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◎Programme

Chairman of the Seminar:

Dr. Reikichi SHIRANE
President of Telecommunications Science Foundation

Part 1:
Lectures on "Science and Society"

Speakers:

Dr. Heinz FISCHER
The Honourable Federal Minister for Science and Research, Austria
(Science and Society)

Professor Ilya PRIGOGINE
Free University of Brussels, Belgium
(Exploring Complexity)

Professor Umberto COLOMBO
President of E.N.E.A., Italy
(Technological Change and Its Effects on Society, A View from Europe)

Part 2:
Panel Discussion on "Innovation and Society"

Discussants:

Dr. Hubert BILDSTEIN
President of Austrian-Japanese Technological Society

Mr. Jiro USHIO
President of Japan-Europe Technology Forum

Mr. Yuzaburo MOGI
Managing Director of Kikkoman Corporation

Professor Masahiro MORI
Tokyo Institute of Technology

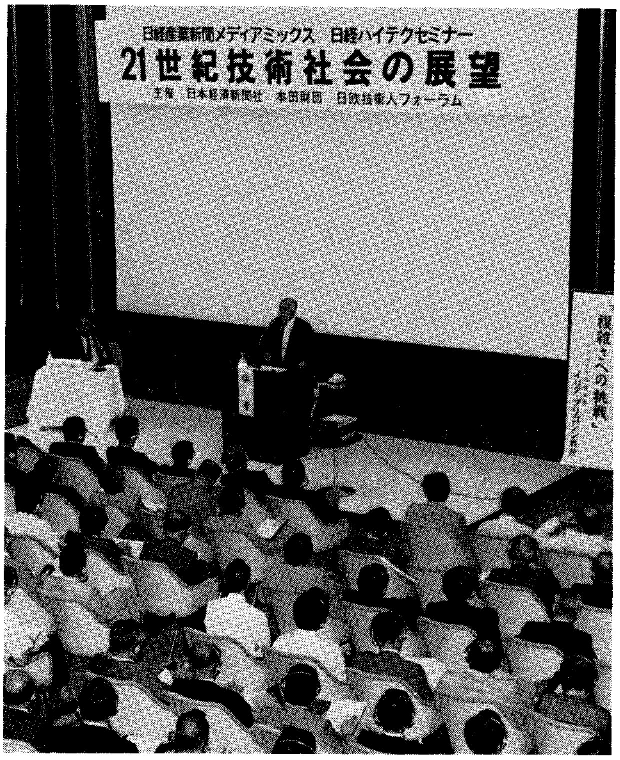
⊙プログラム

1部　基調講演『科学と社会』

「Science and Society」
　オーストリア科学研究大臣　Heinz FISCHER
「Exploring Complexity」
　ブラッセル自由大学教授　Ilya PRIGOGINE
「Techonological Change and its Effect on Society」
　イタリア国立エネルギー研究機関総裁
　Umberto COLOMBO

2部　パネルディスカッション
『技術革新と社会』

司会：電気通信科学財団理事長　白根禮吉
　ウシオ電機株式会社会長　牛尾治朗
　東京工業大学教授　森　政弘
　オーストリア日本技術人会議会長　Hubert BILDSTEIN
　キッコーマン株式会社常務取締役　茂木友三郎



このレポートは昭和60年6月5日、経団連会館において、本田財団、日本経済新聞社及び日欧技術人フォーラムが共催した第43回日経ハイテクセミナーでの講演をまとめたものです。

THE NIKKEI HIGH-TECH SEMINAR
Organized jointly by
Honda Foundation
Japan Economic Journal
Japan-Europe Technology Forum

Theme: The Perspective of Technological Society towards the 21st Century.
Date: Wednesday, June 5, 1985
Venue: Keidanren Kaikan

Part 1: Lectures on "Science and Society"

Science and Society

The Honourable Federal Minister for Science and Research
Dr. Heinz FISCHER, *Austria*

Mr. Chairman,
Ladies and Gentlemen,

I am indeed most grateful to the organizers of the NIKKEI HIGH-TECH SEMINAR – the Japan Economic Journal, the Honda Foundation and the Japan-Europe Technology Forum – for having invited me today to address this most distinguished gathering. It is an honour and pleasure to join on this occasion such internationally renown personalities as Prof. PRIGOGINE, Nobel-Prize laureate from Belgium, and Prof. COLOMBO, President of E.N.E.A

I am certain that this high-level Symposium will further contribute to a better awareness of the manifold implications of the high technology age on human society.

In this context I should like to recall that only last year the Japanese-Austrian Technology Society was founded thanks to the initiative of Mr. Taizo UEDA, Managing Director of Honda Foundation and Mr. Karl VAK, President of Zentralsparkasse und Kommerzbank. The first very successful bilateral Seminar was held by the Society in Vienna last October and I am very happy to see such a large and representative delegation from Austria participating in this important event here in Tokyo. As Minister of Science and Research I indeed know to appreciate the foundation of the Japanese-Austrian Technology Society which – I am confident – will open up new avenues for the cooperation between our two countries in this area of overwhelming importance for the years to come. I do wish them utmost success in their praiseworthy endeavours.

The mutual dependence of technology and society is likely to remain one of the dominant themes of the late 20th century. It is a theme which has already forged the policies of economic reconstruction after the second World War and which has guided unprecedented growth in social welfare for vast majorities of our populations through scientific and technological developments. But the harmony of the underlying melody has also acquired painfully dissonant tunes. Technology and society can no longer be seen as the twin paths of evolution along which the forces of progress simply continue their victorious march through history. Nor can the one–technology–any longer be seen as the active, autonomous driving force, the expression of the free floating inventive genius which is at the service of human needs, while the other–society–is depicted as the merely passive recipient of either the marvelous fruits of this ingenuity or – in the dystopian variant – the helpless victim of the destructive forces of an unleashed technology.

In the course of the last decade it has become obvious that technology and society are interlinked in complex ways and moreover, undergo temporal loops and long-term latent processes which are as yet only poorly understood. One reason for this is, I suppose, our old habits of thought. In fact, we imagine "technology" to be located on one side of an imaginary table of correspondence and "society" on the opposite side of it. There are many indicators in our social and political life which support such a dual classification: there are different sets of institutions on both sides, entrusted with different tasks and functions. There are people with different professional values, outlook and training on both sides. We all know from personal experience how thin the bridges are between engineers, scientists and other "technical" people and those who are engaged in politics, work within bureaucracies or profess the old humanistic values. To some extent we have internalized the belief that one side, technology, is the supreme expression of rational thought and goal-directed logical practice, while the other side, society, and especially politics, is messy, unpredictable, beset by emotions and subject to irrational ups and downs. Although a closer analysis of the public controversies surrounding large-scale technologies in the recent past should lead one to question such views, it still is a widely cherished belief which continues to nurture distrust and mutual misunderstanding.

The cleavage between technology and society therefore exists despite common rhetoric to the contrary. Depending on one's point of view, one is prone to identify one of the two as the "problem side" and the other one as the "side of solutions." It is granted that there is no close correlation between the two and it is also obvious that some solutions may in turn give rise to new problems. But on the whole, I maintain, we associate the two sides of the cleavage with these functions. Let me try to take you through some well-known examples.

Especially in the last decade, technology has become widely perceived as the problem-side. It is fair to say that a new social and political awareness has arisen with regard to the limitations of further reckless expansion of technology. The degradation of the environment which became more and more visible on ever larger scales, spanning the local lakes and forests with the entire biosphere, has undoubtedly acted as the most forceful warning signal against a technology that has been permitted to run wild. A genuine revolution in environmental perception has taken place, recognizing as thoroughly problematic the unchecked and uncontrolled consequences of technological expansion which threaten even the otherwise positive and beneficial sides of economic growth.

Governments in practically all Western democracies – admittedly under the pressure of environmental protest movements and citizens' initiatives – have not only become fully alerted to the local and international scope of environmental threats. They have, as was the case with my government recently, positively responded through a whole range of forward-looking and preventive measures in what has, in fact, become a new policy arena: environmental policies which seek a new balance and synthesis with policies of economic growth. Although many problems remain as yet unresolved – the acidification of the forests is only one of the most glaring ones – on the whole, a new gamut of protective measures, incentives and environmental policies have come forth on the societal "solution-side". The political mechanisms of participatory democracy, after an initially slow beginning, have taken up the new challenge. They are faced with assuring a more equitable distribution of the benefits and risks that accompany technological advances and of guaranteeing new procedures for participation of the population in the decision-making process. In a somewhat simplified way one can say that technology – represented in this case by the negative environmental impact and its undesirable short- and long-term effects – has been successfully incorporated into societal awareness and the political problem-solving capacities.

This is far less the case with regard to the second large set of issues, which tends to be associated with technology as the problematic side. The full range of the social consequences following the unprecedented restructuring of work life through further technological developments (especially in the realm of information technologies) is not yet entirely visible. But the potential of liberating effects is, unfortunately, overshadowed by the fear of the elimination of a large number of working places. Structural unemployment, which looms already large as the most serious problem in Europe, is likely to be aggravated through further technological advances. So far, no convincing solutions are in sight, although a myriad of local and national employment initiatives and social experiments are going on in Europe today, the impact of which still has to be assessed. However, it is inadmissible for a government committed to the ideas of social democracy to accept this state of affairs as being something akin to a natural law, a price that has to be paid for the restructuring of an otherwise demodernizing industry. Nor is it acceptable for any government, I believe, to ignore the tendencies towards a potentially polarized society: into one half that enjoys the security of a working place and the benefits that go with it in terms of income, status and social privileges and another fragmented half, comprised of different groups of population which are in danger of becoming either temporarily or permanently marginalized, since society has lost interest or the capability of integrating them.

We are touching here the reverse side of technological innovation, since the old, slowly dying industries are nothing but the innovative industries of a by-gone age. Yet people – that part of society, whose livelihood depends on being employed there, whose skills, qualifications and life styles have been formed by their jobs over decades – cannot as easily be disposed of as a piece of obsolete machinery. It is in this context that new solutions – perhaps a new social technology for managing not only the birth of technology, i.e. innovation, but also its aging – are badly needed.

The gap between the problem side and the solution side is even wider when we move on to the next set of issues, at least as seen from the perspective of a small, neutral country. I refer to the increasing use of scientific and technological creativity for the purpose of potential destruction. The side of society seems at a total loss in coping with the built-in forces that drive technology within the context of the arms race. But can we only blame technology for it? Are these not also social forces that drive technology and which merely underline our inability to devise better forms of international cooperation and of global conflict-solving mechanisms? Is society not challenged, this time on the global level, to bring its own destructive side under control?

We, therefore, can see that the view of technology as the problem-causing side and of society as the solution-producing one, depends on one's point of view. It alerts to discrepancies, but it does not catch the dynamics of the interlinkage. Moreover, the standpoint can easily be reversed. In numerous instances – from the sewage system that did more to eliminate endemic diseases in the late 19th century than any advances in medical knowledge to the latest pollution controlling technology – the history of technology can be rewritten as one of "solutions" to problems that were posed by societal development.

In fact, this is how the majority of engineers would still define their own professional role. On the other hand, it is easy to see how society produces an endless series of problems through lack of organizational capacity, break-downs in the political consensus machinery, in permitting various forms of societal disintegration and being unable to adjust sufficiently well or rapidly to what technology seems to demand. Examples come readily to mind where discrepancies can be pointed out: In my own country, the one and only nuclear power station, the opening of which was subject to a referendum with a negative result, is unlikely to be opened since the opposition party refuses to debate in parliament the possibility of calling for a new referendum. Political negotiations evidently have failed, while the technological solution has remained unaltered.

But if the sides of technology and society are not so easily and unambiguously identifiable in their problem-causing and solution-producing functions, their interdependence has to be taken seriously after all. We are confronted with an inter-dependence which can be compared to that of the hardware and the software components of modern computers which can only be grasped in their complementarity.

This is, in fact, the lesson that can be drawn from the history of modernization and it is the challenge posed today by the innovative dynamics which manifest themselves on a global scale. Industrial modernization started in England under unique economic, social and technological conditions. Its waves spread on the one side to France, Germany and later Russia; on the other side across the Atlantic, where very different social conditions– for instance the relative scarcity of labour–enabled a more rapid diffusion of machinery in the production process. Historians of technology have at great length pointed out the relative advantages and disadvantages of early and late modernizers, and of early and late adopters of new technology as well. Early modernizers or adopters often have to pay a high price, not only in social terms, as was the case with the industrial revolution in particular, but also in capital investment. Moreover, they have to experiment with institutional adjustments and organizational innovations for which no precedent exists. Late-comers, on the other hand, can in principle learn from the mistakes of their more rapid competitors; they can adopt and adapt to their own needs solutions that have already been tried out elsewhere. They can, therefore, better judge and balance positive and negative effects. Also, in purely economic terms, the costs of new products or production processes usually go down drastically for those who arrive later.

And yet, early modernization or innovation does not only carry the – often national–glory of being first, but may also have a generally invigorating effect. Technological innovation may exert a strong modernizing push in other realms of society and therefore yield not only the expected technological spin-off, but other, more diffuse, social and institutional kinds of spinning-off. Finally, there is the coveted prize inherent in any game of competition: the satisfaction of being first, the desire of being a winner.

Today, the highly industrialized Western world is once more caught in a severe game of competition. The stakes are high, since the race is towards the technologies that will shape the future and determine the sphere of production, of consumption, of life styles and market domination alike. It is as though all these societies had agreed in advance that life will change drastically for them. The new "creative" technologies that exist already in the research plans of R&D managers only await their concrete actualization. But have we forgotten the lessons of history? Has there to be only competition and can we learn nothing from each other?

It is in this context that it is especially appropriate to visit Japan and to hold our reunion in this country. Not only has Japan a demonstrably impressive record as a country that has modernized late and that has been able to catch up and even surpass its competitors in certain areas, but it is also, in quite a unique way, oriented towards a technological future. It has turned towards the mastering of basic technologies, especially of electronics. Emphasis is put on three areas: overcoming energy constraints, improved quality of life, and new knowledge-intensive industries. The key to these developments are new materials technology, biotechnology and new function technology. The reordering of its industrial priorities and the major restructuring which accompanies it – up to twenty (20) percent of Japan's GNP will be directed towards new high technology industry and the aim is to spend up to four (4) percent of GNP on research and development by 1990 – has been signalled as the most significant change of direction since the Second World War, and possibly since Meiji.

In the modest words of a Japanese analyst, Japan could make a lasting contribution in this process, a contribution not only to its own technological and social development, but to the principle of universalisms, otherwise neglected by her:

"The concept of technology has traditionally been opposed to that of spirit ("Geist" in German, or thought) in Japan for a century and been associated with Western culture. The balance between Japanese spirit and Western technology was ideal in the late 19th century. Hence the Japanese felt no need to clarify the idea underlying the Japanese technology system or even has never thought of the existence of the idea itself behind or within technology. But it will be one of the possibly significant contributions of Japan to mankind to develop a new idea of a technology system for the 21st century type...."

It is such a conception of the technology for the 21st century that we should all strive for while learning from our social and cultural diversity. It has to include something like "social technology" and the explicit recognition that technological innovations entail much more than merely the development of new products. If I read the Japanese research plans correctly, they have identified areas of human needs – diet, clothing, dwelling, health, locomotion, intellect (education) and leisure – in each of which general tasks of technological innovation, involving resource allocation for product development, go hand in hand with a conception of the social fabric into which it is to be introduced. In order to identify what social technology is all about, the Japanese are employing something which they call "soft science": these are essentially methods of social management which utilize scientific methods, such as forecasting, analysis, planning and evaluation of complex problems. But the characteristics of soft science are somewhat unusual for Western ears if we associate them with the term science: they are intuitive, normative, interdisciplinary; they are oriented towards a systems approach and towards problem solving; they are ambiguous and future oriented. Even more unusual is the place where such methods are employed: it is neither a large planning bureau nor a special scientific institution, but soft science occurs practically everywhere on the shop floor.

Japan's success in catching up with Western technological and economic development has become the object of intensive study and understandable fascination due to its cultural "other-ness". Whole libraries are filled with books, mainly written by North American authors who are eagerly seeking to detect the hidden factors which may account for Japan's becoming "Number One." What has surprised American authors most is the extent to which the Japanese are committed to systematic search for information and the use they make of it; their commitment to life-long full employment and to the welfare of their employees (contrasting with American business practice); government-industry corporation which as "visible hand" again differs markedly from U.S. patterns, and last but not least, the consensus forming and seeking group dynamic mechanisms, as they manifest themselves, for instance, in the "ringi" system.

Europeans have been less exposed – or rather, have exposed themselves less – to Japanese management and technology policy systems. Perhaps, they tend also to be less baffled by Japanese "other-ness", since they experience more cultural heterogeneity at home to begin with. I must admit, however, that I too, was slightly baffled when reading the case story of a technological innovation – that of the basic oxygen furnace – which originated in Austria in 1952 and which was adopted and rapidly introduced in Japan where it became a major factor in the dramatic increase in the international competitiveness of the Japanese steel industry in the 1960s. The case history tells of the many technological and social obstacles that stood in the way of simply transferring the Austrian innovation to a different context and testifies Japan's ingenuity in overcoming those barriers that we were unable to overcome.

Technological hardware and social software in Japan have undoubtedly entered a new configuration different from that in Western nations. To disentangle this complex pattern of how technology and society are interwoven in a society that in its history, tradition and culture differs markedly from Western societies, is a fascinating topic which we cannot explore here further. But it leads to a number of conclusions for our theme:

(1) Any notion of technological determinism can safely be laid to rest. There is no one single way to modernize or to innovate. This holds for the past and even more so for the future.

(2) Societies may have the capability of transforming initial inherent weaknesses into strength. This is for me one lesson to be learned from the Japanese example. The severe restrictions stemming from the physical environment and the high density under which its population has lived for a long time reinforces a sense of management in the face of adversity. The meaning of strategy in Japan is not that of Western rational planning so much as implying a general sense of preparedness for events which are outside one's own control.

(3) Since technology is far more culture-bound than science – in its use, adaptation and even as to its further innovation it strongly depends on the social infrastructure, on institutional frameworks and on social attitudes – the technologies of the future probably will intensify the organizational software components. This means that people will no longer be seen as extensions of machines, but as complementary to them; they are not expandable spare parts, but valuable resources that have to be developed. The implications of such a "people paradigm" are numerous. They range from restructuring the educational system to new functions

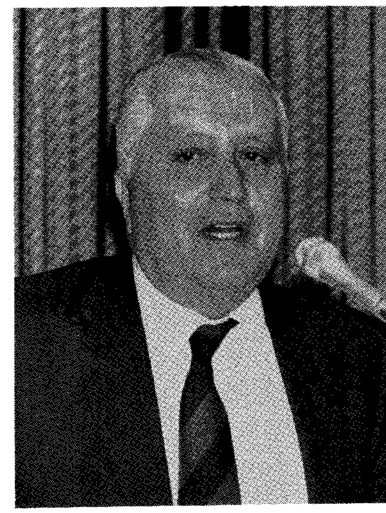
for the unions.

(4) On the political level, management techniques and relations between employers and employees, just as those between government and industry, are forms of social technology which correlate with a particular state of societal development and of technological maturity. With the complexity of organizations increasing, we can also observe a tendency towards more participation on the side of the employees. In general terms, we can expect higher forms of cooperation.

(5) Technologies of the future with their stronger social components thus also offer a new chance for social innovation by leading to higher forms of cooperation – hopefully also between nations. But as the history of the relationship between technology and society shows, higher forms of cooperation rarely are achieved without conflicts. If, however, hardware and software are to match in order to expand human capacities and to increase social well-being, conflicts may perhaps, one day, be harnessed and turned towards productive use.

Thank you.

Exploring Complexity



Free University of Brussels
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Special Advisor to the Commission of European Communities
Prof. Ilya PRIGOGINE, *Belgium*

I

In the classical perspective, there was a clearcut distinction between what was considered to be simple and what had to be considered as complex: there was no hesitation about calling "simple" newtonian laws of motion, perfect gas, or chemical reactions. Also, one would have called "complex" biological processes, and more so human activities such as described by economics or urban planning. In this perspective, the aim of classical science was to discover, even in complex systems, some underlying simple level. This level would be the carrier of deterministic (such carrier would be wave functions in the case of quantum mechanics) and time-reversible laws of nature: Future and Past would play the same role. However, this basic simple level remained elusive.

Today a far-reaching reconceptualisation of science is going on. Wherever we look, we find evolution, diversification and instabilities. We long have known that we are living in a pluralistic world in which we find deterministic as well as stochastic phenomena, reversible as well as irreversible. We observe deterministic phenomena such as the frictionless pendulum or the trajectory of the moon around the earth; moreover, we know that the frictionless pendulum is also reversible.

But other processes are irreversible, as diffusion, or chemical reactions; and we are obliged to acknowledge the existence of stochastic processes if we want to avoid the paradox of referring the variety of natural phenomena to a program printed at the moment of the Big Bang. What has changed since the beginning of this century is our estimation of the relative importance of irreversibility versus reversibility, of stochasticity versus determinism.[1]

Let us consider an example: the long-time variation of climate. We know that climate has fluctuated violently over the past. Climatic conditions that prevailed during the last two or three hundred million years were extremely different from what they are at present. During this period, with the exception of the quaternary era (which began about two million years ago) there was practically no ice on the continents, and the sea level was higher than its present value by about 80 meters. A striking feature of the quaternary era is the appearance of a series of glaciations, with an average periodicity of one hundred thousand years, to which is superposed an important amount of "noise". What is the source of these violent fluctuations which have obviously played an important role in our history? There is no indication that the intensity of solar energy may have been responsible.

The temporal variation of climate is typically a "complex process". Again, in the perspective of classical physics, we would be tempted to attribute this complexity to a basic level, involving a large number of variables, which would enter into the determination of temperature. The situation would then be similar to that induced by the law of "large numbers", which leads to fluctuations distributed in a Gaussian manner.

Recent progress in the study of the behaviour of dynamical systems enables us to determine the number of independent variables linked through differential equations whose solution could generate the observed temporal sequence of temperature. The unexpected outcome of this analysis[2] is that the number of independent variables which determine the climate, is only 4. Therefore, we can no more ascribe the complexity observed to some underlying level, which would involve a large number of hidden variables. On the contrary, we have to attribute to the climatic system an *intrinsic* complexity and *unpredictability*.

In a quite different field, recent work[3] has shown that the electrical activity of the brain in deep sleep as monitored by electroencephlogram (EEG) may be modelled by a fractal attractor. Deep-sleep EEG may be described by a dynamics involving 5 variables; again, this is very remarkable as it shows the brain acts as a system possessing intrinsic complexity and unpredictability.

It is this instability which permits the amplifications of inputs related to sensory impression in the awake state. Obviously, the dynamical complexity of the human brain cannot be an accident. It must have been selected for its very instability. Is biological evolution the history of dynamical instability, which would be the basic ingredient of creativity characteristic of human existence?

There have been other surprises. Even in some of the simplest examples of dynamics such as an elastic pendulum, unexpected complexity has been discovered,[4,5] as it had been in some simple chemical reactions. It appears now that the gap between "simple" and "complex", between "disorder" and "order" is narrower than it was thought before.

Complexity is no longer limited to biology or human sciences: it is invading the physical sciences and appears as deeply rooted in the laws of nature.

These new developments are likely to be of decisive importance. For many scientists, the unknown was lying only at the frontiers of physics: in cosmology and in elementary particles. Today, the interest in macroscopic physics and chemistry, dealing with phenomena on our own scale, is rapidly increasing. Let me present three reasons which, I believe, explain this interest.

1. As we shall show, it leads to a number of potentially innovative technical applications as well as to a better understanding of the main characteristics of our biosphere.

2. It gives us the possibility of transfer of the new theoretical tools coming from mathematical physics to biology and human sciences. It makes therefore the traditional distinction between hard and soft sciences obsolete.

3. The basic characteristics of complexity are irreversibility and stochasticity. These concepts begin now to diffuse into the fundamental level of description of nature.

II

One could state that the first science dealing with complexity in the field of physics and chemistry was the science of thermodynamics. The basic law of thermodynamics is the so-called Second Law, which expresses that entropy increases in isolated systems. (For more details, see refs. 1 and 5.)

For a long time, the interest of thermodynamics concentrated on isolated systems at equilibrium. Today, interest has shifted to non-equilibrium, to systems interacting with their surroundings through an entropy flow. This interaction means that we are dealing with "embedded" systems. This immediately brings us closer to objects like towns or living systems, which can only survive because of their embedding in their environment.

There is another basic difference with classical mechanics. Suppose we have some foreign celestial body approaching the earth: this would lead to a permanent change of the earth's trajectory: dynamical systems have no way to forget perturbations.

This is no longer the case when we include dissipation. A damped pendulum will reach a position of equilibrium, whatever the initial perturbation.

Now, when we drive a system far from equilibrium, the "attractor" which dominates the behaviour of the system near equilibrium may become unstable, as a result of the flow of matter and energy which we direct at the system. Non-equilibrium becomes a source of order; new types of attractors, more complicated ones, may appear, and give to the system a new space-time organisation. Let us consider two examples which are widely studied today.

The so-called Benard instability is a striking example of instability giving rise to spontaneous self-organisation; the instability is due to a vertical temperature gradient set up in a horizontal liquid layer. The lower face is maintained at a given temperature, higher than that of the upper. As a result of these boundary conditions, a permanent heat flux is set up, moving from bottom to top.

For small difference of temperature, heat can be conveyed by conduction, without any convection; but when the imposed temperature gradient reaches a threshold value, the stationary state (the fluid's state of "rest") becomes unstable: convection arises, corresponding to the coherent motion of a huge number of molecules, increasing the rate of heat transfer. In appropriate conditions, the convection produces a complex spatial organisation in the system.

There is another way of looking at this phenomenon. There are two elements involved: heat flow and gravitation. Under equilibrium conditions, the force of gravitation has hardly any effects on a thin layer of the order of 10 mm. In contrast, far from equilibrium, gravitation gives rise to macroscopic structures.

Non-equilibrium matter is much more sensitive to its environment than matter at equilibrium. I like to say that at equilibrium, matter is blind; far from equilibrium it may begin to "see."

Consider next chemical oscillations. We study a chemical reaction whose state we control through the appropriate injection of chemical products and the elimination of waste products. Suppose that two of the components are formed respectively by red and blue molecules in comparable quantities. We would expect to observe some kind of blurred color with perhaps occasionally some flash of red or blue spots. This is, however, not what actually happens. For a whole class of such chemical reactions, we see in sequence the whole vessel become red, then blue, then red again: we have a "chemical clock". This violates our intuition about chemical reactions.[6]

We were used to speaking of chemical reactions as being produced by molecules moving in a disordered fashion and colliding at random. But, in order to synchronize their periodic change, the molecules must be able to "communicate". In other words, we are dealing here with new supermolecular scales – both in time and space – produced by chemical activity.

The basic conditions to be satisfied for such chemical oscillations to occur is auto- or cross-catalytic relations, leading to "non-linear" behaviour, such as described in numerous studies of modern biochemistry. Remember that nucleic acids produce proteins, which in turn lead to the formation of nucleic acids. There is an autocatalytic loop involving proteins and nucleic acids.

Non-linearity and far-from-equilibrium situations are closely related; their effect is that they lead to a multiplicity of stable states (in contrast to near-from-equilibrium situations, where we find only one stable state).

This multiplicity is to be seen on a "bifurcation diagram" when we plot the solution of some nonlinear problem against a bifurcation parameter (for example, the concentration of some chemical component versus the time of sojourn of the molecules in a chemical reactor). For some critical value of this time, new solutions emerge. Moreover, near the bifurcation point, the system has a "choice" between two branches: we therefore expect fluctuations to play an essential role.

We mentioned the fact that dissipative systems may forget perturbations: these systems are characterized by attractors. The most elementary attractors are points or lines. But attractors may present a more complex structure; they may be formed of a set of points. Their distribution may be dense enough to permit us to ascribe them a fractal dimensionality.[7]

Such systems have unique properties, reminiscent of turbulence which we encounter in everyday experience. They combine both fluctuations and stability. The system is driven to the attractor; still, as this one is formed by so "many" points, we may expect large fluctuations. One speaks often of "attracting chaos". These large fluctuations are connected to a great sensitivity in respect to initial conditions. The distance between neighbouring trajectories grows exponentially in time. Attracting chaos has now been observed in a series of situations including chemical systems or hydrodynamics; but the importance of these new concepts goes far beyond physics and chemistry proper. We have already indicated the examples of long-term behaviour of climate or the electrical activity of the brain; there is no doubt that the new concepts are essential features of our environment; their study will permit to model complex behaviour displayed by systems in ecology or economics.

III

The physics and chemistry of complex phenomena leads at present to a new interface between "pure" and "applied" research. This interface is growing at present so rapidly that I can only briefly enumerate a few examples.

A characteristic feature of far-from-equilibrium conditions is the possibility of bistability. For given boundary conditions, there may be more than one stable solution.[5]

A remarkable application of bistability is in optonics, in which the intensity of a coherent light beam through a resonant cavity may induce more than one stable value of the transmitted intensity.[8] This bistability appears as a transposition to optics, of the hysteresis phenomenon well known in magnetism.

The stable states of the system are a function of its history, and not only of the boundary conditions: for a given value of the incident light intensity, it will evolve toward the low transmission branch (opaque state) if it enters the bistable zone coming from below or toward the high transmission branch (transparent state) if it comes from above. It therefore acts as a binary memory.

Potential advantages of optical memories are: three orders of magnitude as far as speed of response is concerned (from 10^{-9} to 10^{-12} seconds); and parallel processing, as a bistable optical element whose section is 1 cm^2 may easily process in parallel more than 10^3 pieces of information. What is perhaps more important, these components are susceptible to act as optical transistors.

It is interesting that this phenomenon of bistability is present in many problems, for example in biological cell dynamics. A simple example, which has been studied by my colleagues in Brussels, is the interaction between tumor cells and immune system cells which kill tumor cells.[9] Most of the effort in the study of cancer is directed to discover the mechanisms which lead to the transformation of a cell to a cancerous cell. In contrast, here we concentrate on the response of the organism to a given population of cancer cells. Basically, a minimal dynamical model would be one in which cancer cells form complexes with cytotoxic cells, which are then regenerated after having killed cancer cells. This situation may lead to one or many steady states. One observes that each cytotoxic cell may bind more than one tumor cell; this leads to highly non-linear processes; for this reason, one has to expect multiple states, some of which have recently been observed *in vitro*. In this perspective, one of the main approaches to cancer would be to study the transition from a dormant form of cancer to a virulent one.

Other recent research concerns nucleation of fractures and the initiation of plasticity in materials submitted to stress.[10] As is well known, every material contains defects. Under stress, some immobile dislocation may become mobile and interact. There is then an obvious analogy with the reaction/diffusion equations, which have been widely studied for chemical systems far from equilibrium.

In conditions involving stress, there is a possibility of spatial dislocation patterns, leading to an accumulation of dislocations in some regions. These regions, which have been observed experimentally, are then likely to lead to fractures and plasticity.[11]

I would like also to mention two types of problems which, in addition to non-linearity, involve fluctuations. Ideally speaking, for systems presenting a bifurcation point leading from one stable solution to two stable solutions, the probabilities of selecting one branch against the other are equal. But completely symmetrical solutions are only limited cases. Currently, we deal with *"imperfect"* bifurcations, which can play a crucial role in the selection of the outcome. An extreme example is the selection of chiral molecules, in which a very small difference in the energy of formation of the molecule could lead to preferential selection. This is basically due to the possibility of polarizing the fluctuations near the bifurcation point.[12)]

We begin to understand also other cases, some of which have great potential importance, such as combustion and ignition where the deterministic description breaks down.[13)] We have an initial induction regime, characterized by a very small rate of change which is followed by violent explosive behaviour. As the result of the induction stage, fluctuations play an important role: one finds a statistical distribution of ignition times instead of a simple, deterministic ignition time.

Abnormal fluctuations have also been observed in many biological problems, such as the distribution of growth rate of young males and females near puberty. This also indicates the existence of an autocatalytic effect, with a long induction period, as is the case in combustion. It would be fascinating to examine these ideas in process such as learning processes, which often proceed by step as has been shown by J. Piaget, and are likely to have long inductive periods.

IV

The discovery of the constructive role of irreversible processes in physics and chemistry and of their importance in understanding physical processes as well as the behaviour of the biosphere leads us to reconsider the microscopic meaning of irreversibility. Traditionally, irreversibility was only tolerated on the macroscopic level. It was supposed to be the result of ignorance of the exact dynamical state of the system. In contrast, on the basic microscopic level, there would be no question of an arrow of time, and no irreversibility.

This problem is closely related to the transition from the basic description involved in classical or quantum mechanics, with its deterministic and time-reversible features, to a description in which probability and irreversibility play a fundamental role. Only a few years ago, this problem seemed to be impossible to solve. These two descriptions, the dynamical one and the thermodynamical one, seemed to be separated by a gap which could not be bridged.

We begin now to see a way out of this difficulty. I would like to describe briefly the basic ideas involved. Classical mechanics may be seen as a point transformation in the phase space formed by coordinate and momenta. Another way of looking at dynamical evolution is in terms of a set of points which occupy some volume zone in phase space. A characteristic feature of classical mechanics is that this volume (the "measure," to use the mathematical term) is conserved in time.

This does not exclude very complex situations. The volume may be highly deformed or even broken into small pieces. This destruction of the initial "simple" volume gives the appearance of an approach to equilibrium, in which all the points would be uniformly distributed in the phase space.

Classical physics shows that conservation of volume and conservation of information are closely related. That is the reason why, in classical dynamics, information is strictly conserved. Initial conditions can be restituted. Indeed, the fragments of the initial volume could be brought back simply by inverting the direction of time.

We see how different the world appears in the thermodynamical description. For the mechanical description, the world appears as a museum in which everything, including information, is conserved. The world of thermodynamics is a world of processes, destroying and creating information; the volume is no more conserved. Think of the evolution of temperature, the inhomogeneity of which disappears without leaving any trace.

The new feature is that for a well-defined class of dynamical systems, we may now go from one description to another. This class is precisely the one in which the initial volume is highly deformed and broken into pieces, time going on. Such systems are highly unstable from the dynamical point of view. Moreover, in such systems, not all initial conditions should be possible. Only initial conditions leading to equilibrium *in the future* are actually susceptible of realisation.[1, 14]

We begin therefore to be able to spell out the basic message of the Second Law. This message is that we are living in a world of unstable dynamical systems:

If the world were built on the image designed for reversible, eternal systems by Galileo Galilei and Isaac Newton, there would be no room for irreversible phenomena such as chemical reactions or biological processes.

For unstable systems, which have a privileged time direction, we see a dispersion of the initial volume in phase space. Then, we cannot impose initial conditions which would force an ensemble of points to concentrate on a single point. The future remains open.

The message carried by the Second Law is therefore not one of ignorance and subjectivity. On the contrary, it gives us some basic information about the overall structure of the physical world.

At the beginning of this lecture, we referred to a basic level of physical description. We have now to take into account the Second Law of thermodynamics, even on this level. Therefore, this level can be formed neither by trajectories nor by wave functions, which satisfy deterministic equations in which the Future would be already included in the Present.

Whenever thermodynamics is valid, the basic objects of physics must be objects less specified than trajectories or wave functions. The new objects are then driven, as time goes on, to equilibrium in closed systems – or, in the presence of appropriate conditions to "dissipative structures". But we cannot go further into this fascinating subject.

V

Let us summarize our main findings. The universe has a history. This history includes the creation of complexity through mechanisms of bifurcation. These mechanisms act in far-from-equilibrium conditions as realised in the earth's biosphere. They may also have been of special relevance in the early stage of the universe, where we have to expect a strong coupling between matter and gravitation.[15]

Non-equilibrium physics is at present a subject in a state of explosive growth. I have tried to show you in this lecture some of the reasons for this fascination. It leads both to new applications of direct scientific and technical importance, and to new perspectives on the very foundations of physics, which will also be likely to lead to new technological developments in the next century.

Rationality can no longer be identified with "certainty," nor probability with ignorance, as has been the case in classical science. At all levels, in physics, in biology,[16] in human behaviour,[17] probability and irreversibility play an essential role. We are witnessing a new convergence between two "visions of the world," the one emerging out of scientific experience, and the other we get from our personal existence, be it through introspection or through existential experience.

Sigmund Freud told us that the history of science is the history of alienation: since Copernicus we no longer live at the centre of the universe; since Darwin, man is no longer different from other animals; and since Freud himself conscience is just the emerged part of a complex reality hidden from us.

Curiously, we now reach the opposite view. With the role of duration and freedom so prevalent in human life, human existence appears to us as the most striking realisation of the basic laws of nature.

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Technological Change and Its Effects on Society, A View from Europe

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I should like to start by congratulating the Japan Economic Journal, the Honda Foundation and the Japanese-Europe Technology Forum for having arranged this seminar. In view of the unique character of current technological advances, this is the right time for such a meeting to take place. May I also say that it is a particular honour to have been invited here today in company with such eminent figures as Minister Fischer of Austria and Prof. Prigogine.

We are living in a period of epochal transformation similar to the Industrial Revolution of the late eighteenth century which marked the passage from an essentially agrarian society to one progressively based on industry.

In the 1920s, the Russian economist Kondratieff discovered the existence of long wave economic cycles – Alvin Hansen referred to them as a sequence of good times and bad times, booms followed by depressions – lasting 45 to 55 years in the history of capitalist society. Kondratieff believed them to be the result of patterns of accumulation and then spending of capital. In 1939, Joseph Schumpeter offered an interpretation of these long waves in terms of a burst of fundamental, breakthrough innovations, their maturation cycle being held to determine the cycle itself.

In Schumpeterian terms, the first of these breakthrough innovations was the steam engine. Steam power, calling into being the factory system, changed the face of the textile industry – a change which was not, incidentally, achieved painlessly. We need only remember the Luddite Movement. Industry, wealth and population conglomerated around the coal fields and especially in northwestern Europe. The next breakthrough was the railways, introducing the concept of modern transport and personal mobility. The railway booms forged the great iron and steel industries and industrialized the eastern United States. Then electricity took over as the carrier of economic growth. All these innovations accentuated pressure toward urbanization, and essentially favoured the rise of industrial democracy. Finally, the inter-linked petroleum, chemical and automobile-led wave took over and held until after the mid-point of this century. It was to prove the last of the technological and economic waves of industrial society.

As industrial society grew, a technological paradigm developed based on the following elements: firstly, low cost of energy and raw materials, both abundantly available as required. Secondly, little or no concern for environmental impacts, nature being regarded as possessing a self-buffering capacity, ensuring regeneration. And thirdly, emphasis on basic industries (mining, energy, chemicals, engineering) and on mass production of goods in large plants maximising economies of scale to satisfy demand from mass markets. Lastly, greater emphasis on quantity rather than on quality.

In the 1960s this paradigm started to show its weak points. Economic growth had not solved some of the basic problems of mankind. Gaps between rich and poor countries increased – even to the extent of the reappearance of famine on a Biblical scale. Gaps between urban and rural areas, between classes and generations, widened. Contradictions within individuals themselves became a social problem. The shadow of nuclear war continued to hang over the world.

Furthermore, environmental and health effects caused anxiety, starting with a series of errors such as thalidomide, phenol, DDT, the chlorofluorocarbons, and single cell proteins. Diseconomies of scale began to emerge, caused by the rigidity of large plants, overcapacity, unemployment, and – significantly – attention to process improvement at the expense of product innovation.

In the 1970s, two major energy crises removed another pillar of the technological paradigm: the low cost and easy availability of energy. This precipitated economic recession, unemployment, trade imbalance, and increasing debts of non oil-exporting developing countries. As regards technology and innovation, it generated a flood of pessimism in the United States and the countries of Western Europe. The law of diminishing returns, which Malthus had applied in 1798 to the labour factor as applied to agriculture, by 1979 was believed by Giarini and Labergé to be applicable to the results obtainable from an increase in the output from technological and scientific research. The question was being asked with insistence: was mankind entering a new down-turn period of a Kondratieff cycle?

The only exception to this gloom was represented by Japan's continuing economic growth. Here, with an expanding economy, real technological innovation showing great originality and creativity remained the norm. An additional exception was provided by growth in the newly industrializing countries (the NICs), most especially in Southeast Asia – South Korea, Taiwan, Singapore, Hong Kong – but elsewhere too.

Now, in 1985 – and there could not be a better place to see this than Tokyo and Tsukuba – it is evident that the world is going through a major transition, under the impulse of not just one fundamental innovation, but of a cluster of major emerging technologies. These are led by microelectronics and the information technologies (IT), the process technologies such as robotics, automation, lasers and the like, new materials, new energies, the biotechnologies, including tissue culture and genetic engineering, ocean and space technologies. They are all (and in particular IT and the process technologies) extremely pervasive and capable of rapid diffusion throughout the economy.

Innovation no longer takes place within a given industrial sector through the improvement of the technologies typical of that sector, or through the origination of new products and processes following the culture of the industry. For innovation has ceased to be a linear, sequential process from small-scale laboratory research to pilot testing, to the commercial exploitation of new products or processes. Innovation now often proceeds through a sector's *invasion* by emerging technologies, and this process is far from linear.

Moreover, many options are now available for innovation. The grafting of new technologies onto traditional sectors prolongs their life. A sector is now to be considered mature when it is incapable of absorbing new technologies. The situation can vary in different firms, industries, even countries. The same industry (examples which spring to mind are iron and steel and shipbuilding) can be mature in one country and highly innovative in another. Those firms, industries, countries, which take up the challenge of innovation and look to the future with confidence in their capabilities will be more successful than those which as Raymond Aron said, "advance toward the future in reverse gear."

One of the peculiar characteristics of the present phase of technological innovation is the scientification of technology. Technology, in other words, is developing along strictly scientific bases, as a form of frequently interdisciplinary scientific work itself. In the past, many fundamental innovations were due to the work of isolated inventors, prior to the development of scientific knowledge to explain them or even independently of it. Instances of this are James Watt and the steam engine – Carnot's basic studies in thermodynamics only follow decades later. Edison developed his incandescent filament lamp well before scientific work on the theory of emission from solids was established. Marconi's pioneer development of radio took place with scant regard for work in electro-magnetic field theory carried out by Maxwell and then Hertz.

Nearer our own time, the harnessing of nuclear fission by Enrico Fermi stemmed directly from his theoretical and experimental work in nuclear physics. The same is true of Shockley, Brattain and Bardeen and the transistor: the outcome of years of study of solid-state physics and the nature of defects in solids. In the future, nuclear fusion – once achieved – will be the result of massive research into plasma physics. The boundaries between further advances in scientific knowledge and technologies which exploit them are becoming impossible to distinguish.

Technology is now used by man to invent new resources. Uranium was not an energy source until the advent of nuclear fission reactors, just as advances in nuclear fusion technologies will liberate the energy in lithium and water. Silicon – essential to the micro-electronics industry – is also a resources creator, making possible the photovoltaic conversion of solar radiation and thus providing a free and ubiquitous new source of electricity. Man is producing new materials specifically designed to solve particular problems or to perform specific tasks, otherwise impossible by reliance on the gifts of nature.

Science and technology have become increasingly close, reducing lead times between invention, innovation and commercialization through stronger links with industry and government. As a result, science and technology have increasingly become instruments of political and economic power for the pursuit of specific objectives: prestige, defense, economic growth. Science and technology policy has become a central factor in governmental thinking, the basis for military supremacy and for superiority in strategic advanced sectors such as nuclear energy, aerospace, telecommunications, electronics and informatics. The impact of scientists on society is now so great that they can no longer carry out their research oblivious of the political, economic and social problems created by the practical application of their work.

Let me here briefly illustrate some of the changes in the economy and in the structure of society induced by technological change and the growth stimulated and made possible by it.

In the market place, the trend is towards "dematerialization." This is a much more profound change than the advent of the "services society" much discussed over recent decades. Industry is at the centre of these revolutionary changes. New goods and services now require efficient, adaptable, market-oriented organization typical of industrial enterprises. Engineering, design, R&D, software, are performed by industrial-style firms providing totally non-material goods whose income is often statistically assigned to the services sector. Traditional conceptual barriers separating industry, agriculture and the services could well be destined to disappear.

Let me just give you one example of how things will change: in coming decades developments in genetic engineering will probably make it possible to fix atmospheric nitrogen at the root of cereals such as wheat, corn, rice. The concept of fertilization (seen as a function) thus would substitute the subministration of large amounts of nitrogen fertilizers. In a similar fashion, the use of extremely small amounts of insect sex attractants to confuse the male and avoid reproduction is one of several methods now available to eliminate the use of massive doses of pesticides. It emphasizes an immaterial function: pest control.

Thus, the agrochemical industry is either going to die or undergo profound transformation -- seeing the emergence of immaterial services or functions and the decline of mass production. The production of genetically modified seeds which have imprinted the nitrogen-fixing function, the biological control of pests on a regional basis, will replace contributions from traditional agricultural and industrial activities. And it is the most innovative chemical companies which are themselves protagonists in this remarkable change.

Some people look at this process as one of deindustrialization. This is a mistaken attitude to adopt. The fact that the source of jobs and income shifts more to the service sector and the production of immaterial products does not mean that deindustrialization is taking place. Just as the industrial revolution which displaced agriculture from centre stage required a vital contribution from an improved and expanded agricultural system, so now the post-industrial revolution is going to need a very strong industrial base (and in fact a strong agricultural one too, when we think that before the end of the century six billion people will inhabit the Earth).

This process of change will throw onto the labour market a great number of workers, but it will in turn draw upon an enormous reservoir of available human talent in the creation of new skills and professions.

The emerging technologies could favour inter-communication with freer and more rapid exchange of opinion in political debate, thus rendering our institutional systems more flexible and participatory. This is another facet of decentralization, made possible by information technologies.

Production systems need no longer be geographically determined by the physical location of workers and/or customers, resources or raw materials. The emerging technologies reconcile high productivity with small scale production. Small is indeed becoming beautiful, if not exactly in the sense described in the 1970s by Schumacher. Economies of scale could count for less, while the much greater flexibility in production management techniques given by new technologies will revolutionize product runs and pay-back times.

Small- and medium-sized enterprises which can count on diffused entrepreneurial talent and a committed and pluri-skilled work force are essential in this new system calling for high productivity, creativity and product quality.

Earlier, I mentioned that emerging technologies rejuvenate mature industries and prolong their life. This may also be said of geographic areas. Decentralization has created conditions whereby the gap between urban and rural areas need no longer be taken for granted: high-tech applications are ubiquitous. In the United States, many new manufacturing activities have risen in parts of the country once considered secondary, most obviously in the South and the sun belt. In Italy, areas outside the industrial triangle of Turin, Milan and Genoa are spearheading the introduction of new technologies in traditional sectors.

Hundreds of villages and towns in Italy – especially in the North-east and Centre, but also in the South – are specializing in a given industrial activity (Prato and Biella for woolens; Carpi, Perugia and Treviso for knitwear; Sassuolo for tiles; Udine for chairs; Osimo and Castelfidardo for musical instruments; Vigevano, Naples and Barletta for shoes, and so on). In each of these centres, hundreds – sometimes thousands -- of small enterprises are active in one or more of the phases of the production cycle, not necessarily in all of them. The whole village or town acts in international trade as a coalition of competitors. It is extremely interesting to see how quickly technological innovation, once achieved, diffuses through the system

Until a few years ago, the conventional idea of the international division of labour was based on the hypothesis that traditional manufacturing – deemed mature and technologically stabilized – would inevitably migrate to the developing countries, being seen as more competitive because of lower labour costs, easy availability of raw materials and greater flexibility. Today things appear in a different light. Over the next few years, unless their access to new technologies is increased, the developing countries appear unlikely to be able to continue to use the leverage provided by their abundant cheap labour and raw materials to produce goods able to compete with the industrial countries' sophisticated products in their home markets. A blending process leading to the effective integration of the emerging technologies with existing traditional ones is becoming ever more essential for these countries.

In our industrial societies, and particularly in Europe, fears of chronic unemployment due to automation, widespread in the 1950s and 1960s, have re-emerged. The relationship between technological change and the creation or destruction of jobs is a complex one. Jobs are lost in industries, and more especially in traditional sectors, where demand in the market for the product does not increase at rates high enough to compensate for rapidly rising productivity. On the other hand, the emerging technologies revitalized the economy and bring onto the stage new products, new services, and a wide range of new job opportunities, new skills, new professions. We at ENEA have calculated that by 1995 the application of new technologies in Italy will create a demand for three million new jobs in such fields as information technologies, office automation, lasers, robotics, the new energy technologies, new technologies applied to the environment, the preservation of monuments and our cultural and artistic heritage, and so forth.

Performance on world markets is clearly linked to readiness to innovate. It seems to me as an outside observer that most Japanese are aware of this. It does not entail the giving up of historical and cultural traditions, rightly prized here in Japan. In any case, innovation for any industrial society is not an option, it is an obligation. Societies which proving themselves hesitant in this climate of rapid and dramatic change lose ground internationally, and this can start a perverse spiral of economic decline. If a country does not take part in the early stages of innovation it may well be forced to import unemployment later, in the hidden form of equipment and machinery to improve process productivity.

There is no automatic balance between jobs lost and jobs created. The labour mismatch can be very severe, and the more so in those countries whose socio-institutional system is slow to adapt to the requirements of the new technological paradigm.

The elements of this new paradigm as it emerges are a society centred on information- and communications-related technologies; a society with high-cost energy and raw materials; a society where large-scale production does not automatically guarantee success. Decentralization at the level of production and in the organization of socio-economic life; a continuing need for training and retraining throughout life; a desire to preserve the integrity of the environment. A society where quality, rather than quantity, matters most – hence, dematerialization, and greater attention to the quality of life. It is evident that the basic rules of societal organization must change to comply with this new model, otherwise the labour mismatch to which I have alluded previously will be more difficult to overcome.

In Western Europe now we have 19 million unemployed (of a total population of some 370 million, of which about 170 million make up the labour pool). In the European Community alone we have as many as 13 million unemployed – and that is over 10 percent of our total work force. Youth unemployment makes up a quarter of the total. European wages are inelastic in the demand/supply relationship. Non-wage labour costs to industry, from welfare provision to health care and pension rights, amount to a considerable percentage of the wage received by workers. It seems undeniable that welfare provisions for the unemployed sometimes act as a discouragement to the search for new jobs. In addition, labour is immobile and linked in an antagonistic relationship to capital by often ritualistic trades union/management confrontation.

This is less true in Japan. For example, geographical immobility seems amply compensated by diffused worker-management consensus and (in the smaller enterprises at least) by quite flexible labour policies. And then there is the United States, with its marked propensity towards both geographical and social mobility, and its highly elastic labour market.

For Europe, innovation is of crucial importance. In the 1970s, oil price rises brought about economic difficulties: scarcity of finance, resource shortages, recession, inflation, growing unemployment. Competition has not been favoured by the defensive policies followed by governments who committed themselves to propping up ailing industries. In some countries assistance has taken the form of direct state intervention in ownership. Thus, social and political factors have assumed a highly inappropriate role in the management of industry, to the detriment of a realistic market approach.

Europe possesses real strength still in fundamental scientific research, with a healthy tradition of technological invention. I can quote a few of the most important products and processes which European industry has developed since the end of the war, starting with the L-D process for steel refining (Linz & Donawitz in Austria), going on to the float glass process (Pilkington's of the United Kingdom) and the invention of polypropylene (by Montecatini in Italy).

Europe is, however, better at technology-pushed than market-pulled innovation. This has continued to ensure Europe a front-ranking position in precision engineering, machine tools, fine chemicals, pharmaceuticals. But now diffusive innovation is increasingly market-pulled, and this favours the US and Japan.

It is the generally defensive, conservative attitude which still pervades European thinking that acts as an obstacle to market innovation. I believe, and my own country's performance is a demonstration of this, that small- and medium-sized firms are key factors for success in this innovation-oriented market approach.

Western Europe is not a homogenous unit. Nor can it be confused with the European Community (ten member countries using seven languages, after next year to be twelve using nine) as the latter does not include Austria, Switzerland, Norway or Sweden. Even at the strictly Community level, the government procurement function is divided. In some key sectors: telecommunications (including telephones), materials, pharmaceuticals, norms and standards vary – reducing the effectiveness even of the formal customs union. Technology imports from outside the Community take place with no intention to learn or to copy, merely to use – yet creative copying has been one of the foundations of the Japanese economic miracle.

If we compare countries to companies, while Japan resembles a well functioning integrated industrial enterprise, Europe still looks like a loose conglomerate, with unclear strategies and each component trying to sub-optimize its performance rather than aiming for global success. Until recently, European countries best cooperated in research and development the further a project was away from the market place – true of both nuclear fusion and high energy physics.

Despite barriers of all kinds, Europe possesses a cultural unity founded on strong historical, scientific and artistic traditions. It still guarantees the average citizen a quality of life which we Europeans feel is to be preferred to those on offer to the citizens of either the U.S. or, if you will permit me to say so, Japan. Furthermore, European creativity and flair when coupled with the new technologies are powerful motors for success. Design factors as well as fashion are now increasing in importance; here indeed Europe excels.

It is obviously unfeasible for each European country to innovate across too wide a front. Specialization at the country level is desirable, and this may require time and effort. Europe must rationalize its basic industries, in too many cases still characterized by excess labour, overcapacity, outmoded technologies. Europe must also strive to make stronger efforts in key high-tech/high-risk industries.

In the US and Japan, confidence in the future is a spur to innovation. The legislative and educational systems in both countries support competitiveness and entrepreneurial drive. I believe most foreigners have a superficial image of the Japanese reality, looking mostly at MITI, the great *zaibatsus* and targeted economic growth. More important is the powerful competitive spirit which permeates industrial life and stimulates risk-taking. I would add to this the ability to change strategic objectives once it becomes clear that something does not work, and to do it quickly.

Our government roles differ greatly. Here in Japan, generally via gradual consensus-building involving government, finance and industry (and here I must pay tribute to Keidanren for its wise long-term vision), strategies are developed which cope with the fundamental structural problems the country has to face. I greatly admired, for example, the study led by Saburo Okita on the implications of demographic changes in Japan from now to the year 2000.

In the US, the federal government has assumed a leading role in stimulating innovation, not only through deregulation, tax cuts and other measures to favour free enterprise, but also via gigantic prestige or defence projects in which through its agencies and departments it exercises its procurement function. The latest of these projects is the Strategic Defense Initiative (SDI), the high-technology programme in which $26 billion will be spent by the federal government over the next five years to create a defence against ballistic missiles using such new technologies as superfast, superpowerful computers, X-ray power lasers, particle accelerators, optronics and optics, new materials and artificial intelligence.

I personally have no doubt about the idealistic spirit that moved President Reagan to launch this programme. It can, however, be criticized as being perhaps somewhat utopistic, in the sense that it may never succeed in providing an effective global shield and, on the contrary, could negatively influence the diplomatic dialogue under way for many years, adding to the sense of insecurity on the adversary front.

But this is not necessarily the angle from which we should examine SDI. It is a programme concentrating vast resources on a relatively small cluster of technologies possessing wide civilian implications. Hence, it is bound to improve the competitive position of the US vis-à-vis both Europe and Japan. Even here, however, a few words of caution are in order. $26 billion over five years means less than ten percent – no more – of the resources which the US already devotes to R&D. Nor is it clear whether sums for SDI will be additional to, or merely a rechannelling of, funds that the US Government already spends.

But it is a fact that Europe has been caught by surprise by this initiative. Fears revolve around certain possible consequences. The individual European high-tech companies and research establishments which are being asked to participate in SDI may end up like subcontractors without any real grasp of the overall strategies involved. Furthermore, the countries of Europe will have little real bargaining power in their separate negotiations with the US. This initiative might spark off another brain-drain of top European scientists and technologists to the US itself. Furthermore, European scientists fear that for some years a shadow of secrecy will surround areas of scientific and technological importance in the US, thus greatly limiting the usefulness of scientific exchange and the international circulation of information.

It is from this point of view that one should examine the Eureka proposal, first advanced by the French Government and now being put together at a wider European level. The aim is a scientific and technological programme enabling the creation of a homogenous European technological space.

Eureka will cover essentially the same technologies as SDI – telecommunications, Earth observation by satellite for metereological and other purposes, rapid transport system, medical and industrial applications for lasers, research applications of high speed computers and so on – but with peaceful applications in mind. It will also probably include families of technologies not considered by SDI, such as the biotechnologies for health and agro-food applications. The programme will require more flexibility than is normally the case within the ground rules of the European Community – in particular, the principle of "variable geometry" will be applied, allowing those member countries which are not interested to step back, and other European countries not members of the Community to participate if they wish.

This would allow Europe to provide a coordinated positive response to the American proposal of cooperation, and a response on a more equitable basis. The question whether Europe will be able to launch this coordinated programme is of fundamental importance. Up to now, the mobilization of substantial resources has only proved possible in the pursuit of defence or prestige objectives seen as vital by governments and public opinion, such as the Manhattan and then Apollo Projects and now SDI in the US, or, in Europe, for assistance to an inefficient agricultural sector safeguarding it from collapse. Two thirds of the EC budget is spent on shoring this up, in an exercise that ignores the basic realities of the marketplace.

In contrast, even the most interesting innovative project launched by the Communities in recent years, ESPRIT (the European Strategic Programme of Research in Information Technologies), which, incidentally is on full display at Tsukuba, has received a very modest allocation of funds: about $600 million over 5 years, to be matched by a further $600 million from European firms operating in this sector. This should be compared with the $3 billion that IBM alone spends each year on R&D!

The fathers of the European Community: Adenauer, Schumann, De Gasperi, Spaak, did not found the Community with the purpose of protecting ailing sectors of the economy. Indeed not: they were hoping that European union would be strongly motivated by a positive vision of the future. Perhaps this is the time for Europe to change gear and courageously take up the challenge presented by this extremely interesting innovative phase in development of the world economy and society.

In the past 26 years, attempts to create large European-based multinationals have generally failed. Examples abound, I will cite only three: Fiat/Citroen; Pirelli/Dunlop, Siemens/Philips. The joint project approach has been more successful, especially in aerospace: the Ariane space launcher, the L-sat satellite, the Jaguar combat aircraft, the Airbus. Some other inter-European efforts have been quite successful technologically, though up to now less so commercially – and I refer to the Concorde and to the Superphénix fast breeder reactor.

European companies on the whole seem more happy alone, or in collaboration with non-European competitors. Just to quote ventures involving my own country, let me mention Olivetti/AT&T,

Italtel/GTE,Alfa Romeo/Nissan, Montedison/Mitsui, Montedison/Hercules and (said to be in the wind) Fiat/Ford. This process, however, is more general, involving closer cooperation between the three sides of the triangle that today leads world technological and economic development, and, perhaps, not only this kind of development. There are already instances of agreements on a world scale to tackle major high-tech projects, such as that for the development of the new generation jet engine, uniting the efforts of firms from three European countries, from Japan and the US.

I firmly believe that rather than closing ranks with each of the three sides of the triangle (US, Japan, Europe) attempting to rely only on itself, we all have a real interest in closer cooperation. A weak Europe is certainly less interesting a partner in such cooperation than one becoming stronger in international competition, and for this we require modern and aggressive European industry.

Improved profitability seems the only way forward. But ways and means must be found not to exacerbate the already intolerable unemployment problem in Europe. Market mechanisms alone may not suffice. Active government intervention is required, of a quite different type compared with the past. We like to say: better, not more, state intervention in the economy.

Innovative firms should receive support which is not only financial but is also in terms of real services: R&D, strategic marketing, help to acquire knowledge of the international market that they lack – especially the smallest among them. Venture capital in high-tech should also be encouraged.

But the most important steps that governments can take concern education and training and retraining systems. The skill patterns of the work force are no longer static. Ironically, the pace of change is such that much of our accumulated knowledge is ceasing to have relevance just at the time when data storage and retrieval systems are making it more accessible. Decision-makers, managers, trade union leaders – all of us, as a matter of fact – have to accept that we must relearn accepted wisdom if we are to avoid applying yesterday's solutions to tomorrow's problems. No one will be an expert all his life. All will have to suffer the salutary experience of returning to basics to relearn their expertise.

Attitudes are now all-important. Technological innovation is changing our world. Innovation, in its widest sense, is urgently required to ensure that these changes produce a better place. The emerging technologies open up a wide range of possibilities, from the most democratic and participative, to the most dehumanising and authoritarian. The industrial democracies must remain true to their ideals. There is now an evident mismatch between emerging technologies and the socio-institutional framework. In short, between what men and women can do and what they are called upon to do.

Let me move to the conclusion of my talk. The technological changes now in full flood will bring about long-term shifts in world economic leadership and in the distribution of power both between and within classes and nations. At the national level, structural changes are involved, to an extent extremely difficult even to comprehend, let alone accomplish, without extensive institutional reform. At an international level, the industrial democracies (Western Europe, North America, Japan, Australasia) must strive to achieve balanced growth to cope adequately with global problems.

Two major tasks face us. First and foremost, to ensure that technological progress will decrease the likelihood of armed conflict, the consequences of which may be of such a magnitude as to destroy human society entirely. Secondly, to ensure that the Third World is not left isolated and in despair.

As I said earlier, the availability of cheap labour in developing countries is no longer a major plus factor. Furthermore, the value-added of production is now shifting further and further downstream of the source of raw materials. With information on markets as they evolve and the control of the advanced technologies firmly in the hands of relatively few industrialized countries, the new technologies could actually increase the already excessive dependence of the Third World on advanced countries, rather than act to reduce it through stimulus toward a healthier inter-dependence.

I feel strongly that this is not in the ultimate interests of the industrial world. We need the growth and development of the Third World. It is crucial for world stability, as well as for natural justice. Appalling crises in certain regions – such as sub-Saharan Africa – have highlighted the potential for disaster across other countries and continents.

Only by facing squarely the challenges now before us and by optimising the use of technology, shall we manage to help mankind further along the road to the realization of its full potential. It is my conviction that in this both Japan and Europe have an essential role to play.

Part 2: Panel Discussion on "Innovation and Society"

Discussants:

Mr. Jiro USHIO
President of Japan-Europe Technology Forum

Mr. Yuzaburo MOGI
Managing Director of Kikkoman Corporation

Dr. Hubert BILDSTEIN
President of Austrian-Japanese Technological Society

Prof. Masahiro MORI
Tokyo Institute of Technology

Mr. Jiro Ushio

As a Japanese, I have two strong impressions after listening to today's lectures. One is that a fair amount of information is shared by Europe and Japan. The patterns of thinking in the two regions have become more similar, when compared with a decade or two ago, which is reassuring.

On the other hand, I also have the impression that there is some difference in emphasis between Europe and Japan in the way we view things. But my frank impression is that commonality is dominant.

Technological innovation has progressed rapidly in recent years, and it is fairly certain that this process will continue into the 21st century at a similar speed. Under these circumstances, management must carry out sweeping changes in its strategies. In recent years, those enterprises that responded effectively to the trend of technological innovation have shifted their strategies to meet the new conditions.

This is evidenced, first, by the fact that they are very active in applying technological innovations directly to their products and managerial systems. We must admit that these enterprises tend to be bold rather than cautious.

Second, they have introduced technological innovations such as office automation, management information and factory automation.

Information-intensiveness has radically altered even the conditions for choosing sites of offices and plants. The way in which enterprises relocate their operation, today without hesitation was not imaginable in the past.

There has been an enormous increase in the rate at which we conceive new ideas, prepare for their implementation and actually carry them out.

In the past, the process from the conception of an idea to its realization in concrete form took about 10 years. Recently, however, some enterprises require only five years. This development must not be overlooked.

Third, there is a change in the market. On the average, the most important factor of the change is that the market has been transformed by technological innovation and enhanced information-intensiveness. In some cases, the clients or consumers are more sensitive to technological innovation and changes in information intensiveness than business enterprises. This means that from now on a major requirement for enterprises is to grasp such changes in the market and consumers and know how to translate the perceptions into actual changes in their own mangement.

Fourth is the change in the desirable characteristics of employees. In this age of everything being speeded up, the emphasis in acquiring the needed human resources is shifting from in-house personnel development to recruitment from outside. When recruitment from outside sources is not adequate, enterprises establish tie-ups with one another. In the past, such a tie-up was difficult in Japan. Yet, today, an enterprise is able to speed up the pursuit of its business goal of higher quality personnel by affiliating itself with outside groups.

This represents a new system of human grouping and the grouping of enterprises in response to change.

The fact that such a system, which had been considered impossible in this country, is being developed signifies a new business environment in Japan, and, at the same time, shows that a very important change is occurring in management itself.

On the other hand, the social reforms deriving from the aging of society, together with society's maturation and internationalization bring about of social change.

Management will not succeed unless it overcomes the two mutually contradictory barriers, namely, technological and social innovation, as we move toward the 21st century. By linking them skillfully, we can continue to achieve innovation. Social change at times can be overcome by enterprises alone but in some areas government assistance is necessary.

The inability to adjust to social change suggests a decline in competitiveness.

Linking together technological and social innovation calls for a new pattern of business management. Instead of the conventional pyramid model of a technology-oriented system, what we need is an Alps-type model – many peaks formed by a variety of specialists.

The job for the people at the top would be to bring the leaders on the peaks together at a round table and coordinate and integrate their varied abilities. This may be said not only of technology but also of marketing, design and idea formation. The dominant form of leadership will also change from that of one man playing a major role to that of playing the role of coordinator. What makes it even tougher is such a person will be required to be very quick in taking action.

Running out of time is the greatest drawback in leadership of a business.

Prof. Masahiro MORI

In discussing the future, whether in terms of the society of the distant future or that of the 21st century, we tend to focus on the question "What does the future hold for us?"

Many people are inclined to answer this by saying that it is either God or the devil that determines the future of events and that all that humans can do is try not to miss the bus.

However, I believe that since each of us certainly does participate in the future, it is only natural that we should also ask ourselves "How do we deal with the future?", acknowledging our ability to influence our destiny.

Mr. Ushio has pointed to the emergence of a community of ideas shared by Europe and Japan. It seems to me that, viewed from another angle, it is we who have adjusted our way of thinking to those of Europe since the days of the Meiji Restoration–that is to say that the Japanese patterns of thought have become considerably Europeanized.

However, whether we are conscious of it or not, it is true that such ways of thinking are impregnated with Japanese traditions and culture.

Professor Colombo has stated that Japan is a country which has retained its ancient traditions in the face of innovation. I would like to ploint out that among the traditional ideas of our country are those of "dō" and "jutsu." One element of the reason that "jutsu" is regarded as superior to "dō" is the Oriental concept of "Musin" (naturalness or freedom from discriminative thinking). Let us take the example of Japanese archery. The best results can be achieved when an arrow is released, not with the conscious aim of hitting the target, but when the mind is a void.

Thus, it is when one is able to turn oneself into the target that"jutsu" rises above "dō."

It seems to me that the same applies to technology. Technology today has not yet attained the status of "gidō," or the "way of technique." We should strive from now on to elevate technology to "gidō." When this is achieved, pollution will disappear and technology will come into harmony with man and nature.

In the history of technology the example of ferrite shows that it was once considered a nuisance in the process of refining zinc. Under such circumstances, it would have been natural to select a refining process that would eliminate the need for ferrite. However, the idea of discovering ferrite's positive features was advanced, leading to the study of the metal for its magnetic qualities.

At first, ferrite showed only weak magnetism, but by compounding it, the magnetism was increased. Today's electronics and mechatronics would not exist without ferrite.

This shows that selectivity will not help technology to become "gidō." Should something bad be found, it is necessary to discover what lies hidden in it. We then need technical ability, intelligence and effort to make use of what we have found.

In Japan we have had in the past, as an alternative to selection, the idea of "sesshu-fusha," that is, "absorb and do not discard." It embodies the idea that all factors should be taken into consideration and not thrown away.

I believe that as we move towards the technology – way, the "gidō" – of the 21st century, it is necessary to adopt this idea of "sesshu-fusha" in production.

Dr. Hubert BILDSTEIN

Ladies and gentlemen, it's certainly a great honor for an Austrian to be invited to such a highly distinguished panel with such a highly distinguished audience to share in a few words some ideas, experiences, and observations on the question of innovation and society from the point of view of a relatively small European country.

Fortunately, two of the main speakers today have mentioned that small is not necessarily negative, and one of the main speakers has in particular mentioned that new materials are of special importance for new technologies and, therefore, a vast field for innovation.

Since I come from a small country and I am responsible for new materials, I am particularly pleased to appear on this panel.

In order to keep within the time allowed, I would like to follow a little bit my concept and present my case in five points.

I would like to begin by describing in brief the European situation. It is clear that there is increasing public concern about the impact of technologies, both existing ones and new technologies appearing on the horizon, on society, on our social structure, on the environment and on the quality of human life.

Yet, the same society is fortunately still fascinated by technological innovation and considers innovation to be a key element and prerequisite for industrial enterprise to remain competitive in the international market, providing growth potential and making possible the profits necessary for positive climatic conditions, for social equilibrium, for progress and further development, and this not only in the areas of natural, human and social sciences.

Sometimes the calls for greater control and intervention become a little bit loud, in a few cases amplified by media, which makes it sometimes difficult to distinguish between the real signals and the background noise.

Such ambiguity in public opinion, sometimes only in Europe, can be manipulated by experts with borrowed authority. This has sometimes led to somewhat irrational reactions, and the situation in Austria mentioned by Minister Fischer regarding the law against the peaceful use of nuclear energy from fission is a prominent example.

It is clear to everybody that such a law does not help to solve the energy problems of a country.

My second point regards the definition of single inventions or innovations as either revolutionary or evolutionary. This may sound semantic, but in industry we don't particularly like the word revolution. It is always, to some extent, related to uneasiness, to disturbance.

I fully follow Mr. Ushio's recommendation to enter into new technologies and innovations with a bold attitude, but it must not always take the form of a revolution.

I believe – and here I am with Professor Colombo – that the introduction of the steam engine, that the utilization of the electro-dynamic principle, and that, more recently, the utilization of micro-electronics, have a revolutionary character. All other inovations such as surface transportation, including air space, are, in my opinion, more of an evolutionary nature, even if the total impact over time does not differ significantly from changes of a revolutionary character.

The present period's innovations are revolutionary, as Professor Mori pointed out, because they include, for example, biological selection in the system.

There is another similarity to biological systems. Modern innovations are usually based on the grafting or fusion of technologies into each other, fusion not in the nuclear sense but fusion in the sense of genetic engineering.

What we can expected in the future and what we see appearing more and more are hybrid solutions.

My third point is related to an observation which is perhaps more true for the European cultural tradition. This is a consequence of the extremely long period of scientific research and innovations between all the technical achievements, on the one side, and the social and philosophical evolution on the other, creating a gap. The reduction in working time which could allow more involvement to close the gap has not yet shown any significant improvement towards closing this discrepancy.

We can certainly blame technology for moving ahead too quickly, but we should not do this. It does not make sense to reduce the speed of technology because social and philosophical evolution has not proceeded at the same pace. We should use, in this case, the phrase Japanese phase and convert or transfer this kind of approach and attitude to the European side.

We receive feedback from recent innovations, the instruments we now have available, but the size and dimensions of this new task must necessarily lead to solutions of a global character, taking into account the complexity of the problem.

However, I am convinced that perfect solutions, absolute solutions, are beyond the grasp of human endeavor just as is absolute truth.

I think we agree that unemployment, energy production, pollution control, national and international security, as well as technological and economic development of underprivileged areas are today the most prominent challenges for which solutions are being found.

But I am convinced that some of these problems will accompany us into the next century.

In my opinion, based on my experience of a number of years, R&D is comparable to a pipe into which a number of people put a number of things, and after a while, five to seven years for technological developments, something must appear on the other side. Whether it is good or not so useful will be decided when it comes out.

When we consider the vast amount of money, especially in Japan, which has been used for research and development in the past ten years, and only a part of it already having appeared, to the free atmosphere again, we can be really very anxious... no, it's not anxious... very desirous to see what's coming up the next time, and the words and skyline Professor Prigogine has demonstrated really that there is even a longer lasting time element to be observed and to be expected to bring forward new solutions.

My next and final point is that we have to work toward a real understanding of each other, an understanding which should include better knowledge and appreciation of our cultural backgrounds.

I was very much impressed by Professor Mori's comment that Japanese are thinking when they are aiming at targets. It is probably impossible to introduce such techniques and to transfer such techniques immediately without any modification into European thinking, but it is just another example of how we sometimes differ from each other that can cause difficulties in understanding.

We need people like those working behind the windows upstairs to make it possible for us to talk and listen to each other today, but what we really need is better understanding, in spite of the differences in countries, in cultures and the social structure, because without understanding we cannot really speak to each other. We can use the best communications systems but it is only wasted time, and time is one of our most precious commodities.

Furthermore, we should aim at avoiding a situation where scientific and technological knowledge and innovation are considered attributes of individual societies which accompany them like luggage on a journey into the future, as if they are riding on a train while others are left behind in railway stations, having only the rails as a link between themselves and the disappearing train in the distance.

Small countries should be welcomed on board, too, even if their relative contribution is small. As an example, the contribution of Austria to worldwide research and development amounts to 0.3 percent, which is very small. But if we compare this to the minute quantities and traces we are looking for in biological systems, when we discuss contamination in terms of parts per million, parts per billion or even parts per trillion, we can see that a tremendous difference can be made by such a small quantity.

Thank you very much.

Mr. Yuzaburo MOGI

As the managing direction in change of our international operations, I would like to speak on the transfer of technology.

There is bound to be an increase in technology transfer in the future. As technological innovation progresses throughout the world, international interchange will become more active, making it necessary to discuss the relationship between technological innovation and global society. Moreover, looked at from the business viewpoint, the more enterprises engage in international activities, the more necessary technology transfer becomes.

Companies usually start their overseas operations with exports. After establishing a sales base, they launch first into partial local manufacture and then adopt a total production system. Such a system always requires the transfer of technology.

As Kikkoman has set up a plant in Wisconsin in the United States, I will draw on my experiences in this connection to outline the points that companies expanding abroad should pay attention to when their operations involve a transfer of technology.

Most important is the adaptation of management methods to local conditions. For an enterprise to continue to prosper it must seek to live and flourish with society, particulary the local one.

When Kikkoman established a plant in the United States, we ran into opposition from local residents who feared that it might damage the environment.

We sought to counter this by persuading them that the manufacture of *shoyu* would not cause pollution and, moreover, that, as an agricultural industry, the plant could exist and prosper with farmers. While doing so, I came to realize how important it was to seek to cooperate with the local society and how necessary it was to adapt management practices that suit local conditions.

Such an adaptation must, naturally, be carried out on a case by case basis, but insofar as we were concerned, it consisted of the four following points:

First, employ as many local people as possible.
Second, conduct business with as many local enterprises as possible.
Third, participate in local activities and seek to meld with the community.
Fourth, delegate as much authority as possible to local people.

Although in developing countries there are generally requirements for the participation of local capital, such restrictions seldom exist in industrially-developed nations. However, even in developed countries, it is necessary to adapt management methods to the conditions of the local society. I believe it is the sole way in which enterprises whose expansion abroad involves a transfer of technology can achieve prosperity in the long term.

The next problem is that of the transfer of Japanese management techniques. To what extent can companies undertaking a transfer of technology to expand their operations to foreign countries take Japanese management methods with them?

Japanese-style management has attracted wide attention abroad and is highly regarded in some sectors. It is extremely dangerous, however, to simply transplant Japanese management techniques abroad.

The reasons for this are, first, that Japanese-style management has both advantages and shortcomings and second, that the managerial environment determines the management techniques.

That is why I consider it extremely risky to simply transfer Japanese management techniques overseas, where the management environment is totally different from that of Japan.

Hubert BILDSTEIN: In Europe, getting things done by having one specialist take full responsibility for the project is dying out. In its place, making use of the dynamic impact of a team or a group is gaining ground. The team approach is inevitable, because of the complexity of modern technology. Are such changes taking place in Japan?

Jiro USHIO: The system of enhancing efficiency by group or team work is a Japanese tradition. There is a certain similarity between this tradition and recent developments in America and Europe. But there is a difference in the actual methods used.

Because the Japanese are a very homogeneous people, a sense of identity or comradeship heightens the strength of any group. A heterogeneous society, on the other hand, lacking these emotional ties, must deliberately bolster the strength of a group by stressing its common purpose. Japanese human relations – I think you are familiar with *naniwabushi* – are different from those in the United States, as described by Professor Drucker. The results may be the same, but the approaches are considerably different. These differences we must take into account, I believe.

Reikichi SHIRANE: Japanese employees tend to focus on the goal of the company itself and its social significance. A Japanese is characterized by the tendency to have high motivation only after finding himself within such a context. This tendency is particularly pronounced in business enterprises whose success is wholly dependent on intellectual productivity. This recent trend is a shift from the pyramid shape to an Alps-type shape with many peaks.

Yuzaburo MOGI: As technological innovation has progressed, the opportunity for an individual to prove his worth has been reduced, demanding greater team work. This trend toward group work will, I believe, spread to the extent of encouraging greater cooperation among businesses, industry and academia, and both the public and private sectors.

Ushio: Until a little over a decade ago, Japan was trying to catch up with the West. This is the reason why, when a problem arose between Japan and the Western nations, the perceptions and ways of solving them were different between the two sides.

Today, Japan finds herself in an era in which she has to take up all the problems of the new age on the same plane with the West, such as the SDI issue, the relationship between man and biotechnology, new materials and society, social progress, etc. This is a time when we must make an effort to have as much common ground as possible with other countries. I believe we must actively endeavor to expand the common ground with the West in order to reduce the perception gap.

Shirane: Japan has, at long last, joined the front group of runners among the Western nations – in some areas of activity. This means that, unlike in the past when we were able to see our models ahead of us, we are in an era in which there are no models to emulate. We are having the experience for the first time of having to run while charting the way by ourselves.

Some countries of Europe have run at the head of the world's nations for a long time. And there are individuals whose wisdom has led the rest of the world. We must humbly accept this fact and try to learn from others. It is important for us to recognize the attributes and contributions of one another and deepen mutual understanding as we solve our common problems and advance toward our common goals.