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# Science and Technology's Impact on Critical Social Issues

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Science and technology are uniquely human activities. Today they are terms well known to all of us.

Science and technology affect

**how we think (some would say, "not enough"),**
**how we communicate (some would say,"constantly but not clearly or credibly") and**
**how we reproduce, use energy and feed ourselves (some would say for each of these, -"too much"!)**

I want to explore briefly the way science and technology affects how we think and, more specifically, their impact on energy and food.

Science and technology are terms we almost always think of as a single concept, yet they have only been related in the past few hundred years. Actually technology is much older than science. In simple terms, technology is the means or activity by which man seeks to change or manipulate his environment. Even more simply, technology is a tool, and man is a toolmaking animal. In fact, man is unique among animals in his ability to make and manipulate tools. Viewed as a toolmaking activity, technology is as old as the history of man. Being but a tool, it can be neither good nor bad. It is simply put to the purposes of man.

Society shapes technology through its needs, its availability of resources in terms of raw materials, capital and skills, and its receptivity to innovation. Without these elements, technology cannot survive. Throughout history, technology has been sometimes mysterious, irrational, cyclical and often stagnating in many civilizations.
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The radical change to the disciplined, cooperative research that had its beginnings in the 17th century was derived from a fundamental change of perception - the universe, formerly believed to be a living, spiritual cosmos, was accepted as non-living and devoid of spiritual and human properties.

Only during the 19th century did technology actually become founded on science. Before that, science belonged to the aristocratic philosopher and embodied all knowledge, while technology was a possession of the working craftsman: the tanner, miller, silversmith, and so on.

### Curiosity — Driving Force of Science

The primary goal of science is knowledge. Scientists are driven by curiosity within the rigorous discipline of their methods. Through appropriately conducted experiments, scientists demonstrate that one hypothesis has a higher degree of probability of occurring than another in such a way that independent experimenters, given the same conditions, can obtain the same results. A conclusion reached in that way we tend to call fact. Yet in contemporary science we know that all such facts are probabilistic.

Facts derived from the so-called hard sciences such as physics and chemistry have a high degree of certainty. In fields of science with more complex variables, there is a lesser degree of certainty that any single event is predictable. Accordingly, biology has less certainty than physics; and psychology, less than biology; and in some of the social sciences, we arrive at situations where almost any event is equally probable. But when the so-called hard facts, in physics and chemistry, for example, are translated into every day technological or engineering terms, they become much more certain in terms of our daily experience. We have a high degree of confidence that this building will remain standing for the foreseeable future. We trust the engineering and physical characteristics behind the structure, just as we do the performance of most of our machines and structures throughout the society. What is fact and what is not, or what we perceive to be true as opposed to what we perceive not to be true, is the information which governs our lives. We base most of our actions and behavior on information we receive. The credibility of that information becomes vital to our behavior.

Science can be frustrating for the individual seeking certainty because it is never conclusive. Each advance reveals more unknowns. Furthermore, it is subject to change, based on new evidence. As a result, although science may be an activity supported by our faith in its successful pursuit, it is, in itself, not a faith. The scientist cannot afford the luxury of untested faith as part of his professional activities. He requires independent verification by numerous investigators under controlled conditions to have an event merit an acceptance as fact - and our technology is built on these scientific facts.

By the early 1900's, technology was believed by many to be the means to achieve the greatest good for every man. Others even then were concerned with the hazards of technology. In Huxley's book, Brave New World, published in the midst of the depression in 1932, he pictures technology enthroned, providing all of mankind's bodily comforts with no pain, but without freedom, beauty or creativity, and robbed of any unique personal existence. Still, the moral optimism of Western Science's conquest of nature was sustained — until the atom bombs were dropped on civilians at Hiroshima and Nagasacki.

### A Centruy of Technological Explosion

The 20th century has seen a technological explosion. The years of 1900 to 1945 were dominated by two world wars, while those since 1945 have been preoccupied by the need to avoid yet another major war. World War I brought about a chemical revolution and World War II has been characterized as bringing about a physical revolution. We have only recently had a biological revolution - with molecular biology

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and the elucidation of DNA and the discovery of recombinant DNA and its applications - contributing to our fundamental understanding of the mechanisms of life. Fortunately, this revolution did not require a third world war. But the great wars accelerated the transformation of small scale science to "big science and big technology," with emphasis on large research teams sponsored by governments and corporations. The relatively short life of modern science was dramatized by Philip Handler, writing in the Science magazine issue of May 4, 1979, with an estimate that 80 percent of all science has been learned since 1950, the year when the National Science Foundation was initiated.

A radical change in perception occurred in the 17th century when man began to see himself as located on one small planet, in one solar system, sharing a vast universe with billions of other solar systems. It was a fundamental change from man's previous view of earth as the center of the universe about which all other planets and stars moved.

It took hundreds of years under that altered perception of earth's place in our galaxy to achieve the first flights into space, to have man walking on the moon and to explore our solar system with unmanned vehicles. Perhaps centuries from our first understanding of the significance of black holes and our first communications with other space civilizations, the full impact of that change in mind-set on our society and its technology will be realized.

**Planning Sharpened by Simulation**

A more mundane and immediate effect of the impact of science and technology on how we think results from the necessity of careful planning in large technology. This has affected not only the science or technology which utilize planning, but also the governments and institutions that derive primary growth from such technology. The extension of technological planning to computer simulations which forecast alternative futures based upon various projections from the past has presented us with further disturbing and sometimes frightening information. The concept of limits to growth, population, energy and food supply in the context of Space Ship Earth moving through a hostile universe has forced us to re-examine the premises of our society, our goals and the manner in which we achieve them. We have reached a state unprecedented in human history with true global awareness of man's dependencies on certain limited resources.

Ancient civilizations have gone through many phases of similar states of awareness but invariably solved them by acquisition of additional territories through exploration, war, or economic exploitation, or by establishing relatively stable societies wherein the population is controlled and excess manpower emigrates to other places still in developmental stages. We are at the end of that era. No civilization is isolated from the world society.

Because awareness of the limits to basic survival resources is relatively recent, particularly in the United States, we have not tended to adopt long range policies which guide the planning to meet transitions to new resources or altered technological uses of existing resources in a fully adaptive and nondestructive fashion.

First, let's assume a strategy which makes our ultimate goal the avoidance of major disaster to man, the plant and animal species he depends on and interacts with, and the environment we cohabit. Simply put, we wish to avoid biotragedy - for us and our biosphere. Identifying probable hazards and avoiding them is an adaptive mechanism not at all unique to man - it is a prerequisite for survival. Factors which, if uncontrolled, lead to biotragedy include population increases, pollution, basic resource depletion and war. There are others, but these suffice to make the point.

Biological systems commonly require that some critical threshold be passed and an appropriate time lag before they react to changes in their environment. Thresholds of awareness obviously differ between societies and people, but if we accept the empirically observable increase in factors leading to potential biotragedy, then it is clear that the threshold of crises awareness has been crossed, particularly with respect to environmental protection, energy and population issues.

As a second premise, once we've agreed to avoid biotragedy, I assume that there must be a basic and direct relationship between authority and planning if any orderly transition is to take place. For more specific examination, let's assume levels of authority as follows:

An executive level such as the President of the United States or the president of a corporation.

An administrative level: perhaps a federal agency such as the Department of Energy or the National Science Foundation, or the corporate staff in a large company.

A consultive level: for example, the recommendation of specialists from academic or the private sources.

Finally, a consensus level of authority which expresses a majority view or a highly vocal and unopposed special interest. This could be a wild cat strike or Ralph Nader's efforts or the voting of the general populace.

Let us also consider the various classes of planning. Planning may be carried out by the decision maker at a local level - - city, county, or corporation - - or the regional level of a state or multi-state area like the Ninth Federal Reserve District; or at a national level through government or major corporations. Planning also may be carried out - - and more frequently is - by non-decision makers; for example, university or corporate staff. In any case, planning by non-decision makers requires communication and acceptance of this communication by the decision makers.

**Point of Critical Decision**

The primary distinctions between these two kinds of planning - the decision maker vs. the non-decision maker - are the time lags that occur between the initiation of the planning, the conclusion of the planning (sharply or inconclusively) and the execution of the recommendations resulting from such planned effort. Perhaps another distinction may occur in the sophistication of the planning. Planning by non-decision makers is frequently more sophisticated (but not necessarily more effective) than that by decision makers.

It should be obvious that these approaches to planning relate directly to the levels of authority. Usually the executive function is a decision making role, while the administrative and consultive levels of authority generally conduct non-decision making planning.

Planning our use of basic resources requires some elementary knowledge concerning these resources, their use, future demand, the technology required to find, manufacture and transport it; the technology transfer price; and the time dependencies of the applications of such technology.

A look at some simple approaches to planning reflects awareness of resources, their limitations and the transitions of society that relate to the use of basic resources. By basic resources, I refer to things such as oil, natural gas, coal, uranium, alumium, copper, steel, fertilizer, food, and others. Let's assume two types of societies: a "Reactive" society which is basically a non-planned structure and a "proactive" or future planning society. Let me further assume that the existence of these social frameworks are dependent upon the awareness of whether such resources are limited or unlimited. The United States during the last 200 years evolved from a primitive frontier land where almost all basic needs could be met by assumed unlimited resources to a position where resources are increasingly recognized to be finite.

A society that assumes its resources are in fact limited and, which takes on the responsibility of planning for the use of such resources or their substitution, evolves in a non-disruptive, adaptive fashion either through transitions to the use of alternative resources or to wiser use of existing resources.

On the other hand, the society which assumes its resources are unlimited, and does not plan for their use, reacts to shortages in a way that any unexpected event is treated as a crisis.

If there is a failure to adapt to the stresses required by unpredictable social transition, we have seen in the past and could see again the ancient Four Horsemen of the Apocalypse - famine, pestilence, war and death - become the characteristics of our species.

The transition mankind faces today in energy technology is simply the start of a shift from liquid hydrocarbon fossil fuel as our predominant energy source to more available solid hydrocarbons (coal) and alternative anergy sources - like nuclear and solar. Ultimately, man must be dependent on renewable energy sources. For the short term, if there is stability in the Mid-East and if the average United States energy prices continue to approach world oil prices, there should be no national energy supply problems. A major disruption in the Mid-East would require the implementation of energy emergency plans affecting the economy and each of us. Even if such a disruption does not occur, there may need to be support for fixed-income and low-income families most affected by increased energy prices.

The lead times to bring on increased energy supplies or alternative technologies are very long. It took 40 years to bring nuclear technology to the level where it provides five percent of the nation's energy demand. Even under most optimistic conditions, if a full scale national effort in solar energy were started now, it would only be able to provide five percent or perhaps up to 15 percent of the nation's energy requirements by the year 2000.

**Facing the Faster Rate of Change**

Transitions become crises when they occur more rapidly than we can adapt to them. What is truly new today is the rate of change throughout the world and at every level of humanity. Thus crises are occurring daily for individuals and segments of our global society and are communicated immediately to each of us via satellite and communication media. Exponential population increases and rising individual aspirations, together with the concurrent exponential evolution of technology and applied knowledge are the critical driving forces causing accelerating change. The increase in world population is made much more critical by universal demand for a higher quality of life, including higher incomes, cleaner environments, improved medical care, and a safe and nutritious food supply. High protein demand through increased meat consumption is a common objective of newly developed countries. Rising aspirations of the world's poor to enter the middle class appear to be becoming more uniform throughout all nations. This is particularly of concern where the middle class person can be estimated to require five times as much food and fuel as the poor person.

After almost two hundred thousand years of dependency on tribal hunting for food and a few tens of thousands of years of dispersed agrarian activities, man has developed in less than two hundred years a highly sophisticated food system. In the United States today about two percent of the population dedicated to producing food meets not only U.S. needs but also a great portion of world food needs. Farming alone did not remove the uncertainties of food supply. Science and technology and other activities beyond those necessary to assure a sustenance level of production make it possible to store, distribute and utilize food more efficiently.

By 1985, we can expect nearly a billion more people on earth than were here in 1975. Even under "business as usual" conditions, we would face a great challenge to meet their growing needs. But faced with the potential of energy shortages and/or major energy price increases, we can only hope that weather cycles will be favorable and that world grain supplies will be unusually productive. So far, the technological "war" on poverty, urban decay, and population control and technological transfer to underdeveloped countries has met with little success.

**Critical Decision Faced by "Toolmakers"**

Technology now presents a dilemma to society. The "tool" is now a multiplicity of tools, resulting in unexpected and sometimes dangerous side effects. The choice is ours as the toolmakers. The resolution of the deployment and control of nuclear power is primarily political. Population control is inhibited by life-extending drugs and medicine, by powerful moral constraints or taboos, and challenged by an enormous need to increase the world's food production through means acceptable to the societies in need and compatible with technological abilities.

To keep technology focused on critical human needs and prevent it from stagnating or from being treated as witchcraft through the spread of technological illiteracy is the critical challenge to our educational systems. It requires that an increasing number of our literate population be knowledgeable of at least the basic elements of modern science.

Preserving a healthy environment is a final challenge to our technological society. If we meet these challenges, we could face a period of adventurous growth which could result in the colonizing of the universe, in abundant and exotic sources of food for a reasonably sized population, controlled fusion and solar power as energy sources and a healthy and well managed environment.

Biology must constantly focus on what biological systems actually do as opposed to what they can do. Man is no exception. Given the sophisticated and powerful tools of modern technology, our concern must focus on how man actually will use these tools as opposed to how he could use them. In a recent dinner meeting with Herman Kahn, the noted futurist of the Hudson Institute, Kahn suggested that the leading indicators of society are to be found in its art and music. He went on to stress that social and ideological factors would limit national and global growth long before resource depletion would. It behooves us as scientists and technologists to be particularly aware of the dynamics of leadership and social change, particularly since most of us are not key decision makers in prominent positions of authority. The 1979 Handbook Officers, Organizations, and Activities of the American Association for the Advancement of Science states association goals as,

> "It is the sense of the Board that for the coming decade the main thrust of the AAAS attention and resources shall be dedicated to a major increase in the scale and effectiveness of its work on the chief contemporary problems concerning the mutual relations of science, technology and social change, including the uses of science and technology in the promotion of human welfare"

This past year I have had my first experience in working closely with the Minnesota Academy of Science. The Academy reflects the long lead times typical of science. Perhaps only one or two items out of the ordinary can be initiated in a year, with accomplishment taking several years. Unfortunately, the Academy's membership has been dropping, finances are tight and flat in a period of dramatic inflation, and over the years specialized associations developing either as offshoots of the Academy, or independently, have tended to rob it of vitality as well as members. The Academy needs an infusion of interest and money to fill its vital role in the state. Minnesota is a state recognized for its skills in science and technology. The Academy can be a forum for the broad yet critical issues facing science and technology in the state. To do so, it requires the active participation of every scientist and technologist in the state of Minnesota.

Returning to the broad themes outlined previously, I contend that ultimately the survival of science and the survival of a humane civilization go together. The problem is only partly technical. It is in even greater measure dependent on the character of the people accountable. The pessimist may view the period from 1600 to 2100 as a brief burst of technological civilization in our solar system brought to an end by a catastrophic return to a primitive, greatly reduced population strangled by its own wastes and nuclear wars. The optimist may view this period as the time when man began to understand himself and his place in the universe - preserving his zest for life and individual freedom through the intelligent use of his unique and sophisticated tools.