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Science and Capacity Building for the Knowledge Society

by

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First of all, I would like to offer very best wishes and congratulations on behalf of the Indian National Science Academy and on my own behalf on your 75th anniversary. Your Academy has a very distinguished record of service to science and allied disciplines, giving due attention to the developing countries and I hope that you will continue to prosper in these endeavours in years ahead. It is a very special privilege for me to address this august gathering of members of your Academy and other dignitaries including HH Princess Astrid. Thank you for the kind invitation.

This afternoon, I am going to focus on a theme that is of utmost importance and concern to the S&T community as well as society at large, of building science and technology capacity for the knowledge society.

In the recent past, many leading lights have addressed the issue of science and technology capacity building and therefore it is not easy to say something profoundly new or original. But, I do believe that as the issue is of great contemporary concern, it needs to be periodically revisited and re-emphasized in a fast changing world. This is particularly so as S&T capacity building is going to be a key element in our transition to the knowledge society, for sustainable development and for a more peaceful and equitable world.

In an overall sense, my presentation on S&T capacity would be from a global perspective but I would develop the theme with particular focus on challenges faced by the developing countries as the issue is of critical

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importance and concern to them. For someone coming from a developing country, this deep concern is natural and emanates from deep within. The structure and content of this narration is an adaptation of the power-point presentation made at the conference and there might be some elements of disconnectivity but I hope it will still convey the main message of my song.

These are very vibrant times and we are fortunate to be living in an era that is witnessing a transition to the knowledge society. There is an emerging consensus that the 21st century will be the "century of knowledge". This stage of transition to the knowledge society has been arrived through an evolutionary process involving economic growth and societal transformations that has run for centuries. Thus, the agriculture society gave way to the industrial society and in the past few decades information society has come to the fore. With the galloping pace of ICT and rapid globalization on the economic front, the era of knowledge-driven world has been ushered in much sooner than could be contemplated even a decade ago. While technology and networks have been the main drivers of some of the earlier transitions, overarching influence of competition, innovations and entrepreneurship, in concert with developments in S&T front, will drive the knowledge society.

What is a knowledge society? It is not easy to confine knowledge society into a definitional framework, but its broad contours can be recognized in the following manner. A knowledge society is the one that uses knowledge holistically to empower and enrich people and is an integral driver of sustainable development. It has to be a lifelong learning society committed to innovation. Besides, having capacity to generate, diffuse, utilize and protect knowledge, it also creates economic wealth and social equity. Lastly, an important aspect of the knowledge society is that it enlightens people towards an integrated view of life as a fusion of mind, body and spirit.

This is an age of science and there is general consensus that the 20th century's unprecedented gains in advancing human development and eradicating poverty have come from wide ranging and at times spectacular technical breakthroughs. The role of science and its applications is going to be even more important in the future. S&T is now recognized as the main engine for development and for sustainable economic growth. It is estimated that at least half if not more of the economic growth in the developed countries is directly attributable to S&T and this contribution is only going to increase in a rapidly globalizing world. This is going to impact societal developments immensely. D. K. Price has said "There is hardly any social problem on which science cannot make some contribution". But, this needs to be tempered with a caveat that "science is never sufficient to solve a problem completely; it is however always necessary". This underscores the need for harmonization of science for policy and policy for science.

Contributions of science and technology to development process and in particular towards improving the quality of life of the people have been overwhelming but the spread of these benefits has been very uneven. The development process is usually defined as "expanding the choices people have to lead lives that they value". But, the most troublesome reality of today's world is that nearly half of the world population lives in conditions of relative to complete deprivation. What choices do they have? Let us look at some alarming figures to highlight both the reality of the present-day world and the challenges that we need to overcome to make our planet a better place to live for all. Nearly 1 billion people have no access to safe drinking water, 2.4 billion live under conditions that lack basic sanitation and over a billion people in our world cannot read or write! And this is really the paradox of the times that we live in. Despite great scientific achievements and technological breakthroughs, and unprecedented economic progress, the inequalities continue to rise alarmingly between nations and within nations. Assets of the world's three richest people exceed combined GDP of the poorest 48 countries. Nearly 1.2 billion people live on less than one dollar a day income, and another 2.8 billion on less than 2 dollars a day. They are 1998 figures and it is doubtful if the figures have changed much for the better. Currently, 50 % of the world's population lives on an income of less than 2 dollars a day. These growing inequalities are both the cause and consequence of the knowledge divide. The world has witnessed the damaging consequences of economic inequalities in the recent past. The knowledge divide can create new and difficult problems that are hard to foresee.

While economic disparities between the countries of the North and South are a matter of great concern, the problem of S&T capacity and human resources in the emerging knowledge society is even more important. Let some figures speak for themselves. If one looks at the power of human capital, in terms of scientists and engineers (researchers) per ten thousand populations, the numbers are 44 for Japan, 26 for the United States, 20 for Europe, 1.3 for India and 0.7 for the poorer countries of the world in Asia and Africa. In these numbers, one can clearly see how the S&T human resource capacity or lack of it manifests into economic strength or weakness. There is another interesting statistic relevant to the knowledge society. 15 % of the world's population lives in the developed countries. They account for 88 % of the Internet connectivity. In the developing world, the situation is reverse. Nearly 85 % of the people live there, but have only 12 % of the worldwide Internet connectivity.

Practice of modern science and technological innovations need creation of R&D infrastructure and require large investments. Once again the asymmetry in scientific spending versus incomes is even more glaring between the developed and the developing countries. The income gap between OECD countries and economically least developed countries is about sixty times. But, the difference in their S&T related R&D spending is two hundred and fifty times. OECD countries account for about 85 % of the total R&D expenditure in the world. This huge difference in spending in R&D is duly reflected in the S&T output. In fact, OECD countries contribute 94 % of world's indexed scientific literature, and 96 % of the world's patents are filed by these countries.

Accumulation and flow of information has witnessed explosive growth and is going to be of fundamental importance in the knowledge society. Let us look at the profile and pace of evolution of information. Since the time of Christ to 1750 AD in nearly 1,700 years, information doubled. From 1750 to 1900 AD, information again doubled but in a shorter time span of over a century. Between 1900 and 1950 it took just fifty years for the information to double again. It is estimated that since 1950 information has doubled every three or four years. There has been an unprecedented growth of information and some estimates indicate that more information has been generated in the last three years than in the previous 5,000 years. The yawning gap between generation, access and diffusion of information among the developed and the developing countries is another area of major concern that needs urgent attention.

In the past few decades technology has been growing at a galloping pace in shrinking time domains. Advances in ICT are taking place at breathtaking pace. Currently, the computer power doubles in 18 months, networking doubles in 12 months and storage or hard disk capacity doubles every 9 months. Time domains from the scientific discovery to technological applications and the market place are getting shortened dramatically. For example, it took over fifty years from Faraday's discovery of electromagnetic theory in 1830 to the commercial light bulbs; Watson and Crick's discovery of DNA double helix in 1952 took just twenty years for first genetic engineering applications. Currently, new innovations in ICT are taking a year or less to get into the market place.

Earlier in this presentation, it was emphasized that creation of modern R&D infrastructure in all parts of the world is not only very important and essential but it is also a capital intensive enterprise. Consider the emerging frontier areas in S&T like genomics and nanotechnology, the investments that developed countries are making in them are more than the GDP of many countries. US alone spend upwards of 2 billion in research in nanotechnology and Japan and UK are trying to catch up with this level of funding. How do the poorer nations of the world do, including the eighty countries classified as scientifically lagging, having no capital to cope with this challenge?

As already mentioned above, among the many challenges of the global knowledge divide, the increasing S&T gap between the North and South is the most important. Distribution of S&T capacities is even more lopsided than the economic power. This is reflected in many facets of life in the countries of the South. Let me illustrate this through the picture of a classroom in some part of the developing world where there is no electricity to light a bulb. You also see in the same projection a classroom offering a business management course in a developed country with online internet connectivity for every student. This picture in a dramatic way symbolizes the challenge ahead to bridge the knowledge and economic divide plaguing our world.

Having portrayed a somewhat dismal and depressing picture of the present, let me turn to hope and promise for the future. Let me show you the famous "hole-in-the-wall" experiment carried out in India, where a hole was made in a wall, and a computer screen was installed with keyboard and internet access in a slum area. It was observed that the semi-illiterate slum children, quickly learned how to surf on the net, and were able to download very useful information. This experiment is actually a demonstration of what is referred as minimally invasive education. In fact it opens up new paradigms in education as such and also for learning science and information access. It highlights the fact that talent and ability are all pervasive but access and opportunity are not. Given an opportunity, the poor and the underprivileged can perform wonders: there can be blossoms in the dust too.

What is clear is that there is a great potential for the rich human capital in the South. Population, though at times an embarrassment and causative factor of poverty, can also be a renewable knowledge resource as important as capital. Of course, I am not making a case for an over-populated planet, which has already crossed 6 billion mark and must stabilize itself at the earliest. The need today is to fully harness the existing human potential in all parts of the world for a better future for all.

A solid foundation for a better future for all, both the developing countries and the developed countries, can be envisaged by capitalizing on the human resources and by building sustainable S&T capacities in an all inclusive manner. S&T capacity needs to be recognized as a global challenge. A new understanding of the South is needed.

What is the road ahead? For the S&T capacity building enterprise, some important milestones need to be recognized. There is need for a global perspective and commitment on the issue along with harmonization with local requirements and contexts. There is an urgent need for new initiatives and strategies by global institutions that deal with scientific knowledge. S&T capacity building is a complex issue and therefore, practical, pragmatic and multi-pronged strategies have to be evolved. There has to be a long-term vision and support should be on a continuous basis. New thinking is needed as the efforts of the past have not fully delivered and appear to be outdated.

It is important to recognize that S&T capacity building is a continuum and not an "on-off" or seasonal exercise. There is also desirability for a "broad-band" approach to building S&T capacities. There is a perception among some, particularly among some international funding and aid-giving agencies, that developing countries need only relevant technologies. I completely disagree with this thesis. Many, even among the scientific community, theorize that desert states in North Africa should focus on improving the breed of their camel or a developing country in Central America should concentrate on building capacity to improve the quality of bananas as these are relevant problems and bring economic benefits. My country, India, is doing well in information technology and some venture to advise us that do only that. I completely disagree with this thesis. Such approaches in my view are justified only in a limited context. I believe a much more long range and holistic view of knowledge and science and technology requirement in all parts of the world is necessary. *Every country needs the capacity to understand and adapt global technologies and therefore needs a self-standing S&T base and it should be the endeavour of all to see that happen.* Such an approach will cultivate self-esteem among all. The road along this path may be long and difficult but the commitment to traverse the distance should not be shrouded in ambiguity. In fact, the universal and compulsive nature of knowledge and sharing it with all was recognized nearly ten thousand years ago, and I quote here from the Vedas, ancient Indian texts of Wisdom, "...Let knowledge come from all sides". I would rather like to paraphrase it by saying, "let knowledge come to all from all sides".

There is a valid perception among some that segmentation of knowledge leads to divisiveness. This is something we should take note of as we make transition to the knowledge society.

What is the road ahead for S&T capacity building and bridging the knowledge divide? I wish to offer you a sampling of a few action points that I think are very important.

As human resources are very important in S&T capacity building, there is need to promote and look for new paradigms in science education. In my view, science education has not undergone much reform in the last 30-40 years. It is time for a "rethink" on science education at both pedagogy and curricular level. In doing so, the intrinsic complementarity between science education and other knowledge streams, particularly, enlightens humanities and social sciences must be taken into account. Science education must rekindle interest in experiments and in the skills of observation. Scientists were always called natural philosophers, who relied on observations through their sensory perceptions. But, today this aspect is nearly forgotten and today many learn chemistry without entering a laboratory and learn machining without touching a lathe.

I should also like to make a strong plea for the restoration of the inspirational role of the teacher as a motivator and mentor. Yes, let us have web-based education, let us have reach-out through internet but without compromising the central role of the teacher in shaping and inspiring scientific careers. Integration of science education with concepts of sustainable development is definitely required for tomorrow's world. There are many initiatives and experiments underway in science education through the efforts of the Inter-Academy Panel (IAP), UNESCO, TWAS and many leading Academies and NGOs of the world are participating in these endeavours. These experiences need to be shared and built upon.

A movement is needed worldwide, encompassing every country for universal, scientific and technical literacy. "Science for all, science for everyone" must get across. Learning science should be projected as an enlightening experience.

Science, its values and its societal engagement need to be brought into central stage. National Science Academies have a major role to play in this endeavour. Scientific revolution as we all know has outpaced social revolution for almost a century now. In this context, the linear conception of science and technology for progress in the emerging knowledge society may be inadequate.

New institutions, active networks and modern infrastructure need to be created, particularly in the context of the developing world, where more than two thirds of humanity live and work. The traditional view of flow of knowledge from the advanced countries to the developing countries, with the latter always at the receiving end, needs to be replaced with a better understanding of the complexity of interactions between nations in tomorrow's world. Every country should be encouraged to think strategically to develop its S&T base giving due attention to local concerns (health, food security, natural resources, etc.) and keeping in mind its traditional knowledge base and future aspirations in the global value chain.

Information access is very important, particularly access to scientific journals, books and data. But there is a silver lining. I will just give a couple of examples here. MIT's open courseware initiative is an effort to make teaching aids and teaching material available on the web. Digital library in Alexandria in Egypt, is again a very fine example of what a developing nation can do to preserve its heritage and information storage and dissemination. As far as journals are concerned, one would like to draw attention to the public library of science, PLOS, which was launched a month ago. The first issue of PLOS in biology is already making waves with some path-breaking findings. Hopefully this initiative will bring some relief. We, of course, know that the National Academy of Sciences does make available proceedings of the National Academy of Sciences (PNAS) after a time gap for ready access.

I should now like to raise a few more issues of concern, although in a random fashion.

The interactive complexity of the S&T innovations and commercialization, modern IPR regimes and the value of indigenous knowledge need new understanding. Recognize indigenous knowledge as a common heritage of humankind as many of its features could be the key elements of sustainable development strategies.

New paradigms need to be devised for exploring the immense potential in international cooperation in S&T, particularly in the context of building both the infrastructure and human resource capacities. Both North-South and South-South cooperation is important. But, I would like to highlight the primacy of South-South cooperation in international collaboration in science and technology. There must be a shift from a culture of patronage to partnership in international collaborations. We must consider new alliances to build capacities for the generation infusion and absorption of technology in real time. This is the kind of capacity that two thirds of humanity need in the next few decades.

Finally, I wish to focus on the role of science academies. I firmly believe that in science and technology capacity building endeavours, science academies can play a very important role. I had earlier referred to the Inter-Academy Panel (IAP) and its energetic role in promoting science education in capacity building and so on. In 2000, more than eighty science academies of the Inter-Academy Panel decided to establish the Inter-Academy Council (IAC), with the mandate of mobilizing the world's best science for a better tomorrow. The IAC strategy is to address pressing S&T issues of global concern through authoritative, merit-based studies by internationally acclaimed experts. These studies are subjected to a review process and then published for wider dissemination. The target audiences for these reports range from national governments to academies to society and NGOs to name a few. There is an executive board of the Inter-Academy council with fifteen representatives (mostly Presidents) of the world's leading academies. The IAC is currently co-chaired by Bruce Alberts, President of the National Academy of Sciences, USA and myself, and the secretariat is located in the Netherlands and hosted by the Royal Netherlands Academy of Arts and Sciences. ICSU, IAP and the Royal Netherlands Academy are observers on the Inter-Academy Council.

As already mentioned, the Inter-Academy Council carries out studies on areas of topical interest and global concern. This is done on a project-by-project basis. The studies are generally initiated through sponsorship and the process is transparent. This is also an independent process, because study panels are established to broad consultation with IAP Academies and the composition of the IAC Board approves of these study panels. This is a merit-based study. The draft reports are subjected to extensive peer review, and then when the IAC Board approves, it is released.

The first study initiated by the IAC Board was on a strategy for building worldwide capacity in science and technology. We can see that this is a burning issue of utmost concern as we make transition to the knowledge society. It is expected that this first study report will be released in the first week of December during the IAC General Assembly in Mexico City.

The second study on science and technology for improving agricultural productivity in Africa is nearing completion and should be ready for release in mid-2004. This study was undertaken on a request from Mr Koffi Annan, the Secretary General of the United Nations.

I would like to end my talk by a quote from Professor Abdul Salam, who was the founder of the Third World Academy of Sciences. And this again focuses on the S&T capacity aspects for the Third World or the developing world. " (...) Some people say there is nothing like Third World, there is only one world. But, this is not the general perception.

Today the Third World is only slowly waking up to the realisation that in the final analysis, creation, mastery and the utilization of modern science and technology is basically what distinguished the south from the north. On science and technology depends the standards of living of nations".

Well, I would once again like to thank KAOW/ARSOM for the kind invitation and opportunity to speak to you today and although my focus has been on the developing world, I do believe that science and technology capacity building is really a global problem. It requires global solution, global approaches and more importantly global commitment. I trust, we will all be able to muster the collective will to see that happen in the near future.