Zygon | *Journal of* RELIGION AND SCIENCE VOL. 10, NO. 4

SCIENCE, RELIGION, AND THE COUNTERCULTURE

by Ian G. Barbour

Though the extreme expressions of the counterculture which emerged in the late 1960s and early 1970s are less common today, many of its misgivings about American society are shared in varying degrees by a significant segment of contemporary youth. A persistent feature has been a disillusionment with science and technology as well as with institutional religion.[1] Scientists and philosophers of science have tended to react defensively to these attacks but have often failed to do justice to the motives of the counterculture or the aspects of its critique which might be valid.[2] The continuing polarization of viewpoints has proliferated rhetoric but hindered communication and dialogue in which each side might learn from the other. The present article sets forth some countercultural views of (1) reason, (2) science, and (3) technology and then attempts a sympathetic but critical analysis of each. Comments on countercultural attitudes to religion will appear at a number of points in the discussion.

Reason and Experience in the Counterculture

Disaffection from science and technology should be seen in the broader context of attitudes toward reason and experience. The

Ian G. Barbour is professor of religion and physics, Carleton College.

[*Zygon*, vol. 10, no. 4 (December 1975).]

counterculture is so diverse and fluid that any generalizations are likely to have many exceptions, but the following recurring themes are pertinent:[3]

1. *Search for Alternative Life-Styles.* The counterculture does not accept such goals and values of a technological society as efficiency, order, rationality, and productivity. It opts out from the competitive pursuit of success, affluence, material possessions, and the obsession with work which is sometimes identified with the "Protestant work ethic." Alternative life-styles are sought in which there is more room for spontaneity, individuality, freedom, and "doing one's own thing." Nonconformity is partly a rejection of authority and a reaction against overt and subtle pressures for conformity. The new goal is to take charge of one's own life and choose one's own pattern rather than trying to fulfill other people's expectations. The focus is on the present rather than the future.

2. *Harmony with Nature.* The counterculture is critical of the technological goal of conquest of nature. It claims that the biblical view of man's dominion over nature has encouraged exploitation of the environment in the West. Eastern religions have considerable appeal because they have stressed man's unity with nature and respect for life in all its forms. Many of the communes formed in the last decade were in rural settings in which a group could grow organic foods and try to express in practice the interdependence in the web of life of which the ecology movement has made us aware. Frequently, there is a keen concern for man's unity with the natural world and a simpler life with a lower level of consumption.

3. *Interpersonal Relatedness.* Many young people are seeking the acceptance of a congenial and supportive group. In a true community there is belonging, affection, and solidarity, in contrast to the anonymity and impersonality of urban mass society. Surely, we must admire these ideals of authentic human relationships—ideals of openness, honesty, freedom, and tenderness—even if we have to acknowledge that in practice most communal groups fall short of such ideals, and internal conflicts have been rather common among them. There has been a variety of models for these communities, from the shared life of an extended family to the social organization of an Israeli kibbutz.

4. *Personal Experience.* The process of self-discovery and the search for identity have always been part of adolescence and early adulthood, but they take new forms today. There is a hunger for intensity of experience and for commitment, peace, and joy. In a world of mechanical routines, the capacity to experience more deeply and vividly is sought. Psychedelic drugs promised heightened aware-

ness and an expansion of consciousness. Charles Reich in *The Greening of America* saw the great hope for the future not in social or political movements but in a new type of consciousness among youth.

5. *Emotion versus Reason.* Our culture in general and the technological mentality in particular tend to repress emotion. We exalt the intellect and seldom appreciate our feelings, our senses, or our bodies. So the counterculture encourages nonverbal communication, awareness of the senses, and the celebration of vitality and feeling. It values the immediate, the concrete, and the subjective, and it distrusts abstract ideas. In its extreme form this becomes an anti-intellectualism, a rejection of reason, and an attack on disciplined thinking of any kind. Such a reaction seems to perpetuate the very separation of reason and emotion which it attacks, though it does so by neglecting reason instead of by neglecting emotion.

6. *Interest in Mystical Religion.* In keeping with the stress on personal experience, the spiritual search of many in the younger generation has led to the meditative practices of Eastern religions. There is interest in yoga and Zen and the teachings of a variety of gurus. The ultimate truth is sought within, by intuition, not through rational thought or the authority of tradition. This renewed concern for the experience of the mystic must be respected, but it is more difficult to respect the growing fascination with astrology, the irrational and the occult, and the attraction of satanism and witchcraft. Many of these occult groups claim secret or magical paths to power over nature.

Roszak's Critique of Science

On the more specific subject of science, the counterculture has found articulate expression in the impassioned writings of Theodore Roszak, particularly in his book, *Where the Wasteland Ends.* Three of his criticisms may be summarized thus:

1. *The Reductionism of Science.* Roszak blames on science the development of a mechanistic world view. Following the brilliant success of Newtonian physics, scientists increasingly viewed the world as a machine and then as a collection of particles in motion. This led to the reductionist assumption that only what can be quantitatively measured is to be considered real. Mass and velocity were taken to be attributes of the objective world, while color and warmth were said to be subjective qualities in man's mind. Science influenced the reality principle of modern society, the "collective mindscape," as Roszak calls it, in which reality is constituted by whatever can be scientifically known. The result is "single vision," the capacity to see and respond

only to the features of the world which can be measured and analyzed by science.

2. *The Objective Consciousness.* The scientist reports impersonal data from which all personal elements have been removed. Ever since Descartes, the knower has been pictured as separate from the known, the detached observer at a distance from the object of knowledge. Newton's ideal of knowledge as understanding was subordinated to Bacon's ideal of knowledge as power, the capacity to master and control the world. Roszak argues that objectivity led to alienation from nature. If nature is a machine, dead and alien and external to man, it becomes an object to be conquered and used. This arrogance toward nature encourages environmental exploitation rather than harmony between man and his environment. The objective consciousness finally leads us to treat other persons like things. In the manipulation of people, the freedom and mystery of selfhood is denied. Roszak is particularly critical of experimentation on man with the goal of prediction and control—for example, chemical modification of behavior, electrical stimulation of the brain, or the genetic engineering of man's evolutionary future.

3. *The Loss of Imagination.* Roszak pictures science as a rather routine and mechanical process in which there is little place for creative imagination. With the spread of science, he says, man's artistic and poetic responses atrophied and the sense of wonder and awe was stifled. To the objective consciousness there can be no mystery or sacredness but only problems to be solved. Science is interested in the repeatable and the general, not in the uniqueness and particularity of individual events or persons. So Roszak turns to the poetry of the Romantic movement—Blake and Wordsworth, for instance, with their defense of imagination, intuition, and uniqueness. But he also goes farther in claiming that we have a lot to learn from alchemy and magic, from dreams, visionary powers, and ecstatic utterances, and even from the visions of Carlos Castañeda's Indian sorcerer, Don Juan. Roszak ends by opposing imagination to reason.

Disenchantment with Technology

Concerning the applications of science in technology, the criticisms made by Roszak and the counterculture can be grouped under three headings:

1. *Destructive Consequences.* A prominent cause of antitechnological attitudes has, of course, been the association of technology with war and environmental degradation. In Vietnam, military technology took an enormous toll in human lives and resources. The environ-

mental crisis, in turn, was in large measure the product of an industrial technology which had been consuming resources and polluting air and water at ever-increasing rates. Acrid air, foul water, and strip-mined hills testify to our failure to take into account the social and environmental costs of our technologies. These are familiar observations but assume greater force when combined with the following ones.

2. *The Concentration of Power.* Technology increases the gap between rich and poor nations and between rich and poor within a nation. It gives to man power over nature, but it also gives to some men power over other men. The control of information, for example, is a form of power, whether it is exerted through communications media, the ownership of computers, or electronic surveillance techniques. A technological society relies increasingly on the experts, the specialists who alone can understand the complexities of technical questions. Planning from the top down is efficient and rational. The critics fear that this reliance on expertise will threaten democratic participation and produce a technical elite, the technocrats who will run society.[4]

3. *The Dehumanization of Man.* Technology leads to mass production and mass media, uniformity, and standardization which threaten human individuality and uniqueness. Efficiency and rational organization require conformity and discourage spontaneity. People become cogs in a well-oiled machine, a mechanical society. The individual feels powerless in the face of a mindless and impersonal bureauracy in which no one has personal responsibility. Man becomes subservient to the machine, adapting to its schedule, adjusting to its needs. The demand for new products is artificially created by advertising, the hidden persuader which stimulates new desires. The ultimate indictment of technology is that the machine becomes man's master rather than his servant.[5]

Such criticisms are not new. The Romantic poets in eighteenth-century England protested that the factories of the Industrial Revolution were blackening the environment and dehumanizing the workers. The existentialist philosophers of nineteenth-century Europe proclaimed that the mechanization of industrial society was threatening the freedom and creativity of the individual. The theater of the absurd in the twentieth century portrayed a mass society in which all individuality and spontaneity were suppressed. Novels such as Aldous Huxley's *Brave New World* and George Orwell's *1984* expressed these antitechnological fears in literary form. But only in recent decades has technology pervaded virtually every aspect of American life, and

only in recent years has reaction to a technological society been evident in a significant fraction of American youth.

The Reunion of Reason and Experience

We must now analyze these countercultural themes more carefully, starting with reason and experience and then considering science and technology. I have suggested that the ideals of interpersonal relatedness, personal experience, and mystical religion deserve our respect. But can the centrality of experience be defended without rejecting the role of reason?

1. *The Diverse Dimensions of Experience.* Life is indeed impoverished if the technological attitudes of mastery and power dominate a man's outlook. Calculation and control do exclude mutuality and receptivity in interpersonal relationships and prevent the humility and reverence which religious awareness requires. The pursuit of rationality and efficiency leads to impatience with individual differences and personal emotions. But the threat to these areas of human existence comes not from technology itself but from an overextension of technological attitudes to the exclusion of all else. The enemy is not technology but an unqualified reliance on technology and a preoccupation with material progress and technical goals which may preclude openness to experience in all its dimensions. Only if we have lost sensitivity to the whole man could we manipulate people as if they were objects.

But here, I suggest, the counterculture has overreacted in the opposite direction by exalting emotion over reason. If our goal is recovery of the wholeness of experience, we must combine reason with emotion, thought with feeling, critical inquiry with creative imagination. Emotion without reason can lead to individual caprice or group fanaticism. Self-criticism and reflective evaluation are correctives for the destructive potentialities of emotion. Perhaps the counterculture deliberately emphasizes the dimensions of human life which are often neglected today, and perhaps every critic has to exaggerate in order to be heard. But our goal, surely, should be a more balanced recovery of the whole man.

2. *A Broader View of Reason.* The technocratic mentality identifies reason narrowly with technical reason, the processes of mathematical calculation and logical deduction which can be carried out by a computer. The counterculture rightly rejects exclusive reliance on technical reason but itself often ends in irrationalism. What is needed by both the technocrat and his critics is a wider understanding of reason. The academic tradition of liberal scholarship is broad enough to en-

compass the sciences and the humanities; there are various kinds of critical inquiry and disciplined thinking, each closely related to a distinctive type of human experience. The complex problems of contemporary society require interdisciplinary collaboration which is only hindered by the continued polarization of the "two cultures" that cannot communicate.

The focus of the counterculture on the present, on the senses, and on the enjoyment of life may be an understandable protest against an excessive future orientation, a Puritan suppression of the senses, or an obsessive work ethic of deferred gratification. But the demand for instant gratification prevents the patient inquiry and critical examination which the pursuit of truth demands. One of the dubious appeals of astrology and the occult is that they promise shortcuts to hidden truths without patient inquiry. Even in the arts, creativity requires not only spontaneity and feeling but disciplined and arduous study and practice.

3. *Reason and Experience in Religion.* Western religion has tended to stress doctrine and belief at the expense of experience. A narrow literalism has distorted the symbolic power of religious writings. We can welcome the new interest in ritual, the celebration of life, the renewed sense of wonder, mystery, and sacredness. We have given too little attention to the mystics, including those within the Jewish and Christian traditions, who have testified to the unity of all things, the sacred in the world, the participation of the individual in a more inclusive Whole. Protestantism, even more than Roman Catholicism, has neglected the practice of meditation in daily life. Along with the counterculture, we can seek the recovery of the experiential basis of religion.

But again, experience does not have to be separated from reason. Religious experience must always be interpreted in terms of some understanding of the nature of reality, some interpretive scheme within which one tries to make sense of one's life. I have suggested elsewhere that models in both science and religion are imaginative constructions for ordering experience.[6] Models are neither literal pictures of reality nor useful fictions but symbolic representations of aspects of reality which are not directly accessible to us. Rational reflection on religious models does not require that they be divorced from human experience. All our theological formulations are partial and limited, yet they are open to discussion. Critical inquiry is not incompatible with personal commitment and existential involvement.

If we acknowledge a plurality of significant religious models, we will be more humble and tentative in the defense of any theological system. In place of the absolutism of exclusive claims to finality, we can

appreciate the diversity of religious faiths without lapsing into a complete relativism which would undercut all concern for truth. We can be sensitive to the experience of men in other cultures and avoid the theological imperialism to which preoccupation with doctrines and literalism in interpretation have often led. In particular, we can benefit from dialogue with the Eastern traditions from which the counterculture has drawn heavily (though sometimes in very Westernized versions). We can perhaps discover for our own lives new possibilities to which we may have been blinded by the assumptions of our culture.

The counterculture's concern for harmony with nature can also be accepted without abandoning the task of theological reflection. The credibility of the traditional understanding of God's relation to the world was undermined by the mechanistic and reductionistic world view for which support from science was claimed. One response is to confine religion to the private sphere of man's inward life and abandon nature as a realm of God's activity. Another alternative, more common among contemporary youth, is to respond to nature in terms of feeling alone, giving up the quest for intellectual understanding. But there remains the possibility of a theology of nature which is both rationally credible and experientially relevant and which expresses conceptually the unity of nature, man, and God. Three components of such a theology of nature are crucial: (1) a doctrine of God which stresses divine immanence as well as transcendence, avoiding the separation of God and nature; (2) a doctrine of man which stresses his continuity with other forms of life and his own psychosomatic unity, overcoming the separation of man and nature as well as the dualism of body and soul; and (3) a belief in the inherent value of nonhuman nature, as against the historic emphasis on man's dominion over nature.

Such a theology of nature is supported by the biblical views of creation, human nature, and man's stewardship. It can also be elaborated within a sacramental or incarnational theology. I have urged that the categories of process philosophy are especially helpful at each of the three points above.[7] Process thought views nature as a creative process, a community of interacting organisms, not a deterministic machine. It sees God as transcending nature but also as immanent in this process, participating throughout cosmic history rather than intervening coercively from outside. Man is understood in the same categories as other beings; there are no metaphysical discontinuities, though the importance of any given category will vary widely among different levels of being. All beings are intrinsically valuable and worthy of respect as centers of at least rudimentary experience. Such

a scheme can do justice to scientific and religious thought and at the same time provide a view of the world which would encourage the ecological attitudes expressed by many of the younger generation.

There is, finally, much to be learned from the counterculture's rejection of the church. Objections to religious institutions may be in part a distrust of organizations in general and a neglect of the positive potentialities of institutions as agents of social change. But many of the criticisms of the church's bondage to dominant cultural values are strongly reminiscent of the prophets of Israel or of the first-century church which stood over against its surrounding society. And in the new quest for interpersonal relatedness we can see a search for what the church should be—a community of love, trust, and honesty, a fellowship of mutual acceptance and support. We will return later to examine other values implicit in countercultural life-styles.

An Alternative View of Science

Let us consider next Roszak's critique of science with regard to reductionism, objective consciousness, and loss of imagination.

1. *Science as Selective, Not Reductive.* Throughout much of his writing, Roszak seems to assume that reductionism is an inherent feature of science. But a section of one of the later chapters of his book and a more recent article suggest that he does see reductionism as an illegitimate extrapolation from science.[8] The distinction is crucial if we are to reject reductionism without rejecting science, and it can be supported only by a discussion of the nature of scientific theories. Reductionism can be understood either as an epistemological claim (e.g., that all phenomena can be explained in physicochemical terms) or as a metaphysical claim (e.g., that reality consists of matter in motion). The epistemological claim is logically prior and can be answered along the following lines:

(1) Scientific models are not literal pictures of reality. A model is an imaginative mental construct for ordering experience, not a description of the world. It is a symbolic representation of selected aspects of the behavior of a complex system for particular purposes. The scientist uses a conceptual model (such as the "billiard-ball model" of a gas) to formulate a theory whose terms are correlated with a set of observable variables. Alternative models arising from different modes of analysis are not mutually exclusive; every theory is selective and abstractive.[9]

(2) The use of concepts and theories applying to one level of organization does not preclude the use of different concepts and theories at other levels. Organisms are multileveled systems and

are in turn members of populations and ecosystems. System laws and higher-level theories are valuable for analyzing distinctive types of activity which do not occur in the component parts separately. Holistic studies of systems and detailed analysis of components are often mutually illuminating.[10]

(3) Biological laws cannot be deduced directly from physiochemical laws. Biology involves distinctive concepts which do not even occur in physics and chemistry; the two sets of concepts can often be correlated, but the correlation is not provided by the lower-level disciplines alone. Historically, the bridges between sciences have often been derived from neither of the original fields, and in the process both fields are likely to have been expanded and modified.[11]

The fruitfulness of the categories of molecular biology today, like those of Newtonian physics in the eighteenth century or of Darwinian biology in the nineteenth, has encouraged the presumption that one set of categories can provide an exhaustive explanation of all phenomena. Furthermore, a scientist's interests can easily be narrowed by the intellectual excitement of his own field, isolation from the complexities of the world outside the laboratory, or preoccupation with the demands of a scientific career. The success of science in the search for quantifiable, repeatable regularities leads some scientists to dismiss all other forms of experience as unreliable clues to the nature of reality. In reply to these reductionistic pressures we can insist that scientific models are not pictures of reality, theories correlate only selected aspects of phenomena, and distinctive concepts are needed for understanding distinctive activities at a variety of levels.

2. *Objectivity and Alienation.* Roszak holds that the main cause of man's alienation from nature and other men has been "objective consciousness," the assumption that science requires the separation of the detached observer from the object of knowledge. A partial remedy may lie in the increasing recognition by scientists and philosophers that a complete separation of the knower and the known is not possible. The measuring process influences the data. In quantum physics, the act of observation inevitably disturbs what one is trying to observe; in relativity, observations vary according to the observer's frame of reference. And observations are always described in terms of concepts from prevalent theories. Philosophers of science today acknowledge that "all data are theory laden"; there is no absolute and unchanging line between data and theory.[12] Theories, in turn, are not given to us ready-made by nature or inferred directly from observations; they are imaginative mental constructs by which the scientist organizes

data. In assessing the evidence and in deciding between rival theories—especially between comprehensive theories of wide generality—the scientist has no simple rules to follow; he must exercise considerable personal judgment, like a judge weighing evidence in a difficult case.

In addition to his involvement as observer and as knower, the scientist is involved in his work as a person with emotions and feelings.[13] Only in idealizations is he "a disinterested and dispassionate observer." But when he writes a scientific report, he avoids any reference to such personal emotions. Scientific thought itself is indeed impersonal in the sense that it seeks reproducible results and agreement among observers. Intersubjective testability requires the elimination of the purely individual or idiosyncratic. An element of "distancing" between the knower and the known does seem to be intrinsic to science. This may engender an impersonal or neutral attitude toward nature or man, but it hardly seems to account for alienation.

In Roszak's eyes, another cause of alienation was the displacement of the Newtonian view of science as a form of understanding by the Baconian view of science as a form of power over nature. I would grant that the scientist "dedicated only to the pursuit of truth" is a mythical figure. Scientists, like other persons, have mixed motives, which may include intellectual curiosity, professional recognition, and public status (as disputes over priority make evident) as well as financial security, power, and influence.[14] Basic research does lead to practical applications—which are emphasized when funding from government or industry is sought. Nevertheless, for many scientists, understanding remains a significant goal in its own right apart from any eventual applications. In particular, the desire to understand man is compatible with respect for persons; it does not inevitably lead to the manipulation and control of other people.

While the demands of objectivity do exclude human emotions from the structure of scientific theories, this does not imply that in the rest of his life the scientist must be indifferent to human relationships or restrict his participation in the rich diversity of experience. Only if an attitude of mastery and control pervades all human interactions does it lead to alienation from nature and from other men. Many of the great scientists of history were men of diverse interests, considerable humility, and a sense of wonder.

3. *Creative Imagination in Science.* There are no recipes for creating new theories. Sometimes a scientist has worked unsuccessfully on a problem, and at a moment when he is preoccupied with other things, a novel idea suddenly occurs to him, perhaps as a product of his subconscious mind which puts images together in new combina-

tions. Some theories arise from looking at familiar phenomena in new ways or from seeing analogies between apparently unrelated phenomena.[15] Newton connected two familiar facts, the fall of an apple and the revolution of the moon. He thought of the moon as continually falling toward the earth even while its inertia carried it forward and away from the earth—and the theory of gravitation was born. Darwin saw an analogy between human population pressure as Malthus had described it and the survival of animal species—and he had the key to the theory of evolution.

Creative imagination in science, as in poetry, often arises from the perception of unexpected analogies or the synthesis of familiar ideas into new wholes. The scientist, like the artist, appreciates pattern in diversity and beauty in form and structure. Now in fairness to Roszak we should note that in a few passages he mentions this more imaginative side of science, even though in most of his writing he portrays it as an unimaginative and routine procedure. Moreover, we should acknowledge that the picture of science as a mechanical and routine process is in part a result of unimaginative teaching; the student memorizes equations and gains little sense of what creative research is like. But here again Roszak should have made it clear that his attack is directed against misconceptions of science rather than against science itself.

The Redirection of Technology

We turn finally to the criticisms of technology made by Roszak and the counterculture: the destructive consequences, the concentration of power, and the dehumanization of man. These judgments are for the most part valid. But to what extent are these features inherent in technology and to what extent are they products of the industrial order in which American technology has developed? Can advanced technology be controlled or must it be rejected?

It should be noted at the outset that Roszak is not against all technology. He does defend a decentralized "intermediate technology" (see below). But the vehemence of his rhetoric and his failure to distinguish the inherent features of technology from its contemporary institutionalization lead many readers to categorize him as antitechnological, despite his disclaimers. Moreover, like many in the counterculture, he tends to romanticize the past and idealize the primitive. But life in prescientific cultures was short and severe, and often bare survival required back-breaking toil. Traditional societies have engendered a sense of community, but they have usually been authoritarian, rigid, and conformist, with little room for dissent or individuality. In the United States we are too preoccupied with mate-

rial things, but for most of the world today technology of the right kind is the only hope of overcoming famine, poverty, and disease.

The counterculture's concern for a new consciousness has led to a neglect of social and political institutions and sometimes to a withdrawal from society. It is predominantly a middle-class, white movement among youth from fairly affluent homes with a security to which they can return. While many of its members have a genuine concern for the underprivileged, its goals are not those of the ghetto resident or of the people of Asia and Africa who still lack the basic necessitites of life. This must be considered a serious issue from the viewpoint of the biblical concern for social justice to the dispossessed at home and abroad. To be sure, many communes are seeking not escape and enjoyment but an alternative life-style which could be an example of a new social order. But does not their disavowal of politics in fact neglect, in practice if not in theory, the poverty of millions and the structures of power in society which perpetuate such glaring inequalities? Let us then consider ways in which technology might be redirected toward some of the very goals which the counterculture seeks.

1. *The Social Responsibility of Scientists.* We must first admit that our own inadequacies as scientists in relation to society have helped to provoke the reaction of the counterculture. Often we have pursued our narrow specialties with no concern for their potential social consequences. When we were involved in policy issues, it was often to defend our own interests. In our ideal, the scientist is independent, critical, and dedicated to truth and human welfare. In practice, scientists have frequently been allied with political power or subservient to the goals of military or industrial interests. The ideal has been public discussion, but in practice scientific advice to the government has often been given through panels whose reports were secret, anonymous, and not publicly accountable.[16]

But there are signs of change. Professional societies which previously dealt only with technical matters now devote portions of their meetings and journals to the social and environmental impact of science and engineering. Within universities, interdisciplinary courses have been developed to explore problems at the interfaces between technology and society. Scientists and engineers who in the past had simply assumed that their work would contribute to the welfare of man have begun to concern themselves with policy issues. On the job they have recognized more frequently their responsibility to the public as well as to their employers and their careers. We can hope that the informed participation of scientists in policy decisions will become even more widespread.

2. *Technology Assessment.* The real targets of Roszak's attack are the economic and political institutions which control the applications of science. How can we improve these decision-making processes? One promising development is the Office of Technology Assessment (OTA) established by Congress in 1972 to analyze the social and environmental consequences of new technologies. In the past, the developers of a technology have been quick to proclaim its direct, short-term benefits, and only later, after it was well established and jobs and investments were at stake, did the indirect social consequences become evident. The OTA will evaluate the indirect, long-range effects of a technology before it is fully developed or has acquired a momentum which would make it difficult to control. There is provision for participation in the assessment process by diverse groups which are likely to be affected. Technology assessments can also be carried out by state agencies, consulting firms, and universities. These will be significant sources of information for legislators concerning the social impact of new technological options.[17]

3. *Policy Priorities.* As priority issues in national policy for technology I would nominate four *P*s: Peace, Population, Pollution, and Poverty.[18] We have allocated massive federal funds for research and development to space and weapons but relatively little to the technologies relevant to basic human needs such as low-cost housing, public transportation, and health-care delivery. We have given major subsidies to air and auto transportation but little to mass transit or railroads which use less energy and are more available to low-income families. We have allowed the cost of an industry's pollution to be borne by people downwind or downstream; the price of its products did not reflect the true cost to society. Environmental legislation has begun to require industries to internalize these external, social costs. The redirection of technology requires a reordering of our priorities in the allocation of research and development funds and in legislative regulation.

4. *Restraint in Resource Consumption.* The United States, with 6 percent of the world's population, is responsible for 30–40 percent of the world's natural-resource consumption each year, and in many instances our consumption has been growing exponentially. One need not accept all the assumptions in the Club of Rome study, *Limits to Growth,* which probably underestimates technological advances that could buy additional time before global limits are exceeded, to realize that the question of growth must be faced. The key issue is not pro-growth versus no-growth but what kind of growth and where.[19] United States growth should be concentrated on services which are

not resource intensive or on goods in which considerable recycling is possible. Global growth should occur mainly in the Third World, since there are such huge and growing inequalities between rich and poor nations. Perhaps we can learn here from the members of the counterculture who seek a simpler life-style that avoids waste and excessive consumption. This will involve new attitudes and values and new definitions of the quality of life.

5. *Intermediate Technology.* Without technology, the developing nations of the world would remain in hunger and poverty. Yet in many cases large-scale technology is not within their reach or suitable for their situations. Our technologies were established when capital and resources were abundant and labor was scarce. Automation, for example, is capital intensive and labor saving. But, in the Third World, capital is scarce and labor is abundant. Intermediate technologies must therefore be relatively inexpensive and labor intensive. They must be small scale, so that jobs can be created in rural areas and small towns to slow down mass migration to the cities. They must be directed to basic human needs—especially food, housing, and health. Intermediate technology must use the best scientific knowledge available. It does not imply a return to primitive and prescientific methods but the use of science under conditions different from those which have governed industrial production in the West. Third World nations cannot support their populations by agriculture alone, and their development must be encouraged in part by much more extensive aid from advanced nations. There are alternative patterns of modernization, some of which may be less environmentally and socially destructive than the path which we have followed, involving varying combinations of large-scale and intermediate technology.[20]

6. *The Defense of Human Values.* A final point at which we can make common cause with the counterculture is in upholding the priority of the personal in an impersonal world. We can share a greater sensitivity to the effects of technology on people, especially when they are manipulated for the sake of efficiency. We can join in defending individuality and freedom in the face of standardization and bureaucracy. Technology does tend to encourage the concentration of power, but I would argue that we must utilize political channels to control that power. In a complex society, freedom means participation in the decisions which affect one's own life, rather than individualism or the absence of restrictions. Likewise, we can join in affirming the importance of interpersonal relationships and a vision of personal fulfillment which goes beyond material living standards. One of the potential contributions of our religious heritage is its concern for the character of personal and community life.

Conclusions

The countercultural critique can make us more aware of the tendency of science to encourage an exclusively technical rationality and a reductionist and alienating consciousness. It can remind us of the dangers from technology in the concentration of power and the dehumanization of man. But these tendencies and dangers do not represent inevitable consequences of science. Our main attention should thus be directed to the social order in which science exists. As the biochemist Erwin Chargaff has said, "Science has been corrupted by technology, and technology in turn by the profit motive, by the military, by the mass media, by advertising."[21] What we need, then, is not less science but more recognition of the finitude of man and the importance of checks and balances on the exercise of power in all its forms and effective use of political mechanisms for the social control of technology.

The redirection of technology for which I have been calling will not be an easy task. As the counterculture rightly asserts, technology itself is so tightly tied to industry and government and the structures of economic power that changes in direction will be difficult to achieve. The person who tries to work for change within the existing order may be simply absorbed by the establishment. The frustrations of Vietnam and Watergate have produced an understandable skepticism about political processes. But I would urge that it is not enough to change individual consciousness or to start communal experiments because technology can be controlled only through social institutions. The welfare of man requires a creative technology which is ecologically sound and directed toward humane ends. The future of mankind on this spinning planet, this spaceship earth, depends on our ability to reunite reason with experience, science with humility, and technology with human values.

NOTES

1. See Theodore Roszak, *The Making of a Counter Culture* (New York: Doubleday & Co., 1969), *Where the Wasteland Ends* (New York: Doubleday & Co., 1972), and "Science: A Technocratic Trap," *Atlantic Monthly* (July 1972), pp. 56–61; N. Wade, "Theodore Roszak: Visionary Critic of Science," *Science* 178 (1972): 960–62. See also Stephen Toulmin, "Historical Background to the Anti-Science Movement," in *Civilization and Science* (New York: American Elsevier Publishing Co., 1972); Stephen Cotgrove, "Anti-Science," *New Scientist* (July 12, 1973), pp. 82-84.

2. Charles Frankel, "The Nature and Sources of Irrationalism," *Science* 180 (1973): 927–31; reviews of Roszak's *Where the Wasteland Ends* by Peter Caws, *New Republic* (October 21, 1972), pp. 34–36, and Leo Marx, *Saturday Review* (September 23, 1972), pp. 69–71. See also Edward Shils, "Anti-Science," *Minerva* 9 (1971): 441–50; Melvin Kranzberg, "Scientists: The Loyal Opposition," *American Scientist* 60 (1972): 20–23.

3. See Keith Melville, *Communes in the Counter Culture* (New York: William Morrow & Co., 1972); Morton Levitt et al., eds., *Youth and Social Change* (Detroit: Wayne State University Press, 1972); Ron Roberts, *The New Communes* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1971); Rosabeth Kantor, *Commitment and Community* (Cambridge, Mass.: Harvard University Press, 1972), and *Communes: Social Organization of the Collective Life* (New York: Harper & Row, 1973).

4. Herbert Marcuse, *One-Dimensional Man* (Boston: Beacon Press, 1964); Lewis Mumford, *The Pentagon of Power* (New York: Harcourt Brace Jovanovich, 1970); John McDermott, "Technology: The Opiate of the Intellectuals," *New York Review of Books* (July 31, 1969), pp. 25–35. For a more critical discussion see Victor Ferkiss, *Technological Man* (New York: George Braziller, Inc., 1969).

5. Jacques Ellul, *The Technological Society* (New York: Alfred A. Knopf, 1964); Erich Fromm, *The Revolution of Hope: Toward a Humanized Technology* (New York: Harper & Row, 1968); Jürgen Habermas, *Toward a Rational Society* (Boston: Beacon Press, 1970), chap. 6.

6. Ian G. Barbour, *Myths, Models and Paradigms* (New York: Harper & Row, 1974).

7. Ian G. Barbour, ed., *Earth Might Be Fair* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1972), chap. 9.

8. Roszak, *Where the Wasteland Ends*, pp. 374–75, and "The Monster and the Titan: Science, Knowledge, and Gnosis," *Daedalus* (Summer 1974), pp. 17–32.

9. See Mary Hesse, *Models and Analogies in Science* (London: Sheed & Ward, 1963); Max Black, *Models and Metaphors* (Ithaca, N.Y.: Cornell University Press, 1962), chaps. 3 and 13; Hans Freudenthal, ed., *The Concept and the Role of the Model in Mathematics and Natural and Social Sciences* (New York: Gordon & Breach, 1961); E. H. Hutton, "The Role of Models in Physics," *British Journal for the Philosophy of Science* 4 (1953): 284–301; Marshall Spector, "Models and Theories," ibid. 16 (1965): 121–42; Peter Achinstein, "Theoretical Models," ibid. 16 (1965): 102–20; J. W. Swanson, "On Models," ibid. 17 (1967): 297–311. See also n. 6 above.

10. Morton Beckner, *The Biological Way of Thought* (New York: Columbia University Press, 1959); C. Grobstein, "Levels and Ontogeny," *American Scientist* 50 (1962): 46–58; George Gaylord Simpson, *This View of Life* (New York: Harcourt, Brace & World, 1964); Theodosius Dobzhansky and Francisco Ayala, eds., *Problems of Reductionism in Biology* (New York: Macmillan Co., 1974).

11. See Ernest Nagel, *The Structure of Science* (New York: Harcourt, Brace & World, 1961), chaps. 11 and 12; C. H. Waddington, ed., *Toward a Theoretical Biology* (Chicago: Aldine Publishing Co., 1969), vol. 2; Arthur Koestler and J. R. Smythies, *Beyond Reductionism* (Boston: Beacon Press, 1971).

12. N. R. Hanson, *Patterns of Discovery* (Cambridge: Cambridge University Press, 1958); Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2d ed. (Chicago: University of Chicago Press, 1970); P. K. Feyerabend, "Explanation, Reduction and Empiricism," in *Minnesota Studies in the Philosophy of Science*, vol. 3, ed. H. Feigl and G. Maxwell (Minneapolis: University of Minnesota Press, 1962). See also Mary Hesse, "Theory and Observation: Is There an Independent Observation Language?" in *The Nature and Function of Scientific Theory*, ed. R. Colodny (Pittsburgh: University of Pittsburgh Press, 1971); Israel Scheffler, *Science and Subjectivity* (Indianapolis: Bobbs-Merrill Co., 1967).

13. Cf. James Watson, *The Double Helix* (New York: Atheneum Publishers, 1968).

14. F. Rief, "The Competitive World of the Pure Scientist," in *Science and Society*, ed. N. Kaplan (Chicago: Rand McNally & Co., 1965); Robert K. Merton, "The Ambivalence of Scientists," ibid.; Walter Hirsch, *Scientists in American Society* (New York: Random House, 1968).

15. Jacques Hadamard, *Essay on the Psychology of Invention in the Mathematical Field* (Princeton, N.J.: Princeton University Press, 1964); Brewster Ghiselin, ed., *The Creative Process* (Berkeley: University of California Press, 1952); Arthur Koestler, *The Act of Creation* (New York: Macmillan Co., 1964), chaps. 8 and 10; Mary Hesse, "Models and Analogy in Science," in *The Encyclopedia of Philosophy*, ed. Paul Edwards (New York: Macmillan Co., 1967), 5:354–59.

16. J. A. Passmore, "The Revolt Against Science," *Search* 3 (1972): 415–22; Martin Brown, ed., *The Social Responsibility of the Scientist* (New York: Free Press, 1971); Frank von Hippel and Joel Primack, "Public Interest Science," *Science* 177 (1972): 1166–71; Daniel Greenberg, *The Politics of Pure Science* (New York: New American Library Inc., 1971); J. Bronowski, "The Disestablishment of Science," *Encounter* (July 1971), pp. 9–16; John Ziman, "The Impact of Social Responsibility on Science," *Impact of Science on Society* 21 (1971): 113–22; Joel Primack and Frank von Hippel, *Advice and Dissent* (New York: Basic Books, 1974).

17. Michael Baram, "Technology Assessment and Social Control," *Science* 180 (1973): 465–73; National Academy of Sciences, *Technology: Processes of Assessment and Choice* (United States House of Representatives, Committee on Science and Astronautics, 1969); Raphael G. Kasper, ed., *Technology Assessment* (New York: Praeger Publishers Inc., 1972); Anne Cahn and Joel Primack, "Technological Foresight for Congress," *Technology Review* (March 1973), pp. 39–48; M. J. Cetron and B. Bartocha, eds., *The Methodology of Technology Assessment* (New York: Gordon & Breach, 1972).

18. Norman Faramelli, *Technethics* (New York: Friendship Press, 1971); John R. Platt, "What We Must Do," *Science* 166 (1969): 1115–21.

19. Donella H. Meadows et al., *The Limits to Growth* (New York: Universe Books, 1972). Two collections of essays discussing this volume are H. S. D. Cole et al., eds., *Models of Doom* (New York: Universe Books, 1973) and A. Weintraub, E. Schwartz, and J. R. Aronson, eds., *The Economic Growth Controversy* (White Plains, N.Y.: International Arts and Sciences Press, 1973); cf. Ronald Ridker, "To Grow or Not To Grow: That's Not the Relevant Question," *Science* 182 (1973): 1315–18. The second Club of Rome report is by M. Mesarovic and E. Pestel, *Mankind at the Turning Point* (New York: E. P. Dutton & Co., 1974).

20. E. F. Schumacher, *Small Is Beautiful* (New York: Harper & Row, 1974); Janine Clarke and Robin Clarke, "The Biotechnic Research Community," *Futures* 4 (1972): 168–73; David Dickson, *Alternative Technology and the Politics of Technical Change* (London: Fontana Books, 1974). See also the December 1973 issue of *Impact of Science on Society*.

21. Erwin Chargaff, "Bitter Fruits from the Tree of Knowledge: Remarks on the Current Revulsion from Science," *Perspectives in Biology and Medicine* 16 (1973): 492.