SCIENCE AND DEVELOPMENT : PROSPECTS FOR THE 21st CENTURY

ACADEMIE ROYALE DES SCIENCES D'OUTRE-MER

ARSOM KAOW

KONINKLIJKE ACADEMIE VOOR OVERZEESE WETENSCHAPPEN

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

in cooperation with

THIRD WORLD ACADEMY OF SCIENCES

1999

SCIENCE AND DEVELOPMENT : PROSPECTS FOR THE 21st CENTURY

International Symposium
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In association with the
World Conference on Science
Budapest, 26 June - 1 July, 1999

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Foreword

This symposium on "Science and Development : Prospects for the 21st Century" is the materialization of a memorandum of understanding signed between UNESCO and the Royal Academy of Overseas Sciences on 15 December 1994.

This two-day seminar (3-4 December 1998), organized by the Royal Academy of Overseas Sciences and UNESCO, together with the Third World Academy of Sciences (TWAS), took place in Brussels at the Palais des Académies. It comes within the perspective of an exceptional "World Conference on Science for the 21st Century : a New Commitment" which will be organized by UNESCO and ICSU in Budapest from 26 June until 1 July 1999.

We would like to express our sincere thanks to Professor Ilya Prigogine, Nobel Laureate for Chemistry, who opened the first-day session, and to Professor José Vargas, President of TWAS and Minister of Science and Technology of Brazil, who chaired the second-day session.

Through the panel structure of the second-day seminar a large number of experts had the opportunity to give — each in his field — a thorough analysis of the actual subject. We were particularly pleased to welcome Professor Mohamed Hassan, Executive Director of TWAS, whose support was most appreciated. We sincerely thank the representatives from UNESCO, the European Commission, the industrial sector, and the Belgian and corresponding members from the three Sections of the Royal Academy of Overseas Sciences for their excellent contributions. The topic of this international conference was orientated specifically towards science and development. Most of the speakers originated from developing countries.

Our gratitude can be extended to all those who have made this seminar such a great success, i.e. the speakers, the moderators and the reporters. In particular, we are most grateful to the secretariat of the Academy for the excellent organization.

Federico Mayor
Director General of
UNESCO

Yola Verhasselt
Permanent Secretary of
the Royal Academy
of Overseas Sciences

OPENING SESSION

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Introduction

by

Michel GRAULICH *

Your Excellencies, Mr director-general, ladies and gentlemen, dear colleagues,

Excellences, monsieur le directeur général, mesdames et messieurs les secrétaires perpétuels, MM. les recteurs, MM. les présidents, mesdames et messieurs, chers consœurs et confrères,

Excellenties, dames en heren vast secretarissen en voorzitters, dames en heren, waarde confraters,

Ce m'est un grand privilège de pouvoir vous souhaiter la bienvenue au symposium «Science et développement : perspectives pour le 21e siècle».

The symposium to which I have the honour and pleasure to welcome you is intended to implement the memorandum of cooperation between the UNESCO and our Academy that was signed on December 15, 1994 by Mr Federico Mayor, director-general of UNESCO, and by the president and the permanent secretary of the Academy, Messrs Robert Leenaerts and Jean-Jacques Symoens.

It also anticipates the great "World Conference on Science for the 21st Century : a New Commitment", organized by the United Nations Educational, Scientific and Cultural Organization and the International Council of Scientific Unions, conference that will be held in Budapest from June 26 to July 1 next year.

Onze Academie houdt eraan de UNESCO hartelijk te bedanken voor haar waardevolle mede-organisatie en haar hulp. We also express our heartful thanks to those who have initiated the project, our colleagues Messrs Mustafa El Tayeb and Robert Leenaerts.

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* President of the Royal Academy of Overseas Sciences, rue Defacqz 1/3, B-1000 Brussels (Belgium).

This international symposium is organized in close collaboration with the "Third World Academy of Sciences", whose executive director, Mr Mohamed Hassan has given us efficient assistance we gratefully acknowledge.

We feel very honoured by the presence at the symposium of three particularly eminent speakers, Mr Federico Mayor, director-general of the United Nations Educational, Scientific and Cultural Organization ; Mr José Vargas, president of the "Third World Academy of Sciences" and Brazilian minister of Science and Technology ; and Mr Ilya Prigogine, winner of the Nobel prize for chemistry. Qu'ils soient tous sincèrement remerciés pour leur participation. Les agradezco muchísimo su prestigiosa presencia y participación.

Excellences, mesdames et messieurs, chers consœurs et confrères,

S'il faut en croire la Bible et d'autres mythologies anciennes, c'est parce qu'ils ont opté pour la science et la civilisation, c'est-à-dire parce qu'ils n'ont voulu dépendre que d'eux-mêmes, que les hommes ont perdu le paradis originel et que la durée de leur vie s'est progressivement raccourcie. Adam et Eve furent condamnés pour avoir cueilli le fruit de la connaissance du bien et du mal, Caïn, l'agriculteur, le forgeron, le bâtisseur de villes, pour avoir tué son frère dont les premiers nés des troupeaux plaisaient plus à Dieu que les prémices des fruits, les anges furent condamnés parce qu'ils apportèrent sur terre les arts et sciences afin de séduire les femmes, les hommes en général pour avoir voulu construire une tour qui montait jusqu'au ciel, ... Depuis, chacun a toujours rêvé d'une vie longue, pleine et heureuse, et cette aspiration a été au cœur même de nombreuses grandes religions anciennes.

Or, depuis trois siècles, cette science qui aurait entraîné notre perte semble nous faire retrouver peu à peu le paradis perdu. Elle a graduellement allongé l'espérance de vie pour des nombres de plus en plus grands et elle entrouvre même, dit-on, la possibilité d'arriver à des âges jamais atteints. D'autres choses dont l'homme d'autrefois se bornait à peupler ses mythes, voyager dans les airs ou vers d'autres planètes, se faire entendre et voir d'un bout à l'autre de la planète, être au courant de tout, ou presque, sont devenues réalité et ne sont même plus réservées à une secrète élite.

La science a permis de produire des vivres et des biens de toute sorte en quantités telles qu'il fallut inévitablement transformer les masses laborieuses en masses d'acheteurs de produits de plus en plus sophistiqués. Leurs conditions de vie s'améliorèrent et il en est résulté des progrès sociaux et des avancées démocratiques constants.

Malheureusement, toujours avec un décalage. Fidèle à son rôle incontournable d'apprentie sorcière, la science a aussi provoqué une formidable explosion démographique, et ce n'est qu'après coup, au fur et à mesure, qu'elle est parvenue, plus ou moins bien, à nourrir tout ce monde et à limiter les naissances. Mais quantité de problèmes subsistent ou surgissent sans arrêt.

De grootste uitdaging van de komende decennia zal hoogstwaarschijnlijk erin bestaan plaats te maken voor enkele miljarden bewoners meer op onze aarde en hen een echt menswaardig bestaan te garanderen, met de mogelijkheid zelf in hun levensonderhoud te voorzien en met minder ongelijkheid.

Even belangrijk is de milieuproblematiek. Bedreigen bijvoorbeeld de gassen met een broeikaseffect ons werkelijk met een klimatologische ramp en zo ja, zullen we bij machte zijn die te ontlopen of tot staan te brengen ?

Sedert 2500 jaar, sedert de Grieken, het christendom, de Reformaties en de revoluties heeft de mens ernaar gestreefd de mens te veranderen, maar men mag niet zeggen dat zijn inspanningen opmerkelijke resultaten hebben voortgebracht. Vandaag stelt de genetica hem in staat werkelijk in te grijpen om zichzelf te veranderen, maar begrijpelijkerwijze aarzelt hij en stelt hij zich vragen over de ethische problemen die daarbij rijzen. In dergelijke materies zullen voortdurende bezorgheid en waakzaamheid de regel moeten blijven.

Un dernier domaine enfin que j'évoquerai est la croissance, inimaginable naguère, de nos moyens de communication et d'information. Les avantages en sont évidents mais ici aussi la vigilance est de rigueur. Ne courons-nous pas le danger, en effet, surtout dans les sciences humaines, d'être noyés par la quantité des informations, de passer plus de temps à en prendre connaissance qu'à les penser, d'avoir de moins en moins la possibilité de prendre du recul à leur égard et de voir péricliter cet esprit de doute systématique qui est l'âme même du savoir et de la liberté ? Ne perçoit-on pas déjà, parfois, un certain retour à l'argument d'autorité et à la scolastique ?

Excellences, mesdames et messieurs, chers confrères, depuis longtemps la science n'a cessé de trouver des solutions à nos problèmes et il n'y a pas de raison pour que cela change. Il se pourrait bien, dès lors, que nous finissions un jour par récupérer vraiment le paradis perdu ou, du moins, que soient limités au minimum les facteurs extérieurs qui menacent notre bonheur. Pour le reste, ce sera à nous de jouer.

Thank you for your attention.

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Science for the 21st Century. Perspectives

by

Ilya PRIGOGINE *

1. Introduction

There are many domains which are at present in rapid expansion such as astrophysics, molecular medicine or exploration of outer space. These activities will of course continue. But there is somewhat deeper. At the beginning of this century the idea was that Nature is simple. With a few laws of classical or quantum dynamics you could describe the large majority of physical phenomena. Great physicists like Salam or Feynman claimed that there are today only islands of mystery such as elementary particles or the brain. However, the second half of this century has discovered complexity. The traditional description applied only to simplified, idealized structures. Everywhere we see now fluctuations, instabilities, evolution. These are properties we assign to complex systems. The understanding of complexity requires new experiments and new theoretical tools. This will certainly be one of the main goals of the sciences of the 21st century. Even if we consider human society, we are going to a more and more complex interacting system. I have just come back from the Information Society Technologies Conference in Vienna from November 29 to December 2 organized by the European Union and the Austrian government. There

* Nobel Laureate, International Solvay Institutes for Physics and Chemistry, Brussels (Belgium). Center for Statistical Mechanics and Thermodynamics, Austin, Texas (USA).

were about 3,000 participants, and I was greatly impressed by the enthusiasm of the audience, the dreams about the future I heard.

We all know that humanity is going to what is called the "information revolution" leading to networks, in short to the networked society. Curiously there is some analogy between the present evolution toward the networked society and the processes of self-organization I have studied in physics and chemistry. Indeed, nobody has planned the networked society and the information explosion. It is a remarkable example of spontaneous emergence of a new, more complex form of society.

Let me start with some remarks on the networked society. It is often stated that the networked society will lead to some form of unification of humanity. My friend Professor Jean-Louis Deneubourg made the observation that other networked societies exist involving social insects. We know today about 12,000 ant species. Their colony sizes are ranging from a few individuals to 20 millions of individuals. It is remarkable that the behaviour of the small ant societies and of the large ant societies are quite different. In a small insect society, individuals know at every moment what they must do. They go foraging, they come back to share their prey, they behave independently. However, once the society becomes large, coordination becomes the major problem. There appear complex collective structures that spontaneously emerge from simple autocatalytic interactions between numerous individuals and the environment, mediated by chemical communication. In small insect societies, the complexity is localized at the individual. In large ant societies, complexity is more on the level of the interactions between the individuals. It is certainly not a coincidence that in the largest and most integrated insect societies, that is in the army ants and termites, the individuals are practically blind.

The networked ant societies are able of extraordinary performances. In recent years, one has found super-colonies of ants which contain hundreds of millions of individuals. They develop a network of communication between individual nests on tens of kilometers. That means millions of times the size of a single ant.

The evolution from the small ant societies to large ant societies was the result of qualitative changes involving discontinuities. Such type of discontinuities appear in many fields of physics, chemistry and biology. They are associated to "bifurcations". Bifurcations play an important role in our present view of nature. They lead to multiple possibilities which are associated to probabilities. They destroy the classical deterministic view of nature. We can identify them both in physics and in human societies. Therefore I think it is appropriate to say first a few words about bifurcations in nature before coming back to the problem of the human networked society.

2. Dissipative Structures

Results in non-equilibrium thermodynamics have shown that bifurcations require two conditions. First, we have to be far from equilibrium. We have to deal with open systems exchanging energy and matter and information with the surrounding world. Secondly, we need non-linearity. This leads to a multiplicity of solutions. As mentioned, which branch of the solution in the non-linear problem will be chosen, depends on probabilistic elements. Bifurcations provide a mechanism for the appearance of novelties in the physical world. In general however, there are successions of bifurcations. This succession introduces a historical element. It is now generally well understood that all structures around us are the specific outcomes of such historical processes. The simplest example is the behaviour of chemical reactions in far from equilibrium systems. They may lead to oscillating reactions, to so-called Turing patterns, to chaos in which initially close trajectories deviate exponentially time going on. The main point is that for given boundary conditions, that is for a given environment, there are many solutions. That is the reason why we can speak of self-organization. In this view the universe including the human universe is only one of the possible realizations of the laws of nature. In other words, the "possible" is richer than the actual.

Many authors have emphasized the importance of self-organization in nature. We experience this every day in our society where information technologies provide the interconnections that introduce high non-linearities and give rise to a lot of new possibilities manifested as bifurcations.

I would like also to emphasize the extraordinary sensitivity of bifurcations. There are quite remarkable experiments by my former student Professor Dilip Kondepudi which show that small perturbations can affect the future of billions of molecules.

In order to assess the intrinsic uncertainty of nature, we have to look for statistical regularities and search for formulations of the Laws of Nature which are probabilistic and break the time symmetry, thus introducing a historical element. As we shall see later, such probabilistic formulations are now known for complex systems. Problems which have no solution on the deterministic level may have one on the probabilistic level. The resulting probabilistic algorithms are useful in pure science as well as in specific technological applications.

In human society, the condition of non-equilibrium is obviously satisfied. Life is only possible in open systems exchanging matter, energy and information with the outside world. It is also clear that a society is a non-linear system. What somebody is doing influences the action of others. This non-linearity increases with the size of the society. Our present society is already full of possible bifurcations. Of course, bifurcation is a rather general term. If I decide to take my umbrella because of uncertain weather, or leave it at home, I may consider this already as a kind of bifurcation. So we have to make a distinction between trivial bifurcations and bifurcations which indeed lead to new historical systems. The great French historian Braudel has written : "Events are dust". This is only partially true. There are "well-defined events" which have shaped human history. A simple example is the neolithic bifurcation associated to an increased flow of energy, coming from the discovery of agriculture and metallurgy and leading to a complex hierarchical society. I have always found remarkable that the neolithic bifurcation emerged everywhere about the same period, which means about 10,000 years ago. But it emerged with different attributions in the Middle East, in China or in pre-Columbian America. This is similar to the branches of bifurcations which appear in chemical or physical systems.

We can of course quote other social bifurcations related to the use of fossil energy : coal, oil which led to the industrial society. Now we have the information technology which leads to the networked society. What will be the effect of the present bifurcation ? Because of the scales involved we can expect a larger role of non-linear terms, therefore larger fluctuations and increased instability. Of course the present revolution is part of the technological bifurcation which started at the end of the 19th century and went through the whole 20th century. We have therefore already a period of about one century behind us. What effect had the technological revolution on the life of humanity in the past ? In the 20th century, there were and still are tragic events : wars, ethnic purification, ... But war and bloodshed are not something new. They have existed always in our history. But there is also a constructive positive aspect of the technological revolution that is the decrease of inequality. At the beginning of this century, we had a gap between the "civilized" and the "non-civilized". The non-civilized were treated only slightly better than animals. The inequality between social classes has also decreased as well as the inequality within the family. Also there is an increasing participation of people in culture. However, we are still far from a satisfactory situation. A large gap is also developing between people who know and people who don't know. This issue acquires a new formulation in the networked society. As Alvin Toffler puts it : "The illiterate of the future will not be the person who cannot read. It will be the person who does not know how to learn". Education objectives and priorities should change towards the ideal of continuous learning.

Of course, there are advantages of the networked society which are well-known. Think about medicine, or business. However, I believe that our judgment has to be based on more fundamental criteria. The American philosopher Whitehead has stated that already the Greeks had developed two aims for humanity : first, the intelligence of nature that is a rational formulation of the laws which rule matter or life and on the other hand the establishment of a democracy based on the role of values. Will the networked society be a step towards the realization of this goal ? From this point of view it is interesting that each bifurcation in the past resulted in people who benefited from it and in people who became its victims. The neolithic society led to extraordinary realizations in the field of arts. It led to the construction of pyramids for the Pharaohs but also to common graves for the common people. Slavery started probably with the neolithic civilization and continued till recently. Similarly the industrial civilization led to the development of the proletariat at the same time as to an increase of wealth. Will the information revolution bring us closer to the ideal stated by Whitehead ?

3. The New Concept of Nature

Let us now ask what kind of concept of nature we need to describe the continuous emergence of novelties, the historical element we now observe on all levels.

Certainly this concept clashes with the traditional formulation of laws of nature which are deterministic and time-reversible (that is past and future play symmetrical roles). There are of course systems which satisfy such law like the ideal pendulum. But there are exceptions. It is hard to imagine that the information to produce 12,000 ant species was already part of the information at the time of big bang.

This problem has been at the centre of our research over the last fifteen years. I shall try to describe the spirit of this work. I apologize but I cannot avoid here the use of some technical terms. In classical mechanics, laws of nature are described by point transformations (the position and the velocity of a mobile on his trajectory). Quantum mechanics has forced us to introduce a more general formulation. Time evolution is described by an appropriate operator (the Hamiltonian or the Liouvillian) acting on appropriate functions (wave functions or probability). Each operator is characterized by eigenfunctions that are invariant in respect to the operator apart a number with the eigenvalues. The expression of the operator in terms of its eigenfunctions and eigenvalues is the spectrum of the operator. Now comes the essential point : this spectrum depends on the type of functions, the function space on which it acts. In orthodox quantum mechanics or statistical mechanics one uses a function space called the Hilbert space which is formed by functions which behave like vectors (they have a length and you can define a scalar product). Then you obtain the usual time symmetrical and deterministic laws. But when you go beyond this space and use generalized functions (such as fractals) you obtain new solutions with broken time symmetry and where the fundamental quantity is probability (and no more trajectory or wave function in quantum mechanics). This is very similar to the step from Euclidean to non-Euclidean geometry to accommodate gravitation in general relativity. Here we need new function spaces to include irreversibility. We know now there exist a variety of dynamical systems from simple integrable systems to chaotic systems. Time symmetry breaking applies precisely to chaotic systems as well as thermodynamic formed by a large number of interacting results.

So this old dilemma between Heraclite and Parmenide is now solved through the progress of mathematics and the theory of dynamical systems. The reformulation of the basic laws of physics are subjects which will likely attract the attention of an increasing number of scientists in the 21st century.

4. Conclusion

The French philosopher Jean Wahl has written that the history of western philosophy is on the whole an unhappy one, torn between being and becoming. Classical science favoured "being" but at the end of this century we have seen the comeback of "becoming" specially through the role of complexity associated to irreversibility. Of course, the idea of a history of nature had emerged already in the 19th century notably with Darwinism. However, physics has resisted and kept a deterministic description. As stated in the lecture we have now overcome some of the main obstacles.

What are the mechanisms of the fundamental bifurcations, be they transition from matter to life, from the vacuum to our universe, or of the main steps in biological evolution. We know very little.

Therefore, we may safely conclude that science in the 21st century will be associated to the exploration of becoming. This is a beautiful programme as it is the exploration of the creativity of nature of which the creativity of man is a special case. With the close relation between science and society we expect that this research will also have important repercussions for the society of tomorrow.

Let me conclude with a sentence of the French minister Claude Allègre published in *Le Monde*: "Je crois que nous entamons une nouvelle ère scientifique où le déterminisme vole en éclat, où le réel, l'analyse de la complexité reprend sa place".

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Scientists and a Culture of Peace

by

Federico MAYOR *

Ladies and gentlemen,

There are those who say, "You cannot put limits on scientific research without putting limits on the human mind". I maintain that we should not want less science, but better science ; in other words, science which contributes to peace, to development and to the well-being of individuals throughout the world. It is not science we should restrict but the abuse of science. During the 20th century, science has too often been put at the service of war, domination and power. Some think that this has been a passing phase, that Hiroshima and the Holocaust are sad aberrations. They conclude that barbarity cannot happen again. I disagree with that view. The examples of aberrant violence throughout history are only too many. For centuries, science has walked in the corridors of power, contributing to the conquest, exercise and conservation of power. We need only recall that Archimedes built machines of war in the service of Syracuse of that Leonardo da Vinci drew plans for war-weaponry. Scientific knowledge and power have long been bedfellows, accomplices perpetrating the culture of war that has dominated for so long.

Does that mean, however, that we should sit back and accept this collusion between science and power as a fatality ? I believe not. The first steps away from a culture of war and towards a culture of peace have already been taken, including the crucial first step of admitting that a change of attitude was necessary. The survivors of the Second

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World War were confronted with a terrible, irrefutable truth : man's capacity for destruction had taken a giant step forward. Man had reached the point of being able to annihilate not only himself but all life on Earth. Logically then, the future survival of mankind would lie in man's capacity to master his mastery of science. This would mean opposing a "culture of peace" to the pervasive "culture of war", including a code of ethics to prevent the abuse of science. In 1945, when the world was still reeling from the massive death and destruction of the most technological war in history, the founders of UNESCO vowed "Never again" and set about the task of "building the defences of peace in the minds of men", through education, culture and science. This remains UNESCO's *raison d'être* today.

We should ask ourselves whether the use of science as an instrument of war is not simply the extension of a project that goes back to the Renaissance period, that of subsuming the laws of nature to the principles of technology and the Cartesian ideal of transforming human beings into the "masters and owners of nature". Could it be that this project has succeeded too well ? Today, we need urgently to propose a new path : that of mastering our mastery of nature. If science has brought us enormous benefits, some of the fruits of this research are exposing us to new, sometimes unforeseen dangers, many of which we are only beginning to perceive.

How does one move from a culture of war to a culture of peace ? Science in itself is not irresponsible. But scientists who disassociate themselves from the practical applications of their research by assuming a neutral stance are denying the tight bond linking science to technology. Science must not be blind. The scientific process cannot be disconnected fully from the end-product, be it a military or civil application. It is time to rewrite the science-society contract that has been in place since the end of the Second World War. It was the publication of Vannevar Bush's famous report to President Harry Truman, entitled "Science — the endless frontier", which launched a linear reservoir model under the terms of which basic research has led to applied research and ultimately to technological development. This model is contested today. It has been said that, "The logic of the present social contract is backwards, because it starts with research and tries to prove it useful, rather than starting with national needs and proving that research addresses them". A major component of the World Conference on Science in June 1999 being organized jointly by UNESCO and the International Council for Science (ICSU) will be the drafting of this new science-society contract to ensure that science makes a greater commitment to society and that, in return, society makes a greater commitment to science.

The Nobel Prize laureate Dennis Gabor has lamented, "Our present society is founded, materially, on extremely efficient technology and, spiritually, on almost nothing". This has led to growing mistrust when it comes to the environment, cloning, genetic engineering, etc., despite a strong desire to benefit from the advances of science. The teaching of the history of science could be one mean of linking society with its scientific roots, a way of avoiding the science-religion confrontation in particular. History of course has its dark moments — the trial of Galileo, for example — but history also contains a little-known golden period in science, namely between the VIIth and XVth centuries in the Arab States and Iran with breakthroughs in algebra, astronomy and medicine. Study of this period reveals that rationality and scientific methods can be essential values of an Islamic society.

Mastering our mastery of nature means endowing science with a conscience. The past role of ethics in science needs to be revised and scientists need to take on greater responsibility. This is no time for scientists to remain cooped up in their ivory towers ; the future of the planet is at stake. We still have only rudimentary knowledge of the impact of biotechnologies, nuclear, bacteriological and chemical technologies on the environment and on human beings. Of the 76,000 chemical products currently circulating on the market today, for example, only 1,600 have been tested for their capacity to induce congenital malformations. In the field of agriculture, the production of fertilizers trebled in the thirty years to 1996. Scientists are now insisting that we need to know more about the release of these untested products — which migrate through the food chain and cross the barrier of species — into the biosphere.

What we lack today are non-violent rebels, scientists who are prepared to speak up in the interests of society at large. Freedom brings with it responsibilities. This axiom needs to be recognized not only by scientists, but also by institutions and all actors of society, including the private sector. Today, with the globalization of markets and heightened competition, scientists are coming under increasing pressure to remain silent about potential risks. It is inadmissible to imagine today's world built solely on the basis of the market model ; a world where scientists — whose stature is linked to their independence and their ability to expand our knowledge — would be nothing more than one player among many in the global market. There would be an immense risk of implosion of any system electing the market as its sole objective. Science must not be reduced to a tool in the hands of those animated by the thirst for power, financial gain and domination, but rather pursue its mission of uncovering the objective truth. With this in mind, UNESCO has created a "World Commission on the Ethics of Scientific Knowledge and Technology" to be chaired by the former President of Iceland, Mrs Vigdis Finnbogadottir ; it is up to us to encourage sectors of society to take a similar stand, to create committees on ethics, citizens' conferences and Parliamentary select committees to reflect on the ethical, social and economic consequences of new technologies.

Citizens should be encouraged to participate in a "cognitive democracy", as Edgar Morin so eloquently put it, a society in which all citizens will be able to understand and reflect on the implications of current scientific technological progress. By cognitive democracy, he meant a society that includes consultation between scientists, representative institutions and society at large when major scientific decisions need to be taken. There can however be no cognitive democracy without lifelong education for all and a "new way of thinking". Science can help us to understand the complexity of our environment, inform the public when there is a threat of irreversible damage and identify which policies are necessary to avoid destroying our planet and ourselves.

Science can also help us understand our responsibilities towards future generations. I have said that science must not be blind ; nor must it be short-sighted. It must also work with the long term in mind. Science — like the rest of society — has a responsibility to see beyond the immediate ; too often, it is guided by the dictatorship of impatience : impatience to see results of research, new products and profits. In a long-term perspective, UNESCO adopted in 1997 two important international instruments : the "Declaration on the Human Genome and Human Rights" and the "Declaration on the Responsibilities of Present Generations towards Future Generations".

Imagine if you will a world in which science contributes to a culture of peace respectful of life and dignity. Alas, we still have a long way to go, even though the survival of our planet depends on our reaching this goal. There are some encouraging signs. According to the World Science Report 1998, investment in military research and development in the European Union declined by 20 % between 1986 and 1995. We can also applaud the signing by 132 countries of the "Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and Their Destruction" in December 1997. The Convention is moving closer to becoming international law, with 40 of the signatories having ratified the Convention as of September of this year, including several former mine producers and exporters, such as France, Germany and the United Kingdom, and nations that have been heavily impacted by land mine use, such as Bosnia and Herzegovina, Mozambique and Zimbabwe. The other side of the coin is more sobering. According to the UNDP, military expenses accounted for some USD 800 billion around the world in 1995, equivalent to the consolidated income of nearly half the world's population. Defence spending — much of which goes on scientific research — is, on average, as high as in the 1970s. Three-quarters of the international trade in arms goes to the developing countries. Think what could be achieved if these same resources were redirected to education and to science and technology development in developing and developed countries alike.

Man tends to have a short memory when it comes to the dumping of arms. Unlike certain forms of weaponry that have the ability to kill and maim the civilian population long after a conflict has ceased. Cyclone Mitch in early November not only set back parts of Central America for some twenty years, but also threw an additional spoke in the development wheel of one of the poorest regions in the world by displacing during its passage thousands of long-buried anti-personnel mines, thus rendering useless all existing maps designating the mined areas and presenting a very real threat to life and limb. It is going to take years — and divert much-needed financial and human resources from crucial infrastructure reconstruction — to locate and destroy this sinister relic of the past.

Military expenses accounted for some USD 800 billion around the world in 1995, according to the UNDP, a sum equivalent to the consolidated income of nearly half the planet. When, last year, I watched Kalimantan in Indonesia burning then Roraima in the Amazonian forest, I asked myself : why is no one crying out in protest ? We have the financial means ; we have the technology to explore space ; why then should it prove so hard to put together an alliance that could expedite a fleet of 200 planes to save the Earth's lungs ?

If science is truly to contribute to peace-building, then we need to share the benefits of scientific research and to encourage co-operation in the sciences between developed and developing nations, but also between the developing nations themselves ; we also need to bridge the gap between rich and poor nations by encouraging access to the new information technologies and all the tools and instruments of scientific research. UNESCO is convinced that science has a major role to play in the construction of a culture of peace in the twenty-first century, but for science to play its role, it has to be made accessible to all, both through education and in everyday life. How can it be that today 80 % of the world's population still has no access to basic means of communication ? The statistics speak for themselves : there are more telephone lines in Manhattan than in the whole of sub-Saharan Africa. In rich countries, there are on average 500 telephone lines for 1,000 persons, as compared to 11 lines in sub-Saharan Africa and 13 in South Asia. Some 600,000 villages are not equipped with electricity. How many millions have never heard of the "information highways" ? Imagine the human potential not being tapped around the world because of lack of access to science and technology. Imagine the contribution these millions could make not only to their own community in terms of practical benefits but to human knowledge *per se* ? It should be made easier for the educated diaspora to return to their homeland. Some 30,000 Ph.D. holders from the South do not live in their country of birth, a "brain drain" that constitutes an enormous loss for these countries.

There is an immediate task for science to work for peace in the construction of basic material conditions of stable, lasting peace, by contributing to the elimination of poverty, undernourishment and diseases, by mitigating disasters through the use of adapted technologies and the tools of science, and to provide people with equal access to basic resources essential for life : adequate, safe freshwater and food, and energy. Neglecting these basic needs and the importance of human dignity will ultimately breed revolt and instability, perhaps even a full-blown conflict. Since governments only dispose of finite resources, the money to improve the socio-economic situation of a nation will have to come from an existing national budget, the most expendable being to my mind the national defence industry. The success of harnessing science to socio-economic development will depend to a great degree on the political will of world leaders, but also on the ingenuity with which scientists justify the vital necessity to convert — or at the very least downsize — the national defence industry.

Some 80 % of the United Nations' budget is devoted to peace-keeping and humanitarian missions. We need to move away from this firefighting approach to problems by investing more in the construction of peace ; we need to anticipate conflicts, in order to prevent them and thereby reduce the need for peace-keeping missions. Together, we can use science to prevent conflicts rather than to foster them. It is up to us.

Science and Development :
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United Nations Educational, Scientific
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The Role of Science and Technology for Development

by

José VARGAS *

Distinguished Members of the Academy,
Ladies and Gentlemen,

I would like to thank the Royal Academy of Overseas Sciences for the invitation to speak at the opening session of this very timely symposium. I am furthermore delighted to meet again with Professor Prigogine, whom I had pleasure in welcoming to Brazil and introducing to audiences in Rio de Janeiro and Campinas, at the lectures he delivered at the invitation of the Brazilian Academy of Sciences. I would like to add that I am also pleased to be here with Federico Mayor, Director-General of UNESCO, a permanent supporter of the activities of the Third World Academy of Sciences.

The unique prospect of the beginning of a new century and of a new millennium offers the opportunity to review past achievements as well as the practice of one of the most popular, dangerous but nevertheless indispensable occupations of mankind : "futurology". This prospect has inspired UNESCO to organize the "World Conference on Science for the 21st Century : a New Commitment", to take place in June of next year, and the Belgian Royal Academy of Overseas Sciences to organize the present symposium on "Science and Development : Prospects for the 21st Century". For although science has plenty of crowning achievements to show for its labours in the present century, there remain major impediments that constrain its potential

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role to benefit Humanity as a whole. Some of these impediments are quite removed from scientists' everyday concerns, as they perhaps should indeed be. Nevertheless, the possibility of overcoming those obstacles must remain an all-important item on our agenda.

At the end of the 20th century, momentous developments — economic globalization and the end of the Cold War — have made it unlikely that war will be used again by advanced nations, as it was in the past, as a sort of instrument of policy of last resort to promote deep structural change. This much we have hopefully learned of the twentieth century. At the same time, the social and economic gap between the developed and the developing world has shown to be quite resistant to the onslaught of change brought about by the globalization of modernity and the increasingly widening use of the results of scientific work. In fact, much has been claimed about the unwitting contribution of science, and especially of technology, to the perpetuation of social unbalances between the rich and the poor in the developing world, and more generally between the North and the South. As a reaction to this, for a time, "adequate" or "appropriate" technologies were proposed to remedy those unbalances and to oppose the apparently dismal effect that an unchecked expansion of modernity would have over so-called traditional societies.

One has to admit that the expansion of the fruits of scientific and technological toil has been anything but fast, and unevenly distributed. Suffice it to recall that about five decades ago, out of the world's two billion human beings, one billion was illiterate. Today, we still carry the collective burden of about one billion illiterate human beings — men, and sadly, especially women. One hundred years after its introduction, the telephone, an ubiquitous resource in some countries, has yet to reach about half the globe's population.

Much of this unbalanced situation between innovation and the diffusion of knowledge is, of course, due to massive overpopulation. Part of the problem is structural. The diffusion of technology, in particular, is an especially complex problem. However, science and technology are intrinsically co-operative activities, and have a long history of successes. There is no lack of tasks to which we may apply a co-operative approach. Indeed, we have come to realize in the last few decades that Humanity is facing an increasing number of truly global problems. From a North-South angle, we should increasingly come to realize that we are, in a major way, actually condemned to co-operate. Scientific and technological co-operation, in particular, has the potential to contribute to finding new and creative solutions to some very real problems.

Environmental problems are intrinsically a global challenge, which squarely fits the international and co-operative calling of science. The solution of current and future environmental problems is thus and exceptional proving ground for the co-operative approach.

Allow me to mention just one such environmental challenge to co-operation : climate change. Over the last few years, Brazil has played a relevant role in the negotiations concerning climate change. Reduction of industrial and other greenhouse emissions by developed nations is a key component of the solution. However, where does that leave the developing world ? At heart, this complex issue involves a fundamental choice concerning development. To limit emissions is to limit energy use, or, in other words, to limit the production of work. This at a point in our history at which most of our population lives at or below the poverty line. To limit development is thus not a solution.

Brazil pioneered the adoption of a mechanism that is under study by the Climate Change Convention subsidiary bodies to be implemented by the year 2000. This Clean Development Mechanism will allow industrial nations to meet part of their reduction commitments by investing in sustainable development projects — profitable or not-for-profit — in the developing world. This mechanism will allow developing nations to absorb, adapt, and to develop science- and technology-based solutions in order to establish a cleaner path to development. It will promote not only investment, but also scientific flows from North to South and within the South. This is an example of how "interested solidarity" may be a powerful catalyst for co-operation.

A talk on the "Role of Science and Technology for Development" could be expected to also dwell on the results of observation, of reasoning and of experimentation, in short, on the application of the scientific method by scientists in the developing world. This, however, would be an impossible task here and now.

In what follows, a much more modest approach is adopted : I shall try to describe, albeit superficially, what one might call an overview of the institutional and structural features of the environment in which science and technology have been emerging in Brazil, to support the nation's development, covering the last few decades up to the present. I am well aware that a comparison between the Brazilian development in this area, with the scientific and technological progress underway in other newly industrialized countries, would show interesting similarities and differences. Broadly speaking, developing countries have adopted one of two basic roads to development. The first one involves the substitution of imports and the development of a domestic market, as practised for a long time by Brazil and other countries in Latin America. The second one involves the creation of an outward-oriented export economy, such as that of countries in East Asia. Both styles of development have promoted the importation and adaptation of technology. At the same time, both have depended, in order to succeed, on the extent of the development of domestic scientific and technical resources. This process starts with education and training of human resources, and goes all the way to the establishment of a scientific and technological infrastructure.

On the whole, our common performances would certainly highlight our insufficiencies as compared to the role science and technology play in the major industrialized countries. It may also offer some guidelines and useful examples to other countries in their struggle for development. Brazil is a lately industrialized developing country, which displays characteristic unbalances, both in personal and regional incomes.

Culturally rooted in Portugal and Spain, it did not benefit from the Enlightenment and the Industrial Revolution. In fact, the Portuguese colonial system, while not as harsh as the Spanish one, was much more culturally retrograde. While, for instance, printing and universities were already active in some Spanish colonies in the 16th century, in Brazil the press and higher education were introduced only at the beginning of the 1800s. A truly modern university started only in the thirties. Illiteracy still affected 50 % of the Brazilian population in 1950.

Incipient industrialization, followed by much faster modern development, took place as a consequence of the first and second World Wars, particularly from the fifties on. The two world conflicts, and the subsequent Cold War, permitted access to foreign technology, allowing for the adoption of a successful import substitution economic model, developed in a market protected by sundry tariff and non-tariff barriers until the eighties. During this period, international liquidity and national market protection, together with the Brazilian favourable natural assets — abundant human and material resources —, led to foreign capital investment amounting to about 100 billion dollars. In the seventies, foreign financing represented up to 20 % of the national savings, leading to a very large technology transfer. On the whole, from 1947 to 1997, the Brazilian Gross National Product (GNP) increased by a factor of 15 — a performance second only to the Japanese in the same period.

This fast growth has run parallel to and was naturally made possible by the concomitant educational expansion, particularly of university level education. Human resource development was essential for the implantation and management of the large and diversified national industry. Science and technology expansion, prompted by the fundamental role they played during and immediately after the last world conflict, was stimulated by a number of significant legal and institutional initiatives under the prestigious prodding of the Brazilian Academy of Sciences and other institutions. By 1951, Brazil, like many developing countries that followed the British Science Research Council model, had founded a National Council of Research (CNPq). A large number of state-owned universities had by that time been federalized and properly financed, and the Ministry of Education started the implementation of a university professor training programme (CAPES). To improve the quality and number of the teaching staff, required by the aforementioned educational expansion, both CAPES and CNPq offered scholarships, locally and abroad. Post-graduate courses were initiated in a number of fields, particularly in engineering, for the urgent need to develop Brazilian consulting firms. This demand was keenly felt as indispensable to assist the implementation of large and complex infrastructure projects in transportation, energy, in the heavy and transformation industries. Thus, post-graduation was consolidated by the BNDE — the Brazilian Investment Bank — and was later taken over by FINEP, an agency devoted to financing projects, particularly those of a technical content. FINEP has become the executive secretary of the Brazilian National Science and Technology Fund (FNDCT), a major supporter of science projects.

As pointed out before, this model met with considerable success up to the end of the 1970s, while it was practically stagnant all along the eighties, under the impact of several factors — international ones, as for instance the two energy crises, as well as to local factors. Politically, in the science and technology sectors, insufficient attention and mistaken policies were unfortunately adopted. Official S&T policy ignored the revolution which was occurring in fields such as computer technologies, material sciences, biotechnology, etc., although, however, considerable success was attained in aviation, chemicals, petroleum, capital and transformation industries.

As a result, Brazil became the only Latin American country to display, already in the 1980s, a positive balance in export-import of high technology products. In the 1990s, the expansion of world trade, the explosive surge of all sorts of new science products and services, particularly those based on biology, information and space technologies, have of necessity called for a number of new measures for the insertion of developing countries like Brazil in the novel socio-economic international environment. To compete and to play a significant role in the future, Brazil has decided to place science and technology policy-making at the highest political level, creating the "National S&T Council" chaired by the President of the Republic himself. The Ministry of Science and Technology acts as the Secretariat of this council, co-ordinating national research and development programmes.

Political guidelines are given by the "Pluriannual Plan 1996/1999" approved by the Congress.

The institutional frame is rather complex. Science and technology research and development activities are accomplished by several Ministries and their research institutions, besides those of the Ministry of Science and Technology.

This Ministry was created only recently, in 1985, and its structure comprises the central administration, four Secretariats, four research institutes and two financial agencies. The role of the Secretariats is to supervise activities in their respective fields, acting as a planning and evaluation body. The research institutes directly under the purview of Ministry's structure accomplish basic research, technology development and even graduate-level training in fields such as atmospheric and space science and technology ; meteorology ; information sciences and computer technologies ; research of tropical forests and their biodiversity ; development of appropriate technologies to deal with those natural resources, among others. The financing agencies are the National Research Council (CNPq) and FINEP, which were incorporated by the Ministry. CNPq is devoted to funding scientific research and training through grants and scholarships. It also supervises ten research institutes, active mainly in the basic sciences, like mathematics, physics, astronomy and astrophysics, biology, anthropology. FINEP is the main financing agency supporting research infrastructure and industrial R&D projects through soft loans and non-returnable grants. The Ministry of Science and Technology also uses it as a financial agent for international loans.

Main actions of Brazilian S&T policy and this institutional framework aim at several major objectives :

— Fostering basic and technical secondary education as a fundamental input to the new production and services technology.
— Promoting the linkage of sciences — until now largely university-based — and industry, and to increase the latter participation in the national R&D expenditures — limited until recently to a mere 10 % share — to the 40 % participation typically observed in most western industrialized countries. To this end, the Federal Government has approved two tax deduction laws to encourage industries to invest in R&D. So far four hundred R&D projects have been contracted, amounting to 4.4 billion US dollars.
— A third line of initiatives was designed to substantially increase the financial resources devoted to science and technology, so as to reach a level of 1.5 % of the GNP by the end of the present administration and, thus, more than doubling the 0.6 % of GNP relative share observed up to 1992.
— Another priority is to reinforce the R&D infrastructures, particularly by the setting-up, the completion and additional support to laboratories dedicated mainly to new materials, computer and space sciences and to the environmental studies.
— Brazil has launched new programs to foster excellence nuclei in basic sciences and technology, the PRONEX program, which currently is benefiting two hundred nuclei, comprising more than five hundred groups.
— We are popularizing science through the concession of several science prizes and grants, particularly to young scientists, by the Federal and State administration or jointly with private organizations.
— Another priority was to adapt Brazilian legislation to international standards and practices, such as in the case of the intellectual property law system ; the biosafety law ; laws concerning dual-use technologies (nuclear, space, technology transfer).
— To guarantee the high investment rates needed to reach these ambitious goals, the Federal administration is resorting, in addition to its own direct support, to :
  - Loans by international institutions such as the Inter-American Development Bank, the World Bank and the Japanese Exim-bank ;
  - Increasing the financial participation by the Federated states ;
  - Funding from the private sector ;

- Resources resulting from royalty shares in the exploitation and/or privatization of services.

Some indicators of success so far achieved may be listed :

— The Brazilian growth rate of participation in the international peer reviewed indexed scientific literature, in the seventeen years comprised by the 1981-1997 period, has been almost 60 % higher than the world average growth in the same period. When account is taken of the scientific production as a function of the GDP, Brazil places itself at reasonably high level, among the first twelve countries. In some key basic disciplines or fields, such as agriculture, molecular biology, astrophysics, mathematics, physics and social sciences, Brazil's performance attains rather respectable levels. Brazilian contribution to the fundamental sciences, as, for instance, in theoretical and experimental physics, mathematics, and microbiology, among others, should be mentioned.
— The number of scholarships from 1990 onwards has grown by 12 % yearly. The granted number of Ph.D. laureates has doubled in five years, at a 15 % per year rate. It has to be mentioned, however, that there still is an unbalance in the distribution among different fields for the first university degrees, with consequent distortion on the graduate degrees. In Brazil, 54 % of the university students read social sciences, 36 % attend natural sciences (including basic sciences, health and agricultural sciences), and only 10 % study engineering. This uneven distribution has to be compared to the figures from other developing and developed countries. Apart from Brazilian contributions to basic sciences such as physics, mathematics and bio-sciences, some worthy examples of technological achievements in agriculture, energy, environment, aviation, space, among others, may, however, be mentioned.
— Thanks to a sophisticated agriculture and earth science institutional framework, which includes EMBRAPA — the Brazilian Enterprise for Agriculture Research —, it has been possible to transform the 3.5 million square kilometer Central Brazil Savannah Region, called Cerrado, into fertile land, open to the majority of crops. Now, this region is producing around 50 % of Brazil's total grain crop.
— The nitrogen fixation by gramminae studied and developed by Dr Johanna Döbereiner may even enhance the success of the largest world biomass alternative energy programme : the alcohol fuel

programme, equivalent to 200,000 petroleum barrels per day. This programme, together with the utilization of hydropower plants, has resulted in one of the most environmentally sound existing energy matrices — 61 % of the Brazilian primary energy supply being generated from renewable sources.

— By 1973, Brazil produced 175,000 barrels per day of crude oil — covering only about 17 % of the national consumption. In barely twenty years, production attained almost 60 % of the national daily consumption of crude oil, largely due to the development of the world's most advanced technology for offshore deep-water oil drilling, which is operating at a record 1,700 m sea depth by Petrobras research centre, CENPES.

— The development of a ^{235}U enrichment process, by means of ultra-centrifugation, and the resulting possibility of independence of the Brazilian nuclear fuel cycle.

— Also in the energy field, Brazil has become a major world producer of high-power turbines for hydroelectric plants.

— The national aircraft and space programmes have led to interesting technological development as well as to some industrial and commercial achievements. In fact, Brazilian medium range jet and engine powered aircraft have met with considerable commercial success abroad.

— In the space field, the first Brazilian designed and built satellite has been in service for nearly five years. It has been collecting important environmental information on tropical forests, on water reservoirs and sea data. In addition to the orbiting SCD1, launched in February 1993, and SCD2, launched in October 1998, two scientific satellites are ready for launching — one of them a joint project with France. We have offered access to this resource to African countries through UNESCO, and several Latin American countries are also interested.

— In the field of international co-operation, furthermore, Brazil will launch together with China, next year, the China-Brazil Earth Resources Satellite (CBERS). A first low-altitude remote sensing equatorial orbit satellite is also being developed and shall bring considerable benefits for the equatorial countries, mainly to the African and Amazon region.

— Also in the field of international co-operation, Brazilian participation in the construction of the International Space Station will offer Brazilian industry the opportunity to improve its high-tech capability and the future utilization of the space facility will open new research opportunities.

— As a direct consequence of the Brazilian Space Programme, advanced weather and climate studies of international importance are being conducted within our major space science institution, the National Institute for Space Research.
— Information technology, particularly in microelectronics and software sectors, has been developing at a fast rate in the last five years. The INTERNET was implanted using the National Research Council Network's backbone.
— As a general indicator of recent improvement of the Brazilian technology capability, it should be mentioned that revenues from technology exportation — royalties, technical services, etc. — have grown at a pace of 24 % per year during the 90s, reaching the total amount of almost US$ 500 million last year. Imports of technology in 1997 were about one billion dollars, which means that the coverage (import/export) is about 50 % — close to the figures shown by Italy and Spain.

In spite of these success stories, much remains to be done. Suffice it to recall that a single multinational firm in the automotive sector, in 1992, spent in industrial research and development 5.9 billion US dollars, not so far from the total Brazilian national investments, which, in 1997, reached an amount of about 8.9 billion US dollars.

To achieve sound and sustainable development it seems necessary, for Brazil and other developing countries, that intense and continuing efforts be devoted to :

— The promotion of generalized education : primary, secondary and vocational.
— The training of advanced technical personnel, particularly of scientists and engineers, through networking at international and national levels.
— The building-up of the indispensable links between invention, innovation, services and products, by the adoption of special legal and financial incentives.
— International co-operation through the exchange of scientists both between developing and developed countries as well as by joint implementation of concrete projects in strategic areas of common interest, such as climate and weather prediction ; fundamental and

applied biotechnology ; environmental problems bearing on regional or global phenomena ; research on tropical diseases and their alleviation ; material, space and information science and technology. These activities are naturally of particular importance for the developing countries.

— Brazilian scientists have established strong and meaningful co-operation programmes with their colleagues all over the world. Allow me to mention just a few. One of the major recommendations of the United Nations Conference on Environment and Development — Rio '92, for short — was to set up research institutes on every continent to monitor and to study climate change. The Americas have been the first and so far the only region to heed that call. The Inter-American Institute on Climate Change Research — I am proud to say — operates out of Brazil. Furthermore, in a few weeks we shall begin a historic journey of discovery in the Amazon. The LBA experiment, which will involve literally hundreds of scientists and cost well over US$ 100 million, will be the largest Brazil-led international collaborative project. LBA will eventually allow us to assess the complex interaction between forest, water and atmosphere dynamics. Brazilian and Argentine scientists have been collaborating since the 1980s in a Bi-national endeavour to develop biotechnology products and services. Furthermore, we are participating with Chile and other major partners in developing the promising field of astronomy in the Southern Hemisphere.

— The clear formulation of policies and goals associated to appropriate public investments, to promote, at least, the installation of basic infrastructures for providing technical services in education, health care, security and basic technological services, such as metrology and standards setting laboratories.

— It is also mandatory to exert efforts so as to develop appropriate entrepreneurial and managerial capabilities at all levels in close links with the R&D communities.

This is a challenging and strenuous route to progress, which becomes even more demanding in face of the tremendous worldwide pace of innovation production, specially in the industrialized countries. There is no other way to overcome underdevelopment and the concomitant social inequities, prevailing in most developing countries, and more shockingly so in those places like Brazil — which may be aptly considered as being more unjust than underdeveloped.

PANEL 1

CONTEMPORARY EVOLUTION OF SCIENCE AND PROSPECTS FOR DEVELOPMENT

Moderator : Prof. Paule Bouvier
Reporters : Prof. René Devisch
Prof. Christian Sturtewagen

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Ethics, Science and Development

by

André JAUMOTTE *

KEYWORDS. — Ethics ; Science ; Solidarity ; Sustainable Development ; Co-operation or Development Aid.

SUMMARY. — Ethics, science, development : three words, three concepts, previously distinct, now closely connected. Two principles, responsibility and care, will guide ethics in the future. We provide two examples : choice of energy and limitation of genetic engineering. The development ethics is reviewed in the particular case of Africa. The humanitarian ethics itself raises a large number of questions. A practical example has been developed : the projects of CEMUBAC (Scientific and Medical Centre of the "Université Libre de Bruxelles" for co-operation activities).

MOTS-CLES. — Ethique ; Science ; Solidarité ; Développement durable ; Coopération ou aide au développement.

RESUME. — *Ethique, science et développement.* — Ethique, science, développement : trois mots, trois notions, hier distinctes, aujourd'hui étroitement liées. Deux principes, celui de responsabilité et celui de précaution, guident l'éthique du futur. Nous en donnons deux exemples : les choix énergétiques et les limites du génie génétique. L'éthique du développement est analysée dans le cas particulier de l'Afrique. L'éthique humanitaire elle-même pose de nombreuses questions. Un exemple d'application est développé : les projets du CEMUBAC (Centre Scientifique et Médical de l'Université Libre de Bruxelles pour ses activités de coopération).

TREFWOORDEN. — Ethiek ; Wetenschap ; Solidariteit ; Duurzame ontwikkeling ; Samenwerking of ontwikkelingshulp.

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SAMENVATTING. — *Ethiek, wetenschap en ontwikkeling.* — Ethiek, wetenschap, ontwikkeling : drie woorden, drie begrippen die vroeger los van elkaar stonden en waartussen nu een nauw verband bestaat. Twee principes, de verantwoordelijkheidszin en de voorzorg, zijn de fundamenten van de ethische waarden van de toekomst. Wij geven daarvan twee voorbeelden : de energiekeuzes en de grenzen van de genetische engineering. De ontwikkelingsethiek wordt geanalyseerd in het bijzonder geval van Afrika. De humanitaire ethiek zelf doet wat vragen rijzen. Een praktijkvoorbeeld wordt uiteengezet : de projecten van CEMUBAC (Wetenschappelijk en Medisch Centrum van de „Université Libre de Bruxelles" voor activiteiten op het vlak van samenwerking).

Why Ethics ? [1] *

1675 : Spinoza completed "Ethics". He had devoted almost fifteen years of his life to writing it.

1677 : Spinoza died in The Hague. On the day of his death he asked for it to be published without his name.

Ethics poses problems and the solutions raise questions.

They did so yesterday, they do so today and ... they will do so tomorrow.

Ethics : a never-ending quest.

Deontology, or a professional code of ethics, is no more than ethics as applied to a trade. The medical profession has long had a code of ethics, but it is only in modern times that we have thought to impose one on advertisers, on politicians, on businesspersons and on engineers, ...

"It is of the essence of man to create materially and morally", wrote Bergson. A century ago everything was in a state of harmony : science and technology were the mainsprings of comfort, the health of the human race, the new myth of progress, and in particular social progress.

Since the atom bomb, applications of scientific knowledge have become ambivalent : beneficial or dangerous, depending on the case. The Chernobyl catastrophe has shown a new order of vulnerability in the face of the sheer scale of certain technological risks and, as a result, the need for a level of protection that is commensurate with risks on such a scale. No one today is in any doubt that the advances of science and technology in all disciplines can raise large numbers

* The numbers in brackets [ ] refer to the notes and references pp. 50-51.

of ethical, economic and social questions. Main systems of thought and long-term thinking have crumbled in the face of globalization and the new technologies which, above all in the field of data processing, have set societies thinking in "real time" and focusing on short-term objectives : the supremacy of the doctrines of the worlds of finance and the media, the tailoring of political decisions to the next election, the importance granted to humanitarian aspects precisely when development aid is on the decline. According to UNCTAD (United Nations Conference on Trade and Development), the funds allocated to development fell from 16.6 to 14.2 billion dollars between 1995 and 1997. Humanitarian aid is itself sometimes paralysed by political considerations (take the case of North Korea for example).

Time seems to be abolished by the instant. "Everywhere", notes Federico Mayor, "man today arrogates to himself the rights of man tomorrow, endangering his well-being, his equilibrium and sometimes his life".

So the time has come to construct a code of ethics for the future, to rehabilitate the long term, to challenge current methods of management based on adjustment, on adaptation and on flexibility elevated to the level of a rigid dogma-based, in a word, on hard-line utilitarianism. We have become responsible for the past, for the present, but also for the future.

Values change : we notice that when we think of the family, of the nation-state and of democracy itself.

Values are a legacy without a will. As Paul Ricœur noted, "values are to be found ... half way between the lasting convictions of a historic community and the incessant reappraisals forced on them by the changes of the age and of circumstances as new problems emerge".

Two developments in time and space have set the agenda.

First development : the temporal change of responsibility. *The Principle of Responsibility* propounded by the German philosopher Hans Jonas (1979) conceives responsibility as being oriented towards the distant future. It is our duty to hand on to the generations to come a world that can be lived in. We therefore have two obligations : to preserve nature within us, *i.e.* the genetic identity of the species, and to preserve nature around us, *i.e.* the biosphere. We have to create an ecological economy.

The principle of responsibility establishes a bond of *solidarity* with the generations to come.

Second development : the extension of uncertainty and risks gives rise to the principle of precaution. The relationship with science has been re-established. But what we are concerned with is not the methodology of science, but rather its dynamics. The spirit that drives the thirst for knowledge forward takes no orders as to the direction it will take. And where it ends up is precisely the point that can turn society upside down. The principle of precaution exhorts us to decide on the future while taking due account of the risks. It is not a principle of action in the true sense of the term ; it simply puts the decision-makers on their guard and urges the specialists to direct their research towards the management of possible risks which must therefore be defined. Above all else, a risk needs to be demonstrated. The principle of precaution is an imprecise, vague concept which enables it to evolve as our stock of knowledge increases. Its basic assumption must be that the notion of zero risk does not exist. For my own part, I consider that the prohibition on the cultivation of genetically modified maize, in the name of the principle of precaution, is a case where the principle has been manipulated ; the principle must not be used as a barrier to invention.

Ethics in the future is therefore dominated by three words : *responsibility, solidarity* and *precaution*, in order to bring about *sustainable growth* (or lasting development) which was given impetus by the Brundtland Report at the beginning of this decade.

Choices of Energy and Future Generations [2, 3, 4]

Two aspects stand out : the greenhouse effect and nuclear waste. They are of minor importance in the short term, but they symbolize our responsibility towards future generations.

The average temperature of the earth has been rising gradually for a century because of the increase in greenhouse gases discharged into the atmosphere. The principal gas is CO_2, which is largely a result of fossil fuel consumption. It is a global phenomenon and responsibility must be shared, but the major part must be assumed by the industrialized countries. Although there is an awareness of this fact (as manifested by the Conferences of Rio, Kyoto and Buenos Aires), recommendations are not sufficiently translated into deeds. Belgium is an example of a country that has failed to honour its commitments (according to the OECD).

Nuclear waste is a child of this century, born of two principal sources : the military and the production of nuclear energy. Such waste is managed in a secure manner by the countries concerned (at any rate by those in the West).

The strategy in the fight against the greenhouse effect has been to reduce the consumption of energy through RUE (the Rational Use of Energy), the use of renewable energy (the potential of which is limited) and nuclear energy. Unanimity on how to achieve it is a long way off, however (with some countries applying arbitrary limits laid down by the authorities, while others levy taxes or impose restrictions on the right to pollute, etc.).

As far as nuclear energy is concerned, everything can be mastered technically at a calculated cost, despite the occurrence of minor incidents reported in the press which exaggerates their importance. The political decision can be considered to have been taken.

Sweden, which derives half of its electrical energy from nuclear power stations, took the decision several years ago : to phase out its nuclear energy production capacity gradually over time. The oft-announced starting date has constantly been put back.

Germany, where nuclear energy accounts for 30 % of its production, has just recently decided its gradual phase-out. For one year the government will seek a consensus on energy with producers of electricity and then pass a law, fixing the date when nuclear energy is no longer produced and nuclear waste no longer stored. This will have to be backed by a credible alternative plan without increasing greenhouse gas emissions. It's all going to prove to be an enormous headache. The initial means have been laid down, and will take the form of an energy-taxation.

The most recent arrival, Switzerland, has decided to do away with nuclear energy once the five nuclear energy power stations in operation in the country have closed down. But it has failed to address the problem of how to replace the energy that will be lost (decision on 26th October 1998 by the government in Bern).

Be all that as it may, the psychological effect is already there.

Nuclear power is no longer *à la mode*, or in fashion. The number of those studying it is in decline.

What remains to be done ? To keep a careful watch on the new fashion and to limit its damage. Because damage there will be. I am convinced of that. You need only look as far as the lack of any definite plan that will be required for making good the shortfall in energy.

The word *mode* — as in *à la mode* or "in fashion" — comes from the Latin *modus* which meant "way" and "means", but was also close to "measured" and "moderation". Let us therefore be *à la mode* in the etymological sense of the word : let us find the way, the means by adopting a measured approach.

The Ethical Limits of Genetic Engineering [4, 5]

For scientific as well as for economic reasons, we have been looking, for half a century now, for a way of achieving descendants copied from a single animal, rather in the same way as we can reproduce plants by taking cuttings. The process has been perfectly explained by Jacques Testart : "The work on cloning, initially carried out on frogs and then on mammals, consists in introducing genetic data from a nucleus into a recipient cell (an ovum) and in making the chimera behave like a fertilised egg. In July 1996 they succeeded in bringing about the birth of a cloned sheep (christened Dolly). The event was not publicised until February 1997. The fundamental way in which it all works is still largely unknown, and the process is only rarely successful, while there is nothing to guarantee that the offspring will be normal". It produced hysteria in the worlds of politics and the media. An age-old fantasy was about to become a reality : how to clone humans.

Cellular cloning techniques (multiplication of cells) already exist in practice for research, diagnostic or therapeutic purposes. The possibility of reproductive cloning of a mammal — and therefore also of a human being — is quite another matter. The world of science is divided between the "for's" and "against's". The International Ethics Committee (an offshoot of UNESCO) is proposing to pursue this logic to its limit by so-to-speak turning the question of ethics into the argumentation hereof.

The French National Ethics Committee is more categorical : cloning humans is unacceptable because it involves turning man into an instrument and hereby removing his dignity, whatever the medical applications that are envisaged may be.

The question of where research into genetic engineering should go raises a question of ethics. Should it be limited ? If so, where do you draw the line ?

Let us rejoice that such reflections are being aired in the public arena, outside the small circle of specialized researchers and even scientists, in an effort to apply the principles of responsibility and precaution.

"What will the new society be like ? I cannot tell. I know not what its laws will be". That has always been the case, since the quotation from Chateaubriand.

Ethics and Development

What development aid for what aim and by what means ? That is the fundamental question.

Whatever the response, every model of development cooperation should be conceived in terms of those whom it is intended to benefit, by entering into their social system, their culture and their values which are quite different to our own [6].

Let us confine ourselves to looking at Black Africa. Africa used to be a stable, immobile continent with an oral tradition, without writing, without property rights, with limited trade, experimental knowledge and a conception of time different from our own.

Objects of African art — the masks, for example, — are expressions of African social life. Our perception of them is aesthetic, and therefore without any relation to their real purpose.

How would African civilizations have evolved, despite relative isolation, had there been no contact with our civilization of trade and technological achievement — those civilizations whose importance we are guessing now that it is too late ?

We will never know because that evolution was cut short by the expansion of the colonial empires during the 19th century, especially during the second half. Colonialism achieved intense development but by dismembering the continent between the appetites of rival powers and replacing local values with those of the colonizers, and doing so in a time-scale too short to allow the development of an entire society — not merely an elite — which could have assimilated the basic values of the industrialized society [7]. So decolonization, holding out so much promise in the beginning, proved a disappointment. The last bastion of colonization — the frontiers of nation-states — is being challenged. The western interpretation of the situation (initially east-west antagonism, then Franco-American rivalry) has turned out to be mistaken. New local orders are being established. The role of the western powers is declining while that of regional powers like Angola or South Africa is in the ascendant.

Africa has the resources it needs for its development. So what has gone wrong ?

On analysis, it boils down to a lack of any national policy on the part of the African developing countries that is adapted not only to the conditions of the region but also to the process of globalization and the new economic order that has developed beyond their borders.

Which African countries have a clear national policy on agricultural reform, appropriate industrialization, public health, economy, foreign debt and above all education — the key to development — that aims to fight poverty and raise the level of social and political well-being and in a way, moreover, that takes account of the fact of globalization [8] ?

The winner of this year's Nobel Prize for Economics, Amartya Sen, has propounded the theory of social choice and has defined the notion of social well-being. It should be measured not in terms of the distribution of goods (or of the income from it), nor in terms of the greater satisfaction of human beings, or of their usefulness, which means one ends up giving less to those who are more easily pleased, but in terms of their "capabilities", or the degree to which individuals are able to accomplish certain fundamental acts such as moving from place to place, finding shelter and food, being cared for and participating in the life of the community [9]. It is a concept adapted to societies where economics is not a sovereign, self-governing domain that recognizes only its own laws as they have become in the case of the industrialized societies in the era of globalization.

Amartya Sen can be said to have reconciled economics, ethics and development. "Truncated man", the "homo economicus" of Adam Smith, the father of modern economics, who was professor of moral philosophy at Glasgow University, has been replaced by a "complex and moral man".

Development in Africa has thus failed for lack of any clear political vision either on the part of the donor countries or on the part of the recipient countries.

Development aid must be recast as part of a political vision based on a code of ethics. Information about Africa has for a long time been inadequate. Today, thanks to the Internet, it is possible to overcome that deficiency, particularly as far as political information is concerned, by visiting the numerous websites that are devoted to Africa.

Humanitarian Ethics

Humanitarian ethics is founded on the Universal Declaration of Human Rights. These are opposed to discrimination between human beings and to intolerance. They combat exclusion born of poverty, insecurity and sickness. They too are based on the Resolution on the "Right to Humanitarian Aid" which imposes the right to life as one of the universal human rights. In that respect they go further than the various systems of thought and their different approaches — sometimes very far apart from one another — to the meaning of life ; and that right constitutes a minimum common denominator for humanity.

Humanitarian action today, born of an essentially ethical concern, is therefore based on notions of responsibility and generosity in order to bring assistance to the victims.

Even so, the experience of these past years has raised a number of arguments over ethical questions concerning humanitarian action and a number of questions remain without any clear answer :

— What are the limits of humanitarian aid ? Who defines them ? Who governs the cooperation that is sometimes necessary but is by its nature a source of conflict between governments and private NGOs ?
— How to reconcile the principle that action should be universal with the need to select projects ? Who makes these selections ? The law of the "humanitarian market" and of the media, political pressure or the needs of the victims ?
— How to reconcile the neutrality that is necessary for intervention with a commitment to defend human rights as inalienable from the word "humanitarian" ?

An Example of Application : CEMUBAC
(in collaboration with Philippe Hennart and Philippe Donnen)
[10, 11, 12]

For over fifty years CEMUBAC has been carrying out research and development in the developing countries and in particular in Central Africa.

Little by little it has built up a model of cooperation that takes account, not only of the priorities it and its partners have identified, but also of the specific characteristics of a university organization devoted to cooperation.

CEMUBAC has always sought to develop the type of cooperation that is rooted in day-to-day realities in the field rather than to impose a technocratic assessment made from outside.

When it comes to intervention in the field of health, since 1984 CEMUBAC has been giving preference to an approach founded on the "primary health care strategy" as defined by the World Health Organization. This approach was adopted when it was found that in most developing countries health resources were allocated mainly to modern medical institutions set up in urban regions, with the result that the vast majority of the population had no access to any health care whatever.

Primary health care is essential health care founded on practical methods and techniques that are scientifically valid and socially acceptable, made universally accessible to all people and to all families with their full participation and at a cost that the community and the country can bear at all stages of their development in a spirit of self-responsibility and self-determination.

The primary health care strategy is therefore founded on a dynamic model which takes into account not only the needs defined by the health professionals, but also the demand expressed by the population as well as the supply that it is possible to guarantee. It therefore seeks to achieve efficiency through equity.

This approach favours long-term development because the actions are initiated by the local population, are carried out almost exclusively by local personnel and are governed more by the resources at their disposal than by a goal they have to achieve at all costs. Such actions therefore have a much greater chance of being renewed year after year than do other types of action that involve huge costs but have not been agreed in advance with the local populations.

As part of the support it gives to this system of basic health, CEMUBAC has accorded special importance to training. For the fact is that if the primary health care strategy makes it possible to establish a sound system on the drawing board, the health personnel must be capable of making it work properly in practice.

CEMUBAC contributes to this training programme in many different ways by promoting the training of personnel at all levels whether locally or abroad.

This strategy makes it possible after a certain number of years to work *in situ* with a highly qualified staff that identifies closely with the population.

Action of this type supported by CEMUBAC, albeit less spectacular than the short-term activities that receive a lot of media coverage, has the merit of exerting a far more lasting influence on development and of giving local populations the means by which to take greater control over their own destinies. A remarkable example of how this has happened has been found in the North Kivu region where, since 1986, CEMUBAC has been giving its support to the running of three health districts. The investment it has put in over a period of ten years to help fund the development of the primary health care policy and the training of local personnel, has enabled these districts to resist the socio-economic disfigurement of the country and the humanitarian crises due to the conflicts in neighbouring Rwanda in a remarkable way. For the fact is that the staff, being local (*i.e.* born and bred in the region), have remained in the region and have continued to work there using the skills and qualifications they have acquired, whereas expatriate staff would have been obliged to leave. In addition to that, CEMUBAC has steadfastly continued to provide adequate financial backing and maintain regular contact. It has not pulled out, despite the difficulty of the situation.

Even though urgent action may sometimes prove necessary, particularly in cases of natural disasters or in times of war, such action must wherever possible be carried out in the context of existing structures and rely on qualified personnel. Often it can prove counter-productive to invest enormous sums in creating temporary structures and in sending over large numbers of expatriate staff who have no knowledge whatsoever of the region.

CEMUBAC has also endeavoured to establish an intervention appraisal system for its projects in order to prevent those in charge of health care programmes being tempted to apply, without giving the matter further thought, solutions others have used elsewhere in contexts that are often entirely different. Applied research is therefore one of the basic activities of our professional health partners *in situ*, enabling them to work out the right methods and techniques for solving the problems they encounter. The principle of responsibility here consists in giving local populations the means by which to identify and then try to solve the main problems they face in the area of health, in the widest sense of the term. In addition to the primary health care strategy which wholly embraces the principle of solidarity, CEMUBAC gives priority to implementing integrated small-scale development projects suggested and run by the population itself. A great deal of attention is given to improving food-producing systems, to promoting family small-holdings, to improving the environment and developing collective village amenities (community mills, reforestation nurseries, maternity centres, etc.). For projects of this kind, priority is given to the poorest populations who have no access to other sources of finance. They seek to improve the conditions under which those populations live and to make them less dependent on aid from outside.

The subject I have been asked to deal with is a difficult one to handle since one has to steer a dangerous course between the commonplace and the provocative. I hope I have managed to avoid both, without sinking into the quicksands of oversimplification.

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Science for Sustainable Development in the 21st Century

by

Adnan BADRAN *

KEYWORDS. — Change ; Human Capital ; Information Age ; Ethics ; Sustainable Development.

SUMMARY. — Without science, there is hardly sustainable development. Science is becoming so essential in solving problems for our complex world, for developmental policies in the decision-making process. It is essential to enhance scientific understanding and sharing, and strengthen capacity building in science to respond to a rapidly changing world and emerging needs. Sciences should continue to play an important role in the efficiency of resource utilization and finding alternatives. Sustainable development requires long-term visions through diffusing knowledge derived from science to reduce uncertainties. Development in the past was characterized by the flow of material capital. However, with globalization "and interdependence" and business "outreach" science is becoming the main human capital in a high-speed, knowledge-driven society. Generation of knowledge through scientific research, and diffusing it through sharing and international cooperation via sustainable networks may overcome "exclusion" and "marginalization". With the depth of many distinct disciplines, interdisciplinary science will be the driving force for "constructing knowledge" for sustainable development. Seemingly all countries, industrialized or developing, have to face the challenge of science, whether in R&D for giving the competitive-edge in economy or in the ethical challenges in the North, or to build the critical capacity for effective teaching and training leading to sustainable development in the South. Indicators, however, between North and South are disturbing : developing countries are responsible for a mere 10 % of total expenditure on R&D, while OECD countries can claim 85 %. Furthermore, the number of R&D scientists in the North is 4 ‰ as compared to less than 0.5 ‰ in the South. This

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disparity in a knowledge-driven economy may accentuate poverty and the divergence of the quality of life.

MOTS-CLES. — Changement ; Capital humain ; Ere de l'informatique ; Ethique ; Développement durable.

RESUME. — *La science pour un développement durable au 21e siècle.* — Sans la science, il n'est guère de développement durable possible. La science devient tellement essentielle dans la résolution des problèmes posés par notre monde complexe, par les politiques de développement dans le processus de prise de décision. Il est indispensable d'accroître la compréhension et le partenariat scientifiques, et de mettre l'accent sur l'amélioration des compétences dans le secteur des sciences afin de répondre à la mutation rapide du monde et à la naissance de nouveaux besoins. Il faudrait que les sciences puissent continuer à jouer un rôle important par leur efficacité à utiliser les ressources et à trouver des alternatives. Le développement durable exige une vision à long terme qui implique la diffusion des connaissances issues de la science en vue de réduire les incertitudes. Autrefois, le développement se caractérisait par l'afflux de capital matériel. Cependant, avec la globalisation, l'«interdépendance» et l'«ampleur» du monde économique, la science est occupée à devenir le capital humain principal dans une société ultrarapide régie par le savoir. La création des connaissances à travers la recherche scientifique, et leur diffusion à travers le partenariat et la coopération internationale via des réseaux durables, peuvent vaincre l'«exclusion» et la «marginalisation». Vu la spécificité de nombreuses disciplines distinctes, la science interdisciplinaire constituera le moteur de la «connaissance constructive» pour un développement durable. Apparemment tous les pays, aussi bien industrialisés qu'en développement, se doivent de relever le défi de la science, que ce soit au Nord, d'une part, dans la recherche et le développement afin de rendre l'économie performante et, d'autre part, éclaircir les questions éthiques, ou au Sud par la création d'aptitudes critiques propres à un enseignement et une formation efficaces conduisant à un développement durable. Néanmoins, les indicateurs entre le Nord et le Sud sont troublants : alors que les pays en développement sont responsables de seulement 10 % des dépenses totales sur la recherche et le développement, les pays de l'OCDE peuvent prétendre à 85 %. De surcroît, le nombre de scientifiques dans le Nord actifs dans la recherche et le développement est de 4 ‰ contre moins de 0,5 ‰ dans le Sud. Cette disparité dans une économie régie par la connaissance peut accentuer la pauvreté et les divergences de la qualité de la vie.

TREFWOORDEN. — Verandering ; Menselijk kapitaal ; Informatietijdperk ; Ethiek ; Duurzame ontwikkeling.

SAMENVATTING. — *Wetenschap voor duurzame ontwikkeling in de 21ste eeuw.* — Zonder wetenschap is er nauwelijks sprake van duurzame ontwik-

keling. Wetenschap is immers onontbeerlijk geworden, voor onze complexe wereld bij het oplossen van problemen, voor het ontwikkelingsbeleid bij het besluitvormingsproces. Het is van essentieel belang wetenschappelijk begrip en uitwisseling te bevorderen en de capaciteitsopbouw te versterken om te kunnen inspelen op een snel veranderende wereld en nieuwe behoeften. Wetenschap moet een belangrijke rol blijven spelen bij het efficiënt aanwenden van hulpbronnen en het vinden van alternatieven. Duurzame ontwikkeling vereist een langetermijnvisie door de verspreiding van de van de wetenschap afgeleide kennis om onzekerheden te beperken. In het verleden werd ontwikkeling gekenmerkt door een stroom van materieel kapitaal. Door de globalisatie, de „onderlinge afhankelijkheid" en de „reikwijdte" van de zakenwereld echter, wordt de wetenschap het belangrijkste menselijke kapitaal in een supersnelle en door kennis gedreven maatschappij. Kennisontwikkeling d.m.v. wetenschappelijk onderzoek en verspreiding ervan door uitwisseling en internationale samenwerking via duurzame netwerken kunnen „uitsluiting" en „marginalisering" ondervangen. Gezien het specifieke karakter van talrijke onderscheiden disciplines zal interdisciplinaire wetenschap de drijvende kracht worden voor de „kennisopbouw" voor een duurzame ontwikkeling. Schijnbaar alle landen, hetzij geïndustrialiseerde, hetzij landen in ontwikkeling, worden met de uitdaging van de wetenschap geconfronteerd : in het Noorden, enerzijds op het vlak van onderzoek en ontwikkeling om de economie competitief te maken en anderzijds het aankunnen van de ethische uitdagingen ; in het Zuiden, door het creëren van het noodzakelijke potentieel voor doeltreffend onderricht en training die tot duurzame ontwikkeling leiden. De indicatoren tussen Noord en Zuid zijn echter verontrustend : de landen in ontwikkeling zijn verantwoordelijk voor slechts 10 % van de totale uitgaven voor onderzoek en ontwikkeling, terwijl de OESO-landen 85 % voor hun rekening nemen. Bovendien bedraagt het aantal R&D wetenschappers in het Noorden 4 ‰ tegenover minder dan 0,5 ‰ in het Zuiden. Deze ongelijkheid in een door kennis gedreven economie kan de armoede en het verschil in levenskwaliteit nog groter maken.

Introduction

As we meet here today reflecting as scientists on "Science and Development : Prospects for the 21st Century" under the auspices of the Royal Academy of Overseas Sciences, we should take stock of our past achievements to identify past failures and success stories. When people renew, they heighten their ethical values, their rigour and vigour to do the impossible for pooling our knowledge to build a new world of interdependence. Therefore, we must prepare ourselves for a "new page"; our contract for future generations of the third millenium. To be effective, we must build peace among men of this planet by outrooting the cause of conflicts through education, science, communication and culture to overcome future conflicts at early stages of incubation to prevent breeding; otherwise, remedies will be difficult, costly and sometimes irreversible. Education and science empower people, with capacity building to eradicate poverty and overcome marginalization.

Knowledge is what we discover through the inquisitive mind at the lab bench in our laboratories or in the field. To disseminate knowledge is to empower the minds of men so that they can apply it to peaceful use. This is the secret formula for human development and eventually the formula of the agenda of peace and development for the future of humanity. It is essential to develop the endogenous capacity of the south so as to overcome disparity and conflicts between those "who know" and those "who know not".

Science literacy is important, so that knowledge will empower all the people to release their individual potential in building democracy and contributing to solving-problems confronting us: population growth, poverty, migrations and degradation. The world is suffering from 900 million illiterates (fig. 1), 70 % of them being women.

Time for a Change

The educational system which was designed at the beginning of the century focused on preparing children to a quick minimum education above literacy to hold jobs in government and public sectors; and, more in the industrialized countries, to raise families in a world relying primarily on physical labour. As a matter of fact, both the industrial revolution and the green revolution are intensive labour dependants. Because of the large role of agriculture, where more than 50 % of the population were employed, and the abundance of natural resources, nations prospered even if many young people did not develop their full intellectual capabilities. However, much of the natural resources were depleted and the agriculture sector which feeds the industrialized nations is now employing only 2.5 % to 3 % of the population. Also, a huge trade deficit was incurred by many countries. So warning signals started to flare from many nations that competitiveness in a global economy for the future must increasingly turn to high technology as a source of security.

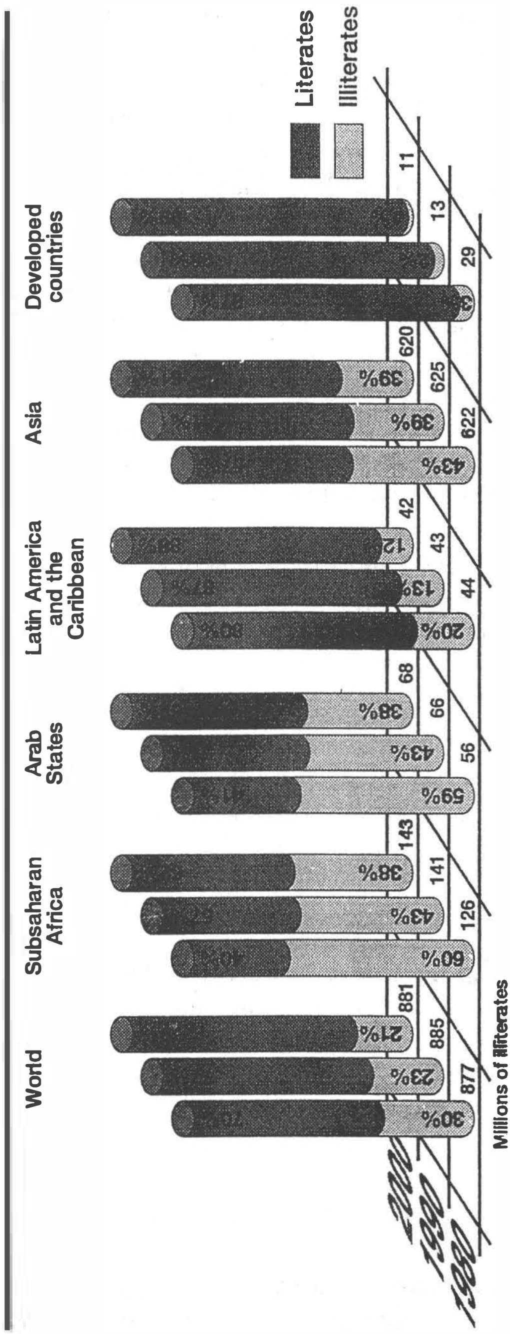

Fig. 1. — Illiteracy : a slow decline.

Globalization is no more a catchword, it is a reality and has emerged strongly after the end of the cold war. It is characterized by fast-moving knowledge-driven information technologies and networks which have the potential change of every classroom practice. The impact of the use of computers and communication technology will not be limited to the learning process (teachers and students), but will change the whole institutional infrastructure and pattern of behaviour within the education system. We are passing through a transformation era of building human capital unparalleled in human history. Therefore, education faces the daunting challenge of preparing individuals for the information-age society :

— How to manage an avalanche of information ;
— How to prepare the most efficient human capital for the brain-intensive market place ;
— How to prepare flexible human resources to meet the uncertainties of a global economy ;
— How to innovate to keep up with a high-speed, knowledge-driven competitive economy at the workplace.

In addition, education has :

— To respond to social needs and to "rights to education";
— To address "education for all";
— To be limited to resources (physical and financial) ;
— To deal with development of citizenship ;
— To maintain ethical and cultural values systems.

The rigid boundaries, separating disciplines of sciences, will soften to give way to a new breed of sciences of transdisciplinary and interdisciplinary fields to address emerging needs of new materials, communications, environmental issues and problems facing society in the next millennium. So education, and in particular higher education, has to change to meet new requirements in the preparation for a new dimension of human capital.

Emerging knowledge is moving quickly to *scientific application* for advancing competition for the market place but cannot be absorbed and utilized commercially, except by a strong knowledge-based society. This again puts pressure on the education system to advocate a wide system of science literacy for the public at large. It is not sufficient to eradicate illiteracy — as has been declared by the Jomtien Conference in 1990 by UNESCO, UNICEF, UNDP and the World Bank — but it is imperative to introduce a strong component in science and technical literacy, so that the whole society becomes science-literate to cope with the knowledge-driven world of the next millennium.

Human Capital for the Information Age

Schools and universities must change to meet the challenges of a knowledge-based economy in the information age. New skills are needed for the emerging information-age workplace. If students are to become intelligent users of technology and information, they should also learn how to be creative and innovative. They should be involved in problem solving and research. They should be able to tackle case studies and understand how to analyse data and draw an intelligent conclusion. Students and researchers should know how to use new technologies and information from new sources and effectively disseminate their ideas, derived from knowledge. Equity and excellence should stay as priorities in any new policy of education.

Learning in the 21st century networking at the school level to provide connectivity and interactivity which is crucial in the new learning process. User-groups and collaborators to search for information will open new venues of thinking ahead and become independent in self-learning how to learn — new setting-up of the classroom and the school, its materials and teaching aids dictated by learning for the information-age so learning for the next century requires :

- New *curricula* integrated with a strong component of interactive multimedia.
- Interactive multimedia to be written by the best scholars in the world, and produced by the best producing and publishing houses.
- Level of communication and computing technology suited for every level of student to energize creativity, inquiry, research and new skills.
- Complete change of text books, to be replaced by a mix of hard-cover and wide versions of instructional software, PCs, laptops, CD-Rom, educational TV, video, interactive radio, cable and satellite educational communication.
- New role of the teacher ; new training (in-service and out-service) to build and share knowledge. Teachers should change from

lecturing to technology users, mentors, researchers, knowledge producers and life-long learners.

— Strong involvement of the "home" school with the help of parents and multimedia of learning.
— Involvement of the community and the neighbourhood environment.
— Involvement of the business community in offering opportunity for training in a business-like environment, so it becomes involved in preparing future human capital for the competitive workplace.
— New version of students' evaluation, assessment and aptitudes for the information age.
— Diversity of education away from the current traditional lines which were born after the Industrial Revolution. Innovative approach to interdisciplinarity to develop new abilities and intelligences.
— Ability to explore and represent knowledge, dynamically, in various forms.
— Ability to "solve problems" and "restructure knowledge".

Science Students' Achievements

Skills in science and mathematics are so critical to economic progress in a technology-based society that it has led countries to survey the competence of the school-age population in science and mathematics (fig. 2), to know what concepts students understand and how they employ that knowledge in problem-solving situations. The Third International Mathematics and Science Study (TIMSS) is the largest and most ambitious study taken by the International Association for the evaluation of Educational Achievement (IEA), to focus on policies and practices in order to enhance mathematics and science learning across systems of education. The study covered half a million students at five grade levels in 15,000 schools and more than fourty countries around the world (4th, 7th, 8th, and 12th grades). Thousands of researchers participated in this worldwide study. Reports were released on the 7th and 8th graders.

Singapore was the top-performing country at both the eighth and seventh grades. The Czech Republic, Japan and Korea also performed very well at both grades. Lower-performing countries included Colombia, Kuwait and South Africa. So reforms in science and mathematics education should be undertaken as priority for meeting the challenge of science and technology. Students should be prepared from an early age.

MATH

TOP FIVE		SCORE
1	Singapore	643
2	South Korea	607
3	Japan	605
4	Hong Kong	588
5	Belgium	565
Somewhere in the Middle		
13	France	538
18	Canada	527
23	Germany	509
25	England	506
28	United States	500
Bottom Five		
37	Portugal	454
38	Iran	428
39	Kuwait	392
40	Colombia	385
41	South Africa	354

SCIENCE

TOP FIVE		SCORE
1	Singapore	607
2	Czech Republic	574
3	Japan	571
4	South Korea	565
5	Bulgaria	565
Somewhere in the middle		
10	England	552
17	United States	534
18	Germany	531
18	Canada	531
28	France	498
Bottom Five		
37	Iran	470
38	Cyprus	463
39	Kuwait	430
40	Colombia	411
41	South Africa	326

Source : TIMSS 1997

Fig. 2. — Ranking math and science skills. A new study of student achievement in math and science ranked fourty-one countries. Scoring was on a scale of 200 to 800 points.

Investing in Science for the Future (fig. 3)

In Korea, there are shifts of funding for science in the universities from governments to corporates. Although funding goes mostly to hot areas of research which yield benefits to the corporate, some universities are spreading the overhead costs over other disciplines in basic and humanity sciences. Most of the graduate students' research now in Korea is funded by the corporate. It is estimated that the corporate support for university research nearly tripled between 1992-1994. Leading companies are placing their R&D facilities on the campus of the university. South Korea began to emphasize science education after the 1953 Korean war to rebuild the country. This spurred industrial and economic development that began in the early 1970s. The illiteracy rate is less than 0.1 %. *Per capita* income is $ 10,000 per year and exports total $ 100 billion per year. Investment in science and technology lead South Korea to be the fifth automobile manufacturer in the world and gain 20 % of the world's semi-conductor markets.

Science in Japan universities was not accorded priority four years ago ; crowded labs, worn-out equipment, scarce funding, few post-doctorates, no technicians. But change has come, relatively quickly. Japan has rediscovered the importance of its universities as a home for advanced research and training and as an engine of economic growth. Many of the country's ninety-eight national universities can point out to newly refurbished buildings, new equipment by truckloads ; super-computers have been installed for research, new competitive grant schemes, often generously funded, are faster than researchers can write proposals. A new five-year plan calls for 50 % (155 billions) increase of 1992 science spending by the year 2000. Universities are charged with producing researchers. The plan of Japan is to strengthen both quantity and quality of graduates with advanced degrees. It calls for doubling 1990 graduate school enrollment by the year 2000. So those graduates will be the new R&D arm for the advancement of science and technology for competitive globalization. A new approach to graduate schools' *curricula* is developing by broadening the horizon of graduates. Interdisciplinary courses, organized graduate programme for Master and Ph.D. and not only training in labs and learning on one's own and writing a good thesis. Basic science is receiving a boost in the Japanese budget (1997) in the hope of securing economic growth — 8 % increase annually for the next five years. Investment in science is needed to break down the walls of a stalled economy. This amounts to $ 26 billion investment in R&D.

Leaders of German scientific organizations in Germany are warning that their nation which produced the best science in the world is in danger of eroding unless both Government and industry increase investment in science and work to make their higher education more compatible. Germany R&D investment has fallen by 2.2 % of GDP since unification with the East in 1990. Germany must increase spending on science to nearly 3 % level to "secure a leading place" in global economy among industrialized nations, some of which spend more than 2.6 % of their GDP on R&D. The budget of 1997 for scientific research was cut by 3.7 %, which was softened by increase of both Max Planks and DFG, the main granting agency by 5 %. Germany should focus more research grants on most dynamic and productive research institutions, rather than spread the funding evenly among mediocre institutions.

In an attempt to reduce the national deficit, Canada's federal government has slashed its science budget by 25 % over four years. In contrast, USA and Japan have adopted a different policy in reducing their budget deficit by investing more in science for assuring an edge in frontier science for the future economy in a competitive market. In seeking alternatives to public funding, Canada has targeted venture and business as major supporters of university-based research. Government portrays business as a cornerstone because of the considerable success of the National Centres of Excellence (NCE) programme established by the Federal government in 1988 to link academies across the country to theme-based scientific networks. The NCE programme gave university-based researchers an additional fund for fostering science research between academia and industry. In 1994, NCE neuroscience network and the country's largest commercial bank teamed up to fund support of the development and commercialization of discoveries in brain and spinal cord research. Subsequently, the Canadian medical discoveries fund (CMDF) was created. Twenty starting companies and university-based research councils to promote interaction with the private sector were created. Many companies have invested up to 10 % of their budget toward partnership as an "average" to university science-based research to siphon discoveries and new knowledge to new products. This has made up for any shortfall in government funding in 1977 of the NCE programme. Government strategy robs Peter to pay Paul. No doubt venture capital is well suited

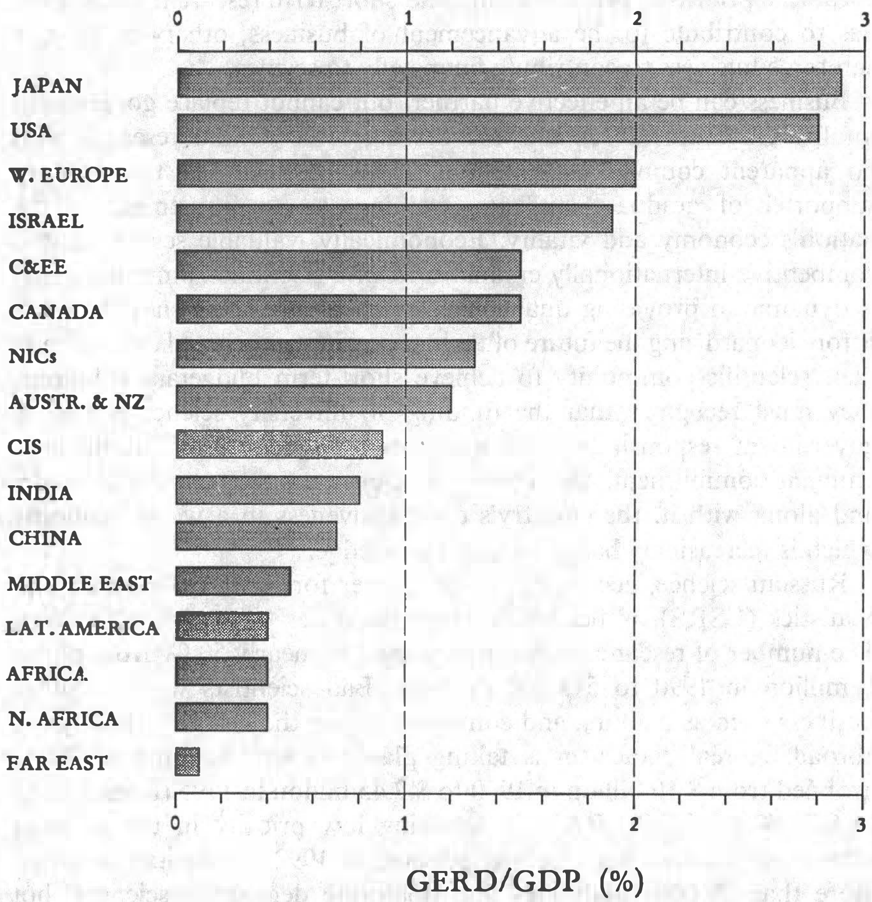

Fig. 3. — Investment in science.

to bring university science to the market place. Business has an important role to play in supporting academic research through mutually beneficial agreements with individual investigators and research organizations. But even the most visionary business must focus on corporate priorities, profit making, and short-term research. But science has to contribute to the advancement of business, otherwise no one can force business to contribute financially to science.

Business can be an effective partner, but cannot replace government totally. Government remains the driving force behind research with no apparent commercial potential. It should also be the primary supporter of graduate students, training, as an investment in the nation's economy and vitality. Economically, valuable science that is competitive internationally emanates from a scientific community that is dynamic in providing quality research. Governments should realize before jeopardizing the future of their scientific strength and compromise their scientific community to achieve short-term budgetary solutions, they must recognize that the funding of university science is both a government responsibility and a long-term investment. Without government commitment, the university science infrastructure will erode, and along with it, the country's competitiveness in a world economy which is increasingly based on new knowledge.

Russian science, according to the Center for Science Research and Statistics (CSRS), is fleeing to other countries or other professions. The number of researchers has plummeted by nearly 50 %, from about 1 million in 1990 to 518,700 in 1995. Bad scientists went to other business such as banking and commerce, while the best ones have gone abroad. A real cataclysm is taking place. Federal funding of R&D dropped from $ 10 billion in 1990 to $ 2.45 billion in 1995 (from 2.03 % to 0.73 % of GDP). R&D is receiving low priority in the Russian federation. Concerning teaching science, in 1992 universities awarded more than 29,000 candidates and doctorate degrees in sciences, but in 1995, only about 14,000.

In a move to boost research in Britain, closer collaboration between universities aimed at creating world-class research centres and widening access to the latest research equipment has been suggested in a white paper to government by the department of education. The future size and structure of higher education and collaboration on mega-research projects are called for, so Britain can still compete for the market place in the world-global village.

In France, where a heavy bureaucratic central government exists, changes in higher education to meet challenges of globalization are taking place by compromise, through consultation rather than the old approach of imposing change from above, to avoid the familiar riots of students' and lecturers' protests. A white paper was produced at the end of 1977. At present, 80 % of the universities' budget comes from public sectors, with pressure on reducing public spending : the only way universities can boost income is to increase students' fees. The overcrowded conditions at universities are in contrast to the highly competitive *grandes écoles* where students enjoy excellent facilities, including well-equipped libraries and laboratories. In France, the cream of those leaving schools undergo a special year of training — *la classe préparatoire* — for the entry competitions to the *grandes écoles*, while the rest goes to university.

Indicators in Science Development : Disparity between North and South (figs. 4, 5)

The main trend revealed by UNESCO World Science Report (1996) is one of continuing asymmetry in the way science is distributed around the world. We see that all the developing countries taken together are responsible for a mere 10 % of the total gross expenditure on research and development whilst the member countries of the OECD can claim 85 %. The industrialized countries commit between 2.0 % and 3.0 % of GDP to R&D, whereas the countries of the South only manage a fraction of this. In Latin America and Africa, for example, the investment ratio is 0.4 % or below. Even countries with important scientific communities in certain disciplines, like India, Brazil or China, are not able to devote more than 0.7 %.

The pattern is repeated, if we take the number of active scientists and engineers. Although some 25 % of scientists are found in the Third World, the regional figures again show a striking imbalance ; whilst the European Union supports two scientists per thousand inhabitant, the USA 3.7 and Japan 4.1, the developing countries have much more modest levels — Subsaharan Africa, for example, has less than one tenth of the Japanese value.

It is clear from these few examples that for many parts of the world two things are needed : firstly, a clearer commitment towards science by governments and politicians ; secondly, a broad investment in

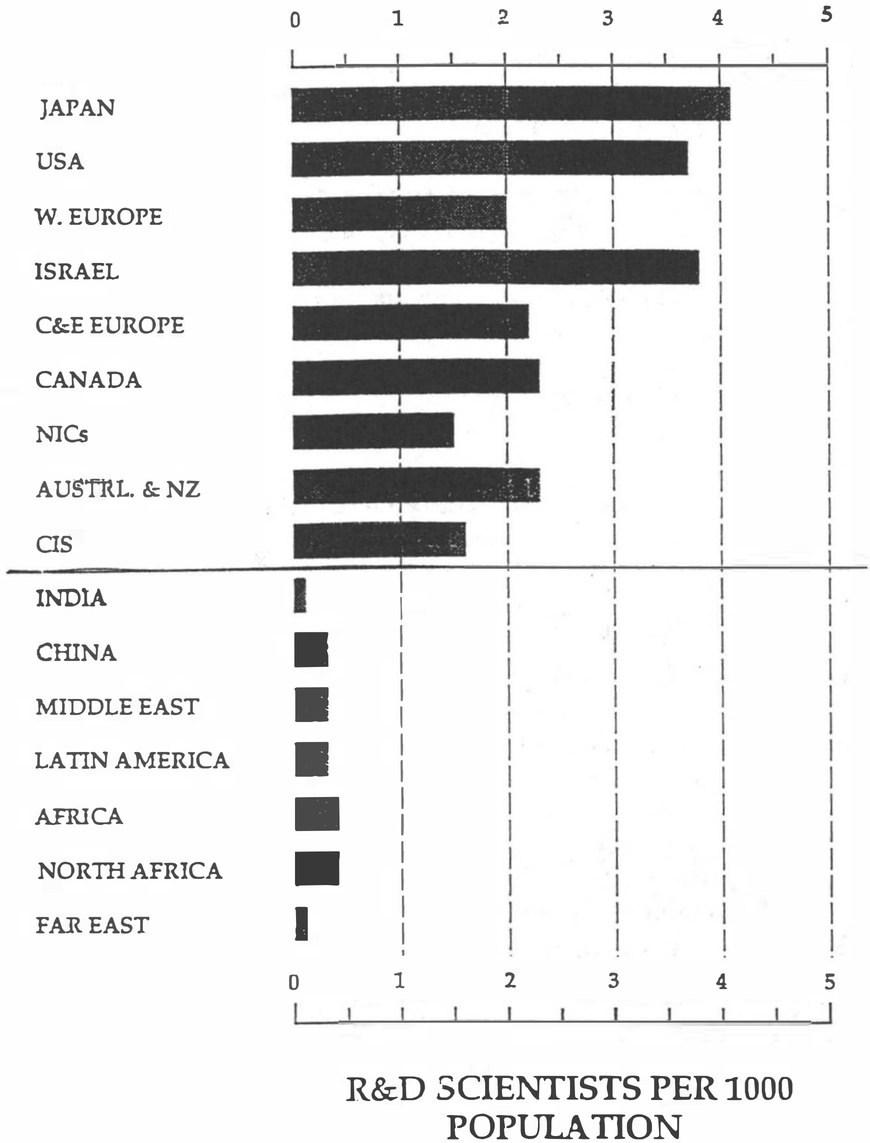

Fig. 4. — Science manpower.

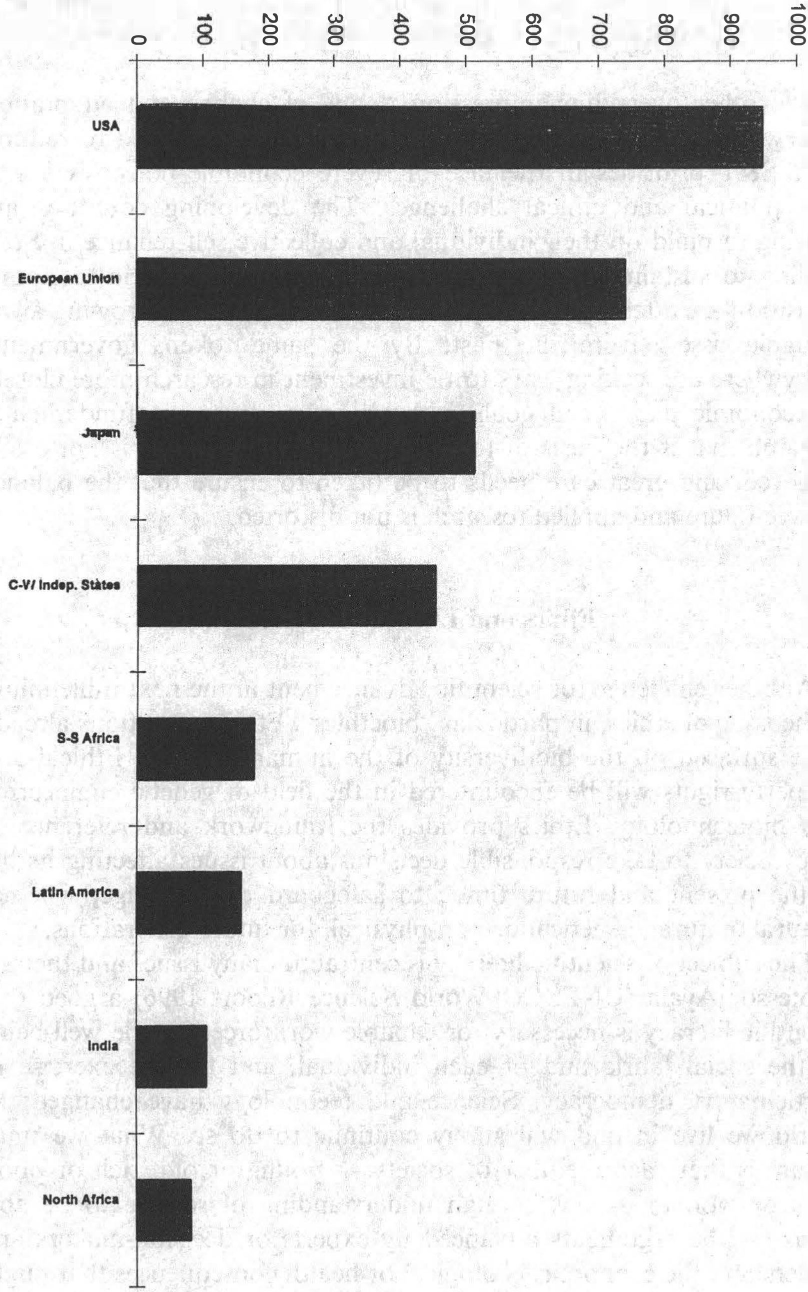

Fig. 5. — R&D scientists+engineers/(× 1000)

capacity building — the strengthening of scientific infrastructure and the development of human resources, particularly in developing countries.

The other overriding impression is one of change and adaptation to new circumstances. The richer nations are being obliged to rethink their S&T priorities in the face of severe economic constraints and new political and ethical challenges. The developing countries are striving to build up their individual and collective self-reliance in S&T leading to sustainable development. The countries in socio-economic transition are attempting to replan their science without throwing away valuable assets from the past. By the same token, governments everywhere are seeking ways to tie investment in research more closely to economic and social goals without endangering the fundamental research that is the basis of tomorrow's innovation. This is not easily achieved, and great care needs to be taken to ensure that the balance between pure and applied research is not distorted.

Ethics and Literacy in Science

Another challenge for scientific advancement in the next millennium is the issue of ethics, in particular "bioethics". Ethical questions already have surfaced on the biodiversity of the human genome. Ethical and property rights will be encountered in the field of genetic engineering and biotechnology. Ethics provides the framework and reference to help society to take responsible decisions about issues affecting its life at the present and future time ; to safeguard our heritage, whether cultural, natural, genetical or non-physical, for future generations.

The subject of scientific literacy is central to many issues and themes. Professor Ayala (UNESCO World Science Report 1996) argued that scientific literacy is necessary for capable workforce, for the well-being of the social fabric and of each individual, and for the exercise of participatory democracy. Science and technology have changed the world we live in and will surely continue to do so. What we must ensure is that each member of society — young or old, rich or poor, man or woman — has enough understanding of science to be able to assess the arguments advanced by experts or decision-makers and understand the economic, ecological or health consequences that might follow.

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Science Policies and Political Commitments for Science-led Development

by

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KEYWORDS. — Political Commitment ; Science-led Development ; Science Policy.

SUMMARY. — Science advances through the years in many parts of the world. Mankind uses science for his own good, making life more comfortable and healthier. Good political leadership have played an important role in the development of science. The progress of science has been partly attributed to the clear policies that regulate its growth. This is observed in both the developed and developing world. In the West and Japan much money has been spent to provide fund and infrastructure for research and development. In Malaysia, the government sets up universities, institutes and research and development infrastructures so as to help scientists produce indigenous technology required for the economic growth. This is in line with Malaysia's aim to become a developed country. A large amount of money is allocated to science education in schools and universities with a view of providing sufficient workforce for the industries. Malaysia is now promoting the use of information technology in education, health, industrial development and services. With this commitment, the country is moving ahead with national development and hopefully the dream of becoming a developed country becomes a reality.

MOTS-CLES. — Engagement politique ; Développement par la science ; Politique scientifique.

RESUME. — *Politiques scientifiques et engagements politiques pour un développement par la science.* — Au fil des ans, la science évolue dans de

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nombreuses parties du monde. L'homme utilise la science pour son bien-être, se rendant ainsi la vie plus agréable et plus saine. Des dirigeants politiques compétents ont joué un rôle important dans le développement de la science. Le progrès de la science a été partiellement attribué aux politiques transparentes qui régulent sa croissance. Phénomène observé tant dans les pays développés qu'en développement. De grosses sommes d'argent ont servi à assurer un financement et une infrastructure pour la recherche et le développement en Occident et au Japon. En Malaisie, le gouvernement implante des universités, des instituts, des infrastructures de recherche et de développement afin d'aider les scientifiques à produire une technologie indigène nécessaire à la croissance économique. Cela correspond à l'objectif de la Malaisie de devenir un pays développé. Des sommes considérables sont allouées à l'enseignement scientifique dans les écoles et universités en vue de fournir aux industries une main-d'œuvre suffisante. La Malaisie est actuellement en train de promouvoir l'emploi de l'informatique dans l'enseignement, la santé, le développement industriel et les services. Avec un tel engagement, le pays progresse vers un développement national dans l'espoir que le rêve de devenir un pays développé devienne réalité.

TREFWOORDEN. — Politiek engagement ; Wetenschapsgeleide ontwikkeling ; Wetenschapsbeleid.

SAMENVATTING. — *Wetenschapsbeleid en politiek engagement voor een wetenschapsgeleide ontwikkeling.* — Met de jaren maakt de wetenschap in vele delen van de wereld vorderingen. De Mens gebruikt de wetenschap voor zijn welzijn ; zij maakt zijn leven comfortabeler en gezonder. Goede politieke leiders hebben een belangrijke rol gespeeld in de ontwikkeling van de wetenschap. De vorderingen van de wetenschap werden voor een deel toegeschreven aan duidelijke beleidsvormen die haar groei regulariseerden. Dit werd zowel in de ontwikkelde landen als in deze in ontwikkeling vastgesteld. In het Westen en in Japan werd heel wat geld besteed om in fondsen en infrastructuur voor onderzoek en ontwikkeling te voorzien. In Maleisië richt de regering universiteiten en instituten op en zorgt zij voor onderzoeks- en ontwikkelingsinfrastructuur om wetenschappers te helpen een inheemse technologie te ontwikkelen, nodig voor de economische groei. Dit ligt in de lijn van het doel dat Maleisië voor ogen heeft, nl. tot een ontwikkeld land uit te groeien. Het wetenschappelijk onderricht in scholen en aan universiteiten krijgt grote sommen toegekend om in een voldoende aantal arbeidskrachten voor de industrie te kunnen voorzien. Maleisië promoot het gebruik van informatietechnologie in onderwijs, gezondheid, industriële ontwikkeling en diensten. Dankzij dit engagement maakt het land vooruitgang wat nationale ontwikkeling betreft ; hopelijk wordt de droom om een ontwikkeld land te worden werkelijkheid.

1. Introduction

Policy as defined by dictionary (Fowler & Fowler 1996) is course of action adopted in state affairs or sagacious procedure in politics. Science policy entails actions by groups or individuals aiming at giving guidelines to regulate science development. Good progress is, therefore, determined by correct and effective policy. In other words, policy helps promote and regulate science that contributes to economic prosperity of any particular country. Politicians play a key role in formulating policies that relate to science development. Their commitments and support determine the success of any policy during implementation.

Most of the discoveries in science and inventions in the past 2,500 years have been utilized for the good of mankind. Science itself has taken control of the way we live, travel, eat, dress, work, etc. It would have taken much more time and energy had it not been for the correct science policies that have been laid down by and the commitments from the world's political leaders. In the developed world such as the US and Japan, science has made great progress that had contributed towards development of IT, aviation industry, electronics, energy generation, environmental quality, construction, consumer goods, space science, health care, agriculture and the like.

Foreign investors are attracted by the political stability as well as the infrastructure available in the country. For instance, British industrial investment in Malaysia has increased over the years because of these (Junid 1980). In Malaysia, the public and private sectors with full political support had formulated policies that led to the establishment of various institutions and agencies. These institutions and agencies have since become full-fledged political machines to attract foreign investments, e.g. investment in IT.

Some people may misinterpret political commitment as something to do with political interference on the part of the government. Politicians interfere with the administration of local governments or public institutions are a common happening in developed and developing countries. They do so for a reason, either good or bad. If it is done for personal gain or to get political mileage, then it is considered unethical. What is meant by political commitment in this paper is the support and insurance given by those in power when a certain policy is implemented. This paper aims to explain how science policies and political commitments help develop the economy of the countries in the West and South for the good of mankind.

2. Development in Science and Technology

2.1. Science in the Early Years

Some degree of political support must have been given to the Greek Philosopher Aristotle, for him to come out with a theory about the universe. It was then thought that the earth was stationary and that the sun, the moon and the other stars moved in circular orbit about the earth. This idea was accepted by the Church at that time. It took the combined effort of Nicholas Copernicus and Galileo Galilei to counter-propose that the earth and the other planets moved in circular orbit around the sun. Galileo, as we know him, was the person responsible for the birth of modern science.

More scientific ideas and theories proposed by Newton and Einstein have led to the many discoveries that we see today. Their thoughts and ideas were translated into actions and inventions. Some scientific theories are so revolutionary that members of the public find them difficult to accept, e.g. the suggestion that the universe is expanding (Hawking 1988).

Development in science and technology is regulated by specific rules and laws. Some of the regulations are made by learned scientific organizations, while others are proposed by government institutions. The aim of having such regulations is to promote science as well as to check abuses. Normally, the highest learned scientific organization set up in the countries where science is in the advanced stage of development is called the Academy of Science (table 1).

Table 1

Examples of learned scientific organizations in the world

The Academy	Established in
British Royal Society	1662
Russian Academy of Science	1725
National Academy of Science of the US	1863
Chinese Academy of Science	1949
Academy of Science, Malaysia	1994

Source : annual report 1993

International research institutes are established in many parts of the world with specific mandates. These include the "International Rice Research Institute (IRRI)" (the Philippines), the "International Institute of Tropical Agriculture (IITA)" (Nigeria), the "International Atomic Energy Agency (IAEA)" (Austria). The funds to run these research institutes are equally shared by renowned international organizations and the host countries. Some reputable scientific agencies are also established under the auspices of the United Nations, e.g. FAO and UNESCO.

Nowadays people can communicate easily through the internet. Using this technology, we can get information at the flick of a switch. Education can be brought to our doorstep via the internet. As a system, the internet is a global collection of computer networks. It encompasses many features, such as www, e-mail, usenet newsgroup, etc. The information available on the internet varies — most are useful while others are not suitable for public consumption. The free flow of information to all over the world needs to be checked and regulated. In other words, new rules, referred to as cyberlaws, must be enforced to regulate the flow of information.

In developing countries, there is a need for commercialized science. Scientists in these countries need to conceive products that have commercial value and that can be mass-produced for export market. In this way, the GDP growth of those countries can be sustained, bringing with it prosperity and good services to the people.

2.2. Science in the West and Japan

It is becoming a trend now that students are encouraged to proceed further with their studies when they finish their first degree. In the US and Japan, 15 and 6 %, respectively of the college seniors, proceed to graduate school. Although investment in education to boost up research and development is a costly affair, it is worth the money. It is in the best interest of the university and the public that basic research is conducted. Basic research is the source of all science and technology. Improving laboratories in the universities that conduct basic research and putting money into bold explorations on the frontiers of knowledge have paid off. Nowadays, the US and Japan are the two strongest economies in the world. They owe much of their success and fortune to their advancement in science and technology.

What made the US and Japan move far ahead in science and technology compared to the others can be traced back to the commitments and political support provided by their political leaders. Research institutes and universities in these countries are established with funds provided by the billions for research in the key areas important for the growth of their industries. It is known that money spent for research and development comes to 2-3 % of their GDP.

Advances in aviation, automobile, computer industries and the like are due in part to the support and commitment given by the public sector. Multinational companies like IBM, General Motors, Intel, Microsoft and Toyota have taken advantage of the friendly policies and have resulted in great improvement in their production line. They have captured the world at large by their advanced technologies and innovative products.

2.3. Development of Science in Malaysia

2.3.1. Vision 2020

Malaysia owes much to the British Colonial administrators for its economic success. British entrepreneurs brought in money and invested heavily in the 1960s in the manufacturing of goods for export market. They were in the beginning attracted by the abundance of raw materials and cheap skilled labour and later by free enterprise policy that encouraged private foreign investment (Junid 1980). The government then had set a clear policy and target for the expansion of economy.

Since independence from the British in 1957, Malaysia has hoped to become a progressive society based on science and technology. The country has formulated a strategic plan to become a developed nation by the year 2020. The dream-dubbed vision 2020 requires concerted development in all areas including science. The balanced development of Malaysia needs strong science and technology capability. Major industries under scrutiny are advanced microelectronics, consumer goods, computers, telecommunication, heavy industries and chemicals. In less than fourty years, the major export of Malaysia has changed from rubber and tin commodities into that of manufactured products and innovative services.

Prime Minister (PM) Mahathir Mohamad has outlined nine challenges facing the nation to realize vision 2020. Challenge number six is establishing Malaysia "to become a scientific and progressive society that is innovative and forward-looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilization of the future" (Mahathir Mohamad 1991).

2.3.2. Allocation of Research Fund

The aim of the National Policy (EPU 1996) is to ensure science and technology development to support and sustain the GDP growth, to accelerate industrial development and to provide basic infrastructure for a developed economy. For this to happen, the government has appointed a science advisor whose duty is to push for inclusion of science in the national agenda. He has to find out how science could contribute to the development of the country as a whole. A logical step is to harness the existing science and technology potential for national development.

To ensure that research fund goes into the right hand, the government established the Intensification of Research in Priority Areas (IRPA) programme. The objective of the IRPA programme is to make sure that research and development resources of Malaysia are invested in areas that can enhance industrial efficiency, productivity and competitiveness. Researchers in the universities have finally received their deserved attention from the government to conduct research for the betterment of the country.

The IRPA mechanism is under the purview of the National Council for Scientific Research and Development (NCSRD) in the Ministry of Science, Technology and Environment (MOSTE). The council is chaired by the Chief Secretary to the Malaysian government. In the 7th Malaysia Plan (1996-2000), a sum of RM 1 billion is allocated to fund research in nine sectors, namely agro-industry, mineral and energy resources, manufacturing, environment, health, science, engineering and services. As reflected by the current economic scenario, the agro-industry sector receives the most fund.

2.3.3. Function of Public Institutions

The NCSRD advises the government on all matters pertaining to the development of science and technology. It also oversees all research programmes undertaken by the public research institutions and universities. In keeping with the camping structure of the economy, the NCSRD is redirecting research funds towards satisfying the needs of the manufacturing in the priority areas mentioned.

The council then has established the Malaysian Technology Development Corporation (MTDC) to provide venture capital for research and development projects. The MTDC promotes technology-driven enterprises by acting as a catalyst for the development of venture capital market in Malaysia.

Reinforcing MTDC's efforts at promoting technology-intensive enterprises is the Malaysian Industry - Government Group for High Technology (MIGHT). The MIGHT draws membership from both corporate and public sectors. It aims at identifying business opportunities through technology exploitation, to jump-start innovation and suggest technology-related policy options to the government.

The government has also set up Technology Park Malaysia (TPM) and Kulim High-Tech Park. The former, featuring the best production facilities in the country, is located in Selangor. The latter, located in Kedah, is a holistic self-contained environment for high technology, research and development. To enhance public awareness in science and technology, the government has established the National Science Centre and National Planetarium. School children are brought to these institutions to get a glimpse at how science works hoping that they take up science option in their careers.

2.3.4. Development of IT

The private sector in the country has the responsibility to play an active role in creating job opportunities. The government decides to promote the telecommunication sector as a vehicle to achieve the objective. Thus, in 1996 an area measuring 15 km by 50 km south of Kuala Lumpur was set aside, linking Kuala Lumpur City Centre (KLCC), Putrajaya (the new government administrative centre) and Kuala Lumpur International Airport (KLIA) in Sepang to establish a new entity known as the Multimedia Super Corridor (MSC). The MSC offers state-of-the-art telecommunication infrastructure as well as conducive business environment for companies. Universiti Putra Malaysia (UPM), Universiti Tenaga Nasional (UNITEN) and the yet to be established Multimedia University, which are given MSC status, have been instructed to link up with the rest of the world via internet to gain full advantage of the available facilities.

Currently, the country is suffering setback due to economic downturn. But the MSC is not only progressing well but also a year ahead of schedule. The project, which sets the stage for Malaysia's entrance into the digital age, is progressing very well. Efforts to garner more support in terms of commitments and business investments in the MSC are continuing. The Prime Minister has repeatedly reaffirmed the government's commitment for its continued support of the MSC. Some of the flagship applications of the MSC are :

— Smart School ;
— Telemedicine ;
— Electronic Government ;
— National Multi-Purpose Card.

A new city dedicated to the MSC, named Cyberjaya, is to be developed. According to the Multimedia Development Corporation (MDC), the steering body of the MSC, about 500 IT companies will be located in Cyberjaya by the year 2020. The MSC envisages Malaysians working with futuristic technology, in which smart cards are used to pay bills and buy goods, communicating via e-mail, shopping on-line and completing financial matters via computers at home. Many of the best in the IT industry, including Bill Gates, sit on the International Advisory Panel of the MSC. The panel, which is chaired by the PM himself, helps formulate policy to regulate its development.

2.3.5. Science Education

Science education in Malaysia is well ahead in the way to achieving the national aspiration. In the 7th Malaysia Plan, 15.4 % of the total public development expenditure have been allocated to education. The huge amount of money spent reflects the government's commitment in transforming the education system with the aim of creating a more technically skilled workforce. The government is trying to create a technological society that can develop its own indigenously built technology. Priority would be given to setting up private universities and allowing renown foreign universities to set up branches in the country. In future, the ratio for students enrolling for science-related courses, when compared to arts in universities, would be 60:40, reversing the current ratio. Various programmes are organized to make students take up science subjects in schools and colleges.

3. Developing Appropriate Science Policies

The government of Malaysia has outlined clear science and technology policy (Anon 1991). Science development in the country has to be sustained at all cost. The government will create the necessary conditions under which technology will be built up efficiently, providing environment conducive to innovation. Deliberate effort is embarked to increase private and public sector investment in research and development so as to increase its share as a percentage of GDP.

To resolve the inequitable wealth distribution in the country, the government of Malaysia has adopted the New Economic Policy (NEP). Under this policy, the *Bumiputra* (the indigenous people) is given extra privilege to catch up with the Chinese community in science education and business. Other policies formulated by the government such as the Industrial Policy and National Agriculture Policy are a way forwards to achieve developed status both scientifically and economically. These policies are essential and found to be effective in the process of restructuring our society (AHMAD ATORY 1996).

The management and utilization of research and development capability in public sector institutions will be reviewed and improved. An adequate and comprehensive mechanism for the promotion and commercialization of discoveries and innovations resulting from research will be developed. The private sector is invited to participate actively in research and development and commercialization of research results.

The government will increase investment in scientific and technological education as well as development of technical and research manpower. Soon more universities producing technical expertise required for the development of the country will be set up at key locations.

To be transparent, the government has from time to time taken a serious look at its past performance. A review of industrial technology

Table 2

Some policies that need to be introduced/refined for continued world progress

Policy on	Comment/What needs to be done
1. Global warming	Scientists are concerned with the build-up of CO_2 and other gases produced by burning of fossil fuels. Need commitment from countries that contribute to it.
2. Internet	A policy is needed to reduce free flow and abuse of information.
3. Food quality	We should evaluate risks of pesticide to human and set tolerances for chemical residues on crops.
4. Utilization of wetlands	Wetlands have always been an important feature in the civilization of mankind. Today these wetlands are being destroyed.
5. Genetic engineering	Cloning of human being is unethical.
6. Weapons of mass destruction	Need refinement and enforcement of existing policy.
7. Agriculture policy	Eradication of rural poverty and food security for developing countries should be the top priority.
8. National education policy	To have sufficient workforce for industrial development.
9. Industrial policy	Step up effort to increase manufactured-based industries.

development was carried out. It was undertaken by the World Bank with the assistance of the Economic Planning Unit, Prime Minister Department and Ministry of Science, Technology and Environment. It was a review of the Malaysian industrial technology policy and infrastructure with a view to providing a more integrated long-term strategy and to accelerating development of industrial technology.

Our civilization will collapse and all we have built up over the years will come to nought unless we do something to prevent their demise. This can be partly done by way of proposing new policies and refining the existing ones and these need to be adopted and respected by all. Table 2 lists some of the policies that we believe should be taken into consideration by those in power.

4. Conclusion

Science contributes a lot to the progress of mankind. We owe much to those who spent their lifetime to come out with theories, conduct experiments, disseminate results, produce consumer goods and proposed rules and regulations for the progress of science and technology. Much fund is allocated to research and development by the public and private sectors. However, new policies are required to regulate the development of science, while some existing policies need to be refined.

In Malaysia, the introduction of clear science and technology policies has helped intensify research and development capacity. This enhances industrial production and efficiency of delivery of goods and services. Hopefully, its aim to become a developed country becomes a reality.

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PANEL 2

SCIENTIFIC INSTITUTIONS AND PRIVATE SECTOR SUPPORT TO SCIENCE FOR DEVELOPMENT

Moderator : Prof. Jean Jacques PETERS
Reporters : Prof. Hendrik DEELSTRA
Prof. Robert LEENAERTS

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Scientific Institutions : Contributions, Inadequacies, Failures

by

Thomas ODHIAMBO *

KEYWORDS. — Emotions ; Ethics ; Innovation ; Paradigm ; Responsibility ; Soul ; Transformation ; Utopia ; Well-being.

SUMMARY. — From approximately 1780, scientific and technological advances and innovations have come fast and in great leaps, starting with the Industrial Revolution and presently merging into the Knowledge Society. This progress has not been matched by the development of an over-arching holistic superstructure. Ethical considerations and value judgements, and the vital role of the soul in giving direction to the social and economic development stemming from science-led progress, have been left out of what could have been an unprecedented era of social well-being and affluence without fear, aggressiveness, and ego-tripping. A new ethos is required, comprising a new millennial utopia of an integrated wholeness of the science-led human enterprise. In this new task, the developing world scientific institutions have a primary hope.

MOTS-CLES. — Emotions ; Ethique ; Innovation ; Paradigme ; Responsabilité ; Ame ; Transformation ; Utopie ; Bien-être.

RESUME. — *Institutions scientifiques : apports, insuffisances, échecs.* — Depuis 1780 environ, progrès et innovations scientifiques et technologiques sont survenus rapidement, à pas de géant, démarrant avec la société industrielle pour maintenant fusionner avec la société de connaissance. Cette évolution n'est pas allée de pair avec le développement d'une superstructure holistique dominante. Des considérations éthiques et des jugements de valeur, sans oublier le rôle fondamental de l'âme dans l'orientation à donner au déve-

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loppement socio-économique résultant d'un progrès axé sur la science, ont été exclus de ce qui aurait pu devenir une ère sans précédent de bien-être social et de prospérité dénuée de toute crainte, agressivité et narcissisme. Un nouvel esprit est nécessaire, impliquant une nouvelle utopie millénaire d'un tout intégré de l'activité humaine fondée sur la science. Dans cette nouvelle tâche, un espoir vital est permis pour les institutions scientifiques du monde en développement.

TREFWOORDEN. — Emoties ; Ethiek ; Vernieuwing ; Paradigma ; Verantwoordelijkheid ; Ziel ; Transformatie ; Utopie ; Welzijn.

SAMENVATTING. — *Wetenschappelijke instellingen : bijdragen, tekortkomingen, mislukkingen.* — Sedert 1780 ongeveer volgden de wetenschappelijke en technologische vorderingen en vernieuwingen elkaar met rasse schreden op, te beginnen met de industriële samenleving, heden ten dage overvloeiend in de kennismaatschappij. Deze vooruitgang ging niet gepaard met de ontwikkeling van een overkoepelende holistische superstructuur. Ethische overwegingen en waardeoordelen, en de vitale rol van de ziel bij het richting geven aan de sociale en economische ontwikkeling voortvloeiend uit wetenschapsgeleide vooruitgang, maakten geen deel uit van wat een periode van sociaal welzijn en welvaart zonder vrees, agressiviteit en *ego-tripping* zonder voorgaande, had kunnen zijn. Een nieuw ethos is noodzakelijk, bestaande o.m. uit een nieuwe millenniumutopie van een geïntegreerd geheel van de wetenschapsgeleide menselijke onderneming. De wetenschappelijke instellingen uit de ontwikkelingslanden stellen al hun hoop in deze nieuwe taak.

1. Introduction

The material well-being of the human society has experienced extraordinary paradigm shifts in the last 2.5 million years of human existence on Earth. The early pivotal technology developments were slow to come — tool-making, which was achieved some 2.5 to 1.5 million years ago (m.y.a) ; the strategic employment of fire, 1.5 m.y.a ; the invention of plant cultivation from 20,000 - 10,000 B.C.E., followed soon after by the domestication of cattle, about 10,000 - 6,000 B.C.E. Each one of these technological revolutions brought about a whole new paradigm shift in the art and practice of life and living, and prepared mankind for the next quantum change in life-style and content.

What has followed the onset of the "Industrial Revolution" at about 1780, by the substitution of human and animal power by inanimate sources of power — first steam, and then, in rapid succession, electricity, hydrocarbons and nuclear energy — is the rapid epochal transformation that has enormously upscaled human production and manufacturing capacities. These have, in turn, called for more sophisticated machines, huge quantities of more varied raw materials, more efficient transportation and communication, more refined marketing expertise, and a whole new way of acquiring skills and the knowledge essential for this more globalized economy. These two hundred years of breathtaking changes in the human industrial processes and economic transactions have not been matched by parallel, equally momentous paradigm shifts in human behaviour to fully take advantage of the vast resources opened up by the Industrial Revolution and its successor revolutions that have followed it in rapid fire — the Electronic Revolution, the Information Age and, now on the horizon, the Knowledge Society.

Yet, the human entity is still wallowing in greed, aggressiveness, and fear of the future. Human ego is grossly overblown : individuals, as well as nation-states, fear to "lose face" ; and an industrial tycoon is proud to be known as "hard-nosed". Because vast possibilities are opened by the pursuit of scientific research and technological development (R&D), by way of strategic discoveries and problem-solving innovations, for the betterment of human life and the material assurance of the future for the entire human society, it is the responsibility of the scientific community and its institutions to contribute in a deliberate, significant way to the evolution of a new way of doing things. In this respect, what happens to the discoveries and innovations that scientists periodically make, the manner in which they make them, and how they are financed, must become an integral part of the responsibility of every scientist, every scientific institution, every specialist in science and technology (S&T) policy, every entrepreneur who uses the intellectual property rights (patents, utility models, biological genes, etc.) which arise from R&D activities, and every promoter and financier of the scientific endeavour, be they individuals, philanthropic organizations, international development bodies, nation-states, or the private sector.

What is being proposed in this presentation, on the eve of the twenty-first century, is manifestly a millennial utopia. It is that scientific enquiry and experimentation, which may well lead to far-reaching discoveries, invention and innovations, must be undertaken within a structured, thought-through envelope of ethical principles of eternal value for the individual as well as the human society as a whole. Even though science, intrinsically, is the pursuit of truth — through acute observation and the experimental method —, that truth is only partial. There are other "truths" — social-cultural truth, truth as seen through the eye of art and music, and moral ethical truth. The millennial utopia presupposes the wholeness of the human entity; the body-brain-soul existences as an integrated, holistic whole; an entity that is, at the same time, materially developed, intellectually rational, and spiritually elevated. The essence of this wholeness is to create, bestow and enjoy a happy, prosperous and peaceful well-being.

2. Social and Political Enabling Environment for S & T

Development-oriented, problem-solving S&T demands a steadfast, enabling environment that is engendered by a political commitment to S&T for development, social appreciation and esteem for the scientific enterprise, an enlightened ethics, and an assured financial and human capital investment into the S&T system.

In such an environment, the science enterprise is given a considerable degree of freedom to determine its priorities, to select its methodology for accomplishing the relevant goals, and to evaluate and assess its own advances in striving for scientific truth and knowledge, often very specialized and particular. In this context, the frontiers of knowledge seem, in the last half-century, to be endlessly being pushed back. Yet, we glimpse the future with a fearful heart: for instance, the meteoric advances in the life sciences are confronted with the ethical dilemma posed by those advances as to what value judgement the scientists can place on the uses to which those discoveries can potentially be put. We need to always remind ourselves that S&T should always be in the service of humanity, and even extend this to the universe in its entirety as we perceive it by all our faculties combined — and never turn mankind (and the universe as a whole) to be the servant of S&T.

Specialized knowledge in any human venture — whether in art, literature, music, or S&T — soon acquires an air of elitism. This is not a bad thing, if our contextual framework is simply one of positive mastery of the field and assuming a healthy self-image. The problem arises when these finely drawn boundaries are crossed, and one then enters into the pose of arrogance and ego-tripping. This can be seen in the emerging tendency to hoard scientific information on fast-developing specialist fields, such as private sector entities which are aggressively locking up genomic information on single nucleotide polymorphisms in the human genome project, through the rapid registration of patents. This being done in the commercial hope of selling licenses to pharmaceutical companies for utilizing such information in developing new gene therapies and designer drugs.

The globalization of science, especially in the wake of the vastly improved transportation and communication with modern high technology, and the rapidity and efficiency in which connectedness is being brought about in contemporary times, is giving a new leap of vision as to the future prospects of science in the service of mankind. Internationalism and intensive communication have always been at the root of the power and success of science over the ages. But this is now being increasingly challenged by the bludgeoning tendency toward technological nationalism and the atomization of the human family by geopolitical power plays, geoeconomic exclusiveness, and the resurgent neo-mercantilism, of which the recently promulgated protocols of the World Trade Organization are a gross symptom.

It may well be that, at this juncture, we should change the manner in which we engage science. Rather than let the advancing edge of science be the landmark from which new processes and innovations arise, let us have a major new pathway — that of deliberately letting problems drive the nature and strategic content of science-led social and economic development. Let us take a concrete example, in a field of concern which is very much at the core of the psychic peace and medical health of the peoples of the tropical developing world — the area of the mind-body medical treatment, or what in North America and Northwestern Europe is termed "alternative medicine" or "complementary medicine".

There is an escalating interest and acceptance of mind-body medical treatment in the United States of America, because it serves a clientele that cares about the empathetic human doctor-patient relationship, and which incorporates the psychological and social dimensions into the healing, rather than merely curing, process. It was estimated, in 1990, that Americans annually spent more than US$ 13.7 billion on mind-body medical treatment. The problem is that the biomedical researchers tend to ignore this emergent area — emergent for modern North America and Europe, but an old art and practice among the indigenous peoples of the Americas, Africa, Asia and Oceania — because "in terms of 'hard-core science', which tend to focus inward, through the molecular level, rather than outward, towards psychological and social factors", the mind-body medical system has still to make its case in rational science (Bunk 1998). This case is painstakingly beginning to be made — often in molecular terms — even though the entire impact is at the holistic level.

A good illustration is to be found in cytokines, molecules that are secreted by the immune system to mediate communication between the immune system itself and the central nervous system (CNS). In this way, cytokines act like hormones ; and they are found in many CNS cells and receptors, for instance neural cytokines which play a vital part in the death or survival of neurones. One finds overexpression of cytokines in the brains of patients with infectious diseases (including AIDS), nerve trauma, Alzheimer's Disease and multiple sclerosis. In each of these diseases, the degeneration of neurones could be caused by the toxic effects of cytokines released from inflammatory cells of the affected tissue. It is now known that, in the case of peripheral cytokines, they are triggered off by inflammatory stimuli (or antigens), which then activate neuronal pathways that regulate the immune system. The final result is the stimulation of stress responses, such as anxiety, lethargy, and "sickness behaviour", which is intimately associated with the feeding of illness (Bunk 1998). In this context, it is crucial to remind oneself that emotions are the pivotal trigger that transforms a person from one state of consciousness into another.

It is clear, then, that scientific institutions must now confront this problem, and all others related to the field of mind-body medicine, with all the tools at their disposal. It is a field of enormous moment for the future holistic health of mankind.

3. Creating Confidence among Developing Country Scientific Institutions

As we have already noted, fragmentation of science, while important in undertaking focused boring into the very core of a specialized area, has the long-range effect — if persisted upon over a very long period of time — of giving us a large number of prospective building blocks, rather than a complete building. We need glue or a cementing substance, and an architectural concept, to give us a complete picture of the edifice we envisage. The socio-ethical goals and value systems of the human society are the architectural plans of that society ; the results of scientific research and technological development are the building blocks, while the human soul, the very basic essence of being, is the cement. This is the premise on which the millennial utopia needs to be built.

On that premise, there is an amazing hope for the scientists and their institutions in the developing world. They have already known great civilizations in their past histories ; they have had, in those bygone epochs, tremendous achievements in scholarship, technology, and in science and mathematics ; and they have been imbued, until recently, with a deep knowledge of the soul and of the universe beyond the material world, remnants of which are still persistent (MASOLO 1995). Their transition to an integrated research venture that captures the kernel of the body-brain-soul reality should be relatively simple, as their own worldview is essentially that. But the endeavour will need courage. The fear of being booed out of the scientific community when one begins to talk about the soul is ever present. But the world is beginning to see that fundamentalist rationalization alone cannot adequately provide us with a complete picture of our being and well-being. Martin REES (1997) says it in eloquent terms :

> Despite this progress in exploring, mapping and interpreting our cosmic environment, we have become more aware that there are stringent constraints and limits to what we can predict, and to the levels of explanation that we can realistically seek. The limits due to quantum uncertainty have been well known for more than 60 years. But it is now also more fully appreciated that many classical 'deterministic' systems are inherently unpredictable — chaos rather than clockwork.

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Industrial Organizations : Contributions and Deviations

by

Patrick De Groote *

Keywords. — Business Community ; Living Conditions ; Investments ; Advisory Councils ; Service ; Industry ; Development.

Summary. — Though the objectives of scientific institutions differ from those of industrial organizations from the private sector, both have a number of outcomes in common related to development, for example improving living conditions in the poorest countries. This improvement will increase investments in industry and infrastructure, launching a positive spiral of development. Hence, the industrial business community is contributing to the development process with, for example, investments, service, advice, training, research and development, etc. Support services to science is part of these efforts. Nevertheless, as speed is a major precondition for the private sector in the development process, several deviations in the relationship with scientific organizations appear in practice. A certain fatigue is perceived when it comes to increasing aid : these organizations are — often wrongly — considered as inefficient, slow, with a poor cost-effectiveness, with long waiting times before results are seen, etc. Referring to the intervention of ABB's (Asea Brown Boveri) Chairman, Percy Barnevik, at the "Retreat" of the Administrative Committee on Coordination of the United Nations in October 1997, we support his proposal of establishing Business Advisory Councils between UN-bodies and the business community. In these councils scientific institutions should be included with the aim of widening the pool of recipients of foreign investment. The present contribution aims at submitting some ideas in relation to this proposal, while including the experience of an important global company with an emphasis on its service activity and its contribution towards science for development.

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MOTS-CLES. — Monde des affaires ; Conditions de vie ; Investissements ; Assemblées consultatives ; Services ; Industrie ; Développement.

RESUME. — *Organisations industrielles : contributions et dérives.* — Bien que les objectifs des institutions scientifiques diffèrent de ceux des organisations industrielles du secteur privé, toutes deux partagent une série de résultats liés au développement, tels que l'amélioration des conditions de vie dans les pays les plus pauvres, avec pour effet des investissements accrus dans l'industrie et l'infrastructure, entraînant une spirale de développement positive. Ainsi le monde des affaires contribue au processus de développement, notamment par l'apport d'investissements, services, conseils, formation, recherche et développement, etc. Une partie de ces efforts concerne l'appui des services à la science. Néanmoins, la rapidité étant pour le secteur privé une condition préalable majeure dans le processus de développement, plusieurs dérives apparaissent en pratique dans les relations avec les organisations scientifiques. Une certaine lassitude se laisse percevoir concernant l'accroissement de l'aide : ces organisations sont considérées — souvent à tort — comme inefficaces, lentes, de faible rentabilité, avec de longues périodes d'attente avant l'apparition de résultats, etc. Quant à l'intervention du président de Asea Brown Boveri, Percy Barnevik, lors de la «retraite» du Comité administratif de Coordination des Nations Unies en octobre 1997, nous soutenons sa proposition d'instaurer des conseils d'entreprise entre les organismes des Nations Unies et le monde des affaires. Ces assemblées devraient inclure les institutions scientifiques en vue d'élargir le pool des bénéficiaires d'investissements étrangers. Le présent exposé vise à soumettre quelques idées relatives à cette proposition, en y intégrant l'expérience d'une importante firme mondiale dont nous soulignerons l'activité de services et la contribution à la science pour le développement.

TREFWOORDEN. — Zakenwereld ; Levensomstandigheden ; Investeringen ; Adviesraden ; Diensten ; Industrie ; Ontwikkeling.

SAMENVATTING. — *Industriële organisaties : bijdragen en deviaties.* — Hoewel de doelstellingen van wetenschappelijke instellingen verschillen van deze van industriële organisaties uit de privé-sector, hebben beide wat ontwikkeling betreft een aantal resultaten gemeenschappelijk, zoals bvb. het verbeteren van de levensomstandigheden in de armste landen. Door deze verbetering wordt er meer geïnvesteerd in industrie en infrastructuur, waardoor een positieve ontwikkelingsspiraal op gang gebracht wordt. Zodoende draagt de zakenwereld bij tot het ontwikkelingsproces, bvb. door middel van investeringen, diensten, advies, training, onderzoek en ontwikkeling, enz. Ondersteuning van de wetenschap maakt deel uit van deze inspanningen. Maar, aangezien de privésector als belangrijke vereiste vooropstelt dat het ontwikkelingsproces snel evolueert, komen er in de praktijk al eens deviaties voor in de verhouding met wetenschappelijke organisaties. Men stelt een zekere moeheid vast als het op het opdrijven van de hulp aankomt : vaak ten onrechte worden deze

organisaties beschouwd als inefficiënt, traag, weinig rendabel ; resultaten laten lang op zich wachten, enz. Asea Brown Boveri steunt het voorstel dat haar voorzitter Percy Barnevik deed in zijn tussenkomst tijdens de „retraite" van het Administratief Coördinatiecomité van de Verenigde Naties in oktober 1997, m.n. de oprichting van zakenadviesraden samengesteld uit organisaties van de Verenigde Naties en de zakenwereld. In deze raden zouden wetenschappelijke instellingen moeten worden opgenomen met de bedoeling de pool van begunstigden van vreemde investeringen te vergroten. De bedoeling van deze voordracht is een aantal ideeën rond dit voorstel voor te leggen, rekening houdend met de ervaring van een belangrijke internationale firma met de nadruk op haar dienstenactiviteit en haar bijdrage tot wetenschap voor ontwikkeling.

1. Introduction

The contribution of the private industrial sector towards science for development in the framework of a co-operation with development institutions can only be successful if a common ground for interest and understanding lays at the basis.

A private industrial organization has as a first objective to create value for its shareholders. The main mission of the development institutions is to contribute to the increase of living conditions in the poorest countries. When it comes to science for development the common ground between the two communities in the private industrial sector and development organizations is exactly the development component : developing poor countries is fulfilling the objective of the development organizations and at the same time is creating purchase power which in turn will boost the industrial investments and this fulfils the primary objective of the private industrial community.

2. Contributions and Deviations

As speed is generally a major precondition for the private sector in the business cycle, contributions from both the development organizations and from the private sector in development projects, have often been suffering from poor efficiency due to several deviations from both sides. A certain fatigue is perceived when it comes to increasing aid from the private sector towards development programmes : most of the development organizations are often wrongly considered as inefficient, slow, with a poor cost-effectiveness and long waiting times before results are perceived, etc.

When in the past the co-operation between the two communities failed in a number of development projects, this was often due to a poor understanding from each other's goals and to a poor interfacing from two actors having a different view on efficiency and effectiveness.

Let's analyse more in depth some of the elements that should attract all attention when joining forces from the development and the private industrial community.

2.1. Efficiency and effectiveness

Private industrial organizations are looking for sustainability in the long run but must at the same time fulfil their short-term targets. These targets are in many cases expressed in financial terms (e.g. orders received, revenues, income before tax, cash-flow, etc.). The accent in the undertakings of such organizations will specifically be put on the effectiveness (= doing the right things). Private organizations will have to consider their profit chain, subject to their deontological values. The projects which can capture their interest will have to fulfil the above-mentioned targets and will primarily focus on well-discussed budgets which are commonly linked to a business plan. This business plan forms the basis of the commitment of the organization into the project and of the agreement of the board of directors.

Development organizations are looking from another angle : they receive a certain amount of money which has been raised according to a budget defined in the project documents and which is secured for the whole duration of the project. Project management consists especially in respecting this budget by spending the money according to a predetermined framework.

The stress on the actors is obviously different when you have to produce income compared to actors who have to secure budgeted spending.

Consequently, the behaviour of these actors in a common development project is totally different : while the ones will continuously try to get rid of all types of losses which might influence the achievement of the target figures, such as those related to the utilization degree of personnel, the production equipment effectiveness, the return on investment, etc., the others will more stick to an often quite too rigidly defined project framework and will hardly be able to face continuously changing outside influences and politico-cultural environment. Here we see how the development organizations are inclined to putting more emphasis on efficiency (= doing the things right).

2.2. The market

Many international development projects in the past failed to fulfil the expectations because they were too much donor-driven and not enough receptor-driven. In fact, when it comes to activities in which our company ABB Service is today strongly involved, *i.e.* maintenance of industrial equipment, the success rate of international development projects in the industrial field was for example in the eighties hardly 20 %. Evaluation missions came up with many reasons for this disappointing result, which were related to all the operating actors. A main recurrent reason was a poor project formulation containing insufficiently measurable performance indicators together with the fact that the projects were not enough driven by the receptor's needs in terms of objectives and expected results.

Due to its major objective, a private industrial organization will definitely disappear when it is not market-driven. The primary role of project identification and project formulation in a development environment is to analyse in how far the project has an impact on the business opportunities. R&D programmes, for example, in our company are submitted to an in-depth analysis as to the effect on the business. A development programme will not be launched when the outlooks for future business are not sufficiently present.

2.3. Project Execution

The above considerations do not suggest that market-driven projects will always be more successful than others. But it has been proven that donor-driven projects contain a high risk of solely focussing on the donor's interests, which are not necessarily compatible with the receptor's expectations. Nevertheless, still all other requirements will have to be fulfilled, for example availability of capable human resources, timely supply of material resources, appropriate infrastructure, effectiveness of all peripheral processes such as legal systems, tax systems, customs, local administration, living conditions, etc.

A particular deviating factor observed during project execution is the problem of capability of human resources. In the project of personnel recruitment process for example, an important improvement potential exists. This remark is valid for the project executing body (private or international) as well as for the national counterpart organization. When especially talking about science for development, only top-class candidates should be attracted for the jobs. The smallest concession as to the quality of these people will irrevocably lead towards a high risk of failure. This includes also the efforts to be made for training/retraining and education from the counterpart's personnel, especially from decision-makers and managers of tomorrow. Tuning up with the private industry sector for training and retraining, where a level of many billions of dollars per year is available, but largely unknown, would give a tremendous leverage effect to the receptor countries.

A similar remark is valid for programmes in which a high equipment component is involved. Statistics give, for example concerning the availability of industrial equipment in the African region during the past decade, hardly 30 %. The reasons are multiple but one of the major is a lack of the maintenance function, be it starting from the equipment maintainability (= a design and reliability problem) up to the execution of the maintenance function (*i.e.* capable maintenance managers and technicians, appropriate methodologies, availability of spare parts, etc.). Also here a tremendous potential for improvement is present in almost every industrial project.

Nevertheless, as the present crisis in Asia has shown, exaggerated emphasis on effectiveness, share holders value, risk control, etc. makes money too hot, which might generate an effect of dislocation. The contribution of development organizations can positively attenuate excessive application of private industry norms.

3. The ABB Experience

3.1. The Global Company

In 1988 ASEA, a Swedish company founded in 1883, and BBC Brown Boveri Ltd, a Swiss company founded in 1891, merged to form ABB Asea Brown Boveri Ltd., headquartered in Zurich.

Today the ABB Group is composed of 1,000 Companies and 213,000 employees in some 140 countries. In 1997, ABB generated $ 31,265 million revenues with $ 1,137 million operating earnings after depreciation.

ABB is a worldwide company: 55 % of its revenues are made in Europe, 20 % in the Americas, 17 % in Asia and the Pacific, 8 % in Africa and the Middle East. Some 20 % of the revenues come from developing economies, where continued rapid urbanization and industrialization due to high population growth is driving the demand for infrastructure development.

The ABB organization is characterized by its strong decentralization, with local profit centres, and is structured into eight Business Segments :

— Power generation ;
— Power transmission ;
— Power distribution ;
— Automation ;
— Oil, gas and petrochemicals ;
— Products and contracting ;
— Financial services ;
— Adtranz, ABB's rail joint venture with Daimler-Benz.

Sustainable development is an ideal to which ABB is fully committed. Our efforts here focus especially on environmental performance and comprise three main elements :

— Developing and supplying eco-efficient products and systems, such as low-emission power generation technology, low-loss power transmission systems, and many others.
— Transferring state-of-the-art technology to developing countries, together with management, quality and appropriate standards.
— Continuously improving our own environmental performance. At the end of 1998, most of ABB's 712 sites will have been certified under the ISO 14001 standard and environmental policies are fully integrated into the strategic planning in our global business areas.

3.2. ABB Service

ABB Service is one of the 37 Business Areas of ABB within the Products and Contracting Segment, which represents approximately 25 % of ABB revenues. ABB Service has a structure in some 50 countries, has 10,000 employees and its 1997 revenue was $ 1,2 billion.

ABB Service aims at satisfying the market demand for getting more out of the industrial investments by focussing on cost-effectiveness and reliability in operation. ABB Service is as such an important contributor to development, both in competitive deregulated markets and in emerging economies.

Its Service concept is composed of the following activities :

— General service : people-driven activities, blue collar workers, arms and legs.
— Component service : workshop-based activity (e.g. rotating ma-

chines, switch gears, transformers, coil-making shops, machine-tooling, mechanical works, metalworking).
- Product/system service : spare parts-based. Typical after-sales service moving more and more towards non-ABB equipment ; linked to OEM's because of the need of spare parts.
- Process service : maintenance of production process-related equipment and dealing with the effectiveness of industrial business and managerial processes ; covers maintenance engineering, R&D in maintenance, training, maintenance methodology centres, in short the brains and know-how factory of the whole organization.
- Full service : long-term co-operation between ABB Service and the customer, during which ABB Service takes over the design, the execution and management of the customer's maintenance function, including maintenance personnel, service-related activities and tools. Full Service means that ABB Service is in the driver's seat for maintenance including the whole responsibility for maintenance efficiency and effectiveness of the customer's plant.

ABB Service's maintenance philosophy is based on :

- A vision and related strategic plan towards the year 2000 for satisfying the market needs and for a profitable growth ;
- A focus on human resources development and related management ;
- The development of world-class methodologies for maintenance management ;
- A very efficient information system ;
- A huge effort in R&D for maintenance ;
- A first-class quality assurance system in line with ISO and EN standards.

Full Service is a main driver for development especially through the commitment which is given to the customer in obtaining results related to the equipment effectiveness and to the maintenance cost. This requires good information and knowledge management systems, including use of state-of-the-art tools.

Therefore ABB Service has developed intensively Maintenance Engineering activities including high-level consulting in maintenance management and systems. This activity is supported by an important R&D programme in Maintenance Methodology Centres allowing to deliver increased maintenance performance more quickly. These centres of excellence capture and develop ABB Service's know-how in a systematic way and make it available worldwide resulting in profitable and world-class maintenance practices.

4. Science for Development through an Important R&D Strategy on Group Level and in Service

Developing innovative technology is a key to make ABB's customers more competitive. R&D within ABB is targeting specific customers' needs. One of the key drivers of ABB is the ability to generate new ideas and transform them quickly into solutions for customers.

Our commitment to research and development has played an important role in this regard. ABB spends 8.5 % of total revenues, or $ 2.7 billion per year, on R&D. Some 20,000 engineers from the business segments are working on R&D projects in multidisciplinary and multicultural teams together with 1,300 scientists and technical people from ABB's nine worldwide research laboratories. Creativity in research and development is ultimately about motivating people and providing them with an environment in which new ideas can thrive. At ABB, we see the cultural diversity as fertile ground in which to cultivate creativity.

Crucial to the success of the R&D programme is the technology review process, which brings together technical, scientific and marketing staff in order to maintain the right balance between the short-term and the long-term objectives. This results into four broad types of technology programmes :

— Close to the market engineering spending $ 1,4 bn/y, which deals to a great extent with customizing ABB products.
— Product development ($ 0,7 bn/y) : ideas are taken from the company's development laboratories and are applied in specific products.
— High impact projects ($ 0,2 bn/y) : the aim of these projects is to tackle important areas of technology which could have a big effect on ABB's business areas but involve a big risk. The above-mentioned Maintenance Methodology Centres from ABB Service have been realized in the framework of this programme.
— Research related to ABB's core competence ($ 0,3 bn/y).

5. Conclusion

Based on the foregoing, one can understand that support to science for development will have another motivation for development institutions and for industrial organizations from the private sector.

To conclude, we support the proposal of our Chairman, Mr Percy Barnevik, as a result of his intervention during the Retreat of the Administrative Committee on Coordination of the United Nations in October 1997 in New York, that it is highly recommendable to set up Business Advisory Councils between the international community and the private industrial sector. These Councils exist already in some countries or have been set up by IMF, World Bank, UNDP, etc. but they are fragmented and far too small. The European Union is discussing similar Councils in the countries applying membership in the EU. These Councils should in our opinion be extended to include also selected scientific institutions. Their goal would be to define a common ground and a common understanding for interfacing when it comes to jointly identifying and implementing investments and development projects together with supporting science for development. They can assist also the receptor-countries in getting rid of internal barriers.

We also totally agree with Mr Barnevik's view on complementary resources from both Communities. The development community helps build a development platform with better functioning institutions and a resulting more attractive investment climate. The private industrial sector provides capital, technology, management techniques, training programmes, supplier networks and export opportunities.

We are convinced that such Business Advisory Councils would boost the co-operation between the development community and the business community. They would surely contribute to a higher success rate of investment and development projects and thus to a fulfilment of the objectives of the development organizations, scientific institutions and the industrial private sector. This would speed up the improvement of the investment climate, create a better platform for development and achieve a dramatic increase in Foreign Direct Investments with all the related consequences including stimulation also of domestic investments.

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Academia, Private Sector and Government Links in Favour of Science-based Development

by

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KEYWORDS. — South Countries ; Education for Sustainable Development ; Science for Development ; Formal, Non-Formal Education Systems ; Agenda 21.

SUMMARY. — This paper on the nature, extent and consequences of links between the academia, private sector and government towards science-based development takes a view that could be characterized as that of the South Countries. While enshrining the science for development philosophy in the context of sustainable development of the South, it takes India as a case in point and assesses how the South Countries address the science-based development issue. Agenda 21, especially Chapter 36 (which concerns itself with promoting education, public awareness and training) forms the backdrop for discussion. The paper recognizes the scope of Chapter 36 of Agenda 21 as being extremely broad and inclusive of formal education systems at all levels and non-formal education and communication about environment and development. Chapter 36 of Agenda 21 provides for a full canvas of links and particularly between academia, private sector, and government. In the South and in India, sustainable development, even while some concepts of it have been practised in indigenous cultures for centuries, is still an evolving notion. Needless to say that the roots of Education for Sustainable Development (ESD) are firmly planted. Education is itself a largely private sector activity, run more like a commercial enterprise. There are private sector industrial units, and print media which support education and research towards science for development. The paper deals with specific governmental pro-

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grammes, private sector industries and private sector print media and their joint efforts at science for development. Prospects for the 21st century are also examined.

MOTS-CLES. — Pays du Sud ; Education pour un développement durable ; Science au service du développement ; Systèmes d'éducation formelle et non formelle ; Agenda 21.

RESUME. — *Le monde universitaire, le secteur privé et les relations gouvernementales en faveur d'un développement fondé sur la science.* — Le présent exposé sur la nature, l'étendue et les conséquences des relations entre monde universitaire, secteur privé et gouvernement à l'égard d'un développement fondé sur la science, est perçu dans une optique qui pourrait être caractéristique de celle des Pays du Sud. Tout en préservant la science propre à la philosophie du développement dans le contexte du développement durable dans le Sud, nous prenons l'Inde comme exemple et évaluons la façon dont les Pays du Sud abordent la question du développement fondé sur la science. L'Agenda 21, notamment le Chapitre 36 (qui se rapporte à la promotion de l'éducation, à la prise de conscience publique et à la formation), forme la toile de fond du débat. Cet exposé témoigne de l'ampleur considérable du Chapitre 36 de l'Agenda 21 qui comprend les systèmes d'éducation formelle à tous niveaux, de même que l'éducation et la communication non formelles concernant l'environnement et le développement. Le Chapitre 36 de l'Agenda 21 prévoit tout un canevas de relations, notamment entre monde universitaire, secteur privé et gouvernement. Au Sud et en Inde, le développement durable, même si depuis des siècles certains de ses concepts ont été mis en pratique par les cultures indigènes, reste une notion en évolution. Inutile de dire que les racines de l'«Education pour un Développement Durable» sont solidement implantées. L'éducation elle-même est surtout une activité du secteur privé, dirigée plutôt à la manière d'une entreprise commerciale. Les groupes industriels du secteur privé et la presse écrite soutiennent l'éducation et la recherche axées sur la science au développement. Cet exposé traite explicitement de programmes gouvernementaux précis, des industries du secteur privé, de la presse écrite du secteur privé et de leurs efforts communs pour une science au développement. Les perspectives pour le 21e siècle sont également examinées.

TREFWOORDEN. — Landen van het Zuiden ; Opvoeding voor duurzame ontwikkeling ; Wetenschap voor ontwikkeling ; Formele, niet-formele opvoedingssystemen ; Agenda 21.

SAMENVATTING. — *Academiën, privé-sector en regering, samen ten voordele van op wetenschap gebaseerde ontwikkeling.* — In deze bijdrage worden de aard, omvang en gevolgen van de samenwerking tussen academiën, privé-sector en regering m.b.t. op wetenschap gebaseerde ontwikkeling bekeken vanuit de landen van het Zuiden. Terwijl de filosofie „wetenschap-voor-ontwikkeling" in de context van duurzame ontwikkeling van het Zuiden wordt geplaatst, wordt India als voorbeeld genomen en wordt de manier waarop de landen van het Zuiden de kwestie van op wetenschap gebaseerde ontwikkeling aanpakken, beoordeeld. Agenda 21, en meer bepaald hoofdstuk 36 (waarin opvoeding, algemene bewustwording en training gepromoot worden), vormt de achtergrond voor bespreking. Er wordt toegegeven dat dit hoofdstuk 36 een zeer groot terrein behandelt, inclusief formele opvoedingssystemen op alle niveaus en niet-formele opvoeding en communicatie over milieu en ontwikkeling. Het voorziet in een brede waaier van contacten, meer bepaald tussen academiën, privé-sector en regering. In het Zuiden en in India is duurzame ontwikkeling, hoewel bepaalde concepten ervan sedert eeuwen in autochtone culturen in de praktijk worden toegepast, nog steeds een begrip in ontwikkeling. Het spreekt vanzelf dat de oorsprong van Opvoeding voor Duurzame Ontwikkeling diepgeworteld is. Opvoeding zelf is voor een groot deel zaak van de privé-sector, eerder als een handelsonderneming beheerd. Bepaalde industriële kernen uit de privé-sector en een deel van de geschreven pers steunen opvoeding en onderzoek gericht op wetenschap voor ontwikkeling. In deze bijdrage gaat het vooral over specifieke regeringsprogramma's, bedrijfstakken en geschreven pers uit de privé-sector, en hun gezamenlijke inspanningen voor wetenschap en ontwikkeling. Ook worden perspectieven voor de 21ste eeuw onderzocht.

1. Introduction

One aspect of increasing interest in science-based development in developing countries is the growing recognition of the roles of, and interactions among, academia, private sector and government. The present chapter takes a look at the South countries and the links between the three organizations with India as a case in point for the South countries. The material on the South is however limited, inasmuch as such efforts at the national and international levels towards providing for a framework for science-based development in these countries come from the international organizations such as the United Nations and its various Commissions and from the goverments themselves. In the scheme of things the international organizations and national governments provide for science-based development, there is an individual role for the academia, private sector and the Government as well as a collective or cooperative role for all of them. The two roles are equally important.

For the purpose of presentation here, the academia include universities and research and teaching institutions in these countries, the private sector includes industries, media (mostly privately owned) and non-governmental organizations (NGOs) which are voluntary, and the government includes the state or provincial and national governments, including the various agencies involved in development activities. They are all involved in India, and in the South countries, in science-based development, for the betterment of almost two thirds of the humanity of the world. The discussion in the paper is about their involvement, in collective cooperation, rather than in their individual capacities. But to set the background for such a discussion, the paper recounts the experiences in India and the developing South countries and analyses the response to Chapter 26 of Agenda 21 of the Earth Summit 1992. Media, information and its uses are also recounted in the task of science-based development in India and the developing countries. The effort is by way of informing what has been happening in respect of science-based development rather than by way of recommending what needs to be done in the contexts discussed.

2. Sustainable and Science-based Development in India

In December 1991, the National Academy of Sciences, India, organized a symposium on "Environment and Development : A Scientific Approach" and indicated the poignancy of the Indian concern with the question of promotion of sustainable, environmentally sound development in every part of the world underlines, and more so in the developing world, primarily as a leader among them. A similar note was also struck at another, early 1992, seminar organized by the private sector Tata Energy Research Institute on global environmental issues. Addressing this seminar, Maurice Strong, the Secretary General of the Earth Summit 1992, stressed the need to help poverty alleviation in developing countries. This — concern for poverty alleviation — has yet again been talked about in recent weeks (October-November 1998) after the announcement of the Nobel Prize for Economics 1998 to Amartya Sen for his contribution to welfare economics and, among other things, for restoring "an ethical dimension to the discussion of vital economic problems" (Ramachandran 1998). In fact, this very concern had been the essence of a Convocation Address by Professor V.K.R.V. Rao, at the Indian Agricultural Research Institute, New Delhi, two decades ago, in 1977.

Poverty has been and is the crux of the current problem of environment and development, for it both causes and results from environmental degradation. Poverty also goes hand in hand with population growth, which is linked with development in complex ways. The experiences of the developing countries and India, in development, have shown that the old approaches to development and environmental protection are no longer going to hold now. To take an example from India, the Indian Council of Agricultural Research initiated several programmes for integrated rural development in several areas of the country. The Council of Scientific and Industrial Research was also operating a programme of integrated rural development in several districts of the country at the same time, in the 1960s and 1970s. In these programmes, the accent was on the use of science and technology for the solution of the problems of rural development. Several universities (Gandhigram Rural Institute, in Tamil Nadu, for example) and private institutions (Kundrakudi Mutt Institutions) also took up programmes of rural development in several areas. In these cases also the accent was on the use of science and technology for rural development. One of the factors that surfaced in these efforts was the inability of science and technology by itself to resolve the problem of rural poverty. This has therefore brought out comments from several of the development analysts, notably RAO (1977, p. 15), who has observed the following :

> Science and technology are, as we have seen in our experience of the green revolution, neutral to size only in theory, indivisible assets and varying degrees of access to divisible assets making for a widening of the income gap and a continuing poverty at the lower and lowest levels of asset holdings.

Because of these experiences, however, Indian science and technology has turned its attention to the development of technology that would be labour intensive, based on local resources, and usable by rural personnel with little or no financial resources. This has now yielded concrete results and on a sufficiently large national scale, even though poverty has also remained all through. SEN (1997), with an active research interest in the Indian economy and Indian society since the 1950s, has expressed the view that perhaps the biggest achievement of independent India was the maintenance of political democracy, not only as an achievement in itself but also as an instrument of political struggle for social and economic progress. On the other hand, Sen remarks that the biggest failure of India is the social inequality. And so, the problem of poverty — a great factor of social inequality —

remains, even after fifty years of independence in India. So it does in the developing South countries, no matter what their political system is.

Despite this experience, however, there is still the belief in the South countries, and in India, that science and technology is the vehicle for rural development and for resolving rural and urban poverty. But the approach to development using science and technology must change. It is this change that the commitment to sustainable development in India and the South exemplifies today.

It may be important at this juncture to recall what has been said about the 21st century. Writing about the 21st century, Christopher Evans designated it as the "Micro millennium" which will be characterized by a rapid obsolescence of central planning, which is too unwieldy and too bureaucratic for the new electronic age. His main thesis was that technology would change very rapidly and new breakthroughs would in turn become so common that centralized planning would have to be abandoned, if we had to make any socio-economic progress. His suggestion for the millennium was for the individual institutions and industries to diversify their production according to the changing needs and adopt a flexible planning so that they could survive and progress. This thesis applies to science-based development of the South and especially to the context where academia, private sector and government link up in favour of science-based development (PRABHAKAR 1998).

India introduced privatization in both liberal and technical education, many years ago. This effort has pushed the country to the forefront of engineering education. For example, in the 1970s and 1980s, Karnataka drew candidates from all over India, particularly from the North of the country, where facilities for engineering education were limited. As the demands for engineering education grew, in tune with the growing demand for technical expertise both within India and abroad, Tamil Nadu, Andhra Pradesh and Maharashtra followed suit and fostered the growth of private initiative for more and more centres of engineering education and science and technology-based development in the country. At the same time, there were efforts at international, collaborative tie-ups with universities abroad towards transferring technology and technical expertise as well as improving standards of science and technology-based education. There are now technical universities, with private industrial tie-ups (one good example being Anna University, Chennai and SPIC Science Foundation link-up ;

SPIC is private petrochemicals industry with substantial stake in science and technology-based agricultural development) and foreign technical collaboration (again Anna University with a German tie-up in Geomatics).

The Indian Institutes of Technology (IIT) in the country have also links with private sector industries in the country, supporting the R&D efforts of the ITTs. There is also international support for their programmes of technical education, as they cater to the needs of governments and private industries abroad as well. In the last few years, there has been an enormous brain drain from India to the United States and industrialized countries, in the field of computer software development. Information Technology (IT)-based private initiatives in the country is poised for a great leap, what with Bangalore, Hyderabad and Chennai in the South becoming major IT destinations (SHARMA 1998, KUMAR 1998, PARTHASARATHY 1998, SRIDHAR 1998). The boom in software industry has boosted the growth of Software Technology Parks and IT industries such that India could become the leader in just about a few years. It is perhaps one of the scientific fields where academia, private sector and the governments stand linked in favour of science and technology-based development. Sustainability of the initiatives is question foremost in the midst of the professionals, industrialists and policy planners of the governments.

The future of the South countries, and in fact the world, is more likely to be determined by the capacity of the academia, private sector and the governments of the time for development, renewal and innovative thinking. Local, regional and national development in future will be more likely affected by the initiatives, competence and creativity of the academia, private sector and the governments. The authors of this paper are of the firm view that science-based development should be founded on the links between the three institutions rather than on the central decisions made in the capitals of the countries, by a small group of people, however well informed they may be.

Gunnar TORNQVIST (1983, p. 92), an eminent Swedish economic geographer, wrote that "fundamental similarities should obtain among those creative processes which lead to new products, new machinery and vehicles, new ways of organizing work, changing paradigms in research, new directions in philosophy, fashion, life styles and art". It is certain, in the same vein, that the need for science-based development in the South should be assumed to apply to our ways of organizing work, gauging efficiency, our consumption patterns and life styles. At a more profound level, science-based development may amount to a need to alter our fundamental, and firmly established, ideas and approaches to development, thereby modifying the ways in which we plan our societies, with improved and increased welfare in mind and with little or no environmental degradation in the end. This idea is also reflected in the work of RAMAKRISHNAN (1996) who studies the conservation of the sacred, from species to landscapes, which are community-based living repositories providing an important contribution to the conservation of biological diversity, complementing the more recent approaches to protected areas management, based on western scientific knowledge, promoted by conservation groups and government agencies. In India, examples of what can be called local, or vernacular conservation, could be observed at different scales and levels, including the protection of sacred species, sacred groves and sacred landscapes.

3. Development Science Information and its Users in India

The Development Science Information System (DEVSIS) study team recognized in 1976 seven groups of users of development information. They are (SATISH & INAMDAR 1987) :

1. Policy makers ;
2. Planners of the socio-economic development projects ;
3. Managers of the development projects ;
4. Researchers and teachers of the socio-economic development subjects ;
5. Financiers ;
6. Communicators and extension agents ;
7. Personnel concerned with information analysis and products thereof.

Of these, researchers in the socio-economic development fields take pride of place in terms of intensity and extensiveness of use of sources of information. In addition, they are also the generators of science-based development information for the public, in an educational and dissemination context aiding in development understanding.

3.1. KNOWLEDGE, INFORMATION USE AND INFORMATION USERS

In India, there has been a phenomenal growth of knowledge in health and nutrition which has to be disseminated to other researchers, scientists, planners, public health workers and other users (laymen, students, universities, industrialists and other health personnel). Speaking of the dissemination in India, MURTHY (1987) pointed out that there are three hundred and fourty-one "primary journals", carrying original research articles. He is also of the opinion that despite increase in journals, the number of journals an individual scientist could read during a particular time period has not changed. It is also not possible to go through all the available articles, even if they are accessible to a scientist (see MISRA 1987, SEETHARAMAN 1986).

There are of course a number of "secondary journals", mainly abstracting the salient findings of the original articles. These have been gaining in popularity because they are less time consuming. There are such secondary journals as *Coreview, Biosis* (biosciences information services) and *Cab* (Commonwealth Agricultural Bureau). The Indian Council of Medical Research (ICMR) has used several modes of dissemination of scientific information, with informatics as the major thrust area in the Seventh Five Year Plan. Dissemination has also been intensified through popular publications, audio-visual programmes, radio and television, and INSAT B (satellite) programmes on priority areas of health. The ICMR has also developed its information activities by strengthening its Integrated Research Information System (IRIS). Let us now turn to some sample cases of science-based development information and the disseminators.

3.1.1. Information for Rural Development Scientists

A study of the ninety-three specialists in the National Institute of Rural Development (NIRD) by SATISH & INAMDAR (1987) has shown that primary data collected through survey are frequently used by a large majority (61.25 %) of the rural development specialists, books and research reports (58.75 %), followed equal in importance by periodicals (37.5 %) and government publications (37.5 %). There are at least six constraints generally observed and are said to come in the way of information use. For 42.5 % of the scientists, materials available in different languages and the limitations of the researchers in their ability to understand the languages pose extreme difficulty. For more than a third of the scientists (36.25 %), getting up-to-date material is a considerable problem. Getting information quickly is a considerable problem for a third of the rural development specialists. Similarly, locating suitable sources is a considerable problem for 33.75 % of them. Finding time to look for and read information is however no problem for 48.75 %. Understanding research reports and statistics is not difficult at all for half the scientists. The mean scores have shown a range of 0.725 (the least constrained) to 1.775 (the most constrained) (see Musib 1991, for information seeking patterns in rural areas by the cottage industries from the public library services in West Bengal, see Raju 1988).

3.1.2. Information for Area Specialists

In area studies, published writings of other and related disciplines constitute an appreciable amount of the total information available and required. Among the secondary sources of information, both monographs and journals are used extensively. Journals carry the current information which is of higher value to the specialist. Area specialists depend on the formal networks more than informal networks. Field trips play an important role in the levels of perception of the area under study, as they afford the specialist with the opportunity to study the object at close quarters and in the natural environment. The area specialist's information search strategy is highly individualistic, though he or she has no reservation in communicating it to others. The preferred mode of communication is print media rather than seminars and conferences (Sethi 1987). Proficiency in the language of the area of study is a *sine qua non* of the area specialist.

3.1.3. Information for Agricultural Graduates

Agricultural graduates use seven types of reading materials : books, scientific and technical journals, indexes and abstracts, microdocuments, dissertations, popular magazines and newspapers. According to a study by Kaur (1996), two sample groups of students (one from Haryana Agricultural University with 157 students and the other from Punjab Agricultural University with 183 students) differ significantly from each other with regard to their priorities for dissertations and newspapers. Maximum response is clustered around the first priority for scientific and technical journals (69 against 91 samples) and books (67 against 64 samples) (Pichappan 1990). Third in sequence come the newspapers (14 against 10 samples).

3.1.4. Information for Nutrition Specialists

Murthy (1987) has shown that about 15 % of all collections in the National Institute of Nutrition, Hyderabad, is of books (12,250 in number), 15.8 % is of periodicals (3,393), 4.21 % reports and 0.22 % is of theses (170). Two thirds of all collections is of reprints. While

58 % of the holdings is gathered from subscribed materials, 31.34 % is *gratis* and 10.42 % is exchange materials.

3.1.5. Information for Environmental Genetic Toxicologists

A bibliometric study of research publications in Indian environmental genetic toxicology has been carried out by REDDY & SHARMA (1988), analysing the distribution of publications according to time, number of authors, classes of agents in various forms of literature, in different periodicals and by institution. The findings of the study are :

- — The increase of pollutants of the Indian environment is reflected in the number of publications and several of them are authored by multiple (two or more) authors. Most publications (47.6 %) are on higher plants, as they are favoured for testing the toxicity of the substances.
- — A third of the publications (32.8 %) in the field are on drugs, as they seem to be the major toxic substances. Most publications (51.7 %) have appeared in seven of the renowned periodicals and there were as many as 105 other periodicals in which the remaining papers (48.3 %) were published. The distribution of publications in the Indian and foreign periodicals is almost equal.

4. Agenda 21, Chapter 36 and How the South is Placed in Relation to It

Chapter 36 of Agenda 21, the action plan approved at Rio de Janeiro, Brazil, concerns itself with "Promoting Education, Public Awareness and Training". In Rio, there was unanimous agreement among the developed and the developing countries alike that "education is critical for promoting sustainable development and increasing the capacity of people to address environmental and development issues".

The scope of Chapter 36 of Agenda 21 is extremely broad and includes formal education systems at all levels and non-formal education and communication about environment and development. The chapter is divided into three "programme areas", namely :

1. Reorienting education towards sustainable development ;
2. Increasing public awareness ;
3. Promoting training.

As a "cross sectorial chapter", it is linked to virtually all other areas of Agenda 21. There is now a new vision of education in the international arena. This new vision of education and public awareness is the essential underpinning for sustainable development. It is also to support advances in *science, technology, legislation and production.* Education, according to this new vision, is a *means* to :

— Ensure an *informed and understanding population* that is prepared to support changes towards sustainability emerging from different sectors ;
— Disseminate *knowledge, know-how and skills* needed to bring about sustainable production and consumption patterns and improve the *management* of natural resources, agriculture, energy, and industrial production ;
— Bring about *changes in values, behaviour and lifestyles* that are needed to achieve sustainable development, and ultimately democracy, human security and peace.

Keeping in view these three means through education, the International Commission on Sustainable Development (CSD) reviewed the progress at its Fourth Meeting in April-May 1996 and adopted a special Work Programme which is shown in table 1.

This work programme outlines the priorities agreed upon by the CSD and the key actors cited by the CSD. The **highlighted** areas of **C**, **E**, **G**, **H** and **K** in table 1 are of particular importance to environmental education in the context of the present study. In India, sustainable development, *even while some concepts of it have been practised in indigenous cultures for centuries*, is still an evolving notion. The evolving nature of the concept is still a concern of educators and communicators.

Needless to say that the roots of Education for Sustainable Development (ESD) are firmly planted in environmental education. As agreed upon by governments at the Tbilisi Conference of 1977, the guiding principles of environmental education encompassed a broad spectrum of environmental, social, ethical, economic and cultural dimensions. These principles are very similar to the perspective articulated at the Rio Conference in 1992 and its follow-up conferences. It is actually the lessons learned in the last twenty years in the implementation of environmental education that form the basis of the special Work Programme on Chapter 36 of Agenda 21.

Table 1

Work Programme of the Commission on Sustainable Development (CSD) : Education, Public Awareness and Training *

	Priorities Agreed Upon by the CSD	Key Actors Cited by the CSD
A	Develop a broad international alliance, taking into account past experience and promoting networks	UNESCO as task manager, in partnership with UNEP, IUCN and other key institutions
B	Integrate implementation of recommendations concerning education, public awareness and training in the action plans of the major UN conferences and conventions	UN system, Governments, major groups
C	**Advise on how education and training can be integrated into national education policies**	**UNESCO, in cooperation with other governmental and non-governmental organizations**
D	Refine the concept and key messages of education for sustainable development	UNESCO
E	**Advance education and training at national Governments level**	**with assistance from the UN system and others**
F	Provide financial and technical support	Developed countries, international organizations, private sector
G	**Develop new partnership arrangements among different sectors of society. Exploit the new communications technologies. Take into account cultural diversity**	**Educators, scientists, Governments. NGOs, business and industry, youth, the media, other major groups**
H	**Work in partnership with youth**	**Governments and all stakeholders**
I	Analyse current investments in education	Bretton Woods Institutions
J	Take the preliminary results of the Work Programme on Chapter 36 into account (in the 1997 Review)	Secretary General of the United Nations
K	**Make relevant linkages with the CSD programme of work on changing production and consumption patterns**	**UN system, Governments, NGOs**

* Summary of the decision of the fourth session of the UN Commission on Sustainable Development (New York, May 1996) concerning Chapter 36 of Agenda 21, prepared by UNESCO as Task Manager.

Source : Hopkins, C., Damlamian, J. & Ospina, G.L. 1996, p. 3.

5. Information Technologies for Communication and Education in India and the Developing Countries

In a civilized society such as that of India, information is the fundamental resource for development. It is information which has been responsible for directed development initiatives, at the national level. So it has been all over the world. An impact of the Information and Communication Technologies (ICT) applications in the academic environment is the creation of digital libraries. These allow teachers and students to take advantage of the wider range of materials accessible and communicate with people outside the formal learning environment. This also permits, and will permit, more integration of different types of learning through sharing of resources, time and energy and expertise to their mutual benefit. The types of services that digital libraries offer are :

- — Knowledge bases in a variety of media ; for example, scientific datasets, textual databases of classical works, image collections of artists and specialized hypermedia materials such as digital encyclopaedia ;
- — Information to individuals and schools which can be obtained and maintained ;
- — Materials accessible in classrooms and homes as well as central library facilities, and opportunities for users to deposit and use information ;
- — Support to communities of interests and more specialized courses.

6. Community Internet Project of Tamil Nadu

Access to internet in Tamil Nadu, one of the states of the Indian Union, for example, is restricted to a few towns and cities at present, but is poised for a quantum growth with the implementation of a "Community Internet Project (CIP)" in collaboration with the WorldTel, a global telecommunication company headquartered in London. The Tamil Nadu Government signed a MoU on September 7, 1998, with the WorldTel (Special Correspondent, The Hindu, September 8, 1998). The CIP aims at taking internet to all parts of the state covering the "information have-nots". The Government is committed to popularizing the use of internet and making it easily accessible (Staff Reporter, *The Hindu*, September 7, 1998). The CIP would create at least 1,000 "public access centres" on franchise in the state. The Private Sector has already begun to work towards a CIP of its own with small towns dotting the countryside, what is known as the NetDrome Centres, which offer internet surfing for less than an US $ 1.00 per hour (it is 30 Indian Rupees (INR)). These centres are already doing very brisk businesses in the country.

A formal launch of the Tamil Nadu Institute of Information Technology (TANITEC) was made on 11 September 1998, which has been registered as a company, to permit flexibility and attract capital from IT industry, with 51-49 share of capital between the State Government and the IT Industry (Mukund Padmanabhan, *The Hindu*, September 10, 1998).

Right to information and equality of access and benefits have already been recognized in the country. As such all information, barring that of national security and individual and corporate privacy, all other information is deemed to fall within the scope of such policy. ICTs therefore calls for new perspectives and change in attitudes and strategies and balanced approaches to derive optimal benefit from its applications in developmental efforts.

6.1. Environmental Education and the Mass Media

A blue print for human awareness development has been prepared by the UNESCO and the International Telecommunication Union. This blue print suggested that the minimum standard for mass media growth for developing countries might be 10 copies of daily newspapers, 5 radio receivers, 2 cinema seats, and 4 television sets for every 100 inhabitants in these countries. It is however a modest objective, and yet the Asian countries fall far short of these minimum standards. Worse still, most have no central news agencies, nor skilled personnel. India, being a country of some socio-economic achievements, is an exception. Those who have skilled professionals suffered from brain drain, lack of national policy, a disorganized system, social and economic backwardness, and science and technology replete with obsolete beliefs and dogmas : it is like "the country attempts crop production and achieves denuded soils, seeks clean clothes and achieves foul water, tries luxury living but achieves respiratory troubles".

Mass media in these countries, including India, are unused or abused, underdeveloped, if not technologically, at least artistically.

There exists, internationally, an "Asian Model of Education Programme" developed by UNESCO which acted as a starter in the developing countries which organized, like in India, specialized institutions, interdisciplinary courses, adult education schemes, lecture-demonstrations, group discussions, colloquia, workshops, seminars, symposia and a variety of other media-related programmes for their people. Environment literature has been developed through such organizations in India as the National Council for Education, Research and Training (NCERT), and National Book Trust (NBT).

In all of these media, especially print, audio and video media, largely privately owned except for National Television Network and All India Radio, have acted as communication tools while technology has acted as *practical tools.* Individually, and in combination, they could bring science-based development and environmental knowledge to popular understanding. They have educated the people, coaxed them, excited and motivated them towards making them ecologically aware, practically wise and involving them in the combat against the decay, disease and destruction.

With the United Nations Systems putting more and more emphasis on the extensive use of the mass media and all other infrastructures in place in the developing countries, providing policies, programmes and actions, through the 1970s and the 1980s, the relationships between development and environment have surfaced in a way there has emerged an environmental media, dedicated to the creation of awareness of development and environment. The Governments (national, provincial or state), the educational systems (schools, colleges, universities and environmental research institutions — public as well as private sector run institutions) and the NGOs have all been engaged in the good work of "telling their people what is generally happening to their environments" in the name of development.

In India, for example, the NGOs have begun to use all media indicated above and more : *the rural theatre, song-dance-drama, story telling and all other useful communication forms with a long history of active performance for thousands of years and an inseparable part of human tradition and culture.* Their application in development and environmental education has been **touching the hearts of the common man**. New Delhi has an Enviro-Media Centre and has been developing the art of mime to present materials on development and environment.

There are innumerable NGO and activist groups which have recource to these methods of environmental education. *Chennai Kalaikuzhu* (Chennai Art Group) is a case in point for theatre, mime and story telling while C.P.R. Foundation, which is a regional umbrella NGO, acting as a networking agency and funneling the funds from the Central Government as a Nodal Development and Environmental Education Agency, is for environmental education through workshops, seminars and publications.

In this era of electronics, satellites and digitals, the television is flooded with programmes on development and environmental issues, day in and day out. India's Doordarshan (National Television) is no exception, although the coverage is piece-meal and programmes are irregular. There are however syndicates which coordinate and activate television programmes.

6.2. Trusts, NGOS, the Universities and the Government

Trusts produce and distribute videos of environmental films to the NGOs. The NGOs organize Eco Clubs in the schools and children hike to natural reserves and mountains and hills, in an effort to learn about the degradation of the environment, most importantly natural vegetation. They go to outdoor schools organized by the NGOs : Vidiyal of Rasingapuram, Theni district, is a case in point, "taking on children and putting them together to learn about the land degradation and land alienation". This rural, local NGO has collaborated with the Department of Geography, University of Madras, in the organization of outdoor schools for children from local schools in connection with a Shastri Indo-Canadian Project. The three schools conducted during the year 1996-97 catered to the development and environmental education needs of 300 children of 12-15 years of age and 30 teachers who are now catalysts in the villages from where they hail.

Efforts are afoot for yet another participatory project which would work towards a Community Action Plan, bringing together Universities (2 Canadian and 3 Indian), NGOs (one local and one regional) and the Government Departments (Department of Forests, Agricultural Engineering Department, Tamil Nadu Water Resources Organization of the Public Works Department, Department of Agriculture and Department of Agricultural Extension) in an area where desertification and land degradation due to socio-economic intervention for development. This project is also funded by the bi-national Shastri Indo-Canadian Institute, Calgary, Canada, with a purpose of sensitizing men and women of five villages in the Thevaram Basin of Kambam Valley, Theni District, Tamil Nadu.

The Indian population is gradually becoming "a population which has the awareness, knowledge, skill, attitude, motivation, commitment and dedication" towards the solution of the existing problems and the prevention of the new ones, especially with development and action projects which have become increasingly science-based and participatory.

Environmental protection needs no longer to be understood in an absolute sense, but against a larger background of sustainable human development (KRISHNAN 1997). Sustainable human development has two basic tenets : *inter-generational equity and common but differentiated responsibility*. Inter-generational equity means that the *present generation has a moral responsibility to manage the earth's vital resources such that it takes no more out of these resources than what can be replaced in its lifetime.*

Common but differentiated responsibility is a socio-economic principle. It recognizes that *a global agreement is necessary for safeguarding the earth's life support systems while at the same time that it must give due credit to the contributions of different societies to the present status of environment.*

That is, the rich and the poor societies cannot be treated alike because their contributions to global environmental degradation are different.

For example, science education which should capitalize upon societal issues and problems as the focus for its processes and content uses mass media in such a way the world is changing in profound ways and the spirit of rational inquiry is driven by a belief in its efficacy and by restless curiosity. As it covers the widest range of knowledge, the learners wonder at the intricacies and mysteries of the universe. The medium has therefore become the message : television, radio, audio cassettes and videotex and the satellite systems have all become the media spreading science and technnology, "liberating and enriching the mind and enlarging the spirit" (KOUL 1991). The electronic media with a large network throughout the country could reach over 300 to 500 million listeners or viewers and thus could play a major role in bringing development and environmental issues to the attention of the rural people. With electronic media's commercial income was more than Rs. 15 billion in 1996-97, it speaks well of the media popularity and its uses.

7. The Reprise

The paper has highlighted, through illustrative examples from various fields, the link in favour of science and technology-based development in India as a representative of the South countries through the collaborative and cooperative efforts of academia, private sector and the government. Although the materials discussed related to several areas of science and technology, particularly those of IT and mass media, the thrust of the thesis has been very clear. There is a science-based development in the country and in the South countries ; they are, in the new millennium, poised for better socio-economic and sustainable development. At the same time, there are the fears of an economic recession which could be overcome if the links established among the academia, private sector and the government continue with vigour and perseverance in science and technology-based development.

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PANEL 3

PARTNERSHIPS
AND SHARING OF KNOWLEDGE

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Prof. Jean-Jacques SYMOENS

Science and Development :
Prospects for the 21st Century
Royal Academy of Overseas Sciences
United Nations Educational, Scientific
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What Kind of Scientific Partnerships for the 21st Century ?

by

Marc DE BRUYCKER *

KEYWORDS. — Equity ; Partnership Criteria ; Developing Countries ; European Commission.

SUMMARY. — Partnership is part and parcel of science. Meaningful, effective and viable scientific partnerships should meet three basic criteria. Fundamental to each of these is the notion of equity. In this paper, certain entrenched attitudes which have an impact on future partnership development are considered and a call for change is made. Partnership trends and the definition of and justification for equitable partnerships are examined. Questions are asked such as : What is the object of partnership ? How does collaboration operate (in the context of common technologies and methods in varied socio-cultural, economic and political backgrounds) ? Where are the problems ? When is preparation and anticipation necessary ? At what point in time of problem solving should collaboration start and end ? In discussing the above, the paper makes particular reference to partnerships with developing countries and supports the premise that they should command as much respect and credibility as those that exist elsewhere. This paper also refers to how the European Commission generates and supports scientific co-operation with developing countries.

MOTS-CLES. — Equité ; Critères de partenariat ; Pays en développement ; Commission Européenne.

RESUME. — *Quelle forme de partenariats scientifiques pour le 21e siècle ?* — Le partenariat fait partie intégrante de la science. Trois critères de base

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sont nécessaires à la création de partenariats scientifiques probants, efficaces et viables. Fondamentale pour chacun d'eux est la notion d'équité. Dans cet exposé, sont évoquées certaines attitudes intransigeantes qui ont un impact sur le développement d'un futur partenariat et un appel au changement est lancé. Nous analysons les tendances du partenariat, la définition et justification de partenariats équitables. Plusieurs questions se posent telles que : Quel est le but du partenariat ? Comment la collaboration fonctionne-t-elle (dans le contexte de technologies et méthodes communes au sein de milieux socio-culturels, économiques et politiques variés) ? Où résident les problèmes ? Quand la préparation et l'anticipation sont-elles nécessaires ? A quel moment, à l'heure de résoudre les problèmes, la collaboration devrait-elle s'amorcer et prendre fin ? Traitant ce qui précède, nous nous référons tout particulièrement aux partenariats avec les pays en développement et nous posons pour prémisse qu'ils devraient inspirer autant de respect et de crédibilité que ceux existant ailleurs. Le présent exposé fait aussi allusion à la manière dont la Commission Européenne génère et soutient la coopération scientifique avec les pays en développement.

Trefwoorden. — Rechtvaardigheid ; Partnerschapscriteria ; Ontwikkelingslanden ; Europese Commissie.

Samenvatting. — *Welk wetenschappelijk partnerschap voor de 21ste eeuw ?* — Partnerschap is een essentieel onderdeel van de wetenschap. Zinvolle, efficiënte en realiseerbare wetenschappelijke partnerschappen zouden aan drie basiscriteria moeten voldoen. Fundamenteel voor elk van hen is het begrip rechtvaardigheid. In deze voordracht worden bepaalde verankerde zienswijzen die een impact hebben op toekomstige-partnerschapsontwikkeling behandeld en wordt er tot verandering opgeroepen. Partnerschapstrends en de definitie van en verantwoording voor billijke partnerschappen worden onderzocht. Er rijzen vragen als : Wat is het doel van partnerschap ? Hoe werkt samenwerking (in de context van gemeenschappelijke technologieën en methodes tegen verschillende socio-culturele, economische en politieke achtergronden) ? Waar zijn er problemen ? Wanneer is voorbereiden en anticiperen nodig ? Op welk moment van de probleemoplossing zou samenwerking moeten aanvangen en eindigen ? Bij de behandeling van dit alles wordt er speciaal verwezen naar partnerschappen met ontwikkelingslanden en wordt de premisse verdedigd dat zij evenveel respect en geloofwaardigheid zouden moeten afdwingen als deze die elders bestaan. Er wordt ook verwezen naar de manier waarop de Europese Commissie wetenschappelijke samenwerking met ontwikkelingslanden tot stand brengt en steunt.

Introduction

Partnership is Part and Parcel of Science

Scientists need access to existing knowledge, access to equals and access to challenging competitors. First, all knowledge has a human source, accumulated and acquired by people since the ancient history over the recent past to the present time. Scientists, by nature, inform themselves as best as possible and use all their means to search and gather information and tap the best of opportunities to enrich their knowledge and understanding. A scientist needs to establish links between all relevant sources and to build on pieces of knowledge. Second, to benefit from the wealth of experience and knowledge and to obtain or keep grip on the vast volume, range and complex nature of the problems under study, scientists are compelled to form alliances and partnerships, which nurture, complement and support their work. No scientist can deliver productive work in isolation. Third, to consolidate and bring science forward, one must also ensure that this process of acquiring and applying knowledge is constantly open to challenge. Competitors are needed to question or validate the work of their peers.

These principles apply to all scientific disciplines, and all scientists everywhere in the world.

Research cannot be separated from the Human Development Process

It is a cornerstone of the past and future welfare of the peoples of Europe. The same assumption must be made for the welfare of developing countries.

Health Sciences and Health Research. Co-operation with Developing Countries

The history of health sciences and health research exemplifies the development and relevance of scientific partnerships. The issue of scientific partnerships with and between developing countries highlights even more the problem and adverse circumstances of structural inequality on a global scale.

Recent initiatives of the European Commission in the field of international scientific co-operation with developing countries illustrate the much-needed process of change in science and development policy, against some obsolete but entrenched attitudes of the past.

Since the dawn of Mankind, the wish to influence health and to repair or prevent disease has occupied people's minds and has created multiple environments where a variety of scientific and medical professions could flourish. Taking advantage of the explosive progress in Science and Technology, medical sciences have taken huge strides in this twentieth century, called the Golden Century of Medicine. Europe has played a major role in the development of tools to control disease with many advances in vaccine, drug and surgical technology. This technology has found eager exporters and importers. As a consequence, Tropical Medicine was born, initially serving humanitarian but rapidly also political, economic and religious interests. These have often reinforced international inequalities.

The post-war, cold war and decolonization period offered several decades of unprecedented socio-economic growth in Europe, the US and Japan. This was coupled with an increase in political awareness and the establishment of democratic movements in many other countries. Gradually, European citizens have begun to enjoy the fruits of scientific discovery in addition to broader access to health care and prevention packages. Health care and health research were and remain heavily state-subsidized. The institutional capacity (public and private) to offer, organize or regulate health research has grown enormously in Europe. In contrast to what has been achieved in Europe, the situation in developing countries has not evolved as was hoped for some decades ago. Today, 90 % of global health research resources are geared to industrialized countries, whereas developing countries represent the vast majority of the global population's health problems.

The inadequacies of the focus on imported or imposed multiple vertical programmes as a sole strategy for health care paralleled with a neglect of the development of a genuine national research capability in developing countries has now been revealed. Particularly in developing countries, it has appeared difficult to adjust between two options : a potentially scientifically valid top-down technical intervention which may have to be imposed on groups of people and a bottom-up approach of responding to demands, although not always considered rational, of people seeking health care. The challenge to marry needs and demands in a context of self-reliance in health research was brought to the agenda. Self-reliance cannot be brought about without an element of reliance on partnership.

European Commission Providing Instruments for Dialogue in Research, Health and Development. A Call for Change

The development of a culture of science and research is everyone's responsibility. The European Commission recognizes this. Its mandate and strength lie in its ability to harness expertise at a supra-national level within Europe, in forging relations with developing countries — adding a European dimension to complement the existing bilateral regional and national interactions. There is a requirement of the programme to establish equitable partnerships, which will facilitate the sharing of knowledge. Therefore, the EC RTD Programme on Scientific and Technological Co-operation with Developing Countries (INCO-DC), sector health, provides the partnership environment and the means to progress. The programme is based on joint research activities, calling for mandatory partnerships, to tackle health problems relevant to developing countries.

Meaningful, effective and viable scientific partnerships should meet three basic criteria. Fundamental to each of these is the notion of equity. Partnerships which show evidence of these criteria will be given priority in the 21st century.

Firstly, scientific standards of the activities undertaken in partnership must be high. It is essential that the process of science is of a high quality and respected on its own merits and rules. Quality should be integral to all research activities, be they classified as basic or applied. The partners' areas of expertise should be relevant to the anticipated outcomes and used to their best advantage. Each must play an appropriate and active role in the research process. What matters is that science flourishes in a variety of socio-economic and cultural environments, where all critical questions can be aired. The relatively limited number of (co-) authorship of leading scientific articles by highly qualified scientists from and in developing countries reflects a deep unbalance. It calls for an urgent need to abandon outdated habits of reinforcing already better established scientific entities which have preferential links with international publishing bodies.

Secondly, there must be consideration given to the societal aspects of science ; there must be clear and tangible benefits to society as a whole. Scientific co-operation must be seen as an instrument for development and social justice. It should be targeted towards what and where it is needed most. Dialogue with the populations concerned is therefore of paramount importance. Health research supported by the European Commission is directed towards tackling the major health problems and related issues in Developing Countries. This covers a range of research themes from research on health policy, health systems to tools such as vaccines, drugs and diagnostic products and the basic biology of diseases. New practices and technologies have to take account of the context in which they may be applied and the health benefits of their application must be clearly established. Public health concepts should be a common platform for all health research. In this context, scientists should stand on their right to be critical and independent, guarding themselves against trends to seek *a posteriori* justifications for imposed ideas or approaches by "sponsors", which are not supported by evidence.

It should nonetheless remain clear that the research results are not necessarily immediately apparent or applicable but are seen in a medium to longer-term perspective.

Thirdly, it would be naive to consider that any scientific interaction can take place in a vacuum. The equitable partnership may flourish only within an environment which provides a minimum of political, structural and economic support. Without this, research investment is compromised and the long-term impact and benefits are restricted. It is also unrealistic to expect fair or equal access for scientists from developing countries to times of undisturbed research work, to publish research results or express and influence opinions in a context of heavily distorted daily living conditions and meagre means in which they have to operate.

Sustainability

Scientists in both Europe and in Developing Countries can only develop their skills in the competitive, international scientific arena if they are supported by political will and economic commitment. What are needed in EU and developing countries are a prolonged intensive investment and other support to ensure capacity and capability strengthening.

Equitable partnerships can only be developed in an environment of equal chances and opportunities. Strengthening the research capacities of the Developing Countries themselves is a crucial point in this process of research partnership towards self-reliance. Support from bilateral and multilateral bodies such as the UN, European national research or development agencies and the EC cannot work in isolation from these factors. A recent resolution of the European Council of Ministers for development co-operation has explicitly recognized the importance of establishing national research capacities as a condition for progress in development.

The EC is not interested in providing strictly preconceived "European" solutions to problems of development. Enormous progress has been achieved in breaking down the entrenched notion of working "for" as opposed to "with" developing countries. A dialogue and collaboration between equally respected partners from a diversity of backgrounds is a prerequisite for further progress in finding solutions for global development. There is an acute awareness that the complex problems of development cannot be contained within national or regional boundaries, they affect all societies. In the 21st century, we must find a common path to achieving improvements in development, bringing together scientists across the globe who will address the problems as an integrated unit, each bringing their own expertise and experience to bear on the problem at hand. If this is done in the right way, the goal of learning to learn will be achieved. A culture of learning, in which scientific methodology becomes an intrinsic part of society, will be established. Hypotheses will be tested and development programmes modified in the light of the results : Partnership and therefore Development will not be left to chance.

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Diffusion of Knowledge *

by

Félix MALU WA KALENGA **

KEYWORDS. — Knowledge ; Change ; Information ; Integration ; Interaction ; Multimedia ; Networks.
SUMMARY. — With the diffusion of knowledge through information highways, the concept of learning open to everyone by means of a home or professional terminal is taking shape. Theoretically the huge mine of knowledge becomes within everyone's capability. The diffusion of knowledge is not limited to the cultural challenge alone. It is also a strong potential factor of economic transformation of the industry, especially the service industry. Consequently it is at the root of a new industrial revolution leading to the creation of a world-scale "Global Information Infrastructure, capable of providing universal service".

MOTS-CLES. — Connaissance ; Changement ; Information ; Intégration ; Interaction ; Multimédia ; Réseaux.
RESUME. — *La diffusion des connaissances.* — Avec la diffusion des connaissances grâce aux autoroutes de l'information prend corps l'idée de l'accès de tous au savoir par le biais d'un terminal domestique ou professionnel. L'immense gisement des connaissances devient théoriquement à la portée de tous. La diffusion des connaissances ne se réduit pas au seul enjeu culturel. Elle est aussi, potentiellement, un puissant facteur de transformation économique de l'industrie, singulièrement de l'industrie des services. Ce faisant, elle est à l'origine d'une nouvelle révolution industrielle et partant à la base de l'établissement d'une «Infrastructure d'information globale au niveau de la planète, à même d'assurer un service universel».

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TREFWOORDEN. — Kennis ; Verandering ; Informatie ; Integratie ; Interactie ; Multimedia ; Netwerken.

SAMENVATTING. — *De verspreiding van de kennis.* — Met de verspreiding van de kennis via de informatiesnelwegen, krijgt het idee van de toegang van eenieder tot de kennis d.m.v. een persoonlijke of professionele terminal vaste vorm. In theorie ligt de immense kennismijn in ieders bereik. De verspreiding van de kennis beperkt zich niet tot de culturele inzet. Het is eveneens een sterke potentiële factor van economische transformatie van de industrie, in het bijzonder van de dienstenindustrie. Zodoende ligt zij aan de basis van een nieuwe industriële revolutie en bijgevolg ook van de oprichting van een „Wereldwijde globale informatie-infrastructuur in staat om een universele service te verzekeren".

Introduction : The Emergence of The Knowledge Society

Telecommunication systems across the world are undergoing a major transformation thanks to the advent of what is now called the "information superhighway".

The concept of the information superhighway seeks to explain the gradual changeover from the computer age to the information age. It has become the new symbol for modernity and democracy (information for all). But more importantly, it has become a challenge for reviving economic growth, with knowledge as the driving force. Information management is required to become the key to economic growth and social progress in the third millennium. The belief is that prosperity and jobs will be based on the creation, dissemination and use of information. The information and communications-related infrastructure is becoming a key ingredient of a mould-breaking economy.

The information superhighway is based on the synergistic effects between telephony, television, the computer, and signal transmission via satellite and fibre optic cable. These different techniques are being put to work to enable the fast-paced, large-scale transmission of information in a digital form, which is more reliable than the conventional analogue one. Digital signals allow for extremely high capacity transmissions able to support multimedia services.

The information superhighway concept has given rise to the idea of universal access to knowledge via a domestic or professional terminal. The huge pool of knowledge is theoretically within the reach of everyone.

However, the information superhighway concept is not merely a cultural concern — far from it. It is also, and above all, a potentially powerful factor in promoting the economic transformation of service industries, now that services may be consulted and purchased without moving from the home : telemedicine, teleteaching, teleworking, banking, insurance at home etc. It has the potential to act as a medium of communication between companies and their suppliers, for just-in-time production, between companies and consumers in the marketing of goods. Within a company itself, it helps improve production quality based on team work.

To sum up, the information superhighway concept is underpinned by the idea of creating a "global information infrastructure capable of providing universal service".

The information superhighway concept actually covers two different systems : the "superhighway using text" and "the superhighway using sound and images", in which the key aim is to convey interactive multimedia services.

The Internet

The Internet consists of a huge number of local networks, connected sites (computers) and users throughout the world.

Electronic interactivity represents both an opportunity and a key asset for universities in developing countries. The electronic network offers these universities an opportunity to break out of their scientific isolation. It is an asset in the sense that it provides these institutions with the means of acquiring dual status, becoming both key players and producers in the global scientific chorus.

The New Information Age

Developing countries owe it to themselves to become involved in the information superhighways, notwithstanding their various disadvantages and weaknesses :

- An inadequate copper cable network that is generally depreciated and technologically out of date ;
- A monopoly by rights very often granted to a public or private operator ;

— An embryonic nomadic telephone market ;
— Lax and inadequate management of the public telecommunications network ;
— Communications costs in excess of the purchasing power of the general public ;
— An outmoded telephone switching system ;
— Ageing telephone switchboards ;
— Poor maintenance of the satellite transmission and reception network ;
— The population's weak purchasing power.

In order to overcome these shortcomings, developing countries must promote the interaction of the information acquisition, processing and transmission systems as they apply both to telephone and television services and computer controlled data transmission (telematics). They must try to exert an influence on the prices established by economic operators and appeal to regional cooperation. No developing country can hope to go it alone in the context of information superhighway projects. The seemingly inevitable need to proceed on the basis of joint efforts is of primary importance. To this end, steps must be taken to revise and scale down telecommunication regulations, granting priority to the accounting and interactivity of telecommunications systems and services and the improvement of State control over economic operators. At the same time, the State must adopt a lower profile in company management. In other words, it must allow significant portions of a nation's productive sectors to be privatised.

The Knowledge Society : The Assets

Information technologies and telecommunications are the driving forces behind a new industrial revolution based on information. Their huge potential resources form the basis for what is now known as the "knowledge society", a society which offers the prospect of a substantial level of economic growth. New services related to industrial production, consumption, culture and leisure activities are taking shape at the present time. Information and communications have long been considered primarily in political terms, but have now lost their value as instruments in the wielding of political power due to their inclusion in the global market. This integration became inevitable with the large-scale introduction and convergence of new information technologies : telematics, satellite communications, and television services using different media (microwave links, satellite, with videocassette recorders and compact disks).

On the social front, the knowledge society allows easier access to information, which, in theory, enables the building of a fairer, more balanced society, promoting the development of individual, social cohesion, and efficient means of social and economic organisation. There is, however, a danger of creating a two-track society, where only one section of the population has access to new technologies and is able to enjoy the advantages. Safeguards need to be devised in order to prevent the emergence of such a situation.

As for employment, the knowledge society leads inevitably to changes. This applies, in particular, to the right to work, and involves the emergence of new professions and skills. The job market should be differentiated less on the basis of social or monetary divisions, and more in the light of access to information and managing technologies. As an example, highly developed software engineering skills are coming to be regarded as a key asset. Those unable to harness key technological capacities or to count upon an effective entrepreneurial spirit, creative resources or the creation of a critical mass in strategic sectors, are therefore very likely to find themselves in a disadvantaged situation. In view of the rapid developments in the information sector, market principles have to serve as a guide, so that commercial forces and not the State play the pivotal role. The input from government should be confined to maintaining competitive forces, creating a favourable climate and a stimulating a regulatory environment.

The multiplier effect of information helps give a boost to economic sectors. This dynamic process is partly a result of information technology procedures helping to speed up the pace of transactions (electronic payment, e-mail, computer control, electronic money). The proliferation of home computers should contribute to this dynamic process.

The Knowledge Society : The Constraints

The knowledge society based on information management does have its drawbacks, however. In particular, it raises problems in terms of intellectual property, respect for privacy, information security and media ownership.

It is of vital importance to protect intellectual property so as to maintain competitiveness. The challenges involve guaranteeing support for creativity and innovation against the background of universalised services.

It is all the more important to protect privacy in that it is becoming all the more easier to manipulate information with the emergence of increasing high-performance technologies. Electronic protection (coding), legal protection and security of data are essential requirements for safeguarding the interests of those operating on electronic networks.

Equally important is the protection of media ownership. In this case, there is a need to safeguard multiplicity and freedom of expression in the light of the universal nature of the knowledge society and its intrinsically cross-border character.

The transformation to a knowledge society is the result of a convergence and a shift towards a digital system of telephony, computer technology and television services. However, each of these realms is tied in with a specific and separate industrial profession. Hence the serious questions raised by the convergence process. It must be decided who is to take the initiative, what the real needs of consumers are, and the best way of organising a system for managing the industrial convergence of all the three sectors. It also has to be decided whether the social applications, that is, the methods of utilisation reoccuring often enough to make a cultural impact, are sufficiently well-established to promote the introduction of "New Information and Communication Technologies (NICT)".

On the legal front, it has to be agreed who should take responsibility in the event of litigation. In the context of a virtual universe, codes of conduct are not necessarily provided for by law. The information transfer process unfolds by ignoring national laws, but it remains to be seen whether this openness can continue indefinitely.

Other examples of constraints are :

— Protection of privacy (Orwell's "Big Brother").
— Copyright (intellectual property).
— Monitoring the type of material in circulation.
— Safeguarding cultural identity.
— More pronounced inequalities between major financial groups, SMEs and the general public and this applies to both the sharing and costs of information. Access to information is another issue that has to be considered. The information superhighway is inevitably destined to become a formidable centre of power as it will

accumulate the combined powers of all its users : the international stock market system, financial institutions, R&D centres, film studios and governments.

Financial problems also have to be addressed. There is some justification for calling into question the financial logic of the massive scale of the investments required by the information superhighways, as it is by no means certain that a suitable mass market will develop in the near future so as to be able to make a suitable return on the planned investments. Moreover, even if a mass market did exist, it might be absorbed by direct satellite television operators, as this technology allows for technological and commercial innovation based on interactivity. 40 % of all multinationals are currently based in the United States, which thus enjoys an advantage over its rivals, whose freedom of movement is reduced against the background of the general deregulation process being sought by the multimedia sector.

The information superhighway also raises cultural problems that some observers deem to be of vital importance. Underlying the multimedia struggle for domination is a major cultural issue. Given the large-scale transmission of information, the one who manages to separate the cultural object from the commercial service can rightly claim to be a shrewd operator. In these circumstances, the cultural exception being sought, particularly by the French-speaking world, seems destined to become nothing more than wishful thinking, unless the strategies recommended for the carrier industries are also applied to the content industries as well.

Political problems also need to be addressed. There are grounds for concern about the possibility of political power being abandoned for the benefit of major business groups. Observers believe that major private information groups already feel they have the muscle to dare to claim political power in areas in which they have a vested interest.

On the economic and trade fronts, the progress made by way of privatisation and deregulation may have given a fillip to international trade, but it has also given rise to illegal activities, criminal organisations, terrorism, drug-trafficking and corruption.

The Knowledge Society : Illusion or Metaphor

The present media excitement over the "wonderful" world of the information superhighway and its potential uses point to the strategic role that social applications play in giving tangible form to convergence and the emergence of electronic networks. It is important to keep a sense of proportion, however, rather than to suggest that anybody with a computer and modem may be a stakeholder in the process (after all, only a minority of the population enjoys such facilities, even in the developed countries) and that it is possible to reach anywhere from any point on the globe (when in fact it is hard to imagine for very many areas of the world where the telecommunications infrastructures are frankly inadequate).

In order for genuine social applications to develop, innovations need to be implemented on a wider scale in the entire social fabric and form an integral part of the socialisation of individuals in a given context. In other words, these applications have to be regarded as learning processes vital to the social development of any individual, as was the case with the motor car, the telephone, television set and the VCR. Even in the event of penetration, the general public still requires the financial wherewithal to become a genuine stakeholder in the NICTs.

Approaches likely to produce favourable results include seeking to speed up the pace at which computer technology innovations are developed and this applies in particular to the miniaturisation of systems, increased storage capacity and the speed for processing computerised information, the widespread digitisation of content : an increase in the capacity of information transport platforms (satellite network, fibre optic networks), decentralised storage media (hard disks, compact disks).

Notwithstanding the technological constraints, the knowledge society will only really take off in earnest if specific answers are found to the numerous questions affecting consumers of goods and services in their daily lives. It is pointless to set up cumbersome and costly infrastructures before user-friendly applications are shown to have some value. It will take time to develop these applications, so in order to speed up the pace, steps should be taken to give priority to competition so as to allow computer network operators to think about the right time for developing new infrastructures. Both applications and infrastructures are intertwined. Revenue from applications will increase as and when they become more attractive, whereas design costs will decrease as technology improves. The main challenge is to ensure that SMEs and the general public are allowed access to the information superhighways. This entails building access routes to the principal infrastructures consisting of the major continental and intercontinental fibre optic connections, or by satellite and microwave systems (cellular telephony and GSM). These access routes are becoming widespread in industry, driven by the profit motive and the need to improve productivity via the large-scale, rapid transfer of information between branches, subsidiaries, suppliers and even major clients at constantly lower cost.

The implementation and access costs related to the information superhighways tend to militate against equality of opportunity, whether we like it or not. Only major groups or organisations can really gain access to large information transmission capacities. SMEs and the general public hardly have a chance.

It may be supposed that point-to-point services will use the standard telephone network in the short term, whilst multipoint-point services will travel over the cable network. The telephone network capacity is set to increase in the medium and long term, whereas cable networks are destined to become more sophisticated and interactive. This means that multimedia series will be transmitted on more or less integrated hybrid networks in due course.

Africa on the Brink of the Information Age

Several questions need to be addressed about how Africa fits into the new knowledge society. The first one focuses on the need to decide the best way to create a computer network linking several national and regional networks. These types of networks can act as powerful incentives for bringing people closer together and encouraging them to pool their human, intellectual and technological resources on an interactive basis.

The second question homes in on the need to create a high-quality, low-priced platform of African networks within a reasonable period of time. The starting point is, of course, the telephone network, which may take advantage of global access. From the switched telephone network, the transmission of information in analogue form, the next stage is the transfer of information between computers, the most spectacular example of this being the Internet. The completion of this network has given rise to a set of rules governing the exchange of information and network control signals. These rules form part of a series of so-called “protocols”.

Networks in the developed countries make use of lines allowing for high data transmission capacities based on various types of links: standard switched lines, dedicated lines and leased lines, microwave links, satellite and backbones links based on fibre optic cable. Every one of these transmission systems requires a specific modem, synchronous modem, asynchronous modem and asynchronous radio modem.

In order to provide links between African countries, it is advisable to start by establishing a public network based on the X25 package-switched recommendation made by the International Telegraph and Telephone Consultative Committee (CCITT). This type of network provides a means of transferring data from the nerve centre of a country to another country or even to the hinterland of the same country.

It is difficult trying to get a full picture of the current situation for network activities in Africa. Several African countries have linked up their research bodies or have set up projects and have an operating X25 network at their command. Multinational data network projects are now in the works. There is no denying that computer networks and access to information services seem to be developing at a slow pace in Africa. The most widely used application is the e-mail system. Most network sites in Africa are not fully linked to all the services available on the Internet. Several projects are being developed or are underway to create computer network facilities in Africa.

The obstacles to network connection in Africa are primarily a result of:

— The uneven development of telecommunications networks;
— A lack of qualified staff to set up installations and manage the equipment and software;
— A shortage of supplies for data communication;
— Rapid global technological developments;
— The high cost of telematic services, even though the "cost/performance" ratio in this sector is decreasing at a rate of 35% a year on average in the developed countries;
— The fact that the telecommunications sector is mainly a low-performance, State monopoly;
— The fact that as a part of the public sector, telecommunication companies do not have the same opportunities as private ones to pass on the full costs of telematic services to users.

African Constraints in The Face of The Knowledge Society

Industrial society is being rapidly transformed into a knowledge society based on information management. This is giving rise to major problems in a bid to change mentalities and convert production structures. Markets, products and processes have been significantly affected by the increasing use of telematic resources. The advent of the information age has made it necessary to rethink managerial skills in general and the sort of cooperation to promote between companies in particular. Innovation, not physical resources, is becoming the key to success in the economy of the knowledge society. As governments are, by their very nature, the main producers, users and supplier of information, the authorities themselves must become leaders in the rapid adoption and widespread use of electronic communication and digital information systems. The rethinking of government services in the light of a digital world calls for a major overall of ministries and public-sector organisations. As a result of the information superhighways, the trend towards paper-free communications and transactions is rapidly increasing. The restructuring process sets challenges at all levels, not only in technological and financial terms, but above all in human terms as well. As a result of this trend, there is a need to focus on the regulatory framework so as to try to ensure a reasonably smooth changeover to sustainable competition on an international scale. After all, the provision of services on the information superhighway will be mainly determined by the level of competition against the background of an extensively deregulated telecommunications sector. The knowledge society is set to change the relationships between producers and consumers, between governments and citizens. The State regulatory framework has to adapt to the new situation.

The knowledge society does indeed offer opportunities, but it is also subject to constraints. The first constraint is quite simply the problem in gaining access to reliable, universal, affordable and equitable information. The second concerns guaranteeing diversity of information. The latter constraint is of major importance, given the trend in the information sector towards company alliances. Although they may form part of the market deregulation process, alliances often give rise to the creation of de facto private monopolies as replacements for state monopolies that still prevail in most developing countries.

On top of the constraints related to the deregulation of information markets are those to do with citizens' participation. This participation implies a suitable management of information technologies so as to be able to derive maximum advantage from the knowledge society. It refers to the creation of open, interactive networks so as to guarantee unconstrained exchanges of information. In order to compensate for the fact that so many people lack the technological skills required, steps have to be taken to facilitate the development of interfaces for making electronic networks user-friendly. What is more, the high cost of computers — the tool for gaining access to the information superhighways — means that public access systems need to be established along lines comparable to telephone services. This recommendation goes hand in hand with the need to market less sophisticated, and therefore cheaper, computers.

Other constraints include the need to protect privacy and assure security for public communications (access controls, information transmission integrity, authentication of information, impossibility of repudiation) and more generally speaking constraints relating to the definition of a code of conduct.

It may be possible to avoid, or at least minimise, the harmful effects of the aforementioned constraints in the developed countries, but this is not the case in Africa. Because of the poor condition of infrastructures combined with technological backwardness and lack of financial resources, Africa is unable to derive maximum benefit from the electronic networks and the key advantages of the knowledge society.

The economy underlying the information superhighways is one where knowledge is becoming a key resource. Consequently, the skills of the working population are becoming a major factor for achieving economic success. This economy implies a constant process of change, requiring the ability to adapt. An ability to adapt also involves a process of continuing learning and training. Success in the knowledge society therefore depends on establishing a culture of lifelong learning at all social levels, with the emphasis being on computer culture. In order to reach all these goals, action must be taken to develop new, state-of-the-art teaching procedures and tools. The entire teaching and training industry has to be overhauled. In any event, the self-sustaining process of innovation has to be underpinned by longer periods of education, hence the structure of the conventional education system also needs to be called into question.

As the educational shortcomings of Africa seem likely to worsen, a more effective approach to teaching must be adopted to counteract current problems and create teaching tools based on an interactive approach to education with distance learning being an option. The technological resources needed to achieve this aim are available, and may be tailored to the situation in Africa.

The highly competitive nature of the knowledge society calls for partnerships, not only among businesses, but possibly among countries as well. Government-to-government partnerships are all the more advisable in Africa, because African companies are fairly small compared to those in the developed countries. Moreover, technological exchange policies need to be coordinated between companies in the various countries.

Conclusion

Government programmes and services in the developing countries are in a position to take advantage of the communications and information technologies so as to enhance government management in all areas ; this applies, in particular, to social sectors such as health care and education. More generally speaking, government services provided by electronic means would help cut costs considerably, at the same time guaranteeing better quality service. In order to take advantage of these resources, the governments of the developing countries must rethink their services in a more efficient digital environment, with lower operating costs and a faster pace of delivery.

To derive maximum benefit from the resources offered by electronic networks, each African government must provide crystal-clear answers to a set of key questions relating to the information superhighways. They must decide :

— The pace at which the information superhighways should be developed and how to pay for the process of upgrading networks ;
— The correct balance between competition and regulation ;
— Whether to question the requirements relating to ownership and national control of the communication network ;
— The pace at which national companies may adopt universal standards and how the standards should be established ;
— The way the State may coordinate its initiatives with those of economic operators ;
— How to address copyright and intellectual property issues ;
— How to encourage the dissemination of national cultural products and services as well as other content-based products and services ;

— Whether to control the type of information transmitted over the network and, if needs be, by what means ;
— How the information superhighways can be expected to improve government services ;
— How to guarantee protection of privacy and an adequate level of security on the information superhighways ;
— How to ensure national information industries derive maximum benefit from R&D opportunities and the technological updating of skills and qualifications offered by the information superhighways ;
— How the information superhighways may boost the expansion and competitive positions of national companies, not least of all SMEs ;
— How to guarantee citizens universal access to key services at an affordable price on the information superhighways ;
— How to sensitise citizens as consumers and what teaching opportunities should be made available to them to help them use the information superhighways as effectively as possible ;
— What opportunities do the information superhighways offer for improving the functioning of the state machinery.

Questions adapted from the document "Le défi de l'autoroute de l'information. Rapport final du comité consultatif sur l'autoroute de l'information" (The challenge of the information superhighway. Final report by the Advisory Committee on the Information Superhighway), Canada 1995, 226 pages.

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APPENDIX

Features of The Information-based Economy

Features of the previous economy	Features of the new economy
Resource-based	Idea-based
Relatively stable advantages	Relatively dynamic advantages
Natural resources and manufacturing are the basis for wealth creation	Knowledge enhances the importance of the services sector in wealth creation
Investment in fixed assets : key for competitiveness	Investment in human capital : key for competitiveness
Protectionist measures	Springboards
Low value added monopolistic infrastructure	High valued added competitive infrastructure
Protection	Openness
Independence from national and international markets	Interdependence of national and international markets
Multinational companies	Global companies and strategic partnerships
Quantity : economy of scale	Quality : wider field of economic activities
Hierarchical organisation	Total quality, strategic agreements, partnerships
Financial assistance acting as disincentives to change	Incentives to adapt

Source : Le défi de l'autoroute de l'information. Rapport final du comité consultatif sur l'autoroute de l'information (The challenge of the information superhighway. Final report by the Advisory Committee on the Information Superhighway), Canada 1995, p. 11.

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Disparities in Production and Utilization of Knowledge

by

Mohamed HASSAN *

KEYWORDS. — Challenges ; Knowledge ; Gap ; Disparity ; Local Capacities.

SUMMARY. — The developing countries face two daunting challenges which will have a detrimental effect on their economic development and competitiveness in the next century. The first is how to narrow the widening gap between them and the industrial countries in scientific and technical knowledge. This growing knowledge gap is the root cause of the existing disparity between rich and poor nations in income and wealth generation. The rich countries (representing 20 % of humanity) control nearly 90 % of the world's current scientific knowledge and share over 85 % of the world's income. Their income share is sixty times that of the poorest 20 % of the world's population. The second challenge is how to build and sustain local capacities in science and technology needed to address practical problems confronting societies in the South (poverty, food, health, energy, pollution, etc.). The solutions to these problems must be generated locally with full engagement of innovative and indigenous scientific personnel. The presentation will first provide statistical data (largely taken from recent reports of Unesco and the World Bank) which reflect the disparities between the developing and industrialized countries in the production of scientific knowledge and in the capacity to create, acquire and utilize this knowledge. A number of strategic initiatives on how to address these two challenges will also be outlined.

MOTS-CLES. — Défis ; Ecart des connaissances ; Disparité ; Compétences locales.

RESUME. — *Disparités dans la production et l'utilisation des connaissances.* — Les pays en développement se trouvent confrontés à deux défis impressionnants qui auront des conséquences néfastes sur leur essor économique

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et leur compétitivité au cours du siècle prochain. Le premier concerne les moyens de réduire l'écart grandissant entre ces pays et les nations industrielles dans le domaine des connaissances scientifiques et techniques. Cet écart croissant sur le plan des connaissances est à l'origine de la disparité actuelle entre nations riches et pauvres dans la production des richesses et des revenus. Les pays riches (qui représentent 20 % de notre planète) contrôlent près de 90 % des connaissances scientifiques actuelles globales et se partagent plus de 85 % des revenus mondiaux. Leur répartition des revenus est soixante fois supérieure à celle des 20 % les plus pauvres de la population mondiale. Le second défi porte sur la manière de créer et de maintenir des compétences locales sur le plan scientifique et technologique nécessaires pour aborder les problèmes pratiques qu'affrontent les sociétés dans le Sud (pauvreté, alimentation, santé, énergie, pollution, etc.). Les solutions à ces problèmes doivent être trouvées localement au prix d'un engagement total du personnel scientifique novateur et indigène. Le présent exposé s'ouvrira par des données statistiques (largement extraites de rapports récents de l'Unesco et de la Banque Mondiale) qui reflètent les disparités entre pays en développement et industrialisés dans la production des connaissances scientifiques et dans la faculté de créer, d'acquérir et d'utiliser ces connaissances. Seront également ébauchées un certain nombre d'initiatives stratégiques sur les moyens de relever ces deux défis.

Trefwoorden. — Uitdagingen ; Kenniskloof ; Verschillen ; Lokale capaciteitsopbouw.

Samenvatting. — *Productieverschillen en kennisaanwending.* — De landen in ontwikkeling moeten het hoofd bieden aan twee ontmoedigende uitdagingen die hun economische ontwikkeling en competitiviteit de komende eeuw schade zullen berokkenen. Een eerste bestaat erin de steeds breder wordende kloof tussen hun wetenschappelijke en technische kennis en deze van de industrielanden te vernauwen. Deze steeds groter wordende kenniskloof is de hoofdoorzaak van de bestaande ongelijkheid in inkomens- en rijkdomontwikkeling tussen rijke en arme naties. De rijke landen (zijnde 20 % van het mensdom) houden ongeveer 90 % van 's werelds huidige wetenschappelijke kennis in de hand en delen meer dan 85 % van het wereldinkomen. Hun inkomensaandeel is zestig maal groter dan dit van de armste 20 % van de wereldbevolking. De tweede uitdaging is de lokale wetenschappelijke en technologische capaciteitsopbouw en -instandhouding nodig om de praktische problemen (armoede, voedsel, gezondheid, energie, vervuiling, enz.) waarmee samenlevingen in het Zuiden geconfronteerd worden aan te pakken. De problemen moeten lokaal opgelost worden met totale inzet van vindingrijk en autochtoon wetenschappelijk personeel. Deze bijdrage levert eerst statistische gegevens (hoofdzakelijk ontleend aan recente Unesco- en Wereldbankrapporten) die de ongelijkheid weerspiegelen tussen landen in ontwikkeling en geïndustrialiseerde landen wat de productie van wetenschappelijke kennis en het vermogen tot creëren, verwerven en gebruiken van deze kennis betreft. Ook wordt een aantal strategische initiatieven m.b.t. de aanpak van deze beide uitdagingen geschetst.

Challenges

At the dawn of the 21st century our world is faced with two important challenges which will shape its stability and transition to sustainable and equitable development.

The *first* is the *existing* and *persisting* huge gap between the science-rich countries of the North and the science-poor countries of the South in the production and utilization of scientific and technological knowledge.

Measured in terms of publications, the industrial North (20 % of humanity) is currently contributing over 90 % to the world's production of scientific knowledge whereas the South (80 % of humanity) is contributing less than 10 %. This has made it possible for the science-rich countries to generate considerable wealth, resulting in the economic inequity that exists today. The income share of the richest 20 % of humanity is about 85 % of the world's total and is sixty times that of the poorest 20 %.

What is more disturbing is that this gap is constantly widening. The advanced countries, with their big investments in Research and Development (R&D), are advancing the frontier of scientific knowledge very rapidly, making it very difficult to the developing countries, with their small investment in R&D, to develop their capacity to catch up. The total Research & Development expenditure worldwide was about US$ 470 billion in 1994 and only 10 % of this amount was contributed by the South.

The *second* challenge is the growing complexity of the problems confronting environmentally and equitably sustainable development. The problems of poverty, health, food and energy shortage, resulting in loss of biodiversity, desertification, climate change, pollution and shortage of fresh water. These problems are becoming increasingly global and their solution will therefore require a global effort involving all sectors of societies and equal participation of highly skilled and motivated scientific communities in both advanced and developing countries.

However, in the majority of developing countries, especially the Least Developed Countries (LDCs), there is an acute shortage of world-class professionals. The challenge therefore is how to reverse this situation and create opportunities to attract and train young talents and sustain them to conduct problem-solving research.

Fortunately, this view is currently shared by leading world economists. In an article published in *The Economist* last month titled "Global Capitalism", Professor Jeffrey Sacks of Harvard University said : "The Developing World lacks basic scientific and technical means to address the environment, health, population and agriculture. Even more hard economic evidence suggests that development problems in the poorest countries come not merely from the lack of political will, as fondly believed in Washington, but from a Lack of Knowledge".

Opportunities and Dangers

Modern scientific and technological knowledge that has sharply divided our world into two districts and highly polarized groups of people, also has the power to mould it into a truly equitable and sustainable global village.

I would like to highlight *four* opportunities that will help to reduce the North-South knowledge gap and hence create a more equitable world.

The *first* and most important opportunity is created by modern information and communication technologies and their networks which have profoundly revolutionized the modes of interaction in research, education and business. Through the e-mail and the Internet, information can now be instantly transferred over vast distances across the globe.

The implication of these rapidly advancing communication technologies to research and education in developing countries is tremendous. They offer unprecedented opportunities to instantly transfer to the science-poor countries the latest scientific and technological information. In addition, isolated scientists in the South now have the possibility to instantly reach out to each other and to their colleagues in the North and form new research teams through this electronic communication system.

Unfortunately, however, a large part of the world's community is currently unable to participate in and benefit from this information revolution. The unfavourable macroeconomic conditions and the high cost of wire-line infrastructure have made it difficult to provide these facilities to people in most Third World countries, particularly those living in remote areas.

The total number of telephone lines in the fourty-eight LDCs is 1 % of the number of lines in the USA. Only 1 % of the world's telephone lines are in Africa and about half of these are in South Africa.

On the other hand, the rapidly advancing wireless digital system based on satellites or cellular transceivers can provide a much less expensive and permanent solution to the communication problem in developing countries. The advantages of wireless telecommunication systems over wire-based systems are many. They can provide services to vast remote areas at very little cost. They can be developed quickly and are not affected by natural hazards.

A number of developing countries such as Argentina and China are currently investing heavily in digital communication systems. Also, the telephone networks of small countries such as Djibouti, Maldives, Mauritius and Qatar are now completely digital, bypassing the older wire-based systems and leapfrogging to this new technology. This is an important trend which should be followed by other developing countries.

It is our hope that in this new information age it will soon be possible for any scholar, teacher or student anywhere in the world to acquire a cheap small portable computer through which he or she, wherever located, can instantly access any source of information anywhere and at any time.

Half a century ago, such a possibility would have been regarded as wild science fiction. About four decades ago, Thomas J. Watson, the Chairman of the Board of IBM, was asked about future computer sales. His reply was : "I think there will be a world market for about five computers".

The world market of computers and software was estimated at over US$ 500 billion in 1995.

The *second* important opportunity relates to the recent proclamation by the World Bank that narrowing the knowledge gap between rich and poor nations should be at the centre of development aid strategies.

This is a tremendous shift from World Bank and IMF strategies of promoting economic development through big infrastructure projects, free trade and adjustment policies.

In its 1998 world development report entitled "Knowledge for Development", the Bank emphasized the central role of knowledge in the development process and called for supporting developing countries to increase their capacities to acquire, absorb, create and utilize knowledge to enable them to make the transition to knowledge-based sustainable economic development.

The report argues that strict international IPR laws may inhibit the easy access and wide availability of knowledge and hence increase the knowledge gap. It calls on developing countries to negotiate internationally for IPR regime that gives adequate consideration to their urgent need to narrow the knowledge gap.

In a dramatic effort to assist in bridging the knowledge gap, the Bank has very recently expressed its willingness to support the setting-up of Centres of Excellence (Millennium Institutes) in a number of developing countries, as an integral part of its new knowledge-based economic policies. This is exactly what the Third World Academy of Sciences, in collaboration with UNESCO and the South Centre, have been promoting for the last five years. TWAS in particular has been pursuing the establishment of an international network of centres of excellence since 1992.

According to the Bank, the Centres of Excellence should be designed to develop human capital, to provide vibrant research environment where state-of-the-art scientific research can be performed, be linked to the private sector and be part of an international network.

The Bank plans to pilot the scheme in a number of Latin American countries, including Chile, Argentina, Brazil and Colombia, during next year and to actively seek the participation of private foundations and international organizations and trust funds in further developing an international network of centres of excellence.

The Bank anticipates a worldwide expansion of the initiative that would build upon, and learn from, the LAC pilot phase. Vietnam and South Africa were mentioned as potential candidates for the second phase.

The *third* opportunity is created by the growth of science and technology in a number of developing countries such as Argentina, Brazil, China, India, Mexico, South Africa and South Korea, and the willingness of these countries to help others in the South to develop their capacities. In a major effort, the Third World Network of Scientific Organizations (TWNSO), in collaboration with the South Centre and TWAS, has published this year profiles of four hundred and thirty scientific institutions of excellence in fifty-two developing countries. These institutions have expressed their readiness to participate in Networks, scientific exchanges and training programmes for young scientists from countries with poor research facilities. A large number of the institutions included in the book are from the *seven* countries I have just mentioned and many of them have achieved a level of competence comparable to institutions in industrialized countries.

Regional and inter-regional cooperation in science and technology within the South based on networking centres of excellence to address specific development-oriented research problems has substantial benefits to the developing countries, many of them, although at different stages of development, share similar social, cultural and economic background. TWNSO has recently formed a network of centres of excellence in dryland biodiversity in twenty developing countries and has designed a project to facilitate the sharing of successful experiences in conservation and sustainable utilization of genetic resources and to promote joint-targeted research and training programmes. Similar networks to address other problems of critical importance to sustainable development such as medicinal plants, fresh water and energy are also being developed. As these problems are also of great concern to the developed world, it will be essential to link the institutions identified by TWNSO with their counterparts in the North and engage them in a truly genuine partnership to find practical solutions to these problems.

The *fourth* opportunity is related to the distribution of the world's natural resources. The developing world greatest asset is that it possesses most of the world's biodiversity and natural resources and the traditional and ethnical knowledge associated with these genetic assets. To the good fortune of the poor countries, the distribution of these resources among the countries of the world is to a larger extent inversely proportional to their material wealth. The poor countries, however, lack scientific and technical skills and financial resources to rationally and sustainably exploit their biodiversity for economic benefits.

Big multinational pharmaceutical and biotechnology companies of the North, on the other hand, are expanding their bioprospecting and gene-hunting in developing countries. In 1990, the World Sales of

Medicines derived from plants, discovered by indigenous people, amounted to US$ 43 billion with very little financial benefits to these people. The 1998 World Development Report mentioned a unique plant in Madagascar which was used by a global pharmaceutical company to develop two anti-cancer drugs, generating over US$ 100 million in sales with no financial returns to the country.

Large developing countries such as India, Brazil and China are designing appropriate biodiversity legislation to protect their genetic resources from biopiracy. While India and China are calling for strict protection laws, the Brazilian Government calls for a relatively liberal legislation to encourage genuine partnerships between domestic and foreign researchers.

The majority of developing countries, especially the least developed ones, have no option but to develop their national capacities in genomics science and IPR issues and to negotiate bioprospecting agreements with foreign companies that give maximum benefits to their local communities.

Conclusion

The disparities between developed and developing countries in their respective capacity to produce scientific and technical knowledge and to utilize this knowledge for social and economic benefits are immensely disturbing and are threatening the stability and future sustainability of our planet. To overcome the causes of these disparities will not be an easy matter. Opportunities, however, do exit and a few of these have been outlined in this presentation. But there are also dangers of further drifts if these opportunities are not seized.

This will require a sound North-South partnership between scientists, institutions and governments and a change of emphasis in the policies and strategies of the leading international development agencies, in favour of assisting the poor countries to develop their capacities to reduce the knowledge gap and to generate, manage and utilize local knowledge for national and global benefits.

It is in this spirit that I wish to conclude by quoting once again from the same article of Professor Sacks of Harvard University, who said : “We need the World Bank not as yet another Bank, but as our pre-eminent international institution for mobilizing the knowledge to address the problem of the developing world. Yet, the World Bank currently makes its money from loans. It finds itself stuck in banking business where it could truly serve the World. Restructuring the Bank, so that it has the means to mobilize real knowledge creation, would cost a lot. This is part of the price tag feared by the American Government. The World will have to decide whether to remain on the cheap, or make the investments in knowledge that could promote a more prosperous future".

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Closing Speech

by

Paul SIMON *

Mr Minister,
Mr Director-General,
Mr President,
Dear distinguished guests,
Dear participants and colleagues,

First, I would like to excuse Mr Yvan Ylieff, Belgian Minister of Science Policy, who cannot participate in the closing ceremony of the International Symposium on "Science and Development : Prospects for the 21st Century". He is presently on travel on behalf of the Government, to attend another important event.

The Royal Academy of Overseas Sciences agreed on December 15, 1994 on a Memorandum for cooperation with UNESCO. The joint organization of this Symposium, which began yesterday afternoon with opening speeches by the Director-General of UNESCO, Mr Federico Mayor, and Mr José Vargas, President of the Third World Academy of Sciences and Minister of Science and Technology in Brazil, is a very good example of the benefit of such a cooperation.

The Secretary-General of TWAS, prof. Adnan Badran, and the Executive Director, prof. Mohammed Hassan, have also taken part in the Symposium as speakers.

On behalf of Minister Yvan Ylieff, I would like to thank you for being with us for this International Symposium, for your support and your active participation.

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I am very pleased to remind you that this Symposium is actually a preparatory event to the "World Conference on Science for the 21st Century : a New Commitment" organized by UNESCO and to be held in Budapest next year from 26 June to 1 July.

During these two days, three specific panels have been dedicated to :

- Contemporary Evolution of Science and Prospects for Development ;
- Scientifc Institutions and Private Sector Support to Science for Development ;
- Partnerships and Sharing of Knowledge.

The variety of themes addressed during this Symposium demonstrates the need for a worldwide reflection on the scientific challenges for the next century. The role of science and technology for development and the public and private partnership for culture, ethics and sustainable development are of paramount importance. The major findings resulting from research and development and issues raised by the scientific community are badly needed for policy makers and worldwide citizens.

Any Minister of Science Policy should take into account all those elements to define an adequate policy, followed by strategic choices to be supported by programmes and projects at the international level.

This dimension, well-known for many years by scientists, must be more deeply integrated into the variety of international scientific committees and organisations.

The federal Minister of Science Policy is sharing your concern on the strong need for a scientific culture dedicated to peace. Up to now, major breakthroughs in scientific knowledge have been the heritage of war. One of the latest examples is the scientific exploration of space which has been recommended by the IGY since 1953 and endorsed in 1955 and 1956 by the USA and the former Soviet Union. But the first satellite launched in October 1957 was mainly the demonstration of the ability of the Soviet Union to send missiles across the Atlantic. The Nazis during the Second World War also developed the rocket technology. The scientific space programmes are still a fundamental pillar for astrophysics and planetology, but also for geophysics with the Earth observation, very important in the context of sustainable development.

Telecommunication is another new space-based technology which should be used not only to make profit but also to improve the worldwide education and the transfer of information, basis of our democratic values.

It is always difficult to predict the future. Science has deeply evolved from the Newtonian paradigm to the concept of complexity, non-linearity and management of uncertainties. How to combine the scientific and technological development towards a peaceful world with social equity ? This is one of the challenges that scientists, policy makers and economists have to cope with, to move forward into the 21st century.

In that context, the Earth and its environment are an important component of the heritage we have to ensure and transfer to the next generations.

This Symposium with its themes reflects also the interest of the Royal Academy of Overseas Sciences. More than 50% of the speakers have come from developing countries. Minister Ylieff is reiterating his thanks to this Academy and UNESCO for their joint collaboration and he is looking forward to a very successful meeting next year in Budapest. He is convinced that Belgium and its Royal Academy of Overseas Sciences will continue to contribute significantly to the improvement of the worldwide access to scientific knowledge, in the prospect of a sustainable development and of a peaceful 21st century.

I thank you for your attention.

REPORT *

The Main Features of Current Trends

The world, shaped as it is today by the progress of science and technological inputs, is marked by the emergence of new, increasingly complex societal forms : a networked, self-managing society. The greater the size of human societies, which are non-linear systems, the greater is their "non-linearity"; fluctuations and instability increase ; as a consequence, the notions of symmetry and balance are no longer relevant to the ways by which this reality is grasped. Hence deterministic views of nature have given way to a rational explanatory system of a probabilistic kind. If the universe is so understood, the human species is only one of the possible outcomes of the laws of nature : "the possible is richer than the actual" (I. Prigogine).

This growing complexity is also a feature of the developing regions, where a series of problems have become increasingly acute : poverty, lack of access to drinking water, to health care and to education, pollution, deforestation, desertification, exploitation of children, migration, armed conflicts, illiteracy, isolation, marginalization and North-South disequilibrium in the production and use of science and technological know-how are all factors of instability and antagonism that threaten our "global village", to quote Marshal McLuhan. This disparity between North and South is demonstrated by the fact that in 1997, for example, there were 442 Internet sites per 1,000 inhabitants in the United States, 76 in Japan, 50 in France but only 4.2 in Brazil, 1.8 in Colombia and 0.05 in India. Another illustration is the fact that 90 per cent of scientific publications are produced in the North, and only 10 per cent in the South, with Africa accounting for scarcely 0.7 per cent.

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* Report prepared under the coordination of Professor Paule Bouvier, member of the Royal Academy of Overseas Sciences.

The Hold of Science and Technological Innovation on Contemporary Society

This situation calls for the application of new concepts and new methodologies, particularly in view of the fact that science has become ambivalent, dispensing both beneficial and adverse effects. The current capacity of science to explore the future, improve the quality of life in North and South alike, circulate information, encourage citizen participation and promote peace and equity comes up in practice against a series of curbs, not to say obstacles : the constraint of the logic of real time, the restriction of the field of vision to a short-term horizon, the possible repercussions of genetic engineering on humanity, the compartmentalization of disciplines, hyperspecialization and the brain drain.

The Challenges and Dangers Confronting Science

In the field of communication technology and the dissemination of information the dangers are as follows : information overload may become unmanageable, prompting a return to ex cathedra pronouncements ; large private companies may monopolize the information highways ; the cultural industries may become entirely market-driven ; control of the quality and objectivity of the data transmitted may be inadequate.

The question therefore arises : What is science for ? Given that, as a result of current developments, the present generation is usurping the rights of future generations. The reply to this question involves several different fields.

Relations between the Various Actors

The first task is to set up constructive interactions between the various actors concerned. Generally speaking, what is needed is a new contract redefining the relations between science and society. In this context, care should be taken to ensure that the globalization of science does not restrict the multiplicity of scientific approaches. The cultural underpinning in which scientific activities are rooted must be taken into account in drawing up this new contract. The gap that is now opening up between those who have access to knowledge and those who do not will have to be filled — an issue requiring the attention of political leaders. From now on, their goal must be to promote equity in the sharing of science and practical knowledge. The sort of interrelations that are needed are among scientists themselves, taking into account the pressures to which they are subjected as a result of technological nationalism, the fragmentation of society brought about by geopolitical power plays, geopolitical exclusivity and neo-liberal commercialism. These interrelations are also between the scientific world and the political world and vice versa. The former must send clear messages to the latter, while the politicians must create the conditions — whether material (infrastructure and equipment), moral (the fundamental freedoms), institutional (public and semi-public bodies) or intellectual (training and mobility) — that are essential to the well-being of researchers and to curbing the brain drain. These interactions also include the private sector. While industrial companies and development agencies pursue different ends in both research and field work, they nevertheless converge in the common aim of promoting economic growth. The potential — and in some cases actual — contribution of the business world to development in terms of investment, advice and services must be harnessed. International organizations should also be involved. It is significant in this respect that the World Bank has recently been talking of the need to "bridge the knowledge gap" between North and South, with the collaboration of private sector partners. Lastly, civil society too should be drawn in ; citizens themselves must be involved in the responses to our question. The restrictions and limits that stand in the way, particularly in countries where fundamental freedoms and human rights are not respected, must be removed as far as possible. However, it has to be acknowledged that under the pressure of public opinion technologically benign solutions in the environmental field (such as the processing of nuclear waste) are rejected for no good reason, while at the same time a desire to reduce CO2 emissions is professed. Encouragingly, the NGOs, in their role as the mouthpieces of civil society, are able to open communications between the creators and the users of scientific inputs, i.e. between those involved in the various stages leading from the researcher to the consumer.

The Research Methods to be promoted

The interrelations to be promoted are not just between the actors but lie within the scientific research field itself. The compartmentalization of disciplines and the distortions resulting from the hyperspecialization referred to above mean that it is no longer possible to take in the realities of the modern world, in particular those of the developing regions. Interdisciplinarity, multidisciplinarity and transdisciplinarity are now imperative. The real world has to be grasped in its many dimensions and facets ; it is not confined to the economic, social, political or academic spheres but embraces the arts, music and alternative medicine. These fields need to be addressed in their totality, employing a holistic approach based on a reading of the pattern of their interactions and retroactions. Consequently, any splitting off of the exact sciences from the human sciences is to be avoided. In the absence of any full equivalence or established hierarchy between science, the applied sciences and the human sciences, the importance of the latter should be emphasized since they are capable of facilitating the transmission of knowledge, highlighting the diversity of cultural content and buttressing development strategies.

The New Demands placed on Education

Alongside the interconnections to be promoted between actors and research areas, the reply to our question is also situated upstream of actual scientific practice, namely in the education system. Its restructuring is absolutely essential if the above-mentioned aims are to be attained, both in quantitative terms (access to education on a democratic basis and development of the various levels and types of training) and in qualitative terms (curricula, disciplines and human resources). The renewal of curricula implied by this approach should focus on greater receptivity and attention to the role of science, to technological inputs and to respect for the environment, including ecosystems and their biodiversity. This should apply to the various forms of transmission of knowledge : theoretical and applied, formal and non-formal, literacy work and continuing education. The aim should be to provide the developing countries, and sub-Saharan Africa in particular, with the capacity they need to manage the new technologies, particularly with regard to national and regional information networks.

These reforms involve further reforms : a redefinition of the role of teachers ; the establishment of links with private enterprise in order to target more precisely the requirements of the job market and to meet them more effectively ; the selection of the languages of education with a view to preserving local languages as the vehicle of culture and to facilitating access to international research findings ; the rooting of education in the underlying local culture and its provision through domestic resources.

Relations between North and South

A final point in response to our question concerns relations between North and South, which also need to be reconsidered. From now on, these relations should be based on the notion of partnership, which implies new obligations : namely, the pursuit of equity in the design and conduct of research programmes and the means of carrying them out, together with the protection and circulation of the results ; the need to establish networks and alliances to prevent research workers from being sidelined ; the promotion by this and other means of greater mobility and more exchanges with a view to mutual benefit and an extension of the notion of citizenship ; and willingness to accept that the methodology, results and application of research should be open to challenge. But in order to be effective, partnership must necessarily fulfil three conditions. All participants must be of a very high level ; the expected benefits for the recipients must be self-evident, tangible and accessible, given that scientific cooperation should be conducive to development and social justice and should respect the sociocultural environment in which the various partners are active ; and lastly, the partnership should be in a context that provides a minimum level of political, structural and economic support. It should also be noted that growing South-South collaboration is at present opening up new horizons. Science and technology have undergone considerable development in Argentina, Brazil, China, India, Mexico, the Republic of Korea and South Africa, all of them countries that have indicated their willingness to co-operate with other countries of the South ; four hunderd thirty scientific centres of excellence have been identified in fifty-two developing countries, which opens up a broad field for cooperation.

What Ethical Principles should govern the Science of the Future ?

The conclusion to be drawn from all these observations is that scientific research and its applications must henceforth be based on an ethics of the future. If we are to achieve sustainable development combined with a higher quality of life, three principles must underpin such an ethical system. First, the principle of responsibility towards the distant future. Two obligations ensue : the need to preserve our own nature, which means respecting the specific identity of the individual, and the need to preserve the nature around us, which implies the invention of an ecological economy that will protect the biosphere and the creation of a "clean development" mechanism. A second principle derives from the first one : that of solidarity with present and future generations. This should serve as a guide for the future development of science and the choice of the technologies to be promoted. The ethics of the future should address such matters as the eradication of poverty and the psychological distress and physical hardship it engenders, the prevention of the conflicts that arise from ignorance, imbalances, frustrations, intolerance and injustice, and the refinement of our understanding of nature in order to protect it. The third element on which the dynamics of science should be based is the precautionary principle. The demise of the old certainties, the growing complexity resulting from such factors as the proliferation of actors and the risks entailed in the very existence of the new areas of activity opened up by science mean that we have to manage its potential with discernment and caution.

* * *

In addition to these observations and pointers concerning the future prospects of science and development in the twenty-first century, a few more specific recommendations can be put forward :

— With a view to protecting the free circulation and equitable distribution of knowledge, the means of communication and of access to information should have the status of a public service ;
— The historical tendency to set up military alliances should be redirected towards the creation of alliances to promote peace and protect the environment ;

— The flow of knowledge should be in two directions: both "top down" towards rural communities and "bottom up" from these communities, since popular knowledge is too often ignored although it can be scientifically developed in ways that are useful to the various actors concerned ; methodological approaches should systematically take heed of local ways of doing and thinking ;
— Consideration could be given to establishing an advisory council, modelled on a works management committee, grouping representatives of international organizations, the business world and scientific institutions with a view to enhancing the complementarity of their contribution to development ; it might be desirable to decentralize such a body in order to ensure a better grasp of local realities ; if the excessive isolation of too many scientific communities in the developing countries is to be remedied, a three-pronged approach is required, involving protection of the results of their work, access to the means of circulating these results, and the extension and acceleration among all the institutions concerned of the free circulation of scientific advances, including those produced in centres of excellence ;
— To stimulate awareness of the impact of science and technology on everyday life now and in the future, greater emphasis should be placed in curricula on mathematics and natural science teaching, given that the effectiveness of this teaching varies greatly from one country to another, even within the industrialized world ;
— The ethical standards underpinning the culture of peace, dialogue that respects individual identities and the empowerment of citizens in the context of their internationally recognized rights and obligations should be included in the curricula of the different levels of the education pyramid.

The ideas developed in this overview of the Symposium open the way towards applications whose introduction will depend not only on scientific organizations and political authorities, but on funding agencies.

Executive Summary

Recent societal changes involving an ever greater degree of complexity and instability, in the developing regions as well as elsewhere, have sounded the death knell of deterministic views of nature, giving way to probabilistic explanatory systems. Because science has become ambivalent in what is expected of it, new concepts and new methodologies need to be applied.

This situation calls for new and constructive interactions among the various actors directly or indirectly involved in the process ; for which purpose a new compact between science and society is indispensable. The present-day world and the countries of the South in particular need a holistic approach ; compartmentalization of disciplines and hyperspecialization are no longer acceptable and must be replaced by multidisciplinarity with special emphasis on the human sciences. To give practical expression to these new approaches, an evidently essential step is the restructuring of education systems.

The partnerships now needed between North and South imply new obligations based on equity and solidarity. At the same time, South-South collaboration is offering new prospects.

Scientific research must consequently be based on an ethics of the future seeking to preserve our own nature and the nature around us. Underpinned by the principles of accountability, solidarity and precaution, such an ethical system also has implications for the circulation of knowledge, institutional renewal, alliances for protection of the environment, and education designed to implant a culture of peace.