DISCOVERIES 1987 SYMPOSIUM

COMPLEXITIES OF THE HUMAN ENVIRONMENT

A CULTURAL AND TECHNOLOGICAL PERSPECTIVE

EDITED BY KARL VAK

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This book contains the Proceedings from the Discoveries 1987 Symposium in Vienna, Austria, that was hosted by the Discoveries 1987 Organizing Committee under the auspices of his honor the Mayor of Vienna, Helmut Zilk, with the support of the Honda Foundation.

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In Cooperation with Zentralsparkasse und Kommerzialbank, Wien

Europa Verlag

Printer: Elbemühl Graphische Industrie GsmbH
Publishing and Printing location: Vienna
Printed in Austria
ISBN 3-203-51063-4

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Introduction

By way of introduction to this book, I would like to relate to you a personal experience I had some seven or eight years ago when I first came into contact with representatives of Honda. At that time the Zentralsparkasse extended an invitation to Mr. Shigeru Shinomiya, then an executive of the Honda Motor Company, to give a talk on Japanese management techniques. The Honda Foundation and the Zentralsparkasse went on to found the Japanese-Austrian Technology Society. Time and again the question of the cultural basis of our industrial society proved to be a topic of discussion. I would like to believe that these various discussions and activities were the beginning of a gradual receptiveness to Japanese conceptual approaches to technological and cultural questions, at least here in Austria.

In Austria, the influence of Japanese culture has always been relatively widespread. It is a well known fact that Japanese art had a strong influence on Austrian Jugendstil. A lesser known fact, perhaps, is that in Mozart's day the *Magic Flute* was performed in Vienna in Japanese costumes and that the character Tamino appeared on stage as a Japanese prince. Even in the eighteenth century, Vienna was intensely receptive to East Asian art. And so the issue of culture and technology in particular now forms an integral part of Austrian-Japanese relations.

Austria, as a member of the western industrial world, has come to feel more and more strongly that the problems that man faces in life are becoming ever more complex. In particular, we are more aware of the problems facing the environment. In 1986 at the Zentralsparkasse's Symposium entitled "Environmental Technology—A Challenge That Transcends All Borders," the idea of eco-technology was presented. This concept originates from the call for a new philosophy which embraces the existence side by side of ecology and technology. It would seem that one of man's biggest misconceptions—at least one of the European's biggest—was to believe that nature could be an object of conquest, that man could make nature serve his needs. Nature, however, is such a complicated system that such a viewpoint must inevitably lead to disruptions and even catastrophes. Our prime concern should not be to dominate nature as a system, but to integrate technology into nature. Eco-technology aims to set up a careful balance with the environment so that man can carry out his activities without adverse effect upon nature.

Recently an eco-technology research center sponsored by the Honda Foundation was inaugurated at the Cranfield Institute of Technology in England. Its objective is to promote research in the field of eco-technology, and to develop an approach for implementing this principle. It is my great honor to sit as a member on the center's board. The center's policy is that its board should not consist solely of scientists but also of managers from the business world.

Keep in mind that the activities of business managers and their companies are carried out in a field of tension which exists between man, nature, technology, and the economy. Within this field of tension, the slightest variation in one single parameter can have far-reaching and unpredictable consequences. It is precisely for this reason that more attention must be devoted to an interdisciplinary way of thinking, as the various changes and transformations which contribute to the emergence of an exceptionally high degree of complexity can only now be adequately evaluated and analyzed from the point of view of a generalist. Even though technology and economics do play a major role in today's world, they do not develop of their own accord but, rather, against the background of the cultural environment.

The mutual influence of ecology, economics, technology, and culture is undoubtedly to a large extent a very long term process, i.e., fundamental changes will only be noticeable after long periods of time. In Austria it is not usual to be deeply involved with long-term issues that seem so remote from daily life. Business enterprises in particular are not in the habit of doing so. The example of Honda shows that the Japanese economy, unlike the Austrian, is in fact prepared to take up this challenge and in this respect is way ahead of Austrian companies. It is obvious how involved the Honda Company is in long-term issues, as illustrated by the activities of the Honda Foundation, with its contributions to the Cranfield Institute, and sponsorship of the Discoveries Symposia. For most companies, the short- and medium-term outlook is by necessity strongly influenced by considerations of profitability and earnings. However, in order to secure the long-term existence of the companies and consequently a favorable trend for the economy and society over the long term, it is essential to have a sincere concern for issues which, while remote from daily business, may one day have a decisive influence on the environment in which the company operates.

It is clear that, given such complex connections, multi-disciplinary action is essential. The aim of the present symposium is to promote a multi-disciplinary way of thinking and to find a possible way of interpreting the complexity of the human environment through a cultural and technological perspective. I am delighted that the Honda Foundation elected to stage its 1987 Discoveries Symposium here in Vienna, and I view it as a great honor and distinction that Austria and its capital city, Vienna, was chosen to host this renowned series. I would like to convey my special thanks to Mr. Soichiro Honda and to the president of the Honda Foundation, Mr. Takeso Shimoda, for selecting Vienna. My thanks also to the Organizing Committee, which put much effort not only into creating the setting for the event but also in defining its scientific theme.

Karl Vak

Opening Session

Welcoming Addresses

Takeso Shimoda

On behalf of all the participants of this symposium, let me thank his Excellency, Mr. Leopold Gratz, President of the National Council of Austria, and his Excellency, the Japanese Ambassador, Atsuhiko Yatabe, for taking time from their very busy schedules to attend today's opening ceremony of the Ninth International Discoveries Symposium. I would also like to thank you, Mr. Tuppy, for having personally taken the chair of the organizing committee of the symposium. Thanks also to the other members of the committee for their generous assistance and valuable cooperation in the preparation of this symposium.

I believe that one of the greatest aspirations of mankind today is building a human-centered civilization. That is to say, a civilization which really contributes towards the promotion of human welfare and happiness. I also believe that this hope can be realized only through the joint endeavors of intellectuals throughout the world and in particular those involved in science and technology. The Honda Foundation's Discoveries Symposiums, founded on this very ideal, have gathered since 1976 the world's leading intellectuals in Tokyo, Rome, Paris, Stockholm, Columbus, London, Melbourne, Brussels, and this year here in Vienna, capital of this ancient land of art and technology.

It is true that modern society has achieved greater prosperity than ever, thanks to sustained high economic growth which has been made possible through a rush of technological innovations in the field of production and other areas of human activity. This achievement, made at a very fast pace, has also had negative effects on human life, such as environmental pollution and other hazards, plus a number of other deeply rooted, complex issues. In the past Discoveries Symposia we have thus far attempted to deepen our awareness of the potential catastrophes lying latent within our civilization and have addressed the comprehensive study of information, the most fundamental of human endeavors, as a means of dealing with the impending crises. Specifically, past symposia have taken up such themes as the social impact of advanced technology (Columbus, Ohio), the social and cultural challenge of modern technology (London), the use of research and technology in the interest of mankind (Melbourne), and the laws of nature and human conduct (Brussels). This year, participants and observers from throughout the world will discuss the issue of the complexities of the human environment.

Let me repeat that, based on the observations and conclusions from these discussions, the Honda Foundation intends to follow the ideal of the creation of a human-centered civilization which contributes towards promotion of human happiness and welfare.

Message from the Prime Minister of Japan, Mr. Yasuhiro Nakasone

Atsuhiko Yatabe

It is my great honor and privilege to convey to you the following message from the Prime Minister of Japan, Mr. Yasuhiro Nakasone.

"I would like to express how pleased I am about the opening of the International Discoveries 1987 Symposium in Vienna, Austria.

"Tokyo, Rome, Paris, Stockholm, Columbus, London, Melbourne and Brussels have already been hosts to this symposium. In each instance the philosophical foundations of technological civilization have been seriously discussed from a global viewpoint. I am personally convinced that the outcome of these discussions provides us with clear guidance for the foundation of a civilization based upon the respect for man, on the eve of a new century.

"It can be seen as particularly significant that a considerable number of outstanding personalities holding leading positions in various fields of science and technology have been invited to come to Vienna, a capital blessed with a great cultural heritage, in order to meet and freely exchange opinions on the topic *Complexities of the Human Environment*.

"In anticipation of future 'Discoveries' I wish you all the best for fruitful discussions at the Discoveries 1987 Symposium."

Hans Tuppy

Allow me first of all in my capacity as federal minister of science and research and as a cabinet member of the Austrian federal government to extend to you a hearty welcome and to express my respect to you, who have come here from all over the world. Allow me further to express my thanks to the Honda Foundation for enabling the 1987 Discoveries Symposium to take place in Austria: a country proud of its contributions in the fields of science and technology; a country which, as bearer of and participant in major social and scientific changes, has always striven, if not always successfully, always with industry and dedication, to integrate these changes in an all-encompassing humane civilization. I speak of a humane civilization which stretches across the entire spectrum, from a mindful cultivation of the soil to the art of *savoir-vivre,* to the work environment, the arts and culture.

I have the great honor to have been asked by Federal Chancellor Franz Vranitzky to convey to you his words of greeting, which are as follows:

"In the name of the Austrian federal government, I would like to take this opportunity at the inauguration of the Honda Foundation's Discoveries Symposium entitled *Complexities of the Human Environment—A Cultural and Technological Perspective* to welcome you to Austria. Let me also say how pleased I am to see that the first symposium in the Discoveries series to be held in a German-speaking country is taking place in the *Redoutensaal* of Vienna's Hofburg—the former imperial palace. Perhaps the upcoming presentations by prominent speakers on key issues of our time will also stimulate new approaches to decision-making both today and tomorrow, and express a cross-section of views on cultural and technological perspectives as ways to interpret our complex overall system. Finding channels of cooperation for the future through international dialogue is one of the biggest tasks that lie before us. Allow me therefore to extend to you my very best wishes for the discussions in the days ahead."

As chairman of the Organizing Committee for this Discoveries Symposium, I would like to express the hope that the results of the present conference, like those before it, will be fruitful and rewarding, and will provide yet another valuable contribution to the creation of a worldwide, humane civilization: a civilization in which technology and culture are not antagonistic but opposites that attract each other; a civilization in which the equilibrium of nature proves compatible with the operative interplay of man and of social institutions. During this symposium we shall be asking ourselves in our first session after this morning's discussions of principles: to what extent may we influence and understand the complex partial systems into which we habitually subdivide the whole; to what extent are we capable of seeing through the reciprocal relationships—which only go to increase the complex nature of the problem—and of intervening in a sensible yet guiding manner that is based on holistic understanding? The second session will be devoted to the relationship of man to his technical products, of man to machine, of technology to civilization. The third session will place man, as an individual being, face to face with the complexity of his environment and will deal with the question of whether and how the human being can cope with the wealth, not to say overabundance, of stimuli and information. Finally, the topic of the fourth session is that of the rapidly increasing rate of change in a social reality where social processes lead to an ever greater complexity that is all the more difficult to withstand and overcome. But are we also capable of coming to terms with this complexity?

May this symposium not only confront us with questions but also give rise to answers which will guide our future thoughts and acts. May it also contribute towards enabling the earth to offer men and women and their communities not only physical survival but also intellectual wealth for many years to come, providing a lasting home. May all these expectations be fulfilled.

Leopold Gratz

First of all I would like to warmly welcome all the participants to this symposium. It is a pleasure and an honor for us that the Honda Foundation has selected Vienna as the venue for this year's Discoveries Symposium, and in this connection I would like to especially note the roles of Mr. Honda and Mr. Shimoda.

I do not wish at this point to broach the topics to be covered in this symposium, but as someone who has been involved in public life for a number of decades, I would like to voice some of the thoughts which occurred to me as I was leafing through the list of lectures. Indeed, I believe that, for the individual, the complexity of today's society and the complexities of its inextricable connections are in many ways also a problem of democracy and the state.

Firstly, I believe this to be true with regard to how well-informed each individual is. It may be a common refrain that only well-informed citizens are capable of rational decisions, but it is something we must remind ourselves of time and time again. Rational decisions are what we in a democracy strive for. We are always talking about how well-informed our society is, not to mention the information explosion. Experts in the United States have even come up with their own jargon stating that the individual media consumer, and particularly the consumer of electronic media, is "overnewsed" and "underinformed." By this they mean that while each individual may be getting thousands more items of information through the media than anyone living at the turn of the century, the information is suspended out of context, atomised, so to speak. And if I may be permitted to use the example of a mosaic, the media consumer of today is not shown the mosaic as a whole, attractive picture; instead, a bucketful of hundreds of separate mosaic stones is poured into his living room day after day. And it is up to him to try and piece them together to form a picture. The question as to whether relationships and interactions can be clearly presented ultimately affects the functioning of democracy; after all, the struggle for democracy is also a struggle against the great simplifiers. Hence the significance of the present symposium, since the main theme of this conference is precisely to present the relationships and explain the interactions.

Secondly, I believe that the issue of government and management organization, which Mr. Vak already outlined in his introduction, is an issue which remains open and unsolved in many areas. We should remember that physics in the 1920s distanced itself from the Cartesian way of thinking, away from the idea that every problem could be solved by dismantling it analytically into scores of small specific areas, each one of them being simple to solve. At that time physics shifted towards a synoptic view in the course of a major revolution in theory and application.

In many companies in Austria and, as I am well aware, in the sector of the nationalized industries, we are still at the stage of the analytical method, breaking down each problem and each responsibility, placing autonomous decisions and responsibilities in the laps of the individual ministries, and we fail to bear in mind that here, too, there are more and more relationships and influences within a larger framework and that in reality each individual decision within a particular department also affects many other areas.

I believe that the state administration has not yet solved the problem of relationships and how to come to grips with it. In Austria, for instance, the setting up of ministerial committees evidently does not appear to be the patent solution when I see how many of them there are and how difficult it is to make responsible decisions within these committees while taking into account the relationships between the different areas. In my opinion the question whether we in Austria are capable of solving this problem from an organizational point of view, for instance within the area of state administration, is also a key determinant for the amount of confidence placed by the population in the ability of the state to solve the problems of today.

Finally, and here again I feel that the contents and the theme of the lectures at the symposium are of the utmost importance, I would like to say that, despite the complexity and the correlations, the issue of the solvability of the problems is also a question which has a bearing on how much people participate in public life, how much confidence and how much justified optimism they have. For as long as those responsible continue only to promise people in the country and all over the world a solution to the problems without actually giving any concrete answers, these same people will out of sheer frustration eventually reach a state of sterile nostalgia, instead of working constructively at shaping their own future. That is why it is so important not only to highlight the problem of complexity but also to show that man is capable of coming to terms with and solving the problem itself. And even if this symposium only takes us a few steps further along this course, it will have been very, very successful. And so, may I wish you all productive work and every success.

New Approaches to Solving Complexities of the Human Environment

Jun-ichi Nishizawa

For most of the earth's existence, nature has operated its various phenomena without disturbances from any animal, including *homo sapiens*. In other words, each animal species has been part of the natural cycles of the living planet. All waste from animals has been recycled through the interactions of plants and sunlight. However, the increasing number of humans has created an amount of waste which cannot be adequately recycled, thus distorting the former balance of nature.

Some of these imbalances induce further imbalance and finally catastrophe. For example, the retrogression of the forest induces the spread of the desert and then the growing desert contributes to the further deterioration of the forest. Such "feedback" phenomena often have a very destructive outcome. Other phenomena are not quite so destructive because of their suppressive feedback character, for example, a fire is suppressed by the generation of carbon oxides which are produced by the fire itself.

Moreover, interactions between various phenomena are so correlated that they resemble an intricate chain. It is important, however, to understand such chains in order to prevent future catastrophe. One complicating factor in these chains which demands attention is the overaccumulation of human-produced wastes. The development of viable methods for the reduction of these wastes is imperative and should prove to be economically worthwhile since many useful products can be recovered in the process. Without a doubt, when efficient waste treatment is implemented at the start of human activities which produce exhausts, then pollution prevention is achieved.

Another important link found in many of these intricate chains is that of natural energy resources. Of course, an abundance of energy is delivered to the earth by the sun. Much of the sun's energy is consumed in the act of warming the earth's surface, a process that also induces rain, and a small portion is absorbed by the chlorophyl in the leaves of plants. After eons, some of the energy absorbed by plants can be found in the fossil fuels of coal and oil—two materials which help meet a big share of human demands for energy. A more direct use of the sun's energy by humans seems to await the introduction of solar batteries with lower prices and higher capacity. Further studies, though, are needed to determine if the widespread utilization of solar power for electricity would adversely affect the climate. Current estimates indicate that the solar battery's efficiency is 15 percent and that the widespread use of such batteries might reduce the surface heat of the earth by the same percentage, resulting in serious climatic changes. Another implication of increased use of solar batteries which needs research is the possible reduction in the amount of photons reacting with chlorophyl, thus inducing some defect in the natural phenomena.

Human population growth puts additional pressure upon the various chains of interlinked phenomena. Even if the number of humans did not increase, the dissipation of natural resources would be likely to continue as the standards of living around the world improved. Such improvement depends upon economic activities, and these activities usually foster the dissipation of natural resources. Therefore, certain controls on economic activities can correspond to the control of natural resource depletion. Keep in mind that whenever the dissipation of natural resources overwhelms the environment's recovery ability, then catastrophe is likely to follow.

More efficiency in the utilization of natural resources would help to fulfill human demands. However, efforts within science and technology to attain such efficiency are hindered by a rapid swelling in the ranks of human beings. It has been found that natural resource depletion is nearly proportional to population growth; thus, to keep the depletion below the critical level, a way must be found to decrease the dissipation per person at a rate inversely proportional to the rate of population growth. Population growth also suppresses the natural recovery abilities of the environment. Extensive deforestation by man is only one example of this suppression which has distressingly severe consequences.

With the increase in population, there seems to be no alternative to an increase in energy consumption by humans, yet such increases further threaten the very conditions which allow life to exist at all on the planet earth. This bleak prospect not only provides critical impetus for the production of more efficient and less expensive solar cells but also the incentive to improve the efficiency of all types of energy-consuming equipment. After all, the efficiency of almost every such device is under 20 percent. In addition, most of these devices lose energy through the dissipation of heat and the waste of various chemicals. By recycling the resultant heat and chemicals, damage to the environment is prevented and more efficient equipment is obtained.

Another negative impact of population growth is the decrease in the area of land per person. Ever smaller amounts of land are available for farming, and the remaining wilderness areas are swallowed up for cultivation. Agriculture increasingly depends on expensive equipment and chemicals to produce enough food for more and more people on less and less land.

Advances in communications may significantly contribute toward relief from some of the aforementioned pressures on the environment by humans. Modern communication technology has made it possible to accumulate and transmit tremendous amounts of data all around the world with amazing swiftness and precision. Such technology, made feasible with high speed electronic calculation and semiconductor integrated circuits, has aided the planning, forecasting, and implementation process for numerous kinds of programs involving agriculture, fishing, manufacturing, transportation, and so on. Another important benefit from advanced communications has been the increasing exchange of opinions between leaders of different nations.

The development of fiber optics for communications is an excellent model of high efficiency and low energy demand. Nowadays, a single optical fiber system, making use of laser diodes and semiconductor detectors, has a transmission ability equivalent to 7,500 copper-wire telephone lines. Soon the capacity of a fiber optic cable is expected to expand to 23,000 lines. Yet, it is believed that the potential for a single fiber is in the range of 20 million telephone lines—nearly 1,000 times today's capability.

Energy engineering is another field which must help to relieve the serious situation already described. For one thing, further development of the solar cell is to be expected. Improvements in generation and transmission of electrical power would also enhance efficiency in the energy field. New high-speed power switching equipment is coming out that is 75 percent less in size and weight than today's equipment and may generate 20 kilohertz with more than 98 percent efficiency. Furthermore, if high temperature superconducting materials are developed for practical application, then enormous savings of energy lost through today's electrical transmission system would be realized.

Even a research area as comparatively old as chemistry is experiencing rapid developments that may have a positive impact on the environment. Through "laser irradiation" it may be possible to sufficiently enhance the radicals or ions of specific elements to yield the single sorts of reactions necessary to produce substances which are difficult to produce at lower temperatures. Laser enhancement would be able to provide the very high temperature chemical reactions not achievable through the usual photon energy. Many new and useful chemicals with a very high level of purity could be produced with this method which would also be expected to decrease energy consumption in the chemical industry.

The increasing use of advanced communications and electronics will likely lead to more electromagnetic pollution caused by the leakage of electrical signals. New technology will be required to eliminate or at least minimize this leakage, just as new technology has been needed to control chemical pollution. "Quiet electronics" should be the goal for electrical and communications systems.

To attain even faster electronic computations, an ultra-high-speed transistor must be developed. Among the possibilities are the "ideal static induction" transistor and the "ballistic" transistor, which are devices that try to reduce the thickness of the transistor to a depth not greater than the length of the carrier mean free path. This rather new field of research may be labeled molecular electronics.

Molecular electronics, laser irradiation for chemistry, fiber optics, solar cells—these are just a few examples of the new approaches that science and technology are taking to solve the complexities of the human environment.

The Role of Technology in the Globalization of the World Economy

Umberto Colombo

Science and technology offer vast possibilities for the construction of a better future, yet I must point out that the outlook is actually more clouded than might be hoped.

The OECD (Organization for Economic Cooperation and Development) area—more specifically what the Japanese strategist Kenichi Ohmae calls "The Triad," the financial and industrial complex based in the United States, Japan, and Western Europe—dominates the emerging technologies and their applications. Although these technologies, their products and applications, are in principle available to all countries in the world, in fact, developing countries are hindered from active participation in the process of technological change. This process is itself so rapid—and indeed is still accelerating—that even many industrialized countries are compelled to make enormous efforts to maintain their ability to profit from new ideas and keep pace with technological change. The Third World is therefore inevitably placed in a position of grave, and increasing, disadvantage.

There is a further limitation that affects the ability of developing countries to derive real benefit from today's rapid changes. The new technologies which are permeating the economic and productive systems of the world are not "off the peg"—they have to be learned, experienced, mastered, and controlled. Their application calls for a preexisting capability to insert new ideas into an amenable system, a trained and open-minded workforce able to adapt the new technologies and sophisticated equipment to suit particular needs and uses, and ready supply of capital to finance diffusion and experimentation of new processes and techniques. All these are, to one extent or another, lacking in the vast majority of developing countries. Thus it would be in vain for us to imagine that the spread of new technologies into the Third World will be an automatic, and almost painless, process—it will not. It will require massive adjustment of frequently rigid systems, a challenge to preconceived ways of thought and preestablished social orders, and a vast investment in physical and nonmaterial infrastructure (e.g., education, training) financed by a new flow of investment which only more growth in today's advanced economies can provide.

In a world already divided into the "haves" and the "have-nots," the risk is an almost inexorable widening of the gap. And the new technologies, which have within them so much power to redress the imbalance and serve the process of world development, may instead become the instrument by which this imbalance is perpetuated and, indeed, consolidated. This clearly must not happen. The development prospects of the Third World must be a primary concern to all of us, and, despite what we inhabitants of advanced industrialized nations may sometimes be led to believe, the world needs much more material growth. In fact, world population is now reaching 5 billion and it will increase to 8 billion by 2050 before stabilizing at something around 10 billion. Three-quarters of today's world population live in the Third World. By the middle of the next century, this proportion will rise to five-sixths. Moreover, the young of our planet are more and more concentrated in the developing countries—our advanced societies are aging as they grow richer. The whole world is becoming a "Third" world. If the inhabitants of industrialized countries at present account for the consumption of three-quarters of the world's energy and mineral resources, it is difficult to imagine that disparity on this scale can continue far into the next century.

The ethical dilemma which the continuing North-South gap poses will only get worse. We cannot accept a situation where our consciences tell us one thing and our appreciation of economic practicalities another once we realize that new approaches are available which challenge those very notions of practicality.

Growth, though, is not needed to pull only the Third World out of its pressing problems. I want to stress that growth is still a requirement also for industrialized countries, where today's technological revolution leads to great increases in the productivity of labor. If not linked to a parallel process of economic growth, this generates unemployment—a source of malaise in advanced nations. In Europe, unemployment has for over fifteen years stayed at levels which would have been regarded as unacceptable in the 1950s and 1960s. In some countries, including my home country of Italy, it is concentrated in sections of the population which are most at risk: the school-leavers and graduates; the middle-aged men and women with half a lifetime's working experience in now obsolete activities behind them in search of a new job; and the populations of entire regions in a less advanced stage of industrial development.

It should be recalled that technological innovation has diffused throughout the European economy more rapidly than elsewhere. The European welfare structure, based on concepts of social equality and protection of the weak, passes on the pain of the individual's loss of job, translating it into a real cost to be born by society, that is, by the remaining citizens active in the labor market.

Japan, if until recently not a prime actor in scientific research, has been and continues to be exceptionally good at exploiting new technologies and creating large-scale market applications. Yet the Japanese themselves are seriously worried, as can be judged from the flow of reports calling for improved economic strategies and science and technology policies. The reasons for this apprehension lie in their very success in terms of export achievement, giving rise to recurrent threats of retaliation from exasperated, less competitive trading partners.

Japan itself must take the lead in finding ways to reduce and recycle its substantial surpluses on current account. Readjustment of the Japanese economy is likely to prove a long term process. Sociological and psychological, and not just economic, changes will be required to modify consumption and savings patterns, social attitudes, and deeply rooted traditional introversion. Any too-fast a switch from the export-led growth pattern followed by Japan in the post-war period to one based on higher domestic demand might only slow down the Japanese economy, with damaging effects on the international economy as a whole. For this reason, at least in the medium term, resource transfers toward developing countries appear the most effective way to start the process of re-equilibrium of what is a vital part of the global economy, besides giving a much needed boost to development worldwide.

The United States, too, has problems. In most traditional sectors, there has been a definite shrinkage of manufacturing capacity within the American economy. It is perhaps simplistic to equate this with a process of deindustrialization, traced back to a loss of U.S. competitiveness in world markets and increasing reliance on imports from overseas. In fact, U.S. industry has largely relocated manufacturing capacity abroad to take advantage of cheaper inputs, nearness to markets, and tax breaks. Evidence would show that the market share of U.S. multinational corporations has actually increased in the last decade, though of course this is not revealed in national economic statistics.

Probably the most serious effect of this changed pattern of production is the loss of impetus in manufacturing inside the United States. While the U.S. economy has been very good at replacing many of the jobs shed in this process with new jobs in other sectors, the makeup of the U.S. labor force in terms of skills and accomplishments has undergone a considerable change, and this may prove to America's disadvantage over the long term. Much of the skilled labor which has been expelled by industry has been driven out of necessity into unqualified, low-skill, low-wage occupations making a less determinant contribution to wealth generation and increasing the division of society into stratified bands delimited by disposable income and real opportunity.

Still, the United States retains the lead in research leading to the development of the more important emergent technologies, and signs are that it will continue to do so for some time to come. Even here, though, the picture is not bright. The profits of successful innovation do not automatically accrue to the inventor, and a national economy that invests in the creation of new technologies must constantly review its performance in terms of whether it is able to capture the economic returns on such advances. The U.S. economy, for instance, seems to be less effective at this than that of Japan, the Federal Republic of Germany, and even Italy.

In addition, the size of the U.S. federal budget deficit and of the country's trade deficit are further motives for concern. The services sector accounts for some 70 percent of U.S. gross national product, and the net balance of trade of this sector has persistently been positive. Agricultural exports and services, however, taken together cannot cover the yawning gap in trade in manufactures.

It is clear therefore from this brief analysis of the problems being faced by Europe, Japan, and the United States that advanced free market economies must all strive to achieve a position where increases in gross domestic product (GDP) directly reflect improvement in the utilization of resources and hence in the quality of life.

So far, I have reviewed the problems. Let us now consider the opportunities before us. The world today is a far better world to live in for all its inhabitants than at any time in the past. There is no such thing as a lost "Golden Age"—if anything, the Golden Age is before us. Science and technology indeed represent new hope for the future. They can help us cope with problems like: the waste of resources, and especially that of the most valuable resource of all—man himself; the paradox of continuing poverty in an affluent world; the arms race, which affects many developing countries with the purchase of weapons from richer countries only too eager to profit by it; and the growing threat to local and now ever more global environments. Science and technology are to be seen as instruments that can help us achieve the creation of more wealth and a fairer distribution of prosperity worldwide.

We are living in a phase of transition between two epochs, comparable to that which occurred with the industrial revolution at the time of the introduction of the steam engine and of coal as the major energy source. Then, as now, in vast segments of society there was widespread fear of the future, deriving from the difficulty of even imagining the range of opportunities which an on-going technological revolution brings in terms of new activities and related jobs.

During a transition of this magnitude, past equilibria are overturned. Just to take one example, we are witnessing the decline of the central role of the factory as the chief labor-absorber in industry. Research and development (R&D), marketing, finance, corporate planning, legal affairs—functions which previously were ancillary to production—are now assuming the center of the stage. It is manufacturing itself that becomes to a certain extent ancillary and often even a candidate for contracting out in corporate strategies. This does not mean, however, that with these on-going dramatic changes the importance of manufacturing and of related technologies is becoming secondary. If anything, the contrary is true.

Today's industry, and manufacturing in particular, presents analogies with the position of agriculture during and after the industrial revolution. All through the history of industrial society, agriculture improved its output and productivity enormously, despite no longer being the economically dominant activity and chief provider of jobs it once had been. This pattern will be repeated by industry as we complete the transition to a post-industrial, service-oriented society.

The present transition is brought about by a whole cluster of technologies exemplified by the microelectronics-information technologies complex, new materials, and biotechnology. All these have the capacity for horizontal diffusion in the economy and society and for cross-fertilization.

Structural changes are generated in both economy and society. Mature sectors, for example, can be rejuvenated thanks to the grafting of new technologies onto their processes and products. When this occurs in industrialized countries, traditional sectors that seemed destined to irreversible decline come back to the forefront in international competition. My own country, Italy, is an obvious case in point: Italian prosperity is in no small measure due to the restored competitiveness of such sectors. Rightly included among the nations of late industrialization, with its strength in medium- and low-tech sectors rather than in high-tech ones, Italy is now singled out for its competitiveness in international markets and entrepreneurial vitality.

To give an example of the process of rejuvenation of mature sectors brought about by the injection of new technologies, allow me to return to agriculture. Over the past 50 years, the productivity of agriculture has greatly increased owing to extensive use of mechanical and chemical inputs. Agriculture is now considered as the paradigm of mature sectors, as shown by such indicators as market saturation and reduction in number and aging of the work force.

The ongoing technological revolution has the potential of producing a new innovative wave in agriculture with important changes both in the products and in the structure of the sector. Biotechnology will bring about unprecedented genetic improvements in agricultural produce and animal breedstock and in the development of crop varieties resistant to pests without use of toxic pesticides and perhaps even able to directly fix atmospheric nitrogen, thus drastically reducing dependence on nitrogen-based fertilizers. Useful agricultural species will be produced which are resistant to arid climates and capable of growing with brackish water. Biotechnologies will be flanked in these forthcoming revolutionary changes in agriculture by the use of new materials, of information technologies, and even space technologies.

Tomorrow, not only agriculture will be in the position to produce the food necessary for a vastly increasing world population, but an increasingly wide proportion of land will become available for the cultivation of renewable energy resources (biomass) and industrial products, with resulting economic and environmental benefits.

In this expanded dimension, agriculture is bound to become a breakthrough sector, a sector which shall attract a growing number of young people eager to apply advanced scientific and technological knowledge for the good of mankind, a situation completely unthinkable only a short time ago. Agriculture thus becomes a source of growth for the economy: growth in job opportunities, in job satisfaction, in resource generation, as well as in wealth creation in advanced and developing economies.

Important developments can be predicted also for a host of other traditional sectors—from construction to textiles, from glassmaking to ceramics, from machine tools to furniture, household appliances, footwear, and so on. Nowadays, a sector of industry can be said to be mature and on the road to decline when innovative elements able to transform it are lacking in the firms concerned; it is not a question of fate or some sort of law governing its development and decline almost automatically. By the same token, any sector that is able to recognize innovative ideas produced within it, or to welcome innovative ideas coming from outside, becomes once again dynamic, innovative, and young.

Until recently, the main technological innovations on the production side have concerned mass production of standardized goods. The emerging technologies make it possible to give an effective answer to the requirement of diversification and personalization, satisfying an existing demand and encouraging the emergence of new demand patterns. In response, the structure of supply is becoming more flexible and innovative. It is now possible to efficiently combine small scale production units with high productivity and high quality at an ever more accessible price.

Innovation is extremely rapid. No individual firm or, as a matter of fact, country can hope to gain—or to retain for long—technological and market superiority in any given area. The pressure of competition and the rapid spread of production capabilities, innovative ideas, and new patterns of demand compel companies to measure themselves very early on in the production cycle with rival firms, at home and abroad, and hence to rapidly exploit in the widest possible market any competitive advantages arising from a lead in innovation.

Time scales are being contracted, with ever briefer lags between discovery and application, between initial invention and commercialization of products incorporating new knowledge. Simultaneously, the dimension of the strategic space open to the firm expands. In the past, the smaller a firm was, the narrower its natural geographic horizon.

Today, it is possible, even necessary, for small firms as well as big ones to think worldwide.

This new space-time perspective implies the need for all actors, big and small, to seek transnational mergers, joint venture agreements, consortia, and other types of perhaps softer alliances—such as shared production, research, and licensing agreements—with other companies. The partners often bring in complementary assets: investment capital, market shares in different geographic areas, technological capabilities in adjacent sectors, and different strategic approaches to push innovation forward. Moreover, the current evolution implies a radical change in the traditional process of multinationalization of industrial companies. Today's need to maximize competitive advantage worldwide as quickly as possible and the increasing openness of individual economies imply that many small and medium-size multinationals will emerge, relying on alliances drawing on the experience and information available to partners in each market in which the alliances operate.

This is one facet of the ongoing globalization of business and finance which is being spearheaded by the countries possessing, to a major extent, resources in terms of science and technology, innovative capability, and investment capital.

Here I must add a note of warning: Trade in goods and services is no longer the driving force of the world economy. Capital movements, credit flows, and foreign exchange transactions—the so-called symbolic economy involves the daily movement of huge sums of money via global telematics and super-sophisticated computers. The computerized Eurodollar market in London (today the principal center for worldwide financial operations) reaches $300 billion every working day, representing in one year an amount of transactions which is more than 25 times higher than worldwide turnover of goods. These are global transactions, strictly dependent on developments in information technologies and telecommunications, which afford ever greater possibilities for arbitrage and other innovative financial instruments that, in turn, allow continuous switches from one financial asset to another and the anticipation of exchange and interest rate movements.

There are, however, some negative consequences, given that widespread speculation in currencies and exchange rates constitutes an element of instability in world money markets. Furthermore, the trend to direct capital towards financial transactions carries the risk of diverting it from investment in long-term activities (such as investment in basic infrastructures—for example, energy or transport networks) and concentrating financial resources, instead, on activities which do not tie up investment.

In other words, conditions for profit are increasingly more favorable in financial speculation than in real investment, and this is occurring in contrast with the fact that the world still needs so much solid economic growth, with unemployment and underemployment seemingly intransigent problems affecting the lives of billions. Nor should we fail to mention here the alarming indebtedness of many developing economies and the difficulties generated by the drain on their scarce resources for debt service payments to advanced countries, constituting a real constraint upon growth.

As I have said, today's world is dynamic and ever more open. Protectionism and defensive attitudes are no panaceas. The experience of the USSR, which can no longer afford to maintain the system of cushions and barriers that isolate its centrally planned economic system from the market economy of the rest of the world, shows that all countries must readily come to terms with this new reality and accept the challenge of technological change. The implications of Gorbachev's new course for the organization of Soviet society are immense, and the resistance to change is likely to be tough.

In our Western societies, it might seem that Europe is less concentrated on avant-garde sectors than either the United States or Japan, though some such sectors do constitute areas of real European strength. The fact that we are still weak in certain critical areas of high tech has to do with the lack of cohesion in many emergent sectors, inadequate sophisticated infrastructures, and a dispersive and fragmented market.

Basic scientific research is still in good shape, though, and individual scientists and relatively small high-level research groups often produce excellent results. The few large cohesive research teams that were created in Europe in certain areas of scientific research are highly competitive. There are even important industrial sectors where Western Europe occupies a leading position: for example, precision machine tools, electronic instrumentation, pharmaceuticals, and specialty chemicals. Serious obstacles to a more active and relevant role for Europe as an entity in the world economy exist, including the lack of common standards and the still largely national character of public procurement policies in European countries. There are, however, heartening signs that Europe is becoming more aware of its weaknesses in this area, with initiatives in science and technology being undertaken both at the European Community level and in industry and in the ambit of the Eureka program of trans-European research and development in advanced sectors. Eureka, which brings together the R&D efforts of industry and public and private research laboratories in 19 European countries in a series of coordinated initiatives partly financed by governments, has so far succeeded in committing almost $4 billion to projects designed to act as motors in a whole range of high-tech areas to create a real European technological capability to be tapped by all countries on this continent.

European industry is fully aware of the risk of being left behind at a time of increasingly global competition, of becoming the weak link in the Triad destined to provide ideas, labor, services, and markets, and in essence leaving strategic initiatives to American and Japanese partners. The path forward is still long; for instance, in terms of decision-making, Europe remains a divided continent. The effort to remedy this lack of cohesion was, until recently, very much left to governments. It is now recognized that policies to pump subsidies into declining sectors and overstretched, generally state-operated, non-market services—the weak European response of the 1970s to economic crisis—have to be reversed. Industry has stepped in, very much driven by the conviction that only a true "Common Market" and transnational industrial cooperation in Europe can ensure competitiveness and rapid innovation. Leading industrialists are making public their impatience at the slowness of European integration. In such fora as the Roundtable of European Industrialists (the Gyllenhammar Group), they are discussing ways to achieve the process at the corporate level.

This is how things are moving for the better in Europe, and similar awareness is growing in the United States and Japan. The appreciation of industry worldwide that problems have now become global, that interdependencies are increasing, means in fact that the new technologies have to be harnessed to serve the needs of global development. More emphasis has to be placed on research, enhancing international cooperation. It is not in the interests of advanced economies to keep developing countries' margins so low as to hamper their take-off and thus preclude their becoming healthy producers and active market forces, leaving them unable to make their full contribution to the achievement of balanced world growth.

Effectively, much depends on the wealthier societies of North America, Western Europe, and Japan. Responsibility to a large extent, therefore, lies with them. As a convinced European, I believe that Europe, with its diversified culture and long-standing tradition of trading partnerships and its experience in application of new technologies in both industry and welfare activities, can play a primary role in helping developing countries to seize the new opportunities that are now being offered, thus contributing to the emergence of a world where more growth will equate with more equality, where the fair distribution of prosperity and human happiness becomes as important to us all as their generation.

First Session

The Complex System We Live In

Holism in Science, Technology, and Society

Klaus Michael Meyer-Abich

Industrial economy has brought a hitherto unexperienced level of general wealth to some nations of the world. At the same time, industrialization has led to many problems which otherwise would not exist. Since industrialization's success has been based on science and technology, its problems must be attributed to the same. We therefore find ourselves in a prima facie paradox: We are looking for scientific and technological solutions to problems which we wouldn't have without science and technology.

In general, the paradox is easily overcome: the science which is expected to solve the problems must be somewhat different from the one which was involved in bringing about the problems. For example, chemistry has had an important role in producing industrial societies' wealth; at the same time, it has been significantly involved in producing environmental pollution. To date, much of the effort to tackle the problems of pollution has been devoted to "end-of-the-pipe" solutions; that is, everything remains as it was up to the outlet, where some new controlling technology is installed in order to take care of the environmentally hazardous substances discharged.

But this, of course, can only be a first step. Environmental effects should be taken into account from the beginning and become internalized into the original process. And the beginning is in the science itself. For instance, what can be expected from a chemist who already in his first semester at the university learns to turn on the ventilator when it begins to stink so that the emissions are blown outside the building? The ventilators and sinks, therefore, should be plugged up in the chemical institutes where students are trained. Students have got to learn that chemistry must proceed in cycles, just as nature does, and that the chemical cycles have to be kept apart from those of the environment as long as harmful effects cannot be excluded.

Chemists who are aware that they are taking part in a complex whole are different from those who do not care about waste disposal. But not only are the people different, their science has changed as well. As soon as a chemist considers his subject to be embedded in the broader context of life, chemistry itself is seen to be embraced by biology so that the interface between the part and the whole is given special attention wherever it is approached. When a science studies its subject as part of a whole, I call it holistic. The opposing reductionist approach considers the whole as nothing more than a collection of parts.

The mainstream of science so far has not been holistic, and disregarding the whole in scientific knowledge certainly has implications for economic awareness of the natural environment in the industrial society. It is true that, practically speaking, we do not care enough that we are jeopardizing the world around us in spite of knowing that we are doing so, but this has at least become a political issue and has begun to change. Still, not even this consciousness exists where science itself is not aware of how partial actions are affecting other parts and the whole itself.

Disregarding the whole, however, is by no means essential to modern science. The core of science is physics, and the paradigm of physics was put forward by Plato in his dialogue *Timaeus.* According to this paradigm, the elements of matter are constituted by ideas shaping an indefinite recipient. Told about modern molecular biology, Plato might be fairly satisfied to learn how organic matter originates from organic information (the DNA molecule), even if the preceding step—the origination of elementary particles and atoms from information or "ideas"—has not yet been described. Biology, however, has only recently begun to merge into the Platonic stream of thought.

Biology's foundations can be traced to the philosophy of Aristotle. Unfortunately, from our viewpoint, in the Middle Ages he was adopted by the Roman Catholic Church as the secular authority of reference. Galileo, therefore, had to turn against Aristotelian thought as well when he revived Plato's mathematical and theory-minded approach—and got into trouble with his church. The eventual outcome of the conflict between Galileo and the church was an unconditional victory for Galileo's type of modern science. It seems that the churches and Christian theology have yet to recover from this defeat.

Of course, biology as well might have been further developed along Platonic lines had it not fallen back to Anaxagoras, another ancient Greek philosopher. Plato had put forward his ideas in opposition to those of Anaxagoras, who could be called the "nothing but-er-ist" of

Greek philosophy. Anaxagoras claimed, for instance, that the planets were nothing but stones and fire and not divine as the Greeks—like most civilized people in history—conceived them to be. Now, Plato's great point was *not to dispute* the material constitution of the heavenly bodies but to ask a further question, namely: Granted, they are made of stones and fire, but what are stones and fire made of? This is as if a modern materialist came and proudly claimed that whatever happens is nothing but material change, and somebody replied: "Yes, my good man, this will certainly be as you say; nobody is disputing this, so please calm down, and let's ask a further question, namely: What do you mean by matter and material change? We will grant to you and materialism the material nature of whatever happens, but now let's consider the nature of matter!" This is the point where Plato's philosophy of ideas comes in, but, the level of philosophical discussion in Greek antiquity being somewhat higher than that found at the time of modern science's origins, Plato's further point was not recognized during the formative period of modern science.

In fact, modern science up to quantum theory has developed mainly as a kind of enlightened Anaxagoreanism. Mathematically and scientifically, of course, this was done far more successfully than in antiquity, but the theory of life along these lines fell back to reductionism— philosophically behind Plato and philosophically as well as biologically behind Aristotle. The paradigm for biology became, as the physician-physicist Hermann von Helmholtz put it in 1869, to find out about the motions and forces which give rise to the observed changes, that is, "to dissolve into mechanics."

In modern times, mechanistic thought or mechanism began with Descartes' surprising discovery that the laws of nature seem to be the same as those of mechanical engineering. Like atomism in antiquity, mechanism is a paradigm of understanding the whole by its constitution from the parts; science is primarily aware of the elements, and the whole is supposed to be explained by derivation or construction from the parts. Taking into account that mechanics was even shown to rule the heavenly bodies, and since this was the first great success of modern science, it understandably became its paradigm for centuries. Not to be aware of the whole even proved to be a kind of virtue.

However, even if the word element is put together from the three letters l, m, and n (or lambda, mu, and nu in Greek), it cannot be a general virtue to conceive the whole in terms of its parts. Generally, words are not put together from letters. Actually, it is just the other way around; letters are derived from words. Likewise, the world is not put together from parts, but parts can be defined, or limited, within the world. This is also the message from quantum theory: atoms are not made up of elementary particles but can be divided into such particles, and time does not consist of moments and time spans but permits corresponding divisions.

Although predominantly mechanistic thinking has shaped biology over the years, again and again an awareness of the whole has been exercised as well. Leibniz, Schelling, Goethe, and the German philosophers of nature at the beginning of the 19th century prepared the way for holistic science even if they remained outside the mainstream. Finally, about a hundred years ago, Hans Driesch performed a convincing experiment which showed that in the early stages of development parts of an organism may compensate for other parts which are separated from it, thereby allowing growth to proceed toward the development of not just part but the whole of the organism. This indicated that the whole must be present in each cell. The whole, therefore, proved to be more than an assembly of the parts. This, of course, has also been confirmed by modern genetics. A little after Driesch, in 1907, the biologist J. S. Haldane put forward the idea that the unification of physics and biology might not come about by reducing life phenomena to physics (or even mechanics) but the other way around, so that ultimately biology would embrace physics, or physics would evolve into biology.

The term "holism" was coined in 1926 by J. C. Smuts, the South African statesman. In the philosophy of nature it was my father, Adolf Meyer-Abich, who first developed the holistic approach, thereby leading biology back to Plato and away from the Anaxagorean diversion. These ideas, however, remained outside mainstream biology until recently when ecology as well as molecular biology finally took what look like holistic turns.

Ecology, on the one hand, considers how organisms are embedded into their environment and how they interact with it. Ecosystems are even defined from the inner surface of their environment, or the ecological niche, so that parts are conceived with respect to the whole, and not the other way around. Molecular biology, on the other hand, is still basically concerned with elements (genes), but DNA molecules are displaying a kind of wholeness beyond the elementary interactions of genes. They do not seem to consist only of genes but have a kind of individuality beyond the gene level. Moreover, the DNA molecule contains a maximum amount of information on a minimum amount of matter, i.e., it is relatively immaterial. This again is a feature of wholeness insofar as knowledge is what is most embracing in the universe.

As for technology, it is obvious that even techniques developed with respect to ecosystems and their interactions may still have undesirable and unforeseen impacts on the environment in spite of the fact that one is aware of natural embedding in general. This awareness does not necessarily belong to biotechnology, because any technology which follows the paradigm of natural processes may be expected to be less harmful to the environment than one which does not. Traditionally, technology has mainly been based on classical physics and on chemistry, be it inorganic or organic (but not on the biological level), without accounting for effects on the biosphere. This also applies to atomic technology which, after all, apart from its application as an energy source, is not particularly innovative. Biotechnology, on the other hand, is a much better place to start. For instance, natural processes require far less energy than traditional industrial processes—occurring, for instance, not at a temperature of 1,000 degrees and a pressure of 1,000 atmospheres but at the environmental temperature and pressure. Such a reduction in power requirements alone reduces the degree of violence inflicted upon the environment.

Those technologies which are based on holistic science, where the concept of taking care of the whole reflects a scientific awareness, may be called holistic themselves. Such technologies, which from the start are based on biological reasoning, have an important advantage with respect to technology assessment. Since biological reasoning—at least in principle—is implied here from the start, these technologies do not rely on a so-called end-of-the-pipe assessment which is so cumbersome and generally can only be partly successful. Usually the complexity of the whole does not allow one to follow the different branches of a particular impact on natural cycles and ecosystems, and one is soon enough lost in attempting this kind of impact assessment. Therefore, we know that it is essential to consider the complexity of the whole from the start and at all stages of development. Holistic technology tries to do so and also knows and respects the limits of scientific knowledge.

Holism, however, is not confined to the level of biological systems or the biosphere in general, i.e., including only the objects and processes of physics and chemistry. The idea, rather, is that there is a sociosphere beyond the biosphere, and, as important as the biosphere is, an awareness of the whole should not stop there but should also include the social and political reality of natural, or biological, processes. Apart from other philosophical implications, this is certainly true for the social and political impacts of technological innovation, which must be evaluated in addition to the environmental impacts. Before concluding, I will try to show how even here the idea of not relying on end-of-the-pipe assessments comes in again.

Until fairly recently, technology was viewed by the general public as a matter for experts, and these experts were supposed to be scientists and engineers. Gradually, more and more people have begun to feel that decisions about technical innovations imply decisions about how life in industrial societies generally will look in the future. As a result, people are recognizing that technologies are not just technologies but also have political dimensions. Microelectronics, for instance, has reshaped one out of two jobs, which is many more than any politician has achieved in an economics or labor department. Politics, therefore, loses sight of a most basic political development and in this sense becomes fairly unpolitical when science and technology are left to the experts and are not taken as political matters—perhaps as the most basic political matters in the future of industrial societies. For the public, this has become particularly clear with the debate on atomic energy.

This debate also showed the public that the scientists and engineers who were summoned as experts to advise on political decisions had gone beyond the appropriate roles of the scientist and the engineer. Here is where my holistic viewpoint comes in again. To assess whether some technology is *environmentally* acceptable, it has to be spelled out in terms of biology to show how partial action would affect the whole of the biosphere. So what has to be done to assess *social and political* acceptability? The answer is again that the innovation in question has to be approached in terms of the social and political sciences.

For example, energy systems are technically described in watts, energy sources, and a lot of technical figures, but from these alone, no one can tell whether it would be better to have a particular system or to get along without it. What should be known is, for instance: (1) What kinds of abuse could occur through the technology? (2) What laws or regulations would become necessary to prevent improper uses? (3) How can these laws and regulations be abused themselves?

When we did a study at my institute on the comparative social acceptability of different energy systems, I said to one of my collaborators: "Imagine you were head of an office for the protection of technical facilities against non-technical hazards, and figure out what you would have to do with respect to this or that system."

Generally, the outcome was what we called the social construction of a technical system, or the translation from its description in technological terms into a social system. Of course, hazards of abuse are just one dimension here, and other dimensions, such as changing values, interests of the unborn, or the balance of power, also have to be taken into account (see K. M. Meyer-Abich and B. Schefold: "Die Grenzen der Atomwirtschaft," C. H. Beck, Munich, 1986). Now, this kind of expertise is obviously necessary before a political decision can be made, and it is equally obvious that this is not engineering but social science expertise, which also includes the input of lawyers and economists.

Since the implementation of technical innovations implies political decisions, this process should not be left to the experts, among them the natural scientists and engineers. Even though, within their scope, these experts have been careful about implementing new technologies, in the future an equal amount of attention will be required from social scientists so that their expertise can be taken into account before a political decision is made.

Finally, I would like to point out the implication of this holistic approach for another most relevant issue, namely the problem of climate change caused by carbon dioxide. The CO^2 problem is by no means only a matter of climatology and politics. In fact, climatological statements such as temperature, humidity, and pressure do not yet provide a basis for political decisions. Such decisions, however, can be based on (1) an ecological assessment, spelling out the climatological facts in terms of changing habitats for different organisms; (2) a sociopolitical construction or spelling-out of those facts:

- in terms of changing agricultural productivity in different countries,
- in terms of implications for the construction business, tourism, etc.,

- in terms of political conflict patterns and effects on balances between political powers.

The holistic approach in science and technology will give rise to studies and considerations which deserve more attention than they have received in the past. Only if we begin to care for the whole can solutions to the problems of industrial societies be found again through science and technology.

National Rivalries and International Science and Technology

Harvey Brooks

Introduction: Science and Technology as a Complex System

In the words of Professor Braun "the world we live in . . . is characterized by a number of individually complex systems related to each other, thus forming a complexity of a higher order." One of the most complex of these individual systems is the world system of science and technology. The world system is comprised of many national systems, each with a rather distinct character, and with many complex linkages among them. There are also many international institutions or transnational institutions, which, however, represent a rather minor fraction of the system as a whole. World expenditures on research and development (R&D), the "system" we are talking about, total about $300 billion, more than 90 percent of it spent by the developed countries. Of these expenditures more than $100 billion is devoted to the development of military weapons systems, and this activity engages about 25 percent of the world's scientists and engineers.

The complexity of the world R&D system arises not only from the remarkable diversity of the institutions which perform the work and the purposes to which it is directed, but even more from the close linkages between R&D and other systems: the industrial economy, the health care system, the food system, environment, energy, education, governance, national security—to name but a few. The product of R&D is information only, and its impact depends on elaborate structures and investment designed to embody this information in goods, services, laws, regulations, and education programs. Expenditures on converting the information derived from R&D to artifacts or operations which serve human needs are a large multiple of R&D expenditures alone, and require trained manpower, some with skills equivalent to those needed to conduct R&D itself.

A unique characteristic of the science and technology (S&T) system is its universality. Its basic ideas and principles are culture-independent and, in principle at least, accessible in all cultures and political systems. Only the purposes and uses of science and technology depend on culture. Thus, given the universality of S&T, it is rather remarkable that, as a human activity and as a system, it is so tightly tied to the nation-state. Most of the priorities for R&D activity are set either by national governments or by private corporations with headquarters in a particular country, and they are designed to advance the welfare of people within a delimited geographical region, although, as I shall emphasize later, the spill-over effects or "externalities" of R&D cannot be as closely confined within national boundaries as its planners implicitly assume.

In most of the advanced countries roughly half of R&D expenditures are made by governments and the other half by private institutions, mostly industrial corporations. An exception is Japan, where only 25 percent of R&D expenditures are made by government. Even in this case, however, because of government influence on the private sector, non-government R&D priorities may be more influenced by government than in most other industrial countries. In developing countries, R&D spending as a fraction of gross national product (GNP) is much smaller than in the developed countries, and a much higher proportion of it is spent by governments, even when the purpose is economic development.

The complexity of the R&D system is further enhanced by the enormous volume of the scientific and engineering literature, and by the increasingly rapid movement of technical information around the world. It is this mobility of information that constitutes the biggest change in the S&T system in recent years. Among the effects of this mobility is the fact that, in the industrial world at least, it is becoming more and more difficult to derive an economic advantage through temporary monopoly of new information, especially information of a rather fundamental and generic nature. The mobility of technical information has increased the comparative advantage of nimble imitators relative to originators in both science and technology.

Rivalrous Science and Technology

As I have already indicated, R&D policy and priorities are overwhelmingly national in character, and to a large extent competitive rather than cooperative. Governments and companies behave as though scientific and technological prowess were key national assets, to be nurtured for both military and economic advantage. And prowess is equated with being first in new discoveries and inventions. All governments seem to identify the same set of key technologies, whose mastery they deem necessary to maintain and further their sovereignty: microelectronics and "informatics," nuclear power (though its reputation has been tarnished), aeronautics, biotechnology, advanced materials, space. Furthermore, there is an increased tendency for the state to be deeply involved in these developments, even in countries which believe in the wisdom of the market. State sponsored "big science" projects, quite apart from the military, have become an important feature of national science policy in almost all countries. Such projects can be purely scientific or heavily technological, and the connection to either military security or national economic competitiveness is seldom obvious or very explicitly stated. Examples of technological projects are the French breeder reactor program, the British-French Concorde project, the Arianne space launch system of the European Space Agency (ESA), the French "SPOT" (remote sensing satellite), the Japanese Very Large Scale Integrated circuit program (VLSI) and its "Fifth Generation" computer programs, the Japanese nuclear power and fast breeder programs, and the European Airbus program. More recent have been the European Eureka program in response to the U.S. Strategic Defense Initative (SDI), and several other similar national initiatives such as the British Alvey. All of these are characterized by heavy government subsidies, though usually with at least equal private financial participation. Some programs have been cooperative among several European governments. The most recent American example, apart from SDI, has been the proposed Space Station, for which European, Japanese, and Canadian participation is under discussion. Pure science programs include high energy particle accelerators, synchrotron radiation sources, optical and radio astronomical facilities, and intense neutron sources. The rationale for such projects can never be very precisely stated. Certainly there is a human resources aspect, in that important industrial skills are learned, even in some of the pure science projects. For example, a study of industrial subcontractors to the European Center for Nuclear Research (CERN) estimated that the new commercial business developed as a byproduct of their work for CERN was many times the value of the original subcontract. None of the technological projects, however, appears to have been an unequivocal commercial success, although Airbus might eventually be. Their continuation has depended on large government subsidies.

Almost all these projects were stimulated by national rivalries, although they may have been given other public justifications. What we see is a rather complex blend of islands of cooperative activity in a rather chaotic ocean of competitive rivalry in science and technology, frequently with enormous duplication and incompatible objectives among different countries. If anything, the reliance on technological prowess as the key to future economic competitiveness appears to have grown as the actual economic performance of the nations involved has deteriorated.

Even in cooperative projects, particularly those involving Europe and the United States, as in Space Lab and proposed European participation in the Space Station, cooperation has been inhibited by U.S. fears of technology transfer, ostensibly for military reasons, involving leakage of militarily relevant technology to the Soviet Union, but there is also a suspicion on the part of many that commercial considerations are equally involved.

Another area of competition, though never explicitly admitted as such, is the R&D/GNP sweepstakes. Advanced industrial countries are looking over each other's shoulders to see what fraction of GNP each is spending on R&D in the apparent expectation that this is a convenient measure of innovative activity and, by inference, of future economic competitiveness in world trade. Some U.S. observers have pointed to the fact that the ratio of U.S. *civilian* R&D to GNP has lagged behind that of both West Germany and Japan as a possible explanation of America's declining competitiveness, even though the absolute magnitude of American R&D spending dwarfs that of Japan or of any three major European countries of the European Economic Community (EEC). In both Europe and America there is a tendency to look for deficiencies in national R&D systems or performance as an explanation of deteriorating economic performance and to advocate increased R&D spending as a solution.

R&D as a Public Good

One of the characteristics of the R&D system as compared with many other complex systems is that, even when R&D is successful, it is difficult to guarantee that economic benefits will accrue to the organization or agency that makes R&D investment. This is obviously particularly true for basic research, or indeed any type of research where the object is to make the result public and as widely available as possible in order to achieve recognition or priority. But it tends to be true to some extent even for development work, especially when the resultant technology is "science-based," i.e., depends mainly on applied science rather than on empirical know-how or craft-like "art." In many cases the mere knowledge that something is possible may be sufficient to induce an imitator to reproduce it based on general scientific and technological background knowledge already in the public domain. This means that there is almost always a large "spillover" effect even from highly proprietary R&D or R&D that is classified for military reasons. Frequently, the only advantage of the originator is priority in time, the fact that there is sufficient delay in the diffusion of the information he has acquired to enable him to make the "downstream" investments and decisions necessary to bring a new product to market based on the technology he has originated before an imitator. Furthermore, if there is a steep "learning curve" and/or economies of scale in production, the innovator may be able to maintain a cost advantage in the market, even though a competitor learns how to make the same product. As I have pointed out earlier, the much greater speed with which technical information diffuses in today's world, due to communications and travel, and due to the more "scientific" character of innovations, provides the innovator with less and less lead time in which to exploit his temporary monopoly of "know-how" and recover his initial investment before price cutting by imitators reduces his "supernormal" inventor's profits. David Teece of the University of California has recently analyzed some of the factors that determine the ability of an innovator to appropriate the economic benefits of his priority. Teece emphasizes the importance of control over "complementary assets"—for example, excellence in manufacturing or an extensive distribution system—in enabling an imitator to beat out an innovator in the market and appropriate most of the economic benefits of the innovation. An imitator who has better control of such complementary assets can of course be thought of as the beneficiary of the "spillover" from the R&D which generated the new technology in the first place. It is also possible that most of the benefits of an innovation are captured by consumers rather than producers, as has generally been the case with agricultural innovation, where farmers are "price-takers" in an auction market in which reductions in the cost of production are immediately passed along to consumers. Here again we have a case where spillover benefits consumers because many producers adopt a cost-reducing innovation simultaneously.

This view of spillover from even proprietary R&D is supported by studies by Mansfield, Griliches, and others, which show that, on average, the social returns from industrial R&D are about double the private returns, or, in other words, the investor in R&D, or the innovator, is able to capture only about half the value of the total benefits to society. Because returns on R&D are frequently much larger than returns on ordinary capital investment, it may still be worth the innovator's while to invest in innovation.

All of this is quite familiar in the literature on the economics of innovation. The social return argument is usually used to justify public investment in R&D, particularly basic research; because innovators cannot capture all the benefits of R&D investment, they under-invest, and part of the investment must therefore come from the public if the total investment is to be a social optimum. This is why national governments find it increasingly expedient to invest public funds in R&D, with particular emphasis on basic and "generic" research, which have much bigger spillover effects per unit investment than more applied research and development.

The difficulty with the argument outlined above from the viewpoint of national policy is that the spillover from R&D does not stop at national boundaries. Just as a company that invests in R&D cannot expect to appropriate all the benefits, so a nation that invests in R&D—and again particularly basic research—cannot be confident that the economic exploitation of the results it achieves will take place within its borders or benefit only its citizens who paid the taxes which supported the work. By this argument it is not only firms, but also nations, that would under-invest in R&D, at least if they acted in accordance with strict economic rationality. This argument becomes even more powerful if one takes into consideration the possibility that other nations may be more adept in acquiring and exploiting the complementary assets needed to convert inventions into commercial products and services. It would appear that this is exactly what has been happening between Japan and the United States (as well as many European countries) in the last decade. Specifically, by concentrating on excellence in manufacturing (not just with technology but with novel human resource management, which may be harder to imitate), the Japanese have been able to capture the benefits of innovations originally made by the United States by producing the resulting products sooner, with better quality and design, and at lower cost. Moreover, they have also been able to gain entry to the continent-wide distribution systems of the United States which, being not tied to any single producer, scan the whole world for the best and cheapest products for the American consumer. In effect, the Japanese, through the adept use of complementary assets, have been able to exploit the powerful American R&D system better than the Americans themselves.

One could argue that the world is better off for this. It may be thought of as representing just another example of how division of labor can be used to benefit the consumer by producing better, innovative products at lower cost than would be possible in a single nation. Perhaps this is true in the long run, but in a world where not all the factors of production are equally mobile—and in particular, workers are much less mobile than capital and technology—it leads to the difficulties of which we are now so well aware.

But I think the account given above does show clearly why attempts to base national strategy for industrial competitiveness on science policy or R&D investments alone are doomed to failure. The world as a whole can be better off because of the large American R&D capability, but that does not mean that the U.S. population or work force is necessarily better off. Today's primarily *national* science policies are predicated on the assumption that the benefits of national R&D will automatically accrue largely or exclusively to the nation which makes the investment, and that, since advances in technology account for the largest share of economic growth, the nation that makes the biggest advances in technology will experience the greatest growth. When technology and capital were much less footloose than they are today, that may well have been a valid assumption, and of course it is not completely wrong today—yet. But it is getting less and less valid. If it still has some validity this is for one simple reason—the fact that a good deal of technical know-how still resides in and moves with people, who are less mobile than other factors of production, such as capital and abstract or codified knowledge. Thus national R&D investments still do have localized benefits to the extent that they enhance local human resources which tend to stay more or less put, at least as long as local economic opportunity does not erode too drastically.

What these arguments lead to, I think, is a conclusion that the time is long overdue for us to be thinking about a true global science policy rather than a mere sum of relatively uncoordinated and competitively motivated national science policies. To use the terminology of this conference, we have to move our thinking about science policy to higher levels of complexity, and focus our attention on the world system, rather than just on our own national systems.

We can also carry the complexity theme one step further by remarking that Teece's concept of complementary assets is what in effect links the R&D systems of the world to its economic, industrial, and social systems. Therefore, it is misleading to think about the R&D system, whether on a global, national, or subnational basis, in isolation from the complementary assets that link R&D at any level to the various levels of the world economic system.

International Cooperation in Science and Technology

It is, of course, an exaggeration to claim that science policies today are only national. International cooperation has been growing, and there are increasingly effective multinational scientific institutions. These are, however, weak and fragile relative to their national counterparts, except possibly in the case of a few multinational corporations. In the United States, for example, federal support of international research institutions is generally not considered unless the results expected are at least as valuable *to the United States* as a comparable investment in a U.S. institution. In respect to official bilateral scientific exchanges, a somewhat similar standard is in effect, and furthermore each proposed exchange is evaluated separately to assure that the national benefit to the United States is at least as great as the benefit to the cooperating country. To put the matter succinctly, the United States contributes to international science, at least in theory, entirely within a national frame of reference. International science policy is thus simply an extension of national science policy. The present U.S. administration has a strong preference for bilateral exchanges over multilateral institutions because only in bilateral arrangements can true reciprocity of benefits be guaranteed on a case-by-case rather than just an overall net basis. Although the present American administration has interpreted these matters more rigidly than earlier American administrations, the same philosophy has generally applied in the past. Multinational organizations, to which the United States contributes, are almost always the most vulnerable to cutback during periods of national budgetary stringency.

There are two areas in which international cooperation has been somewhat more effective: areas where equipment is so expensive that it is no longer considered affordable by any single country, and areas, mostly in the environmental sciences, where the coordinated efforts and equipment of many countries can yield better results than the sum of uncoordinated national efforts.

With respect to major facilities it is only relatively recently that countries have begun to give serious consideration to collaborative arrangements for the financing and construction and operation of large-scale "big science" facilities. In the 1960s, investment in such facilities was almost always justified at least partly on competitive grounds. The most telling argument in the political arena, particularly in the United States, was that another country already had or was building a new instrument at the frontiers of research in a field, and we could not afford to let them get ahead of us. This argument was most frequently used in connection with accelerators for particle physics and with large radio astronomy arrays. It continues to be used today in connection with space facilities, particularly in relation to the Soviet Union. For example, the decision of the United States to go forward with a Space Station was undoubtedly strongly influenced by the aggressive Soviet program in manned space flight during the last few years. Conversely, the Russian space program appears to have been strongly influenced by the U.S. Shuttle program. There are rather ambiguous military overtones in all this, which have been greatly exacerbated recently by America's energetic pursuit of SDI and the "militarization of space." Even in the 1960s, though, the ostensibly civilian Apollo program was thought of as quasi-military in the minds of the public and many politicians, although no clear relation to military needs was ever spelled out.

Nevertheless, the situation is changing gradually as large-scale scientific equipment gets more and more expensive. The future of the American superconducting supercollider (SSC) is still somewhat uncertain, but one of the options under discussion in the last two years has been multinational financing, and the scientific proponents of the program have attempted to recruit foreign support, at least moral support. On the other hand, it would appear that the U.S. administration would accept a multinational program only if the machine were located in the United States, and an explicit argument used in support of this has been the benefits of the industrial "fallout" from building much of the equipment by United States industry. Similarly, there have been serious discussions of multinational financing of the Space Station as well as supplying of particular components by European nations as well as Canada and Japan. Yet these discussions have frequently foundered on the issue of technology transfer and just how much access the cooperating countries will have to the core technologies involved in the program. It is clear that the United States is torn between the costs involved in maintaining what is seen as its leadership in space technology, and the potential for compromising this leadership through sharing costs and technology with others.

Perhaps one of the most successful areas of collaboration in "big science," politically if not technically, has been in the fusion program. Here the Soviets have been more completely taken into the fold than in almost any other joint effort, in part because they were thought to have more to bring to the table than in most other areas of potential collaboration. Serious consideration is being given to the construction of a multinational experimental test reactor as the next step toward the achievement of a self-sustaining fusion demonstration. Again this may well founder on the issue of technology transfer, in this case more for military than for commercial reasons. Skeptics of the whole fusion effort, however, are arguing that international collaboration involving the Russians is simply a measure of last resort to preserve funding for a program whose ultimate promise in practical terms looks more and more dubious.

Probably the single most successful collaborative effort has been the European Center for Nuclear Reseach, CERN, near Geneva. This has been a truly multinational effort, with joint financing, joint management, as well as a long track record of successful research. However, it is a western European effort, not directly involving the United

States or the Soviet Union, and its continuing political support undoubtedly derives in part from competition with Fermilab in Illinois. Despite this competitive aspect, however, both Fermilab and CERN are truly multinational laboratories open to scientists from all over the world, and many of the research teams that use the facilities are themselves multinational. Thus, the national competitive aspects of these giant laboratories have become more and more attenuated in actual operation. There is now a much stronger feeling in the high energy physics community that the next step in the creation of some future instrument will be, in effect, a world accelerator, jointly financed and jointly operated, and open on a worldwide basis. Whether and how this may come about depends both on politics and on developments in the science itself. The point is, however, that the opportunity for international collaboration may have come to be a political factor in its favor rather than an obstacle to future implementation.

With respect to future cooperation in space, U.S. Congressman George E. Brown, Jr., a representative from California, has recently given a number of speeches in which he held forth the vision of a series of bold new goals in space, all to be undertaken on a multinational, worldwide basis. Brown is a space enthusiast, and one may doubt whether all his "visions" make sense, while still supporting the basic idea of a world space program rather than a series of partly competitive, partly cooperative national programs, with much wasteful duplication, and objectives more modest than necessary because of the lack of coordination of resources. If there is any technical area that is truly ripe for the development of a truly "world science policy" it is that of space science and technology, and yet this possibility seems very remote as long as most of the political leaders of most nations see space as an area for the achievement of national competitive advantage, particularly with respect to military security, but also political prestige and international "clout."

Turning to the environmental sciences (involving oceanography, the atmospheric sciences, geophysics, biogeochemical cycles) the outlook for something resembling a world science policy seems more promising. There is a long tradition of international collaboration in the environmental sciences, in part because of their applicability to the facilitation of worldwide commerce. The international ice patrol dates back to the loss of the Titanic in 1912. World programs of research date back to the International Geophysical Year of the 1950s, and there have been a whole series of such internationally planned national research programs ever since, the most recent being the very ambitious International Geosphere Biosphere Program (IGBP) organized by the International Council of Scientific Unions (ICSU). For the most part, these have been coordinated national programs rather than truly international programs, but significant multinational financing has gone into the planning and coordination process, and the programs have served to enhance and focus national commitments in such a way as to make the whole more than the sum of the parts. Most of the actual data collection and analysis is done by national institutions in national facilities, with only the planning of observations and the creation of data bases being carried out on an international basis. The question, of course, arises whether this type of informal coordination of national efforts will be enough for the future or whether delegation of more autonomous decision-making power to a stronger international organization will be necessary. As communications and transportation steadily improve and decline in cost relative to other aspects of scientific activity, the necessity for collocating scientists permanently in single locations in order to enable them to collaborate effectively may decline, but I doubt whether it will ever entirely disappear. Indeed, experience seems to indicate that when more efficient communication means are available for collaboration, there is more demand for face-to-face interactions as well. Rapid communications and face-to-face personal interactions appear to be complements rather than substitutes, i.e., the more communications are available, the greater the demand for personal contact and joint work. A number of people have been thinking about the construction of international quasi-institutions built upon the exploitation of modern telecommunications technology. One example is a proposal for "The University of the World," a plan for a new approach to higher education by long-distance transmission among faculties of universities in Europe and the United States. This plan has been proposed by Dr. James Grier Miller, a psychologist who has pioneered the application of systems concepts to living systems. But this is only one of many proposed or already existing international electronic networks, which will undoubtedly continue to proliferate in the future. However, such networks will undoubtedly create a demand for additional permanent multinational institutions where scholars from many countries and disciplines can work together on common problems over extended periods of time.

A possible model for a future international or world science policy for many fields of research may be the existing systems of international agricultural research centers (IARCs). This is a worldwide system of multinational laboratories set up in different agricultural regions of the world, dedicated to problem-solving research organized around particular crops or livestock. The system is funded out of a common pool of funds provided by donors consisting of government technical assistance agencies, international financing institutions, and private foundations. The allocation of the funds is carried out by the Consultative Group on International Agricultural Reseach (CGIAR) with the advice of a multinational technical advisory committee (TAC). Economic studies indicate that the return on investment in these research institutions has been extraordinarily high as measured by their contribution to increased productivity of the crops or livestock to which their research has been devoted. They do both basic and applied research, with relatively stronger coupling to the international science base than typical national agricultural research institutions. The returns to crop productivity have been considerably higher than for national institutions working in the same commodity areas; one of the reasons for this is apparently the fact that the results tend to affect more than one country so that the spillover to countries other than the one in which a given center is located tends to be much larger than for counterpart national laboratories in the same country. In addition, the IARCs have apparently not competed with the national laboratories, but have in fact influenced the allocation of more resources to national institutions in the same commodity fields. In fact, econometric studies indicate that marginal returns to increased investment in the IARCs beyond the current level would have considerable higher payoff than most other types of international investment, as measured by internal rates of return.

There is no strong case for internationalization of research when informal or formal coordination of national efforts is clearly and demonstrably doing the job. There are significant transaction costs associated with international laboratories, which tend to be more expensive per scientist-year than national institutions, particularly when located in less developed countries. Nevertheless, the intangible benefits from internationalization may be greater than appears on the surface. For example, in the case of the IARCs the rate of return is higher to IARCs than to national laboratories even though the cost of the research per scientist-year of effort is two to three times greater than in the national laboratories. Outside of agriculture there have been almost no studies on the returns from international as opposed to national efforts in R&D, and such studies would be extraordinarily difficult to carry out. They are easier in agriculture because one is dealing with single commodities which are more or less the same wherever they are produced. Returns to basic research are hard to measure, since the effects of basic research are mediated through many other institutions and do not have an easily measurable economic value in their own terms. Returns to industrial type research have been well-measured on a national basis but are much harder to study across national boundaries.

Conclusion

Nevertheless, the case for something beyond negotiated coordination among separately funded and organized national research programs is likely to grow increasingly persuasive over time as both the magnitude of the equipment investments necessary for frontier research in a growing number of areas of basic science and the transnational and global nature of a growing number of problems that are tackled by applied science continue to increase. Both the rate of advance of scientific knowledge and the growth of the impacts or potential impacts of technology may be too large to allow time, at least in selected cases, for negotiated consensus-building on the design of the research programs that are required to exploit new opportunities or attack new problems. There will, almost inevitably, have to be much more pooling of resources, with delegation of substantial decision-making power to international technical bodies to allocate these resources in the most cost-effective way from a global rather than a national standpoint. Although the national members on such international technical bodies must remain accountable to the political authorities in their respective countries, they will have to be accorded considerable discretion in respect to detailed scientific strategies and tactics, without being required to obtain detailed national approval on each decision, once the broad goals of the program have been agreed upon. This is what we really mean by an international, as opposed to a national, science policy.

Scientific Methodology and Complexity

Mutsuo Michael Yanase

It has been a great pleasure to be invited to Vienna and speak to you at the Discoveries Symposium. Vienna is the city which I almost might call the hometown of my soul since I have extensively studied the philosophy of Wittgenstein, the literature, novels, and music of many Viennese, and also, in the fields of natural sciences and technology, the works of Ernst Mach and Erwin Schrödinger, who are highly esteemed here as well as throughout the world.

With an original background in physics, I have long had an interest in the philosophical basis of physics or the natural sciences related to the inanimate world in general. Only recently has my interest shifted to the natural sciences related to the animate world and to scientific methodology in general.

I would like to communicate a few ideas on what I consider a "general methodology." I do so because I think that a close look at methodology is essential for the understanding of the symposium's theme. Basically, I would like to put forth the question whether we do not have to reconsider the methodology of the natural sciences as well as of the human and cultural sciences. At this symposium, the term "holism" will be mentioned and complex systems will be discussed many times. I wonder, however, whether we have already got a clear methodology. Sometimes, I have the impression that we are still confronting today's complex systems with yesterday's analytical methodology.

I am particularly interested in two problems: that of space-time on the one hand, and that of logic on the other hand. From my studies of the space-time problem in physics, one can say that the quantum field theory can be regarded as the furthest advanced theory in modern theoretical physics to the degree that it can be considered nearly complete in its formal aspects. This means that quantum mechanics and the theory of relativity—however incomplete they may be as yet—have to be considered as interdependent.

My field of specialization is the problem of the theory of measurement in quantum mechanics. If one wants to raise philosophical problems on the interpretation of the quantum field theory, the basic problem here is the subject himself, namely the observer, performing the measurement. On the one hand it is impossible to describe the problem of the observer with the existing concept of space-time as being a combination of the three-dimensional space with time as a linear aggregate, i.e., the four-dimensional world. In the theory of relativity, where we also have to look at this four-dimensional world from the outside, we have to admit that this space-time framework is insufficient. This is not only true within quantum mechanics and the theory of relativity but also true in dealing with the problems of man or society as men living together, or highly complex systems in general.

For reasons of time, I will leave this intriguing problem aside, but if you would kindly consult the references found at the end of my paper, you will find sources which more fully explain the various issues connected to this problem.

Let me proceed now to a brief discussion on the problems of logic. As a person who underwent training in scholastic philosophy, I have the feeling that the extremely rigid framework of formal logic with regard to the multitude of problems which we are facing in all subject fields from theoretical physics to the social and cultural sciences constitutes a much too narrow form of logic. In contrast to this sort of logic, the American professor L. A. Zadeh has advocated the use of so-called "fuzzy logic" ("Aimai Ronro" in Japanese). Assuming that we might be able to handle things more accurately by using a logic which is somehow less precise than conventional formal logic, its application has spread considerably.

I would like to point out that while we are meeting here in Vienna the Second International Conference of the Fuzzy System Association has convened in Tokyo, Japan. An extraordinary number of contributions will be presented at this conference and will cover a wide range of topics from system engineering to logic to philosophical problems. I will not attempt to discuss in depth why the conference covers such a wide scope, however, today, when we regard our analytical methods as insufficient, when we should apply, for instance, a holistic methodology or way of looking at things, it is a matter of course to wish that the logic which we are using would be more adequate.

In fact, it is possible to conceive such a logic. By re-examining, if not even revising our methodology, we may be able to contribute to a solution of some of the numerous problems which we are discussing here at this symposium.

Among the list of references you will find my article "Verborgener Realismus" (Hidden Realism) in a book published in West Germany entitled *Japan und der Westen* (Japan and the West). In this article I have explained in much more detail these two ideas of mine about the space-time framework and logic.

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Life in a Complex System

Remarks from a Social Scientific Point of View

Kurt W. Rothschild

Not so long ago, the former chancellor of Austria used to tell journalists who asked various overly pointed and provocative questions at the press conference following the weekly cabinet meeting: "Look here, this is all very complicated." His stereotypical reply was frequently ridiculed; after all, one expected or desired from a leading politician clear and simple answers and solutions, as many resolute politicians have offered in the past and present. But this somewhat awkward response, that everything was very complicated, is in my opinion not only an "excuse" for nothing else to say but also a statement which has some real justification and function. A comment like his emphasizes to the public and also teaches it that today it is almost impossible to give short and simple answers to seemingly simple political and economic questions. Any such simple answers must very often be wrong because the relevant interconnected factors are so new and intricate that they cannot be extensively explained on the spot but at most can only be outlined. Furthermore, a sharpening of public consciousness for complex problem-solving is essential for the creation of that "informed citizen" who would enable democratically governed countries to pursue efficient and long-term oriented strategies.

Now, let me as an economist deal with this problem of complexities from the point of view of a social scientist, and ask why it has gained such prominence in the last few decades. Complexity as such is nothing new—novelists have for a long time attempted explorations of the complications of the human soul—and complexities are certainly not limited to the social-political arena. We find among the natural sciences, whose practitioners once proudly called themselves "exact scientists," that the degree of complexity has increased and that expert opinions widely diverge over the possibilities and questions surrounding atomic energy, dying forests, etc. This indicates how large the areas of uncertainty are even for some disciplines of the natural sciences. Nevertheless, the problem of increasing complexity in the social sphere is basically different than that encountered with the phenomena of natural sciences.

For centuries, the object of research of the natural sciences remained virtually unchanged; changes, if any, evolved very slowly. Very early in the attempt to solve the "Puzzles of Nature," quite simple and relatively useful answers were discovered which facilitated an understanding and manipulation of nature. From these early beginnings which reach back many hundreds if not thousands of years, the thirst for knowledge has been unrelenting. Especially over the last two centuries, the knowledge and horizons of the natural sciences have experienced a tremendous expansion. With the object of research unchanged it has been possible to increase, differentiate or modify previously gained knowledge, or put it into totally new forms by probing further and further into contexts and correlations. As a consequence, a growing complexity has come into existence by the continuous expansion of information and the ensuing necessity to replace or enlarge earlier, simpler points of view with always more differentiated, specialized, and complicated theories. This has broadened the spectrum of possible insights and knowledge, but has also created new problems of transparency and of a proper combination of various special theories. Consequently, new areas of uncertainty are created. But the fact still remains that in principle in the natural sciences growing complexity with all its attendant problems is only an accompaniment and consequence of a steadily expanding knowledge.

The situation is different within the social universe and the social sciences. There is also in this much younger scientific area something like a self-propelled progress of knowledge accompanied by increasing complexity, in the course of which simple and general hypotheses are replaced by constantly more refined and detailed insights and theories. But this is not the central source of the complexity problem. It lies far more in the fact that the social realm is not only a very complex area, but is also undergoing incessant change and taking on ever more complex forms. Whereas in the natural sciences one has to deal with a steady enlargement of knowledge about a given material, which unavoidably brings with it a greater complexity of theories which reflect the complexity of the material more clearly, in the social sciences one is constantly confronted with a changing and far more complex reality. As a consequence, the social scientist cannot simply build on acquired knowledge, since some portions of it will always be obsolete.

In recent times this problem has become especially acute because the speed and range of change have enormously increased and resulted in new complications. Beginning with the industrial revolution, the relative stability of economic and social conditions which existed in previous centuries came to an end. The transparency and simplicity of former conditions which made it possible for philosophers, politicians, decision-makers, etc., to utter clever remarks on politics and economics based solely on common sense were replaced by drastic and hardly understandable upheavals in technology, production methods, demographics, and social relations which required far more than historical experience and common sense to comprehend. As had been the case earlier with the "Puzzles of Nature," there emerged a desire to investigate the "Puzzles of Society." The eighteenth and nineteenth centuries marked the emergence of the social sciences. During the last two centuries in an unceasing flux between the refinement of existing theories and their rejection and replacement due to changing reality, the social sciences have been able to attain a certain but still rather limited level of knowledge as well as some value in practical application, although these achievements are under constant threat by a rapidly changing and increasingly complex society.

This problem has become seriously aggravated since the Second World War. To begin with, there has been the influence of technological progress. Not only has the research establishment grown enormously, and with it the acceleration of technological change bringing all its consequences, but also the quality and amount of certain inventions have created totally new economic and social constellations. For instance, one can think of nuclear research with its profound impact on international relations, health risks, etc. No less profound are the developments of micro-electronics, computers, and robotics upon economic and social structures in general and employment in particular. Immense problems emanate from the swift diffusion of old and new technological processes with their increasingly felt ecological effects. These technical inputs which change social structures and processes are intensified and complicated by political and organizational influences. Of special significance is the greatly increased interdependence of world economics and international relations as compared to earlier times. The formation of the European Economic Community, the advance of Japan and the NICs (Newly Industrialized Countries), the presence of the Third World with its industrialization problems and also with its hunger and debts—all point in this direction. Acting as catalysts and pressures behind these tendencies are a highly developed information and transportation technology, the rapid spread and increased presence of transnational companies, and the ever tighter integration of capital markets.

All these developments have helped to merge the economy and society into one system which is internationally interdependent in a much more intricate way than ever before. It has become so powerful and extensive that it now also encompasses the natural environment which was once regarded as stable and inexhaustible. The sort of economic and social environment which has come into existence has forced politicians and populations to face new situations of high complexity which require action that cannot so easily be executed with old knowledge and recipes. Until the middle of our century, several known theories and policies could satisfactorily deal with questions and problems from the perspective of state action in a given frame of reference and unchangeable nature. Quite plausible cause and effect chains could be deduced from such models of a relatively "closed" economy and society as a basis for economic measures and prognosis.

Today, these analyses no longer suffice. Individual states or groups of states have become subsystems that more tightly than ever before have become interlinked by numerous interdependencies, international agreements, and environmental influences. Thus, a complex entity of mutual dependencies has developed in which traditional views of causal relationships are inadequate and can also lead one totally astray. It is not easy to find one's way in this new complex reality which is undergoing continuous alterations. These difficulties mirror themselves in the perplexity of many politicians and the so-called "crisis of social science." After all that has been said, it should be clear that there is no easy route out of this quandary.

One conclusion that can be drawn from all this is that two things are necessary for social sciences as well as for economic and social policy. On the one hand, the new and difficult to perceive constellations require a development of *new* and relatively simple approaches and theories which make the emerging interdependencies more transparent for public awareness and effective policy. Dennis Meadows' "famous-infamous" Club of Rome model is a masterful example of such an effort. On the other hand, it will be necessary, building on existing knowledge and methods, to develop elaborate models, theories, and analyses that are better able to grasp and utilize the various interconnections and interdependencies. The help that the computer is able to provide is well known. However, during this time of swift and complicated changes, the main requirement in terms of scientific and practical terms will be to preserve a high degree of openness and flexibility in research and action in order to make timely discoveries of new phenomena and above all to prevent the emergence of irreversible negative developments.

An International Approach for Solving Complex Systems Problems

Thomas H. Lee

The International Institute for Applied Systems Analysis (IIASA) was formed 15 years ago by a joint United States and Soviet Union initiative with the idea to build an East-West bridge for scientists to get together to address global problems. We now have 16 national member organizations. Through the generosity of the Austrian government, the 250 people now working with the institute are comfortably situated in Laxenburg Palace—once a summer residence of the Hapsburg imperial family. I would like to make two important points relating to the establishment of IIASA.

First, the institute's founders recognized the importance of systems problems, which explains why the name "Applied Systems Analysis" was chosen 15 years ago when the recognition of the importance of systems was not quite as widespread as it is today.

The second point, which I believe to be equally important, is that they recognized the practical problems in organizing teams of scientists from different countries with different cultural and political conditions. The way in which these teams were to be assembled in order to solve systems problems was carefully deliberated by the founders. Some of the lessons we have learned will be useful, I hope, to a larger, global community. Since this conference emphasizes "learning," I would like to talk about what we have learned at IIASA.

We started out, like many other people, by trying to solve the systems problems with mathematical approaches. We had such noted experts in system studies as Leonid Kantarovich, Tjalling Koopmans, and George Dantzig to help us. But after a number of years, in spite of the sophistication in the analytical approaches and their adaptation or in the number of distinguished scientists working with us, we found that the actual use of our results by policy makers was rather disappointing. To describe our experience, I would like to quote from a speech made by a very famous systems scientist, Professor Song Jian, whom many of you may know, especially if you are members of the International Federation of Automatic Control. About two years ago he moved into a policy-making role when he was appointed chairman of the State Commission on Science and Technology in China. I invited him to come to IIASA and give a speech on his experiences, from which I would like to quote the following passage:

"Some years ago, when I was wholly devoted to research, I too felt that systems analysts could one day unequivocally formulate all problems of the world with mathematical equations. It seemed to me that political leaders are often caught in dilemmas and troubles only because of the ignorance of systems analysis. I was even convinced that as long as we could discover the key control variable of any problem under consideration, we would be able to solve it readily. Of course, if that were true, we would be living in a much better world today. However, since I have begun to handle government affairs, I have gradually come to realize that my idea about the omnipotence of systems science was at least partially wrong, if not all wrong. We must admit frankly that many important issues are simply beyond quantitative description ..."

Professor Song has not been alone in having this experience. This year I had the opportunity to attend two conferences: the annual meeting of the European Operational Research Society held in Lisbon and the annual meeting of the International Society for General Systems Research held a few weeks ago in Budapest. The subjects we discussed were similar to the experience Professor Song talked about. The keynote speech at the Lisbon meeting was on the "OR crisis," the crisis being the lack of acceptance of OR techniques by policy makers, and another speech dealt with the manner in which operational researchers should work with policy makers. Similar speeches were given in Budapest. However, I think we are making progress. We are beginning to recognize the fact that in order to have methodologies and tools to solve real life problems we must take an approach which reflects Professor Ernst Braun's statement that "a number of individual and complex systems related to each other form a complexity of a higher order."

In developing our tools, we should have a number of individually sophisticated models, but we must inject another element into that collection of models in order to have a more useful system of a higher order. What we need to introduce is the integration of these individual models by a user friendly methodology which utilizes modern information technology and high resolution graphics, resulting in what we call the interactive decision support system whereby the user is part of the system.

Some of the work pursued at IIASA already reflects Professor Braun's description of the complex system of higher order. For instance, there are many environmental problems such as those dealing with carbon dioxide, sulfur oxides and nitrous oxides (or the acid rain problem), and water management. Each problem could be handled as an individual systems problem, but there is in fact a complex systems problem of a higher order, namely, the interactions between the activities of humans and the ecological system they live in. The recognition of this complex systems problem has led to the institute's project called "The Ecologically Sustainable Development of the Biosphere." This project examines the entire continent of Europe to study the interactions between human activities and the ecological system. The goal is to propose viable policy choices for the policy makers to use in their decision-making process.

This project, by the way, is financially supported by the governments of France, the Netherlands, and the Federal Republic of Germany. We have organized the study team into two groups. A scientific committee explores the questions of scenarios and models as well as different phenomena involving such disciplines as atmospheric chemistry and soil chemistry. A policy committee studies the question of what can be done today in order to prevent disasters a hundred years from now. Both committees interact with each other in the pursuit of project objectives.

We also have a number of other projects that utilize interactive decision support systems. Let me just mention some of them.

In the acid rain project, IIASA works with all the member countries of the United Nations Economic Commission of Europe (ECE).

Through the Joint Research Center of the Commission of the European Communities, we are developing systems to manage the transportation of hazardous wastes.

For the government of the Netherlands, we are developing a system to manage the distribution system of chlorine throughout the country.

In another project, which is for the People's Republic of China, we are devising a tool to help the decision makers in comparing alternatives for developing the vast coal resources in the province of Shangxi.

I would like to use this project conducted for China to illustrate what we have learned in terms of the practical implementation of international research. I believe that when I finish describing this accomplishment you will agree with me: "Yes, it can be done." The econometric model for this project was designed by scientists in China. We used a dynamic simulation model originally developed by IIASA and the International Atomic Energy Agency, principally for use by that agency. The water management model came from the civil engineering department of the Massachusetts Institute of Technology. The chemical industry planning model was done partly in Poland and partly in the German Democratic Republic. The air pollution model came from the United States' Environmental Protection Agency, and the mathematical methodology was done by IIASA and its Polish network of cooperating scientists where techniques of multicriteria optimization were developed.

I would like to conclude by telling you that recently we had two well-known speakers from the Soviet Union. One, a leading economist, Abel Aganbegyan, and the other, a leading sociologist, Academician Tatjana Zaslavskaya, gave very interesting speeches about the Soviets' new reform policies. At the end of their speeches, the inevitable question by audience members was: "The policies are very clear, but how are you going to implement them?" Both speakers admitted that implementation was going to be a real problem.

Someday, I wish, we will have global science policies, as suggested by Professor Harvey Brooks. But, in general, policies have limited periods for measurements and if the policies are not successful, they may not survive. How to implement a policy is probably as important as the formulation of a policy.

I certainly hope that IIASA's experience will be useful if the day ever comes to consider global science policies.

Economics and Complexity

Béla Csikós-Nagy

The classical economists built up their science upon two hypotheses: (1) the free market is the most efficient allocation mechanism of resources; (2) economic development brings about a situation where mankind can get rid of economic problems. The first hypothesis was promulgated by the British classicists of the eighteenth century such as Adam Smith and Ricardo; the second by Marx and Engels, i.e., by the founders of scientific socialism in the nineteenth century.

The common root of these hypotheses was the distinction between free and economic goods. In the frame of natural resources the distinction between free and economic goods was the renewability of resources. Land was considered a nonrenewable resource, so economics had to extend its scope to cover its utilization. On the other hand, water, air, sunshine, etc., since they were believed to be indestructible gifts of nature, were considered free goods.

British and German classical economists proceeded from the point that the subject of economics was production, distribution, and consumption of labor products. This is to say, value is a product of labor in spite of the fact that production involves the utilization of land, labor, and capital. That is why, according to the classicists: on the one side, economic laws derive from the value theory of labor; and on the other, that free-of-charge renewable natural resources are a basic principle in economic behavior.

To all this, Marx and Engels added the theory that the collectivization of productive forces will speed up economic growth based on which an affluent society can come to the fore, and with it the scope of free goods (air, water, sunshine, etc.) will be extended to labor products.

However, general socioeconomic development has not actually taken place in the way supposed by the classicists. First, the scope of free goods has not been extended but has rather been limited. A new category of products has appeared, the so-called environmental products, due to the fact that what had been considered indestructible proved to be wrong: environmental damage appeared as a by-product of economic activities. Second, in the sphere of the economy, the scope of market has not increased but has rather narrowed down, not only because of the appearance of environmental products, but because the sphere of public goods in the frame of labor products has gained ground. The market can only work within the scope of individual goods. And third, collectivization has not brought affluence to society in a realistically foreseeable amount of time.

These divergencies do not mean that economics must or should be based on profoundly new foundations. But a general reappreciation is unavoidable.

Such a reappreciation must start with the general equilibrium theory, which was considered only as an action of the market mechanism. The equilibrium theory must take into account the existence of the three groups of products (i.e., public goods, environmental goods, individual goods), as well as environmental protection. In this case, the quality of life is equal to material and social welfare with environmental protection.

This brings us to the term gross national product (GNP). This term, as it is understood nowadays, comprises individual and collective labor products, but concerning environmental products a bias can be observed. The harmful effects, such as adverse by-products of production, distribution, and consumption will not reduce the GNP. At the same time, production aimed at diminishing environmental damage will increase the GNP. This distortion means that the rate of growth figured into the GNP statistics overestimates economic development.

GNP statistics are based on a definite accounting system relevant to calculation and pricing. For this very reason irrationalities involved in the GNP result in a misallocation of resources. To make this clear: the free market is an efficient allocation mechanism of resources only if individual benefits (benefits to the consumer) are equal to social benefits. In the case of by-products, when external effects appear, divergencies arise. If an activity imposes costs on others for which there is no compensation, the market price is lower than socially necessary. In the same way, the market price is higher than socially desirable when a beneficial externality exists.

It was first of all Marshall, but even more so Pigou and the representatives of welfare economists, who investigated the possibilities of internalizing external effects and in this way attempting to correct relative prices. But environmental products—because they are not divisible—cannot have market prices. This is one of the reasons why cost-benefit analyses have developed. This kind of analysis is, among others, a tool for quantifying external effects.

Environmental products have no market, and thus internalization of externalities must be controlled by governments, e.g., by imposing taxes or penalties or granting budget subsidies or preferences. In this way, relative market prices can be corrected with the intention to influence supply and demand relations more adequately with the ecosystem.

Considering economic activities from the standpoint of the ecosystem, the market price system must be examined in a broader sense too. External diseconomies can be diminished by:

— energy conservation,
— the modernization of technologies,
— material substitutions,
— the utilization of secondary materials,
— by a rational waste economy, and, last but not least,
— by promoting production technology and technical parameters of products taking into account environmental protection.

All this can be influenced by adequate relative prices.

Even with a perfect solution, the price system cannot entirely avoid detrimental externalities. Not only because:

— relative prices have their own logic inherent in the law of supply and demand, and because
— there are limits to transforming by-products into money terms, or to internalizing them, and
— because "willy-nilly" the market mechanism cannot be organized in an altruistic line. One can fully agree with economists who believe what we can do in this respect is no more than make the best of a bad job.

That is why direct government interventions seem to be necessary. What I have in mind is not the substitution of the market mechanism by political measures, because bureaucracy is even more imperfect than the market. What we need is a rational legal order of economic activities which can be controlled only by the government. If government interactions respect the range of the market function, then a good framework can be ensured for economic development.

It is a slogan much liked by representatives of environmental economics that the basic principle for environmental policy should be the prevention of pollution because—as a general rule—this is the cheapest way. But the integration of economics with ecology cannot be implemented on this hypothesis.

Economists must proceed from the point that the resources of decision makers are limited in all respects. For this very reason, using more resources for a definite aim is possible only by giving up resources for another aim. That is why rational decision-making must be based on opportunity cost calculations. In this respect what is decisive is not the input but the forgone value of the next best alternative that has not been chosen. In other words: all costs for environmental protection represent a misallocation of resources if their utility is less than their opportunity cost.

Thus—with a certain simplification—one can say: the real issue is whether environmental damage tends to be more serious than the public interest can tolerate.

Environmental protection will not stop economic growth, it will only harmonize economic development with social welfare. The rate of growth will, of course, be affected by environmental protection, but the line of development will eliminate the distortions, unavoidable, when the profit motive is decisive and renewable natural resources can be used free of charge.

In spite of all this, the release from the pressure of economy will not vanish in some Utopian future but presupposes a much higher level of technology, which not only means humanized techniques with wasteless technologies. What I deem even more important is the ability of human knowledge to replace limited natural resources with renewable ones. This seems to be a realistic possibility, if one starts from the point that two-thirds of natural resource inputs in production are required for energy. For instance, consider the contribution of solar energy—which is already on the program of many research institutes—toward a possible solution to the problem of limited resources.

One can be rather optimistic about the future of mankind in the long run but only if a really peaceful coexistence of different socioeconomic systems comes to the fore. This can promote the creation of an atmosphere in which it is not the annihilation of the other, but a genuine cooperation for promoting general welfare that is decisive.

Time urges such a trend, because day after day the arms race increases the risk of the introduction of immature technologies with incalculable external diseconomies that may ruin our natural environment even without an open war.

Second Session

Technology: A Cultural Phenomenon

A New Human-Machine Relationship

Some Social and Cultural Implications

Thomas B. Sheridan

*Homo Faber: Nobilis et Corruptus**

Standing atop China's Great Wall northwest of Beijing, gazing north across the valley and into distant hills, one sees the massive white structure, wide enough at the top for a brace of five horses to gallop between battlements, snaking up one hill and down the next as far as the eye can see. This achievement of Emperor Shi Huang Ti, founder of the Ch'in dynasty, built 200 years before Christ, remains one of the few man-made objects visible to the naked eye of an astronaut in orbit 200 miles above the earth.

Seated in a front pew in the nave of one of Europe's finest Gothic cathedrals, with the great columns and arches of stone towering overhead, one is made to feel quite insignificant, as well as respectful of the many artisans who devoted their lifetimes to create this magnificence. As the great baroque organ begins a Bach Tocatta and Fugue one cannot help but be thrilled by what man has built out of respect for something even greater.

Lounging comfortably in the international departure lounge of a busy airport, one can see a giant jumbo jet being readied for an overseas flight. Uniformed technicians, together with trucks and special vehicles of various kinds, groom the aircraft as though it were a knight about to do battle, loading on tons of jet fuel and enough food and drink for several hundred passengers to ride in comfort to the other side of the globe. Farther out beyond the ramp one sees a second great aluminium bird about to ascend, and a third just now landing. Reflecting that simultaneously this same scenario is repeating itself all over the world, one cannot help but marvel that man has not only learned to fly, but does so on such a scale.

One enters the modest control room at California Institute of Technology's Jet Propulsion Laboratory and observes several men rou-

* **Author's Note:** *Homo faber,* man the maker/user of tools, is to be distinguished from *homo sapiens,* man the wise. Man's tool-making/using can be either noble or corrupt depending on his purpose.

tinely monitoring their computer displays, making notes in log books, and checking their watches. The spacecraft Voyager has recently swung by Uranus and, as it did with nearer planets many months ago, sent back incredible photographs, better than anything the astronomers could have dreamed of only a few years ago. Now headed for Neptune, it is about three billion kilometers from earth, so far away that it takes three hours for the radio message to travel from the spacecraft back to earth. There can be no doubt that this is an incredible feat for mankind.

Into the home audio player one inserts a small shiny laser disk, an optical likeness of Mozart chamber music, recorded ten years ago by a renowned quartet. Amazingly realistic sound, with all the subtle nuances, as though the musicians were present, is brought right into one's own living room. The miracle of modern electronics made this happen, as it did with telephones which permit conversation from one side of the globe to the other as though the conversants were seated next to one another, and computers that can do in seconds what formerly took armies of clerks months to do.

Some will say the greatest achievements of homo faber in the coming years will be in biotechnology and genetic engineering. We can already speed up by a factor of thousands, relative to the pace of natural selection, the improvement of strains of corn, wheat, and other agricultural products. The bioengineers promise to produce new bacteria which will consume oil spills and perform other needed functions. New drugs are helping people to stay healthy and to live longer.

From the great engineering feats of the Ch'in dynasty and the medieval cathedral builders, to the modern feats of aerospace, electronic and bio-engineers—there is little doubt but that homo faber has ennobled the race.

Or is there some doubt?

Consider that the intention of the Great Wall was to keep out the Mongol tribes and to maintain the purity of the Chinese race and the authority of the emperor. It seemed to work—for a brief time. So have other great walls of history. Walled city states, the Maginot line, the Berlin wall—all seem sooner or later to delude their builders and produce more harm than good. The nation state itself, with its artificial quotas for immigration and emigration, its barriers to free trade and free exchange of ideas across national borders, is seen by many as the ultimate wall of delusion.

Consider that the Great Wall, the Gothic cathedral, and indeed most of the world's great constructions have been built on the backs of the poor and at the whims of the rich. Though they were variously billed as glorification of the emperor, or God, or the state, often this was a thinly veiled gimmick to get more work for less pay. We would like to think that the situation is much better today than it was earlier, but some union leaders and champions for the poor might dispute this.

Consider the modern airplane, the automobile, the ship, and other modern means of transportation. What have they provided? Fast and cheap transportation, to be sure, but also some concomitants which seem less desirable. The world's petroleum resources are being used up at an ever increasing rate. The air is being polluted. Acid rain is taking its toll on the forests and smog is affecting the city dwellers' lungs. Some families are being stressed to the breaking point by spouses who work in different cities and commute to be together only on weekends; the nuclear family could someday be a quaint cultural relic. The airplane has changed the course of warfare, making the prospect much greater for innocent civilians to be bombed indiscriminately and anonymously from thousands of feet in the air.

Consider modern spacecraft. They are already effective as spies in the sky and are rapidly becoming platforms from which to launch or at least control the trajectories of laser beams, nuclear bombs, and military operations of all kinds.

Consider modern electronics—greater and greater computer power in smaller and smaller packages—and all the potential for replacing people in jobs, taking over control of industry and commerce, and, as some would charge, ushering in a new era of artificial intelligence and robotized bureaucracy of which even George Orwell never dreamed. Much more will be said of the impacts of electronics below.

The worst fears about genetic engineering seem to have been allayed for now, but clearly it is too early to know the whole story.

The point is clear, however, that along with the vast benefits of technology also come costs. The proponents of a technology seldom warn of its costs, for in most cases the costs are much less known or understood and may appear much later. Further, those who pay the costs (whether unwittingly or in protest) are often different persons and different groups from those who reap the benefits.

The Computer's Impacts on the Human Worker: Elevation and Alienation

As a particular case let us examine what computer technology is doing to the human worker. Coming from a mechanical engineering background I have been particularly conscious of how the computer has gradually found its way into machines, physically and functionally. Computers are now well integrated with sensors, actuators, and robots. These combinations are already at work in large factories, power and chemical plants, aircraft, ships, automobiles, banks, hospitals, schools and homes. The computer has invaded the entire infrastructure of technology, and I, for one, would not turn back the clock (conveniently, this paper was composed on a word processer).

At an earlier time there was an invasion of relatively large and crude machines to replace the muscles of workers. Mostly those workers welcomed the machines, though the early mechanical intruders were noisy, dirty, and often unsafe. With time they got quieter, cleaner, and safer. And then, about the time of the Second World War, came the earliest wave of computer technology, namely that of continuous analog signal processing and control. "Servomechanisms" provided true and faithful slaves in military systems for accurate control of ship rudders, aircraft ailerons, and the aiming of guns and radar antennas, all under remote control by human operators. Earlier, people's gross muscle efforts had been replaced. Now their finer motor skills were being taken over by machines, this time with analog electronics added.

The third stage is occurring now. This third stage is the computerization of functions heretofore regarded as non-rote "pattern recognition" and "thinking." This means that the computer is programmed with relatively sophisticated instructions, including multiple tiers of "if—then—, else—" rules. These programs can interact with video cameras or other devices, see patterns in the environment, build up data bases of "knowledge" or "world models," search large computer memories to associate what is known from the past to what is currently happening, make decisions about what actions to take, and implement those actions. The emerging disciplines of artificial intelligence and robotics are associated with such activities. The generic "robot," more general than the anthropomorphic "R2D2" of the film *Star Wars,* should be seen as the integration of sensing, computing, and actuating functions. An airplane or power plant is a robot of this more general sort.

The human operator of such systems is being removed from direct hands-on contact with the sensing, decision, and action implementation and is being elevated to the role of supervisor [1]. This means giving high-level instructions to one or many robots (robotic systems) under his charge. It also means monitoring the robots' behavior while they perform their assigned duties automatically, and determining whether any has failed, or stopped midway through its normal task execution to ask for help, or finished its assigned task. Finally, it means reprogramming as necessary or intervening more directly to take over control or do maintenance or repair. As such computerized robotic systems become more intelligent, such supervisory control looks more and more like what a human supervisor in a firm does relative to a subordinate group of human workers.

Developments in broadband communication technology have allowed the human supervisor to become physically removed from the locus of action, i.e., where the robotic system performs its functions. Gradually, in factories, power plants, and other large man-machine complexes, the human supervisors are drawn into centralized control rooms to perform their instructing and monitoring activities. Gradually they are being aided by flexible and sophisticated command languages and means to communicate either through keyboards or voice, by exotic multi-color computer-graphic displays to summarize what is happening and to predict what will happen, and by computer-based "expert systems" to answer questions and give advice.

For robotic systems which perform inspection and manipulation tasks in the hazardous environments of space or the deep ocean, the human supervisor is likely to be provided a comfortable control room on the ground (or in a ship on the ocean surface). Human supervisory control from such a base has come to be called "telerobotics."

As noted above, the trend is for human communication with robots to be by means of high-level language approximating natural language, for to communicate in low-level code would be too slow and too prone to errors. The result, however, is that the human supervisor removes himself not only spatially but also functionally and cognitively from the ongoing physical process he is directing. This is because what he does and what he thinks has a different form, causal order, and timing from what the robot does and thinks. The human supervisor becomes an alien to the physical process.

It is natural for aliens to become alienated, in terms of what they know and how they feel. It is not surprising that people who have been put out of work, pushed sideways into jobs which do not make use of the skills of which they pride themselves and in which they have had their identity, will feel frustrated and resentful. It is to be expected that people who no longer understand the basis of what they are asked to do will become confused and distrustful. Especially if they perceive a powerful computer to be mediating between them and what is being produced at the other end, it is natural for people to be mystified about how things work, question their own influence and accountability, and ultimately abandon their sense of responsibility.

In regard to the impacts of the computer on man's perception of himself, I am fond of citing my colleague Bruce Mazlish, who refers to the computer as the "fourth discontinuity" in this self-perception [2]. At first, says Mazlish, man saw himself as the center of all things, but Copernicus jarred this perception by showing that man was an isolated dweller of a tiny planet of a minor star (which turned out to be at the edge of but one galaxy). Darwin came along and rudely asserted that we were descended from the apes and they from lower creatures still. Later Freud suggested that homo sapiens is not even consciously in charge of his own faculties, that our egos and ids drive us. Now the computer may be dealing us the ultimate affront—surpassing us intellectually—beating us in our best suit.

Two Discouraging Properties of Technology and A Reason for Hope

1. It is easier to apply technology for destruction than for construction.

Stated another way, it is easier to use technology to hate than to use it to love.

Technology has many of its roots in making war. The profession of engineering grew out of the military: the design and construction of weapons and fortifications, armor and warships. Civil engineering was the first domesticated variety, and it was so named to distinguish the engineering of civilian roads and bridges, dams and buildings from military projects. Mechanical, electrical, chemical and metallurgical, ocean and aerospace engineering all came later, and now the distinction from military engineering no longer seems relevant (especially since all of these engineering disciplines today derive much of their sustenance from the military).

Arguing from simple physics, it is obviously easier to destroy a building or other structure with a bomb than it was to construct that building or structure in first place, brick by brick, component by component. Destruction goes much quicker and takes less energy. Perhaps a more sohisticated argument would call upon the second law of thermodynamics, namely the law of increasing randomness or disorder (or entropy), that to put things in order runs against nature (negentropy), while nature left to her own devices militates in the direction of randomness, disorder, and decay.

Life itself, both individual life (conception, gestation, birth, growth) and the evolution of species, defies the second law. Destruction of life is quick and easy, as with non-living structures. Gestation, child rearing, and human relationships are slow and labor intensive. By and large they are not particularly amenable to being improved by technology. True, medical technology makes its contribution to obstetrics and pediatrics, educational technology has something to offer, but neither seems major—certainly not in proportion to the capability of current technology to destroy human life.

Today commerce in the technology of hate thrives. International trade in both addictive and debilitating drugs and military weapons are major components of the economy. In my own country, for example, we build an ever greater arms industry, spurred on by the largest fraction of academic technological research being directed from the Pentagon, and by manufacturers of arms making almost twice the profits as do manufacturers serving the domestic sector. Our military pervades the national scientific establishment. The most exciting new technological research (e.g., in computers, artificial intelligence, lasers and optics, superconductivity) is largely controlled by the military. Star wars and battlefield robots are the latest fashions. Things are surely not so different in the Soviet Union. Most tragic of all, poor third world nations, who should be putting all their technological effort into providing water, sanitation, roads, buildings, and industrial infrastructure, are squandering their meager capital by purchasing arms from the superpowers, aggravating internal strife and killing their own peoples.

2. It is easier to produce and employ new technology than to understand and predict the social and cultural impacts of existing technology.

There are several reasons for this.

The production of new technology is driven mostly by extrapolation from existing technology plus new physical discovery, not by societal need. Both existing technology and new discovery tend to be well documented in objective terms, and there is little controversy about what it is and what its direct and intended physical impacts are. On the other hand there is little or no public understanding about the indirect physical impacts (e.g., the drift of air pollutants geographically or of water pollutants through aquifers—the drift of DDT through the food chain). This often is in spite of good and available scientific evidence (e.g., the effects of acid rain on putrifaction of lakes and deforestation).

Technologies, at least in a democracy, are brought forth mostly by the initiative of one or a small group of individuals. After the promise (usually of the positive aspects only) has been evidenced, a much larger number of people will participate in the development, manufacture and marketing of the product. But the social and cultural impacts appear long after the technology is in place, only after exposure of the technology to the whole community and the multiple cause-effect chains have had time to work. The inherent limitations of the "commons" resources—available arable land, sufficient forestation to provide necessary carbon dioxide and wood, clean air, sufficient unpolluted water, mineral resources—are not met until this later stage. Only then is the "tragedy of the commons" encountered.

Thus the antagonists of a technology are likely to mount their efforts much later than do the protagonists, that is, only after the protagonists have had a good start, and the deleterious impacts are well in evidence. The protagonists are likely to be working together on a cooperative basis, usually a relatively wealthy and powerful group. The antagonists, once they appear, are likely to be diffuse and without a power base. Anyway, who enjoys being against something new and creative and exciting? So the initial production and deployment of the technology is relatively unfettered by the negative impacts.

Typically, the engineers of a new technology will seek to quantify as much as possible the "trade offs" among the various objective attributes of the product: for example, size, material, strength, speed, and cost. They will assert that safety has not been compromised, though necessarily it always must be, since maximum safety requires infinite monetary cost, which most of us cannot afford. These engineers may even claim to be providing an "optimum" design (military suppliers are fond of making such claims) when all engineers should know that optimality exists only when all considerations are expressed precisely in mathematical form. It is rare that for any actual physical product more than a few of its attributes can be expressed mathematically in relation to the others, this limitation being especially true of attributes pertaining to economic and human behavioral aspects.

There is likely to be little public consensus on social impacts (e.g., the effects of the automobile upon family life, or television upon the democratic political process). The media do a relatively good job of reporting the judgments of various experts about these impacts, but at the same time they seem to want more to foster controversy than to move the public toward fair and rational solutions.

Ironically, some groups who have most successfully exploited technology have ends that are antithetical to science and technology. The fundamentalist "electronic church" in the United States has exploited television to aggregate millions of faithful supporters and contributors while at the same time promoting "creationism" to replace the teaching of Darwin in the public schools.

Currently there are various attempts to anticipate the negative economic and social impacts of technology. In the United States, the Congress has set up a special "Office of Technology Assessment" to advise the government and the larger community. However, being an arm of an agency wherein day-to-day politics determines what questions are considered and even what results are aired publicly, it continues to give far too little attention or credibility to long term assessment.

3. The general public is appreciating these two negative aspects of technology as never before.

There is hope. Ordinary people are now very concerned about the destructive aspects of technology. There is also new appreciation for discovering or anticipating the social and cultural impacts of technology, though such impacts are usually more subtle than is the destructive potential.

Particular world events such as the accidents at Three Mile Island, Bhopal, and Chernobyl, combined with the widespread availability of television, have brought this message to people everywhere. Technology is being eyed with more suspicion than it was earlier, and with realization that current benefits tend to bring future, not always predictable, costs.

Developing countries such as China want very much to have the modern technology of the West, but they are anxious not to bring along other aspects of Western technological culture which are threatening to their traditions.

There are many new academic programs in universities which seek to integrate the "two cultures," not simply to make engineers more culturally refined (God knows that we need it!), or to ensure that all humanists know about the Second Law of Thermodynamics, but to train people how to do technology forecasting, and incorporate the public into the assessment. Science and engineering journals now include many more articles on social impacts of technology than appeared two decades ago. Technology is now more acceptable as a subject of historical analysis, art, and literature.

Both the general public and the political establishment have tended to be critical toward such work, since it is judgmental (often negative relative to the establishment), is far from an exact science, and can be expensive. But one sees that changing.

Conclusions

Man the maker produces technology which may be said to ennoble the human spirit but at the same time to corrupt it. The computer, for example, is elevating the worker to a new and more powerful role, but at the same time alienating him from the ultimate production of goods and services.

It may be said that it is easier to employ technology for destruction and hate than for construction and love, and also that it is easier to produce and employ new technology than to understand and predict the social and cultural impacts of existing technology.

All of this would be extremely discouraging were it not that people of every nation and stratum are becoming more aware of these negative aspects of technology. It is crucial that scholars encourage this more enlightened and mature perception of our machines, and make every effort to improve our capabilities for comprehensive technology assessment.

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Homo Faber
The Epistemic and Technical Nature of Man and His World

Jürgen Mittelstrass

Knowledge and Work

The modern world is comprised of both technical and cultural aspects. The technical aspect leads to a "knowing how" upon which the world's rationalities are based, whereas the cultural aspect spawns a knowledge that, or knowledge of itself. At the same time, the world combines this "know-how" and "knowing that" into a scientific form. Rational cultures such as our modern industrial society are scientifically-supported technical cultures. As such, they constitute the modern world in their state of becoming.

Thus our world is the product of a rational history. It is furthermore the product of the epistemic and technical nature of man. The epistemic nature of man refers to the fact that man is a creature who creates knowledge and whose being is dependent on knowledge. Knowledge is the medium of man's orientation, not only in its scientific form but in its everyday form. Knowledge and action are intertwined both in theory and in practice. This means that man finds his orientation not only theoretically but also practically in and through knowledge. Where there is no knowledge, man loses his orientation or becomes the tool of a foreign, unfathomable knowledge. At this point he no longer belongs to himself because his orientation doesn't belong to him. This orientation should be understood not only as the familiarity with objects and their relationships to each other, but also its acquisition through interpretation and explication. Those rules which can be applied to scientific knowledge are also applicable for perceptual knowledge, empirical knowledge, and rational knowledge. They are all various forms of orientation and appropriation although they do not achieve orientation and appropriation in their rational form until they are synthesized in scientific knowledge. Aristotle's statement that all men by nature desire knowledge is the basis for reason in the epistemic nature of man.

Besides his epistemic nature, man also possesses a technical nature. Man is not only the being who creates and is dependent upon knowledge, he is also the being who in his way of living creates and is then dependent on tools. Anaxagoras maintained that man is the most intelligent being because "he has hands"—a statement inverted by Aristotle to describe the epistemic nature of man: it is thanks to man's intelligence that he has hands. Both are correct. Only an intelligent creature has hands and it is in his hands that a good portion of man's intelligence resides. This is his technical intelligence, his technical rationality. Through his technical rationality man extends the organs with which he interacts with the world by creating additional "artificial" organs. The hand, itself a tool, generates new tools. Technology is the part of man with which he transcends non-human nature—of which he, by the way, was never a part as a historical being. And technology not only compensates for what is missing by "completing" the nature of man, it also develops its own laws, achieves its own form of rationality, and creates a new nature. The societal product of both this constructive force and the previously mentioned epistemic force is the modern world.

There is a strange dialectic between both forces which already emerged in Anaxagoras' and Aristotle's diverging opinions on the significance of hands: does the nature of technology reside in knowledge or is the nature of knowledge in technology? Or, to put it more simply and less rhetorically: What came first—the epistemic or the technical nature of man? But besides the fact that this question echoes the old dilemma of which came first, the chicken or the egg, it is in fact senseless. It plays upon the differences between *homo sapiens* and *homo faber* (man the maker) while ignoring the unique dual nature of man which has shaped his reason and his world throughout history. The dialectic of both constructive forces lies in the use man makes of both the epistemic and the technical domains of his being, not in the concept of these dual natures themselves. Here, for example, Marx may have been quite correct in stating that "the historical reality of industry is like an open book on the spiritual energies of mankind." And Bergson also has a great deal of anthropological plausibility behind his assertion that homo sapiens is a product of homo faber's reflections on his work. This need not, however, signify, as Nietzsche claims, that reason is "only an instrument." Here, too, this argument confuses the application—in this case the application of reason as an instrument—with the object itself. That reason can be technical reason (or at least applied as such) does not mean that technology is the essence of reason.

It is also not necessarily the dark side of reason, the "other." If the rationality of man lies in the epistemic and technical nature of his being, this does not mean that the one is to be defined in terms of the other. All forms of reductionism applied to mankind are false; this form is no exception. Neither homo sapiens nor homo faber is the real human being. Man is rather a combination of the two as long as he remains true to his nature.

The same applies to the modern world inasmuch as it displays both technical and cultural aspects. Thus our modern world, which is a scientifically-supported technological world, is not the haphazard product of man's history but rather the inevitable result of the development of man's being. Scientific and technical reason make man a rational subject and his world a rational world. At the same time, the anthropological interpretation of man as an epistemic and technological being lends legitimacy to the modern world.

The "New Science"

The foundations for this world were laid down in the beginning of the modern era. The epistemic and technical nature of man that we have just spoken about can also be documented historically. A "new science" beginning with Galilean physics constitutes a new world. The revolutionary character of this science is not to be ascribed, as it is widely held, to new scientific discoveries such as the formulation of the law of inertia, nor to the cumulative weight of such discoveries, nor even to the "mathematization" of nature and the natural sciences. Rather it is traceable to a pivotal revision of methodology which fused two previously separate traditions: the tradition of academic scholarship and the tradition of the guild halls.

Among the representatives of academic tradition we have Aristotle, Archimedes, and Euclid. In reading these philosophers, scholars concern themselves with their own scholarship. There can be no study devoted to the practical application of scientific theory, where practical application is viewed as unscientific and has no place in the concept of a science whose elements include the classics. With its Renaissance representatives such as Brunelleschi, Ghiberti, Alberti, Leonardo da Vinci, and Tartaglia, the tradition of the guild halls is just the opposite. Their knowledge was not that of academic scholarship but rather technical know-how. This know-how transformed their world, even in such dubious areas as cannon and fortress building. It is Galileo's concept of physical theory broadened by empirical elements that united the two traditions by creating a methodological bridge between technical know-how and theoretical reason. Ever since, this link, expressed in the phrase "reason and experience," has survived as the foundation for all the natural sciences as well as for the relationship between the natural sciences and technology.

A short look at the history of mechanics illustrates the significance of the fusion between academic theory and technical know-how. Up until Galileo's time, mechanical problems had been approached not from a scientific but rather from an "artistic" perspective—that is, as know-how with which to "trick" nature. Thus mechanics was studied as the application of tools and machines to circumvent natural laws, rather than the application of the natural laws themselves. Mechanics was concerned with "unnatural" motion, e.g., motion which could be produced by such simple mechanical means as levers, wheels, and pulleys. Even Guidobaldo del Monte, a contemporary of Galileo, wrote a mechanics handbook referring to the work performed by carpenters, engineers, and construction workers as "contrary to the laws of nature." Thus, at that time, mechanics belonged neither to physics nor to any other particular science; it was merely skilled knowledge and know-how which were implemented by instrument-makers, shipbuilders and weapons-makers far from the academic circles of scholars. Not until Galileo did mechanics join the natural sciences, whereupon the ground work was laid for the bridge between natural science and technology.

From the vantage point of epistemology this radical change, so decisive in shaping our modern world, was brought about within the context of a new understanding of experience. A new instrumental concept of experience replaced the old Aristotelian phenomenological concept. Whereas pure everyday experience appeared to verify the theoretical principles of the scholastic Aristotelian system (and to substantiate its methodological structure), within Galilean or modern physics this function is assumed by instrumental experience, in the sense that the experience has to be first fabricated. Thus experience (within the scope of natural science and technology) becomes a construction. The theoretical knowledge of scholars in fields such as geometry and statics was combined with the technical know-how of the guilds in the medium of this construction to create the "new science." The modern world in its form of technologically-supported cultures is the direct result of this synthesis.

To revert to our own terminology: homo sapiens and homo faber merged with the inception of the "new science" and its resulting world. The two had previously followed separate paths; one the road of tradition in academic scholarship, the other the skilled traditions of the guild halls. There was no common world just as there was no common ground for (theoretical) reason and (technological) experience. At this point in time these two worlds became one. The differing rationalities of these worlds, the rationality of homo sapiens and the rationality of homo faber joined to form the rationality of the scientifically-supported technological world.

Appropriation

Nonetheless, the fact that the modern world is a product of the epistemic and technical nature of man joined in a rational history, which is the expression of the merger of two modes of rationality, does not mean that there are no problems involved. Rationality itself does not always solve problems; in the above-mentioned forms it also creates them. The troubles of our modern world are above all attributable to the fact that—unlike the past worlds such as the ancient Greek world or the Christian world of the Middle Ages, which both had strong cultural forms—our world tends to seek its orientation primarily in the technological forms of society. Technical rationalities are freeing themselves of non-technical, "cultural" rationalities. The first is represented by the natural and engineering sciences with their efforts to appropriate the future, while the latter finds its figurehead in the humanities, with their inherent limitations in appropriating the past.

But problems are not only caused by the growing self-sufficiency of technological rationalities. Another factor is that modern man with his scientific technological reasoning is not only the creator of the world he lives in, but is also a part of it. Man's appropriation of the past as well as his efforts directed at appropriating the future culminate ultimately in the appropriation of mankind by the modern world itself. The subject of progress is transformed, at least partially, into an object of progress. On the one hand, due to the reasons cited above, the rationalities which man set into motion by making himself a rational subject have taken on a life of their own. On the other hand, man faces an ever-so-much more powerful self in the form of these rationalities, his own world-creating rationalities. The world, as a scientific technological world, itself a product, an artifact of mankind, assumes productive powers of its own. The world shapes man, modifies his environment and changes him.

Examples for this appropriation can be seen in various areas:

(1) There is no subject recognizable any more in the progress, particularly in the so-called technological revolution, which is based on scientific-technological rationality. This progress is taking place behind the back of the individual; it is unfathomable and anonymous to him. Therefore, it cannot simply be stopped. It acts, in a certain sense, independently of man. It is not going to become our fate as it is described in various utopian novels; it already has. Or to put it less dramatically: scientific and technological progress have their own rationality, their own dynamics. Not only the modern world but, far more, modern man himself is subservient to this progress.

(2) Knowledge and information are on divergent tracks. The modern world is pleased to think of itself as a world of information. Despite the fact that information is derived from knowledge, problems arise because information is gradually usurping the role of knowledge. The more information made available to us, the less understanding it evokes in us. Such information, divorced from the knowledge that created it, results in epistemic dependency as opposed to knowledge itself, which is an expression of epistemic independence. At the same rate, however, at which our dependence on information grows and individual, self-acquired and self-mastered knowledge shrinks, the incomprehensibility of the scientific-technological world we live in spreads. In the medium of information, knowledge and opinion become indistinguishable.

(3) Technological societies turn themselves into expertocracies. The ever-increasing scientification and technification of our modern world create the expert, who alone seems to be capable of combining knowledge with practical application, or of reconciling the individual with society. Simultaneously, the fact that our problems always ap-

pear to be technically soluble places them squarely in the hands of our experts. The truth is, however, that not in all cases, and these are mostly the important cases, do these problems yield to scientific and technical rationality. It is a distorted view he gets when man observes himself only in the mirror of the world that he created with his scientific-technological rationalities. This world does not explain mankind. But where it does appear to do so, once again the consequence is mankind's appropriation by the modern world.

(4) The appropriation of nature in scientific-technological cultures not only leads to environmental problems but in fact to the loss of nature as, among other things, a source of orientation. What nature really is and how nature should really be becomes an ever-greater puzzle to cultures with their appropriating structures. Neither economic nor biological-ecological knowledge tells us how "natural" nature should be. They only tell us how nature is in relation to the purpose of man and his development. Paradoxically enough, even nature becomes an artifact which increasingly cannot be converted back to nature.

(5) What is valid for "external" nature seems to be true for the nature of man as well. In the course of progress made in biological research (e.g., in gene technology), man has become able to evolve himself, i.e., to change even the nature of his own being. What was once considered beyond our reach has been broken down into elements at least partically accessible to "technology" in the face of the growing possibility of penetrating the genetic identity of man. Scientific and the resulting technological progress which ensues assume a new dimension: man becomes not only ideologically but also biologically manipulable. The subject of progress becomes its object.

So much for these examples of appropriation of man by the modern world. They are incomplete without (6) the gradual "consumption" of the world as evidenced by the decline in our natural resources. This, together with (7) the increase of irreversible structures as evidenced in the nuclear fall-out and waste disposal problems of today, will make the earth a poorer and more dangerous place to live for future generations, as well as limiting their *lebensraum,* and offers no compensation other than the continued shift of the world (and man himself) towards becoming an artifact. This shift encompasses (8) the political world as well, in which technocratic conditions foster the spread of areas neutral toward democracy. As Helmut Schelsky said back in 1961, "In a state that is a universal technical body, the classical definition of democracy as a community governed by the will of the people becomes ever-more illusory. The 'technical state' sucks the basic substance of democracy dry, without any intention of being antidemocratic. Technological and scientific decisions can simply not be based on democratic convictions. They would only be rendered ineffective." Although here—as well as in (9) an arms race long since unhampered by any pretence of democratic principles—it may look like homo faber gaining ascendancy over homo sapiens, what is in reality taking place is the ascendancy over both by the conquered object itself—the appropriation of man by the modern world.

Boundaries

In the appropriation of man by the modern world, it becomes clear that scientific-technological progress knows no boundaries of its own. It follows its own will into the known as well as the unknown; it recognizes no frontiers. Its achievements make the worlds of research and development not poorer but richer. Each insight gained provides new questions, each problem solved engenders new problems, opens new horizons in the fields of science and technology. And throughout all of this—by the very laws of the "new science" which gave birth to our modern world—scientific and technological developments remain irrevocably interdependent on each other. Progress in one sparks progress in the other and vice versa. By its very nature progress in science and progress in technology are limitless, or to put it in other words: if there should be an internal limitation to science and technology, then it can only be the predestination to exceed all limits. Limit here means border, boundary, whereas scientific and technological rationalities can be defined by the temporary nature of their frontiers.

Thus, any speculation on the finite quality of nature and our limited capacity to aquire knowledge is moot and superfluous. It is based on the hypothesis that both the history of scientific discovery and the ability to correlate scientific information are either absolutely finite or else at some point in time verge on an asymptotical approach to what man is capable of knowing at all. At this stage, evaluation and refinement would fill the vacancy left by the dearth of new discoveries and new knowledge. Sooner or later progress itself would no longer have any future since all there is to discover will already have been discovered and everything there is to know will already be known. Not only the previously mentioned limitlessness of scientific progress but above all the indestructible bond between scientific and technological research on the one hand, and purpose on the other, refute this hypothesis. It is the combination of the state of research attained in conjunction with the (internal and external) goals attached that determine the course of research. Thus the concept of the end of progress in reference to scientific and technological research would have to postulate not only the assertion that "we know everything that there is to know," but also the assertion that "we are now aware of all of the goals which we could ever hope to achieve." They, however, are infinite. This also means that in order to answer the question "does progress have a future?" we would have to know what we do not know, what only progress itself or its absence is capable of revealing.

We must therefore conclude that the boundaries of progress can only be self-imposed boundaries and that the limits of progress can only be self-imposed limits. The idea that the world, that nature itself, draws boundaries beyond which scientific reason cannot pass, and that progress is limited by its own essence, does not make sense. It is a historical idea which can always be falsified. Thus the boundaries of progress do not lie where one can point to them and assert that man is unable to pass beyond, but rather they lie exactly where they should lie because man realizes he must not transgress. Self-imposed boundaries are therefore ethical boundaries. The same may be said of limits. If there is a limit to progress, then it is not a natural limit but rather an ethical limit. It likewise presupposes the answer to the question "what kind of progress does man want to achieve—and what not—or what kind of progress measured by ethical standards can he justify making—and what not?" At least in his ethical nature, man remains the measure of his world, if he is capable of resisting his appropriation by this world both in moral and political respects as well as in scientific and technological areas.

There are, of course, external boundaries to progress and external factors which curtail it, such as economic limitations. The hypothesis put forth by Rescher states that innovative developments achieved by basic research in the field of natural science remain nearly constant, that is to say, the amount of significant scientific discovery rises linearly, while the costs for research rise exponentially. The measure of essential scientific results is proportional to the measure of the logarithm of the funds appropriated. This, of course, means that the more advanced the state of research we achieve, the more financial resources must be made available to attain comparable progress (labeled by Rescher "Plank's Principle of Increasing Effort"). The fact that such a statement is based on the qualitative as well as the quantitative assessment of innovative development is evident. At any rate however, progress sets its own limits when costs rise faster than profits.

The Leonardo World

If the limits to science and technology are for the most part self-imposed limits and if the boundary of science and technology is an ethical one, then progress, which is fueled by science and technology, is in reality not a theoretical but a practical problem (in the philosophical sense of the word). It is not a theoretical reason but rather a practical reason which is called upon to solve it. This is the type of reason that is based on the determination and the assessment of goals, and whose component is also political reason. But this type of reason does not seem to be too prevalent in the modern world. The reason of the modern world consists of diverging rationalities whose legal adviser is the expert. What we have spoken about in referring to the appropriation of man by the modern world makes practical reason appear to be no more than a philosophical dream, which reality has long since out-distanced. Not only are the ownership titles between man and his world changing hands, but there has also been a change in the balance of power between reason and rationality. Whereas reason has always dreamed of the unity of the world, rationality devotes its energy to splitting up the world and mankind, who now belongs to the world he created.

There is an ancient debate which no longer seems to apply to the modern world yet which could help us visualize what is meant here: the contrast between *natura naturans,* i.e., a creating nature, and *natura naturata,* i.e., a created nature. In ancient Greece, nature was considered to be the true creative agent, with man being a part of this nature as well as its product (natura naturata). In the post-Greek era this natura naturans became God and in recent times, man. First as a miniature God *(alter deus*—as God creates, so creates man), then as the paradigm of autonomic ability: as man creates, so creates God (Kepler). Today we seem to have entered the fourth stage: the world which man himself created is now assuming the role of natura naturans. The work man created in his own image, his world, has become an independent productive reality, whereas man himself is no longer the mirror of God but the mirror of his world. The world is reflected in man. Man not only lives in a *Leibniz World,* to which he relates through interpretation, he also lives in a *Leonardo World,* in which he is the product of both his own making and of his own world.

We must resist this development. Not by turning against the modern world but by turning it back into our world. This brings us back to ethics. Ethics which not only regulates relationships between men and defines the limits and boundaries of scientific and technological development, but ethics which is also the medium by which man and his world can find their way back to a unity whose subjective side is no longer the world but is once again man. To achieve this we need not theoretical but practical reason. Reason which must not be understood as something that is already present, as a finished product, as a philosophical system or a social reality. Reason which, instead, is a form of resistance, which is simultaneously a critique of our present state of being and a plan for the future, reason which is enlightenment. Reason at the same time is a declaration of the will to go back to living in one world, the human world. This indeed may be where the challenge facing modern man is to be found: in recapturing the unity of his world and his own existence.

Upon observing the de facto individuality of life forms in the modern world with their divergent rationalities, it becomes clear that there is no unified world, that no common world exists. Accordingly there is also no single type of reason which could conquer all of these individual worlds and their rationalities; there is only the will toward reason, which is also individual. But this will clings to the idea of unity in the world and in life. The creation of this unity and thus of a common world would be the true work of reason.

What sounds like a vision here is possibly the only chance man has left to nullify his appropriation by the world, our modern world, without the world losing its rational nature entirely. We must not lose sight of the fact that man has no alternative to the modern world with its scientific and technical rationalities unless he were to take leave of this world, were to step out of the history of his own culture. This world is the direct result of how man's being in its dual epistemic and technical nature has developed. Reason and man's essence cannot be played off against each other. Or to put it another way: there is no point in asking whether the world would be better off with or without science and technology, with or without rational orientation—not even in the name of reason. But we should work on developing the epistemic and technical aspects of our nature so that they do not end up working against reason's goal, i.e., the creation of a common world free of appropriating structures.

Predicting Future Complexities

Toshiyuki Furukawa

In order to forecast the relation between science and technology on the one hand and human society on the other hand, quite some imagination is required.

At the beginning of our century, a survey was conducted to help forecast the future development of the automobile society. A majority of the replies focused on the advantages of the auto, such as its speed of 60 miles per hour, compared to the disadvantages of horse-drawn vehicles such as their small size, a maximum speed of 16 miles per hour and the many difficulties encountered in handling and/or possessing horses. Among the people who answered the survey's questionnaire was the famous science fiction writer H. G. Wells, who replied amazingly enough that if cars became cheaper and more widespread then the number of people living in the outskirts of cities would increase. He predicted that people commuting to the town centers with their cars would need parking spaces. In fact, the increasing use of automobiles brought about traffic jams and also led to major changes in the social relations between middle-class men and women. No one who participated in this survey, apart from Wells, foresaw such social changes.

In 1920, an inquiry was conducted to forecast the direction of Japan's society, culture, technology, etc. The results of this inquiry were published by the noted Japanese thinker Seturei Miyake in his own publication. He had conducted this study by asking the opinions of 300 leading persons from the fields of politics, administration, academia, education, and religion. Surprisingly, the majority of these people replied very honestly. Seen with today's eyes, the content of their responses represented a very accurate forecast. In particular, replies which predicted the extinction of the nobility, equal rights for men and women, the reduction of differences in wage levels and other aspects of democracy, the shift to wearing European dress and footwear, the wider diffusion of a meat and bread diet, the change from Japanese straw mats to the use of European chairs and other tendencies of "Westernization," motorization, and the utilization of air transport were completely correct. Moreover, even environmental pollution as well as an energy crisis were predicted.

This journal, which was just recently republished, included a number of very interesting illustrations, some of which accompany this paper. It goes without saying that during the 1920's Japan was still a developing country dependent on primary industry and that "modernization" was not yet advanced. To give you an example, the death rate for pre-school children at the time was around 20 per cent. This means that one of five children died before the age of six. Needless to say, the average life expectancy was short—only 48 years—compared to an average life expectancy of 75 years for men and 80 years for women according to last year's Japanese population statistics.

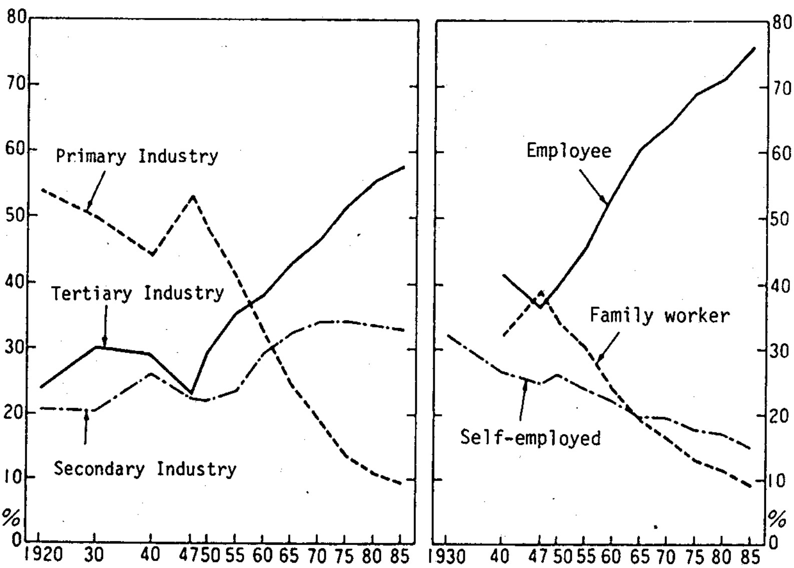
From these various illustrations it is clear that almost all of the forecasts for the Japanese future made in 1920 have come true in less than 100 years. Even though the prediction of environmental damage went a bit too far, it along with the other predictions nevertheless reveals an astonishingly flexible imaginative power on the part of Japanese leaders in all fields at that time. In my opinion, this kind of vision must be developed in today's men and women. Although we may not attain the imaginative power of these former leaders, it is possible to make fairly accurate predictions with the use of available information and statistics.

Figure 1 shows the structure of employment in Japan from 1920 until 1985. One chart clearly shows how Japan in 1920 was almost entirely dependent upon primary industry, whereas today primary industry is in decline and tertiary industry is in expansion. Keep in mind the interdependence between the decrease of the population engaged in primary industry and the development of productivity in this industry. As productivity increased in the primary sector (i.e., agriculture, fishing, mining), manpower became available and was absorbed by the secondary (i.e., manufacturing) sector, thus accelerating the development of manufacturing industries. In the course of subsequent "de-industrialization," manpower has been absorbed by the tertiary sector (service industry). Likewise, during this process, as shown in the other chart, the numbers of family workers and self-employed individuals (more common in the primary sector such as in agriculture and fishing) have constantly dropped as the number of employees has skyrocketed. At the base of this transformation of society is technology.

In my opinion, research into the revolution in communications and transportation is quite valuable in understanding the relationship between technology and society. We know, for instance, that various means of transportation were developed from the beginning of civilization, yet most researchers would mark the onset of the transportation revolution with the introduction of steamships and railways. Cars, however, being of a completely different nature since they provide an individual means of transport, have perhaps had a more profound impact on the way of life in modern society. Of course, the airplane was an important invention that has radically reduced travel times and distances.

Figure 1

Structure of Employment



Seen from a historical perspective, information technology, which is largely shaping our modern-day lives, started with the introduction of the telegraph and telephone and then grew with such innovations as radio, television, magnetic recording, optical fiber communication, and, last but surely not least, electronic computers. In my presentation at the 1982 Discoveries Symposium in Columbus, Ohio, I noted that one aspect of information's impact is upon our average life span. At that symposium, I pointed out that there was a very close relationship between the average life span of a country's citizens, their wealth, and the amount of existing information. Although the number of physicians and medical facilities could well have the effect of lowering the mortality rate, these factors did not extend the average life span, whereas the amount of information available did affect life span. I arrived at this conclusion through my research which used a cluster analysis of social indicators from over 63 different countries. It was and is my contention that since transportation and communication play very important roles in disseminating information throughout society, they also consequently accelerate the modernization of a society and extend the life span of its members.

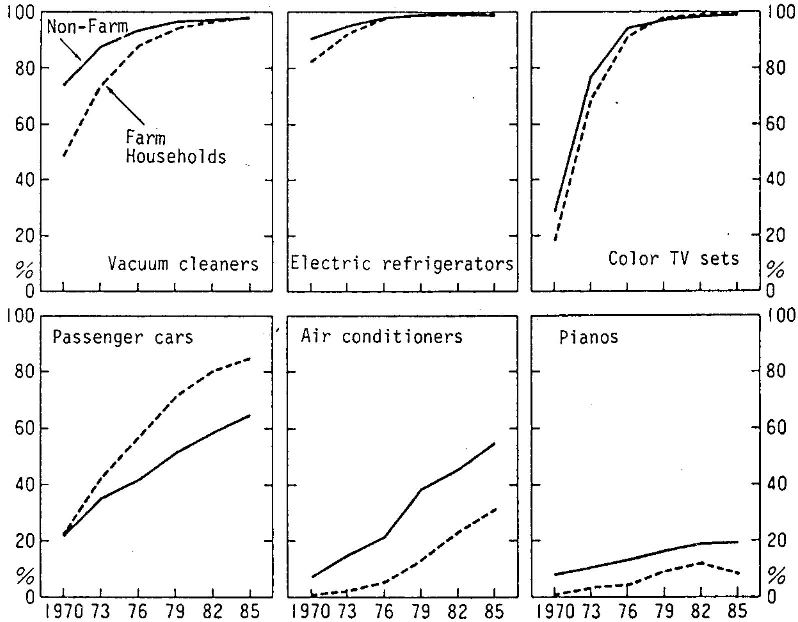
In Figure 2, you will observe another statistical chart that shows the ownership of durable consumer goods in Japanese households. In both urban and rural areas there is almost a 100 percent rate of ownership for vacuum cleaners and refrigerators. The ownership rates for color televisions are likewise nearly identical for urban and rural Japanese, which indicates that there is a strong trend toward an even distribution of information technology in the nation.

As most know, telecommunication is basically a way of transmitting information which consumes very little in the way of natural resources. Of course, we must always keep in mind that it is not only the quantity but also the quality of information which counts. However, in order to select useful information, we first need large quantities of information. This was one reason why I pointed out at the Discoveries Symposium in Columbus that there was a distinct relation between the quantity of information and the life span of individuals.

To attain a better mutual understanding between people from around the world, I look forward to the practical application of machine-generated translations. We cannot expect the number of excellent interpreters, such as those who provide simultaneous interpretations at syposiums such as this, to increase to any large extent. For

Figure 2

Household ownership of durable consumer goods



this reason, we will increasingly need the assistance of machine translation if we are to communicate our ideas to those who do not know our native language. Unfortunately, currently available machine translation is still very unreliable. Suppose we have to translate a text related to bacterial cultures and have a sentence like: "Some kinds of bacterial cultures require several days to develop." The machine might produce this sentence: "Some different kinds of civilization will appeared in a photo processing laboratory within several days," which would be a totally meaningless translation. However, some progress has been reported in this field. Since September 1986, the Japanese economic newspaper *Nikkei* and the *Wall Street Journal* have been using machine translation, although this has been limited to stock market information. I can imagine that machine translation must be just as necessary, if not more so, between Western countries. Ever more positive results from efforts to improve machine translation, such as the project under the sponsorship of the European Commission, are eagerly awaited, for they promise to enhance mutual understanding in the world of the future.

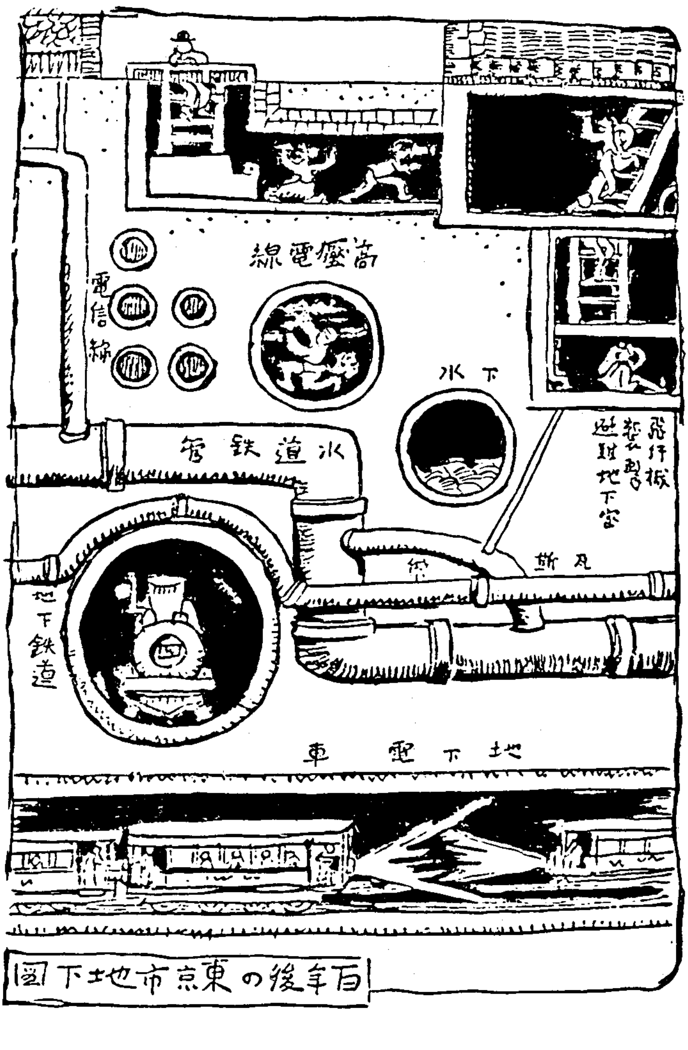
Although we have witnessed a variety of technical innovations in mass tranport, we should not forget about individual transport. With regard to car ownership, the statistics differ from those for other durable consumer goods. Car ownership is higher among rural Japanese households, where it exceeds 80 percent, in contrast to the 60 percent for urban dwellers (see Figure 2). The reason for this situation is that rural areas are less populated, commuting distances are greater, and public transport facilities are limited. Under these circumstances, rural inhabitants are very dependent upon their own means of transport.

Due to poor policies, the price of land in today's Japan is soaring and forcing people to live farther and farther away from the city centers. As a result, workers are faced with ever-longer commuting distances and times. In my opinion, there are alternatives. Consider the new academic and research town of Tsukuba, built approximately 60 kilometers from Tokyo, which is the same distance that Tokyo's international airport is from the city. It takes about one hour to cover this distance by car. Let us imagine the development of an individual means of transport similar to a car but running at four times the speed. Then the time traveled between Tsukuba and Tokyo would be equivalent to a walk on foot. The impact of such technology would be enormous.

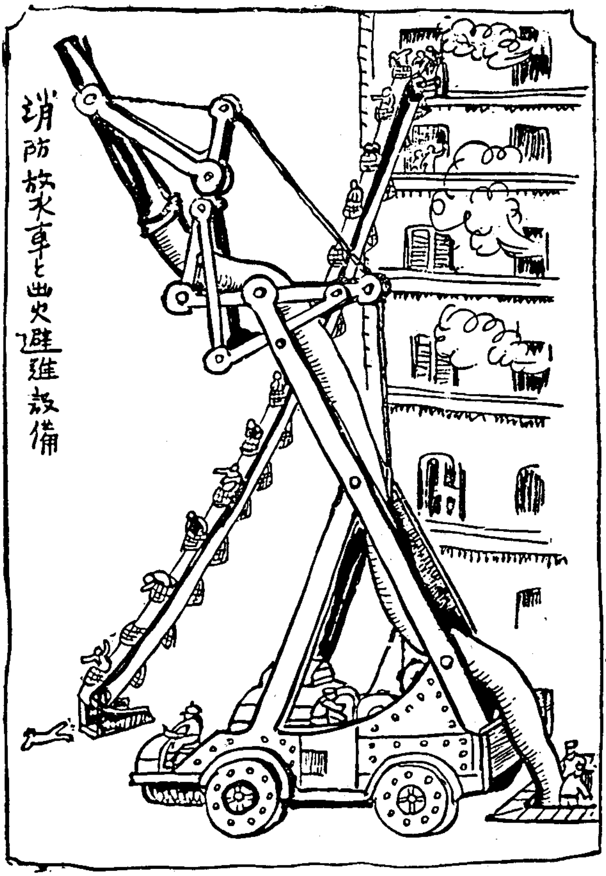
From my background as a physician, I know that the Japanese government has taken measures to establish one medical university in every prefecture in order to decrease the number of areas without expert medical care. This has been accomplished and represents a structure very similar to the regional hospital system of Sweden. In spite of this accomplishment, there are still many places which are situated more than one hour away from a medical university. If we were to develop the aforementioned transportation system which had a fourfold increase in speed, that is to 240 kilometers per hour, then everyone could reach the nearest medical university in about 15 minutes.

Please take these remarks as those of an incurable optimist who does not want to impose his ideas on the direction of various technical developments. However, it is my strong belief that if one analyzes the data correctly, does not neglect technical developments, and is provided with a courageous imaginative power, then ideal ways may open to allow human society to proceed toward a brighter future.

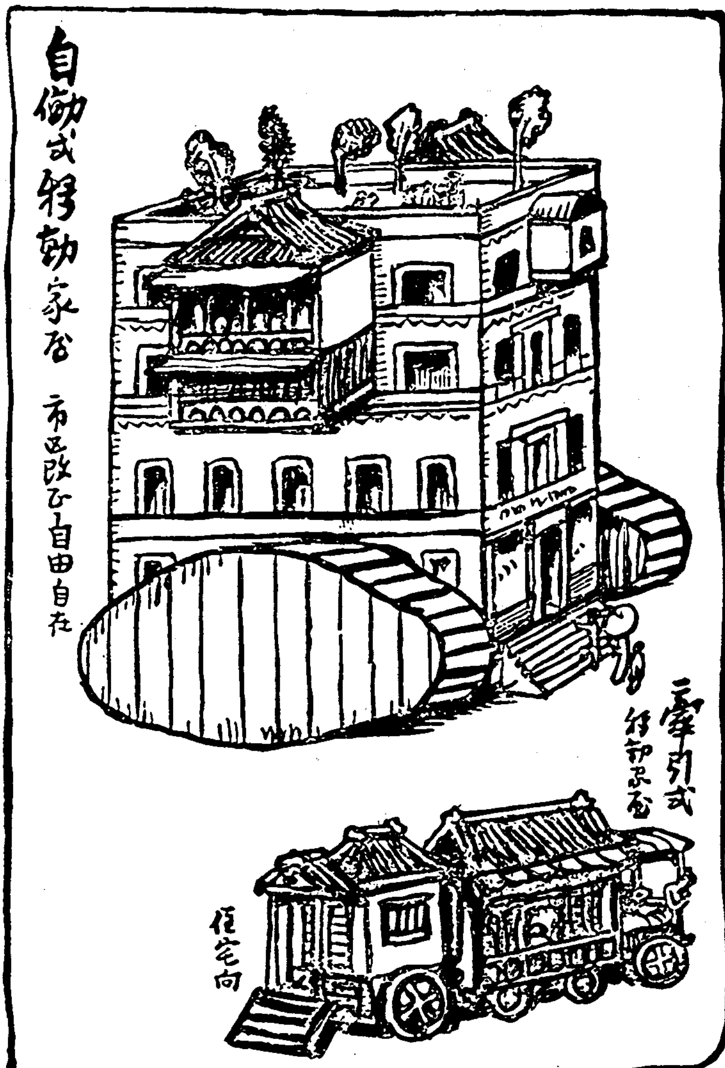
Note: The 11 illustrations accompanying Professor Furukawa's paper are reprinted from *The Prophecy of Japan 100 Years Hence,* edited by Seturei Miyake in 1920, and reissued by Takeuchi Publishing Company. These illustrations are reproduced here with the kind permission of the publisher.



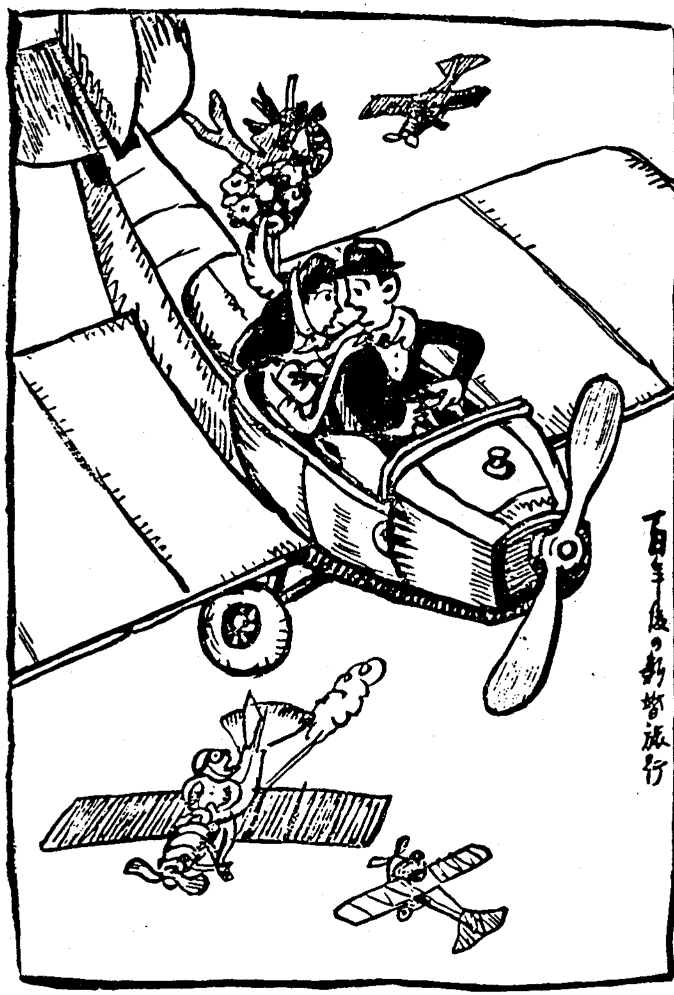
(1)
The development of the metropolitan infrastructure of Tokyo. In 1920, Tokyo lacked such an infrastructure; nevertheless, as this cartoon shows, various underground constructions such as subways, water supply and sewage systems, electrical power, and gas and other energy distribution systems were foreseen.



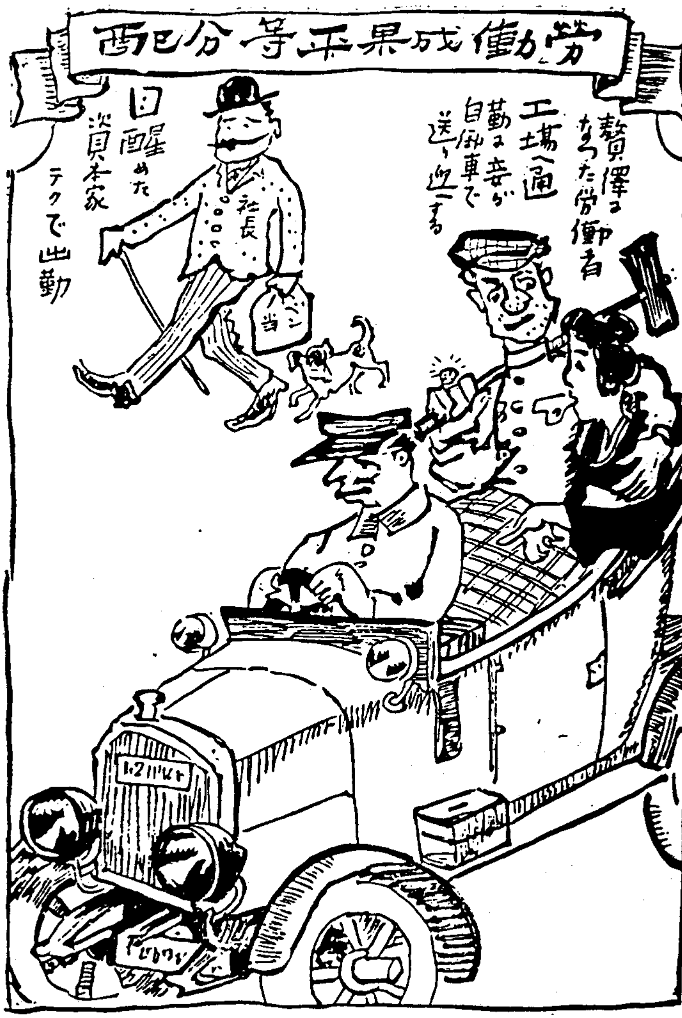
(2)
An advanced fire engine and rescue vehicle. Japanese who were aware of Western conditions could have imagined the need for such a vehicle. At that time, however, high buildings made of concrete and steel were not seen in Japan. If such high-rises were to be built in Japan, the survey respondents predicted that special life-saving devices would be necessary (it is most likely that very few of the respondents knew that equipment similar to that shown here—a vehicle having a large hose with a nozzle and an automatic ladder—was already a common feature in Western cities with tall buildings).



(3)
Mobile residences. Redesigning an urban district would become easier with these two models—an apartment house propelled by tank-like traction, and a traditional Japanese house mounted on coach wheels.

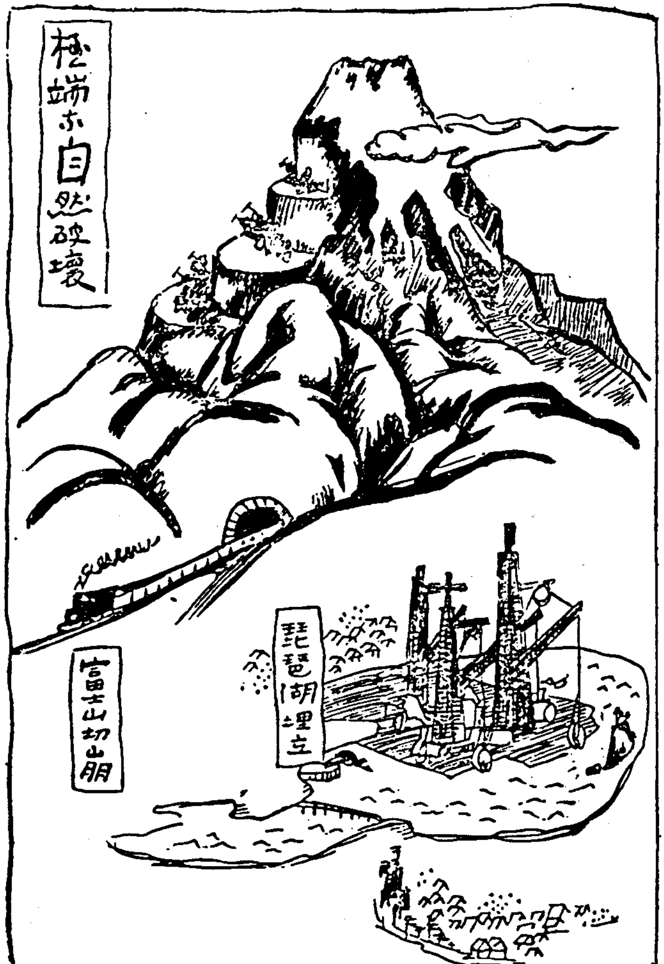


(4)
Sixty-seven years ago, this study guessed that honeymoon couples would travel by plane. Nowadays, nearly 100 percent of all Japanese getting married look forward to their honeymoon trip by plane. However, the respondents did not foresee wide-body jet aircraft and thus imagined that couples would have to fly their own small "cub" planes.

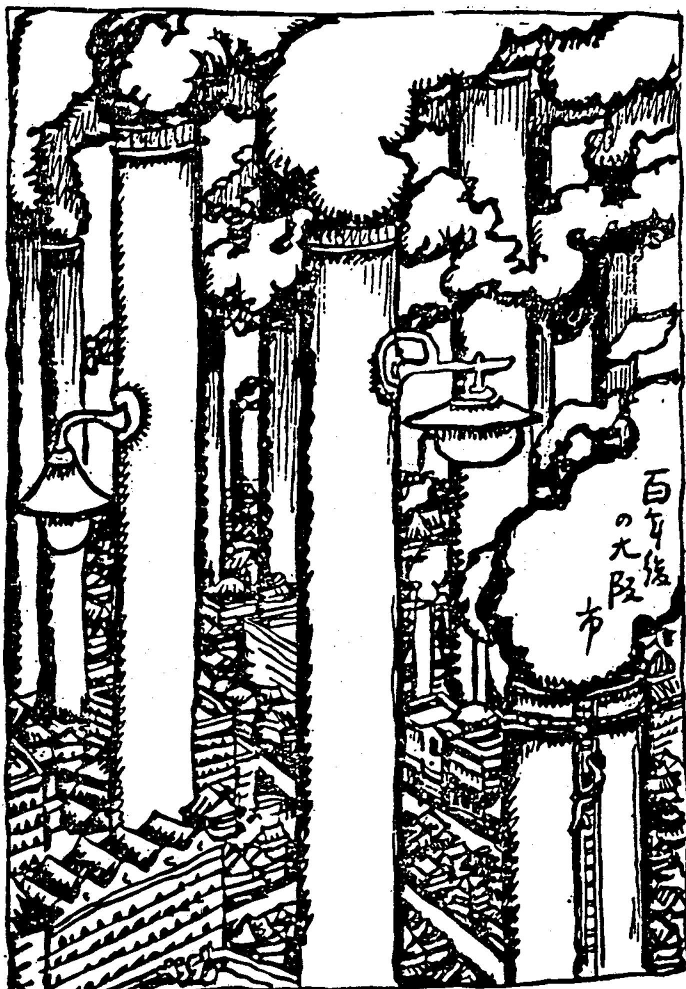


(5)
Motorization and the equalization of wage distribution. In this illustration, the president of the company walks to the office for health reasons while the working man drives to the factory in his own car. Today, this has actually become not such an uncommon phenomenon.

(6)
According to the 1920 predictions, housemaids in the future would hold an academic degree in home economics and would be very haughty. This cartoon shows the housewife bowing in front of the maid. Actually, in today's Japan the profession of housemaid has almost completely disappeared.



(7)
The effects of environmental degradation were depicted in this illustration which shows considerable destruction of nature. Mount Fiji is being levelled and Lake Biwa, which is the largest lake in Japan and is located east of Kyoto, is being filled in, to be used for industrial plants and a housing complex. Fortunately, this prediction has not taken place and, it is hoped, will not occur in the future.

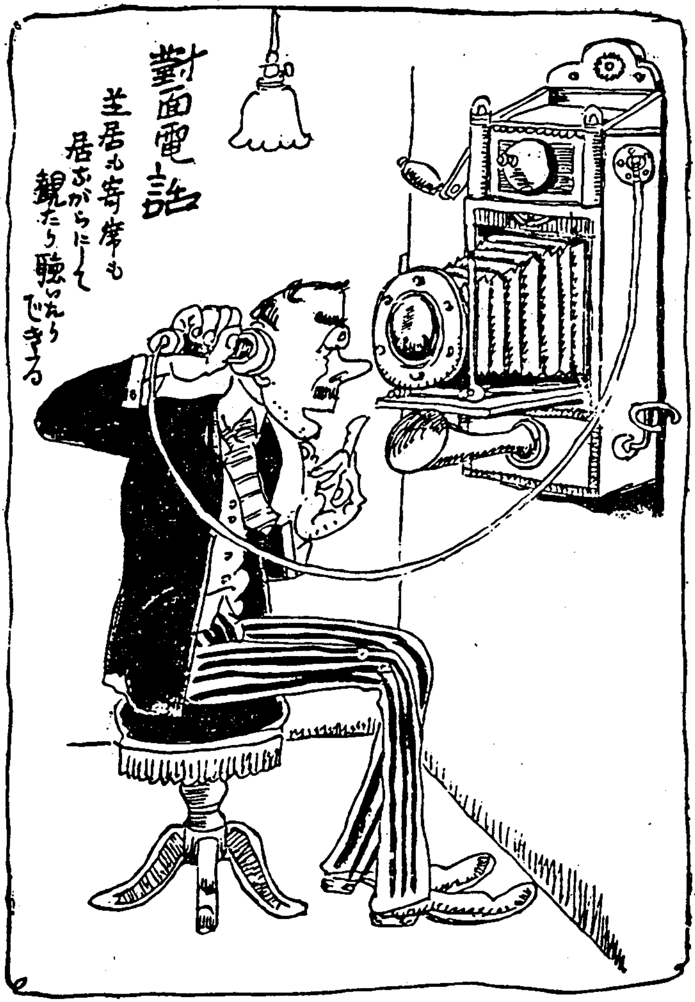


(8)
Osaka was and is one of Japan's largest industrial cities. Its power source at the time was almost exclusively coal. It was predicted that due to the smoke from burning coal the city would be in darkness even during the day and would require that chimneys be illuminated. This is another situation which luckily has not come to pass.

(9)

It was forecast that artificial heads would one day be possible. This illustration does not provide any explanation on whether the second head is just a "cosmetic" device or whether it really could fulfill all the appropriate functions. Although heads cannot be transplanted, it has become an almost routine operation to transplant hearts, kidneys, and other organs.

(10)
This giant gramophone was envisioned for the purpose of giving open-air speeches. It is obviously a variation of the old type of mechanical gramophone invented by Thomas Edison, only larger. The machine worked mechanically, not electrically. A speech was recorded on a wax cylinder, and the speaker only made powerful gestures for the crowd to see. This device brings to mind the large electronic speakers and amplifiers used at today's stadiums for rock concerts and sporting events.



(11)
You could use this forerunner of a modern video telephone to look at the person you are speaking with or even to watch theater. It is a bit like a television, but this imaginative device obviously would have its limitations since it is only an old-fashioned telephone combined with an old-style camera with bellows.

Anthropological Transformations in Technological Civilization

Gernot Böhme

Philosophical anthropology has as its objective the understanding of man about himself. This task is put before us anew time and time again, and that is why philosophical anthropology, depending on historical and social contexts, will always be renewing itself. This is not as clear an objective as it first seems, because it is not evident that man himself is constantly becoming another self. That is why anthropology, contrary to history, has been understood as the discipline dealing with the question about the "anthropological constants," i.e., those invariables that define or determine man independent of history and across cultures.

My own approach to philosophical anthropology has been determined by the question: What effect do the sciences of man (sociology, psychology, ethnology, etc.) have upon human existence? It is my belief that the knowledge gained from these sciences has profound consequences for the way men conduct their lives. This knowledge usually regards man as an object of study, i.e., as "the other," while in the field of philosophical anthropology we have to realize that we ourselves are the object of this knowledge. Since I aimed at drawing practical consequences from the scientific knowledge of man, I have chosen to give my approach a name which reflects Kant's influence: "Anthropology in a Pragmatic Perspective" (see Böhme in reference list). This report deals with a similar topic, specifically: What does being human mean in a technological civilization? Hence, some theoretical concepts from my book will be applied to our question.

This question makes sense only if one supposes that the changes that originate from life in technological civilization are of a very profound kind. "Profound" in the sense that they deeply affect the essential character of mankind. Following ideas from existential philosophy, I have put my view of anthropology under the thesis that man does not have an "essence." Accordingly, the existential philosophy of Heidegger has used the formula: "Existence preceeds essence." The fact that being human determines human essence is usually—at least as it was put by Sartre—understood as an individual self-definition. From the anthropological point of view, one would have to claim that historical, social, and cultural conditions define alternative forms of human existence. As a matter of fact, this thesis has been richly proven by historical anthropology and ethnology. The essence of being human has been defined differently depending on where and when the definition has been made.

Therefore, I shall speak on "anthropological states" instead of the essence of man. These states are various forms of organizations of what I refer to as "humana." Under the term humana, I include the many possible characteristics of human existence such as body, soul, and intellect as well as speech, work, and sexuality. But these humana are in no way a totality which can substitute for the essence of man, on one hand because they can appear as innovations during the course of history (in this sense, Bruno Snell spoke of the discovery of reason and Hermann Schmitz spoke of the invention of the soul) and on the other hand because they can relate to each other as manifestation and suppression. Therefore, I include as a further theoretical concept the concept of "difference," by which I refer to the stylization of certain humana as the human essence of man with the suppression of other humana into the realms of unclarity, diffusion, and unrecognizability. One example of this is the self-stylization of man as a being of reason, by which his corporeality has been suppressed into irrationality or bestiality. "Anthropological states," therefore, are, as such, historically and culturally conditioned forms of organization which in a non-restricted field of humana are forms of organization that include both his stylization towards "essential being" as well as his strategies to suppress and to expel certain humana from this "essential being."

This theoretical framework tries to overcome Euro-centrism within philosophical anthropology. Bear in mind that overcoming Euro-centrism is not achieved in so far as anthropology becomes hypertrophic by universalistic claims, but that it is pursued explicitly as part of the process of self-understanding (i.e., for us as European intellectuals in the technological civilization). In addition, we must maintain a constant consciousness of other possibilities for the formation of the human being, especially by avoiding that kind of logic of development according to which the European intellectual is the "telos" or goal of all human development.

My presentation can be summarized in the following theses:

Thesis 1:

The growing importance of technology in our world means a reversion, at least since the beginning of this century, in the process of civilization as described by Norbert Elias (see reference list). In this century, we can observe no further advancement in our sense of shame; in fact, we can detect a regression. In the same way it seems there is a reversal in the process of transforming external coercions into internal pressures. It is true that it is less the direct physical or political violence that determines the behavior of the individual and more the pressures of "things," namely of technical conditions of life and conditions of work and economic transactions. Since, in this connection, sanctions for wrong-doing come immediately, they do not have to be moralized as in previous times. So, hand in hand with outside forces of this kind in our society, we can observe a slow decrease in inner-psychological pressure mechanisms at work.

Thesis 2:

The existence of material "means-structures" (of technology) leads to a separation of life pursuits and rational, purposeful action. Looking backwards from the accomplished differentiation between those two components, we can say that nature obviously reaches its objectives indirectly or in a casual manner. By this point, I mean that what our appetite or urge propels us toward is normally not the aim of nature. One example of this is the relation between lustful love and procreation. This thesis claims that through the existence of technical means it splits into two actions of different types, what in nature can only be divided analytically as the object of urge and the purpose of nature. Examples of this are the division between eating and nourishment, sexuality and procreation, bodily movement and vehicular traffic, and thinking and electronic calculation. Currently, these divisions are still incomplete, and their tendencies can only be made clear by using science fiction; for example, imagine that the reproduction of the human species is pursued more and more technologically while at the same time the eroticization of humans living together progresses; or as another example, on the one hand nourishment is achieved by the calculated consumption of pills, while on the other hand there develops a ritualization of eating and a gourmet culture.

Thesis 3:

Technological civilization leads to a detached rendering of the world of images. In order to understand this thesis or even to express it, one must clarify the relation between image and emotion. One supportive thesis for this would be that originally to make an image of reality meant to figure it onto oneself, in other words, to bring one's own body into reality-related dispositions. In this sense, an image would have the function of an activation of the body's physical potential. Technological civilization, which under the supreme maxim of security organizes our lives into a poverty of real experiences and actions, now at the same time gives us the means to reduce emotional potentials that have become useless. Parallel with industrialization we have a separation of fact from fiction, leading to an independent rendering of the "world of images." Today a very important aspect of human life takes place in the world of autonomous images which we get from novels, films, and television.

Thesis 4:

In technological civilization, what has been esoteric becomes exoteric. Mysticism, meditation, and yoga practices which were once developed for exceptional forms of living and only meant for an inner circle of monks or hermits now get public currency with a tendency to become mass culture. This process is by no means a counter-movement against technological civilization, but part of its very substance: the fact that the human body is not needed any more for work in society makes a "discovery of the body" possible. In addition, the fact that physical presence has become irrelevant for social interaction makes the body free as a frame for individual fulfillment. Thinking in the sense of rational processing can be increasingly given to machines, and so we get liberated from the narrowness of object-oriented rational consciousness and are able to discover other forms of consciousness. The anthropological condition of "Cartesian dualism," i.e., "res extensa" and "res cogitans" = body and intellect, increasingly dissolves in the technological civilization and as such makes room for new anthropological forms of organization.

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Architecture Operating Within A World View

Christopher Alexander

As I listen to the various talks and read the abstracts of the papers being presented at this conference, I feel a mixture of anxiety and fantasy which is centered around the theme of technology. I think one of the reasons why this meeting even exists is because of certain anxieties over the direction of technology. On the other hand, some of the speakers do not necessarily deal with the anxieties but deal with possible fantasies which may evolve from the continuous development of technology. So, as I understand it, this is very much at the core of what is being discussed here.

In the middle of his speech, Professor Sheridan mentioned that several hundred years ago the idea of man at the center of the universe was essentially supplanted by a series of other ideas and that man has in a way been pushed further and further into retreat. Basically, I think he was saying that this is in part responsible for the anxieties which are felt. One feels that technology, which produces our modern environment, has more and more autonomy with its own rules and its own forms of development while man cowers in a little corner trying to look out and still establish himself as a being of normal deep feeling—but somehow this development of technology is not permitted.

I am an architect and a builder. So, for me, the practical problem I deal with is simply: How is it possible to produce buildings, streets, parks, environments, rooms, etc., in which people feel deeply comfortable and where they can do what they want to do and feel some profound sense of themselves while they are doing it?

I have become fairly convinced during the last 15 or 20 years that this task—i.e., the task that I have as an architect, or the task that other people have as architects and builders—is just not possible within the world picture that we owe essentially to Descartes and to the three or four hundred years of intellectual development which have taken place since the time of Descartes.

The reason is quite simple, and it is directly related to this problem of technology. Descartes and his colleagues introduced the idea that if we want to find out about the world, we need to make little mental pictures, which are essentially mental machines with which we can describe the behavior of certain things. If we attempt to describe those little machines, we will find out how they work. Such attempts have been unbelievably successful. Indeed, after several hundred years of this kind of effort, we know an incredible amount about the way the world works, as Descartes predicted we would. The problem is that this idea of the world, the idea of making models of things, mental machines, to describe how things are, is only a very useful trick to find out how things are. But what has happened in the last hundred years, starting toward the end of the nineteenth century and certainly developing ever more strongly by the middle of the twentieth, is that people have actually begun to believe that that is how reality really is, i.e., instead of merely using it as a useful trick to find out how something works, people are believing that the world really is a giant machine of some sort. Within the mental framework that one inhabits, one is thinking that, "of course, I don't know what to do," because, as has been observed many times, this intellectual transformation has taken the "I" out of the world, i.e., by choosing to describe the world in terms of these mental machines or models, the "I," the "Person" (what it means to be a person), is simply not part of our world picture at the moment.

I intentionally say "our world picture" because I assume that what we share is the scientific world picture. I think that so far the efforts of various religious groups to modify that picture are really relatively unimportant because the real picture that everybody believes in is the scientific picture. And in that world picture there is no "I."

I have summarized a lot of things very quickly, but in grappling with this problem I need to say one thing clearly. When one is making an environment, i.e., as an architect, as a builder, or as an engineer, you confront the making of a neighborhood, the making of a room. In this context and depending on what you do, your actions must be arbitrary, i.e., it is left up to you to choose the goals, the purposes, and the aims, because quite explicitly inside the Cartesian world picture and inside the scientific world view that has developed in the last century this is considered as a personal and essentially arbitrary matter. The world picture itself has nothing to say about it. So, you have to choose. As a consequence, different people choose quite differently. Each person chooses, sometimes with a partial sense of conviction, but essentially with a sense of, I would almost say, inner absurdity and anxiety and unsureness.

For instance, imagine a hotel with a huge fountain outside it. Let us say it is a very expensive granite fountain made up of all kinds of fantastic shapes, such as ones which we can find all over the world today, in Rio de Janeiro, New York, London, or just about anywhere. You ask yourself, what was the person who made that fountain really trying to do? The honest, of course, superficial answer is: "Well, it's Art." It is something, you know, and everybody pretends that this is really something intelligible, but the honest answer is that there is no deep knowledge of what to do behind the existence of that fountain, and so we experience the arbitrariness of that object, and somehow we have to live with it. But if you compare it mentally, for instance, with a small fountain made in a village in Italy maybe several hundred years ago by simple people, there you can sit by that fountain and feel a deep calm and strong sense of yourself. This is not some kind of accident; it is not a romantic view. It is simply because the people who made that simple fountain were operating with an understanding of structure different than the arbitrary and problematic view of the middle and late twentieth century which with we have been struggling as we try to make things.

Now, how do we deal with this problem? What I believe, and what I have attempted to follow in the last few years, is the constructive view in which a portion of the world, that is a part of the environment, together with ourselves, can be understood objectively to be alive in varying degrees, i.e., more alive or less alive, more whole or less whole. You can immediately imagine that this is very problematical because it appears to be introducing some kind of evaluation through the back door, which is not permitted within the scheme of things that we have been taught to do in the scientific world view. Nevertheless, I will briefly explain how it is possible to do it. I believe that one can successfully construct a picture in which you can say that the wholeness of a certain thing is more profound or less profound. Of course, each thing has its wholeness, which is an uncontemporary view since we are not even used to describing that wholeness as a structure. So, first of all, it is necessary to try and describe this wholeness as a structure. It is a rather complex and recursive structure, in which wholeness is built out of wholeness. Without the mechanistic essence of the "bottom," it is extremely difficult to express mathematically or even to conceive.

But when wholeness is described like this, you begin to understand that those places which have more of this structure are more alive, and places which have less of this structure are less alive. This explanation makes intelligible all of the variations that we perceive as we look at architecture from different periods of history. What is more important, the structures are explicit enough so that one can directly and intentionally move towards the production of that wholeness or of that deeper life in the thing.

Now, a very strange and puzzling phenomenon occurs which in a way is the crux of the whole matter. It turns out that those structures which have the deeper wholeness or the greater life appear to be pictures of the human self. I realize that this is a very enigmatic and strange statement which prompts the question: "What kind of experiment would you perform to try and check that out?" It is possible to do such an experiment by confronting people with different portions of an environment and asking them to evaluate what they see, simply in terms of: "To what extent is this a picture of your own deepest self?" This is a very difficult question to answer. Experimental conditions under which it could be done are quite tricky, because even the understanding of the question would develop while such an experiment was underway. However, what such an experiment shows is the remarkable way in which those things which have the deepest wholeness and which are alive and beautiful appear to be pictures of the self of the person who experienced such things.

Now you are likely to say: "Well, within the framework we are used to, each person is different, each culture is different, etc. So, how could there be such a thing as the self, how can an object or a portion of environment have that same kind of relationship to millions of people who are inherently so different from one another?"

Apparently, the self which is encountered in these kinds of experiments or in these interactions between people and the environment is at a level which is so deep that it reaches quite clearly across personal and cultural levels. If I was to perform that experiment, let's say with a small back street of a traditional village in Japan and take the streets, and the steps, and the doors and screens, and introduce a person, not from Japan, into that situation, and ask them to make these comparisons, it will turn out that the thing mirrors the person's self, even if that person is an African or a German, or whatever nationality. In other words, the self which I am speaking about is at a very deep level which appears to correspond to real living structures that can be described objectively in the world. The result of working within the mental framework that I have described here is immediately practicable. The kind of buildings and environments which can be produced, when they are produced within this kind of understanding, leave people with an altogether different sense of the place and of the selves from the one we have become familiar with in the late twentieth century.

Although it is only now that we are just beginning to be able to build things on any sort of scale which have these characteristics, the results of building them are that people feel the same sense of deep comfort that they have felt historically and occasionally as tourists in the few places on earth that are left which were made in centuries when this was the normal way to do things.

The kind of considerations that I have been speaking about require a fundamentally different view of space and matter. It is consistent to some degree with the discoveries which have been made in quantum mechanics during the last fifty years and the way in which the events that take place locally in space are dependent on a whole, in ways that simply cannot be described well in "element-" or "part-"based models.

I am quite confident that once this sort of picture becomes part of our normal world view and we understand the world in a way that lets us make it become alive, give it life, and recognize while we are doing it that our own self and the selves of others will be reflected in that thing as we make it, that at that point the apparent problem, the so-called "problems of technology" will really disappear. We will discover that technology is not a monster at all and that the only monstrous thing about the technology that we have currently is that the world view which guides it is so confused that we just do not know exactly what to do with the technology. As soon as you operate within a world view, where the life of the world is the central concept, the direction that one takes with the various processes, constructions, etc., of technology will become completely comfortable in the service of that life.

Technology, Culture and Social Change

Thomas Luckmann

As I see it, this Discoveries Symposium is not a research workshop nor is it an interdisciplinary colloquium. It is a symposium sponsored by a variety of institutions, addressed to a big, or at least, potentially big public. It has convened many illustrious speakers and, I am sure, it has many renowned listeners. But, let me repeat, the present occasion is not a workshop nor a colloquium. The themes are "big" ones and the speakers are evidently expected to take the "big" view. Inevitably the speakers and those of us who discuss what they say are obligated to simplify complex issues. This occasion demands a form of discourse which is not yet a fully established genre with clear rules—I am referring to what one might call a political-scientific-public relations discourse, a mixture of scientific symposium with presentations intended to influence funding policies, to allow for a public soul-searching, to offer a chance for a self-legitimation of science in response to its true or imagined loss of respectability, etc.

Inevitable or not, I, for my part, shall try to streamline my own comments, asking you to keep in mind that I too am simplifying complex issues. Both Sheridan and Mittelstrass presented impressive sketches of the development of technology, highlighting the role of warfare and military engineering (Sheridan) and the workshops situated near schools (Mittelstrass). Both speakers seem to assume that the growth of modern technology with the kind of society and culture which technology helped to shape to a certain extent was inevitable. In fact, Mittelstrass explicitly asserts this: "Thus our modern world, which is a scientifically-supported technological world, is not the haphazard product of man's history but rather the inevitable result of the development of man's being."

Homo faber is presented as the natural or (to use a term borrowed from one of the founders of German philosophical anthropology) the *natural-artificial* result of the essence of *homo sapiens*. Homo sapiens created homo faber. Yet, I would add that members of various kinds of human groupings created—in social-communicative activities over long time spans—many other varieties of human cultures and social structures in addition to homo faber. However, if homo faber displaces other varieties, as he seems to be doing, then this proves nothing more essential about homo sapiens and his potentialities than this: Homo faber fabricated the tools, technological and in part socio-organizational, to be able to displace the other varieties—from Neanderthal man to the homo sapiens of ancient American civilization, from Tasmanian aborigines to Confucian Chinese.

Let us return to the structure of the arguments by these two speakers. It first presents homo faber and the world he created for himself (and less fortunately, for his descendants) as inevitable. It then shows its many beneficient effects. And then, following a classical rhetorical device, it presents the dark side. Fortunately, one may say, we have come at least a short way from the old position when science was simply extolled for its benefits to mankind, especially, to use the device successfully used a long time ago by Hermann von Helmholtz, to plead for government noninterference with the basic research of "pure" science. Science was praised for what it brought mankind—and all its negative effects, if any were admitted, were attributed to misuse. Jerry Ravetz once coined an amusing aphorism to characterize this well-established legitimatizing rhetoric: "Science takes credit for penicillin, society takes the blame for the Bomb!"

We are fortunately a little more thoughtful about this practice than past generations of scientists. Neither of these two speakers used this time-honored but shopworn rhetorical trick. Mittelstrass, for example, used a Marxian metaphor to characterize the reality created by homo faber as an alienated reality, a reality which in turn creates the final version of homo faber in its own image as alienated man and woman. Sheridan also spoke of alienation and persuasively argued that it is easier to apply technology for destructive than for constructive ends, and that it is easier to produce new technologies than to understand them and foresee their unintended consequences. (I am tempted to formulate Sheridan's Law: It is easiest to produce new technologies for unanticipated destructive consequences.)

Now where does this argument leave us? Let me repeat the premises from which the two speakers reached rather similar conclusions:

(1) technology (as prominent scientists, philosophers of science and engineering experts tell us) is inevitable and, furthermore, new technologies are inevitable;

(2) this has unforeseeable consequences which, in addition, have probably incalculably dangerous effects on life-quality and possibly life itself of future generations.

(3) therefore, something must be done.

Now to the question of what precisely should be done. Both speakers replied in rather similar terms:

(1) Sheridan spoke of hopeful signs of a growing awareness of the unpredictable consequences of science and technology;

(2) Mittelstrass demanded a new ethic based on the determination to be reasonable, i.e., on the "Willen zur Vernunft." (Since I have indulged my fancy once already by proposing a new "Sheridan's Law," I will do it once again and speak of Mittelstrass' "Die Welt des Willens zur Vernunft als reine Vorstellung!" or roughly translated: "A world of the will to be reasonable is pure imagination!")

This is certainly a laudable departure from the old self-justification used by scientists, engineers, and technologists for public relations purposes. Their departure fits in with this new genre of discourse between scholars, scientists, statesmen (or just plain politicians), and the representatives of the socioeconomic base of technology. However, this involves only the form of discourse about technology and society. What about the matter itself?

Let us then turn to the substance of the argument and my own admittedly speculative opinion of the parallel conclusions reached by Sheridan and Mittelstrass.

Whatever hope these two speakers have for the future, and whatever prescription they offer for the *morbus technologicus,* the technological malady I cannot share as easily as I can share their diagnosis. Their solutions turn upon what I may describe as versions either of "moral rearmament" or of *consciencizacción* (the Latin-American effort at raising the level of political awareness of the masses). The first solution called for individual moral renewal based on insight and self-discipline, an approach which has not exactly been a howling success in raising moral standards in either business or government. The second solution of consciencizacción—the medicine prescribed by Westernizing intellectuals as a cure for the ills of Latin America—has not done much to change that region's social and economic realities even though it may have had something to do with securing a degree of political democratization in some Latin American countries.

In short, even an updated version of moral rearmament and consciencizacción are unlikely to develop into genuine pivots of cultural and social change. Both speakers told us themselves—and with considerable plausibility—that this social-technological process is relatively independent of the individual views of individual persons. Given the political and economic basis inextricably and, at first sight, it might also seem irreversibly committed to what one might call "blind" development (with business and national interest pretending to be seeing-eye dogs for the blind public)—given all the commitment in such industries as armaments, pharmaceuticals, and biotechnology and even in such relatively innocuous matters as river regulation—given all that, I confess that I consider "growing awareness," such as it is, and a call for the "Willen zur Vernunft" (will to be reasonable), and in "Vereinzelung" (isolation) at that, less than reassuring. If that is our only chance of survival—as Mittelstrass suggested (Sheridan did not commit himself to this with such specificity)—I, for one, would despair.

Are there not better grounds for hope? Apart from listening to the *spiritus loci,* the voice of the philosophical attitude of which the Viennese are reputed to be possessed, which counsels *Weiterwurschteln (on s'arrangera,* things will arrange themselves in the long run), I have a more specific although entirely speculative expectation that individual fears, hopes, knowledge, and anticipation of the future will be condensed and socially organized in a religious form (if you prefer, for reasons of your own, call it quasi-religious) as a cultural movement within different social institutions and organizations.

Let me explain:

(1) Given that we all benefit in innumerable ways from science and technology, starting with the managing director of an atomic energy plant and ending with the secretary of the Green Party, and given that we do not want to give up what we take for granted such as penicillin and electricity;

(2) and given that there are, on the other hand, signs of a growing awareness of the unforeseeable costs of technological progress (indeed, the costs of some old technologies have become rather visible in recent years);

(3) then given points 1 and 2, something must be done.

I suggest that subjective will, individual reason, personal insight, good intentions, *Aufklärung* (enlightenment), symposia, etc., will not do the job, although they certainly are not useless. But they are unlikely to motivate socio-political control of technological effects of present technologies for future generations—not under present mass-society conditions of political articulation.

I hope just as fervently as everybody else who has "eyes to see and ears to hear" that there is a chance for, shall we say, containment without abandonment of our kind of "Progress." I see that chance in a cultural force that is not science; I see it in a religious dimension of social movements—to be more specific, in a partial sacralization of nature and a corresponding desacralization of the sacrilegiously sacralized homo faber.

If anything can achieve such containment without abandonment, it is not individualistic moral rearmament, it is certainly not that beautiful but extraordinarily limited sub-universe of human existence which is science; if anything, it will be a kind of religious movement. It would have as much chance of success in changing the course of history as have had Buddhism, Christianity, and Islam. Such a movement would, in my view, have to start the famous/infamous "march through the institutions." It would have little chance, in my view, as a counter-church or counter-party (the very limited success of the Greens seems to support this view; and may I add that it is unfortunate that, in addition to the religious component of a veneration of nature and fear of technological hubris which originally inspired them, the Greens had to saddle a full dozen of other ideological hobby-horses!). Such a movement would have to ritualize certain human actions that could be shown to be relevant to the semi-sacralized object of fear and veneration. It would have to motivate certain forms of asceticism (e.g., the consumption of certain goods) and inspire conspicuous consumption of other goods (for instance, the "re-meandering" of regulated rivers). Without a certain organization of individual fervor and commitment into a religious component of our secular culture, without institutionalization of certain factually or at least symbolically relevant actions, such a movement is likely to fail.

The "Willen zur Vernunft" was institutionalized in the form of modern science, and there is every hope for technical solutions for specific problems there—but no hope for overall containment. Irrational abandonment—which is presently its opposite—is not yet quite institutionalized and so far is practiced, rather temporarily, in a few marginal subcultures and political groupings. Should there be a "Third Force," it will, in my opinion, combine the wellsprings of religion, veneration of something that transcends the individual, and fear of and hope for and commitment to the future, with rational insights into possible futures under different scenarios—and combine these heterogenous elements by cultural symbols and ritualized models of action into a movement within the established religions and political parties.

In short: Growing awareness in itself is not translatable into containment; if anything, it leads to subjectivistic abandonment. And the will to be reasonable, "der Wille zur Vernunft," is—as I maliciously called it—"Die reine Vorstellung vom Willen zur Vernunft" ("the pure imagination of the will to be reasonable"). Their chance to become forces in reasonably containing blind development lies in their being transformed into disciplined religious fervor, into socially organized asceticism, into rituals of maintaining the "Whole Earth," and last but not least, into an acceptable "theodicy of Progress."

Third Session

The Individual's Means of Coping with Complexity

Medicine in the Biomation Age of the Twenty-First Century

Kazuhiko Atsumi

Around 600,000 years ago, the average life span of humans was estimated to be 13 years. In the eighteenth century, the average life span of the Viennese was estimated to be 22 years. In Japan at the beginning of the twentieth century, the average life span for a male was 36 years and for a female was 37 years. Recent statistics show that Japanese life expectancy has increased to over 80 years for females and 74 years for males.

Infant mortality in Hamburg in the nineteenth century was so widespread that one-fourth to one-third of all infants died from infections. However, these deaths have been reduced by progress in medicine and health education. Today in Japan for instance, the infant mortality rate is estimated at less than 0.5 percent—one of the lowest in the world.

Recent studies indicate that increasing numbers of humans in different regions of the world will be surviving to the age of 100. Increases in life expectancy are a result of the continuing advances of medical science. For instance, the nineteenth century is noted for such developments as antibiotics and many other types of pharmaceuticals, anesthesia, blood transfusions, and life-saving surgical operations; the twentieth century has witnessed a proliferation of medical wonders, and as we head into the twenty-first century we are seeing profound contributions from biomedical engineering and biotechnology.

Already, these two disciplines have provided medicine with more precise diagnostic techniques, improved therapies, and advanced pharmaceutical products. Further developments in both fields will continue to revolutionize medicine and health care well into the next century.

Here are just a few of the contributions of biomedical engineering:

- electrocardiograms for the diagnosis of heart ailments;
- electronic monitoring of patients in intensive care units;
- ultrasonic ecography for use in coronary diagnosis;
- x-ray CAT (computer assisted tomography) provides a non-invasive method for imaging tumors or bleeding in the brain as well as for whole-body imaging;

- magnetic resonance imaging (MRI) shows fine details of the brain and can even indicate chemical shifts in this organ (see photo illustration);
- magnetoencephalography using the SQUID (superconducting quantum interference device) system makes biomagnetic images of the brain;
- positron CAT can display details of brain metabolism;
- infrared thermography produces patterned images of body surface temperatures; for instance, this method has been used recently to make a diagnosis of pain and to detect its pathogenic origin in spinal lesions;
- ultrasonic holography for tumor imaging (see the photo illustration which shows a breast tumor);
- laser endoscopy for use in surgery to vaporize tumors and tissues; with the aid of a quartz optical fiber the laser's near-infrared beam easily can be applied to stop stomach bleeding or to eliminate cancerous tissue in the gastrointestinal region and in the brain;
- laser angioplasty, which introduces a laser catheter into a blood vessel to vaporize an atheroma or to recanalize a blocked vessel; it is expected that this method will be applied in the percutaneous recanalization of an obstructed coronary artery and thus one day replace the arterial-coronary bypass operation;
- the artificial heart; although still in a developmental stage, it is thought that in the future this device will be implanted successfully and will allow survival beyond the almost two years currently achieved. Research and development in the field of artificial organs will undoubtedly continue in the next century and yet may yield a "hybrid human" (or as a former American television show called him the "bionic man").

These feats of bio-engineering are of course concentrated in the developed countries of the world, which have also seen an expansion of medicine's objectives beyond diagnosis and treatment of patients to cover an ever-wider scope, including disease prevention, rehabilitation, health education, environmental protection, neonatal health care, traumatology (treatment of severely injured accident victims), and geriatrics. In other words, the aim of medicine should be to take care of the individual from birth to death. This so-called comprehensive medicine will change the relationship between doctor and patient and will require greater coordination and planning, particularly on a regional basis.

It is clear that the need for medical care has grown rapidly over the past few decades, not only in developed countries but also in developing countries. Unfortunately, the medical needs in developing countries have been and continue to be unmet, thus making it all the more necessary to seek optimum allocation of severely limited resources.

In those countries which have been able to afford the innovations of medical technology, increasing attention has been focused on numerous ethical questions involving the use of various new inventions and techniques. This has resulted in the growing importance of bioethics. However, medical technology is not the only concern of bioethics. Another significant issue for bioethics is the treatment of psychosomatic illness as well as environmental and social stress. Such treatment is usually provided by psychiatry and the other mental health sciences, but so often these treatments prove ineffective. In this case, bioethics may help the public recognize the limitations of modern medicine. It is likely that the work done in the field of bioethics will bring about more communication and even cooperation between medicine and religion.

Turn now to a consideration of how humans have developed from an agricultural society to an industrial society to an information society. In my view, the next step in this evolutionary process will be a "biomation" society. Biomation is the linkage of automation with the bioorganism, resulting in a hybridization of man-made technology and the natural realm. I think that biomation will transform our mechanical civilization into a humanistic civilization.

Recall how science has progressed from an emphasis on mechanics to physics, then to chemistry, and finally to biology. In a similar way, technology started with simple machines and gradually proceeded into the development of electronics, optics, polymers, and so on. Throughout this process of progress, interdisciplinary efforts within science and technology as well as efforts between science and technology have led to important contributions toward human welfare.

In Table 1, you can see how engineering over the years has had the goal of making substitutions for such human activities as manual labor, sensory processing, and even thinking. The history of engineering is clearly marked by the automation of human activity. This progress in automation is moving ever closer toward natural creation.

Table 1
Mechanical Replacement and Aiding of Human Activities

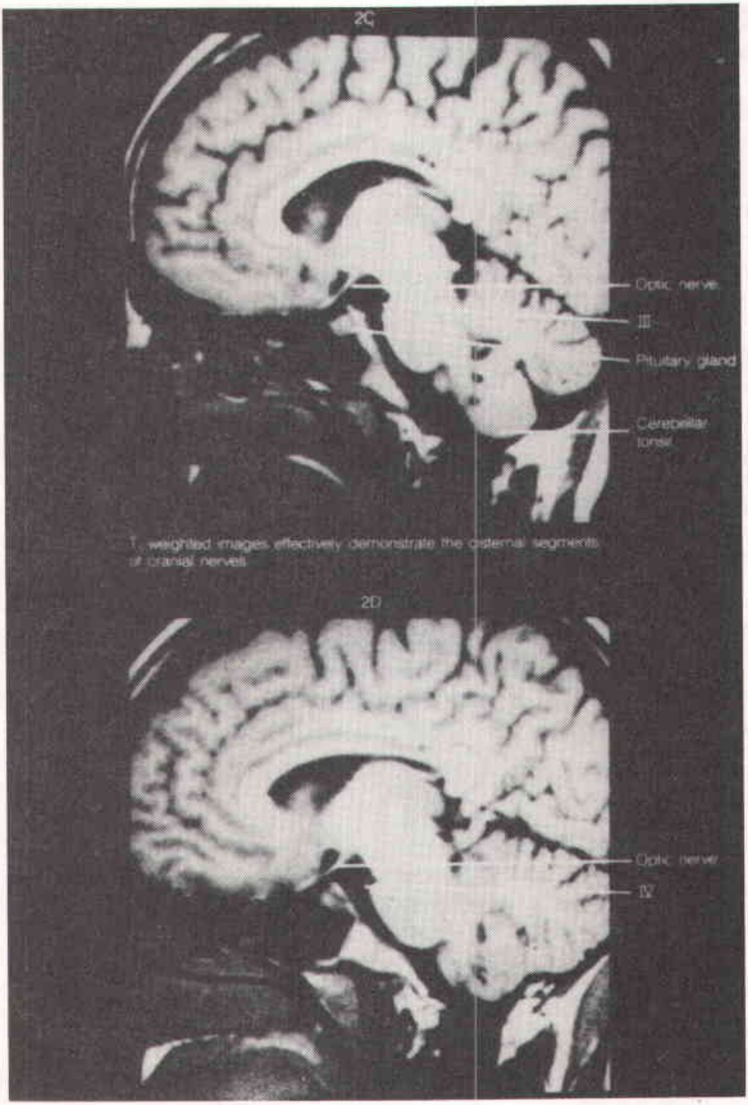
Human Activities	*Machines*	*Appx. Date*
Creative Thinking	(highly unlikely to be fully mechanized)	
Learning	Intelligent Learning Computer	2000
Manipulation	Automatic Trolley	1985
Amusement	Video Games	1980
Hearing	Audio Recognition Instrument	1980
Reading	Handwriting/Printed Text Recognition Device	1980
Speaking	Audio Response Device	1978
Writing	Ink-Jet Printer	1976
Precision Work	Robotic Device	1960
Calculation	Electronic Computer	1940
Duplication	Xerographic Device; Tape Recorder	1935
Broadcasting	Radio	1920
Light Manual Labor	Conveyor/Assembly Line	1910
Communication	Telephone; Telegraph	1876 1843
Transportation	Automobile; Steam Locomotive	1865 1814
Heavy Manual Labor	Steam Engine	1705

One example of technology moving toward nature is the development of devices used for calculation (see Table 2). As can be seen from this table, between 1 billion and 10 billion of the super integrated circuits (also known as fourth-generation semiconductors) can fit in a space which is equivalent to the size of the brain. This number approaches the number of cells in the brain. Here is an example of human technology coming close to natural creation.

Table 2
Technological Innovations in Data Processing

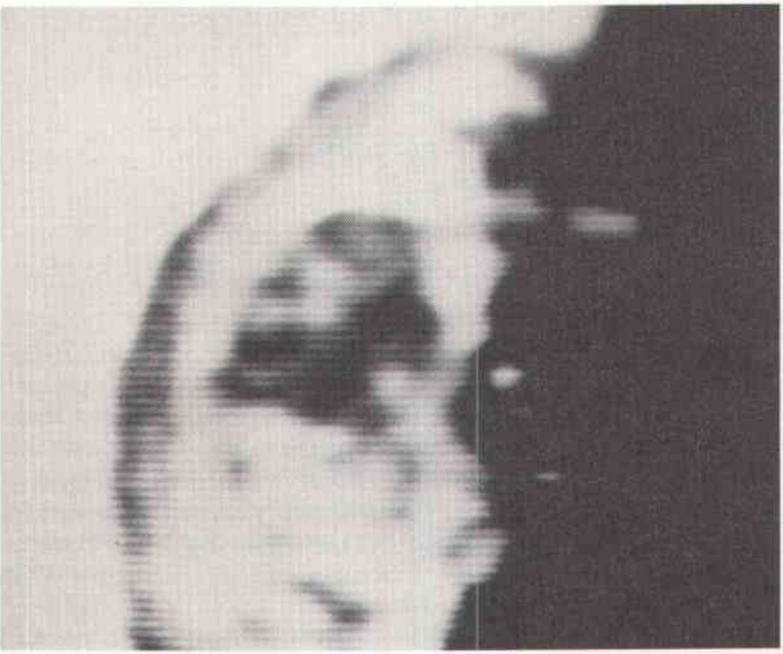
Device	*Date of Development*	*Number of Devices in 1,000 cubic cm (i.e., a space equivalent to the size of the brain)*
Vacuum Tube	1906	4—5
Transistor	1947	up to 150
Integrated Circuit (IC)	1965	50,000
Super IC	1980	1 billion—10 billion

It is my belief that in the biomation society we will see major shifts in the following directions—from hardware to software, from standardization to individualization, from centralization to decentralization, from subsystem to total system. Such trends will also be reflected in the twenty-first century's health and medical care as it becomes more comprehensive, individualized, and quality-oriented.



(Photo 1)

This magnetic resonance image of the brain shows the fine anatomical structures revealed through the non-invasive MRI technique.



(Photo 2)
Internal structural details of breast cancer are revealed in this image made through ultrasonic holography.

Appearance and Potentiality not Matter vs. Mind: A Program for the Twenty-First Century

Karl H. Pribram

Introduction: The Rift in our Culture

C. P. Snow popularized the conception that in our day there are two cultures: the scientific-technical and the humanist-spiritual. These two cultures are seen as mutually exclusive and to a large degree antagonistic. The thesis of this essay is that this very real division in our culture is due to an outmoded view of what science and technology of the last decades of the twentieth century are about: insights derived from experiments and theory in quantum physics and in the information technologies have so revolutionized science that the rift in our culture can and should be healed.

It is now a half-century since discoveries in nuclear physics revealed an order of complexity which defied explanation in terms of classical Newtonian mechanics. Pioneers in these explorations immediately saw the relationship between what they perceived and the spiritual traditions of our culture. Thus Bohr took as his emblem the ying and yang of the Chinese Tao and Schroedinger wrote of the Upanishids. Heisenberg dealt with the new order in terms of a different view of the relationships between the part and the whole, a relationship drawn out more clearly by Bohm in terms of implicate, enfolded vs. explicate, unfolded, orders. It is the implicate order that is encountered not only in the quantum domain but also as a result of exercises such as those undertaken in Zen and Yoga in what we ordinarily consider to be the spiritual domain.

The order discovered at the quantum physics level of investigation has been thought to be limited to that level. This is not the case. Rather, the results of experiments in psychophysics and in brain physiology indicate that the principles of organization that characterize the quantum theory also describe the organization of the brain processes coordinate with our perceptions. Another way of stating the issue is that the rift in our culture is due to a pervasive mind/matter dualism in our worldview and that the remedy lies in demonstrating, with scientific data and by rational means, the limitations of such a worldview. The full documentation of this proposal is contained in a book entitled *Brain Organization in Perception: Holonomy and Structure in Figural Processing* (Pribram, 1988). Here is summary of some of the ideas basic to this worldview.

Metaphysics

Some Recent History

The story of current thinking on the mind/brain issue begins with Ernst Mach (1914) and the positivist approach. Mach was a dualist, and a parallelist-mind and brain for him had identical structures but were forever separate entities. Mach's position gave rise to two major approaches, each centered on a particular problem. The first of these approaches accepted Mach's dualism but noted that mind and brain do interact, i.e., influence each other. The question arose as to how that interaction might take place. Popper answered this question by suggesting that mental processes create a "World 3" of language and culture which in turn feeds back, through the senses, to influence brain mechanisms. Mind itself was noted to be an emergent of this interaction, an emergent immersed in the sensory (and motor) processes which relate brain to the organism's environment.

The Vienna Circle, and especially Feigl (1960), addressed a different problem in Mach's formulation. If indeed identical structures characterize brain and mind, what is it that is structurally identical? Feigl, in keeping with positivist tradition, focused on language and suggested that mind talk and brain talk were different aspects of some underlying Machian structure. Identity theory in his hands gave up dualism and opted for the monistic emphasis on basic structure.

Both Poppers's and Feigl's programs have much merit, but each also poses new questions—questions which can lead to further insights. These questions are: Just what is it that makes up World 3? What is the essence of language and culture which can so readily influence the brain? In the multiple aspects view, what is it that the aspects refer to? My answer to these questions is presented as a scientist rather than as a philosopher. By this I mean that I am to identify the data set which each of the philosophic programs addresses rather than to push each program to its logical limit. The result of this approach is a neutral monism, neutral to the mind/brain duality, with the potential for multiple realizations. A new duality is discovered: the duality between potential orders and their realizations.

Behavior and Experience

By contrast to philosophers, psychologists under the banner of a realist radical behaviorism eschewed any scientific reference to mind. Both Skinner (1971, 1976) and Quine (1960) have pointed out that no two people mean exactly the same thing when they use a particular word or phrase. Further, we can never be sure that even when we use a word such as green that it denotes the same experience to each person using it. But this is an issue common to all of science and indeed to all cognition as Berkeley (1904) so persuasively argued. Are we therefore to give up, hang our heads and sit in isolation in our respective existential corners? Of course not. Nor does it mean, as the behaviorists would have us do, that in constructing a science we *must* exclude reference to our conscious experience. A common alternative is to make inferences and to proceed to deal with them. Cognitive science can and does proceed in just this fashion (see, e.g., Johnson-Laird, 1983).

The issue is not just a philosophical one. When a patient with an occipital lobectomy tells you that he is blind even though he is able to respond correctly to the location and configuration of visual cues (Weiskrantz, Warrington, Sanders and Marshall, 1974; Weiskrantz, 1974), how are we to deal with his "blind-sight" except to distinguish his instrumental response from his verbal report of introspection? A radical behaviorist would want to discount the introspective report as not "real"— in fact, several died-in-the-wool behaviorists have told me that they are certain that either the patient or the experimenter were lying. But this type of patient is not unique. For instance, H. M., Brenda Milner's famous subject who had sustained a bilateral medial temporal lobe resection, has a similar difficulty: he cannot consciously remember Brenda even after some 30 years of repeated testing, while at the same time he performs perfectly in an operate situation which he learned many months before (Sidman, Stoddard, and Mohr, 1968).

The alternative is to ascertain to the best of our ability that we can accept at face value both the instrumental behavior and the verbal report and to go about the search for the neural mechanism that, when injured, can account for the dissociation. We accept the inference that the subject has a "mental life," that his psychological processes are accessible by way of his verbal reports and instrumental behaviors, and further, that these different forms of behavior may reflect different processes.

Philosophers and psychologists of a nonbehaviorist persuasion may counter that any argument about mental phenomena derived from behavior is spurious. They would rather begin with "the phenomenon itself existentially experienced," but there is little that can be done with such experiences except to attempt to describe them (behaviorally) and to organize the descriptions (structurally). Thus Maurice Merleau-Ponty, an existentialist philosopher, has authored a book entitled *The Structure of Behavior* (1963), which in both spirit and content shows remarkable resemblences to our own *Plans and the Structure of Behavior* (Miller, Galanter, and Pribram, 1960; see also Pribram, 1965), which tackles the issues from a behavioral and information-processing vantage. I do not mean to convey here that there is no distinction between a behavioristic and an existential-phenomenalistic approach to mind. Elsewhere I detail this distinction in terms of a search for causes by behaviorists and a search for information structure reasonably (meaningfully) composed by phenomenologists (Pribram, 1979). What I do want to emphasize here is that both approaches lead to conceptualizations that cannot be classified readily as either mental or material. Behaviorists in their search for causes rely on drives, incentives, reinforcers, and other "force"-like concepts that deliberately have a Newtonian ring. Existentialists in their quest for understanding mental experience come up with structure much as do anthropologists and linguists when they are tackling other complex organizations, and structural concepts are akin to those of modern physics where particles arise from the interactions and relationships among processes. The view to be developed here is that in neither case can this result of inquiry be characterized as mental or material unless one wishes simply to state a bias in favor of one or the other as being more meaningful to oneself.

Hierarchy, Reciprocal Causation, and Mind/Brain Identity

Let us look at this issue of structure in terms of computers, programs, and the processing of information in some detail, because in many respects these artifacts so clearly portray some of the problems involved in the mind/brain issue. As has been repeatedly noted (see, e.g., Searly, 1984), the computer is not a brain, and its programs are constructed by people who do have brains. Nonetheless, computers and their programs provide a useful metaphor in the analysis of the mind/brain issue in which the distinctions among brain, mind, and spirit can be seen as similar to the distinctions among machine (hardware), low-level programs (e.g., operating systems), and high-level programs (e.g., word processing programs). Low-level programs such as machine languages and assemblers are not only idiosyncratic to particular types of computer hardware, but there is also considerable similarity between the logic of these languages and the logic operations of the machines in which they operate. In a similar vein, to some extent, mental processes can be expected to share some similarity to brain processes. On the other hand, high-level languages such as Fortran, Algol, and Pascal are more universal in their application, and there is obvious similarity between their implicit logic and the logic of machines. At the highest level, in languages such as English, with which I am addressing my computer in order to use it as a word processor, the relation between its logos (word, concept, logic) and that of the machine is still more remote. However, English relates me to a sizeable chunk of the human social order. To complete the analogy, the spiritual nature of man strives to make contact with more encompassing orders whether they be social, physical, cosmological, or symbolic.

Understanding how computer programs are composed helps to tease apart some of the issues involved in the "identity" approach in dealing with the mind/brain relationship; because our introspections provide no apparent connection to the functions of the neural tissues that comprise the brain, it has not been easy to understand what theorists are talking about when they claim that mental and brain processes are identical. Now, because of the computer/program analogy, we can suggest that what is common to mental operations and the brain "wetware" in which the operations are realized is some order which remains invariant across transformations. The terms "information" (in the brain and cognitive sciences) and "structure" (in linguistics and in music) are most commonly used to describe such identities across transformations.

Order invariance across transformations is not limited to computers and computer programming. In music we recognize a Beethoven sonata or a Berlioz Symphony irrespective of whether it is presented to us as a score on sheets of paper, in a live concert, over our high fidelity music system, or even in our automobiles when distorted and muffled by noise and poor reproduction. The information (form within), the structure (arrangement) is recognizable in many realizations. The materials which make the realizations possible differ considerably from each other, but these differences are not part of the essential property of the musical form. In this sense, the identity approach to the mind/brain relationship, despite the realism of its embodiments, partakes of Platonic universals, i.e., ideal orderings which are liable to becoming flawed in their realization.

In the construction of computer languages (by humans) we gain insight into how information or structure is realized in a machine. The essence of biological as well as computational hierarchies is that higher levels of organization take control over and are controlled by lower levels. Such reciprocal causation is ubiquitous in living systems; thus the level of tissue carbon dioxide not only controls the neural respiratory mechanism but is controlled by it. Discovered originally as a regulatory principle which maintains a constant environment, reciprocal causation is termed "homeostasis." Research over the past few decades has established that such *feedback* mechanisms are ubiquitous, involving sensory, motor, and all sorts of central processes. When feedback organizations are hooked up into parallel arrays, they become feedforward control mechanisms which operate much as do the words (of bit and byte length) in computer languages (Miller et al., 1960; Pribram, 1971a).

Equally important, programming allows an analysis to be made into the evolution of linguistic tools which relate the various levels of programming languages. Digital computers with binary logic require a low-level language (coded in the numeral 0 or 1) which sets a series of binary switches. At the next level, switch settings can be grouped so that the binary digits (bits) are converted into a more complex code consisting of bytes, each of which is given an alphanumeric label. Thus, for example, the switch setting 001 becomes 1, the setting 010 becomes 2, and the setting 100 becomes 4.

Given that 000 is 0, there are now eight possible combinations, each of which is an octal byte.

This process is repeated at the next level by grouping bytes into recognizable words. Thus 1734 becomes ADD; 2051 becomes SKIP, and so forth. In high-level languages, groups of words are integrated into whole routines which can be executed by one command.

It is likely that some type of hierarchical integration is involved in relating mental processes to the brain. Sensory mechanisms transduce patterns of physical energy into patterns of neural energy. Because sensory receptors such as the retina and the cochlea operate in an analog rather than a digital mode, the transduction is considerably more complex than the coding operations described above. Nonetheless, much neurophysiological investigation is concerned with discovering the correspondence between the pattern of physical input and the pattern of neural response. As more complex input is considered, the issue becomes one of comparing the physically determined patterns with subjective experience (psychophysics) and recording the patterns of response of sensory stations in the brain.

These comparisons have shown that a number of transformations occur between sensory receptor surfaces and the brain cortex. These transformations are expressed mathematically as transfer functions. When the transfer functions reflect identical patterns at the input and output of a sensory station, the patterns are considered to be geometrically isomorphic (iso = same; morph = form), i.e., of the same form. When the transfer functions are linear (i.e., superposable and invertable, reversible), the patterns are considered to be secondarily or algebraically isomorphic (Shepard, 1970). Thus, as in the case of computer programming, levels of processing are recognized, each cascade in the level producing transformations which progressively alter the form of the pattern while maintaining intact some basic order, an informational structure.

In short, holding the identity "position" with regard to the mind/brain issue involves specifying what it is that remains identical. Unless something remains constant across all of the coding operations which convert English to binary machine code and back to English, my word processing procedures would not work. Identity implies stepwise causation among structural levels. Contrary to the usually held philosophical position, identity does not necessarily mean geometrical or even algebraic isomorphism. Transformations, coding operations, occur which hierarchically relate levels of complexity with one another. A level is defined by the fact that its description, i.e., its code, is in some non-trivial sense more efficient (i.e., requires less work, less expenditure of energy) than use of the code of the components which compose it. In the case of the word processor the coding is arbitrary, and the arbitrariness is stored on a diskette and copyrighted. In the case of the mind/brain relationship the nature of the coding operations is more universal, and the efforts of a century-and-a-half of psychophysical, neuropsychological, and cognitive research have provided knowledge concerning at least some of the coding operations involved.

I am belaboring these findings of scientific research to indicate that, contrary to what some philisophers hold (see, e.g., Dewan et al., 1976), they have relevance to philosophical issues. If the mind/brain problem arises from a distinction between the mental and the material, and we find that at a certain level of analysis we no longer can clearly make such a separation, then the very assumptions upon which the issue is based may be found wanting.

Within the frame of these considerations, let us now look at some specific dualistic and mentalistic proposals that have been forwarded recently and place them within a perspective which states that the material-mental dichotomy holds only for the ordinary Euclidean-Newtonian world of appearances.

Do Experiences Matter or Does Matter Become Experienced?

In the ordinary world of appearances there is no question but that human mental experiencing can be distinguished sharply from the contents of the experience. The issue has been labeled "intentionality" (or intentional inexistence) by Franz Clemens Brentano and has given rise to inferences about the nature of reality (Brentano, 1973; Chisholm, 1960). The question is often phrased: Are my perceptions (my phenomenal experiences) "real," or does the content of those perceptions make up the "real" world? My phenomenal experiences are mental; the world as it appears to me is material. I can give primacy to my experience and become a mentalist, or I can give primacy to the contents of the experience and become a materialist; but I can also give primacy to neither and attest to the dual nature of reality.

Materialism and mentalism run into difficulty only when each attempts to deny the other. As long as only primacy is at stake, either view can be made consistent. After all, our experiences are primary, and empiricism is not inimical to a real material world. We do appear to be experiencing something(s), so our experiences may well become organized by those real (material) somethings.

Nevertheless, by accepting such a moderate position with regard to mind and matter we immediately come up against a set of dualistic problems. Are the contents of perception "really" organized by the experience of the perceiver? Is that experience in turn organized by brain function, sensory input, and the energies impinging on the senses? Would a complete description of the brain function of an organism also be a description of the experience of that organism? If so, are not the material descriptions of brain, senses, and energies sufficient? Or at least do the descriptions of experience add anything to the material descriptions? Cannot the inverse be equally true—what do the descriptions of brain, senses, and energies materially add to what we so richly experience?

Epistemology

Transcending Dualisms Without Denying Them

I believe that today there are answers to these questions where only a few years ago there were none. These answers come from "unpacking" conceptual confusions and demonstrating that each conceptualization captures a part of a truthful whole.

A semantic analysis shows that descriptors of brain, senses, and energy sources are derived from an analysis of experience into components. The components are organismic and environmental (biological and physical or social), and each component can be subdivided further into subcomponents until the quantum and nuclear levels of analysis are reached. This procedure of analysis downward in a hierarchy of systems is the ordinary way of descriptive science. Within systems, causes and effects are traced. When discrepancies are found, statistical principles are deduced and probabilities invoked. Scientists have become adept and comfortable with such procedures.

Mental language stems from different considerations. As in the case of descriptive science, mental terms take their origin in experience. Now, however, experience is validated consensually. Experience in one sensory mode is compared with that obtained in another. Then validation proceeds by comparison of one's experience with that of another. A little girl points to a horse. Until now mother has allowed her to say "cow" whenever any animal is pointed to. But the time has come to be more precise, and the experience of horse becomes validly different from that of a cow. Mental language is derived from such upward validations in a hierarchy of systems.

Elsewhere I detail the differences in scientific approach which this upward—or outward—look entails (Pribram, 1965). It is certainly not limited to psychology. When Albert Einstein put forth his special and general theories of relativity, he was looking upward in the set of heirarchically arranged physical systems. The resultant relativistic views are equally applicable to mental and to physical conceptualizations. These are the relativisms which existentialists and phenomenologists constantly struggle to formulate into some coherent principles. My own belief is that they will be successful only to the extent that they develop the techniques of structural analysis. But structured analyses often depend on enactment to clarify the complexities involved. Abhorrent as the computer and other engineering devices may be to philosophers and psychologists of the existential-phenomenal persuasion, these tools may turn out to be of great service to their mode of enquiry.

If the above analysis is correct, then a dualism of sorts can be entertained as valid. First I caution, however, that this form of dualism is concerned with the everyday domain of appearances—of ordinary experiences. Commencing with such ordinary experiences, two modes of conceptualization have developed. One mode operates downward in a hierarchy of systems, analyzing experience into components and establishing hierarchical and cause-effect relationships among these components. The other operates upward toward other organisms to attain consensual validation of experiences by comparing and sharing them.

Thus two mirror images—two optical isomers, as it were—are constructed from experience. One we call material and the other mental. Just as optical isomers in chemistry have differing biological properties, though they have identical components and arrangements, so the mental and material conceptualizations have different properties even though they initially arise from the self-same experiences.

I suggest that this is the origin of dualism and accounts for it. The duality expressed is of conceptual procedures, not of any basic duality in nature. As we will see, there are other dualities that are more basic, but these are not the ones that have become the staple of those arguing for dualism.

Mind as Emergent and as Actor

The views expressed thus far have provided a coherent theory which accounts for dualistic views, but transcends them by showing them to arise from procedural differences which separately realize a common structure. That structure is neutrally described in mathematical and information-processing (or similar) terms—terms which cannot readily be characterized as either material or mental.

This theory is considerably different from more classical dualistic views which hold a fundamental separation between mental and material. This separation has also been ameliorated recently by the proposal (Popper and Eccles, 1977) that interaction between mental and material takes place by way of a material-like cultural domain which feeds back through the material senses to the material brain. Mental processes are then the emergents which result from this interaction. However, I have argued elsewhere that the way Popper and Eccles define mind in terms of such interactions is akin to a colloquial use of the concept "force" (Pribram, 1976). We say, for instance, that gravitational force, "gravity," pulls us to the earth. The concept "gravity," however, was derived from studying the interactions of masses in motion. Gravity is thus by definition an interaction term; gravity would not "exist" were there no "us" to be attracted to the earth. We would deify gravity and have it pull us, and appearances certainly confirm this way of conceiving forces—that they are being "produced" by one body and operating on another. Popper develops his thesis of World 3 being "produced" by World 2 in this spirit.

What I see as helpful in the World 2-World 3 division is the attempt to portray the same issue that I discuss in terms of structure and its realization. In a sense, what I call "structure" is what Popper and Eccles call "mind." The difference is, however, that my "structures," also derived from sensory and behavioral interactions, are realized in material, physical environments (such as the structure of a symphony being embodied in a printed score or a magnetic tape). If these structures are to be identified as mental, my formulation would be akin to those of Alfred North Whitehead (1925), Roger Sperry (1980), John Searle (1983), and Eugene Wigner (1969)—a form of mentalism. I am not willing to go that far; rather I prefer to hold the line by stating that structures transcend both the physical and mental realities in which they become realized.

Strictly speaking, mentalism *per se* implies dualism since there would be no need for mentalism if there were no materialism. There is no up without a down. Furthermore, Sperry and Searle attempt to limit their mentalism to those structures which are organized by and in turn organize the brain. It is not clear whether they are willing to go the epistemological limit which holds that at base all the elementary components making up the universe (quarks, hadrons, etc.) are mental or whether only our knowledge of these particles is mental. Since they are adamantly opposed to an "independent existence of conscious mind apart from the functioning brain" (Sperry, 1980, p. 195), their mentalism does not stretch to cover the very essence of what motivates mentalism in the hands of those who suppose it to be materialism, i.e., the *primacy* and independence of mental structures.

Constructional Realism: A Pluralistic Monism

Before I proceed with a precise delineation of the experimental and theoretical basis for the approach taken here, it may be helpful to summarize what has been proposed thus far: a "monism" which simply states that the truly basic components of the universe are neither material nor mental, but neutral. The dematerialization of matter at the level of analysis that concerns modern physics—reviewed below—supports such a "neutral monism" (James, 1909; Russell, 1948). Critical philosophers (e.g., Herbert Feigl) steeped in linguistic analysis developed this monistic view by suggesting that the "mental" and "material" are simply different ways of talking about the same processes. Thus "mind" and "brain" come to stand for separate linguistic systems, covering different aspects of a basic commonality. The problem has been to find a neutral language to describe the commonality without being either mental or material in its connotations.

I have taken this "dual aspects" view a step further by proposing that each aspect is not only characterized linguistically but in fact is a separate "realization" or "embodiment" (Pribram, 1971b). As noted, I have further proposed that what becomes embodied is informational "structure." Thus in essence I have stood the critical philosopher's approach on its head: the enduring "neutral" component of the universe is informational structure, the negentropic organization of energy. In a sense this structure can be characterized as linguistic—or mathematical, musical, cultural, etc. Dual aspects become dual realizations—which in fact may be multiple—of the fundamental informational structure. Thus a symphony can be realized in the play-ing at a concert, in the musical score, or on a record or tape and thence through a high-fidelity audio system at home.

"Mind" and "brain" stand for two such classes of realization, each achieved, as described above, by proceeding in a different direction in the hierarchy of conceptual and realized systems. Both mental phenomena and material objects are realizations and therefore realities. Both classes of reality are constructions from underlying "structures." It is the task of science to specify these constructions in as neutral a language as possible (neutral, i.e., with respect to connotations that would suggest that the "structures" belong in one class or the other). I note elsewhere the relationship of such a constructional realism to critical realism, pragmatism, and neo-Kantian rationalism (Pribram, 1971a).

There are important differences between a constructional realism such as I propose and mentalist, dualist and triadic interactionisms. In a constructional scheme the precise place of brain mechanisms can be specified. The sensory and brain perceptual mechanisms that are used to construct the Newtonian reality of appearances; the cognitive, "intrinsic" (my term of Eccles' "liaison") brain mechanisms that are necessary to the formulation of quantum and nuclear physics; the connative, motor brain mechanisms that organize intention and plan; the emergence of feelings from the neurochemical organizations of the brain—all can be fitted into their precise and proper places in the scheme. There is no global "mind" that has to make mysterious contact with global "brain." Many mysteries are still there—to name only one, for example, how emergents come about and how they are so utterly different from their substrate. But issues become scientific and manageable within the broader context of philosophic enquiry.

Ontology

The Dematerialization of Energy

The fundamental assumption that has given rise to the mind/brain problem is that mental phenomena and the material universe are in some essential fashion different from each other. As we have seen in the ordinary domain of appearances, at the Euclidean-Newtonian level of analysis, this view is certainly tenable. At the level of microphysical universes, however, dualism becomes awkward. Niels Bohr's complimentarity and Werner Heisenberg's uncertainty principle emphasize the importance of the observer in any understanding of what presumably is observed (Bohr, 1966; Heisenberg 1959). Eugene P. Wigner states the issue succinctly: Modern microphysics and macrophysics no longer deal with relations among observables but only with relationships among observations (1969).

An objection can be raised that the difficulties of distinguishing obervables from observations encountered by physicists today are temporary, superficial, and of no concern to philosophers interested in the eternal verities. That is not the message these thoughtful pioneers in physics are attempting to convey. They have been exploring universes where the everyday distinction between material and mental becomes disturbingly untenable at a very fundamental level. As we proceed I shall tender some explanations that may help account for their views.

The dematerialization of matter can be traced in some sense to earlier formulations. For instance, physics was conceptually understandable in James Clerk Maxwell's day when light waves were propagated in the "ether." Then physicists did away with the "ether." Still, they did not rid themselves of Maxwell's wave equations or the recent ones of Erwin Schroedinger (1928) or Louis Victor Prince de Broglie (1964). One can readily conceptualize waves traveling in a medium, such as sound waves traveling in air, but what is the meaning of light or other electromagnetic waves "traveling" in a vacuum? Currently physicists are beginning to fill that vacuum with dense concentrations of energy, potentials for doing work when interfaced with matter. It is this potential which, I propose, is neutral to the mental/material duality.

Energy and Entropy (Informational Structure) as the Neutral Potential

In science such potentials are defined in terms of the actual or possible work which is necessary for realization to occur and are labeled Energy. Thus multiple realizations imply a neutral monism in which the neutral essence, the potential for realization, is energy. In addition, as stated in the second law of thermodynamics, energy is entropic, i.e., it has structure.

Heisenberg (1969) developed a matrix approach to understanding the organization of energy potentials. Currently this approach is used in s-matrix and bootstrap theories of quantum and nuclear physics by Henry Stapp (1965) and Geoffry Chew (1966). These investigators (among others, e.g., Dirac, 1951) have pointed out that measures of energy potential are related to measure of location in spacetime by way of a Fourier transform. The Fourier theorem states that any pattern of organization can be analyzed into and represented by a series of regular wave forms of different amplitudes and frequencies. These regular wave forms can in turn be superimposed, convolved with one another and, by way of the inverse Fourier procedure, can be retransformed to obtain correlations in the original space-time configuration. Thus the Fourier transform of a set of patterns displays a spectral organization which is, of course, different from that which is displayed after the inverse Fourier transform has again converted the pattern into the space-time order.

In terms of the proposition put forward by Stapp and Chew, this means that the organization of energy potentials is considerably different from the space-time organization of our ordinary perceptions which can be expressed in Euclidean, Cartesian, and Newtonian terms. David Bohm (1971, 1973, 1976) has identified these non-classical organizations of energy potentials as "implicate," i.e., enfolded, and he has used the hologram as an example of such enfolded orders. As noted earlier, Dennis Gabor (1946, 1948), the inventor of the hologram, based his discovery on the fact that one can store interference patterns of wave forms produced by the reflection of light from an object on a photographic film and reconstruct from such a film the image of the object. The description of the enfolded organization of the stored potential for reconstruction is related to the unfolded space-time description of the object by a Fourier transform.

The dual properties of an enfolded fine-grain (technically, the receptive field organization) and a gross-grain space-time organization apply to other sense modalities as well, although the experimental evidence is not as complete. Georg von Bekesy (1967) performed critical studies in the auditory and somasthetic modalities, Walter Freeman (1960) likewise in the olfactory modality, and Pribram, Sharafat, and Beekman (1984) have shown that cells in the sensory motor cortex are tuned to specific frequencies of movement. At the same time, the spatial organization of the receptor surface in all these sensory systems is topographically represented in the gross-grain arrangement of the cortical cells which receive the sensory input.

Thus, there is good evidence that another class of orders lies behind the ordinary classical level of organization, which we perceive and which can be described in terms of Euclidean and Newtonian views and mapped in Cartesian space-time coordinates. This other class of orders is constituted of fine-grain organizations which describe potentials which had been poorly understood because of the radical changes which occur in the transformational process of realization. When a potential is realized, information becomes unfolded into its ordinary space-time appearance; in the other direction, the transformation enfolds and distributes information as is done in the holographic process. Because work is involved in transforming, descriptions in terms of energy are suitable, and as the structure of information is what is transformed, descriptions in terms of entropy (and negentropy) are also suitable. Thus complete understanding involves at least a duality; on the one hand, there are enfolded orders manifested as energy potentials; on the other, there are unfolded orders manifested in negentropic space-time.

Is Information Material or Mental?

When forces are postulated to exist between material bodies, the forces are often conceptualized as "material" even though they themselves are not constituted of matter. When matter and energy are related by the equation $E = mc^2$, energy is commonly assumed to be "material." This is a misreading of the equal sign. The equal sign does not indicate sameness; for instance, $2+2 = 4$ and $2x2 = 4$. Were the equal sign to indicate sameness, "x" and "+" would be the same, which they are not. $2+2 = 2x2$ because they are equal though different. When mathematicians want to describe identity they use "≡". This is a point I have had to make repeatedly when I present evidence that men and women are biologically and psychologically different — I am *not* arguing, therefore, that they are unequal.

Energy is not material, only transformable into matter. It is measured by the amount of work that can be accomplished by using it, and the efficiency of its use depends on its organization as measured by its entropy. The invention of devices subsequent to the vacuum tube have shown that minute amounts of properly configured energy can control large expenditures and that these minute organizations provide "information;" that is, they inform and organize energy. Measures of information and entropy were thus seen as related (see, e.g., Brillouin, 1962, and von Weizsacker, 1974). Computers were constructed to process information, and programs were written to organize the operations of computers. Is the information contained in a program "material" or "mental"? If it is either, then what of the information in a book or the entropy that describes the behavior of a heat engine or of a warm-blooded mammal? Clearly we have come to the limit of usefulness of a distinction between the material and the mental, and we must come up with a biological based "naturalist" philosophy (see Churchland, 1986) that repairs the current view. The holonomic brain theory (Pribram, 1988) is formulated with this end in mind.

Conclusion

A New Duality: The World of Appearances Versus the World of Potentiality

The point was made earlier in this paper that the dualism of mental versus material holds only for the ordinary world of appearances—the world described in Euclidean geometry and Newtonian mechanics. An explanation of dualism was given in terms of procedural differences in approaching the hierarchy of systems that can be discerned in this world of appearances. This explanation was developed into a theory, a constructional realism, but it was also stated that certain questions raised by a more classical dualistic position were left unanswered by the explanations given in terms of a constructional realism.

What are these questions? Recall that Popper and Eccles propose entirely different—and, in a fundamental sense, opposite—views of how mind and brain interact. Popper has mind an emergent from brain functioning; Eccles has mind operation on the intrinsic "liaison" formations of brain cortex. Still, these authors managed to publish a book together. Each must have felt some affinity for the other's views. What is it they may have sensed to have in common? What deep feeling did they fail to articulate adequately in their book?

I believe that the analysis provided earlier in this paper may help "unpack" this issue. Note that when one looks downward in the hierarchy of systems that compose the ordinary world of appearances, essentially reductive analyses are engaged. To take account of new properties that arise when components become organized into higher-order, more complex structures, "emergence" is proposed. The proposal is essentially descriptive of what is observed. The upward look in the hierarchy, as in the phenomenal and existential approaches, simply takes these "emergents" as the fundamental achievements of observations. Constructional realism is compatible with such views of emergence, and, as noted above, I believe Popper is attempting to achieve a similar end by his construction of World 3.

Eccles by contrast is holding out for a very different sort of formulation. He insists that mind transcends brain function in that mind operates upon brain, not because mind emerges from the functioning of the brain. Articulated in this fashion, Eccles' formulation makes no scientific sense.

Consider now the brain as a spectral analyzer and the general characteristics of the transforms which occur. These characteristics have been appreciated fully only recently. The recording of the spectral patterns by holography has provided a visible artifact whose properties can be readily conceptualized.

Essentially space and time become enfolded in the holographic domain. This accounts for translational invariance, the fact that transformation into the ordinary domain can be accomplished from any part of the encoded record. In the holographic record information becomes distributed, spread over the entire surface of a photographic film, or brain module, much as the waves produced by throwing a pebble into a pond spread to its edges. Several such waves initiated by several pebbles will interact or "interfere," and the record of these interference patterns constitutes the hologram. If a moving picture were made of the origin and development of the interference patterns, the movie could be reversed and the image of the pebbles striking the pond could be recovered. Image reconstruction by holography accomplishes much the same effect by an operation that performs an inverse transform on the record. Thus image (and object) and holographic record are transforms of each other, and the transformations involved are readily reversible.

Consider further the fact that in the holographic domain space and time are enfolded. Only the density of occurrences is manifest. These densities can be recorded as wave number or in scattering matrices representing n-dimensional (Hilbert) domains such as have been used in quantum physics (Pribram 1988). Holography has become a window through which we are able to conceptualize a universe totally different from that which characterizes the world of appearances. David Bohm points out that most of our conceptions of the physical world depend on what we can observe through lenses (Bohm, 1971, 1973). Lenses focus, objectify, and draw boundaries between parts. Lenses particularize. Holography by contrast is distributive and holistic, and does not draw boundaries between parts. Bohm refers to our lens-given ordinary perceptions and conceptions as explicate and those that are holographic as implicate. Thus there are at least two discernible orders in the universe—an explicate and an implicate. The explicate order gives an account in terms of particles, objects, and images. The implicate order, still poorly cognized, begins with densities of the fluctuating properties of wave forms.

Bohm and other physicists have become excited by the similarity of conceptualizations of the implicate order and those described by mystics who have experienced a variety of religious and other "paranormal" phenomena (Bohm, 1976; Capra, 1975). The lack of spatial and temporal boundaries, the holographic characteristic that the whole is represented in every part, and the transformational character of shifting from explicate to implicate order are all beyond ordinary human experiencing which apparently is limited to the everyday, explicate, Euclidean-Newtonian universe to which we have become accustomed.

It is probably no accident that holograms are a mathematical invention (by Dennis Gabor) which use a form of mathematics—the integral calculus — invented by Gottfried Wilhelm Leibniz, who also came to a vision of the implicate order. Leibniz's monadology (1951) is holographic; his monads are distributed, windowless forms, each of which is representative of the whole. Substitute the term lens-less for windowless, and the descriptions of a monad and a hologram are identical.

The fact that the brain is, among other things, a spectral analyzer, that it encodes information in a distributed fashion akin to that which characterizes a hologram, also means that the structural boundaries that characterize the ordinary limits of "brain" and "body" can, on occasion, appear to be transcended. Take as an example our current-day world in a large city. The space surrounding us is filled with spectral forms generated by radio and television stations. We are insensitive to these spectral forms unless we use a receiver tunable to one or another of the spectral forms. Only then do we "explicate" into the everyday domain the spectral forms broadcast and enfolded in the space about us. The "mystery" of mind is resolved not by holding to the neo-Cartesian view that Eccles has taken, which is inappropriate to Popper's formulation, nor that of either the materialist or the mentalist stance. Rather, we must recognize the transformational and potential nature of the implicate domain and the fact that our sense organs "make sense" by tuning in (and out) selective portions of this domain.

Summary

Structural realism is thus primarily an ontological neutral monism that deals with a number of epistemological dualities, two of which are especially significant for unpacking the issues involved in a mind/brain dualism:

1) a procedural duality that faces upward and downward in the hierarchy of systems discerned in the ordinary world of appearances, and
2) a transformational duality that opposes the ordinary world of appearances to that viewed through the window of the spectral transform domain characterized by descriptions akin to those of the experiences of mystics, which provide the basis for some important insights into various religious traditions.

Other dualities may well be discovered to underlie as yet unarticulated premises of dualism. What appears clear at the moment is that a dualism based on the distinction between mental and material is too limited to deal with the very issues that it poses. Other dualities can articulate solutions to the problems raised by these issues and deal not only with their substance but also with their spirit. Furthermore, these dualities can be specified by scientifically sound procedures and mathematically precise formulations which are encompassed by neutral monism from which a plurality of duals are constructed. Finally, their constructions are known to stem directly from discoveries in the physical, information, and behavioral sciences. Thus the often-made argument that the results of scientific research have no bearing on philosophically framed issues has been shown to be wrong. In fact, what has been shown is that only through the results of scientific research can philosophical issues, even at the ontological level, be refreshed.

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Coping with the Environment and the Complexity of Our Conceptual World

Richard V. Mattessich

What is Complexity?

Complexity is a function of the number of elements and the relations between them (cf. Mattessich, Chapter 2, 1978). Complexity is also a property of a system or of its environment or of the interface between the two. A system may be relatively simple but its environment may be complex, or vice versa; or both may be simple or both complex, depending on the number of elements and relations within the system as well as the relations of the interface.

My definition of complexity may seem to be simple, perhaps even simplistic, but when it comes to measuring this property, the complexity of "complexity" soon becomes obvious. As long as the number of internal and external systems relations is relatively small, it hardly is a problem to count them and thus directly express the complexity of a system by a natural number. But in most cases an immense number of relations would have to be counted, and resorting to an indirect measurement becomes inevitable. Professor Pribram correctly points out that "the measure of information (as 'entropy' à la Shannon) has also proved to be a useful measure of complexity." Indeed, Sagan (1977, pp. 21–29) and others have tried to compare and grade systems of different complexity by expressing their information potential in binary digits (e.g., a bacterium: circa one million bits; the Viking Lander: a few million bits; an alga: over 100 million bits; a mammal: over 10 billion bits). But is that the best we can do in measuring complexity, or should we search for alternative measures? After all, it is questionable whether all complexities can be reduced to informational complexity. Or as Elias (1983, p. 500) says: "the fact that entropy has been proved in a meaningful sense to be the unique correct information measure for the purpose of communications does not prove that it is either the unique or a correct measure to use in some other field in which no issue of encoding or other changes in representation arises."[1]

Above all, complexity is an evolutionary phenomenon and must first be understood in terms of historical change (cf. Lorenz 1978 and Platt 1981) and is not, per se, necessarily a negative feature—without complexity neither would man have emerged nor would the stability of our biosphere be possible (cf. Margulis and Sagan 1986, p. 263). Complexity was born during the first second of our universe, and it has grown ever since. The more evolution progresses (be it physical, biological, social, scientific, or technological evolution), the more complex will be some of the systems that emerge. Indeed, the complexity of those systems is the major criterion and hallmark of most evolutions. But obviously less complex systems may and usually do continue to coexist with more complex ones. Sometimes those less complex systems may even be more stable in the long-run and may linger on after some complex ones have disappeared.

Of course, there is no denying that one of the most important systems or interface relations is of an informational nature. And it often is the complexity of those informational relations (number of pathways, number of alternative signals, etc.) which are crucial for the degree of complexity of the system or its interface.

But since it seems doubtful that all systems relations are informational or can be reduced to informational relations, I have some reservations of accepting Pribram's suggestion to use the term "in-formation" to designate the invariability between logical constructs and empirical phenomena.[2] My own suggestion is to use the terms structure or structural invariance to indicate this invariability—provided one is aware that the logical structure described by a model usually corresponds only to a subset of the factual structure inherent in the corresponding empirical phenomenon. Usually it is the logical structure that forms the common ground, hence it is the limited form expressed by the model and not the larger form in, or possessed by, the empirical phenomenon.

One of the major questions in my mind concerns the distinction between inevitable or uncontrollable complexities, on the one side, and avoidable or controllable complexities, on the other. Is such a distinction meaningful? If it is, then our *first main objective should be to find out how to minimize or avoid the avoidable complexities.* Let me try an approach which identifies the complexities of nature (e.g., the structures of atoms and their nuclei) as uncontrollable and the social and technological complexities (e.g., complexities of bureaucratism and other institutions such as automated manufacturing processes or electronic credit card systems) as potentially controllable.

Our *second main objective would then be to determine how best to adapt to uncontrollable complexities or those difficult to control.*

Our Mind's Ability to Cope With Complexity

If I speak of "coping with complexity," I refer to both the reduction of controllable complexities as well as the adaption to uncontrollable ones. The mind's major tools for coping with a complex world are abstraction and generalization.[3]

Nobody doubts that this world was already pretty complex when man (*homo habilis*) emerged some two million years ago. He has always been forced to cope with this complex world by representing it conceptually as far as the functions of his brain, his language, and his knowledge permitted. But he was ignorant of a good deal of this complexity (i.e., in spite of the innumerable variables and connections in his environment, there may have been fewer interconnections in his brain and incomparably fewer interface connections). Nowadays we have some knowledge about that long process of the brain's evolution and its adaption to an environment that must have seemed growing in complexity merely because his knowledge became more and more complex. But the ability to recognize greater complexity does not necessarily mean that this complexity did not previously exist. My point is that, particularly nowadays, we ought to distinguish as clearly as possible those two fundamentally different kinds of complexities referred to above (i.e., uncontrollable and potentially controllable). On one side the "complexities of nature," most of which were around for some time, but which were previously not (or not as clearly) perceived, and on the other side the social and technological complexities, which were created by man and his mind. Both complexities are equally perplexing. But the question is whether one of them is more critical than the other, or whether we here should be equally concerned with both categories.

Perhaps we need to be less concerned about what I called "the complexities of nature" (which will be revealed more and more as pure science progresses). Their disclosure is a matter of time and is probably as inevitable as was the discovery of nuclear fission. But for us the greater problems and genuine dilemmas are caused by our decisions of how to apply those novel scientific insights and how fast to introduce into society new and perhaps "unnecessary" complexities (e.g., the harnessing of nuclear fusion and fission to solve our energy problem).

Mastering the Complexities of Nature

Nevertheless, the increasing realization of the complexity of nature is bewildering enough, and we shall point out some of the ways with which scientists try to cope with them:

The most obvious step is *increasing specialization.* The present body of scientific knowledge is so vast that specialization in a relatively limited area is inevitable, and it is the only hope of understanding certain scientific relations and discovering new ones. This may be regrettable and certainly harbors many dangers, but to some extent those dangers can be countervailed by the next step.

Further *generalization and cross-fertilization of disciplines.* Precisely speaking these are several steps but they are closely enough related for putting them into a common item. Increasing generalization is clearly visible in modern mathematics where more and more abstraction leads to higher and higher levels of generalization (e.g., group theory, category theory, and modern topology). While increasing cross-fertilization between disciplines has led to such new border disciplines as biochemistry, nuclear chemistry, socio-economics, and myriads of even more specialized sub-areas.

Related to the previous item is the need for *improved communication,* particularly between scientists of different areas, and the *need for techniques and new methodologies,* as well as a more holistic and philosophic overall understanding of the scientific process. An excellent illustration of this, and the fact that technological complexity can be highly beneficial, is the recently developed automated DNA sequencer. It enables us to analyze an entire human genome (i.e., all of a man's chromosomes) relatively quickly and cheaply—in contrast to previous techniques which would require for the same task no less than 30 years of man hours and would cost about three billion dollars.

There is also a need for recognition of the *law of diminishing marginal return as being valid for scientific research* (no less than for economics). It may well be that in many scientific areas considerable resources are poured into areas that become more and more sophisticated and complex without any hope of an adequate return—while areas less well explored might result in much higher yield per research-dollar. The difficulty, of course, lies in the measurement of research benefits as well as in the political game and competition for those research funds among scientists of the same discipline or even among various disciplines. It is precisely this political process which is responsible for a good deal of social and perhaps avoidable complexity.

Mastering the Social and Technological Complexities

Like Goethe's "Sorcerer's Apprentice," man has created a social and technological complexity that threatens to drown him. In Goethe's poem there is a master possessing the knowledge of stopping the floods, but man has to muster his own wisdom to disentangle himself from the complexities he has created. Which kinds of means are available to him?

First, E.F. Schuhmacher's book *Small is Beautiful* contains one set of basic suggestions that may help us to eliminate unnecessary complexities. This slogan and its fundamental idea of applying simple technologies is not only applicable to underdeveloped countries but also to our private lives and, to some extent, even to the industrial complex of highly developed nations. The day may come when ecological-environmental circumstances will force us to lead materially poorer but hopefully spiritually richer lives. But knowing the nature of man, and particularly of politicians and captains of industry, I am not optimistic that this reversal of life style will be initiated by the politicians or industrialists of the Western hemisphere, who, in spite of some lip service, still cling to a policy of relentless industrial growth.

Of course, such growth often begins with population growth, and for Austria with its unique and almost static population growth pattern the chances are much greater to materialize Schuhmacher's slogan than for most other countries. Indeed, "small is beautiful" is almost a description of Austria itself.

James Burke in his renowned book and television series *Connections* showed that our technologies and economies are so intricately connected with ever-increasing complexity that, even if we wanted, we could not abandon technological progress. This may well be our inescapable fate, but I still think that a second step should be pursued, namely the development of simple back-up technologies. The latter could prevent utter social chaos in the likely case of a complete breakdown of our complex technologies. The installation of such back-ups should of course begin in every individual household. Here we may learn much from the Japanese. Although they practice the complex Western ways in the business world, many of them revert at home to a simpler and healthier Japanese lifestyle. I personally consider this item one of the most important on our agenda. Although the family unit may have to take the lead in such technological back-ups, government and industry can, on one side, do much to promote them and, on the other, learn from household practices (e.g., the avoidance of large deficits—which strikes a note I should like to take up in the next item).

If I speak of complex technologies, I do not limit myself to techniques in the engineering sense but have commercial, medical, and other practices in mind as well. Let us dwell for a moment on modern financial practices. As in many other cases of complexities, America has here again taken the lead. The progressively growing public and private debts and the innumerable financial devices draining not only our present savings but also our future earnings have reached a level of complexity that more that any other can spark a financial breakdown. The recently announced refusal of Brazil, Argentina, and other South American countries to make interest payments on their enormous national debts shook the international financial community and made banking stocks tumble. But all this was merely the advance tremor of a much stronger earthquake to come.

I mention this example not for the sake of doom saying, but as a vivid illustration of complexities that could have been avoided by wiser and less greedy industrial, financial, and governmental policies. Furthermore, this example illustrates the connection to the conceptual world, the pivot of my topic. All those financial gimmicks, from the innumerable Registered Retirement Saving Plans to the new computerized future stock tradings and illegal insider tradings, are inventions and not discoveries. That is to say, they are conceptual complexities that were artificially created and, in contrast to physical or biological discoveries, are not a mental reflection of the complexities of raw nature (i.e., nature without the human brain).

Hence my third recommendation is *to minimize the artificial and avoidable complexities by farsighted industrial, techonogical, and government policies.* But this will not be possible by scientific means alone; it also requires a strong ethical commitment by everyone, particularly by the leading political and industrial personalities. And it is my belief that on this point our society grossly failed. Unless we succeed in adopting values different from those currently pursued by many leading statesmen, bankers, and industrialists, there is little hope that our problems, that is to say, our most painful complexities and perplexities, will be eliminated.[5]

We obviously have to assign higher priorities: (1) to political and economic cooperation between East and West as well as between industrialized and underdeveloped nations; (2) to the prevention of further pollution of "mother earth"; (3) to the initiation of a more enlightened resource management; (4) to the pursuit of sane credit structures and fiscal policies; above all, (5) we have to instill greater respect for honesty, culture, and creativity into the next generation and have to struggle for a more disciplined and just society.

Will such radical changes be possible in our lifetime? Will they ever be possible? No one knows, but by recognizing that science and morality are equal partners in our endeavor to cope with the complexities of our age, we may have made an important step towards resolving the greatest problem mankind has ever faced.

Notes

1. On the other hand the entropy function has been proved useful in other areas such as thermodynamic and statistical mechanics as well as in "traffic systems," etc. (see Montroll, 1983, pp. 503-511). Furthermore, close ties exist between systems theory and information science (cf. Mattessich, 1983 a, b).

2. As much as I agree with the linguistic appropriateness of identifying the "form within" with "in-formation," the latter expression sounds too similar to "information," which has traditionally a quite different meaning.

3. Although these two notions are related, they should not be identified. I understand under abstraction the conceptual representation of a concrete object or event which may be specific, while generalization refers to the conceptual summarization of a whole family of concrete objects or events.

4. Cf. Tom Dworetzki, "Opening new Frontiers in Molecular Biology" in *Discovery* (March 1987), pp. 14-15.

5. The fact that recently (May 25, 1987) *Time* magazine devoted, under the title "What ever happened to Ethics?" an entire issue to the immorality in American politics and business may illustrate the acuteness if not importance of this issue.

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Complexity and Nondiscrimination

Masahiro Mori

The Wisdom of Nondiscrimination

Each day our minds become progressively burdened with the ever growing complexity of society, organizations, and information around us.

In Japan, however, we have a wisdom dating from old with which to overcome such problems. This is known as "nondiscrimination."

Why Are Things Complicated?

Why are things so complicated? One reason may be the proliferation of laws and regulations to meet each new problem, or because organizations must expand to satisfy constantly growing human desires, or because we have created various types of work to stave off unemployment even though such jobs are not necessarily vital to society. All sorts of rationales come forth, yet most of them prove to be extraneous.

It is possible to find an internal or subjective answer to the question: overdiscrimination on the part of the individual. That is, no matter how complex the outside world may become, it is actually very simple if one does not attempt to make discriminations. Grounded in this sort of subjective view, it could be said that "complexity is the result of excessive differentiation."

Zazen—Training in Total Nondiscrimination

While the significance of *zazen* in East Asia may be discussed from many different angles, one way of defining it is as "a form of training in total nondiscrimination." The following instructions are found in the work of the Japanese Zen Master, Dogen, entitled *Fukan Zazengi* (A Universal Guide on the Right Way to *Zazen):*

"For *zazen,* forget all relationships, set body and mind at rest, do not make any judgement of good and evil, and do not discriminate between right and wrong. Stop the movement and working of the mind and empty the mind of all thoughts: do not strive to become a Buddha."

It also states:

"You should not become a commentator who looks only at words and phrases. You should stand back and turn your mind inward. Then your body and mind will spontaneously be free and your true-self will appear."

Usually, our mind is in constant motion, like high waves on the sea. It has also been compared to the movements of a restless monkey. The discipline of Zen entails, first of all, calming these high waves, then the small waves, and finally the ripples.

Training oneself in this way will keep the mind from falling victim to the complications of the external world.

Nonattachment

If the mind can attain this state, one will not become attached to anything or any situation whatsoever. If one is disturbed by the increasing complexities of the surrounding world, it is because one has become a prisoner of the external world.

It should be emphasized that nonattachment does not mean ridiculing or ignoring matters or events. One must realize that material things and phenomena are like phantoms, dreams, or echoes, and yet one must respect them even more than those people who are attached to them.

Doing this frees the mind. One's mind will no longer be burdened by excessive information. One will be able to either receive or shut out information skillfully.

Correct Discrimination Through Nondiscrimination

Discrimination and nondiscrimination are, in fact, mutually complementary.

We think, for example, of driving a car in terms of the following dimension:
moving—accelerator
stopping—brake
This, of course, is not incorrect. Yet, driving with the accelerator pedal only would lead to serious consequences. The brake pedal is also necessary. Thus, the following sort of relationship emerges:

moving —
- causing the car to move forward (accelerator)
- causing the car to stop (brake)

In other words, driving a car smoothly requires more than an ability to cause it to move forward. One also needs the capacity to stop it.
Similarly, the functions of discrimination can be schematically represented as follows:

discrimination —
- discrimination
- nondiscrimination

It is precisely because accelerator-like discrimination and brake-like nondiscrimination help each other that it is possible to discriminate things appropriately and correctly.

The Abyss of Dichotomy

In Zen, an attitude that affirms only one side of a dual proposition and does not recognize the utility of its oppposite (as in the abovementioned notion regarding the accelerator and the brake) is known as an abyss. If one attempts to discriminate things without having had any practice in nondiscrimination, one's unsettled mind will reflect things askew, seriously distorting one's perception. When one's mind is calm like a mirror, it can reflect the external world as it is. Nondiscrimination is a necessary condition for correct perception.

Nondiscrimination Is the Shutting Out of Information

It is impossible to spend even a single day without somehow getting involved in the affairs of others. Yet, it is necessary for one to possess a "solitary" or "private" world of one's own, insulated from the external environment—in other words, a complete shut-out of information. This is the only way to restore our inherent human qualities.

What we need to get through this increasingly complex society is a sense of detachment—attaching importance to information (discrimination), but not becoming overly attached to it (nondiscrimination).

Brain Research and Complexity

Giselher Guttmann

In my opinion, it is not particularly problematic to derive suitable measures for complexity which are also psychologically relevant. Rather, the essential question must be: Which is the element worth determining? And very often, in psychology, we come across solutions which actually only then give rise again to the problem. And I am convinced that, as Professor Pribam outlined in a wonderfully broad approach, modern quantum physics—for instance if we take the Einstein-Podolsky-Rosen paradox to its logical conclusion—can lead us much deeper into psychology or perhaps even parapsychology than conventional psychological approaches can. A simple, fundamental rule applies to practical conversion: There is undoubtedly an average extent of complexity for which the human brain is geared and which enables us to overcome a specific problematic situation. Too little, and we sink into paralysis; too much, maybe due to the percolation effect, like a small drop of water causing the barrel to overflow, and we resort to the "play dead" reaction to a situation we are unable to cope with.

I would like to present some approaches from the work of the Brain Research Project of the University of Vienna which show that we are indeed capable of making progress with individuals and of enabling them to control and raise current performance ability, at least for a limited period of time.

To start with, consider the characteristic values for the brain's electrical activity. I wish, however, to add by way of a warning that we are not talking about conventional electroencephalograms (EEG) but about recording direct voltage components. In other words, the human brain, like a battery, is electrically negatively charged to widely varying degrees, and this constituent potential is subject to slow fluctuations. If we record these potentials in a simple survey, from front to back, left and right, we recognize a number of quite strange variations. It is not our entire brain which activates and deactivates accordingly; rather, more like a stone falling into water and triggering a series of waves with more or less unpredictable sequences, the left hemisphere activates while, concurrently, the right hemisphere rests. This shows us how different areas of performance switch on and off.

Next we studied the psychological significance of these small oscillations with a simple man-computer link. Indeed, with the help of modern electronics, it is easy enough to demand a performance precisely at the moment in which, for example, the left rear brain hemisphere is activated and the remaining sections of the brain rest, or to get someone to learn something precisely at the moment the right hemisphere is activated and the left hemisphere rests, etc. This was tested using a Brain Trigger Design, a setup in which the subject is presented tasks in various areas of brain performance. So we presented a task, such as a dexterity test, on the screen the very moment the computer signalled a sufficiently strong negativity or positiveness. The results of these links were astounding. Human performance capability varies by about 25 percent if negativity increases by a tiny fraction of 20—30 millionths of a volt. In other words, the fluctuations in performance of which we are all only too well aware but which we are unable to control or to influence are the expression of these spontaneous oscillations. It is a fact, therefore, that we are never able to maintain the same level of efficiency over a long period of time and that our performance capability is subject to slight, lasting modulations. It is the state of negativity which increases performance capability an average of 25 percent under experimental conditions. This applies in particular to learning, retaining, concentrating, problem solving, and thinking, as well as to other areas.

Obviously it is tempting to bring about and trigger this state of readiness to learn, this state of increased ability to perform, voluntarily. Is it possible, then, to increase, to switch on this cortical negativity intentionally? It is—provided that biofeedback is given to the test subject in the initial learning phase. It would not be inconsistent from an evolutionary point of view if humans had developed a sensory organ for such cortical negativity. Humans have none, however, and therefore are not aware of this possibility initially.

Yet, with the help of modern electronics, we easily generate such a sensory organ by providing the test subject with feedback (in our case, a small green cross) on a screen where the current negativity is displayed with a target line that is to be reached. In our experiment, we tell the test subject to cause the cross to move as high up as possible, and, as in the video games popular today, the person begins to move the cross. This is not done, however, with a joystick. The test subject learns to control the cross, through his cortical negativity, by cranking up the surface negativity of his brain. I am not quite sure how the subject is able to achieve this, nor is the subject himself, but this interplay, this biofeedback, enables anyone to assume control over cortical negativity within the relatively short period of time of 15 to 20 minutes. We can witness how the person is capable of raising the negativity, or of bringing about a state of increased positiveness, as required. Once control has been effected, the person is able to use this—we could say in general terms—activation and deactivation, tensioning and relaxing without biofeedback.

This now leads to the question of practical application. It is probably no coincidence that we have borrowed the word tension from physics to refer to both the mental state and the physical state. It has indeed been shown that very routine techniques such as certain breathing strategies and above all the use of certain rituals of tensing and relaxing the skeletal muscles have a lasting effect on cortical negativity. In another experiment, we recorded the electrical brain activity of a well-trained person who was beginning to relax. At a certain point, in the two frontal leads, an enormous shift built up, which at the calibration peak of 300 microvolts was well above anything I spoke about previously, where 20 or 30 microvolts induced changes in performances of around 25 percent. In this case, the test person brought about changes of several hundred microvolts and, according to our findings, was capable of maintaining this state of modified function for approximately five minutes. With such evidence, you can consider daily performance situations. We have gathered most of our experience in the educational sector, where these considerations were integrated into the curricula as the "Viennese teaching model" or "learning under self-control," starting with primary schools and continuing on to secondary schools and colleges. Phases of muscularly induced activation followed by relaxation phases, in part with the backup of music, are initiated, which then progress into short stress phases, which must not, of course, exceed the aforementioned five-minute period. Experience in other performance situations has also been collected, especially in the model situation of sports with its punctual performance requirements and also in the model case of the public speaker or performance artist. We are attempting to relate these experiences to professional day-to-day routines, in which people are subjected to specific, overly stressful situations which either are difficult to foresee or recur regularly.

Although I may not have contributed new material on the terminology of complexity, I hope I have indicated some interesting, if not fruitful, applications of brain research to a better understanding of the individual's means of coping with complexity.

Fourth Session

Complexity Created and Mastered by the Social Processes

Non-Material Production in an Information-Oriented Society

Robert H. Reichardt

Introduction

In the last decade, the economies of advanced countries were confronted with problems of affluence in durable goods, in energy, and in food. The way out of economic stagnation was seen to be making durable goods more sophisticated, introducing more innovations into the market, and turning to an expansion of the information sector. At the same time, however, there was also a problem of affluence in information. Naisbitt (1984, p. 17) found the convincing formula: "We are drowning in information but starved for knowledge."

In this paper, I would like to look at the expansion of the information sector from the points of view of culture and of society and to discuss the conditions under which this expansion hopefully will lead to an improvement of human conditions as well as to economic prosperity.

Colin Clark (1940) introduced comparing the proportions of the working population in different broad occupational sectors as a way of describing society and economic development. This has proven, since then, to be a valid tool, although today we not only are distinguishing the three sectors of Clark—the agricultural, the industrial, and the service sectors—but are adding a fourth one, namely the information sector. Despite some problems of definition, the OECD (Organization for Economic Cooperation and Development) studies of 1981 still give a clear picture of developments underway. The impressive result of these studies is that in all the industrialized countries considered, there has been a steady and almost linear increase since about 1950 in the percentage of those occupied in the information sector within the working population (p. 25). In most countries, the gains came from a shrinking agricultural sector and to a lesser degree from a slightly shrinking industrial sector (p. 29). Thus, the term "information-oriented society," as used in the title of this paper, seems to be justified.

Today, however, economists—especially American economists—are skeptical about the emphasis on the expansion of the information sector as a characteristic trait of economic progress. Cohen and Zysman from Berkeley insist that physical production in industry is still the main factor of wealth. They certainly are right in saying that the service sector and the information sector are both interwoven to a high degree with the development of the industrial sector. My point in the following sections will be that, although industry will remain the cornerstone of economic development, the expansion of information production will inevitably continue, although it will perhaps remain partly outside the commercial realm.

The Value of Information

A closer look at the term "information" is necessary. It makes sense to use the mathematically founded measurement of information flow "bits" for describing the capacity of a communciation network or system. As soon as humans are involved as senders or receivers, however, we have to consider the codes used, which makes the picture enormously complicated. Each message has a multidimensional meaning.

Before we turn to the exchange value of information on a market, let us first discuss the intrinsic value of information. If a given message creates inner satisfaction for the receiver by itself, I speak of the **contemplative** value of that message. This is easily understood if we think of works of art. Esthetic pleasure should not be attributed solely to emotional states. Also cognitive insights—we may think of a novel—are able to stir feelings indirectly. In most cases, it will be hard to distinguish how much contemplative value goes with a given message for a given person. Even if another use of the message may be in the foreground, still, a contemplative value may go with it; the elegant formulation of a mathematical derivation may have its esthetic merits, the ability to handle a complicated machine may give the feeling of power or of prestige, etc.

We can speak of the **instrumental** value of a message if its utility comes into existence only when the message's content is applied to carrying out a certain task. I prefer to speak of an **internal instrumen-**

tal value if the message shows us how to influence our inner states in order to achieve a desired psychological goal. To modern man, this may seem to be a rather peripheral aspect, although the favorable market situation for pyschiatrists is certainly a counter-example. Nevertheless, when we look at the history of human culture, we can observe that this very sort of information usage seems to have been quite prevalent. For instance, consider the importance of prayer and religious teaching in Western culture or the very elaborate methodology of meditation found in Asian cultures.

Those information processes which are handled by modern technology are mostly, of course, of an **external instrumental** value. Further distinctions of this type of information use may best be made by considering how much human action is involved in such handling. In order to illustrate processes without human influence, let us mention the control of fuel injection in automobile engines by microprocessors, something with which humans do not interfere. As an example of the interplay between man and electronics, we may think of the "action plans" for fire brigades, supplied and modified for specific situations by computer-telecommunications systems; furthermore, there is monitoring which informs the human factor about the state of the environment and which leaves any decision about action to the human factor. At the extreme end of the scale, in the case of simulation procedures, possible consequences of different modes of action are explored and judged by the human decision maker.

There is a third type of instrumentality of information which improves the creation, transmission, and handling of information itself. We may call it **informative instrumentality.** It ranges from old-fashioned catalogues and bibliographies to data banks, retrieval systems, communication software, and information about computer architecture and the methodology of software production. Besides the contemplative value which elegant architecture or software construction may have, the value for us as humans is derived even more indirectly, namely through the improvement of the information handling itself and then through the utility of the purpose for which the information is used.

In order to assign value to information of an **instrumental** character, we have to resort to the main goal it serves. In this way, information value is grasped indirectly and by something outside the information itself. This casts doubts on the correctness of the term "information society," as what is improved is the efficiency of the functioning and use of physical objects.

There are many proposals, especially scientific ones, for ways of measuring the creation of information. Pommerehne and Renggli (1986) have discussed this problem in economics. The procedure used most often is counting the number and length of journal articles, each weighted by the importance of the periodical in which it is published. This importance is determined by using the Social Science Citation Index (SSCI). The frequency of citation is used to establish a rank order of the periodicals. An interesting result is that by using the classical Cobb-Douglas production function in its log-linear form, rather plausible relations emerge between scientific output on the one hand and working hours and resource input on the other when the analysis is confined to the "top twenty" American universities. This approach certainly has its merits, but it also has the disadvantage of a certain circularity of the value attribution. This type of measurement works in a situation of "normal science" in the sense of Kuhn, but it has led to false conclusions when applied to situations of "revolutionary science" in the sense of Kuhn, as at their first appearance, of course, scientific outsiders will not be accepted in established periodicals.

The circularity problem has a much vaster scope for the attribution of value to information than just scientific achievement. The demand for goods and for their production devices is the result of foregoing experiences and is modeled by habits and by advertisement; it is not just the expression of anthropological data, defining optimal ways to satisfaction. To a large degree, however, the instrumental value of information can be derived only from the demand for physical goods or services.

Information in a Market Economy

Many authors have pointed to the enormous difficulty of integrating the concept of information into economic theory. Braun (1984, p. 179) comes to the conclusion: "... our understanding of basic economic relationships with regard to information is infinitely poorer than that for other subjects of economic activity such as the production and marketing of manufactured goods or of primary products."

He lists several aspects which make it difficult if not impossible to evaluate information. One of his most important points is that the value of a message cannot be attached to that message separate from its context. The utility of a durable good can be estimated before a purchase, but as Braun (p. 181) puts it: "Not only do we not know the utility of an item of information until after we have consumed it, we often only know it when, by some chance or creative act, we have brought the item of information into a constellation of other factors in which it may play a key role." Boulding (1986, p. 23) reminds us that it is often very difficult to establish ownership of items of information and "... if a thing cannot be property, it obviously cannot be a commodity."

Until today, the market has been *that* social invention which offers the greatest chance that productivity is stimulated and goods and services are going to those places where they are needed most. Of course, all real markets we know have many distortions and imperfections, but also very plausible and rational limitations, for instance through environmental legislation. For information, the market principle cannot be appplied in the same way as it can be applied to goods and services. This is demonstrated by the example of product innovations where the appropriation of the innovative information would prevent the spread of the improvement of a good by that innovation. As another example, we might imagine a stock market alongside a market for inside information about the firms concerned. The markets would mutually destroy themselves.

Behind these reflections stand two contradictory postulates, namely that information should flow freely and that inventors should have an incentive to work on inventions. Silberston (1967, p. 266) clearly formulated this dilemma when he wrote: "However, if information about inventions was made freely available as soon as they were invented, this might not give incentive for anyone to incur the risk involved in undertaking research in order to make inventions or to spend money on developing them." The solution to this problem as exhibited by the patent legislation of the industrialized countries is to protect the information for a limited, automatically expiring period of time.

Recent developments show that patent laws can give only imperfect solutions to this dilemma. Very large companies in highly innovative business branches will not need patent protection at all as the lead they get over their competitiors just by developing a new product will remain, whatever the competitors may do. On the other hand, more and more knowledge about production processes exists in the form of computer software. The vulnerability of this knowledge is demonstrated by the simple fact that software can be copied faster than verbal descriptions, and plans can be translated into an industrial procedure.

All this is not the main difficulty with information economics. The strain on economic growth stems from enviromental problems, from limitation of land use, and from—at least in the long run—exhaustible resources; in short, by the physical nature of the traded merchandise. Of course, we will always need physical goods—a world of ghosts is not the solution. The increase of information processes and the expansion of the information sector within the world's economies certainly can be considered as a solution to the problems mentioned. A considerable part of these ever-increasing information processes are devoted to the production of physical goods, thereby creating instrumental value of the sort I have described. This may also be so in a more indirect way in the case of software exchange through electronic channels or of electronic banking, exemplified by the SWIFT system in Brussels, to which about 250 banks are connected.

With the emergence of ISDN (Integrated Service Digital Network), in which all types of data—voices, pictures, texts, and machine languages—are transmitted by the same network in digital form, the various aspects of use can no longer be distinguished. (For the Austrian perspective on ISDN see Bonek, Bratengeyer, and Schupita, 1987.)

Still, in view of environmental problems, we have to keep in mind that a considerable part of information production is directed to mass media consumption. I will deal with this aspect in the following section of this paper.

Social and Cultural Assimilation of Information Affluence

As with food, the absorption capacity of humans for information is not infinite. After an estimation of Quastler and Wulff (1955, quoted in Klapp, 1978, p. 52), the human nervous system as a whole can handle 1,000 to 3,000 bits per second, including for conscious processes only about 18 bits per second. But next, we have to ask how we attribute **meaning** to messages. Meaningfulness applies to the contemplative as well as to the instrumental value of messages. Finding meaningful information in a 15-volume encyclopedia can be a hard task for a farmer, but it might not be any easier for him to find meaning in the "farmer's corner" program shown on television. Evidently Marschak's (1968) idea of searching costs will be relevant to the attribution of meaning to information too.

What is the relation of the notion of meaning to the considerations found in the second section ("The Value of Information"), in which several types of values of information were differentiated? Any type of value can imply meaning as long as it is embedding the given information into an overall structure of guidelines, of ideas, or simply of interests vital to its recipient.

What is **meaning**? It cannot be derived in a hedonistic way from contemplative pleasure or from need satisfaction through the instrumental use of information. As Luhmann (e.g. 1984, chapter 2) has convincingly put it, meaning can only be gained in a self-referential procedure. Meanings constitute a system in which—although with ever changing modifications—a specific meaning is defined from within. Meaning is a way for a system—in this case a person—to cope in a selective mode with the infinite complexity of the world, as an actor in the world or as a witness to the world. Meaning does not destroy those possibilities that are not realized; rather, it carries with it a symbolic memory of the choice situation in which all possibilities were still open. Meaning makes the seeming contingency of events endurable. Of course, the meaning a person attributes to a given possibility of action or experience is the result of the history of personal development and of interplay between cultural and social influences.

Let us have a closer look at the social dimension of meaning. Obviously it is easier for a person to attribute a specific meaning to an event if he or she knows that other or many other significant people will attribute the same meaning to that event. In so-called "primitive societies" and in small communities, the repertoire of events is small, similar events are often repeated, and the socialization experiences of the members are similar. For a given object, for example a tool or nutriment, there exists for both partners of an interaction a vast and almost identical chain of connotations, stemming from similar physiological and sensual experiences, which goes far beyond what language could express. In his movie, *The Bird of Paradise*, Jean Renoir has beautifully depicted the almost silent encounter of two young Cambodians who understand almost everything about and from each other without talking, due to their common cultural and educational background.

We can go even further and assume that the signals an amoeba is experiencing due to its chemical environment are all essential for its survival—and thus meaningful; otherwise there would not be any experience at all. For more complex systems, a greater amount of meaningless information is registered, but the scope of possible alternatives is much larger. A similar comparison is possible, of course, between primitive and complex societies. The fact that we have a great deal of meaningless information is the price we pay for having the chance to select from a great variety of possible personal and societal developments.

In his theory of "anomic suicide"—as part of his general theory of suicide—Durkheim (1897) differentiated two types of crises: one in which the means people have are insufficient for fulfilling the socially defined goals; and another—which he called "crises heureuses" (crises of prosperity)—in which there are more means available than can be used for the goals. He came to this concept by observing that suicide rates rise not only during economic depressions but also during periods of booms and over-prosperity.

On the other hand, in periods of war the number of suicides (and of crimes) declines. In wartime everybody knows exactly what to do in order to survive. The society, so to speak, cannot afford to circulate too much meaningless information. We can draw the conclusion that situations of war and disaster produce older forms of social life, forms which are related to more primitive social structures, than exist otherwise. Human development would not make sense if, in order to bring upon situations of predominantly meaningful information, we would invoke outside forces such as war or disaster.

In a more systematic way, I would like to discuss several socio-cultural strategies for coping with information affluence in the sense of instrumentally unusable messages. I would like to avoid any hypostasis of society. The term "strategy" is not used in the sense of an intention but rather as a state of society which emerges from a vast number of individual actions, a situation where the "new" way of behavior will be considered more and more normal and might thereby gain a certain normative power.

The retreat to small, specialized social units. From the foregoing considerations, it easily can be understood that meaningfulness of information can be increased if an individual concentrates his or her interactions on small and durable social units and leaves the huge flow of mass-media messages aside. Of course, the primary groups such as family and peer groups exist in any case and fulfill, to a certain extent, this purpose, but not fully, as they lack "official" character. As Klapp (1978, p. 61) puts it: "Specialization of work, for example, provides a partial shield against information overload by restricting what one must know to a narrow sphere of expertise or formal responsibility." We may add that the specific language use, the jargon of the group, reinforces this effect. We may conclude that the process of differentiation of more and more subsystems within the overall society is associated with the need for meaningful information. Luhmann (1986) has elaborated recently the emergence of a such a subsystem—with its self-referential definitions—for the field of art.

Such subsystems are not self-sufficient when it comes to demands for basic needs. In modern societies, therefore, people will not only interact with each other on a very general level but will also still find it necessary to expose themselves to media messages, where meaningfulness is not easily guaranteed. Klapp mentions the following as another mechanism for coping with this situation.

Ideologies. These allow people to bring structure and meaning into an otherwise chaotic flow of news. A serious economic crisis in a given Western country will be interpreted by a Jehovah's Witness more as one mark on the apocalyptical timetable, by an adherent to Marxism as another step towards the decay of late capitalism, and by a racist as the result of the relative inferiority of a race.

The mass media are simulating the behavior of small social units. One way of doing this is to give the audience the feeling that everybody has a chance to get into the focus of public attention. Actors and commentators, on one hand, behave like "ordinary people," like the "man on the street"; on the other hand, very "ordinary people" are invited for interviews, for quiz performances, etc., thus giving everybody the feeling that he or she has a chance of getting into the spotlight of the central common concern too. This mechanism works best in areas where only a few television channels can be received. This guarantees that almost everybody in the workplace will have seen the same program. Where cable and satellite TV are available, this effect is reduced to a certain extent.

Simplifying techniques among anonymous partners. The hackneyed phrases with which propagandists describe the stars of politics and movies are examples of this, and it also may well lead to a spread of thinking only in terms of stereotypes. It is my observation that such simplified thinking is also invading the universities, thus verifying what Nietzsche wrote about a century ago when he posed the rhetorical question: "Does not somebody who wants to agitate the crowd become a parodist of himself? Is he not forced to transform himself into a dazzling and grotesque image and to present his personality and his concerns in a crude and simplifying manner?" (Nietzsche, 1930, No. 56).

One could argue that meaning is simply emerging. This is true, but it shows that there are several possible meaning systems. Richer and more flexible meaning could be attributed to those contents to which we often observe the attribution of stereotypical meaning.

The electronic search system. Software can perform the task of selecting books, articles, messages, movies, broadcasts, etc., according to given characterizations. The scope of possibilities goes from simple data banks and retrieval systems which use indications given by the authors of the units, to very elaborate systems of content analysis and of making excerpts. I will discuss this below.

The depreciation of information. It is a quite general and "normal" cultural phenomenon that the value assigned to a category of objects declines the more affluent these objects are. It is also true for information, whether we think about news, the availability of books with popular and readable accounts from all fields of science, the marvelous visualization of mathematical structures on screens, or data banks. The remarkable cultural achievement of making this knowledge easily available and broadening the interest in it should be stressed, but we also have to look to the strain on the receiver who must digest all this and make the right selection.

One aspect is what I call the "schizophrenic attitude." In comparison with older cultural situations, we are all "schizophrenics" in that we are able to switch from a news broadcast on the victims of a famine catastrophe to a beauty contest or to an economic debate. It seems to be a cultural tendency to use information elements just as a means of surprise and of titillation for our nerves. A comparison of old-fashioned entertainment movies with modern ones will make this clear. The latest developments are bombardments with surprising and disconnected visual impressions of very short duration, as seen in recent video clips.

Communication between humans and information systems

The interaction already existing between computer systems and mass media certainly is expanding and may well lead to a complete merger. It seems useful to me, therefore, to speak in the following section of "information systems" as comprising both aspects as defined at the end of section 3, inasmuch as the possibilities of ISDN are discussed.

The man-computer dialogue has received much attention in the last few years and very often has been considered under the assumption that such interactions could get closer and closer to the way humans interact with each other. As was hoped, the acceptance and optimization of computer use should be brought on by such endeavors of AI research as artificial voice, voice recognition, automatic translation, and "understanding systems" for ordinary language dialogue. The optimism which prevailed a decade or two ago about the achievement of this goal has vanished. In order to understand very simple phrases, we as humans use a host of knowledge common with the speaker.

Authors such as Dreyfus are very skeptical about such possibilities. Even Winograd is now lecturing on Gadamer and Heidegger in his courses at Stanford. (As early as 1927 in "Sein und Zeit," Heidegger argued that language does not give a picture of the world. Thus, for him, the communicator does not give new information to his partner, but rather draws attention to an aspect of the world already known by both communication partners.)

Dreyfus (1987, p. 51) argues that we should give up the idea of making dialogue with computers "human-like," not only in view of the obstacles but also because of the danger that sooner or later advice given by expert systems or similar devices would be taken as human due to the "human-like" language. It should be possible for a person of average intelligence to learn certain comfortable modes of communication with computers which still are not in the style of ordinary language. He gives two examples of such comfortable modes: the "Natural-link" software by Texas Instruments, in which the system at each step offers a menu of alternative expressions for use, and the "Q & A system" by Symanteck, in which the user sticks to unambiguous ordinary language phrases and is told by the system if these are not understood. He or she thereby quickly learns to avoid any metaphorical speaking and grasps the specific language suited for that system.

The conclusion drawn by Dreyfus is that in the near future, people of average eduction will have to develop, besides ordinary language skills, language competence for interaction with advanced software systems. He has a convincing counter-argument against those fears which depict future generations as people who, having learned just these computer-directed language skills, have lost the ability of appropriate verbal interaction with humans. He argues that even though many people have the habit of frequently using the telephone, most of them still have preserved their face-to-face interaction skills. There is a further argument for being optimistic that the average user of future expert systems will be able to use and to distinguish human and computer codes: we already have to switch between many codes. For example, consumers are forced to translate the exaggerated and bragging phrases of advertising into their real meanings.

The essential problem of making man-computer dialogue easier is the background knowledge we have and apply, very often subconsciously, and which, until now, computers do not have. The "Microelectronics and Computer Technology Consortium," located in Austin, Texas, and supported by 22 American firms, is now sponsoring a research project directed by Douglas Lenat, with estimated funding of $10 million. The research team is selecting 400 examples from a set of 30,000 encyclopedia articles. In each article, they analyze the background knowledge that is necessary for understanding it. They are sorting out things which are for us quite obvious and reflexive. For example, one would have to know that the life span of a person is continuous and not interrupted, that people are able to lie, that two solid objects cannot occupy the same space at the same time, etc. Lenat plans to link such background knowledge with expert system software. A test for the efficiency of such a system has yet to be devised. This is just one example of such an endeavor.

A great effort is presently being made in the field of parallel processing. This technique of information processing comes closer to replicating what happens in a human brain than previous methods. Cross-over effects between simultaneous runs promise to give some sort of association chains. Japan's leading role in this field is well known. Recently, Kazuhiro Fuchi, director of the Institute for the Computers of the Fifth Generation, gave an account on Austrian television of the Japanese work toward this goal.

The question remains open how far these activities will go beyond the improvement of expert systems and will foster the idea of making man-computer interaction human-like. An expert on AI-based teaching systems, Stevens from BBN Laboratories Inc. in Cambridge, Mass. (1986, pp. 313-314), explains the situation very clearly: "The major impact that AI techniques are having is in making domains *inspectable*. That is, these techniques make it easier to build things that allow students to examine them, to see inside of them, to experience them in dynamic ways, to explore their conceptual relationships, and to see dynamically created explanations... This should be contrasted with what I do think AI currently offers. It does not offer, nor will it for a while, a way of building smart teachers that encode substantial, sophisticated teaching strategies and understanding students well enough to apply these strategies. We are barely scratching the surface of what teachers actually do and are a long way from constructing systems that actually do active teaching."

Non-material Production

The notion "non-material production" as used in this paper has a meaning broader than "creativity." The latter term bears on those activities which bring something essentially new into existence, essential from the point of view of its structure as well as from the point of view of its relation to human concern. (For a full discussion and for the literature, see Reichardt, 1987.) We can speak of "nonmaterial production" if valuable information is created as defined in section 2. Of course, that information which mainly has an external instrumental value will exhibit that value only if it is applied to physical processes. This type of production also can be called "nonmaterial," as, e.g., a country may use it internally and sell its result abroad, thus creating economic value on a immaterial basis. The trade with patents and licences is an example of this possibility.

If compared with the notion of "creativity," the processes of immaterial production carry with them a lot of routine work which, however, is indispensable for useful results. Examples are the measuring of objects in view of a scientific theory, the structural analysis of documents in the service of content-analytical interpretations, etc. In the following section, I would like to discuss the applications of information technology to nonmaterial production with an emphasis on computer technology. By doing this, we should not make the mistake of just looking at productivity as such; rather, we should concentrate on those nonmaterial products for which there is a demand, as this exhibits their value. (As we are able to accumulate large quantities of information and preserve it for a long time, we do not encounter the same problems as does European agriculture where mountains of butter and lakes of milk are squeezing the mood of the decision makers. Still, we should not stimulate idly-running information processes in the false hope of having real growth.)

In order to discuss some applications of computers to nonmaterial production and to study their impact on the work situation of humans, let us distinguish the following possibilities:

—*analysis of structures,*
—*synthesis of structures,*
—*simulation, and*
—*real-time interaction of humans and computers.*

Analysis of structures: Much more complex structures can be handled in a shorter time with information technology than without it. Here are a few examples:

1) Assume a metal alloy is known with highly desirable qualities which almost vanish if the percentages of the components are slightly off or if the material is slightly contaminated. We can make a host of possible materials with such disturbing factors, but if we put the surface polishings under an electron microscope and polarized light, then the different microstructures become visible. The data obtained in this way can be compared with what is known about the structure of molecular grids, and new insights about the influence of contaminating substances and their quantities can be had. As there would be so many possible cases, the task could not be performed without electronic data handling.

A much more dramatic problem was posed in this field by a discovery on April 2, 1982, when icosahedral crystals of an aluminium-magnesium alloy were found, contradicting the hitherto valid theory of crystals which stated that you cannot fill a three-dimensional space with icosahedrons without gaps. Work on such problems can only be done by using data banks of known structures and by software allowing stereometric representation and deflation of them to lower dimensions. (In this case a gapless filling would be explainable only in a six-dimensional superspace.)

2)In esthetic analysis, rather primitive approaches were used formerly by giving statistical distributions of certain elements. A more sophisticated analysis follows: In a given musical work or a collection of works by a composer, a list of chords is established and a statisical investigation about the transitions from one chord to another is made. Then a Markov chain can be derived, indicating transition probabilities for each pair of chords. Barbaud from IRIA at Rocquencour has done this for the works of Anton Bruckner.

Synthesis of structures: The aim of the synthesis is to find structures which are interesting esthetically (have great contemplative value) or which are candidates for the solution of some technical or analytical problems.

1)For the structural synthesis in esthetics, the simplest case is that we have a formula for beauty and put it into a software system which then creates for us the most beautiful structures possible. The idea of such a formula for beauty was coined by the American mathematician George D. Birkhoff at a congress held in Bologna in 1928. His formula for aesthetical beauty was:

$$M = \frac{O}{C}$$

where M is this measure, O is a measure of order, and C is a measure of complexity. He demonstrates this approach in a by-no-means banal way with polygons and shapes of pottery. Such an idea cannot be discussed outside cultural considerations. Beauty cannnot be defined without regarding culture; furthermore, we also get used to forms we often see, whether these might be natural scenery, architecture, or any type of artifact.

2)Barbaud has used the Markov chains, as explained above, also for the synthesis of musical structures. One should keep in mind that in these cases a random process is involved. Thus, of course, each Markov chain can lead to a large number of actual realizations. The results, presented by Barbaud at one of the "ars electronica" meetings in Linz, were not very convincing.

3)Susan Brennan, from the Hewlett-Packard Laboratories at Palo Alto, California, has developed software for drawing pictures of human faces. Each face is characterized by the coordinates of 186 important points, e.g., of the left outer end-point of the eyebrow. From a data bank of faces, Brennan derived "standard" faces. The deviation of a given face from a standard face (or any other pivot-face) can be measured through these 186 points. It is possible to interpolate faces with any distribution desired or to extrapolate the deviation of a given face to make a picture which deviates to a higher degree from the standard face than does the real face. In this way caricatures emerge, emphasizing the characteristics of a face.

My point now is that in many such applications in their early states the human user was doing a less interesting job than the computer. He or she had to measure coordinates from photographs or count chord transitions in a musical score, whereas the computer was drawing or composing music. With the development of hardware and software, the less interesting jobs now can be done by the electronic system. For instance, optical recognition systems can put the picture of a face into graphic electronic memory. On the screen, by moving a mouse, the user now can quickly mark the 186 important points of the face.

Simulation: Here not only the results of a process are studied, but also the way in which they are reached. Let me mention that simulation procedures are especially useful for the study of very slow processes, e.g., the growth and development of forests. Forest schools have used simulation models for some time in order to simulate the effects of different natural conditions and human activities, effects which would have been visible only after years or decades.

Real-time interaction between humans and electronic systems: Let me just mention this field for the sake of systematic overview. It is of special interest for the work of robots in the context of human work. Possibilities in this area have grown considerably since improvements in sensors have been made.

All of the foregoing examples were designated to emphasize three aspects of nonmaterial production: first, that there certainly is a problem with rationalization and with replacing people by machines; second, that it is important to identify the areas in which humans cannot be replaced by machines; and third, that vast areas of growth of nonmaterial production can be envisaged. To mention just one example, in order to test the above-described construction of caricatures from the point of view of person recognition, one needs great numbers of test subjects. The same is true for hundreds of other areas of recognition. In the future, to be a test person in such research fields should be as respectable a job as it is to produce steel today which cannot be sold on the world market. In any case, such test persons would be doing a more useful job than many people in the physical production sector.

Conclusions and Recommendations

In this last section, I would like to draw some conclusions from the foregoing sections and to arrive at some recommendations.

The *first* point is that much more knowledge should be spread about electronics, information systems, and computers. I would fully endorse the view of Haefner (1984) that we need some sort of a "driving license" for information techniques which could be acquired by anyone who is willing to take the respective courses. He also advocates a considerable expansion of teaching about computers in school curricula, comprising an understanding of the areas of applications, the impact on individuals and society, etc. In this way the helpless and naive attitudes of many people toward this technology and the extreme over or underestimations would vanish.

This should be accompanied by much more research on the social aspects of information technology. In my opinion, very many useful applications of this technology have not been made; extreme simplifications of the interactions between the individual and public administration are quite possible; a more detailed monitoring of environmental quality would make the "polluter pay" principle applicable, which when it was coined about thirty years ago was perhaps unrealistic. Research not only should trace out such useful applications and study the causes of non-realization, but it should also concentrate on the vast realm of interaction between information systems and humans from the point of view of psychology as well as sociology and economics. In these fields, studies of human perception and the esthetical problems posed by the new possibilities would have their place too.

It should not be forgotten that the interaction of humans with information systems will be faced with world-wide networks and—in a not too distant future—with ISD networks in which the different types of information are transmitted by the same channels. We can expect that the ultimate aim—or by-product—of that development should certainly be to strive for a much clearer understanding of how humans differ from electronic information systems.

My *second* point has a broader perspective. Throughout the history of human civilization, progress has been achieved essentially by the spread of analytical thinking and the restriction of arguments to those pertinent to the given objective (we call this in German "Sachlichkeit"). Anthropomorphic and metaphysical explanantions of natural processes have proven to yield more inferior results than analytical methods when applied to reality. For the first time in its history, humanity is confronted with devices which prove to be superior in many respects of these very analytical procedures. The restriction of knowledge to instrumental value and its purification from contemplative aspects hitherto was an important task. It no longer has this importance inasmuch as information technologies by themselves enforce this purification within their realms.

This results in the postulate that all those activities in which humans still prove to be superior to computers should be upgraded in their social value. These are phenomena of gestalt-perception, esthetical expression and experience, the application and integration of the vast and heterogeneous life experience, etc. Shigeru Shinomiya (1985, p. 132) very convincingly urges the distinction of those tasks which are better done by humans and those which are not. Automation should be restricted to the latter type of work. This idea of a meaningful division of labor between humans and electronics seems to me to be a very fruitful postulate and can be applied to macrosocial considerations as well.

Unfortunately, just the opposite of this seems to prevail in the mass media. They glorify just those human abilities in which computers certainly are superior to us. In a recent television quiz series, "Wetten daß," people excelled who were able to recognize each country from its contour or a large number of cities from the network structure of their tramway lines, not to mention ridiculous championships of memory, mostly regarding ephemeral details of a field, and this in an age of data banks. The same can be observed in sports, where more and more subdivisions of disciplines are established, each of which has its own champions based on the ground of quantitative measurable performances, whereas essential human performances today lie outside quantification more than ever. We should not forget how strong the influence of such media content is on the minds of young people.

Thirdly, if we take the idea seriously that we should expand those activities in which humans are still superior to computers, we will have to postulate an expansion of the cultural sphere, and we will have to demand that artistic creation get a much broader share of social relevance than is the case today. I have on several occasions (e.g., Reichardt, 1978) quoted those schoolmasters of 15th century Europe who, in their old-fashioned language, complained that their pupils did not have enough time to learn Latin as they were occupied too often by—and dependent financially on—singing in churches. Is it not a paradox that in an age in which the productivity for manufacturing physical goods is so high that it leads to unemployment, such specifically human activities do not have an impact on the labor market? Rather, we observe the absurd development that "live" dance musicians are replaced everywhere by phonograph records.

From the same considerations, an expansion of scientific work with an emphasis on broad investigations in the "human factor" would be desirable, as was exemplified above for the face-recognition tests. It is a pity that today work like establishing reference systems, bibliographies, or retrieval systems has a lower reputation than other tasks in academics. In an information-oriented society, these very duties which help us make selections from the abounding influx of information should get high esteem and should be promoted.

The expansion of the sector of specific cultural activities would bring a serious problem with it: cultural progress can be brought about neither by governmental regulations nor by commercialization. If we say that cultural achievements cannot be submitted to meaningful quantitative evaluation or purely analytical description, we also have to admit, by the same token, that cultural progress essentially will not be stimulated by economic competition of nonmaterial producers as compared with that of physical producers, in which competition certainly has a beneficial effect in view of improvements and progress. In my opinion, despite an expansion of the cultural field, the market economy should and will remain, but it only can have impact on and efficiency with physical production. One could argue that competition has sometimes proved also to be beneficial in the educational field. I think that this holds only for the teaching of instrumentally useful knowledge but not of knowledge in culturally relevant domains. A new mentality would have to evolve which would judge cultural achievements from within culture and leave out trials of quantification, commercial thinking, or governmental regulation.

In view of the ever-increasing productivity in physical production, in my opinion, our societies have gotten so rich that they can afford to do this.

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The Age of Information and the Symbiosis of Culture and Technology

Reikichi Shirane

The Japanese-style Advanced Information Society

The phenomenon of a high-information society in Japan has begun to blossom in earnest in the 1980s, nurtured by the economic abundance gained during the period of rapid growth from the mid-1950s through the early 1970s. A notable feature of the information society as it appears in Japan is the very high degree of equality, as compared to the situation in other countries, with which this rapidly accumulated economic abundance has been distributed. This equality was noted with admiration and surprise by a Dutch intellectual in reflections on his travels in Western Europe in the mid-1970s: "Japan certainly enjoys an enviable economic strength when ordinary farm folks can travel abroad in groups organized by their agricultural cooperatives."

Whether organized by agricultural cooperatives or not, the travels of Japanese abroad start out as group tours in most cases. This fact, which reinforces the image of Japanese as people who subjugate their individuality to the group, has drawn criticism both at home and abroad. We should not, however, lose sight of the great significance for Japan's future cultural growth inherent in the fact that so many of her ordinary citizens have enhanced their experience through foreign travel and have later gradually added variety and individuality to their modes of travel.

Discussion of future high-information scenarios for Japanese society was stimulated by the issuance, in 1963, of a paper entitled *Joho sangyoron* (The Information Industry) by Tadao Umesao. It should be remembered that this paper was issued five years after the beginning of a period of especially rapid economic growth, and at a time that was witnessing the rapid diffusion of color TV broadcasting, which had begun in 1960. This article, published by an authority in the fields of anthropology and ecology, was replete with ideas that were very innovative at the time, and it is too bad that other social scientists and humanists did not immediately follow Umesao's lead and undertake basic research into the themes he proposed. Later, after computers (including on-line applications) began coming into widespread use in the mid-1960s, enterprises and government offices began using the term *johoka shakai* ("information society") as a sort of catch-phrase to promote Japan's computer industry. The use of this phrase diminished somewhat in the 1970s, however, with the development of optical fibers and the increased maturity of TV broadcasting. These new developments were associated with the first so-called "HiOvis" (Higashi Ikoma Optical Visual Information System) experiments of 1978, promoted under governmental guidance, in creating the image of an "advanced graphics society" *(kodo eizo shakai).*

Nevertheless, as suggested by a variety of important indicators, Japan was indeed advancing steadily throughout this period in the direction of a high-information society. For example, in 1980 the percentage of Japan's population engaged in service industries passed the 50 percent mark, while that sector engaged in so-called "indirect labor" exceeded 60 percent, a figure which has continued to increase rapidly.

In 1984 (by coincidence the year chosen by George Orwell for his own peculiar version of the future), a number of elements of the infrastructure for an advanced information society made their appearance, including the beginnings of systematic research into artificial intelligence, large-scale experiments with the integrated digital network known as INS (ISDN outside Japan), the first commercial use of a Videotex system (the CAPTAIN System), and the inauguration of such "new media" in the field as tele-conferencing and commercial high-speed digital communications services. Also at the infrastructure level, the liberalization of Japan's telecommunications enterprise—now said to represent the most complete form of liberalization in this field anywhere in the world—became effective as of April 1, 1985, stimulating truly remarkable vitality in this field.

But despite the evident progress with these innovations, and despite the surface situation, one cannot deny an uneasy feeling that something fundamental is lacking.

This feeling stems from an awareness that, unlike the earlier case of the industrialization of manufacturing, the development of an advanced information society is not accompanied by specific responses. This is because the specific goals seen in the promotion of industrialization and the "scenario writing" for their attainment cannot be so clearly described for the transition to higher levels of "informationalization." In other words, the traditional sociological and economic paradigms are shown to have lost their descriptive powers with respect to the advanced information phenomenon.

Taking this vantage point, this paper will seek to point out problem areas with respect to the "Japanese-style advanced information society" and to consider possibilities for the future based on the concept that there are certain commonalities between technology and culture.

Euro-American Versus Japanese Patterns

The biggest task for present-day Japan is to draw future scenarios for an advanced information society for which there are no previously existing models.

In Japan as in most other late-developing countries, modernization and progress were traditionally seen as synonymous with Westernization. Thus, the greatest priority has been placed on attaining an economic level commensurate with that of America and certain European countries.

Among basic concepts for planning Japan's progress, the idea of "innovation" discussed by the Austrian economist J. A. Schumpeter has long wielded great influence. In addition, a belief in the omnipotence of the marketplace (e.g., Adam Smith), especially in financial circles backed by conservative governments of long-standing stability, and Keynesian ideas, which are rather deep-rooted among government economists, have continued to be influential up to the present, though both have undergone cycles of relative ascendency or decline. In other words, at any given time, scenarios have been written according to what were considered to be the best European and American concepts, and the path to a high level of industrialization has been followed steadily by importing both the scenarios and the performance techniques, and sometimes even the stage props and production knowhow.

In this endeavor, Japan's own long traditions and cultural legacy have not been without relevance. Not satisfied with mere imitation, the Japanese have in a great many instances added and successfully institutionalized the strengths of their culture in their society, establishing a coexistence between their traditional culture and the new technologies necessary for modernization.

From manufacturing to the service sector, the fostering and building up of Japanese-style quality control has been highly evaluated in the international arena. It should be remembered that, in the environment of the Japanese islands with their small ratio of habitable land to population, such developments as motorization and the introduction of household electrical applicances have had different connotations than in Europe and America. The motor car has come to be thought of as a mobile "residential capsule," greatly widening the scope of everyday life, at least at the level of popular conception. Thus, small cars have been produced which can meet the strict exhaust emissions regulations, which are fuel-efficient, and which also have excellent "habitability" characteristics. Electrical household appliances have greatly reduced household labor and have done much to enable women to take a more active part in society. And, as might be expected, they have played a major role in the transition from an industrial to an information society. The rapid diffusion of television broadcasting and of telephones is creating a new "communications culture" through the sharing and expansion of "information space."

Nevertheless, we should remember that these efforts at progress have always, up to the present, had models already available, either in terms of Euro-American social ideals taken as indices of progress, or in terms of the scenarios for achieving these goals.

Today's Japan, however, faces the challenge of the unknown as it progresses toward the realization of an advanced information society requiring a basic shift of previously existing paradigms.

Following Japan's defeat in the war, Europe and America—and especially the latter—represented long-sought-after goals in the "American dream." The late 1960s, however, saw not only the shining landmark of the Apollo Project, but at the same time the coinciding frustration of the Vietnam War, which gave rise, especially among the young, to anti-establishment and anti-technological sentiments and to "counter-culture" movements. As counterpoints to the American-style large-scale technology, there appeared in Western European countries various proposals for "appropriate technology," "intermediate technology" (associated with the famous slogan "Small is Beautiful"), and "Alternative technology." The impacts from the Report of the Club of Rome entitled *The Limits to Growth* and from the oil crisis not long afterward in 1973 seemed to bring an end to oversimplified beliefs in "progress."

These factors raised basic questions concerning the concept of the "American way of life," which had symbolized modernization. Thus, Islamic fundamentalism and other "Southern" concepts gained importance as "horizontal" alternatives to European and American ideas of modernization, into whose hierarchical systems they did not fit. The discussions in Japan about the advanced information society are concerned with similarly significant alternatives to industrialization and at the same time express feelings that there is something to be learned in this regard from "Eastern thought."

Unfairness and Amenities

The story is told of a certain top American executive who, when visiting a sophisticated Japanese manufacturing plant, was unsparing in his admiration for its outstanding production systems but who afterwards, while paying a courtesy call to the firm's main office, expressed his surprise at the latter's poor facilities with the words: "It's just this sort of unbalance which shows Japan's 'unfairness.'"

In regard to Japan-America trade friction, following removal of numerous Japanese tariff barriers, the continued existence of non-tariff barriers has been pointed out as "unfair." The reference to these "invisible barriers" as "unfair" suggests problems that should be properly categorized as "cultural friction." It was in this same context of cultural friction that Japanese were once harshly criticized in EC countries as "workaholics living in rabbit hutches."

But in any case, Japan, which exports inexpensive and high-quality goods with an energy that might be compared to a torrential rain, is "unfair" for neglecting efforts to build living and office environments appropriate to an advanced country, while sparing no money to raise the efficiency of production facilities through the application of "mechatronics" and other means.

Starting from the conditions of extreme poverty that followed defeat in the war, forty years of effort have borne fruit. In statistical terms, at least, Japan has acquired abundance as an "advanced country." Even though the rapid rise in the value of the yen means Japan's export-dependent industries are being pushed into a tight spot, the strong yen and the foreign exchange surplus plainly attest to the prosperity of Japan's economy.

Life expectancies among the longest in the world, the relatively small proportion of unemployed and persons receiving public assistance, and, most especially, the safety of Japan's cities are all representative of much that is good about Japanese society. And in spite of the unkind criticism about "rabbit hutches," statistics on residential living space outside the Tokyo region show that the average residential floor space does not fall much below international standards.

Many people abroad see the Japanese, in comparison with the people of other advanced countries, as not yet having made their abundance an integral part of their lives and, especially, as not enjoying enough psychological or spiritual freedom. Yet this impression is less balanced that it should be.

Specialists say that the extreme dedication to work on the part of the Japanese is a phenomenon of the last 120 years, since the Meiji Restoration, when it became the national goal to catch up with Europe and America. It is said that, at least during the long period of stability in the Edo era preceding this period, people of both the samurai *(bushi)* and merchant *(chonin)* classes cared a great deal about home life and developed their culture and arts upon the foundation of their lives within the family and home. It is to be hoped that this commendable tradition will be received, even though the specifics of life are different now, especially among the younger generation raised in an era of stable growth.

Indeed, the sort of advanced information society Japan is aiming at may be said to be one which is balanced in this way and which promises the reestablishment of various individualistic life patterns. Its realization will surely require giving full expression to the basic concept of "the symbiosis of technology and culture," a concept which has a long tradition as an aspect of Japanese-style wisdom.

One example to be considered is the concept, first developed in America, of office automation (OA). The automation of production facilities already has a long history, and the efficiency of today's advanced manufacturing processes has almost reached the limits of feasibility through "mechatronics" and a large number of new information-related applications. Office work, on the other hand, which aims at intellectual production, is conspicuous for its relatively low productivity in line with its low ratio of mechanization (with the exception of computers for certain routine types of operations). The general concept behind OA involves the possibility of introducing technologies to raise office productivity, given the appearance in recent years of the so-called "new media." As can be expected, in Japan as elsewhere personal computers, facsimile units and various types of multipurpose information terminals have been introduced with the result that what might be called an "OA boom" is now under way.

If the true purpose of OA is not merely to increase the efficiency of office work, but to raise its creativity and intellectual productivity, it will be important not merely to introduce new OA equipment but also to improve office environments. Much attention must be paid to "human-engineered" designs for chairs and desks as well as to such matters as lighting, air conditioning, and color, in keeping with the work operations in question. As has already been pointed out, Japan is still a backward country with respect to its offices, and OA should be interpreted as going beyond mere office automation to include the pursuit of office amenities.

Fortunately, efforts at improving offices along these lines are already beginning, and I should like to hope that these efforts will lessen criticisms from abroad concerning "unfairness." Moreover, going beyond the office and aiming at the development of "techno-amenities" for the entire sphere of everyday life will surely encounter a large-scale expansion of domestic demand and suggest concrete ways of resolving current difficulties occasioned by trade friction and the high yen.

While the "eco-technology" which the Honda Foundation advocates is a vital theme which should be pursued by the entire human race, I suggest that Japan should treat the realization of some of the needed new amenities as a basic and indispensable concept.

Japan's Possibilities and Limitations

Before Japan can be fully accepted as a desirable member of the international community, it is to be expected that many difficulties remain to be overcome. Japan has developed at a fast tempo from a small country in the Far East into a leading country with a great influence on other countries. But the question of whether it can build upon its base of economic strength to successfully advance along the path to becoming an advanced information society—in other words, whether or not it can successfully prepare scenarios for becoming a "great cultural power" *(bunka taikoku)*—will become clearer in the twenty-first century.

As I have already stated, as Japan looks to the future it faces the challenge of the unknown. In this connection, Japanese society may be thought of as exhibiting dual features; it is both giving expression to practical possibilities and revealing certain limitations as to what is practically possible.

Homogeneity and Heterogeneity

When discussion turns to Japan's special characteristics as a country, it is likely to be described as a mono-ethic country with a homogeneous society. Is is incontestably true that among countries with populations in excess of 100 million, Japan stands alone in being 99.5 percent composed of a single ethnic group.

It is worth remembering that the world has approximately 3,000 ethnic groups and that, with 159 countries in the United Nations, this means an average of some eighteen ethnic groups per country, even if there were no overlapping.

If we accept the viewpoint that, as in the case of the United States, contemporary vanguard culture is created by the coexistence of heterogeneous elements (i. e., cultural pluralism), then Japan's homogeneity becomes a negative factor.

But on the other hand, the world offers no other example of a country such as Japan that, in the span of just forty years, has transformed itself from a "developing country" into first a medium-developed country and then into an "advanced country." This has meant that people live together not only with those of their own generation but also with those of other generations whose life experiences have been quite different. The older generation sometimes views today's younger generation as a "new human species" *(shin jinrui),* often with the lament that the young people belong to a different culture with which it is difficult to effect communication. In the advanced countries of Europe and America even the oldest citizens have been conscious from childhood of belonging to an "advanced country." In Japan, by contrast, the older generation, which even now cannot free itself completely from a developing-country or medium-developed-country consciousness, inhabits the same land with a younger generation that has had an advanced-country conciousness from childhood.

If we consider that it is mutual contacts among *heterogeneous* elements which best act to stimulate creativity, it is this very range in value perceptions among generations which suggests new possibilities for Japanese society in the future.

Another factor is the relative lateness, compared to other advanced countries, with which women have come to participate in the society at large. In Japan, participation by women in every area of society has in very recent years finally begun, and the social potential afforded by the abilities of Japan's women will continue to generate new possibilities.

Projects for Expanding Domestic Demand

I have already mentioned that a notable characteristic of postwar Japan's economic growth has been a very high degree of equality in the distribution of wealth. This has developed into a circle of positive mutual reinforcement which, as the private-sector market has been stimulated, has in turn produced a Japanese-style economic society characterized by the activity and vitality of the so-called private sector.

It has been primarily at the initiative of Japan's business circles, operating in a free-competition market for goods produced privately to meet private demand, that low-cost (typically with profits to the manufacturer of less than 5 percent) and high-quality mass-produced goods have, in response to the merits of economies of scale, exceeded domestic demand and flowed into the export market, where they have become involved in today's difficult problems of trade friction and the very strong yen.

The ideas for further study that have suddenly emerged with respect to the task of broadening domestic demand include building large artificial islands by means of landfills in Tokyo Bay and building extremely large structures attached by pylons to the floor of the continental shelf that would develop into offshore cities. Giant projects such as these, involving from 100 billion to 1 trillion dollars, are presently under discussion.

Though a decisive impetus for considering such giant projects has been pressure from abroad to resolve the trade friction, there are in fact a plurality of inducements for such projects.

First among these is the precipitous rise in land prices, especially in the Tokyo capital region. It is even said that, reflecting the yen's appreciation against the dollar, the total land value of the Japanese archipelago now exceeds the total market land value of the North American continent. National projects to create new living space on a large scale are consequently also worth considering from the point of view of keeping down land prices.

Second, in the Japanese archipelago with its long history, rights to ownership and use of already existing land are very complicated. As suggested by the persistent opposition to the building and expansion of the Narita Airport, it would seem that in some cases there is no alternative to looking offshore for large-scale development projects.

Third, a good policy for preserving Japan's industries in ways which maintain a well-balanced and high technological potential (whether we are speaking of the heavy chemical industry, including the basic materials industry, or sophisticated electronics, or even the "information industry") and for contributing to international society will be the long-range development of cooperation with international bidders for assistance in carrying out these types of projects.

Numerous other important factors can be thought of as well, including the utility of such "substitute land" as a measure to mitigate damages from large earthquakes and other natural disasters to which the Japanese archipelago is unavoidably prone, and the utility of developing new space for receiving on a large scale persons from abroad.

Whether or not Japanese society, which has kept up its vitality largely around private business circles which aim at short-term surpluses, can in fact handle such enormous projects requiring long-term investments and planning will no doubt be severely tested in the future.

The Symbiosis of Culture and Technology

Japan's limitations include, firstly, the fact that it has no earlier analogous experience of being truly in the world's forefront; secondly, shortcomings in abilities to communicate internationally; and thirdly, a bias toward short-term business interests. In each instance, capabilities to overcome these limitations, over the long term, must be internalized by trial and error, i.e., through concrete experience.

On the other hand, with a view to Japan's possibilities for the future, I wish to emphasize that the Japanese have long been accustomed to a "culture of symbiosis." It is a traditional Japanese mode of thinking to view things which are different, and even concepts which at first sight seem to be in mutual opposition, as having some sort of causal or functional continuity and thus to allow their coexistence, recognizing in many cases a certain "symbiosis."

The symbiosis concept has been alive with respect to man and nature, with respect to man and technology, and even with respect to man and God. Thus, Japan's modernization was efficiently carried forward by means of a type of wisdom which recognizes the symbiosis of matter and spirit, rationality and feeling, the individual and society, science and art, the Occident and the Orient, the old and the new.

In other words, the "post-modernist" way of thinking that has become an important current of thought in today's world was already an established tradition in Japan, where the simultaneous appreciation of atomism, with its analytical approach, and the "holonic" (this is a newly-coined term) concept of cohesion and unity was, so to speak, one of the household arts.

Although the multifaceted character of the individual will be highlighted through the further development of the advanced information society, the continued vitality of the "morality of moderation" that prevents the destruction of the whole will at the same time help draw the basic contours of Japan-type society in the future.

An important question for divining Japan's future will be whether or not the special characteristics of Japan's industrial technology, which have indisputably developed around a concept of "symbiosis of culture and technology," will continue to have the same vitality in the new paradigms of the twenty-first century.

Science-Technology Administration and the New Role of the Science-Technocrat Officials

Toru Yoshimura

Abstract

Some pertinent issues are presented that are relevant to the growing complexity of our information/high-tech society and the expected role of government in mastering this complexity, especially with regard to the planning and coordination of research and development (R&D).

The New Role of Government

Today, the governments of advanced countries, including Japan's, are faced with many societal problems stemming from complicated and wide-ranging factors. Expanding the governmental capabilities for dealing with these problems has become an urgent task. The astounding revolutions sweeping science and technology (especially in relation to information and communications technology) and contemporary society as a whole, itself driven by these constant innovations in industrial technology and organization, share one major characteristic. That is, we are coming to expect as "normal" societal changes of ever-increasing scale and speed, together with a growing interdependence among social subsystems and organizations, both domestically and internationally. As a result, whether we are speaking of relations between government and industry, between different industrial sectors, or between central and local governments, interaction on all levels is becoming greater and at the same time more complicated.

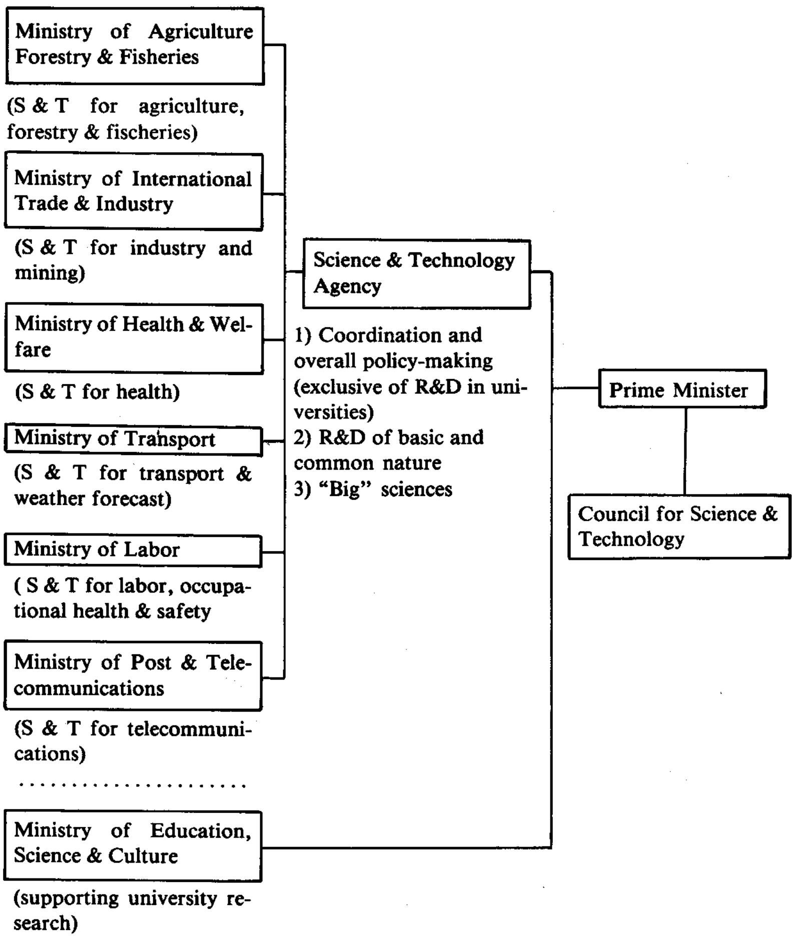
Thus, problems grounded in such complexity cannot be effectively resolved when merely left to the forces of competition based on market mechanisms alone. There is a need for planning and coordination that relies on a longer-range vision. And this is government's new role.

Basic Structure of R&D in Japan

The basic organizational structure of Japan's science and technology establishment is indicated in Figures 1 and 2. During Japan's in-

Figure 1

Basic Concept of the Japanese Administrative Structure for Science and Technology (S & T)



Major Administrative Organs for S & T

(1) Ministry of Agriculture, Forestry & Fisheries (MAFF)

- Agriculture, Forest & Fisheries Research Council
- National Research Institutes (29)
  Agrobiological Resources; Agro-Environmental Science; Animal Industry; Grassland, Fruit Tree, Vegetable; Ornamental Plants & Tea; Agricultural Engineering; Agricultural Economics; Sericulture; Animal Health; Food; Tropical Agriculture; Agriculture Research; Agricultural Experiment (6 regional laboratories); Forestry & Forest Products; Fisheries (7 regional laboratories); Agriculture; Fisheries Engineering
- Bio-oriented Technology Research Advancement Institution

(2) Ministry of International Trade & Industry (MITI)

- Industrial Technology Council
- Agency of Industrial Science – Technology (AIST)

  National Research Institutes (16)
  Metalurgy; Mechanical Engineering; Chemical; Fermentation; Polymers & Textiles; Geological Survey; Electro-Technicals; Industrial Products; Pollution & Resources; Regional Institutes (7)

- Patent Agency
- Japan Key Technology Center

(joint jurisdiction with Ministry of Post & Telecommunications)

(3) Ministry of Health & Welfare (MHW)

- National Research Institutes (11)
  Population; Hospital Administration; Public Health; Health; Nutrition; Mental Health; Leprosy; Cancer; Cardiovascular Disease; Hygienic Science; Rehabilitation for Disabled

(4) Ministry of Transport (MOT)

- Council for Transport Technology
- National Research Institutes (5)
  Ship; Electronics Navigation; Port & Harbour; Traffic Safety & Nuisance; Meteorological

(5) Ministry of Education, Science & Culture (MESC)

- Science Council
- National Universities .... Research Institutes (59)
  Research Facilities
- National Inter-University Research Institutes (7)
  High Energy Physics; Polar, Space & Astronautical Science; Genetics, Statistical Mathematics; Okazaki (Molecular Science, Basic Biology, Physiological Science); Science Information Systems
- Japan Society for the Promotion of Science

(6) Prime Minister's Office

Council for Science & Technology
Atomic Energy Commission
Nuclear Safety Commission
Space Activities Commission
Council for Ocean Development

Science & Technology Agency (STA)

Council for Aeronautics
Council for Electronics & Other Advanced Technologies

National Research Institutes (5)
Ship; Electronics Navigation; Port & Harbour; Traffic Safety & Nuisance; Meteorological

(Governmental Corporations)

Japan Atomic Energy Research Institute
Power Reactor & Nuclear Fuel Development Corp.
National Space Development Agency of Japan
Marine Science & Technology Center
Research Development Corp. of Japan
Japan Information Center for Science & Technology

Figure 2: Money Flow for Japan's R&D in Fiscal Year 1982

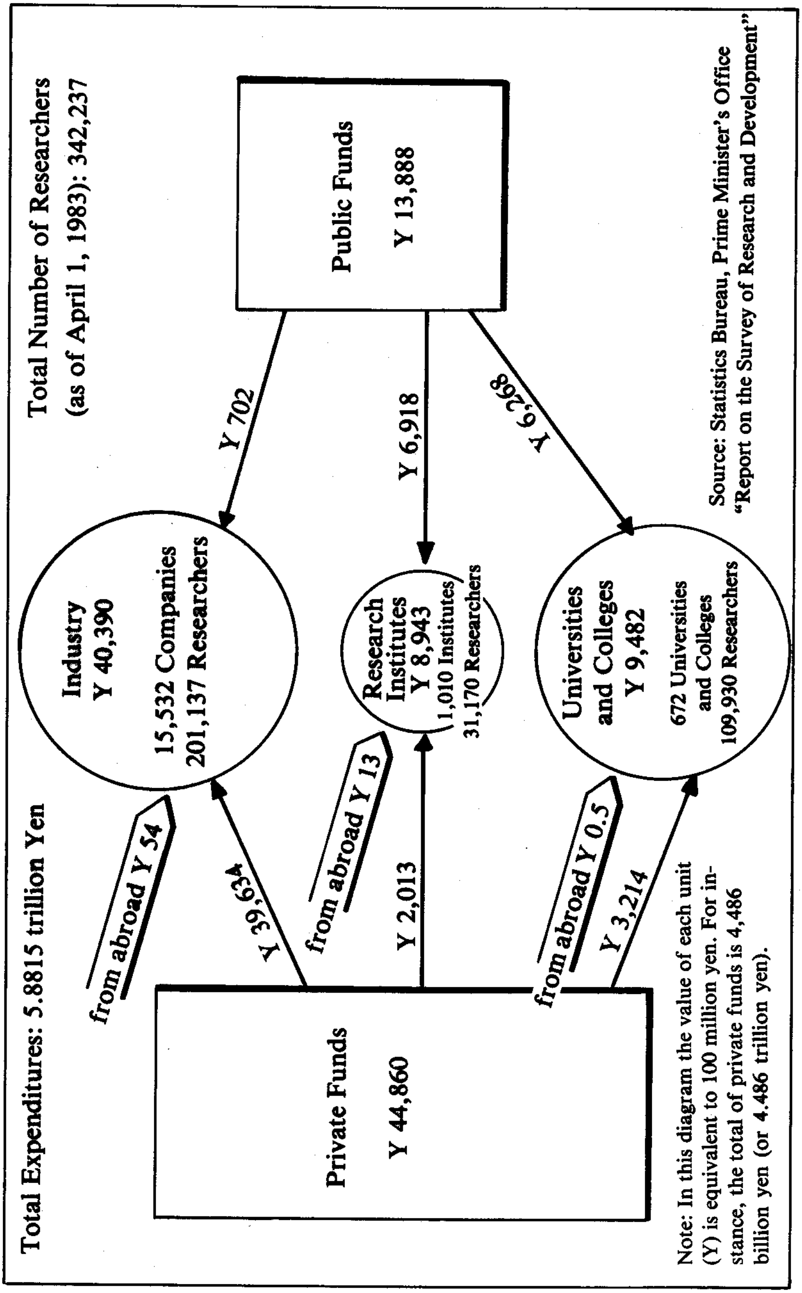


Table 1

	Industry			Public Research Institutes			Universities and Colleges			Private Research Institutes			TOTAL		
Year	Basic Research	Applied Research	Dev't. Research	Basic Research	Applied Research	Dev't. Research	Basic Research	Applied Research	Dev't. Research	Basic Research	Applied Research	Dev't. Research	Basic Research	Applied Research	Dev't. Research
1965	11.2%	31.3%	57.5%	23.2%	49.5%	27.3%	–	–	–	27.9%	48.7%	23.4%	30.3%	31.1%	38.6%
1966	10.4%	28.4%	61.2%	25.4%	46.5%	28.1%	–	–	–	24.7%	43.8%	31.5%	29.8%	29.0%	41.2%
1967	10.2%	28.4%	61.4%	24.9%	44.3%	30.8%	–	–	–	17.8%	62.9%	19.3%	28.3%	28.8%	42.9%
1968	11.4%	27.4%	61.2%	20.3%	47.2%	32.5%	–	–	–	20.0%	46.8%	33.2%	26.6%	28.5%	44.9%
1969	9.1%	27.0%	63.9%	20.5%	42.2%	37.3%	–	–	–	31.1%	52.2%	16.7%	24.3%	27.7%	48.0%
1970	9.3%	27.2%	63.5%	17.4%	42.7%	39.9%	–	–	–	22.3%	35.8%	41.9%	23.3%	27.6%	49.1%
1971	9.1%	25.9%	65.0%	19.5%	33.5%	47.0%	–	–	–	22.2%	36.4%	41.4%	23.9%	25.8%	50.3%
1972	8.1%	22.3%	69.6%	15.1%	32.5%	52.4%	–	–	–	22.5%	57.0%	20.5%	22.5%	23.6%	53.9%
1973	6.7%	19.5%	73.8%	15.6%	29.0%	55.4%	–	–	–	16.4%	53.4%	30.2%	21.5%	21.3%	57.2%
1974	6.3%	19.4%	74.3%	16.5%	38.2%	45.3%	75.4%	18.5%	6.1%	7.2%	16.4%	76.4%	15.0%	21.7%	63.3%
1975	5.2%	19.0%	75.8%	15.8%	34.3%	49.9%	70.9%	21.6%	7.5%	6.5%	21.1%	72.4%	14.2%	21.5%	64.3%
1976	5.1%	18.6%	76.3%	18.1%	34.6%	47.3%	56.4%	38.2%	5.3%	9.7%	26.6%	63.7%	16.5%	24.7%	58.8%
1977	4.7%	19.6%	75.7%	18.0%	35.5%	46.5%	57.3%	37.0%	5.7%	13.5%	30.0%	56.5%	16.2%	25.1%	58.7%
1978	4.6%	18.2%	77.1%	18.5%	34.9%	46.6%	57.3%	37.3%	5.4%	12.2%	61.6%	26.2%	16.6%	25.1%	58.3%
1979	4.6%	19.5%	75.9%	18.9%	37.1%	44.0%	55.2%	38.1%	6.7%	14.5%	63.8%	21.7%	15.5%	25.9%	58.6%
1980	5.0%	19.5%	75.5%	15.8%	39.3%	44.9%	55.8%	37.0%	7.2%	12.6%	46.0%	41.4%	14.5%	25.4%	60.1%
1981	5.2%	21.8%	73.0%	14.2%	32.2%	53.6%	55.8%	36.2%	8.0%	9.9%	36.7%	53.3%	13.9%	25.7%	60.4%
1982	5.5%	21.9%	72.6%	14.3%	31.8%	53.9%	54.9%	37.6%	7.5%	8.5%	33.1%	58.4%	14.1%	25.9%	60.1%
1983	5.7%	22.0%	72.3%	13.9%	30.7%	55.4%	54.9%	36.9%	8.2%	9.2%	31.4%	59.4%	14.0%	25.4%	60.6%
1984	6.6%	22.0%	72.4%	13.9%	29.9%	56.2%	54.9%	36.6%	8.5%	11.1%	31.7%	57.2%	13.6%	25.1%	61.3%

dustrialization, R&D systems gradually became institutionalized: (1) universities (including affiliated research institutes and laboratories); (2) national and prefectural research institutes (including R&D public corporations); and (3) various industrial sectors. The numbers and sizes of these facilities are indicated in Figure 2.

Table 1 breaks down ongoing research by category and organization. Compared to other advanced industrial countries, Japan: (1) draws a higher proportion of R&D funding from the private sector (79.2 percent) than from government sources (20.8 percent); (2) relies to a greater extent on private enterprise for the funding of research; (3) focuses less on basic research than on applied and development research; and (4) has up to now seen relatively little contribution from the basic research conducted in universities which helps the progress of R&D as a whole.

These facts reflect Japan's heavy reliance to date on imports of new technology from abroad. Japan has generally imported new basic technologies whose feasibility and potential have already been verified in Europe or the U.S. and has then concentrated on research to further improve, refine, and adapt them to practical use and into marketable products, with an eye to innovation in manufacturing processes. Thus, R&D activities in industry have mainly focused on development, while basic research has been very weak. Even national research institutes have mostly been concerned with applied research directed toward specific administrative missions or toward facilitating the transfer and diffusion of new technologies. Thus, Japanese universities have not been a primary source of new basic research. The emphasis has been, rather, on the importation of new technologies, particularly from university and industry research in advanced countries abroad.

Societal needs have hardly been reflected at all in research carried out at Japanese universities. They have, with the encouragement of the Ministry of Education, tended to limit themselves to esoteric research with no orientation toward any clear societal objectives.

Overcoming the Problem of Compartmentalization

In the past, the management and financial support of R&D have come, in the case of universities, mainly from the Ministry of Education; in the case of the national research institutes, from other government ministries and agencies; and in the case of private research, from industry. Funding has flowed along similar lines. As a result, these sectors and institutions became "compartmentalized," and cooperation across sectors or institutions was rare. Of course, there have been a few exceptions, such as the joint research projects planned and coordinated by the Ministry of International Trade and Industry's (MITI) Agency of Industrial Science and Technology (AIST), the communication technology research projects initiated and sponsored by NTT's Bureau of Technology and NTT's Electrical Communication Laboratories, and the projects carried out by Tohoku University's Communications Research Institute (initiated by Dr. Junichi Nishizawa). In these exceptional cases of industry-government-academic cooperation, long-term planning and coordination functions were "built into" the organizational structure, allowing the basic research, applied and developmental stages of projects to be integrated.

However, apart from these exceptional examples of success, in most cases interaction among sectors and institutions has been rare. In particular, research activities at universities, as a result of funding patterns of the Ministry of Education, have been isolated and therefore have lacked vitality.

I believe that the insular character of Japan's R&D and its administrative supports has partially grown out of a traditional conceptualization of R&D within a limited sequential model (basic – applied – development – production), rather than a more complex dynamic model.

However, in recent years, with the increasing vitality and sophistication of R&D activities, the traditional way of thinking has yielded to the complex dynamic models.

This is especially true of recently developed highly-advanced technologies, where practical applications have often emerged from long-term basic research acitivities. The creation of new technologies increasingly requires long-term research and at the same time adds impetus to the rapid pace of technological innovation. High technology research, while interacting with other spheres of activity, stands apart from, and precedes, product development, laying the groundwork for technologies of the next generation.

The emerging dynamic and complex process of R&D activities makes a number of policy issues particularly important today. The first is strengthening and giving greater weight to basic research in industry and national research institutes. The second is reorganizing and reintegrating R&D activities, recognizing the complexity and dynamism of the process itself. On this point, there are two fundamentally differing views. One holds that since private industries have vastly improved their financial and research capabilities, they should be relied on to conduct research (including basic research) in the future, while government's role should be eliminated. In this view, as in the past, no great reliance should be placed on the universities. The other view holds that government should increase its role in planning and coordination to strengthen long-term basic research, and that universities should play a major part in basic research. Personally, I agree with the latter point of view.

While it is true that private industry has boosted its capacity and funding for R&D, it lacks the experience and knowledge needed to manage basic research. What it can manage is short-term research designed to develop practical applications within three to five years at the most. Ultimately, long-term basic research is dependent on the personal intellectual predilections of the researchers themselves.

Around 1983 or 1984, a large number of private enterprises established or planned to establish their own institutes for basic research. However, since 1986 there has already been a change in direction, and this earlier trend is now in decline.

New Policies

It is not surprising that a reevaluation and revitalization of the role of universities and national research institutes is considered necessary. With respect to universities, the conservative Ministry of Education has finally initiated action with the adoption of guidelines for the following activities:

— joint research programs (1983)
— contract research projects (1984)
— contract researchers (1984)
— donations (1984)

New national research institute roles are now being discussed by panel committees of the Council for Science and Technology (the chief advisory body), and it appears likely that new policies and recommendations for reform will be ready in the autumn of 1987.

Research management guidelines adopted by MITI's Electro-Technical Laboratory (ETL) are expected to serve as a model for other national research institutes. They are simply: (1) to gain an overall view of technological trends by accurately assessing societal needs and technological frontiers; (2) to use this assessment as the basis for developing technological innovations and the knowledge and new techniques behind them; (3) to make research results widely available in Japan and the world—in other words, to promote basic research that will serve the development of society as a whole; and (4) to plan and coordinate this kind of basic research.

The government's aim of seeking R&D integration through joint research is exemplified in the following programs:

ERATO (Exploratory Research for Advanced Technology)

ERATO is a rather new scheme, started in 1981, for basic research. The basic concept of ERATO is to entrust a project director with research in a certain field which is aimed at a basic understanding of nature or matter and is expected to generate breakthroughs in interdisciplinary fields, bridging science and technology. A project director has an overall responsibility for research project management including expenditures and staff recruiting. A project team consists of less than 30 researchers who are recruited from academic, governmental, and industrial circles, as well as from overseas, and is then broken down into three or four subgroups. These researchers are employed by the Research Development Corporation of Japan on a yearly contract renewable for up to two or three years. The maximum term of each project is five years.

The research results are made public. Any patent rights are shared between the Corporation, the source of funding, and the researchers who produced those results, on a 50:50 basis. The research themes which have been adopted, up to 1986, are ultra-fine particles, amorphous and intercalation compunds, fine polymers, perfect crystals, bioholonics, bio-information transfer, superbugs, nanomechanisms, solid surfaces, quantum magneto flux logic, molecular dynamics assembly, and biophotons. Average research funding for five years is about two billion yen per year.

This scheme is unique in a number of respects, considering the rather rigid management of R&D in Japan. First, the project director has total control over the management of R&D. The Corporation, the source of funding, does not interfere in the R&D management. Secondly, the researchers are recruited from various sectors and overseas. This makes possible the mixing of disciplines and their cooperation. This is unfortunately not easy in the traditional model of R&D. ERATO's performance has been highly evaluated.

IFRP (International Frontier Research Program)

The International Frontier Research Program (IFRP), operated by the Institute of Physical and Chemical Research (RIKEN), was initiated in 1986 to discover new knowledge that will serve as the basis of technological innovation in the twenty-first century. The work of IFRP is so basic in nature that it lays the foundation for the ERATO basic research. Research fields presently cover two areas: one is on the biological background of homeostasis mechanisms of animals and plants, and the other is on frontier materials aimed at producing new functional materials. The research system is flexible and internationally open. Scientists in a wide range of scientific fields are invited from universities, governmental institutions, private sectors, and overseas. The researchers and laboratories are reorganized when the focus of research shifts. The budget for this program is 1.5 billion yen in 1987.

Human Frontier Science Program

The world now faces such serious problems as increasing environmental burdens on a global scale, a depletion of useful resources, skyrocketing energy consumption, a swelling population, and tension between technological advances and human needs.

To facilitate solving these problems, various measures have been tried, such as the development of alternative forms of energy, technologies to prevent environmental pollution, and control technologies using microelectronics. But we have had many difficulties with respect to the basic direction of technological development. If we are to fundamentally reform the existing technological system so as to reduce energy consumption, alleviate global environmental burdens and improve technological reliability, all of which are needed to achieve lasting human development into the twenty-first century and beyond, scientists and technicians must observe various biological functions—those of metabolism, motility and thinking—and utilize and apply them in new developments.

Considering the importance of Japan's contributions to advances in science and technology and cooperation in international research and development, there is great value in its taking the initiative in promoting international research cooperation programs. Thus the Ministry of International Trade and Industry is studying the Human Frontier Science Program, a large-scale international R&D project aimed at producing findings that will be useful to society. The following is an outline of this program:

Basic Ideas

— Frequent exchange among different fields under an open international research system; combination of Japanese and foreign minds.

— Contribution by Japan to the international store of knowledge in basic fields so that all countries benefit from results. — Flexible programs to bring out optimum creativity of researchers.

Content of R&D

— Technologies applied to biological functions (metabolism, motility, thinking) are expected to become the mainstream of technology in the future.

Focal Points

— Solve problems of the twenty-first century, among which are expected to be a growing stress between technology and man and coping with an aging society.

— Develop a new paradigm of science and technology by conducting basic research into the functions of organisms and the artifical construction thereof.

— Research the functions of organisms at the molecular, cellular, tissue, and overall levels, as well as the correlation of these levels; related research will attempt to reproduce these functions through bioengineering techniques.

Specific Areas of Concentration

(to be selected through cooperation with well-known researchers, both Japanese and foreign)

— Elucidation of biological functions: explaining substance, energy, and information-convertible functions, e.g., elucidation

of enzymatic functions (i.e., how enzymes operate in nature); elucidation of brain functions, including cognition and memory.
— Basic research for using and applying biological functions and replication of various biological functions *in vitro,* e.g., artificial enzyme building; artificial realization of various reactions taking place in nature; development of artificial intelligence having thinking and acknowledging functions similar to the human brain.

Establishment of the Japan Key Technology Center

The Japan Key Technology Center, established in response to a proposal by the private sector, conducts activities directed at the overall improvement of the environment for private research and development in fundamental technologies. Its activities include:

(1) Capital Investment
The Center provides capital investment for research carried out by companies established for joint research purposes (FY 1986 = 12.5 billion yen).

(2) Loan Services
The Center provides conditional interest-free loans to aid in reducing R&D-related risks and costs (FY 1986 = 5.7 billion yen).

(3) Mediation in Arranging Joint Research
Mediation is performed for private companies wishing to conduct joint research with national research institutions.

(4) Execution of Consigned Research
The Center brings together experts from government, industry, and academia to conduct research consigned to the Center by private companies.

(5) Japan Trust International Research Cooperation Service
The Center has established a charitable trust called the Japan Trust Fund. The operating profits from this fund will be used to invite foreign researchers in key technologies to Japan.

(6) Research Information Service
The Center collects and sorts a wide variety of important research literature which is kept on file at national research institutes and other organizations.

(7) Surveys and Other Services

The Center conducts various kinds of surveys to aid private-sector research in key technologies.

This is a new scheme operated by the Japan Key Technology Center, with provisions for capital investment and conditional interest-free loans. In case two or more private enterprises set up an R&D enterprise to conduct a joint R&D project, the Center provides up to 70 percent of the capital required for facilities, equipment, and operation of the R&D project. Conditional interest-free loans mean that interest is conditional upon the outcome of a project. If the project fails, only the principal needs be repaid. If the project is successful, both principal and interest should be repaid. Loans may be up to 70 percent of the cost of an R&D project specified in advance. The capital investment was 13 billion yen for 47 R&D projects and the financing was 6 billion yen for 90 R&D projects in 1986. A similar scheme is being arranged for bio-oriented technology.

Each of these new governmental programs recognizes the complexity of contemporary R&D activities, gives due weight to long-term planning and coordination, and promotes industry-government-academic cooperative endeavors. All of these new programs are also open to international cooperation.

Science-Technology Administration

Although my remarks so far have been confined to the situation in Japan, it is my belief that most other advanced Western nations are also confronted by significant questions regarding the role of government in scientific and technological research and development. Undoubtedly, a crucial question involves the administration of governmental efforts in R&D.

For any government to be truly effective in its R&D role it must not only be concerned with the content and extent of its various programs but also with the status and caliber of its civil servants who are responsible for the administration of these programs. There is a definite need to train and orient governmental officials who have engineering or technical backgrounds in the "systems" aspects of the programs they administer; that is, to focus their efforts on the coordination and development of information networks, not just the technology in question.

Let me review then the activities of the Japanese government relative to the personnel of its science-technology administration.

Bringing in the Science Technocrat

The Ministry of Education through its control over universities, has responsibility for the training of Japans's researchers and high-level engineers. At the same time, through the development of academic research programs in universities and institutions affiliated with them, it shares much of the responsibility for promoting Japan's R&D activities. In other words, it is one of the major government agencies responsible for science and technology policy.

It is commonly recognized that the situation of Japan's science and technology R&D is in a period of radical change. R&D systems, which have up to now been strongly weighted in favor of applied and development research aimed at developing new marketable products, are being revised, and budding new revolutionary technologies grounded in medium- to long-term perspectives are coming into view. In other words, more weight is being given to basic research, and the establishment and improvement of R&D systems aimed at a new integration of basic, applied and development research is seen to be an urgent task. This goal has come to be loudly proclaimed in various reports and "white papers" put out by the Council on Science and Technology and other governments agencies. Given the historical development of universities, it is natural that the scientific research conducted at universities is for the most part of a "basic" variety.

Although this basic research is not at present necessarily given a high evaluation, society nevertheless holds high expectations that universities should be able to develop their basic research capabilities. Thus universities will be asked to play a more central role in the future.

Consequently it is expected that the Ministry of Eduation, together with the Science and Technology Agency, MITI, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Health and Welfare, and the Ministry of Posts and Telecommunications, will play an important, leading role in the formulation of science and technology policy and R&D administration, and that it will in particular play a core role in the promotion of basic research.

For government organs responsible for such roles, it is indispensable that there be administrators who are graduates of specialized science and technology university programs and who have both basic qualifications and expertise. In other words, it is necessary that they include administrators, i.e., groups of technical officers, who have completed science and engineering programs, agricultural programs, and medical programs at the undergraduate and graduate levels, having a good grasp of contemporary research trends, and who have expertise concerning research management. It is only after these science technocrats are trained as administrators on entering their government posts, cooperating with other administrative employees whose academic background are in jurisprudence or social sciences, that effective science and technology policy can be formed, the planning of policy programs can be made, and R&D activities can be carried forward.

The Increasing Utilization of Technical Personnel in MITI

With the exception of the Ministry of Education and the Ministry of Posts and Communications, the other above-mentioned government ministries and agencies with especially strong links to science and technology have all organized technical expert groups. Here we shall focus attention on the Ministry of International Trade and Industry (MITI).

MITI systematically trains technical personnel, especially through its Agency of Industrial Science and Technology (AIST). The employees take part in every field of MITI administration and lend support to administrative activities and the formulation of policy from a scientific-technological perspective.

In its role of furthering the development of technologies used by industries, the AIST, as a semi-independent organ attached to MITI, seeks to gain an understanding of trends in technological development on an international level and then, on the basis of close cooperation among industrial and academic circles and other informed persons, to clarify which technologies are likely to be most important for Japan's industries. After hearing opinions from industry, it establishes outlooks on the practical utilization of the various technologies in question and promotes research and the registration of patents with a view to attaining the needed technologies within an appropriate period of time. It employs some top-ranked researchers of its own and carries out a certain amount of basic research, but its foremost objective is to assess the development of technology and to maintain management capabilities.

The head staff members of the AIST are elite MITI technical personnel, and their number is approximately the same as that of the elite office staff at the MITI headquaters. Each year approximately 25 graduates of technology-related departments of major universities enter the ministry, as a so-called "career group," to take part in the administration of science and technology, serving alternately in ministry headquarters and in the AIST. At MITI headquarters, they deal with the whole spectrum of science and technology policy, while at the AIST they are engaged in choosing and managing specific research projects. Besides these technical personnel, other specialized researchers and technical staff are effectively organized within the 16 research institutes which operate under the AIST's aegis.

MITI's technical personnel have always played a very important role and have the backing of good traditions dating from the Meiji-era "Industrial Ministry" *(Kobusho)* which once took the lead in introducing technology from the advanced countries of the West. It was MITI technocrats who administratively supported the policies of fostering sophisticated industries following the Second World War, the modernization of the steel industry, and technical innovations in various other branches of industry. Their role became particularly important after the second half of the 1960s, when MITI's industrial policy changed from the so-called old industrial policy to a "New Industrial Policy." The role which they have played is being highly evaluated internationally, especially due to the encouragement given to the growth of today's computer and other information industries. To promote the growth of the information industry requires much more complex R&D than in the case of shipbuilding or steel. Plans had to be made not just for a single industry but rather for covering a whole group of industries and a whole complex of technologies. MITI recognized early on that computers and the industries related to them would be the most important strategic industries for the further development of the economy. Aware of the competition from IBM, MITI developed a series of effective policies and strategies to help the growth of computer-related industries. At its base was a technology development policy which around 1965 saw the inauguration of a system of large-scale projects. A Large-Scale Project Office was set up within the AIST, and large projects were begun centering around national research institutes (in the case of the computer project, the Electro-Technical Laboratory) operating under AIST sponsorship. Around this core, a new type of research project was created, making use of industry-government-academic cooperation and a role for participating private enterprises.

One of these "national projects" was the Super-Capacity Computer Project, which expended 10 billion yen over a six-year period. The so-called Engineering Research Association, to which foreign researchers have recently been paying much attention, has since that time become firmly established. In this system, national R&D funding is channeled to private enterprises in the form of subsidies or "special contract research expenditures." In the course of these projects, the AIST has gained much new know-how with respect to the organization of large-scale joint technological development, and this helped lead to great success with the VLS I Project inaugurated in the latter half of the 1970s. As a result, Japanese industry has come to lead the world in the field of semiconductors.

MITI may be said to have established a policy measure in which plans and guidelines for R&D are first made primarily at the AIST level and then, as they are refined and made more complex, the participation of private enterprises in relevant industries is invited. "Engineering Research Associations" are formed using a research institute like the Electro-Technical Laboratory as a coordinator or center. MITI thus aims at an integration of R&D activities by creating these types of industry-government-academic joint projects, providing them with information and raising their effectiveness through the channeling of assistance funds.

The Role of Technical Personnel in Government

In the operation of these types of R&D systems relying on industry-government-academic ccoperation, groups of administrative personnel with technological backgrounds have played important and decisive roles. As they constantly exchange information with researchers and technicians in universities and in industry, they collect and analyze relevant and useful data, on the basis of which they establish complex and multifacted research plans. At the stage of implementing these plans, their role is to make the R&D programs operate effectively; they must thus act as project coordinators, putting to use their expertise in regard to research management. Various specialists such as data analysts, planners, and coordinators give overall support to MITI's administrative policies, i.e., to the dynamic operation of its industrial policies. Given the widespread recognition, after the beginning of the 1980s, of the importance of basic research to R&D in *avant garde* science and technology, these technical personnel have been actively engaged in looking toward new vistas for R&D and in developing the next stages of achievement, based on the knowledge they have gained through their significant achievements of the past.

Looking within MITI, it should not be expected that there will be no friction between the administrative personnel and the technical personnel. In Japan's bureaucratic organization, there has traditionally been a strong trend to greatly respect administrative personnel with law-faculty backgrounds as "general managers," while bureaucrats with technical training have been looked on as specialists and accorded a lower standing. Thus it is an undeniable fact that with respect to the acquisition of managerial posts there has existed a certain degree of struggle (sometimes quite intense) between administrative and technical personnel. However, in the overall picture, Japan's industrial policies, which have gained a good reputation worldwide, may be said to have succeeded because they had the support of MITI's groups of technical bureaucrats. And in the future, too, for the development of highly-advanced science and technology and the development of *avant garde* industries, the role of these technical bureaucrats may be expected to become ever greater.

By contrast, the Ministry of Agriculture, Forestry, and Fisheries and the Ministry of Health and Welfare, while having very capable groups of technical personnel who have received university training in agriculture, forestry, medicine and pharmacy, cannot be said at present to be using these capacities in as effective a way as in the case of MITI. In other words, at the level of policy activities—e.g., the active planning of R&D programs closely linked to policies for fostering agriculture and medical industries and the formulation and coordination of large-scale research programs including the participation of private enterprises and academic circles—these groups of technical bureaucrats are still not being systematically or optimally utilized. However, in accord with the recognition recently being given to the importance of life sciences and biotechnology, development strategies for making better use of this potential are being explored, and in the case of the Ministry of Agriculture, Forestry, and Fisheries new efforts are being made to expand the planning and coordination functions of these technocrat-administrators, for example, through the strengthening of the functions of the secretariat of the Council for Science and Technology of Agriculture, Forestry, and Fisheries.

The Science and Technology Agency has traditionally set national science and technology policies and exercised the main responsibility for coordination functions affecting the various concerned ministries and agencies. It may be said, as an organization, to be a veritable "kingdom of technical bureaucrats." Because it is a relatively new government agency, what is currently problematic is the fact that these technical bureaucrats, given their training and predilections, have not received sufficient training as administrators. Nevertheless, for the future development of science and technology policy, the expectations placed on these technical bureaucrats' activities will probably become ever greater.

Compared with the aforementioned ministries and agencies, both the Ministry of Education and the Ministry of Posts and Telecommunications lack a sufficient number of administrators with technical backgrounds. The Ministry of Posts and Telecommunications is a descendant of the earlier "Communications Ministry" *(Teishinsho),* which in its time had an outstanding group of technical bureaucrats, in fact the best among any of Japan's bureaucratic organizations. The former ministry was divided in 1949 into the Ministry of Electronic Communication and the Ministry of Postal Services, and then, following the end of the postwar American occupation in 1952, the former became the Nippon Telegraph and Telephone Public Corporation (NTT) and was placed under the supervision of the latter (whose English name became Ministry of Post and Telecommunications). Because the NTT was a very large body and because, too, most of its head staff had been technical bureaucrats, it became rather independent of the Ministry of Post and Telecommunications. In the process of reorganizing the fields over which the former Communications Ministry had exercised jurisdiction, almost all the technical bureaucrats moved to NTT, while the Ministry of Post and Telecommunications was left without outstanding personnel with technical backgrounds, with the exception of a small number of personnel engaged in the management of radio frequencies, and was thus transformed into an organization of mainly administrative personnel. Since that time, the Ministry of Post and Telecommunications has been principally concerned with postal services and the allocation and licensing of radio and television broadcasts and has until today not been able to cast aside its old-fashioned administrative characteristics. It is no exaggeration to say that Japan's policies for communications technology R&D have in reality been carried out by NTT. Looking to America's AT&T as a model, NTT's Electro-Communication Laboratories (ECL), of which there are presently four, located in Musashino, Ibaragi, Yokosuka and Atsugi, are modeled after the Bell Laboratories. While AT&T is supplied by its subsidiary, Western Electric, NTT, in pursuit of the merits of competition, has placed under its "umbrella" the so-called "*Denden* family" of communications equipment makers, including Nippon Electric Company (NEC), Hitachi Seisakushi, Fujitsu, and Oki Electric, and has tried to foster their growth. R&D systems for communications technology have been set up by joint consultations among the NTT's elite Bureau of Technology, the ECLs and the *Denden* family. In this system, there has been a successful integration of basic, applied and development research, together with a successful commercialization of finished products. This system corresponds to the MITI network linking the AIST, the Electro-Technical Laboratory, and private enterprises.

Within this system, development strategies for various types of innovative communications technologies (culminating in optical fiber communications) have been laid out. However, it is widely recognized that in this process it has in effect been NTT, and not the Ministry of Post and Telecommunications, that has functioned as the policy-making organ.

However, now that NTT has been privatized, the Ministry of Post and Telecommunications is faced with the vital need of metamorphizing into a new policy-making organ befitting the advent of the current information age built around the marriage of computers to communications. It is to be hoped that the Ministry of Post and Telecommunication will waste no time in progressing from a licensing to a policy-making organization and that as the No. 1 party responsible for policy affecting the "informazation" of society it will become, in a good sense, a competitor of MITI. Just as in the case of competition among private enterprises, there can be brought about a leveling-up of the quality of governmental activities through the stimulus provided by such competition. To make this a reality, the Ministry of Post and Telecommunication will need to quickly train and organize technical personnel with the capabilities of assessing and managing technological developments as well as planning the specific development of communications and information technologies.

The Lack of Technocrats in the Ministry of Education

Together with the Ministry of Post and Telecommunications, the Ministry of Education must also be singled out as sharing the most serious problems with respect to the lack of personnel with science and technology training. These are problems about which the top-ranking bureaucrats in the ministry seem, in fact, to be hardly aware.

In the Ministry of Education, administrators with technical backgrounds are wholly absent with the exception of technical personnel with architectural training who are concerned with the construction of school buildings. The ministry's point of view has been that, unlike other governmental ministries and agencies, the Ministry of Education has under its umbrella universities and their affiliated research institutions which employ large numbers of very capable researchers and specialists. Thus, with respect to the promotion of academic research, whenever it might be necessary the ministry can invite these university professors as advisers and make use of their expertise. The ministry has felt that it is therefore unnecessary to copy other ministries and agencies which train and organize their own contingents of technical staff. And in fact, up to the present it has given university researchers simultaneous appointments as Ministry of Education staff members under such names as "scientific staff members" *(kagakukan)* or "trainee staff members" *(shigakukan),* for limited periods of time, and has relied on their cooperation in administrative activities. The ministry has plans for increasing the number of such temporary posts in the future, with the intention of actively enrolling large numbers of university professors and carrying out other personnel exchanges with universities.

However, this strategy is quite inadequate. First of all, these jointly appointed "scientific staff members" and observers are, first and foremost, researchers who have received neither the qualifications nor the training to act as administrative staff. Their main role is thus limited to being advisers, from their specialist standpoints, for the non-technical administrative personnel and to assessing the ways in which the latter are organized; they cannot be expected to play the role of administrators themselves. And secondly, Japanese universities have over a long period been isolated from the world of industry and other aspects of society, and university researchers have been trained in such a way that they habitually orient themselves toward academic societies. These academic societies, which are grounded in very specialized areas of knowledge, tend to be at the center of these researchers' fields of vision and thus restrict their fields of action. Thus, as advisers, these researchers tend to have fields of vision that are rather too narrow. They furthermore have a tendency to try to act as spokesmen for specific academic societies and disciplines, or special interests involving their specialized fields. Besides, for university professors who are accumulating successful experience and are active as leaders in joint research projects with MITI or other government organs or private industry, a post as a Ministry of Education "scientific staff member" is not that attractive and does not usually elicit very great enthusiasm. As a result, those who do gather in these posts tend to be a somewhat clubby assemblage of university professors with a certain "Ministry of Education" stripe. From the standpoint of formulating science and technology policy for the country as a whole, they cannot evince the vigor needed for putting together appropriate policy programs. A necessary condition for the Ministry of Education to overcome this sort of situation so as to strengthen its functions as a policy-making organ and play a leading role in R&D administration (including the core role for the promotion of basic research) is that the ministry itself recruit and train administrative staff with science and technology backgrounds and plan their organization along the lines demonstrated by MITI.

Although there will probably be no future lessening of the importance of the generalist-type approach to policy-making whereby overall administrative judgments are made by generalist administrators, the back-up and support of specialized knowledge in each field will take on increasing importance. Especially in the case of the Ministry of Education's administration of science and technology research, we must strongly hope for policy innovations reflecting the collection and analysis, by elite technical personnel, of basic information on research trends, as well as a strengthening of coordination functions for research carried out in universities.

Needless to say, it will not be possible for the Ministry of Education, which lacks the sort of experience built up by MITI and the Ministry of Agriculture, Forestry, and Fisheries in training elite technical staff groups, to create such new groups overnight. But to begin this process it is desirable, first of all, that some technical staff members with thorough scientific grounding be recruited and then sent to MITI's Agency of Industrial Science and Technology (AIST) for training as administrators; and secondly, that elite technical staff from MITI and already trained research managers from private enterprises be sent to the Ministry of Education to introduce and help with the digestion of methods of research management and policy-making based on new concepts. From this sort of exchange and cooperation among, so to speak, "different sectors," innovative administrative methods and management techniques will surely emerge. And the participating administrative personnel from MITI and other ministries and agencies will, on the basis of this experience, no doubt be able to elaborate new policy-making and management methods of their own for promoting basic research and for integrating it with applied and development research.

It must be said that improving the capabilities of the Ministry of Education for policy-making through the introduction of personnel with technical training into ministry headquarters is alone not sufficient for revitalizing and raising the level of the research done at universities. Universities' administrative organs, and especially those at a university central headquarters, must also be provided with new types of administrative personnel with specialized skills in research management, i.e., personnel who might be called "research project coordinating staff." Almost all present-day university administrative personnel are persons concerned with monetary accounts and so-called "general affairs" (Somu). They have meager experience and knowledge with respect to research management and tend to relate university research activities with the same concepts with which they treat personnel or accounts management. Thus in many cases an authoritarian coloration is strongly present which dampens researchers's enthusiasm and hampers the development of research projects. Overcoming this problem is an indispensable task for university revitalization.

Yet at the same time, the Ministry of Education must employ elite administrators with science and technology backgrounds and transform itself into a policy-making organ with core responsibility for the promotion of basic research. To this end, it should create an organ similar to MITI's AIST.

According to a once widely-held opinion, administrative personnel with academic backgrounds in law or economics are able to make overall administrative judgments based on their wide range of vision as generalists, but government personnel with science and technology backgrounds are generically incapable of becoming "general managers" because of a too-narrow range of vision induced by their specialist training. However, in our new age of science and technology, this is already a dying myth. And in any case, this issue is a problem limited to careers and training within government organizations. Excellent proof is afforded by the fact that many major private enterprises have in recent years produced managers and company presidents which have come from technical backgrounds.

Observing and Describing Complexity

Niklas Luhmann

Introduction

My main concern is an interest in and an appeal to precision in the social sciences, in particular in the theoretical sciences. I do not refer to the sort of precision to which mathematicians lay claim; nor the sort of precision arising from formal calculation, the price of which is the exclusion of inconsistencies, the paradoxes, and the ambiguous expressions in everyday language; nor do I mean precision in the technological sense. Technology observes objects from the point of their relative differences, from the whole to the broken, from the faultless to the defective, in order to determine, fairly rapidly and fairly accurately, whether or not something is functioning. I am not concerned with issues such as these, but rather with the obligation of the social sciences to develop a language which is as precise, conceptually clear-cut, transparent and controllable as possible. This is all the more necessary at a time when technological development is rapidly progressing and when its consequences are being strongly felt, leading to social agitation and social movements.

Let me proceed to a presentation of my major points, for which argumentation must await another occasion. I hope that these opening remarks have at least helped clarify my basic intentions.

Point One

The complexity of the environment, as of society, is a product of observations and descriptions. In other words, the complexity is not inherent in the matter itself. Nature is not complex. It is as it is; it is the way it is. It develops as it develops. Likewise, society is not all that complex. It appears to be complex only in that moment when it is observed. This fact is of great importance because we must observe the observer if we want to find out who it is that believes that things are complex and why it is that people think that things are complex.

Point Two

Describing a description as complex is in itself paradoxical. Perhaps it has not occurred to you before, but we use this descriptive concept in the singular: e.g., complexity or the complex society. It is treated as a unit, but the unit is made up of multiplicity. And in turn, it is a multiplicity only because we choose to describe it as a unit. How do we unravel this paradox? Or expressed in another way: How can we observe the way in which others deal with this paradox?

Point Three

There exists a variety of ways to go about observing complexity. For example, when we view modern society as complex, we orient ourselves toward that which we consider to be the reality. If we are scientists, we will have points of view that are different from those which we would have if we were active in business or politics. But we do not stop and reflect on the fact that we ourselves are simply observers. I share the view which both Christopher Alexander and Thomas Luckmann pointed out in their presentations at this symposium that the observer is part of what is observed or is involved in some way in the observations. Consequently, we must differentiate our observing of complexity, namely observing ourselves as observers, or observing others as observers.

This leads to a type of analysis which recently has been gaining attention and goes by such names as neo-cybernetics or second-order cybernetics or radical constructivism. This approach has as a starting point that one always networks all observations recurrently; one observes another observing and at the same time knows that one is being observed as an observer. This implies that, while observing and describing, one is aware that there are always other possible options. Observations can always be made from other vantage points. In a cybernetic context, Robert Rosen reformulated the concept of complexity in this fashion: complexity is something which one can observe in a variety of ways, and in a variety of ways in the sense that one can never reduce the various observations to a common denominator, that there is no one right way to observe. And so it follows, there is no authority which can be called upon to instruct others on the correct way to observe the complex world or society.

Point Four

For about 200 years, especially in Europe, there has been a "feeling" for this situation. Today, we can see tendencies emerging to concentrate on observation that the observers themselves cannot see. In modern society we are no longer a community which identifies its objects and describes its objects correctly by listening to those who are supposed to know.

The modern interest in latent structures and unconscious motives was first used by the eighteenth century European novelist and was later reworked by Marx in his criticism of political economy in which he observed something the capitalists themselves could not see: their own decline. The approach is tangible in Freud's works: the unconscious as a block to our ways of observing, the interpretation of motives, the discovery of latent functions and structures. Thus far, however, we have not yet succeeded in approaching complexity by trying to see what others cannot see, to describe what others cannot describe; we cannot incorporate this observation in the theory of knowledge. By and large, we still assume that there is a correct description of society and that science has the responsibility and the authority of being able to teach others what the "real" situation is, e.g., what technologies are "good" and what possible "negative" consequences they might have. If, however, we assume a recursive networking, assume that observations are always affected by the point of view from which they are made, must we then not conclude that the number of options is arbitrarily large and that each of us can make whatever sense we want to out of it. Is it only a matter of imagination and creativity? Have we arrived somewhere at the rococo of post-modern arbitrariness where everyone can pursue their own discourse free from the criticism of others? Or are there structures in modern society, quirks, characteristics, differing forms which limit us? Consider that we might be limited to observe in which forms society describes itself as complex, albeit in a variety of ways, even though we are able to conceptualize complexity against a structural backdrop.

Point Five

I believe that this is the place where epistemological or cybernetic considerations can be applied to sociology and to a theory of society. How does a society describe itself? What types of structures make descriptions, such as this, possible? Viewed from this perspective, the dominant ways of dealing with complexity would seem to be grossly oversimplified.

An initial strategy might be a description with implicit reductions. One would no longer approach society thematically. One would simply not pay attention to a system in which oneself, in one's role as observer, is a part. The problems of self-reference are ignored when building up complex systems, and the observer focuses on individual phenomena which can be arbitrarily dissected, recombined and structured in very complex ways. This is done, for example, when technological problems or their consequences are discussed. This type of description does not lead to a theory of society. This may or may not have its legitimacy, but we are surprised when society reacts to consequences of technology in an unpredictable, emotional, irrational manner. When anxiety increases, when the awareness of risks grows, when critical rejection is more frequent—such phenomena are not accounted for but simply registered with surprise.

A second way of dealing with complexity is also insufficient: complexity can be perceived as intransparency or ambiguity, a view which provides either an explanation for irrational reactions or for the possibility of somehow modelling and simulating or coping with the incomprehensible by new instruments or techniques that make imperfect solutions more perfect or capable of being improved. The modelling approach has led to a divergence between model and reality, as all are aware who are familiar with this approach. Now, it is apparent that the models have become very complex. The possibilities of what we can do by modelling are today much greater than they were prior to the invention of the computer. However, modelling or simulation techniques appear increasingly to have little to do with reality itself and so they are unable to predict the surprise reactions produced by society itself. I return to my third point: would it not be more useful to view the complexity of society as allowing a number of different descriptions none of which can be reduced in terms of the other? And would it not be more useful to admit that there is no single authority of the sort one finds in technological fields to decide what is right and wrong, what is faultless and defective?

There must not be a strategy but a realization: it seems to me that—what I shall call polycontextuality—the variety of description options is inherent in the structure of society, because we distinguish things in society within various different functional systems, i.e., the functional systems of science, economy, politics, law, education, medicine, etc. In respect to its own function or its own code, each system operates autonomously according to its own program and each system generates its own descriptions of the world and of society. For example, scientific analyses proceed in a way completely different from economic analyses, in which circumstances are viewed according to monetary concepts as objects of capital, investment, rational profitability, and the like. Each of these systems "constructs" its own environment and thus "produces" its own description of society. Likewise, science would "understand" the complexity of society in a way different from politics, and by the same token, politics in a way much different from economics, or economics in a way different from law. Since there is no central or supreme authority, or pinnacle of society, from which society could be correctly described, this may lead to a certain skepticism about the notion that progress in society could be directed or could be based on political or scientific principles; or about the possibility of developing a conceptual model which could be used to continually monitor the balance between the positive and negative effects of technology and to effectively maintain a balance in any positive sense of the word. Our society does not produce a representative depiction of itself within itself. And if such a representative text were to exist, according to which we were forced to observe and to experience nature and society, it would be quite intolerable for us or at best untenable. We would immediately observe that someone proposing such an idea would be criticized, for all such attempts are subject to observation. And if one did succeed in implementing such an idea for a given period of time—an example is at present the mandatory text for describing the society which exists in North Korea—the success is only regional and is usually greeted with amazement.

Summary

The following factors are all interconnected in one way or another:

(1) the dependence of complexity upon the observer. The main question is not: "What is complex?" but rather, "How does the observer describe it?"

(2) the systematic exercise of recursive observation of observers in the course of social evolution, exercised in Europe since the Enlightenment period or perhaps since the inception of the European novel;

(3) the functional differentiation of a societal system without having to reduce one function in terms of another as a decisive structural characteristic of the modern world;

(4) the view that the complexity of society results from the fact that society has many different versions of self-description and can only be described by using a plurality of descriptions.

Since all of these factors are integral to the structure of our society, we would have to study a totally different society to avoid them. And for this reason, anything we say about them can only be expressed in very abstract terms. I nevertheless hope that future research into the issue of complexity will consider the concept of polycontextuality.

Complexity: Created and Mastered by Technology

Achilles van Cauwenberghe

Introduction

"Simple is nice, but nothing is simple anymore."

The Greek historian Herodotus (fifth century B.C.) described a very complex building situated next to the mausoleum of Amenemhat III on Lake Moeris in Egypt. This giant construction (300 meters long, 240 meters wide) was built about 2,000 years before Christ and was used for the training of priests in astrology and astronomy. It had more than 3,000 rooms connected by a labyrinth of passages and corridors.

The most famous labyrinth, however, was that of King Minos at Knossos on the island of Crete, in which he held in captivity the dangerous Minotaur—a "Hercules" with a bull's head who was born from the adulterous love of his wife with a powerful bull. All those who wanted to fight the Minotaur got lost and killed in the complexity of the labyrinth. Finally, Theseus, the king of Athens, succeeded by using a long thread that Minos' daughter had given him because of her love for him.

The labyrinth was probably the first large-scale complex system to be described in history. It could only be mastered by a simple thought from a woman in love.

Historical Development Leading to Increasing Complexity

"Most great visions that have molded history have been built on concepts that could be stated very simply."

The history of mankind is characterized by:

- increasing population density (hence an increase in the number of brains per unit surface—see Table 1);

- increasing complexity of the artifacts, tools, artistic productions, and systems conceived and made by men (see Table 2).

Table 1

Epoch	Type of Civilization	Population Density (inhabitants/sq. km)
50,000 B.C.	nomadic hunter (fire, some tools)	0.1
20,000 B.C.	nomadic herder (domestication)	1
10,000 B.C.	agriculture	10
1800 A.D.	industrialization	500

Table 2
Major Inventions of the Industrial Revolution since 1700

Year	Invention	Inventor
1705	industrial steam engine	Papin (France), Necomen (England)
1745	automated textile loom	Vancanson (England)
1783	hot air balloon	Montgolfier (France)
1807	steamship	Fulton (United States)
1814	steam locomotive	Stephenson (England)
1827	photography	Niepce (France)
1843	electric telegraph	Morse (United States)
1866	dynamite	Nobel (Sweden)
1867	typewriter	Sholes (United States)
1871	electrical dynamo	Gramme (Belgium)
1876	telephone	Bell (United States)
1878	electric lamp	Edison (United States)
1883	automobile	Benz (Germany)
1890	airplane	Wright (United States)
1896	radio telegraph	Marconi (Italy)
1934	telex	
1935	television	
1940	computer	Zuse (Germany), Bell Labs (US)
1942	nuclear reactor	Fermi (United States)
1947	transistor	Bardeen, Brattain, Shockley (US)
1970	integrated circuits	(United States)

From a review of the history of technology (see Table 2) it is not difficult to distinguish *three waves of the industrial revolution:*

First Wave

1750—**steam-powered mechanization** began in Manchester, England, soon reaching a population of one million inhabitants or one percent of the world's total; this populace had little if any access to technological literature but still possessed considerable artisanal know-how.

1875—**electricity** becomes more widespread throughout Europe, which had 50 million inhabitants or about 10 percent of the world's population; characteristics of this time included widespread immigration to urban areas, massive impoverishment, social upheaval and revolutions, improvements in transportation and communications.

(1876—England passed red flag act for vehicles speeding over 5 miles per hour; English parliament elected by 10 percent of adult population.)

Second Wave

1950—**petroleum** is the preeminent energy source in the developed nations, which are home to about one billion people or one-third of the world's population; characteristics of this "wave" include cheap energy and many useful polymers from petroleum but also much environmental pollution from the various uses of petroleum and its derivatives.

(1975—Industrial production of the less developed nations or "Third World" is equivalent to the entire world's industrial production in 1900.)

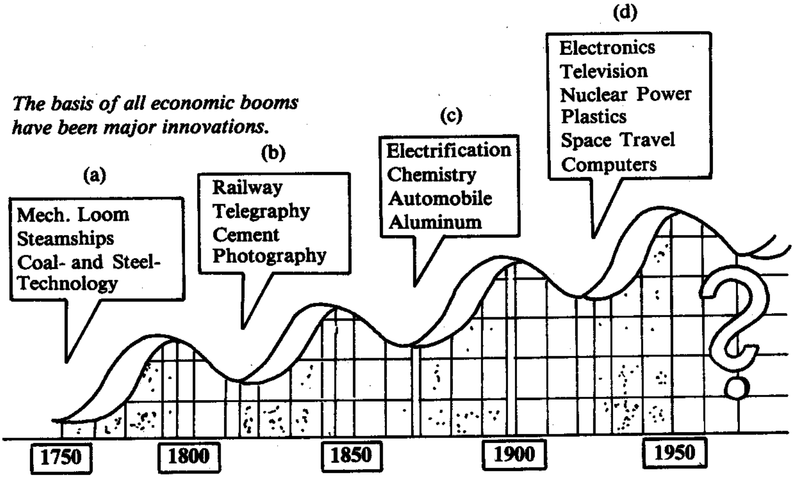
Third Wave

1980—**computers** "reign" in what some label the "Information Age" which seems to encompass most nations of the world; at least in the more developed nations characteristics of this age include: a broadened access to information; democratization; individualization, although this often means isolation and loneliness; depersonalization; and ongoing computer developments in such areas as expert systems and artificial intelligence.

It has been shown that inventions generate economic upsurges producing Kondratieff cycles with a periodicity of several decades (see Figure 1).

Figure 1

Waves in the World Economy Produced by Technological Developments



The driving force behind the world's development and the accompanying increases in wealth-creation is the growth in energy consumption. Consider Table 3.

Table 3

World Energy Consumption in 1980	=	6.4×10^9 ton oil equivalent
	=	25.0×10^{19} joule/year*
	=	8.0×10^{12} Watts
	=	2 kilowatts (kW)/ inhabitant**
	=	48 kilowatt-hour (kWh)/man, day

* 1 year = 3×10^7 seconds
** world population = 4 billion

The energy output of a human "slave" turning a dynamo is 75 watts or the equivalent of 1.8 kWh/man, day. If you take the 48 kWh/man, day, then divide it by the 1.8 kWh/man, day of the "slave" equivalents of energy consumption, you find that each inhabitant of the globe in 1980 had 26 "slaves" at his or her disposal. Conversely, one could state that modern technology has made slavery superfluous!

The Age of Information Technology

"Knowledge is power."
—Francis Bacon

Information technology (IT) has fostered greater understanding of large and complex systems (see Table 4). This is just as true for biol-

Table 4

Evolution of Information Technology

?	spoken language	
?	drawing	
c. 3600 B.C.	writing	written information stored and transmitted
c. 1700 B.C.	alphabet	
1000 B.C.-1000 A.D.	paper, books	
c. 1445 A.D.	movable-type printing	
c. 1830	photography	sound, text and pictures stored and transmitted at electronic speed
1840	telegraph	
1870	typewriter, phonograph	
1890	motion pictures, magnetic recording	
1900	radio	
1930	television	
1940	stored-program computer	expertise stored and transmitted interactively, accessible at electronic speed
1950	electro-photocopier	
1960	computer network	
1970	computer network with 200m connections	
	microprocessor	
1980	personal computer (PC)	
	optical transmission (1,000 megabytes/sec)	

ogy and medicine, or economics and management science, as it is for social sciences and engineering. Thanks to IT, people now know far more about the workings of self-regulating structures, such as governments, industrial enterprises, and economic systems, as well as about other large-scale complex systems like traffic systems, telecommunication networks, multilayer systems and ecological systems. In biology, IT helps further unravel the genetic code. In bioengineering, IT helps in the development of new molecules, new "species," new pharmaceuticals, etc. Large and complex systems can now be modeled and simulated on computers and their properties examined with greater consistency and detail than ever before.

Computers gifted with artificial intelligence (AI) will soon make logical deductions and reasonings that would be difficult for humans to follow and check. Expert system programs containing the compiled rich expertise of the world's best specialists in a particular field of knowledge (e.g., medical diagnosis, machine/factory monitoring, search of legal antecedents, automatic translation, etc.) will be difficult for non-computer aided humans to surpass in exactness.

This will result in the fourth major disenchanted awakening or disillusion for humankind's self-perception. The four disillusions are as follows:

First: cosmological (by Copernicus and Galileo)—humans are not the center of the universe;

Second: biological (by Darwin)—humans are not specially created beings but only the last step in a long evolutionary chain;

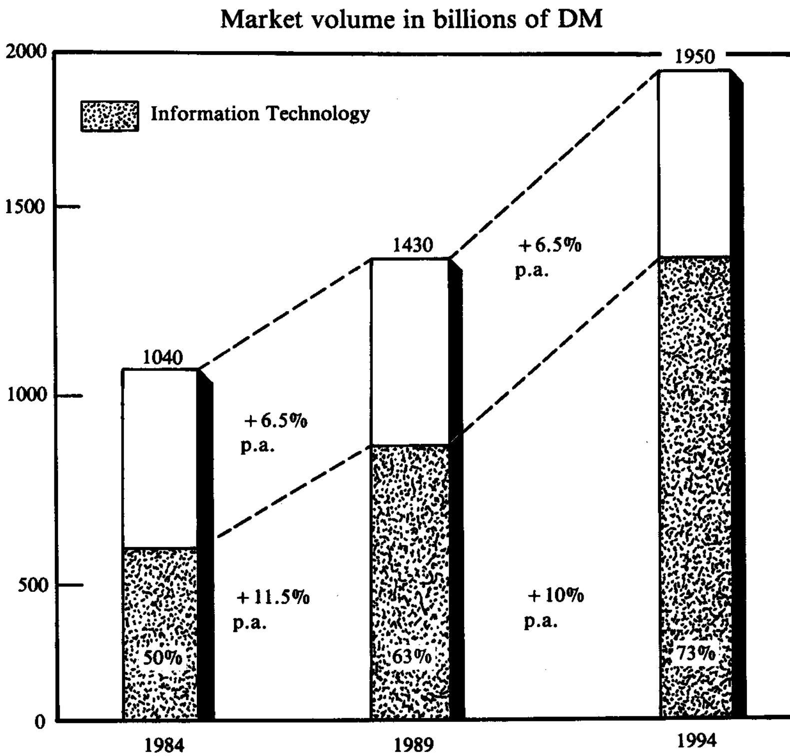
Third: psychological (by Freud)—humans do not consciously control their own faculties (i.e., subconscience, emotions, etc.);

Fourth: intellectual (by numerous discoverers, inventors)—humans may have to make use of the superior intelligence offered by a human-made computer system.

The information technology market is currently estimated at 250 billion dollars (in the Western world only) and is expected to triple within the next 10 years (i.e., annual increases of more than 10 percent). Its share of the world electrical and electronics market (not including consumer goods such as domestic appliances and entertainment electronics) will grow from 50 to just under 75 percent (see Figure 2).

Figure 2

Information Technology's Share of the World Electronics Market



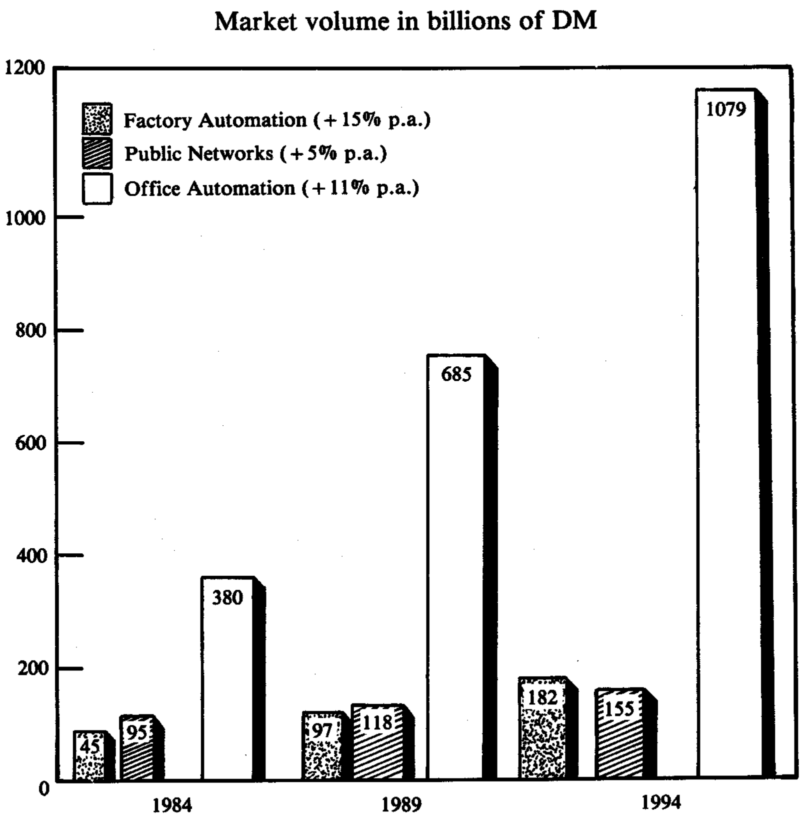
*Note: 2 DM (Deutschmarks) = $1 U.S.

Source: K. Kaske, "Information Technology and Individual Automation," Siemens Magazine COM, 15 (2) pg. 8, 1987.

If mainframes are included, office automation makes up the largest part of the IT market (see Figure 3). Although factory automation can claim distinctly higher growth rates, this segment of IT starts with a much smaller user base. Digitalization and integration of public telecommunications networks as part of the implementation of the ISDN (Integrated Services Digital Network) will be a relatively slow process.

Figure 3

Information Technology Market Segments



Source: same as Figure 2, pg. 9.

The total electro-market (electrical and electronic) is clearly dominated by the United States with 30 percent of market, followed by Japan with 20 percent, and the European Community with 20 percent.

Complex Systems

"There are three ways to ruin yourself: gambling, women, and technology! Gambling is the fastest, women the most pleasurable, technology the most certain."

Nature is complex, but still the human mind tries and often succeeds in grasping it using rather simple ideas. For instance, all chemicals are combinations of about 100 different atoms; all organisms are made up of two nucleic acids and about 20 amino acids; all forces can be explained by four basic forces.

However, not everything can be explained by this reductionist method. Complex systems do have special characteristics that are not (yet) explainable from the behavior of their constituent elements. The reader who concentrates on single letters will not necessarily understand words or sentences. Living organisms have a richer and wider spectrum of behavior than their constituent molecules. It has been necessary to introduce global characteristics that are different from the microscopic characteristics such as temperature and entropy of a thermodynamic system. New insights into the behavior of complex systems have been revealed by such scientific disciplines as fluid mechanics, systems theory, non-equilibrium thermodynamics, and computer science.

The better control of systems requires the implementation of new control levels, with further control equipment complicating the system. More audacious use of automation and information technology, most of which is already available today, will lead to higher productivity of human-controlled and/or conceived factories. Developments in monitoring and management systems will lead to even better but more complex high-yield/high-performance systems.

However, the principal issue for the coming years is not technological but rather the management of cultural and organizational change required to exploit the benefits from increasingly complex control systems (i.e., integrated control and management) such as wide-area integrated telecommunications networks, or continental power grids which tie in a variety of power stations to serve a wide-range of consumers.

Increased levels of technology, particularly the application of computers as a panacea, result in systems of unusual complexity that are prone to breakdown. The alternative is the use of technology in conjunction with, and complementing, human experience, creativity, knowledge and special human traits (taste, touch, emotions, scene recognition, etc.).

A major problem to be avoided is the application of too much technology too soon, i.e., to do things in such a complex way and at too early a stage that it does not turn out as well as hoped for in the initial planning. Systems are often made so complex that they may fail from "their own weight."

In the development of new technological systems, there seems to be a relation between a drive to eliminate human input, the generation of complexity, and poor performance of systems once put into use. While it is possible to design systems that minimize direct human input, often the result is a greater reliance on indirect input. To keep the equipment operating, workers must struggle against designs that seek to avoid their intervention as well as the actual problems of production. The result can be long periods of boredom when the operator's intervention is not needed, alternating with bursts of extreme stress when it is needed. At the time the intervention is critical, it is often difficult to exercise it effectively due to lack of practice. This may result in longer "down-times" or catastrophes (for example, the nuclear power plants at Chernobyl, U.S.S.R., and Three Mile Island, U.S.A.; or the chemical plants in Bhopal, India, and Seveso, Italy).

"On July 11, 1987, United Nations statistics 'pretend' that the five billionth world citizen was born. This infant has a 92 percent chance to survive to adulthood with a life expectancy of slightly more than 60 years. This child will enter school at the age of five. After finishing elementary school, the child will have to look for a poorly paid job in agriculture since the government will not be able to provide any further education. At age 20 or later, this person will try to emigrate to a town hoping for better living conditions. Unfortunately, town life will be spent in a shanty or slum dwelling without electricity or water supply and will continue amidst poverty, unless . . ."

—UNESCO

Closing Session

Complexity: The Historical Dimension

John M. Roberts

Introduction

Most of our distinguished speakers have been drawn from the applied or social sciences. My own selection for the honor of delivering the concluding address therefore finds me conscious of a certain isolation. I have been educated not in any of those disciplines, but in one of the traditional humanities: I am a historian. I can only try to identify ways in which my own discipline—history—may throw some light on the complexities of the human environment which we have been exploring. I cannot promise that this will point to easy solutions—or any solutions at all—to our problems. It may even leave some of you feeling a little more confused, or troubled by the ironies of history. Nor have I general lessons to draw. In a few minutes I want, rather, to emphasise the particularity of history and take a microcosmic rather than macrocosmic approach to our subjects. It may seem cautious, but that is the way my discipline proceeds.

The setting of our debate: a certain uneasiness

Let me begin with a historical observation: neither this gathering nor our discussion could have been held a hundred years ago. To say this is not simply to draw attention to the banal fact of material change in the last hundred years which has made it easy for so many people from different parts of the world to come together, or even to the generosity of the Honda Foundation whose industrial base did not exist then. I mean rather that a century ago this conference would have been psychologically impossible. The cultural setting could not have produced or sustained it; the themes we have been debating would not have occurred to our nineteenth-century predecessors, not just because they did not have access to our information technology, our psychological knowledge, or a hundred and one other things, but because the sum total of all these specific differences in experience presents us with a whole new cultural situation.

This is manifest, it seems to me, in the tone of the papers read to us. Perhaps it is going too far to call that tone pessimistic, but it is at least cautious, even apprehensive. It reflects a broad uneasiness. There is no point in attempting to develop this observation. I only wish to suggest it reflects a more general recession of confidence. Our culture has become more skeptical about human solutions, and we are used to questioning the old belief in the inevitability of progress. *Grosso modo*, that belief and the confidence it generated were created by the Europe of the Enlightenment. They rose to become the dominant strain in western culture during the late nineteenth century and the first decade of this one. Now they have ebbed and, even if they have not completely disappeared, a symposium such as this has become possible, even necessary.

Much could be said about the slow ebbing of a predominantly optimistic attitude and a diminishing faith in the capacity for betterment. We have only too clearly *not* mastered the complexity of our environment when staggering recent increases in agricultural productivity coexist with chronic famine or near-famine in some parts of the world,[1] and when we have succeeded in putting men on the moon, but cannot liberate ourselves from urban structures which have often ceased to be frameworks of liberation and are, instead, prisons for millions of slum-dwellers.[2] In reflecting on such familiar paradoxes, a historian, however much he or she is by nature an activist and wishes to find solutions, nonetheless tends to think about them from a historical point of view. Whatever the data provided by "nature" (and however we draw the boundary between that slippery notion and the world we humans have created and contrived), the present complexities of the human environment are historical products. They have origins in the past which can in principle be identified and scrutinized. Some of these origins, too, are not hard to discern. For example, it is not difficult to see that the emergence of new problems follows upon the solution of older ones, as does night upon day. It needs no great insight to say that our population difficulties owe something to a welcome increase in food production which has made it possible to feed more people, and to advances in public health or medicine which have made it possible to keep more people alive, even if in dire poverty. There seems to be a dialectical principle at work which almost guarantees that technological advance will sooner or later, generate new difficulties and pose new problems. In advanced countries, for instance, we are now beginning to talk not only about a seemingly ineradicable structural unemployment, but about leisure itself becoming a problem as technology modifies demand for labor. A leisure problem! When leisure itself was for thousands of years an undreamed-of luxury for most of mankind and the notion of an annual holiday has only been established in advanced economies within the last half-century or so.

Perhaps a more somber reflection for the historian, though, is our daily awareness not of the appearance of new problems but of the survival of older problems still unsolved. We have not had a great war between great powers for over forty years, but there has been no day within that period when men, women, and children have not been killed in war-like operations somewhere in the world. Violence is not a problem which has been mastered or gone away, old and familiar as it is, even though it and its specific origins have (often by historians) been much researched. A more specific instance and the most sinister single revelation of problems which have not gone away or been solved, of course, remains the monstrous reemergence in the horrors of Hitler's New Order of tendencies long thought dead and buried. Here is an appalling instance of history's contribution to the complexity in which we live.

Historical complexity

Of this historical complexity in the human situation I wish to speak in the remainder of this address. It is a matter of the weight and richness of an environment, of our historical environment, of our past. Usually, we sense that past as a matter of physical legacies. We are today in Vienna, a great city with a rich physical heritage of buildings, monuments, and works of art to bring its history vividly to our eyes. But consider that historical environment in a different way, as a matter of intangibles. Vienna was, after all, for four centuries an imperial capital shaped by governmental needs arising from dynastic possessions which sprawled across Europe from Flanders to the valley of the Po, and by peoples of many tongues and ethnic origins. This city—as quite trivial signs such as its restaurants can remind us—was also a gathering-place of those peoples; it was cosmopolitan, and that deeply marked its cultural inheritance and cultural products. Among those peoples, notably, were large numbers of Jews. Many of them came from the east to a city long conscious of itself as a frontier bastion of civilization and a standard-bearer of religion, for Vienna was also a great Catholic city of the Counter-Reformation. This was some of the background vividly present to the resentful, half-educated mind of the disappointed but ambitious young Hitler, who tramped these streets at the beginning of this century, as well as to the careers of Freud, Mahler, and many others. Neither they nor Hitler could be untouched by the historical environment in which they moved and the atmosphere which surrounded them.

The persistence of an inhibiting past is one of the many ways in which history contributes to the complexitiy of the human environment. Such past is literally a social determinant of much that we say, do, believe, and think. Certain things we cannot do, just because this past is there, a *datum*; certain solutions, however persuasive their logic, are not available to us. To pursue such solutions is like asking the trombones of the orchestra to play the violin part of the score. They are not a part of the repertoire history has left to us. The management of affairs in Northern Ireland, for instance, is made immeasurably more difficult by historical memory and tradition. That this is often untrue memory or invented tradition is neither here nor there; the names of Oliver Cromwell and William III are alive in Ulster's popular politics, however misleadingly they are used. Of course much of the past which determines our present is mythological. But what is important about myths is not their correspondence or lack of it with reality, but their effectiveness in moving men to action or inhibiting them from it.

Let me give you two less familiar, almost anecdotal, but revealing examples of historical legacies which show how the historical dimension complicates social and political change. Both come from violent periods of upheaval, one much better known to this audience, perhaps, than the other, and both show people turning to a mythological apparatus inherited from the past in order to grapple with the difficulties of surprising and unaccustomed change.

The first comes from the France of the French Revolution; the year, to be exact, is 1796.[3] At that moment large areas of the country were disturbed and virtually in rebellion against the central revolutionary government in Paris. It had suited that government, in the crisis of the revolution, to represent all its opponents as a unified royalist-clerical coalition intent on bringing back all the Revolution had swept away, bent on restoring the *ancien régime* as much in its religious as in its secular reality. For the revolutionaries, the outlook was simple. Who was not for the Revolution, was against it. You had to be committed, if you were a Frenchman, to the reactionary, superstitious past or the revolutionary future—that was the ideological code in which information was to be read.

The west of France was still in 1796 a specially troubled region. One day, a young girl from a village on the edge of the Sarthe, of a family who was, like herself, committed to the revolutionary cause, was attacked and murdered by ruffians. The word went round quickly that she was a victim because of her revolutionary sympathies and that her attackers were royalists—opponents of the regime. Yet it is hard to believe they were anything but casual rapists such as now flourish in the unpoliced streets of our great cities and in those days made it unsafe for a girl to walk in the lonely countryside. Soon, at her grave, people began to gather to lay flowers and little gifts; miraculous cures were reported. The girl was spoken of as a republican "martyr": she was alleged to have been seen rising to heaven, an angel with wings of red, white, and blue (the colors of the Revolution), although angels were usually regarded as the stock-in-trade of the reactionary clergy of the counter-revolution. A chapel was built on the site. Committed to the Revolution though they were, the local inhabitants found it easiest to express that commitment in the forms of traditional religion usually associated with the anti-revolutionary cause.

For my second example, I go to the other side of the world, to Indonesia, and to a period much nearer our own, just a quarter-century ago. Many of you will recall that in 1965 large-scale massacres took place in Indonesia which effectively broke the power of the Indonesian communists, wiping out the bulk of their cadres and known adherents. What is less well-known is that the likely onset of these massacres, which had wide popular support, was announced by mounting messianic, milleniarist fervor. As in 1825, when the native Javanese princes made a last attempt to resist the encroachments of Dutch power and its concomitants of European and Chinese immigration, it became widely felt in 1965 that a golden age of justice was on its way, to be preceded by a violent cataclysm in which the unjust and unbelievers would be destroyed. In each instance, indigenous resistance to the introduction of unwelcome and alien ideas found expression in the minds of the masses in a traditional imagery. What is more—I am reliably told—on each occasion the dissemination of the hopes of a new era was achieved by the use of traditional forms. One such form was the shadow-puppet theatre. The shadow-play of Indonesia had always been a religious rite as well as a popular entertainment. The repertoire of the shadow-theatre was mainly based on the legendary Hindu epics of the Ramayana and Maharabata. The main characters of these epics were well-known—as well-known, say, as the characters of certain saints in the Christian Middle Ages. The people could identify with many of them. As the moment of outbreak came closer, it appears that both in the early nineteenth century and the 1960s the characters in the shadow-plays began to spell out messages of approaching cataclysm. In 1965, indeed, groups of soldiers who seized buildings and murdered communist officers sometimes bore names taken from the plays.

When one considers episodes such as these—and, since I have no time to do more, I must simply assert that other examples could be cited—it is surely difficult to deny that very powerful traditional psychologies are at work. Evidently, people find it easy to turn to deeply-rooted historical mythologies in order to handle their problems. This is easiest to see when it is just a matter of stereotypes—of ethnic or communal identity, for example—which provide a shorthand language for the management of the raw data of experience. "X behaves like a typical Englishman: insensitive, hypocritical, and materialistic"—and so on. Such observations are so crude that it is easy for us to underrate their potency. But in some cases more elaborate mythologies are employed (as in the two instances I have cited) to deal with disturbing realities. Yet we often ignore such historical legacies as operative facts. We should rather recognize their efficacy; they make it possible for people to understand and endure change. They may be false history, from the professional and scientific point of view, but they are often pragmatically useful, even if sometimes harnessed to degenerate or inadmissible purposes.[4] Even more, though, we should pay attention to them because they also have major negative implications. After all, though they often succeed in setting men's minds at rest by putting unfamiliar facts in a familiar framework, they also limit men's understanding of what is actually going on. This often stops us from seeing new situations and new problems as they really are. Historical legacies clog up our information systems. So they can also make adaptive change more difficult.

Obviously this historical environment is something of which we are usually not totally aware. It can operate upon us, if we are not careful, without our knowing it. In many contexts this does not matter. Few Frenchmen or Englishmen, for instance, do other than take it for granted that the *maire* of a French town wears a tricoloured sash of office, whereas his English counterpart wears a chain which suspends on his breast a heraldic medallion displaying the coat-of-arms of his locality. Yet these little signs are condensations of centuries of history and two quite divergent traditions of local government. The French *maire* wears the emblem of the state, *l'etat*, the republic; he is an official of the nation administrating a portion of its affairs. The English mayor is the elected head of a community, chosen to speak for his fellow-citiziens, often against the policies of central government. The rich historical legacy is in each case taken for granted and probably not wholly understood, but that does not much matter. In other cases, such legacies have often proved dangerous. Someone once said that nineteenth-century English statesmen did everything they could do for the Irish—except to treat them as Irishmen, and not as Englishmen.

History as inhibition and misdirection

Sometimes the traps in which history entangles us are very subtle indeed. For example, if one looks at the way other countries saw Nazi German between 1933 and 1939, it seems clear that, at least in England, many statesmen and politicians lacked historical understanding of what Nazism meant, or else had false understanding of it. England's rulers tended to treat it as some sort of aberration. Many of them attributed it to the inexperience, or sometimes to the criminality, or even to the derangement of Nazi leaders. There was little willingness to recognize it as the outcome of a certain historical culture and of German society. Of course, some observers tried to give a short-term historical setting to Nazism. British liberals, for example, often emphasised that Germans felt their country had been unjustly treated at Versailles. But few Britons recognized that Hitler also expressed aspirations and dreams widely-treasured among many of his countrymen, or that these could be traced back long before 1919; little historical understanding was shown of the acceptability to many Germans of aspirations to hegemony in *Mitteleuropa*, of dreams of racial colonization in the East and of racial purity, and of a world-historical role for Germany.

In spite of one or two prophetic nineteenth-century voices—that of Burckhardt springs to mind—those raised in a liberal, progressive culture found it hard to give due weight to forces long believed to have been superseded, mastered, or excised from European history. For all its scholarly achievements, the culture of the nineteenth-century European world had been in one way profoundly anti-historical. It was confident of progressive, humanistic values and gave them a superhistorical standing. It *knew* where history was going—in the direction of the mastery of history by culture and reason. This was the doctrine of progress. It implied, really, that history could be ignored. The notion that a man like Hitler could cherish dreams capable of being accepted as practicable goals in a society so advanced (and in many ways so liberal) as Germany was hardly imaginable even to many who were sincerely opposed to him as a threat to peace. They were trapped by history, by their own history and that of their culture, and one of the salient features of the trap was that they did not realize they were in it.

Not all historical traps inhibit action, though. Some encourage it—but it is inappropriate action. Examples occur to me from the history of my own country, in, for instance, the way that the shadow of the First World War hung like a cloud over British foreign policy in the 1930s. What was believed to be the lesson of history—that what had happened was something so dreadful that nothing could ever justify running the risk of another war—helped to maintain what has become known as the foreign policy of "appeasement," practiced most notably between 1933 and 1939. Members of the governments of the 1930s believed that a democratic electorate was not prepared to tolerate rearmament and its risks, nor to resist Hitler by being ready to go to war in defense of the Treaty of Versailles. Twenty years later, the past was again misread in the crisis over Suez. (I am tempted to apply to it all a well-known witticism of Karl Marx: "Hegel remarks somewhere that all facts and personages of great importance in world history occur, as it were, twice. He forgot to add: the first time as tragedy, the second as farce.") In the Suez crisis, there is ample evidence, that British policy was heavily influenced by a particular reading—or, rather, misreading—of the history of the 1930s.[5] By 1956 it had become a widely shared view in England that failure to check unjustifiable and predatory seizures of territory by Hitler had led to the suffering and destruction of a second World War, which could have been avoided had people stood up to him earlier. Nor was this view shared only by the Conservative government and its supporters. The leader of the Labour Party, Hugh Gaitskell, himself invoked a parallel between Nasser and Hitler in his first speech to the House of Commons about Suez. As late as November 1, the *New York Times* was drawing analogies with Hitler's remilitarization of the Rhineland twenty years before. The parallel was, of course, fantastically inappropriate. There could be no comparison between Germany in the 1930s and Egypt in the 1950s as a potential power-base for aggression.

Here, it seems to me, the same country's foreign policy, within the compass of a quarter-century, shows all too well that the conscious scrutiny of the past as a search for guidance can come up with the wrong answers. Somehow, the weight of the past upon the feelings and emotions of men impeded their achievement of a true perspective upon it. No doubt one could find similar episodes in the history of other countries. Perhaps this only shows that the wrong way to start to disentangle the historical complexities of situations in which we find ourselves is by seeking close parallels. That approach tends to strain out of any situation just what it is that makes it unique and individual. This does not mean, though, that historical judgment and reflection, properly brought to bear, may not be helpful.

History and the understanding of social process

Let me turn, briefly, to another phenomenon which commands much attention today and to which the Suez episode makes a natural prelude. This is what we may loosely call "the Islamic resurgence" of recent years. Immensely diffuse and varied phenomena are lumped together in blurred fashion under that label, but one of their common characteristics is that they are all, often quite consciously, responses to history. They all rest on certain readings of history. This history is a long one, but the part that really matters is that of the last two centuries or so. It begins, if we wish to have a specific date, in 1798, with the arrival of a French army under Bonaparte in Egypt, then part of the Ottoman Turkish empire ruled from Istanbul. From then on, the history of the Islamic world of the Near East was for nearly a century and a half one of disruption by the West. Some of the forces of disruption were military and political: that was how, for instance, the Ottoman Near Eastern empire was shattered in the First World War, and how the British, French, and Italians established themselves in its former territories. Some disruptive forces were economic, French banks and American oil companies among them. Sometimes they were more indirect and subtle; it was through French schools and American missionaries and educationalists that elites in Egypt and Lebanon were successfully introduced to Western ideas and ideals. One way or another, though, the awakening of aspiration and of envy of Western techniques launched the Islamic world of the Near East on to the road of modernization.

Modernization is the establishment of a claim to respect. It is also, and not only in the Islamic world, one of the major dislocating forces of our age. In Western Europe and North America, it advanced sufficiently slowly for the dislocations (or most of them) to be contained. Elsewhere, where modernization has been more sudden in its onset, those dislocations have often been much more difficult to manage. Let us continue for a moment to limit our observations to the Islamic Near East. There, the responses to the challenge of modernization were very varied. In Turkey, the Kemalist program was one of revolutionary conversion. Islamic custom was downgraded, a Western script was adopted, a new national state replaced the old dynastic multi-national empire, and so on. In Iran, Reza Shah pursued (slightly less vigorously) a similar line. Egypt turned to nationalism and, less assuredly, democratic government and economic planning. Saudi Arabia and the Gulf sheikdoms long took a much more cautious stance: protected by remoteness and the wealth their oil gave them they could, it seemed, safely rebuff, or canalize and regulate, change.

Yet, in whatever degree it was achieved, modernization was almost everywhere a disappointment to millions in the old Arab, Turkish, and Iranian lands. Often it delivered economic development—but not to the benefit of the masses. Sometimes it brought political disorder and disruption. Almost everywhere it deeply offended fundamental religious susceptibilities. The most dramatic evidence was the resurgence of Moslem fundamentalism in the Iranian revolution which brought Khomeni back from exile to power. This institutionalized a cultural, political, and ideological struggle to reverse the tide which had appeared for so long to have run in favor of westernization and modernization, and at the cost of Islam. It was not something which should have taken Western observers by surprise, but it did. They had ignored signs that though Islam had not provided an effective political framework for resistance to overt alien interference, neither had the modernizing Western alternatives of nationalism, liberalism, and communism. They should have paid less attention, perhaps, to political and economic elites than to straws in the wind—such as that provided in 1978 at the Cairo medical school when three young women refused to dissect male corpses, took to the veil and *chador*, demanding academic segregation from male students and a dual curriculum reflecting Islamic notions of appropriate roles for women.

Many in the West still construe this struggle in inappropriate terms. They overlook its rejection of both of the major ideologies of the West—Soviet communism and capitalist liberalism. They are baffled by analogies drawn by Islamic spokesmen between the short-lived Crusader kingdoms of the thirteenth-century Levant and the modern state of Israel (often seen as a similar intruder from an alien culture). They are amused or simply puzzled by the identification of the United States as "Great Satan," assuming at best that it is a fragment of exasperated rhetoric; they do not grasp the resonance of a phrase whose roots lie deep in the Persian past, before the commitment to Shi'itism, before even Islam itself, in Zoroastrianism and the primal myth of cosmic dualism.

If, though, Western observers need to take more history into account in order to assess the Islamic revolution correctly, so, I think, do the Moslem fundamentalists. Though my ignorance of their culture should disqualify me from expressing a view, I hazard the suggestion that great abstractions are always a danger to understanding. Of course we can talk, and talk meaningfully, about "Islam," as we can talk about "Christianity," but the "Christianities," of, say, the third or twelfth or twentieth centuries A.D. are, all scholars recognize, very different things. Consider only one aspect of this, the role of Christianity as a corrosive and solvent of other cultures. Across the centuries it has often shown its destructive power. This was long ago recognized in Gibbon's splendid sneer about the decline and fall of the Roman empire being a triumph of "barbarism and superstition." But it could as well be discerned in the fear and loathing Christians have often shown of other cultures and of their ruthlessness towards them, from Aztec Mexico and Inca Peru to Hindu Goa and Confucian China. The Christian impact was long mediated through missionaries and soldiers as well as through the less explicit devices of cultural bribery. Only in this century, when Christian doctrinal coherence has fragmented or collapsed and when self-confident conviction of its uniqueness has ebbed, has it seriously started to exploit syncretic, adaptive forms of interplay with other cultures. But it has also seen much of its melioristic, humanitarian concern taken over by nonreligious agencies; this has often ensured that the fundamentally corrosive nature of many Christian ideas is still undermining and destabilizing other cultures at a time when its old overt hostility to them has ebbed. Given such colossal changes in Christianity's historical role, and even allowing that they have taken place within what has been for centuries the most dynamic of the major cultures, is it not surely likely—whatever the myth-makers say—that another world religion, Islam, has similarly changed deeply across the centuries as it has come to terms with new facts? And that one of those facts is the process of modernization?

If we are to come to terms with such facts, surely we must try to see them in a truer historical perspective. Modernization is, after all, the outcome not of some abstract system of forces but of a unique cultural tradition. It is, in the end, the product of a European past. Its assumptions, goals, and methods, for good or ill, all bear the stamp of the past, however now mediated through non-European and non-Western agencies. This past lies behind the phrase used by Mr. Shimoda at the start of proceedings when he spoke correctly of "*our* civilization." It is only in the last fifty years or so that it has become possible to use that phrase, as a particular tradition has come to be dominant worldwide. There is not time and there is no need to embark here upon a discussion of the full implications of the European past for the world. But perhaps you will tolerate an attempt at a very bald overview of the outcome of centuries of modernization. First, we should note that severance from ancestral ways always created a potential for destabilization. Secondly, almost universally, grave damage was done to indigenous culture, which was always thrown on the defense and was sometimes wiped out. Thirdly, one early result was usually, in some measure, the assimilation by elites (rather than masses) of many Western ways of thinking, many Western values. Fourthly, the process is still continuing (even if there are now strong signs of reaction and resistance in the Islamic world). Fifthly, it shows no sign of reversal.

Curiously, modernization seems to have been most successfully managed in one country where the presence of ancient, deeply-rooted civilization might have been expected to stimulate the deepest resistance: Japan. It is perhaps the exception which proves the rule, for many other countries evidently lacked the particular historical preparation which made it possible for the Meiji statesmen to launch their revolution successfully. China lacked that preparation and took a century and a half of internal debate and struggle before opting formally for a version of modernization which is no less Western because it comes wrapped up in red trappings. It is a striking paradox that one quarter of mankind should now be ruled in the name of the ideas of a German intellectual whose mind was formed by the classics of the Greece and Rome, Hegelian philosophy and classical political economy. India came to modernization by yet another road, that of forcible integration with the West through British imperialism; it seems to owe much to the relatively long period of adjustment which that permitted before the non-indigenous ideals of nationalism and democracy—or, if you prefer, of Mazzini and Mill—were institutionalized. In Africa, on the other hand, the impact of modernization is still largely negative, except in a few places heavily marked by former imperial rule. Islamic and Mediterranean Africa share, perhaps, the diverse experiences of the Islamic Near East, but in Black non-Islamic Africa, the costs in destroyed and disrupted institutions and economies seem pitifully obvious, while the positive result in the adoption of alternative, originally Western institutions seem tiny.

It will, I am sure, not have escaped your notice that I have, hitherto, always spoken of modernization as if we all knew, and agreed, what we meant by that term. I have refrained from definition and, instead, presupposed that we all had something which social scientists might call a "model" of the phenomenon in our minds. That is, of course, a recognized and legitimate way to proceed. One can then assess "success" or, to use a less evaluative term, "performance" in modernization by classifying societies according to the degree to which they have, or have not, met the postulates of the model. For example, we might say that tests of modernization would include considerable national economic strength, a risen standard of living, the presence of advanced technology in many economic sectors, high productivity of labor, and a wide diffusion of education and literacy. Yet, as I have already remarked, modernization comes in many packages, mediated by many agencies—the practice of European administrators, ideologies like Marxism or nationalism are some of them—which give it distinctive coloring and impact. The concept may be universal, but the actuality certainly is not. Not only is the reception of modernization conditioned by the receiving environment, but modernization is always a particular positive experience, historically conditioned at each point of application, always relative, always itself a developing reality.

You will understand now why I feel so strongly that when we cast about (understandably with urgency) for solutions to our complex problems, we are always in danger of neglecting the way such an instantly recognizable and even, *prima facie*, instantly understandable process as modernization is confused by and cluttered up with legacies of history and that history must be given due weight in approaching it. To the understanding of the richly varied pattern of response to it, nothing but confusion can be brought if it is approached in a schematic, generalized way, as a single phenomenon likely everywhere to yield similar results.[6]

Conclusion

I must not shirk the attempt to come to a conclusion; it is the professional vice of a historian to suspend judgement while waiting for more evidence, but you are entitled to expect me to say where I think our debate has got to. You will not be surprised that it is my view that only close attention to the historical record in each instance can reveal the true nature of the problems which now confront us. But that is to leave matters at a very general level. Let me return to the subject of the whole symposium and approach my conclusion through another question. Is the mastery of our complex environment an attainable goal? I believe that before we can say, we must ask something else: can its historical component be mastered so that we control it and it does not control us? Or is that historical component systematically uncontrollable?

Quite a lot of evidence seems to the point in the direction of skepticism. There is a certain logical incoherence or circularity in pretending to understand (and so to master) the history whose creatures we are. Marx himself never faced the paradox that his own intellectual authority depended on the belief that he alone had transcended the limitations of historical relativity which he discerned was encumbering all other thinkers. He sought to deliver mankind from the thrall of history while himself being the creature of a particular history. Asking for a nostrum for all our ills, then, might be too much; perhaps an exhaustive and wholly effective science of society is incredible. We need to plan for the fortuitous, the contingent, and the circumstantial, and that sounds to me more like an exercise of judgment than of science.

What about asking for a therapy? That, in the end seems a little more promising. I have always been attracted to the idea that history might be a kind of collective psychoanalysis, releasing, by identifying, the constraining forces of the collective subconscious: received ideas, entrenched myths, and the like.[7] The next stage might be to ask what else we can ask for from better historical understanding. Well, to begin with, there is nothing like history for making one humble, and that is a good first step toward prudent action. It must be good to be cautious because we know the future will always be somewhat surprising. Yet to accept that demands that we reconsider the place which the study and teaching of history has in our society, a very big implication indeed.

One thing, at any rate, seems to me as certain as anything can be: we shall not get better at tackling the huge problems of the first global society there has ever been, and nothing is going to be very different, if we do not recognize and strive to give due weight to all the complexities of the human environment. And these are historical as well as technological, psychological, and sociological.

Notes

1) *The Economist* of June 21, 1986 pointed out that British wheat yields per acre had risen 50% in a decade, that the United States was already storing 80 million tons of grain (roughly a quarter of her annual output), and that China had increased coarse grain production by a third since 1978.

2) The old phrase, *"Stadtluft macht frei,"* could hardly be comprehensible in, say, Mexico City today.

3) I borrow my instance, well-known to specialists, from A. Soboul, "Sentiment réligieux et Cultures populaires pendent la Révolution: Saintes patriotes et martyrs de la liberté," *Annales historiques de la Révolution Francaise*, xxix (1957), pp. 193-213.

4) Although I have not been able to check the original source, I find a helpful comment by the psychoanalyst A.J. Solnit quoted in D. Lowenthal, *The Past is a Foreign Country* (Cambridge, 1985), p.xxiv, on the need for the individual to achieve "a useful and self-respecting past", "a knowledge of his own history that does not dominate, overburden, or destroy him."

5) See, e.g., Eden's long telegram to President Eisenhower setting out the analogy in the first volume of his *Memoirs, Full Circle* (London, 1960), pp. 464-7.

6) Cf. a remark made by a Western scholar with specific reference to China: "We must resist the temptation to let our drives as Western moderns (*sic*) color our judgment as to the forms modernity could take in a post-Western world." (P.A. Cohen, "Wang Tao's perspective on a Changing World" in *Approaches to Modern Chinese History*, ed. Feuerwirker *et.al.*)

7) It has been suggested that this beneficial effect of historical debate can already be seen in contemporary Germany as historians strive to grapple with the historical explanation of Nazism.

“From the Mechanics of Power to the Mechanics of Intelligence”—The Form of Civilization Calls for (F + f)

Shuhei Aida

Introduction

I had the honor to give a lecture at the recent ninetieth anniversary ceremony of the Japanese Society of Mechanical Engineering. The Society’s slogan for the next 10 years is “From Mechanics of Power to Mechanics of Intelligence,” which I find to be extremely attractive, and which encourages me to speak on “eco-technology,” a subject often heard when we discuss the encounter of man and technology in the twenty-first century.

With this slogan in mind, I would like to focus on some of the structural changes in society which are related to complexity.

Structural Changes in Mass Society

The development of automation technology and information technology is, as is widely known, bringing about great changes in the social structure. This would indicate that high tech has reached a certain level and has matured enough to even affect our culture.

High tech innovation has made a distinct mark in the mechatronics field and has succeeded in automating many appliances used in our daily life. The camera, for instance, now requires no high-level training in its handling for it has become possible to take a good photograph merely by directing the finder to the object while the focus and exposure are set automatically. The emergence of these foolproof cameras, followed by continuous improvement in mechanical functions, has greatly changed our attitude toward the camera. It has now become possible for anyone interested in photography to take pictures equal to those of first-rate photographers with just a little guidance on the handling of the camera.

Does this not, however, indicate that man's mechanical ability is being lowered? The old-style machine, with which it was possible to take photographs only after a proper study of the principles of the camera and its structure, has practically disappeared and has been replaced by a "black box" mechanism which produces good photos just like the "cream of the crop." It is ironical that improvements in mechanics have caused a decrease in knowledge of machinery and mechanical techniques.

This is also true of factories and offices. The development of automation technology based on computers has gone so far as to cover such areas as robots and automatic drawing instruments and is rapidly spreading to the fields of clerical processing in the forms of personal computers and word processors, with the result that people working in these areas are able to undertake a certain level of job without needing as much training as before. The highly mechanized jobs, in effect, are turning out large numbers of "anybodies." With the introduction of high tech, the worker's output on a job has become uniform.

After a certain period of training in the operation of machines, a worker new on the job is able to take on the same kind of job as a worker with 10 years' experience and can turn out similar results. With just a little effort he can acquire the technique to operate machines.

Such high tech applications have also brought about an even more distinct ranking of people in society. For those who show no interest in high tech and confine themselves in their own shells, high tech machines have absolutely no significance. As a result, a growing gulf of hitherto unimagined depth has arisen between these people and those who are able to make use of high tech. In spite of this, there is no doubt that in the fields of traditional arts old techniques will be maintained and upgraded. For ordinary people, however, it is being made ever more clear with the development of high tech and especially now in this age of transition that the waves of high tech do not necessarily bring about the betterment of daily life.

The necessity of "life-long education" comes to mind. To put it specifically, there is now a need to build up an environment in daily life in which each person is able to take an interest in and carry out something. If the interest is directed also toward high tech machinery, then it is necessary to take active measures to provide the people with equal opportunities for the training in and access to high tech mechanics in their daily life.

This idea should also be reflected in the construction of high tech information communication systems. I feel strongly that we are now undergoing a transfer from the age of the mechanics of power to that of more human "intelligence."

The Completion of the "Mechanics of Intelligence"

Waves of high tech are hitting us in rapid succession. Faced with a wide variety of high tech products, we are now in an age where we are obliged to make a selection of our own from the numerous things on offer. Automation technology has allowed the production of small amounts of a wide range of goods and, accompanied by the continuing fruits of the development of new technology, all products are now imbued with a heightened element of fashion, thus consumers need to make clear their individual tastes.

I hear that today's young girls visit the same shop three times before they buy their clothes. They go with their friends the first time just for looking, the second time they take their boyfriends along, and the third time they go with their parents or whoever will pay the bill to actually buy the item. This shows that these girls lack confidence in their ability to make a choice by themselves since they are uncertain of their tastes and are worried about what others will think.

This tendency, however, is prominent among the majority of people, and those with tastes enough to be original are actually in the minority. The extension of choice in our life, needless to say, does not merely affect the field of daily life, but is of great significance in the whole of our lives. If the technology for choosing the gender of babies in advance becomes perfected in the near future, people will have to make such a choice for their children-to-be. If a technology is found which enables humans to foretell the time of death, each person will have to select a time to die.

For such advanced technologies we will need an even higher technical knowledge if we are to avoid an unfathomable gap between those with such knowledge and those without. There are clear dangers if we do not spread among the general puplic the knowledge and experience which have hitherto only been the privilege of specialists.

In the modern age where the "artificial power" of technology is flying around the world through information systems in the form of electronic messages, it is most important for human intelligence, or the correct "mechanics of intelligence," to be present. The technical innovation of artificial intelligence (AI), which is gaining increasing attention, should be planned to take this direction. It is truly to be regretted that at present more importance seems to be placed on the "artificial" aspect of AI as being quintessentially representative of Japan's product-oriented society. Whereas, the really important problem is how to develop human intelligence by means of the artificial, i.e., high tech, and to build up a new age of civilization. In other words, we are faced with a question of how to exert human intellectual energy and with the need to draw up a scenario based on the recognition that information is strongly related to energy reaction, and we should undertake the comprehensive direction of high tech for the future.

Setting the Stage for Technological Philosophy

Japan has accumulated much experience in technological innovation. It is perhaps more appropriate to say that Japan is yet accumulating experience. The industrial fields, especially, are bearing technological fruits, and new areas such as biotechnology are being opened up. Looking carefully at this matter in perspective, we find, however, that biotechnology is literally a product of seeing biology in terms of the existing technology, and that it is not the development of a new technology based on new findings in biology itself. Here can be seen the limitation of today's biotechnology.

Thus, although biotechnology, like other existing technical fields, offers us many interesting topics while in the present early phase of research and development, it is probably correct to say that it will not be of much active use, in the near future at least, in our society. Regarding the development of today's high tech in terms of mechanics, taking biotechnology for an example, the problem boils down to the way in which the mechanics of intelligence (i.e., creativity) can be made to operate on the existing technology of mechanics. There is a need to find a basis on which to construct a new age of civilization, combining the existing technological results from the accumulation of experience with the humanistic desire for a new idea or thought.

The problem is how to make the "mechanics of intelligence" operate on the "mechanics of power." To construct a structure worthy of the name of new cilivilization, we should create a desirable climate in view of the concepts of "+" and "x." That is, the "addition" of mechanics of power is no more than mechanical development consisting of accumulation, but if the mechanics of intelligence is applied in the form of "multiplication," there will be great development. Fundamental changes in the structure of civilization itself become possible. To put it more concretely, networks in which mechatronics and information systems are brought together are subject to infinite development and use. Such a network is already in active use in the swap market of international finance.

Another example is SDI (Strategic Defense Initiative), which was conceived in the United States and has attracted considerable worldwide attention. SDI is an attempt to establish a highly advanced defense system by reconstructing existing technology with the "mechanics of intelligence" unique to the United States.

It is certain that the "multiplication" of existing technology by the mechanics of intelligence will bring about new developments in our civilization, and it is necessary to come up with a scenario with this fact in mind. The important thing here is the establishment of a more humane technological philosophy. Even with the mechanics of intelligence, a wrong choice is extremely dangerous in multiplication, due to the likelihood of unthinkable damage. It is clear what would become of the world of humans if negative or zero mechanics of intelligence were to operate—our civilization would be destroyed and the human race would be obliterated.

The more firmly the mechanics of power are established due to high tech, the more we need to feel the importance of the mechanics of intelligence and its effects. This is the basis which sets the stage for technological philosophy.

Internationalization Through Creative Ability

Nothing is more dangerous than a one-sided "facile understanding" of another culture when considering how we can achieve more internationalization through creativity ability. This is because another person always intervenes and that person can be someone who does not always act on logic. As a result, we have a clash of the "mechanics of intelligence" which leads to the "mechanics of power." We can see here a fundamental problem in complexity, but let us move now to the issue of internationalization as a means of developing creative ability. It is necessary to hold dominant the principle of mutual criticism of culture without denying the contradictory thoughts of "truth lies in analysis" and "truth lies in synthesis" within the context of relativity.

The existing thoughts of mechanism have tended to be influenced by analytic thought. A scientific analysis, for example, that "man is nothing but 90 percent water and 10 percent matter" is more harmful than meaningless when contemplating the nature of man. We need to start with the rejection of this "nothing but-ism."

In my visits to Europe and the United States I have met many scholars and researchers with various cultural backgrounds. From these meetings I came to think that internationalization starts with the acquisition of new territory for thought made possible through the emotional frictions with foreign ideas. This is in effect the achievement of "a creative place" for both parties in which the clashing and interaction of power and intelligence takes place in a way different from the one discussed above and gives birth to a hitherto unknown cultural territory which allows the coexistence of both parties.

As the first step to making this territory, it is necessary to have common knowledge, be it only "how to" knowledge. This is, as it were, the preparation of a place for communication. The original meaning of the English word "communication" is connected to the "communion" of Christianity, i.e., communication (or the taking of communion) took place only among the people with this religious doctrine, and thus, "excommunication" or expulsion from the church meant a person could no longer take communion with his or her co-religionists. From this perspective, communication is possible only among people with the same values. It could then be said that Japan and Europe have been in a state of "excommunication" from the start, and it is important to bear this in mind in the consideration of internationalization.

The promotion of internationalization will certainly aid the development of creative ability. It seems clear that uncreative persons should not be allowed to become diplomats even if they have passed examinations which often merely call for good memorizing ability. Human communications which result from strong clashes can give rise to a new place for creativity. Dialogues become possible in this territory thereby allowing for the construction of an information highway toward the twenty-first century and a new age of civilization.

Soseki Natsume, one of Japan's greatest writers, is said to have suffered from a severe nervous breakdown during his period of study (1900-1903) in Great Britain due to the size of the cultural gap between the two countries. Considering the difference between the Japanese and British traditions at that time, we can easily imagine the cultural shock felt by Natsume, or indeed by anybody else in similar circumstances.

For a while during his stay in London, Natsume lived in the same lodgings as the chemist, Professor Kikue Ikeda. Ikeda's influence can be seen in the opening lines of Natsume's Literary Theory which he wrote during his stay in London, and which begins: "As a rule, the form of literature needs to satisfy (F + f). 'F' indicates the focal impression of concept, and 'f'indicates the emotion accompanying it."

Changing this to: "As a rule, the form of eco-technology needs to satisfy (F + f)," we obtain a sufficient basis for the Discoveries movement to grasp the various problems of complexity and reconstruct the modern mechanical civilization.

Concluding Remarks

Hiromori Kawashima

The ninth Discovery Symposium in Vienna on "Complexities of the Human Environment" has now completed its work, and our discussions on this difficult, pressing topic have yielded better results than we had expected. To a large degree we owe this excellent outcome to the beautiful, cultured city of Vienna. This historically rich center of science and art in the heart of Europe has traditionally been a meeting place between East and West. Mr. Vak spoke of the dimensions and the complexities of the problems which were to be considered by this symposium. His words impressed us as coming from profound personal experience and achievement. As I listened to his observations, I realized that Vienna is the city most suited for discussion on the topics presented at this symposium. Minister Hans Tuppy, the chairman of the Organizing Committee for this symposium, expressed his confidence for its success and impressed us with his vision concerning the problems of our century. Leopold Gratz, the president of Austria's parliament, who can look back upon a long and distinguished political career, provided us with some deep insights into human nature and political behavior in today's society. Last but not least, on behalf of the Honda Foundation, I would like to express my cordial respect and gratitude to the Organizing Secretariat of this symposium, particularly for its admirable teamwork as well as for its most considerate services.

I personally believe that these three days of fruitful discussion have left a deep impression upon our minds. First of all, I would like to congratulate Mr. Jun-ichi Nishizawa and Mr. Umberto Colombo for their lectures. Professor Nishizawa's expectations for the viability of science and technology in today's world reflected his originality, self-confidence, and courage. Professor Colombo's lecture not only analyzed the present condition of the world economy, it noted the global nature of economic problems and suggested many approaches to meet the challenges which the world faces today. Professor Colombo pointed out that the economic growth and tremendous advances in science and technology found in the industrialized countries only serve to widen the gap with the Third World, where three-quarters of the earth's population lives. He certainly increased our awareness of how serious these problems are. On the one hand we heard of a possible bright future opening up in the twenty-first century, and on the other hand many of us were left uneasy about the immediate prospects facing today's world society. The world economy has already become a global economy and it has reached a degree of integration that does not allow for the prosperity of one's own country alone. The technological revolution promises an active, vital industrial structure, but will we be able to bear the growing pains which accompany the necessary structural changes and reorganization? Will the world market be able to maintain its stability without bringing about the ruin of the Third World?

How can we avoid the violent frictions of a tripolar economy? I am deeply worried about such questions which reflect today's real and imminent problems. The reason for this concern is that the solution to these problems cannot be achieved by technology alone. We must also consider, perhaps, the moral state of mankind, which has rapidly deteriorated in the wake of technological progress. Take for example the cult of self-serving materialism, which is deeply rooted nowadays in people individually as well as nations collectively. Beyond this are the problems of communication needed to bridge the cultural gap. I think it is clear that if we do not overcome these obstacles, we will not achieve tomorrow's global society. The opening session, during which we heard an outstanding lecture by its chairman, Mr. Vak, was followed by five more sessions. Each of these sessions was in the hands of equally capable chairmen and gave rise to much fruitful discussion. All of the speakers provided us with the salient results of their research and experience, which provoked strong criticism and spurred heated debates to the extent that all observers in the auditorium became involved in the general discussion. The large number of specialists, together with the group of journalists, yielded results beyond all our expectations. All that we have learnt here can help to guide us from now on, and for that reason I would like to congratulate all the participants.

The matter of nature and environment also arose during our sessions. We all realize that the natural environment is unfortunately not unlimited. For example, even under optimal conditions, trees cannot grow forever; they will stop growing after they have reached a certain size. If they grow beyond their normal size, they would disrupt the ecological balance. Thus must nature obey her own laws, and I think nature tries to make the human race recognize its own limitations.

As everyone knows, the word "culture" comes from the Latin word "cultura," which referred originally to the cultivation of land. In other words, "culture" conveys the meaning of refining and caring for nature. I believe it also means making nature more beautiful, perhaps to harness it, but always keeping the basic connection with nature. If human beings are part of nature, then the "cultivation" or the improvement of mankind creates "culture." Man is full of imagination and ideas—there is no limit to human achievement. Man always strives for something bigger, stronger, more beautiful; he constantly seeks the ideals of truth. To this we owe the advances in technology. At this point we must remind ourselves of Goethe's famous tale, the "Sorcerer's Apprentice." In Goethe's story, the sorcerer tells his apprentice to fetch water for the bath. The apprentice in turn orders the magic broom to carry the water up from the river. But the apprentice does not know the magic formula to stop the broom from bringing up more water, and soon the bathtub overflows. In an effort to put a stop to the broom, the young apprentice cuts it in two with an axe. But instead of stopping the broom, there are now two running back and forth to fetch water, and soon the whole house is flooded with water. The master sorcerer puts everything right, and, if I remember correctly, severely scolds his foolish apprentice. In a similar way, have not technology and civilization begun to develop faster and faster with a dynamism all their own, beyond our control? If man does not use his wisdom, science and technology will separate themselves from man and continue to grow as if man himself did not exist. I believe that the value judgment between good and evil lies in the context of man's harmony with nature. Do we not need someone to warn us when we have taken the wrong path? We simply cannot afford to wait for these warnings; we must deepen our wisdom ourselves. I believe that we can find the measure for human wisdom in our own conscience and morality. We must never lose human conscience and morality. Are we strong enough to know our own limits, to control ourselves, to respect others—does not our very humanity provide the foundation of our culture?

Here in Vienna I could see and hear for myself that the Austrians still cherish harmony with nature and respect for the environment. This was for me a very important aspect of the Vienna Discoveries Symposium, as well as my personal joy of having met many distinguished people who together make up today's global wisdom. The opportunity to meet under the auspices of this symposium arose, in part, out of the principles of Mr. Soichiro Honda, which advocate that there be a humanistic driving force behind technological advances. On June 5, 1987, International Environment Day, the United Nations awarded Mr. Honda with a prize for his contributions to humanity.

I should like to pay homage once again to the magnificence of the universe and nature. It cannot be stressed enough that today's mechanized civilization is not God's work, but man's. Nevertheless, I believe that the leaders of the development of civilization must continue to have the wisdom of recognizing man's limitations. Our Honda Foundation is still very young, but it will continue to strive fervently to bring about eco-technology.

Hannes Swoboda

I would first of all like to welcome you on behalf of the city of Vienna and especially on behalf of Mayor Zilk, who is prevented from being here personally by a commitment abroad. I would at the same time like to express my special thanks to the Honda Foundation for selecting Vienna as the site for this meeting. We are—as you can well imagine—very pleased and gratified that you have done so.

It is not my purpose today to go into detail on specific points, and yet I would like to touch briefly on those points which by their very nature apply directly to Vienna as well and to the contribution Vienna can make to the broad range of discussion topics brought up thus far. At the beginning of his presentation, Christopher Alexander summarized the discussions that had taken place up to that point as "a mixture of anxiety and fantasies." And, in my opinion, both of these elements are essential. There is nothing wrong with a sense of fantasy. Nor is it necessarily wrong if we show anxiety about certain developments. And it could certainly be a contribution of Viennese or Austrian skepticism when we also bring up in the discussion all those things which cause us anxiety—not as a way of blocking developments or of preventing progress—but, if combined with optimism and a will for change, this anxiety can save us from going down wrong paths, can help us minimize our mistakes. With regard to the same topic, mention was also made, very pointedly, of the existence of limits and the need for such limits. And that—as was so rightly pointed out—these limits are set neither by nature nor by technology. It is man, the whole of mankind, who must set limits where he feels they are needed. Mr. Kawashima, speaking before me, remarked that one should not allow ethics to go by the wayside. And perhaps Vienna and Austria are in a special position to contribute something on the subject of ethics as well, in view of our university's achievements in this field. The importance of ethics should be emphasized especially in the area of medical technology, noting in particular the dangers of genetic technologies. Thus, the anxiety and the limits which we are supposed to perceive are there to help guide us along the "right" path of progress, the path which is right for us, because to claim one "right" path is certainly not possible.

Professor Mittelstrass summarized it all very well, I think, when he said that what we have to do is to make the world once again our world. That, I believe, is the crux of the matter. After all, technological progress is not the only thing that counts. It is of course important, even crucial, but it must not lead us to ignore societal progress. The one can not replace the other. For example, yesterday Professor Atsumi told us a great deal about all the new vistas which are being opened up by technological innovations in the medical field: laser technology, computer tomography, nuclear spin tomography, and much more. And if you paid close attention to the slides he presented, you will have noticed that the final slide shown by Professor Atsumi, more or less as a summation of his talk, was one which depicted what he—and, I might add, what I—imagines as the optimal health system. In such a system, the emphasis is not placed so much on the area of curative medicine, which, for the most part, we already have under control, but rather on fields which are of even more importance to us, such as preventative medicine, epidemiology, and rehabilitation, especially for the aged. Living in societies which are aging more and more all the time, and in a city like Vienna, which is, from the population structure, a very old city, we are highly aware of the necessity of developments in these areas. And thus, technical progress represents only one side of development; societal progress must not be ignored. This is perhaps another area in which Vienna can make some contributions, by achieving progress which encompasses both these aspects, the technical as well as the societal.

But, in concrete terms, what are the tasks which Vienna faces in this area? I believe that the population structure of Vienna puts this city in a unique position to create an all-encompassing, holistic approach to society, to societal policies. That is, if Vienna can retain its positive aspects and, at the same time, undergo changes. For a sense of complacency is something we must always fight against. What aspects of Vienna should we preserve? Our city's role as a cultural center, certainly. The very pleasant and natural environment in which we live. But on the other hand, we need and want to incorporate changes in this city and in our all-encompassing view of what it should be. Greater reflection about economic issues certainly would not harm us, nor would a more intensified discussion of scientific questions. And, above all, a great deal could be gained if we were able to encourage and bring about greater cooperation between the business and the scientific communities than we have been able to thus far. In my opinion, this has not taken place to the extent that it could. Many good and very admirable beginnings have been made. But I believe that we need to see a deeper commitment toward this cooperation, from the scientific community and the business community, and certainly from the political community as well.

However, I have not come here today to level criticism, but rather to offer a promise that the City of Vienna will intensify its efforts to contribute to this cooperation, for the benefit of our business community and our scientific community, for the benefit of all Viennese and the world at large. It is only from the multiplicity and the interaction of culture, a clean environment worthy of human beings, a technologically aware economy and a responsible scientific community, it is only from the interplay of all these factors that we, the City of Vienna, will be able to make our special contribution to the future. And it should not be—in the words Professor Luhmann used earlier today—a roccoco of postmodern arbitrariness. No, there must be attempts made to create a system which, as he most rightly noted, could be viewed differently by economists and politicians, by scientists and legal professionals. But one with an integrating function. Because—without criticizing other approaches—I view an integrative approach as the only feasible one for us here in Vienna. The only one capable of encompassing in one city all these things, the traditional aspects as well as the aspects which need to be changed. The concept of technology, of creating the scientific city, is, from our point of view—from the Viennese point of view—not one which we should pursue for ourselves. For we want to include science and business in a city which is at the same time culturally oriented and environmentally aware. And Professor Roberts brought up the principle: "Town air makes free." He was skeptical as to whether this was at all possible today. But if we are to have one goal, it should be to make this statement valid once again. Not as a contrast to rural life, but at least in the sense that freedom can be found in town air as well, perhaps especially there. It is certainly utopian, but I would say, as Ernst Bloch once expressed it, that it is a tangible utopia. In any event, a goal very worth aiming for here in Vienna and one which I view as our special task.

Lastly, what we sorely need is more openness towards the world. We need less isolationism and more openness towards the East and towards the West. And whether we look to the East or to the West, in either case we come once again to Japan. And I feel that this is as it should be, because although no nation incorporates all the things coming from another country, there is a great deal that we can learn from Japan. Thus, we should not retreat into ourselves but open our eyes to the world around us. This is something that we in Vienna must keep clearly in mind.

Hans Tuppy

The 1987 Discoveries Symposium is coming to a close, but its effect will surely be a lasting one. I am sure I am right in saying that all the participants intellectually profited, were culturally enriched, and had their motivation strengthened. We are now more than ever aware of how large and difficult a task it is to combine and blend scientific and technical progress with the quest for scientific prosperity, the striving for individual and social development, and the safeguarding as far as possible of a life-sustaining environment. We have examined the cross-linkages between specialized subjects and life functions, in their multitude of dimensions, in their complexity, as well as the historical roots of this dimension. And we were given a message of warning, that we should act with the appropriate understanding, wisdom, and responsibility.

This symposium has done more than just increase the awareness of its participants. It has also been well received in the media, and I feel that its main concerns are now being drawn to the attention of a wide public. Science, technology, economy, and environmental sensitivity compel us to a truly global way of thinking. They propel us toward a policy which takes into account both the complexity and the interdependencies. Worldwide, we all share a common concern for these problems. And we are deeply obliged to the Honda Foundation for the promotion of this concept of interdisciplinary and international cooperation aimed at a more humane, modern civilization. We are very thankful that the 1987 Discoveries Symposium was able to take place in Vienna. We owe recognition to all the speakers, to the chairmen, and to the participants in the discussions.

May the 1987 Discoveries Symposium be more than a happy memory: indeed, may its repercussions be long lasting, and give rise to a way of thinking and acting that is characterized by cooperation and open-mindedness, and oriented towards global problems and global solutions.

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Christopher Alexander
Professor, Director of the Center for Environmental Structure in Berkeley, California, USA.

Kazuhiko Atsumi
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Gernot Böhme
Professor, Institute of Philosophy, Technical University of Darmstadt, Federal Republic of Germany.

Ernst Braun
Professor, Director of the Institute of Socio-Economic Research and Technology Assessment, Austrian Academy of Science, Austria.

Harvey Brooks
Professor Emeritus of Technology and Public Policy at Harvard University, Cambridge, Massachusetts, USA.

Achilles van Cauwenberghe
Professor, Director, Laboratory for Automatic Control, University of Ghent, Belgium.

Umberto Colombo
Professor, President of ENEA (Italian National Commission for Nuclear and Alternative Energy Sources), Italy.

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ISBN 3-203-51063-4