South-South & South-North Collaboration

Present Scenario and Future Prospects

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Present Scenario and Future Prospects

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FOREWORD

There is an emerging consensus on the significant role of science, technology, and innovation in economic growth and alleviation of poverty. Limited S&T related capacity in the developing countries hinders adoption, creation and dissemination of new knowledge and tools to advance developmental agendas. The gap between Science and Technology is, therefore, linked to the developmental gap in the third-world. Increasing investment in building S&T capacity and linkages at institutional, regional and international levels are the focal areas for decision-makers, wishing to narrow the ever-widening gap between industrialized and developing countries.

South-South Cooperation, a useful strategy to build S&T capacity, is not enough on its own. Today more than 90% of global investment in Research and Development (R&D) and innovation occur in industrialized countries. The linkages with the developed world are, therefore, considered critical to build and sustain a critical mass of knowledge, institutions, and policies for S&T capacity-building. At present, international assistance and collaboration has to be exploited fully and linkages established to make S&T capacity- building institutionally and financially sustainable, and more relevant to growth and developmental goals. Ample opportunities exist in this area that require commitment and collective efforts to materialize, for the benefit of all stakeholders, in the South and the North.

Analyzing the present scenario of South-South and South-North Collaboration, it has been observed that there is a realization to adopt new directions for technical cooperation among developing and developed countries. There have been attempts for technical cooperation among developing countries to work with the developed countries, in order for them to play a more active role, in both promoting and supporting collaborative activities. As a result, a large number of developing countries would be benefited.

The COMSTAS' Meeting on *South-South and South-North Collaboration in Science and Technology: Present Scenario and Future Prospects*, which was organized in collaboration with the Third World Academy of Sciences (TWAS), Trieste, and the Islamic Educational, Scientific, and Cultural Organization (ISESCO), Rabat, was a follow up on the initiative of encouraging collaboration in the field of S&T. Being a facilitator organization, our role is to build and encourage South-South partnership and strengthen linkages between the South and the North. This Meeting also served as a platform to exchange ideas about the identified priority areas, where we need to develop strong and enduring linkages between the developing and the developed countries.

There were a total of 23 speakers in the Meeting who made presentations in 6 Technical Sessions, of which 11 were foreign experts, representing countries like Italy, Morocco, Jordan, Switzerland, Senegal, Germany, Sudan, Nigeria and Turkey. Other participants included eminent scientists, heads of S&T institutions, scholars and students from various academic and research institutions. This book of proceedings comprise some selected papers and the recommendations that emerged during the conference.

In the end, I would like to express my gratitude to both Prof. Dr. M. H. A. Hassan, Executive Director Third World Academy of Sciences (Italy), and Dr. Faiq Billal, the Director Science, ISESCO (Morocco), for their ardent cooperation and support for organizing this conference. My earnest praise also for Dr. M.M. Qurashi, Ms. Uzma Ikram, Ms. Noshin Masud, Mr. Irfan Hayee and Mr. Imran Chaudhry from COMSATS, whose devotion made publication of the proceedings of this conference possible.

Dr. Hameed Ahmed Khan, H.I., S.I.
(Executive Director, COMSATS)

CERN, A WORKING EXAMPLE OF GLOBAL SCIENTIFIC COLLABORATION

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ABSTRACT

The topic of this conference is 'South-South and South-North Collaboration in Science and Technology', which is being addressed in this contribution, in the context of basic research in high-energy physics (HEP). The question, whether developing countries can or should invest scarce resources in big science, is not covered. HEP may be less expensive than one might fear, but cheap it is not; so priorities have to be set and these may indeed differ from country to country. The scope of this article is not to argue, one way or the other, but rather to give an indication and practical examples of both the requirements and the opportunities for scientific collaboration with CERN.

I. CERN

The European Organization for Nuclear Research (CERN) is an inter-governmental organization (comprising 20 member states: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom), located in Geneva, Switzerland, but straddling the French-Swiss border. It is the world's largest laboratory for fundamental research in particle-physics, with a support-staff of nearly 2500 and an yearly budget of $\sim$ 1 billion CHF. Its mission is to provide facilities and infrastructure for carrying out experiments in basic research, primarily high-energy physics (HEP) and, to a smaller extent, also in the nuclear physics, astro-particle physics and theory, to answer fundamental questions, concerning structure and composition of matter ('What is the Universe made of') and forces ('What keeps it together').

CERN was founded in 1954 with the help of UNESCO with the prime aim to pool European resources for basic research, which would be beyond the means of individual countries. Less explicit, but at least of equal importance, were economical and political considerations in the aftermath of Word War II: to create a center of excellence, which would make and keep Europe competitive in leading-edge science and technology; stop the brain-drain of its most educated and creative citizens and rebuilt trust, collaboration and coherence between the nations of Europe.

Celebrating this year its 50th anniversary, CERN is considered a success almost beyond the most optimistic expectations. In research, it is today the foremost center for high-energy physics in the world, with several Nobel Prize winning results; it has not only stopped but reversed the brain-drain (more than half of the world's particle-physicists participate in its programs). In terms of economical benefits, it is a vibrant incubator for R&D and technology-transfer, whose impact is not only limited to Europe (the Word Wide Web was invented at CERN in the 90's as a communication-tool for scientists collaborating across the world). On the political level, CERN is a most successful and effective example of international collaboration, which served as a blueprint for other research-organizations (ESA, EMBL, ESRF). During the cold war, scientific collaboration between West and East could be established via CERN, which kept open one of the very few communication channels between citizens across the iron curtain.

Given its excellent record in the past and the present, what does the future hold for CERN? On the research frontier, CERN is currently building the most powerful accelerator ever, the Large-Hadron Collider LHC. It will come into operation in 2007 and run for at least 10 – 15 years, keeping research at CERN at the cutting edge, well into the next decade. CERN has since long outgrown the N (for Nuclear) in its name by going to ever higher energies, and now it has effectively left behind the E (for European) with the LHC machine and its four large experiments (named ALICE, ATLAS, CMS and LHCb). Both the machine and, even more so, the detectors are designed, constructed and exploited by a global, world-wide Collaboration of scientists and engineers, which by now encompasses about 60 countries, including very significant participation from the 'South' and 'East'. Some 2000 physicists from non-member states today participate in the CERN program, corresponding to about 1/3 of all CERN users. While CERN is not likely to change its name or its administrative structure as a European organization, effectively it has reached out to the world, both to the developed and developing countries. This not only brings with it new opportunities, but also new challenges.

II. CERN USERS: EXPERIMENTS & COLLABORATIONS

CERN, as a facility, provides the large scientific tools and infrastructure needed to carry out experiments in high-energy physics to its users. These users are based in their respective home countries in university or research labs (CERN employs only a very small number of researchers, and most of them for a limited duration only). Research is both initiated and executed by these users, after review and ranking by scientific peer committees. The users organize themselves around individual experiments and collaborations, which are groups of scientists, ranging in size from below 10 to almost 2000 people. These collaborations propose, design, build and operate their experiment and all members of the collaboration have free and unfettered access to its data and results, which in the end are made public in the scientific literature. Funding for both construction and operation of the experiment is provided by national funding agencies, in general, directly to the individual participating groups. Otherwise the collaborations are rather administratively and scientifically independent and self-governing, i.e. they decide who can take part, who does what.

The four experiments at the LHC are amongst the most complex and challenging technical endeavors ever undertaken, requiring many years of R&D to push technology well beyond existing limits, and many years of construction by literally thousand of experts (the smallest experiment includes more than 500 people, the largest almost 2000 !). Almost 20 years would have passed from first ideas to final realization, when the experiments will actually start taking data in 2007. Technologies employed are all state-of-the-art (and sometimes just beyond) in a number of areas: from mechanics and engineering (micrometer precision in objects of tens of meters, lightweight but stable structures), advanced materials in a hostile environment (radiation and chemical), sensor technology (from micrometer sized silicon sensors to hundreds of tons of heavy metals), micro-electronics (custom designed VLSI circuits and electronic boards) to information-technology (virtual communication & document sharing, large scale distributed computing with the GRID). All these technologies have obvious potential for technology-transfer and industrial spin-off.

A practical example of how such a collaboration works, and in particular, how the nations of the South can participate in this frontier research, is illustrated by the 'midsize' ALICE experiment. It consists of about 1,000 members (2/3 from CERN member-states, 1/3 from outside) from over 80 institutions in nearly 30 different countries. The construction cost is about 150M CHF. While Italy is the largest country in ALICE (with 160 scientists from 12 institutions), contributing well over 20% of the construction-funding, very significant participation and contributions are made by 'countries of the South', ranging from India (55 people, 7 institutes, 3M CHF) over China, Mexico, and South Africa to Cuba (1 Institute, 4 scientists, 0.045M CHF). India, which has been a member of ALICE since 1992 and contributes both scientifically and financially at the level of a number of CERN member-states in ALICE, has slowly but very steadily built up an international scientific reputation in the field explored by the experiment; it contributes with original research and state-of-the-art equipment (from sophisticated sensor technology to VLSI electronics) developed and manufactured, using indigenous talent and industry. On the other hand, South Africa and Cuba have been members since 2003 only; they have started on a more modest scale (with 1-2 staff and many students) and are involved, for the time being, in less capital intense activities, like computing and physics.

III. REQUIREMENTS AND OPPORTUNITIES

The example of ALICE shows that participation in research, even on the scale of an LHC experiment, can come over a large range of topics and scales. Experiments expect from their collaborators that they are motivated by scientific interest (exceptionally by technology for 'associated institutes'), that they are capable of supporting their activity largely by their own means and funding, and that they are actively participating by contribution talent and resources within their capabilities. Sheer size matters less, and a new activity usually starts on a small scale, sometimes as small as one single group with a few staff and a number of students. A minimum infrastructure at the home-institute has to be in place (or has to be created), most importantly for good communication (computers and networking). Indigenous hardware contributions will, in general, need access to workshops and/or local industry. Funding is required both locally (salaries, infrastructure, international travel) and for investment in the experiment. The latter will differ from case to case but can start as low as 10,000 CHF per year in justified cases. A strong backing and support by the relevant national authorities and funding agencies is very important. International collaboration on this scale is governed by a Memorandum of Understanding, which is in general signed at the national level; while not legally binding it implies both benefits and commitments over a long-term scale.

The most important motivation (and benefit) for participating in an LHC experiment for the individual researchers is (or should be) scientific: To be a participant rather than a spectator in one of the most exciting and fundamental endeavors undertaken by the inquisitive human-mind. This may however not be sufficient reason to get the necessary resources. While it is not within the scope of this contribution to dwell in any depth on the various other benefits and opportunities for developing nations, participating in frontier HEP experiments, a few shall be listed briefly. High amongst them are the ones mentioned previously as one of the reasons for creating CERN in the first place. Even if the actual experiments are carried out outside national borders, participation will provide ample research-activity and infrastructure based at home, which is crucial to develop and keep a resident scientific elite; allow the 'good' to become 'excellent' (and internationally known), stop the brain-drain and maybe attract back some emigrants. Training and education of students is one of the main missions of CERN, with over 1,000 coming every year, for typical periods of several months up to 3 years. They receive 'hands-on' training in a variety of technologies in an international environment with clear objectives and deliverables, strict selection criteria and in general, return at the end, to the institute of origin. The large LHC collaborations are also an excellent place for 'international networking', as they allow (and in fact require) a multitude of personal and institutional contact and collaboration all over the world.

Technology-transfer, spin-off and industrial return are subjects, which have been extensively discussed and studied; they are recognized as a major benefit for most companies dealing with CERN and its experiments. Of relevance, in particular for developing countries, is the direct involvement of nationals and their incentive to involve local industry, for either convenience or price reasons. The often unique and 'custom tailored' specifications open a window of opportunity for small or midsized specialized industry, even if not internationally known. To quote again some specific examples, ALICE has, with the help of national physicists, found excellent and very competitive providers of tungsten in China, crystals in Russia, power cables in India, micro-cables in the Ukraine and soon.

IV. CONCLUSION

High-Energy Physics (HEP), as carried out at CERN, is science in the 'top league', at the cutting edge of science and technology. Participation requires talent, resources, and a long- term commitment. HEP is BIG science, in terms of scale, but also in terms of importance and scope. Nevertheless, participation on a smaller scale is possible and even welcome. HEP is international and collaborative science and being part of one experiment means being connected to much of the world. CERN and its experiments are open to the scientists of the world, offering access to a unique research infrastructure and participation in multimillion dollar experiments at the absolute forefront of science and technology. HEP is a truly global venture, in both spirit and in execution if governments are willing to support it, scientists can make it work.

NORTH-SOUTH AND SOUTH-SOUTH SCIENTIFIC CO-OPERATION: LOBBYING FOR TRANSFORMATIONAL TECHNOLOGIES IN DECISION-MAKING CIRCLES

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1. ABSTRACT

The fall of the Berlin Wall marked the end of the Third World-War, …the Cold War, and the rise of the so-called "New World Order." It also marked the start of a new World S&T Order, with the coming to the forefront of the Transformational Technologies (TTs) of Information-Technology, Biotechnology and Nanotechnology.

Especially, Information Technology and Biotechnology are areas where tangible North-South and South-South collaborations have taken and can, in future take place; there also exist successful examples of how IT and BT have contributed to socio-economic development of the South. Research in the field of Nanotechnology is almost exclusively carried out in the North, notwithstanding the big strides made by China and India in this domain. Cultural Technology, which manifests itself primarily in the form of satellite-television, is a powerful tool that again may be used by the countries of the South to inform and educate their peoples, as well as reach out to the countries of the North.

Endorsed by all 189 member-states of United Nations in 2000, the Millennium Development Goals (MDGs) represent unprecedented agreement within the development-community on the key development objectives.

This paper addresses policy-and decision-makers/politicians rather than scientists. It aims to project the value of science as a tool for advancement, and outlines a fresh track for North-South and South-South S&T collaboration.

It is primarily based on extensive research carried out by experts and international agencies, over the last five years, and attempts to provide the decision-makers involved in North-South and South-South scientific collaboration, with a remodelled contemporary outlook, on how to speed up their socio-economic development-related efforts and strive to achieve (their national) Millennium Development Goals (MDGs), partly by focussing on Transformational Technologies.

2. NORTH-SOUTH DIVIDE

2.1 A Timeline

Division among countries, regions, and civilisations have existed since the dawn of time. Socio-economic or developmental divisions have always existed among countries and regions. 2000 years ago, the world was divided into several empires; the Persian and Roman empires, further east there was China.

Islam was founded in Mecca around 610 AD. Within 150 years, the new Islamic state stretched from the Himalayas in the East to the Pyrenees in Europe. The Islamic civilisation blossomed between 750 and 1258 AD, in terms of scientific and technological output amongst other feats, with a South-North divide in terms of scientific advancement appearing between the Islamic state and the rest of the them known world, especially Europe. The flow of knowledge and science through Muslim Spain to Europe (i.e. South-North) contributed to the renaissance in Europe around 1500. That period marked the start of the slow decline of scientific enterprise in the South.

200 years ago, the industrial revolution was underway in Europe, marking yet another phase in the progress of science and technology in the world. The twentieth century was marked by three world wars: the First World War (1914-1918); the Second World War (1939- 1945); and the Third World War … the Cold War (1945-1990). The first two wars declared the defeat of a Western power, namely Germany, at the hands of a

Figure-1: A Proposed S&T 'Divide' Timeline

diverse alliance of powers, whilst the third saw the defeat of the Eastern Block at the hands of America and Europe.

2.2 North-South and South-South Co-operation

2.2.1 Some of the landmarks/players: The end of the Second World War gave birth to a number of international organisations that were founded to help humanity get back on its feet again; like Europe was almost completely destroyed, many countries were bankrupt, and most of the countries of the South eager to gain political independence.

Apart from the United Nations and its various off-shoot organisation, a number of regional political groupings were established, for a number of reasons. The Organisation of the Islamic Conference (OIC), grouping 57 countries of the South at present, was for example launched in 1969 [1].

Some of the key-players that were/are broadly involved in North-South and South-South S&T co-operation are:

1964: ICTP, Trieste, Italy;
1966: International Foundation for Science, Sweden;
1981: COMSTECH, Pakistan;
1983: Third World Academy of Sciences (TWAS);
1986: Islamic Academy of Sciences (IAS), Amman, Jordan;
1994: COMSATS, Pakistan.

2.2.2 Other international players: The United Nations system, which was created in 1945, developed into an elaborate set-up over the years, with science and technology being part of the mandate of almost every UN body. UNESCO, UNDP, FAO, WHO; such UN agencies formed a sizeable portion of international activities in S&T.

Moreover, academies of sciences have also played a vital role as the science-advisors of the political leaderships of their 'catchment areas.'

Worldwide, there exist around 90 regional, national and international academies of sciences, according to the InterAcademy Panel (IAP) [2]. Such organisations have, throughout their history, managed to act as science advisors/promoters in their respective catchment areas.

3. THE NEW WORLD S&T ORDER

3.1 General

The fall of the Berlin Wall witnessed the start of what may be called the New World Order of S&T, with the coming the Transformational Technologies to the forefront of Information Technology, Biotechnology, Nanotechnology and Cultural Technology.

Whereas the twentieth century was often referred to as the Century of Physics, the twenty first century is expected to be the Century of Biology ... and its transformational technology-component, Biotechnology.

The globalisation backdrop has contributed to, and most strikingly manifested itself through, the information revolution and the tremendous advancements in Information Technology, which led to the birth of the Internet in the 1990s.

3.2 Divided We Stand

The First-World is composed of mostly of the English-speaking countries and Europe. Apart from Australia, most of the countries that belong to the economic or industrialised North actually lie North of the equator. According to Brandt's division, Russia belongs to the Second World [3].

The South is made up of the countries of South America, Africa, Middle East, South and South East Asia, including China and India (Figure 2).

3.3 New World Order of S&T: The Alarming Trends

The Cold War was painful and costly for humanity in all its aspects, with an arms-race that ate away the badly needed resources for socio-economic development. However, it represented a period of 'steadiness,' with countries knowing which global political pole to associate with: the East, the West, or the Non-Aligned Movement.

The end of the Cold War marked the start of a period of confusion in many countries. The demise of the Soviet Union meant that countries that were part of that superpower

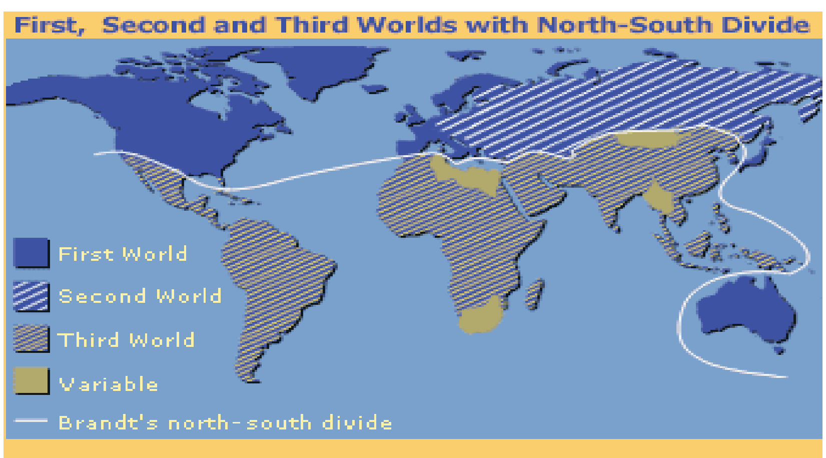

Figure 2. Brandt's North-South Divide [3].

suddenly found themselves, in some instances, even without a government. Some of the alarming trends, which marked the post Cold War era, can be summarised as follows:

a) An overall reduction in developmental aid (partly due to the demise of the USSR);
b) Tendency of industrialized countries to choose and pick recipients (countries) of aid, purely based on political considerations;
c) WTO and related agreements likely to exclude many developing countries;
d) Privatisation of public research systems (especially in the UK and the US);
e) Increased South-North Brain Drain;
f) Widening rift between decision-makers and the science community both in the North and the South.

4. THE MAIN GLOBAL CHALLENGES AT THE TURN OF THE MILLENNIUM

4.1 What are the challenges?

The world, shaped as it is today by the progress of science and technological inputs, is marked by the emergence of new, increasingly complex societal forms: a networked, self-managing society. This growing complexity is also a feature of the developing regions, where a series of problems have become increasingly acute: poverty, shortage of drinking water, healthcare, pollution, deforestation, desertification, exploitation of children, migration, armed conflicts, illiteracy, isolation, marginalization and North-South disequilibrium in the production and use of science and technology, are all factors of instability and antagonism that threaten the world.

The Twenty First Century will see problems of a magnitude, never experienced before. Population growth is the main driver for it. Population growth is invariably leading to food and water insecurity, uncertain energy outlook, the spread of HIV/AIDS, as well as environmental degradation. Outlined below are some of the major challenges that will confront our world in the twenty-first century.

4.2 World Population

According to the Population Reference Bureau [4], world population stands over 6.134 billion at present (May 2004) [5].

Population factors have an impact on many facets of life. The need for health-care preoccupies the political leaders of the North, whose populations are “aging,” while the need for classrooms, employment opportunities, and housing preoccupies the leaders of the countries of the South. Its example are the high-fertility countries in the Middle East and Africa, with large proportions of young adults and children. Populations of the North are relatively old.

A population’s age-structure affects its living style. Developing countries (of the South) have relatively young populations, while most developed countries have old or “aging” populations. In many developing countries, 40 percent or more of the population is under age 15, while 4 percent is 65 or older. In all but a few developed countries, on the other hand, less than 25 percent of the population is under the age of 15 and more than 10 percent is 65 or older.

Countries of the South can implement joint programmes to strictly control the high rate of population. As many developing nations share the same religious and cultural heritage with their neighbours, they may be able to learn containing population increase from each other’s experiences.

4.3 Food Insecurity

Worldwide, the UN Food and Agriculture Organization (FAO) estimates that 842 million people were undernourished in 1999-2001. This includes 10 million in industrialized countries, 34 million in countries in transition and 798 million in developing countries.

According to the FAO’s annual report The State of Food Insecurity in the World 2003 (SOFI 2003) [6], hunger is on the rise again after falling steadily during the first half of the 1990s. FAO's latest estimate signals a setback in the war against hunger.

Given the rate at which hunger has declined since 1990 on average, the World Food Summit goal of reducing the number of undernourished people by half by 2015 cannot be reached. The goal can, according to the FAO, only be reached if the recent trend of increasing numbers is reversed.

Only 19 countries, including China, succeeded in reducing the number of undernourished throughout the 1990s, says the report. Twenty-two countries, including Bangladesh, Haiti and Mozambique, succeeded in turning the tide against hunger. In 17 other countries; including India, Indonesia, Nigeria, Pakistan and Sudan however; the number of undernourished people, (which had been falling), began to rise.

The potential impact of Biotechnology and Genetic Engineering on Food Security would be touched upon later in this presentation.

4.4 Water Scarcity

Many parts of the world suffer from water scarcity. This is not only due to the low rates of precipitation they receive, but also due to the increase in demand on water resources for domestic, agricultural and industrial usage. Central and northern China, northwest and southern India, parts of Pakistan, western United States, North Africa, Middle East and the Arabian Peninsula as well as the Gulf states, are areas with serious water deficits.

Oil rich countries in the Middle East have adopted water desalination as the main means of supplementing their fresh water budgets, while other Middle Eastern countries such as Jordan, (with no oil resource), are struggling to make ends meet. Jordan is one of the world's ten most poor countries in water resources.

Population growth, pollution and climate change, all accelerating are likely to combine to produce a drastic decline in water supply in the coming decades, according to the World Water Development Report published in 2003 [7].

At present 1.1 billion people lack access to clean water and 2.4 billion lack access to proper sanitation, nearly all of them in the developing countries. Yet the fact that these figures are likely to worsen remorselessly has not been properly grasped by the world community, the report says: "Despite widely available evidence of the crisis, political commitment to reverse these trends has been lacking."

Faced with "inertia at the leadership level and a world population not fully aware of the scale of the problem", the global water crisis will reach unprecedented heights in the years ahead, the report says, with growing per capita scarcity in many parts of the developing world.

A major difficulty with water issues is that, at least in the rich North, it is largely taken for granted. After all, it is the most widely occurring substance, whilst in the arid and semi-arid countries of the South, it is a matter of critical importance.

The direst, direct effects of water scarcity will undoubtedly be on health. The presence of water can be a bane as well as a benefit: Water-related diseases are among the commonest causes of illness and death. Contaminated drinking water causes water-borne illnesses, such as gastric infections leading to diarrhoea; the mosquitoes and small snails (that use water to breed) pass on vector-borne diseases, such as malaria and schistosomiasis. Millions contract such diseases. In the year 2000, the estimated number of people died from water/sanitation-associated diseases, was 2.2 million, and a million of them was from malaria.

Regional co-operation in water matters is imperative if countries were to achieve some level of water security [8].

4.5 Energy

According to the International Energy Outlook (IEO2004) [9] mid-term outlook, developing nations are expected to account for the increment in world energy-consumption. In particular, energy-demand in the emerging economies of the South, especially in Asia, (including China and India), is projected to more than double over the next twenty-five years. In the developing world as a whole, primary-energy consumption is projected to grow at an average annual rate of 2.7 percent between 2001 and 2025.

Oil is expected to remain the dominant energy-fuel throughout the forecast period, with its share of total world energy-consumption remaining unchanged at around 40 percent during 2025. The IEO2004 projects declining oil-use for electricity generation, with other fuels (especially natural gas) expected to provide more favourable alternatives to oil-fired generation.

In the countries of the South, oil consumption is projected to increase. In some countries where non-marketed fuels have been widely used, diesel generators are now being used to dissuade rural populations from decimating surrounding forests and vegetation - most notably, in Sub-Saharan Africa, Central and South America, and Southeast Asia [10]. infrastructure necessary to expand natural gas use has not been as widely established in the developing world as it has in the industrialized world, natural gas use is not expected to grow enough in the developing world to accommodate all of the increased energy demand.

Electricity generation is expected to nearly double between 2001 and 2025, from 13,290 billion kilowatthours to 23,702 billion kilowatthours. Strongest growth is projected for the countries of the developing world, where net electricity consumption rises by 3.5 percent per year in the IEO2004 reference case, compared with a projected average increase of 2.3 percent per year worldwide.

4.6 Health and HIV/AIDS

A crucial moment in the history of HIV/AIDS has been reached. The world now has an unprecedented opportunity to alter its course. The most important message of the latest World Health Report [11] is that, the international community today has the chance to change the history of health for future generations and open the door to better health for all. Unknown barely a quarter of a century ago, HIV/AIDS is now the leading cause of death for young adults worldwide. More than 20 million people have died from it and an estimated 40 million others are now infected with the virus. There is as yet no vaccine and no cure. The World Health Report 2004 - Changing History, published by the WHO, calls for a comprehensive HIV/AIDS strategy that links prevention, treatment, care and long-term support. Until now, its treatment has been the most neglected element in most developing countries: almost 6 million people in these countries will die in the near future if they do not receive treatment - but only about 400,000 of them were receiving it in 2003.

WHO and its partners have launched a drive to provide 3 million people in developing countries with antiretroviral therapy by the end of 2005 - one of the most ambitious public health projects ever conceived. Looking beyond 2005, how can international organizations, national governments, the private sector, and communities join efforts and simultaneously fortify health systems for the enduring benefit of all?

Some of the ongoing research to develop an affordable and effective preventive vaccine against HIV was discussed by Azad et al. (2001) [12].

5. NORTH-SOUTH AND SOUTH-SOUTH CO-OPERATION: SUCCESS STORIES

5.1 General

Before attempting to map out a course of action for increased North-South and South co-operation for development, it is worthwhile to highlight some successful examples of North-South S&T co-operation. These were primarily moved by the will of the North-partners to extend a helping hand to its counterpart(s) in the South. A number of South-South examples of collaborations manifest the willingness and readiness of the countries of the South to implement joint activities in science and technology.

A common feature of the majority of North-South and South-South co-operation programmes is the strong political will that often backs such programmes.

5.2 Some examples

a) A number of small countries in the South have made significant advances in education, and combating alphabetic illiteracy, primarily due to national efforts (Jordan, Kuwait, Bahrain and Iraq are primary examples). The role played by UN agencies in this domain, especially UNESCO, has been very significant;
b) Some countries of the South have made marked strides in *Transformational Technologies* (IT, BT and to a lesser extent NT), e.g., China, India, Brazil, Cuba, and Malaysia;
c) Over the last two decades or so, there have been a number of institutional successes, such as ICTP and CERN. Both institutions have a world reputation for providing Third-World scientists the opportunities to undertake high-level R&D;
d) An interesting example of North-South collaboration in the area of education is manifested in the experience of the *French Academy of Sciences*, and it is by now familiar programme *La main à la pâte* [13]. Activities based on the programme are being implemented in China, Indonesia, Egypt, and Malaysia. Figure-3 shows the countries involved in the programme (See Section 5.3 below);
e) Germany and Jordan had an extensive joint programme in solar-energy research that lasted for almost thirty years. In the field of renewables including wind-energy research: Jordan, Tunisia and Egypt have implemented a number of long term co-operation programmes with a host of international specialised agencies;
f) In the area of water-resource development/management and saline-water agriculture, a number of Middle Eastern and Sub-Saharan countries, as well as countries such as Pakistan, have been implementing many programmes in the domains of: saline water agriculture; irrigation systems; and transnational water-resources.

5.3 Education: *La main à la pâte*

Often described as an experiment in renovation of teaching science in France, the *La main à la pâte* programme was launched in 1995 by George Charpak [14], and subsequently joined by Pierre Léna and Yves Quéré.

The general idea of *La main à la pâte* is to encourage children to participate in the discovery of natural objects and phenomena; to bring them into contact with the latter in their reality, directly through observation and experimentation, and to stimulate their imagination. It attempts to broaden their minds and improve their command of the language.

The main aim of *La main à la pâte* is to bridge the teacher/science gap and to contribute to their training. A number of distinct resources including an Internet website are now offered to them. Given the success of this French site, an international portal has also been commissioned to *La main à la pâte* through the *French Academy of Sciences*.

5.4 Water: The International Centre for Biosaline Agriculture (ICBA)

A successful example of South-South co-operation in an area of critical importance to many countries of the South; namely saline-water agriculture, is represented by the International Centre for Biosaline Agriculture (ICBA).

The need for ICBA arose from the realization that fresh water-resources are overexploited in much of the developing world and that other sources of water must be used for further agricultural expansion. Expert consultations concluded that one source of such water is saline-water, which has not been optimally utilized for irrigated agriculture [15].

5.5 Basic Sciences: The Sesame Project

A successful example of North-South and South-South collaboration, involving an international body, is the recently launched Sesame Project. The foundation stone of

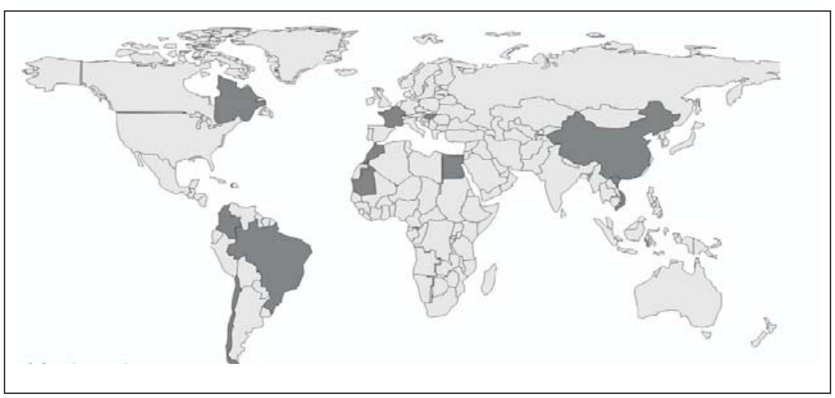

Figure-3. World-wide distribution of *La main à la pâte* and its Hands-on partners.

the SESAME Project (International Centre for Synchrotron-light for Experimental Science and Applications in the Middle East) was laid at the campus of Al-Balqa Applied University, near Amman, Jordan.

The Centre will help to improve basic research in the region and to facilitate the creation of an infrastructure for regional scientific co-operation. The SESAME Centre will be a bridge in the region between the South and the North and it will open new vistas for North-South and South-South cooperation.

The project was launched in 1997, when Germany offered BESSY I: it decommissioned synchrotron, to the Middle Eastern scientific community free of charge. A group of scientists based at the European Organization for Nuclear Research (CERN) asked UNESCO to be the host-organization and broker inter-governmental negotiations.

Created under the auspices of UNESCO, the SESAME Centre is an autonomous institution whose function will be to put into place, develop, maintain and improve sources of synchrotron-light, beam-line radiation, spectrometers and other detectors, as well as the auxiliary material and laboratories. It will offer research facilities and training possibilities to scientists in the Middle East and elsewhere.

The SESAME Centre had officially been launched as seven of its founding members had accepted the statutes of the project. Those members - Bahrain, Egypt, Iran, Israel, Jordan, the Palestinian Authority and Turkey - now form the new SESAME Council. Kuwait is an observer-nation and new member-states and observers are expected to join soon. Libya has submitted a request to become an observer. Several non-middle eastern countries that were observers in the Interim Council - Armenia, Cyprus, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom and USA - are expected to confirm their status as a feasible study of the project established that hundreds of scientists working in research activities in the Middle East would benefit significantly from a source of synchrotron radiation [16].

5.6 South-South Alliances: The Importance of Political Commitment

Little is new about scientific agreements between developing countries, which have been a part of the staple diet of diplomacy (in both North and South) for many years.

President Nelson Mandela of South Africa for example, early on in his presidency, set up a joint commission with his Indian counterpart on a range of issues, including scientific and technological cooperation [17]. China for several years has been closely involved in arranging bilateral agreements, particularly covering scientific training.

In the past, however, too many agreements were lacking the political incentives, necessary for effective implementation, but now that is changing. A striking feature of the new wave of agreements is that they are grounded in real social and economical needs. There is also recognition that these needs have a similar shape in different countries, and moreover that realising involves juggling scientific and political concerns, such as one country can learn productively from the experience of another.

These have given the substance of the new agreements both significance and urgency. Take, for example, the question of the complex relationship between indigenous knowledge and patent rights; India and South Africa (for example) are rich in both biodiversity and local cultural traditions; making them prime targets for those seeking traditional knowledge that can be incorporated into, (for example), new medicines. Each is facing the task of devising methods to protect their traditional knowledge that are compatible with the intellectual property rules of the new international knowledge economy. There is therefore, a strong incentive to share both experiences and novel solutions. Which is what India has offered to do, for example, with its promise to help South Africa set up an electronic database of traditional knowledge comparable to the one established in Delhi by the Centre for Scientific and Industrial Research (CSIR) [18].

Another example is genetically modified crops. Again each country is facing a similar dilemma: how to square the disquiet about the potential environmental impacts of such crops with the strong social and economic forces that favour them. Again it is significant that when the Indian science and technology minister Murli Manohar Joshi visited Brazil with a high level delegation in July 2001, considerable time was spent discussing this issue at the Agency for Agricultural Research in Brasilia. It was the same minister who later, at a TWAS's Delhi Conference in late 2002, expressed his country's willingness to help scientists and researchers from other developing countries especially in the area of Biotechnology [19].

Atta-ur-Rahman, Pakistan's Minister of Science and Technology has also championed the cause of effective South-South S&T co-operation by signing a number of focussed S&T co-operation agreements with Kazakhistan [20].

6. MILLENNIUM DEVELOPMENT GOALS

6.1 The Need for Policies and Actionable Plans

Decision-makers are in the North as well as the South are aware of the various global problems that by faced humanity, (as partly outlined above). However, difficulties arise when policies need to be formulated and actionable programmes instituted to steer the countries in these domains.

6.2 The MDGs as a Benchmark for Development Effectiveness

The MDGs are comprised of 8 goals, 18 targets, and 48 performance indicators relating to poverty reduction, including income and non-income measures of well-being [21].

The themes and issues embedded in the MDGs such as gender and environmental sustainability, are well known to the international development community. The first of the MDGs, poverty reduction, has been the overarching objective for international organisations such as the World Bank since 1990. The focus on education and health has been a main tenet of the basic needs approach adopted by development agencies since the 1970s.

6.3 Significance of Millennium Development Goals

The newness of the MDGs lies in three main dimensions:

a) By incorporating quantitative and time-bound targets, the MDGs demand specificity in development actions and emphasize on systematic measurement;
b) By defining the goals in terms of outcomes - as distinct from inputs and outputs - the MDGs draw attention to the multi-sectoral determinants of outcomes; and
c) By including Goal 8, which aims at developing a global partnership for development, the MDGs emphasize on the role of both developed and developing countries.

These new elements may warrant changes in some practices and programs adopted by countries.

The MDGs serve as a visionary challenge to help galvanize new energies and resources for the developmental agenda, with a focus on outcomes. At the same time, the adoption of the MDGs entails risks and challenges for the larger development community.

Since it is clear that many countries and regions will not achieve the MDGs by 2015, the risk of disappointment and cynicism must be mitigated. And there are other challenges: customizing the MDGs to local conditions, harnessing contributions from sectors without explicit MDG goals or targets, focusing on outcomes among poor countries and population groups rather than on average outcomes, and addressing incentives for both achieving and monitoring outcomes.

MDGs manifest a commitment by countries - rich and poor - North and South - to do all they can to eradicate poverty, promote human dignity and equality and achieve peace, democracy, and environmental sustainability. In other words, they represent the marriage of POLITICS and POLICIES!

7. WHERE DO WE GO FROM HERE?

7.1 Some Prerequisites

South-South scientific collaboration can never replace collaboration with the more scientifically advanced countries of the North, where most of the world's advanced science is still carried out. Hassan [22] advocates that collaboration avenues even remain open at what has been called the "meta-scientific" level - the area where science and politics overlap - since what happens in one part of the world affects the way that issues are both perceived and handled in another (ranging from the issue of human cloning, to the conditions required for membership of the World Trade Organisation).

It would be however naïve to believe that such avenues are sufficient to ensure building of the necessary capacity to handle such issues in the South. Many of the challenges currently facing the South, from malaria to infant mortality to water (as discussed earlier), are of little interest to countries in the North.

One risk to avoid is that such capacity-building through collaborative efforts becomes limited to the major developing nations. It is essential that they, in turn, should share their own knowledge and experience with the less advanced parts of the developing world. And indeed: there are already promising signs of movement in this direction; at the recent meeting of the Third World Academy of Sciences (TWAS) in Beijing, for example, a number of countries (including China, Brazil and Mexico) announced new research fellowship programmes specifically targeted at young scientists from the least developed nations.

Initiatives of this nature reflect a moral commitment; over and above having the highly pragmatic outcome that they will help to identify and train talented scientists in countries whose scientific efforts are likely to be beneficial to the developing world, as a whole, but whose potential skills might, without such assistance, be going to waste. The more the larger developing countries can ensure that their efforts at collaboration - in science as elsewhere - have a constructive social as well as economic outcome, the greater is likely to be their positive contribution to global development during the rest of the 21st century [23].

7.2 The First Bottom Line: Global Challenges are Our Challenges

Notwithstanding some success stories with a population of around 5 billion inhabitants, countries of the South face an unprecedented socio-economic development challenge. It is imperative for the science community in the South to, reach out and convince the political leaderships, as well as the public at large, of the value of science as one sure means to realise national development targets.

7.3 Can Science help?

The value of science and science capacity as a means to achieve socio-economic development, and go beyond to achieve economic might, has been proven beyond doubt, especially since the end of World War II. The rise of the economic power of the United States, Germany, Japan, and other OECD countries can be inextricably linked to S&T advancement. Moreover, the rise of the Pacific Rim Tigers can also be due to scientific and technological advancement. Having said that, it is probably worthwhile to deduce a number of pointers as to how advancement in S&T in such instances, has been achieved. In other words, the success of such countries may be attributed to their following traits:

- Will to advance;
- Sound educational systems;
- Building up their capacity including S&T capacity;
- Implementation of sound S&T policies;
- Increased funding thereto;
- Increased (formal and non-formal) regional, North-South, South-South co-operation.

8. A PROPOSED ROADMAP

8.1 General

Most scientists are unlikely to be effective in their work without strong institutions to support and harness their efforts. Building and supporting effective institutions for science must become a key goal for development. It is critically important that science, and scientists, achieve a much higher degree of influence throughout the world!

In our attempt to increase global S&T collaboration, let us not 're-invent the wheel,' … Let us maintain and upgrade all existing programmes keeping interest in Basic Science - the backbone of S&T advancement - firmly in our minds. Let us also selectively ride the Transformational Technologies wave! Why?

8.2 Why Transformational Technologies?

Transformational Technologies would not provide the answer to all the development problems of the South. But, coupled with the classic development outlook adopted by most developing countries, TTs may be useful in terms of addressing some the MDGs, and/or getting help form the North.

Transformational Technologies may be the appropriate tools to help the countries of the South to achieve at least some of the Millennium Developmental Goals (MDGs). This is essentially true for their quest to achieve food security, combat HIV/AIDS, combat illiteracy, eradicate poverty, and increase poplar participation. This presumption is in part based on the following factors (which are outlined below in particular order):

- There is an international commitment to achieve MDGs with funds made available by donor countries of the North for the purpose;
- TTs hit home with decision-makers, and are an attractive option; They understand what achieving food security means (BT) or launching an educational channel on satellite television,

- An attractive option for the business community especially in the pharmaceutical (BT) and media industries (Cultural Technology) and (IT). Turkey's experience in facilitating private sector ownership and operation of satellite television channels is a case in point for Cultural Technology;
- CT and IT industries can create jobs and IT exports can be a source of foreign currencies;
- IT assimilation can lead to Brain Gain and contribute to Basic Science capacity;
- Catching the eye of the decision-maker in the context of TT will lead to more resources diverted to Basic Sciences;
- TTs, especially IT and BT, require limited start-up absorption capacity…

8.3 Biotechnology

Several firms and public institutions in the world are offering products and services that are the result of the new technology; Biotechnology. In the USA alone, there are 300 public (biotechnology-based) companies with a market capitalization of $353 billion and an annual turnover of $22 billion. Moreover, the growth of biotechnology-based industry is not restricted to developed countries. Developing countries such as Cuba, Brazil, India, and China have been pretty quick to identify the potential benefits of the technology; and own it too [24]. Singapore and Malaysia seem to sense Biotechnology's potential and are moving in at a fast rate.

Modern Biotechnology has already made significant contribution to the health and agriculture sector. Development of several drugs, various pharmaceuticals, and vaccines using recombinant DNA technology has given rise to multi billion-dollar industry (see Azad et al. [12]) In addition, PCR-based diagnostics has also emerged as an important component of health care.

BT can make an important contribution to our national priorities, particularly in the area of human health (including HIV/AIDS, malaria, Hepatitis, reproductive health, maternal and child health, typhoid and TB), besides food security and environment. In pursuit of these priorities, countries of the South are fortunate to be guided by the experiences of other countries.

Countries of the South should enable their organizations to anticipate and respond to current and future opportunities and challenges of Biotechnology. Some guidelines of a possible Biotechnology strategy that could be adopted by countries of the South have been discussed in detail by Shinwari et al. (2003) [25].

Biotechnology and genetic engineering carry great potential for economic and social development in the South. Of all emerging technologies, biotechnology has three main advantages:

- Low cost compared with IT, micro-technologies, and so forth;
- Availability of trainable manpower;

- Adaptability to division of labour even in a narrow field - not just between workers in different laboratories, but also between workers in different countries - resulting in a more economically viable system.

Of the distinct advantages of venturing into BT R&D is the likelihood of identifying a commercially viable field for which no more than a handful of researchers and technicians, would need to be trained in fewer than a dozen specialised techniques.

8.4 Information-Technology

Information and Communications Technologies (ICTs) have been expanding at a staggering rate over the last 10 years in our newly globalized world. It is an area where a divide has been developing - and already exists - between advanced and developing countries (an international digital divide) over an above, other existing "development" divides.

Reacting promptly to the IT tidal wave (bridging digital divides) can help in narrowing social and economic inequalities and offer new hope to local wealth creation. So it can be a major factor for speeding up socio-economic development as a whole as well as in a number of specific areas including commerce, governance, health, education (identified together with environment as development imperatives at the UN Millennium Summit) as well as science and technology [26].

Addressing national and international digital divides, is a multifaceted and multi-layered task, the foundation for which must be defining clear and achievable objectives, at the national and regional levels. Governments, private sector and science development organisations have parallel yet overlapping roles to fulfil in order to help developing countries to 'leap frog' into a position whereby they would reap maxim benefit from the current phase of the ICT revolution.

It is important to emphasise that by addressing the digital divide, we are not marginalizing other divides, but rather appraising how riding the ICT wave can lead to more efficient production, boost trade, revitalise governance and better deliver social services including health information. It can therefore, lead to a general improvement in the welfare of society and narrowing some of the other divides.

In countries where citizens still struggle for reliable sources of food, water, medical care and educational opportunity, bridging the digital divide may seem like a lofty goal. Information and communication technologies will never be the magic wand that eliminates the need for sound developmental investments, but they can serve as an *enabler*, enabling governments and individual citizens to improve the quality of life of their people and humanity.

8.5 Cultural Technology

One aspect of Cultural Technology is the use of satellite television to bridge cultural divides within and among countries. Indeed, satellite television in countries such as Turkey, China, India, Egypt, Pakistan and Indonesia has become a medium as well as being a powerful educational tool, with hundreds of channels featuring educational output that cater for school as well as for university students.

8.6 The Second Bottom Line: Give TTs a Chance

Transformational Technologies are a feature of the close of the twentieth century and dawn of the twenty-first. They are inextricably linked to globalisation via a complex set of relationships. Of the various Transformational Technologies, Biotechnology and Information Technology may provide countries of the South with the opportunity to jump-start their development efforts. Cultural Technology can be a powerful educational tool.

8.7 9/11: An Afterthought

There can be no doubt that North-South and South-South collaboration suffered a set-back after the events of 9/11.

"Some might argue that the war on poverty must take a backseat until the war on terrorism has been won. But they would be wrong. The need to eradicate poverty does not compete with the need to make the world more secure. On the contrary, eradicating poverty should contribute to a safer world…."

UNDP, Human Development Report 2003, p.1 [27].

9. CONCLUSION

This paper does not primarily address scientists or researchers. Rather, it is aimed at the decision-makers and politicians in countries of both the South and the North. It aims to reiterate the value of science as a tool for development and advancement. It presents political decision-makers in both the North and the South with an overview of what problems the world is likely to face in the 21st century. It promulgates the adoption of the Millennium Development Goals as yardsticks for development.

The adoption of Transformational Technologies, especially Biotechnology, Information Technology, and Cultural Technology, may help countries of the South speed up their development efforts and realise some of their developmental objectives as outlined in the Millennium Development Goals.

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SOUTH-NORTH COLLABORATION IN SCIENCE & TECHNOLOGY: A NECESSITY FOR THE SOUTH

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Development of a country is a complex phenomena. Development takes place by making best use of the number of resources, which are identified in the Development Matrix (Figure-1).

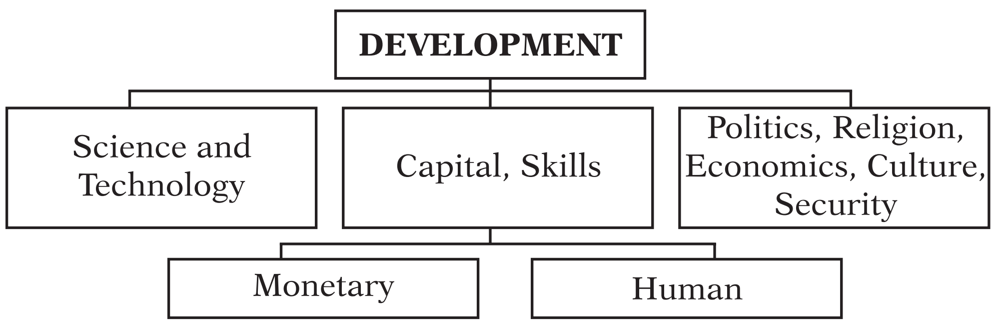

Figure - 1: Development Matrix

Let me elaborate that Science and technology alone cannot guarantee genuine progress, although they provide a very important ingredient in creating wealth and skills. We shall come to this point later. Without political will, nothing can move. Religion could be an inspiration and it could also be used as an hindrance for genuine progress. Although science and technology can flourish in every culture, but in a culture where questioning is encouraged, progress becomes quicker, particularly in science. Historically, national security has played an important role in deriving a technology. Just to give one example, the problem of detecting low-flying aircrafts during the second World-War led to the invention of Cavity Magnetron, a small device which powered the microwave-radar and gave a crucial advantage to British and American forces. Since this device could be installed in airplanes, it revolutionized not only the science of warfare, but also the civil aviation. This is also a good example where a war-time invention had civilian spin off. Of course, requirements of national security could work the other way around, particularly in developing countries where, more often than not, instead of acting as economic multiplier they become a drain on economy. The only remark I want to make about monetary capital is that a nation must save and invest in productive enterprises. A figure usually quoted is that a nation must save more than 5% of its national income[1]. This minimum of just about 5% offsets the depreciation of existing wealth. To double the standard of living, in 40 years, it needs an investment-rate of 10-15%; to double in a decade, a nation needs to make an investment of about 25% of its national income.

Now we come to the role of science and technology for development. I will discuss its two roles. First, we notice that science originated from the fusion of two old traditions [2]: *Philosophical thinking*, which supplied concepts for science, and *Skilled crafts*, which supplied tools. Until the end of the 19th century, science and craft-industries developed along separate paths. For example, the first industrial revolution was brought about by "handy men" while academic science played almost no role. Only in the 20th century, science and craft-industries became inseparably linked [2]. Atomic particles like electrons, nuclei and atoms played an essential role in development of modern technology: here the development of physics in universities played a crucial role. The remarkable thing is that it resulted, in the first place, from two conceptual revolutions, *relativity* and *quantum mechanics*, which took place in the 20th century. Investigations that seemed totally irrelevant to any practical objective or practical problem, yielded all the modern scientific and technological developments. Nuclear energy, lasers, X-ray technology, NMR imaging, semi-conductors, transistors, computers, internet, superconductors only exist because we have relativity and quantum mechanics. To our society and to our understanding of nature, these are all-encompassing [3]". A nation must invest in basic sciences, not only for the reason given above, but also for the following:

- Sustainable growth cannot be based on mere transfer of technology, since the underlying scientific knowledge would not be there to sustain the growth;
- "I am appalled that many organizations seem to think that technology is all that matters. Tomorrow's technology is today's science, so technology-transfer, if it is to work in the long term, must be accompanied by science-transfer" - *Abdus Salam*. We must be aware of potentialities of today's science for emerging technologies.
- It must be realized that when the revolution of new technologies that would govern the minutiae of living and non-living matter (e.g. biotechnology, nano-structures, new materials, quantum-information and quantum-computing) takes place by 2010-2020, we be ready for it. It would only be possible then, if we invest in frontier sciences now.

Now I come to another very important role of science in development, which is in producing entrepreneurs with skills. I will give two examples: one at very low level and the other at high technological level.

For the former I will give the example of a provincial town, Ludhiana, now in East Punjab, India, where I was born and spent my childhood before partition of India into Pakistan and India. Ludhiana was then an artisans town. Every other house in lower middle class neighborhood in Ludhiana had a hand-loom or hosiery machine. These were supported by mechanical workshops with lathe machines, for making small tools, needed for hosiery machines and looms. These very small enterprises run by semi-skilled workers, which provided work and living, not only for themselves, but also for a few young persons working with them. Ludhiana could also absorb unskilled labor from other parts of India, who would temporarily migrate to this city during different seasons of the year. Soon hand-looms were replaced by power-looms and ultimately by textile-mills. The choice for the next generation was to either become workers in these big enterprises or to go ahead and learn new skills, which the sciences in the mean time provided. During the first half of the 20th century, young entrepreneurs learned new skills and started new industries, like making motor-bikes, electronics-based radio-receivers and transmitters, microscopes, telescopes, etc. [2]. Each of these new industries grew out of small beginnings as a craft-industry before evolving into large-scale enterprises and mass production. Mass production dominated the new technologies of TV, synthetic materials, etc. [2]

When craft-industries themselves evolve into large-scale enterprises and mass production, apparently young people have two choices: either to become employees of big enterprises or to loose interest in technology altogether [2]. The third alternative, to make a living as a skilled entrepreneur, was no longer practical [2]. But then science filled the gap and this is repeated again and again as shown in the Figure-2.

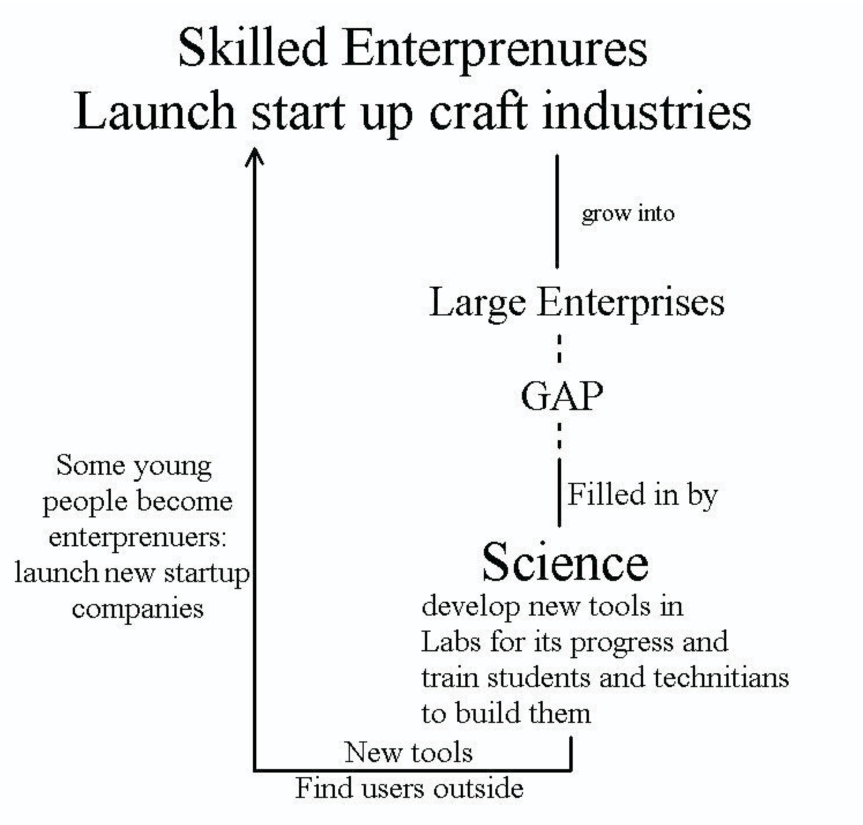

Figure - 2

During the last 50 years, science has ushered a new golden age of craft-industry [2]. One main difference from the past is that these craft-industries grew around big centers of scientific research, e.g. silicon-valley around Stanford University. Then, do the developing countries, which do not possess big centers of research, have a chance? The answer lies in linkages with big science centers and industry. Before I elaborate on it, let me mention one of the most important tools of modern science, namely computers, which started as craft-industry by entrepreneurs, to be replaced by big producers later, and software, which started as a tool for science but spread to all areas of industry [2]. This led to the information-technology revolution and World-Wide Web, which was invented at CERN, an European Particle Physics Laboratory in Geneva.

It may be noted that the technology of micro-chips and software is very special. Its most revolutionary aspect is its mobility, it travels light. It needs only human-capital and hence a sound educational base. This technology will survive, inspite of rise of Microsoft and other giant producers, as craft-industry because of [2]:

a) the enormous variety of specialized applications, needing individuals to write software based on their unique knowledge.
b) availability of software and skills to use it gave rise to a set of new craft-industries from desktop-publishing to computer-aided design and manufacturing.

A large fraction of the small businesses, now operating, owe their existence to software(s) that in turn owes its existence to science [2]. This is true even for a developing country like Pakistan. An example is Communication-Enabling Technologies, dealing with software and hardware. This enterprise was started by young entrepreneurs. The parent company is headquartered in Los Angles, but some work is done in Islamabad. It develops its own intellectual property, but also get subcontracts from large enterprises.

Science is constantly changing and as such craft-industry that it creates must also change [2]. To keep abreast with change require linkage with Higher Education (University), as well as research. Research, particularly in frontier sciences, whose importance I have indicated earlier, requires linkage with active research-centers, like CERN-Geneva and, ICTP-Trieste, to maintain high degree of awareness of rapid change in science and technology. Research also requires tools and it trains students and technicians to build them. Some of them might hopefully become entrepreneurs and launch startup companies.

CERN is a fine example, in which high technology and science reinforce each other and that of international collaboration. Exploration of unknown is hall mark of fundamental research. This requires, on one hand, cutting edge technology for developing detectors for the world's largest accelerator, LHC (proton-proton collider with center of mass energy of 14 TeV). On the other hand, it requires new concepts in computer-software(s) for storage and analysis of enormous amount of data. This is a challenging task since the amount of data to be analyzed per year by two thousand users, distributed geographically in various parts of the World, will be 10 Gbytes. This will be done by using the Novel techniques and computing Grids.

Data-Grids provide a framework for collaborative and data-exchange in large-scale projects, linking widely separated resources by high speed networks, to form "virtual organizations". They represent a new class of parallel and distributed systems for managing and exchanging data, delivering results, and enabling collaboration on global scale. The vision behind Grid is a computing environment, where anyone can play in, from anywhere and access any resource on the Grid. The end-users would be able to rent processing power, as well as software-resources, such as web-services.

Pakistan has already established a linkage with CERN. The CERN – Pakistan cooperation agreement was signed in 1994. In 1999, National Centre for Physics (NCP) and CERN signed a protocol for assembling and testing 432 *Resistive Plate Chambers* (RPC's) with 46,000 channels; these are sub-components of the big detectors called *Compact Muon Solenoid*, CMS, being built for doing LHC Physics.

The above collaboration would provide an opportunity of learning in front-end electronics and cutting edge computing-technology for young scientists of Pakistan. The window of opportunity that CERN has provided us would enable our young scientists and engineers to contribute to man's stock of Knowledge at the very frontiers of Physics and Technology.

To summarize knowledge is becoming a leading factor of production and economic development, around the world. We must take steps to create, master and mobilize knowledge for betterment of our society. For this, we need Human-Capital, which requires research and training in frontier areas of science, for which we have to establish linkages with active centres of research in the North.

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IDENTIFIED ROLES OF INFORMATION-TECHNOLOGY IN PAKISTAN'S HEALTH AND HEALTH CARE

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ABSTRACT

Pakistan's healthcare system is faced with many challenges. Among them is the unexpected impact of globalization on the health of the ordinary people. On the one hand, massive advancements are taking place in the bio-medical and health-research. On the other, it is becoming extremely hard for the patients, especially in the developing countries, to seek appropriate information about causation and prevention of disease. Not only is it hard for patients to seek health related information, in a traditional healthcare system, but it is also difficult for individual practitioners to keep track of the patient's history and deliver effective healthcare services. The problems are confounded by factors like poverty, lack of education and awareness about causation and prevention of disease for majority of population living in the less developed countries. This paper addresses these problems and suggests ways through which a more informed healthcare system can help: (i) reduce adverse health- outcomes; (ii) improve access to quality healthcare services; (iii) promote good health- related practices; and (iv) be able to respond to emerging health-threats, mainly as a result of globalization. In order to face new challenges, Health Information Technology and Systems (HITS) need to be developed, promoted, adopted and lessons need to be learned from other developed and developing counties. Pakistan's healthcare system is in transition, from the traditional provision of healthcare to adopting more modern healthcare norms. Awareness is increasing among healthcare professionals, workers and patients about how to best manage health-practices at all levels.

In order to remain informed and make preparations at par with other countries, to fight threats of (a) infectious diseases, (b) non-communicable diseases, (c) injuries and (d) other health-effects of global environmental change, it is important that a well designed health-information system is developed and modern healthcare techniques are adopted, so that it results in better health-outcome. This paper identifies routes through which health-information technology can pave the way for improvements in health and healthcare of Pakistan.

INTRODUCTION

In recent years, due to massive advancements in information-system and technology, the classical paradigm of a one-to-one relationship between the patient and the healthcare-professional is being challenged. In the classical paradigm of provision of healthcare and treatment, it is assumed that patient-doctor contact is essential. However, there are several instances, especially in the developing countries, where on-time patient-doctor contact is not possible, either due to lack of a healthcare-facility, doctor-absenteeism, remoteness, socio-economic norms and also due to long waiting lists. It is also becoming extremely difficult for healthcare-providers to manage client-cases or exchange information among healthcare-professionals. This exchange of patients and health related data is very important for correct diagnosis and treatment. However, lack of information and specialist training, in many remote or rural areas of Pakistan, demands strategic steps to be taken in provision of healthcare and dissemination of information. Advancements in information-technology show that massive improvements in health-outcome are possible without the traditional patient-doctor contact and can turn out to be more cost-effective, efficient and less time-consuming, both for the patients and healthcare- providers. It is, therefore, argued that access to complete and accurate health-information is critical for enhancing patients' welfare.

One way in which health-information technology and system can help improve health-outcome is increased awareness, on the part of patients, about causation and prevention of disease. Lack of health-information is not only harmful for patients, but also makes it difficult for the healthcare-providers to keep track of medical history, make effective and informed diagnosis, and deliver effective healthcare service to patients. As a solution to this problem, current medical practices are now increasingly relying on what is called an Electronic-Health Record or (EHR). According to the US Institute of Medicine (IOM, 1991), an EHR system is defined as: "The set of components that form the mechanism by which patient-records are created, used, stored, and retrieved". Electronic health-records are in vogue in many developed countries. However, developing countries are still trying to follow suit and the problem is confounded by lack of proper infrastructure, poverty and medical illiteracy. Nonetheless, it is evident that the benefit of using electronic health-record outweighs not having one. The obvious benefits are that (i) EHR provides online information about patient's complete medical history that is considered to be very important for correct diagnosis, and (ii) enhanced accessibility that is useful for a second advice. Electronic health-record is maintained for each patient by a healthcare-professional or the concerned healthcare-organization. The health-data need to be collected for patient's (i) name (ii) address (iii) date of birth (iv) patient's medical history (v) record of each visit for disease, (vi) symptoms (vii) diagnosis (viii) treatment (ix) outcome and (x) rehabilitation. Other useful information that is required and should be obtained from the healthcare-facility is (i) treatment as in-patient (ii) as out-patient (iii) interaction with the other healthcare-system and (iv) access to healthcare services.

Through EHRs, online-information can be provided not only for patients and doctors, but this information can be shared with other healthcare-providers, pharmacists and healthcare-administrators. Therefore, one potential benefit of implementing EHR is that it can retain huge healthcare-costs and result in improved health-outcome, due to better health-information management. The largely paper-based traditional health-system of medical record keeping can successfully be replaced with electronic healthcare-information exchange. The process of introducing an EHR in a healthcare-system, thus, requires: (i) an initial design; (ii) collection of relevant data from patients, healthcare-professionals and pharmacists; (iii) storage; and (iv) transfer of medical data. This also needs acceptance of healthcare-authorities to undertake investment in providing and linking health-information with all the relevant stakeholders, e.g. doctors, healthcare-professional, pharmacists, clinicians and patients. Clinical decision-support system can improve diagnosis and result in better disease-management, wherein patients can become managers of their own health. It is, therefore, expected that increasing the use of information-technology in healthcare will help clinicians work more efficiently and enable patients to receive better and safer healthcare.

The other benefit of Health-Information Technology (HIT) is the prevention of communicable and non-communicable diseases. Incidence and prevalence of diseases can be reduced if patients, doctors, and healthcare-providers have accurate information about causation of disease and know the measures to prevent them. This can especially, be useful in areas where: access to information is restrained, due to remoteness; and other healthcare-facilities do not prevail. This is because an EHR can be accessed through wireless networks or mobile health- professionals.

The use of health-information technology can promote good health-practices and can result in preparedness for unforeseen health-threats. Similarly, better surveillance and monitoring of health-information can result in better public health-outcome. By providing latest information about healthcare, we may enable patients to manage diseases, with minimum help and support by the healthcare-providers, and help reduce associated costs. In more developed countries, for example, patients have access to home healthcare, mainly aided by tele-health, rather than in personal care. In a developing country like Pakistan, home healthcare has a lot of potential of resulting in positive health-outcome. This is because caretakers are usually family-members who can be assisted through online-health aids in disease-management. Hence, through health-information technology, integrated patient-management is possible through online-decision aids and better healthcare and administrative support. This only cannot result in saving time and money/costs, but will result in better health-outcome. The argument is that all efforts should be made to translate health-technology into better health-outcome. The result can be in the form of reduction in the number of cases of a particular disease as a result of prevention and better health-information sharing.

However, besides the obvious benefits of implementing electronic health-records, there are concerns about loss of confidentiality and privacy of patients' data. Personal-data handling, therefore, requires more secure measures and law about privacy enforcement. There is need to develop a regulatory framework for effective implementation and ownership of data. For this, a national standard should be developed that minimizes the risk of misinterpretation of information and misuse of technology. Another expected problem is the acceptance by traditional healthcare-providers and patients themselves, to incorporate technology into their usual health-practices. Lack of education can also be a hindering factor that may restrict the use of health-information technology in a developing country like Pakistan. However, for this purpose, a more user-friendly system with audio-visual help can be developed and introduced. The healthcare-system should have a infrastructure of health-information and technology that is accessible to all patients and providers. The basic aim of health-information technology is, therefore, to empower its stakeholders. For example, patients should be able to manage their own health, and clinicians should able to provide a more evidence based safe health care when relying on health-information technology.

With the financial assistance of donors and technical expertise of SDPI and COMSATS, an experimental dynamic web can be designed, developed and implemented with the consent of the Ministry of Health, Government of Pakistan. Such a site will provide the following services to the patients, doctors and pharmacists in Islamabad:

1. *for patients*, record of medical history, status of current health, health-education, awareness and prevention;
2. *for medical practitioners*, complete medical history, diagnosis, treatment, and

Table - 1: Impact and Stakeholders of Health-Information and HIT

Patients	Practitioners	Pharmacists	HIT Providers
Easy access to Health-information	Access to patient's medical history for better diagnosis and treatment	Better understanding of prevalence of diseases	Provide quality health-services to all stakeholders through more Informed technology
Improved awareness leading to better prevention	Sharing information for a second opinion	Improved competition for providing quality Products	Enhanced networks and potential for expansion
Improved home care/ non-visit care	More information about emerging threats	Better drug-administration	Cost containment, information about quality care, efficient and less time consuming health-Information and services

outcome;

3. *for pharmacists*, information about costs of drugs, new drugs and therapies, demand and supply conditions; and
4. for HIT professionals, information gathering and dissemination for all stakeholders.

From the Table-1 it is clear that health-information technology can increase awareness among stakeholders. However, there is a need to develop regulatory framework for its effective implementation and ownership of data. Active collaboration among all stakeholders is required to minimize the risk of misuse of technology. For this purpose, it is necessary to train health-information technicians, with the responsibility of working in either small or large healthcare-facility for medical-record keeping. For a country like Pakistan, where information-systems are growing rapidly due to government's commitment to develop science and technology, healthcare provides an application where IT personnel cannot only be employed but also will contribute in the social and human-development of the country. The main stakeholders of the e-health are patients, medical practitioners, health-information professionals, and pharmacists. Health IT professionals need to design and develop a dynamic website,

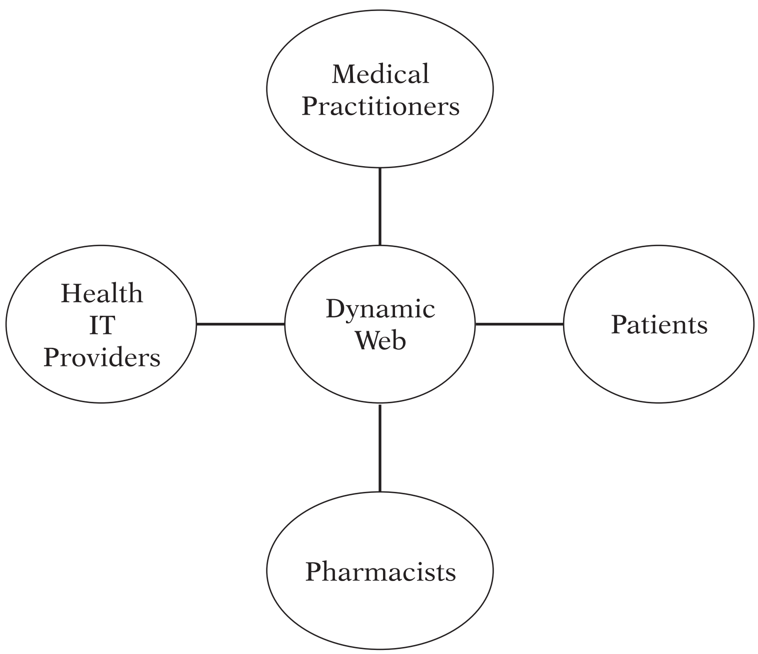

Figure - 1: Stakeholders of Health-Information Technology

accessible to all stakeholders and extend the scope at national level. Stakeholders in health-information are presented in the following Figure-1.

The benefits of the e-health are expected to outweigh the traditional healthcare-practices. The major benefits are ready access to health-information, online appointments by the patients, self-management against disease, case management of client, sharing of information among healthcare personnel. However, there are certain issues that need to be addressed before implementing electronic health-record and online health-information. The broad issues are privacy of patients' data; quality and authenticity of health-information; provision of proper infrastructure and equipment, and adopting technology according to healthcare norms. The issues require that the government develops a regulatory mechanism to ensure timely and quality dissemination of health-related issues, and use of online health-information turns out to be cost-effective by saving resources on excess labor and administrative costs.

BIOTECHNOLOGY: GLOBAL SCENARIO AND INTERNATIONAL COLLABORATION

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ABSTRACT

In this manuscript emphasis is being placed on biotechnology, as an example of one of the leading technologies for future economic development. The specific initiatives taken by COMSTECH and COMSATS for the promotion of biotechnology have been discussed as possible approaches for promoting cooperation in biotechnology. In addition some of the other initiatives by COMSTECH for international collaboration have also been discussed.

INTRODUCTION

Economic prosperity, poverty eradication and development are complex, interrelated processes, which depend on a number of factors operating in any society. The topic of the present seminar focuses on the significance of collaboration, not only between South and North but also South-South cooperation. In the present global scenario and with the rapidly changing infrastructure, and enormously increased facilities of internet, cooperation among scientists has certainly become much easier, and such new avenues offer us a unique opportunity to work together and achieve our common objectives for improving quality of life.

Knowledge has become the main driving force of the world economics and the basis of socio-economics development of individual countries. Recent advances in Information-Technology, Genetics, Biotechnology and other emerging disciplines hold immense prospects for the well being of mankind as a whole. Collaboration among nations is considered vital for development, there is a dire need to collaborate and cooperate among South-South and South-North regions, so that the poor nations can prosper. This can be best illustrated by the example of a specific discipline like Biotechnology, which is the application of science and engineering to the direct or indirect use of living organisms, or parts or products of living organisms in their natural or modified forms. Its can offer enormous benefits to mankind; from an improved environment to better crop-yields; from better health to more effective healthcare.

More than 325 million people worldwide have been helped by the more than 155 biotechnology-drugs and vaccines, approved by the US *Food and Drug Administration* (FDA). 70% biotech-medicines have been approved in the last six years. There are more than 370 biotechnological drug-products and vaccines currently in clinical trails, targeting more than 200 diseases, including various cancers, Alzheimer's disease, heart disease, diabetes, multiple sclerosis. Aids and atriums biotechnology is helping in hundreds of medical diagnostic tests, while environmental biotechnology-products make it possible to clean up hazardous waste more efficiently by harnessing pollution-eating microbes, without the use of caustic chemicals. The total value of publicly traded biotech-companies at market prices was US$ 206 billion, as of mid-April 2003.

Biotechnology is a fast emerging field of the 21st century. The innovative capability of biotechnology is being looked upon as pivotal, in maintaining/expanding the national share in the global economy. Biotechnology has immense impact on the core-fields like industry, medicine, agriculture and environment that have direct impact on human-life. I would like to give some examples of COMSTECH's collaborative activities, within the OIC member-states and with some western organizations.

The development and dependence on biotechnology has largely increased in countries all over the world, in the last few years. The *Human-Genome project*, production of antibiotics and improvement of crops by agricultural biotechnology are some of the major breakthroughs provided by this technology. Biotechnology is a revolutionary and accessible concept that can boost agriculture and the overall economy. Biotechnology has brought us to the brink of world industrial processes. Biotechnology has been described as "Janus-Faced"; this implies that there are two sides; on one side the techniques allow HNA to be manipulated to move genes from on e organism to another, while on the other, it involves relatively new technologies whose consequences are untested and should be met with caution.

The benefits offered by biotechnology are promising hope to the developing world for producing healthier foods, delivering edible vaccines, protecting water-quality, reducing chemical pesticides and developing environment-friendly weed-control. Apart from this, the most recent advances that have taken place in the field of biotechnology are: the new test for colon cancer, evaluation of spinal-chord injury and function, combating the threat of bioterrorism, decontaminating the explosive soils and odor-control.

ICGEB DEDICATION

The International Centre for Genetic Engineering and Biotechnology (ICGEB) is an international organization dedicated to advance research and training in molecular biology and biotechnology, with special regard to the needs of the developing world. It was founded by UNIDO and it has its offices in Delhi, India, Trieste, Italy. Collaborative Research Programme (CRP) was established to stimulate collaborative research between ICGEB and its network of affiliated centers and focal points, and to develop new research programmes of specific interest to participation countries. There are eighteen OIC member-countries, which have ICGEB affiliated centers and focal points.

COMSTECH ACTIVITIES

Keeping in view the importance of this technology, OIC standing committee on scientific and technological cooperation (COMSTECH), has included biotechnology among the frontier-sciences, owing to its great economic and commercial potential in revolutionalizing the base of developing countries. While going through the scientific advances taking place in the developed countries, the fifty-seven OIL member-states gather on one platform to enhance scientific collaboration. The underlying agenda is to nurture biotechnology at three distinct levels viz. Agriculture, Health & Industry, and examine ethical issues in the light of Islam. The vision of COMSTECH is to enable the Islamic world to achieve self-sufficiency in the development and use of biotechnology and to carve out future strategies for exploiting the commercial potential of biotechnology. Unfortunately, the biotechnological revolution, characterized by modern-day advances in agriculture, medicine, industry and environment, is bypassing most of the OIC member-states and unless the OIC sets priority for investing in the critical areas, and declares biotechnology as a critical area for immediate development, this revolution will by-pass us.

COMSTECH recently held an Inter-ministerial meeting on Biotechnology. Delegates from 11 OIC member countries, and 4 international organizations participated in the meeting and gave their presentations. They reviewed the current status of biotechnology in their respective countries and discussed their future plans. These discussions highlighted the pivotal role of biotechnology, in the future economic development of OIC member-states, and suggested that the member-states take concrete steps to derive benefits from this innovative technology and address the legal and ethical issues, in accordance with the social and cultural perspective of the Islamic polity. During the meeting, the following three draft COMSTECH-documents were circulated among the participants.

a. Model Biosafety Guidelines;
b. Islamic Biomedical Ethics: Issues and Resources; and
c. Strategy for Development of Biotechnology in the Islamic Countries

It was recommended that these be approved in principle and comments or changes be conveyed to COMSTECH Secretariat within one month, so that the documents are revised and presented in the next COMSTECH General Assembly Meeting for approval. In the final session, a panel discussion was held and the recommendations were discussed.

INTER-ISLAMIC NETWORK ON GENETIC ENGINEERING AND BIOTECHNOLOGY (INOGE)

Considering the rapid evolution of science and technology taking place throughout the world, COMSTECH set up an Inter-Islamic Network on Genetic Engineering and Biotechnology (INOGE), in Cairo, Egypt, hoping to strengthen the national efforts to enforce the capabilities of Muslim countries; it aimed to make best use of science and technology as a principal field of revolution and progress.

COMSTECH INTERNATIONAL COMMITTEE ON BIOETHICS (CICB)

Issues raised by the latest innovations, in the field of biotechnology, are crucial. Realizing this fact, COMSTECH look a timely initiative and formed an International Committee on Bioethics, comprising eminent Muslim scholars from around the world. The first meeting of CICB was held in Beirut, Lebanon, from March 1 to 2, 2003. During the meeting different themes were assigned to the scholars, to prepare comprehensive papers.

COMSTECH-IFS COLLABORATION PROGRAMME

COMSTECH, in collaboration with the International Foundation of Science (IFS), Sweden, provides research grants to young scientists on merit from OIC member-countries under the COMSTECH-IFS research-grants programme. Research grants upto a maximum value of US$ 12,000 per year, for a period of one to three years, are awarded in six different research-areas like aquatic resources, animal-production, crop-sciences, forestry/agroforestry, food-science and natural products, within the general framework of management, use and conservation of biological resources. So far, 87 researchers from 26 OIC member-states have benefited from this programme.

COMSTECH-EMRO COLLABORATION PROGRAMME

The focus on genomics and biotechnology research and development is supported both by EMRO and COMSTECH, which launched a joint funding programme to support research in health-related applied genomics and biotechnology. The initial grant will be around US$ 200,000, with a contribution of US$ 100,000 each by EMRO and COMSTECH. The grant will be made effective in the current year, and EMRO will develop mechanisms for calling for research proposals, peer review, selection and follow-up of the research grants.

COMSTECH-COMSATS COLLABORATION

The National Commission on Biotechnology (NCB) of COMSTECH, in collaboration with Commission on Science and Technology for Sustainable Development in the South (COMSATS), is in the process of developing a web-portal on Biotechnology, for providing quick access to the information about institutions involved in the subject and on-going research projects, as well as, the expertise available. The formation of this Web-portal will lead to transfer of technology and expertise, sharing of resources among the developing countries in general and COMSTECH's and COMSATS' member- countries, in particular.

The features of this web-portal include, informational resources on Biotechnology institutes and universities, research projects being run by them, publications, events and job openings. This way, scientists will have quick access to each other and they would remain informed about new developments taking place in this field. Apart from this, there is a definite need to facilitate interaction amongst Bio-technology specialists. This Web-portal will also give an opportunity to the biotechnology scientists to share their ideas and maintain linkages. Discussion-forums on the web-portal will enable the scientists to share their views with their peers.

JOINT RESEARCH AND TECHNICAL COLLABORATION BETWEEN GIKI AND UNIVERSITY OF LIMOGES, FRANCE: A SUCCESS STORY

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INTRODUCTION

This is a summarized report on the presentation made at the Meeting on South-South and South-North Collaboration in Science and Technology: Present Scenario and Future Prospects. The meeting was organized by COMSATS on March 12 and 13, 2004, in Islamabad.

PRESENTATION OF THE TWO COLLABORATING INSTITUTIONS

A. The Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan

The GIK Institute was created in 1988, with a view to establish a centre of excellence in the Engineering Education in Pakistan. The first batch of undergraduate engineers was inducted in 1993. This is the premier institute for engineering in Pakistan. The Faculty of Materials Engineering has high-quality materials-characterization equipments, including an Electron-Microscope, Instron Mechanical Testing Machines, Heat-Treatment Labs, Corrosion-testing labs and X-Ray diffraction facility. Research on advanced materials is conducted by qualified researchers and students. More than 100 research-articles have been published by the faculty-members of this Faculty in different international journals and conferences.

B. Laboratory of Ceramic Materials and Surface-Treatment University of Limoges, France

The Laboratory of Ceramic Materials and Surface-Treatments (LMCTS), University of Limoges, France, is classified among the top 5 research organizations in France, in the field of Materials Engineering, especially ceramic materials. There are more than 250 scientists and Ph.D. students working in this lab at any time of the year. They are leaders in cutting-edge research and technologies, such as surface-engineering, coatings, high-temperature novel ceramics, ceramics for electronics, non-oxide ceramics and thin-films for radiation-detectors. Several of these research projects are even applied for defense purpose in France. They have a vast experience of managing a graduate and post-graduate teaching program.

PROLOGUE TO COLLABORATION

Purpose and Objectives of Collaboration

The Faculty of Materials Engineering has good characterization facilities. In order to have a balanced research in materials, characterization and production have to go side by side. Production of advanced materials requires expensive equipment and relevant experience. This also requires support from local industry.

Under the given scenario in 1998, the *Faculty of Materials Engineering* was required to established facility for production of advanced materials, and to train Ph.D. students on this equipment. Research in fields such as Surface-Engineering was also the target.

Professor Jean Claude Labbe, from the University of Limoges, visited the GIK Institute in 1998, and saw the possibilities of collaboration. It was decided to initially start a few projects, which would help in establishing research facilities and training of the staff of the GIK Institute. His visit was also useful for Continuous Education program, through arrangement of a workshop on advanced materials. On these lines, a Memorandum of Understanding (MoU) between the two Institutes was prepared and signed, on one side by the President of the University of Limoges and on the other by the Rector of the GIK Institute. Prof. Jean Claude Labbe and Dr. Amir Azam Khan signed the document as coordinators from each side. This Memorandum was handed over to the Ambassador of France, in Islamabad, in July 1999, as the French Embassy was one very important partner and the prime mover to this collaboration.

PROGRESS SINCE 1999 TO DATE

Initially in 1999 and 2000, there was a need for a number of exchange-visits from the two Institutes. This was necessary in order to understand the requirements and assess abilities of both partners. Prof. Jean Claude Labbe, along with Professor Pierre Fauchais, visited the GIK Institute just after the signing of the MoU. During their visit, they saw the research and laboratory facilities of the Institute, conducted a two-day workshop on "Surface Engineering and Coatings Technology”, in which 22 participants came from industry, several research organizations of the country as well as Professors of the GIK Institute. This workshop had a lot of success in preparing local minds for new fields like Surface Engineering. Another workshop was organized in the following year, on the subject: “Joining of Materials".

COMBINED PH.D. PROGRAM

The quality of the GIKI graduates was underlined each time when the French Professors visited Pakistan. It was then decided to start a joint Ph.D. Program on a topic in which both partners were interested. One immediate topic of interest was the development of coatings of Stainless Steel, on any simple substrate, like Mild Steel, using a DC blown arc plasma-flame. This was supposed to be a very cost-effective solution, as this would avoid making complete containers out of SS for chemical and food-grade liquids. The scientific component of the research (as it was of interest to both Prof. Jean Claude Labbe and Pierre Fauchais) was to study the reactions taking place under highly non-equilibrium conditions under 14000 K, between the reactive plasma and liquid-steel or Chromium. Mr Asif Ansar, a graduate from the GIK Institute, was selected as a student and Dr. Amir Azam Khan became his Co-Supervisor from the GIK, whereas Prof Jean Claude Labbe and Prof Pierre Fauchais became his Co-Advisors from the University of Limoges. Mr. Asif Ansar started his research work in the academic year 2000-01.

The results obtained from this work were very interesting. He discovered a rather strange form of oxidation and characterized non-stoïchometric oxides, formed during a very short-time interaction between Fe and highly reactive atomic oxygen at very high temperatures. These oxides got arrested in the centre of the liquid-drop, rather than remaining on the surface. This behavior was explained keeping in view the convective movement of liquid-drop at a very high speed, as plasma accelerated the liquid-drop at speed as high as 300 m/s^2 from virtually no speed when a solid particle enters the plasma flame, within a fraction of a second. An acceleration of several hundred m/s^2 is expected under these conditions.

These results were compiled in the form of research papers in journals and conferences. Almost 4 such research papers have been published. Mr Asif Ansar successfully defended his Ph.D., on the 26^{th} February, 2004, at the GIK Institute. Among the jury members were Dr. Hameed Ahmad Khan, Executive Director - COMSATS (President); Prof Muhammed Naseer Khan, Rector GIK Institute; Prof. Dr. Zakaullah, Department of Physics, Quaid-i-Azam University; Prof. Fazal Khalid, Dean Faculty of Metallurgy and Materials Engineering, GIK Institute; Prof. Pierre Fauchais, University of Limoges, France; Prof. Jean Claude Labbe, University of Limoges, France, and Dr. Amir Azam Khan, GIK Institute. The thesis was evaluated by Prof. Berndt, Chief Editor Journal of Thermal Plasma Spraying, USA, and Prof. Jean Amouroux, France. His thesis was adjudged to be an excellent piece of work by the jury members and by the external evaluators.

The defense of the thesis was kept as open and several known scientists from all research organizations and universities were invited on the occasion. Almost 50 scientists and engineers were present on the occasion, as this being the first Ph.D. in engineering discipline awarded by the GIK Institute.

Dr. Asif Ansar has since, produced 2 more publications from the work he has done during his Ph.D. Presently one more student, Mr. Syed Salman Asad, a graduate of the GIK Institute, has registered for Ph.D. under the same program.

TECHNICAL COLLABORATION

It was felt in 1998, that GIK Institute lack in development and production facility, although excellent characterization-facilities exist (as mentioned earlier). One important component, for producing high-temperature materials, is a controlled atmosphere high-temperature furnace. Such an equipment is sold in the market for over Rs. 25 million. On the lines of the MoU, it was decided that GIK Institute would undertake a project of building such a furnace with the help of University of Limoges.

After analyzing the existing facilities and skills available with GIK Institute and within the country, it was decided to produce mechanical parts and power-unit locally, according to a design supplied by the French University. Some bottlenecks were expected in acquiring advanced materials, like molybdenum nuts and bolts; isotropic polygranular graphite for resistance, and carbon-felt (wool) for insulation. As far as the power-electronics and optical temperature measurement-system, synchronized with the power-electronics, for programmable Logic Control, these were to be supplied by Limoges, on payment. This effectively brought the cost down and resulted in transfer of technical know-how to Pakistan. The project was initiated in the year 2000, and was finally completed in May 2002, at a total cost of Rs. 5 million, excluding the help that the French Government provided in the form of logistics. The furnace was inaugurated on the 2nd of May, 2002, by the French Ambassador in Islamabad, Monsieur Yannick Gerard, and Engr. Illahi Buksh Sommo, the then Rector of the GIK Institute.

This furnace .can heat samples to a temperature of 2000°C, under controlled atmospheres of Argon, Nitrogen or vacuum. Materials such as oxides, nitrides and borides can be sintered and refractory metals like tungsten and molybdenum, or alloys based on refractory metals, can also be sintered in this furnace.

This is the present status of the collaborative venture undertaken on the lines of the MoU signed in 1999. In addition to this, translation of useful books from French to English is being carried out. One book was translated by Dr. Amir Azam Khan under the title "Electrochemistry and Chemistry of Solutions" for the level of first and second-year University students. This book, written by Prof. Jean Claude Labbe and Prof. Jacques Mexmain, is already published in France, by "Ellipses" and currently a suitable publishing house is being contacted for printing its translation in Pakistan through legal copyright transfer-policy.

RECOMMENDATIONS OF THE MEETING

The meeting on "South-South and South-North Collaboration in Science & technology: Present Scenario and Future Prospects" attracted speakers and participants from around the world, and led to thought-provoking deliberations during the course of this two-day meeting.

The most useful aspect of any meeting is the set of concrete recommendations that are the outcome of the thorough discussions and deliberations of the speakers and participants. Given below are some of the key recommendations that should prove to be guidelines for the decision-makers:

A.

- Establish concrete S&T policies, closely tied to overall national economic goals, inclusive of strategies for technological innovation.
- Develop human-resource through bilateral and multilateral training-activities, exchange-programmes, utilization of expatriate national's expertise and exchange of ideas, experiences and information.
- Strengthen existing institutional capacities to adapt to changes in socio-economic and political environment.
- Tap new sources of funding, especially from private sector.
- Develop Venture-Capital Mechanisms, to allow for commercialization of innovation.
- Create mechanisms for evaluating and monitoring follow-up actions
- Involve all stakeholders of the society, including policy-makers, and beneficiaries to evoke political will.
- Endeavour not to lose focus of the development of low-end technologies, in pursuit of costly and difficult high-end technologies.
- Strengthen the linkages between R&D centres and productive units
- Strengthen legal and financial institutions that foster participation of private sector
- Form an international "Panel of Advisors" to advise policy-makers in areas of critical importance.
- Devise an effective mechanism of partnerships with the North. In this case, the role of development/donor-agencies and the United Nations must be explored fully.
- Encourage and facilitate the flow of funds and knowledge from North to South and focus on brain-gain and on reduction of brain-drain.

B.

- It is to be realized that countries today are so interdependent that it is virtually impossible for the North and South to follow divergent trends for long.
- The North has to show respect for human-development, which needs the science of

values, rather than put its entire stakes in technical development.

- For long-term prosperity, it is important for stakeholders to work on a BOT (Build, Operate and Transfer) system in scientific projects/collaborations.
- Role of centers of excellence should be enhanced, and these centers need to be strengthened, so as to fully realize the potential of collaboration (be it South-South or North-South).
- In order to make collaborative initiatives (South-South or North-South) effective, a three-tier approach is recommended. This would include i) Clear identification of potential areas of collaboration, ii) Plan of Action/Implementation clearly defined and understood by all partners and iii) a firm commitment for the provision of finances by the stakeholders.
- It is also useful to learn from successful models and case studies from around the world, such as the Chinese way of development.
- Attracting young people towards the fields of science and technology. In this regard, young aspirants should be provided with the opportunities to learn and then apply their knowledge.