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BEYOND GROWTH— ESSAYS ON ALTERNATIVE FUTURES

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FOREWORD

François Mergen
Dean and Pinchot Professor of Forestry

It is a pleasure to introduce this volume which reflects our School's continuing interest in problems of natural resource management and environmental planning, Beyond Growth—Essays on Alternative Futures, which is the latest in a series of volumes originating in the Spring of 1969 at a time when environmental problems were first coming to public attention. The earlier volumes dealt with the nature of the environmental problems facing mankind and presented some thought and reflections on an agenda for survival.[1] All of these volumes are based on lectures made possible through a grant by the Ford Foundation.

During the 1971–72 academic year, a group of faculty and students explored the enormous task of dealing in a scholarly manner with the potentials and problems involved in the concept of an equilibrium state society. An extended symposium was viewed as the best means to examine this issue and formed the nucleus that led to the establishment of a series of lectures, most of which appear in this volume.

Eminent scholars from the fields of ecology, economics, anthropology, demography, and sociology were invited to come to Yale to present their points of view. Extensive discussion followed each of these seminars, and we looked upon the occasions as important educational experiences not only for our School, but also for the University as a whole and for citizens of the greater New Haven area. By publishing this volume we share our experience with a larger audience in the hope that it will stimulate fruitful discussion.

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[1] "Man and His Environment: The Ecological Limits of Optimism," 1970, edited by François Mergen, Yale School of Forestry Bulletin No. 76.

"The Environmental Crisis: Man's Struggle to Live with Himself," 1970, edited by Harold W. Helfrich, Jr., Yale University Press.

"Agenda for Survival: The Environmental Crisis," 1971, edited by Harold W. Helfrich, Jr., Yale University Press.

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ACKNOWLEDGMENTS

We are most grateful to Orville Tice, Gary Taylor, Pat West, Garth Voigt and François Mergen who gave freely to organize, create, enthuse, challenge, and make successful the idea of a survival congress. This volume is truly their dedication.

The operation of the lectures, demonstrations, discussions, and the concluding celebration of life was dependent upon the energy and good humor of Ruth Allen, John Cannon, Buzz Constable, Mary Kuzia and Tim Wood.

Doug Sprugel, Dan Botkin, Paul Harcomb, Liz Mikols, Al Worrell, Peter Jordan, Norman Noyes, R. Lautenschlager, and George Woodwell made valuable contributions to the series.

In preparing for publication we were most grateful for the variety of administrative and other skills which Judith H. Burch devoted to this volume.

INTRODUCTION

In spite of the modern passion for converting words into numbers, our efforts to divine the future often seem only a more quantified staging of Pirandello's play, "Six Characters in Search of an Author." Pirandello's characters portray a confusion in understanding where illusion ends and reality begins. One character asserts that there is no reality, only "words"—"words" which mean one thing to you and one thing to me, and something else to another. Thus, Pirandello argues that "reality" is composed of social images and meanings which arbitrarily transpose illusion into the "reality" of the shifting moment.

In recent years we have had considerable experience as to how often official "reality" has been only an illusion. The promise of unending, ever-increasing and ever-spreading affluence has been tarnished by rampant inflation and an energy 'crisis,' while poverty is ever more with us. Other experts promise us end-of-the-world scenarios whose time scales and 'real' consequences are so vague and contradictory as to destroy any hope that we can plan for the future. It would seem that in spite of the much proclaimed rationalism of the modern era we are no better at managing the future than were the tribal *shamans.*

That the future may be composed of doubt, ambiguity, and random accident is no reason to avoid hope or planning. But if we wish to touch genuine reality we must begin such planning by first identifying those constraints which have universally proscribed the human condition and those prescriptions which humans have universally felt compelled to observe. That is, there are things which humans cannot do, and there are things they must do if they are to survive as a group, society or species. Once we empirically know these polar constraints, then the middle realm of "may do" should be populated with a range of alternative futures. Yet in recent decades the predominant worldwide faith has been that there are no constraints for mankind's ever-cumulating technology, and thus eternal economic growth is the central solvent for all social problems. Whether communist, capitalist, or socialist, developed or third-world, industrial or agrarian, the older debates as to respective merits of each system are muted now by a unifying ideology that unending growth is the mainspring of all human hope, motive and welfare.

A smoldering revolt against this philosophy has been focused in

two short, highly-speculative and highly-controversial works—*Blueprint for Survival* and *Limits to Growth. Blueprint* was more dependent upon social science and *Limits* was more dependent upon physical and biological science. But both argued for an equilibrium state and provide the most fundamentally radical social designs since Marx challenged the Victorian Era with the Communist Manifesto. For, like the Manifesto, both volumes spring from the world of scholarship and demand actions which run directly contrary to the prevailing world trends. And, like the Manifesto, both volumes observe the rationalism of science and yet are more dependent for their force of conviction upon poetic intuition and outrage at prevailing trends; and both volumes have created an angry assemblage of establishment enemies.

The questions raised and the designs provided by these two books are fundamental to human welfare and well-suited for fulfilling the university's function to examine and discuss unconventional ideas. Therefore the editors, along with students and other faculty, organized a series of symposia to: (1) understand the ideas and the data from *Blueprint* and *Limits*, (2) ask what kind of world it might be if such a limited growth design were implemented, and (3) speculate as to the effectiveness and consequences of achieving a steady state economy.

The reader may feel that we have employed a biased, one-sided analysis since we have allowed no "growthist" rebuttal to *Blueprint* or *Limits*. It was not our goal to debate this point, but rather to examine the concept of the equilibrium state. Further, we felt that the weight of two hundred years of growth in industrial societies, combined with easy access to the media, has provided ample opportunity for scholars to disseminate their opposition to *Limits* and *Blueprint* and to present the case for the growth ideology.

This decision did not mean a consensus and celebration of affirmation around the ideas of *Blueprint* and *Limits*. Though the author's in this volume generally agree on the need for alternatives to the prevailing trends, they exhibit considerable differences as to the sorts of data, the interpretations of the available data, and the means by which a different world order might be attained. It should be noted that in the process of assembling this volume the editors and the authors had many spirited discussions regarding a variety of matters —factual and otherwise. Yet, though the editors' pet biases, credulity, and beliefs were sometimes strained, where an author insisted on

his view the editors so accepted the decision. Therefore, even though this volume is unified around a "one-sided" search for alternatives to constant economic growth, it reflects considerable internal debate, dialogue, and strong disagreement rather than dogma. We think that such controversy is the best way to avoid confusing illusion with reality.

Though most of the contributions to this volume are revisions of talks presented at the Yale School of Forestry and Environmental Studies in the 1972–73 academic year, the chapters by Wilcox, and Ophuls were first presented elsewhere. While talks presented by Edward Goldsmith and Andrew P. Vayda are not included in this volume. And the talks by Georgescu-Roegen[1] and Ezra J. Mishan have been published elsewhere.

The order of this volume has a degree of logic which the lecture series was not always able to maintain. We first move to two chapters which outline the basic reasons why current growth rates in population and material production cannot or should not be sustained. In the first chapter, Dennis and Donella Meadows present their reasons why they believe such growth rates cannot be sustained while in the second chapter, G. Evelyn Hutchinson presents some biological reasons why we cannot sustain such rates.

The Meadows' paper provides a valuable look at the history of their work and that of their colleagues on the Club of Rome Study which indicates a far broader corpus of work and a more tentative and cumulative approach than their critics usually reflect. They, also, provide a concise and tightly reasoned summary of the foundations of their study which is, in addition, an equally excellent summary of the reasoning underpinning the concern of all environmentalists—past, present and future. With this essential background covered they then respond to their critics by suggesting why changes in price, technology, and social value are not likely to work.

G. Evelyn Hutchinson provides some analogies for human population patterns from other species. He clearly cautions us that the simple form of the logistic curve does not apply to human populations. However, the example of laboratory populations which maintain stable populations through misery and wild populations through

[1]"Energy and Economic Myths," *Southern Economic Journal.* 41: January, 1975. Reprinted in *The Ecologist.* 5: June, 1975 and *El Trimestre Económico.* 42: October, 1975.

more 'humane' checks has its own strong implications for human choice. He concludes that a future of improved human welfare will require deep personal and scholarly investigation as to the optimum human population.

Our next sections present papers which attempt to specify some of the elemental factors in a steady state system, some ways in which it is maintained, and some of the consequences of such a system. We do this by considering most of the fundamentals of human life systems—ecology, energy, population, economy, polity, equity and morality.

In chapter three, Eugene Odum deflates the analogy that ecosystems follow life cycle patterns of individual organisms. He indicates how the holding of such a false analogy might make a person fear that maturity and leveling social growth means that his society's death is near at hand. Odum illustrates how stabilization of growth in the G.N.P. does not mean that other patterns of growth, such as life quality, will also cease. Indeed, he argues that these other forms of growth will increase with stabilization of the G.N.P. Thus, maturity at the ecosystem level denies death by continual invigoration from new forms of growth.

All the papers in this volume were written long before the 'energy crisis' of late 1973, yet many, such as the chapter by Herbert G. Wilcox seems remarkably timely. He concentrates upon the organizational, political, and moral issues involved in maintaining the delicate and subtle interconnections which are characteristic of 'high energy' societies. He clearly details the high degree of technical skill, personal morality, and institutional stability required if nuclear energy systems are to remain safe. With a series of vivid illustrations, he then argues that *all* high energy technologies require the same vigilance and moral stamina which is required of nuclear systems. His illustrations raise doubts as to our ability to long sustain the fine tuning required by high energy technologies.

Chapter five by demographer-sociologist Lincoln Day, begins with a crisp description of what demographers mean by a stationary population. He then illustrates why discussions of optimum population should focus upon characteristics rather than size of populations. He outlines the factors which will determine the consequences of a stationary population. He concludes by describing potential social and demographic consequences of a stationary population, and clear-

ly indicates that such a population, though older, is not likely to have many of the gloomy characteristics often assigned it.

Economist Herman Daly provides a detailed look at changes in economic institutions. Daly accepts institutions such as the pricing mechanism and private property in order to build a new paradigm for a steady state economy. Thus, he argues for the need to extend, not do away with, the market system such that population and ecological depletion rates are stabilized and there is more equitable distribution of wealth. Daly's suggestions for expanding the market system are certain to provoke discussion in a wide range of directions —most notably in his proposal for using the market to control pollution and population.

William Ophuls provides a sobering political analysis of the likely political forms which will emerge if human beings fail to plan for the constraint of scarcity. He argues that we are not likely to halt demand, that market solutions are not likely to work and that technological solutions have their limitations. Therefore, we face profound changes in the political system we have built our faith upon; yet to change it so that there are better hopes of its survival runs against our grain. He then illustrates how the problems of managing and maintaining common resources such as air and water raise the Hobbesian solution of a sovereign power. His is a chilling and provocative discussion of the fateful decisions facing mankind.

The chapter which follows Daly and Ophuls seems to have less faith in the market system and more optimism regarding the larger social design. Charles Green gives most emphasis to issues of distribution and life style. Green believes that the positive value of an equilibrium state will be the increase in cultural diversity. He argues that this cultural diversity will be attained through equality for 'the Other America'—a population of "minorities" which ranges from homosexuals and Amish through Blacks, Polish-Americans, and southern rednecks. He builds a strong argument that growth beyond a certain point inhibits rather than aids equity and that equality is essential to cultural diversity. Along the way he provides pertinent summaries of most classical and contemporary social thought regarding the causes and consequences of such central social issues as freedom and equality. He concludes with a critical analysis of appropriate strategies for obtaining equality and cultural diversity.

In our last chapter Paul Sears provides a broad humanistic over-

view which, in its gentle way, renews our sense of optimism. He reminds us that we are not the first to be concerned with environmental issues. He then surveys some of the ideas and concerns expressed by past and present persons from the fields of literature, science, and history as they have looked at 'their' environmental problems. He calls for humane vision and hope, a love of others and of nature. His tone and vision is that of the poet who understands science.

We write this Introduction during a period of supreme irony, where the persons who very early identified various problems and who sought more effective planning are now often blamed for "causing" whichever crisis is at hand. We hope that the reader will question, challenge, and argue with the ideas in this book, for the great need is not allegiance to the specifics presented in the papers, but commitment to the search for alternatives to conventional wisdom—a widsom, we might add, which seems regularly to bring us crises. This volume suggests a range of interdependent and often overlapping alternatives for ecosystems, demographic patterns, energy systems, economies, social systems, life styles, property systems and political structure.

It should be noted that all the chapters provide insight into some facet of the 'energy crisis' officially created in 1973. For example: Odum argues that energy may not be the limiting factor as much as the costs and consequences of energy conversion; Wilcox argues that the requisite moral complexity of high energy technology may be the limiting factor; while other authors suggest that the pollution consequences of energy production, entropy limitations, property obligations, market defects, or supply deficiencies, and so forth will affect our future energy options. Perhaps unfolding events will bring us the best proof that our search for alternatives is essential.

W. R. Burch
F. H. Bormann
New Haven, Connecticut
1975

PART ONE

Problem: Where we are, how we got there and why we can't go that way any more

CHAPTER ONE

A SUMMARY OF LIMITS TO GROWTH: ITS CRITICS AND ITS CHALLENGE

Dennis L. Meadows
and
Donella H. Meadows

This discussion was originally presented at Yale University, September 1972, in the School of Forestry's Symposium on "Limits to Growth." An extended version of the text appeared in *Futures*, February 1973.

Introduction

Over the past two years we have worked with a group of scientists and students to understand the long-term causes and consequences of growth in the globe's population and material output. From our research we have been lead to conclude that current growth rates cannot be sustained even for the lifetimes of the children being born today. *If* society maintains its current reliance on growth to solve short-term problems, we believe that population and material production will grow past sustainable limits, that the carrying capacity of the earth will be eroded, and that there will then be an uncontrolled decline in population and economic activity. However, this outcome does not appear inevitable. Mankind could instead begin to assess realistically the limits to its material growth. Society's goals and institutions could be altered to reduce growth now and to move ultimately towards an orderly accommodation with the finite constraints of the globe. If these changes were made, it would probably be possible to sustain the world's population more or less indefinitely and to provide for all its basic needs.

Our view of growth and its consequences were developed through the construction of World3, a mathematical model of the physical, biological, psychological, geological and other causes underlying

growth. Many objections have been raised to our approach and results. In this presentation we would like to describe the history of our work, to summarize the basic foundations of our thesis, and to respond to the most common criticisms of our conclusions.

Historical Summary

With the publication of *World Dynamics*,[1] Professor Jay W. Forrester challenged the world's scientists and decision makers to extend their time horizons and to examine in holistic fashion the long-term causes and consequences of growth in the world's population and material output. To contribute to analysis and understanding of global problems, Forrester proposed a formal model of the interactions among population, capital, and several factors that influence their growth: food, resources, and pollution. Recognizing that his model was not perfect or complete, Forrester emphasized that no perfect or complete model exists, and that the models on which decisions are now based are not even explicit enough to be discussed and improved:

> In spite of the tentative nature of the world model described here, various conclusions are drawn from it. Man acts at all times on the models he has available. Mental images are models. We are now using those mental models as a basis for action.
>
> It is to be hoped that those who believe they already have some different model that is more valid will present it in the same explicit detail, so that its assumptions and consequences can be examined and compared. To reject this model because of its shortcomings without offering concrete and tangible alternatives would be equivalent to asking that time be stopped. (*World Dynamics*, p. ix)

In order to facilitate the development of improved long-term global models, our group has since prepared three additional documents on the dynamic implications of physical growth in the global system. In *World Dynamics*, Professor Forrester described the basic objectives of the world modeling effort initiated by the Club of Rome and presented the structure of a preliminary model called World2. This model was subsequently expanded by our team and related more

[1]Forrester, J. W., *World Dynamics*, Wright-Allen Press, Cambridge, Mass., 1971.

thoroughly to empirical data. The revised model was called World3. (Henceforth, when we are discussing a point that applies to both World2 and World3, we will speak simply of the World models.)

In *Limits to Growth,* we described several attributes of growth in population and material output; attributes that give the world system a tendency toward unstable behavior.[2] We proposed material equilibrium as a sustainable alternative to the goal of perpetual growth that is the inplicit basis of most contemporary policies.

Thirteen short papers that discuss the history and the implications of our project and that describe the detailed simulation submodels underlying the World models were published in the technical literature. They have now been collected into a third book, *Toward Global Equilibrium: Collected Papers.*[3]

Our technical report, *The Dynamics of Growth in a Finite World,* is the fourth and final report on our work for the Club of Rome.[4] This technical report presents the assumptions, equations, and data underlying World3 and analyzes the model's behavior under alternative assumptions.

Foundations of The Limits to Growth

The Limits to Growth (henceforth referred to as *Limits*) deals with fundamental properties of the world system such as exponential growth, finite limits, and feedback delays. These properties are the real basis of our concern about physical growth, and they can be understood and discussed independently of the precise numerical assumptions of any model. In fact it was to call attention to these basic dynamic properties, rather than the model equations, that we presented them to a nontechnical audience in a publication separate from the technical model description. We shall summarize here the five main points from *Limits* and discuss critical responses to them.

1. *Exponential growth is an inherent property of population and*

[2]Meadows, D. H. et. al., *The Limits to Growth,* Universe Books, New York, New York, 1972.

[3]Meadows, D. L. and D. H. Meadows (Eds.), *Toward Global Equilibrium: Collected Papers,* Wright-Allen Press, Cambridge, Mass., 1973.

[4]Meadows, D. L., et. al., *The Dynamics of Growth in a Finite World,* Wright-Allen Press, Cambridge, Mass., 1974.

industrial capital but not of technology. Population and material capital grow exponentially by the very nature of the reproductive and investment processes. This is not an arbitrary assumption, it is a fact derived from empirical evidence and knowledge of underlying causes. New people can only be produced by other people, and machines and factories are needed to generate other machines and factories. Whenever the change in a quantity depends on the quantity itself, the change tends to be exponential in form.
The numerical exponent, or the rate of growth, varies, both in the real world and in the World models. The growth process is, nevertheless, inherently exponential.

It may be true that human knowledge is also inherently exponential; knowledge can aid in the accumulation of more knowledge. However, it does not follow that any given technological application of that knowledge is inherently exponential. To bring a major new technical discovery into widespread use requires social recognition of the existence of a problem. It may also require that new institutions be established, often at the expense of the old, and that investment be diverted from some other possible use into physical capital that embodies the new techniques. Social perception and consensus, institutional change, and the diversion of capital to needs are *not* inherently exponential.

Discovery of oil is not in the long run made easier by the fact that certain fields of oil have already been discovered. The next increment of pollution abatement is not directly facilitated by the increment that went before. One doubling of land yield does not enhance the possibilities for the next doubling. Any suggestion that these "exponential" technologies are inevitable is based on a profound misunderstanding of the inherent cause of exponential growth. The suggestion also implies a rather sweeping disregard for the social basis of technological change, the second law of thermodynamics and the law of diminishing returns.

2. *There are physical limits to population and capital growth.* The World models are built upon the Malthusian assumption that the earth is finite, and that some change in current exponential growth processes will thus be necessary to accommodate man's physical presence and activities to the earth's limits. The purpose of the models is to investigate what kinds of changes might and should occur. We chose to investigate a Malthusian view of a limited world because our own impressions and much empirical data suggest that

the world is finite in several important ways. It seems to us not only more realistic, but more socially responsible and more useful to investigate the ways in which society might adjust itself to earthly limitations, rather than to assume away all such limitations.

The World models express the idea of the earth's limits through four explicit assumptions: there is a finite stock of exploitable nonrenewable resources, there is a finite capacity for the environment to absorb pollutants, and still function in ways to which we are accustomed, there is a finite amount of arable land, and there is a finite yield of food obtainable from each hectare of arable land. No one has exact information about where these limits are. In fact it is probably impossible to express any one of these limits by a single number since they all vary with time. We know that to a certain extent they are expandable by technology. We also know that they can be reduced by misuse.

By attempting to represent the world's limits and the growth of the physical system toward them we did not expect to gain any more precise information about the location or values of the limits themselves. We did try to achieve two other purposes. First, we sought a framework in which many growth processes and limits could be considered together, to illustrate that solutions proposed for any one problem related to growth are meaningless without considering the system as a whole. The traditional approach of specialists in any one area, for example resource economics, food production, or environmental deterioration, amply illustrates how easily any single resource, food, pollution, or population problem can be mentally "solved" by assuming that sufficient capital, energy, labor, land, material, and time can be allocated to that one problem. Because they are holistic, the World models force one to explore the possibility that several of these problems may have to be solved simultaneously. We are interested in that possibility because our perception of exponential growth indicates to us that these problems will not come slowly, one at a time.

Our second concern was to represent not only the forces that can *increase* the earth's carrying capacity for human activity but also the forces that can *reduce* it. From our Malthusian point of view, Western man is entirely too prone to rejoice in his newly-irrigated land, underwater oil-drilling rigs, Green Revolutions, and catalytic converters and to ignore the eroded, salinized, or strip-mined land, the dumps of wasted resources, the depleted ore bodies, the simplified

ecosystems, and the deprivation of other humans in other cultures that he leaves in the wake of his "progress". The World models contain assumptions of possibilities for considerable future progress, but they also take into account mankind's fallibility. They assume that the limits can be pushed downward, as well as upward, by man's activities.

There are, of course, other limits we have not included in the World models. The most obvious omissions are the limits to the sustainable rate of use of renewable resources—fresh water, timber, fish, and game for example. We also recognized the importance of social limits, but omitted them from specific analysis. We stated in *Limits* (pp. 45–46) that social limitations (unjust distribution, waste, wars) would only decrease the possibilities for growth allowed by physical limits.

3. *There are long delays in the feedback processes that control the rate of physical growth in the world system.* Delays are the main source of instability in the global system. When rapid growth is coupled with a long delay between cause and effect, the growth may proceed far beyond sustainable limits before the effects that can stop it come into play. We have not assumed that mankind is unresponsive to the changing situation around him. We have simply assumed that social institutions respond only to situations about which they have information, that the information they act on is often incomplete and late, and that the social response is not immediate but is itself delayed. The response delay can be caused by political, physical, or biological processes. It is increased by the time required to invent/construct/test/perfect new technologies. Many response delays are beyond control, such as the delays inherent in the population age structure or in the transportation and decay of persistent materials within the environment.

The combination of three major assumptions causes the "overshot mode" of the models: the assumption of feedback delays, the assumption of limits to the earth's carrying capacity, and the assumption that the human value system will promote population and material growth until counteracted by very strong forces. When, in the "equilibrium" mode, we assume a change in man's value system in favor of stability and against sustained population and capital growth, the overshoot no longer occurs. The overshoot could also be eliminated, or minimized, by assuming that the society can avoid the implications of delays by conducting accurate long-term planning. Of course

our purpose in publishing *Limits* was to encourage both the value-change and the long-term planning processes.

4. *There are two possible social responses to the limits to growth; weaken growth forces or remove the symptoms of impending limits.* The common response of modern social systems to the pressure caused by limitation of any resource is to increase the resource so that growth can continue. Highways are jammed; build more highways. Copper reserves are depleted; import copper. Electric power is insufficient; develop nuclear power plants. People are hungry; buy fertilizer.

It is only very recently and very weakly that an alternative set of solutions has been seriously proposed; reduce the use of automobiles, use less electric power, extend the useful lifetime of material goods, have fewer children. This second set of responses recognizes that the problem to be solved is not scarcity of a specific resource; highways, copper, power, or food. These scarcities are symptoms, or signals, of the underlying problem; population and material growth against a finite resource base. The first set of responses serve to remove temporarily the adverse symptoms of growth. If they are not accompanied by responses of the second type, that weaken the social values causing growth, further growth will eventually cause different resource scarcities. These scarcities will call for additional technological solutions to remove the signals of impending resource limits. The real danger of responses of the first type, responses that ease the symptoms of the problem, is that they are often used to discourage responses of the second type, those that control growth itself. The more successfully the signals of resource scarcity are masked and denied, the more likely it is that the necessary social value change will come too late.

As we stated in *Limits*, we have no desire to stop the development of technology. Combined with the necessary value changes that will control physical growth, carefully selected new technologies can create magnificent possibilities for human society. We are, however, concerned that technological successes have almost invariably been used to enhance, rather than reduce, the strengths of the positive population and capital feedback loops that drive the global system. We do not oppose technology. We do oppose the present trend of technological "progress" that is not only poorly guided by social wisdom or restraint, but is used as an excuse not to develop that wisdom or restraint.

5. *The equilibrium state may be a desirable option regardless of what the limits to growth may be.* It is not necessary to agree with the World models or to believe in the imminence of any physical limits to growth to become intrigued by the nature and potential of an equilibrium state. An equilibrium state is a society that has stabilized its population at a desired level and that supplies its material needs with a minimum throughput of nonrenewable, pollution-creating resources. *Limits* ends with a rather Utopian description of such a state. We sincerely believe that some form of deliberate material and population equilibrium is attainable, not immediately but within a generation or two. We also believe that the exercise of understanding and planning how such a state might work is both exciting and useful in that it might provide the realistic, sustainable, long-term goal that is now lacking in nearly every part of world society. It seems impossible to us that material growth can be successfully controlled unless there is some well-defined goal towards which it may be directed. There is no way of deliberately changing the composition of growth or its distribution unless there is a clear vision of what growth is for. The specifics of the goal will change and develop as more is learned about the world. We feel that it is only important to have such a goal and to keep it consistent with present knowledge.

The idea of physically non-growing society is so foreign to some people that they have invested the idea with some strange mental models of their own. They have suggested that an economy at material equilibrium must be stagnant intellectually or technologically; that it must be rigid and dictatorial; that it must preserve the present maldistribution of resources or income. We have already suggested in *Limits* that we would expect just the reverse. We would hope that more imaginative respondents will accept the challenge of thinking through the economics and sociology of a physically stabilized state.[5] We suspect that the exercise would be more than theoretical; that it would illuminate some of the current economic and sociological problems of a growing state as well.

We have not suggested in *Limits* or elsewhere that the equilibrium state should be attained immediately, or that physical growth should be brought to a sudden halt. On the contrary we have pointed

[5]Several have already started, such as Kenneth Boulding, Ezra Mishan, Herman E. Daly, Nicholas Georgescu-Roegen.

out long delays in the social system and the necessarily gradual nature of demographic change, and we have suggested that an orderly shift to equilibrium from present rates of growth may take as long as 100 years. Thus although the first steps toward equilibrium should be small ones, they should be taken soon. A good beginning might be a common recognition that physical growth cannot be forever substituted for the social resolution of difficult choices.

In summary, we believe the basic points of our modeling effort, as described in *Limits,* merit consideration even though none of them can be supported by rigorous proof. No social model can be rigorously proved true. Furthermore, the basic points constitute a holistic hypothesis about the world system that is generally consistent with real-world observations. We do not believe that the same can be said for the mental models on which important decisions with long-term implications are currently based.

Price, Technology, and Values

Let us turn now to the three mechanisms that many critics of *Limits* believe will allow mankind to sustain and control material growth without any changes in the current system—price, technology, and social value change. All three are actually included in the World models, but in implicit and oversimplified form. Of course all three are important, complex, dynamic sub-systems in themselves. We will describe here, very briefly, how more complete representations of these sub-systems might be constructed. However, none of the added details would alter the basic conclusions of our work.

Economic price is a function of two socially determined variables —the current marginal value society places on a certain good or service and the apparent marginal cost of supplying that good or service. Economists postulate that the long-term stabilizing role of price in a growing system is to signal resource scarcity. They point out that price changes guide social values and the economic system so that the declining supply of a scarce resource is utilized more efficiently.

When increasing scarcity causes the price of some material to rise, numerous social responses may be triggered. There may be a more intensive search for natural deposits of that material, or increased

recycling of discarded products containing it. Food shortages leading to rising food prices may stimulate farmers to adopt more efficient methods of production, governments to irrigate more land or people to eat less food. These dynamic effects of the price mechanism will indeed influence the way in which a growing system approaches its physical limits.

World3 contains several causal relationships between the real supply of some economic quantity (such as food, nonrenewable resources, industrial capital, service capital) and the response of the economic system to scarcity of that supply (develop more agricultural land, allocate more capital to resource production, increase investment rates).

These relationships are most realistically represented with price as an intermediate variable:

decrease in supply $\longrightarrow$ rise in price $\longrightarrow$ social response

In World3 we have simplified the real dynamics of the price mechanism by eliminating explicit reference to price, the intermediate variable: The representation of the causal chain has been shortened to:

decrease in supply $\longrightarrow$ social response

The ultimate regulating effect of the price system is thus included, but price does not explicitly appear in the model.

The only purpose of eclipsing the price mechanism in this way is to increase the model's simplicity and understandability. Omission of price is equivalent to assuming that the signals provided by the price system are available to social decision points with a delay that is insignificant on a 200-year time scale. To check the validity of this omission, several of our submodels explicitly included price and its effects on technological advance and resource availability. The general long-term behavior of these submodels was similar to that of the World models' resource sectors.

To the extent that prices do not immediately reflect actual resource costs in the real world, the price system will be a source of additional instability in the world system. Instability will also be increased if cost information is transmitted immediately, but transmitted to institutions able to adjust their production or consumption

patterns only after a long delay. In either case, the delay between decreased availability and social response will reduce the stability of the economic system as it adjusts itself to any limit.

Thus by assuming in World3 that the price system works instantaneously we may have omitted a source of system instability. To the extent that prices are actually delayed signals of scarcity, our model will *underestimate* the tendency of real economic systems to overshoot physical limits.

We view technology, like price, as a social phenomenon—it is the application of man's general knowledge about the world to the solution of a specific, perceived human problem. If we were to make a complete dynamic model of the development of a given technology, we would include the following:

—a level of accumulating general knowledge, with the rate of accumulation dependent on the resources devoted to basic research.

—a widespread perception of some human problem.

—an allocation of physical resources, human effort, and time to search for a technical solution to the problem, with a realization that the solution may not be found if the level of knowledge is not yet great enough.

—a delay to allow social acceptance and implementation of the new technology, the length of the delay dependent on the magnitude of the required departure from the present way of doing things.

—a representation of the total impact of the technology on the system, including social, energy, and environmental costs.

This model of technological advance might be contrasted with the one advanced in separate papers by Boyd, Oerlemans, and the Sussex group.[6,7,8] Each assumed that technology is inherently exponential, and that the appropriate technical capabilities are instantaneously available whenever needed. They have supposed that technological advance costs nothing, requires no capital investment, has no harmful side effects, and encounters no resistence from institutions

[6]R. Boyd, "World Dynamics: A Note," *Science*, Vol. 177, August 11, 1972.

[7]T. W. Oerlemans, et. al., "World Dynamics: Social Feedback may give Hope for the Future," *Nature*, Vol. 238, August 4, 1972.

[8]H. S. D. Cole *et al* (Eds), *Models of Doom; A Critique of the Limits to Growth*, Universe Books, New York, 1973.

already present. Not surprisingly, when their representations of technology were inserted in World2, the model grew far beyond the original point of collapse. We would suggest that their theories of technological advance are so completely foreign to anything available in the real world, that their revisions of World2 provide no useful information whatsoever about the real implications of physical growth in a finite world.

Nearly every causal relationship in the World models could conceivably be changed by some sort of new technology. In the past various technologies have, directly or indirectly, improved birth control effectiveness, increased land productivity, and increased the average generation of persistent pollution per unit of industrial output. The advance of technology has created more costly and destructive weapons, increased life expectancy through medical advance, and hastened the rate of land erosion. It is by no means certain that technologies will continue to do any of these things in the future, since the human values and social institutions that govern technological development are always subject to change.

In other words, we view technology as socially-determined, discontinuous, infinitely varied, and delayed. It is nevertheless an important determinant of the functioning of the world system. How can such a concept be included in a world model? Since so many causal relationships might be altered by some conceivable technological change, we had to consider building technological change into each relationship as we formulated it. We did this by assigning possible technologies to three categories; those that are already feasible and institutionalized, those that are feasible but not institutionalized, and those that are not yet feasible.

Some causal relationships have historically been altered by technology and continue to be altered regularly today. These are in areas where there is social agreement about the desirability of change, and where resources and institutions to bring about that change are already integral parts of the system. Examples are medical technology to improve health, industrial technology to raise production efficiency, agricultural technology to increase land yields, birth control technology to plan family size, and mining technology to discover and exploit lower-grade nonrenewable resources. A significant fraction of the world's people have adopted the value system that will continue to promote these technologies as long as their costs can be afforded. They are effectively built into the world socio-economic system.

Therefore, they are also built into the relationships of the World models, with the assumption that they will continue to develop and spread through the world, without delay, as long as there is economic support for them.

There are other technologies that have not been so widely accepted that they can be considered a functioning part of the world system. It is not yet clear that all the nations of the world are willing to institutionalize and pay for technologies such as pollution control, resource recycling, capture of solar energy, preservation of soil fertility, alternatives to the internal combustion engine, or increased durability of manufactured goods. All of these technologies are feasible, and there are signs of the changes in social values necessary to incorporate them into the world system. It is not possible to know when or even whether they will be adopted on a worldwide scale. Therefore we have not assumed them in the model relationships, but we have included many of them as optional functions, which a model operator can "turn on" at any specified time in the future. The model can be used to test the possible impact of any or all of these technologies and the relative advantage of adopting them sooner rather than later.

There is a third set of technologies that is not included in the model at all. That is the set of discoveries we cannot possibly envision from our perspective in time. Of course no model, mental or formal, can incorporate these unimaginable technologies as they will actually occur. That is one reason why no model can accurately predict the future. Any long-term model that is being used to aid the policy making process must therefore be updated constantly to incorporate surprising discoveries as they occur, and to assess how they may change the options of human society.

It is possible, of course, to include in the model the assumption that some unimaginable discovery will come along in time to solve every human problem, including the limited resource base of the earth. Many mental models seem to be based on that assumption. However, our bias as both modelers and managers is to search for understanding and for better policies based on the constraints of the system as it appears now, not to rely on developments that may or may not come in the future.

We have already indicated that both technology and price are dynamic elements directly dependent upon the values, needs, and choices characteristic of the human society. Of course values underl-

ie many of the other dynamic elements of interest in a model of physical growth. In fact, the whole socioeconomic system might be thought of as a constant interplay of human desires and goals within physical and biological contraints. Therefore, although the World models are not intended to be models of social value change, they must contain some assumptions about the dynamics of human values insofar as they influence and are influenced by the processes of physical growth.

In the difficult task of modeling human values we have tried to include only those most basic values that can be considered globally common. These basic values begin with requirements for survival, such as food, and go on to include a hierarchy of other desires; for longevity, children, material goods, and social services such as education. Some of these values are represented explicitly in the model as variables that have an important influence on economic decisions. Examples from World3 are desired completed family size, and preferences among food, material goods, and services at different income levels. Others are included implicitly, for example in the allocation of service output to health services or in the quantity of nonrenewable resources used per capita.

All of the values included in World3 are assumed to be responsive to the actual physical and economic condition of the system; they are all involved in feedback loops. The patterns of dynamic value change included in the model, however, are limited to the patterns of change historically observed in individual countries over the last hundred years or so. During that time the major force behind value change in the world system has been the process of industrialization, a process that is still underway in most of the nations of the world. Therefore the values that both shape and respond to the development of the model system follow the historic pattern of industrialization. As industrialization increases in our model (measured, say, by the level of industrial capital per capita) the aggregate social demand in our model shifts in emphasis from food to material goods and finally to services. Other changes occur in the model in the preferences for children, education, and health care, and in the distribution of various goods and services throughout the industrializing population.

We have not built into World3 any global shifts in values other than those that might be expected to take place as the world becomes more industrialized. Again, the model cannot predict value changes,

but it can serve as a test device to show the results of any given assumption about the future evolution of values. Human values, like human technologies, may evolve in the future in directions we cannot possibly foresee at this moment in history. Therefore we have also included, in several model relationships, test switches that can be used to activate postulated value changes at any date specified by the operator. (Examples of such changeable values are desired family size, fraction of output consumed, and the relative desires for food and services. All of these are changed to produce the model's "equilibrium" runs.) We have used these switches extensively. As we demonstrated in *Limits*, an appropriate set of value changes can bring the model system into a stable and desirable equilibrium state. However, the members of that set are different from those value changes that have occurred as a result of industrialization in any country. We believe that such value changes are possible to achieve in the future, but only by a concerted and conscious effort. The shift in values that normally accompanies industrialization, the one we might expect to occur if the world continues "business as usual", is the very value shift that leads to the overshoot and decline behavior mode.

The Modeler and his Environment

It has been suggested that the World models arose only because of the sudden widespread concern with the environment in modern, western societies. Of course computer models, like any product of man's intellect, must be evaluated as part of the cultural context within which they are constructed. This statement is also true for the mental models of the critics of *Limits* and for the models that guide current public policy.

Every model of a social system must omit some details of the real world. Simplification is the essence of model building. A model is constructed to improve *understanding* of the nature and implications of complex relationships in the real world. If the model were identical to the real world in all respects, it would be as difficult as the real world to understand.

> It is a very fundamental principle indeed that knowledge is always gained by the orderly loss of information, that is, by condensing and abstracting and indexing the great buzzing

> confusion of information that comes from the world around us into a form which we can appreciate and comprehend.[9]

Thus even if we had comprehensive and accurate information on all important aspects of the real world, our models would be simplifications of reality.

Human judgment is inextricably involved in the choice of the issues addressed by a model and in the identification of those "unimportant" details that may be eliminated without detracting significantly from the explanatory power of the model. Every model is thus inevitably influenced by prevailing social values and goals. In short, there is no model useful for understanding all issues and no "scientific" or "objective" way to construct a perfect model.

The greatest advantage of formal, or written, models over mental models is that their constituent assumptions are precise and explicit and thus subject to the scrutiny of critics. This is no guarantee against error or against the effects of unwarranted social biases, but it makes the discovery of errors and biases more likely. Most critics of *Limits* have not defined the bias that underlies their own approach, nor have they presented assumptions explicit enough to be judged by their audience.

The accusation that the World models have been unduly influenced by the prevailing environmental concern implies that therefore the models must be addressing random, unimportant, or spurious issues. The latest wave of environmentalism may indeed turn out to be a fad, merely the product of rising expectation, or boredom, or alarmist journalists, or all of these. However there is an alternate possibility. The current concern with the environment may be a response to current perception of a changed external reality. It may be a result of the first glimmerings of human understanding about total systems and the first perception of a real worldwide negative impact of man's activities on the ecosystem. If so, the World models may represent a small manifestation of a healthy social reaction to an environmental change; a reaction that will lead to new values, technologies, and economic prices that attempt to adapt socioeconomic systems to the newly-perceived constraints. In that case the critics, the technological optimists, the foot-draggers who claim that there are no constraints and no reasons to change values from the present pro-growth set, represent exactly the social and institu-

[9]K. E. Boulding, *Economics as a Science*, McGraw Hill, N. Y. 1971

tional delays that tend to destabilize the system and send it shooting past its ultimately sustainable limits.

Growth and Income Distribution

Some critics have rejected the no-physical-growth argument as irrelevant to the "really important" problems of the composition and distribution of growth. As we have already indicated, we find it impossible to view the rate of physical growth, its composition and its distribution as independent or mutually exclusive problems. Human societies will not achieve a more equitable distribution of wealth until they better understand the processes of growth. Historically at least, growth of population and of capital has been correlated with the concentration of wealth and with rising gaps in the absolute incomes of the rich and the poor. We believe that there are at least two basic reasons for these trends. First, physical growth inevitably worsens the resource/population balance. When there are fewer available resources per person, there are also fewer real social options to resolve conflicts of interest. Second, by relying on the false promise of growth, social institutions are able to delay facing the very important and difficult tasks of making social tradeoffs and defining social goals. Until these tasks are squarely faced there will be no real redistribution of income.

The no-growth argument is an appeal for readjusting the composition and distribution of economic output. The pro-growth argument is an attempt to postpone this readjustment; to confer it on future generations. Simultaneously this approach ensures that those generations will have fewer resources and thus fewer real choices to make. Our sociopolitical concerns are actually quite similar to those who argue that redistribution must come first. We differ only in our perception of how to deal with those concerns. Our own choice was to begin by questioning what we view as the basic cause of the growing gap between the rich and the poor—unexamined, uncontrolled physical growth.

The Concept of Man

This brings us to the final point that we regard as basic to all discussions among ecologists, "environmentalists", Malthusians,

economists, industrialists, pessimists, and optimists. The pro- and anti-growth faction are organized around two very different concepts of man.

One concept of man, the one held by advocates of indefinite growth, is that Homo sapiens is a very special creature whose unique brain gives him not only the capability but the right to exploit for his own short-term purposes all other creatures and all resources the world has to offer. This is an age-old concept of man, one firmly rooted in Judeo-Christian tradition and newly strengthened by stunning technical achievements in the last few centuries.

> Not only ingenuity but, increasingly, understanding; not luck but systematic investigation, are turning the tables on nature, making her subservient to man.[10] According to this belief man is essentially omnipotent, he can develop at low cost a technology or a social change to overcome any obstacle, and such developments will occur quickly upon perception of the obstacle. Underlying this view is also the belief that mankind's social, economic, political, and technical institutions operate flexibly and without significant error, and the best response to any apparent problem is to encourage these institutions to do more of whatever they have done in the past.

The opposite concept of man is also an ancient one, but it is more closely related to the Eastern religions than to the Western ones. It assumes that man is but one of many species embedded in the intricate web of natural processes that sustains and constrains all forms of life. It acknowledges that man is one of the more successful species, in terms of competitiveness, but that his very success is leading him to destroy and simplify the natural sustaining web, about which he understands very little. Subscribers to this view feel that human institutions are ponderous and short-sighted, adaptive only after very long delays, and likely to attack complex issues with simplistic and self-centered solutions. They would also point out that much of human technology and "progress" has been attained only at the expense of natural beauty, human dignity, and social integrity, and that those who have suffered the greatest loss of these amenities have also had the least benefit from the economic "progress". People who share this concept of man, as we do, would also question strongly whether technology and material growth, which seem to have

[10]H. J. Barnett and C. Morse, *Scarcity and Growth*, Johns Hopkins Press, 1963.

caused many problems, should be looked to as the sources of solution of these same problems in the future. Technological optimists invariably label this view of the fallibility of man as "pessimistic"; Malthusians would simply call it "humble".

We see no objective way of resolving these very different views of man and his role in the world. It seems to be possible for either side to look at the same world and find support for its view. Technological optimists see only rising life expectancies, more comfortable lives, the advance of human knowledge, and improved wheat strains. Malthusians see only rising populations, struggle for limited natural resources, social instability, destruction of the land, extinct species, urban deterioration, and increasing gaps between the rich and the poor. They would say that Malthus was correct both in his own time and today in his observation that:

> . . . the pressure arising from the difficulty of procuring subsistence is not to be considered as a remote one which will be felt only when the earth refuses to produce any more, but as one which actually exists at present over the greatest part of the globe.[11]

The Challenge

The glaring problem before mankind, should it choose the concept of man as a humble part of the biosphere, is the essential lack of sufficient knowledge upon which to base the restructuring of institutions, and values. Two hundred years of growth have left biases and blind spots throughout the physical and social sciences. There is today no economic theory of a technological-based society in which there are essentially zero interest rates and no net accumulation to society's productive capital, and in which the principal concern is equality rather than growth. There is no equilibrium sociology which is concerned with the social aspects of a stable population, whose age composition is skewed toward the elderly. There is no equilibrium political science in which we might look for clues to the ways democratic choice could be exercised when short-term material gain is ruled out as the basis for political success. There is no equilibrium technology, which would place high emphasis on the recycling of all

[11]T. R. Malthus, *A Summary View of the Principle of Population*, 1830.

matter, on the use of the sun's pollution-free energy, and on the minimization of both matter and energy flows. There is no psychology for the steady state that might provide man with a new self-image and with feasible aspirations in a system where material output is constant and in balance with the globe's finite limits.

Each of our traditional disciplines could respond to the challenge of working out the details of a viable and attractive equilibrium society. The effort would pose many difficult technological and conceptual problems, whose solutions would be intellectually satisfying and of enormous social value. After all, we are not merely talking of a distant and unattainable utopian state. Physical growth of populations and capital *will* stop on this finite planet. The only uncertainties lie in when it will stop and how—by deliberate social choice and under careful human management, or by the harsh backlash of a disturbed and depleted natural environment.

We may all find that the study of a utopian steady-state society may be the best possible preparation for the real future—a future that we are shaping already, with every social and individual decision we make. We will almost certainly discover as we become better acquainted with the possibilities for an equilibrium society that we would prefer the end of physical growth to occur under our own management and sooner, rather than later. Those of us who have already spent several years contemplating the idea of a no-material-growth society find without exception that we agree with John Stuart Mill, who contemplated the limits to growth more than one-hundred years ago:

> I cannot, therefore, regard the stationary state of capital and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. I am inclined to believe that it would be, on the whole, a very considerable improvement on our present condition. I confess I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of humankind. . . . It is scarcely necessary to remark that a stationary condition of capital and population implies no stationary state of human improvement. There would be as much scope as ever for all kinds of mental culture, and moral and

social progress; as much room for improving the Art of Living and much more likelihood of its being improved.[12]

[12]J. S. Mill, *Principles of Political Economy.* 1848.

CHAPTER TWO

SOME BIOLOGICAL ANALOGIES[1]

G. Evelyn Hutchinson

I begin with a brilliant mathematical biologist who died relatively young, Pierre-François Verhulst (1804–1849), and who in 1838 and in subsequent papers (Verhulst, 1845, 1847) published the first rational treatment of growth in a limited system, which is what this symposium is intended to discuss. Verhulst introduced the theoretical growth curve, which he called the logistic, as the simplest continuous expression based on reasonable assumptions of growth towards an upper asymptote. His particular way of proceeding excited practically no interest during the nineteenth century. Even his great friend Quetelet (1850), who invented the "average man", and who had interested this young mathematician in demographic problems, thought that deriving an equation was, to say the least, bold.

Verhulst was incidentally a rather picturesque character; Miner (1933) has published in translation such documents as relate to his life. In 1831 he went to Rome on account of his health and there became friendly with Queen Hortense, Napoleon's step-daughter Hortense Beauharnais, whom the emperor had married to his brother Louis Bonaparte, for a time King of Holland, and who became, during her unhappy married life, the mother of Napoleon III. With Queen Hortense's help, Verhulst elaborated a constitution for the Papal States which, after discussion with various cardinals, he

[1]Two weeks before the oral presentation of this contribution, there died in Princeton one of the greatest ecologists that this century has seen, Robert Helmer MacArthur. He was a graduate student at Yale in the late fifties and at the time of his death, Henry Fairfield Osborn Professor of Biology in Princeton University. He had extraordinary capacities as a field naturalist combined with deep mathematical insight, and his work will undoubtedly continue to influence our thoughts in all branches of ecology during the rest of this century and well beyond. In a sense, this contribution is in his memory; I will mention specifically some of his work in one context only, but those of you who know it will recognise certain recurrent themes as due to MacArthur. In the book that he wrote when he was taken ill in 1971, the review of which in *Science* was read to him on the telephone by Edward O. Wilson of Harvard the day before he died, MacArthur, who was extraordinarily cooperative in all his work, wrote that he often did not know which ideas were his own and which due to his collaborators. I can say the same about him.

presented to the Cardinal Vicar, hoping that he might induce the Pope to adopt it. Gregory XVI, however, had no interest in constitutions and so disappointed Verhulst who was quickly banished from Rome as a dangerous character. When he died he may well have felt that he had accomplished very little, though we now see, what his contemporaries in the less crowded world of the nineteenth century could not, that his mathematical ideas about population meant a great deal.

It is mainly not the people who work with human populations who honor Verhulst. Good standard textbooks on demography may pass him over altogether, or merely indicate that Raymond Pearl was using the concept of the logistic curve in the early 1920s, nothing more being said about this work. When, however, a biologist wants to discuss population growth in a general way he tends to start by drawing Verhulst's curve, as has been done in Figures 1 and 3. The curve is a most interesting one for many reasons and the fact that it is apt not to work when we apply it to nature is one aspect of its interest. It is important to realise that whether a theoretical formulation is confirmed or not, may be quite irrelevant to its significance. If the postulates of a theory seem sensible and the theory in fact does not work, it shows that nature or, more usually, the investigator, is not really as sensible as was first thought. The difference between what was expected and what was found becomes a measure of the incorrectness of the postulates underlying the theory, and this incorrectness may be a very important thing to measure.

The logistic curve is the integral curve of a differential equation

$$\frac{dN}{dt} = rN\,\frac{(K-N)}{K}$$

which may be read as:
"The rate of change of a population with respect to time is proportional to its size (N), to a constant r which expresses the potential rate of increase of any individual, and to an expression $(K-N)/K$ which can formally be regarded as the relative number of vacant spaces still to be filled, K defining the limit to growth." The constant r which expresses the rate of increase when no restraints have been imposed by the prior development of a population is sometimes called the Malthusian parameter, as without the corrective term $(K-N)/K$, the equation becomes

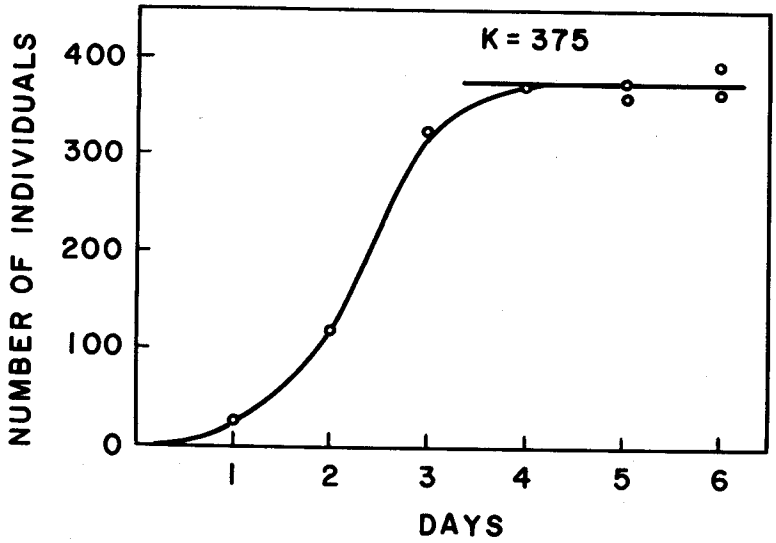

Figure 1. Growth of a laboratory population of *Paramecium caudatum* Ehrenberg, fitted by Gause (1934) to a logistic curve.

$$\frac{dN}{dt} = rN$$

characterizing the unrestrained type of exponential increase usually associated with the Reverend Thomas Robert Malthus.

It is important to realize that although r is in effect the difference between the unrestricted birth rate and the inherent death rate per individual, it cannot be negative, for, as Levins (1971) points out, if it were, starting from a population in excess of K, the rate of change would be perennially positive with an over-saturated population subject only to death. This situation has certain ironical possibilities but is hardly biological. The interpretation of the corrective or negative feed-back term $(K-N)/K$ in any given case may be far from obvious. Though people looking for vacant spaces may learn of an empty house or apartment from a real estate agent, the critic may ask how an individual in a growing culture of *Daphnia* is to know how many spaces are vacant. This difficulty emphasizes that in setting up the logistic we assume a constant supply of resources which in any system determine the value of K. As the population grows each individual

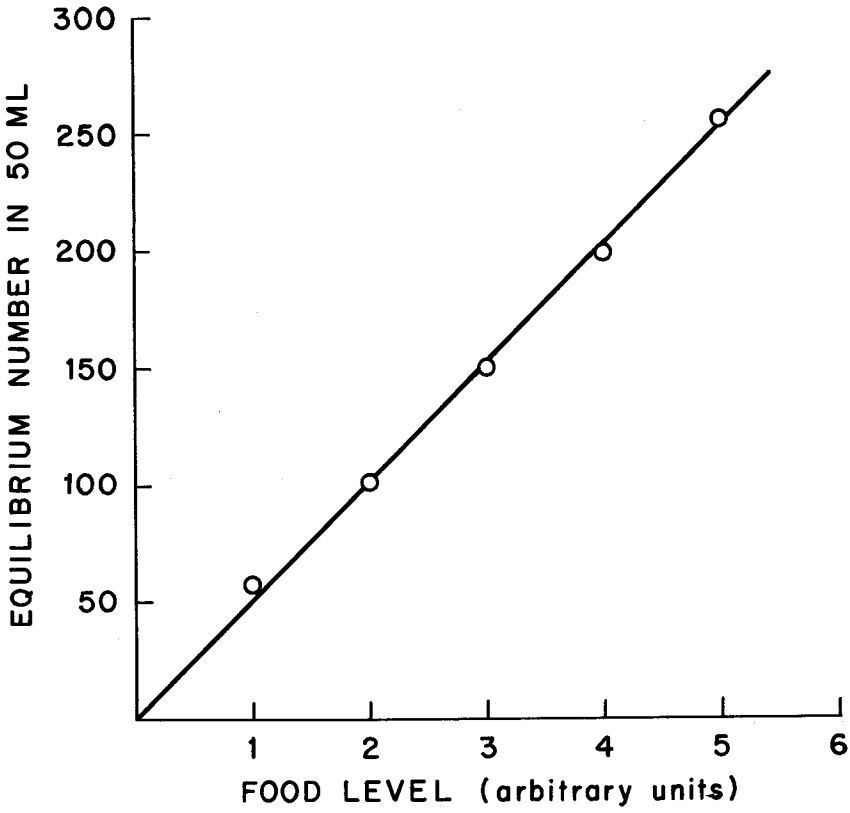

Figure 2. Relationship of population size near equilibrium to food supply in *Daphnia obtusa* Kurz (Slobodkin 1954).

has a continuously smaller share of these resources. As K is approached, the share approaches what is needed to provide only for the non-reproductive metabolism of the population; on an average, reproduction then only occurs when a death has taken place, giving a slightly larger amount of resources to the survivors. A vacant space means just enough food to produce one offspring.

The first question that may be reasonably asked about the equation is whether the hypothesis that it expresses can be confirmed. The answer is that of course it can. All that has to be done is to set up an experiment which incorporates all the postulates that have gone into the derivation of the equation and nothing else of importance. The equation assumes a continuously reproducing organism in an envi-

ronment providing usable energy as food at a constant rate, and in which excretory products do not accumulate in sufficient quantities to poison the organism. If one chooses a small rapidly breeding organism like the protist *Paramecium* (Figure 1) or the water-flea *Moina*, in neither of which sexual processes are necessary conditions for reproduction, and provides a constant supply of bacteria or yeast cells as food changing the medium at sufficiently frequent intervals, the conditions are adequately satisfied and the growth of the population is logistic. (For further refinements and developments see particularly Smith 1963). Practically no biological advance has been made by this process of confirmation, because the biological postulates are so obvious as to be uninteresting. All that the experimenter has done is to build a poor analogue computer for estimating K. There are, however, significant further aspects of the case.

In cultures of water-fleas (*Daphnia obtusa* Kurz) in an equilibrium state, Slobodkin (1954) found that the size of the population was quite accurately proportional to the food supply (Figure 2). When the population is equilibrated, it consists of pale animals with a negligible reproductive rate, while early in an experiment the few individuals present would be deeply colored and with brood pouches full of embryos.

It is, I think, reasonably obvious in dealing with human affairs that we do not want an equilibrium condition analogous to that exhibited by such chronically starved *Daphnia* cultures in which an extreme lack of food is the fundamental agent of birth control. Man may perhaps approach this sort of thing in some tropical slums in which enormous numbers of people find a way of living on the streets without houses and with very little food. This sort of approach to the limits of growth is about as undesirable as anything we can conceive.

There is a further development of the logistic which is very interesting, though unfortunatley it lacks the simple mathematical elegance of Verhulst's formulation. In the latter, as we have interpreted it, there is an implicit assumption that the conditions defined by the cybernetic term $(K-N)/K$ operate to regulate the rate of increase of the population instantaneously. In a *Daphnia* culture this would mean that as the partitioning of the constant food supply among the increasing number of individuals reduced each one's share, the reproductive rate fell immediately to a level appropriate to the reduced food intake. Actually during the growth of the population, any individual that is born and starts to feed will have been initiated as

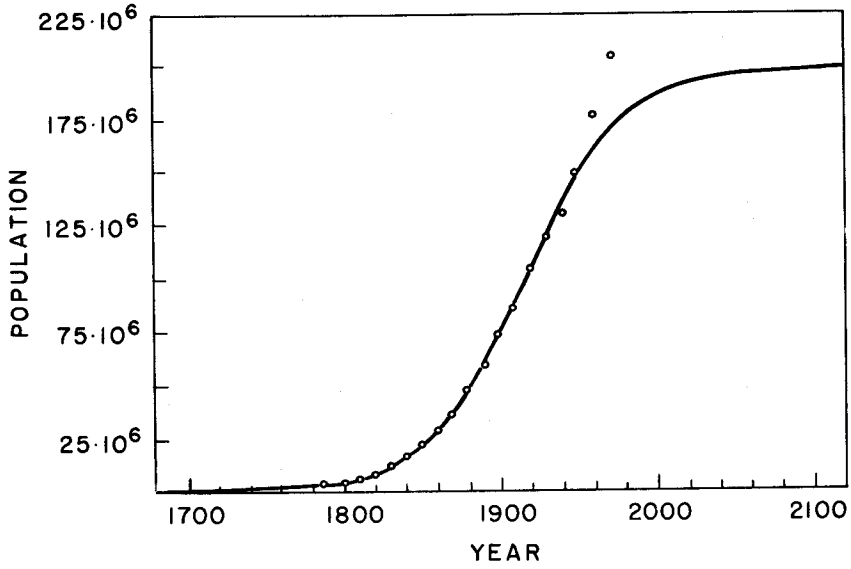

Figure 3. Logistic curve derived by Pearl and Reed from the census data for the United States up to 1910, with the actual figures to 1970, showing marked divergence from the curve in recent decades.

an egg a day or two earlier, when the food supply was greater. During the growth of the population there is inevitably a time lag in the operation of the regulatory feed-back term. We take a time τ as representing this time lag so that the differential equation now becomes

$$\frac{dN_t}{d_t} = rN_t\frac{(K-N_{t-\tau})}{K}$$

This equation is intractable, but approximate solutions can be obtained by analogue computer technique or after some rationalization, which gives an almost equivalent but soluble form (Cunningham 1954). This procedure indicates that if τ is sufficiently short, the population increases to an equilibrium level as in the Verhulst model but rather faster. If $\tau > 0.7/r$ (note that r has the dimension T^{-1}) then oscillations begin to appear, the population increases above, and then declines to a value below K. When $0.7/r < \tau < 1.8/r$ these oscillations are damped and disappear, but at higher values of

τ a limit cycle is generated with very high narrow peaks and very deep broad troughs. Such a situation is dangerous because at the time of such a trough random events can easily exterminate the species. It should be noted that the higher the rate of natural increase r, the greater the danger of generating oscillations. It is reasonable to attribute the oscillatory behavior of some experimental populations to this deductively derived phenomenon (Figure 4).

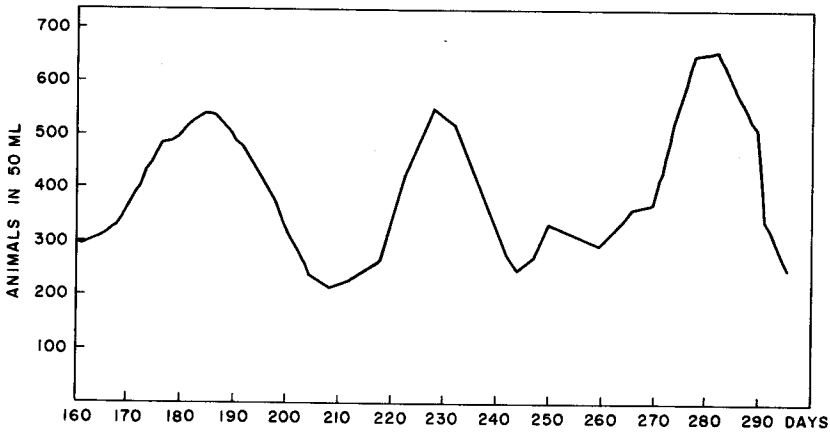

Figure 4. Part of the history of an oscillating population of *Daphnia obtusa* kept at a constant temperature and with a constant food supply (Slobodkin 1954).

The picture derived from culture experiments is, as we shall see, a very inadequate representation of what happens in nature, but it does suggest that for the evolution of any population at least three quantities, r the intrinsic rate of increase, K the possible equilibrium population, and τ the response time when rate of increase is being adjusted to the current conditions, are likely to be of paramount importance. Selective processes increasing r are likely to be of importance mainly when a population is colonizing a new area while in mature associations, selection raising K, by increasing the efficiency of utilization of the resources available, would be expected (MacArthur and Wilson 1967). In more general terms, *opportunistic species* which increase enormously to produce immense populations, only to lose practically all of the individuals when conditions become unfavorable, will be more subject to r selection and less to K selection than *equilibrium species* (MacArthur 1960) in which any increase in numbers is likely to be followed fairly rapidly by a decrease and vice versa.

These general ideas have been used to great effect by MacArthur and Wilson in their study of insular population. The possible significance of r selection has been little considered (*cf* Hutchinson 1948; Levins 1957).

If we go out into nature, provided we are dealing with equilibrium species in MacArthur's sense, in an environment not subject to repeated physical catastrophes, we find a situation quite unlike the equilibrium *Daphnia* culture, or the human inhabitants of a tropical slum. When we look at the ordinary kind of zoological population, oscillating rather irregularly about a mean value, we find that such populations do not resemble the half starved, almost sterile members of a monospecific equilibrium culture of *Daphnia* but rather appear quite well-fed with a reasonable reproductive rate. There are probably a variety of reasons why this should be so, but two are likely to be particularly important. Predation, particularly on juvenile individuals, ordinarily limits the populations of all but the top level predators. The enormous production of juveniles in some species and the numerous adaptations, including the family, that protect the young in others testify to the importance of juvenile mortality throughout the animal kingdom.

Territoriality undoubtedly plays a great part in limiting the populations of all species which are complex enough to exhibit the phenomenon, which is in fact known in mollusks, crustacea, and insects as well as in most vertebrate groups. Where territoriality exists it presumably came into being as a mechanism insuring a better chance of survival for the young of the more aggressively territorial parents. The result would be a smaller total population but better survival in the young of those parents that were able to breed. Though to me it is doubtful that territorial behavior came into existence as an adaptation to reduce the population below a dangerous level, in effect it has operated in this way. Wynne-Edwards (1962) has done a great service in emphasizing this functional aspect, even if some of his ideas about the matter ultimately prove to be erroneous. It is parenthetically interesting to note that if parental care has been largely developed to avoid predation, both the latter phenomenon and territoriality, each of which reduce populations, have in quite different ways underlain a good deal of human evolution.

Competition between members of the same trophic level is less likely to be important in most cases for at equilibrium it nearly always implies niche specificity.

When we turn to man we find that the sort of theory that has

proved so useful in biological demography is of little value. Though Verhulst developed his logistic as a theoretical construct for use in the study of human populations, and Pearl and Reed about eighty years later independently used the same approach, there is no clear evidence that human populations grow in this way. Considering the United States, Pearl and Reed (1920) concluded from the 1910 census data that the value of K would be about 197 million with an inflection point around 1914 A. D. and a very close approach to equilibrium about 2010 A. D. From a later recomputation, from the 1940 census made after the great depression had lowered reproductive rates, Pearl, Reed and Kish (1940) concluded that the upper limit would be about 180 million, again reached about 2010 A. D. Actually we have already passed the larger value of K of 197 million well before the end of the century (Figure 3).

Evidently in its simple form the logistic does not apply to human populations, any more than it is likely to apply to populations of any individual species in a complex natural association. In the latter case predation, territoriality and perhaps other phenomena, prevent most populations from reaching the K value that might be expected.

In man, where there is a continual tendency towards elimination of all asymbiotic species other than *Homo sapiens,* a comparable situation usually develops by the continual artificial increase in the value of K as N tends to approach it. This has presumably been going on at least since the neolithic, but with the increase in technological skill as well as the increasing problems set by ever larger populations, K has been kept increasing ever more rapidly. The fundamental questions raised by this symposium are firstly, whether there is a limit to K, and secondly how near to the limit is it desirable to go. If we can at any time increase K, should we just have more resources per person or just more people or some intermediate situation. These questions are discussed by other contributors in considerable detail even if not in these formal terms. All I can hope to do is to call attention to a few fundamental biological considerations and suggest a few unfamiliar avenues for future research.

There are, of course, obvious physical limits to the human population. Very crudely, if the inhabitable surface of the earth had a population density of one individual per square meter, it would be getting very close to the simplest sort of physical saturation. If, however, the population were only one individual per square kilometer or $10^6 m^2$, most people would feel that it was too sparse for a social

organism. It is worthwhile to note that going from the latter condition to the former would take only twenty doublings, which, with a modern death rate, could easily have happened within the Christian Era, if the environment could have permitted such an increase. Of course long before the limitation by physical space began to appear, other critical problems would have arisen.

Incidentally, it is by no means certain that one person per square kilometer would be too sparse for effective social action. Archaeological remains dating from the late neolithic and early bronze age indicate that the whole of Britain, from the Orkneys to Cornwall and Kent was inhabited, yet estimates of a total population of 40,000 persons in all, or about one in every 5 km^2, have been made.[2] It must be remembered that this was the time when the inhabitants of the island were making the first monuments that still entrance us and were beginning to play a major role in the economic development of Western Europe. Apart from the mere occupancy of physical space, it is obvious that an upper limit can be set by the area available for food production. Various estimates have been given as to the possible development of food supply; all suggest saturation in the first or second century of the next millenium. Population growth limited by starvation would produce a condition comparable to an equilibrium *Daphnia* culture, except that our reproductive mechanisms are probably less sensitive to food supply than are those of the Cladocera, so that a more distressing picture than is seen in the laboratory would probably develop.

It is now becoming clear that pollution might become serious long before a food-limited population equilibrium developed. Pollution takes two fundamental forms, namely the accumulation of the waste products of human metabolism on the one hand, and of industry on the other. The evidence from medieval cities probably indicates that a human population can stand more of the former, however unpleasant it may seem, than is now regarded as tolerable. The problem of industrial pollution of a modern kind is more serious. Many people are now saying that too much fuss is being made about the approaching extinction of the peregrine falcon and the brown pelican as a result of poisoning by persistent pesticides. Much of the significance of this case seems to escape the attention of those who try to minimize it. From a purely practical point of view, what is important is

[2]See Brothwell 1972 for an admirable summary.

that the rapid decline of these birds could not have been predicted when DDT was first used as an insecticide. An enormous number of chemicals are now liberated into the biosphere and new ones are added each year. The extinctions or great reductions in abundance that have been recorded as due to such materials are as yet few, but are almost certain to increase. I know of no data on the actual change in faunal diversity of any superficially natural area in which the indirect effects of industry can be felt; casual experience over half a century of life as a naturalist would suggest that in areas reasonably accessible to cities there might well have been a loss of 10% of the species. If this process continues till say 50% of the species become extinct, and if the process is essentially unpredictable in its action, how do we know whether *Homo sapiens* will be in the surviving group? My rough estimate of a 10% local extinction rate is based on experience in England during the 1920s and today. It is a pure guess and even if of the right order of magnitude is probably biased, owing to my interest in insects which are, of course, predictably reduced by insecticides. Nevertheless, if the process of unpredictable industrially determined extinction continues to occur, it will ultimately catch up with us. On the way it will greatly reduce the beauty of the biosphere and will probably forever prevent a full understanding of evolutionary processes.

Considering all possible limitations set by Verhulstian kinds of process, it is surely sensible not to tempt fate too much by believing that populations look after themselves. They certainly may do so, but the process is too unpleasant to inflict on our descendants.

If we are convinced that continually approaching an increasing value of K merely produces ever increasing poverty by putting more and more people into the human analogue of individuals in an equilibrium *Daphnia* culture, the question immediately arises as to at what level should we attempt to stabilize the population. This question might have seemed academic ten or twenty years ago, but the falling birth rates in many countries not accompanied by marked economic depression indicate that the recognition of the possibility of undesirable effects of overpopulation is at last entering into the feedback term. This should encourage us to examine the possibilities. In doing so, it is desirable to divide the problem into two parts. We can consider, independent of the actual value of K, what population would be desirable, and we can consider how far, given an optimal

population N, it is desirable to increase the potential K so that each individual has more resources. I shall mainly discuss the first of these topics.

Though we do not know the answers to either question we can see their importance. Using the biological analogies that we are developing, we are asking how we can keep a human population in a condition like that found in a complicated ecosystem and avoid the tropical slum of the equilibrium *Daphnia* culture. Moreover, we have to do this without reintroducing predators to eat off our surplus young, and without permitting territoriality to get out of hand as it is apt to do in human populations in which stylized non-lethal combat is less well developed than say in some species of birds.

Various answers to the problem of the optimal population have been given but in a rather casual manner. As far as I know, no really deep and extensive treatment of the subject exists.

In the past the Biblical (Genesis I.28) injunction to be fruitful, multiply and replenish the earth has been felt binding by some people, and there are still some around who seem to think that unlimited reproduction is a good thing. Initially such an attitude was obviously desirable, because the command was a perfectly impossible one to obey. Infant mortality was great and whenever a reasonable little population had been built up, famine, pestilence or someone who had domesticated a horse or built a chariot came down like a wolf on the fold, and the population in the fold naturally declined. To those who still have such ideas, I would suggest that this is the one Biblical commandment that has now been quite adequately obeyed.

There are also ideas that have often been put forward that it is very wrong for the other fellow to be fruitful and multiply but since he insists on doing so we must do likewise. This is an example of the lowest form of applied demography. The attitude nowadays is generally expressed in a complaint about genocide. Whatever group we belong to, we have to be very careful that we are not unconsciously adopting this position. The only way out is to set a good example; this may not work, but all other alternatives are likely to be worse.

The economic arguments for a large and particularly an increasing population are less popular than they were. This aspect of the symposium has been well discussed by other contributors. The only thing I would say about economics, is that I believe the late Lord Keynes,

under whose economic influence we all live, said somewhere that economics constituted a practical means of getting what human beings need for their development but fundamentally was a rather dull and ultimately unimportant subject.

Though at the present time we have no real knowledge of what constitutes an optimum population, many people intuitively feel that it is not much greater than that present today; some, like myself, may suspect that it would be considerably smaller. Few people would now claim that some sort of control of growth is not needed and at the moment we appear to be adopting this control fairly easily in the so-called developed countries. There will, however, be many difficulties ahead. Most of these difficulties will be due to radical changes in age structure, and so have a great fascination for the biological demographer. Any stabilization would mean a gradual replacement of many young people by old. This means that either the old must be killed off or kept unemployed or that the working population would have to settle for very slow promotion or achievement of seniority. Unemployment is a condition against which I fancy I am reasonably immune; how far the immunity can be induced when the employment is not economically gainful I do not know, but I expect a good deal of progress can be made in this. The idea of senecide at fifty is something that I would not take very seriously; my own concluding remarks were published prematurely when I was fifty-four. I think in spite of these rosy alternatives it would be possible to have a society in which the economics of aging are satisfactorily worked out. It would be necessary to devise a system in which income increased to a maximum in middle life and then slowly declined, but with the decline compensated by honorific status of some sort.

It is, I think, quite likely that in the moderately near future there will be a tendency for reproduction to take place and be restricted to an earlier age than today. This would at first run counter to the stabilization process, but if the tendency developed slowly enough and the resulting families were small enough, of one or two children, the process would probably be demographically tolerable. It would be in keeping with the reduction in the age of sexual maturity that we are now experiencing, whether this reduction be due to nutritional improvements, heterosis, parental attitudes or artificial illumination. Early reproduction would have the enormous advantage in reducing greatly the incidence of Downes' syndrome, commonly called mongolism, and conceivably other deleterious chromosomal

abnormalities. It also has another advantage of some ultimate importance in the present context.

When we have taken away religious, nationalistic and economic reasons for population growth we are still faced, in the presence of all the modern techniques of contraception, with the fact that people just like having children. Of all the implicit arguments for a growing population this is the hardest one to counter. It is clearly something that goes exceedingly deep and is something with which I cannot avoid sympathizing and in fact would find someone not so sympathizing quite distasteful. Yet for the sake of the children whom we love, an overpopulated world must be avoided. If the idea of having a baby or at most two before going to Yale is biologically appealing, the idea of grandparents, who, when the new system had become fully functional, would be in their middle thirties, becomes very important. The incoming student body would leave their two-year olds at home. Every child would have in effect four parents, all with rather different functions; the idea of becoming a grandparent would raise as much or perhaps more expectation than that of becoming a parent. With the present life span the role of great grandparents in their middle fifties would take on the familiar function of the grandparents today, helped out by a respectable number of great-great-grandparents in their seventies. We should have extended families developed over time rather than over space. Social scientists would probably call them longitudinal. Everyone would have some contact with children over as long a time as is now customary in a multiparous family, so sharing the satisfactions of child rearing and also much of its labour. Some child psychologists would doubtless be worried by this idea, and incidentally would, in worrying, probably produce effective modifications of its details so that it became psychologically practical. There is, however, nothing absurd about the notion, because in the past when a young woman went into the fields instead of to senior year in high schoool, as soon as her baby was too big to have on her back while working, but too small to help with the weeding, it would have been at home with its grandmother.

We still have not really faced the problem of optimal human density but merely looked at some of the questions that arise in maintaining it. Quite frankly, I do not know what the optimal density is. I do feel strongly that the problem is one that requires a great deal of thought which should be started at once. It is not so much a question of research in the ordinary sense of the word, but of trying to or-

ganize one's desires, aspirations and whole ethical outlook in such a way that life is not frustrated at every turn as it is apt to be for so many people in human societies today. The problem not merely involves the number of people but the number of commodities that they use. This earlier was described as the problem of setting N constant and asking how far the potential value of K may be increased. The first thing to find out is what are the requirements for a human being to live a happy life. I suspect that in general we have not the slightest idea. Like everyone else I have had a share of frustration and tragedy, but on the whole I suspect my life has been as good as a human being can at the moment reasonably expect and I know quite a lot of the conditions that have made it so. Though such conditons may not necessarily operate for anyone else, I suspect that there is a fairly large subclass of humanity who would look for and find in the world much of what I have looked for and found to be good. It is obvious that one needs enough food to keep alive and adequate protection against the cold in those areas that are cold in winter and in which many of the more complex cultures have developed. Enough medical services to avoid decimating diseases and enough water, soap and the like to keep clean are ordinarily regarded, I think rightly, as also essential. I am told the lice are coming back in England, which rather worries me as it means that typhus may be coming back too; though members of the genera *Pediculus* and *Psithirius* have an evolutionary message to give us, they are among the few organisms that I would not mind seeing on the endangered species list.

Apart from these preliminary elementary physical requirements, we presumably need many other things to be fully human. One of the tragedies of the present time, as I fancy is always the case when old traditional patterns are disintegrating, is that so many people find that when they have what they thought they wanted, they are still unsatisfied. It would surely be a very good thing if people really sat down and tried to find out what the best things are. It is not valid to claim that this must wait till nobody lives in a walkup cold-water flat, because much of the greatest literature and music must have been written, and many of the greatest paintings painted, in buildings that would be condemned by health and housing authorities today. This sort of study, though it initially requires a deep personal motive, will involve real research in an academic sense, because one way to study the problem of human happiness is obviously to see which cultures

appear to have promoted the condition and which appear to have prevented it, and then ask ourselves how the promotion or prevention happened. All the time, however, we must remember that we are dealing with huge numbers of individual people who legitimately have many tastes and desires. It would make me happier if there were very much less government encouragement of new highways and very much more government encouragement of music and painting and poetry and the kind of science we have been considering in this series. I don't know how far this would help other people, though I suspect it would be appreciated by a number of those who willingly came out on a very wet evening to hear my oral presentation and may later be reading these words.

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PART TWO

Patterns, constraints and implications for natural resources in a stabilizing world

CHAPTER THREE

HARMONY BETWEEN MAN AND NATURE: AN ECOLOGICAL VIEW

by
Eugene P. Odum

Our generation enjoys the fruits of technological achievements which have increased energy and resource availability far beyond subsistence. But at the same time we are confronted with exploding populations, dwindling natural landscapes, and mounting pollution which threaten to cancel many of the advantages of this energy-rich society. The realization that man is an integral part of his surroundings has directed our attention, more and more, to understanding and protecting our endangered environment and to re-ordering technology to achieve new goals. Thus, interest in ecology and application of ecological principles to human affairs has become a new intellectual frontier. Environmental awareness, worldwide in scope, reflects that, for the first time in its history, humanity faces ultimate rather than merely local limits to human needs and aspirations.

In revolutionary times such as these it is to be expected that many long-accepted concepts and attitudes relating to man and his environment should be brought into question. Intense analyses and debate on issues is to be encouraged as is the establishment of communication between vested interests within our society. This is a necessary step in making decisions for the good of the whole. Controversy is equally important at the professional level because such specialists, in emphasizing precision of communication *among* themselves pay the cost of lessened communication with other professional groups, or the public at large. Each profession has its "articles of faith". These need to be re-examined periodically to make certain that they are consistent with new knowledge and changed conditions. In this discussion I shall make a special effort to *broaden* the concepts in the hopes that all can understand them. I am optimistic that the basic intelligence of man will surface in time to implement orderly reforms that must be made to meet environmental contingencies, provided controversies do not become refractory and

there are not too many false starts and backlashes which generate dangerous oscillations and uncertainties.

One long-accepted concept, now being challenged, is the belief that economic and population growth are necessary to raise the standard of living and cure societal malfunctions associated with pollution, hunger, crime, and unemployment. Writing in a current symposium volume entitled "Energy, Economic Growth, and the Environment" (Schurr, editor, 1972) economists Walter Heller and Kenneth Boulding present contrasting viewpoints. Heller says, "One rightly views growth as a necessary condition for social advance, for improving the quality of the *total* environment". Boulding says, "One might even have an optimistic image of the present period of human expansion as a kind of adolescence of the human race in which man has to devote a large portion of his energy to sheer physical growth. Hence we could regard the stationary state as a kind of maturity in which physical growth is no longer necessary and in which, therefore, human energies can be devoted to qualitative growth—knowledge, spirit and love".

As an ecologist with a holistic view of man and nature, I would agree that Boulding's youth-adolescence-maturity sequence is a useful, but, by itself, an inadequate analogy for comparing development at different levels of organization. Almost always what is true at one level explains only part of what is true at other levels—this being the well-known principle of "integrative levels" (see Fiebleman, 1954). To understand a process, such as development, at a particular level we must consider the process *at that level.* Although there are parallels between the individual and society in regard to growth and maturity, there are additional "scale factors" to be considered when we move from individual levels to the level of society, and especially when we consider man and his environment as an ecosystem.

My principle theme is as follows: Development at the ecosystem level *differs* from development at the individual level in that *aging and death do not inevitably follow achievement of maturity,* as is the case in the individual organism. I sincerely believe the reason many people become highly emotional on the subject of "Limits of Growth" is that they fear that if physical growth of society stops it will then deteriorate and die. Taking cues from what we can observe about the development of large systems, I believe we can show that this is by no means the case. In fact, the truth may be just the opposite. If the physical growth of society does not level off at an

optimum size in terms of the resources and life support system on which it depends, the *continued improvement of the quality of human life will be more and more threatened by cancerous growth;* uncoordinated and uncontrolled parasitic growth that becomes lethal when it can no longer be supported by the system of which it is a dependent part.

In the ecological context, the important questions do not relate to limits of growth *per se,* and certainly they should not focus on making a choice between the extremes of "zero growth" and "laissez-faire (i.e., uncontrolled) growth". Rather, after sheer physical growth in size becomes undesirable or impossible, the focus should be on the extension of growth in quality human existence. It is the "law" of the ecological system that individuals or components within the system die and are replaced by perhaps better individuals. This makes it possible for the whole system to improve rather than to age and die. Likewise, if society is not to age and die, economic and social institutions must also evolve (i.e., be replaced by more adapted ones) as the stages in development change. To blindly adhere to social and economic institutions based on the concept that "bigger is always better", just because it is true during the early stages of development, would be to invite death of the system, because it prevents necessary movement to the next stage. To rephrase this viewpoint, we could say that the problem society faces is to make an orderly transition from a youthful stage, in which man's relationship to environment must of necessity be exploitative and parasitic, to a more mature stage of harmony between man and nature. We can find interesting models of this transition in natural systems where we observe that parasitism tends to evolve into mutualism when components live together over long periods of time in a stable system. Any parasite that does not make this transition risks extinction by destroying its host (for additional discussion of such models see Odum 1971, pp. 220–233).

In our society, with its specialists and special interests, the word "growth" means different things to different people. Many businessmen, economists, and planners are preoccupied with growth in size, while the ecologist recognizes many other kinds of growth that do not involve a net increase in size of the system or in the number of components. For example, in a forest developing on an abandoned field, through time there will be growth in efficiency of use of energy and resources and in recycling of materials; there will be growth in

diversity of organisms, in stratification, and in the size and quality of individuals. All of these kinds of growth, which do not require increase in size, function to prevent "aging" of the ecosystem. There is no reason why "substitutes" for growth in size cannot generate employment, GNP and higher standards of living in the equilibrium society just as effectively (or maybe even more effectively) as does growth in size in the pioneer society. Refining, rebuilding, recycling and servicing already developed systems to make them more efficient can certainly furnish plenty of opportunity. In Table 1 are listed eight types of growth which not only appear to be important in the natural mature ecosystem, but which could theoretically also play a role in preventing aging in the total man-environment system. Poor people and culturally disadvantaged people need not fear that phasing into a mature society will cut off their opportunities for individual development. Economists and social scientists scheduled to speak in this symposium series will be discussing with you, I am sure, some possibilities along these lines and I shall draw a few parallels myself at the end of this presentation.

Table 1—Types of growth that do not require a net increase in size, but which can function to prevent aging, not only in the mature (steady-state) natural ecosystem, but also in a mature society.

1. Increases in efficiency in the use of energy.
2. Increases in efficiency in use of resources.
3. Increases in turnover rate of components (repair before deterioration occurs)*
4. Increase in rate and efficiency of recycling of materials.
5. Increase in proportion of energy devoted to maintenance.
6. Increase in diversity of components.
7. Increase in stratification.
8. Increase in quality of components (continual improvement of existing superior components rather than proliferation of more inferior ones).

*It is interesting to note that according to one theory, aging in the individual comes when cycling cells (components) become non-cycling (see Gelfant and Smith, 1972 for a review of this theory). Whether this is a useful analogy for the ecosystem yet remains to be determined.

While most thoughtful people will probably agree with the overall logic of my argument, there is still a widespread belief that we have not yet reached any real limits for physical growth, or that technology can somehow extend the limits indefinitely. Since energy is the common denominator for man and nature, let us analyze the role of

energy in development of society and try to determine if (a) the time has come for man to plan for a transition from quantitative to qualitative growth; or (b) can we continue to enjoy youthful growth for some time to come and let some future generation worry about the mature state?

There are five basic principles for such an analysis. These are:

1. In a technologically advanced industrial society, energy itself is not likely to be limiting, but the consequences of converting energy from one form to another is limiting. When we run out of fossil fuel there is plenty of potential energy in the atom, but tapping such new sources will be more difficult. The technology will be more sophisticated and its maintenance and repair will be more difficult and costly. In a recent case in the New York area seven months were required to repair a malfunction in the heat generating component of an atomic power plant; only a couple of days would have been required to repair a similar breakdown in a coal-fired plant. Accordingly, it is a challenge to keep the unit cost of a kilowatt or BTU of energy from rising. In fact, unit costs are rising and will rise despite our best efforts. The relatively cheap power rates of the past decade, responsible for so much recent rapid industrial development, resulted both from the relative ease of converting fossil fuels to useful work, and the fact that we have postponed paying some of the costs, especially environmental costs. As the cost of energy conversion increases and the space for environmental waste treatment decreases, the *total cost* (not just dollars and cents cost) of energy will be driven higher which means that its conversion from one form to another must be much more prudently managed than is now the case. At the present time, as shown in Table 2, only about half of all the energy used in the United States is converted to useful work, the other half is waste (i.e., pollution). Automobiles and electricity are very convenient and important in generating economic wealth, but as presently designed, both are particularly inefficient in energy conversion (only about 30%) and generate huge amounts of waste that strains our life support systems. Increasing efficiency, of course, is one way to provide more energy to people who do not now have enough without increasing the total consumption. As already mentioned, this is one of the growth substitutes utilized by mature ecosystems.

2. There is no technological way to bypass the 2nd law of thermodynamics, which states that as energy is used a proportion is converted or dispersed in an unusable (by man) state; energy cannot be

TABLE 2. U.S. Consumption, Use and Waste of Energy – 1970

Type	Gross Consumption	Consumed as: Electricity	Consumed as: Fuel	Useful Work Accomplished: Household & Commercial	Useful Work Accomplished: Transportation	Useful Work Accomplished: Industrial	Totals: Useful Work	Totals: Waste
Nuclear	.05							
Hydropower	.68							
Gas	6.13	4.28	12.0	3.18	1.03	4.06	8.27	8.01
Petroleum	6.02	(26%)	(74%)	(38%)	(13%)	(49%)	(51%)	(49%)
Coal	3.40							
	Total 16.28	16.28		8.27			16.28	

Figures in Kcal x 10^{15}. Table based on Cook, 1971, chart on Page 138-139 (with conversion of BTU's to kilocalories). Since conversion of fossil fuels to electricity and to automotive power is only about 33% efficient and since these energy consumptions have increased dramatically in the past several years it is likely that the overall efficiency of energy conversion in the United States has now dropped well below 50%.

recycled as can materials. One can ameliorate thermodynamic disorder created by energy conversion, but one cannot avoid the basic cost of dealing with it. Concentrating and intensifying the use of energy within small areas (cities, heavy industries, etc.) creates especially difficult thermodynamic disorder problems. It is evident that disorder problems (various forms of pollution) have already resulted in diminishing economic returns and in leveling growth in parts of the U.S. Even our efforts to increase food production in fuel-subsidized agriculture, (where large amounts of fossil fuel are used to raise agricultural output), are beset with increasing thermodynamic disorder that will eventually increase the cost per unit of food produced. To double plant food production a 10-fold increase is required of fertilizers, pesticides and horsepower—all of which pollute (see Odum, 1971, page 412 for documentation of this relationship). Modern methods of converting grain into meat bring additional losses and costs, as evidenced by water pollution caused by animal feed lots. We have scarcely begun to think about paying for the treatment of agricultural waste. In contrast to most countries, agriculture in the U.S. now consumes more fuel energy calories than it produces in food calories.

3. Exponential growth cannot continue for very long. We have two options (1) let positive feedback run its course until overshoot occurs (boom and bust), or (2) install some negative feedback to control growth, to prevent overdevelopment and to buy necessary time for solving problems. Lost in the controversy between the extremes of "zero-growth" and "laissez-faire growth" is the simple, common-sense truth that a controlled, moderate rate of growth not only prolongs the time when we can enjoy the undeniable benefits of growth, but also reduces the cultural and technological lags that are inherent in rapid growth.

4. As the size of a system increases, the cost of maintenance of a network of services increases as some kind of power function, at least as a square, viz:

$$C = \frac{N(N-1)}{2} \text{ which approximates } \frac{N^2}{2}$$

where N is the number of units in a network and C is the maintenance cost. Thus, doubling the size of a city or a power plant is likely to more than double the cost of maintenance. Since there are other

"trade-off" advantages to an increase in size, (i.e., "economics of scale" factors), bigger is better up to a point. Theoretically there is an optimum power concentration per unit area beyond which any increase in size costs more than it's worth. In other words, cost-benefit curves are really humpbacked and not the straight lines all too often projected by "superficial optimists". Figure 1 shows a generalized information input-output performance curve that has been shown to apply to several levels of biological organization. Presumably some such curve applies to power-in, benefit-out relationship. One insidious feature of such a curve is that the downward trend that comes after the optimum is reached is so much more gradual than the pre-optimum upward trend. Thus, increases in output per unit input benefits are quickly recognized in the early stages of development, but declining benefits after the optimum has been passed are not so easily recognized. Unfortunately, large, power-hungry, man-made systems have an inherent tendency to overdevelop, since profits can be made by going beyond the optimum so long as payment for the increased cost of maintenance is avoided or delayed. In my opinion, locating the optimum plateau in the energy-performance curve is the greatest challenge in systems research today. Fortunately, most factions in our political system are beginning to talk about economic reforms, especially in the area of taxation, designed to counter the over-development syndrome.

5. The natural environment, the life support system for both man and his energy-consuming machines, is the major means for tertiary waste treatment. The work of nature in pollution abatement has been underevaluated, because this service has been *free.* Present cost/benefit procedures generally fail to include this basic dependence on the natural environment until *after* the overshoot, i.e., until the environment is badly polluted and suddenly we have to pay for treatment that was previously free. In terms of energy flow, there are three basic kinds of ecosystems that must function together in some kind of balance if man is to prosper. Natural systems operate on dilute sun energy and, therefore, are low powered. (Table 3) At the other extreme, cities and industrial complexes are subsidized by huge fuel imports (Table 3) and, therefore, operate at a power level three orders of magnitude higher than those natural systems. However, nature is very efficient at its level of power when one considers that natural systems are self-maintaining and (by-and-large) take care of their own wastes—in contrast to cities which, as we now manage

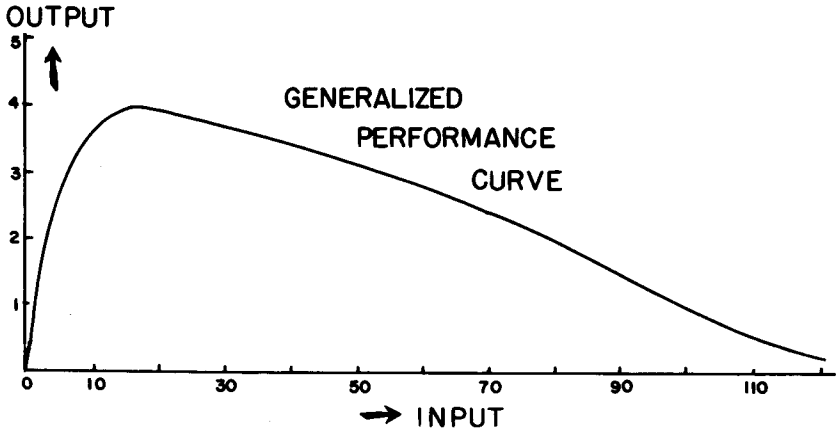

Figure 1. Theoretical curve based on performance date of biological systems under various rates of information input. Figures are in relative information units—bitssecond X 10^3. By "output" is meant proportional output per unit of input. After Miller, 1965.

them, are almost completely parasitic on types 1 and 2 systems, as listed in Table 3. Furthermore, nature does its work without economic cost to man, so long as its capacity is not exceeded. Because of the low unit-area capacity, *very large areas of natural environment are required to absorb the thermodynamic disorder produced by high energy systems of man.* When such environment is not available, or is so severely stressed that it is unable to maintain itself and also do extra work of pollution abatement, then artificial tertiary treatment of large volumes of low level wastes (CO_2, heat, NO_2, SO_2, tritium, etc.) becomes necessary. In the long run it will be these low level, large volume wastes, together with the outright poisons (lead, mercury, DDT, industrial phenols, etc.) that pose the greatest threat to the quality of human life. If all these wastes had to be treated artificially, costs would skyrocket!

Based on two different models, my brother and I (see Odum and Odum, 1972) have suggested that in a state or region with one or more large industrial cities, at least 50% of the land and shallow waters should remain in a natural state if quality, in terms of human health, nutrition and use options of both city and country, is to be maintained. Whatever proves to be an optimum mix of developed and undeveloped environment, one thing is certain: The former will

TABLE 3. Ecosystems Classified According to Source and Level of Energy.

	Power requirements	Energy Flow Kcal/m²/year
1. Natural solar-powered, unsubsidized ecosystems[1] (These are the basic autotrophic, self-maintaining life support systems)	1,000	– 10,000 (av. 2000)
2. Solar-powered ecosystems subsidized by free natural[2] or man-controlled, but expensive, inputs[3] of energy and materials (These are the basic food-producing systems)	10,000	– 40,000 (av. 20,000)
3. Fuel-powered urban-industrial systems (These are the wealth (and pollution)–generating systems that are parasitic on ecosystem types 1 & 2.....	1,000,000	– 3,000,000 (av. 2,000,000)

[1] Oceans, natural forests and grasslands are examples.

[2] An estuary is an example of a natural ecosystem subsidized (and its productivity thereby enhanced) by natural tidal energy.

[3] Industrialized agriculture is an example of a solar-powered ecosystem heavily subsidized by fossil or other fuel at appreciable cost to man.

overshoot the latter unless comprehensive regional land-use and energy management plans are adopted—soon.

When these five basic principles are considered, it is evident, (1) *that for the first time in his history man does indeed face ultimate, rather than merely local limitations, not so much in terms of energy sources but rather in terms of impacts created by the concentration and conversion of energy, and* (2) *that environment is rapidly becoming the factor that sets the limit for man's fuel-powered developments,* and, in turn, for the number of people that can be supported at a reasonably good standard of living.

The Forrester-Meadows models (see Forester, 1971, Meadows et

al 1972) show that a disastrous overshoot could occur between the year 2000 and 2100 if present day economic and population growth and resource-wasting technology continues unmodified. The great value of their models is the easily understood warning of what *could* happen. A logical response is to examine the parameters in the model to see which ones need to be changed to prevent an overshoot. My review of the five basic principles suggests that reducing the economic pressures that push the development of fuel-powered systems beyond the capacity of the life-support systems would reduce chances of an overshoot. Likewise, a general shift from quantitative to qualitative growth would greatly change the output of the Forrester-Meadows model.

While the specific environmental models briefly referred to in this paper are not yet firm enough to provide a basis for broad-scale environmental-use planning, they do indicate that all the oceans and other large bodies of water, plus perhaps as much as 4–5 acres of solar-powered terrestrial natural, or semi-natural, environment *per person* must be kept in good working order as tertiary treatment systems if the quality of urban-industrial areas is to be maintained. Since the density of the U.S., and also the world as a whole, is now about one person in ten acres of land area, we have time and opportunity to develop plans for maturation at an optimum rather than a maximum level of energy flow.

It is clear, at least to an ecologist, that new strategies are necessary when society moves into the mature state. I say "when", because some regions are yet undeveloped and need quantitative growth, while others have already passed the optimum. In an overall sense, reforms in two major human institutions, economics and planning, are needed *now* so that the transition to maturity can be made as needed without first suffering dangerous overshoots.

For example, present economic and political systems tend: (1) to favor the wastemaker over the public interest, (2) to stimulate an artificial demand for hard goods, and (3) to encourage a wasteful technology which converts degradable natural resources into non-degradable and poisonous by-products. It should not be too difficult to alter tax procedures, which now stimulate these responses, so as to discourage them.

In the area of planning, we must move toward regional environmental-use planning. As an indication of how this might be accomplished, I call your attention to the recently published "California Tomorrow Plan" (Heller, 1971). It is remarkable that this little book

outlining two alternate plans for the state was the work of a citizens group rather than professional planners, although, of course, the expertise of planners was drawn upon extensively. One plan, called "California one", projects what California would be like in the year 2000 if present approaches to problem solving continue without change. The present disruptive forces would, in all probability, intensify. The "California two" scenario has government and private enterprise join forces in a well-financed state commission to design a statewide land-use plan. The plan, amended by open discussion, would be voted into effect by the public. It is interesting to note that the projected land-use plan calls for large areas (perhaps 40% of the state) to be in "conservation" and "regional reserve" categories (i.e., preserved in natural and semi-natural states). While "California two" is no Utopia, it is projected that many disruptive tendencies, such as crime, pollution, environmental decay and social disorder would be reduced rather than intensified. Further, "California two" is shown to be politically and economically feasible, requiring no change in our form of government. Perhaps even more important, coordinated regional control of environmental quality is thought to reduce, rather than increase, centralized (i.e., Federal) control of the individual's options regarding such things as housing, health, education, and recreation. These matters would be more under local control with a strong regional plan in operation. This is important because many people now reject the idea of large-scale planning in the belief that it reduces individual liberty and brings on more bureaucratic control. According to Heller's little book, this need not be the case.

Faced with a choice between "California one" and "California two", most people would certainly be inclined to choose the latter option. In any event, I believe we have here the first tentative step in the direction of putting into practice the theory of "ecosystem management".

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CHAPTER FOUR

HIGH ENERGY SOCIETY—A FAUSTIAN BARGAIN

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Science, Technology, and Free Lunches

The second half of the 20th century has seen the destruction of two illusions which were born of the idea of limitless progress based on the growth of science and technology. The central and popular faith was—and unfortunately, still is—that technological progress based upon ever-expanding scientific knowledge of the physical universe would provide humanity with a future of felicity and happiness, unmarred by pain, anxiety, conflict, or arduous physical, mental, or spiritual toil.

While the present might witness events such as depression, international war, famine, social and racial conflict, oppression, and generally inhumane conduct by a significant part of mankind; a convenient explanation was available. The existing discord was intelligible as cultural lag, W. F. Ogburn's convenient formulation, meaning that changes in institutions and behavior "lagged" behind changes in technology. It was largely this failure of social structure, organization, and culture to move in lockstep with technology that was responsible for "social disorganization," a label that conveniently categorized and seemingly tamed the recognized ills of the world.[1]

Two assumptions made plausible the belief that the ills afflicting

[1]A convenient late summary statement of the cultural lag hypothesis may be found in W. F. Ogburn, "Cultural Lag as Theory," W. F. Ogburn, ON CULTURE AND SOCIAL CHANGE (Chicago: University of Chicago Press, Phoenix Books, 1964), pp. 86–95, reprinted from SOCIOLOGY AND SOCIAL RESEARCH, XLI (Jan-Feb., 1957). For an application and critique of the concept in relation to the contemporary world, see Victor C. Ferkiss, TECHNOLOGICAL MAN: THE MYTH AND THE REALITY (New York: George Braziller, 1969), pp. 203–44.

humanity would be eliminated by progress of scientific knowledge and technology. It was optimistically assumed that the elimination of scarcity of material things through the ever-increasing application of greater quantities of energy to the production of goods and their distribution—would eventually abolish the grosser forms of disharmony and conflict between peoples. A corollary is the concept of economic man, the proposition that the important factor in behavior is rationally motivated effort to secure economic goals.

Hence, if the scarcity of material goods was replaced by abundance, the major source of human conflict and aggression would be removed, and man's individual and social behavior would move to a more humane and spiritual plane. Material riches for all would destroy deprivation, greed, and envy. Alas, this assumption has been proven false by events. We live in a society whose affluence has no historical precedent. But we also live in a society racked by conflict.

The evidence is clear that man seeks not only material riches, *tangible stimuli,* such as automobiles, cassette recorders, and wall-to-wall carpeting; but also *symbolic* (status and prestige) and *social* (significant interaction) *stimuli.* Tangible stimuli like food, shelter, and clothing also have symbolic and social meanings. A surfeit of material goods in and of itself, however, cannot provide a basis for human amity and harmony. A superfluity of goods does not eliminate the scarcity of available symbolic and social stimuli and an associated pattern of human dissatisfactions. On the contrary, a strong case can be made that the superfluity of goods merely exacerbates the aggressiveness and desperation of interpersonal and inter-group conflict for symbolic and social satisfactions.

It is also assumed that the advancement of scientific knowledge and the development of increasingly complex technologies with accelerating energy demands provide mankind with enhanced control over his environment, giving humanity freedom never before experienced. Just as the germ theory of disease made possible the release of man from quackery and superstition in the treatment of disease, it is assumed that science, with the derivative technical knowledge, provides a more controlled and controllable environment.

> Science and technology took on the sacred aura of an almost supernatural force, the weapons that would drive famine, disease and pestilence from the earth. Together these be-

> liefs acted like a gigantic valve opener in the flow of energy through the progress culture, . . .[2]

The unpredictable and threatening became understood, manageable, and controllable, if not in fact, at least in principle. Given the reduction of uncertainty in the environment, there would be a reduction in care and anxiety. Technologies, based upon mastery of extraordinary levels of energy conversion and utilization, would provide a salubrious environment with greatly enhanced physical comfort and weal, along with freedom from the necessity for strenuous and irksome mental and moral exertion.

But it is illusionary to believe that the achievements of science, technologically transformed into an affluent existence, are costless. This is counter to Barry Commoner's fourth law of ecology, "There is no such thing as a free lunch."[3] A costless good is not to be found on planet Earth. High energy technologies in the service of man impose inexorable and inescapable demands upon human frailty. The question is: can man pay the price?

Technological Fixes and Faustian Bargains

An illustration of the costs of a high energy technology is provided by the public statements over the past few years of Alvin M. Weinberg, Director of the Oak Ridge National Laboratories. This is a facility for research into the problems of nuclear energy, and is operated for the Atomic Energy Commission by the Union Carbide Corporation. Weinberg is one of the most outspoken and aggressive advocates of nuclear power for the generation of electrical energy.

In 1966, when receiving the University of Chicago Alumni Award, Weinberg made an address entitled: "Can Technology Replace Social Engineering?" which received widespread attention. Weinberg said that nuclear energy was a "crisp and beautiful technological solution" to the problem of an eventual shortage of energy. He observed that the ready availability of such a technological solution for

[2]Bernard James, THE DEATH OF PROGRESS (New York: Alfred A. Knopf, 1973), p. 25.

[3]Barry Commoner, THE CLOSING CIRCLE: NATURE, MAN AND TECHNOLOGY (New York: Alfred A. Knopf, 1971), pp. 45–46.

the emergent possible energy shortage facilitated the effort to focus concern upon it.[4]

Weinberg added that social problems are more difficult to solve than technological problems, implying that the impending energy shortage, in the absence of the putative nuclear solution, was a technological problem.

> A social problem exists because many people behave, individually, in a socially unacceptable way. To solve a social problem, one must induce social changes—one must persuade many people to behave differently than they have behaved in the past.[5]

Weinberg said the methods of social engineering invent the social devices—usually legal, but also moral and educational and organizational—that will change each person's motivation and redirect his activities to ways that are more acceptable to the society.

The social engineer is confronted with the fact that people do not behave rationally—that they prefer the immediate short-term personal gain or pleasure to the long-term gain of society. Given the complexities and difficulties inherent in social engineering, Weinberg asks, why can't social problems be reduced to technological problems, which in comparison are easy to solve? Weinberg suggests that "Quick Technological Fixes" be substituted for social engineering in the solution of social problems; and he gives examples of two such "fixes," one for poverty and the other for war between the major powers.[6]

According to Weinberg, the Marxian dogma for the solution of poverty, the maldistribution of goods, by the elimination of profits is typical of the social engineering approach. The objective is "to convince or coerce many people to forego their short-term profits in what is presumed to be the long-term interest of society as a whole."[7] The technological fix for the social problem of poverty has been, Weinberg maintained, affluence generated by extraordinary

[4]Alvin M. Weinberg, "Can Technology Replace Social Engineering?" BULLETIN OF THE ATOMIC SCIENTISTS (Dec., 1966), p. 4. Currently (February 1976), Dr. Weinberg is Director, Institute for Energy Analysis. In 1974, he served as director of the Federal Energy Administration's Office of Energy Research and Development.

[5]IBID., p. 5.

[6]IBID., pp. 5–6.

[7]IBID.

advances in the technology of energy, automation, and mass production of goods. The resulting enormous volume of goods enabled the capitalist societies to solve the problem of poverty without undergoing the social revolution predicted by Marx.

Possibly Weinberg is right, that affluence abolishes poverty for most of the population and obviates social revolution. But, as I will show, affluence is a "fix" in the slang meaning of that term: an intravenous injection of heroin or some other narcotic, and all of the developed societies will be confronted with the fact of their addiction.

War also has a technological fix. Weinberg notes that war is evil in the traditional Christian view. But this religious variant of the practice of social engineering has been ineffective. War is a familiar and expected event in Christendom. But, says Weinberg, the nuclear physicist, Edward Teller, provided a fix—the hydrogen bomb. This weapon has made large-scale war too destructive. The motivations of people have not been changed, but the instinct of self-preservation has been heightened by the existence of the H-Bomb. Although the resulting peace has been tenuous, war has been avoided.[8]

Weinberg finds, in 1966, that the advantage of the technological fix is that it avoids the necessity inherent in social engineering of changing people's habits and motivations. It "accepts man's intrinsic shortcomings and circumvents them or capitalizes on them for socially useful ends."[9] Weinberg observes that the technological solutions to social problems tend to be "incomplete and metastable," replacing one social problem with another. He recognizes that technological solutions are short-term and that fixes create new problems as they solve old ones. However, technological fix furnishes options and reduces the pressure of crisis. He comments:

> But technology has provided and will continue to provide to the social engineer broader options, making intractable social problems less intractable; perhaps most of all, technology will buy time, the precious commodity that converts violent social revolution into acceptable social evolution.[10]

The limitations of technology as a solution for anything, including technological problems themselves, was beautifully illustrated by Mr. Weinberg five years later, in 1971. In the Rutherford Centennial

[8]IBID.
[9]IBID., p. 7.
[10]IBID., p. 8.

Lecture, Weinberg called for a social engineering solution for a technological problem, that of safety in the developing nuclear energy industry. Weinberg proposed that the complex and grievous problem of nuclear reactor safety can be solved if we can secure, in Weinberg's words, "both a vigilance and a longevity of our social institutions that we are quite unaccustomed to."[11]

To make nuclear energy safe for this and future generations, Weinberg proposed that we find a social engineering solution embracing the molding of human motivation, not in the time frame of a year or a century, but in tens of thousands of years. According to Weinberg, there is no technological fix for the safety of nuclear reactors and the radioactive pollutants they create. The solution for those problems, if a solution is possible, requires social engineering applied for thousands of years, a "Faustian Bargain," in Weinberg's description.[12]

The developments which probably influenced Weinberg to espouse social engineering to solve a presumably technological problem go to the core of man's dilemma in using high energy technologies. Two or three years before Weinberg's talk, considerable dissent arose among some members of the scientific personnel concerned with reactor safety at the National Testing Station in Idaho and the National Laboratories at Oak Ridge.[13] This dissension centered on delays in the safety program and the resulting demoralization of the safety research personnel. With increasingly powerful nuclear power plants being built, "the safety program . . . accumulated an enormous backlog of unfinished research and unanswered questions." The AEC itself stated in 1970 that there were 139 unresolved safety problems or issues, and 44 of them were characterized as " '*very urgent, key* problem areas, the solution of which would *clearly* have great impact, either directly or indirectly, on a major critical aspect of reactor safety.' "[14]

The LOFT project, an acronym for "Loss of Fluid Test," was central to this matter. As originally conceived and initiated in 1963, a 50

[11]Alvin M. Weinberg, "Social Institutions and Nuclear Energy," SCIENCE, Vol. 177, No. 4043 (July 7, 1972), pp. 27–34.

[12]IBID., pp. 33–34.

[13]A summary statement of the complex factors in a rather sorry state of affairs is presented by Robert Gillette, "Nuclear Safety (I): The Roots of Dissent," SCIENCE, Vol. 177, No. 4051 (Sept. 1, 1972), pp. 771–76; and Robert Gillette, "Nuclear Safety (II): The Years of Delay," SCIENCE, Vol. 177, No. 4052 (Sept. 8, 1972), pp. 867–71.

[14]Gillette, "Nuclear Safety (I) . . . ," OP. CIT., p. 771. (AEC's emphasis)

megawatt reactor was to be built and run at full power with an abrupt draining of its cooling water. Initially, the purpose was only to proof test the type of containment shell that surrounds all nuclear power reactors. But the test reactor, which originally was to be completed in 1966, was given an additional and main purpose of testing emergency core cooling systems (ECCS) in 1967. However, after nine years (1972), the LOFT facility was only 89 per cent complete and not expected to become operational until 1974 at the earliest.[15]

In connection with the LOFT program, some frightening questions relating to the safety of the more than twenty operating nuclear plants emerged in the late 1960's. The central problem relates to the probable sequence of events should a nuclear core lose its cooling fluid. The normal operating temperature of a reactor core, composed of a bundle of thin metal zirconium alloy tubes containing pellets of uranium oxide, is 315 degrees centigrade. This temperature is maintained by circulation water around and between the elements. If the cooling fluid is lost the temperature of the reactor core would increase at a fantastic rate, reaching 1800 degrees of centigrade, the melting point of zirconium, in a minute or less. Chemical reactions between metal and water would become " 'significant' " at 1100 degrees centigrade.[16]

The sequence of events resulting from a loss of coolant accident is unknown. However, an AEC advisory group depicted a molten 250-ton mass of radioactive materials, structural metal, and other materials containing approximately 50 megawatts of heat energy derived from decay of fission products and chemical reactions. This would be sufficient to allow the molten mass to melt through the steel reactor vessel and supporting concrete, giving rise to what has been characterized as the " 'Chinese Syndrome.' "[17]

This radioactive molten mass would retain its heat, melting through all obstacles, with the conjecture that it would ultimately melt its way through to Peking. Of course, there is the additional likelihood of violent chemical explosions breaching the containment structure, releasing radioactive elements to the atmosphere, with a frighful loss of human life and terrible human suffering. It is difficult to envisage the extent of destruction. However,

[15]Gillette, "Nuclear Safety (II) . . . ," OP. CIT., p. 867.

[16]Gillette, "Nuclear Reactor Safety: A Skeleton at the Feast," SCIENCE, Vol. 172, No. 3986 (May 28, 1971), p. 919.

[17]IBID., p. 918.

> It is sufficient to point out that there are power reactors sited so as to expose millions of persons to possible lethal radiation in the event of single reactor core meltdown, and the installation is rare where 10,000 or more persons are not within lethal range of an accident.[18]

The safety device for preventing a core meltdown is the backup device, an emergency core cooling system. The design of these backup safety systems is based on " 'computer codes,' " or models. The models are based "in large part on the performance of key components in miniature laboratory-bench experiments." By mathematical extrapolation of the variables, the safety systems are designed for commercial power-producing reactors.[19]

Not having data on the actual operation of the emergency core cooling systems (ECCS), the AEC, in November and December of 1970, conducted a series of small-scale experiments at the National Reactor Testing Station. These were a part of the LOFT tests, previously mentioned. These experiments—some half-dozen—demonstrated complete failure of the designed backup systems. It was found in the nine-inch scale models, when from 30 to 100 per cent of the cooling water escaped, high steam pressure prevented the emergency cooling water from reaching the core.[20]

These revealing tests showed that the nation was exposed to a peril of unknown dimensions. At the time of these tests, there were some 20 operating nuclear reactors, with more than 50 in construction or design stages. (Presently, there are 31 nuclear power plants in operation in the U.S., with 60 under construction, and 30 in the planning stages.)[21]

The Rand Corporation, a research organization identified primarily with national security and strategic research, in a subsequent report (1972) prepared for the California legislature, warned, on the basis of those tests

> . . . the efficacy of all accident control systems on current and planned nuclear reactors is in doubt.

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[18]Excerpts from UCS Testimony, STOCKHOLM CONFERENCE ECO: ATOMIC REACTOR SAFETY HEARINGS, Vol. II, No. 2 (Aug. 9, 1972), p. 8

[19]Wilson Clark, "Scientists Criticize the AEC," NOT MAN APART, Vol. I, No. 12 (Dec., 1971), p. 6.

[20]Gillette, "Nuclear Reactor Safety: A Skeleton . . . ," OP. CIT., p. 919.

[21]WASHINGTON POST (May 17, 1973), p. H1.

> It is not clear yet what will be required or how long it will take to design and *fully* test an adequate ECCS. In the meantime, although the necessary experiments on ECCS still have not been performed, reactor construction and plans for new construction continue.[22]

The Nixon Administration's reponse to the oil crisis, created jointly by the Arabian embargo and a shortage of domestic refining capacity, can have the effect of accelerating the growth of this mounting peril to lives and property. Over 40 per cent of the funding for Nixon's five-year, $10 billion Project Independence is devoted to R & D for the so-called "fission option," a spending alternative which contributes nothing to the alleviation of the short-term energy problem.[23]

Given the rate of construction of these nuclear power facilities, with an AEC projection of 800 operating nuclear plants by the year 2000, the hazards and dangers promise to grow prodigiously. Consequently, Weinberg was confronted in December 1971, with the fact that there was considerable doubt about the operating safety of conventional reactors. An ECCS failure is an irreversible event. There is no scientific means or technological fix for dealing with an approximately 250-ton molten radioactive mass resulting from a loss of coolant. Thus the problems of safety for the existing nuclear plants compels Weinberg to propose a social engineering solution for the possible technological problem of a core cooling system breakdown. If there is no technological fix for the technological problem of an ECCS failure, there is only the logical alternative of invoking fallible human means, which, Weinberg must assert, must infallibly prevent the disaster from occurring.

A second factor unquestionably prompted Weinberg to opt for social engineering solutions. Nuclear reactor technology, both in design and operation, requires extraordinary standards of performance from both equipment and men. But in the late 1960's, it became increasingly apparent, as more nuclear reactors went into operation, that poor quality control and operational sloppiness were not rare and isolated events with this technology.

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[22]R. D. Doctor, K. P. Anderson, et al., CALIFORNIA'S ELECTRICITY QUANDARY, Vol. III: SLOWING THE GROWTH RATE, R-1116-NSF/CSA (Santa Monica, Calif.: The Rand Corporation, 1972), p. 24.

[23]Robert Gillette, "Energy R & D: Under Pressure, A National Policy Takes Form," SCIENCE, Vol. 182, No. 4115 (Nov. 13, 1973), pp. 898–99; David J. Rose, "Energy Policy in the U.S.," SCIENTIFIC AMERICAN, Vol. 230, No. 1 (Jan., 1974), pp. 20–21.

The evidence for this became so overwhelming that the Rand Corporation researchers warned the Claifornia State Assembly that this factor, in conjunction with increases in the operating power of projected reactors—currently the largest is 800 MW, but manufacturers are selling 1200 MW systems—along with the ECCS problem, was reason to question the wisdom of permitting the construction of additional facilities. The Rand researchers said:

> Combine these difficulties with increased reports of poor quality control and documented carelessness in manufacture, operation, and maintenance of these complex nuclear systems and with potential catastrophic consequences in case of accident, and one can question whether California should proceed with its nuclear future as currently planned.[24]

Yet another aspect of nuclear energy development doubtless prompted Weinberg to advocate social engineering. On June 4, 1971, President Nixon sent to the Congress an energy message which gave primary emphasis to the developmental program of the Liquid Metal Fast Breeder Reactor (LMFBR) as the solution for the nation's projected long-term energy needs, and involving minimal environmental contamination and degradation. The President's message and the commitment to the so-called fast breeder reactor was not a new policy initiative. The internal critics of the AEC insisted that between 1968 and 1971, the AEC's Division of Reactor Development and Technology, under the direction of Milton Shaw, had "bootlegged money from water reactor safety to accelerate the breeder. . . ."[25] Nixon's new policy was merely an incremental augmentation of an existing program for the AEC.[26]

The breeder program immediately came under attack from environmental and other concerned groups. These considerations appear dominant in the estimate of knowledgeable critics: A LMFBR would be potentially much more dangerous than a light water, non-breeder reactor. The "power density" of a proposed demonstration reactor

[24]Doctor, Anderson et al, OP. CIT., p. 25.

[25]Gillette, "Nuclear Safety (I) . . . ," OP. CIT., p. 773.

[26]In 1968, the AEC made a study entitled COST-BENEFIT ANALYSIS OF THE U.S. BREEDER PROGRAM, subsequently published as WASH 1126. This was updated and republished in January 1972, as COST-BENEFIT ANALYSIS OF THE U.S. BREEDER REACTOR PROGRAM.

(one-third commercial size) would be twelve times that of light water reactors now producing electricity. The heat generated by the reacting plutonium is to be removed by liquid sodium flowing, at a rate of five cubic meters per second in two cubic meters of space. The liquid sodium, reactive with both air and water, will be a 1000 degrees Fahrenheit and highly radioactive. Further, the core of a breeder reactor would contain about one ton of plutonium, as compared with a few kilograms of this material in conventional reactors.[27]

If the technological problems of the emergency core cooling system have not been solved, if there were repeated human and technological errors in the design and operation of conventional light water reactors, it would seem extraordinarily foolhardy to embark upon the development of a breeder reactor which could involve a hazard several orders of magnitude greater.

Further, the development and operation of the LMFBR would aggravate an unsolved problem with the current reactors, namely, the storage of radioactive reactor wastes, which are dangerous for thousands of years. The AEC, in cooperation with a committee of the National Science Foundation, determined that salt beds would constitute a perfect site for the permanent and indefinite storage of these dangerous pollutants. Salt beds were considered ideal, for the presence of a stratum of salt indicates that it has not been in contact with water since the time the salt deposit occurred; and salt heated by the radioactive wastes would become molten and plastic which, when cooled, would form a plastic seal. An abandoned salt mine near Lyons, Kansas, appeared to have all the desired properties, and in 1970, the AEC announced that it would undertake large scale storage there.[28]

The situation confronting the AEC and Weinberg has been aptly characterized by the Rand Report to the California State Assembly:

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[27]David Brower, "FOE [Friends of the Earth] Testimony," THE STOCKHOLM CONFERENCE ECO: Atomic Reactor Safety Hearings, Vol. II, No. 11 (Sept. 8, 1972), p. 3. Plutonium is created by the neutron flux in a light water reactor. While none is present as fresh fuel, spent fuel contains 8.6 kilograms of plutonium per metric ton of fuel. George C. Berg, "Hot Wastes from Nuclear Power," ENVIRONMENT, Vol. 15, No. 4 (May, 1973), "Table 1. Composition of 1 metric ton of fuel in a Standard Light-Water Cooled Reactor," p. 37.

[28]Weinberg, "Social Institutions . . . ," OP. CIT., p. 32.

> These wastes are highly radioactive and will remain extremely dangerous for tens of thousands of years. Because they are radioactive they generate heat and, in most present schemes for long-term storage, they must be cooled. With present and foreseeable technology they cannot be neutralized. The AEC has proposed burying the wastes in deep, dry salt formations and abandoning them there. Initial experiments for such a system were to take place in salt formations near Lyons, Kansas. But the plans went awry when . . . it was learned that the dry salt formation might not be so dry as had been assumed since numerous oil wells and dry exploratory holes had been drilled through them. The AEC has abandoned the Lyons site but not the salt storage scheme. As the matter presently stands, the problem of perpetual storage of high-level radioactive wastes is unresolved . . . .[29]

Given the specific characteristics of radioactive wastes, their extreme heat, which makes large-scale, permanent containment without artificial cooling difficult if not impossible, and the long radioactive life, abandonment, without continuing human surveillance, is not a solution. The experience with the location in Kansas pointed up that wastes could not be "abandoned" in salt strata with requisite safety. If the salt bed solution was practical from every other standpoint, the waste storage location would have to be guarded for milleniums from accidental or intentional release that might put noxious materials into the atmosphere or ground water.

The nuclear energy industry, the apex of high energy technology, both in operation and development was beset between 1966 and 1971 by a series of problems which were not susceptible to crisp technological solutions. Let us examine, then, in greater detail the social engineering solution, the "Faustian Bargain" between nuclear engineers and society, announced by Weinberg as the price exacted for the inexhaustible source of energy. He says:

> The price that we demand of society for this magical energy is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to.[30]

He illustrates vigilance and longevity in social institutions by reference to nuclear weaponry and the "military priesthood," which guards against inadvertent nuclear war. He observes that the atom

[29]Doctor, Anderson et al, OP. CIT., p. 25.

[30]Weinberg, "Social Institutions . . . ," OP. CIT., p. 33.

bomb placed "an additional demand on our social institutions."[31]

According to Weinberg, these new demands are connoted by the words "vigilance" and "longevity." "Longevity" does not provide any difficulties in meaning. In the context given by Weinberg, it has the accustomed meaning of greater duration, longer life or continuance than is usually to be found in social institutions. The guardians—or to use Weinberg's term, the "priesthood"—must be members of a social institution of unusually long duration, in this case, possibly tens of thousands of years.

"Vigilance" is a little more difficult. It has at least three distinctive meanings: the quality or state of being vigilant; watchfulness in regard to danger and hazard; and alertness or readiness to respond to stimuli. To be vigilant means to be alert or watchfully awake, especially to the discovery and avoidance of danger.

Weinberg provides us with some help. He advocates that "we exercise in nuclear technology the very best techniques and that we use people of high expertise and purpose."[32] Thus, Weinberg finds two components of vigilance, namely, high expertise and high purpose.

High expertise is a cognitive ability—technical knowledge of the physical processes involved in the operation of nuclear tehnology. High purpose refers to morality—the adoption of morally correct behavior as opposed to wrong behavior in individual action. This I identify as an emotive aspect of behavior. That is, whatever the costs with respect to his psycho-physiological states (muscular, respiratory, cardiovascular, hormonal or cerebral), the "nuclear priest" would engage in the morally correct behavior in every instance. There are, then, two major components of vigilance as developed by Weinberg, which are necessary for guarding against nuclear catastrophe: (1) "high expertise" to guard against technological error; and (2) "high purpose" to guard against events which are usually characterized as human failure.

High expertise must be implemented by individual choice and action. But Weinberg recognizes that such relatively rare qualities in individual behavior cannot be obtained except in highly specific situations. This is expressed in his requirement that there must be an unusual longevity in human institutions. Unusual behavior, however,

[31]IBID., p. 34.
[32]IBID.

cannot be obtained unless there are institutional arrangements which reward and support such behavior and consistently support it over a very long term.

This requirement means that the human institutions must be unusual —ahistorical in that they are stable, rewarding high expertise and high purpose and punishing alternative behaviors, over tens of thousands of years; and this is a condition without precedent in the history of man.

Weinberg summarizes the technical skill, personal morality, and institutional stability required of nuclear energy by reference to the depth of change in social behavior and institutions brought about by the shift from hunting and gathering of natural products to agriculture as the major source for society.

> Before agriculture, social institutions hardly required the long lived stability that we now take so much for granted. And the commitment imposed by agriculture in a sense was forever; the land had to be tilled and irrigated every year in perpetuity; the expertise required to accomplish this task could not be allowed to perish or man would perish; his numbers could not be sustained by hunting and fishing. In the same sense, though on a much more highly sophisticated plane, the knowledge and care that goes into the proper building and operation of nuclear power plants and their subsystems is something that we are committed to forever, so long as we find no other practical energy source of infinite perpetuity.[33]

Weinberg asserts that some elements of the Faustian bargain, supposedly imposed by nuclear power, were present in early societies based on irrigated agriculture, with both technologies requiring the nurture of the technically necessary expertise and the maintenance of stable institutions for the preservation and exercise of the technical skill. Weinberg is wrong. The Faustian bargain he discusses was made when culture change, rather than genetic change, became the dominant factor in man's and his phylogenetic prececessors' adaptation to environments. Many milleniums of the history of this genetic commitment to cultural adaptation passed before man first shifted from hunting and gathering to agriculture as the energy source at approximately 9000 B.C.[34]

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[33]IBID.

[34]Graham Clark and Stuart Piggott, PREHISTORIC SOCIETIES (New York: Alfred

Weinberg implies that the peoples of the early agricultural societies made an institutional commitment to maintain, "in perpetuity," the technology of irrigated agricultural systems and the human expertise to operate them. The evidence supplied by Weinberg is that the species survives; man did not perish. But Weinberg's implication is wrong. It assumes that at some point in time all or most human societies secured their energy from the technology of irrigated agriculture, rather than from the alternatives, hunting and gathering and pastoral nomadism. On the contrary, sufficient numbers of men were always engaged in the latter economic activities to give man a reasonable prospect for species perpetuation in the event irrigation failed.[35]

Morever, the implication that irrigation technologies were maintained and operated "in perpetuity," which in the context suggests a time span of milleniums, is wrong—unless Weinberg is willing to settle for 400 to 500 years as "perpetuity." The fate of four civilizations in Ancient Mesopotamia, all based on irrigated agriculture, shows that the terms of Faustian bargains are, indeed, hard to keep. A closer examination of this transaction with the natural world, in which man is a very junior partner, must be closely examined. Man does not dictate any of the terms of the Faustian bargain.

High Energy Technology and the Moral Problem

It is my belief that these moral, intellectual, and institutional terms of the Faustian bargain are not unique to nuclear technology. Rather, they apply with equal force to all technologies that utilize a high proportion of energy from other sources in relation to that expended by humans, regardless of whether these sources are other animals or

A. Knopf, 1967), pp. 44–54, 156–71.

[35]The pastoral nomads of the Eurasian landmass supplemented their major economic activity with periodic predation upon the sedentary agricultural societies of the East and West. Their parasitic energy extraction from the environment by despoiling other societies was ended with the adoption of artillery by the agricultural and commercial societies. Rene Grousset traces the fascinating history of the interface between the two systems of culture and technology from 2000 B.C. to 1800 A.D. THE EMPIRE OF THE STEPPES: A HISTORY OF CENTRAL ASIA (New Brunswick, N.J.: Rutgers University Press, 1970).

physical systems: the sun, fossil fuel, fission, fusion, geothermal, tidal, or whatever. The central factor is not the specific form of the energy, but rather the magnitude of energy extracted from the environment and employed in the conversion and utilization processes of the technology in the society in relation to the amount of human energy employed.

Therefore, the requirement of high expertise, high purpose, and appropriate institutional arrangements rewarding the associated behavior on a permanent basis—which involves a rare stability in the functioning of institutions—is not a particular consequence of nuclear energy. As will be shown below, this demand has always existed for man. The cultural and social equivalents of high expertise, high moral purpose and appropriate, stable institutions, existed in hunting and food gathering societies with a technology for energy extraction from the environment based exclusively on human labor power. If there was a technological failure or human ineptness in the application of the technology, or if the society did not meet the culture and social equivalents mentioned above, as a consequence of the attractiveness of leisure, freedom from tension, or other innocent pursuits; the feedback was quick; the group went hungry. In the absence of corrective measures, the society would starve, with its eventual disruption.[36] The demands mentioned by Weinberg, which can be summed up by the words "hard work," will be found in any culture which depends upon a high proportion of inanimate energy in proportion to human energy, with the demand being most intense in the high energy societies developing in the industrial nations after World War II.

Of course there is always the possibility that a society may opt to absorb the degrading human, social, and cultural costs, one of the

[36]The Ik of Uganda, who are confined by the state to an impoverished habitat, are so limited in their ability to extract energy from the environment by the dominant technology of sheer scavenging, that adults do not provide sustenance or socialization for children beyond the age of three. According to Turnbull, there is a complete absence of morality in interpersonal relationships between husbands and wives, children and parents, and siblings. Colin M. Turnbull, THE MOUNTAIN PEOPLE (New York: Simon & Shuster, 1972). The poverty of the culture of the Ik illustrates that culture is dependent upon energy extraction and utilization by the social group. Turnbull observes that the group survives intergenerationally without morality and love, the basic culture for humans. But survival for one generation under these conditions is not proof that it can do so for many generations—and remain human.

most important being a high risk, unpredictable social and physical environment, with the increasing likelihood that the civilization will collapse through destruction of the environment and/or technological failure.[37] To the extent that this option is selected by humanity, the survival of the species or man, as he is known today, with his present genetic composition and cultural potentiality, will come into question.[38]

The behavioral and sociocultural requirements of technology stem from its role in relation to man's specialization as a biological species. Culture is a man's primary mode of biological adaptation to his environment for extracting energy necessary for species survival, a proposition which has wide affirmation.[39] Sahlins tersely states the

[37]Assuming that 800 nuclear power plants are operating by the year 2000, as predicted by the AEC, and there is no technological solution to the problem of a reactor core meltdown, this is a definite possibility. The unpredictable nuclear accident, with frightful destruction of human life and property, at least from the standpoint of contemporary values and culture traits, would become a normal fact of life, with a feedback creating unpredictability in the social order. In that physical and social environment, high risk, maximal short-term gain alternatives would appear to be the most rational and indulgent choices, with "Live, for tomorrow you may die," becoming the categorical imperative. To an unknown extent, this imperative may be influencing behavior in contemporary developed societies living in the shadow of a nuclear holocaust caused by war or accident.

[38]"Since the environment in which man functions and multiplies is primarily the sociocultural environment that he creates, the genetic evolutionary changes most likely to emerge out of a certain form of culture are the ones that increase man's fitness for this very culture. Moreover, the genetic changes that increase the fitness of their carriers for a particular culture also increase dependence on that culture; they stimulate thereby further cultural developments and these in turn instigate further genetic changes." Rene Dubos, SO HUMAN AN ANIMAL (New York: Charles Scribner's Sons, 1968), p. 57 Cf.: "Indeed, any major social or political change is bound to be reflected in an alteration of the gene pool of the population subjected to such change. This is a consequence of the fact that the magnitude as well as the direction of natural selective pressures depends on the environment, and the environment that exerts a decisive influence on the human species is the social environment." Theodosius Dobzhansky, MANKIND EVOLVING: THE EVOLUTION OF THE HUMAN SPECIES (New Haven, Conn.: Yale University Press, 1962), p. 322.

[39]Contributions to the concept of culture as a biological phenomenon significant for the evolutionary development of the present characteristics of man and society have been made by authorities from a number of fields: Dobzhansky, OP. CIT., Bernard Campbell, HUMAN EVOLUTION: AN INTRODUCTION TO MAN'S ADAPTATIONS (New York: Aldine/Atherton, 1971); Julian H. Steward, THEORY OF CULTURE CHANGE: THE METHODOLOGY OF MULTILINEAR EVOLUTION (Urbana, Ill.: University of Illinois Press, 1963); Marshall D. Sahlins, "Evolution: Spe-

relationships between culture and technology in man's adaptations:

> Culture provides the technology for appropriating nature's energy and putting it to service, as well as the social and ideological means of implementing the process. Economically, politically, and in other ways, a culture also adjusts to the other cultures of its milieu, to the superorganic part of its' environment. . . .[40]

Technology has two functions in man's adaptation: (1) the extraction of energy—food, fossil fuel, wind, falling water, gravity, nuclear fission, draft and grazing animals, and (2) the conversion and utilization of the appropriated energy in the production of goods and services overcoming the limitation upon man's capacity to make a purely biological adaptation. In some instances, the processes of extraction and utilization of the energy are combined in the same technical means. The sailing ship exemplifies this. However, more typically the two processes of extraction and utilization are distinct temporally and technically, e.g., the hunter tracking down his quarry and then consuming it—raw or cooked, the stripping of an Appalachian mountainside of the overburden to extract the coal beneath and the utilization of its energy in the operation of a home appliance or a neon sign. There is enormous variability between cultures both past and present in the amounts of energy they can extract from the environment and consequently have for utilization, ranging from those with the least, i.e., the hunting and food-gathering societies of Africa and Australia, to that with the most, the United States.

A major consequence of this disparity in energy available to this wide range of societies is a wide divergence in their culture and

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cific and General," Robert A. Manners and David Kaplan (eds.), THEORY IN ANTHROPOLOGY: A SOURCEBOOK (Chicago: Aldine Publishing Co., 1968), reprinted from Marshall D. Sahlins and Elman Service (eds.), EVOLUTION AND CULTURE (Ann Arbor, Mich.: University of Michigan Press, 1960). Culture is not an exclusively human mode of adaptation to an environment: "A great deal of the behavior of primates can be called cultural in the sense that it is transmitted by learning from generation to generation. This is true not only of social behavior but of behavior toward the environment . . ." Alison Jolly, THE EVOLUTION OF PRIMATE BEHAVIOR (New York: The Macmillan Co., 1972), p. 350. Extra-genetic transmission of behavior has been observed in species other than those in the order of primates. This significantly illustrates the commonality of man with other species in adapting to environments, physical, social, and *cultural.*

[40]Sahlins, OP. CIT., p. 233.

social systems. It is generally recognized that culture and social organization is an energy-dependent phenomenon, that is, related to amount of energy available on a per capita basis to the populations of the different kinds of socio-cultural systems.

Further, it is widely recognized that cultures and their societies can be classified into "stages:" hunting and gathering, agricultural, commercial, industrial, and the putative post-industrial, with each being related to the technological dominance of some specific means, e.g., human labor or steam, of capturing the energy of the environment and making it available for utilization. The passage of a people or a civilization through some or all of the "stages" in the sequence given is characterized as "progress," for the reason that at each successive stage, the amount of energy available to the culture through technology for the production of goods, services and leisure on a per capita basis increases. Also, the social organization at each of these stages of increasing energy capture and utilization takes on some typical characteristics which for our purposes can be summed up by two concepts: higher levels of "integration," and increasing complexity in patterns of "specialization." Alternatively, the different states of social organization can be designated by reference to structural and functional complexity. It is manifest that however conceptually compared, Bushmen societies have much less structural and functional complexity than American society. The latter has states, research laboratories, industrial pollution, hospitals, churches, freeways, commercial entertainment, and so on; all involving institutions and social processes which are not found among the Bushmen. The level of integration and pattern of specialization in a given stage is the societal and organizational basis for the energy capture and utilization. Sahlins has given precise statement to this process of general evolution in societies and has pointed out the parallels, particularly in relation to energy capture and utilization and structural and functional complexity, to biological evolution.[41]

For our present purposes and for a comprehensive understanding of the contemporary predicament of mankind, it is essential to realize that from the environmental and biological standpoint, each of these stages is a specific kind of adaptation through culture and technology to environments. But more important for our purposes is the *maladaptive potential* of any culture-technology system.

[41]Sahlins, OP. CIT.

Greater specificity will be given below to this concept, but here it is sufficient to note that at each stage of energy capture, conversion, and utilization, there are potential maladaptive factors in the society or civilization's total relationship to its environment which can become detrimental or antagonistic to the continuation of that culture, social organization, and technology—and correspondingly, the perpetuation and survival of the species.

The illusion that a society is liberated from constraints and limitations imposed by environments upon individual, social, economic and political choice (including the exercise of technological options) constitutes a culture trait with the highest maladaptive potential. This cultural trait, which has both theological and scientific expression achieves its greatest force in the post-World War II industrial societies by the fact that these societies have political, economic, and limited technological (physical) control over historically unprecedented aggregates of inanimate energy per capita.[42]

The theological aspect of that cultural trait is to be found in Christianity's tenet that it is "God's will that man exploit nature for his proper ends."[43] Presumably, God intended only results beneficial to man, for only a malevolent diety—and not a God of love—would impose a Providential imperative to exploit the environment, permitting the possibility that man's acting upon it might destroy His creatures' society.

The scientific aspect of this cultural trait can be discerned from Ogburn's theory of cultural lag, Weinberg's optimism about the efficacy of technological fixes, and the historic lack of scientific interest in the ecological and environmental consequences of man's adaptations. Steward advances the proposition: "Relevant environmental features depend upon the culture."[44] For the subcultures of science, the maladaptive consequences, the neglected so-called secondary consequences of man's intervention and exploitation of the

[42]The time frame of reference for this observation is now, say fifty years with 1974 as the midpoint. In general, the focus of attention upon economic growth, environmental degradation, and the possibility of biosphere collapse is bringing the perdurability and persistence of this trait into question. In short, a healthy cultural change is possible, which may have appropriate effects upon political and social organization, institutions and behavior, reducing the maladaptive potential.

[43]Lynn White, "The Historical Roots of Our Ecological Crisis," SCIENCE, Vol. 155, No. 3767 (March 10, 1967), p. 1205.

[44]Steward, OP. CIT., p. 40.

environment had little relevance for the scientific enterprise until a recent date, except for isolated individuals such as Aldo Leopold.[45]

Fortunately, and this is a "signal" of the changes potential in the subculture of science, researchers dealing with highly specialized areas of science are beginning to evince a sharp sensitivity to the implications of the knowledge in their fields for the possibility of environmental degradation and collapse: For example, Whittaker and Feeny, two specialists in allelochemical phenomena (the study of interactions between species and their environments by chemical agents), state in a recent article on their research findings that high energy societies; with their release of herbicides, pesticides, industrial wastes, combustion products and radioactive particles to the environment; are engaged "in a great enterprise of antibiosis." They explain:

> The needs of civilization for power imply accelerating release of combustion pollutants for the foreseeable future and of radioisotopes from increasing number of nuclear power plants as well.
>
> civilized man is consequently faced with a phenomenon new in history—progressive toxication of the biosphere. We are cast, like some pathogens and successional species, in the role of an unstable dominant population that effect its own demise by autotoxicity and degradation of the environment.... The signals, environmental and cultural, of approaching limits on the growth of technological civilization are many, and the intensities of these signals are now sharply increasing. The present combination of large and increasing populations with expanding technologies represents an unstable and ultimately self-destructive course.... A strategy for survival is needed to replace man's present role as an unrestricted superdominant of the biosphere, for this role is a strategy for self-defeat.[46]

It is arresting that Sahlins, an anthropologist, in an article concerned with evolution as a biological and a cultural process, and with no reference to environmental problems, should find that a self-

[45]For an attempt to develop a descriptive classificatory scheme for the analysis and possible measurement of the unintended consequences, so-called environmental impact, of technology, see Eugene S. Schwartz, OVERSKILL: THE DECLINE OF TECHNOLOGY IN MODERN CIVILIZATION (Chicago: Quadrangle Books, 1971).

[46] R. H. Whittaker and P. P. Feeny, "Allelochemics: Chemical Interactions Between Species," SCIENCE, Vol. 171, No. 3973 (Feb. 26, 1971), p. 766.

regarding attitude as an "unrestricted superdominant" is a cultural trait of major significance in high energy societies. Sahlins describes the trait in these terms:

> General progress can . . . be viewed as improvement in 'all-round adaptability.' Higher cultural forms tend to dominate and replace lower, and the range of dominance is proportionate to the degree of progress. So modern national culture tends to spread around the globe. . . . The dominance power of higher cultural forms is a consequence of their ability to exploit greater ranges of energy resources more effectively than lower forms. Higher forms are again relatively 'free from environmental control,' i.e., they adapt to greater environmental variety than lower forms . . . By way of aside, the human participants in this process typically articulate the increasing all-round adaptability of higher civilizations as increase in their *own* powers: the more energy and habitats culture masters, the more man becomes convinced of his own control of destiny and the more he seems to proclaim his anthropocentric view of the whole cultural process.[47]

Although Sahlins does not include the biological process in this statement, his evolutionary perspective embracing both biological and cultural phenomena makes it applicable. The fact is that our socio-cultural system, virtually up to the present moment, has envisaged only one possibility: that any technological change involving the increased use of inanimate energy will have only adaptive consequences—that is, to strengthen the civilization and the control of his destiny and, correspondingly, to ensure the felicity of man's fate on this earth. But this is to ignore the fact that from the time that the phylogenetic ancestors of man became biologically committed in structural and functional properties to culture as a mode of adaptation, there was no guarantee provided the species that this evolutionary experiment would work. On the contrary, the fossil record of evolution shows that most of these experiments have failed, through inadequacy of the gene distribution in the species and/or too rapid a change in the habitat.

Culture as a mode of adaptation does not free man from bondage to the uncertainty of his biological survival. Dobzhansky states: "For at least 10,000 and perhaps for 1,000,000 years, man has been adapting his environments to his genes more often than his genes to his

[47]Sahlins, OP. CIT., p. 238. (Sahlins' emphasis)

environments."[48] This means that for man, his cultural heritage is more important for the species' relationship to its environment than its genetic endowment. But man's capacity to change his technology does not provide him an escape into freedom from the limitations upon all living systems. All living systems are committed to changing and modifying their environments by the necessity of extracting energy from them. A greater dependence upon cultural adaptation, as opposed to genetic, does not alter this fundamental relationship between living systems and their habitats.

The simplest organisms, the viruses, which are "at the threshold of life," except in the scientific laboratory, are capable of growth and reproduction only in the cells of living organisms. The energy and, so to speak, building materials required by the viruses for growth and reproduction are extracted from the host cell, the environment of the virus.[49] A virus, by this process of extracting energy and building materials, modifies and transforms the host cell. The virus grows and multiplies by adapting its environment to itself and incorporating a part of the environment into its structure and functional processes. Thus, the biological circumstance is the same for all organisms, from the proto-living viruses to that complex form of life with self-awareness and mental images of the future: man. The similarity in the biological circumstance is that each of these disparate types of organism, in its adaptation, must extract the energy and materials from its environment for individual and species survival, and in that process, the environment is inexorably modified. The relationship is the same, whether the adaptation is solely genetic, as in viruses, or partly cultural, as in man's case. In both, there is a *maladaptive potential.* The adaptation that the virus *Herpes simplex* has made to its host cells in man provides a demonstration.

H. simplex, it has been said, has made a perfect adaptation to its environment in that it rarely, if ever, is lethal to its host organism, thus assuring itself of the necessary environment, the living cells and supporting tissue for growth and multiplication. This pathogen never so modifies its environment, man, by reproduction and growth sufficiently to motivate him to find chemical or other agents that will rid his cells of *H. simplex.* This virus in man's skin tissue, the favored

[48]Dobzhansky, OP. CIT., p. 319.

[49]Heinz Fraenkal-Conrat, DESIGN AND FUNCTION AT THE THRESHOLD OF LIFE: THE VIRUSES (New York: Academic Press, 1962), pp. 100–101, 109–110.

environment being the lip area, is the source of aggravating cold sores and fever blisters. For the most part, this species has a benign and tranquil existence in this environment, with only an occasional outbreak of growth and multiplication, manifest in skin eruptions. These outbreaks are caused by a slight change in the virus' human environment, such as colds, emotional tension, excessive exposure to sunlight, or food and drug ingestion. But this benign existence for *H. simplex* depends upon relative stability of its gene pool. Any modification so transforming its growth and multiplicative possibilities that it would irreversibly modify its environment—becoming lethal to man or so aggravating as to move the host to find a counter agent that would disorganize *H. simplex's* genetic and chemical structure, would make the survival of this species problematical. To the extent that there is a probability of this happening in the genetics of *H. simplex,* say, through a mutation induced by nuclear radiation, there exists a maladaptive potential for this species.

Biologically, maladaptive potential is the inverse of the adaptive value of the gene pool:

> The adaptive value of a gene is not constant, it depends on environmental factors and on the other genes present in the same population; its genotypic milieu. Therefore, changes in environmental conditions will generally induce changes in the adaptive value of some of the genes present in the population.[50]

Dobzhansky states that adaptive value is the equivalent of Darwinian fitness, i.e., reproductive efficiency.[51]

H. sapiens, in its relationship to its "cell," the biosphere, is a pathogen (a disease-causing agent), as suggested by Whittaker and Feeny, with a potential capacity to destroy the habitability of its environment. Its combined genetic and cultural adaptation does not have nearly the adaptive value of *H. simplex* to human cells. Fortunately, for *H. sapiens,* the earth, as far as we know, cannot deliberately adopt therapeutic countermeasures to man's destructive cultural ac-

[50]Ernest W. Caspari, "Introduction to Part I and Remarks on Evolutionary Aspects of Behavior," Jerry Hirsch (ed.), BEHAVIOR-GENETIC ANALYSIS (New York: McGraw-Hill Book Co., 1967), p. 4.

[51]Dobzhansky, OP. CIT., p. 159. Reproductive efficiency for contemporary man is the capacity to produce socialized, acculturated adults with minimal maladaptive potential in their behavioral traits.

tivities. But man, through the extraction of energy and natural resources from the biosphere for incorporation into his own structures and functional processes, can progressively modify the earth to its ultimate destruction as his host cell.

Man's demands for energy and materials, such as iron ore, aluminium, chrome, nickel and so on, stem from needs such as the following: The number of people on the globe, their supporting physical structures, such as appurtenances of personal and social life styles; extraterrestial, surface and subsurface vehicles; roadbeds for vehicles; buildings for all purposes; the machines and tools of defensive and aggressive warfare; and the energy necessary to conduct the economic, social, and political (including war) processes. Man is a prodigious consumer at the expense of his host—or more conventionally, "hostess," Mother Earth. But he will have to supress his appetite, for his command of energy to extract and utilize energy maximizes his maladaptive potential.

While inventing labels for antagonists in the cultural fray of limited as opposed to unlimited growth may be dangerous, leading to conflict exacerbation rather than resolution, I lack the restraint not to observe that the advocates of economic growth and the overriding necessity to secure an "energy source of infinite supply," such as Weinberg, are "viral agents." An infinite supply of energy at the command of man would assuredly lead to the destruction of the host. In short, the earlier *H. sapiens* perceives that there are the same restraints upon his exploitation of earth as *H. simplex* observes in relation to man, the quicker man's destiny in the longer run of biological time will be assured.

Turning to the maladaptive potential in man's adaptations, there are several known episodes for consideration. One is to be found in the controversy as to whether man, with his adaptation as a hunter, or climatic change was responsible for the world-wide extinction of late-Pleistocene megafauna in a brief period of time.[52] Only a brief mention can be made here of the hypothesis that prehistoric man, with weapons of stone, made an adaptation to his environment which

[52]P. S. Martin and H. E. Wright, Jr. (eds.), PLEISTOCENE EXTINCTIONS—THE SEARCH FOR A CAUSE. Vol. 6 of the Proceedings of the VII Congress of the International Association for Quarternary Research (New Haven, Conn.: Yale University Press, 1967). See also, Paul S. Martin, "The Discovery of America," SCIENCE, Vol. 179, No. 4077 (March 9, 1973), pp. 969–74.

led him to hunt the megafauna (mammoths, mastodons, and a number of other species) to their extinction. These animals, it is hypothesized, became the primary source of energy in the form of food for hunting societies. The adaptation was specialized to this energy source and, apparently, functioned upon the premise that this energy supply was inexhaustible.

Consequently, the hunters' use of energy was wasteful; more game animals were killed than could be efficiently consumed by the hunting group. One of the maladaptive factors was the absence of any technology for food preservation. The available energy had to be used immediately, since there was no way to preserve the meat and thus conserve energy for needs at a later date. The meat which was not consumed was energy lost. Moreover, the "harvest" of each of the species was greater than its reproductive capability. If it is the case that climatological change was not the sole cause of the extinctions, the adaptation of the megafauna hunting societies had a great maladaptive potential. The salvation of *H. sapiens* was in the fact that either there were alternative sources of food for energy at their techno-cultural level, or there were some societies which were not committed to this specialization.

There is an interesting parallel in the contemporary (winter of 1973–74) shortage of oil afflicting the industrial nations. These societies also became highly specialized in their adaptation by the use of oil, which will soon be exhausted as the energy and material source for transportation, plastics, heat, pharmaceuticals, agricultural fertilizer, and electricity. The short-term critical shortage, induced by the Arab embargo and oil company policies, exposed the maladaptive potential in this adaptation. Accordingly, the oil shortage of 1973–74 may have been, or prove to be, a blessing in disguise, for it brought the public and decision-makers' attention to the maladaptive potential in their civilizations' extreme dependence upon this adaptation.

Another instance of maladaptive potential is found in the collapse of the agricultural economies based on irrigation in Ancient Mesopotamia, embracing in time the Sumerian temple cities in the third and second milleniums B.C. to the Abbasid Caliphate ending about 1100 A.D. The collapse of these civilizations has been traced to soil salinization in the earlier period, and sedimentation in the later.[53]

[53]Thorkild Jacobsen and Robert M. Adams, "Salt and Silt in Ancient Mesopotamian Agriculture," SCIENCE, Vol. 128, No. 3334 (Nov. 21, 1958), pp. 1251–1258.

The technology for modifying the environment by bringing water to a land, parched, but amply supplied with solar energy for photosynthesis, permitted the growth of flourishing civilizations based on the energy derived from agriculture. But in the water came sodium, which by a complex physio-chemical process made the soil structureless and almost impermeable, and sediment, which was deposited in the canals and irrigated fields disrupting the important topographical relationships permitting a gravity flow of the water. In regard to soil salinity, the problem appears to have been a lack of knowledge of the factors responsible for the creation of the saline condition. There is documentary evidence that there was an awareness in the officialdom that the soil became progressively less productive and ultimately sterile.[54] The critical missing factor in the tragedy of the Sumerian civilization to which contemporary man is heavily indebted, was knowledge of the cause and effect relationships—or in Alvin Weinberg's terms, high expertise. Obviously, there was a high maladaptive potential in the irrigation technology of the Sumerians.

In the case of sedimentation, Jacobsen and Adams have identified, for the Parthians (150 B.C.-226 A.D.), Sassanids (226–637 A.D.), and Abbasids (750–1100 A.D.), a recurring pattern. The irrigation technology remained operable, effective, and free of destructive sedimentation "*so long as there remained a strong central authority committed to its maintenance.*"[55]

The technology of these civilizations, through its undesirable and unintended environmental modifications, destroyed their economic bases. Irrigation as a technology had specific institutional requirements, chiefly, a strong centralized political system committed to the maintenance of that technology. When the institutions of this specific form and commitment fundamentally failed, the technology, so to speak, "self-destroyed." In short, the relevant institutions could not maintain the essential stability and longevity, which Weinberg claims are uniquely required for a nuclear technology.[56] The

[54]IBID, p. 1252.

[55]IBID., pp. 1256–57. (emphasis Jacobsen's and Adams') The authors note that the irrigation system was not destroyed by the Mongol invasion. The Mongols found a desert when they arrived a century later.

[56]External aggression by Romans, Arabians, and Seljuk Turks coincided with the collapse of the technologies through sedimentation. Jacobsen and Adams speculate about this as a factor in the failure of Abbasid authority to maintain the system. A military threat inevitably changes the reward system for the personnel of a central

successful operation of these irrigation technologies, however, also depended upon the functioning of institutions that would suppress the maladaptive potential.

Prehistoric and historic evidence must show many examples of "Faustian bargains" that were not kept, i.e., the human and social means for the reduction and suppression of the maladaptive potential were not maintained with the requisite vigilance by the personnel of the appropriate institutions. There is also the possibility that some "bargains" were not kept because the society involved did not understand the terms of the bargain, lacking knowledge either of the maladaptive potentiality of a given technology or of a means of coping with the problem if it was known. The former was the predicament of the late-Pleistocene hunters, and the latter the problem of Sumerian officialdom.

High energy societies face similar predicaments. Our technologies may be making changes in the environment which will create irreversible changes, making the biosphere uninhabitable. This is somewhat similar to the predicament of the late-Pleistocene hunters in that we may not have an awareness of the maladaptive potential of a technology or technologies-in-combination in their modifications of the natural environment. The most dramatic of the maladaptive potentialities known to us, and for which there is no technological solution upon the horizon, is the possible breakdown of an emergency core cooling system, resulting in a reactor core meltdown.

Another example of maladaptive potentiality is the sulfur compound emissions to the atmosphere, originating in the combustion of fossil fuels. Nuclear core meltdown and sulfur emissions together exhibit maladaptive potential for which adequate knowledge, technology, individual moral purpose and institutional commitment all are now lacking in our society.

Energy is the factor in both culture and technology which can bring about disruptive and destructive change of the biosphere, threatening the elimination of man and even the survival of the genus, *Homo*. Man has an ability to command energy which, as will be shown below, is much greater than his ability to control it. Whittaker and Feeny have suggested that in the ecological community of

political authority and would tend to weaken the commitment to the maintenance of a technological system. To what extent does this situation exist in America today in relation to the problem of the technologically created environmental crisis?

the biosphere, man is cast in the role of an unrestricted superdominant animal by virtue of his expanding technologies and population. In this ecological role, man has continued to extract ever more energy from his environment, including lesser species, one means being the denial of access to energy by the alteration of their habitats. The consequence is that man operates as a pathogen in relation to other species and the inorganic physical systems of the biosphere. Man in the high energy societies, has gloried in this role. As Sahlins notes, we have celebrated our supposed independence and freedom from environmental control. We falsely believed, theologically and scientifically, that our ability to command energy through the technology to do such marvelous things as to transport men and objects through space, to destroy all living things and objects over several square miles in less than a second, to transfer hearts, and most important of all, to free unprecedented numbers of people from arduous physical labor while at the same time providing them with unparalleled physical comfort and leisure time activities; also conferred an ability to control that energy. In this sublime faith, the high energy societies and their institutions have acted on the policy premise that we are gods in relation to our habitat, earth.

Man does command energy to extract energy from the earth's surface for conversion into the innumerable intermediate and end products of producers' and consumers' goods and services. But this command over energy, in automobiles, nuclear reactors, industrial processes, synthetic hormones, is very imperfect and subject to wide errors in prediction as to what will happen with the energy. The limitations of existing scientific knowledge about the environmental impact of man's contrivances for the extraction and use of energy upon the earth's natural climatological and physical-chemical systems, with their relationships to the natural communities; the limitations of technology; and the probability of human error; seem to be the most important factors.[57]

[57]At a theoretical level, because we are dealing with the interrelationship between man's deterministic systems for energy capture, and utilization, political systems and social systems, and homeostatic, self-regulative natural systems, the problem of control is in the field of cybernetics. A British management cyberneticist, Stafford Beer, has given excellent description of the state of knowledge, its uses, and the problems of application. His DECISION AND CONTROL: THE MEANING OF OPERATIONAL RESEARCH AND MANAGEMENT CYBERNETICS (New York: John Wiley & Sons, 1966), affords an insight into the meager possibility of control over the environment.

The magnitude of the problem of control is positively related with increasing intensity to the magnitude of the energy in man's systems. This is not intuitively obvious, for we are addicted culturally to the worship of inanimate energy. But the following facts speak with authority that does not need support from general theory; Ten pounds of hydrogen fusion material in a violent explosion make destructive changes in the environment that are many times greater than the destruction resulting from the explosion of an equivalent weight of TNT. The proposed and unlamented supersonic transport threatened much more impact upon the environment than a Boeing 707. Energy differences between the isotopes of hydrogen and trinitrotoluene and between the SST and the Boeing 707 are the source of the differences in the impact upon the environment, creating the increase in maladaptive potential. Further, the energy requirements for extracting the hydrogen isotopes and building the SST were far greater than that necessary for making the Boeing 707 and TNT.

Control over the energy of the late-Pleistocene hunters, who may have exhausted their energy source, was in the cerebral cortex and central nervous systems of those hunters. In short, the control was cultural, and the over-exploitation of the energy resource occurred because of the hunters' cultural limitations. The primitive nature of our control over technology is revealed by Weinberg's assertion that high expertise, high moral purpose, and institutions with stability and unusual longevity are required to prevent nuclear accidents and to protect the environment from radioactive wastes. In effect, he advocates for the control of nuclear energy, culture, the same kind of control which failed the late-Pleistocene hunters. But note, Weinberg recognizes the present culture is unequal to the requirements for control of nuclear, for he admits that the present expertise, the present moral purpose, and the present institutions are inadequate for control of nuclear technology, for he admits that the present expertise, the present moral purpose, and the present institutions are inadequate. Consequently, Weinberg advocates *cultural change* to provide the vitally necessary control over the technology, revealing that both the cultural and technological means for control are inadequate.

The greater man's power to intervene in the functioning of the natural probabilistic systems with energy and its consequences from his deterministic systems, the higher the improbability of his exercising control.

cally, high energy technology, by the cultural interpretation it fosters of man's relationship to his environments, undermines the cultural and hence the behavioral and institutional bases for the control of high energy technology. There is a reciprocally reinforcing relationship between the analytically separate maladaptive potentials of culture and technology. The psychology of domination and affluence generated by the high energy technology becomes general in the society and extends to the personnel who, in their occupational roles, are directly responsible for the level of expertise and moral and institutional purpose applied in the control of the technology. The culture traits and the associated behavior are apparent to the knowledgeable and discriminating observer. Examples of this behavior and the associated cultural milieu follow.

For example, automobile seat belts were relatively unknown in American automobiles until the 1960's. What gave rise to their introduction? The total automotive power increased about sixfold between 1940 and 1968: from 2,511,000,000 to 16,854,000,000 horsepower.[58] The average horsepower of 100 in 1946 increased to 240 in 1968.[59] This increase stemmed from two sources: the increase in the number of automotive units, and the increase in the average horsepower of the units. To borrow a term from nuclear technology, the "power density" on the highways underwent a corresponding increase, with the most significant parameter being higher operating speeds.

Human and technological failure, appearing as automobile accidents, resulted in a rising tide of human pain and suffering, death, and economic loss. To reduce social and economic costs, seat belts, a technological fix, were made mandatory for newly manufactured automobiles in the mid-sixties. Now the moral problem associated with higher energy technology emerges. Seatbelts were found to be ineffective for the reason that only a small minority of motorists would take the slight time and effort to fasten them! The fact is that if all occupants of motor vehicles used the protective restraints, the

[58]U.S. Bureau of Census, STATISTICAL ABSTRACT OF THE UNITED STATES: 1970 (91st ed.). Washington, D.C.: Government Printing Office, 1970, Table "No. 773: Total Horsepower of all Prime Movers: 1940–1969," p. 505.

[59]Commoner, OP. CIT., p. 168.

fatality and injury rate would go down appreciably. This failure by the majority of motorists to use the seat belts is characteristic of the moral and behavioral problem associated with a high energy technology.

Disregarding the factor of habit, the individual auto-driver or passenger, in deciding whether or not to use a seat belt, is weighing the "cost" of the present time and physical effort to arrange and fasten a seat belt against the probability of an accident and the negative effects of that event. Now it is obvious from the failure to use these safeguards that most people, most of the time, prefer their present comfort and time, to taking the precautionary action against both the possibility and the probability of future physiological, psychological, and economic costs. Note that this choice is made in a situation in which the consequences of the decision are specific to the decision-maker. If, on the average, decision-makers are willing to take risks with respect to their own physical and economic welfare, the question arises as to how willing are decision-makers, on the average, to take risks when negative results or consequences are generally distributed in the population.

A further example of the so-called "human factor," which Weinberg would have us circumvent by unusual human behavior in unprecedented institutions so that we can preserve the opportunity to use nuclear energy is seen in the subsequent events relating to seat belts. Since July 1, 1972, the Department of Transportation has required an accoustical warning device to be installed so that when the ignition is turned on, the annoyance of a buzzer will impel the fastening of seat belts. But this buzzer device is easily circumvented. Either a knot can be tied in the belts or the belt drawn taut across the seat surface to secure the tension, preventing the buzzer from sounding. Such are the costs of time and effort in fastening seat belts that most people, most of the time, will go to considerable effort once to make them inoperable.

The third step in technological fixes, to compel people to undertake action in their own welfare, is "starter interlock" belts which were required on all autos manufactured after July 1, 1973. The starter interlock system prevents the ignition from being turned on until the seat belt is fastened. But this device is not "fool" proof. It can be tinkered with and made inoperative. Therefore a fourth generation of fixes is in the works. In 1976 or sometime after, cushions,

inflated automatically upon the automobile's impact, will become mandatory.[60]

Thus, technology and the fix will have triumphed. Motorists will be freed from the thralldom of fastening seat belts. But this victory of technology is somewhat problematical and in the tradition of Rube Goldberg. The bag must inflate in an interval of time substantially less than that which is taken by the movement of passengers from a seated position to contact with the auto's interior in the event of a collision.

Inflating a bag in tenths of seconds or less is similar to the problem of emergency core cooling, to try to cool a mass rising 1400 degrees centigrade in less than a minute. In each instance, high energies must be brought under control in an eye wink, figuratively speaking. We should not be astonished if there is a convergence or growing similarity in high energy technologies; they are homogeneous in their most central element: energy magnitudes.

There is a message in the four generations of active and passive restraints in autos. The development took this trajectory because people do not observe their most elemental obligation to society—to protect themselves from injury. They do not observe that obligation, of which they are the primary beneficiaries, because the risk of their injury or death is discounted by the cost of present time and present effort. What are the implications of this mass behavior in relation to protective restraints for other situations in which the individual should discount the present cost of time and effort against risk of injury to other parties? In the final analysis, the reduction of the probability of injury or death is behind Weinberg's requirement of high expertise and purpose in nuclear energy.

Another enlightening example of the moral demands made by the artifacts of a high energy technology relates to the huge military jet transport, the C5A, built by Lockheed. This aircraft has been so beset by mishaps and incidents that it can only be operated at a fraction of its capacity. For example, the maximum permissible load was dropped from 265,000 pounds to 190,000 pounds. Its rated operational life has been reduced from an anticipated 30,000 hours to 7,000 hours; and it is operationally limited to prepared runways. The C5A was designed to operate on unprepared runways. These reduc-

[60]Mary Russell, "Senators, Aides Test Air Bags," WASHINGTON POST (May 6, 1973), p. 4.

tions in its operational capacity result from the fact that it has been troubled with wing cracks, defects in pylons holding engines to the wings, and repeated landing gear failures.[61]

The sources of these structural defects appear to have been identified in documents released by Congressman Clarence D. Long (D.-Md.). Many of the structural parts for the C5A were precisely cut on milling machines in the production machine shop of Lockheed. In the event a mistake was made in the production of a part, the unusable item had to go to the plant's quality control section, and a " 'discrepancy report' " had to be filed by the worker. Thereupon, new material would be issued. However, the procedure was time-demanding, and discrepancy reports reflected negatively on both the workers and the Lockheed management. The practice, then, was established of removing the identifying marks for damaged and unusable material and substituting for it " 'bootlegged' " scrap metal or requisitioning other materials. There was no way of knowing whether the substituted materials had been heat-treated or otherwise met the strength requirements for that particular part.[62]

The significance of this C5A episode is this. The C5A is the largest operating aircraft. Its weight requires unusual strength in structural materials. To facilitate observance of such structural specifications, each piece of structural material in the C5A had an identifying number on it. The demands of technological and moral responsibility were the same upon Lockheed management and the individual workers, namely, that discrepancy reports be filed so that material of requisite strength would be available for the manufacture of the part in the C5A. But the reports were not filed, because omission of the reports was more rewarding than the filing of the reports.

Weinberg's advocacy of social engineering solutions involves stable institutions, rewarding the required individual behavior of highest expertise and moral purpose. It seems evident that the Lockheed-Georgia Company, as an administrative organization, rewarded precisely the opposite behavior. Mr. Henry M. Durham, a former employee of the firm, brought a series of charges against the company, testifying before the Subcommittee on Priorities and Economy in Government of the Joint Economic Committee. His

[61]Anthony Ripley, "Lockheed Faces New Inquiry on C5A; Use of Untested Materials is Alleged," THE NEW YORK TIMES (March 7, 1973), p. 69.

[62]IBID.

testimony included information about the substitution of materials and the failure to file discrepancy reports. Durham asserted that both workers and the management had a common interest in suppressing the filing of discrepancy reports, as excessive numbers were a reflection on both the worker and the plant management. Mr. Durham's charges were backed by a study of the General Accounting Office. A review of the GAO's study by the interested parties, Lockheed and the Air Force, confirmed 12 of Durham's charges, rejected 4, and remained undecided on 4. Since leaving Lockheed, Mr. Durham has had telephone threats upon his life and at one point, his home was guarded by federal marshalls. At the time of the newspaper article, March, 1973, the Air Force Office of Special Investigation was conducting a new inquiry into the Durham charges.[63]

These elements are involved in the C5A episode. The transport of a large mass of freight over long distances at high speeds requires great quantities of propulsion energy and unusual strength requirements in the vehicle. This additional strength was obtained by using heat-treated structural parts. Additional energy, in the crystalline organization of the metal, had to be in the structural parts of the airframe if the aircraft was to operate as designed. This is an example of the ubiquity of energy in not only the processes but the tools and machines of high energy technology.

To ensure that each structural part had the requisite energy, and consequently the required strength, a clerical procedure was devised to ensure the maintenance of this quality standard. But the workers, with, at a minimum, the tacit approval of management, evaded the quality standard control. The motive of both parties involved the minimization of present time and effort at the expense of the structural strength of the C5A.

This moral lapse, considered as behavioral time alone, was probably a negligible element in the total time required for the design and construction of the aircraft. However insignificant it was, the behavior was crucial for the effectiveness of the C5A as an air transport. The failure to take the time and effort to file discrepancy reports has the result that the C5A has only a fraction of the utility for which it was designed. Vigilance—that is, high expertise and moral purpose—must be a constant, not a variable, in a high energy technology.

[63]IBID.

Since the close of World War II, we have experienced a revolution in the application of energy to the production of things. Barry Commoner and his associates computed the changes in industrial and agricultural production for several hundred items for a twenty-five year period. Their findings, which have been questioned in some particulars, are partially reproduced here to illustrate the increased output over the past twenty-five years:

Synthetic fibers	4,980%
Mercury	3,930%
Air-conditioning compressor units	2,850%
Plastics	1,960%
Electric housewares	1,040%
Synthetic organic chemicals	950%
Chlorine gas	600%
Electric power	530%
Pesticides	390%[64]

In this listing of prodigious increases in the basic materials of an affluent society, there are several items which must be carefully considered: synthetic fibers, plastics, synthetic organic chemicals, and electric power. The increased production of electric power, 530 per cent, is in large part utilized in the production of synthetic fibers, plastics, and synthetic organic chemicals. To simplify—and perhaps, to oversimplify—a complex situation, the process is this: By the application of extraordinary magnitudes of energy, we can break the chemical bond and reconstitute it, establishing the molecular basis for materials which are not produced by natural processes and which are foreign to the natural environment. Let us examine several recent episodes in "better living through chemistry."

The technological ability to synthesize organic chemicals involves the capacity to manufacture chemical compounds that either replicate natural hormones or mimic their behavior in some respects constituting a chemical analogue. Hormones are powerful. They constitute the means of communication between the organism's cells. One of the natural hormones that has its manufactured chemical analogue is estrogen. In mammals, this hormone in several distinct forms is produced in the ovaries; and it controls, along with other

[64]Commoner, OP. CIT., pp. 142–43.

processes, the development of sex organs and secondary sex characteristics in the growing animal.

Two analogues of estrogen—stilbestrol and diethylstibestrol—have recently made national news. Since the 1940's, stilbestrol, until it was banned in 1972 by the federal government, was widely prescribed for pregnant women with a high risk of miscarriage. In 1971, a team of physicians at the Massachusetts General Hospital traced eight cases of adenocarcinoma, a rare vaginal disease, to stilbestrol, which had been administered to the mothers of the victims during pregnancy. Followup studies, completed in 1972, revealed that of 66 adenocarcinoma victims, for whom the medical histories of their mothers were available, 49 had taken stilbestrol, and nine had taken some unidentified drug for bleeding or miscarriage during pregnancy. This is believed to be the first instance in which it is known that the carcinogen passed through the placental barrier to the fetus. The dose level that could lead to cancer in the second generation was as low as 1.5 milligrams. The average dose was 150 milligrams.[65]

Three factors show the power and complexity of the stilbestrol-human organism interaction. The cancer-producing properties of the synthetic hormone are time-delayed and intergenerational. The stilbestrol administered to the mother causes cancer in the daughter some eight to twenty-five years later. Further, the action is synergistic. "The age of the patients suggests that the development of the cancer is stimulated by the ovarian hormones that are produced when menstruation begins."[66] The synthetic hormone apparently becomes actively carcinogenic under specific hormonal conditions. That is, stilbestrol acts synergistically with other chemical compounds, naturally produced by the human body. Further, there appears to be little evidence of a less-than-threshold dose. A little bit goes a long way—in the same fashion as natural hormones.

Diethylstilbestrol (DES), another manufactured analogue of estrogen, has been approved for use in cattle feed by the Federal Drug Administration since 1954. To date, it has been fed to about 75 per cent of the 30 million cattle slaughtered in the United States annually, despite its being "a chemical of bizarre and far-reaching properties, chief of which is that it is a spectacularly dangerous carcinogen."

[65]Robert Reinhold, "Link Between Drug Taken by Pregnant Women and a Rare Cancer in Daughters is Confirmed," THE NEW YORK TIMES (Dec. 21, 1972), p. 9.
[66]IBID.

As a consequence, some 22 countries ban the use of DES.[67] The United States, however, did not exercise such prudence until April 27, 1973.[68]

As early as 1959, the National Cancer Institute advised that "it would seem to be the better part of reason to exclude this known potent carcinogen from our diet. . . ." The responsible federal regulatory agencies, however, did not act. In fact, the responsible governmental agencies are distinguished by their culpability and irresponsibility in extending the risk. Staff writer Nicholas Wade says, in the journal SCIENCE, a publication which has been reproached for being establishment- and status quo-oriented, that

> The history of the attempt to control DES is a record that includes negligence, deception, and suppression by the USDA and prevarication by the FDA.[69]

Involved in this episode is the enforcement of the Delaney Act of 1958, which states unequivocally that no known carcinogens shall be allowed in foods. An amendment to that law, in 1962, permits the use of known carcinogens if no residues are left in the food. Regulation then became a struggle between the development of technology with ever greater sensitivity for the detection of DES residues and the efforts of the government agencies to preserve the utilization of DES. However, with the publication of the discovery of the vaginal cancer cases in 1971, the FDA process of evasion came to a halt. Simultaneously, the Department of Agriculture was compelled to disclose that it had been finding DES residues in beef. Typically, the residues were 2 parts per billion in beef liver, which at that level of concentration amounted to about 0.3 micrograms in a 150 gram serving of liver, "a quantity that represents an appreciable addition to a woman's own supply of natural estrogen."[70]

The response of the FDA was to increase from two to seven days

[67]Nicholas Wade, "DES: A Case Study of Regulatory Abdication," SCIENCE, Vol. 177, No. 4062 (July 28, 1972), p. 335.

[68]Morton Mintz, "U.S. Ends Use of DES as Livestock Stimulant," THE WASHINGTON POST (April 26, 1973), p. 1. Subsequently the FDA's ban on DES was removed by a judicial decision owing to the failure of the agency to hold a hearing. The Senate voted to ban DES on September 9, 1975, by a vote of 61 to 29. Spencer Rich, "Senate Votes to Ban DES," THE WASHINGTON POST (Sept. 10, 1975), p. A6.

[69]Wade, OP. CIT., p. 335.

[70]IBID., p. 336.

the period of withdrawal of DES from cattle feed prior to slaughter, taking advantage of the 1962 amendments to the Delaney Act. But in June, 1972, residues were found in 10 per cent of all samples.[71] As a result of hearings before the House Intergovernmental Relations Subcommittee, the FDA banned DES in feed in August, 1972, but not to take effect until January 1, 1973, so that the existing supplies could be used up. The ban of April 27th related to implants of DES.[72]

From the standpoint of the responsible personnel in the USDA and FDA, Wade's and my characterization of their performance as negligent and deceptive might be unfair. For in fact, they can justify their decisions on the authority of college and university teachers of political science and public administration. A generation of scholars have been teaching an interpretation of the public interest and how the civil servant can best serve it, which appears to justify such behavior. Space here does not permit, nor necessity require, an analysis of the ramifications, nuances of interpretation and logical niceties of those teachings, but they can be reduced to the following proposition: The public interest is the summation by governmental policies and programs of each of the separate economic and social group interests in the society. The duty, therefore, or "high moral purpose," which must be observed by the tenured civil servant in his official capacity is to aid those groups which constitute the clientele of his agency in the satisfaction of their interests.

Under the covering rubrics of "political pluralism," "representative bureaucracy," and "incrementalism," there are a variety of interpretations of this proposition; but for candor and explicitness, none is superior to the statement of Long in a paper dealing with the responsibility of the non-political, tenured civil servant in relation to the conflict of interests—between his own private interest and his responsibility to the public interest:

> The conflict of interests is acceptable. A conflict of interest

[71]IBID., p. 337.

[72]Mintz, OP. CIT. There is a parallel to the sad experience Henry A. Durham had with the Lockheed-Georgia Company. John N. S. White, a meat inspector, noticed that cows fed heavy doses of DES acquired anatomical abnormalities. White prepared an article on his observations, suggesting that DES be placed under strict controls. He was told by the U.S.D.A. not to publish the article. Nonetheless, he offered the article for publication and, as a consequence, was advised that a repetition of that effort would result in a severe reprimand and possibly discharge. White secured publication of his article after quitting the department. Wade, OP. CIT., p. 335.

> is not. It is expected that interests will struggle to control the government. It is even expected that they will struggle quite selfishly. *It is acceptable that they should be represented* in government by officials who in their official capacity will seek *with might and main to further them.* What is not acceptable is that officials should further their own personal interests.
>
> ... There seems no sense of any opprobrious conflict of interest when officials in their official capacity represent sectional or functional interests. *This is true not only for legislators and members of the political executive, where it seems expected, but holds for permanent civil servants as well.*[73]

The "high moral purpose," generated by the complexity of the interests in a high energy society, among other factors, predisposes the permanent civil servant to give the "interests" served by his agency—in this instance, stock growers and feeders as well as the manufacturers and marketers of the synthetic hormones—the "benefit of the doubt" in the absence of logical certainty about the effects of the hormone upon humans. Plainly, the subcultures of the bureaucracy and their academic instructors serve a maladaptive potential in the face of the problems confronting a high energy society.

There is every indication that this episode, involving hormones, the USDA, and FDA, will be repeated. With the elimination of DES, there is an alternative, Synovex, manufactured by Syntex laboratories. This product is several times more costly and difficult to manufacture; hence it was not competitive with DES. However, it is potentially as dangerous. It is a compound of the estrogen, estradiol benzoate, which, according to the FDA, has been demonstrated to be carcinogenic in animals, and progesterone, which metabolizes to estrogen and is, according to the FDA, potentially carcinogenic. There is a regulatory problem of major dimensions in that there is no known method of detecting residues in meat distinguishing the synthetic from naturally occurring estrogens.[74]

The central problem has this form. The defenders of the use of

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[73]Norton E. Long, "Conflict of Interest: A Political Scientist's Point of View," Maurice E. O'Donnell, (ed.), READINGS IN PUBLIC ADMINISTRATION (New York: Houghton-Mifflin Co., 1966), p. 289, reprinted from SOCIAL RESEARCH (Winter, 1964), pp. 423–34. (emphasis supplied)

[74]Daniel Zwerdling, "The Meat Risks," THE WASHINGTON POST (May 13, 1973), pp. C1, C5.

hormones in the production of meat correctly assert that the individual is subject to carcinogenic hazard created by the hormones coming from his own endocrine glands. Consequently, the hazard introduced by artificially produced hormones is only, so to speak, an "add on." This is strictly analogous to the argument that, given naturally occurring background radiation as a source of malignancies, there should be no objection to a slight increase in the rate of the malignancies occurring as a consequence of the operation of nuclear power reactors. The clincher in this argument is that the resulting increase in the illness and morbidity rate for the population is such that the additional risk undergone by the individual is minimal. But the blindness of that argument is exemplified in a recent incident involving synthetic "foam rubber" used as insulation in Skylab.

Skylab, an orbiting space station, is based on the high energy technology of space flight, allowing only "zero defects," that is, no human error or mistakes in technology. Space engineers, at enormous expense, try to avoid failure.

> They test and retest every rivet, diode and engine, they run computer analyses of failure probabilities. Wherever possible, they include backup components for every critical system—built-in redundancy is the term—and devise elaborate contingency plans to handle failures most likely to occur. But things can still go wrong as happened . . . with the Skylab space station.[75]

This description of test and retest, computer analyses of failure probabilities, backup systems, contingency plans, sounds familiar; for it is nothing less than the standard procedures which must be employed in high energy technologies. This statement is as applicable to core cooling and emergency core cooling in nuclear reactors as it is to space vehicles.

Some 63 seconds after liftoff, and 40,000 feet above the ground, Skylab was in deep trouble. At that point, the aluminium shielding on the craft ripped away. This was learned about one hour later when the two large panels, providing solar-generated electricity, failed to deploy. The mechanism for deploying the panels was apparently fouled by the attachment of the shield, with the consequence that Skylab had only half of its rated electricity capability. But that was

[75]John Noble Wilford, "Murphy's Law' Trips Skylab," THE NEW YORK TIMES (May 20, 1973), Sec. 4, p. 3.

only the beginning. The missing shield, which was also designed to be deployed some five inches from Skylab, was to serve as a barrier to high energy cosmic waves and to reflect the intense rays of the sun. Lacking the shielding, the interior of Skylab was heated to an average in all internal areas of 120 degrees Fahrenheit.[76]

Further, not only was the interior of Skylab hot; it was lethal, with three deadly gasses, hydrogen cyanide, toluene diisocyanate, and carbon monoxide, coming from the polyurethane insulation lining the walls. Dr. W. Royce Hawkins, deputy medical director at the Johnson Space Center in Houston, is quoted as saying:

> We think we are seeing concentrations of gasses from 2 to 20 parts per million. . . . The cyanide could be lethal at that level because of the pulmonary damage that would result.

He went on to say that both carbon monoxide, a very familiar asphyxiant, and toluene diisocyanate are both toxic. The latter, in low concentrations, is an irritant to the eyes and lungs and causes bronchial spasms. The hydrogen cyanide and diisocyanate were supposedly "locked up as bubbles" inside the polyurethane foam during manufacture. The carbon monoxide apparently came from a chemical reaction or chemical decomposition in the insulation material under the heat conditions in the space lab. Skylab was purged—by release to the vacuum of space—of the toxic gasses from urethane on May 19, 1973.[77]

But a curious sequel occurred on earth, which had connections with the Watergate conspiracy and burglary. On May 25th, the National Transportation Board announced that it would conduct an inquiry into the charges, by an independent investigator, Sherman H. Skolnick, that the December 8th crash of a United Airlines aircraft in Chicago was caused by sabotage in a Watergate coverup. Mrs. E. Howard Hunt, wife of one of the men convicted in the Watergate affair, died in the crash with $10,000 in her possession. An autopsy report revealed that the pilot and six other persons had cyanide in their bodies. Skolnick had, in his allegations, related that fact to the recent appointment of Dwight Chapin, President Nixon's former appointments secretary, whose name had been mentioned previous-

[76]IBID.

[77]Thomas O'Toole, "Toxic Gases are Purged from Skylab," THE WASHINGTON POST (May 20, 1973), pp. 1, 8.

ly, as an executive of United Airlines. At the time of the announcement of the pending investigation, a "senior official" of the National Transportation Safety Board said "that cyanide was found in the victims not only of plane crashes but also fires in homes, explaining this is because of a chemical reaction in the blood stream resulting from the inhaling of smoke produced in the burning of certain synthetic materials."[78]

Subsequent action by the responsible federal agency was swift. On May 26, the Federal Trade Commission by unanimous vote agreed "to limit the use of popular foam insulators that produce highly poisonous fumes when heated. . . ." The news article announcing this action stated that the plastics had been employed in high-rise buildings, airline interiors and Skylab. It further noted that "The Federal Aviation Administration long has been aware that certain plastics can produce toxic fumes when heated." Reference was also made to the results of tests by NASA on the plastic in Skylab, which showed that it gave off poisonous gasses when heated. No immediate details were available as to the specific plastic involved in the FTC limitations upon the use of the plastics.[79]

This sequence of events leads to provocative speculation. If there had not been a failure in Skylab; if there had not been allegations of sabotage of an aircraft in which the wife of a Watergate conspirator had been killed; if this charge did not promise to bring the element of violence for the first time into the Watergate crisis; would the Federal Trade Commission have acted as expeditiously as it did? According to news reports, the Federal Aviation Administration was aware for some time that plastics used as insulation in aircraft and in buildings give off toxic gasses when subject to heat higher than the normal ambient temperature. But apparently that fact was unknown to NASA, for it conducted tests, according to news reports, so as to determine the reaction of urethane to excessive heat. In short, in the absence of this sequence of rare events, there is every reason to believe that the danger associated with polyurethane and its use as an insulation material would have been regarded as tolerable, giving the manufacturers of urethane the "benefit of the doubt."

[78]Robert Lindsey, "Board to Check Jet Crash Charge," THE NEW YORK TIMES (May 26, 1973), p. 11.

[79]"FTC to Limit Use of Plastic Insulation," THE WASHINGTON POST (May 27, 1973), p. A21.

Foamed polyurethane plastic, which may be either rigid or flexible, is versatile and ubiquitous in high energy domestic households. It is used for furniture, transport, toys, packaging, thermal installations, aircraft, and as sponges.[80] Having many of the advantages of plastics, it is widely used. But completely apart from the fact that it emits toxic gasses when heated, there are additional reasons for using it with caution. The chemical monomer of polyurethane, urethane, is a fascinating substance with properties which are not unusual with products of high energy chemistry; it is carcinogenic. Experiments established that, given by injection or by mouth, it produces tumors in mice.[81] It is used in the treatment of myeloma, a malignant tumor of the bone; and it interferes with cell division by acting on chromosomes of rapidly dividing cells.[82]

In short, urethane is a powerful substance with not-too-clearly established potentiality for causing cancer in man and animals. Therefore, its polymer form should have been used cautiously from the beginning. But it was not. It was accepted as a multiple use substance with qualities superior to the natural fibers, rubber, and wood, that it replaced. But the costs of those advantages have yet to be calculated.

Assuming that the annual rate of malignancies from the use of polyurethane is small, could that justify the use of it? That is the same justification which is used in relation to nuclear energy and synthetic hormones in accelerating animal weight gain.

What this argument ignores is that a high energy technology creates a multiplicity of possibilities of carcinogenity, e.g., food additives, medications, nuclear radiation, air pollutants from industrial processes and autos, pesticides, herbicides, and so on. Quite likely, all of the cancer-causing agents created by high energy have not been identified. The hazard the individual is subjected to is not the probability of contracting cancer from one of these sources, but rather the sum of the probabilities of contracting cancer from all sources. We are now faced with the sum of those probabilities which is a high and

[80]"Foamed Plastics," ENCYCLOPEDIA BRITANNICA, Vol. 18 (Chicago: Encyclopedia Britannica, Inc., 1970), p. 11.

[81]"Carcinogenic Chemicals, Urethane," ENCYCLOPEDIA BRITANNICA, Vol. 4, p. 889.

[82]"Cancer, Chemical and Biological Agents," IBID., p. 773; "Urethane," OP. CIT., Vol. 22, p. 889.

growing rate of cancer as a cause of death from each of these sources.

Currently, malignancies are one of the most important causes of death and constitute about 300,000 events per year, approximately one-sixth of all causes of death including accidents. Dr. Umberto Saffiotti, associate director for carcinogenesis, National Cancer Institute, asserts that cancer experts estimate that 75 per cent of all human cancers are caused by environmental factors.[83] Alvin Weinberg has been reported to say "If a cure for cancer can be found, the problem of radiation standards disappears."[84] Conceivably, one motive for the present crash program in cancer research is to find a technological fix for the carcinogenic consequences of our high energy technology. Given the limitations of fixes, this course would be suicidal.

There is conclusive evidence that a high energy technology introduces potentially toxic, cancer-creating substances into the environment. A reading of the appropriate entries and cross references in the ENCYCLOPAEDIA BRITANNICA establishes the case. But this is only one of the catalogue of environmental and ecosystem consequences of such technologies. Barry Commoner points out that early in the twentieth century, modern physics and chemistry became capable of creating new forms of matter. But this knowledge was not exploited until after World War II. Human beings finally developed a unique capacity—that of producing materials not found in nature and not subject to its bio-degrading processes.[85]

Commoner notes that these non-natural products have extraordinary environmental impact. One of the impacts is directly upon the cells of man. Thus, a technology utilizing high energy works modifications from the micro- to the macro-level in the biosphere.

There is not space here to elaborate upon the effects of high energy atmospheric pollution, water pollution, noise, destruction of land surface and soil, which have come about as a result of scientific and technological advance and application. The environmental impact and the possibility of ecosystem destruction is ever-present, because

[83]Harold M. Schmeek, Jr., "30,000 Mice, Rats in a Cancer Study," THE NEW YORK TIMES (May 18, 1973), p. 11.

[84]"Miraculous Cure," STOCKHOLM CONFERENCE ECO, op. cit., Vol. II, No. 1, p. 3, quoting THE NEW SCIENTIST. Is the proposing of technological fixes as addictive as narcotics?

[85]Commoner, OP. CIT., pp. 128–32.

with high energy at the command of man he has the means to change profoundly both his habitat and himself.

If the benefits of a high energy technology are to be enjoyed without human degradation in the short run and catastrophe in the long term, it must be used selectively and with discipline. High moral purpose and expertise are essential, for that human enterprise. But the cruel fact is that a high energy technology, in its impact upon society and culture, is subversive of the individual and societal basis for those human qualities.

The Trickle Effect: High Expertise and Purpose

Societies based on a high energy technology are confronted with a cruel paradox, which possibly may mean their destruction through a sociopsychological failure. High energy societies require, for coping with maladaptive potential, high expertise and high moral purpose exercised in institutions which reward those behaviors and those behaviors only.

However, there is evidence indicating that high expertise and purpose become increasingly rare and difficult to obtain in a high energy technology as the exercise of those qualities, on an individual basis, is incompatible with the milieu provided by the culture of a high technology. The population enjoying the affluence of a high energy technology becomes increasingly unwilling to pay the individual human costs of fail-safe, errorless tasks which are tension-producing and exacting in their requirements for mental, emotional, and physical energy. The Faustian bargain, necessitated by maladaptive potential, will not be kept unless innumerable individuals are willing to make great expenditures of personal energy through time.

The basis of stability in high energy societies has a dynamic which reduces that willingness, precisely at the same time that it creates conditions generating a need for it. In short, the culture of a high energy technology destroys a necessary condition for its maintenance.

The sociologist, Gerhard Lenski, has shown that in pre-industrial, agricultural and commercial societies, social stability (the inhibition of social revolutions and the minimization of internal change) is obtained by the process of vertically downward social mobility, greatly in excess of upward social mobility. In these societies—in which, it

should be noted, the major energy source is man and animals, the number of positions in the status structure and the associated privileges in the consumption of goods and services is relatively fixed and inelastic. The only available alternative for attaining social stability, in the face of potential population growth, is to force a significant number of individuals down the social structure into a pariah class, which Lenski calls "the expendables," the bottom class in the social structure which, by reason of a high death rate and other factors, would not reproduce itself. By the process of downward mobility into the expendable class, estimated by Lenski to be from five to ten per cent of the population, the positions available in the social status structure and the population numbers were in a crude equilibrium, thus preserving the social peace.[86]

In industrial societies, in contrast, the rate of vertical mobility not only increases but undergoes a very fundamental change. Upward movement in the social class structure dominates over downward movement. Lenski finds two principal factors responsible for this significant development: Technological and organizational changes brought about by the industrial revolution produced a more complex occupational structure, with more rewarding and desirable jobs. Second, the introduction and diffusion of birth control reduced the number of potential aspirants for rewarding positions in the society.[87]

Presumably, then, in industrial societies, under the impact of continuing technological and organizational change, upward social mobility serves the same purpose in preserving social status quo as downward mobility and a high death rate of the expendables did in agrarian societies.

The proposition that stability in industrial societies depends upon upward mobility in the social structure is one which is widely held by political and social scientists. As Lipset and Bendix state:

> Many political analysts have declared that the political stability or instability in an industrial society is determined by its social mobility; one with a high rate is stable, one with a low rate is not.[88]

[86]Gerhard E. Lenski, POWER AND PRIVILEGE: A THEORY OF SOCIAL STRATIFICATION (New York: McGraw-Hill Co., 1966), pp. 41–42, 266–95.

[87]IBID., pp. 412–14.

[88]Seymour Martin Lipset and Reinhard Bendix, SOCIAL MOBILITY IN INDUSTRIAL SOCIETY (Berkeley, Calif.: University of California Press, 1967), p. 76.

But this proposition encounters a fatal objection, as Lipset, Bendix and Lenski are well aware. There are great differences in the internal stability of industrial nations, but in Lenki's words, "*all show a striking stability in overall rates of mobility together with in most cases, a gradual rise in the rate of upward mobility.*"[89] The available data indicate that in any one nation the mobility rate shows little change through time and that the rate is about the same for all nations.[90] So there is reason to doubt that actual upward social mobility plays the role in creating social stability attributed to it.

For some generations, the term "trickle down" has been popular in American political rhetoric. Social scientists more recently have been analyzing this phenomenon under the term "trickle effect," that is, the tendency in developed societies for new goods and styles to be introduced into the consumption patterns of society by the socio-economic elite and then later to "trickle" down the status hierarchy as these items enter into mass consumption.[91]

Lloyd A. Fallers, an anthropologist, makes an incisive analysis of the dynamics of the trickle effect as a source of social motivation in developed societies. He notes that consumption patterns for goods and services are symbolic of status and that most Americans are oriented toward upward social mobility.[92]

There are popular and influential behavioral theories, most notably A. H. Maslow's "hierarchy of prepotent needs," stating the proposition that man's appetite for goods is easily satiated by merely

[89]Lenski, OP. CIT., p. 415. (emphasis Lenski's)

[90]There is another way of looking at this matter. In the absence of a high rate of population growth, a high rate of social mobility would in effect be an indication of social instability. It is difficult to envisage a high rate of change under those circumstances in which there would not be a radical transformation in social structure.

[91]Herbert G. Wilcox, "Goods Consumption for a Better Way of Life: A Closed System for Man's Destruction?" Prepared for delivery and distribution at the Annual Meeting, West Virginia Political Science Association, Concord College, Athens, W.Va., Oct. 23–24, 1970. In this paper, I advanced the proposition that there is in all industrialized societies a causal linkage of a neurogenic motive ("effectance"), increasing goods consumption, social stability, continuing technological innovation with increasing energy requirements, and catastrophic modification of the biosphere. The hypothesis is that there is a chain of determinate relationships connecting basic human motivation with the possibility of an ecological calamity. The analysis of the trickle effect here is partially drawn from that paper.

[92]Lloyd A. Fallers, "A Note on the 'Trickle Effect,' " PUBLIC OPINION QUARTERLY, Vol. 18, No. 3 (Fall, 1954), pp. 214–21.

satisfying needs at a physiological level.[93] In the face of the historical and contemporary evidence, this proposition is preposterous. As Lenski puts it, a "normal feature of the world of nature" is that the objects of striving have a demand that is greater than supply.

> To some extent man has been able to free himself from these difficulties. Thousands of years ago, he learned to increase his food supply, and more recently, he has learned to control reproduction. Yet while man enjoys certain advantages when compared with other living things, he also suffers from certain disadvantages. Unlike the various plants and animals, *man has an insatiable appetite for goods and services.* No matter how much he produces and consumes, he always desires more. This is true chiefly because the goods and services he consumes have a *status value* as well as utilitarian value.[94]

Or as Herman Miller puts it: " 'needs' stem not so much from what we lack as what our neighbors have. . . . So long as there are people who have more, others will need more."[95]

The swift dissemination of women's fashions down the status ladder, Fallers observes, probably mitigates the development of rigid stratification patterns. He also notes that a similar process of diffusion from the top applies to consumer durables such as automobiles and refrigerators. This process, described by Fallers, involves many products: black and white and then color TV, the second family auto, home swimming pools, wall-to-wall carpeting, power lawnmowers, dishwashers, air conditioning, the backyard barbecue syndrome, air travel, exercise equipment, and the flood of recreational equipment;

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[93]Abraham H. Maslow, MOTIVATION AND PERSONALITY (New York: Harper and Bros., 1954. The writer has critically analyzed Maslow's theory and the uses that have been found for it in "Hierarchy, Human Nature, and the Participative Panacea," PUBLIC ADMINISTRATION REVIEW, Vol. XXIX, No. 19 (Jan./Feb. 1969), reprinted in Hillman M. Bishop and Samuel Hendel (eds.), BASIC ISSUES OF AMERICAN DEMOCRACY, 7th ed. (New York: Appleton-Century Crofts, 1973).

[94]Lenski, OP. CIT., p. 31. (emphasis Lenski's)

[95]Herman P. Miller, RICH MAN, POOR MAN (New York: Thomas Y. Crowell Co., 1971), p. 46. An argument from evidence can be constructed that an emotion akin to envy is a major factor in social cohesion in primates. For an insightful and informative exploratory work on envy as a motive in man, see Helmut Schoeck, ENVY: A THEORY OF SOCIAL BEHAVIOR (New York: Harcourt, Brace and World, Inc., 1969).

which is increasingly incomplete without an internal combustion engine or an electric service plug. Fallers writes:

> (T)he trickle effect is a mechanism for maintaining the motivation to strive for success, and hence for maintaining efficiency of performance in occupational roles, in a system in which differential success is possible only for a few.[96]

Fallers reasons that the major value in Western society is individual success through individual achievement based upon performance and competence in occupational roles. However, there is a major difficulty in sustaining motivation. While many are aroused to compete—and many *must* be so motivated if competition is to exist—only a few will succeed for the distribution of advancement and rewards is pyramidal, inversely related to the number of people. Degrees of success will be inversely related to the number of individuals enjoying it.

What will motivate the majority of the population doomed to disappointment and frustration of their strivings for upward social mobility? The answer is the trickle effect, giving the illusion of upward social mobility, although by any criterion other than goods consumption patterns, the individual's position in the status structure is static. A person can regard himself as a "success," for he can compare his present consumption pattern of goods and services with his previous pattern and his superiors' patterns at that time.

Comparison of the present with the past shows to most individuals that they consume now what their status superiors did formerly, subjective proof that they have moved up the status ladders. Thus, the majority of the population, those who have not suffered personal or economic misfortune, will have an illusion of upward social mobility. In actuality, of course, what is happening is that all levels of the status structure, through growth in the national product, are experiencing a change to "higher" consumption patterns. Although the status symbolic value of specific items in consumption patterns becomes somewhat "inflated" through greater diffusion, some goods have "absolute" value in terms of the individual's life history.[97] The

[96]Fallers, OP. CIT., pp. 214–15. (emphasis Fallers')

[97]To illustrate: The percentage of American families possessing selected goods increased as follows: two or more autos, 16.4 in 1960, 29.3 in 1970; a color TV set, 6.8 in 1965, 37.8 in 1970; home air conditioning, 12.8 in 1960, 37.8 in 1970. Jack Rosenthal, THE NEW YORK TIMES (Dec. 9, 1970), p. 37.

system "pays off" even for the majority who are not status mobile by giving them the goods symbolic of status advancement.

Marion J. Levy Jr., a political scientist, further analyzes the trickle effect:

> One of ther major problems for stability characteristic of the relatively modernized societies lies in the fact that the members of such societies cannot live with stagnation or depression in the economic aspect of their lives. . . . One of the strongest integrations of . . . stresses and strains . . . lies in the possibility of preoccupation of the members of such societies with continuously increasing material acquisitions.[98]

The strategic importance of economic growth, an increasing flow of new goods and services, is in the fact that it provides societal integration and stability, alleviating many social stresses stemming from other sources. The appeal of an increasing flow of new goods and services to the populations of relatively modernized societies is in (a) the irreducible interest of man in material goods and services and in being relatively well off in terms of them, and (b) "the fascination with novelty." Levy notes that "there has never been a society whose members were indifferent to novelty or found it totally lacking in a favorable fascination for them."[99]

The phenomenon of goods and services first being available to elite groups and then to the middle and lower clases, with a greater volume of production and lower costs, is to be found in all developed countries, whether the ideology is socialist or capitalist. Levy says:

> (R)egardless of the ideology characteristic of the society concerned, there is for all societies, and especially relatively modernized societies, a correlation between income [or favored position with regard to scarce goods and services] and general social prestige. Insofar as demand operating either through state decision or free private purchases results in increased production at lower costs, these goods and services become available to members of a society who are lower down in the income scale and hence to a considerable extent likely to be lower down in the prestige scale as well.[100]

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[98]Marion J. Levy Jr., MODERNIZATION AND THE STRUCTURE OF SOCIETIES: A SETTING FOR INTERNATIONAL AFFAIRS, 2 vols. (Princeton, N.J.: Princeton University Press, 1966), II, 783.

[99]IBID.

[100]IBID., II, 784.

The acquisition of goods and services, which as a consequence of their association and identification with elites, by persons lower in the status structure, gives the illusion of social mobility, with important integrative consequences.[101]

The status symbolic element of goods consumption militates against the realization and observance of a "voluntary consumption maximum," to use Steffan B. Linder's term. Even establishing that maximum at the current level enjoyed by the highest income groups, which is clearly not possible from the standpoint of resource extraction, capital investment, and technological development required; would not establish a voluntary maximum for the population. This would entail the acknowledgment of a degree of equality that would be inevitably unacceptable to some minority constituted on some principle, historical, ethnic, functional—the possibilities are many. It appears then that Linder is on solid ground when he concludes:

> Whether through advertising or not, the appetite of the mass consumer can always be relied upon to be whetted. Decreasing marginal utility might affect individual commodities but not aggregate consumption.[102]

The consumption of goods identified with elites and higher status groups facilitates the societal reward of achievement. Levy explains:

> The trickle effect ties in the integrative possibilities of increasing income and its use to acquire increasing material goods and services and increasingly novel ones with important structures of individuals to strive for achievement. This structured striving for achievement is also of the essence of these societies.[103]

But in the developed societies, which depend upon structured striving for achievement, a fine balance must be maintained between the actual opportunities for its realization and the disruptive consequences of disappointments stemming from the failure of individuals

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[101]IBID., II, 784–85.

[102]Steffan B. Linder, THE HARRIED LEISURE CLASS (New York: Columbia University Press, 1970), p. 124. As a British historian has aptly said, "the enjoyment of much does not exorcise the desire for more ..." H. Hale Bellot, AMERICAN HISTORY AND AMERICAN HISTORIANS: A REVIEW OF RECENT CONTRIBUTIONS TO THE INTERPRETATION OF THE HISTORY OF THE UNITED STATES (Norman, Okla.: University of Oklahoma Press, 1952), p. 77.

[103]Levy, OP. CIT., II, 786.

to achieve in societal terms of upward mobility. Moreover, actual upward mobility would be disruptive of societal integration. Therefore, an expanding operation of the trickle effect is basic to stability.

> Above all it permits the illusion of social mobility ... to exceed far the level of actual mobility as measured by other criteria, though from the point of view of members concerned this illusion of social mobility may be quite as real as any other measure of social mobility might be. This is important because, however great the absolute amount of social mobility as measured by other criteria, regardless of political ideologies, it is never as great as the members of relatively modernized societies wish it to be or feel that it should be. In the absence of the trickle effect, desire would outrun performance by an even larger margin.[104]

In brief, an increasing flow of goods and services, as well as new goods and services, both for their intrinsic motivational consequences as well as their greater significance for the trickle effect and accompanying illusion of social mobility, are essential for integration in modern social systems. Unfortunately, an increasing flow of goods and services increases the maladaptive potential.

Levy examines the consequences of either a reduction in the absolute volume of goods and services, or a relative decrease in the growth rate of the economies of developed societies. The evidence indicates that developed societies can weather a stagnation or a decline of incomes only if the population perceives that the society is in a mortal crisis such as war. Either a reduction in the GNP (Gross National Product) or the failure to provide an increasing GNP over a term of years will result in political and social instability. An increasing GNP is essential to stability in the developed nations. The difference between the Soviet Union and the United States in this regard is merely in degree. The people of the Soviet Union have a lower standard of living and are accustomed to a slower rate in the trickle effect. But the degree of freedom available to the political leadership of both the Soviet Union and the United States is declining. Both are increasingly locked into a high rate of economic growth.

The Soviet Union and the United States, as well as the other developed countries, are confronted with continuing expansion of their prestige economies, at whatever cost—or undergoing political and social instability with the possibility of social revolution. This is the

[104]IBID.

dilemma of the developed nations of the world. We have a tiger by the tail and cannot let go.

There is another peril stemming from the trickle effect. The expanding operations of the trickle effect, with its inevitably increasing flow of goods and services in a high energy technology, have consequences subverting the cultural foundations of a high energy society. The goods and conditions relating to their consumption habituate the population of a high energy society to demands, expectations, and behavioral traits which are incompatible with its preservation. That is, the price of a zero defect technology, which a high energy technology increasingly requires because of its maladaptive potential, is the highest expertise and moral purpose. Conditions of consumption in a high energy technology militate against the development and maintenance of such traits in the population.

High moral purpose is an aspect of culture, yet culture, in either its creative or appreciatory phase, demands human energy—mental, emotional, and sometimes physical. In both phases, culture demands discipline and the undivided attention of the individual, because cultivation of the mind and spirit, as distinguished from manners, entails change or a transformation in the individual—not in a moment but over time. Appreciation in a cultural sense cannot be an experience of the untutored; the learning process takes time, hard work, and self-discipline. The application of inanimate energy can facilitate this process marginally in the sense that the electric light and thermostatically controlled central heat are advantageous for these purposes as compared with the tallow candle and fireplace, but the products of a high energy technology are not intrinsic to the culture process.

Our goods-affluent society has supposedly undergone a "culture boom," with greater attendance of arts performances, book purchasing, and so on. However, by an analysis of the data relating to the boom, Steffan B. Linder, a Swedish economist and member of parliament, presents strong grounds for skepticism about any such "boom."[105] There is a separate ground for skepticism. Attendance at cultural performances, exhibits and lectures, and the acquisition of cultural artifacts, expensive paintings and the like, are in many instances an example of "conspicuous consumption," in Thorstein Veblen's definition for that term. Conspicuous consumption is for the

[105]Linder, OP. CIT., pp. 101–109.

purpose of making a symbolic statement by the individual about status or an expression of his efforts to satisfy status aspirations. Elite Romans collected and adored the artifacts of the superior Hellenic culture. The cultural content and the cultivation of mind and spirit attending such consumption could be incidental and not intrinsic to the occasion or material acquisition. In short, goods consumption is often disguised as appreciation of culture.

In reality, culture, the effort to refine the mind and spirit, is little dependent upon goods. Goods are only incidental to cultural pursuits, never central to the activity. Time allocated in culture can be utilized in two ways: either to further extend or develop the culture, contributing to its progress, or by developing a greater depth in appreciation and understanding of it as the summit of man's achievement. Inanimate energy and the technologies which exploit it cannot furnish a substitute. There is no technological fix for the absence of high expertise and moral purpose, and the psychology of affluence and domination do not contribute to their attainment. These requisite qualities can only be acquired through unremitting application of human, mental, emotional and physical energy. In brief, a high energy technology and its society—particularly in relation to the necessity for combating maladaptive potential, on the one hand, and the development of culture, the cultivation of the mind and spirit, on the other, require unremitting concentration, discipline, and the expenditure of mental, emotional and physical energy. But it is precisely these forms of behavior which high energy consumption-oriented society is designed to eliminate from leisure, domestic, and economic production sectors. We have a population which is increasingly habituated to behavior which does not require or reward these qualities. The implication is obvious: a high energy technology first undermines and then destroys its moral and behavioral basis—maximizing maladaptive potential.

The dilemma confronting the high energy societies can be summarily expressed: Progress through science and technology has been described as the growth of man's mastery over nature. But man is a part of nature. Until he achieves self-mastery, which can only come through culture, the cultivation of mind and spirit, his destiny is problematical.

CHAPTER FIVE

IMPLICATIONS OF A STATIONARY POPULATION

by
Lincoln H. Day

My focus will be on the *consequences* of a stationary population, not on how such a population might come into being or how it might be maintained. I have dealt with these other two topics elsewhere-and so, incidentally, have a number of others.[1] Of course, some of the consequences I'll enumerate would have the function of reinforcing a stationary population; but my emphasis will be on the likely consequences, themselves, rather than on the institutions and patterns of human behavior that could be expected to give rise to a stationary population.[2]

Demographers define a "stationary" population as one with a zero growth rate and an unchanging age/sex distribution. Thus, in a stationary population the birth rate always equals the death rate and the proportions at each age/sex level always remain the same: there is the same proportion of males at age 15, for example, in year n as there was 5 years earlier, and as there will be 5, 10, 15, ... x years later.

Although presented when the author was a member of the United Nations Secretariat, the views and opinions expressed in this paper are the author's and do not necessarily reflect those of the United Nations.

[1]Lincoln H. Day and Alice Taylor Day, *Too Many Americans*, Boston; Houghton Mifflin, 1964, Chap. 10; Lincoln H. Day and Alice Taylor Day, "Family Size in Industrialized Countries: An Inquiry into the Socio-Cultural Determinants of Levels of Childbearing," *Journal of Marriage and the Family*, May, 1969; and Alice Taylor Day and Lincoln H. Day, "Toward an Equilibrium Population," in John Harte and Robert H. Socolow (eds.), *Patient Earth*, New York: Holt, Rinehart, and Winston, 1971.

[2]See, e.g., Kingsley Davis, "Population Policy: Will Current Programs Succeed?" *Science*, November 10, 1967; Alice Taylor Day, "Population Control and Personal Freedom: Are They Compatible?" *The Humanist*, November-December 1968; and Bernard Berelson, "Beyond Family Planning," *Science*, February 7, 1969. For models of various demographic developments on the way to a stationary population see Tomas Frejka, "Reflections on the Demographic Conditions Needed to Establish a U.S. Stationary Population Growth," *Population Studies*, November, 1968.

Obviously, such a population is a statistical construct, not an actual fact. The reason for concerning ourselves with it lies not in the fact of its existence, but, rather, in the fact of its desirability. The stationary population is not an actual entity, it's a *goal.* Though we cannot say that every stationary population will be an optimum (some will be too large, others too small), I think we *can* say that every optimum population will, at least, be *stationary.*

Now, any discussion of optimum population implies the existence of goals, the attainment of which is thought to be affected by the number and characteristics of the population. An optimum population is not a goal isolated from other social priorities, nor is it an end in itself. It is, rather, a means to the achievement of conditions of life considered desirable. Thus, when we ask, "What is the optimum population?" what we are really asking is: "What are the demographic conditions most conducive to some desired state of affairs?"

Most discussions of optimum population can be faulted on three grounds: First, they commonly apply only narrowly economic criteria of value and, in doing so, fail, of course, to deal either with the wide variety of human needs or with the fact that these needs are different for individuals in different cultures and at different stages of life. Second, most discussions of optimum population make few, if any, concessions to the existence of limits—either ecological limits or social limits. And finally, these discussions commonly focus on population *size* to the exclusion of population *characteristics.*

It is this emphasis on size instead of characteristics that is of particular interest here. Because any idea of optimum *size* must depend essentially on values and styles of life, there can be in any particular instance quite a range of different optima. But with the *characteristics* of an optimum population the situation is quite otherwise. Here there would seem to be much less room for argument.

If we take as our goal something general enough to be agreed to by nearly everyone—something like "happiness," or "the good life," for example—it seems to me that, whatever its size, the population most congruent with such a goal would embody three characteristics: first, a low level of mortality; second, an unchanging age/sex distribution; and third, a zero growth rate. In short, this optimum would be a stationary population enjoying a low death rate.

The desirability of a low death rate comes out of the value placed on individual health and longevity; the desirability of a zero growth

rate, out of the necessity to adjust to limits. But the desirability of an unchanging age/sex distribution may be less obvious. In addition to being a demographic necessity if birth and death rates are to remain equal, an unchanging age/sex distribution will help reduce any problems there may be in making adequate provision of schools and similar social services, and also of providing employment for new entrants into the labor market.[3] With such a structure there would be no problems of the sort occasioned in the United States by the fact that for every three children born in 1945 there were more than four children born only two years later.[4]

* * * * * *

There is, I understand, an old Arab admonition that you should beware of wishing, for you may get what you wish for. If we are to "wish for" a stationary population, what might we reasonably expect to follow from getting what we wish for? Let me begin with three basic premises that will, I think, put this question in proper context.

First of all, we must recognize that the consequences of a stationary population will be determined, in part, by its other demographic attributes: its fertility and mortality level, the degree of its geographic dispersion, and, particularly, its size. I won't review here the evidence of how the present size of human population, and its potential for future growth, threatens human well-being. The present situation is, as you know, wholly unprecedented; and even with a remarkable reduction in growth rates, the potential addition to human numbers over the next few decades cannot help being greater than ever before. For example, 28 years from now (according to the United Nations' "medium" forecast), there will be 4/5 as many women of childbearing age in southern Asia *alone* as there were in the *entire world* in 1965;[5] while, as far as the distribution of these vast numbers is concerned, it is expected that, by that time, cities of 10 million or

[3]For a more extended discussion of the concept of optimum population, see Lincoln H. Day, "Concerning the Optimum Level of Population" in S. Fred Singer (ed.), *Is There an Optimum Level of Population?* New York: McGraw-Hill, 1971.

[4]United Nations, *Demographic Yearbook* 1954, Table 8.

[5]United Nations, Population Division, *World Population Prospects, 1965–2000, as Assessed in 1968* (mimeo), 1970, Table 4.1.

more inhabitants will be more numerous than were cities of 1 million or more inhabitants at the turn of this century.[6]

The second basic premise is that population is only one of several prime determinants of the human condition. The human and ecological consequences of demographic conditions are necessarily mediated through cultural practices and standards. The chances for present and future generations to enjoy "the good life" depend not only on demographic conditions, but on the *interplay* of *demographic conditions* with the *rate of consumption of resources* and the *use that is made* of the resources consumed. We could halt population increase tomorrow and still consume scarce resources at ruinous rates; or, conversely, we could have a zero population growth rate and also a rational rate of consumption of scarce resources, and yet fail utterly to make any socially useful allocation of the resources being consumed. An optimum population, itself, is not sufficient to ensure the "good life."

Finally, the consequences of a stationary population will be determined, in part, by the economic conditions under which that population lives and the extent to which it experiences equality in the distribution of wealth and privilege. The elimination, or even merely the reduction, of many of the present costs attributed to population increase and material affluence will depend, I should think, as much on eliminating gross inequities in wealth as on halting population growth and achieving an ecologically sound style of life.[7]

In sum, as with so much else in social causation, there is no one-to-one relationship. What proceeds from a condition of stationary population will depend on a whole collection of other elements. Nevertheless, it is possible to discern some of the general implications.[8] So far

[6]United Nations, Population Division, *The World's Million Cities, 1950–1985,* 1972.

[7]The role of equality of wealth is discussed in more detail in Lincoln H. Day, "The Social Consequences of a Zero Economic Growth Rate," in Andrew Weintraub *et. al.,* the *Economic Growth Controversy,* White Plains, N.Y,: International Arts and Sciences Press, 1973.

[8]These are discussed in more detail with particular reference to the United States in Lincoln H. Day, "The Social Consequences of a Zero Population Growth Rate in the United States," in United States Commission on Population Growth and the American Future, *Population and the American Future* : The Report of the Commission on Population Growth and the American Future, vol. 1, Washington: Government Printing Office, 1972.

as I can determine it at the present time, the demographic character of a stationary population would represent no very great departure from what already exists in some countries and, moreover, the consequences of a stationary population would be more often favorable than unfavorable—from the standpoint of human well-being. Now to some specifics.

We don't really know what *size* future optimum populations will be, except that, apart from a very few countries, they could hardly help being substantially larger than they are at the present time. This is because of the growth inherent in present age structures.

But if we don't know what size future stationary populations might be, we do know they would be *older*—assuming the existence of low mortality. A stationary population could be expected to have a median age of approximately 37 years, as against the present median of 28 years in the United States and some 17 years in such countries as the Philippines and certain of the Central American republics.[9] However defined, the proportion of school age would be lower, the proportions of working and retirement age, higher. The proportion of "dependent" age (that is, school and retirement ages together) would be lower and the proportion of "non-dependent" age, higher.

The sex ratio of such a population would show a slight, but slowly diminishing, excess of males over females up to about age 48. With the absence of great swings in annual numbers of births, there would be an absence, as well, of any "marriage squeeze." Where custom decrees, for example, that a groom should ideally be two years older than his bride, a 35% increase in births over the number two years earlier (which is what happened in the United States in 1947) would result in sex ratios of only 77 males per 100 females at what have been in the United States the prime marriageable ages for women (i.e., 20–24).[10] The result: for some, a departure from the "ideal"; for others, postponement of marriage; and for still others, possibly no marriage at all. With an essentially stationary population, there would be no *demographic* pressure in any of these directions. With

[9]Calculated from U.S. Dept. of Health, Education, and Welfare, Public Health Service, *Vital Statistics of the U.S. 1967.* vol. II—Mortality, Part A, Section 5, Washington: U.S. Government Printing Office, 1969, Tables 5-2 and 5-3. These Life Tables for 1967 offer a slightly more favorable mortality schedule than do those for more recent years. Data on age structures of other countries from United Nations, *Demographic Yearbook 1970,* Table 6.

[10]United Nations, *Demographic Yearbook 1949–50,* Table 15.

little annual variation in birth rates (and hence in numbers of births), sex ratios within the age groups socially defined as ready for marriage would remain constant and nearly equal.

This would have no necessary implications for the *pattern of marriage,* however. A stationary population in itself would seem no more conducive to one pattern of marriage than to another. All we can expect is an absence of a "marriage squeeze" and but minimal fluctuation in annual marriage rates.

Mortality has already been assumed to be low. Such an assumption is not incongruent with a continuation of group differentials, however. Higher mortality could continue among the various disadvantaged groups of the population and also, of course, among those with life styles characterized by smoking, over-eating, lack of exercise, or aggressive driving. The one difference is that, overall, because of the older age structure, the proportion of the population dying each year would be about 50% higher than it is at the present time.

As far as *fertility* is concerned, there are a number of possibilities. They range between the one extreme in which childbearing is confined to a small group having large numbers of children and the other extreme in which there is nearly universal childbearing at the level of two children per woman. There is nothing about a stationary population in itself that necessitates any particular distribution of family sizes. All that maintenance of a stationary population requires is that the annual number of births be equal to the annual number of deaths.

What non-demographic conditions would flow from a stationary population is, as I've already suggested, pretty conjectural. There seem to be no one-to-one causal relationships. The range of possible consequences is wide, indeed. Life could be meager or bountiful, violent or peaceful, miserable or happy. Demographic conditions will not, except at the very extremes, be the ultimate determinants of the conditions of human life. We must beware of lapsing into demographic determinism. Ultimately, of course, a zero rate of growth is requisite to survival itself, but a stationary population would only make the "good life" more attainable; it would not, in itself, produce it. Under any set of demographic conditions short of the extremes, conditions of life will be more a consequence of institutional structures and social attitudes and policies than of any population characteristics as such.

This is, perhaps, nowhere better illustrated than in the area of

health. It would be reasonable to expect the demand for medical and hospital services, for old age homes and wheelchairs, to increase with an aging of the population. But even here there is no one-to-one relationship. Aging is a social and psychological process every bit as much as a biological one. Given conditions that enable older persons to remain active and useful, and that do not rob them of status and livelihood, the higher proportion of the population in the upper age groups that we could expect with a stationary population may well contain a smaller proportion of "aged" in a social and psychological, and possibly even physical, sense than is the case today in a country like the United States—where access to medical care remains costly; where the decline of small-scale agriculture and small-scale business has lessened the economic opportunities for older people; where pensions hardly compare with wages; and where urban sprawl is combined with little opportunity for healthful exercise like walking and cycling (both of which are common activities among the aged of Europe), with few opportunities for informal and chance encounters, and with a woefully inadequate system of public transportation. Obviously, aging cannot be prevented; but *when* aging begins and *how* it manifests itself would seem to be explained less by considerations of birthdays than of conditions of life.

As in the case of health, the principle of a wide range of possible consequences applies also to the relationship between a stationary population and *economic conditions.* Now, a pattern of economic conditions different from what now exists in this country and most other countries as well, might be highly desirable—from the standpoint of the conservation of resources or the enhancement of the quality of life.[11] But there is nothing in a stationary population that would seem to point in the direction of any particular economic conditions. Economic growth, economic stability, and economic decline are all possible with such a population. Though a stationary population would have a lower proportion in the economically "dependent" ages, a lower ratio of dependency is itself no guarantee of better economic conditions. I should also expect less tendency toward inflation in a stationary population, but surely the major sources of inflation lie elsewhere than in the demographic structure.

[11]See the excellent discussion in E. J. Mishan, *The Costs of Economic Growth,* London: Staples Press, 1967.

Once again, population sets the limits, but the limits set are broad, indeed.[12]

There could presumably be more certainty in *economic forecasting,* particularly at the national and (to a lesser extent) at regional levels. But if internal migration is at a high rate—and it could be, even with a stationary population—forecasting by local firms, with a local labor market or a local sales market, could continue to be a rather uncertain activity. A stationary population should also permit more accurate *forecasting* with respect to the provision of social services—particularly at national and regional levels. But here, too, migration could create difficulties at the local level.

In any system in which power and position are determined at least in part by length of service, a stationary population enjoying low mortality is going to afford less opportunity for *promotion.* At the probabilities of death used in my calculations for this paper, a stationary population would have fully 90% as many males at age 50 as at age 20—and 95% as many females. Contrasted with the present condition in the United States of 62% and 68% as many, respectively, this represents a considerable reduction in opportunities of advancement for younger persons. It should be noted, however, that even with a growing population, success in this competitive struggle can be enjoyed by only a minority, and that fluctuation in annual numbers of births will give some birth cohorts a decided advantage and others a decided disadvantage in such competition.

Whether a lower rate of social mobility is to be viewed with satisfaction or alarm is largely a matter of values. It would probably have some effect on the rate of internal migration, however, as fewer executives and professionals were moved about to "higher" positions, and as fewer families changed houses in response to "upward" (or "downward") movement. As neighborhoods thus became more demographically stable, real estate speculators and salesmen might suffer a bit, but housing could come to take a smaller share of one's income, and neighborhoods might come to be less subject to inward and outward movements of persons who, because of the likelihood of having to move, could afford to have little emotional attachment to their places of residence.

A shortage of opportunities for promotion could work in two direc-

[12]Lincoln H. Day, "A 'Young' Population is Not Necessarily Good for a Nation or Its Business," *New York Statistician,* January-February 1971.

tions, however. It could lead to more job-switching, including a greater tendency to go into business for oneself on the assumption (in this instance, false) that the structural limits to status mobility would be less constraining elsewhere. It is possible, too, that for a time there would be a heightened competitiveness in response to the diminished number of opportunities. But it seems unlikely that aspirations for higher position could be entertained for very long without some positive reinforcement. A more likely response would seem to be a reduction in the levels of aspiration, which—given the fact of a lower rate of social mobility—would be the more rational psychic response. I should also expect a greater emphasis on equality, first, in receipt of basic services (e.g., health and welfare, environmental protection, public transportation), but equality, eventually, in wealth itself.

Whether a decline in status-striving would necessarily delay the march toward "progress" (or some other similarly metaphysical concept) is at best a debatable point. But surely there is more to human motivation—even in the occupational sphere—than can be accounted for by the hope of invidious distinction. The satisfaction of doing a job well, the approbation of one's peers, the intrinsic interest one might have in certain activities, the quality of the on-the-job associations with one's fellow workers, for example, all figure in the motivation of a work force. To attain a given end, these types of motivating forces might have to play a more prominent role than they do currently, but there seems no reason to doubt their capacity for taking up whatever slack might remain after the virtual disappearance of the, even now, limited opportunities for promotion.

If there is, indeed, a decline in competitiveness and in levels of aspiration, one undoubted consequence would be a reduction in status frustration; for promotion can be socially disruptive and emotionally frustrating by creating aspirations where formerly there were none, and super- and subordinates of those who were formerly peers. Surely there are enormous emotional costs in any system, such as that, today, in the United States, that condemns a high proportion of its total work force to the self-defined category of occupational "failure." If the advent of a stationary population serves to reduce the incidence of such "failure," this must surely be adjudged one of the positive consequences of such a demographic change.

There have been a number of claims that *personality structure* differs with different orders of birth, and with different parent-child and sibling relationships originating in different family sizes. If there

are, indeed, differences in personality originating in this manner—and the evidence on this is at best equivocal—any change in the distribution of family sizes will alter the distribution of personality types, as well. More research on this issue could be of some interest. But before we devote too much time and energy to the question, two points should be emphasized: first, that the family is only one of many socializing influences, and possibly not even the most important one; and second, that whatever the results of such an inquiry, the policy implications inherent in the need for a stationary population, in conjunction with the likely desires of the great majority for parenthood, would surely outweigh in importance anything turned up on this score by the psychologists. Just suppose that, by some miraculous development of social consensus we *could* find agreement on the most desirable personality traits and that, by an even more miraculous development of the methodology of psychology, it *was* found that the best personalities were formed in families consisting of four children, would this be worth continued population increase—or, if we shrink from that, would it be worth denying motherhood to half the world's women and forcing the other half to bear four children apiece? Surely it's a matter of making the best of the situation, rather than of sacrificing more important values in a misguided effort to avoid a demonstrably lesser evil—if evil it even is, in this particular instance. Besides, even in a stationary population, with births equalling deaths, individual choice could well give rise to childless families and, on the other hand, to some families with four or even more children.

As far as *social security* is concerned, I think we could expect a stationary population (enjoying low mortality) to place a greater emphasis on social, as opposed to private, means for the support of the aged, infirm, and disabled. This would arise, in part, in the presumably greater political power of the older population—because of their relatively greater numbers—and in part in the substitution of a greater dependency of age for a formerly greater dependency of youth. Only a population with a youthful age distribution can effectively relegate support for the aged exclusively to the contributions of children and relatives. I should expect further development of procedures for enabling (or, from another point of view, requiring) the aged to support themselves by means of forced savings—customarily in the form of social security payments during the years of peak earnings. The transition to a stationary—and therefore older—

population would thus merely reinforce a trend already well underway in most countries.

Finally, let us turn to the question of *behavior.* Among those who have on occasion succumbed to the temptations of demographic determinism, the main anxieties expressed about a stationary population concern the behavioral consequences of its age structure. A well-known economist-demographer claims that a society with the older age structure of a stationary population "would not be likely to be receptive to change and indeed would have a strong tendency towards nostalgia and conservatism."[13] And a French writer has characterized such a population as one of "old people ruminating over old ideas in old houses."[14]

As it happens, the cause of such concern is an age structure little different from the current age structures of Sweden and England and Wales—populations hardly characterized by rampant decrepitude. As can be seen in the following table, in which the age structures of Sweden and England and Wales are compared with that of a particularly low-mortality stationary population (represented in this instance by the 1965–67 life table population for the non-Maoris of New Zealand), only at the highest age category (70 and over) does the stationary population differ much from that of these two actual populations; and then to the extent of but 2.01 percentage points in the case of England and Wales, and but 1.57 percentage points in the case of Sweden. Rather a lot would seem to have been made of rather a little.

Moreover, is receptivity to change always desirable, and nostalgia and conservatism always undesirable? Shouldn't one ask: Receptivity to what *kinds* of change? Nostalgia and conservatism about *what?* And, for that matter, *which* "old ideas" in *which* "old houses"?

"Conservative," "progressive," "reactionary," "radical" are spongy concepts, especially when removed from their specific referents. Were Hitler's youthful storm troopers "progressive"? Were the aged Townsendites "conservative"? And even if we know, ourselves, what we mean by these terms, can we assume that the "conservative" on one issue is going to be "conservative" on others as well; or—more germane to the present discussion—that these views, how-

[13]Ansley J. Coale, "Should the United States Start a Campaign for Fewer Births?" *Population Index,* October-December 1968.

[14]Quoted in *Ibid.*

Percentage Distributions by Age of the 1970 Population of England and Wales, the 1969 Population of Sweden, and the 1965-67 Non-Maori Life Table Population of New Zealand.*

Age	(a) 1970 England and Wales	(b) 1969 Sweden	(c) 1965-7 non-Maori New Zealand life table	Ratios: a/c	Ratios: b/c
0-9	16.48	14.22	13.68	1.20	1.04
10-19	13.91	13.69	13.61	1.02	1.01
20-29	14.23	15.53	13.49	1.06	1.15
30-39	11.96	11.50	13.34	.90	.86
40-49	12.73	12.95	13.04	.94	.99
50-59	11.97	12.77	12.25	.98	1.04
60-69	10.55	10.74	10.44	1.01	1.03
70-79	5.94	6.32	7.08	.84	.89
80+	2.22	2.27	3.08	.72	.74
				.80	.85

*Percentages for England and Wales and Sweden calculated from Nathan Keyfitz and Wilhelm Flieger, *World Population* (Chicago: Univ. of Chicago Press, 1968) pp. 508, 538; New Zealand percentages calculated from New Zealand Dept. of Statistics, *New Zealand Life Tables 1965-67 and Life Annuity Tables*, Wellington, December, 1969, Tables 1 and 2.

ever categorized, are causally related to age? In terms of the demonstrated willingness to introduce changes in economic behavior, education, and the status of women, the world's most conservative societies are those with the youngest—not the oldest—populations. And this holds even when we consider only the adult portions of those populations.

Here in the United States, a recent public opinion poll finds older women more willing than younger to remove legal restrictions on access to abortion.[15] Is this lesser receptivity to change? In 1968, the *New Republic* continued with its long-standing custom of rating congressmen on the basis of certain "key votes" during the previous session. On the 12 Senate votes selected, despite considerable overlap, "progressivism," as defined by this self-designated "liberal" magazine, was, indeed, associated with "youth": the median age of Senators with no more than three "unfavorable" votes was four years younger than that of those with no more than three "favorable" votes. Yet, on the one issue of the 12 selected that might show

[15]Judith Blake, "Abortion and Public Opinion: the 1960–1970 Decade," *Science*, February 12, 1971.

something about attitudes toward the Vietnam War, the "hawks" and "doves" had the same median age, and there was no difference between the two groups in distribution by age.[16] Concerning the 80th Congress of 1947–48, against whose record President Truman based so much of his campaign of 1948, and which probably more than any other since World War II separated the "liberals" from the "conservatives," the *New Republic's* ratings again show a difference of four years between the median age of the "liberals" (those with no more than four "unfavorable" votes out of the 15 selected) and the "conservatives" (those with no more than four "favorable" votes). But, this time, the relationship is reversed: it is the "liberals" who are older.[17]

To argue in terms of age is to commit a fallacy—the fallacy of misplaced emphasis—for the behavior of any group above the age of infancy is determined by its position in society, not its accumulation of years. To worry about the supposed behavioral consequences of an aging, or more aged, population is to divert attention from the real issue, which is how to incorporate a higher proportion of old people —given the inevitability of a cessation of population increase and the desirability of low mortality—into society in a socially and emotionally meaningful way.

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And now to a four-sentence conclusion: (1) A cessation of population increase is inevitable; (2) The consequences of any population structure will be primarily a function of the social/cultural setting, not the demographic; (3) Yet, a stationary population with a low death rate is desirable; (4) To the extent that population structure is itself a determinant, the results of a stationary population are far more likely to be favorable than unfavorable.

[16] *New Republic,* 2 November 1968; ages of senators from *Who's Who in America,* 1968.

[17] *New Republic,* 27 September 1948; ages of senators from *Congressional Directory,* 1948.

PART THREE

Patterns, constraints and implications for social institutions in a stabilizing world

CHAPTER SIX

A MODEL FOR A STEADY-STATE ECONOMY

Herman E. Daly

> "More and more people are coming to realize that the growth of material wealth, which the British industrial revolution set going, and which the modern British-made ideology has presented as being mankind's proper paramount objective, cannot in truth be 'the wave of the future.' Nature is going to compel posterity to revert to a stable state on the material plane and to turn to the realm of the spirit for satisfying man's hunger for infinity."
>
> Arnold Toynbee, *The Observer,* June 11, 1972

This statement by Toynbee indicates two propositions of massive importance: (1) our economy must, sooner or later, conform to a steady state in its physical dimensions of population and stock of artifacts—i.e. in its stocks of endosomatic and exosomatic capital; (2) our pursuit of the infinite must take place in the realm of the spiritual which is infinite rather than the material realm which is finite. The main purpose of this article is to develop the first proposition and to suggest a "prescriptive model" for institutionalizing the steady state. But the second proposition is closely related to the first and this relationship requires some preliminary discussion.

Man's physical existence is everywhere subject to the laws of steady-state open systems. The entire ecosystem of which man is a part is a steady-state open system, the living organism itself at maturity is a steady-state open system, as is a population of organisms when in ecological equilibrium. Of course the qualitative nature of the steady state evolves over the long run—organisms grow old, populations evolve, and entire ecosystems undergo succession. Likewise a steady-state economy would evolve qualitatively in response to technological and moral mutations. As a result of such qualitative evolution it may become both possible and desirable to change the quantitative dimensions of the steady state—to move to a different

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A fuller treatment of some of the ideas here discussed will be found in Herman E. Daly, editor, *Toward a Steady-State Economy,* W. H. Freeman Co., San Francisco, 1973.

level of stocks. But quantitative growth (or decline) would then be a temporary, self-conscious, adjustment process of moving from one steady state to another. Continuous, automatic, quantitative growth, far from being the norm of a healthy economy, is ruled out. This contrasts vividly with the prevailing economy of high mass consumption, characterized by W. W. Rostow in the following words: "Growth becomes its normal condition. Compound interest becomes built, as it were, into its habits and institutional structure."* But the solution has become the problem. Our habits and institutions must be weaned away from their addiction to compound interest.

To attempt to redesign the world so as to allow for unlimited physical growth is sheer hubris. Yet man's craving for the infinite has been corrupted by the temptation to satisfy this hunger in the material realm. Turn these stones into bread, says Satan, and modern man sets to it, even to the literal extent of devising energy-intensive schemes to grind up ordinary rock for minerals. But Jesus's answer to the same temptation was that man does not live by bread alone. The object of economic activity is to have *enough* bread, not infinite bread, not a world turned into bread, not even vast storehouses full of bread. The infinite hunger of man, his moral and spiritual hunger, is not to be satisfied, is indeed exacerbated, by the current demonic madness of producing more and more things for more and more people, world without end. Modern man has an infinite itch, but he is scratching in the wrong place and his frenetic material clawing is drawing blood from the life-sustaining circulatory systems of the biosphere.

It is necessary to be clear on the paramount importance of the moral issue contained in the second proposition. We could opt to destroy the spaceship in a scratching orgy of procreation and consumption. The *only* arguments against doing this are religious and ethical: the obligation of stewardship for God's creation, the extension of brotherhood to future generations, and of some appropriate degree of brotherhood to sub-human life. Furthermore, although moral and social limits to growth are less recognizable than biophysical limits, they are likely to be much more severe. For example, the social problem of safeguarding plutonium from immoral uses and consequences is a more stringent limit to breeder reactor usage than

*The Stages of Economic Growth, Cambridge, England, Cambridge University Press, 1960, p. 7.

is the physical constraint of thermal pollution. The apparent willingness of many to push the commercialization of a technology so dangerous that in Nobel laureate Hannes Alfven's words, "no acts of God can be permitted," and that is not even insurable by market criteria, is an impressive index of the strength of the growth idolatry. It is simply not true that there is no alternative for confronting the "energy shortage." It is true, however that the obvious alternatives of solar energy, improved use of coal, and perhaps fusion, would probably require higher energy prices and a period of stable consumption. Stockholders would no longer enjoy a growth boom.

It will be objected that many people today do not yet have enough bread. Surely brotherhood requires *more* growth, including crash development of atomic power. But past growth in aggregate bread has done little for these people, since distribution has remained very unequal, and since population has grown rapidly, especially the poorer populations of the world. Distribution is a moral problem, as is population control, and we lack the moral resources to solve these problems because our limited energies have been overwhelmingly devoted to material growth, while morality has been relegated to the status of pre-scientific superstition. And not just in the United States. Witness the Soviet authorities' negative response to Alexander Solzhenitsyn's advocacy of "ethical socialism" or "ethics first, economics afterward." The following passage from his *Cancer Ward* tells the story of both the U.S.A. and U.S.S.R.

> When we have enough loaves of white bread to crush them under our heels, when we have enough milk to choke us, we still won't be in the least happy. But if we share the things we don't have enough of, we can be happy today! If we care only about 'happiness' and about reproducing our species, we shall merely crowd the earth senselessly and create a terrifying society . . . .

The Biblical admonition, "Seek ye first the kingdom of God and his righteousness, and all these things will be added unto you," has been inverted—"add unto yourselves more of all these things, and righteousness can go seek itself." The sins of present injustices will be washed away in a sea of future abundance vouchsafed to us by the amazing grace of compound interest. We thought we could grow our way out of poverty and injustice, but we were wrong. There is just not room for that much growth, even on the doubtful assumption that growth tends to lessen poverty. We have chased the infinite in

the limited material realm, and have accepted shamefully modest limits in the infinite moral realm. Our present economic institutions are designed in harmony with this double mistake. To reverse the double mistake, to achieve a political economy of biophysical equilibrium and moral growth, or for short a steady-state economy, will require radical institutional changes as well as paradigm shift in economic theory.

The current economic paradigm begins with non-physical parameters (technology, preferences, and distribution of wealth and income are all taken as "givens"), and then inquires how the physical variables of quantities produced and resources used must be adjusted to fit an equilibrium (or an "equilibrium rate of growth") determined by these non-physical parameters. The non-physical conditions are considered to be autonomous, while the physical conditions are accommodating. The new paradigm, however, must begin with physical parameters (a finite world, a complex ecosystem, the laws of thermodynamics) and inquire how the non-physical variables of technology, distribution and life styles can be brought into a feasible and just equilibrium with the complex biophysical system of which we are a part. The physical conditions become autonomous and the non-physical patterns of economic life assume the accommodating role.

Three Institutions for a Steady-State Economy: Some Disciplined Speculations

The guiding design principle for the three institutions is to provide the necessary social control with a minimum of sacrifice of personal freedom, to provide macro-stability while allowing for micro-variability, to combine the macro-static with the micro-dynamic. To do otherwise, to aim for micro-stability and control is likely to be self-defeating and result in macro-instability as the capacities for spontaneous coordination, adjustment, and mutation (which always occur on the micro level) are stifled by central planning with its inevitable rigidities and information losses. The micro is the domain of indeterminacy, novelty, and freedom. The macro or aggregate is the domain of determinacy, predictability and control. We should strive for macro control and avoid micro meddling. A second design principle, closely related to the first, is to maintain considerable slack between

the actual environmental load and the maximum carrying capacity. The closer the actual approaches the maximum the less is the margin for error, and the more rigorous, finely-tuned, and micro-oriented our controls will have to be. We lack the knowledge and ability to assume detailed control of the spaceship, so therefore we must leave it on "automatic pilot," as it has been for eons. But the automatic pilot only works when the actual load is small relative to the conceivable maximum.* A third design principle, important for making the transition, is to build in the ability to tighten constraints gradually.

If our speculative model is ever to amount to more than speculation it must not present insurmountable problems of transition. In other words, it must build on existing institutions and be approachable from existing initial conditions, rather than requiring an impossible "clean slate." The model outlined below builds on the existing basic institutions of private property and the price system, and is thus fundamentally conservative. But it demands an extension of these controlling institutions to areas previously exempt from their discipline: control of aggregate births, and aggregate depletion. Extending the domain of the market to these vital areas highlights the main weakness of the market system—excessive inequality in wealth and income distribution. Such major extensions are intolerable unless this principle defect is removed by setting definite limits to the degree of inequality. In this respect the model is "radical," or if one prefers, "reactionary," in the sense of seeking a return to Populist and Jeffersonian traditions.

The kinds of institutions required follow directly from the definition of a steady-state economy: constant stocks of people and physical wealth maintained at some desirable chosen level by a low rate of throughput. We need: (1) an institution for stabilizing population (the Boulding marketable license plan); (2) an institution for stabilizing physical wealth and keeping throughput below ecological limits (marketable depletion quotas auctioned by the government); (3) a distributist institution limiting the degree of inequality in the distri-

*To the optimistic micro meddlers who do not believe in "automatic pilots" or "invisible hands" and thus want to assume detailed control of spaceship and crew, I can only quote Elisa Dolittle's reply to Mr 'iggins, "without your pulling it the tide comes in, without your twirling it the earth will spin, without your pushing them the clouds roll by, and if they can do it without you, ducky, so can I!" Skeptics who totally deny the "invisible hand" should read Eastern European economists' discussions of overcentralization and the resulting waste of resources.

bution of the constant stocks among the constant population (maximum and minimum limits to personal wealth and income).

Let us outline briefly how each institution might function, and how they interrelate.

DISTRIBUTIST INSTITUTION

The critical institution is likely to be the minimum and maximum limits on wealth and income. Without this, private property and the whole market economy lose their moral basis, and there would be no strong case for extending the market to cover birth quotas and depletion quotas as a means of institutionalizing environmental limits. Exchange relations are mutually beneficial among relative equals. Exchange between the powerful and the powerless is often only nominally voluntary and can easily be a mask for exploitation, especially in the labor market, as Marx has shown.

There is at least some political support for a minimum income financed by a negative income tax, as an alternative to bureaucratic welfare programs. However, no such support exists for a maximum income or for either maximum or minimum wealth limits. In the growth paradigm there need be no upper limit. But in the steady-state paradigm there is an upper limit to the total, and the higher the minimum per capita share, the lower must be the maximum per capita share. A minimum wealth limit may not be feasible, since one can always spend his wealth and could hardly expect to have it restored year after year. The minimum income would be sufficient. But maximum limits on wealth and income are both necessary, since wealth and income are largely interchangeable, and since beyond some point the concentration of wealth becomes inconsistent with both a market economy and political democracy. John Stuart Mill put the issue very well:

> Private property, in every defense made of it, is supposed to mean the guarantee to individuals of the fruits of their own labor and abstinence. The guarantee to them of the fruits of the labor and abstinence of others, transmitted to them without any merit or exertion of their own, is not of the essence of the institution, but a mere incidental consequence which, when it reaches a certain height, does not

> promote, but conflicts with, the ends which render private property legitimate. (*Principles of Political Economy,* Book II, Chapter I, "Of Property")

According to Mill private property is legitimated as a bastion against exploitation. But this is true only if everyone owns some minimum amount. Otherwise private property, when some own a great deal of it and others have very little, becomes the very *instrument* of exploitation, rather than a guarantee against it. It is implicit in this view that private property is legitimate only if there is some distributist institution (like, for example, the Jubilee year of the Old Testament) which keeps inequality of wealth within some justifiable limits. Such an institution is now lacking. The proposed institution of maximum wealth and income, plus minimum income limits would remedy this severe defect and make private property legitimate again. Also it would go a long way toward legitimating the free market, since most of our blundering interference with the price system (e.g. farm program, minimum wage, rent controls) has as its goal an equalizing alteration in the distribution of income and wealth. Thus such a distributist policy is based on impeccably respectable premises: private property, the free market, opposition to welfare bureaucracies and central control. It also heeds the radicals' call of "power to the people" since it puts the source of power, namely property, in the hands of the many people, rather than in the hands of the few capitalist plutocrats and socialist bureaucrats.

Maximum income and wealth would remove many of the incentives to monopolistic practices. Why conspire to corner markets, fix prices, etc., if you cannot keep the loot? As for labor, the minimum income would enable the outlawing of strikes, which are rapidly becoming intolerable. A labor monopoly would not be needed as a means of confronting the power of concentrated wealth since wealth would no longer be concentrated. Indeed, the workers would have a share of it and thus would not be at the mercy of an employer. In addition, some limit on corporate size would be needed, or else a requirement that all corporate profits be distributed as dividends to stockholders.

With no large concentrations in wealth and income, savings would be smaller and would truly represent abstinence from consumption rather than surplus remaining after satiation. There would be less expansionary pressure from large amounts of capital seeking ever-new ways to grow exponentially.

The minimum income could be financed out of general revenues, which, in addition to the progressive income tax within the income limits, would also include revenues from the depletion quota auction, and 100% marginal tax rates on wealth and income above the limits. Upon reaching the maximum most people would devote their further energies to non-economic pursuits, so the latter revenues would be small. But the opportunities thus foregone by the wealthy are available to the not-so-wealthy, who will still be paying taxes on their increased earnings. The effect on incentive will be negative at the top, but positive at lower levels leading to a broader participation in running the economy. There may also be an increase in public service. As Jonathan Swift argued:

> In all well-instituted commonwealths, care has been taken to limit men's possessions; which is done for many reasons, and, among the rest, for one which, perhaps, is not often considered; that when bounds are set to men's desires, after they have acquired as much as the laws will permit them, their private interest is at an end, and they have nothing to do but to take care of the public. ("Thoughts on Various Subjects," in *The Literature of England,* G. B. Woods et. al., eds., Scott, Foreman and Co., 1958, p. 1003)

MARKETABLE LICENSES TO HAVE CHILDREN

For maintaining a constant population an ingenious institution has been proposed by Kenneth Boulding. Unfortunately it has been treated more as a joke than as a serious proposal, and in fact does seem absurd until one has thought about it for a while. The idea is to issue directly to individuals licenses to have children. Each person receives certificates in an amount permitting 1.1 children, or each couple at marriage receives certificates permitting 2.2 children, or whatever number corresponds to replacement fertility. The licenses can be bought and sold on a free market. Thus macro-stability is attained, micro-variability is permitted. Furthermore those having more than two children must pay for an extra license, those having fewer than two children receive payment for their unused license certificates. The right to have children is distributed equally. Market supply and demand then redistribute these rights according to differing preferences and abilities to pay. People who do not or cannot have children are rewarded financially. People who wish to have

more than two are penalized financially. And the subsidies and penalties are handled by the market with no government bureaucracy.

A slight amendment to the plan might be to grant 1.0 certificates to each individual and have these refer not to births but to "survivals." If someone dies before he has a child then his certificate becomes a part of his estate and is willed to someone else, e.g. his parents, who either use it to have another child or sell it to someone else. The advantage of this modification is that it offsets existing class differentials in infant and child mortality. Without the modification a poor family desiring two children could end up with two infant deaths and no certificates. The best plan of course is to eliminate class differences in mortality, but in the meantime this modification may make the plan initially easier to accept. Indeed, even in the absence of class differentials the modification has the advantage of building in a "guarantee."

There is an understandable reluctance to couple money and reproduction—somehow it seems to profane life. Yet life is physically coupled to increasingly scarce resources, and resources are coupled to money. If population growth and economic growth continue, then newly scarce resources such as breathable air will either become coupled to money and subject to price, or allocated by a harsher and less efficient means. Once we accept the fact that the price system is the most efficient mechanism for sharing and rationing the right to scarce life-sustaining and life-enhancing resources, then perhaps rather than "money profaning life" we will find that "life sanctifies money." It is not the exchange relationship that debases life, it is the underlying inequality in wealth and income beyond any functional or ethical justification, that loads the terms of free exchange against the poor. The same inequality also debases the "gift relationship" since it reduces the poor to the status of a perpetual dependent, and the rich to the status of a weary and grumbling patron. Thus gift as well as exchange relationships require limits to the degree of inequality if they are not to subvert their legitimate ends.

Let us dispose of two common objections to the plan. First it is argued that it is unjust because the rich have an advantage. Of course the rich *always* have an advantage, but is their advantage increased or decreased in Boulding's plan? Clearly it is decreased. The effect of the plan on income distribution is equalizing because (1) the new marketable asset is distributed equally, (2) as the rich have more children their family per capita incomes are lowered, as the poor

have fewer their family per capita incomes increase. Also from the point of view of the children there is something to be said for increasing the probability that they will be born richer rather than poorer. Whatever injustice there is in the plan stems from the existence of rich and poor, not from Boulding's plan which actually reduces the degree of injustice. Furthermore, income and wealth distribution are to be controlled by a separate institution, discussed above, so that in the overall system this objection is more fully and directly met.

A more reasonable objection raises the problem of enforcement. What to do with law-breaking parents and their illegal children? What do we do with illegal children today? One possibility is to put the children up for adoption and encourage adoption by paying the adopting parents the market value, plus subsidy if need be, for their license, thus retiring a license from circulation to compensate for the child born without a license. Like any other law breakers the offending parents are subject to punishment. The punishment need not be drastic—e.g. a year's paid labor in a public child care center. Of course if everyone breaks a law no law can be enforced. The plan presupposes the acceptance by a large segment of the public of the morality and necessity of the law. It also presupposes widespread knowledge of contraceptive practices. But these presuppositions would apply to any institution of population control, except the most coercive.

Choice may be influenced in two ways: by acting on or "rigging" the *objective* conditions of choice (prices and incomes in a broad sense), or by manipulating the *subjective* conditions of choice (preferences). Boulding's plan imposes straightforward objective constraints and does not presumptuously attempt to manipulate peoples' preferences. Preference changes due to individual example and moral conversion are in no way ruled out. If preferences should change so that, on the average, the population desired replacement fertility, the price of a certificate would approach zero and the objective constraint would automatically vanish. The current decline in the birth rate has perhaps already led to such a state. The moral basis of the plan is that everyone is treated equally, yet there is no insistence upon conformity of preferences, the latter being the great drawback of "voluntary" plans which rely on official moral suasion and Madison Avenue techniques. Some people, God bless them, will never be persuaded, and their individual nonconformity wrecks the moral basis (equal treatment) of "voluntary" programs.

DEPLETION QUOTAS

The strategic point at which to impose control seems to me to be the rate of depletion of material resources, particularly non-renewable resources. If we limit aggregate depletion, then by the law of conservation of matter and energy we will also indirectly limit aggregate pollution. Entropy is at its minimum at the input (depletion) end of the throughput pipeline, and at its maximum at the output (pollution) end. Therefore it is physically easier to monitor and control depletion than pollution—there are fewer mines, wells, and ports than there are smokestacks, garbage dumps, and drainpipes, not to mention such diffuse emission sources as run-off of insecticides and fertilizers from fields into rivers and lakes, and auto exhausts. Given that there is more leverage in intervening at the input end, should we intervene by way of taxes or quotas? Quotas, if they are auctioned by the government rather than allocated on non-market criteria, have an important net advantage over taxes in that they definitely limit aggregate throughput, which is the quantity to be controlled. Taxes exert only an indirect and very uncertain limit. It is quite true that given a demand curve, a price plus a tax determines a quantity. But demand curves shift and are subject to great errors in estimation, even if stable. Demand curves for resources could shift up as a result of population increase, change in tastes, increase in income, etc. Every time we increase a price (internalize an externality) we also increase an income, so that in the aggregate the economy can still purchase exactly as much as before. The government taxes throughput and then spends the tax. On what? On throughput. If government expenditures on each category of throughput were equal to the revenues received from taxing that same category, then the limit on throughput would be largely cancelled out. If the government taxes resource-intensive items and spends on time-intensive items there will be a one-shot reduction in aggregate physical throughput, but not a limit to its future growth. A credit expansion by the banking sector, an increase in velocity of circulation of money, or deficit spending by the government for other purposes could easily offset even the short-run reduction induced by taxes. Taxes can influence the amount of depletion and pollution (throughput) per unit of GNP but taxes provide no limit to the increase in the number of units of GNP and thus no limit to aggregate throughput. The fact that a tax levied on a single resource could usually reduce the throughput of

that resource very substantially should not mislead us into thinking that a general tax on all resources will reduce aggregate throughput (fallacy of composition). It is *quantity* that affects the ecosystem, not price, and therefore it is ecologically safer to let errors and unexpected shifts in demand result in price fluctuations rather than in quantity fluctuations. Hence quotas.

Pollution taxes also provide a much weaker inducement to resource-saving technological progress than do depletion quotas since in the former scheme resource prices do not necessarily have to rise and may even fall. The inducement of pollution taxes is to "pollution avoidance," and thus to recycling. But increased competition from recycling industries, instead of reducing depletion, might spur the extractive industries to even greater competitive efforts. Intensified search and the development of technologies with still larger jaws (e.g. strip mining) could speed up the rate of depletion and thereby lower resource prices. Thus new extraction might once again become competitive with recycling, leading to less recycling and more depletion—exactly what we wish to avoid. This perverse effect could not happen under a depletion quota system.

The usual recommendation of "pollution taxes" would seem, if the above is correct, to intervene at the wrong end with the wrong policy tool. Intervention by pollution taxes also tends to be micro control, rather than macro. There are, however, limits to the ability of depletion quotas to influence the qualitative nature and spatial location of pollution, and at this fine-tuning level pollution taxes would be a useful supplement.

How might a depletion quota system function? Let there be quotas set on new depletion of each of the basic resources, both renewable and non-renewable, during a given time period. Let legal rights to deplete up to the amount of the quota for each resource be auctioned off by the government, at the beginning of each time period, in conveniently divisible units, to private firms, individuals and public enterprises. After purchase from the government the quota rights are freely transferable by sale or gift, and can be retained for use in subsequent time periods. As population growth and economic growth press against resources the prices of the depletion quotas will be driven higher and higher. Reduction of quotas to lower levels in the interest of conservation of non-renewables and sustainable exploitation of renewables would drive the price of quotas still higher. The increasing windfall rents resulting from increasing pressure of

demand on fixed supply would be captured by the government through the auctioning of the depletion rights. The government spends the revenues, let us say, by paying a social dividend. Even though the monetary flow is therefore undiminished, the real flow (throughput) has been physically limited by the resource quotas. All prices of resources and of goods increase, with the prices of resource-intensive goods increasing relatively more. Total resource consumption (depletion) is reduced. Moreover, by the law of conservation of matter-energy, if ultimate inputs are reduced so must ultimate outputs (pollution) be reduced. The aggregate throughput is reduced and with it the gross stress it puts on the ecosystem.

With depletion now more expensive and with higher prices on final goods, recycling becomes more profitable. As recycling increases, effluents are reduced even more. Also higher prices make consumers more interested in durability and careful maintenance of wealth. The extra burden to the poor of increased prices can be more than offset via the distributist institution. Most importantly there is now a strong price incentive to develop new resource-saving technologies and patterns of consumption. If there is any static efficiency loss in setting the rate of depletion outside the market (a doubtful point), it seems to be more than offset by the dynamic benefits of greater inducements to resource-saving technological progress.

The adjustment of depletion and pollution flows (throughput) to long run ecologically sustainable levels can be effected gradually. In the first year depletion quotas could be set at last year's levels, and if necessary gradually reduced by say 2 percent per year until we reach an equilibrium level of stocks of wealth requiring that "optimal" throughput for its maintenance. Thereafter the constant stock will be maintained by the minimal throughput.[1] As we gradually exhaust non-renewable resources their quotas will approach zero and recycling will become the only source of inputs. By this time,

[1]Over the long run maintenance of a constant stock will require an *increasing* throughput, because of the entropy law. As concentrated mineral deposits are exhausted ever greater quantities of materials must be processed using ever greater amounts of energy and capital equipment to get the same amount of pure mineral. Improved technology can lower throughput per unit of stock in the short run and "middle run," but cannot reverse the long run trend. Since minimum throughput requirements will increase over the long run, a steady-state economy, in the strictist sense of the term, is an impossible ideal which can be approximated but never attained.

presumably, the ever-rising price of the resource would have induced a recycling technology. Without quotas this resource exhaustion need not be gradual. Also, without quotas, the incentive to develop the new technology is less, since one must face the uncertainty that some newly discovered reserves will lower resource prices and make the resource-saving technology temporarily uneconomic. When the rate of depletion becomes a social parameter it can be taken as known, and uncertainty will be less. Discoveries of new reserves will increase the length of time until exhaustion, rather than lowering the price.

With depletion quotas the aggregate rate of depletion becomes a social decision. This can be regarded as the correction of a market failure. For renewable resources quotas can be set at a calculated optimum sustainable yield or maximum rent, thus correcting the market failure of over-exploitation. The quota on renewables must be such as to avoid "eating into our capital." For privately owned and well-managed renewable resources the quotas would be redundant and could be dispensed with. Since with non-renewables mankind is always eating his capital the rate of depletion should be a collective decision based largely on value judgments—once we are below ecological disaster thresholds. But two considerations argue for lower rates of depletion and higher prices than now prevail: first the conservationists' moral concern about future generations, and secondly the idea that resource-saving technology can be induced by high resource prices. The rate of depletion of the stock of terrestrial low entropy is fundamentally a moral decision and should be decided on grounds of ethical desirability (stewardship), not technological possibility or present value calculations of profitability. By fixing the rate of depletion we force technology to focus more on the flow sources of solar energy and renewable resources. The solar flux cannot be increased in the present at the expense of the future. Thus let technology devote itself to learning how to live off our solar income, rather than our terrestrial capital. Such advances will benefit all generations, not just the present.

The issue is clarified by the following simple, yet insightful observation by Georgescu-Roegen:

> Man's natural dowry, as we all know, consists of two essentially distinct elements: (1) the *stock* of low entropy on or within the globe, and (2) the *flow* of solar energy, which slowly but steadily diminishes in intensity with the entropic

> degradation of the sun. But the crucial point for the population problem as well as for any reasonable speculations about the future exosomatic evolution of mankind is the relative importance of these two elements. For as surprising as it may seem, the entire stock of natural resources is not worth more than a few days of sunlight.*

The exosomatic or technological evolution of mankind over the last two centuries has depended almost entirely on the less abundant stock source of man's "natural dowry," thus shifting our dependence away from the more abundant solar flow. How ironic, then, to be told by growth boosters that technical progress has reduced man's dependence on natural resources! But this does not mean that technical evolution cannot be redirected. Indeed, the main goal of the depletion quota plan is to turn technical change away from increasing dependence on the terrestrial stock and toward the more abundant flow of solar energy and renewable sources. As the stock becomes relatively more expensive it will be used less in direct consumption and more for investment in "work gates" which increase our ability to tap the solar flow. Instead of taking long run technical evolution as a parameter to which the short run variables of price and quantity continually adjust, the idea is to take short run quantities (and hence prices) as a social parameter to be set so as to induce a direction of technical evolution more in harmony with mankind's long run interests.

The depletion quota plan should appeal both to technological optimists and pessimists. The pessimist should be pleased by the conservation effect of the quotas, while the optimist should be pleased by the price inducement to resource-saving technology. The optimist tells us not to worry about running out of resources because technology embodied in reproducible capital is a nearly perfect substitute for resources. As we run out of anything prices will rise and substitute methods will be found. If one believes this, then how could one object to quotas, which simply increase the scarcity and prices of resources a bit ahead of schedule and more gradually? This plan simply requires the optimist to live up to his faith in technology.

Like the maximum limits on income and wealth, the depletion quotas could also have a trust-busting effect if accompanied by a

*Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, 1971, p. 21.

limit—e.g. no single entity can own more than x per cent of the quota rights for a given resource, or more than y per cent of the resource owned by the industry of which it is a member. "X" and "y" could be set so as to allow legitimate economies of scale while curtailing monopoly power.

A further effect of the quota scheme is that relative factor prices would change, with labor becoming cheaper relative to natural resources and capital. This effect by itself would tend to increase employment, which in itself is not a benefit, but is necessary as long as we maintain an income-through-jobs system of distribution. However, reduced aggregate consumption would tend to reduce employment. If the latter effect predominated, a job-sharing reduction in the work week might be needed, or increased reliance on unearned income, such as a social dividend financed out of receipts from the auction of resource quotas, or capital income to a worker resulting from wider distribution of capital ownership. But we have a distributist institution designed to accomplish these ends, which are desirable on their own account.

The actual mechanics of quota auction markets for three or four hundred basic resources would present no great problems. The whole process could be computerized since the function of an auctioneer is purely mechanical. It could be vastly simpler, faster, more decentralized, and less subject to fraud and manipulation than today's stock market. Also, qualitative and locational variation among resources within each category, though ignored at the auction level, will be taken into account in price differentials paid to resource owners.

The depletion quota and birth quota systems bear an obvious analogy. The difference is that the birth quotas are equally distributed and privately held initially, and then redistributed among individuals through the market, while the depletion quotas are collectively held initially and then distributed to individuals by way of an auction market. The revenue derived from birth quotas is private income, the revenue from depletion quotas is public income.

The scheme could and probably must be designed to include imported resources. The same depletion quota right could be required for importation of resources, and thus the market would determine the proportions in which our standard of living is sustained by depletion of national and foreign resources. Imported final goods would then be cheaper relative to national goods, assuming foreigners do

not limit their depletion. Our export goods would then be more expensive relative to the domestic goods of foreign countries. We would tend to a balance of payments deficit. But with a freely fluctuating exchange rate a rise in the price of foreign currencies relative to the dollar would restore equilibrium. It might be objected that limiting our imports of resources will work a hardship on the many underdeveloped countries who export raw materials. This is not clear, because such a policy will also force them to transform their own resources domestically rather than through international trade. Finished goods would not be subject to quotas. Also foreign suppliers of raw materials are treated no differently from domestic suppliers. In any case it is clear that in the long run we are not doing the underdeveloped countries any favor by using up their resource endowment. Sooner or later they will begin to drive a hard bargain for their non-renewable resources, and we had best not be too dependent on them. Eventually population control and environmental protection policies might become preconditions for membership in a new free-trade bloc or common market.

Political Feasibility

As of 1973 the political feasibility of these institutions is obviously nil. Nor should it be otherwise, since this suggestion represents a tentative beginning, not a detailed, widely-critiqued, mature proposal. It may contain terrible mistakes. If so critics will discover them, and will suggest remedies and improvements.

But over the medium run of say ten years, such institutions may appear less extreme than the physical costs of the trends generated by our current institutions. Consider, for example, that although the President's Commission on Population Growth and the American Future did not advocate a marketable licence plan for population control, it did recommend that the nation "welcome and plan for a stabilized population." Furthermore, it listed some criteria for a good stabilization plan. The Commission prefers "a course toward population stabilization which minimizes fluctuation in number of births; minimizes further growth; minimizes change required in reproductive habits and provides adequate time for such changes to be adopted; and maximizes variety and choice in life styles while minimizing pressures for conformity." On these criteria the marketable license

plan scores better than any alternative that I have seen or am able to imagine.

We now have a National Commission on Materials Policy and it remains to be seen what they will recommend. Probably they will recognize the need for higher resource prices. From this recognition will follow the intensification of the distribution issue, and the search for the most just and efficient way to raise resource prices. Depletion quotas will perhaps be discussed, though pollution taxes are almost certain to be favored initially. Economists have made the case that pollution taxes are superior to direct regulations and to subsidizing pollution abatement. But the alternative of depletion quotas (input control rather than output control) has not yet been widely debated. The 1952 Materials Policy Commission (the Paley Commission), though acknowledging that "We share the belief of the American people in the principle of Growth" (their capital G), also went on to make the following enlightened observation, "Whether there may be any unbreakable upper limit to the continuing growth of our economy we do not pretend to know, but it must be a part of our task to examine such limits as present themselves." This would be a good point of departure for the 1972 Commission.

The minimum income part of the distributist institution already has some political support. How much support one gets for the maximum income and wealth depends partly on where the limits are set. There are very, very few voters with more than $100,000 income and $500,000 net worth, and not many citizens who really believe that anything beyond those limits should not be classed as greed rather than need. The same could be said of limits set at one half the above. Exactly where we draw the line is less important than the principle that such lines must be drawn. A widespread recognition of the general closure of growth should increase the appeal of maximum limits and perhaps revive our Populist heritage. If we really want decentralized decision making and participatory democracy rather than a "plutonium-powered corporate kleptocracy," some such limit is essential. Yet there is still ample room for the principle of differential reward for differential effort and contribution. A jealous homogeneity is not the goal.

All three institutions operate on parameters of the price system and thus do not inhibit its proper functioning and the attainment of static allocative efficiency. All three institutions are capable of gradual application during the transition to a steady state. The birth quota

does not have to be immediately set at replacement, but could begin at existing levels and gradually approach replacement or even lower fertility. Initially the price would be zero, and would rise gradually as the number of certificates issued to each person was cut from say 1.1 to 1.0, to 0.9, or to whatever level is desired. The depletion quotas could likewise be set at present levels, or even at levels corresponding to a slower rate of increase than in the recent past. They could be applied first to those materials in shortest supply, and to those whose wastes are hardest to absorb, and then gradually extended to include nearly all minerals and fossil fuels. Initial prices on quota rights would be low, but then would rise gradually as growth pressed against the fixed quotas, or as quotas were reduced in the interest of conservation. In either case the increased scarcity rent becomes revenue to the government. The distribution limits might begin near the present extremes and slowly close to a more desirable range. The three institutions are amenable to any degree of gradualism one may wish. However the distribution limits must be tightened faster than the other two if the burden on the poor is to lightened.

But it is also the case that these institutions could be totally ineffective. Depletion quotas could be endlessly raised on the grounds of national defense, balance of payments, etc. Real estate and construction interests, not to mention the baby food and toy lobby, might convince Congress to keep the supply of birth licenses well above replacement levels. People at the maximum income and wealth limit may succeed in raising that limit by spending a great deal of their money on TV ads extolling the Unlimited Acquisition of Everything as the very foundation of the American Way of Life. And everything would be the same, and all justified in the sacred name of growth. Nothing will work unless we break our idolatrous commitment to material growth.

Thus we are brought back to the all important moral issues with which we began. A physical steady state, if it is to be worth living in, absolutely requires moral growth. Future progress simply must be made in terms of the things that really count, rather than the things that are merely countable.

CHAPTER SEVEN

LOCKE'S PARADIGM LOST: The Environmental Crisis and the Collapse of Laissez-Faire Politics[1]

by
William Ophuls

> Men are qualified for civil liberty in exact proportion to their disposition to put moral chains upon their own appetites.... Society cannot exist unless a controlling power upon will and appetite be placed somewhere, and the less of it there is within, the more there must be without. It is ordained in the eternal constitution of things, that men of intemperate minds cannot be free. Their passions forge their fetters.
>
> —Edmund Burke

The causes and political implications of the environmental crisis are basically the same everywhere. The U.S. and the U.S.S.R. present the same symptoms and, to a surprising extent, confront similar political dilemmas.[2] For poor nations, the crisis appears in a cruder Malthusian form, but the underlying similarities are apparent. Although environmental problems are clearly international in scope, I shall focus on the American political system and assert that we are about to enter a period of "extraordinary politics"[3] that will overthrow or drastically modify the paradigm of politics, based primarily on the thought of John Locke and Adam Smith, that we have held to since becoming an independent nation. The reader should have little trouble extending or modifying the analysis comparatively and internationally.

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[1]Revised version of a paper presented at the 1973 Annual Meeting of the American Political Science Association.

[2]Marshall I. Goldman, "The Convergence of Environmental Disruption," *Science,* Vol. CLXX (2 October 1970), p. 42.

[3]Sheldon S. Wolin, "Paradigms and Political Theories," *Politics and Experience,* ed. Preston King and B. C. Parekh (Cambridge, England: Cambridge University Press, 1968), pp. 125–52.

To grasp the meaning of the environmental crisis for politics, we must understand that the fundamental teaching of ecology is limits and that our encounter with these limits raises a specter we thought we had banished—scarcity. It is not just that many of those best things in life that once were free, like fresh water and clean air, have become exceedingly scarce goods. Rather, we must come to terms politically with the exigencies of what Boulding calls a "spaceman economy." We must avoid living on our capital and begin living more on our ecological income, while at the same time tailoring our numbers to our income to achieve a society in balance with nature over the long term. Like men on a spaceship that has no mines or sewers, our welfare depends not upon rapid consumption or more and more consumers, but on the extent to which we can create maximum richness and amenity for a reasonable population from minimum resources. A good, perhaps even affluent, life is possible, but "it will have to be combined with a curious parsimony"; in fact, "far from scarcity disappearing, it will be the most dominant aspect of the society. Every grain of sand will have to be treasured, and the waste and profligacy of our own day will seem so horrible that our descendents will hardly be able to think about us . . ."[1]. Let us examine some of the consequences of coping with this new and daunting kind of scarcity.

There are demonstrable limits on our ability to feed the number of people who will be with us in the next few decades; on the nonrenewable resources we need to sustain our style of civilization; on the ability of natural habitats and ecosystems to support the consequences of the scope and magnitude of exploitation to which they are about to be subjected; on the energy resources that are essential to maintain our current and projected levels of affluence; on our ability to come up with technological solutions to projected needs; on our ability to implement technological solutions in a timely, effective, and safe fashion even when they are available; and so forth. The crisis of industrial-scientific-technological civilization is global and it is developing very rapidly. The battle over auto emissions, the consequences of the energy crisis, the controversy over nuclear safety, the "cod war" between Britain and Iceland, starvation in Bangladesh, and other headline issues in recent months are a mild foretaste of the

[1]Kenneth E. Boulding, "Is Scarcity Dead?," *Public Interest*, No. 5 (Fall 1966), pp. 42–43.

kinds of difficult political, economic, and social issues that will increasingly confront us—but in starker form. To say this is not to make a doomsday *prediction.* There are many things that can be done to forestall the *projections* of the Club of Rome study,[1] and even in the absence of deliberate human action, various kinds of direct and indirect negative feedback effects—steeply rising prices of materials and energy, Malthusian catastrophes in the Third World, and our ad hoc responses to various sub-crises like those mentioned above—will change the time, intensity, and nature of our final collision with natural limits in ways that are mostly beyond our power of prediction.

If we accept these projections, however, a major problem for man is that most of what needs to be done by way of deliberate policy action entails political and social consequences that go against the grain. For example, the single most effective step that could be taken to stretch out the final collision with limits would be to reduce total ecosystem demand by stopping population growth, holding resource usage to current levels, and checking the rise in individual affluence. However, given the strongly held belief that the purpose of our government is to satisfy personal desires for expanding affluence, it is clear that reduction of demand in the foreseeable future will either be impossible or will require Draconian measures and probably a value revolution as well.

A second strategy for coping with emerging environmental imperatives—the use of various economic devices, such as the internalization of environmental costs, in order to bring the price system into line with ecological realities—also turns out to contain political problems. The internalization of costs means that consumers pay for what they used to get free, and the resulting price rise reduces people's standard of living. This too goes against the grain. Furthermore, the impact of raising the cost of essential goods and services will not be shared equally, but will be borne most heavily by lower-income groups. The current auto-emissions control strategy is a case in point. It will substantially increase the cost of owning and operating a private car in the next few years, and lower-income groups will feel the pinch far more than the middle class. Since the internalization of environmental costs does not increase productivity, wages at the

[1]Donella H. Meadows *et al., The Limits to Growth* (New York: Universe Books, 1972).

bottom of the income pyramid cannot be increased across the board to compensate for such price rises, and redistributive measures of the kind that the American political system has traditionally eschewed would be necessary to maintain even the present degree of inequality in purchasing power between income groups. It also appears as if even an essentially market strategy would still require a much greater degree of day-to-day political intervention and supervision of economic affairs than we have any precedent for in this country. Moreover, making explicit and open political decisions about economic issues we have hitherto left mainly to the invisible hand turns out to be anathema to dominant political and economic interest groups, for capitalism (whether market or state) is to a great extent an economy of hidden costs in which some benefit disproportionately from growth while others are forced to swallow most of the costs. In other words, to use Hirschman's apt term, there is a "hiding hand" behind the invisible hand.[1] Thus—as the political battles over environmental impact statements, the SST, and other issues show—the kind of honest assessment needed to make the market strategy of environmental management work effectively is resisted by those who now run the show and would stand to lose under the new dispensation. Finally, the basic issues involved in the internalization of costs and other economic devices are political and social—that is, they involve choices between competing goods which have no market price that can only be made by political decision. Daniel Bell sees in this development the end of a political economy dominated by the "economizing mode," which he contrasts to the "sociologizing mode"—"the effort to judge a society's needs in a more conscious fashion and . . . to do so on the basis of some explicit conception of the 'public interest' ".[2] But, says Bell, this will involve major political change, because "the movement away from governance by political economy to governance by political philosophy—for that is the meaning of the shift [from market to non-market decision-making]—is a return to precapitalist modes of thought".[3] Buried in the economic strategy for environmental

[1]Albert O. Hirschman, *Development Projects Observed* (Washington: Brookings Institute, 1967), chap. i.

[2]Daniel Bell, "The Corporation and Society in the 1970s," *Public Interest,* No.24 (Summer 1971), p. 18.

[3]*Ibid.*, p. 32.

management is, therefore, the abandonment of laissez faire and a return to something akin to classical politics.

The third line of defense against the emerging crisis is technological innovation. However, even if successful, this leaves us with serious political issues, for it exposes us to greater and greater risk of accident and error. It is strange that technologists—who discovered the infamous Murphy's Law stating that "If something can possibly go wrong, it will"—should so often assume that they can make their creations invulnerable to acts of God or fool-proof and fail-proof in normal operations. Given our dependence on a complex technological superstructure, even relatively benign failures, such as area-wide blackouts, can create serious problems. How much more so with the untried and inherently dangerous technologies we are now rushing into use to cope with burgeoning demand. Take, for example, the breeder reactor. Plutonium, the basis of the breeder's fuel cycle, is one of the most toxic substances known to man. Its hazard to human health is extreme even in miniscule doses, and it has a half-life of about 25,000 years, meaning that any plutonium released to the environment will be around to plague us for a quarter of a million years. Alvin Weinberg is one of the few technologists to have confronted squarely the political and social issues embedded in this kind of technological "progress":

> We nuclear people have made a Faustian bargain with society. On the one hand, we offer . . . an inexhaustible source of energy [the breeder reactor] . . . . But the price that we demand of society for this magical energy is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to.[1]

Technological fixes offered as the answer to our environmental crisis will thus involve some rather major social fixes as well, and Weinberg tells us that one imperative is "the creation of a permanent cadre or priesthood of responsible technologists who will guard the reactors and the wastes so as to assure their continued safety over millennia."[2] Obviously, major political questions are raised. Can we hope that our institutions will achieve the necessary level of efficiency and sustain

[1]Alvin M. Weinberg, "Social Institutions and Nuclear Energy," *Science*, Vol. CLXXVII (7 July 1972), p. 33.

[2]Alvin M. Weinberg, "Technology and Ecology—Is There a Need for Confrontation?," *BioScience*, Vol. XXIII, No. 1 (January 1973), p. 43.

it over millennia? Do we wish to be ruled by a priesthood of nuclear engineers? Is Weinberg's Faustian bargain really a pact with the Devil that will lead us inexorably down the path to total domination by technique and the machine and therefore to a society that may at best resemble Aldous Huxley's Brave New World?

These are but a few of the major political issues implicit in the environmental crisis. Let us now consider some specific challenges to American political institutions and values that result. My discussion is framed in terms of some possible answers to the issues found in the thought of the great theorists of politics. However, it is not my purpose to provide pat doctrinal answers. Too much is yet uncertain about the exact nature of ecological limits, the response of peoples and governments to the emerging crisis, and other factors to permit anyone confidently to assert a particular doctrine as the final solution. Instead, my purpose is to make clear the profound nature of the crisis and show that it re-raises the classic questions of political philosophy in an acute form. What is the nature and purpose of man and what is the good life for him here on earth? How is the common interest of the collectivity to be achieved when men throughout history have shown themselves to be passionate creatures prey to greed, selfishness, and violence? Or, if you prefer a more modern formulation, I wish to make plain that the question of *who* gets *what, when, how,* and *why* will probably have to be reexamined from start to finish.[1] Thus, I believe I am raising questions of profound importance that will dominate our political agenda in the decades to come in the way that the issues of church and state or the grounds of justified rebellion have been the overriding issues on the agenda of times past.

The environment is a common property resource of limited capacity and extent. The environmental crisis has its origin in the fact that this resource is no longer adequate to meet the level of demand placed on it. That is, environmental goods are now scarce. Because a scarcity of desired goods tends to produce conflict, we find in every human society the institution of property, designed to prevent or at least control the conflict over scarce resources. The controls assume many guises, from tabu to the English common law, but they are

[1]Harold D. Lasswell, *Politics: Who Gets What, When, How,* (Cleveland: World Meridian, 1958). The "why" part of the question is overlooked by Lasswell, a behavioral scientist rather than a political theorist, but it is an essential problem for the political philosopher.

universal. However, the environment is no one's property, for we have never regarded water, air and other taken-for granted ecological resources as scarce. Thus, the harm that men do to their environment and to their fellow men when they use common resources for their own benefit goes largely unregulated, and now that environmental goods are scarce, this creates problems.

There are many examples of inadequate controls over common property resources. Unregulated oil pools and ocean fisheries are notable illustrations. The whaling industry, in particular, is an example of what largely uncontrolled exploitation of a common property resource can do and of the difficulties of control when there is no common authority standing above the exploiters. However, underlying all examples of competitive overexploitation of both stock and flow common property resources is a single dynamic, first recognized by William Forster Lloyd, a little-known eighteenth-century political economist, who called it "the tragedy of the commons," a concept popularized in the 1960s by Garrett Hardin.[1] Lloyd used the example of a common pasture land that can support only so much grazing without deterioration. As long as the herds of the users are small in relation to the carrying capacity there is no problem. However, once the carrying capacity is reached, the situation changes radically. Any further increase in grazing will damage the commons and diminish the resource on which the herdsmen depend. Yet, even knowing this, each individual herdsman is likely to keep adding animals to his herd. He reasons that the additional gain from the added animals outweighs his proportionate share of the damage done to the commons, for the damage is done to the commons as a whole and is thus suffered by all the users. Worse, even if he is personally inclined to self-restraint, an individual herdsman justifiably fears that others will not be. They will increase their herds and gain thereby, while he will have to suffer equally the resulting damage. As a result, each herdsman is damned if he does but even more damned if he doesn't, so that competitive overexploitation of the commons is the inevitable and tragic result. (Pollution simply turns the problem around without altering the dynamic: the cost to me of controlling my emissions is so much larger than my share of

[1]Hardin has revived Lloyd's analysis and has extended it to modern population and pollution problems, with political implications to be explored below, in "The Tragedy of the Commons," *Science*, Vol. CLXII (17 December 1968), pp. 1243–48.

the environmental cost that it will always be rational for me to pollute if I can get away with it.) It is this "logic of the commons" leading to its ruin that underlies the exploitation of any common property resource.

The problem is that, as the human race has approached the carrying capacity of the earth, those things which used to be free goods, sharable by all men in peace and on equal terms, now become common property resources subject to the dynamics of competitive overexploitation. Thus, air and water are no longer free goods, but common property resources of great and increasing value. If men are permitted to continue to use them as though they were free goods, then we can expect a tragedy of the commons. This then is the crux of the pollution and population problems. What was free has become scarce and must therefore be placed under political and economic controls to prevent mutual ruin. The historical commons was rarely destroyed because social norms and political controls prevented overgrazing. We lack these kinds of restraints and must create them if our environmental commons is to be preserved.

It might be thought that the answer is to privatize all resources. Unfortunately, this is not possible. Air, water, outer space and the upper atmosphere, the oceans, biological cycles, and most other environmental resources cannot be effectively privatized. The smoke from factories or the exhaust gases from automobiles cannot be confined so that their noxious effects harm only those who produce them. There is no way that a farmer can prevent his DDT and fertilizer use from having an impact on others. Nor conversely, can others be prevented from enjoying the benefits of actions taken to clean up or enhance the environment. Even those kind of resources that we have usually controlled by privatization in the past turn out to be part of the commons after all. The timberman in cutting his trees may produce flooding, siltation, and generally lower water quality many miles away. The owner of a marshland who decides to sell to a developer intent on building a marina may also produce negative externalities that extend well beyond the boundaries of his marsh. If only one marsh is converted into a marina, the problems created are probably insignificant, but if all such marshes are developed, the aggregation of the single effects will cause serious and irreversible ecological degradation—again, the tragedy of the commons, for each owner stands to gain handsomely by selling out and knows that, if he does not sell, the next owner will.

Privatization alone also fails to preserve potentially renewable resources. The reason some timbermen practice clear-cutting instead of sustained-yield logging is that it is profitable. Why accept a modest income from your renewable resource when you can get rich quick by destroying it? Thus, men acting with complete rationality in their own self-interest find it advantageous to destroy resources, like air and water quality or future timber supplies, that are the basis of our common prosperity and sustenance. But given the nature of the "logic of the commons" outlined above, it is virtually guaranteed that this will happen. The life support system we humans share in common is indeed a "commons" of the kind described by Lloyd, and we seem bound to overexploit and abuse it if we are free to do so. Hardin's conclusion is that "freedom in a commons brings ruin to all" and that only stringent controls—"mutual coercion, mutually agreed upon by the majority of the people affected"—can break the logic that leads to mutual self-destruction.[1]

We have here the dynamic of the Hobbesian state of nature. Where men desire gain and the desired goods are scarcer than men's wants, they are likely to fall to fighting. They each know individually that all would be better off if they abstained from fighting and found some way of equitably sharing the desired goods. However, they also realize that they cannot alter the dynamics of the situation by their own behavior. Personal pacifism merely makes them a prey to others. Unless all men can be persuaded or forced to lay down their arms, nothing can prevent the war of all against all. The crucial problem in the state of nature is thus to make it safe for men to be reasonable, rather than merely "rational," and thereby share peacefully in what the environment has to offer. Hobbes's solution, of course, was the erection of a sovereign power by a majority that would constrain all men to be reasonable and peaceful.[2]

In the tragedy of the commons, the situation is not as stark—political order is not at stake—but it is in many ways much more insidious. Hobbes is widely held to have had an excessively gloomy view of human nature—that all men are wolves, say some critics—but this is, in part at least, a misunderstanding of Hobbes's argument

[1] *Ibid.*

[2] For a paper outlining the virtual identity of analyses and prescriptions in Hobbes and Hardin, see my "Leviathan or Oblivion?," *Toward a Steady-State Economy*, ed. Herman E. Daly (San Francisco: W. H. Freeman, 1973), pp. 215–30.

in *Leviathan.* Hobbes finds that even a sizable number of reasonable and good-hearted men cannot abolish the state of war between men, for in a state of nature without common authority to compel men to keep the peace, the substantial minority of unreasonable men is bound to dictate the terms of social interaction. In the commons situation, however, we need not assume evil propensities on the part of any man or group of men to demonstrate that the tragedy will occur. In most cases of competitive overexploitation, individuals are not even aware of the damage that their acts are causing, and if they are, their responsibility seems infinitesimally dilute. Thus, to bring about the tragedy of the commons, it is not necessary that men be bad, only that they not be actively good—that is, not altruistic enough to limit their own behavior when their fellows will not or to perform acts of public generosity on a regular basis. This can be verified in the behavior any one of us sees around him on a daily basis.[1] All that is thus required is that men be *hommes moyens sensuels* who behave in an accepted social fashion. A good illustration of the tragedy of the commons in operation is the situation of the inhabitants of Los Angeles vis-a-vis the automobile. Here is what Francis Carney has to say:

> But the automobiles are also the bearers of our greatest curse, the smog. Every person who lives in this basin knows that for twenty-five years he has been living through a disaster. We have all watched it happen, have participated in it with full knowledge just as men and women once went knowingly and willingly into the "dark Satanic mills." The smog is the result of ten million individual pursuits of private gratification. But there is absolutely nothing that any individual can do to stop its spread. Each Angeleno is totally powerless to end what he hates. An individual act of renunciation is now nearly impossible, and, in any case, would be meaningless unless everyone else did the same thing. But he has no way of getting everyone else to do it. He does not even have any way to talk about such a course. He does not know how or where he would do it or what language he would use.[2]

[1]Thomas C. Schelling, "On the Ecology of Micromotives," *Public Interest,* No. 25 (Fall 1971), pp. 61–98, provides dozens of homely examples.

[2]Francis Carney, "Schlockology," *New York Review of Books,* 1 June 1972, pp. 28–29.

Another example of how good and reasonable men, with little to gain personally, may nevertheless decide matters in ways that are calculated to bring on the tragedy of the commons is contained in the report of a committee of The National Academy of Sciences convened to study the DDT issue by the Environmental Protection Agency. In the words of *Science*'s reporter, the "panel concluded that, while DDT and its breakdown products were 'serious environmental pollutants', an outright ban of the pesticide in the United States would accomplish little, since the 'world burden of DDT is so high compared to current annual use in the U.S.' "[1] But it is precisely the essence of the tragedy of the commons that one's own contribution to the problem seems infinitesimally small, while the disadvantages of self-denial loom very large. Whenever one's interests are engaged, self-restraint appears to be both unprofitable and ultimately futile unless one can be certain of universal compliance.

It thus appears that if individuals rationally pursue their material self-interest in a situation of ecological scarcity unchecked by any common authority that would restrain them, the eventual result is bound to be mutual environmental ruin. In such a situation, the Hobbesian answer applies. We must somehow erect a sovereign to keep ecological order among us—Hardin's "mutual coercion, mutually arrived at by the majority of the people affected" or Hobbes's injunction that men come together and by majority decision form a commonwealth with sovereign power to compel obedience to what any reasonable man recognizes as the common good. The situation also exemplifies Rousseau's distinction between the "general will" and the "will of all." The former represents what reasonable men leaving aside their self-interest would regard as the right and proper course of action; the latter is the mere addition of the particular wills of the individuals forming the polity, based not on a conception of the common good, but only on what serves their own self-interest. In essence, Rousseau's answer in *The Social Contract* was not all that different from Hobbes's: man must be "forced to be free"—that is, made obedient to his real self-interest, which is the common good or general will. The problem that the tragedy of the commons forces us

[1] Robert Gillette, "DDT: In Field and Courtroom a Persistent Pesticide Lives On," *Science*, Vol. CLXXIV (10 December 1971), pp. 1108–10.

to confront is, in fact, the core issue of political philosophy: how to protect or advance the interests of the collectivity as a whole, when the individuals that make it up (or enough of them to create a problem) behave (or are impelled to behave) in a selfish, greedy, and quarrelsome fashion. The only answer is a sufficient measure of coercion. Following Hobbes, a certain minimum level of ecological order or peace must be established; following Rousseau, a certain minimum level of ecological virtue must be imposed by our political institutions.

It need hardly be said that these conclusions about the tragedy of the commons call into question fundamental American values. In a situation of ecological scarcity, the individual, possessing an inalienable right to pursue happiness as he defines it and exercising his liberty in a basically laissez-faire system, will inevitably produce the ruin of the commons. Accordingly, the individualistic basis of society, the concept of inalienable rights, the purely self-defined pursuit of happiness, liberty as maximum freedom of action, and laissez faire itself all require major modification if we wish to avoid inexorable environmental degradation and perhaps extinction as a civilization. Thus, democracy as we know it cannot survive. Either we reform ourselves deliberately on basically Hobbesian or Rousseauian principles, or we wait until ecological collapse brings on social and political collapse, and with it the destruction of our system of government—but this time in a completely unplanned way.

Some hope or assert that attitudinal change will bring about changes in individual behavior that will prevent a democratic, laissez-faire system from generating the logic of the commons. However, excepting very small and tightly-knit social groups, education or the inculcation of rigid social norms is not proof against the logic of the commons. It seems to be simply not true that, once they are aware of the gravity of the situation, men will naturally moderate their desires for children and their other demands on the environment. A recent study of members of Zero Population Growth (ZPG), a radically antinatalist pressure group, produced this melancholy conclusion: "In short, knowing that one child is necessary for immediate population stability [a ZPG goal] . . . has no bearing on personal intentions . . . and a majority of those recognizing the necessity of the one-child family intend to have two children—even when they believe the United States is already past its optimum population

size."[1] Similarly, a poll of Cornell students and faculty in the life sciences showed that, even when well aware of the potential contribution of their individual reproductive behavior to the overall problem, individuals still did not intend to regulate their behavior accordingly; a substantial majority (65%) intended to have at least three children.[2] If the individuals who are presumably among the most knowledgeable and concerned about population growth will not restrain themselves, how much less can we expect of the common man? As Hardin notes, hypocrisy is rampant: "It is fair to say that most people who anguish over the population problem are trying to find a way to avoid the evils of over-population without relinquishing any of the privileges they now enjoy."[3] Perhaps this harsh judgment is merited in some cases, but I believe that the individuals who were surveyed and polled are neither hypocritical nor irrational. They are simply caught in the "commons" dilemma and recognize, consciously or unconsciously, that their sacrifice of a desired good, in this case more children than their awareness tells them they should have, avails nothing unless everybody else goes along too. And population may be one of the easiest problems to solve by persuasion (in the United States). By contrast, even Dr. Pangloss would not expect us to solve the air pollution problem in Los Angeles via mass abstention from auto use.

The difficulty is, as previous examples have shown, that mere awareness of the gravity of the situation and of one's complicity in it is insufficient. It is not enough that individuals avoid evil. To forestall the logic of the commons, they must be prepared in overwhelming numbers to do positive good, whether or not cooperation is universal; and in a culture that conceives of the common interest as being no more than the sum of our individual interests, it seems unlikely that we can, as prudent men, count on too much help from unsupported altruism.

Others look for a solution not so much to individual conscience, but instead to the development of a collective conscience in the form of a world view or religion that would see man as the partner of nature

[1]Larry D. Barnett, "Zero Population Growth, Inc.," *BioScience*, Vol. XXI, No. 14 (15 July 1971), p. 764.

[2]Thomas Eisner *et al.*, "Population Control, Sterilization, and Ignorance," *Science*, Vol. CLXVII (23 January 1970), p. 337.

[3]Hardin, "The Tragedy of the Commons," p. 1243.

rather than its antagonist.[1] While this will undoubtedly be an essential development for our survival in the long term, Tuan points out that the treatment of the environment in China in ideal and in actuality differed considerably.[2] Despite a philosophy that was profoundly respectful of nature, the Chinese people have damaged their environment in many ways throughout their long history. Ironically, they were in fact far more destructive of their environment than premodern Europeans, who lacked a philosophy expressive of natural harmony. Chinese ideals were not proof against the urgency of human desires.

An additional problem is time. A serious lag in public understanding accompanies high rates of change and exponential growth. It seems to take two to four generations before the ideas at the frontier of science filter down even to the informed public. We have still not completely digested Darwin, much less Einstein and quantum mechanics. Many social scientists and educated laymen inhabit a totally Newtonian universe. There are very few modern men, according to Carl Jung's dictum, and I regret to report that for the most part even the faculties of our great universities appear to be no exception. It seems hard to believe that a reasonably sophisticated level of ecological understanding will be produced overnight, and even a dogmatized version could not be inculcated except over several decades. But, lacking such understanding, we as a society simply do not know the score and seem unlikely to learn it anytime soon; yet without knowing the score, even a completely altruistic society cannot behave responsibly.

Some, like Charles Reich,[3] say that our age is different and that a new consciousness is emerging. This view cannot simply be brushed aside, for substantial value changes are clearly occurring in some segments of American society, and out of this essentially religious ferment great things may come. However, the belief that these new values will become universal in the future would appear to be essentially a matter of faith at this point. Since past hopes for the emergence of a "new man" have been rudely treated by history, I

[1]Lynn White, Jr., "The Historical Roots of Our Ecologic Crisis," *Science,* Vol. CLV (10 March 1967), pp. 1203–07.

[2]Yi-Fu Tuan, "Our Treatment of the Environment in Ideal and Actuality," *American Scientist,* Vol. LVIII, No. 3 (May June 1970), pp. 244–49.

[3]Charles A. Reich, *The Greening of America* (New York: Random House, 1971).

find it difficult to be optimistic. Also, serious questions can be raised about the appropriateness of many so-called counter culture values, which too often seem to be mere inversions (or occasionally exaggerations) of those held by the majority culture. In any event, it would seem unwise, to say the least, to base public policy on what must regretfully be regarded as prophecy.

It appears therefore that individual conscience and the right kind of cultural attitudes are not by themselves sufficient to overcome the short-term calculations of utility that lead men to cause environmental degradation. Real altruism and genuine concern for posterity may not be entirely absent, but they are not present in sufficient quantity to avoid the tragedy. Only a government possessing great powers to regulate individual behavior in the common interest can deal with the tragedy of the commons effectively.

There appears to be very little hope that our political institutions as presently constituted can do much to prevent the tragedy of the commons from working itself out remorselessly. Although many critics depict policy-making as a kind of bargain struck between rival Mafia chieftains mutually guaranteeing each other in their respective turfs—"You leave me the drugs, and I'll leave you the prostitution"—at the expense of the public, in fact the general preferences of the American people are reasonably well reflected in political output. People want jobs and economic opportunities and a growing economy, and even if special interests benefit disproportionately from the measures taken to promote these ends, much of the benefit is transmitted to the vast majority of ordinary citizens. It is also a truism among political commentators that Congress rarely gets very far ahead of the public. In fact, it prefers to lag behind, waiting until enough popular pressure builds up to make it politically safe to support a measure that is in any way controversial. Naturally, to the extent that government is largely a brokerage house for special interests, the situation is worse, because they are the most direct beneficiaries of the exploitation of the environment. The problem is, then, that our political institutions are supremely responsive to our wills—but what we ask generates the tragedy of the commons. Moreover, the logic of the commons is enshrined in the style of decision-making known as "disjointed incrementalism," which is characteristic of all our institutions. Let us examine that style in some detail to show how under current conditions it is bound to bring about the destruction of the commons.

Lindblom[1] contrasts two different approaches to problem-solving. In the "synoptic" style, one identifies and rank-orders the values one wishes to achieve, comprehensively surveys all possible means of achieving those values, exhaustively examines the probable consequence of employing each of those means, and then chooses policies that will maximize achievement of the desired values. Lindblom finds this ideal unattainable. The limits on our intellectual capacities, the inadequacies of information (plus the cost and expense of remedying them), uncertainty about our values and conflicts between them, the exigencies of the time constraints on policy-making, and a number of other lesser factors make this model of decision-making an impossible one to practice.

Lindblom calls an alternate model, which he correctly says characterizes the actual way in which policy is made, "disjointed incrementalism" (or "muddling through," which more accurately conveys the flavor of the style). It has the following features:

1. Comparison and evaluation of increments or marginal changes only.
2. Consideration of only a restricted number of policy alternatives and of only a few of the important consequences for any given alternative.
3. "Reconstructive analysis"—i.e., the adjustment of objectives to what is "feasible" and "realistic."
4. Serial analysis and evaluation—i.e., dealing with problems piece-meal—combined with a remedial orientation—i.e., policies are designed to remedy obvious immediate ills rather than bring about some desired future state.

The comprehensiveness of policy is further reduced by the fact that analysis of policy alternatives is performed by partisan actors in the political system, who then bargain with other partisan actors to reach a compromise that is likely to give everybody something of what they ask for.

Lindblom's critique of the synoptic style is powerful. It is clearly an ideal type that is unachievable in practice. By contrast, disjointed incrementalism, very much like the market, is highly adapted to bringing about bargained compromises among political actors that satisfy their needs reasonably well at minimum intellectual and

[1]Charles E. Lindblom, *The Intelligence of Democracy: Decision Making Through Mutual Adjustment* (New York: Free Press, 1965).

financial cost. Yet, as Lindblom recognizes, such decision-making has no built-in guarantee that all relevant values will be taken into account, and otherwise excellent policies not suggested by past experience are likely to be overlooked. Thus, "policies will continue to be as foolish as they are wise."[1] Also, it is not well adapted to handle profound value conflicts, revolutions, crises, grand opportunities, and other situations where simple continuity of the past may not be the best guide to an appropriate response. Fundamentally, however, although he indicates that the use of the computer may give us a somewhat greater capacity for synoptic analysis in the future, Lindblom seems to feel that this is the best we can do. And he may be right.

There are, however, a number of fundamental difficulties with muddling through as a policy-making process in the context of the environmental crisis. First, in essence it is business as usual and laissez faire dressed up in fancy words, but as we have seen, these will be fatal impediments to meeting the challenge of the crisis. The short-term adjustment and stability achieved by muddling through can easily come at the expense of long-term stability, and since resistance to major change is the process by which most civilizations collapse, simple acceptance of the results of incrementalism is dangerous. It is perfectly possible, for example, to take a series of decisions that each seem eminently reasonable on the basis of short-term calculations of costs and benefits and that satisfy current preferences but which produce results that are unsatisfactory in the long run. This is, in fact, just how we got ourselves into an ecological mess—via the "tyranny of small decisions."[2]

Muddling through is also hand-tailored to fall into all the traps Forrester says await the non-systematic policy maker.[3] The remedial approach leads to relief of one set of symptoms, but this may well provoke a worse set somewhere else in the system (e.g., solving the energy crisis with the breeder reactor or killing pests with DDT). Also, intuition often leads to intervention in the system where leverage is weak and expenditure useless. In addition, the goals of

[1]Charles E. Lindblom, "The Science of 'Muddling Through,'" *Public Administration Review*, Vol. XIX, No. 2 (Spring 1959), p. 87.

[2]Alfred E. Kahn, "The Tyranny of Small Decisions: Market Failures, Imperfections, and the Limits of Economics," *Kyklos*, Vol. XIX, No. 1 (1966), pp. 23–47.

[3]Jay W. Forrester, *World Dynamics* (Cambridge: Wright-Allen, 1971), chaps. i, vii.

various sub-systems are likely to be maximized, producing a sub-optimal result for the system as a whole.

Moreover, the excessively short-term orientation of the muddling through approach is potentially fatal. Compromise is elevated to an end, when it should only be a means toward some desired end. Without some kind of long-range goals to guide our short-range choices, the cost/benefit and other calculations that we use to make decisions will not reflect our true values. For example, when Lindblom says that the costs of information gathering and analysis are high, these are short-term costs; in the long run, they might seem cheap if careful analysis produced a superior policy. Similarly, a shift to solar energy now might be the cheapest course of action for society over the long run, even at five times the current cost for nuclear power. Besides, without some consistency, coherence, and comprehensiveness in policy, we are simply adrift and at the mercy of the tyranny of small decisions, to say nothing of the tragedy of the commons.

The philosophy of disjointed incrementalism also assumes that one man's values are just as good as another's. Nobody has the right to impose his values on anyone else; the common interest does not exist; or, rather, what emerges from the policy process must be accepted as the only valid definition of the common interest. This is reinforced by positivist, "value-free" epistemology. If values are mere prejudices and all men are equal, then their values are equal, and the majority must rule. But if we want to survive, which is not so much a prime value as simply a basis for having any values at all, then to a large extent objective ecological values must dominate our personal prejudices and interests, and some particular interests will have to be suppressed in the interest of the whole. If we wish to do more than barely survive, then we must incorporate additional ecological values into our public philosophy. Thus, we can no longer have a policy-making process that simply aggregates and expresses the sum of our particular values as disjointed incrementalism is designed to do.

Finally, as critics have noted, disjointed incrementalism is a prescription for inertia, conservatism in the bad sense, and a passive acceptance of whatever the system cranks out as the best that we can do, all on the grounds that to ask more is to be "unrealistic." But obedience to this kind of "realism" in our current situation means that radical or revolutionary measures are ruled out right at the start,

and it is therefore a recipe for continued environmental degradation.

In sum, as a description, disjointed incrementalism provides an almost sufficient explanation of how we have proceeded step by step into the midst of an environmental crisis and of why we are not meeting its challenges at present; as a normative philosophy of government, it is a program for ecological catastrophe; as an entrenched reality with which the environmental reformer must cope, it is the chief cause for pessimism. And, in the final analysis, Lindblom is almost certainly correct in believing that little better is achievable within a democracy. Worse, abandoning a democratic politics oriented around process in favor of a democratic politics focussed on outcomes could have unpleasant consequences, for we have no ideological consensus apart from an agreement on process. Exchanging a political system in which the market process is paramount for one in which the ends of government are paramount may mean permanent crisis, a constant struggle over ends and means. With our ideological consensus about the nature and ends of politics shattered, we might experience at first-hand the darker side of democracy, documented all too fully in the pages of antiquity. In the face of deep crisis, democracy may simply not be a valid system of politics.

The presumption against democracy, at least as we know it, is strengthened when we consider the issue of competence. As Dahl notes, there is no necessary conflict between democracy and the criterion of competence, since it is entirely rational for a person to wish that the relevant decisions on issues that are beyond his personal competence be made by the most competent authority.[1] However, Dahl also notes that, where highly significant differences in competence exist, then effective rule may require the sacrifice of political equality:

> The case for democracy in the form of political equality and majority rule is therefore strongest where competence in the affairs of the association is widely diffused among the members, and where they share a substantial consensus on all important matters. Conversely, the greater the differences in competence among the members the weaker the case for political equality; the greater the amount of disa-

[1]Robert A. Dahl, *After the Revolution?: Authority in a Good Society* (New Haven: Yale, 1970), pp. 28–40, 56–58.

> greement among members, the weaker the case for majority rule.[1]

Dahl goes on to say that, where the members of a political association "differ *crucially* in their competence, [as is clearly the case with respect to hospitals and passenger ships,] a reasonable man will want the most competent people to have authority over the matters on which they are most competent".[2] In other words, the closer your situation resembles being embarked on a ship making a perilous voyage, the greater the rationale for placing power and authority in the hands of the few who know how to run the ship, which is more or less the argument of Plato's *Republic.*

Serious questions have long been raised about the competence of the average man in a highly complex civilization to decide on issues that he perforce little understands—that, in fact, even other highly-trained specialists attentive to policy matters do not understand fully. Yet, it is unlikely that people in a democracy will acknowledge the depth of their incompetence, and if politicians hold office on sufferance of the mass that may know little more than when its ox is gored, how can they impose heavy present costs or make policies that violate popular expectations in the interest of future advantages that are revealed only by knowledge or complex analysis? And even if the people accepted the competence of their elected political leaders, how competent are the latter, selected by an incompetent electorate, likely to be? Clearly very few have anything like a profound grasp of the environmental challenge in all its dimensions. Yet the earth and its various territories approach more and more closely the reality of the spaceship metaphor with each step toward the ultimate ecological limits, and it will require an extraordinarily high degree of competence to run this over-burdened, hard-pressed spaceship. In such a situation, political equality as we know it and simple majority rule cannot be retained if we wish to ensure our survival.

It will help in understanding the problems of our age if we place them in historical perspective. The historian Walter Prescott Webb notes that, in Europe before the discovery of the New World, "population pressed hard on the means of subsistence," and there was

[1] *Ibid.*, p. 57. Dahl thus supports the doubt expressed in the previous paragraph about the continued viability of majority-rule democracy in a society whose value consensus is broken.

[2] *Ibid.*, p. 582 (my italics).

"very little freedom [and] no means of escape for the people living in this closed world."[1] Then the "Great Frontier," an "enormous body of wealth without proprietors," was discovered, and

> the by-product of this wealth was freedom and our peculiar modern institutions and values. Individualism, democracy, etc., are all founded on boom conditions, a windfall, a horn of plenty—i.e., a sudden excess of land and resources for fixed numbers of people.[2]

Webb goes on to say that, of course, the idea of individualism antedated the discovery of the New World, but until then it had little opportunity for concrete expression. And individualism is the basis for the other features of modernity—self-rule or democracy, self-enrichment or capitalism and industrialism, and self-salvation or Protestantism. But "it is only in the presence of great abundance that such a free-for-all system of wealth-getting can long operate."[3] Furthermore,

> if we grant the boom, we must concede that the institutions we have, such as democracy and capitalism, were boom-born; we must also admit that the individual, this cherished darling of modern history, attained his glory in an abnormal period when there was enough room to give him freedom and enough wealth to give him independence.[4]

There are, says Webb, touts and peddlers of various new frontiers—space, technology, religion. But none of these are a free gift. To get them you have to pay in money or faith, so they cannot serve the same function as the Great Frontier. Webb concludes: "If the frontier is gone, we should have the courage and honesty to recognize the fact, cease to cry for what we have lost, and devote our energies to finding the solutions to the problems now facing a frontierless society."[5]

Webb is perhaps overstating the case, but a number of other analysts also insist on the "abnormality" of the growth era, and most

[1]Walter Prescott Webb, "The Frontier and the 400 Year Boom," *The Turner Thesis*, ed. G. R. Taylor (Boston: Heath, 1956), p. 59.

[2]*Ibid.*, pp. 89–90.

[3]*Ibid.*, p. 94.

[4]*Ibid.*

[5]*Ibid.*

reach the same conclusion.[1] They too find that we can no longer tolerate a "free-for-all system of wealth-getting" and must switch from a growth ideology and morality to a limits ideology and morality. Platt provides the best analogy: our period of rapid growth has been like adolescence; now, or very soon, we must stop growing and start maturing.[2]

It is easy to show that cornucopian assumptions are fundamental to the philosophies of Adam Smith and John Locke (see, for example, the discussion of property in Chapter V of Locke's *Second Treatise*—there is always more of nature to be appropriated), and it is also easy to understand why Americans, blessed with what was truly a cornucopia of unexploited wealth, should have adopted their doctrines in an extremely libertarian form. Thus, our political values and institutions had a particular historical setting for which they were in most respects entirely realistic and even morally appropriate. But no set of values and institutions has eternal validity, and the new historical conditions now emerging oblige us to create new values appropriate to an era of ecological scarcity.

The core of the American political problem vis-a-vis the environmental crisis is that our system was quite deliberately set up along the lines propounded by John Locke and Adam Smith to allow—nay, to encourage—the ruthless, competitive exploitation of the commons. The logic of the commons is thus enshrined in our political institutions and mores. The government's role as referee has grown over the years as the number of players and the complexity of the game has risen, but the fundamental nature of the game has changed not a whit. Our problem is not so much that our institutions no longer work the way they should—they work only too well even now in promoting the exploitation of nature—but that the assumptions about the carrying capacity of the commons which supported these institutions are no longer true. Now we have reencountered scarcity and thus the necessity for the strong sovereign power found both in Hobbes and in the original thought of Locke himself (as opposed to

[1]See, among many others, John R. Platt, *The Step to Man* (New York: Wiley, 1966); Harold F. Dorn, "World Population Growth: An International Dilemma," *Science*, Vol. CXXV (26 January 1962), pp. 283–90; Harrison Brown, *The Challenge of Man's Future* (New York: Viking, 1954); and Derek de Solla Price, *Science Since Babylon* (New Haven: Yale, 1961).

[2]Platt, *The Step to Man*, pp. 187, 196.

the simplified and absolutized version of Locke adopted by Americans); strongly-held individual desires and scarcity create a situation that requires strong, centralized, sovereign power in order to achieve the acknowledged common weal. In effect, Spaceship Earth must have a captain, some man or body of men who will exercise the absolute sovereign power needed to keep ecological order in our commonwealth and make us obedient to the general will. Otherwise, the collective selfishness and irresponsibility produced by the tragedy of the commons will destroy the spaceship, and any sacrifice of freedom by the crew members is clearly the lesser of evils. That such a regime has its dangers is obvious, but there is little alternative. As Hardin notes, paralleling Hobbes, even if such dangers exist, "an alternative to the commons need not be perfectly just to be preferable," for "injustice is preferable to total ruin."[1] Along with Hobbes and Rousseau, Hardin insists that the unrestrained exercise of our liberties does not bring us real freedom: "Individuals locked into the logic of the commons are free only to bring on universal ruin; once they see the necessity of mutual coercion, they become free to pursue other goals"; by recognizing the necessity to abandon many natural freedoms we now believe we possess, we avoid tragedy and "preserve and nurture other and more precious freedoms."[2] The choice thus appears to lie between Leviathan, whatever the dangers, and oblivion.

We are left then with the problem of determining the concrete shape of Leviathan. What political structure will guarantee survival (for surely the worst fate would be to get *both* Leviathan *and* oblivion) while giving us a life worth living? How do we ensure the perpetual benevolence of our sovereign? And how do we achieve it without creating as many problems as we solve or causing abysmal human suffering? I have no ready answers to these questions. Nor does anyone else. We have only just begun to think seriously in these terms. *The most fundamental task of our era is to construct a new political philosophy that will show us what we must do to survive with dignity and will incorporate as many as possible of the values and institutions we now rightly cherish.*

Although the exact shape of this new political philosophy remains to be determined, two of its major tenets are already clear: we must

[1]Hardin, "The Tragedy of the Commons," p. 1247.
[2]*Ibid.*, p. 1248.

grant much greater power over our actions to government than we have ever been willing to concede, and we must adopt a much more communitarian ethic. Both of these are bound to seem unpalatable to Americans. Increased government power is fearsome, for we tend to see political systems that do not have our kind of economic liberties as "totalitarian," a word that evokes all the evils of past dictatorships, and thus interpret every loss of individual rights as a prologue to tyranny. But even Hobbes, no matter how firm his convictions on the necessity of absolutism, certainly did not have Stalinesque tyranny in mind. Hobbes makes clear that order in the commonwealth is not the goal, but the means. Without it the fruits of civilization cannot be enjoyed: the sovereign is to procure the "safety of the people . . . But by safety here is not meant a bare preservation but also all other contentments of life which every man by lawful industry, without danger or hurt to the commonwealth, shall acquire to himself."[1] And it is part of the task of the sovereign actively to promote these "contentments of life" among his subjects. Furthermore, Hobbes will not countenance tyranny. The sovereign must rule lawfully, give a full explanation of his acts to his subjects, and heed their legitimate desires. Through wise laws and education, the subjects will learn moral restraint. Also, the sovereign is not to be a dictator regulating every action of the citizen: it does not "bind the people from all voluntary actions" but only guides them with laws which Hobbes likens to "hedges . . . set not to stop travelers, but to keep them in their ways."[2] Thus, many different styles of rule and of life are compatible with his basic analysis. Provided an essential network of laws controlling war, population growth, destruction of the environment, and the like was enforced, we could have a large degree of decentralization and great social diversity. Rigid hierarchical structures—to say nothing, in our era, of the monarchy that Hobbes preferred—and lock-step discipline are neither inevitable nor, I believe, workable in the long run.

Although not quite so fearsome as the loss of rights we now possess, the switch from rugged individualism to a communitarian ethic may involve even more painful readjustments in our political life. Our

[1]Thomas Hobbes, *Leviathan, or the Matter, Form and Power of a Commonwealth, ecclesiastical and civil,* ed. H. W. Schneider (New York: Bobbs-Merrill, 1958), p. 262 (chap. xxx).

[2]*Ibid.*, p. 272 (chap. xxx).

political myth has told us that there can be no value higher than what the individual wants. Thus, we have no "general will," only a "will of all," to use Rousseau's terminology, that is a simple summation of our individual self-seeking. Now, ecology, in effect, demands certain kinds of higher community values as the price of survival, and if we wish to retain any semblance of a democratic politics, we as individuals must learn to put the common interest ahead our own particular interests. As both ancient and modern theorists have pointed out, democracy is the hardest form of government, demanding an unusually high degree of civic virtue, for it requires the citizens to determine the common interest and then impose *on themselves* the sometimes onerous laws necessary to achieve it. Thanks to the abnormal period of growth in which our institutions were created and flourished, we have rarely found it necessary to achieve this level of self-discipline. Instead, we have been able up to now to take full advantage of our rights while for the most part neglecting our obligations to the community. We no longer enjoy such luxury. Now that we have reencountered scarcity, we are once again brought face to face with the political syllogism propounded by Edmund Burke in the epigraph to this chapter, a syllogism that expresses the epitome of political philosophy throughout the ages: Man is a passionate being, and there must therefore be checks on will and appetite; if these checks are not self-imposed, then they must be applied externally as fetters by a sovereign power. The choice is ours.

Nevertheless, it is possible that some would prefer to evade this choice and accept less than certain survival and virtually certain ecological devastation as a calculated risk in order to avoid abandonment of our sacred way of life for even the most benevolent Hobbesian-Rousseauian regime. I have no real reply to this objection—*as long as this outcome is the result of a conscious decision, and not just the product of drift*— but I cannot conceal my distaste. I can admire the ancient Greeks who were willing to die rather than compromise their political values, for they did so in defense of their noble ideal of public life in the polis. The same tenacity of belief in defense of what Stewart Udall calls "slovenly affluence" does not inspire my admiration, particularly when the alternative is not starvation and poverty. However, it is also possible to argue that, although Leviathan could in theory be relatively benign, it seems very unlikely to be benign in practice under modern conditions. Aldous Huxley's *Brave New World* is probably the best that one can imagine. More

realistically, when factors I have ignored so far, such as international conflict, are added to the equation, the product of current trends might well resemble George Orwell's horrible vision in *1984*. All the biological and psychological techniques for either dystopia are now being perfected in our laboratories or have already, in some cases, been put into practice. And once such a total Leviathan is in place, it will almost certainly be implacably permanent. Therefore, according to this line of thought, working for a benign Leviathan is utterly futile, and as repugnant as it might seem, a serious ecological crash, extinguishing perhaps billions of humans and shaking the structure of our civilization to its foundations, would actually be preferable. With luck, our progress toward post-civilization and the steady-state society would be set back one or two hundred years, giving the survivors time to absorb the lessons of our first failure to clear the jump to a new phase of civilized existence and then to reorganize for a second and, one hopes, more successful run at it. Thus, according to this argument, all things considered the best strategy may be to do nothing to surmount the environmental crisis. However, apart from the frightful loss of life and turmoil that would result, we cannot be sure than an ecological crash would be so mild. Harrison Brown doubts that a fall from our exalted height could stop short of the agrarian level of civilization and is pessimistic about our chances of ever climbing up the ladder of civilization again on the resource base that would be left.[1] I share his doubt. Furthermore, I suspect that we will get Leviathan whether we want it or not. In the first place, as indicated earlier, technological solutions have an attached "social fix"—perpetual vigilance and surveillance by a priesthood of scientists, technologists, and social engineers. In a crowded world where only the most exquisite care will avoid the collapse of the technological Leviathan we are well on the way to creating, the grip of planning and social control will of necessity become more and more complete. Accidents cannot be permitted, much less the random behavior of individuals, and the technocrat pilots will run the ship in accordance with technological imperatives. We are in fact headed already for Brave New World, in many ways a model Hobbesian polity. As C. S. Lewis observed, "what we call Man's power over Nature turns out to be a power exercised by some men

[1]Brown, *The Challenge of Man's Future*, passim.

over other men with Nature as its instrument." [1] The greater the technology, the more absolute the power that must be yielded up to some men over others. Second, if we go on pretty much as we have toward an ecological crash, things are going to get very desperate, and desperate situations call forth desperate responses. It seems hard to believe that a closely-impending ecological crash would not result in the establishment of a de facto Leviathan. Therefore, if because of emerging technological imperatives and likely future political imperatives Leviathan is virtually inevitable, then a serious effort to shape it in a benign direction is not futile after all, for we may at least be able to choose the particular version of Leviathan we prefer, and an effort along this line seems to be the least odious alternative from among a repugnant array of possible strategies.[2]

[1] C. S. Lewis, *The Abolition of Man* (New York: Macmillan, 1965), p. 69.

[2] For a more complete (and less starkly Hobbesian) argument than is presented here, see my *Ecology and the Politics of Scarcity: Prologue to a Political Theory of the Steady State* (San Francisco: W. H. Freeman and Co., 1976, in press), which takes the position that only a basically Jeffersonian or "minimal, frugal" steady-state society would constitute a "benign" Leviathan.

PART FOUR

Patterns, constraints and implications for social relations in a stabilizing world

CHAPTER EIGHT

THE EQUILIBRIUM STATE AND THE OTHER AMERICA

Charles S. Green III

Introduction

I am not going to discuss the implications of the equilibrium state for reducing rates of pollution, environmental degradation, or resource depletion. Nor will I be concerned with the pros and cons of the book, *The Limits to Growth* (Meadows, *et. al.*, 1972). Rather, I shall argue that once sufficient resources are secured through growth to assure physical survival, further growth becomes increasingly dysfunctional for the preservation of cultural diversity.

My concern with cultural diversity stems from a value judgment: that individual freedom is good in and of its own right. Moreover, I believe that individual freedom cannot be fulfilled without providing a wide range of choice among diverse life styles and diverse conceptions of how social reality should be constructed. Thus my usage of the term "the other America" refers to diverse cultural minorities such as homosexuals, hippies, women, blacks, Amish, radical intellectuals, Polish-Americans, and southern rednecks who are minorities in terms of numbers or power, or both. Hence this paper is concerned with the implications of the equilibrium state for "the other America" and with the kinds of social, economic, and political changes necessary for the equilibrium state to become acceptable to "the other America."

The argument developed in this paper is relatively simple. The attainment of an equilibrium state in America will give rise to and indeed necessitate thoroughgoing equality: equality of income and wealth, equality of education, and equalization of autonomy at work. In turn, the attainment of equality in America will provide the necessary conditions for preserving cultural diversity. In my opinion, enlargement of cultural diversity is one of the major justifications for

seeking an equilibrium state, and failure to recognize this is one of the major failures of the *Limits to Growth.*

GROWTH STRATEGIES, LIBERTY, AND EQUALITY

I am not suggesting that nations de-industrialize which, of course, would be one way of arriving at an equilibrium state. Rather I think that without a standard of living sufficiently high to assure reliable physical comfort, security, and safety, the attainment of cultural diversity ranks low in the priority assigned by people to various goals (Cf. Maslow, 1954, 1967; Marcuse, 1968, 1972). Hence, the attainment of a high standard of living through growth is an important prerequisite for the re-ordering of priorities among goals. Henceforth when I refer to an equilibrium state, I assume equilibrium at a high standard of living. But in order to know how to bring about such an equilibrium state it is important to examine how growth itself is brought about. Since growth basically involves increasing the per capita resources available to a population, there is a large variety of growth strategies from which to choose. The major types of growth strategies are reviewed in the following paragraphs.

One sort of growth strategy is population reduction: that is, the purposeful reduction of population through birth control, infanticide, etc. Accidental depopulation during plagues and unintended depopulation through wars and famines also create surplus resources for those remaining after such events.

The imperialist strategy for increasing per capita resources involves conquest and/or capture of the needed resources. Even though in the course of world history these imperialist strategies have been and still are significant ways of increasing resources, we should recognize that their importance has declined relative to such strategies as capital formation and technological innovation.

The favorite growth strategy of economists until fairly recently has been simply to increase the rate of resource input into an economic system. Thus it was thought that manufacturing would expand and growth would result if only more money were available for purchasing greater amounts of raw material, hiring more workers, and buying a larger number of machines. To achieve this, capital formation strategies were required. For example, economists consulting so-called underdeveloped countries recommended that they obtain

loans and/or engage in vast efforts to encourage savings in order to secure funds for the expansion of labor forces, raw material supplies, and plants and equipment. More recently this sort of strategy has come under serious question.

Economists (and occasionally sociologists) have now come to realize that growth has come about more from increasing the efficient use of existing resources than from the use of capital to obtain more resource inputs (Cf. Rosenberg, 1972; Schmookler, 1966, 1972; Cottrell, 1955). What this means is that the real long-term payoff in growth has come about from technological strategies that promote investments in scientific research and, more reliably, in technology. These strategies involve investments not only in "hard" technology (e.g.—new kinds of machinery) but also in "soft" technology, such as new ways of organizing work activities.

There is one parallel between technological growth strategies and capital formation growth strategies. Both sorts of strategies require investment. And investment, as economists have long recognized, comes from the *sacrifice* of that standard of living which would otherwise be possible given the existing stock of a nation's resources in hopes that such sacrifice will pay off in increased resources in the future. This sort of sacrifice has been little studied by sociologists and political scientists. This is most unfortunate because one cannot understand the political implications of growth without taking into consideration the necessity for sacrifice. Because freedom itself must be restricted in direct proportion to the societal resources which are sacrificed to investment, our understanding as to how nations grow must be balanced with an understanding as to how the political system restricts and extends various kinds of freedom. Thus both capital formation and technological growth strategies have direct influence upon political rights of citizens.[1]

There are two basic patterns for achieving rapid economic growth. The first of these patterns I shall call the monist strategy to connote a "top down" method of securing investment funds for growth, a method which implies a command economy, one directed by the state. The monist strategy involves limiting the liberty of citizens, that is their rights to free speech, contract, and the franchise. Citizens are severely limited in the way their resources can be used for

[1]For further explication of these strategies, see Green (1971). For a somewhat similar approach, see Needler (1968:889–897).

consumption and for challenging the government's investment decisions. However, the government or the state pays a price of sorts to gain the cooperation and loyalty of its citizens: it extends the rights of equality (Cf. Bendix, 1969). Therefore, the state makes health care, welfare, and education available to all as a matter of right rather than privilege. In short, under the monist strategy, the state secures funds for investment by limiting the liberty of its citizens but at the same time maintains its legitimacy by guaranteeing a modicum of equality for all.

In contrast is the pluralist or capitalist strategy of development as typified by the United States and Great Britain. In a sense this is a "bottom up" strategy of growth where liberty is preserved by the state but very little is done to guarantee the rights of equality. In extending liberty to its citizens, the state in effect removes the legal and ideological underpinnings of the status and class differences characteristic of a feudal or traditional society. Everyone to whom the rights to liberty are extended is then free as far as the state is concerned to improve his or her socioeconomic standing in society and thereby influence the goals and values to which societal resources are allocated. Since liberty by definition prohibits the appropriation or theft of others' resources, investment remains the sole strategy for maintaining and improving one's standing. Since individuals, groups, and institutions are likely to allocate different proportions of their resources to investment and since, in any case, these investments may yield different returns over differing periods of time, inequality will tend to develop and increase over time. Further, to preserve the incentive for private investment, the state must preserve these inequalities. The state thereby allows, indeed encourages, those who have been most successful in investing to retain the benefits and returns from investment and to pass on these returns and benefits to their heirs. In so doing, the state legitimates its rule—at least among the successful.

The inescapable and sobering conclusion is that *growth can be accomplished only through sacrifice and sacrifice requires the restriction of one of those two sets of freedom—individual liberty or social equality—that we normally associate with democracies.* Furthermore, the greater the rate of growth, the more must one set of freedoms be extended and the more must the other set be restricted and ideologically disvalued. But let us now consider what is required if the equilibrium state rather than growth is desired.

The fight over relative shares of the economic "pie" in America

was made less intense to the extent that the absolute size of that "pie" kept growing. Not only were vast inequalities of income and wealth tolerated, but inequality has, if anything, been regarded as a positive cultural value whose realization must be facilitated and certainly not hindered by governmental activities. Inequality has been valued because it has facilitated saving and investment by providing the incentives for the self-imposed sacrifices embodied in hard work and technological innovation.[1] But if the social costs of growth are absorbed in the future returns to investment will be reduced and the incentives for investment will be lessened (Cf. Hirschman, 1958:Ch. X; Shonfield, 1969:57ff). Moreover, the minimized material production defined by the equilibrium state will encourage massive unemployment which, along with sharply reduced investment, would remove any further possibility for legitimating socioeconomic inequality. Therefore, demands for equality would be impossible to resist—at least without curtailing liberty.

How Equality Can Give Rise To Cultural Diversity

As I have already indicated there are only two major types of technological strategies by which nations can rapidly grow. Now I would like to discuss in somewhat more detail how these strategies are related to cultural diversity. The relationship of the monist growth strategy to diversity can be summarized very briefly by noting that under such a strategy resources for culture-making are distributed more or less equally. But, in restricting liberty, such a growth strategy restricts the *range* of cultural alternatives which favor growth. Hence the monist strategy restricts cultural diversity. In contrast, while the capitalist growth strategy places no *legal* limits on the range of cultural alternatives which can be created and sustained with the resources available to the citizenry, the economic inequality characteristic of the capitalist growth strategy undermines cultural diversity.

[1]My contention that Americans value inequality, or at least do not disvalue inequality, is an explicit challenge to Lipset's (1964) thesis that the development and functioning of American institutions can be explained in terms of our values of achievement and equality. For other challenges to this thesis, see Bottomore (1964) and Gans (1971:275–289, 1972:43–46).

Much has been made by both foreign observers and domestic social scientists of Americans' devotion to conformity (Cf. Lipset, 1964:Ch. 1–2). Paradoxically, another impression is that Americans are dedicated to rugged individualism and competitiveness. Resolving this paradox hinges on recognizing the difference between the expressive and instrumental or utilitarian aspects of both conformity and innovation.

Americans value liberty. We especially value using that liberty for creativity and achievement which has been tantamount to seeking heaven on earth. All this is a direct reflection of our puritan heritage. A further manifestation of this heritage is our asceticism, which discourages frivolous, erotic, playful, and "merely" expressive behavior. Thus conformity with the value of liberty means for us the channeling of behavior in the direction of instrumental creativity rather than expressive creativity. We have, therefore, become a nation of innovators when it comes to inventing new products, new production processes, new ways of extracting raw materials from the environment, and new ways of distributing products. These values have been institutionalized in our Constitution. Specifically, our conceptions of property rights guarantee to the innovator the right to use and pass on the rewards of his innovation; our patent system, our copyright and trademark laws, our laws with respect to inheritance, all guarantee that benefits accrue to innovators and their heirs. We have thereby established a powerful system of material incentives for continued innovation and hence for continued growth. But there are unanticipated consequences of this system.

The cumulative effect of allowing benefits earned through the innovations of one generation to be passed on to the members of the next has been to create substantial inequality. Thus it is no longer true, if it ever were, that the members of each generation are engaged in a one hundred yard dash with all the "racers" given an equal chance of winning, i.e.—an equal amount of resources such as wealth and education with which to conduct the race. Rather we have institutionalized an unending relay race in which an individual's position at the end of his "lap" is largely determined not by the effectiveness with which his resources are applied but by how far ahead his or her parents were when they passed on the "baton" (Cf. Milner, 1972). Despite the efforts of social scientists to demonstrate the unfairness of such a relay race, we persist in perceiving the achievement of economic success as a matter of indivivual hard

work, competition, and application of free will.[1] The wealthy maintain these perceptions because changing them would imply that they are undeserving of the wealth that they have (Cf. Gans, 1971:275–289). Peace of mind is therefore guaranteed by not admitting that poverty is due to factors other than the characterological defects of the poor. Hence the culturally proscribed behavior patterns of the poor are held responsible for their poverty.[2] Manifestations of such patterns are taken as *prima facie* evidence of disqualification for mobility. Thus conformity to our value on liberty has come to mean liberty placed *solely* in the service of instrumental innovation, that lonely, endless aggressive and competitive striving so characteristic of our cultural heritage (Slater, 1971). Indeed, we define deviance in America in terms of this heritage and reserve our harshest punishments for those who engage in non-productive activities and/or who exercise their liberties to create and innovate in expressive rather than instrumental ways. We are therefore much more harsh with thieves, gypsies, skidrow bums, hippies, prostitutes, and potsmokers than we are with those who engage in activities such as price-fixing, the sale of defective goods, corruption of public officials, or industrial espionage. Also we deal more harshly with expressive uses of liberty than do Latin societies whose cultures define individualism more in terms of expressive activities than in terms of instrumental activities. This harshness in manifested not only in the kinds of people typically found in our prisons, mental hospitals, and welfare rolls, but also in the fact that

[1]For extensive documentation of this point, see Centers (1949) and Schuman (1971:382–390).

[2]Many readers may feel that such cultural ethnocentrism passed on with the New Deal and the acceptance of Keynesian economic theory. They could hardly be more wrong as the following passage by a prominent social scientist attests: . . . the problems posed by the lower class can be solved fundamentally only if the children of that class are removed from their parents' culture . . . the child should be taken from its lower class parents at a very early age and brought up by people whose culture is normal." (Banfield, 1968:229; for further explication of his views see Chapters 3, 9 and 10).

For histories of Anglo-Saxon fears about race and ethnicity, see Nash and Weiss (1970) and Gordon (1946). For the contrast between the American melting pot and the Canadian segregating approaches to cultural diversity, see Porter (1965, Chapter 3, esp. pp. 60–100). That sociology and presumably other social sciences have been implicated in perpetuating the ideology of assimilation is a theme argued most persuasively by Metzger (1971:643–644). Novak (1972) also has some trenchant things to say about the cultural biases of intellectuals vis-a-vis ethnics.

we have few mechanisms for returning deviants to society unstigmatized (Erikson, 1966).

In summary, while our cultural heritage affected our choice of growth strategy, the economic inequality resulting from that strategy constitutes an incentive system which reinforces that cultural heritage. By systematically discouraging the elaboration of cultural attributes incompatible with economic growth in general and competitive striving in particular, economic inequality sustains cultural inequality.

EQUALITY AND CULTURAL DIVERSITY

Thus, I would argue that elimination of economic inequality would increase the opportunity for expressive as well as instrumental creativity because, by reducing competition for economic or material resources, equality will transform attitudes to work. For if the same economic returns are available from virtually any job, then the choice among jobs can be more fully based on such intrinsic attributes of jobs as autonomy, responsibility, creativity, and self-regulated pacing. The fact that choices among jobs are no longer based primarily on economic criteria would create a powerful inducement for employers to increase responsibility and autonomy in order to recruit workers to their jobs. Transformations of work also imply transformations of leisure. Hitherto only professionals, some managers, and some artists enjoyed that intertwining and blurring of work and leisure in which leisure functions as a complement to work, and oportunity to regenerate, to refreshen, and to remobilize the creative energies required in challenging and interesting work.[1]

What effect might equality have on the family? It has recently

[1]The work-and-leisure debate continues unabated, increasingly focusing on the possibility rather than the desirability of the fusion of work and leisure. For representative views on various sides of this debate, see Friedmann (1961), the essays of Smigel's edited collection (1963), Burch (1971:160–187), Seligman (1965:319–412), and Bottomore (1964). Robert Dubin is one of the few to argue for the separation of work and leisure: "All of what we mean by secularization of life, by freedom, and by privacy derives from this segmented and compartmented way in which modern life is lived out . . . the rate of innovation and the radicalness of innovations in all realms of modern living . . . can be traced directly to the segmentation of the realms of life." (Quoted by Parker, 1970:116–117, from a personal communication.)

been shown that the nuclear family is not necessarily solely the result of industrialization (Goode, 1963), nor is the "fit" between the nuclear family and industrialism as neat as some scholars have believed (Cf. Sennett, 1970). Nevertheless, competition and geographic and social mobility do tend to favor the nuclear family as a defensive, if not an adaptive, structural form (Cf. Sennett, 1970; Thernstrom, 1964).

More specifically, competitive striving for economic success involves by definition economic and often geographic mobility. Mobility in turn means the creation of economic differences and often spatial distances between members of kinship groups. For example, economic mobility has led to age stratification and, in combination with geographic mobility, to age segregation (Klatzky, 1972; Townsend, 1971; Riley, Johnson, Foner, 1972). Economic equality, on the other hand, by definition would minimize economic differences between generations and, by eliminating the monetary incentives for geographic mobility, reduce the spatial segregation of generations as well. Furthermore, for similar reasons equality would facilitate the establishment of intimate friendship and family-like relations among individuals and families not biologically related. Facilitating the establishment of intimate relations among strangers would embody that revitalization of local communities which both liberals and conservatives have called for since the early years of the industrial revolution (Nisbet, 1962). At the same time, equality would reduce the economic dependence of individuals on any particular grouping of persons—kin, friends, or employer. Equality would therefore facilitate mobility motivated on non-economic grounds; for example, the desire to explore a new life-style.

In addition, equality would further blur sex roles by minimizing the necessity for that lonely, aggressive competitiveness which has been equated in America with manliness. Men would, therefore, be free to choose expressive roles hitherto restricted to women. Such an outcome is far more revolutionary than merely opening up opportunities for women to become as aggressive, competitive, and lonely as men are in seeking economic success in a society devoted to growth (Cf. Greer, 1971:313–328).

In summary, equality would mean the equal distribution of resources required for cultural diversity and the elimination of the incentive structures which have favored instrumental creativity rather than expressive or artistic creativity.

IS CULTURAL DIVERSITY DIVISIVE?

Since Marx, intellectuals have tended to assume that turmoil over systems of production are the most important conflicts. Yet the conflicts which have consumed the most lives seldom have had more than an indirect connection with the issues dividing capitalists and socialists. These conflicts have had a great deal to do with skin color, language, religion, and in general with cultural differences. Recently much of this conflict has occurred in the Third World: Bengalis in East Pakistan, Moslems and Hindus in India, Chinese in Indonesia, Indians in East Africa, Tutsi and Hutu in Burundi, Moslems and animists in Sudan, and Ibos in Nigeria. But such conflict is not absent in Europe and North America; subcultural nationalisms persist in Northern Ireland, the Netherlands, Canada, England, Spain, Russia, Yugoslavia, and Czechoslovakia, to name a few (Adelman and Morris, 1967; Green, 1971; Tilly, 1969:4–42).

Since so much blood has been spilled over cultural diversity, it might seem that we should do everything possible to minimize diversity. Marxist scholars, however, reject the notion that cultural diversity, *per se,* can lead to conflict, believing that all conflict is solely economic in origin.[1] While the Marxists have no place for diversity in their theories the non-Marxian pluralists have sought ways to attenuate or dissolve the primordial attachments to cultural groups.[1] (Cf. Dahrendorf, 1962; Lipset, 1960; Rose, 1967; Galtung, 1965:145–198; Lieberson, 1970:172–181).

Pluralist theory calls for the transformation of *inter-group* competition and conflict into *inter-individual* competition and conflict. The pluralists would have us purchase the stability of our society at the price of individuals' peace of mind.[2] Pluralists, in their concern

[1]Note especially Cox's (1950) treatment of race relations. In contrast, Cruse (1967) has attempted rather successfully to develop the case for cultural pluralism as have Metzger (1971:643–44) and Greeley (1971a:343–365).

[1]See Shils (1957:130–145) for what is still the best treatment of primordial and other types of loyalties.

[2]As a matter of background, Kornhauser (1959) attempts to synthesize the aristocratic version of mass society theory as represented by Arendt and deGrazia with the democratic version of mass society theory. The former fear the loss of exclusiveness of elites and their consequent inability to govern either politically or culturally, while the democratic theorists fear elite dominance over an atomized mass. Kornhauser sees the solution to such fears in a plural society, one characterized by strong, autonomous association which reduce the availability of masses for mobilization by counter-elites

with reducing conflict, seem to be more concerned with increasing economic development and with decreasing superimposition (i.e.—that situation where individual's political, economic, and social positions are perfectly congruent) than with minimizing the underlying differences. To the extent that elimination of differences has been a concern of pluralists, they have tended to focus more on reducing cultural diversity through assimilation and on reducing differences in political power through expansion of the franchise rather than on reducing differences in the realms of income, wealth, and authority at the work place.

It is my contention that the pluralists' focus has been myopic. If we wish to preserve cultural diversity and reduce conflict, then minimizing differences in income, wealth, education, and authority is a far more effective solution than reducing superimposition. Finally, it might be asked, even if all but cultural differences are minimized will not these differences give rise to severe competition and conflict? As I have argued earlier, resources *are* required for culture making, and to this extent pluralists are quite correct in stressing the significance of economic development as a means for providing these resources. However, at an equilibrium state, competition among culturally distinct groups, life styles, or views of reality, becomes a qualitatively different phenomenon when other differences are minimized. For at equilibrium, again presuming equality, economic status is not predicated on cultural attributes.

Hopefully I have convinced my audience that cultural diversity need not be divisive and that diversity is a valid justification for seeking the equilibrium state. But there are some apparent obstacles

who would otherwise threaten the capacity of elites to govern effectively. At the same time, to the extent that these groups and associations remain strong and autonomous, they prevent domination of the masses by the elites. Kornhauser's synthesis is suspect on at least two grounds. First, the synthesis retains the elitist assumptions of the aristocratic critics of mass society. Second, Kornhauser's sole criterion of democracy is stability: "Mass politics occurs when large numbers of people engage in political activity outside of the procedures and rules instituted by a society to govern political action. Mass politics is anti-democratic, since it contravenes the constitutional order" (1959:227). For critiques of Kornhauser, see Green (1971), Bottomore (1964), and Needler (1968:889–897). For rather different perspectives on mass society see Talmon (1960) who manages to fudge the distinction between totalitarian and pluralist societies, and Nisbet (1962) whose pluralism calls for decentralization and a strengthening of diverse, small-scale communities.

in the way of attaining the equilibrium state so it is necessary to examine these both carefully and critically.

Ironically, the implication of much recent research seems to be that the growing affluence or "embourgeoisment" of the working class is one of the prime obstacles to attaining the equilibrium state. Earlier I noted that while the capitalists' vested interest in maintaining inequality conflicts with the workers' vested interest in reducing inequality, economic growth makes it possible for both parties to make substantial absolute gains in their standard of living. Denton Morrison (1972) noted that ". . . the most important economic conflicts in this country are not between capital and labor but between a coalition of organized labor, capital, and management of industries threatened by the costs of environmental reforms and those who push those reforms . . ." Indeed, so long as growth continues, it appears that the sheer fact of extreme inequalities cannot even become defined as a political issue.[1] Thus the success of managerial and Nixon Administration appeals to the "work ethic" and for greater productivity can only be understood in terms of both the economic and political functions of economic growth.

The liberal version of the embourgeoisement thesis argues that affluence, improved job control, upgraded status, middle class residential patterns, etc., have given workers a stake in the capitalist system. However, there is a Marxist or rather Neo-Marxist version of this thesis that deserves our attention.

Neo-Marxists are now willing to concede that capitalism has provided workers with a level of affluence unanticipated by Marx himself (Cf. Baran and Sweezy, 1966). What they deny is that the satisfaction of survival needs contributes to other human needs such as autonomy, creativity, and responsibility (Cf. Marcuse, 1964, 1968, 1972). Neo-Marxists see the emergence of such unsatisfied needs as the *potential* basis for the radical opposition to capitalism. In addition, Neo-Marxists focus on different effects of technological change than liberals do. Even though Neo-Marxists may concede that work-

[1]The revisionist historian William Appleman Williams (1968) argues that Americans have chosen expansion rather than redistribution as a means of avoiding the contradictions between liberty and inequality. My own work (Green, 1972) leads me to believe that the direction of causation is reversed, albeit *only* to the extent that technological strategies of growth are used; we maintain the contradiction between liberty and inequality in order to expand, just as Russia and other communist nations must maintain the contradiction between equality without liberty in order to expand.

ing conditions are ameliorated in the expanding service industries and under automated processes of production, authority differentials persist; workers are still subordinates. Furthermore, even service industries such as education are increasingly being subjected to criteria of efficiency under the discipline of cost-benefit analyses, with the result that even service work is becoming routinized, standardized, regimented, and supervised by more and more explicit criteria of effectiveness (Cf. Perrow, 1972). These features are most evident in new community colleges, but the financial bind of many universities is pushing them as well in the direction of "bureaucratic rationality." At the same time, Neo-Marxists believe that the new technological developments enhance the potential power of a working class and even white-collar functionaries and semi-professionals because (a) the new working arrangements facilitate solidarity among workers, technicians, and lower level operating managers, and (b) the new capital equipment required for automatic production processes is so expensive that management cannot afford the down time in strikes (Cf. Mallet, 1963). Finally, Neo-Marxists see in suburbanization the potential of developing a nationwide rather than a parochial class-consciousness (Cf. Westergaard, 1965). But note that the Neo-Marxists see the radicalization of the working and/or white-collar classes as only a potential consequence of economic, technological, and ecological changes.

Why hasn't this potential been realized? Such Neo-Marxist writers as Marcuse (1968, 1964) and Birnbaum (1969) are convinced that the means of creating class consciousness—the cultural apparatus embodied in research, education, leisure, and mass media institutions—are monopolized or controlled by the dominant class. Furthermore, they maintain that the output of this apparatus is profoundly conservative: the values and beliefs propagated by the cultural apparatus are solely those conducive to the imperatives of economic growth.[1] Thus

[1]It is worth noting the diversity of views among those who constitute the core of the opposition to science and/or technology. For Ellul (1965a, 1965b, 1967) science and technology are subsumed by the concept *technique.* Ellul's analysis is a form of sociologism in that for him *technique* pervades the "collective conscious" of Western societies. *Technique* thereby has laws of development of its own and is therefore not subject to control by its creators, let alone politicians. Ellul, then, is attacking the whole Western world-view. For an excellent critical review of Ellul's and others' work see Sklair (1970a:479–89, 1970b). Nettl (1970:57:134) is less despairing than Ellul but nevertheless perceives that the existence of intellectuals is inhibited by modern soci-

Marcuse and his followers see no contradiction the stern ascetic morality of the Protestant ethic and the fun morality of the "Playboy Philosophy." The former philosophy facilitated economic growth when it was still opposed by feudal aristocracies and when human energy was crucial to production. The latter philosophy legitimates through "repressive desublimation" the radical separation of work and leisure required for economic growth in affluent post-industrial societies.[1] In such societies the workers' consumption efforts are even more crucial to growth than their productive efforts.

In summary, neither the liberal nor the Neo-Marxist version of the embourgeoisment thesis leads us to expect anything but resistance to the equilibrium state. In the final sections of this paper I will argue against the pessimism of the embourgeoisment thesis. First, however, I would like to point out some apparent international obstacles to change.

INTERNATIONAL OBSTACLES TO CHANGE

The American quest for national security has implied for us the achievement and maintenance of dominance in each of the various status orders—economic, political, and prestige—of the international system of stratification. While the recent emergence of a multi-bloc

ety, most notably by the ideology that "changes are acceptable only if they can be scientifically justified." Marcuse (1968, 1972) takes a somewhat more benign and pragmatic view of technology than does Ellul but, as noted in the text of the paper, is profoundly pessimistic about overthrowing the culture of industrialism. Birnbaum (1969:106–166) is also concerned with the industrialization of culture. He believes the industrialization of culture has occurred through fragmentation. Fragmentation has occurred not only because of the split between the humanities and the sciences but because of the internal specialization within each of these two branches of philosophy. Furthermore, fragmentation has occurred because of the split between the producers and consumers of culture. The result, according to Birnbaum, is that culture has become a commodity, as marketable as eggs or automobiles, and hence irrelevant for illuminating the human condition. Birnbaum views this irrelevance of culture as the ultimate form of alienation. In contrast, Gellner (1964) is a technological optimist, albeit a highly sophisticated one who sees industrialism as culminating in the dissolution of tribalism and the emergence of a global civilization.

[1]Kurt Back (1972) provides evidence that the success of the encounter movement and of sensitivity training in America is a manifestation of "repressive desublimation." Apparently mysticism is taking on these same functions (Cf. Levine, 1972:116ff).

rather than a bipolar international system has reduced somewhat the post-Sputnik panic to overcome the Russians and Chinese in every human endeavor, our efforts to maintain dominance persist. This international competition is itself a force which we (and other nations) continue to see as requiring the subordination of cultural diversity, environmental sensitivity, and other domestic problems to the imperatives of growth (Cf. Lagos, 1963; Nettl and Robertson, 1963). Since the international system of stratification does not appear to be subject to our modification in any major way in the foreseeable future, it would appear that regardless of any domestic changes we may wish to make, we are forced in self-defense and self-interest to push for economic growth. Nevertheless, I shall argue in an ensuing section of the paper that this view may well be too pessimistic.

Effecting Change: Possibilities

As the above paragraphs indicate much recent scholarly work is extremely pessimistic about the possibility for attaining the equilibrium state. I believe that both liberals and Neo-Marxists have seriously misinterpreted the evidence on the possibilities for change in contemporary America. In the following paragraphs I shall attempt to specify where I think they are in error both with respect to the magnitude of discontent in America and the means of turning that discontent into political action. I shall conclude this paper by outlining some specific strategies for bringing about the equilibrium state.

THE QUEST FOR THE DISCONTENTED

The failure of the American Left in general and the New Left in particular can be traced to a mistake made by many earlier revolutionary theorists. The mistake is to look for a single driving force or agent of revolutionary change. Thus Marx looked to the proletariat, Lenin and especially Mao looked to the peasants, while C. Wright Mills and Richard Flacks look to intellectuals or the students as agents of change (Cf. Friedland, 1972).

Failure to perceive multiple sources of discontent in a society probably results from failure to recognize that particular experiences of any class or group tend to shape its particular world views and

ideologies. Hence the existence of inequality not only tends to fragment society into social classes but fragments perceptions of the class structure as well. Each class fails to see its own predicament as one instance of a more general predicament imposed on all classes by the growth strategy adopted by the society as a whole. Mobility and status inconsistency tend to prevent the crystallization of even class-specific ideologies.

In any event, the particularistic concerns of the New Left and the environmental movement betray their white upper middle class social base. The parochialism of these groups alienates potential allies (Cf. Lasch, 1971:318–334; Morrison, 1972).

Sources of Working Class Discontent

In their three volume series on the affluent worker, Goldthorpe and his associates (1971) have been rightly critical of the embourgeoisment thesis for its tendency to confuse the convergence of blue-collar and white-collar incomes with a convergence in work situations and life styles. The blue-collar work situation is still distinguishable from that of the white-collar worker in terms of (a) such working conditions as shift work hourly rather than salary wage payments, machinery controlled work pace, safety, continuity of work, fringe benefits, long-term income prospects and promotional opportunities; and (b) such amenities as quiet, lighting, temperature, humidity, cleanliness, and food services. Moreover, there are not only persisting differences in life styles, but there is also little evidence that there is any increase in the mutual acceptance of white-collar and blue-collar workers.

We might speculate that this lack of mutual acceptance is itself related to the ecology of work. For example, white collar workers are concerned with the control and coordination of production rather than with production *per se,* with securing inputs (e.g.—purchasing the warehousing), and with distribution. Thus white collar and blue collar workers are segregated spatially as well as by the kinds of processes (input, output, production) with which they are concerned.

In short, the absorption of blue-collar workers into the white-collar middle class has been exaggerated. But this leaves an important question unanswered: Are blue-collar workers discontented with their situation?

Recent newspaper stories about protests over work pacing at GM assembly plants in Lordstown and Mansfield, Ohio and elsewhere suggest there is discontent in the working class. While these instances are too few and isolated to permit us to answer such a question unequivocably, there is other evidence available that the probability of more such protests in the future is very high. The high probability is caused by (a) the disparity between occupational change and educational change during the past twenty years or more and (b) the impact of education on values.

Consider that between 1950 and 1970 the proportion of the labor force engaged in white-collar work has increased from 37 percent to 50 percent, while the proportion of high school graduates in the over—25 population has increased from 33 percent to over 75 percent. It might be assumed that this relatively greater rate of educational change was stimulated by technological changes requiring more skills in blue-collar occupations and/or by the requirements of the expanding while-collar sector. Such an assumption is thrown into doubt by the finding that both the highest absolute gains and the highest percentage gains in education between 1952 and 1967 were made in those occupations requiring little or no skill: laborers, both farm and non-farm; private household workers; and operatives.[1] The assumption is virtually destroyed by recent systematic research studies. Jaffe (1966:35–46), for example, found (a) no relationship between technological change, as measured by output per worker in various industries, and worker education; (b) no evidence of a significant degree of mobility of more highly educated into industries characterized by high rates of technological change. Collins (1971:1002–1019) has come to similar conclusions, noting that education is used as an ascriptive criteria in selecting employees and in rationing the "better" employment opportunities. In sum, it appears that the education required to obtain jobs far exceeds that necessary to perform them. This gap between education and job requirements forebodes increasing discontent in the world of work (Cf. Kohns, 1969).[1,2] Finally, it must be emphasized that the effect of education transcends the realm or work.

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[1]Author's computations from Table 28, page 62, *Handbook of Labor Statistics* (USDL, BLS:1968).

[1]One of my colleagues, Murray Milner (1972) has used the term "status inflation" in his analysis of still another sort of discontent. He traces discontent to the changing

Regardless of demographic variables such as sex, occupation, income, and age, the more educated persons become the more likely are they to (1) follow politics and pay attention to election campaigns; (2) acquire political information; (3) have a wider range of opinions on political subjects; (4) engage in political discussion; (5) discuss politics with a wider range of persons; (6) consider themselves capable of influencing government; (7) be active members of some organization; (8) express confidence in their social environments (Almond and Verba, 1963).

White-Collar Discontent

As noted earlier, not a few observers anticipated that white-collar work is becoming routinized, standardized, and closely regulated as well. Moreover, there are increasing manifestations of discontent. Lower level white-collar workers—the clerks, the typists, the key-punch operators—are becoming increasingly restive and joining such unions as the Retail Clerks and the American Federation of State, County, and Municipal Employees (AFSCME). Further, recent years have witnessed the unionization of even semi-professional groups previously thought immune to organization: nurses, social workers, and secondary school teachers. The growth of the American Federation of Teachers (AFT) and AFSCME have led more traditional organizations such as the National Educational Association and the American Nurses' Association to become more militant in self-defense and to even flirt with merger.

As is well known, unionization has come to have appeals among many college professors and engineers. This latter development is

distributions of the population on all measures of status rather than to discontinuities between distributions. For example, he believes that the social value attributed to a college education has become eroded because such a large proportion of the population now possess higher degrees. Similarly, the social status attributed to a $10,000/year income, a white-collar occupation, and possession of an automobile have become inflated.

[2]Kohn stresses that education is relevant to a preference for autonomy and self-expression to the extent that it " . . . provides the intellectual flexibility and breadth of perspective necessary for self-directed values" (1969:186). The point behind recent efforts at educational reform is, of course, that much contemporary education does not provide "intellectual flexibility and breadth of perspective" (Cf. Katz, 1971).

not exclusively a matter of narrow, economic self-interest. These as well as other professionals have increasingly seen their talents put at the service of war, urban renewal, "workfare," and other socially destructive programs. They too are discontented.

In summary, we must conclude that the embourgeoisment thesis is incorrect. There are persisting differences between blue and white collar workers in terms of working conditions, amenities at work, and life styles preferred. Yet we must not exaggerate these differences. There are important areas of convergence in the work situation of blue and white collar workers. Within the broad category of blue collar work, there has been a general shift of workers from the unskilled to the more skilled jobs, especially those skilled jobs concerned with the monitoring, servicing, and repairing of production machinery.

At the same time, white collar work is becoming transformed. Professional and semi-professional jobs are increasingly located in large scale complex organizations and are becoming more rationalized as greater accountability is imposed through such techniques as cost benefit analysis and program budgeting. The routine decision-making characteristic of lower level managerial and clerical jobs up to the 1960s is being transferred to computers and automatic form processing devices. In short, the white collar—blue collar dichotomy is becoming harder to discern as the work performed by both is made to resemble that of technicians. Further, sources of discontent among these two categories are complementary. The blue collar worker has seen educational requirements for skilled work rise faster than the level of skill demanded. The white collar worker has seen the skill level demanded reduced while educational requirements have remained the same or even increased.

Ethnics Versus Pointy-Headed Intellectuals

So far I have been guilty of concentrating on the discontents of those who are or have been the exclusive constituents of the Left. Among many Leftists certain of the urban intelligensia seem to hold in lowest esteem the bus-burning, bigoted, flag-waving, warhawk, white ethnic. The Leftists have tended to ignore any evidence which might overthrow their pet myths. But there is such evidence. Andrew Greeley's (1971; Greeley and Sheatsley, 1971) research has left

little doubt that "ethnics" are more in favor of peace and more in favor of integration than white Anglo-Saxon Americans of similar age, sex, and social class background. Indeed, Greeley and his associates have found that the more "ethnic" a person is the more likely he is to favor the liberal causes.

The Left has also been unable to see that the equilibrium state may well have its attractions for the Right. The equilibrium state has implications not only for the conservation of natural resources but, as I have indicated earlier, for the conservation of local community, ethical dealings among individuals unsullied by the pressures of competition, and the preservation of kinship and generational ties. In short, the American Left has again failed to appreciate, let alone articulate, the views of groups which might otherwise be sympathetic to substantial change.

CULTURAL CHANGE: IDEAS AS WEAPONS

At least as important as its failure to articulate the views of diverse groups is the failure of the American Left to abandon the quest for power as a strategy for effecting change.[1] There are differences within the Left, of course. The liberal "Old" Left uses a rather emasculated power strategy, preferring to work for reform through the system and the existing establishment. On the Far Left are those who believe in direct action: street fighting, barricade manning, and terrorism. But it is still a fair generalization to say that the Left has sought and still seeks change through the acquisition of power rather than using communications media and other techniques to change consciousness and thereby build a constituency of the discontented.

In contrast to earlier mass communication research (Klapper, 1961; Larsen, 1964:348–381; Katz and Lazarsfeld, 1955; Bramson, 1961), recent research indicates that mass media do have an effect on at least certain kinds of people (Cf. Stephenson, 1967; Nimmo, 1970). Moreover, this recent research suggests the ways in which media appeals must be addressed to those groups most likely to be

[1]Lowi's (1969) brilliant and devastating critique of liberalism is marred by his devotion to a narrowly political solution to American problems. His recommendations nevertheless deserve wider attention.

receptive to perceptual rather than attitudinal changes. Media appeals must be dramatic and attention-getting; they must be repeated over and over, and they must be focused on changing perceptions about reality, for those perceptual changes are a prerequisite to behavioral changes which then result in attitudinal change.

But do such research results validate Neo-Marxian pessimism on the possibilities for change? I believe such pessimism is warranted only if Neo-Marxists are correct that the ruling class not only has complete control over the cultural apparatus but exercises that control in such a way as to prevent any counter-cultural ideas from being printed, viewed, or aired. If, on the other hand, the Neo-Marxists are wrong, then the results of the research just cited requires the optimistic conclusion that not only is cultural change possible, but that we know something about how to bring it off effectively (Cf. Edelman, 1964).

First of all, I think that Neo-Marxists underestimate the extent to which alternative, non-official media are available. I have in mind here such phenomena of recent years as underground newspapers, comics, posters, and films, free universities and teach-ins, guerilla theater, street theater, and other dramatic happenings such as sit-ins, parades and marches. Furthermore, access to conventional mass media will be vastly increased in the future. For example, the advent of video-tape cassettes, television sets capable of handling these cassettes, and inexpensive video cameras means that underground TV tape networks will be feasible within a few years. Inexpensive movie making and projection equipment is already available.

Moreover, I think that the Neo-Marxists have tended to underestimate the autonomy of cultural gatekeepers and disseminators. As one investigator has recently noted, "The organizational segregation of the producers of cultural items from their disseminators places definite restrictions on the forms of power which cultural organizations may exercise over mass media gatekeepers to effect the selection of particular items for coverage. Widely shared social norms mandate the independence of book review editors, radio station personnel, film critics, and other arbiters of coverage from the special needs and commercial interests of cultural organizations" (Hirsch, 1971:647–648). In addition, Neo-Marxists also have tended to overestimate the willingness and capability of the ruling elites to control the mass media, let alone the kinds of ideas and beliefs presented through these media.

I think that Joseph Schumpeter's (1950:146–150) views are still applicable:

> In capitalist society . . . any attack on the intellectuals must run up against the private fortresses of bourgeois business which, or some of which, will shelter the quarry . . . Lawless violence the bourgeois stratum may accept or even applaud when thoroughly roused or frightened, but only temporarily . . . for the freedom it disapproves cannot be crushed without also crushing the freedom it approves . . . From this follow both the unwillingness and the inability of a capitalist order to control its intellectual sector effectively.

Thus the media are effective in modifying beliefs and perceptions and, through these, attitudes. Furthermore, they are sufficiently loosely controlled and unsubject to censorship that they can as well be used for purposes of change as well as for purposes of maintaining the moral order of capitalism. Combined with the possibilities of alternative media, we are therefore quite free to act, to begin to take advantage of wide ranging discontents and to begin to bring about the equilibrium state. Therefore, I see two distinct but related tasks before us. The first of these is the delegitimation of existing institutions. The second task is the provision of cultural alternatives to industrialism in general and capitalism in particular.

Change Strategies: Delegitimation and Cultural Alternatives[1]

[1]In developing this section of the paper I have leaned heavily on Charles Reich's (1970) ideas. Reich has, of course, been attacked not only by the Right and by liberals but in particular by Marcuse and other Neo-Marxists who feel Reich is unrealistic in saying that "The new generation must make the revolution by the yeast theory; they must spread their life" (Reich, 1970:297). Such critics do not believe that a cultural rather than a power strategy of change can be effective. As I have argued in this paper, a cultural strategy may be the only one available to effect major change; indeed it is a strategy tailored for those who do not command the heights of the dominant existing institutions. There are examples of the success of such strategies: the emergence of Christianity (Cf. Haley, 1968), the Reformation, and most obviously Marxism itself. Thus the objection to Reich's strategy constitutes what C. Wright Mills would have called "crackpot realism."

There is a further irony here. Reich's failure to convince even sympathetic critics like Marcuse is due in part to his failure to demonstrate empirically why his strategy could be successful. In discussing change, I have tried here to show that there is empirical evidence that the strategy is possible. Yet the fact that proposed changes—

DELEGITIMATION

Objectives

In delegitimating existing institutions our purpose is to show how the urban crisis, the energy crisis, the environmental crisis, the race-relations crisis, the crisis in international relations, and the law and order crisis all originate in growth, whether capitalist or otherwise. We must demonstrate that "modernity" increasingly destroys that for which modernization was originally undertaken: the expansion of the range of cultural alternatives open to human beings. If our efforts at delegitimation are successful, we will have demonstrated that growth eventually becomes unhealthy for people and other living things.

The attack on growth must itself be articulated in terms of inequality which transcends the particular discontents of particular classes and groups. For the poor, and the black poor in particular, the focus of discontent is economic inequality; for the working class, economic inequality persists as a focus of discontent but inequalities of authority, responsibility, and autonomy are of increasing concern; for the white collar worker, the latter forms of inequalities are the primary foci of discontent. For others—women, homosexuals, ethnics, hippies and so forth—inequalities in the cultural or moral order are the foci of discontent. Obviously the issue of inequality is the basis for uniting all groups and classes because it is the proximate cause of all the discontents I have identified in this paper. What, then, is to be done?

Tactics

Our attack on existing institutions must demonstrate the interconnections between growth and inequality, and show how illusory the benefits of economic growth are when social costs in pollution and alienation from work are taken into account.

Our attack must also be directed at those existing institutions which are most crucially linked to value creation and maintenance. For this purpose we must make greater use of that underestimated

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and change strategies—must be scientifically justified for even those opposed to the dominance of science and technology is the clearest evidence I can offer of the constraints imposed by our cultural heritage (Cf. Nettl, 1970:129).

but highly crucial institution, the Supreme Court. Many of us have assumed that the Court is a hopeless instrument for directing our attack because it has defended and must continue to defend property rights which often, if not always, conflict with individual rights. I would contend, however, that this is not the case and in fact that there are Supreme Court decisions which give precedence to individual rights over property rights. For example, in the case of the United States vs. Carolene Products Company, Footnote 4 by Justice Brown, the substance of two relevant concepts may be found: (1) that Bill of Rights freedoms and the right of equality under the 14th Amendment stand in a preferred position; (2) therefore while a law restricting personal freedoms may be presumed unconstitutional until the contrary is shown, a law restricting business interests is presumed to be constitutional until the contrary is shown.

Such a precedent not only legitimates inquiry into the social and environmental impact of business and other forms of organization but almost demands such investigation. Further, in a number of civil rights cases, property interests have been subordinated to individual liberties. The doctrine here is that individual liberty must take precedence because it is the ultimate value in terms of which the public interest is defined; property, therefore, is merely a means to a higher end. Thus one of the main obstacles to the attainment of socioeconomic equality, that is, the large-scale propertied social organizations prevalent in business, education, medicine, science, religion, etc., are subject to attack on the grounds that individual liberty should take precedence over the property interests of such organizations. Specifically to the extent that property is seen as a means by which individuals are to realize liberty, the exclusive control which organizations exercise over property is indefensible. The latter principle, it might be noted, should be equally acceptable to both the Left and those conservatives committed to the ideals of classical liberalism.

A Harris Poll of about a year ago indicated that consumers are becoming increasingly disenchanted with the products that they are being sold and Harris for one attributed this to Ralph Nader's efforts. Increasingly consumers have come to realize that they cannot trust most manufacturing organizations in the United States to produce safe, let alone workable or attractively designed products. Consumers are learning that *caveat emptor* is still the rule of the business world. Furthermore, there is even some indication that material

goods *per se* are having less appeal to the American people. All such efforts at delegitimating materialism ought to be encouraged.

Furthermore, we not only need to delegitimate materialism but we also need to demonstrate the connections among shoddy goods, resource depletion, environmental pollution, and especially the character of work. As I indicated earlier, the equilibrium state does not imply de-industrialization. The equilibrium state means increasing the life span or durability of any given product rather than preserving our current practice of accelerating the rate of product obsolescence. The environmental consequences of more durable products should be obvious: we need not deplete natural resources at the same rate, we need not pollute the environment with discarded products at the same rate, nor invest so much in a recycling industry. Moreover, more durable products mean better quality products, and better quality products offer the possibility of restoring a sense of craftsmanship and pride in work. It is through such arguments that we can unify the discontents of workers, consumers, and environmentalists.

Another mode of delegitimating existing institutions consists in what T. R. Young (1971:276–281) has called "conflict methodology." Young recommends adopting adversary relationships vis-a-vis powerful organizations and institutions similar to those prevailing in law suits. By such means information is obtained and introduced to systems under conditions of overt and hostile contrast. He is particularly concerned with those non-trivial kinds of organizations so seldom studied by academic social scientists: the Federal Bureau of Investigation, the multi-national corporations and their institutionalized ties with both domestic and foreign counterrevolutionary forces, the professional associations, the Defense Department, the mass media, and the more powerful educational institutions. As Young notes, the law suit and such tactics as infiltration and the copying of ostensibly secret documents (e.g.—the Pentagon Papers) are often far superior to questionnaires, interviews, content analysis, and other "consensus and cooperation" tactics of research.

Finally, we must also make greater use of satire, parody, the put on and the put down, for the effectiveness of these techniques for attacking power have been seriously underestimated (Cf. Dahrendorf, 1970:53–56; Elliott, 1960). It is time to realize that ... "the ability to ridicule is not only the power to hurt, but also the ability

to transcend the constraints of the immediate situation and to suggest to our rulers that omnipotence is not theirs, that they may not prevail without their victims' cooperation. Rulers must enjoy a belief in the fundamental seriousness of their existence" (Kress, 1971:313). Hence it must be our task to make sure that rulers are unable to "enjoy belief in the fundamental seriousness of their existence." We therefore need more movies like *Dr. Strangelove, Catch-22,* and *M.A.S.H.* We need more people on the stage and in nightclubs like Lennie Bruce. We need more writers like Russell Baker, Art Buchwald, Paul Krasner, and even William Buckley.

Moreover, we need to begin to appreciate that the tactics and strategies invented by the Yippies are not to be taken lightly; Jerry Rubin and Abbie Hoffman are possibly the most significant revolutionary theoreticians on the American scene (Friedland, 1971:27–29). Their ability to make officials look ridiculous, to utilize the media to gain attention, and to explain and teach the merits of their cause have been vastly underrated. For Rubin and Hoffman appreciated the significance of consciousness raising through the device of dramatic, emotional, and symbolic communication. They understand that the most devastating thing that could happen to a king, his ladies in waiting, his knights, and his barons and dukes is to be told by little boys that they are wearing no clothes.

CULTURAL ALTERNATIVES

One of the bugaboos of revolutionary theorists has always been that they have resisted demands thay they specify what their future utopia would be like or, in responding to that demand, they have been unable to provide satisfactory images of that future. We are now beginning to get a glimpse of what that future may be like. And as we begin to do so we see that the question is indeed irrelevant. For to the extent that we are able to effect cultural diversity, social life will no longer be lived in homogeneous residential communities and large-scale bureaucratized work organizations. Instead, social grouping will be far more diverse with structures improvised and dissolved as the needs of their members dictate. There is no need to construct a utopia for cultural diversity implies a plurality of diverse communities, each of which is utopian largely for those choosing to join it.

Yet we need not wait until the equilibrium state arrives to begin to create cultural alternatives. Many such alternatives already exist. In fact, what we need to do is to begin to live them in order to bring about the equilibrium state. Here again the Yippies have offered us some theoretical insights. The very act of participating in new and alternative cultures is a beginning of the erosion and destruction of the old society which becomes irrelevant as it is laughed out of existence. But we need not only drop out. Cultural alternatives should be publicized not only by means of writing about them in stories and novels but by means of opening up alternative communities to visitors and inviting them to become involved if only temporarily to try on a new way of life. Not only can those still committed to "straight" ways of life be invited in but those committed to new ways of life can proselytize within existing institutions by infiltrating them, participating in them and seeking to change them, while continuing to refuse to be seduced by the promises of material gain and promotion. Thus I am suggesting the possiblity of subversion by example.

Conclusion: What About the International Realm?

So far in this paper I have suggested that the domestic obstacles to change can be overcome. I suggested that there are substantial sources of discontent in American society, that indeed discontent is all—pervasive. I also suggested some strategies of change. These strategies must focus on articulating the particular discontents of particular groups of people in particular situations in order to be relevant to the issues with which they are concerned. I have emphasized that we must build bridges between the various fragments of our society by showing that all of the various particular discontents have their source in our continued commitment to growth and its proximate manifestation, inequality.

Furthermore, I have tried to stress that power-seeking strategies are totally inadequate to the task at hand. Given the power of the state and other dominant institutions, destruction of power by power is virtually impossible either in capitalist or in totalitarian societies. Our only effective strategy is a cultural one: the demonstration that the institutions set up to serve such values as liberty are in fact

destroying these values by channeling them solely in the direction of instrumental or productive creativity.

However, I have not directly addressed the international obstacles to change. I did indicate earlier that the quest for security in the international system would appear to force us to subordinate any of the domestic changes I have been discussing to the maintenance of our international positions. Yet is the international system of stratification as out of our control as I intimated earlier? I think not, for reasons to be sketched out below.

Increasingly the natural resources required to supply the growing economies of highly industrialized countries are being drawn from those countries which are less highly modernized. We of the industrialized, modernized countries have, therefore, developed powerful inducements for the newly modernizing countries to disregard environmental problems in their own countries. We have already been able to externalize many of our own environemental costs.

What would happen, however, to the international stratification system if increasingly the industrialized nations gave up the quest to maintain or increase their position in the international stratification system by slowing if not completely stopping growth? One main consequence would be that the demand for non-renewable natural resources would be substantially diminished, forcing newly modernizing nations to concentrate their energies more on non-extracting industries, and diversifying their economic base. Further, their task of catching up with more modernized nations would be made easier and could be accomplished more quickly if the most affluent nations would simply stop growing. Minimizing international inequality in this way would remove one of the prime sources of discontent among nations and thereby one of the most important sources of both conflict and overly Draconian attempts to modernize.

We must also become conscious of another impending international crisis, albeit one which could serve as a superordinate goal uniting all humanity. This impending crisis derives from the limits to world growth: our planet's material resources are not sufficient to permit the entire world's population to ever enjoy that material standard of living now typical of the most affluent societies, let alone the standard projected for the year 2000. In conclusion, it is our growth which perpetuates international stratification and thereby threatens us with a variety of crises. As Pogo remarked some years ago—"We have met the enemy and he is us."

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CHAPTER NINE

ENVIRONMENTAL EQUILIBRIUM AND THE QUALITY OF LIFE

Paul B. Sears

In the present concern over environmental problems we ought not forget that they have long been in the minds of thoughtful individuals. True, much of the earlier interest has been based upon intuition, stimulated by such observations as were possible before the rise of modern science.

Centuries before Plato (circa 400 B.C.) described the damage done by man to the Grecian landscape, the poet Hesiod (8th century B.C.) left us the fable of Prometheus who incurred the wrath of the gods when he introduced technology to man by bringing down fire from Heaven. Woven into this story is that of Pandora, given a box which she was enjoined not to open. When she yielded to curiosity a host of evils was released to plague mankind; only hope remained.

Thus, more than 2500 years before our time, sensitive poetic imagination foresaw that innovation might cut both ways, either for good or ill to humanity. From a voice in the ancient past is a warning both to those who insist that scientific technology will save us from our present dilemma, and to those who blame it for our misfortunes. Not instruments or facilities but those who direct their use are accountable for results.

In more modern times the poetry of Shelley expresses a similar concern. So does his wife's story of FRANKENSTEIN (1818) where scientific invention produces, not a servant, but a master. The same theme recurs in DARWIN AMONG THE MACHINES, an imaginative essay by Samuel Butler written for the New Zealand PRESS in 1863. Meanwhile Victor Hugo, himself no mean poet, denounces, in LES MISERABLES, the waste through the sewers of Paris of organic material needed for the fields of France.

(I recall having heard an allegory many years ago that tells of a scientist, struggling with weary muscles up a steep and rugged cliff to reach a crest said never before to have been visited by man. When he arrived, the first thing to meet his eye was the footprint of a poet.)

We have heard much about models in the discussions of this series.

This is as it should be; environmental equilibrium is a goal, not a present actuality. Whether we are moving toward or away from it is a question that calls for models both of current trends and of the goal itself.

Two models we have been given come especially to mind. One is the profoundly convincing thermodynamic analysis of Nicholas Georgescu Roegen, and the other is the computer model of Dr. Meadows from *LIMITS TO GROWTH.* The latter has been criticized by an eminent physicist, John Maddox, editor of the renowned journal *NATURE* in an article *THE DOOMSDAY SYNDROME* that appeared in a November, 1972 issue of *THE SATURDAY REVIEW* and as a book in 1973.

Here Maddox quotes, with apparent approval, Gunnar Myrdal's statement that Meadow's computer model is "pretentious nonsense." As I understand computer modeling, it must comply with three rules—what it attempts, how it proceeds, and what are its limitations. It seems to me that Dr. Meadows has been completely frank in all of these respects, nor can I question, from a very different approach, his conclusion of the urgent need for an immediate change of direction.

I must confess deep respect for the art of devising models, but we should recognize that modeling is only a recent extension of an ancient practice. This practice, in my judgment, is essential to the survival and development of human cultures. Models are the often intangible yet powerful distillate of values associated with the folkways of any culture, tending to become explicit in tradition and ritual. With the rise of writing and printing they become even more formalized in law, and in literature and the other arts.

May I seem to emphasize the obvious with two examples? Years ago an Irishman named Carberry was visiting his mother, a helper in our family. He told us some of his experiences as a soldier with Kitchener in Khartoum. Walking with a comrade over a battlefield, the two heard a wounded enemy cry for water. As the comrade bent over with his canteen to answer this appeal, he was immediately disembowelled by a scimitar. The fallen enemy knew of course that this meant certain death at the hands of the surviving British soldier, which it was.

Both victims exemplified the power of their respective models. Each was moved by the highest conception of virtue inherent in his code, regardless of what we may think of that code.

For another example I am indebted to the late Walter Campbell who wrote under the pen name of Stanley Vestal. Gathering material for a life of White Bull, nephew of Sitting Bull, he was told of a winter when his subject's camp was starving. Hunting through deep drifts, White Bull finally killed a deer. When Campbell heard this he instinctively remarked that the hunter had at least provided for himself. "Not at all" the Indian replied "everyone got his share." This instance is the more striking because Campbell was an unusually generous man. But he was a product of the free enterprise system, as the Sioux was of his own culture. Each man reflected the model of his own folkway.

As with all literature that of models reflects the interest and knowledge of its day. So let us note a few landmarks:

Sir Francis Bacon in the day of Elizabeth I was an early enthusiast for the promise of science to the future welfare of mankind. A more sober note was sounded by Benjamin Franklin. Discussing the population increase in the colonies since European settlement, Franklin pointed out that numbers tend to grow until the limits of subsistence are reached.

Better known is the *1798 ESSAY ON POPULATION* by the Rev. Thomas Malthus. Neither man ignored environment completely but both thought of it in terms of its capacity to furnish food. To this Malthus added the social factor of war and the biological one of disease.

Critics have insisted that Malthus' explanations are not valid for industrial society. The bitter truth is that scientific technology has not resolved the problem of unrestricted population growth. Rather it has intensified the pressure both in absolute numbers and unbalanced distribution, increasing the drain on natural resources and piling up wastes that contaminate air, water, and soil.

Early in the 19th century the economist John Stuart Mill saw the ultimate necessity of social and economic equilibrium, a truth not yet of much general interest. His view should be no surprise to anyone familiar with Mill's interest in chemistry and particle dynamics.

The publication of Charles Darwin's ORIGIN OF SPECIES in 1859 established the decisive influence of environment on the evolution and survival of living organisms although its relevance to human destiny remains to be fully appreciated. Five years later George Perkins Marsh issued his monumental MAN AND NATURE demonstrating the mischief to old and modern societies by environmental

abuse. In the same decade came the first volume of a critique of the social environment, *DAS KAPITAL* by Karl Marx.

The literature that followed—tenuous at first, but reaching a crescendo during the past four decades—is really an elaboration of the themes set by Darwin and Marsh. At first it was concerned over the depletion of natural resources, notably in a warning by the American Association for the Advancement of Science, in 1876, later at a White House conference of governors under Theodore Roosevelt with its emphasis on forests and minerals.

Interest was revived, after a lull due to World War I and the deceptive prosperity that followed, as a result of the drought and depression of the 1930's. Not only was there danger that resources might be used up, but that the natural processes affecting soil and water might be disrupted.

By the 1940's the threat of overpopulation, obscured by a temporary fall in the birth rate, began to take center stage. Then with the remarkable expansion of industry following World War II the accumulation of waste and pollutants created concern in a public that had been largely indifferent to environmental matters.

Today the relevant literature is in full flood, a library in itself. I find it impossible to do justice to all but a small portion of that which reaches me unsolicited. Books, journals, pamphlets, and daily press bring material that ranges from scholarly analysis and good reporting to the sensational but which is, on the whole, remarkably sound.

Writing that attempts to project the future may often be a form of social criticism. It includes not only prophecy and Utopian material but science fiction and such anti-Utopianism as Julian Huxley's *BRAVE NEW WORLD* and George Orwell's 1984. With these we must include the blue-prints for a communist society laid down by Karl Marx. A majority of the human race is now living under some approximation of the Marxian dream—sufficient answer to anyone inclined to dismiss the making of models as an idle business.

Much that is labelled prophecy is nonsense. Some gains credence through double-talk. Croesus, for example, was told by the Delphian oracle that a great empire would fall. He assumed it would be Persia; it turned out to be his own. The classical Hebrew prophets, expressing their predictions of disaster in scorching language, were men of an acute sense of trend in the face of ignorance, indifference, or complacency.

I have been assured by a student of the Old Testament that much

of their indignation was aroused by cultural disintegration as traditional pastoral and agricultural life gave way to urbanism. Among these prophets Isaiah sounds curiously modern in the 8th verse of his 5th chapter where he proclaims "Woe to them that join house to house, that lay field to field, till there be no place."

Social criticism by the early Utopians was more subtle, making its point by picturing ideal social and political conditions rather than by denunciation. Environment was tacitly assumed to be favorable. The best of their work was so highly imaginative and well-written as to place it among the classics. To those interested I recommend Volume 5 of the Daedalus Library, *UTOPIAS AND UTOPIAN THOUGHT*, Houghton Mifflin, 1966.

New sources for assessing trends came rapidly during the 19th century. Thermodynamics gave perspective to environmental processes. To it have been added cultural anthropology, genetics, the new psychology of Freud and Pavlov, developments in economics and political science, and finally ecology. The resulting appraisals range from complete confidence in science and technology to get us out of any environmental scrape to a growing anti-scientism. One of the most serious problems we have is to reconcile economics with ecology.

Long unfamiliar, the word "ecology" is now in common, sometimes reckless use. Other sciences have suffered in like fashion. Mysterious chemicals with impressive names are advertised as having sovereign power in what amounts to the practice of medicine by air. Normal functions of mind and body, amenable to cleanliness, proper diet, and exercise, are exaggerated by those who have such compounds to sell. Ecology is not the only victim of the public's blind faith in white coats, microscopes, and the jungle of laboratory gadgets.

We live in a society whose means of producing consumer goods from a finite supply of raw materials exceed all reasonable demand. Too much of what we call R & D—research and development—is aimed at reducing labor costs in mass production, while millions are unemployed. In some cases a third generation knows only relief payments as a way of life. A friend who had served his time on the assembly line once remarked with sadness that many of his coworkers had no other challenge than to plot against the human race.

With the mass production of consumer goods no longer a major challenge, industry is preoccupied with the persuasion and mental

conditioning of the buying public. The evidence of this is in the relentless advertising that assails our ears and eyes and the impressive budgets that make it possible. Too often the arts, and even science, are employed with a guile that amounts to prostitution. Appeals to reckless consumption are designed to stimulate vanity, fear, and the avoidance of physical and mental effort. Yet without effort, no animal, man included, can be healthy. The push-button has replaced the harp and golden wings of yesterday.

Yet advertising is certainly integral to our way of life, and a source of many benefits when it remains an honest and rational instrument of cultural change, and an agent of public information. I like to think of the remark of Dr. Phillip Morrison that John Wesley did more for public health than all the physicians of his day, simply by preaching that cleanliness is next to godliness. Certainly all possible means of information must be used if we are to start towards environmental balance.

Since this is an ecological challenge, just what is ecology? Like geology it must deal with observations not always under experimental control. Both sciences have taken punishment, even in scientific circles, on this account. As to geology, this may surprise many who have not read *A SENSE OF THE EARTH* by David Leveson.

In approaching the interrelations of life and environment the ecologist must draw upon the best relevant information he can get from whatever source, as well as on his field observations and experiments. For example, and again like the geologist, he must try to reconstruct the past so far as possible.

One cannot explain the cultural atmosphere of St. Louis, Cincinnati, and Milwaukee apart from the influence of talented German immigrants. Nor the presence of thousands of acres of open grassland in the forest environment of northern New Mexico without knowing of exploitive lumbering and fires during the 1880's. Only through the accounts of elders do we know that lush pastures in the Taos valley were degraded into sagebrush by vast herds of sheep during dry years around 1900.

The ecologist must draw heavily upon help from those who have expert knowledge of the physical, biological, and social components of the environment. This has led at least one eminent scientist to declare that ecology does not exist. Yet one does not write off architects and builders because masons, carpenters, plumbers and other craftsmen are specialists.

The business of the ecologist, as the late Frederic Clements used to say, is with process. It is to this end that he must use his knowledge of natural conditions as a standard by which to judge change. Only in this way can he hope to make his most valuable contribution to society by revealing the trend of our present environmental processes.

Now the study of trends is a tricky matter as I well know from my own efforts to understand past climates by means of pollen analysis. The climatic record is one of minor pulsations of varying length and intensity against a background of more fundamental changes. How often are we assured by old-timers that the weather ain't what it used to be? In the opinion of some competent Pleistocene scientists, the present climate is not postglacial but interglacial. Whichever it may be, we are reminded that if a warming climate becomes sufficiently intense and prolonged, the melting of polar ice caps will threaten disaster to seaboard cities.

In 1948, at the request of the late Dr. Pablo Martinez del Rio, historian and anthropologist, I undertook a study of the influence of climatic fluctuations on human cultures. As he outlined the problem to me, early agricultural activity flourished on lake shores in the Basin of Mexico previous to 500 B.C. At that time there was a shift to higher ground where the great pyramids of Teotihuacan and adjacent ruins lie.

This impressive site, according to Dr. del Rio, was abandoned around 900 A.D. Lake margins in the basin below once more became the source of subsistence. The resumption of this earlier practice, known as *chinampa* gardening, sustained the Nahua civilization found by the Spanish in 1519.

Fossil pollen and artifacts taken from cores in lake sediments around Mexico City indicated that a prolonged dry period had preceded the shift of cultural activity to Teotihuacan. There was also evidence of a marked increase in moisture, probably about the beginning of the Christian era.

Our findings suggested that the lakes sustaining early agriculture had been greatly lowered by the long dry period preceding 500 B.C. If true this would have made necessary a move to high ground where water from the mountains was available. With the later return of moist conditions lake levels would have risen and chinampa farming on their margins once more become possible.

Search for confirmation of this idea led us to Chimalhuacan where

drainage of a lake exposed a portion of the bottom that had been dry land at some previous time. Here were artifacts which I was assured corresponded to the oldest at Teotihuacan. When lakes dry up any culture that depends upon them must move, in this case to higher ground.

This had happened west of Socorro, New Mexico where there is a large basin known as the San Augustin Plains. Occupied by a large lake during glacial times, it is now empty due to conditions of topography and rainfall that do not permit recharge.

Bat Cave at the margin of this vanished lake contains deposits of cobs showing that maize was cultivated there during the late phase of drying—an activity that ceased around 200 A.D. Later archeological sites are all on higher ground around springs where water from the mountains was available.

Has modern knowledge made us less vulnerable to natural disaster than more primitive cultures have been? On the contrary, we see developments such as the recently shattered Managua built along known geological fault-lines; housing is permitted along valleys known to be subject to recurring flood, as was shown in New England in 1955; likewise, for example in California, on inclines subject to slippage. Again farming has been allowed to expand into semiarid range land where intervals of drought are inevitable, while shady real estate promotion continues to flourish in areas without water.

These are matters already clear from observation, yet so great is our obsession with numerical proof that we insist on further surveys for data, preferably in terms of dollars and cents.[1]

Now ecological principles can seldom be applied for private and corporate profit. In the short run at least they may run counter to this end, so readily expressed in figures. Instead the most important use of ecology depends upon major changes in social values which are notoriously hard to measure.

From an initial concern with vegetation, then with animal life, ecology has expanded to include Man, the dominant organism on earth. As I tried to show in an informal, somewhat whimsical little book *THIS IS OUR WORLD* (1937) the key to man's ecological role

[1]The difficulty of such analysis is clearly stated by Russel E. Train, Chairman of the Council on Environmental Quality in an editorial in *SCIENCE* for 13 October, 1972, entitled *THE QUEST FOR ENVIRONMENTAL INDICES.*

comes from anthropology.[1a] Human relationships to environment are functions of culture patterns.

We need only compare forest practices in Scandinavia and the Danish rule of nationalizing mineral deposits with our own exploitive behavior to appreciate this. I recall that Dr. Charles Kellogg remarked, at a time when he was critical of the Soil Conservation Service which he later headed, that soil conservation was basically a human rather than a technical problem.

For my own convenience in dealing with environmental problems I have found it useful to borrow a form of notation from our friends in mathematics: (R/P) f (C)—to indicate that the ratio of resources to population is a function of culture. If one wishes, this memorandum can be expressed as an equation: lim (R/P) f (C) = 0 since many resources such as space, minerals, and often fresh water are finite in amount. Continuously increasing pressure on them approaches the extinction of the whole process as a limit.

Cultures have been shaped by the kind and abundance of natural resources. In turn their values have determined the treatment of such resources. While some Indian parties, after the introduction of horses and firearms, engaged in wanton slaughter, the ritual apology to an animal needed for food indicates a respect for the wildlife upon which the Indian depended. There is no reason to believe that extermination was generally sanctioned.

The relation between human numbers and environmental damage is not a simple linear one. The Near East and Mediterranean regions were devastated by populations of moderate size as compared with modern ones. In our own country, forests, rangelands, and soils were pillaged before 1900 when there were less than half as many of us as there are today.

Yet the growth of world population is so rapid and the pressure on finite resources so obvious that many of our colleagues give primacy to this situation. The rate of population growth is a complex resultant of economic pressure, concern for the well-being of offspring, and even of fashion. It is difficult to predict, no less to control. Population control is an ancient as well as persistent cultural problem and has involved many procedures. French law, for example, has encouraged the retention of peasant land within the family. Since Napoleonic

[1a]Incidentally, this book notes (page 32) the probability that fossil fuels will be used up and the role of modern warfare in hastening this eventuality.

times the canny French farmer, sensing the folly of dividing workable units among too many children, has limited family size by techniques more primitive than those now available, but no less effective.

The influence of economic factors was shown in 1935 when the birthrate, lowered by depression, caused some demographers to predict that the population of the United States would level off at 140 or 150 million by 1960. It is now about 210 million; again, a decreasing birthrate has given rise to predictions of zero population growth.

Agreement on appropriate means to limit population is difficult; most of us share an innate fear of government control of reproduction. Yet, I think, most of us could agree that children should not be biological accidents. Every child who enters this world deserves to be welcomed and to have a reasonable chance for a good life. I would be satisfied with this ethical principle as a guide in the hope that it would forestall controls less congenial to our humane instincts.

Population, of course is only one of several far from simple factors influencing environmental equilibrium. It is well to remember that extremely complex problems may be approached in two ways. One, the more familiar to the working scientist, is to break them up into small components that can be readily studied and analyzed in the hope of an eventual synthesis; the other is to scan the problem as a whole, searching for evidence of a pattern.

The latter approach calls for intuitive judgment. In case we judge this method ineffective we need to recall that even in mathematics, as Poincare has pointed out, solutions may be arrived at by intuition as well as rigid logic. And it is by recognizing pattern that we are often guided to the most useful way of breaking up a complicated problem into segments for detailed study.

It is largely this sense of pattern, emerging from the ecologist's knowledge of living communities and of what can be gleaned from the record of more than two billion years of planetary life, on which he bases his own approach to a model. In my judgment this provides an indispensable background to the convincing thermodynamic analysis of Georgescu as well as a check upon other analytical formulations.

The ecological model sets forth a remarkable economy in the use of materials and energy in natural communities. Waste products are returned to earth, air, and water step by step, making them once again available for use. This recycling is accomplished by food chains involving an integrated variety of organisms making up such com-

munities. Despite reversals, disasters, and extinctions such an economy tends to enhance the capacity of environment to sustain life.

During a visit to the vast game preserves of East Africa I was struck by the beautiful efficiency of the process that has kept life going since its ancient origin. The great savannas with their grasses for pasture and trees for browsing support a wealth of plant eaters, each with its preferred food. In this way competition is kept at a minimum.

Unlike the packs of dogs for whose wanton killing of livestock the coyote and mountain lion are unduly blamed in New Mexico, the flesh eaters of East Africa kill only what they need. Their table scraps are cleaned to the last vestige by carrion eaters. Of this, the droppings of the hyena, white with the calcium of bones, are ample proof.

Green plants return oxygen to the air, retaining the carbon and other elements needed for the manufacture of food. The organic substances made from these materials support food chains at whose end are the microorganisms that return organic wastes to earth and air, usually in oxidized condition ready to be used again by green plants.

Sustaining this process is energy from the sun, stored in foods, to be released step by step as these foods are used in food chains until broken down into the raw materials from which they have been made. The energy thus released is not available for use again by organisms, thus a continuous input of solar energy is required to keep the system running.

On the whole, and with fluctuations, this process has operated since the origin of life on our planet, so far as we can reconstruct the past. Ideally it represents a type of environmental equilibrium approximating what is known in the physical sciences as a *steady state.* Since it depends upon a continuous input of solar energy it is an *open* steady state so far as energy is concerned.[2] But with respect to the materials which must be recycled to maintain it, since they are finite in amount, it represents a *closed* portion of the system.

At times during geological history the production of carbon compounds has resulted in a surplus of stored energy in the form of fossil fuels. It is a curious fact that much of our present disequilibrium comes from our new-found skill in substituting these vast but finite

[2]Sears, P. B. 1959. "The Steady State: Physical Law and Moral Choice." *The Key Reporter* 24:2–3 & 8.

energy reserves for the current sun energy stored in food which has made possible, through almost all of human history, the work done by man and his domestic animals.

The cultural dilemma this created is vividly expressed by Nan Fairbrother in her perceptive book NEW LIVES, NEW LANDSCAPES. "I abominate pylons" she writes "as I do the Eiffel Tower and . . . all such . . . Meccano-like constructions. I accept them in the landscape only as anyone would who brought up a family without electricity or gas . . . Even now I never quite believe that simply by pushing buttons I can have hot water and a cooking stove and a warm room to sit in, and rather than lose my miracle buttons I would welcome the largest-size pylon in the middle of the garden."

Elsewhere in her book Nan Fairbrother describes the change in the British landscape due to mechanized mass-production farming. The picturesquely hedged small fields, tilled by the labor of man and beast, have been merged into broad open fields, cultivated by machines using fossil fuel. This brings up a violation of the ecological model too often overlooked.

The small farm, now in economic distress, had its faults but it was a viable ecosystem. It combined plants, animals, and people, sustained by solar energy and recycling its wastes. At its best it approached the efficiency of natural systems, maintaining and even enhancing the productivity of the soil. Along with plant and animal industry it involved responsible human activity, especially important in the training of the young.

One characteristic of most natural ecosystems and of sound agricultural practice is the development of a soil condition known as crumb structure. Mineral particles are held together in small masses by organic colloids. These crumbs help to conserve water and nutrients and aid the circulation of air within the soil.

They also serve as intermediaries between the soil nutrients and plant roots. This is the basis of so-called organic gardening, using humus from composted plant and animal wastes. Under completely mechanized farming in the absence of animal industry, using only artificial fertilizers, crumb structure can be lost. One consequence is the leaching of costly fertilizers that may pollute ground and surface water.

In East Anglia and elsewhere a further consequence is diminishing crop yields. The report of this condition written by a physical scien-

tist, Dr. N. Pilpel (1971)[1] is a revealing example of obsessive faith in artificial remedies. The author urges research to find some chemical additive that will restore the lost crumb structure!

Rural ecology cannot be considered apart from the problem of cities. In 1945 I was invited to attend a conference in the Mississippi Delta, then a major cotton-growing area. The conference itself was encouraging in many ways; local conditions were not. Fields were plowed to the foundations of the workers' cabins; there were no gardens, no poultry, fruit, or cows. Workers were entirely dependent upon their field wages.

A planter with whom I talked told me that he was experimenting with cotton-picking machinery, adding "Cotton is selling at thirty cents. We're fixing to make money if she goes down to twelve." When I asked what would happen to his field hands and their families he replied good-naturedly "We'll let you worry about them in Cleveland and Detroit."

In the same year I visited a well-known and highly respected head of agricultural extension in another state. He confessed that he was greatly troubled. "Until now" he explained "we have been expected to give all the help we could to the small family farmer. Now the orders are to promote large-scale, heavily financed and mechanized farming." In the years that followed the number of farms and farmers has shrunk more than half, while the acreage per farm has grown correspondingly, along with payments for keeping land out of production.

There is something radically wrong with an economic system that violates ecological rules of experience and whose effects radiate inward to great urban concentrations. It is quite possible to shape a technology that would not only serve small-scale rural living but make it more attractive than life on the assembly line. A study some years ago found plenty of young men and women who would prefer farm life if it could support them.

We should not overlook the viability of agrarian life. Harrison Brown, James Bonner, and John Weir in their book *THE NEXT HUNDRED YEARS* have this to say: "Our technology will permit us to continue without . . . (our present high grade mineral deposits) . . . for as long as industrial civilization keeps functioning. But if for any

[1]N. Pipel, 1971 "Crumb Formation" *Endeavor.* 30:77-81.

reason disaster strikes and the industrial network is destroyed, it seems doubtful if we shall ever again be able to lift ourselves above the agrarian level of existence."

Earlier these authors remark that "a society such as that of the United States is far more vulnerable to disruption than an agrarian society such as that of India . . . Were the major cities of India to be destroyed it would be a long time before some of the villages would hear about the catastrophe, let alone be seriously affected by it."

Chairman Mao in his rebuilding of China wisely gave priority to agriculture. For glimpses of the result I recommend an article by Melville Maxwelle in the autumn (1972) issue of the *AMERICAN SCHOLAR* and another by Arthur Galston in the October (1972) issue of *NATURAL HISTORY*. Not only do they report no unemployment; they give an impression of motivation in these rural communes. Yet Dr. Galston shrewdly observes that the final outcome will rest upon decisions made by central government. This should not surprise citizens of our own country whose energies and sacrifices in a population of over 200 million have been largely directed for more than a decade by the decisions of a very few leaders.

But even revolutionary and authoritarian change is tempered by the inertia of the culture in which it occurs. Chinese tradition ranked the farmer only below the scholar, and both above the merchant and soldier. At best it will be a slow and painful process to bring into harmony with the ecological model a civilization such as our own with its almost unrestricted apotheosis of the free enterprise and profit system and its gigantic capacity for converting natural resources into armament and consumer goods regardless of genuine need.

I would be the last to discount the many privileges we enjoy or to condemn in blanket fashion the leaders in economic life. I have experienced too many instances of their responsible and enlightened action. But as one of them explained to me "while much can be accomplished by voluntary cooperation, we have our share of those who recognize only compulsion."

The obsession with growth is not limited to industry and finance. It has also rendered cities unmanageable. As Lewis Mumford has reminded us, cities were originally functional in relation to the rural economy. They were centers for exchange and fabrication. Their priesthoods developed astronomical knowledge and encouraged

engineering skills, regulating seasonal activities, surveying, and irrigation. They established military protection, political controls, and through feast and ritual, served to stabilize cultural values.

With time, and repeatedly, the relation of cities to the total landscape has changed from a mutual relationship to one which in the eyes of a biologist most nearly represents parasitism. As cities have grown in power and despite their dependence upon the soil and its products, their economic, social, and political exploitation of rural life has increased. The status of the farm worker has declined, often to serfdom or slavery. With this decline has come corrosion of the art of husbandry and wastage of the soil, followed by military adventure for access to fresh sources of food and fiber.

As urban populations grew faster than the supply of useful employment various measures were necessary. These included conscript armies, great public works such as the pyramids, rations and diversions at public expense, caste systems and even human sacrifice. In this way, and again in biological terms, parasitism developed within cities as well as between city and country.

This term is not meant to condemn the helpless victims nor to neglect the potential for good in urban life. When the population of Manhattan began to decline more than thirty years ago, an anthropologist remarked that only its rich and poor had anything like a valid community life. Those in between spent their lives in daily passage between the cells where they worked and those in which they slept. An exaggeration perhaps, but a suggestive one.

This comment was a reminder that the poor had, within their own neighborhoods, personal relationships, small shops, and a measure of attention from their political leaders. Frequently these relationships were strengthened by a discipline persisting from religious and ethnic heritages. It has been my privilege to know, and to know of, creative individuals who emerged from the hardships of such backgrounds to enrich our culture.

Cities may have facilities that can make them both liveable and enjoyable; recreational space is one. Copenhagen's apartment dwellers have outlets in the incomparable Tivoli Park and in open areas around the city where garden plots are available for their use. The small urban parks of Paris, the Kew Gardens in London, the Bronx and Brooklyn Botanical Gardens and—thanks to William Cullen Bryant and Frederick Law Olmstead—Central Park in New York show

what can be done to mitigate the less pleasant features of metropolitan life. The role of museums, concerts, and theatres is obvious.

Yet too often what is called urban planning runs counter to ecological experience. The organisms in a viable community, human or not, must have a foothold or niche; each must also have a valid function or role. Resettlement plans fail without an economic base. City planning dare not stop at city limits; each city is part of a larger ecosystem. Neighborhood facilities such as small stores have been allowed to suffer the fate of the family farm, making the automobile or bus necessary even for the purchase of daily bread.

However gratifying the interest of central government in environmental problems, the United States is too big, too varied to have all of its solutions emanate from there. Most such problems need the responsible attention of those who live with them. I have seen planning agencies spend their time and energy trying to get money out of Washington when they should be getting out and looking at their own surroundings.

Even living under a democratic regime we can sink into the apathy of "Big Brother knows best." The remedy lies in a citizenship trained to see and appreciate what goes on around it. Human beings will take care of what they have learned to cherish and in which they have a stake. Pride of ownership can be vested in community or landscape as well as in private property.

Even indifferent students respond, in my experience, when given a chance really to see the environment and get their teeth into some of its problems. For myself, I have never seen an uninteresting landscape since my introduction to geology; this goes even for those landscapes showing depressing signs of misuse.

The best planning in the world will fail if we fail our children. Recently I have had the privilege of working with our community youngsters in a "Project Discovery," an effort which has involved artists as well as naturalists. Two age groups, one from six to nine, the other from ten to fourteen went out with adult guides into mountains and forests, viewing valleys and human activities in perspective. Later they were given supplies of art materials with which to record their impressions.

To the elders who took part in this experience it was a revelation to see, not only the interest, but the grasp of these children when confronted with reality instead of merely being told about it. I have

concluded that we greatly underestimate, in our conventional schooling, the capacity of the young.

I am not underestimating the importance of language; without such mastery even good native intelligence is crippled. But there is no substitute for direct experience, nor the intensely personal relationship which is the heart of teaching and learning. I am skeptical of mass education and too many mechanical aids to learning.

Teachers teach what they are, not merely what they know; good teachers are as rare as exceptional individuals in any vocation. They deserve to be ranked with the best personnel of their communities. They must have rein to furnish tangible experience unclouded by mere words and devices that obscure as much as they reveal. Technical details and terminology, and certainly this is true in ecology, must await, like the use of the microscope and other apparatus, an appetite for them.

If these comments seem to bring us around to what a friend once called "the intolerable subject of education," I have no apologies.

Every environment is an expression of constant change. That further change should cease is inconceivable and with change comes challenge. This should dispose of any fear that equilibrium between Man and environment would bring monotonous stagnation, the end of incentive and adventure.

Environmental equilibrium is a distant goal at best. The quality of life has no meaning unless there are human beings to enjoy it. Whatever may be the fate of our species, the most immediate threat to the human adventure comes from Man himself.

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