International Symposium

Science in Society
A New Social Contract

27-29 January 1999

A Report

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FOREWORD

The United Nations Education, Scientific and Cultural Organization is convening a World Conference on Science during 26 June to 1 July 1999 at Budapest, Hungary. The objective of the meeting is to provide a forum that will deliberate on the issue of whether science needs a new social contract in society, and if so what the outlines of such a contract should be. For many decades after the end of the Second World War the social contract that science has had with society has been implicitly based on the ideas contained in the well-known report entitled, *Science, The Endless Frontier* that was submitted by Vannevar Bush to the US President in 1945. In recent years increasing numbers of people have begun to question whether the nature of this contract should not now be modified.

The World Conference will consider the role of science as well as the use of scientific knowledge so that it may be better harnessed to further improve and enrich the quality of life of people and the development of society in the twenty-first century. The deliberations of the Conference will lead to the adoption of two documents, namely a declaration on *Science and the use of scientific knowledge* and *Science agenda: framework of action.*
In preparation for the Budapest Conference an International Symposium on *Science in society: A new social contract* was organized at the National Institute of Advanced Studies during 27-29 January 1999. The Symposium addressed various issues related to science, technology and development, particularly from a social science perspective. The focus of the Symposium was mainly on issues that have priorities for developing countries. Widespread concerns became evident at the Symposium on issues connected with indigenous, traditional and civilizational knowledge systems – a subject that has clearly not received the attention that it deserves. These concerns have been embodied in the *Bangalore Communique*, which was adopted at the end of the Symposium and is available as a separate document from this Institute. The *Bangalore Symposium* also proposed a variety of amendments to UNESCO’s *Draft Declaration on Science and the Use of Scientific Knowledge* that will be placed before the Budapest Conference.

The present document is a summary report on the Bangalore Symposium along with a collection of relevant documents that are attached as appendices. The report is being issued both as a partial record of the major issues debated at the Symposium and as a summary of the view-points that emerged. The report is not intended to be a complete “Proceedings” of the meeting, but it is my hope that it will nevertheless be found useful in getting a flavour of the discussions that took place at what, undoubtedly, was a very lively and animated meeting.
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The report as now published leans very heavily on a document that was prepared by R Ramachandran, to whom I am greatly indebted for the effort that he has put in in preparing an excellent summary. I am also grateful to my colleague, Dr A R Vasavi, who helped us in organizing the Symposium and in ensuring that the programme went through smoothly. The programme itself was formulated by a National Organizing Committee, and I wish to thank all my colleagues on this Committee, Prof M N Srinivas (NIAS), Prof Moegiadi (UNESCO), Dr D M Nanjundappa (Indian Council of Social Science Research), Dr S Mahapatra (UNESCO), Ms Sadhana Relia (DST, GoI), Mr D P Singh (DOE, GoI) and Dr Vasavi (NIAS) for their numerous suggestions that helped in making the programme so rewarding.

The Symposium was sponsored by UNESCO, the Departments of Science & Technology and of Education of the Government of India, and this Institute.

R Narasimha
Chairman
National Organizing Committee
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INTRODUCTION

Science and technology (S&T) have, particularly in the last five decades after the war, made rapid and spectacular advances which have impacted our lives immensely. Thus, achievements in the area of health care and in developing curative and preventive therapies through drugs and vaccines for a variety of diseases have increased life expectancy significantly. Agricultural output has risen to meet the increasing needs of the growing population, thus pushing over the horizon the Malthusian spectre that was once said to be looming large, especially in the more populous regions of the world like India.

New energy technologies and more efficient exploitation of known energy sources have created capacities around the world for increased productivity on the one hand and comfortable living on the other. More recently, the phenomenal growth in
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Communication and information technologies has brought about unforeseen opportunities for interaction amongst people and individuals. These have also led to an information explosion; the rate at which information is being generated, stored and retrieved globally is mind-boggling. All these developments have resulted in steady economic growth, increases in per capita income and level of consumption of material goods, and indeed a general improvement of life globally—but only in a gross sense.

For, all the above notwithstanding, large sections of human population have either remained outside the sphere of influence of these developments or have been only marginally touched by them. A major failure of the current modes of development and science-society linkages has been that the gains of S&T have not reached a large fraction of the world population who cannot meet their basic needs of adequate nutritious food, potable water, good health, hygiene, universal primary education, employment and shelter. The gap between the developed and developing countries, and between the rich and the poor within countries, is still far too wide.

In addition, applications of S&T have also often led to depletion of natural resources, widespread environmental pollution, unsustainable growth paths and loss of plant and biological diversity. Indeed, even where S&T successes have led to economic growth, like agriculture and energy technologies, they have been accompanied by ecological degradation, displacement of local
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societal groups, massive rural-urban divides, large scale migration of rural populations into cities etc. As a result, on the one hand, these very achievements have not been accessible to large sections of the population and have even led to the total exclusion of certain social groups and tribal populations who draw sustenance from nature itself. On the other, non-sustainable life styles based on high consumption have been promoted in the developed world, and these are already beginning to have a long-term impact on human lives through such global effects as climate change.

In the five decades after the war, scientific and technological progress has also resulted in the building and amassing of weapons of mass destruction, including nuclear, biological and chemical, with stockpiles enough to destroy life on the earth several times over. Along with these weapons enormous resources are being spent in perfecting sophisticated delivery systems. Despite the end of the Cold War, military spending and arms trade have not significantly declined globally, and application of science for the purposes of war continues to be high on the agenda of both developed and developing nations.

From the perspective of developing societies in this region of the world, this palpable failure in realizing the advances of modern science as public good for a vast majority calls for a reassessment and a redefinition of the current science-society linkages and the existing paradigms of a "science-society contract". These is an imperative need for evolving new relationships in the science-
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society interface and for reorienting the discourses on S&T to include social sciences and humanities so that the diffusion of the benefits of S&T occurs in a socially more equitable and sustainable manner. The current situation is critical, and demands renewed commitment on the part of different players at every node of this multidimensional network of linkages which spans across diverse societal groups, cultures and nations. Indeed, as the millenium comes to a close, a “new social contract” for science needs to be drawn up that redefines the role of science and the use of scientific knowledge for public good.

SCIENCE FOR THE 21ST CENTURY: A NEW COMMITMENT

The World Conference on Science (WCS), scheduled to be held in Budapest during 26 June – 1 July 1999 under the aegis of the United nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICS), will serve as a forum to deliberate on the new social contract that is necessary for the benefits of S&T to spread across society at large. The Conference will examine ways and means in which S&T can be better harnessed to improve and enrich the quality of life of the people and the development of societies in the 21st Century. The forum will involve the scientific community, international scientific organizations, governments, inter-governmental and non-governmental organizations (NGOs), and the public. The deliberations at the Conference are expected to lead to the adoption of two documents: a Declaration on Science and the Use of Scientific Knowledge and Science Agenda: Framework for Action.
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These in turn are aimed to providing a long-term strategic framework for promoting cooperation and coordination among all interested persons in the scientific community, governmental authorities, non-governmental and international organisations and the private sector.

THE BANGALORE SYMPOSIUM

In preparation for the Budapest Conference, an International Symposium titled Science in Society: A New Social Contract was held at Bangalore during 27-29 January 1999 focussing on the social dimensions of S&T. This preparatory UNESCO-sponsored symposium was the result of an initiative by the former Indian Union minister for science and technology, Prof. Y.K. Alagh. It was co-sponsored by the Departments of Education and of Science and Technology of the Ministry for Human Resource Development, Government of India and the National Institute of Advanced Studies (NIAS), an autonomous centre for multi-disciplinary research and training in Bangalore.

A total of 126 people, of which 11 were from abroad, participated in the three-day meeting (Appendix I). Besides UNESCO officials, the gathering comprised eminent scientists, industrialists, economists, social scientists, science journalists, scholars, policy planners and science administrators. The chief objective of the Symposium was to address issues related to science, technology and development from a social science perspective. Indeed, given this objective, there was a deliberate attempt to ensure a greater
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participation from the social sciences as compared to the natural or physical sciences and engineering (roughly in a 3:1 ratio). The deliberations covered issues related to science policy, science and gender, science for development, the relevance of science to meeting social needs, the potential capabilities of science to cater to regional requirements, the impact of globalization on S&T, the science-industry interface and science education, all from the perspective of developing countries.

Since the purpose of the meeting was to generate inputs to the Budapest Conference with a developing countries' perspective, the agenda of the Symposium included formulating a set of recommendations for consideration at the WCS. Called the Bangalore Communique (Appendix II), the recommendations made, therein, set out the strategy to meet the expectations of a developing society from science in the 21st Century, and a plan of action that will reinforce as well as reorient the science-society relationship for development and for protection of the environment.

Besides, the Symposium also proposed amendments to the Draft Declaration on Science and the Use of Scientific Knowledge to be adopted by the Budapest Conference. Towards this end, the UNESCO had sent a draft of the declaration (Appendix III). There was much disagreement at the Symposium with the formulation of the draft. After extensive discussion the draft was amended to include the special elements and concerns from the
perspective of this region of the world which accounts for nearly two-thirds of the world population. The Amended Draft Declaration (Appendix IV) was adopted by the Symposium on 28 January and has been forwarded to UNESCO, Paris, through the Department of Science and Technology (DST) of the Government of India and other appropriate governmental channels.

Similar preparatory symposia, to provide inputs to the WCS from other perspectives, have been held in other parts of the world as well. The Sydney Symposium, for example, was on the subject of Priorities for Science in the 21st Century for the Asia-Pacific Region and was held during 1-5 December 1998. The Sydney Communique is appended to this report as Appendix V.

Inputs of a different kind for the Budapest meeting, through task forces on specific areas of importance with regard to the science-society linkages, are also generated by the basic sciences division of the UNESCO. Recommendations of one such UNESCO task force on Science for the Development of the South, which were made in March 1998, were highlighted by Dr D. Balasubramaniam, the former director of the Centre for Cellular and Molecular Biology, Hyderabad. The task force included, besides Dr Balasubramaniam, Drs. J. Vargas (President of the Third World Academy of Sciences and Minister of Science in Brazil), M. A. M. Hassan (Executive Director of TWAS), A. Cetto (Mexican Academy of Sciences), S.O. Wandiga (Kenyan Academy of Sciences), B. Ottoson (Norwegian Academy of Sciences), C.N.R. Rao (TWAS
and Jawaharlal Nehru Centre, Bangalore), Y.X. Lu (Chinese Academy of Sciences), J.F. Stuyk-Taillandier (ICSU) and V. Zharov (Director, Basic Sciences Division, UNESCO).

**THE NEW SOCIAL CONTRACT**

Dr. Ali Kazancigil, Executive Secretary in UNESCO’s Ministry of Science and Technology in Paris, referred in his inaugural keynote address at the Symposium to the two basic foundational elements of the social contract that has operated between science and society for the past five decades.

1. The intellectual element, as put forward by Vannevar Bush, the Scientific Advisor to President Roosevelt, in 1954 in his now famous document called, *Science: The Endless Frontier*.

2. The political and strategic element, which, because of the Cold War, brought in enormous effort into S&T chiefly led by defence R&D, resulting in spin-offs into civilian areas across the board.

While there have been country-specific variations in terms of detail, depending on the institutional arrangements and the policy-level modes of interaction, the Bush Report remains the mainstream framework of science policy making or the science-society contract in the West, a model which has been borrowed by many developing countries as well including India. The Bush model is a ‘linear one’ based on the assumption that well developed science will eventually spread into society as useful
products. Basic research, it said, is to be adequately funded by the state
and is meant to be regulated by the scientific community itself, while
applied science and development work (like defence, health, agriculture
etc.) is subject to mission orientation following practically determined
mandates such as commercial enterprise, security issues etc.

This linear chain of innovation disregarded the socio-economic,
organizational, cultural and other contexts including such factors
as the character of the marketplace, domestic or otherwise. In
this contract, pure science is valued above applied science or
technology and the connection of science to its societal context is
devolved. As a recent historical evaluation of the Bush Report
observed: “Societal benefits (in the Bush mode) result not in spite
of isolation from the broader environment, but rather because
isolation, as autonomy, is a necessary element of the scientist’s
ecology”.

Subsequent events have shown that the innovation chain is far
more complex than this simplistic linear, unidirectional paradigm
of science-push based development. Even in the context of the
West, particularly with the emergence of Japan as a technological
power in the 1880s, a mix of supply-driven and demand-driven
science policy doctrines, for example the OECD reports and the
Foresight initiatives modelled on the Japanese experience, began
to evolve. The boundaries between basic, applied and socially
mandated sectors were becoming increasingly blurred and a
hybridization of scientific communities, which divided tasks
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between the laboratory and the industry through contract research and consultancy, was taking place.

Also, research areas such as genetic engineering and assisted reproductive technologies brought forth ethical issues calling for greater regulation by involving social scientists and environmentalists. In the 1990s the process of globalisation, privatisation and corporatisation of research and attendant issues of intellectual property rights (IPRs) and proprietary information, particularly in such areas as biotechnology and medicine, have led to negotiating research priorities in a broader social context. As a result, new models of the innovation chain and new paradigms of the science-society contract have emerged in the West over the last decade or so.

In the post-Cold War era, the second element of the old contract, namely innovation driven by defence spending and its subsequent diffusion into society through technology 'spin-offs', has also come in for a major revision in countries like the USA where defence spending has led investments in R&D. The same model has been incorporated in some form or the other in many countries including India. The notion of spin-off was predicated on the linear innovation chain model a la Bush which in the new thinking needs to be replaced.

In a global context, therefore, a major S&T issue of discussion is the 'conversion of military to civil technologies' and the new
concept of 'dual use technologies', rather than spin-offs. Pacifist arguments of the past - which have had little impact - against a defence-led mode of technology innovation have now given way to economic arguments, based on the successes of the industrial policies of Japan and Europe led by explicitly civilian technology. For example, the aim of the new Clinton strategy is to redirect the massive US defence investment so that it will become more effective and more supportive for a broader industrial base. As the 1993 Technology Policy of the Clinton Administration states: 'We cannot rely on the serendipitous application of defence technology to the private sector. We must aim directly at these new challenges and focus our effort on the new opportunities before us, recognising that the government can play a key role in helping private firms develop and profit from innovations'.

This is a clear statement of how dual-use technology development, instead of the notion of spin-offs, has to be pursued in cooperation with commercial industries as a technology diffusion policy approach. An effort in this direction is the Clinton Administration's Technology Reinvestment Project of 1993, the largest multi-agency project in the US to date. The programme is aimed at stimulating a transition of defence technologies to a growing, integrated national industrial capacity and is financed by the Defence Reinvestment and Conversion Initiative involving about $1.7 billion.
But from the perspective of developing countries the issues that should underpin a renegotiation of the science-society contract are vastly, if not entirely, different. On the one hand are the differences in the cultural contexts, the post-colonial evolution of institutional arrangements, the widespread illiteracy (not merely scientific), the gender inequality, and the rich traditional and civilizational knowledge systems that many of these countries possess; on the other are the globalisation process (dictated by the new global trade regimes under the WTO) into which nations have been pushed, and the computerised information highways that remain inaccessible to the vast majority in this region of the world – the new have-nots.

At another level are the various technology denial regimes of the West which do not allow access to leading edge technologies from the developing countries. The spin-off technologies of yester-year (products as well as their know-how and know-why) were as controlled as today’s dual-use technologies are. In that sense, defence spending in the developing part of the world, whatever its value, never led innovation or technology diffusion the way it did in the USA or elsewhere. So this issue of military to civil conversion is only of limited value from the perspective of developing countries.

Moreover, developing countries are far from homogeneous. While countries like India, Brazil, China and South Africa may have the capacity to establish appropriate S&T strategies and implement
them, there are many which lack the basic infrastructure to support an S&T-led development.

These considerations imply that any new science-society contract for the developing world has to be predicated on different concepts. Dr Kazancigil urged that developing countries, as a whole, should make their approach visible in the elaboration of the new social contract. For example, he pointed out, one of the rallying points could be the concept of sustainability itself, which has different meanings in the ‘North’ and the ‘South’: the contract should take into account these differences. The Bangalore Symposium aimed to address the various issues from this perspective and lay the basis for a new science-society contract that incorporates the concerns and aspirations of developing countries.

It may be pertinent to add here that, as pointed out by the eminent agricultural scientist Dr M.S. Swaminathan at the Symposium, the UN system has been seized of the problem of translating the advances in S&T into benefits for the societies of the developing world for the last two decades or so. Accordingly it has constituted commissions and panels to advise on how to bridge the gap between developed and developing countries in technology development and its application. In 1979, an Intergovernmental Advisory Committee on Science and Development proposed what was called the Vienna Plan of Action. According to Dr Swaminathan one of the chief
recommendations of this Plan was 'technology blending' that would enable developing countries to absorb modern technologies and adapt them to the varying social and cultural contexts of nations so that their endogenous capacities get strengthened. Aware of the fact that things were only going to become worse and international funding was not going to be available, the Committee had asked for a 'minimum amount' of about $12-15 m to implement the plan, but even this minimum sum never came.

Ten years later, a panel of eminent persons convened by the UN Secretary-General issued a statement under the aegis of the UN Centre for Science and Technology Development reinstating the Vienna Action Plan (Appendix VI). Not much seems to have come out of that statement either. Now, ten years hence, under a new world order of globalisation, with a diminished role for the state and public institutions, the same issues are being debated, but on a larger scale involving the world scientific community. He hoped that WCS at Budapest would make a difference, and that the processes of science and the generation of technology, which today derive their direction and agenda from the developed nations, get sensitized to the concerns of the developing world.

When one speaks of the science-society interface, there are both forward linkages – the technology innovation and production chain and the consequent process of diffusion, and the backward linkages – literacy, science education, public awareness, the mass media and the use of innovations in science itself to further these.
While the deliberations at the Bangalore Symposium did span a good deal of this multidimensional linkage space, the science-government linkage and the instruments of state policy for the diffusion of science in society received less attention. Other factors notwithstanding, the failure of diffusion even within the framework of the Bush model can often be traced to inappropriate policy frameworks in the socio-economic sectors, including such aspects as industrial, fiscal, trade, health and education policies. As the examples of Japan and other newly industrialising countries of South East Asia have shown, appropriate state guidance and intervention through policy instruments can make a substantial difference to the manner in which S&T impacts the nation.

THE BANGALORE DISCOURSE
Science, however one may define it, is a knowledge system built upon universal principles. Indeed, one of the issues which came up repeatedly for discussion at the Symposium was “What is science?” Terms such as ‘parallel’, ‘indigenous’ and ‘civilizational’ knowledge systems kept cropping up. While there may be no pre-ordained definition of science, the elements of science – the various disciplines and discoveries therein – are established through a widely accepted ‘methodology of science’ whose cornerstones are observation, verification, repeatability, hypothesis-making, theorization and a formal and universally valid structure based on a minimum set of universal laws or principles. Nothing in this approach prevents the other forms of knowledge
from being co-opted in what is generally called science.

Historically, science – irrespective of discipline – has advanced on the basis of a mechanistic and reductionist paradigm. One seems to be inevitably led to this approach if one desires the universality implied in the italicised part above. The manner of application of this ‘universal’ science, in the form of technologies and products, brings in the society for which the application is meant. What definitely are not universal are the modes of science-society linkages which involve complex interactions among science, technology, economics, culture and politics, the last three varying from country to country. An important component in this interface is the support for capacity building in S&T, which again would vary, in the form of education infrastructure, S&T policy making etc. The science-government-industry interface is what determines what diffuses into society, and, as Dr. Kazancigil emphasised, decision making here should take place through open democratic debate. In this sense, therefore, science (taken to include both the process and products of science – technologies – as well) has both an exogenous and endogenous character.

However, given the historical basis of the formation of modern nation states, as products of colonialism, science in the developing world has tended to be predominantly, if not wholly, exogenous in character so much so that very often technologies are merely transplanted from the developed nations, call it the ‘West’ or the ‘North’. These, more often than not, are rendered irrelevant. This
has resulted not only in an unsustainable dependency on the West for technologies but also a vulnerability when that flow of technologies is prevented for politico-strategic reasons. This post-colonial legacy of the West-driven S&T system that obtains in countries like India has had another important consequence. It has suppressed the endogenous aspects not only of the application of science but even of the process of science itself. The latter has been largely, if not entirely, displaced by modern or 'Western' science.

As a result of the long neglect of these forms of knowledge from different cultures, mainstream science has failed to draw and assimilate elements from these traditional knowledge systems, like the Indian Ayurveda or traditional farming and water harvesting methods. There is, however, an increasing realisation today that there is an imperative need for scientific pluralism. These ‘other knowledge systems’ or ‘indigenous knowledge systems’ have to be given their due place and value in the society, especially at a time when, as was pointed by Dr Anil Kakodkar, President of the Indian National Academy of Engineering (INAE), in his address, the process of globalisation is threatening to appropriate elements of this collective knowledge of societies into proprietary knowledge for the commercial profit of a few.

Given this perspective, one of the main thrusts in the Symposium was to articulate facets of science-society interface that would help consolidate, strengthen and bring to the forefront of societal
development the endogenous aspects of knowledge and integrate them into modern science while at the same time maximising the benefits of the latter as well.

The important themes of discussion at the Symposium included:

- Science and Civilization
- Environment, Bio-Diversity and Development
- Science and Basic Human Needs
- Promotion of Science Education
- Implications of Globalisation for Science
- Science Expertise and International Negotiations

The other science-society linkages discussed were:

- Science, Knowledge and Industry as Public Good
- New Mechanisms for Funding of Science
- Gender Equity in Science
- Science and Ethics
- Beyond Science: Other Forms of Knowledge

The inaugural session and the discussion on *Science-Society Linkages* broadly set the stage for the thematic discussions that followed.

**Science-Society Linkages**

Even though the details and specifics of responses to the changing science-society linkages in the West may not be of immediate relevance to developing societies, their broad contours do offer
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lessons to draw from. Providing what he called "an anthropologist's perspective", Prof Michael Fischer outlined the evolving new contract in the US and its experiences. While the question of involving social science and humanities in the natural sciences was addressed 50 years ago in the US, it has assumed new relevance in view of developments and transformations in science itself, he said.

According to him, there are four different levels of concerns, all of which require various levels of cultural and social analysis: national level nation-state strategic policy planning, the organization of different sciences, the place of universities and training institutions, and cultural imaginaries. There was, he observed, an overall shift in the relative positions of different sciences – physics, computer sciences and biology – today. Till now the university had been perceived as a place where the culture of the nation-state is enshrined. While the role of universities remained central, their orientations needed to change, he felt. "Universities of the present should be the place where experiments of different systems are brought together", he said. The laying of a certain social basis to the pursuit of science was happening by widening the curriculum base in institutions like his own (MIT), to give rise to what he termed "the post-modern engineer of the contemporary era".

At another level, he pointed to the practice of science shifting from academic institutions to commercial enterprises, from
government centres to transnational corporations, from hitherto separated-from-the-market research to market and patent-protected research, from individual credit giving way to dispersed and commercialised knowledge, from government regulation to social movements (like environmental sciences entering the public sphere). Industrial processes today not only produce wealth but also carry risks perceived only by sophisticated instrumentation, and this called for inputs from various sectors/disciplines to avoid associated risks.

This tendency towards instrumentalisation of science towards the market was also emphasised by Dr Kazancigil as a development that the new contract has to recognise as undesirable. For, it has led, on the one hand to ‘global competitiveness and the consequent shrinking of state intervention and reduced public funding, and, on the other, restricted access to information, data and results arising from commercial interests.’ This has also imposed a certain ‘short-termism’. Good science, however, requires long-term or medium-term vision which comes with open science. ‘Science as public good is increasingly at threat,’ he pointed out.

Talking about the changes that were occurring in the larger global context, Prof Fischer said that S&T has often been thought of as a structure with a centre and a periphery “mapped out with certain statistical indices”. The existing mode of this centre-periphery interaction, with centre being dominated by the West, has been
such that experiments done at the periphery have to be repeated and validated at the metropole. There is now pressure towards new forms of institution to link mainstream science and development to alternate knowledge systems and cultural geneologies as well as to the larger polity. This aspect, which he referred to as ‘cultural imaginaries’, was the most challenging for the new contract.

Prof Roddam Narasimha, who spoke on science, technology and society, emphasized that it was necessary to keep in mind the distinction between science and technology. When the title of the Symposium refers to Science in Society, is technology deliberately left out or is it subsumed in ‘science’? A frequent reply to such questions is that science includes technology (and sometimes engineering as well), but a careful reading of the Draft Declaration would show that one could not read or add technology wherever the word science appears. It was important to realize that knowledge in science and in technology cannot and would not be propagated in the same way. Unless this distinction was kept in mind he feared that the Declaration, as worded in the draft, would lead to considerable confusion and disagreement. Prof Narasimha noted that although science and technology were not identical, a strong alliance between them was essential for the progress of either. Indeed he considered that it was the development of such an alliance that was responsible for the scientific and industrial revolutions that swept Europe from the 18th century: till about the beginning of the 19th century Asia had
a positive balance of trade with Europe, and manufactured goods had contributed significantly to this positive balance, but the industrial revolution changed the situation. In reply to a comment by Prof R K Kochhar he agreed that unfavourable economic conditions of this kind could have been one of the major forces that drove the industrial revolution in Europe. Developing societies had to recognize the importance of making a strong science-technology alliance. Although pioneers like the distinguished chemist Sir P C Ray had laid the foundations for such an alliance in India early in the 20th century, it was only towards the end of the century that the alliance was beginning to develop vigorously, especially in the larger public sector technology projects.

**Science and Civilization**

In recent times there has been an economic and political shift towards the South. The consequences of this shift of the ‘civilizational axis’ of the world towards Asia, including production and manufacturing, are likely to be significant for the two information sciences – computer sciences and biotechnology, according to Dr Susantha Goonatilake of the Buddhist Institute in Phnom Penh, Cambodia. He cited the examples of the human genome project and the Hubble space telescope which are producing huge amounts of data whose handling is going to be fully automated and for which he believed the enormous technical computational skills of the Asian region will need to be tapped.
Science, he said, is a civilizational construct. While the Southward shift he foresaw is a modern example of the interrelationship between science and civilization, he regarded mathematical and computational skills as a civilizational attribute. Science had in the past flowered in the Western context with the influence of such ‘civilizational knowledge’ (which Dr Goonatilake sought to distinguish from indigenous knowledge) from these parts of the world. In the recent past the input of psychological knowledge from the East has migrated into medical knowledge in textbooks, for example. Following Benson’s study on transcendental meditation, the National Institutes of Health of the US, refused in 1984 to fund studies on Freud, but instead recommended studies on Yoga, Upasana techniques, the Tibetan system of medicine etc. Dr Goonatilake pointed to the growing opinion, as was evidenced in the Vienna Conference two years ago on “Emerging Issues in General Evolutionary Thought”, that the existing apparatus of evolutionary thinking is not sufficient and new approaches from alternative philosophies would be required. He predicted that knowledge in the next century is not going to be Eurocentric.

Modern science seems to be a Western cultural expression. From another perspective, therefore, when we talk of science, civilizational knowledge in the sense of traditional knowledge systems is hardly taken note of; still less is there a systematic study of these to broaden the framework of science and include non-western knowledge systems. “Monoculture in the domain of
knowledge systems limits civilizational options, and cultural diversity is essential for civilizational evolution. Destroying cultural identity is already having the same impact as the loss of biodiversity, remarked Dr Darshan Shankar of Foundation for Revitalization of Local Health Traditions, Bangalore.

Traditional medicine, like Ayurveda, is one such discipline where contemporary contributions may be of value particularly in conditions not treatable by modern medicine, such as for example Retinitis Pigmentosa, a degenerative disease of the eye, nervous and muscular disorders, and even cancer. India has 60,000 traditional bone-setters whose competence ranges from primary management of dislocations and simple fractures to open-wound compound fractures. For example, these bone setters have a very simple non-surgical method to cure club foot with herbal oil which softens the tissue. According to modern orthopaedics in the country, 60 per cent of broken bones are still managed by traditional bone-setters. Similar is the dai tradition, the traditional birth attendants (TBAs) who number about 700,000 at present and manage 90 per cent of village deliveries. The WHO has helped to revitalise this dai tradition. Dr Shankar pointed out that unfortunately present family welfare programmes in India tend to focus on the weaknesses of TBAs rather than documenting and building upon their strengths. The traditional medicine industry manufactures 350-400 herbal, herbo-mineral and animal products for managing a wide range of health problems in the country. In the oral tradition, a very large number of species and as many as 10,000
herbal medicinal products are known, and a detailed understanding of these plants and their properties also exists. Clearly, these knowledge systems are vital for a developing society like India where the modern health care system does not have the requisite resources to cope with the magnitude of health problems across the country. As Dr Shankar emphasised, there is a need for foundational linkages between modern science and traditional knowledge systems. New forms of international cooperation in 'knowledge exchange' can be most beneficial.

Rigorously conducted animal and clinical trials at the KEM Hospital, Mumbai have recently demonstrated the therapeutic effects of some herbal extracts detailed in the Ayurveda (Appendix VII). A validation of the civilizational and traditional systems of knowledge using the methodology of science – like the above KEM Hospital experiment – is essential for their integration into modern science and a 'knowledge exchange' internationally. Such an approach should form an important component of the new science-society contract.

While some hold the view that such validation is itself centred on Western science and therefore not an entirely correct procedure, there is inherent in this line of argument a Catch-22 situation which does not contribute to advancing the cause of the other forms of knowledge. What is, however, more important from the perspective of evolving such ‘knowledge exchanges’ is to first ensure protection of IPR for these other knowledge systems.
Unfortunately, the TRIPS agreement of the WTO makes no distinction between this knowledge, which has been evolved by societies over centuries, and the inventions of modern science (Appendix VIII). The new social contract must demand an amendment of these articles to give due protection to such knowledge bases.

**Environment, Bio-Diversity and Development**

Ecosystems are complex systems whose properties cannot be described by a small number of parameters. There are a multiplicity of pathways for a given ecological effect of interest and every manifestation of the system is significantly different. The methodology of formal or codified science can successfully investigate only simple systems whose behaviour can be adequately described by a small number of parameters. Therefore, it is only the experience of past behaviour, i.e. ecological history, that can provide important clues to the identification of key parameters. The science of ecology thus cannot have universal generalisations of applied value, and practical management of ecology is best done on a case by case basis with empirical data from history providing key information.

In the nineteen fifties aquatic farming techniques based on mathematical models were propagated in the Atlantic for sustainable fish yields. But today the fisheries of the Atlantic stand overexploited. So-called scientific prescription with no historical ecological data has very little value for management. Such historical information
lies with people who have no formal training in science and no role in formal scientific endeavour. Herein lies another knowledge system which needs to be recognised, with people made partners in the new science-society contract.

‘Practical ecological knowledge’ is how Prof Madhav Gadgil of the Indian Institute of Science (IISc), Bangalore, described the knowledge system of the people intimately dependent on nature for livelihoods, having a much greater stake in the understanding of nature and in treating it with prudence. As an example, he described the case of harvesting of *Phyllanthus Emitya* (Amla) in the Biligiri Rangana Betta Hills of Karnataka, where the Sholiga tribes live. The fruit of *Phyllanthus* was heavily harvested for its medicinal qualities from this region and regeneration of the species had gone down. Ecologists felt that it was heavy and indiscriminate harvesting that led to the problem and then worked out a complicated statistical method of harvesting with stratified random sampling. The tribals, however maintained that the level of harvesting was irrelevant for regeneration. They wanted the authorities to allow them to light fires in the forest. First, the forest officers, typical of the prevalent attitudes, treated such knowledge with disdain. But when after three years of the statistical experiment regeneration did not improve, they followed the tribals’ advice and regeneration was found to improve.

In a new social contract for science, such people must be given a greater role in managing and monitoring resources. The Kerala
Shastra Sahitya Parishad’s 25 years of experience has shown how to involve people. Dr Gadgil called for a Panchayat level resource mapping and peoples’ biodiversity registers. This should form the basis for a cooperative endeavour of the people of the ecosystem, students and teachers and scientists for providing inputs to planners, administrators and decision makers.

In a similar vein, Dr Pramod Parajuli of Oregon, USA, who looked at the issue of environment, ecology and development from an anthropological perspective, pointed out that the claim of universality of a knowledge system has the effect of being monopolistic and dominating. Knowledge has a locality and contextuality, he said. He saw social movements as a knowledge generating process which emphasised the learning process as well. As a result of such movements, people have now learnt to say not only “we do not want this” but also “we want this”. Social movements, he said, had the effect of resurrecting submerged knowledge systems. He referred to the Subarnarekha Dam Project where the social movement had the effect of recharging traditional knowledge of alternative irrigation systems.

Social movements, he believed, were the outcome of the global movement of capital in the regime of globalisation. This, he said, caused an uneven articulation between industrialised economies and non-industrialised ones. This had the consequence of sharpening the north-south, rural-urban and inter-generational divides, and the resultant crises (of nature, of social justice, of survival, of knowledge
and identity and of governance and political autonomy) have often lead to responses in the form of social movements.

Technology Development and Poverty Elimination

The sociologist's perspective of the failure of purely S&T-based development to eliminate poverty through the assumed mode of a linear filter-down principle was driven home once again in this session. Prof. Yogesh Atal pointed out how fifty years of technology development had failed in overcoming "society deficits" and in the delivery of societal services, a fact that was acknowledged in the World Summit on Human Development in 1995 in Copenhagen. "The age of simple prescriptions and simple clinical solutions is over," he said. He emphasised that the technologists' view of the potential of technology to solve all problems needed to be questioned. Pointing out that till now only the social impact of a technology was discussed and never the society's response to such a technology, he stressed the need to address the aspect of "social desirability" of a technology before deploying it. He sought to differentiate between technology development and use of technology, the latter demanding a culture-specific solution; there was no single model for development. For example, he said, responses to technology in the North (in the form of high consumption) had created problems for the South.

From the specific perspective of eliminating poverty, the fact that both the developed and developing countries had poverty implied
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that there were other factors promoting poverty. For example, the relationship between literacy and poverty is not a straightforward one. While there were only 800 million illiterate, the number of poor is rising at the rate of 12-13 per cent and today it stood at 1.3 billion. There were several indicators of poverty and there were different kinds of poor; therefore, a single strategy of using S&T for poverty elimination cannot work, he pointed out. The techno-solutions had to be anthropologically and culturally located thus calling for studies on anthropological and cultural responses to technological development as part of the new contract.

The technology-led model of development had only resulted in a proliferation of institutions and bureaucracy in the third world in which people had no role in decision making. Making this point, Mr Anil Bhattarai of Nepal said: “The ideas came from outside and not from among themselves resulting in the erosion of traditional knowledge. Technological development began with good intentions but the institutions that came up created a negative effect because they did not leave any democratic space,” he said, emphasising the important role that the NGOs have acquired as a result. This also reiterated Prof Alagh’s point above evolving new institutional mechanisms to deliver basic human needs.

To deconstruct the existing mechanisms and construct new ones in a new social contract for science, it is important to know the
profile of poverty in a developing country where technology has been deployed. Prof Zeqi Qiu, of the University of Peking (PRC), provided that important perspective based on a study he had carried out, in 1996, of poverty in China. According to him, the gap between the rich and the poor had widened greatly in the last ten years. The profile of the poor in rural and urban China was substantially different and in a country where government intervention is even less the situation would be worse. In China the proportion of urban poor in 1996 was 3 per cent while that of rural poor was 7.1 per cent. Over the last ten years, the poor in urban China had grown by a factor of 12 while in rural China, the number had grown by a factor of 58. Rural poor were concentrated where there was a shortage of resources (like dry areas), and in regions which were technologically underdeveloped and largely belonged to minority communities. The urban poor, on the other hand, were from the working class; statistically speaking the average 3.7 person family required at least two people to be employed for it to be above poverty.

The beneficiaries of technology development in recent times have only been technology investors, Prof Qiu emphasised. For, technology required for poverty alleviation is low-end and can never be a profitable commercial venture. He believed that properly directed technology programmes such as food preservation techniques or use of information technology as training tools can help remove poverty. While in China, government programmes have been instrumental in poverty
alleviation, in other countries the agencies have to be different, he felt, because even in China the government alone was not adequate to carry out the task and the role of NGOs, scientists and others was becoming important.

Science and Basic Human Needs
Apart from the failure of the prevailing models of S&T-based development and current institutional mechanisms in delivering “basic human needs” of food, shelter, education and employment in a sustainable fashion to the people of the developing world, the strategies advocated by scientists, on the one hand, and social scientists, on the other, have failed to find common ground. The scientists seem to feel that the failure lies in the instruments of policy of a given nation state that fail to make the best use of what modern science has to offer. Social scientists reject this approach altogether and favour a decentralised mode of development where traditional and localised knowledge systems and a holistic approach to the problems, that is inherent in such traditional approaches, assume importance.

The typical scientist’s view of things was evidenced in the presentation of Prof G Padmanaban, a reputed molecular biologist and the former Director of the Indian Institute of Science, Bangalore. From a biologist’s perspective he felt that modern biotechnology offered enormous possibilities to alleviate human suffering in developing countries. In meeting the basic needs of health, two applications of biotechnology were certainly possible
at low cost in developing countries – namely, diagnostics and vaccines. While today’s imported diagnostic kits – which number 637 on a global scale – are unaffordable to the poor of the developing countries, he felt that a joint effort of scientists and the industry had the potential to develop indigenous diagnostic kits for Rs. 10-15. “It is high tech but child’s play today,” he said. Though as many as a dozen kits had been developed in the country, it was the lack of appropriate institution-industry linkages, lack of industry interest and, above all, the societal belief (as a nation) that “imported is superior”.

Production of cheap DNA-vaccines, he said, was a distinctly possible approach for developing countries and these, being highly stable, did not require a cold chain, whose absence was a major cause of loss of potency of vaccines and inefficacy of immunization programmes, in developing countries. Funding from international agencies, such as the UNESCO, he felt, could initiate programmes towards developing new diagnostic kits and vaccines. One of the major problems that one faced, he felt, in putting traditional medicinal knowledge to use is a lack of systematic evaluation, validation and standardization of the number of formulations that are available in the market.

Similarly in the field of agriculture, despite the raging controversies, transgenic technology held great promise to improve productivity, nutritional quality and the use of molecular markers would bring down the breeding time for new varieties. However, he expressed
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cconcern with regard to the emerging intellectual property regime a la WTO which lacked “a human face”. He wanted the new social contract to ensure that the contribution by traditional innovation to biodiversity by “faceless men and women” should be adequately compensated. There was a definite need for major patent holders to evolve special dispensations for the poor of developing countries in making technologies relevant to health and agriculture – although this seemed an unlikely possibility in the current scheme of things under globalisation.

Presenting a case for the other paradigm of sustainable development was Mr Smithu Kothari, who gave examples of ecological regeneration at two different degraded areas in the country – Ralegaon Siddhi in the Ahmednagar District of Maharashtra and Chennakotapalli in Anantpur District of Andhra Pradesh. This was achieved through traditional means which did not prioritize production over sustainable and responsible livelihood but respected the regenerative cycle of nature. Solutions based on the same system had clearly failed. “Growth for the sake of growth is akin to that of a cancer cell,” he said.

In the former case, cultivable land was increased from 50 ha to 1100 ha with assured irrigation and tripling of output. In the case of Anantpur, the country’s second most drought-prone area, the experiment by the Timbuktoo Collective has been able to generate a surplus of fuel wood and food grains, a good vegetative cover and an increase in the soil retention of moisture. These have
enabled a rise in the ground water table from 250 ft to 50 ft. The regeneration has laterally spread and the forest department had given the rights to the Collective.

In both these areas, while meeting the “basic human needs”, the approach had enabled export of materials from the region, promoted self-reliance not restored the ethics of voluntarism. Mr Kothari opined that these examples, which showed a creative effort at building new relationships between institutions and local populations, could be multiplied in large parts of the country. How to make this one of the important paradigms to be included in scientific research under a new social contract is the basic question, he said.

To achieve this, Prof Alagh felt that there was an imperative need to evolve new methods of doing science and new institutional mechanisms. And to forge a new relationship between science and society, given the different ways of thinking of scientists and social scientists, science think tanks and social think tanks should perhaps merge, he said. One such successful grass-root people-institution relationship which has apparently been eminently successful is the Sarvodaya Shramadana Movement in Sri Lanka – an alternative people-centred movement, which has provided models through its various sub-agencies and programmes for the government to adopt in its own programmes of development. One can see echoes of similar movements in India in the past, recently revived in Anna Hazare’s experiment in Ralegaon Siddhi.
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Prof M S Swaminathan had referred to “blending of technologies” in his key-note address which one could describe as an attempt to bring these desirable new elements into scientific research. The tools of modern science like eco-farming including biotechnology, information technology, space technology, renewable energy systems, ecotechnology etc., he felt, should be brought to bear to meet the objectives of science for public good – which would be pro-nature, pro-women, pro-employment and pro-food security.

Integrated gene management (IGM) is a concept that Dr Swaminathan has been trying to propagate to conserve biodiversity. There are three methods of IGM which can be used for the purpose of conservation, depending upon the context (there are in all 19 million species). They are in situ, in situ-on farm and ex situ methods of plant gene conservation. In situ-on farm techniques are now gaining importance, he said. He gave the example of the wheat revolution where the gene deployed was sturdy: carefully assembled genes could be distributed across the country. He pointed to the important role played by the conservation efforts of the farming communities, who were conserving for public good at personal cost. A precautionary package was required to ensure rights to the traditional communities over the varieties this conserved over generations, and to prevent their unfair commercial exploitation. He called for a convention for the plant genome analogous to the one adopted by UNESCO for research on the human genome.
Promotion of Science Education

If one wishes to build a superstructure of science, one must have a proper base in science education. Among the backward linkages of the science-society interface, perhaps the weakest one in the developing countries is that of science education. With illiteracy being high, universality of primary education being a formidable challenge to planners and educationists, the question of scientific literacy and universal “minimum science education” becomes inseparable from the former.

One has this paradoxical situation of formal school science education being far removed from societal needs, ground reality and relevance, on the one hand; and, on the other, of striving to achieve universalisation of education through various policy instrumentalities. Indeed, as Dr Anil Sadgopal of the University of Delhi remarked, “universalisation” can never be achieved by this approach. If science education has to inculcate the spirit of scientific inquiry in young minds, if it has to be made relevant and equitous, what one needs, as Dr Arvind Kumar suggested, is a pluralistic approach with many frameworks and curricula being made available for institutions/groups to choose from, so that science education can be contextualised. Or, it may even be worthwhile to make complete break from the existing formal framework in favour of non-formal methods like the Hoshangabad Science Teaching Programme (HSTP) in Madhya Pradesh (Appendix IX), whose elements and methods can be incorporated into the formal system depending on the context. The real
problem, in his view, was in reforming the entire school system in a non-colonial mode.

Some of the impediments to achieving "equity, excellence and relevance" in science education, which Dr Arvind Kumar highlighted, included language barriers (both natural and artificial), widespread socio-cultural and gender stereo-types, and the cascading effect of poor learning at the primary stage, particularly mathematics, and the overarching disabling factor of grossly inadequate national investment in education itself. A major administrative hurdle, he pointed out, was the centralisation of the process of text book writing; the institutions and NGOs which did produce alternate textbooks and curricula had no statutory authority to implement them.

Drawing on experience from the HSTP, Prof Vijaya Varma of the University of Delhi said that if the aim was to develop a spirit of scientific inquiry it could not be done in the class room alone; given the current system, one will have to "fight for" achieving it. In order to negotiate a suitable curriculum, he said, curricular reforms not only in science but also in other disciplines would be required. The process of reform must be decentralised and must involve teachers in a meaningful fashion so that they have a greater role in management. The need to move away from current examination methods, which only encouraged rote learning, information retrieval and rapid arithmetical calculation; testing of aptitude and ability to think were more important. But
Prof Varma wondered whether a society which lacked the political will to deliver the constitutional promise of universal education was ready to accept such changes.

On the other hand, the non-formal methods themselves have been difficult to expand and replicate because a model for expansion that retains quality has not been easy to agree upon, he emphasised. But what has become clear is that the content of the science curriculum must change. It must emphasise the processes and not the products of science, and allow children to cognise experiences in their own terms in and outside the classroom.

Some of the methods that could be deployed even within the current scheme of things are places like science museums which provide a mechanism for making hands-on experiments and planetaria with programmes conceptualised around folklore and mythologies. The experiences of the Bangalore Planetarium and the Bangalore Association for Science Education according to Prof C Visweshwara of the Indian Institute of Astrophysics (IIA), Bangalore, had been particularly rewarding. Easy-to-do science kits have been particularly popular with children. Their experiment with science for the under-privileged, like hearing-impaired, is an idea which needs to be made widespread. Other methods which need to be popularised and expanded are olympiads, vacation camps etc. Besides the already established programme for national and international mathematics olympiads,
programmes have been started for national olympiads in physics, chemistry etc., by the Homi Bhabha Centre for Science Education, Mumbai.

Implications of Globalisation

The Nineties have witnessed a move towards globalised trade regimes and competitiveness and, as a result, as has been remarked earlier, there is an increasing tendency towards withdrawal of state support and intervention to direct R&D towards social good. Even whatever public good as achievable through the existing mechanisms of innovation and science-society interface is giving way to research spending moving into private spheres. With globalisation, science is increasingly viewed as market good rather than public good. Research agendas are being dictated by short termism and private profit and other instrumentalities of the market, including all-encompassing IPR regimes that bestow proprietary rights even to research findings and data, and such thing as algorithms, databases, gene sequences and genetically engineered life-forms.

As Prof V V Krishna of the Jawaharlal Nehru University (JNU) pointed out, the concept of “science as market good” is bound to have a serious impact on the growth of S&T in developing countries where 70-80 per cent of R&D investment is from public sources. The trend of globalisation and corporatisation of research has had the effect of cutting down of research expenditures in welfare, education, health and other socio-economic sectors. “Developing
countries are getting increasingly entangled in a double bind in responding to market forces, on the one hand, and sustaining research activities directed to public good, on the other. If the East Asian experience is of any relevance, the state must shoulder a major responsibility and intervene to strike a balance until society is able to absorb the shocks generated by the market forces, he observed.

One significant impact of shifting research priorities and increasing commercialisation of knowledge has been a relative loss of the traditional research autonomy besides the emergence of the hybrid research communities mentioned before. The entrepreneurial mode of work is on the rise even within public research institutions and universities, both at the level of the individual scientist and the institution. Reduced state spending has meant a greater need for external earnings through industrial and private consultancy, contract R&D etc., which could reduce the effort in socially relevant areas of research even in public-funded institutions.

With globalisation, there has been an expansion of multinational corporations (MNCs) and an increasing flow of foreign direct investment (FDI) from the developed North to the developing South "influencing the institutions of science and its structure of relevance". Even if there are presumed benefits of such a translocation of R&D by the MNCs, they will come with certain socio-economic costs. This overseas R&D is predominantly of the "adaptive type", geared to local markets and local production capacities. "Targetting local markets in developing countries in
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this manner is not only compounding the challenges for local scientific institutions by gradually taking over the latter’s legitimate role, but is also attracting the best scientific and technical skills leading to a form of ‘internal drain’.

There is also a point of view, exemplified by the presentation of Dr N S Siddharthan of the Institute for Economic Growth (IEG), Delhi, that globalisation could lead to an increase in the export of high-tech goods (the “presumed benefits”). However, even this, according to Dr Siddharthan, could be in the nature of intra-firm trade rather than third party trade. The WTO and the protection of IPRs would in general lead to mere licensing of production rather than technology transfer.

But a facet of gloablisation, which runs counter to the very concept, is the increasing trend towards restricting movements of scientists and free exchange of even basic research-related knowledge and information. “Instrumentalities of geo-techno politics” are now being used to restrict access to research information and data in the name of national security. Dr V Siddhartha of the Defence Research and Development Organisation of the Government of India urged that “universality of science”, as enshrined in the charters of UNESCO and other agencies of the UN, must be reemphasised in the new social contract for science. The charter of the International Council for Science (ICSU) includes a specific statement on the “Universality of Science and Freedom of Pursuit of Science” which its member
countries are required to adhere to. Therefore, the increasingly frequent violation of this spirit by Western governments needs to be reversed through new commitments of the world scientific community towards the global society.

**Scientific Expertise and International Negotiations**

From yet another perspective, Dr G Thyagarajan, the scientific secretary of COSTED, voiced similar concerns with regard to some disturbing recent developments that seek to restrict free flow of information and prevent international cooperation in basic research, which he felt posed a serious threat to the integrity of science. He referred to the increasing reticence in publishing research papers in biological and material sciences which may have technological implications in the long run. The simplistic paradigm of basic research through applied research to technology, in which basic research findings were in the realm of public knowledge, no longer applies as the dividing line between basic research and applied research has got blurred. For example, the mere functional identification of a gene sequence today has immense commercial value.

A related issue is the multitude of laws that today govern the various kinds of IPR. There are already 14 such laws, and last year there was a move to push through a ‘Database Treaty’ that seeks IPRs even over databases, which will have serious implications to the conduct of research itself. All sorts of compilations of datasets that have traditionally been in the public
domain for lack of sufficient originality (to make them copyrightable) will now, under the proposed treaty, be protected against unauthorised use. Thus, databases that have only investment of time, money and effort, but no intellectual input, will now qualify for a new IPR beyond copyright.

This could have the implication that information needed for research and teaching could get restricted. There have been repeated attempts to push it under the aegis of WIPO. In September 1997 it was rejected because of a strong stand taken by the US National Academy of Sciences and ICSU. But now that the EC has passed a similar law, it is feared that the proposal may rear its head again. And this development is symptomatic of the emerging trend consequent to trade liberalisation and globalisation. An important aspect of this trend, that is, of concern, is that people who do not understand the process of science have begun to take control of science and are taking decisions, pointed out Dr Thyagarajan. He wanted that the national and global science agencies should go on the offensive against such trends in international fora like the forthcoming WCS. Otherwise, he said, the results could be very damaging to the intellectual level of a nation, to capacity building and to the capacity of industrial innovation of developing countries.

The number of international laws and regimes of trade seems to be ever growing: besides the above, we now have labour and environmental standards all of which are not only technical but
also have very complex legal formulations. To take part in these multilateral negotiations so that developing countries' interests are not bartered away, now requires multidisciplinary expertise, not mere technical knowledge; but increasingly bureaucrats are handling these matters and are undermining the country's interests, felt Dr Arun Ghosh, an economist and a former member of the Planning Commission.

He voiced particular concern with regard to the IPR regime in the area of biotechnology. Patenting of life-forms poses the biggest problem. He pointed out that all the articles of the TRIPS that govern the patenting of life-forms run counter to the UN Convention on the Conservation of Biodiversity (AppendixX). All the thrust of the developed countries through the WTO and its diverse agreements is one towards covert imperialism, Dr Ghosh warned. All these called for a multidisciplinary understanding even for the scientific community, and the new social contract for science, he said, should envision a proactive role for the scientific community in suggesting agendas through new forms of institutional mechanisms that can counter such harmful developments.

The session on Gender Equity in Science produced debates, from which it appeared that the vigorous discrimination and problems faced by women in the conduct of science are related to the gender bias that obtained socially in the country. This larger social issue, which of course needs to be tackled at all levels,
including within scientific institutions, does, of course, reflect in the attitudes of males within the system towards women scientists. The number of women one comes across at the top echelons of science administration – directors of laboratories, members of scientific advisory bodies etc. – is still extremely low.

With regard to Ethics in Science, what emerged was that there are many ethical frameworks in the major civilizations of the world other than the West. The new social contract must recognise that there may be slightly different perceptions with regard to an ethical framework in an all encompassing discourse on ethics in science.

ON TO BUDAPEST

The Bangalore Communique (Appendix II) captures the essence of the discussions elaborated in some detail in this report and encapsulates what needs to be articulated in a world forum like the WCS so that the concerns of developing countries get heard and are given due place in future practice of science and modes of development.
# List of Speakers (India)

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# List of Speakers (International)

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APPENDIX II

THE BANGALORE COMMUNIQUÉ

THE DELEGATES OF THE
INTERNATIONAL SYMPOSIUM ON

SCIENCE IN SOCIETY:
A NEW SOCIAL CONTRACT

Organized by the National Institute of Advanced Studies, Bangalore, India, under the auspices of the United Nations Educational, Scientific and Cultural Organization and the Departments of Science and Technology, and Education, Government of India,

Having met in Bangalore from 27 to 29 January 1999, with the aim of assessing the potential rôle of science and technology in improving the quality of human life everywhere in the world, and particularly in the developing countries, in the coming millennium, and

Recognizing
• that food, security, shelter, access to quality health care and to education and knowledge skills are the cornerstones of development,
• that the developing countries possess an untapped wealth of human resources,
• that the empowerment of women and the protection of the young hold the key to population stabilization, healthy families and collective prosperity,
• that the majority of people everywhere express themselves effectively and creatively in their own culture, ethos and language,
• that prevailing concepts of community and sharing among many indigenous cultures are in conflict with the present regime of monetised intellectual property rights,
• that the nurturing of open societies and the elimination of existing gross inequalities in wealth, power and status are essential for the long-term stability of human civilization,
A Report

• that the ability to assimilate any new technology is not uniform across, and even within, cultures,

• that developing countries are caught in a cycle of poverty and dependence which they can break through radical social and economic transformation, strong political will and the appropriate use of science and technology.

Proclaim the principles that follow and adopt the present Communiqué.

SCIENCE WITH A HUMAN FACE
1. Science, in the coming millennium, should be recognized as a multidisciplinary enterprise and interpreted to subsume the natural sciences, social sciences, and technological sciences, including engineering and medicine.

2. All the nations of the world are urged to unite in a common vision of our collective future and commit themselves to the use of knowledge derived from the natural, social, and technological sciences to address basic human needs, improve the quality of life for all the citizens of this world, and generate a healthy environment for present and future generations.

3. All national governments and parliaments should fund and promote scientific research to the best of their economic abilities and use the knowledge gained from such endeavours to address important global problems, including those of social and economic inequalities, poverty, social injustice, inadequate health care and education, and environmental degradation.

4. Fragmentation of traditional societies under the influence of certain existing techno-economic regimes have to be checked, and technologies with a human face developed where life values are as much respected as are functional aspects.

5. Appropriate technology drawn from modern scientific advancement, and indigenous and civilizational knowledge systems, must both be incorporated into microplanning programmes for alleviation of poverty by governments at the national level, and international cooperation promoted to enable developing nations to develop and utilize such technology to enhance the quality of life.

6. There is an urgent necessity for careful social impact studies during implementation of development projects, which would facilitate the
aiding of displaced populations to avoid downward mobility and degradation in the quality of life.

SCIENCE AS A KNOWLEDGE SYSTEM
7. It must be recognized that indigenous and civilizational knowledge systems, which evolved in different civilizations, led to distinctive worldviews and effected the emergence of diverse systems of social structure and governance.

8. Modern forms of knowledge must not be allowed blindly to marginalise the more indigenous knowledge systems, and dialogues between these systems should be promoted in order to arrive at the most appropriate pathways of sustainable development and consumption, thus opening up new relationships between people, science and society.

9. Modern applied scientific research should take account of indigenous and civilizational knowledge systems to enhance our understanding of social problems and to effectively draw upon such knowledge systems to promote the social and economic welfare of the local populations and for better management of the natural resources of the area.

10. There is a clear need for systematic and in-depth analysis of the parallelism of insights between indigenous and civilizational knowledge systems, on the one hand, and certain areas of modern science concerned with fundamental aspects, on the other.

11. In the face of increasingly rapid social transformation and globalization, modern scientific methodologies have to be harnessed to exploring existing indigenous and civilizational knowledge systems to ensure the survival, protection and propagation of the cultural heritage and diversity of all peoples across the world.

EQUITY IN SCIENCE
12. Inequalities and inequities having been created among nations and within nations as a result of exploitative forces in cultures, the international society at large is called upon to participate in the creation of a more equitable, prosperous and sustainable world.

13. Developing nations should harness available scientific knowledge and technological skills to meet the challenge of sustainable development whereby the economic and social needs of all peoples are met without compromising on the maintenance of a healthy environment and the conservation of vital natural resources.
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14. Developed nations, which account for the bulk of the global consumption of the earth's natural resources and the damage caused to the environment by human activities, are called upon to recognize and practise sustainable consumption of such resources.

15. Global economic institutions must provide incentives for widespread diffusion of institutions which have demonstrated capabilities of sustainable development in different agro-economic regions with artisan-based industry and culture-backed services linked with larger markets.

16. Concerns for intellectual property rights should not be allowed to exploit the various forms of indigenous and civilizational knowledge so faithfully preserved by indigenous populations over millennia, care being taken to ensure that the benefits derived from such biological and intellectual resources are not misappropriated.

17. A firm commitment should be made to the principle of equity in sharing benefits from existing indigenous knowledge and the biodiversity conservation ethics of rural and tribal communities with active support being given to initiatives like that of the World Intellectual Property Organization in developing and rewarding indigenous knowledge and traditional technologies.

ACCESS TO SCIENCE

18. Access to scientific knowledge and technological skills are a fundamental right of every citizen of the world as is the right to education.

19. The problems of privatization and monopolization of science, and that of proprietary knowledge, should not lead to the denial of benefits of technological innovations in the areas of food and health security to the economically and socially under-privileged sections of society everywhere.

20. There is a need to ensure that concerns for intellectual property rights do not end up as a mechanism for building newer forms of knowledge monopolies.

SCIENCE AND EMPOWERMENT

21. Information empowerment for people has to be effectively realized through the development of accessible data bases which inform people about their rights and entitlements, and other such programmes that are need-based rather than globalized, demand-
driven rather than supply-driven, and locale-specific rather than generic.

22. Dissemination of appropriate information must be carried out and new social fora established to enable proper public participation and debate in ethics and policy decision-making processes.

23. Scientific knowledge derived from the natural and social sciences have to be applied to reduce gender imbalances, particularly for working women where time spent in work has to be reduced but the value added to such labour enhanced significantly.

24. Opportunities for women in the areas of primary and higher education, health care and health education, as well as vocational training need to be developed and strengthened.

COOPERATION IN SCIENCE

25. Scientific capacity should be built up, particularly in the developing countries, through training programmes, cooperative networks and other interactions between universities, government-funded research institutions and industry, which would involve natural and social scientists as well as technologists.

26. Communication, cooperation and information linkages have to be built up between the scientific community, on the one hand, and decision-makers from the productive sectors, on the other, so that better focussed applied research programmes can be executed and results obtained from such programmes incorporated more successfully into policy-making.

27. Funding and support for scientific research at the national level needs to strike an effective balance between the public and private sectors so that there is absolutely no compromise on social welfare programmes and other forms of public good.

28. International cooperation in fields such as information technology, particularly among developing countries, must be promoted so that technologies and research experiences can be shared.

SCIENCE EDUCATION

29. Formal and non-formal education programmes directed towards promoting basic education in general and scientific literacy in particular need to be developed and executed at all levels and for people of all ages.
30. Attempts should be made to introduce and internalize the methods of science and scientific culture within the school system.

31. Social perceptions of science have to be recognized, comprehended and documented, while scientific culture is spread within the society.

32. There is an urgent need to reorient the education system in most developing countries to provide scientific knowledge in forms that are compatible with the cultural ethos of that particular society.

33. Programmes should be initiated and public policies declared, with the full support of international agencies, to allow the contextualisation of formal educational systems within different social frameworks.

34. Public awareness about the nature and applications of scientific research, particularly for public good, has to be promoted through cooperative activities directed towards major groups such as youth, women, indigenous populations, the media, as well as appropriate governmental and non-governmental organizations.

SCIENCE IN THE NEXT MILLENNIUM

35. Our future lies in eco-technologies, involving appropriate blends of traditional wisdom and modern science, which should be able to overcome some of the serious deficiencies in contemporary developmental pathways such as the rich-poor divide, gender inequity, unemployment and environmental damage.

36. Biosphere reserves need to be set up in different climatic zones and ecosystems of the world where modern scientific knowledge and traditional knowledge derived from the indigenous peoples inhabiting these areas can be integrated and harnessed to conserve biological diversity and better manage natural resources.

37. Agricultural research has to be promoted at various levels and proper distribution systems applied successfully to ensure basic food security for every citizen of the world.

38. Meteorological and hydrological research should be actively supported to understand the relationship between climatic changes, variability in weather conditions, and their hydrological components in order to develop better management strategies for groundwater resources, for overall sustainable water management in tropical arid and semi-arid regions, and thus to substantially enhance the
availability of clean water to rural populations, particularly women, in developing countries.

39. Socially appropriate, economically viable and environmentally sound construction materials should be developed and used for housing of homeless people across the world.

40. Basic and applied scientific research on renewable energy resources has to be promoted to provide clean energy and thus improve the socio-economic conditions of millions of rural people, particularly women, in developing countries.

41. Global research must be initiated to assess and protect the health of the world’s oceans, marine life, and coastal environments, and develop ecologically-conscious national programmes to harvest marine resources on a sustainable basis.

42. The power to manipulate the very blueprints of life, provided by the modern advances in recombinant DNA technology, must be used with caution and with a strong sense of ethics and equity.

**PLAN OF ACTION**

The delegates of the symposium, hereby

**Recognizing** that UNESCO has the duty of mobilizing and uniting various forms of international action,

**Suggest** a Plan of Action for inclusion in “Science Agenda: Framework of Action”, to be adopted at the World Conference on Science, Budapest, June 1999, whereby the member-countries of UNESCO are called upon to

1. Establish an International Initiative for the Conservation and Promotion of Indigenous and Civilizational Knowledge Systems, to enable the member-states to recognize, protect, and promote such knowledge systems.

2. Design a series of projects that would recognize the range of influence and economic value of technologies either residing in indigenous and civilizational knowledge systems or emerging from
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growth-root innovations, and study how best to protect and reward such intellectual property leading to a revised International Convention on Protection of Intellectual Property Rights with special emphasis on Indigenous and Civilizational Knowledge Systems,

3a. Recognize the many philosophical and ethical frameworks in the civilizations of the world other than those in the West, and develop a truly all-encompassing discourse on ethics in science which would necessarily incorporate these frameworks, and thus, in the process,

3b. Draw up an International Code of Ethics for Science and Technology wherein a range of issues including the regulation of knowledge monopolies will be addressed,

4. Prepare an International Convention that would recognize the major socio-economic problems faced by developing nations which lose trained scientists and technicians to the more developed countries, and evolve strategies to compensate for the loss of economic investment in human resources involved in science and technology,

5. Support an International Initiative in the exploration of emerging loci of scientific research in areas other than Europe and North America, and examine the role of the cultural milieus of these regions in the shaping of the sciences in the coming millennium,

6. Sponsor a Programme on Promotion of Scientific Culture Accessible to All,

7. Take suitable initiatives to consciously promote such projects that contribute positively to the integration of the natural and social sciences,

8. Support training programmes for natural and social scientists and for technologists on legal and policy issues, and regulations guiding international research and development in areas such as information and communication technologies, biodiversity conservation and biotechnology,

9. Launch an International Initiative to extend the scope of UNESCO’s Declaration on the Human Genome to include plant genomes so that exclusivity in the control of life processes can be avoided,
10. Draw up a Scheme for promotion of international cooperation to help the developing nations develop and utilize appropriate technology for poverty alleviation, and

11. Prepare an International Convention on Sustainable Consumption, which would lay down guidelines to regulate the utilization of the fast-eroding natural resources on our planet.
Preamble

We have come to recognize that we all live on the same planet and are all part of the biosphere; and that the future of humankind is intrinsically linked to the preservation of the global life-support systems and to the survival of all forms of life. All nations of the world are called upon to acknowledge the urgency of using knowledge from the natural and social sciences to address human needs without indulging in its misuses. Science should be at the service of humanity as a whole, and should contribute to providing a deeper understanding of nature and society, a better quality of life for everyone and a healthy and productive environment for present and future generations.

Steadily improving scientific knowledge on the origin, functions and evolution of the universe and of life provides humankind with conceptual and practical approaches which profoundly influence its conduct and prospects. Scientific knowledge has yielded applications that have been of great benefit to humankind. Life expectancy has strikingly increased, cures are available – or foreseen – for many diseases, and health care has improved dramatically. Agricultural output has risen to meet
population needs, at least in global terms. Technological developments and the exploitation of energy sources have created the capacity for freeing humankind from the most arduous labour. The new communication and information technologies have brought unprecedented opportunities for interaction between peoples and individuals.

However, all these benefits are unequally distributed, and this has widened the gap between industrialized and developing countries. In addition, the applications of scientific advances have also let to environmental degradation and have been a source of social imbalance or exclusion. Scientific and technological progress has also made possible the construction of sophisticated weapons, including atomic, biological and chemical ones, having the potential to destroy life on a mass scale or even put at risk the entire planet. Today, there is an opportunity for fewer resources to be allocated to the development and manufacture of new weapons and for military research facilities to be at least partially converted to civilian use. The United Nations has proclaimed the Year 2000 as the International Year for the Culture of Peace as a step towards a lasting peace between and within countries; science and the scientific community can and should play an essential role in this process.

Today, whilst unprecedented advances in science are foreseen, there is need for a vigorous democratic debate on the ethical, cultural, environmental and economical aspects of the use of scientific knowledge. Enhancing the role of science for a more equitable, prosperous and sustainable world requires a long-term commitment of all stakeholders: governments and parliaments, scientists and engineers, industry, the media, international organizations and society at large. Greater interdisciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with crucial social, economic, cultural, environmental and health issues. It will also require that public trust and support for science be strengthened through a new social contract.

We, participants in the World Conference on “Science for the Twenty-first Century: a New Commitment”, assembled in Budapest, Hungary, from 26 June to 1 July 1999 under the aegis of the United National Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU):

Recognizing that science is a powerful intellectual resource for understanding natural and societal phenomena and that the role of science promise to be even greater in the future, also because of the growing complexity of the interrelationship between society and nature;
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Recognizing that scientific information is indispensable today for decision-makers and for society at large;

Considering that scientific research yields inestimable returns in terms of sustainable development and improvement in the quality of life;

Convinced that science and its applications are a major factor for socio-economic development and that the future of humankind will be more dependent on the production, distribution and use of knowledge than even before;

Acknowledging that scientific issues are largely of a universal nature, know no borders and require international recognition, assessment, coordination and cooperation;

Taking into account the recommendations of major conferences organized by the United Nations system and the meetings associated with the World Conference on Science;

Stressing that access to scientific knowledge is part of the right to education and the right to information belonging to all people; and that science education is essential for human development and for creating endogenous scientific capacity;

Recalling that scientific research and the use of scientific knowledge should respect human rights and the dignity of human beings, and recalling further the relevant articles in the Universal Declaration of Human Rights;

Stressing the need to practice and apply science in line with appropriate ethical requirements;

Emphasizing that the use of scientific knowledge should respect biological diversity, as well as the life-supporting systems of our planet;

Appreciating the importance of traditional and local knowledge and the need to safeguard and make better use of it;

Considering that a new social contract between science and society is necessary to cope with such pressing contemporary problems as poverty, environmental degradation, public health and food security;

Underlining the need for a strong commitment of political, economic and social partners to science, as well as an equally strong commitment of scientists to the well-being of society;
proclaim the following:

1. Science for knowledge; knowledge for progress

1.1 The inherent function of the scientific venture is to carry out a comprehensive questioning of nature leading to new knowledge. It is this new knowledge that provides cultural and intellectual enrichment and leads to the technological advances and benefits stemming from science. Promoting fundamental research is a priority towards achieving endogenous development and progress. There can be no applied science if there is no science to apply.

1.2 Government should give recognition to the key role of scientific research in the acquisition of knowledge, in the training of scientists and the education of the public. Scientific research in the private sector has increased, but cannot be a substitute for public research. The public sector should adequately finance scientific research for long-term goals, especially those that are expected to give rise to applications of social importance.

2. Science for peace

2.1 Governments should be aware of the need to apply natural and social sciences and technology to address the root causes of conflict, such as social inequalities, poverty, lack of justice and democracy, inadequate education for all, insufficient health care and food provision, and environmental degradation. Governments should therefore increase investment in these areas of scientific research.

2.2 Scientific should uphold the principle of full and open access to information; scientific research should be subject to public accountability. The scientific community, sharing a long-standing tradition that transcends the borders of nations, religions or ethnicity, should promote the "intellectual and moral solidarity of humankind", which is the basis of a culture of peace. All nations should facilitate the free circulation of scientists and recognize their constructive cooperation as a valuable contribution to the peaceful development of human civilization.

3. Science and development

3.1 Government and the private sector should provide enhanced support for building up an adequate and well-shared scientific and
technological capacity as an indispensable foundation for economic, social, cultural and environmentally sound development. Technological development requires a solid scientific basis and needs to be resolutely oriented towards cleaner production and more environment friendly products. Investment in science and technology aimed at a better understanding and safeguarding the planet’s threatened life-support system and at integrating the economic, social and environmental objectives of development must be increased in the future.

3.2 Science education at all levels and without discrimination is a fundamental need for ensuring sustainable development. In recent years, world-wide efforts have been initiated to develop and strengthen educational programmes to provide all children, youth and adults with basic education. It is on this platform that science education, communication and popularization need to be built. It is more than ever necessary to develop and expand science literacy with reasoning ability and skills so as to increase public participation in the decision-making process related to the application of new knowledge.

3.3 National strategies and institutional arrangements should be set up to enhance the role of science in development, and in particular: a long-term national policy on science and technology; the creation and maintenance of national authorities for risk assessment, safety and health; and incentives for investment, research and innovation. Parliaments and governments should provide a sound legal, institutional and economic basis for enhancing scientific and technological capacity.

3.4 All countries, and in particular the developing ones, need to strengthen scientific research in higher education and post-graduate programmes. Regional and international co-operation should be used to support scientific capacity building to ensure both equitable development and the spread and utilization of human creativity without discrimination of any kind (sex, ethnicity, etc.). All efforts should be made to create conditions that ensure a marked reduction or reversal in brain-drain.

3.5 Progress in science requires various types of co-operation at the intergovernmental, governmental and non-governmental levels, such as: multilateral projects, fellowships and grants to promote research, particularly in the developing countries; international agreements for the joint funding of megaprojects; international panels for the
evaluation of complex scientific results; and international arrangements for the promotion of post-graduate training. New initiatives are required for interdisciplinary collaboration through national and international research facilities, research networks and targeted projects. Support for international collaborative projects, especially if of global interest, should be significantly increased. Access to these facilities for scientists from developing countries should be facilitated.

3.6 National policies on science and technology should encourage all partners, particularly the private sector, to support scientific research and to develop university-industry co-operation. Whilst intellectual property rights need to be appropriately protected, access to data and information are essential for undertaking scientific work. The development of a universally accepted legal framework is necessary; this should take into account the specific requirements of developing countries with regard to access to scientific information and data.

4. Science in society and science for society

4.1 The practice of scientific research and the use of scientific knowledge should always aim at the welfare of humankind, men and women alike, and be respectful of the dignity of human beings and of their fundamental rights, and take fully into account our responsibility towards future generations; there should be a new commitment in this respect.

4.2 A free flow of information on the possible uses of new discoveries and newly developed technologies should be secured so that ethical issues can be debated in an appropriate way. In each country a suitable mechanism should be established to address the ethics of the use of scientific knowledge and its applications. The World Commission on the Ethics of Scientific Knowledge and Technology can provide a means of interaction in this respect.

4.3 All scientists should commit themselves to high ethical standards. The possible development of a pledge similar to the Hippocratic Oath for all scientific professions should be considered as an expression of this commitment.

4.4 The difficulties encountered by women, as well as by minorities, in entering and pursuing a career in science and in gaining access to decision-making in science and technology should be addressed
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urgently through adequate institutional mechanisms and other appropriate measures. Equality in access to science is not only a social and ethical requirement for human development, but also a necessity for realizing the full potential of scientific communities and to orient scientific progress towards meeting the needs of humankind.

4.5 The social responsibility of scientists implies that they exert a rigorous quality control of their findings, share their knowledge, communicate with the public and educate the younger generation. A free flow of scientific information and open access to it should be guaranteed by parties concerned.

We, Participants in the World Conference on “Science for the Twenty-first Century: a New Commitment”, consider that the Conference document “Science Agenda – Framework for Action” gives practical expression to the new commitment to science, and can serve as a strategic guide for international partnership between all stakeholders in the scientific venture in the years to come.

We commit ourselves to act co-operatively through our own spheres of responsibility to strengthen scientific culture and its peaceful application throughout the world, and to promote the use of scientific knowledge for development, taking into account the societal and ethical principles illustrated above.

We adopt therefore this World Declaration on Science and the Use of Scientific Knowledge and agree upon the Science Agenda – Framework for Action as a means of achieving the goals set forth in the Declaration.
APPENDIX IV

World Conference on Science
Science for the Twenty-First Century:
A New Commitment
Budapest, Hungary, 26 June – 1 July 1999

AMENDED DRAFT DECLARATION

Preamble

It is time, at the turn of the twenty-first century, to call for a new social contract between science and society recognizing the dramatic changes of the past half century in the structure of society, to encompass new sites and participants in knowledge production, and to build upon the accumulated social understandings of how knowledges are generated, distributed and used. The new contract between science and society should protect against the devastations, disruptions, and disempowerments, that have often been byproducts of earlier deployments of science and technology.

Changes in society in which the calls for a new social contract are rooted include:

- the end of the Cold War which should allow for the redirection of funding from military into peaceful directions;
- the unleashing of a globalization of the world economy which has put pressures upon both the biosphere and upon the intellectual property regimes thereby threatening to exacerbate rather than reduce injustice and inequalities between the haves and have-nots;
- new social movements with strong knowledge claims and the possibilities of strengthening democratic civil societies;
- the growth of the social studies of the sciences and technologies, recognition of diversity and plurality of knowledge systems;
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and a variety of experiments in new social forms, including the dissemination of new information technologies for making the benefits of continuing scientific and technological developments available to all.

We have come to recognize that we all live on the same planet and are all part of the biosphere; and that the future of human beings is intrinsically linked to the preservation of the global life-support systems and to the survival of diverse forms of life and cultural heritages. All nations of the world are called upon to acknowledge the urgency of using knowledge from the natural and social sciences to address human needs without indulging in its misuse. Science should be at the service of humanity as a whole, and should contribute to providing a better understanding of nature and society, a better quality of life for everyone and a healthy and productive environment for present and future generations. Highest priority should go to eliminating both unacceptable poverty and unsustainable life styles. Sustainable consumption is the pathway to arrest the further degradation of environmental capital stocks.

Improving knowledge on the origin, functions and evolution of the universe and of life provides a stimulus to human beings and encourages them to adopt world views and practical approaches. Scientific knowledge and its applications have provided benefits:

- Life expectancy has strikingly increased for many, cures are available – or foreseen – for many diseases, and health care in many parts of the world has improved dramatically.

- Agricultural output has risen to meet population needs in global terms, although sometimes at the cost of ecological damage, destruction of bio-diversity and the displacement of unprecedented numbers of people.

- Creation of new energy sources promised to free human beings from the most arduous labor, although sometimes at the cost of creating new problems, such as the disposal of nuclear waste and threat of radiation accidents.

- The new communication and information technologies have brought unprecedented opportunities for development and have catalyzed interaction between peoples and individuals, although there is the threat of exacerbating power and wealth differentials.
Benefits of these scientific and technological developments are unequally distributed, and this has widened the gap between industrialized and developing countries, and between the rich and poor within countries. In addition, the applications of scientific advances have also led to environmental degradation and have been a source of social imbalance or exclusion. Scientific and technological progress has also made possible the construction of sophisticated weapons, including atomic, biological and chemical ones, having the potential to destroy life on a mass scale or even put at risk the entire planet. The United Nations has proclaimed the Year 2000 as the International Year for the Culture of Peace as a step towards a lasting peace between and within countries. Today, there is an opportunity for fewer resources to be allocated to the development and manufacture of new weapons, and for many military research facilities to be converted to civilian use. Science and the scientific community can, and should play an essential role in this process.

Today, whilst unprecedented advances in science are foreseen, there is need for a vigorous democratic debate on the ethical, legal, cultural, environmental and economic aspects of the use of scientific knowledge. Enhancing the role of science for a more equitable, prosperous and sustainable world requires a long-term commitment of all stakeholders: governments and parliaments, scientists, engineers and social scientists, industry, the media, international organizations and the different segments of society. Greater trans-disciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with crucial social, economic, legal, cultural, environmental and health issues. It will also require that public trust and support for science be strengthened.

We, participants in the World Conference on “Science for the Twenty-first Century: a New Commitment”, assembled in Budapest, Hungary, from 26 June to 1 July 1999 under the aegis of the United National Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU):

Recognizing that science is both a powerful intellectual resource and a source of power and that the role of science promises to be even greater in the future;

Considering that scientific research yields inestimable returns in terms of new knowledge, which when used wisely, can lead to sustainable development and improvement in the quality of human life;

Convinced that science and its applications are a major factor for socio-economic development and societal transformation, and that
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the future of human beings will be more dependent on the production, distribution and use of knowledge than ever before;

Taking into account the recommendations of major conferences organized by the United Nations system and the meetings associated with the World Conference on Science;

Stressing that open access to basic scientific and technological knowledge is part of the right to education;

Recalling that the applications of scientific research should respect human rights and the dignity of human beings, and recalling further the relevant articles in the Universal Declaration of Human Rights;

Stressing the need to pursue and apply science in line with appropriate ethical requirements and considerations of social responsibility;

Emphasizing that the use of scientific knowledge should respect cultural and biological diversity, as well as the life-supporting systems of our planet;

Recognizing the importance of plural knowledge systems, including contextualized local knowledges, as well as the knowledge systems evolved in different civilizational traditions;

Underlining the need for a strong commitment of political, economic and social partners to science, as well as an equally strong commitment of scientists to the well-being of society;

Considering that a new social contract between science and society has become necessary;

proclaim the following:

1. **Science for knowledge; knowledge for social justice**

1.1 The function of science should be to promote endogenous development and social justice. There can be no applied science if there is no science to apply.
1.2 Governments should give recognition to the key role of scientific research in the acquisition of knowledge, in the training of scientists and in the education of the public. Scientific research in the private sector has increased, but cannot be a substitute for public research. The public sector should adequately finance and assure open access to scientific research for long-term goals, especially those that are expected to give rise to applications of social importance.

2. **Science for peace**

2.1 Governments should encourage and support research in the natural and social sciences and technology to address the root causes of conflict, such as social inequalities, poverty, lack of justice and democracy, inadequate education for all, insufficient health care and food provision, environmental degradation and mal-distribution of information resources. Governments should therefore increase investment in these areas of scientific research.

2.2 Scientists should uphold the principle of full and open access to information and scientific research should be subject to public accountability. The scientific community, sharing a long-standing tradition that transcends the borders of nations, religions or ethnicities, should promote the intellectual and moral solidarity of human beings, which is the basis of a culture of peace. All nations should facilitate the free circulation of scientists and recognize their constructive co-operation as a valuable contribution to the peaceful development of human civilization.

3. **Science for development**

3.1 Technological development requires both the expansion of scientific and social scientific understanding, and needs to be resolutely oriented towards cleaner production, more environment friendly products and social justice.

3.2 Education at all levels and without discrimination is fundamental for ensuring sustainable development. It is on this platform that science education, communication and popularization need to be built. It is more than ever necessary to develop and expand science literacy with reasoning ability and skills so as to increase the ability of all parts of society to participate in the decision-making processes related to the application of new knowledge.
3.3 National strategies and institutional arrangements should be set up to facilitate the new social contract, including democratic forums for risk assessment, safety and health; and socially responsible incentives for investment, research and innovation. Parliaments, governments and international organizations should devise new legal, institutional and economic structures to support the new social contract.

3.4 Regional and international co-operation should be used to support scientific capacity building to ensure both equitable development and the spread and utilization of human creativity without discrimination of any kind.

3.5 Co-operation at the intergovernmental, governmental and non-governmental levels should contribute to the new social contract. Fellowships and grants should be created to enhance scientific capacity, particularly in the developing countries; on global problems. New initiatives are required for inter-disciplinary collaboration through national and international research facilities, networks and targeted projects. Access to these facilities for scientists from developing countries should be facilitated.

3.6 National policies on science and technology should encourage all partners, including the private and non-governmental sectors, to support scientific research. Whilst intellectual property rights need to be appropriately protected, access to data essential for undertaking scientific work also needs to be protected. The development of a new universally accepted legal framework is necessary; this should take into account the specific requirements of developing countries with regard to access to scientific data. There is a need to ensure that concerns for intellectual property rights do not end up as a mechanism for building newer forms of knowledge monopolies and that traditional resources, both biological and intellectual, are not pirated.

4. Science in society and science for society

4.1 The practice of scientific research and the use of scientific knowledge should always aim at the welfare of human beings, men and women alike, and be respectful of the dignity of human beings and of their fundamental rights, and take fully into account our responsibility towards future generations. There should be a new commitment, a shared vision of our future on this globe.
4.2. A free flow of information on the possible uses of new discoveries and newly developed technologies should be secured so that ethical issues and socially responsible applications can be debated in appropriate ways. A clearing house and archives should be established for experiments in, and evaluation of, new social forums for informed public debate on the ethical and socially responsible application of new scientific developments.

4.3. The difficulties encountered by women, as well as by minorities, in entering and pursing a career in science and in gaining access to decision-making in science and technology should be addressed urgently through adequate institutional mechanisms and other appropriate measures. Equality in access to science is not only a social and ethical requirement for human development, but also a necessity for realizing the full potential of scientific communities and to orient scientific progress towards meeting the needs of human beings.

4.4. Scientists have an obligation to constantly interact with members of society at large to educate them and to learn from them and thus contribute to the well being and enlightenment of humanity.

We, Participants in the World Conference on "Science for the Twenty-first Century: a New Commitment", consider that the Conference document “Science Agenda – Framework for Action” gives practical expression to the new commitment to science, and will be can serve as a strategic guide for international partnership between all stakeholders in the scientific venture in the years to come. We commit ourselves to act co-operatively through our own spheres of responsibility to strengthen scientific culture and its peaceful application throughout the world, and to promote the use of scientific knowledge for development, taking into account the societal and ethical principles illustrated above.

We adopt therefore this World Declaration on Science and the Use of Scientific Knowledge and agree upon the Science Agenda – Framework for Action as a means of achieving the goals set forth in the Declaration.
APPENDIX V

The Sydney Communique

A Regional Conference on Priorities for Science in the 21st Century for the Asia-Pacific Region was held in Sydney, Australia on 1-5 December 1998 in preparation for the UNESCO/ICSU World conference on Science in Budapest, 1999.

Delegations from the following countries attended the Conference: Bangladesh, China, Fiji, India, Indonesia, Japan, Kiribati, Lao People’s Democratic Republic, Malaysia, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Sri Lanka, Thailand, Tonga, Uzbekistan, Vanuatu, Viet Nam and Australia. Individuals from Argentina, Ecuador and Slovenia also attended.

The Conference agreed on the following key points and recommends to the World Conference on Science that:

- the new millennium see the establishment of a new and balanced relationship between science, society and the environment at all levels from local to global;

- science be interpreted as SET (Science, Engineering and Technology);

- UNESCO, ICSU and other bodies concerned with SET promote actively science and social sciences and the relationship between them as the basis for sustainable and equitable living and for building a lasting peace;

- SET, in a transformed science-society partnership which ensures a sustainable and equitable future, be one where the experiences and knowledge of women and men from all cultures are equally valued and respected and where all people participate meaningfully at all stages of the SET process;

- scientists have a social responsibility to focus on matters of economic value to people in alleviating poverty, which is both a global and a gender issue;

- accessibility to knowledge (including issues of education, gender and traditional knowledge) be addressed as a priority by UNESCO, as lead agency for science within the UN system;
the role of UNESCO as lead science agency within the UN system be reaffirmed, within the context of increasing partnerships between nations, NGOs, industry and the intergovernmental sector;

in particular, the urgent need be recognised for UNESCO and ICSU to promote SET to assist with improved management of freshwater and marine resources, including reducing pollution and effectively managing catchments;

UNESCO and other UN bodies increase support for SET that will mitigate disasters including risk assessment and predictive activities, particularly those associated with anticipated effects of accelerated climate change;

high priority be given to enhancing communication of the processes of science and its outcomes, especially through improved linkages to policy makers and increasing popular presentations of science so as to enhance understanding and appreciation of SET by policy makers and civil society;

UNESCO initiate an international programme for enhancing the extent and professional quality of reporting of SET in the mass media and independent interpretation of the issues involved, adapting the programme to the situations and requirements of individuals and groups;

promotion of scientific literacy and awareness be facilitated using both formal and informal methods and encompass modern and traditional science. UNESCO should facilitate joint activity between its education, science, culture and communication sectors to achieve this objective.

UNESCO and other bodies devote resources to ensuring international equity in training in all aspects of SET including Research and Development management. Scientific competence will only come if there is a sound educational base; accordingly nations should provide for adequate gender inclusive training at all levels.

nations and international organizations concerned with SET develop frameworks for ethical standards in SET. UNESCO and ICSU should play a lead role in promoting the adoption and use of an international code of ethics in SET.
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Detailed consideration of these recommendations is to be found in the Attachment. The Proceedings of the Conference contain the full background papers.

ATTACHMENT

Issues and Suggested Actions

GENDER-RELATED ISSUES

Issues/problems relating to women's participation in SET include:

- Lack of gender-based data collection, indicators and collation of information
- Lack of a gender-responsive environment in SET, limiting provision for women's career development in SET.
- Inflexible work organization in SET careers.
- Gender stereotyped public images of SET cultures reflecting SET as a male-dominated area.
- Insufficient women in decision-making roles such that the interests of women, particularly disadvantaged women, are not taken into account.
- Design of educational systems not conducive to women's full and equal participation in SET.
- Lack of training and understanding of gender issues in SET communities.
- Lack of involvement of women in the design of technology resulting in the production of technologies that do not respond properly and adequately to women's concerns. In a number of cases, these technologies lead to the exploitation of women.
- Lack of consultation in factory design may exploit the health of women workers.
Thus UNESCO should:

• Take the lead in reviewing and reforming its own offices, programmes and research projects for responsiveness to gender.

• With other UN agencies, establish a clearing-house for data, indicators and case studies that support successful interventions that have created change for women and girls in relation to SET.

• Establish a project to develop, document and disseminate lighthouse projects that involve end-users, especially those from disempowered groups, in knowledge-generation.

• Establish an information technology project to cross-link Asia-Pacific networks that promote gender reform in SET.

Nations should:

• Ensure that all government policies and reports relating to SET include gender analysis.

• Redesign the educational system to ensure gender sensitivity.

• Ensure that governments and other professional associations address gender balance on all peer-review panels.

Non-governmental organizations including SET professionals, trade unions and professional associations should be encouraged to pay attention to downstream processes, particularly the mass production and use of new technologies, to ensure that gender issues are not compromised.

PROMOTING SCIENCE TO SERVE HUMANITY

• UNESCO should actively promote the social sciences and SET as the basis for sustainable development to ensure the livelihood of future generations.

• All nations need to share information, knowledge and research findings incorporating intellectual property rights.

• The social and natural sciences should meet these basic survival needs by building local capacity in a spirit of cooperation, sharing resources and knowledge between nations, and aim at simple solutions appropriate to local technology and facilities.
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- Not all answers stem from science, but may be found in political, cultural or institutional areas.

- Processes and mechanisms need to be in place to enable scientists to work with local people to find solutions based on local knowledge.

- Monitoring and evaluation of science programmes should ensure that they are appropriate to the needs of local people.

- **Scientists need to:**
  - be sensitive to the idea of sustainable development.
  - work with local people.
  - use local equipment/food etc. to build solutions.
  - work with scientists from other disciplines and use a team approach (scientists need an awareness of, and a sensitivity to, not only SET but also social and cultural issues, and the humanities.
  - talk to local men and women in terms they understand.
  - have a hands-on approach and be versatile in applying science to meet local conditions.
  - share their knowledge and problems across disciplines and with the global community.

- Local women and men need to be trained to train others.

- Science funding structures need to provide incentives to attract and sustain scientists with the qualities identified above and support their training.

- There is a need to increase the use of SET to counter environmental degradation.

- Inadequate water supplies will limit the capacity to ensure future health and peaceful co-existence among nations. There is an urgent need for scientists to provide information that ensures future freshwater supplies and their sustainable exploitation, and protects freshwater resources from degradation, including pollution and saline intrusion.

- Appropriate technologies for waste disposal and sanitation must be developed.

- Input from SET is required to protect the oceans ad ocean and ocean resources from pollution, prevent over-exploitation of Asia-Pacific fisheries and tackle threats to the coastal zone.
Science in Society: A New Social Contract

- Appropriate development of new methodologies for increasing sustainable food production is required.

- Research is required on the links between unsustainable farming practices on sensitive ecosystems and the loss of land and desertification.

- There is a need to continue SET that will mitigate disasters and this should include risk assessment and predictive capabilities.

- Research is required on the efficiency of appropriate sustainable energy, for example through the World Solar Programme.

- SET is required to mitigate effects of global climate change, especially the threat of sea level rise and water shortages.

- Governments must be encouraged to lay emphasis within the science curriculum on the sustainable use of resources (reduce, re-use, re-cycle initiatives).

- UNESCO should set up a facility to act as a clearing-house for curriculum development to assist governments that have yet to establish the above in their science curricula.

- A regional centre should be established to promote sustainable development in the Asia-Pacific including a coordination and training facility for scientists implementing activities in this area.

- There is a desperate need for further research and exchange of existing information between countries on the handling and rehabilitation of nuclear and other toxic waste.

TRADITIONAL SCIENCE – INDIGENOUS PRACTICES, EQUITY AND ACCESS TO SCIENCE

- The UN system as a whole should address the sustainability of, and access to, SET (modern and traditional) as a matter of great priority.

- UNESCO should recognise the value of traditional knowledge through greater support for its research and transmission.

- There should be widespread adoption of successful models showing the benefit of greater accessibility to SET by grass-root communities.
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- There should be encouragement of greater accessibility to information and promotion of research into conservation-based entrepreneurial activities that are successful.

- Every effort should be made to see that appropriate equipment is provided, or is accessible, for science education and science research in schools/educational institutions and research centres.

- Dialogue between practitioners of modern and traditional science should be facilitated.

THE IMAGE OF SCIENCE, ETHICS AND TRUST

- There should be standards of ethics which incorporate community consultation.

- Applications for research funding should include a statement on ethics which provides for community consultation.

- Individual scientists working in commercial enterprises must take responsibility when the commercialisation and promotion of their work is carried out.

- Local knowledge and local natural resources need to be valued and SET use of natural resources should avoid bio-piracy and unethical bio-prospecting.

- UNESCO should be active in providing international standards to ensure an appropriate framework for ethics and moral issues through consultation with all interested parties.

- There is a need to improve the image of science and scientists within society, and scientists should be encouraged to be actively engaged in science management and politics.

- Training programmes for scientists should include management, ethics, image building and communications.

- UNESCO should foster the optimal use of emerging electronic technologies, such as the Internet and World Wide Web sites, for facilitating SET communication.

- UNESCO should encourage popularization of SET, for example through science centres, science festivals, and museums.
Science in Society: A New Social Contract

- NGOs play an effective role in the communication of science, and scientists should be encouraged to take an active part in such strategies.

- Institutions should develop regular review processes to ensure that science is responsive and accountable to community and gender concerns.

SCIENCE EDUCATION

With the support of UNESCO, Asia and Pacific Governments should:

- Increase literacy and numeracy rates in developing countries.

- Raise the level of comprehension of languages most generally used in scientific communities.

- Encourage the teaching of Science for Sustainable Living, which is related to local circumstances, early on in schooling.

- Give priority to the teaching and learning of science and allocate sufficient funding for this purpose.

- Review and develop approaches to make the teaching and learning of SET enjoyable and effective.

- Provide adequate incentives to make science teaching an attractive career.

- Ensure that all schools have adequate laboratory and library facilities, especially in rural areas.

- Ensure that science teaching is directed towards understanding the processes of science.

- Encourage the introduction of information technology into schools at the earliest possible stage.

- Ensure greater interaction in SET education between school and tertiary-level institutions.

- Encourage the inclusion of instruction in scientific method and research skills in school science curricula.

- Remove institutional, cultural and economic barriers that disadvantage girls and women in science education and make the curriculum resources and teaching methods gender-inclusive.
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- Require science teachers to have a degree in science and a diploma or degree in teaching.

- Make adequate resources available at university level to support research and development activities.

- Ensure there is a resourcing balance to support both basic research and applied research (engineering, technology).

CO-OPERATION/LINKAGES IN A GLOBALIZED WORLD

- The World Conference on Science outcomes should:
  - support government-private sector joint initiatives promoting the entry of persons into fulfilling careers in SET education and research.
  - Be directed towards enabling researchers from developing countries to participate in international research projects, and gain access to advanced research facilities.
  - Emphasize the pursuit of scientific research and training through multilateral arrangements.

- UNESCO should promote the establishment of international interdisciplinary research centres in frontier areas of SET.

- UNESCO’s SET initiatives in the next millennium should be developed in close co-operation with other UN bodies/agencies/commissions.

- To complement initiatives like the World Science Report, UNESCO should co-ordinate the gathering of more comprehensive and analytical data on SET. These data should assist in understanding issues and trends in SET education, careers and employment.

- UNESCO should promote international co-operation between Member States oriented towards understanding and using traditional scientific knowledge and practices.

- Recognising the potential of engineering and technology in industrial development, UNESCO should assist the development of partnerships between universities, research and development laboratories, and industry.

- Through co-operation between its education and science sectors, UNESCO should support initiatives to create a clearing-house for educational courseware in science and technology.
APPENDIX VI

Statement
on Behalf of Panel of Eminent Persons
Convened by the Secretary-General

Preamble

The Panel convened by the Secretary-General pays its tribute to the Intergovernmental Committee, Advisory Committee and the Centre for Science and Technology for Development, for the work done during the last ten years to implement the Vienna Programme of Action. It noted with regret that the original funding proposals made at Vienna could not be realised. Nevertheless, the UNFSTD has done its best to support projects of relevance to the implementation of the Vienna Programme of Action. The Panel also wishes to record its appreciation of the work done by the U.N. system as a whole to help developing countries to strengthen their endogenous capacity.

During this decade, the world has witnessed revolutionary progress in several areas of science and technology which have opened new opportunities in agriculture, medicine, industry, communication and materials. Particular mention may be made of the advances in biotechnology, information technology, space technology and microelectronics. However, the gap in both technology development and application between industrialised and developing countries as well as among developing countries themselves has been widening. Also, the life support systems of our planet are being placed under increasing stress. The World Commission on Environment and Development has therefore warned that unless current trends in environmental degradation and biological impoverishment are arrested, the future of humankind will be in jeopardy. At the same time, increasing population pressures and the prevalence of chronic hunger, absolute poverty and widespread unemployment have made accelerated advances in economic growth, essential and urgent in most developing countries.

The Challenge thus lies in harnessing modern science and technology to achieve the desired economic growth rates based on sound ecological ground rules. The nineties will be a critical decade in our ecological and scientific evolution. Unless steps are taken to promote sustainable
and equitable development, it will be difficult to achieve a better common future. This realisation has provided an opportunity for promoting a new global solidarity among all members of the human family. The climate of peace now gathering strength has provided a unique opportunity for rechanneling substantial scientific, managerial and financial resources for launching a bold Planet Assurance Programme which will help us to avoid the adverse changes associated with phenomena such as desertification, loss of biological diversity, ozone layer depletion, global warming and rise in sea levels.

Based on these considerations, we would like to suggest a five point action plan for the nineties and beyond.

First, the prevailing political will for sustainable development should be converted into political action to avert our planet from experiencing the effects of an unclear winter without a nuclear war. This will call for a new rationale for international cooperation, manifesting itself in a meaningful manner at the local, regional and global levels. We urge Member States to include in the Human Rights Declaration the right of access to technology for all people and to give concrete shape to this concept at the ongoing Uruguay round of GATT negotiations.

Secondly, we appeal for a New Deal for the lowest income billion of humankind, by launching a special programme designed to extend the benefits of science and technology to the economically disadvantaged sections of the human family world wide. For this purpose it will be essential to associate grass root level peoples organisations in both the planning and implementation of training and technology dissemination programmes. What is needed is low-cost but high quality and socially compatible methods of technology sharing.

Thirdly, we emphasize the urgent need for strengthening and expanding the science and technology infrastructure in developing countries, in view of the growing gap in endogenous capacity between industrialised and developing countries. For this purpose, we request the Secretary General to convene a meeting of interested Governments, Foundations and Industries for the establishment of a Consultative Group on Science and Technology for Sustainable Development. Such an initiative could result in a coalition of resources and their optimum utilisation. In particular, the proposed Consultative Group could support a network of Centres on the lines outlined by Prof. Abdus Salam. Sustainable development to become real will need the support of location specific technologies, tailored to suit the needs of local ecological, socio-cultural and economic conditions. This will call for a massive programme of
education and training. Mass media can play a valuable role in the dissemination of new technologies. Recent advances in communication technology provide opportunities for easy access to relevant information. We recommend the establishment of a network of Media Resources centres to provide professionally credible software for the media.

Industrialised countries should also take steps to develop and adopt environmentally sound technologies and strengthen R&D efforts in the area of sustainable development. This will call for a reappraisal of growth patterns, life-styles and technology options. The experience gained under the proposed Consultative Group will be equally valuable for industrialised countries.

Fourthly, the conservation and sustainable management of biological diversity are essential for achieving continuous improvements in biological productivity. Unfortunately, many habitats rich in biological diversity are under threat of extinction. Also, gene patenting procedures are resulting in conflicts regarding ownership and patterns of utilization of plant, animal and microbial genetic resources. The time is therefore ripe for the establishment of a United Nations Commission on Biological Diversity which will help to ensure both the conservation and sustainable utilization of our global genetic estate for the benefit of food and ecological security in all nations.

Finally, the unique opportunity now generated by recent developments in the UN General Assembly in the area of disarmament and strengthening of peace initiatives, have created opportunities for converting resources from defence to development. The scientific, managerial and financial resources which will become available in the process of conversion could be utilised for strengthening ecological and food security as well as the livelihood security of the poorest billion of the world. We urge the initiation under the United Nations system of case studies to highlight the opportunities for improving the quality of life on earth, if both industrialised and developing countries pursue vigorously the path of linking disarmament with fighting the battles against hunger and poverty.

It is our conviction that action on the lines recommended by us would help to transform the vision projected at Vienna ten years ago, into reality.

Science in Society: A New Social Contract
The scenario of herbal drugs is rapidly evolving for better today all over the world. Herbal medicines have become increasingly respectable to consumers and physicians. An important reason for this appears to be consistent research evidence for the beneficial effects of many plants. This has mainly come from Germany, China and Japan.

India has a rich tradition of systematised knowledge of use of plant drugs coupled with rich biodiversity. Ayurveda, the principle system of health care practised in India relies heavily on plants. Charaka describes more than 600 varieties of plants as medicines and even classifies them into different groups according to their mechanisms of actions or therapeutic uses. Their pharmacology is described in great detail sometimes chaming the most modern of theories. (Charaka Samhita).

A glimpse of ancient wisdom can also be obtained in pharmaceutics - a very evolved technological branch of Ayurveda. Take for example purification of guggulu, which used to be carried out using dolayantra. Today we know the rational behind this; a process which allows use of only soluble nontoxic, effective fraction of guggulu in formulation. (Sukha Dev, 1987). Or the concept of ama. Ama according to Ayurveda is formed due to incomplete digestion of food, resulting due to incompatible combination of dietary constituents, stress and certain other conditions. When absorbed it can get deposited at distant sites and produce diseases like amavata, yarkritaroga or sangrahani. (Vagbhata).

And is formed by the assimilation of dietary items. The other tissues receive nutrients from the rasadhatu, picking up the components they need. It is obvious then, that the quality of the rasadhatu is very important as it would influence the working of tissues throughout the hierarchy (Dahanukar and Thatte, 1996).

Drugs that improve the quality of the rasadhatu and thereby of the entire body are the rasayanas (Thatte and Dahanukar, 1997). The term rasayana has been split up into rasa and ayana meaning the path that rasa takes. This therapy promotes excellent quality rasadhatu and improves the quality of other tissues as well as of the other regulators of health like the doshas and mala, leading to a state of positive health.
This information on rasayana raised some questions. How was it possible for one plant, with its usual array of phytochemicals, to produce such a variety of effects like delaying ageing, improving mental functions and giving freedom from several diseases including those caused by infection? If specific rasayanas are used to strengthen specific tissues, would they have any organ selectivity as described in Ayurveda? How did one rasayana plant differ from the other? Were there any clues to the pharmacokinetics of the plant?

In this paper attempts are made to generate evidence for the traditional use of rasayana plants by answering these questions by formulating hypothesis, designing experiments and drawing conclusions from the hard data obtained.

The most possible hypothesis to explain the apparently diverse actions of rasayanas was that the plants were modulating an endogenous system of the body setting into motion a cascade of events leading to the multiple events.

Using the knowledge from the field of psychoneuroimmunology as a frame, we devised experiments evaluating actions of rasayana at three target sites namely neuroendocrine system, the immune system and peripheral organs.

Six rasayana plants were selected for study. Emblica officinalis (EO, Amla), Tinospora cordifolia (TC, Guduchi), Asparagus racemosus (AR, Shatavari), Withania somnifera (WS, Ashwagandha), Terminalia chebula (TCH, Haritaki) and Piper longum (PL, Pippali). These plants were chosen from a large number of rasayanas as they are specified to be ‘ekdravya’ i.e. can be given as single entities.

The words may be different but modern science today knows that absorption of macromolecules can cause formation of immune complexes which produce diseases like arthritis, cirrhosis and ulcerative colitis. (Wiggins & Cochrane, 1981).

It is also to be noted that modern medical approach today is inclined towards accepting multifactorial etiologies for diseases, individualising treatment and has started giving emphasis on homeostasis which are all strongholds of Ayurveda.

Ayurveda is by and large a conceptual science where concepts have been evolved around principles of health, etiopathogenesis of diseases and approaches to treatment, which include not only drugs but also
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therapeutic diets and therapies to correct disturbed balance of the body, as against modern medicine which is basically an experimental science.

In spite of having tremendous wealth of knowledge based on real experience and astute observations, the system has been relegated to back benches and considered a non-science because efforts were not made to apply cartesian principles of drawing inferences and conclusions based on hard data, obtained by designing experiments around a hypothesis.

Hence, what appears essential is to create a base of evidence for fundamental principles of Ayurveda, which are explained in its own purashtha. And for this purpose, interpreting the purashtha in contemporary scientific language is necessary as only then it is possible to design protocols for experiments. (Dahanukar & Thatte, 1989).

The concept that had interested me the most was that of Rasayana - the claims of rasayana therapy are far reaching. Several plants are described to have general rasayana properties and specific rasayanas are described to strengthen specific weak tissues or organs in an individual. In order to understand the Ayurvedic rationale underlying the use of rasayanas, one has to appreciate the concept of health in Ayurveda, which states that the foundation of health is based on the tripod of dosha (humors), dhatu (tissues) and mala (metabolic end products of these tissues). These components have to be in equilibrium for the state of positive health. Seven types of dhatus or tissues are described and arranged in a hierarchical fashion, rasa dhatu, which has been likened to plasma, is the first; it is followed by rakta or blood, mansa or muscle, meda or fatty tissue, majja or neural tissue, asthi or osseous tissue and shukra or germinal tissue. Rasadhatus is the primordial tissue.

After proving that one of the rasayana was indeed a safe immunostimulant, we explored its potential in clinical conditions.

A depression in neutrophil function and an increased susceptibility to infection with resultant increase in mortality was earlier documented in patients with obstructive jaundice (surgical) and efficacy of TC was shown in the animal model of surgical jaundice. (Rege et al 1989, Nazareth et al 1990, Dahanukar et al 1990).

Clinical studies were conducted after obtaining approval of the Ethics Committee of our institute. The safety and tolerability of the formulation were confirmed in human volunteers.
Initially TC was given as an “add-on” to conventional therapy in an open prospective study in patients with OJ. Patients received the conventional treatment of Vit K and antibiotics peri-operatively and TC was given in addition to conventional therapy, for 3 wks prior to surgery in one group of patients while the other did not receive TC. We found that as against a 61% mortality in the patients treated conventionally, there was only a 25% mortality in the group given TC in addition. The incidence of infection was also reduced from 44.4% to 12.5%. The depressed PMN functions observed before therapy with TC (21.2±5.5%) phagocytosis and 29.47±6.5%, ICK.

Subsequently, a double blind placebo controlled study was conducted in 30 patients wherein patients were treated with either placebo or with TC in addition to the conventional therapy. We found that as against a 39% mortality in the placebo treated group, there was a mortality of only 6.25% in the TC treated group. (Rege et al, 1993).

Complications of jaundice like infection related mortality, renal dysfunction, bleeding diathesis and reduced gut motility improved after administration of TC. Along with the reduction in mortality and complications, treatment with TC also improved the quality of life and we could explain these results through carefully designed experiments in animals. (Dahanukar et al 1994).

The second clinical situation in which we investigated the effect of TC was pulmonary tuberculosis (TB).

Our approach was different from other workers in the field. The first point was related to the preparation and administration of plant products. It was decided to follow the principles outlined in Ayurveda with respect to drug administration. After authenticated identification, the parts of the plants were processed exactly in the manner prescribed in Ayurveda. We opted to use the whole extract considering the complex nature of chemical, physical and biological components of a single plant and the fact that all these work together by some unknown, diverse way to deliver the desired effects.

The does used in experimental animals was extrapolated from the human dose and all animals were pretreated with the respective drug for a sufficiently long time. Pretreatment with the dose known to be effective in clinical practice was used to ensure achievement of adequate levels in the body.
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This approach differs from the current practice, as most workers use extracts (either alcohol, methanol, petroleum-ether or filtered aqueous) of Indian Medicinal Plants. These are administered in doses derived from LD50 studies. The method of pretreating the animals is not always followed and even if pretreatment is given, the drug is administered a few hours prior to stressor.

The outcome of these experiments was we could demonstrate that rasayanas protected animals against various induced infections in normal or immunosuppressed conditions. (Dahanukar et al 198, Thatte et al 1989). The mechanism was mediated through an immunostimulant effect rather than antibacterial actions. PMN functions in terms of phagocytosis and intracellular killing were stimulated in animals treated with the rasayanas as compared to control animals in all experiments (Thatte & Dahanukar, 1989). Reticulo endothelial system function was assessed using carbon clearance method (Heller, 1958). RES was greatly activated, further proving that rasayanas are immunostimulatory (Dahanukar & Thatte et al, in press). Through our recent experiments we have proved that some rasayanas activate mononuclear cells to produce cytokines like GMCSF (Thatte et al, 1994) and IL-1 in a dose dependent manner. We could also document that those rasayanas which have madhura vipaka were immunostimulants, those having katu vipaka were not. (Dahanukar et al, 1997).

Can be used as an effective adjunct in management of patients and have a great impact on health economics, by reducing the duration of hospitalization and causing minimal morbidity.

There is a place for well researched plant medicines particularly for diseases which are not well treated by synthetic medicines and it is possible to generate unbiased, objective scientific data on such medicines taking leads from Ayurveda, interepretating them in contemporary scientific language of using modern scientific tools from the fields of immunology cell biology and pharmaceutic phytochemistry.

A placebo controlled randomised, double blind study was carried out in 50 patients of pulmonary tuberculosis. 23 were given TC and 27 were given placebo in addition to usual anti-TB regimen. Radiological findings were scored and graded. When these observations in the two groups were compared at two months, it was found that only 47% of placebo group showed some improvement on X-ray. On the other hand, 75% patients of the TC treated group showed marked improvement, underlining the potential of TC as an adjuvant in the therapy of tuberculosis. Anti-TB therapy led to side effects in 40% patients in the
placebo group. In comparison only 15% developed side effects in the TC treated group.

A placebo controlled, double blind randomised study in collaboration with the Tata Memorial Cancer Hospital, Mumbai was conducted to evaluate the role of TC as an adjuvant in cancer chemotherapy.

We found that the number of patients whose peripheral WBC counts fell below 3000/cu mm. were significantly less i.e. 55% in the TC treated group as against 70% in those that received a placebo. Similarly, in the placebo treated group, the count fell below 2000/cu mm. 24 times as against only 14 times in the TC treated group. In the placebo group the count went below 500, 4 times while in the TC group this happened only once.

The patients receiving TC had a significantly improved appetite and a general sense of well being. Above all, there were no side effects and no postponement of chemotherapy cycles. This trial is ongoing with escalated doses.

Thus we have been able to create a sound base of evidence using state of art technology for therapeutic utility of plants commonly used in Ayurveda like amrita, Amalaki, Haritaki, Shatavari, Pippali and Musta. While this work on plants continues the place of Ayurvedic Therapies as adjuvant to modern therapy and its health economics is also being evaluated.

Ayurveda Research Centre at K.E.M. Hospital and Seth G.S. Medical College has evaluated Ayurvedic therapies for haemorrhoids, Fistula-in-ano, asthma (Vaman therapy) and chronic non healing ulcers due to venous stasis (leech therapy); using modern research methodologies. (Dahanukar et al 1997). The results indicate that these therapies
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Amrita: from Stem to Pill

*Amrita*, the Sanskrit name of Tinospora cordifolia is derived from *Amrit* which means Nectar of Life. The stem of this ubiquitous climber belonging to family Menispermiaceae is classified in Ayurvedic *samhitas* as a Rasayana and has been used in traditional practices for centuries. It is indicated in a plethora of conditions ranging from fevers to arthritis and is also used prophylactically as a tonic in conditions of general debility or during convalescence. *Amrita* is constituent of many polyherbal formulations used in Ayurveda but interestingly it is one of the few plants that are used singly and does not require individualization. The drug is described to be *'Swashta'* which conveys the meaning that it is safe for consumption and promotes health.

The stem of *Amrita* offers many challenges to modern pharmacologists and phytochemists alike. Can the variety of effects that Ayurveda claims it to have, be confirmed? How can one plant produce such diverse effects? Is it possible that it modulates some key mechanism in the body, setting into motion a cascade of events leading to the multiple events? Which of its numerous phyto-constituents would be responsible for this action? Would it be possible to separate it out? Which would be...
the clinical conditions in which it could be used safely, effectively and rationally?

Over a period of 20 years we have been able to generate answers to these questions and Nature's treasure chest from stem of Amrita is formulated as a standardised tablet, delivering the same amount of phytoconstituents each time. The chemicals from the water extract of dried stems of Amrita are proven to be safe in animal and human studies. The tablets effectively stimulate the macrophages to secrete GMCSF, IL-1 and IL-2, thus increasing the phagocytic and intracellular killing function of phagocytes. The formulation of Amrita has been evaluated in clinical conditions where immune functions are depressed like obstructive jaundice, tuberculosis and cancer chemotherapy in which it has proved to be significantly superior to placebo. Thus, Amrita in modern dosage form fills up the existing gap in the availability of safe, effective and orally administerable immunomodulator.
APPENDIX VIII

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Differ from known designs or combinations of known design features. Members may provide that such protection shall not extend to designs dictated essentially by technical or functional considerations.

2. Each Member shall ensure that requirements for securing protection for textile designs, in particular in regard to any cost, examination or publication do not unreasonably impair the opportunity to seek and obtain such protection. Members shall be free to meet this obligation through industrial design law or through copyright law.

Article 26
Protection

1. The owner of a protected industrial design shall have the right to prevent third parties not having the owner’s consent from making, selling or importing articles bearing or embodying a design which is a copy or substantially a copy of the protected design when such acts are undertaken for commercial purposes.

2. Members may provide limited exceptions to the protection of industrial designs, provided that such exceptions do not unreasonably conflict with the normal exploitation of protected industrial designs and do not unreasonably prejudice the legitimate interests of the owner of the protected design, taking account of the legitimate interests of third parties.

3. The duration of protection available shall amount to at least 10 years.

SECTION 5: PATENTS

Article 27
Patentable Subject Matter

1. Subject to the provisions of paragraphs 2 and 3, patents shall be available for any inventions, whether products or processes, in all

For the purpose of this article, the terms “inventive step” and capable of industrial application” may be deemed by a Member to be synonymous with the terms “non-obvious” and “useful” respectively.
fields of technology, provided that they are new, involve an inventive step and are capable of industrial application. Subject to paragraph 4 of Article 65, paragraph 8 of Article 70 and paragraph 3 of this Article, patents shall be available and patent rights enjoyable without discrimination as to the place of invention, the field of technology and whether products are imported or locally produced.

2. Members may exclude from patentability inventions the prevention within their territory of the commercial exploitation of which is necessary to protect ordre public or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment, provided that such exclusion is not made merely because the exploitation is prohibited by their law.

3. Members may also exclude from patentability:
   
   (a) diagnostic, therapeutic and surgical methods for the treatment of humans or animals;
   b) plants and animals other than micro-organisms and essentially biological processes for the production of plants or animals other than biological and micro-biological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof. The provisions of this subparagraph shall be reviewed four years after the date of entry into force of the WTO Agreement.

Article 28
Rights Conferred

A patent shall confer on its owner the following exclusive rights

(a) where the subject matter of a patent is a product to prevent third parties not having the owner’s consent from the acts of: making, using, offering for sale, selling, or importing for these purposes that product.

(b) where the subject matter of a patent is a process, to prevent third parties not having the owner’s consent from the act of using the process, and from the acts of: using, offering for sale, selling, or importing for these purposes at least the product obtained directly by that process.

2. Patent owners shall also have the right to assign, or transfer by succession the patent and to conclude licensing contracts.
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Article 29
Conditions on Patent Applicants

1. Members shall require that an applicant for a patent shall disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art and may require the applicant to indicate the best mode for carrying out the invention known to the inventor at the filing date or, where priority is claimed, at the priority date of the application.

2. Members may require an applicant for a patent to provide information concerning the applicant’s corresponding foreign applications and grants.

Article 30
Exceptions to Rights Conferred

Members may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties

Other Use Without Authorization of the Right Holder

Where the law of a Member allows for other use of the subject matter of a patent without the authorization of the right holder including use by the government or third parties authorized by the government, the following provisions shall be respected

(a) authorization of such use shall be considered on its individual merits.

(b) such use may only be permitted if prior to such use the proposed user has made efforts to obtain authorization from the right holder on reasonable commercial terms and conditions and that such efforts have not been successful within a reasonable period of time. This requirement may be waived by a Member in the case of a national emergency or other circumstances of extreme urgency or in cases of public non-commercial use. In situations of national emergency or other circumstances of extreme urgency, the right holder shall, nevertheless, be notified as soon as reasonably practicable. In the case of public non-commercial use, where the government or contractor, without making a patent search, knows or has

This right, like all other rights conferred under this Agreement in respect of the use, sale, importation of other distribution of goods is subject to the provisions of Article 6.
demonstrable grounds to know that a valid patent is or will be used by or for the government, the right holder shall be informed promptly;

(c) the scope and duration of such use shall be limited to the purpose for which it was authorized, and in the case of semi-conductor technology shall only be for public non-commercial use or to remedy a practice determined after judicial or administrative process to be anti-competitive;

(d) such use shall be non-exclusive;

(e) such use shall be non-assignable, except with that part of the enterprise or good will which enjoys such use;

(f) any such use shall be authorized predominantly for the supply of the domestic market of the Member authorizing such use;

(g) authorization for such use shall be liable, subject to adequate protection of the legitimate interests of the persons so authorized, to be terminated if and when the circumstances which led to it cease to exist and are unlikely to recur. The competent authority shall have the authority to review, upon motivated request, the continued existence of these circumstances;

(h) the right holder shall be paid adequate remuneration in the circumstances of each case, taking into account the economic value of the authorization;

(i) the legal validity of any decision relating to the authorization of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member;

“Other use” refers to use other than that allowed under Article 30.

(j) any decision relating to the remuneration provided in respect of such use shall be subject to judicial review or other independent review by a distinct higher authority in that Member.

(k) Members are not obliged to apply the conditions set forth in subparagraphs (b) and (f) where such use is permitted to remedy a practice determined after judicial or administrative process to be and competitive. The need to correct anti-competitive practices may be taken into account in determining the amount of remuneration in
such cases. Competent authorities shall have the authority to refuse termination of authorization if and when the conditions which led to such authorization are likely to recur.

(i) where such use is authorized to permit the explanation of a patent ("the second patent") which cannot be exploited without another patent ("the first patent") the following additional conditions shall apply.

(i) the invention claimed in the second patent shall involve an important technical advance of considerable economic significance in relation to the invention claimed in the first patent.

(ii) the owner of the first patent shall be entitled to a cross-licence on reasonable terms to use the invention claimed in the second patent; and

(iii) the use authorized in respect of the first patent shall be non-assignable except with the assignment of the second patent.

Article 32
Revocation / Forfeiture
An opportunity for judicial review of any decision to revoke or forfeit a patent shall be available

Article 33
Term of Protection
The term of protection available shall not end before the expiration of a period of twenty years counted from the filing date.

*It is understood that those Members which do not have a system of original grant may provide that the term of protection shall be computed from the filing date in the system of original grant.

Article 34
Process Patents Burden of Proof
1. For the purposes of civil proceedings in respect of the infringement of the rights of the owner referred to in paragraph 1(b) of Article 28, if the subject matter of a patent is a process for obtaining a product the judicial authorities shall have the authority to order the defendant to prove that the process to obtain identical product is different from the patented process. Therefore Members shall provide in at least one of the following circumstances that any identical product when
produced without the consent of the patent owner shall, in the absence of proof to the contrary be deemed to have been obtained by the patented process.

(a) if the product obtained by the patented process is new;

(b) if there is a substantial likelihood that the identical product was made by the process and the owner of the patent has been unable through reasonable efforts to determine the process actually used.

2. Any Member shall be free to provide that the burden of proof indicated in paragraph I shall be on the alleged infringer only if the condition referred to in subparagraph (a) is fulfilled or only if the condition referred to in subparagraph (b) is fulfilled.

3. In the adduction of proof to the contrary the legitimate interests of defendants in protecting their manufacturing and business secrets shall be taken into account.

SECTION 6: LAYOUT-DESIGNS (TOPOGRAPHIES) OF INTEGRATED CIRCUITS

Article 35
Relation to the IPIC Treaty
Members agree to provide protection to the layout-designs (topographies) of integrated circuits (referred to in this Agreement as "layout-designs") in accordance with Articles 2 through 7 (other than paragraph 3 of Article 6), Article 12 and paragraph 3 of Article 16 of the Treaty on Intellectual Property in Respect of Integrated Circuits and, in addition, to comply with the following provisions.

Article 36
Scope of the Protection
Subject to the provisions of paragraph 1 of Article 37, Members shall consider unlawful the following acts if performed without the authorization of the right holder: importing, selling, or otherwise distributing for commercial purposes a protected layout-design, an integrated circuit in which a protected layout-design is incorporated, or an article incorporating such an integrated circuit only in so far as it continues to contain an unlawfully reproduced layout-design.

The term "right holder" in this Section shall be understood as having the same meaning as the term "holder of the right" in the IPIC Treaty.
Innovating School Science Education — The Hoshangabad Science Teaching Programme (HSTP)

Perspective

An effective intervention in the way science is taught in our schools has been perceived as an essential step towards achieving a society more capable of developing and absorbing technology creatively as well as giving a more scientific foundation to our cultural political and economic fabric. This tall expectation from science education has been strongly articulated in various policy statements and recommendations of various eminent commissions and committees which have deliberated on our education system. The directive perspective of the HSTP has been formulated to overcome the gap between these expectations and the reality in our schools:

(1) To remould school science education to fulfill universally accepted national goals and educational objectives. HSTP has attempted to base science education on the principles of ‘learning by discovery’, ‘learn through activity’ and ‘learning from the environment’ in contrast to the prevailing text-book centred ‘learning by rote’ method. A major objective is that the child should become an active participant in the process of learning science through field studies, experiments, observation, recording, analysis and discussions with his or her teacher, fellow students and others. There is a conscious attempt to move away from the prevailing discipline-centred approach to a child-centred approach. We are convinced that treating the child like an empty receptacle in which latest scientific knowledge is to be filled in is not desirable for pedagogic reasons. The process of science needs to be emphasized if we have to fulfill the constitutional goal of promoting scientific temper and make the child a confident self-learner for the rest of his or her life. Science curriculum must relate closely to science and technology experiences of everyday life.

(2) Perceiving Innovation as an integrated whole. It was recognized that it would not be enough to merely rewrite the textbooks and to instruct the teachers to perform experiments in the class room. An effective
innovation will have to take into account all the factors that effect the teaching process in the classroom and tackle all of them in an integrated manner. Thus the total package is concerned not only with curricular innovation but also with teacher training, kit to do experiments with, examination system, school administration, extra curricular inputs, etc. all of which have been suitably modified to form the innovative HSTP package. In particular, examination reform has been seen as a crucial factor which really dictates how the curriculum is transacted in the classroom.

(3) From innovative model to expansion and adoption by the larger system. The IISTP group has been keenly aware that innovative work can be effective only if it finds acceptance in the larger system and is a model that can be adopted on a larger scale. Thus rather than try it out with a few well-equipped elite schools, the HSTP model has been evolved in Government schools in rural and semi-urban areas in close collaboration with and involvement of the district and state level education department.

(4) Empowering the Teachers. Recognizing the key role of the teachers in the education system, the HSTP innovation has actively involved the teachers themselves in the evolving of the innovative package. This has helped in motivating the teachers and has also resulted in very meaningful contributions to the innovation. It is naturally so because with their grassroots level experience, they are best equipped to critically examine and advise on what would really work in the classroom, apart from providing interesting insights into the process of education and child learning. We strongly believe that empowerment of the teachers academically, administratively and intellectually is an essential precondition for effective reforms at the classroom level. Technological aids can at best support the crucial role of the teacher.

(5) Administrative Decentralisation. Kothari Commission had very strongly recommended decentralisation of the school education structure using the school complex model. Utilising and equipping the block-level higher secondary school to administratively and academically coordinate the programme has effectively decentralised the field level implementation of the programme. A limitation has been the inability to decentralise financial powers, a problem that needs to be resolved by policy decisions at the higher level.

(6) Participation of Institutions of Higher Education and Research. HSTP group strongly believes that the effort to improve our school education system needs the involvement and commitment of some of the best


(7) Role of NGOs. HSTP is an ideal example of close and complementary working of the State Education Department and NGO groups to implement an innovative programme. The initial innovation and system was evolved on a pilot scale by Kishore Bharti and Friends Rural Centre, two voluntary organisations working in Hoshangabad district of Madhya Pradesh. With the district level expansion of the programme, the day to day administrative and academic responsibilities were taken over by appropriate cells and units within the State Education Department. The HSTP group played a major role in training of department personnel including teachers as well as administrative officers. Eklavya was formed in 1982 at the initiative of the HSTP group to provide an institutional base for further development of innovative programmes. It now has a coordinating role in further development of HSTP in collaboration with the SCERT and the State Education Department.

The Innovative Package
The HSTP package consists of the following:

(1) The 'Bal Vaigyanik' books. One book each for classes 6, 7 and 8 have been prepared. Special characteristics of these books are:

• These books are in combined format of work-cum-textbooks. Based on the discovery principle, the books mainly consist of instructions for activity along with guidelines about how to observe, record and analyse the data and observations. These are followed by a series of guiding questions answering which, with the help of the teacher, the children arrive at their own conclusions and understandings, which then they have to record. These are also interspersed with interesting and relevant information and accounts of scientific discovery, as well as problems for further practice;

• the layout design of the book has been specially designed to make it attractive and easy to read and follow for the children;

• simple and commonly spoken language has been used to make it
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easily comprehensible, difficult and complicated scientific terminologies have been avoided;

• each book has section called kit-copy which contains useable parts like graph papers, cut-outs and charts to be used in experimental activity;

• the books have been prepared after intensive field testing incorporating a variety of feed-back gathered from the teachers and children. Two editions of the books have been published till now. Presently the task of revising the books is on;

• the curricula material has been prepared by resource persons from leading institutions of scientific research and higher education who closely interacted with the teachers and children in the field to prepare and reprepare and reprepare drafts before final versions were ready;

• the books are being published by the M.P. Text Book Corporation since 1978. Since innovative books are published in smaller number, in order to make them available to the children at the same price as other books, the corporation has been subsidising the additional cost of printing, the developmental cost of the books being borne by Eklavya from its grants.

Teacher selection and training. No special criterion has been applied for selection of teachers and the teachers teaching science in the programme schools have been trained further. Interestingly, many teachers teaching science in middle schools have themselves never studied science beyond elementary classes and the training package has had to be suitably designed to take this into account. Even those who have studied science have done so by traditional rote-learning and have to be re-oriented to teach by innovative methods. Each teacher undergoes three trainings of three weeks duration for classes 6, 7 and 8 each, the trainings being organised during the summer vacations every year. During training, the 5-hour training daily consists of:

• doing all the experiments and activities of the Bal Vaigyanik and through analysis and discussion reaching conclusions and conceptual understanding expected;

• giving additional information regarding the subject and discussing possible queries that the children may raise;
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• discussions about the educational and academic understandings underpinning the programme and the administrative structure of the programme;

• training in evaluation methods and making new questions for open-book examinations;

• the training is conducted in a format similar to a typical classroom with the teachers working in groups of four each;

• apart from the formal training of five hours, extra curricular activities like origami, paper cutting, environment monitoring, lectures, film or slide show on popular science topics, etc. are arranged for teachers to take advantage of.

The training is conducted by a resource group consisting of HSTP resource persons from research and higher education institutions, and resource teachers from amongst previously trained school teachers who have shown exceptional motivation and ability. The resource group normally meets four days before the training to prepare and plan in advance. A ratio of 1:8 for resource persons to trainees is kept.

(3) Resource Group. The quality motivation and commitment of the resource group has been a crucial factor in the achievements of the HSTP. The resource group has played a key role in:

• development and improvement of Bal Vaigyanik books;
• training of teachers and resource teachers;
• preparation of teachers' guides and other manuals;
• conducting follow-up and monthly meetings;
• preparing test papers for annual evaluations for written and practical papers;
• preparing evaluation guidelines;
• answering questions asked by children through letters to 'Sawaliram', a fictitious character created for children to correspond with.

Apart from this, this group has been conducting trainings, exposure workshops, science popularisation programmes in other states. The resource group consists of following category of persons:

• middle school teachers who have undergone the training earlier and have shown exceptional motivation and ability. At present about 200 such resource teachers have been identified;
• science teachers of higher secondary schools, about 25 such teachers are involved;

• teachers from colleges and universities of Madhya Pradesh who voluntary give time for various needs of the programme, about 15 such persons are actively involved;

• professors, scientists and field workers from various research, higher education and non-governmental organisations all over the country, about 50 such persons.

(4) Kit. The kit designed for this programme is an activity kit designed for children to do their own experiments in groups of four. At present rates, a kit for an average school with 40 children in each class costs about Rs. 3,500. A steel almirah (Rs. 2,000) is required for its storage. The kit consists of three types of items - consumable, breakable and non-breakable. On an average about 20% of the kit needs to be replaced every year to make up the loss of consumable and breakable items. Thus Rs. 700 replacement cost needs to be provided annually which works to less than one rupee per child per month. In addition to the supplied kit, the children gather a lot of material from their environment to be used in various experiments. In HSTP, the kit procurement has till now been done through a centralised purchase system which has had its severe limitations. A decentralised system is now being worked out with teachers being given control over financial resources raised through a science fees.

(5) Monthly meetings and follow-up. In order to assist the teacher in the school situation and to encourage peer group interaction, a system of monthly meetings and follow-up school visits has been worked out. Every month, on a fixed date, the teachers gather at the block headquarter higher secondary school, designated as ‘sangam kendra’, for a day long meeting. In this meeting they share their experiences, discuss their problems and are also given a refresher or enrichment lesson by resource teachers. The resource teachers from all the sangam kendras come together on a fixed day at the district head quarter for a preparation meeting to plan and prepare for that month’s monthly meeting.

Follow-up visits to schools are organised by assigning a school each to resource teachers to visit and guide the teacher in the school situation itself.

(6) Examination and evaluation. An evaluation system designed according to the objectives of the programme consists of:
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- a written as well as a practical examination;
- the written exam is an open-book exam, designed to test analytical skills and de-emphasise learning by rote;
- the practical exam consists of five short experiments to be done and recorded by the child in a sequential setting.

The teachers are trained to design and use small test items in the class to assess children's learning and understanding to assist their teaching.

(7) Administrative structure. The decentralised administrative structure of the programme and its functioning has been codified in an administrative manual of the programme issued by the state education department. Main features of the structure are:

- block-level coordination through a designated higher secondary school (sangam kendra) with its Principal as in-charge, assisted by a senior teacher and a specially appointed assistant teacher;
- divisional-level coordination through a specially created cell, Vigyan Ikai, in the office of the Joint Director Public Instruction;
- State-level monitoring and coordination through a representative Sanchalan Samiti under the chairmanship of the Commissioner of Public Instruction.

(8) Extra curricular inputs. To strengthen curricular achievement and toustain children and teachers' enthusiasm, a number of extra-curricular inputs have been inbuilt into the programme:

- creation of Sawaliram, a fictitious character. Each book has a letter from Sawaliram addressed to the children asking them to ask questions and much more. Arrangement has been made to reply to their letters. These letters are a rich source of feedback from the children as well as a way of communicating with them. Replies to many questions prepared by subject experts but meant to communicate with children are now being compiled for publication;

- publishing of 'Chakmak', a monthly magazine for children, as well as small booklets containing interesting activities to do;

- publishing magazine 'Hoshangabad vigyan' and journal of resource material 'Sandharbh' for teachers;
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- encouraging teachers and children to participate in various science popularisation activities like jathas, bal melas, etc.

The Present

Now in its twenty sixth year, the HSTP has a comprehensive base of operation involving:

- nearly 500 middle schools spread over 14 districts of Madhya Pradesh covering over 1500 teachers and annually 40,000 children;

- a decentralised academic and administrative support structure based on the school complex model of the Kothari Commission working under the aegis of the Madhya Pradesh State Department of education and the SCERT;

- an academic resource group consisting of about 200 trained and motivated school teachers, backed and supported by a group of scientists and academicians from leading centres of research and education like Delhi University, Tata Institute of Fundamental Research, Indian Institutes of Technology, national Institute of Immunology, and Colleges and Universities of Madhya Pradesh;

- an academic package that encourages learning of science by activity-centred, discovery-oriented, environment-based methods;

- a large scale training system which emphasises hands-on experience in activity-based teaching and attitude building for innovative science education for teachers and teacher educators;

- a comprehensive feedback and follow-up system at the field level which continuously gives directions for further improvement and provides an effective and wide ranging forum for new and innovative inputs in the programme;

- a model situation for comparative evaluative studies in concept formation, cognitive and affective development, programme implementation strategies, etc.;

- a wide network of contacts, exchange and involvement programmes with a number of individuals, groups and organisations all over India working towards innovation and improvement in science education.
The Future Directions

Given the immense possibilities of this base, the following areas of innovative work have been taken up for further development.

(i) **Large scale expansion of the programme.**

We have been working at the idea of large scale expansion of the programme, eventually leading to a state-level expansion. Keeping in mind the size of Madhya Pradesh, this can only be done in phases. Exercises have been carried out to plan out the logistics and the financial implications of such an expansion. Implementation of such a large expansion would be possible only with decision at the political level. Eklavya and the HSTP group remains committed to laying the groundwork for such an extensive exercise. This would consist of:

- Identification and training of state-level and district-level resource groups which would be primarily responsible for teacher training and other academic inputs for the programme at the field level. About 500 such persons would be required.

- Developing and producing detailed manuals for Teacher training and other academic and administrative aspects of the programme.

- Evolving decentralised systems for kit procurement, distribution and replenishment. This has been a major stumbling block for the programme and alternative effective system is being worked out.

- Development and dissemination of resource material for science teachers in form of magazines, booklets and books. A beginning has been made with the launching of ‘Sandarbh’, a biomonthly magazine for teachers.

The Eklavya group hopes to play a participative role in large scale expansion of this effort to innovate science education over the entire state.

(ii) **Academic innovations in the curriculum material.**

Continuous innovation is an accepted norm in the HSTP group. The central concerns of the present round of innovations are twofold:

- the accumulated feedback since the last revision more than five years ago indicates that curricular material needs to be presented in a still
more attractive and child friendly form. Another area of concern is the efficacy of conceptual development and the ability to articulate it directly or through use in problem solving in key conceptual areas.

- A common criticism of the HSTP curriculum has been that while duly emphasising the ‘process’ aspect of science, the ‘product’ aspect or content is underplayed. Acknowledging this criticism, an attempt is being made to develop materials presenting new areas of content through innovative methods combining activity and narration emphasising understanding rather than rote learning. Initial attempts have been made in areas like ‘Atoms and molecules’, “Chemical Nature of Materials” and “Chemical Bonding”.

The material prepared is first being tried with teachers and then with children at various levels to establish its affectivity and appropriateness. The question of proper balancing so that the final curricula package does not overload the student or the teacher will of course have to be worked out finally in consultation with the teachers themselves. In order to arrive at a larger consensus on these issues, we propose to involve persons concerned with curricula design and development at various levels in this process through a series of workshops. We have sought collaboration with creative artists and designers for layout design and illustrations.

(iii) Spreading the Innovative Spirit.

The People’s Science Movement has proved to be an effective means for spreading the ideas and sharing the experiences of the HSTP. We have been responding to invitations to send our resource persons in meetings and workshops of teachers and people’s science activists in various states from time to time. Contingents of participants from various states are a regular feature of our training programmes. Two years ago a workshop was organised under the aegis of the All India People’s Science Network in which teams from various states worked together to translate books developed in Eklavya’s education programmes into various regional languages. Interaction with other groups continues to be important to our attempt for idea-level expansion of the HSTP. We have committed ourselves to the extent of providing close and extensive collaboration to groups attempting to develop innovative programmes in their states. The prime example is the Adhyaita Kendrit (Learner Centred) Science Teaching Programme in Gujarat.

The Gujarat programme is a joint programme of three field based groups - Gandhi Vidyapeeth, Vedchhi, diist. Surat, Lok Bharti, Sanosara,
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distt. Bhavnagar, Rural Science Extension Centre of Gujarat Vidyapeeth, Sadra, distt. Gandhinagar - and Vikram A. Sarabhai Community Science Centre, Ahmedabad. The group is developing learner-centred activity-based science teaching package for classes 5, 6 and 7, the upper primary classes in Gujarat. The programme has been developed in about 30 rural primary schools with permission and collaboration of the Gujarat State Education Department and the Gujarat Council of Science and Technology.

Eklavya has participated in this programme actively from the stage of conceptualising the project, preparing the proposal and now its implementation. Experimental versions of books in Gujarati for classes 5 and 6 have been prepared and are under trial in schools. Class 7 material is presently under preparation. We have had a major role in developing their resource group by participating in material development, teacher training and school follow-up programmes. The present development phase of the programme will continue for three more years.


Keeping in mind the projected needs of the programme, a conscious effort has been continuously made to develop the resource group in numbers as well as quality. A number of motivated and capable school teachers have been prepared to take up various academic and administrative tasks including training new teachers. Dealing with children themselves, most of these resource teachers are confident in handling the method part of the training. However, many have not had a chance to study science subjects beyond school level themselves, or even if they have, their own training has been so superficial that they do not feel confident as far as the content aspect of the curriculum is concerned. This has prompted us to plan content enrichment trainings for the resource persons. These trainings will have to be supplemented by providing reading and work material for them which is pitched at their level of understanding. Given a general lack of familiarity with basic mathematics, the challenge facing our group is to develop modules and materials which would be simple and begin from the basics, and naturally, be in Hindi.

Last summer two courses of ten day each were organised. Everyday a morning two hour session was devoted to a common lecture. Some of the topics covered (with names of the resource persons) are listed in the appendix. The rest of the day was spent in group work taking up an intensive study-cum-labwork project on any of the offered topics (also
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listed in the appendix). The list of the topics is by no means exhaustive and many more are likely to be added in future trainings.

A first attempt at this kind of training has been highly appreciated by the resource teachers and they have asked that more such courses be organised periodically. Materials prepared and tried out in this training are being reviewed and prepared in modular form along with additional supplementary reading material in Hindi either prepared originally or by translation.

This attempt is leading towards evolving of a general method and materials for training of resource persons and teacher educators. Keeping in mind the level at which it is being pitched, we expect additional fallouts from this effort:

- this package can be suitably modified for training of PSM activists, etc.

- the material generated is roughly of the level of high and higher secondary school level and could be of direct use to students also. It will give us a good base to attempt similar innovative science education at that level.

- this training also provides the base for introducing science teachers to specific technological inputs and science-technology-society issues, something that the restrictions of present school curricula tend to restrict. This exposure will reflect in the future as these resource teachers also get involved in further curricular innovations.

(v) Comprehensive Evaluative Studies and Documentation.

The nature and expanse of the HSTP offer an ideal situation for a comprehensive comparative evaluation of academic, administrative and social impact of such an innovative effort. While some piecemeal evaluations have been attempted from time to time, the expressed need for a comprehensive effort and documentation remains unfulfilled. Such an evaluation requires a complex exercise of selection and development of evaluation tools and their standardisation before the actual evaluation and analysis. We are looking for a suitable group or agency which can take the major responsibility of organising such an exercise in collaboration. This would have to be undertaken as a separate project with independent funding.

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APPENDIX X

The Convention on Biological Diversity*

The Contracting Parties,
Conscious of the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural recreational and aesthetic values of biological diversity and its components,
Conscious also of the importance of biological diversity for evolution and for maintaining life sustaining systems of the biosphere,
Affirming that the conservation of biological diversity is a common concern of human kind,
Reaffirming that states have sovereign rights over their own biological resources,
Reaffirming also that states are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner,
Concerned that biological diversity is being significantly reduced by certain human activities,
Aware of the general lack of information and knowledge regarding biological diversity and of the urgent need to develop scientific, technical and institutional capacities to provide the basic understanding upon which a plan and implement appropriate measures,
Noting that it is vital to anticipate, prevent and attack the causes of significant reaction or loss of biological diversity at source,
Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimise such a threat
Noting further the fundamental requirement for the conservation of biological diversity is the in situ conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings,
Nothing further that in situ measures, preferably in the country of origin, also have an important role to play,
Recognising the close and traditional dependence of many indigenous and local communities embodying traditional lifestyles on biological

* Signed by over 15 nations during the UN Conference on Environment and Development held at Rio De Janeiro in June, 1992
resources, and the desirability of sharing equitably benefits arising from
the use of traditional knowledge, innovations and practices relevant to
the conservation of biological diversity and the sustainable use of its
components,

Recognizing also the vital role that women play in the conservation and
sustainable use of biological diversity and affirming the need for the
full participation of women at all levels of policy-making and
implementation for biological diversity conservation,

Stressing the importance of, and the need to promote, international,
regional and global cooperation among States and intergovernmental
organizations and the non-governmental sector for the conservation of
biological diversity and the sustainable use of its components,

Acknowledging that the provision of new and additional financial
resources and appropriate access to relevant technologies can be expected
to make a substantial difference in the world's ability to address the loss
of biological diversity,

Acknowledging further that special provision is required to meet the
needs of developing countries, including the provision of new and
additional financial resources and appropriate access to relevant
technologies,

Noting in this regard the special conditions of the least developed
countries and small island States,

Acknowledging that substantial investments are required to conserve
biological diversity and that there is the expectation of a broad range of
environmental, economic and social benefits from those investments,

Recognizing that economic and social development and poverty
eradication are the first and overriding priorities of developing countries,

Aware that conservation and sustainable use of biological diversity is of
critical importance for meeting the food, health and other needs of the
growing world population, for which purpose access to and sharing of
both genetic resources and technologies are essential,

Noting that, ultimately, the conservation and sustainable use of biological
diversity will strengthen friendly relations among States and contribute
to peace for humankind,
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Desiring to enhance and complement existing international arrangements for the conservation of biological diversity and sustainable use of its components, and

Determined to conserve and sustainably use biological diversity for the benefit of present and future generations,

Have agreed as follows:

ARTICLE 1. OBJECTIVES

The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

ARTICLE 2. USE OF TERMS

For the purposes of this Convention:

"Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: that includes diversity within species, between species and of ecosystems.

"Biological resources" includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity.

"Biotechnology" means any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

"Country of origin of genetic resources" means the country which possesses those genetic resources in in-situ conditions.

"Country providing genetic resources" means the country supplying genetic resources collected from in-situ sources, including populations of both wild and domesticated species, or taken from ex-situ sources, which may or may not have originated in that country.
"Domesticated or cultivated species" means species in which the evolutionary process has been influenced by humans to meet their needs.

"Ecosystem" means a dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

"Ex-situ conservation" means the conservation of components of biological diversity outside their natural habitats.

"Genetic material" means any material of plant, animal microbial or other origin containing functional units of heredity.

"Genetic resources" means genetic material of actual or potential value.

"Habitat" means the place or type of site where an organism or population naturally occurs.

"In-situ conditions" means conditions where genetic resources exist within ecosystems and natural habitats, and in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

"In-situ conservation" means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.

"Protected area" means a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives.

"Regional economic integration organization" means an organization constituted by sovereign States of a region, to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve or accede to it.

"Sustainable use" means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

"Technology" includes biotechnology.
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ARTICLE 3. PRINCIPLE

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

ARTICLE 4. JURISDICTIONAL SCOPE

Subject to the rights of other States, and except as otherwise expressly provided in this Convention, the provisions of this Convention apply, in relation to each Contracting party:

(a) In the case of components of biological diversity, in areas within the limits of its national jurisdiction; and
(b) In the case of processes and activities, regardless of where their effects occur, carried out under its jurisdiction or control, within the area of its national jurisdiction or beyond the limits of national jurisdiction.

ARTICLE 5. COOPERATION

Each Contracting Party shall, as far as possible and as appropriate, cooperate with other Contracting Parties, directly, or, where appropriate, through competent international organizations, in respect of areas beyond national jurisdiction and on other matters of mutual interest, for the conservation and sustainable use of biological diversity.

ARTICLE 6. GENERAL MEASURES FOR CONSERVATION AND SUSTAINABLE USE

Each contracting Party shall, in accordance with its particular conditions and capabilities:

(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this convention relevant to the Contracting Party concerned; and

(b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.
ARTICLE 7. IDENTIFICATION AND MONITORING

Each Contracting Party shall, as far as possible and as appropriate, in particular for the purposes of Articles 8 to 10:

(a) Identify components of biological diversity important for its conservation and sustainable use having regard to the indicative list of categories set down in Annex I;

(b) Monitor, through sampling and other techniques, the components of biological diversity identified pursuant to subparagraph (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use;

(c) Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques; and

(d) Maintain and organize, by any mechanism data, derived from identification and monitoring activities pursuant to subparagraphs (a), (b) and (c) above.

ARTICLE 8. IN-SITU CONSERVATION

Each Contracting Party shall, as far as possible and as appropriate:

(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;

(b) Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;

(c) Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;

(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;

(e) Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;
(f) Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, inter alia, through the development and implementation of plans or other management strategies;

(g) Establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health;

(h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;

(i) Endeavour to provide the conditions needed for compatibility between present uses and conservation of biological diversity and the sustainable use of its components;

(j) Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices;

(k) Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations;

(l) Where a significant adverse effect on biological diversity has been determined pursuant to Article 7, regulate or manage the relevant processes and categories of activities;

(m) Cooperate in providing financial and other support for in-situ conservation outlined in subparagraphs (a) to (l) above, particularly to developing countries.

**ARTICLE 9. EX-SITU CONSERVATION**

Each Contracting Party shall, as far as possible and as appropriate, and predominantly for the purpose of complementing in-situ measures:

(a) Adopt measures for the ex-situ conservation of components of biological diversity, preferably in the country of origin of such components;
(b) Establish and maintain facilities for ex-situ conservation of and research on plant, animals and micro-organisms, preferably in the country or origin of genetic resources;

(c) Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions;

(d) Regulate and manage collection of biological resources from natural habitats for ex-situ conservation purposes so as not to threaten ecosystems and in-situ populations of species, except where special temporary ex-situ measures are required under subparagraph (c) above; and

(e) Cooperate in providing financial and other support for ex-situ conservation outlined in subparagraphs (a) to (d) above and in the establishment and maintenance of ex-situ conservation facilities in developing countries.

ARTICLE 10: SUSTAINABLE USE OF COMPONENTS OF BIOLOGICAL DIVERSITY

Each Contracting Party shall, as far as possible and as appropriate:

(a) Integrate consideration of the conservation and sustainable use of biological resources into national decision-making;

(b) Adopt measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity;

(c) Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements;

(d) Support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced; and

(e) Encourage cooperation between its governmental authorities and its private sector in developing methods for sustainable use of biological resources.
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ARTICLE 11. INCENTIVE MEASURES

Each Contracting Party shall, as far as possible and as appropriate, adopt economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biological diversity.

ARTICLE 12. RESEARCH AND TRAINING

The Contracting Parties, taking into account the special needs of developing countries, shall:

(a) Establish and maintain programmes for scientific and technical education and training in measures for the identification, conservation and sustainable use of biological diversity and its components and provide support for such education and training for the specific needs of developing countries;

(b) Promote and encourage research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries, inter alia, in accordance with decisions of the Conference of the Parties taken in consequence of recommendations of the Subsidiary Body on Scientific, Technical and Technological Advice; and

(c) In keeping with the provisions of Articles 16, 18 and 20 promote and cooperate in the use of scientific advances in biological diversity research in developing methods for conservation and sustainable use of biological resources.

ARTICLE 13. PUBLIC EDUCATION AND AWARENESS

The Contracting Parties shall:

(a) Promote and encourage understanding of the importance of, and the measures required for, the conservation of biological diversity, as well as its propagation through media, and the inclusion of these topics in educational programmes; and

(b) Cooperate, as appropriate, with other States and international organizations in developing educational and public awareness programmes, with respect to conservation and sustainable use of biological diversity.
ARTICLE 14. IMPACT ASSESSMENT AND MINIMISING ADVERSE IMPACTS

1. Each Contracting Party, as far as possible and as appropriate, shall:

a. Introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimising such effects and, where appropriate, allow for public participation in such procedures;

b. Introduce appropriate arrangements to ensure that the environmental consequence of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account;

c. Promote, on the basis of reciprocity, notification, exchange of information and consultation on activities under their jurisdiction or control which are likely significantly to affect adversely the biological diversity of other States or areas beyond the limits of national jurisdiction, by encouraging the conclusion of bilateral, regional or multilateral arrangements as appropriate;

d. In the case of imminent or grave danger or damage originating under its jurisdiction or control to biological diversity within the area under jurisdiction of other States or in areas beyond the limits of national jurisdiction, notify immediately the potentially affected States of such danger or damage, as well as initiate action to prevent or minimise such danger or damage;

e. Promote national arrangements for emergency responses to activities or events, whether caused naturally or otherwise, which present a grave and imminent danger to biological diversity and encourage international cooperation to supplement such national efforts and, where appropriate and agreed by the States or regional economic integration organisations concerned, to establish joint contingency plans.

2. The Conference of the Parties shall examine, on the basis of studies to be carried out, the issue of liability and redress, including restoration and compensation, for damage to biological diversity, except where such liability is a purely internal matter.
ARTICLE 15. ACCESS TO GENETIC RESOURCES

1. Recognising the sovereign rights of States over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation.

2. Each Contracting Party shall endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and to impose restrictions that run counter to the objectives of this Convention.

3. For the purpose of this Convention, the genetic resources being provided by a Contracting Party, as referred to in this Article and Articles 16 and 19, origin of such resources or by the Parties that have acquired the genetic resources in complete with this Convention.

4. Access, where granted, shall be on mutually agreed terms and subject to the provisions of the Article.

5. Access to genetic resources shall be subject to prior informed consent of the Contracting Party providing such resources, unless otherwise determined by that Party.

6. Each Contracting Party shall endeavour to develop and carry out scientific research based on genetic resources provided by other Contracting Parties with the full participation of, and where possible in, such Contracting Parties.

7. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, and in accordance with Articles 16 and 19 and where necessary through the financial mechanism established by Articles 20 and 21, with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilisation of genetic resources with the Contracting Party providing such resources. Such sharing shall be upon mutually agreed terms.

ARTICLE 16. ACCESS TO AND TRANSFER OF TECHNOLOGY

1. Each Contracting Party, recognising that technology includes biotechnology, and that both access to and transfer of technology among Contracting Parties are essential elements for the attainment of the objectives of this Convention, undertakes subject to the provisions of this Article to provide and/or facilitate access for and transfer to other
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Contracting Parties of technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and do not cause significant damage to the environment.

2. Access to and transfer of technology referred to in paragraph 1 above to developing countries shall be provided and/or facilitated under fair and most favourable terms, including on concessional and preferential terms where agreed, and where necessary in accordance with the financial mechanism established by Articles 20 and 21. In the case of technology to patents and other intellectual property rights, such access and transfer shall be provided on terms with recognise and are consistent with the adequate and effective protection of intellectual property rights. The application of this paragraph shall be consistent with paragraphs 3, 4 and 5 below.

3. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that Contracting Parties, in particular those that are developing countries, which provide genetic resources are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights, where necessary through the provisions of Articles 20 and 21 and in accordance with international law and consistent with paragraphs 4 and 5 below.

4. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, with the aim that the private sector facilitates access to, joint development and transfer of technology referred to in paragraph 1 above for the benefit of both governmental institutions and the private sector of developing countries and in this regard shall abide by the obligations included in paragraphs 1, 2 and 3 above.

5. The Contracting Parties, recognising that patents and other intellectual property rights may have an influence on the implementation of this Convention, shall cooperate in this regard subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to its objectives.

ARTICLE 17, EXCHANGE OF INFORMATION

1. The Contracting Parties shall facilitate the exchange of information, from all publicly available sources, relevant to the conservation and sustainable use of biological diversity, taking into account the special needs of developing countries.
2. Such exchange of information shall include exchange of results of technical, scientific and socio-economic research, as well as information on training and surveying programmes, specialised knowledge, indigenous and traditional knowledge as such and in combination with the technologies referred to in Article 16, paragraph 1. It shall also, where feasible, include repatriation of information.

ARTICLE 18, TECHNICAL AND SCIENTIFIC COOPERATION

1. The Contracting Parties shall promote international technical and scientific cooperation in the field of conservation and sustainable use of biological diversity, where necessary through the appropriate international and national institutions.

2. Each Contracting party shall promote technical and scientific cooperation with other Contracting Parties, in particular developing countries, in implementing this Convention, inter alia, through the development and implementation of national policies. In promoting such cooperation, special attention should be given to the development and strengthening of national capabilities, by means of human resource development and institution building.

3. The Conference of the Parties, at its first meeting, shall determine how to establish a clearing-house mechanism to promote and facilitate technical and scientific cooperation.

4. The Contracting Parties shall, in accordance with national legislation and policies, encourage and develop methods of cooperation for the development and use of technologies, including indigenous and traditional technologies, in pursuance of the objectives of this Convention. For this purpose, the Contracting Parties shall also promote cooperation in the training of personnel and exchange of experts.

5. The Contracting Parties shall, subject to mutual agreement, promote the establishment of joint research programmes and joint ventures for the development of technologies relevant to the objectives of this Convention.

ARTICLE 19. HANDLING OF BIOTECHNOLOGY AND DISTRIBUTION OF ITS BENEFITS

1. Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, to provide for the effective participation in
biotechnological research activities by those Contracting Parties, especially developing countries, which provide the genetic resources for such research, and where feasible in such Contracting Parties.

2. Each Contracting Party shall take all practicable measures to promote and advance priority access on a fair and equitable basis by Contracting Parties, especially developing countries, to the results and benefits arising from biotechnologies based upon genetic resources provided by those Contracting Parties. Such access shall be on mutually agreed terms.

3. The Parties shall consider the need for and modalities of a protocol setting out appropriate procedures, including, in particular, advance informed agreement, in the field of the safe transfer, handling and use of any living modified organism resulting from biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity.

4. Each Contracting Party shall, directly or by requiring any natural or legal person under its jurisdiction providing the organisms referred to in paragraph 3 above, provide any available information about the use and safety regulations required by that Contracting Party in handling such organisms, as well as any available information on the potential adverse impact of the specific organisms concerned to the Contracting Party into which those organisms are to be introduced.

ARTICLE 20: FINANCIAL RESOURCES

1. Each Contracting Party undertakes to provide, in accordance with its capabilities, financial support and incentives in respect of those national activities which are intended to achieve the objectives of this convention, in accordance with its national plans, priorities and programmes.

2. The developed country Parties shall provide new and additional financial resources to enable developing country Parties to meet the agreed full incremental costs to them of implementing measures which fulfil the obligations of this Convention and to benefit from its provisions and which costs are agreed between a developing country Party and the institutional structure referred to in Article 21, in accordance with policy, strategy, programme priorities and eligibility criteria and an indicate list of incremental cost established by the Conference of the Parties. Other Parties, including countries under-going the process of transition to a market economy may voluntarily assume the obligations of the developed country Parties. For the purpose of this Article the Conference
of the Parties shall at its first meeting establish a list of developed country parties and other Parties which voluntarily assume the obligations of the developed country Parties. The Conference of the Parties shall periodically review and if necessary amend the list. Contributions from other countries and source on a voluntary basis would also be encouraged. The implementation of these commitments shall take into account the need for adequacy, predictability and timely flow of funds and the importance of burden-sharing among the contributing Parties included in the list.

3. The developed country Parties may also provide, and developing country Parties avail themselves of, financial resources related to the implementation of this Convention through bilateral, regional and other multilateral channels.

4. The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account the fact the economic and social development and eradication of poverty are the first and overriding priorities of the developing country Parties.

5. The Parties shall take full account of the specific needs and special situation of least developed countries in their actions with regard to funding and transfer of technology.

6. The Contracting Parties shall also take into consideration the special conditions resulting from the dependence on distribution and location of biological diversity within developing country Parties, in particular small island States.

7. Consideration shall also be given to the special situation of developing countries, including those that are most environmentally vulnerable, such as those with arid and semi-arid zones, coastal and mountainous areas.

ARTICLE 21, FINANCIAL MECHANISM

1. There shall be a mechanism for the provision of financial resources to developing country Parties for purposes of this Convention on a grant or concessional basis the essential elements of which are described in this Article. The mechanism shall function under the authority and guidance of, and the accountable to, the Conference of the Parties for
pursposes of this Convention. The operations of the mechanism shall be carried out by such institutional structure as may be decided upon by the Conference of the Parties at its first meeting. For purposes of this Convention, the Conference of the Parties shall determine the policy, strategy, programme priorities and eligibility criteria relating to the access to and utilisation of such resources. The contributions shall be such as to take into account the need for predictability, adequacy and timely flow of funds referred to in Article 20 in accordance with the amount of resources needed to be decided periodically by the Conference of the Parties included in the list referred to in Article 20, paragraph 2. Voluntary contributions may also be made by the developed country Parties and by other countries and sources. The mechanism shall operate within a democratic and transparent system of governance.

2. Pursuant to the objectives of this Convention, the Conference of the Parties shall at its first meeting determine the policy, strategy and programme priorities, as well as detailed criteria and guidelines for eligibility for access to and utilisation of the financial resources including monitoring and evaluation on a regular basis of such utilisation. The Conference of the Parties shall decide on the arrangements to give effect to paragraph 1 above after consultation with the institutional structure entrusted with the operation of the financial mechanism.

3. The Conference of the Parties shall review the effectiveness of the mechanism established under this Article, including the criteria and guidelines referred to in paragraph 2 above, not less than two years after the entry into force of this Convention and thereafter on a regular basis. Based on such review, it shall take appropriate action to improve the effectiveness of the mechanism if necessary.

4. The Contracting Parties shall consider strengthening existing financial institutions to provide financial resources for the conservation and sustainable use of biological diversity.

ARTICLE 22, RELATIONSHIP WITH OTHER INTERNATIONAL CONVENTIONS

1. The provisions of the present Convention shall not affect the rights and obligations of any Contracting Party deriving from any existing international agreement, except where the exercise of those rights and obligations would cause serious damage or a threat to biological diversity.

2. Contracting Parties shall implement this Convention with respect to the marine environment consistently with the rights and obligations of States under the law of the sea.
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ARTICLE 23, CONFERENCE OF THE PARTIES

1. A conference of the Parties is hereby established. The first meeting of the Conference of the Parties shall be convened by the Executive Director of the United Nations Environment Programme not later than one year after the entry into force of this Convention. Thereafter, ordinary meetings of the Conference of the Parties shall be held at regular intervals to be determined by the Conference at its first meeting.

2. Extraordinary meetings of the Conference of the Parties shall be held at such other times as may be deemed necessary by the Conference, or at the written request of any Party, provided that, within six months of the request being communicated to them by the Secretariat, it is supported by at least one-third of the Parties.