was known because so much valuable knowledge was unrecorded. He believed in learning from the occupations of daily life, from men—and children too—at play, whether at games of skill or of chance. "Concerning unwritten knowledge scattered among men of different callings, I am convinced that it surpasses in quantity and in importance anything we find in books, and that the greater part of our wealth is not yet recorded."[28]

With his ideas of a divinely preestablished harmony, his enthusiasm for the doctrine of final causes, his conviction that the arts and sciences were on the march, that, encouraged, they would prevent a return to barbarism, with his belief that progress was characteristic of the cosmos, Leibniz saw no reason why the inevitable progress of mankind could not be balanced by a similar process with relation to the earth, its ultimate perfection being a witness of the cumulative talents of man:

> And in addition to the general beauty and perfection of the works of God, we must recognize a certain perpetual and very free progress of the whole universe, such that it advances always to still greater improvement (*cultum*). It is thus that even now a great part of our earth has received cultivation and will receive more and more. And although it is true that sometimes certain parts of it grow up wild again or again suffer destruction and deterioration, this nevertheless must be understood as we interpreted affliction above, that is to say, this very destruction and deterioration leads to some greater result, so that we profit in some way by the loss itself.[29]

[25] *Ibid.*, Pt. 1, sect. 34–35, pp. 52–54.

[26] Van Veen, *Dredge, Drain, Reclaim*, pp. 34–47. The quotes are on pp. 34, 39. On Dutch activity abroad, pp. 47–59 with maps. See also L. E. Harris, "Land Drainage and Reclamation," in *A History of Technology*, ed. Singer *et al.*, Vol. 3, pp. 306–308, 319.

[27] Descartes, "Discourse on Method," 6, in *Discourse on Method and Other Writings*. Trans. with an intro. by Arthur Wollaston. Penguin Books (1960), p. 84.

[28] "Discourse Touching the Method of Certitude, and the Art of Discovery in Order to End Disputes and to Make Progress Quickly," *Leibniz Selections*, ed. Wiener, pp. 46–47.

[29] "On the Ultimate Origin of Things" (1697), *Leibniz Selections*, ed. Wiener, p. 354.

This is an important passage because it reveals the optimism possible in the doctrine of final causes and in the idea of a preestablished harmony which includes the earth as a physical body within this harmony. All changes on the whole can be for the best; the entire earth will ultimately be cultivated like a garden. The slow gathering of isolated fragments of information showing that man could cumulatively make undesirable changes in nature, that these could not be overcome by mere belief in an inevitable progress, unfortunately have proved this assumption, this bold vision of Leibniz, wrong.

The spirit of Francis Bacon and Descartes and their precursors, Leonardo, Paracelsus, Agricola, and Palissy, continued among many prominent thinkers of the seventeenth century to whom the industry of man, lifted to a higher plane of human experience, illustrated a widening control over nature through the arts and sciences. Philosophically this industry might be considered as an exercise of the mind and the skillful hand toward desirable ends, theologically as the activity of a being who was both a steward of God on earth and a worshipper of the divine workmanship he could see everywhere in nature, and practically as useful activity which used the earth's resources and brought order to an otherwise chaotic nature. This vision of man's controlling nature and changing his environment was to Descartes evidence of a remarkable achievement, a divorcement from the past, and to Leibniz evidence of a progress characteristic of the cosmos.

We have already seen the role that Hakewill (and John Jonston of Poland, a popularizer of his work) played in combatting the notion of a decay of nature sponsored so vigorously by Godfrey Goodman. Hakewill believed that the earth would come to an end, as predicted in the Bible; how this end would come about he thought was unascertainable by reason; it would be brought about by a miracle. Since he did not believe that any processes now observable on earth were bringing about its decay in the sense that an organism decays, he became a Columella against Lucretius and discovered more immediate and plausible reasons for changes taking place in the environment.[40]

The quality of Hakewill's mind and his discernment are revealed in his discussion of the physical decline of the Holy Land. Hakewill says it has undoubtedly decayed; possibly its early fruitfulness may have been a special favor of God. (Quotes Deut. 11:3, Levit. 26, "If you walk in mine ordinances and keep . . ." etc.) The decline there, he concludes after considering Scripture and the reports of Brocardus' *De Terra Sancta* (Pt. 2, chap. 1), may be owing to the curse of God or to "their ill manuring of the earth, (from which the proverbe seems to have growne, that where the Grand Signiors

[40] For a comparison between the views of Hakewill and Goodman on the decay of the world, the earth being designed for man, teleology, and final state of the earth, see Victor Harris, *All Coherence Gone*, pp. 82–85.

horse once treades, the grasse never growes afterward), than to any *Naturall decay* in the goodness of the soyle." Labor and industry have a dignity in Hakewill's conception of man's relation to the earth, for human industry makes things better than unassisted nature could. "And it is certaine that God so ordained it, that the *industry of man* should in all things concurre with the *workes of Nature*, both for the bringing of them to their perfection, and for the keeping of them therein being brought unto it."[41]

The conflict between the older pessimistic ideas regarding the effects of the curse on nature and modern aspirations for improvement in the natural surroundings by purposeful and planned industry is well brought out in Robert Burton's *The Anatomy of Melancholy*.

Burton accepts this older pessimistic view of a decay in nature owing to the Fall, man's sins being reflected in the barrenness of the earth.[42] Among the secondary causes bringing these conditions about are unfriendly influences of the stars, though he grants that astrology inclines but does not compel, the air (meteors, bad weather inducing plague, referring to Giovanni Botero's observations of the unhealthiness of Cairo and Constantinople), earthquakes, floods, fires, and the animals at war with man. However, he does not take too serious a view of these calamities visited on man by the elements and by other forms of life; the knavery of man to man is far worse and cannot, like the others, be avoided.[43]

This conventional pessimism, however, does not mix well with other prescriptions of this authority on melancholy.[44] Burton in fact is very much interested in human creativity, in the increase of man's power to control nature. Citing Botero's observation with approval (quoted above, p. 371), Burton says that kingdoms, like men, are subject to melancholy. Rulers should improve the physical environment of their kingdoms to overcome this morbid state. He admires the Dutch and the improvements they have made in their country and contrasts the progress achieved by them with the inertia of his own countrymen.

> Yea, and if some travellers should see (to come nearer home) those rich United Provinces of Holland, Zealand, &c., over against us; those neat cities and populous towns, full of industrious artificers, so much land recovered from the sea, and so painfully preserved by those artificial inventions, so wonderfully approved, as that of Bemster in Holland, so that you would find nothing equal to it or like it in the whole world, saith Bertius the Geographer, all the world cannot match it, so many navigable channels from place to place, made by men's hands, &c., and on the other side so many thousand acres of our fens lie drowned, our cities thin, and those vile, poor, and ugly to behold in respect to theirs, our

[41] *Apologie*, pp. 151, 156. Quotes Columella, and Pliny, xviii, 3. Quotes Calvin, p. 157.
[42] *Anat. of Melancholy*, Part 1, sect. 1, memb. 1, subs. 1, pp. 113–114.
[43] *Ibid.*, pp. 113–117. On astrology, Part 1, sect. 2, memb. 1, subs. 4, p. 179.
[44] See also Victor Harris, *All Coherence Gone*, pp. 138–139.

trades decayed, our still running rivers stopped, and that beneficial use of transportation wholly neglected, so many havens void of ships and towns, so many parks and forests for pleasure, barren heaths, so many villages depopulated, &c., I think sure he would find some fault.[46]

Burton agrees with Botero that fertility of soil is not enough; art and industry must be added to it. Of Holland he says, "their chiefest loadstone which draws all manner of commerce and merchandize, which maintains their present estate, is not fertility of soil, but industry that enricheth them, the gold mines of Peru or New Spain may not compare with them."[46] He also agrees with Columella that there is no tiredness or exhaustion in the soil; it becomes barren through laziness; he is interested in the correct management of water, in irrigation, in the drainage of fens, bogs, and moors, in stream pollution, in the relation of water to disease, in running water, in the settling of water as it flows, and in the history of cisterns and aqueducts.[47]

In *The Primitive Origination of Mankind*, Sir Matthew Hale considered the broad questions posed by the multiplication and dispersion of mankind over the earth, man's place in the scale of being, and the implications of his growing control over nature. (See *supra* pp. 400–405.) To Hale man acts as the steward of God on earth, man is a being who creates order in what without him would be chaos; he implies that man's works, stimulated by self-conscious intelligence, and the control man has achieved over the lower forms of life confer a dignity and value on all life that it would not otherwise have. This is broader and more defensible than is the view that the earth is made for man.

In an exciting and imaginative discussion, Hale says that man's place in nature can be known from observation without revelation. The creation of man seems to have an end or a purpose with relation to the order of nature on earth. The wild untamable animals need man's coercive power to prevent their destroying the more profitable and weaker animals. Man can preserve from extinction the useful but easily destroyed domesticated animals; he can protect the useful birds; he can war on the beasts and birds of prey. He can play a similar role in the care of tender and delicate plants lest they become extinct or degenerate; fruit trees, herbs, choice flowers, are examples of his loving care. Man has a duty to protect the world from the ponding of water in marsh and bog, and from too luxurious a plant growth; his is a "superintendent industry" correcting their excesses lest the spontaneous plant production make of the earth a wilderness of trees, weeds, thorns, briars. Without a "superintendent Cultivation" the earth's surface would grow marshy, boggy, weedy, "overgrown with excessive excrescences." It is a frame of mind quite similar to Count Buffon's in the eighteenth century.

[46] *Anat. of Melancholy*, Intro., Democritus to the Reader, p. 72.
[46] *Ibid.*, p. 74.
[47] Part 2, sect. 2, memb. 1, subs. 1, pp. 397–398.

It does not take Hale long to dispose of the question of the curse. This infertility and unprofitable excrescence might be the result of man's sin; God foreseeing sin, also provided a remedy. Man had to work harder after the Fall, but his employment did not differ from the times in Eden where God put man in the garden to dress it and keep it.

To my knowledge, there is no more masterly exposition of Christian belief in the reality of man's dominion over nature as set forth in Genesis than the following words of Hale:

> In relation therefore to this inferior World of Brutes and Vegetables, the End of Man's Creation was, that he should be the Vice-Roy of the great God of Heaven and Earth in this inferior World; his Steward, *Villicus*, Bayliff or Farmer of this goodly Farm of the lower World, and reserved to himself the supreme Dominion, and the Tribute of Fidelity, Obedience, and Gratitude, as the greatest recognition or Rent for the same, making his Usufructuary of this inferior World to husband and order it, and enjoy the Fruits thereof with sobriety, moderation, and thankfulness.
>
> And hereby Man was invested with power, authority, right, dominion, trust, and care, to correct and abridge the excesses and cruelties of the fiercer Animals, to give protection and defence to the mansuete and useful, to preserve the *Species* of divers Vegetables, to improve them and others, to correct the redundance of unprofitable Vegetables, to preserve the face of the Earth in beauty, usefulness, and fruitfulness. And surely, as it was not below the Wisdom and Goodness of God to create the very Vegetable Nature, and render the Earth more beautiful and useful by it, so neither was it unbecoming the same Wisdom to ordain and constitute such a subordinate Superintendent over it, that might take an immediate care of it.
>
> And certainly if we observe the special and peculiar accommodation and adaptation of Man, to the regiment and ordering of this lower World, we shall have reason, even without Revelation, to conclude that this was one End of the Creation of Man, namely, To be the Vice-gerent [*sic*] of Almighty God, in the subordinate Regiment especially of the Animal and Vegetable Provinces.[48]

Sir Matthew Hale was a famous lawyer, far more famous as a chief justice and for his work on the English common law than for *The Primitive Origination of Mankind*. But the lawyer's touch is there, too. Man assumes tasks that a lawyer thinks should be done, the tasks of the steward, the bailiff. Hale outlines the legal obligations of a lord on earth to administer it justly, fairly, sternly, and without cruelty. The earth is in need of a superior creature to keep it in competent order, otherwise the balance in nature would be lost, forests and wilderness would engulf both the earth and man; the useful animals, the prey of savage beasts, would be on the road to extinction. Man is capable of this role because of his intellectual endowments, because of the *organum organorum*, the hand. He controls nature for the earth's sake and for his own. The hierarchy of life, the balance in nature on earth, is main-

[48] *Prim. Orig. of Man.*, p. 370; previous discussion is based on pp. 369–370.

tained and kept in order by the agency of man. "Thus the infinite Wisdom of Almighty God chains things together, and fits and accommodates all things suitable to their uses and ends."[49]

To Hale (and many seventeenth and eighteenth century thinkers agreed) man's control over nature is based on his position in the scale of being; he enjoys the topmost rung of the ladder, but he is a master whose rights are circumscribed by obligations, by a *noblesse oblige*. Man's position is a legal one; he is also an overseer of nature, like a husbandman with the earth as his farm, whose activities Hale describes in the language of law and commerce.

Man's "intellectual sagacity and contrivance" qualify him for his superintendency; he can domesticate the larger and more powerful animals—the horse, the elephant, and the camel—and make the weaker animals subservient to him. Man's ability to change nature by domesticating plants and animals seems to have impressed thinkers of this period as it did those of the past; Buffon also, as we shall see, is much impressed by it. Men's hands, manipulators of swords, pikes, arrows, darts, nets, traps, tools, give them an overwhelming advantage in struggles against the brutes. Man must continually exert his mastery over plants and animals; if he does not, he will be overwhelmed by them, an argument which anticipates the famous Romanes lecture of Thomas Henry Huxley in 1894.[50]

Men must actively interfere with brute nature, to use a characteristic expression of his time, in order to maintain civilization. Nature untouched by man is a lesser nature and the economy of nature is best where man actively superintends it. The role of man as a caretaker of nature, a viceroy, a steward of God in his relation with other forms of life, justifies both his place in the chain of being and the accomplishments of his technology—in clearing, mining, canal building, and many other activities which are perhaps not revolutionary nor radically divorced from the past, but which produce cumulative change.

In his *History of the Royal Society*—one might call it a history of Solomon's House—Sprat shows an equal enthusiasm for man as a changer of nature. Its dedication extols the value of the vulgar arts, its later pages, the wisdom of the creator as shown in his works. Sprat praises the practical things, the homely inventions and discoveries. The idea that man can improve upon nature by art is a source of pride and of self-congratulation.[51] Man can make these environmental improvements by plant introductions, by using animals, by comparative husbandry. There was no romantic primitivism in men like Sprat, in John Ray, nor later in Count Buffon. Civilization through

[49] *Ibid.*, p. 371; discussion is based on pp. 369–371.
[50] See "Evolution and Ethics. Prolegomena" (1894), in *Evolution and Ethics and Other Essays*. New York, 1896.
[51] Sprat, *History of the Royal Society*, pp. 119–121, 386.

the arts created an environment having little resemblance to the crude conditions of earlier periods in human history.

John Ray speaks for many devout Christians who are also self-confident admirers of and advocates of improvements in their natural surroundings.

> If a country thus planted and adorn'd, thus polished and civilized, thus improved to the Height by all Manner of Culture for the Support and Sustenance, and convenient Entertainment of innumerable Multitudes of People, be not to be preferred before a barbarous and inhospitable *Scythia*, without Houses, without Plantations, without Corn-fields or Vineyards . . . ; or a rude and unpolished *America* peopled with slothful and naked *Indians*, instead of well-built houses, living in pitiful Huts and Cabbins, made of Poles set endways; then surely the brute Beasts Condition, and Manner of Living, to which, what we have mention'd doth nearly approach, is to be esteem'd better than Man's, and Wit and Reason was in vain bestowed on him.[52]

Moreover, Ray made a cogent synthesis, including environmental changes by man within his physico-theology. This synthesis included the following elements: heavy reliance on teleological explanations of processes in nature, emphasis on the beauty and usefulness of nature, a vision of man as actively changing nature under the guidance of God, and the conviction that changes made by man become part of a harmony thus newly created.

To Ray, mankind clearly plays an active role in nature, and man advances by increasing his knowledge of the ways he can use the earth's resources. God designed the earth, providing an abundance for the use of man who, He knows beforehand, has the necessary reason and understanding to adapt its offering (while he is adapting himself to it) by means of discovery and invention to his own uses.[53]

In the following passage notable for its elegant smugness, Ray composes a speech for the Deity who tells man precisely what He has done for him.

> I have now placed thee in a spacious and well-furnish'd World; I have endued thee with an Ability of understanding what is beautiful and proportionable, and have made that which is so, agreeable and delightful to thee; I have provided thee with Materials whereon to exercise and employ thy Art and Strength; I have given thee an excellent Instrument, the Hand, accommodated to make use of them all; I have distinguished the Earth into Hills and Vallies, and Plains, and Meadows, and Woods; all these Parts, capable of Culture and Improvement by thy Industry; I have committed to thee for thy Assistance in thy Labours of Plowing, and Carrying, and Drawing, and Travel, the laborious Ox, the patient Ass, and the strong and serviceable Horse; I have created a Multitude of Seeds for thee to make a Choice out of them, of what is most pleasant to thy Taste, and of most wholesome and plentiful Nourishement. . . .[54]

[52] Ray, *Wisdom of God*, p. 165.
[53] *Ibid.*, p. 161.
[54] *Ibid.*, pp. 161–162.

There is no suspicion here of the Malthusian "niggardliness of nature," or of the Darwinian struggle for existence. "I have made thee a sociable Creature, [*Ζῶον πολιτικόν*] for the Improvement of thy Understanding by Conference, and Communication of Observations and Experiments." Furthermore, God has given man the curiosity to see strange and foreign countries, to improve his knowledge of geography, politics, and natural history.

> I persuade myself [Ray adds after the Deity has had his say] that the bountiful and gracious Author of Man's Being and Faculties, and all Things else, delights in the Beauty of his Creation, and is well pleased with the Industry of Man, in adorning the Earth with beautiful Cities and Castles; with pleasant Villages and Country-Houses; with regular Gardens and Orchards, and Plantations of all Sorts of Shrubs and Herbs, and Fruits, for Meat, Medicine, or Moderate Delight; with Shady Woods and Groves, and walks set with Rows of elegant Trees; *with Pastures cloathed with Flocks, and Valleys cover'd with Corn*, and Meadows burthened with Grass, and whatever differenceth a civil and well-cultivated Region, from a barren and desolate Wilderness.[85]

Many of these thinkers from Paracelsus and Agricola to Bacon and Ray were optimistic because the long-sought-for application of theoretical knowledge to the control of nature was being realized; to them, the difficulties were in achieving this application of knowledge, not in the consequences of control once success had been achieved. These thinkers regarded the applications as beneficent because they were purposive; men knew what they wanted and what they were about. And many of the dramatic man-made improvements in the landscape of Europe during this general period were purposive, especially the widespread drainage activities and canal building, of which the construction of the Canal du Midi (Canal de Languedoc), under the ministry of Colbert and the supervision of Pierre-Paul Riquet de Bonrepos, was the proudest example.

5. Silva and Fumifugium

These optimistic conclusions were based on the assumption that human modifications of the land were planned and beneficent, but some men also saw that certain traditional practices in resource use were wasteful or incompatible with other types of use which were emerging out of new economic conditions. In general, complaints in the early modern period are found in areas whose economic base is in mining, forestry, or agriculture. Forests especially were threatened with destruction by demands for wood in mining and metallurgy, shipbuilding and agriculture, and by the demands for more cleared land for agricultural purposes.

[85] *Ibid.*, pp. 163–164, 165.

It is possible to cite hundreds of illustrations of these conflicts, to show the existence of similar problems in Germany, Norway, and Sweden, but I prefer to mention and to discuss at some length two famous documents, John Evelyn's *Silvâ: or, A Discourse of Forest-Trees* (1664), and the *French Forest Ordinance of 1669*, which mark, it seems to me, the beginning of a more reserved attitude toward the modification of nature by man in the history of Western thought. They are by no means the first, but they are among the earliest attempts to understand—what is so often emphasized in modern literature—the unsought for, unplanned, often unnoticed consequences of modifications in the environment undertaken for rational economic reasons. Both recognize the influence of the past in the continued vigor of customary rights of use; both recognize the claims of posterity. Both are important divides: Colbert's ordinance not only exposed the nature of centuries-long abuse, but it codified French law and superseded all previous legislation on the subject, while it has been said of Evelyn's *Silva* that it looks back on the old era of forest exploitation, forward to a new era recognizing the need for conservation.

In a broad sense, Evelyn's work is an appeal for proper understanding of the relationship of forestry to agriculture, grazing, and industry. In forceful, often earthy, language ("And the reader is to know, that if these dry sticks afford him any sap, it is one of the least and meanest of those pieces which are every day produced by that illustrious assembly [the Royal Society]"), frequently testy and haughty ("It is not therefore to gratify these magnificent fops, whose talents reach but to the adjusting of their perukes, courting a Miss, or, at the farthest, writing a smutty or scurrilous libel, which they would have to pass for genuine wit, that I concern myself in these papers . . ."), he states the case for forest conservation and for considering forestry as a science, deploring the snobbery of those who consider it unworthy of their talents. His discourse, he says, is not for rustics who cannot understand such matters, but for gentlemen who can. It is therefore no horticultural manual written for the barely literate, but a work appealing to councillors, knowledgeable horticulturalists, and men of science. (Evelyn was one of the founders of the Royal Society, becoming its secretary in 1662.) His plea for dignifying forestry as a science and field of learning reminds one of Agricola's earlier plea for mining: it is no discipline for the ignorant, it requires knowledge of the sciences and of techniques, respect for artisanship. There is an occasional quotation from others with a similar respect for artisanship like Palissy and Francis Bacon. Evelyn defends the Royal Society against the criticisms of well-placed or well-born but hopelessly uninformed triflers; he sees, through its agency, applications of science to the amelioration of the human condition and to the improvement of the land. But he is no doctrinaire. If, in his opinion, the ancients have anything

are absolute prohibitions against conveying or kindling fires (Title XXVII, 27, 32).[80]

Historical evidence of gradual destruction had created the forest ordinance of 1669.[81] On the death of Mazarin, it was realized that strict measures were needed to give France a renewed forest. A memoire of 1665 explains the reasons for the king's action. The royal forests had been wasted for a long time; there were no provisions for a reserve for great projects and occasions; in the majority of provinces they had produced no revenue in forty years. They had almost been entirely alienated in Normandy, and revenue from them, formerly approaching a million livres, now scarcely reached fifty thousand.[82]

The ordinance symbolizes an awareness of a broader relationship between men organized in societies and the physical environment; it epitomizes Bagehot's "cake of custom" which intervenes between the exploiter and the resource being used. It calls attention to the philosophic attitudes toward the earth engendered by the *moeurs*. Were the ancient usages and rights dissipating or even destroying resources, making them progressively inaccessible to newer and more modern uses, which were now demanding their share, too?

7. Conclusion

In the period roughly from the end of the fifteenth until the end of the seventeenth century one sees ideas of man as a controller of nature beginning to crystallize, along more modern lines. It is in the thought of this period (not the commands of God in Genesis to have dominion over nature, as the Japanese authority on Zen Buddhism, Daisetz Suzuki,[83] thinks) that there begins a unique formulation of Western thought, marking itself off from the other great traditions, such as the Indian and the Chinese, which also are concerned with the relationship of man to nature. This awareness of man's power increases greatly in the eighteenth century, as will be apparent in the works of Buffon and others. It increases even more dramatically in the nineteenth century with the host of new ideas and interpretations, while in the twentieth, Western man has attained a breathtaking anthropocentrism, based on his power over nature, unmatched by anything in the past.

[80] Discussion of the law's enforcement and its efficacy is beyond the scope of this essay. In the early eighteenth century complaints like those which preceded its enactment were still common. It is believed, however, that without it things would have been much worse, at least until 1789. The law remained almost intact until 1827. Two frequent criticisms made of it are the severity of the punishments and its subordination of the interest of the individual to that of the state. On these points, see Clément, *Histoire de Colbert*, Vol. 2, pp. 75–76.

[81] *Ibid.*, Vol. 2, p. 65.

[82] *Ibid.*, Vol. 2, pp. 71–72.

[83] "The Role of Nature in Zen Buddhism," *Eranos-Jahrbuch 1953*, Vol. 22 (1954), pp. 291–321; see esp. pp 291–296.

Several trends may be discerned at the end of this period. They keep their own identities; they are like the Brenta, the Adige, and the Po, streams whose sources are far removed from one another, but whose courses roughly parallel one another as they flow to a common delta.

The religious idea that man has dominion over the earth, that he completes the creation, becomes sharper and more explicit by the seventeenth century. Hale's ideas are the clearest; man by his existence is a balancing force in the existence of other forms of life. He becomes an arbiter, checking the spread of the wild plants and the wild animals, encouraging the dispersion of the domesticated plants and animals. The encroachments of the wild are soon apparent in areas from which man has withdrawn his superintendence. Through eliminating natural vegetation, by draining, in frightening wild animals into retreats by his presence, through his protection of the domestic plants and animals, he exercises almost a juridical role over living nature. Men like Hale had an eye on their own times; they realized that cultural landscapes—drained bogs, cleared lands, lands in grains—and wild lands of forest, scrub, and brush were explainable only as the result of human activity; hunting, a foray into a land not held by man directly, showed too that wild animals lived under the threat of extinction.

These ideas were associated with a belief that man with tools and knowledge was improving the earth as surely as he was improving himself; the two improvements could go hand in hand. How could mankind progress on an earth dying of decay, or unimproved by tillage, drainage, and clearing?

Then there are the ideas which one distinguishes only with difficulty from the first: those from which religion is not excluded but in which religion is not the dominant motif. If the idea of man as a finisher of nature, a completer of the creation, leads both to piety and to practical-mindedness, the latter attitude alone can encourage a predominantly secular emphasis on achievement by mind, manual skill, knowledge. Agricola, Palissy, Bacon, and Descartes represent this point of view.

Finally there is the antiphonal idea that men make undesirable changes in nature, changes which are reckless and devoid of conscious purpose as far as long-term trends are concerned, purposive for narrower ends. If trees are felled so that the iron-master can smelt the iron, using conscious techniques based on science and his trade secrets to manufacture a tool, the whole process is purposive as far as the iron-master is concerned even if the long-term change —perhaps deterioration—of the natural environment brought about by him and others is not. From time to time in the past, evidences of these conflicting trends in land use appear, but in Evelyn's *Silva* and in Colbert's *Forest Ordinance* they are dramatized and become harbingers of more complex and more widely distributed conflicts.

The idea of a purposive human control of nature, so forcefully expressed by Bacon, Descartes, and others, has led historically to an emphasis on human

society and its accomplishments, to the possibility of improving society by the purposive application of scientific law to the needs of food, housing, transportation, and the like.

The idea that men can and do make undesirable changes in nature (often without realizing they do, because these ill effects may not be understood or may be too slow in showing themselves) has, on the other hand, led historically to the study of environments disturbed by man, the emphasis being placed on physical changes on the earth, not on changes in human society. It is this point of view which has produced much of the literature on environmental change by human agency, and has stimulated historical geography, ecological studies of vegetation change, and investigations in many other fields today.

What lay behind this more self-conscious awareness of man as not only a part of nature but as an extremely active form of life with ambitions for control and change? A proper answer would require volumes, drawing liberally from economic and religious history, philosophy, and the history of technology; here there are three or four points I wish to make. First, the observation that there were few contacts between science and technology in the Middle Ages compared with those in the seventeenth century is correct, in my opinion. "Only in the seventeenth century (though the idea had been adumbrated in the Middle Ages) was it realized—and even then by few—that science and the crafts were alike concerned with natural phenomena and could aid each other. Gradually it was seen that knowledge of nature conferred power to control its forces."[84]

If there was no great revolution in existing technologies in this period, if there was no new invention of a prime mover, there was nevertheless a certain majestic sweep in the geographical expansion of known activities. An important one was the spread of metallurgy and the concomitant extension of forest use and forest destruction. A second was the popularity of drainage and land reclamation, polder building in the Netherlands, draining the fens in England, controlling the river courses and draining the swamps of Italy, and draining marshes, ponds, and lakes in France. (In 1891, the Comte de Dienne published a history, of over five hundred pages, of the drainage of lakes and swamps of France alone before 1789.)[85] Finally there were the canals and bridges, conspicuous and dramatic evidence of an elementary victory over physical handicaps, crowned for this period by the completion under the ministry of Colbert and the supervision of Pierre-Paul Riquet de Bonrepos (1604–1680) of the Canal du Midi (the canal of Languedoc, the canal of the two seas). Few canals have fired the imagination of men more (at least prior to Suez and Panama) than this one joining the Atlantic and the Mediterranean.

[84] Preface by the editors to Vol. 3 of *A History of Technology*, pp. v–vi.

[85] Le Comte de Dienne, *Histoire du Desséchement des Lacs et Marais en France avant 1789* (Paris, 1891).

Even in the next century, Voltaire, in his *Siècle de Louis XIV*, said that the most glorious monument of the reign, because of its utility, grandeur and difficulties, was "ce canal de Languedoc qui joint les deux mers," and not the Louvre, nor Versailles, the Trianon, Marli, nor any other construction of the time.[86]

With hindsight, one can now see that the prevailing optimism was based on ignorance of the extent of both old custom and new technique as potential forces in changing the environment. Hidden also were the realization that a great upsurge of world population was beginning, and a real awareness of the awesome and frightening complexities of man himself.

[86] "Siècle de Louis XIV," in *Oeuvres de Voltaire*, Beuchot ed., Vol. 20, p. 252. On the history of the canal, see also Clément, *op. cit.*, Vol. 2, pp. 97–126.