# Green Delusions

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## An Environmentalist Critique of Radical Environmentalism

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# Technophobia and Its Discontents

## The Radical Position

### *Appropriate Technology*

The third foundation of environmental radicalism is the belief that technological advance bears much, if not most, of the responsibility for the ecological crisis. Yet only the most extreme eco-radicals oppose all forms of modern technology. Far more actually favor technological developments, but only those that they consider appropriate. How one defines "appropriate" is, however, a matter of some debate. Evidently, what is appropriate to one writer can be considered deadly by another (Dobson 1990:98–101). Barry Commoner, for example, a vocal critic of many forms of modern technology, has been accused by another writer of evincing a "remarkable technological optimism" (Rubin 1989:45). Nonetheless, common to the entire movement is the thesis that technology has spun out of control and must be socially reharnessed if we are to avoid both the nightmarish future of a brave new world and the apocalypse of ecological meltdown.

Most green radicals define technologies as appropriate if they are small of scale, lend themselves to decentralization, emit little pollution, and do not require extensive consumption of natural resources. While the more sophisticated thinkers (for example, Porritt 1985) argue that some forms of high technology may be allowable, the larger eco-radical agenda makes it clear that appropriate technology must exclude virtually every innovation made over the past century—if not the past five millennia. If one were to take bioregionalism seriously and forbid trade across bioregional boundaries, virtually all metallurgy would cease. Of course, even the most strident may allow a few exceptions to the principle of autarky, but the denunciation of all truly complex technologies remains a staple of eco-radical thought. The editors of *Earth Island Journal*, for example, tell us that to save the earth, people should have their power lines disconnected, unplug their television sets, bury their cars, avoid all products that run on batteries, never travel on airplanes, and, most importantly, consume only products produced within their own bioregions (G. Smith 1990). In a "Neo-Luddite Manifesto," Chellis Glendinning (1990b:52) similarly advocates "dismantling the following destructive technologies": nuclear, chemical, video, electromagnetic, and computer. And in regard to agriculture, the eco-philosopher and small-scale farmer Wendell Berry (1977:212) informs us that the Amish are the "truest geniuses of technology."

The opposition to computers is perhaps the most controversial item on the antitechnology manifesto. Many green extremists, after all, use computers extensively in their own writing. To the uncompromising true believer, however, computers "cause disease and death in their manufacture, enhance centralized political control, and remove people from direct experience of life" (Glendinning 1990b:52). Berry (1990:170) provides another reason why the environmentally principled person should disdain computers: "I disbelieve, and therefore strongly resent, the assertion that I or anybody else could write better or more easily with a computer than with a pencil." Remarkably, Berry goes on to boast that his wife cheerfully prepares all of his manuscripts on a 1956 typewriter.

Underlying the eco-radical fear of technology is a longing for the preindustrial world of craft production, especially as typified by the medieval and early modern guilds of Europe (for example, Bookchin 1989:87; see Mumford 1966:272–73 for an early eco-romanticization of the guilds). The craft system, most green extremists assert, is both socially and environmentally superior to technologically oriented mass production. Craft industries are said to rely on natural, nonpolluting raw materials and to provide workers a humane environment in which to perform a variety of pleasant tasks. Consumers too would benefit under a craft regime, since they would be able to purchase goods that are far more durable and meaningful than the shoddy products of the industrial system. If select means of ingenious production developed by modern tinkerers could be harnessed to traditional, small-scale technology, craft manufacture would become more productive while remaining ecologically benign and socially beneficial.

The eco-radical critique of technology spans a wide range of products, many of which are not normally considered high tech. Even a simple material like cotton cloth, if woven by intricate machines that cannot be locally produced and maintained, implicates an unnecessarily sophisticated technological structure. Most fervent greens regard machine-driven production as objectionable in itself, since it allegedly alienates human beings from the creative process. As such, the eco-radical assault on technology can be seen as the spearpoint of a much broader attack on industrial production.



The anti-industrialism of radical environmentalism represents the survival of an old strain of extremely conservative thinking. One of the staunchest opponents of the English industrial revolution, the archreactionary Thomas Carlyle, also wished to return to the small-scale world of craft production—a system in which master was master and all workers had a secure place within a communal, if stratified, social order (see Williams 1983:71–86). While nominally opposing social hierarchy in all forms, contemporary eco-radicals echo Carlyle's basic thesis. And many have convinced themselves that preindustrial European society was not in fact highly stratified, at least when contrasted with regimes that were to follow. Glendinning, for example, argues that the Luddites, early saboteurs of factory machinery (and heroes of the Earth First!ers), "favored the old, relatively grass-roots economy over the *more hierarchical*, expansionist industrial capitalism" (1990a:180, emphasis added). Similarly, Brian Tokar, it may be recalled, saw medieval peasants as sufficiently "free of the pressures to overproduce" that they could devote most of their efforts to celebrations (1987:11).

In sum, the eco-radical critique of advanced technology, and of the manufacturing systems that accompany it, centers on four objections: it is dehumanizing; it is harmful to human health; it destroys the environment; and it entails an unabashed human arrogance toward nature. Each of these objections requires careful consideration.

### *Dehumanization*

Following Jacques Ellul (1964) and Lewis Mumford (1966), most eco-radicals argue that the dehumanizing qualities of modern technology are most clearly evident in the labor organization required by industrial production. Factory work entails repetitive, unnatural tasks that are mind numbing if not brain destroying. Industrialism destroys the organic, life-affirming world of craftwork and replaces it with a crudely powerful but utterly lifeless production regime. Immured in industrial processes, workers begin to employ mechanistic metaphors for society and nature, thus contaminating and dehumanizing their very worldviews as well. Increasingly, people come to separate their long hours of drudgery from their *real* lives, their labor becoming nothing but a means to other ends. In contrast, in all preindustrial ages the modest amount of work people actually had to perform was thoroughly integrated with their basic life processes (Mishan 1973:71).

Eco-radicals also condemn industrial processes for destroying preexisting social relations. Before the industrial revolution, workers were comfortably supported by their families and natal communities; afterward they were immersed in the cold, cruel world of the machine, an environment that "squelches the individuality and uniqueness that fed the human spirit in times past" (Glendinning 1990a:144). Tender familial relations were replaced by rigid social hierarchies, with each worker becoming a slave to the masters of the mechanism. Here the argument against technological advance merges with those leveled against centralization and the development of capitalism, three processes that are pictured as conspiring to destroy humanity and nature.

Moderate as well as radical environmentalists often fear that technological developments will destroy jobs, thus threatening the populace with the dehumanization that accompanies mass unemployment (Dobson 1990:86; Young 1990:162, 200; Tokar 1987:87; Paehlke 1989:224). This is pictured as a process of long standing. In the early industrial revolution, spinners and hand-loom weavers lost their livelihoods to power machines, just as factory workers today sacrifice their jobs to process automation and robots. Newly redundant workers, in turn, have little option but to take even more menial and lower paying jobs in the service sector. As production becomes increasingly automated, eco-radicals tell us, high-skilled, well-paying jobs will grow ever more scarce. Some fear that this will lead to a vicious, downward economic spiral: the growing horde of poorly paid service workers will have less money to spend, undercutting the foundation of our mass-consumption economy. While technological optimists promise that robots might someday free humans from repetitive, mind-dulling tasks, in the absence of other employment options, such freedom will prove but a cruel hoax.

Many eco-radicals believe that the consumer goods produced by the factory system in shoddy forms and obscene quantities are themselves dehumanizing. Few contribute to truly meaningful activities, and as a package they demean the human spirit by lulling us into a stupor of consumer greed. Eventually we come to believe that happiness derives from the accumulation of mere things. "Material life alone flourishes," Donald Worster tells us (1985:58), "and for the manipulated mass man that seems to be enough: an iron cage with all the amenities will do nicely in the absence of other possibilities." Our machines produce abundant playthings that we discard into ever accumulating piles of waste once we tire of them, a phenomenon visible not only in our cancerous land-fills, but also in the toy-chests of every upper- and middle-class family in the United States. Electronic goods destroy our spirits more directly by disseminating droning technological propaganda (Tokar 1987:94, 95). Many eco-radicals would like to outlaw television, and the smashing of TV sets is an occasional ritual at their rallies and celebrations.



As discussed in chapter three, eco-radicals' strongest fear may well be that technological developments, particularly those in the fields of computers and telecommunications, will lead directly to increased central power, providing governments and corporations even more devious means of control. "In the past few decades," argues Brian Tokar (1987:24), "the increasing computerization of all spheres of life has allowed methods of social control and surveillance to evolve to staggering proportions." According to Glendinning (1990a:140), even the telephone was "consciously developed to enhance systems of centralized political power."

### *Technology and Human Health*

Environmental radicals also view modern technology as a direct threat to human health. Factories have always been dangerous places to work, and industrial accidents are still appallingly common. But far more deadly, they warn, are the modern chemical and nuclear technologies that attack the very substance of life. Within the high-tech factory, workers breathe a wicked fog of cancer-causing and immune-system-destroying substances. Many of these same death-dealing chemicals are disseminated throughout the biosphere; some are intentionally sprayed on crops, others are dumped in toxic waste pits from which they invariable seep out to contaminate the groundwater. Consumer products can also be toxic in their own right; the side effects of many modern medicines are more dangerous than the maladies they were designed to control, and even the most common plastics spew out small but potentially lethal quantities of formaldehyde and other unnatural gases. Unseen and subtle threats are ubiquitous in the modern world. Everything that generates an electromagnetic field, for example, presents a grave and immediate danger to all life forms. As our dwellings and offices grow ever more synthetic, increasing numbers of persons will develop the syndrome of "total environmental sensitivity"—in essence a debilitating set of allergies to the twentieth century.

Chellis Glendinning (1990a) offers the most concerted eco-radical assault on the medical hazards of modern technology. In her view, industrial society is suffering a virtual epidemic of cancers and immune-system disorders stemming directly from the poisons spewed into the environment by high-tech operations. Nature is now so wounded, she informs us, that it has some difficulty even supporting life. Glendinning's own social network is evidently composed largely of scarred technology survivors, individuals now organizing to challenge the central structures of high-tech society. Like most eco-radicals, they hope to reclaim a Luddite vision that will guide them in recreating a clean, safe, small-scale social world directly connected to the healing powers of nature. In such an intimate society, even such obnoxious commonplace contraptions as telephones will be unnecessary, since each person will be able to converse directly with everyone she or he knows (Glendinning 1990a:140).

*Technology and Nature*

While all eco-radicals decry the effects of technology and industrial production on human dignity and health, most fear primarily for nature. Technology's assault on the natural world is a fact of long standing; but in earlier days, when scale was small and techniques simple, damage was relatively minor and could easily be healed by nature's own recuperative powers. The more complex technology has grown, however, the further it has diverged from the basic processes of life and the more destructive each new advance becomes.

Barry Commoner (1990) argues that the creation of a major synthetic chemical industry epitomizes the decisive rift between nature and technology. In the post-Second World War era, factories began blindly to produce an ever increasing array of substances never before encountered. Many, perhaps most, of these chemicals turned out to be inherently destructive to life. Thus, even Commoner, who endorses a wide array of technologies deemed unacceptable by many other radical greens, calls for nothing less than the dismantling of the entire petrochemical industry. In an ecologically benign future world, he tells us, human society would rely on natural products that harmlessly biodegrade, like wood and cotton, and sedulously shun all unnatural plastics.

Although Commoner's denunciations of the petrochemical industry are powerful, Jeremy Rifkin (1983; 1989) again supplies a more thorough attack on modern technology of all varieties. Rifkin, who bases his argument on the second law of thermodynamics, tells us that the more we transform nature, the more quickly the universe's total energy will



dissipate, leading ultimately to the remorseless state of "heat death." We would be wise, he cautions, to expend as little energy as possible so that we might forestall entropy's inexorable progress. Life may be doomed, but by dismantling our technological infrastructure we will be able to prolong its existence for a short spell.

*An Affront to Nature*

The eco-radical distrust of high technology has deeper roots than one might expect, roots extending well beyond fears about damage to organisms and ecosystems. Modern technology and its philosophical justifications are fundamentally viewed as arrogant *affronts* to nature even in the absence of firm evidence of actual harm. In essence, this is a secularized (or better, naturalized) version of the old religious creed that only God (nature) has the power to create, and that humans ought not to infringe on this divine prerogative. While few Christians now hold this view, it retains a certain currency in its eco-theological guise. The more we diverge from nature's patterns, green stalwarts believe, the more we deserve its wrath.

Two technologies are singled out as particularly offensive in this regard: nuclear engineering and gene splicing. Nuclear technologies, to be sure, are opposed primarily because of the very real dangers they present. Biotechnology, on the other hand, is denounced essentially because eco-radicals are wary of human beings playing God. The fear that mutant bacteria may escape from the laboratories and wreak havoc on the earth is real but secondary. Even in the absence of potential ecological hazards, most radical environmentalists would still find all forms of genetic engineering repulsive. To Bill McKibben (1989:166), such biotechnological manipulation represents nothing less than the "second end of nature." Jeremy Rifkin further claims that once we begin the process of manipulating genetic material we will not be able to stop: "As bioengineering technology winds its way through the many passageways of life, stripping one living thing after another of its identity, replacing the original creations with technologically designed replicas, the world gradually becomes a lonelier place. From a world teeming with life . . . we descend to a world stocked with living gadgets and devices" (1983:252).

Another tenet of the eco-radical gospel is that technology further usurps God/nature in becoming a religious focus in itself. A belief in material progress is said to have emerged as the central creed of contemporary consumer society. Glendinning (1990a) argues that this myth is so deeply embedded in American culture that any technological advance is automatically hailed. Thus we blindly embrace every new development, no matter how lethal it may be. Indeed, technology drives madly forward virtually of its own accord; as Jacques Ellul (1964:83) explains, "[t]echnical activity automatically eliminates every non-technical activity." Rational decisionmaking and public debate, according to eco-radicals, have long since evaporated in the arid techno-worshipping atmosphere of modern society. This new secular religion may deny the reality of the apocalypse, but it actually functions to bring it about.

Eco-radicals also criticize the central tenet of technology worship, that progress must continue at all costs, as being in direct contradiction to the laws of nature. In nature's ecosystems, equilibrium prevails. If we are to coexist with the planet's other creations we must learn again how to fit within the earth's own modes of operation. Eco-salvation thus demands an emphasis on being rather than doing, on stationary existence rather than progressive movement. Behaviors that progress-obsessed moderns might regard as slothful are thus revealed as truly exemplary. Environmental historian Donald Worster (1985:335), for example, longs for an America in which "people are wont to sit long hours doing nothing, earning nothing, going nowhere, on the banks of some river running through a spare, lean land."

### *Questions about Science*

The eco-radical antipathy to technology often extends to science as well. Denounced not only as the progenitor of harmful technologies, the scientific worldview is implicated in the intellectual rift that has torn humanity away from nature. "The modern scientific project," Dobson (1990:198) informs us, "is held to be a universalizing project of reduction, fragmentation, and violent control." Scientists are often depicted as brazen reductionists who attack the unity of nature by carving it up into isolated bits that they can proceed arrogantly to manipulate for their own satisfaction. Even the science of ecology is often suspected of harboring an unduly mechanistic and insufficiently spiritual appreciation of the unity of nature (Merchant 1989:9).

Environmental radicals also disparage science for its emphasis on specialization, a charge leveled against virtually every profession (for example, Milbrath 1989:207). Thus Young (1990:86–87) argues that since scientists now work in "large hierarchically organized teams, in which there is an increasing division of labor," the field itself has become "inherently conservative" and therefore ecologically destructive (see also Glendinning 1990a:24). Devall (1988:48–49) blithely informs us that "experts on nature" have "killed their positive feelings of identification" with the natural world and that "[s]tudents in natural resource sciences and management . . . are much like the guards in Nazi death camps." In fostering an atmosphere in which only the expert is accorded respect, science, technology, and capitalism are equally to blame. One gets the feeling from the more extreme texts that a specialist is little more than a half person, a being who has abandoned the meaningful in order to engage for hire in some petty and ecologically destructive activity. The specialist is thus but a cog in the death-dealing mega-machine (see Mumford 1966:200–201), utterly disengaged from the oneness of humanity and nature.



## ■ The Promethean View

### *Dystopia of Craft Production*

Since eco-radicals idealize craftwork and disparage industrial production, it is first necessary to examine the social relations and environmental impacts associated with manufacturing prior to the industrial revolution. An appropriate starting point is Europe's medieval guild system, which several writers have touted as exemplifying social and ecological harmony. If the guild system can be proved socially exploitative, an important element of the eco-radical attack on industrialism will be discredited.

Eco-radicals are correct in arguing that working conditions within the guilds were, on average, far more humane than those imposed on the first industrial laborers. But medieval guilds most certainly were not the caring, familial institutions pictured in eco-radical fantasies. Many were authoritarian, if paternal, organizations; apprentices and journeymen worked firmly under the fists of their masters, and not all graduated to the status of independent craftsmen. Moreover, in heavy proto-industrial crafts, like metalwork, labor was hardly safe, let alone pleasant.

The medieval system of craft production is revealed to be even more objectionable when examined within its social context. The medieval world that made small-scale, socially organized craft production possible was rigidly hierarchical. The vast majority of Europeans in this period were impoverished peasants unable to buy anything produced by the guilds. In fact, until the 1820s members of the working class in France typically purchased their clothing second hand; only with the introduction of modern manufacturing and retailing could they afford to buy new goods (Reddy 1984:96). In preindustrial times, Fernand Braudel reminds us, the poor "lived in a state of almost complete deprivation" (1981:283). Sturdy craft objects were destined for the elite: the landed aristocracy, the ecclesiastical hierarchy, and the small but rising bourgeoisie within the towns. The entire guild system was founded on an extraordinarily inequitable distribution of resources. This should not surprise us; even today, craft goods (as well as many "natural" products) are purchased primarily by the rich, the only group able to afford them.

It was precisely because medieval and early modern craft production was so inefficient that only the truly wealthy could afford more than an extremely meager store of material possessions (Braudel 1981). While one could argue that poverty was widespread because the aristocracy monopolized consumption, it must be realized that the elite constituted a minuscule fraction of the population (Braudel 1982:466–72). Moreover, even many medieval and early modern aristocrats were not as wealthy as we enjoy picturing them. In preindustrial Europe there was nothing at all oxymoronic in the phrase "impoverished noble"; some were even reduced to begging for living (Blum 1987:25).

The material deprivation of medieval Europeans was not founded on a spiritual appreciation of the world uncorrupted by base material desires, as some eco-radicals seem to believe. Quite the contrary, material goods were actually valued more highly, relative to human life, than they are in modern society. As Braudel (1990:553) writes: "In the thirteenth century, '30 meters of Flanders cloth sold at Marseille [reached] two to four times the price of a Saracen woman slave.' [Such a price] may leave us 'pondering the mentality of the age, the price set on human life, the extraordinary value placed on a length of drapery from the Netherlands, and the considerable profits to be made from it by producers and *négociants*.' "

In select preindustrial societies, to be sure, certain social classes accumulated great hordes of material wealth, and in a few favored societies, such as in the seventeenth-century Netherlands, prosperous middle classes grew to substantial proportions (Schama 1988). But such wealth as did exist was made possible only by large-scale transregional exchange or imperial plundering. In the immediate preindustrial period, much of Europe's prosperity rested on trade with, and exploitation of, the rest of the world. Even in the medieval period, trade networks spanned the subcontinent and extended ultimately to many far reaches of the globe. Bioregionalism was never an operative principle in the world of the guild.

One should also recognize that centuries before the mechanization of cotton spinning, Europe as a whole had been benefiting from technological innovations that many eco-radicals would disparage. Historian Jean Gimpel (1976) argues that the first industrial revolution occurred precisely in the Middle Ages. Medieval engineers and entrepreneurs were already damming rivers to harness water power, digging for coal in strip



mines, and processing select raw materials in reasonably large-scale operations. Such technical advances vastly increased the subcontinent's meager store of wealth, but they also brought about a sometimes substantial level of industrial pollution. Gimpel's (1976:86) description of tannery wastes is apposite here: "Tanning polluted the river because it subjected the hides to a whole series of chemical operations requiring tannic acids and lime. Tawing used alum and oil. Dried blood, fat, surplus tissue, flesh impurities, and hair were continually washed away with the acids and the lime into the streams running through the cities. The waters flowing from the tanneries were certainly unpalatable, and there were tanneries in every medieval city."

In short, the preindustrial world was far from the ecological and social paradise imagined by some eco-radicals. Only by embracing an idealized and ultimately fraudulent picture of life before mechanization can one accept the eco-radical faith in craft production.

*Disease: Technological and Natural*

The second prong of the eco-radical attack on modern technological products and processes lies in the assertion that they constitute a massive threat to human health. While there is certainly much truth in this general proposition, the more extreme writers go so far as to argue that health standards have been progressively declining as our environments have grown more synthetic. To disprove this strong version of the technophobic disease thesis, we can simply compare incidents of death and disease under preindustrial and industrial regimes.

No one acquainted with the rudiments of medical history could deny that health has vastly improved since the industrial revolution. Most of the credit for such amelioration belongs precisely to the medical, dietary, and sanitary advances associated with the transition to industrialism. One has only to examine average longevity, which stood in the United States at a miserable forty-seven years as recently as 1900, to grasp the magnitude of progress over this period. If we go back to medieval Europe, socio-ecological idyll of many eco-radicals, we find that in some villages average life spans were as low as seventeen to eighteen years (Cohen 1989:124).

By other indices as well, the health standards of most preindustrial regimes were atrocious. Again, consider medieval and early modern Europe. As Braudel (1981:91) relates, the ancien régime was characterized by "very high infant mortality, famine, chronic under-nourishment, and formidable epidemics." Moreover, nonelite Europeans were contaminated by a wide variety of toxins on a regular basis. Few even experienced the delights of breathing clean air, for the atmospheres of their own dwellings were horribly polluted. "It is difficult . . . to comprehend," writes Norman Pounds (1989:187), "how fetid and offensive must have been the air about most cottages and homes." Indeed, indoor air pollution has long been (as it perhaps still is) a greater contributor to respiratory illness than industrial airborne waste.

But the most severe toxic pollution problem of the premodern world was associated with natural poisons produced by molds infecting the food supply. "Everyone suffered from food that was tainted," Pounds reminds us, "and the number who died of food-poisoning must have been immense" (1989:213). Especially pronounced where rye was the staple food, poisons produced by the ergot and *Fusarium* molds massively suppressed immune systems, reduced fertility levels, brought on delusions and sometimes mass insanity, and reduced blood circulation to such an extent that gangrene in the lower extremities was commonplace (Matossian 1989).

Even where the food supply was safe, poor nutrition resulted in widespread immunological stress. Infectious diseases were rife, and periodic plagues would decimate most populations in a cruel manner. Water supplies, especially in towns, were so contaminated by human waste as to become deadly in their own right. Skin and venereal diseases were often rife and difficult, if not impossible, to cure. Other scourges abounded, including those—such as leprosy—that have been virtually eliminated by modern medicines and sanitary techniques. Individuals deformed by genetic inheritance or accident typically led short and brutal lives. And every time a woman went into labor she faced a very high risk of dying.

This cursory review of the horrors of preindustrial European life may seem a pointless exercise in overkill; all of this is, or at least used to be, common knowledge. But it is important to recall in detail the kind of social environment many eco-radicals would seek to recreate. And were we to adhere strictly to the tenets of bioregionalism, even the levels of prosperity achieved in the medieval world would be difficult if not impossible to maintain without first experiencing a truly *massive* human die-off.

If the eco-radical vision of the preindustrial past is highly distorted, its view of the past half century is hardly more realistic. The notion that the last fifty years have seen a cancer epidemic visited upon the world is based on highly questionable statistical evidence. Glendinning (1990a:56), for example, argues from the fact that while only 3 percent of total deaths in the United States in 1900 could be attributed to cancer, now one in every three persons can expect to contract the disease. There are several problems here. First, it is misleading to compare death rates in the former period and disease rates in the latter. More importantly, while it would be foolish to deny that many cancers are linked to industrial toxins, the long-term rise in cancer cases at least partly reflects the fact that in 1900 most persons died of other causes before they had the chance to experience this disease. As more individuals survive into old age, the total number of cancer patients will necessarily increase.



Eco-radicals are absolutely right to decry the appalling illnesses induced by toxic wastes and agricultural chemicals. Promethean environmentalists readily join in the struggle first to reduce, and ultimately to eliminate, human-generated environmental toxins. But the elimination of toxic waste is a technical problem that demands technical solutions. *Dismantling all modern industry is not the answer.* Moreover, we must carefully balance concerns about human health with other environmental issues, many of which are more pressing. As *The Economist* reports (March 30, 1991, p. 28), the Environmental Protection Agency (EPA) has at times "behaved more like a cancer-prevention than an environmental agency." To spend billions of dollars attempting to reduce slightly our cancer risks, while entire ecosystems perish for the want of a few hundred thousand dollars, shows a questionable and highly anthropocentric sense of priorities.

### *Industrial Amelioration*

The eco-radicals' critique of industrial labor conditions proves to be more instructive than their disease thesis. Early factories did subject their workers to a brutal existence, and many plants operating today in the less-developed parts of the world are equally dismal. In fact, much evidence suggests that the industrial revolution was accompanied by a general downturn of average living conditions, a decline that lasted several generations (Braudel 1984:614). Both wage levels and industrial work conditions were eventually to experience steady improvement, but progress remains unacceptably halting. Moreover, certain industries, such as meat packing in the United States, sometimes experience sharp regressions toward increased workplace danger. And even where they are safe, assembly-line jobs remain mind-dullingly tedious and poorly remunerated. Eco-radicals are also correct in pointing out that industrial toxins present a massive threat to worker health, and that the lack of attention given to this problem has been shameful.

But despite these massive remaining problems, the solutions to workplace brutality and injustice do not lie in stepping backward to a system of craft production. Rather, we should continue to move forward, through both technological improvement and regulatory advance. Together, these two forces have been responsible for a tremendous amelioration of industrial conditions. The vigilant enforcement and continued extension of safety regulations remains absolutely essential. But equally important is the continuation of the automation process itself. In an eco-Promethean future, hazardous and deadening tasks would not be performed by human beings at all, but rather by unfeeling robots and other automatic devices, many of which may well exist at the nano scale of molecular assemblages.

Much improvement has already been brought about by automation. This is readily visible if we compare, circa 1990, the relatively safe and humane industrial work conditions found in western Germany with those located in technologically stagnant eastern Germany. Eastern Germans working in the glass industry, for example, suffered horribly in: "investment-starved factories [that] are hazardous industrial relicts. Jenar's glass-makers toil in temperatures that can reach as high as 140 F. They blow molten glass by hand a few feet from fire-belching open hearths" (*Fortune*, April 22, 1991, p. 224).

Yet even where automation clearly reduces workplace hazards, eco-radicals still reject it for generating massive unemployment. Although automation does result in an initial displacement of workers, an issue that can and *should* be humanely addressed through retraining programs, in a healthy industrialized economy its long-run consequences are clearly positive. Substituting capital for labor, if done intelligently, boosts productivity, creating a larger economic pie for society as a whole. Moreover, as Joel Mokyr (1990) explains, technological progress itself is a positive-sum game, one in which winners far outnumber losers. Increased productivity leads to economic expansion, with the end result being that extinguished jobs will be replaced, on aggregate, by *better* paying jobs in other sectors. How else can one explain the phenomenal rise in living standards that eventually accompanies successful mass industrialization? Alternatively, how can one account for the modest unemployment rate and mounting prosperity of Japan, the world's pace-setter in automated production? If the eco-radical unemployment thesis had any merit, industrialization would have been a self-canceling process from the very beginning.

Groups directly threatened by technological advance have always considered it socially destructive, and many have been able to prevent or delay the introduction of highly beneficial innovations. Few eco-radicals, I imagine, would today prefer roman to arabic numerals, and only



the most extreme would object to printing. Yet as Mokyr (1990:179) relates, in 1299 the bankers in Florence were forbidden the use of arabic numerals, whereas "in the fifteenth century, the scribes guild of Paris succeeded in delaying the introduction of printing into Paris by 20 years." The modern opposition to computers and many other forms of technology demonstrates the same kind of thinking that led Parisian scribblers to resist Gutenberg's invention.

Those who believe that mechanization brings massive unemployment overinterpret the high rates of joblessness experienced in the United States (and much of Europe) in recent years. Several factors conspired to generate widespread unemployment in this period. One of the more important ones was demographic; when the huge baby-boom generation began to seek jobs, employment opportunities naturally diminished. The same era also witnessed the massive entrance of women into the job market, as well as a continuing influx of job-seeking immigrants, both unskilled and skilled. But the most significant reason for joblessness—as well as for America's general economic malaise—was simply the productivity slowdown. As both Lester Thurow (1985) and Paul Krugman (1990) clearly illustrate, lagging American economic productivity, and our consequent failure to remain internationally competitive, is the root cause for economic alarm. To a significant extent, the productivity crisis reflects a lack of capital investment, itself a symptom of the short-term thinking characteristic of many American executives, rather than the overinvestment feared by eco-radicals.

Japan offers a perfect counterpoint to the eco-radical unemployment thesis. A fierce labor shortage has encouraged Japanese managers to invest heavily in automation and robotization. Although often not initially profitable, long-term automation projects have been made possible by the strategic autonomy of Japanese corporations. American firms, by contrast, are usually required by Wall Street to seek extremely short payback periods for their investments. Indeed, this is a major reason why the Japanese economy continues to rack up much more impressive productivity gains than does the American economy. Not surprisingly, Japan has in the process come to dominate the global robotics industry. American robotics firms, once the global pioneers, are now virtually extinct (*Fortune*, April 16, 1990, pp. 148–53). As the Japanese economy continues to grow and as Japanese firms continue selectively to replace labor with capital, resources are made available to retrain workers for more skilled and higher paying employment elsewhere in the Japanese economy.

Radical environmentalists not only misrepresent the relationship between automation and unemployment, but they also cling to an outdated vision of the former. Successful automation no longer necessarily entails mass production. On the contrary, through flexible automation, small, individualized batches of goods can now easily be produced. Flexible automation has the potential to fuse the best features of the old and the new production regimes; according to one optimistic prognosis, "the craft-era tradition of custom-tailoring of products to the needs and tastes of individual consumers will be combined with the power, precision, and economy of modern production technology" (Dertouzos et al. 1989:131). Where radical greens see only increasing uniformity, those who are actually observing the evolution of technology discern rather uniformity's demise.

*Toxin Production and Destruction*

The eco-radical critique of technology becomes most vehement on the subject of toxic by-products and other pollutants. Although concerns here are absolutely on target, the solutions proposed are fundamentally misguided. Rather than dismantling our technological infrastructure, a politically unfeasible agenda to say the least, we should reengineer it so that destructive contaminants never reach the environment in the first place. Developing clean production systems will require sustained technological advance, as well as a tremendous rechanneling of capital, but it is by no means beyond the reach of human ingenuity. Political timidity and short-term economic fixations, not technology per se, dictate that we continue to contaminate our environment with deadly substances.

For the sake of brevity, the following section concentrates on the more dangerous toxic discharges rather than the more common forms of air and water pollution. The former are both more debilitating in the long run and more challenging to eliminate. If we can continue to develop our technological apparatus while eliminating toxic wastes, we should easily be able to handle the more conventional varieties of pollution.

Most toxic wastes are composed of chemical compounds that can be reduced, with some effort, to their harmless constituent elements, such as carbon and hydrogen. Various means of decomposing toxins are currently in use or being developed. Some rely on physical processes, particularly focused solar energy or combustion at high temperatures, but many of the more sophisticated techniques employ biological metabolism. Certain species of bacteria thrive on, and devour, many varieties of toxic sludge. By providing these microorganisms with a favorable environment, decomposition may be greatly accelerated. And if genetic engineering fulfills its promise, crud-devouring bacteria may be expected



to work much more efficiently in the future (see Kokoszka and Flood 1989; National Research Council 1989; Johnston and Robinson 1984; Omenn and Hollaender 1984).

In many instances firms may find it more efficient to use rather than to destroy (or dump) what were formerly waste materials (Freeman 1990). Recovery of wastes has in fact been on-going for several hundred years (Mowery and Rosenberg 1989:55; Wilkinson 1988:95). Capturing such materials and recycling them in other industrial processes reduces their contact with the environment. Further chemical processing, moreover, can render certain kinds of wastes both inert and useful. Several companies have already learned to profit from what were until recently polluting by-products; Du Pont, for example, has discovered that it can sell its acid iron salts to wastewater treatment plants (*Fortune*, February 12, 1990, p. 48). One company's garbage is often another's raw material, and the interfirm marketing of waste products is a growing business (Patterson 1989).

Those forms of toxic waste containing heavy metals, which are dangerous in their elemental states, are obviously inappropriate candidates for decomposition. But genetically engineered microorganisms can again be employed, in this case to collect metallic molecules so that they can more easily be sequestered (Higgens 1985:235). Advances in membrane technology and filtration systems will also allow more efficient isolation of heavy metals as well as other forms of toxic waste. Once collected, lead, mercury, and other metals can be recycled, offering financial benefits as well as reducing the need for further environmental disruption through mining.

As companies learn to reduce their waste streams through these and other methods, they sometimes discover that their operations grow more efficient in the process. Minnesota Mining and Manufacturing, for example, through its Pollution Prevention Pays program, has realized savings that already amount to over one billion dollars (*Fortune*, February 12, 1990, p. 48). As recycling, decomposition, and sequestering techniques grow more sophisticated, increasing numbers of companies can be expected to adopt them—especially if regulations grow more stringent. As this occurs, economies of scale will emerge, further reducing the costs and increasing the economic benefits of pollution control in a virtuous spiral of environmental cleansing.

*Synthetic Materials: Sin or Salvation?*

Eco-radicals disdain synthetic materials (typified by plastics) in part because they are not biodegradable. From the Promethean perspective, however, resistance to rot can be highly advantageous. Nonbiodegradable materials are, on aggregate, easier to recycle than are their natural alternatives. Paper fibers, for example, break down during the recycling process, limiting their potential for reuse. Paper also spoils if improperly stored, rendering it unsuitable as a raw material. Many synthetics, by contrast, can be recycled a vast number of times.

Admittedly, plastic beverage containers cannot be sterilized, severely restricting their potential for immediate reuse. They can, however, be melted and reextruded to form durable products, a process known as secondary recycling (Leidner 1981). Recycled plastic has long been a substandard product, limiting its applications, but researchers at Battelle Memorial Institute have recently developed a process by which plastics can be reextruded with no decline in quality (*Business Week*, April 15, 1991, p. 72). While glass, also a nonbiodegradable product, remains an environmentally superior food and beverage container, plastic is clearly preferable to wood (see below) in the manufacture of consumer durables. Not surprisingly, Japan and Western Europe have pioneered the development of secondary recycling techniques. Such processes have long been unappreciated in the United States, in part because of our heavy subsidization of the wood products industry (Leidner 1981:157).

Contrary to eco-radical doctrine, biodegradation itself, given our current waste disposal system, can generate serious environmental contamination. Most paper bags in the United States, for example, are disposed in sanitary landfills. Once buried they are isolated from oxygen, and thus decompose, if at all, anaerobically. Anaerobic decomposition, in turn, produces methane, a very powerful greenhouse gas. Plastic bags, in contrast, are relatively inert, limiting rather than magnifying their environmental damage. Only in areas where garbage might find its way into an aquatic environment should plastic be avoided as intrinsically damaging.

The outgassing of potentially harmful molecules by plastics and other synthetics is a threat that must be taken seriously. Since demands for energy efficiency will lead to the construction of increasingly airtight buildings, indoor pollution will become a mounting hazard in the absence of concerted action. We may expect technological advances in organic chemistry, however, as well as advances in ventilation and filtration systems, to reduce the problem.

Promethean environmentalists agree with Arcadians that some technological products are intrinsically destructive. A prime example would be the ozone-attacking chlorofluorocarbons (CFCs). Given the proper incentives, however, engineers are usually able to devise relatively benign substitutes in a remarkably short time, as the CFC dilemma has already demonstrated. Devising such substitutes, however, requires a major commitment of economic resources and especially scientific expertise. But scientific expertise is itself under attack by the eco-radical community.



### *Science, Monitoring, and the Environment*

The eco-radical attack on the reductionism and specialization inherent in science is environmentally threatening in its own right. If we were to abandon scientific methodology we would have to relinquish our hopes that environmentally benign technologies might be developed. Advances in solar power will not come about through holistic inquiries into the meaning of nature.

The scientific method also must be applied in environmental monitoring. Had it not been for highly specialized measuring techniques, we would not have known about the CFC threat until it was too late. Moreover, the requisite devices would never have been made were it not for the organization of the scientific community into distinct specialties, each framing its inquiries in a reductionistic manner. To avoid environmental catastrophe we need as much *specific* knowledge of environmental processes as possible, although it is also true that we must improve our abilities to combine insights derived from separate specialities. Much greater emphasis must be placed on basic environmental science, in both its reductive and synthetic forms, a project that would be greatly hindered if we insist that only vague and spiritually oriented forms of holistic analysis are appropriate.

Eco-radicals can be expected to counter that environmental monitoring is only necessary in the first place because of industrial poisoning; dismantle industry, and environmental science will cease to be useful. Although seemingly cogent, this argument fails on historical grounds. As discussed previously, toxins can be produced by nature as well as by humanity. For centuries Europeans attributed the delusions they suffered after eating ergot-infected bread to evil spirits. Thousands of women were burned at the stake because of the fearful reactions of a patriarchal, religiously fundamentalist society to the psychological effects of an unknown, natural, environmental toxin. Once scientists, using *specialized* techniques, isolated the agent, ergotism and its associated social pathologies began to disappear (Matossian 1989).

In many different fields specialized scientific techniques are now proving invaluable for the efforts to control pollution and preserve natural diversity. For example, the development of biosensors—mechanisms that "combine biological membranes or cells with microelectronic sensors"

(Elkington and Shopley 1988:14)—promises vastly improved means of pollution detection. Similarly, the development of Geographic Information Systems (GIS), based on the construction of spatialized computer data bases, has allowed geographers and planners to predict the ecological consequences of specific human activities and thus minimize deleterious impacts on critical ecosystems. Nature Conservancy field agents, for example, have found GIS a useful tool in devising conservation strategies for Ohio's Big Darby Creek, one of the Midwest's few remaining clear-flowing streams (Allan 1991). Geographers have also repeatedly proved the utility of satellite image interpretation for developing and implementing conservation plans at the national level (Elkington and Shopley 1988). We may expect eco-extremists to have little patience with such philosophically impure forms of environmental work. Yet rejecting such techniques outright would only intensify environmental destruction.

*Natural Products and the Destruction of Nature*

Assessing the eco-radical aversion to technology also requires considering the environmental effects of natural, low-tech products. Although this is an extremely intricate issue, many natural substances actually prove to be far more ecologically destructive than their synthetic substitutes.

Wood provides a good example of a destructive natural product. By relying on wood for building materials, simple chemicals, and fuel, countless societies have deforested their environments. The switch from wood to coal as an energy source helped save European forests from total destruction in the early modern age, just as it did for American forests in the 1880s (Perlin 1989). Pressures on forests were also reduced when the Leblanc process was developed, allowing soda to be manufactured from salt rather than from woodash. (This discovery also drastically reduced the cost of soap, tremendously benefiting human health.) The Leblanc process was, however, highly polluting, but the subsequently developed ammonia process proved to be considerably cleaner and more efficient as well (Mokyr 1990:121).

The common belief that wood is an environmentally benign and renewable resource is dangerously naive. Forests are effectively renewable only where population densities are extremely low. Unfortunately, areas of requisite density are becoming increasingly rare throughout most of the world. In the contemporary Third World, technological deprivation forces multitudes to continue living within an unsustainable wood economy. Poor women often spend hours each day scrounging for firewood, a process both ecologically and socially destructive. Where electricity



is available and affordable—as it should be everywhere—deforestation rates decline drastically.

The use of wood as a construction material in contemporary industrial societies is also environmentally devastating. The havoc wreaked on Southeast Asian tropical rainforests by the Japanese construction industry is a commonly acknowledged environmental outrage (see Laarman 1988), but the effect of American house-building on our own temperate rainforests is hardly less objectionable. Economic considerations ensure that even sustainably and selectively harvested forests are degraded as wildlife habitat. Foresters shudder at the idea of preserving dead and dying stumps that might form disease reservoirs, but it is precisely such hollow trees that provide denning sites for many mammals and nesting sites for many birds. While radical environmentalists might argue that we should therefore adopt less efficient forms of forestry, the problems that would ensue because of the resulting decline in timber yield are not addressed. With a growing population continuing to demand lumber, a deintensified forest industry would be forced to seek new supplies elsewhere, thus degrading even larger expanses of land. In the end, only by developing substitutes for wood can we begin to create an environmentally benign construction industry.

Many wood substitutes are readily available. Concrete, for example, is easily and efficiently employed in all manner of construction. Yet eco-radicals like Catton (1980:135) warn against using concrete on the grounds that it is a nonrenewable resource. I would counter that the prospect of abandoning cement making and aggregate mining for fear that we will exhaust the planet's supply of limestone, sand, and gravel is an example of green lunacy. We might as well dismantle the ceramics industry for fear of exhausting the earth's clay deposits.

Paper, another natural product, embodies extraordinary environmental destruction. Papermaking remains one of the most polluting industrial processes in existence. Even if paper-mill wastes can be minimized (at some cost), and even if recycling becomes commonplace, paper production will continue to demand vast quantities of wood. Resource economics dictate that the necessary quantities of fresh pulp be derived largely from small, fast-growing trees, generally harvested in clear-cuts. The resulting pulp plantations are typically as ecologically impoverished as agricultural fields. By continuing to prefer paper to synthetic and electronic substitutes, we only ensure the needless degradation of vast tracks of land.

Many other examples of the ecological destruction inflicted by natural products could easily be cited. The damage entailed in cotton production, for example, was noted twenty years ago by Ehrlich (cited in Paehlke 1989:60). While cotton could be cultivated without biocides, yields would plummet, necessitating a substantial increase in acreage to meet the present demand. The area devoted to cotton is expanding at a rapid pace already, due both to population growth and to the mounting demand for natural fibers. Vast expanses of natural vegetation are now being cleared in order to grow cotton and to supply it with the water it requires. To provide high-class textiles, the Ogallala aquifer of America's southern Great Plains is being depleted, rain forests in Central America are being devastated, and the extensive Sudd Swamp of the southern Sudan is being threatened with drainage.

The standard environmentalist credo that renewable resources are intrinsically superior to nonrenewables rests on two fundamental errors. First, both eco-radicals and old-fashioned conservationists presume life to be so abundant that through wise use, directed either by primal affinity or scientific management, humans can obtain their needs organically without detracting from other species. Second, both camps have assumed that nonrenewables are so scarce that if we dare use them they will be quickly exhausted. Both principles are suspect.

In fact, the primary organic productivity of the planet is essentially limited. The more living resources are channeled into human communities, the more nature itself is diminished. The essential nonrenewable resources, by contrast—elements such as silicon, iron, aluminum, and carbon—may be tapped in extraordinary quantities without substantially detracting from living ecosystems. Aluminum and silicon are so wildly abundant that it is ludicrous to fear that we will exhaust the earth's supply. Moreover, except in nuclear processes, elements are never actually destroyed; as recycling and sequestering techniques are perfected, resource exhaustion will become increasingly unproblematic. Even coal and oil would be fantastically abundant if only we would cease the insane practice of burning them and instead, as suggested by Amory Lovins, dedicate the remaining supplies to the production of synthetic organic materials (see Paehlke 1989:77).

A society based on the principles of Promethean environmentalism will cease as much as possible to provision itself through the killing of living beings, be they animal or plant. Instead, it will strive to rely on nonliving resources, whether formed of long-dead matter, like oil and coal, or simple inorganic substances, like silicon. Learning to build our material world out of nonliving resources will entail both high-tech and low-tech methods. Simple technologies using stone, brick, tile, and concrete have eventually been devised by all forest-destroying civilizations



(Perlin 1989), and they continue to be useful. More sophisticated approaches entail the development of superior composite materials and synthetic organic compounds. Many such products deliver additional environmental payoffs; certain composites, for example, are both strong and light, giving them profound advantages for energy-efficient transport systems.[1]

Telecommunications and computer systems present another field in which technological advance could yield vast environmental benefits. Consider the advantages of electronic mail (E-mail) over the conventional mail delivery system. To operate the latter, entire forests must be dedicated to paper production, while huge fleets of trucks and airplanes must be maintained and fueled for parcel delivery. Transmission of E-mail, on the other hand, requires only silicon chips, glass cables, and energy-sparing pulses of information. Similarly, one would hope that improved transmission of video images will eventually obviate the need for much—perhaps most—business travel. The sooner we embrace the telecommunications revolution and dispense as much as possible with paper and with unnecessary personal contact, the less environmental damage our communications will inflict.

*Energy*

As all environmentalists recognize, deriving the bulk of our energy from fossil fuels is an unsustainable practice. Oil, gas, and coal deposits will eventually be depleted, undermining in the process the future of the synthetic organic chemical industry. The combustion of fossil fuels is also intrinsically damaging to the environment, especially by releasing stored carbon that threatens the planet's heat balance.

Many environmentalists have proposed that we obtain energy by burning renewable resources. Biomass derived from agriculture and forestry, they claim, could be endlessly recreated in future crop cycles (Porritt 1985:177). But as the preceding pages have argued, large-scale biomass conversion would prove to be an ecological catastrophe. To supply our energy needs, tremendous expanses of natural habitat would have to be converted to croplands or tree plantations, resulting in a massive reduction of natural diversity.

The solution to the energy bind lies, as most members of the environmental community realize, in a combination of solar power and conservation. What eco-radicals fail to recognize, however, is that both effective conservation and the commercialization of solar energy demand highly sophisticated technologies. The modern frontiers of energy conservation may be found in such areas as low emissivity windows, energy-sparing fluorescent light bulbs, and computer-integrated sensor systems (Fickett et al. 1990; Bevington and Rosenfeld 1990). Due to a wide variety of such advances, the energy intensity of American industry in fact declined at a rate of 1.5–2 percent per year between 1971 and 1986, allowing industrial production to increase substantially while energy consumption actually fell (Ross and Steinmeyer 1990).

When it comes to harnessing solar power, technological achievements are even more vital. Admittedly, several important solar applications demand little technical sophistication. Simply by placing windows properly a significant power savings can be realized. But in order to do something slightly more complicated—such as heat water—certain high-tech applications are essential. The simplest passive solar water heating systems usually rely on components made of plastic, a substance many eco-radicals would like to ban.

But to address our needs for an ecologically benign power source, solar-generated electricity must be commercialized on a massive scale. No matter how this is done, significant technological advances will be necessary.

A certain amount of electricity can be indirectly obtained from the sun by harnessing wind energy. Careful estimates show that fifteen American states could supply all of their electricity needs from environmentally benign wind-driven turbines (Weinberg and Williams 1990). As incremental advances are made in turbine technology, wind power may be expected to become ever more competitive with conventionally obtained power. Such improvements are already being seen, the cost of wind-generated electricity having dropped nearly 90 percent since 1981 (Weinberg and Williams 1990).

Yet in California, the state most committed to this alternative energy source, eco-radicals have recently begun to struggle against wind power development. The reasons: high levels of bird mortality caused by the spinning blades (admittedly a serious problem), and the fact that wind farms are an unsightly affront against the pristine landscapes in which they are typically located (discussed in Paehlke 1989:99). That only a minuscule portion of the state even has the potential for wind power development has not lessened their outrage. Here again many eco-radicals demonstrate a highly dangerous opposition to an environmentally promising technology.

Although wind power may someday be crucial in meeting the energy needs of a few windy states, direct solar power is far more promising as a possible solution to the energy crisis. Several competing technologies, notably solar thermal and photovoltaic, may supply tremendous



amounts of relatively cheap electricity in the near future (see Weinberg and Williams 1990). Of the two, photovoltaics, or PVs, show the most promise.

The cost of PV generated electricity has plummeted in recent years as solar cell efficiencies have increased and as economies of scale in manufacturing have begun to appear. At some 20 cents a kilowatt hour, PV electricity is now competitive with conventionally derived electricity in locations not yet connected to power grids. With continued investment in both design and manufacturing techniques, PV costs are expected to continue to fall, offering the possibility of an impending breakthrough into the mass market. One especially promising horizon in photovoltaics is the development of solar cells composed of thin film amorphous silicon, which may potentially prove both inexpensive and highly efficient. Manufacturers are also conducting research on nonsilicon materials, including copper indium diselenide, gallium arsenide, and cadmium telluride, all of which offer specific advantages. Arco Solar, for example, has recently reported a very impressive 15.6 efficiency rate using translucent silicon and CIS (copper inidium diselenide) (Bernstein n.d.:10; Ogden and Williams 1989). The most exciting recent breakthrough, however, is the development of silicon bead technology, pioneered by Texas Instruments and Arco Solar. This method of production appears to be so inexpensive that some researchers believe that it will soon make solar electricity fully competitive with conventional sources (*Business Week*, April 22, 1991, p. 90).

As large-scale PV generation becomes more feasible, the difficulties of storage will grow more prominent. Since PV electricity flows only when the sun shines, the challenge is to deliver power at night and on cloudy days. The lead-acid batteries now used for storage are both expensive and inefficient. Research is being conducted, however, on sodium-sulfur and zinc-bromine batteries that "store more energy in less space, offer longer lifetimes, and cost less than lead-acid batteries" (Bernstein n.d.:14). Superconducting magnetic energy storage may offer even greater benefits, but only if a daunting series of technical and economic obstacles are first overcome (Bernstein n.d.).

Although a variety of problems remain, the successful commercialization of photovoltaics, unlike fusion power, will not require major scientific breakthroughs. Continued incremental advances along several fronts can be expected to render PVs increasingly competitive with conventional electricity sources. Importantly, PVs offer greater potential for the realization of economies of scale than do most competing power sources because they are constructed in the factory rather than the field

(Ogden and Williams 1989:50). The difficulties currently being faced by the PV industry stem ultimately from its own immaturity—and from the negligible amount of governmental assistance that it has received—rather than from any intrinsic failings.

Yet even if solar-generated electricity were soon to fulfill its promise, the challenge of supplying energy for mobile applications would remain. Several automobile companies (most notably GM) have made great strides in designing electric cars, although the development of lightweight storage batteries remains a stubborn obstacle. Equally promising is the creation of hydrogen-powered vehicles. Unlike other fuels, hydrogen burns cleanly, releasing little but water vapor. In an integrated, environmentally benign energy system, solar-generated electricity could be used to reduce water to its constituent elements, supplying in the process high-energy hydrogen fuel (Weinberg and Williams 1990). Certainly many challenges remain, especially that of rendering hydrogen both safe and easily transportable. But several companies, notably Daimler-Benz, BMW, and Mazda are presently working on these problems (*Business Week*, March 4, 1991, p. 59; Ogden and Williams 1989).

Tragically, many eco-radicals have joined anti-environmentalists in disparaging the possibility of a transition to a full-fledged solar economy. Radicals voice a variety of predictable concerns. Many consider the devotion of large expanses of land to solar collectors completely unacceptable. Especially galling is the prospect of relatively pristine desert environments being sacrificed for energy collection. More fundamentally, eco-radicals shun photovoltaics because of the sophisticated technology required (see Dobson 1990:103)—the same technology implicated in the feared information revolution. PV manufacturing also generates toxic wastes, which many regard as reason enough to ban the entire industry. Moreover, PV systems could not possibly be constructed and maintained on a bioregional basis, thereby excluding them from the realm of the environmentally correct.

The anti-environmental opposition to solar power is a bit more curious. While anti-environmentalists exude unshakable optimism when considering ecologically destructive technologies such as nuclear fission, their forecasts quickly turn dismal when confronted with ecologically benign innovations. Dixy Lee Ray (1990:128), for example, dismisses solar power out of hand, stating simply that "solar generated electricity is not a practical alternative." If the prognosis for solar power were really so miserable, one might well wonder why the Japanese government and major Japanese corporations are pursuing it so avidly. According to the logic of Promethean environmentalism, solar technologies *can* provide our energy needs, but only if we are willing to adopt a long-range economic perspective. Seen in this light, the antisolar stance of writers like Ray seems little more than a pathetic attempt to justify the short-term thinking that is presently leading the American economy along a sustained curve of relative decline.



Techno-environmentalists like Oppenheimer and Boyle (1990) argue that if we have the foresight and fortitude to develop a solar-based economy, we can both avert the potential catastrophe of global heating and propel the United States into a renewed era of sustained economic growth (the so-called fifth wave of the Kondratiev cycle). Certainly a solar economy will entail some adverse environmental impacts, but compared to any of the alternatives, they are minimal indeed. Despite eco-radical fears that PV collectors would monopolize the earth's desert surfaces, careful calculations show that all of this country's electricity needs could be met be devoting only .37 percent of its territory to PV arrays (Weinberg and Williams 1990:149). This is one sacrifice that the earth can certainly afford. As Oppenheimer and Boyle argue, economic and ecological health are mutually supportive, not mutually contradictory. But so long as American environmental protagonists and antagonists continue to regard the two as incompatible, the United States will remain a sorry laggard in the global transition to an ecologically sustainable economic order.

### *Nanotechnologies*

Although Oppenheimer and Boyle present an exciting vision of the environmental possibilities offered by select high technologies, K. Eric Drexler (1986; Drexler and Peterson 1991) offers a far more daring and (guardedly) optimistic scenario of a future society enjoying the fruits of "green wealth." Drexler powerfully argues that molecular nanotechnologies should make virtually all present-day technological forms obsolete, perhaps within the next few generations. "The industrial system won't be fixed," he informs us, "it will be junked and recycled" (Drexler and Peterson 1991:22). In his vision molecular assemblers guided by minuscule nanocomputers will be able to construct atomically precise yet surprisingly inexpensive goods of tremendous variety. A veritable cornucopia of smart materials, able to repair themselves and rearrange their shapes to fit the needs of their users, supposedly awaits just the other side of the impending nanotechnology revolution.

For the Promethean environmentalist, the appeal of nanotechnology lies more in its environmental promises than in its potential to provision human needs and wants. Not only will molecular processing release no pollutants, but molecular devices could be employed for cleansing the earth of its twentieth-century contaminants. Indeed, these very pollutants, especially waste carbon dioxide, should provide nearly the entire resource stock necessary for the new economy. Forestry, fiber growing, and even mining will therefore become obsolete. Drexler even gives hope to the ultimate eco-Promethean fantasy: species restoration. Combining nano- and genetic technologies, he believes, may allow us to recreate extinct forms of life, so long as their genetic codes are preserved in tissue samples. Here one can appreciate how the Prometheans' perspective exceeds that of the Arcadians in its ultimate vision of environmental restoration.

Despite its careful grounding in physics, chemistry, and mechanical engineering, nanotechnology is still a somewhat distant dream, and the advances sketched above may never be realized. And even if the visionaries are proved correct, great dangers still await. As Drexler unhesitatingly reveals, nanotechnology could prove a potent carrier of military destruction (see also Milbrath 1989). A certain degree of social control is thus vital, just as it is for other forms of advanced technology. Moreover, nanotechnologies will never allow a complete decoupling of human beings from the natural world, most importantly because they will never yield foodstuffs (molecular devices will not mimic biological structures). As the following discussion reveals, agriculture continues to present some of the most intractable environmental problems.

*Agriculture*

The environmental dilemmas of agriculture seem especially vexing. The human population has no option but to feed on other living organisms, thereby of necessity monopolizing a large percentage of the planet's primary productivity. Because agriculture necessarily entails the manipulation of ecosystems, decoupling processes are not easily applied. The spatial organization of agriculture also makes pollution control remarkably difficult. Whereas factories spew out waste from a limited number of stacks or pipes, farmers disseminate fertilizers and biocides over a wide expanse of territory. Sophisticated pollution control devices cannot easily be installed where waste seeps from such nonpoint sources.

The eco-radical answer to the agricultural impasse is a return to organic farming. Chemical-free cultivation does indeed have much to recommend it, although if it is to become economically competitive, concerted (and highly specialized) research will be necessary in such areas as integrated pest management (IMP). In the absence of significant IPM advance, increasing production costs will translate into either significantly increased food bills or lowered dietary standards, a situation few Americans would tolerate. In the near term, methods derived from organic farming might be combined with selected new technologies, allowing farmers to reduce their reliance on chemical inputs, especially those that present the greatest environmental hazards. In the Third World especially, such intermediate tech approaches to agricultural production are desperately needed (see *The Economist*, "The Green Counter Revolution," April 20, 1991, pp. 85–86).



Many green extremists, however, deny that anything new is needed. Instead, they point to the agricultural success of the old order Amish, a people who rely on traditional farming techniques, shunning agricultural chemicals and modern machinery (Berry 1977: 210 ff.). What they fail to mention, however, is the fact that Amish patriarchs owe much of their success to their exploitation of the labor of their *numerous* children. If all of our farmers were to adopt an Amish way of life, rural America would begin to resemble rural Bangladesh, both in terms of population density and in regard to patriarchal tyranny, within the span of a few generations.

Yet agro-environmentalist tracts, even those of a radical bent, do contain many worthwhile suggestions. As most argue, the need to adopt a less carnivorous diet is paramount. Meat production is energetically inefficient and ecologically unsound; when cattle convert grain into meat, most of the original food value is lost in metabolic processes. By relying substantially on grain, pulses, and farm-raised fish,[2] we could return vast expanses of agricultural land to nature, reduce our increasingly suffocating medical expenditures, and at the same time drastically curtail our use of pesticides and fertilizers. Eco-radicals are also correct in arguing that small-scale cultivation must persist at some level, if only to preserve the genetic diversity of crop plants. Modern farming *relies* on the diverse array of genetic materials maintained by indigenous farmers, particularly those living in remote Third World villages, yet consistently *undermines* that diversity by disseminating "improved" cultivars. Gardeners in the industrialized nations can do their part by assiduously cultivating "heirloom" fruits and vegetables, and by carefully selecting and exchanging their seeds (Pollan 1991, chapter 11). In agriculture, high-tech approaches are often helpful, but they will never prove adequate.

More innovative ideas from the eco-radical community could also help us devise less destructive forms of agriculture. The geneticist Wes Jackson, for example, daringly argues that we should abandon annual crops, such as wheat, and instead rely on perennial plants that produce year after year (Jackson and Bender 1984). The cultivation of annuals demands plowing, leading inevitably to soil erosion. Although no-till farming practices are now being explored by conventional agricultural researchers, these techniques generally require massive applications of herbicides and fungicides. Jackson, therefore, advocates cultivating perennial grain crops that would require neither constant plowing nor chemical control. The only hitch is that such crops do not yet exist; Jackson and his colleagues are presently working to create them through traditional breeding techniques. A similar and more immediately practical idea was forwarded several decades ago by geographer J. Russell Smith (1953), who urged farmers to reorient their agriculture toward perennial tree crops, such as chestnuts, primarily in order to save the country's remaining topsoil.

Yet while organic farming, reduced meat consumption, and permaculture offer some hope for solving the agricultural crisis, their impact to date has been marginal at best. Organic crops are generally too expensive, and often too imperfect, to appeal to a broad market. Despite a modest reduction in red-meat consumption (due primarily to health concerns), the deep attachment to animal flesh seems too strong to be overcome through moral persuasion. Finally, the perennial grains developed thus far yield insubstantial harvests, while arboriculture remains untenable for both economic and gastronomic reasons.

But these same environmental dreams could perhaps be realized if we were willing to harness technology to the task. Genetic engineering is particularly promising in this regard (Gasser and Fraley 1989).[3] The traditional breeding techniques of artificial selection ultimately depend on the random appearances of desirable genetic mutations; at best they require dozens of plant generations to come to seed before modest improvements can be realized. High-yield perennial grains may someday appear, but probably not until many decades have passed—a time span we cannot afford. Through recombinant DNA, on the other hand, "designer" organisms can often be created in months. The careful application of biotechnology to other agricultural problems offers further environmental advantages. Organic farming, for example, will receive a tremendous boost as geneticists fabricate crops that manufacture their own internal pesticides. Similarly, fertilizer inputs can be drastically curtailed once genes for nitrogen fixation can be inserted into nonleguminous crops plants.

As advances in biotechnology make agriculture more efficient, large tracts of land can be progressively returned to nature. Similarly, intensive greenhouse cultivation, relying on high-tech glass construction, advanced atmospheric chemical control, and perhaps even the use of molecular antifungal agents, could increase food supplies while at the same time tremendously diminishing the extent of land needed for food production (Drexler and Peterson 1991:175). Yet some American politicians appear to rule out such possibilities beforehand, assuming that increasing production will only translate into larger commodity gluts (Sagoff 1991:353). Certainly the biotechnology revolution will require a difficult set of adjustments for American farmers, but only an anti-environmentalist would automatically rule out the possibility of reducing the extent of land monopolized by agriculture. Agricultural gluts represent political, not technological, failure.



Advanced techniques in food science, especially those concerned with enzyme production and protein synthesis, may also offer substantial environmental benefits. Especially desirable is the development of palatable, vegetable-based meat substitutes. If soy burgers become indistinguishable from, and less expensive than, the genuine product, we could expect widespread cutbacks in meat consumption, allowing us to liberate vast tracts of land from agricultural production. Such environmental benefits would, however, be impossible to realize if consumers were to take at face value the eco-radical tenet that artificial products are to be avoided in all instances.

Radical environmentalists will likely respond to the proposals sketched above with disgust if not revulsion. In their view, tampering with DNA is blasphemy, and even the consumption of artificial foods is something of a venal sin. But by sanctifying the human place within the natural world, radical greens only ensure the destruction of nature. The more we feel compelled to consume natural products, the more we monopolize the earth for ourselves.

The eco-radical denunciation of genetic engineering also betrays a misunderstanding of our historical relationship with the natural world. We commenced playing God millennia ago, as soon as neolithic humans began to domesticate plants and animals. There has never been, for example, a single stalk of wild corn; maize was not domesticated so much as created by the crossing of different wild plants that would never have shared their genes without human meddling (Heiser 1981:107). The primitivists, who do grasp this truth, conclude that agriculture represents our original sin. Perhaps it does. Yet I continue to believe that we can best atone for our past environmental crimes not by retreating toward an unreachable Arcadian past, but rather by moving forward into a benign Promethean future.

Of course, genetic engineering, like other forms of high technology, can certainly be misapplied. One current project that borders on insanity involves the development of a herbicide-resistant strain of tobacco (Gasser and Fraley 1989). This will only offer the world a more abundant supply of an addictive, deadly drug—as well as a more poison-filled environment. Genetic technology, like all others, requires firm political and moral guidance.

The proposals sketched above may offer hope for the long term, but for the short term more immediate steps must be taken. American agriculture is indeed in a crisis situation, which has very dangerous environmental implications. Heavily indebted farmers are forced to expand recklessly in order to ensure harvests large enough to cover their interest payments, a situation that leaves them no room in which to experiment with ecologically sound alternative methods. Because of its intimate connections with nature, farming cannot be considered just another economic activity, and the market certainly cannot be relied upon to generate solutions to the current impasse. Unfortunately for the consumer, somewhat higher prices for agricultural commodities are probably necessary if American farmers are to receive the breathing room they so desperately need. We must begin to break our addiction to chemical farming—a process that will entail some pain for society at large.

### *Conclusion*

The development of ecologically forgiving technologies is not inevitable. Desirable advances can only be realized through great efforts undertaken by large segments of human society. Americans should devote unyielding efforts to enhance education, scientific research, and economic productivity. If present trends continue, any fifth wave of economic growth will be dominated by Japan, not the United States. It would not bode well for either human freedom or environmental protection if the United States were simply to abandon the effort. Yet the chances of American leadership in the development of an ecologically sustainable socioeconomic order seem slim indeed. Both eco-radicals, who despise capitalism and denigrate technology, and anti-environmentalists, who worship at the alter of the free market oblivious to environmental destruction, seem perfectly willing to watch the United States shed all its competitive advantages. As Porter (1990:173) shows, nations either move ahead or fall behind in international economic competition. And as Mokyr (1990) demonstrates, the historical reality is that the forces of conservatism—in this case, including both the extreme right and the eco-radical left—more often than not thwart the development of promising new technologies, even in societies that were once technological leaders.

Technological advance has clearly been something of a two-edged



sword. The vast majority of people in preindustrial times may have lived short and impoverished lives, but industrialization has brought us face to face with global warming, ozone depletion, and acid rain. Given this trade-off, most green radicals would conclude that ecological salvation is more important than human comfort or longevity.

There are two fundamental problems with this line of reasoning. For one thing, it fails to recognize that industrial pollution is only one kind of environmental degradation. Preindustrial peoples have proved themselves capable of extraordinarily destructive acts, notably by deforesting entire landscapes and exterminating major faunal species. More importantly, the antitechnology thesis ignores the fact that technological advance has the power to heal as well as to destroy. In the modern world technological poverty often forces immiserated peoples to degrade their environments. Similarly, old industrial processes are virtually synonymous with dirty industrial processes. I am convinced that we can develop a clean, environmentally benign industrial system, but only if we have the will to embrace technological innovation and support the educational infrastructure that makes it possible. And despite the claims of *all* eco-radicals, such a transition will only be possible if we retain a capitalist economic system.