# Education, Science and Technology in Developing Countries: Some Thoughts and Recollections

Hameed Ahmed Khan


Commission on Science and Technology for Sustainable Development in the South

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**Commission on Science and Technology for Sustainable Development in the South**

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# FOREWORD

Science and technology are the vehicles of development in the modern globalized world of today. No nation can envisage progress and prosperity without effectively building and harnessing capacities in them. Developing countries stand at a juncture where they are presented with no other choice than to use science and technology as tools of sustainable development. An integrated and systematic effort to build these competencies must be instigated within developing countries at the highest level, which should trickle down to the grass-root levels.

I am pleased to see that this book is a compilation of thoughts and recollections of a scientific mind, aiming to address the developmental challenges of the countries of the Third-World. With an objective stance, topics of science and technology based development with particular reference to Islamic and developing countries have been thoroughly analyzed and addressed. Burning issues of higher education and Information Technology for development have been tackled with great skill and command, and concrete and implementable recommendations have followed.

It is my opinion that this book presents modern day concerns, spanning an era of 6-7 years, with a different approach altogether. The novelty, I believe, is due to the credentials of Dr. Hameed Ahmed Khan, who is a seasoned physicist and now a forerunner in bringing about sustainable socio-economic sustainability in the South through the judicious use of S&T. Dr. Khan has a keen eye for detail and excellent analytical abilities. My view is that a compilation of a scientist's opinion can always be referred to with great value and assurances of reasonable objectivity, and for this reason I am sure that this monograph will stimulate policy-makers and scientists of the developing world to think from a different angle, on issues governing sustainability and progress.

I thoroughly recommend this book to those with a visionary eye, as well as those attempting to grasp issues concerning education, science and technology in developing countries.

**Prof. Dr. Atta-ur-Rahman**
UNESCO Science Laureate,
Chairman, Higher Education Commission (HEC),
(Federal Minister)

# PREFACE

In the fast paced information-era of today, the rules of survival and sustainability are dynamically shaping. In the wake of such a scenario, the importance of knowledge, especially in the field of science and technology, cannot be emphasized enough. Developing countries must give serious thought to devising and implementing result-oriented strategies to initiate the process of bridging the increasingly widening knowledge-divide between themselves and the developed world, before it becomes unconquerable.

In the twenty-first century, science and technology are the powerful resources for understanding natural and social phenomena, and undoubtedly, their role promises to be even greater in the future as the understanding of mankind regarding the growing complexity of the relationship between society and the environment becomes deeper. It is no secret that science and technology are the keys to development, prosperity and sustainability, nations well equipped with the tools of S&T open-up gateways leading themselves to limitless horizons of success.

However, given the perilous and recurrent challenges confronted by the developing countries, in attaining true scientific and technological progress for sustainable development, it is imperative to identify primary and strategic areas of importance, and subsequently prioritize them. Arguably, one of the most effective strategies, to achieve the cherished goal of development, is to channel planned and calculated investment for grooming the future of the nation in the form of education, especially higher education. No nation can dream about launching its science and technology programme in full throttle, unless it has a sound S&T education-system in place.

This compilation is a collection of some of the extractions from my articles, papers, keynote addresses and lectures, which engulf the theme of the above-stated facts and arguments governing the concepts, importance, challenges and solutions of education, science and technology in the developing world. Written in the capacity of Director General, PINSTECH; Executive Director, COMSATS; and more importantly, as a scientist, I have endeavored to address the most pressing issues of their times concerning S&T and higher education in Muslim and developing countries.

Taking a different approach to publication, this recollection begins with a generalized debate on the importance of science and technology, followed by detailed research on the status of higher education in developing countries and the future scenario thus envisioned. A candid measure of the scientific and technological progress of the developing countries is taken next, while remedial actions are also suggested side-by-side. Information Technology is later identified as one of the key drivers of prosperity and last but not the least, the integral significance of sustainable development led by science and technology is touched in detail.

This book constitutes ideas and addresses issues spanning from 1998 to the year 2004. Some write-ups have been updated for relieving ambiguity, however the reader must view all extracts in the context of the time-frame during which they were written, so that greater clarity as to the intention of the writer may be achieved. Any mistakes are, nonetheless, regretted and comments and suggestions for improvement are most welcome.

Lastly, I wish to thank all my colleagues who assisted me in writing these articles, lectures, keynote addresses and papers. With particular reference, I would like to thank Ms. Zainab Hussain Siddiqui for extracting, compiling and updating my write-ups. I would also like to thank Dr. M. M. Qureshi, Mr. Irfan Hayee, Mr. Salman Malik, Ms. Uzma Ikram, Mr. Barkaat Ali, Ms. Merium Khan, Ms. Noshin Masud, Ms. Nazish Ashfaque and Mr. Imran Chaudhry for their valuable support and assistance.

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

# Chapter One

# SCIENCE AND TECHNOLOGY

# 1. INTER-RELATIONSHIP OF SCIENCE AND TECHNOLOGY

'Science and Technology' is among the most frequently used terms of modern times. All educated persons seem to know its relevance in their lives and the impact it has made on the progress of developed countries. This consciousness is coupled with a conviction in the case of those who are lucky enough to experience the benefits provided by the promotion of Science and Technology in their societies. For them, there is no other way but to regard it as the top most item of national priorities. A consensus among the ruling class and the general public in this matter is well reflected in all spheres of their social activities. On the other hand, for many in the Third World countries, Science and Technology appears to be an alien enterprise, which may benefit them only to the extent permitted by foreign owners holding patent rights. Their leaders use the terminology mostly as part of political rhetoric rather than serious policy-instrument. The vested interests of local, as well as, international establishments are also well served by the suppression of indigenous growth in this sector. To this end, the ignorance of masses, as well as, the educated laymen is exploited to adopt unfruitful courses of action, leading to enormous wastage of human and financial resources. In this connection, it is necessary to first delineate the boundary between what is Science and what is Technology.

Unfortunately, the inter-relationship of Science and Technology is generally understood in a broad sense but hardly conceived with respect to specific details, even by the well-informed educated class. While the two terms are often used as a composite word signifying their inter-dependence, the presence of additive conjunction also signifies their mutually exclusive aspects. The educated common man is apt to use this term as part of a widely accepted jargon, even if its true significance is obscured from him. In fact, better insight into the real correlation of science and technology arises only out of a deeper study of the evolution of human civilization. Whereas, it is relatively harmless, if an ordinary person harbors misconceptions about pedagogic issues, a misinterpreted terminology in the hands of policy-makers can lead to grossly erroneous decisions, adversely affecting large groups of individuals or the society as a whole. It is, therefore, a matter of considerable social importance if the boundaries between science and technology are unambiguously defined and their dialectics is clearly spelled out. An exercise of this nature necessarily requires awareness of historical events as well as, intimate knowledge of scientific methodologies and technical procedures. Fortunately, this has been done by quite a few people who are endowed with necessary qualities to understand the dynamics of human progress. In this brief article an attempt is made to clarify the duality of science and technology, in the light of opinions held by outstanding intellectuals and notable philosophers.

People linked with science are known as ‘scientists’; while those involved with its applications are called ‘technologists’. There is a clear-cut distinction between the two classes. Freeman Dyson, in his book, “Disturbing the Universe” has given a simple but very graphic definition of the two. According to him, *“a scientist is a person with original ideas. A good engineer (technologist) is a person who makes a design that works with as few original ideas as possible”*. It is thus, clear that the two types of activities are rather different since they involve people who have different skills, different mental characteristics and even different personality traits. This is , of course, a general trend. One may find exceptions to this – there may be a few scientists who are also excellent technologists. It is also possible that some very good technologists may have excellent scientific skills.

Not very long ago, it was thought that the scale and dimensions of natural phenomena were limited to what can be perceived by our primary senses of hearing, sight, touch, and smell. At that time, the technology was largely based on this limited part of observable nature. Also, at that time, the nature was thought to be fairly nicely studied by trial-and-error procedures and empirical ingenuity utilizing our primary senses. Therefore, the old technology employed simple machines like levers, cogwheels, waterpower, etc. This trend of thinking, based upon direct observation, was greatly responsible for the progress made in disciplines of mechanics and heat in physics.

The above-mentioned situation took a drastic change during the last century or so. Technology based on the limited store of knowledge or “immediate experience”, obtained from the observable everyday phenomena, was soon exhausted. Man was forced to look into domains of knowledge far remote from our everyday experience. The new “sensors” were found which could explore dimensions (mass, size, distance, time-duration, temperature-range, etc.) far broader than those previously accessible by our bodily senses. Technology moved one step further and the need for a more systematic knowledge of nature and natural phenomena become unavoidable.

The limitations of the old technology based on hit-and-trial method and the necessity of the scientific approach for modern technology is well illustrated in the following example:

Let us provide an assortment of items, such as wooden and metal rods and plates, nails, nuts and bolts etc., along with some welding and other mechanical facilities to someone and give him a task to produce a product such as a “reaping machine”. A sensible person (or a technologist) using these tools and materials is expected to produce a fairly useful “product” or a “machine” in reasonably good time. His machine may not be very efficient or may not be so economical (from modern standards). It is also possible that the machine so designed may not last very long. One thing is clear that the desired machine with fairly useful functions can be produced in a reasonable span of time. Let us take now another example. The same person is given a card-board box along with some pieces of copper, some insulators like glass, germanium, wood, and some necessary instruments required to process these materials. He is asked to make use of these bits and pieces and to produce a transistor radio-receiver. Can he do it? It is obvious that he cannot perform the miracle by only hit-and-trial method, unless he has sufficient knowledge of "solid state physics" and the "characteristics of semiconductors". This one example is enough to show the severe limitations of the "old principles" on which the technology of the 19th century was based, and the "power" of the modern science as a base to support the 20th century technology. One can cite many such examples to illustrate the point, emphasizing the necessity of scientific knowledge to support modern technology.

The realization of this fact is the key to sustainable progress. The eminent Pakistani Nobel Laureate, Prof. Dr. Abdus Salam, has gone so far as to say, "…*one might discern sinister motives among those who try to sell to us, the idea of technology-transfer without science transfer*". He further stressed, "…. *The imperative necessity for a third-world country is to find the most effective policy to bring about rapid macro-transfer of science on which to base its development. Without such transfer of science, a third-world country will continue to be technologically dependent and, hence, economically and politically one-sidedly dependent; more simply said, prone to exploitation in the international markets.*"

It is, therefore, necessary for a society to have people with scientific skills apart from those with technical abilities. Once the mind-set of immediate utility is changed and it is realized that the generation of abstract knowledge is just as important as the invention of a gadget to handle a given situation, then the whole complexion of education would have to be changed in a fundamental way. Students would not be required just to cram a certain number of facts, but they would be encouraged to raise questions and seek answers that satisfy their minds.

While stressing the need of scientifically produced knowledge in order to accomplish high technology ventures, it must not be over looked that new science needs new tools.

The successful nuclear tests in May 1998, by Pakistan Atomic Energy Commission, is an excellent example of the importance of scientific base for technological advancement. The success of nuclear tests is ultimately an "end-product" of the sound scientific base, provided by the Pakistan Institute of Nuclear Science and Technology (PINSTECH), in support of the over all programme of PAEC. The manpower which played a key role in this venture had acquired thorough knowledge of physical, chemical and materials sciences at PINSTECH, over the last thirty-five years or so, which helped them in mastering the most sophisticated technology of the world.

This requirement points to the fact that science cannot flourish without a credible technological base. It is, therefore, a futile exercise to prove the superiority of science over technology or vice versa. The two have an inseparable mutuality. Any attempt to diminish one, as compared to the other, leads to lamentable consequences, as witnessed in many countries where the buzz-word "Technology" has been given precedence over its counterpart world "Science".

**The views of some eminent thinkers on the subject of science and technology are presented below in the form of brief quotations:**

## 1.1 SCIENCE

*"Science has a simple faith, which transcends utility. Nearly all men of science, all men of learning for that matter, and men of simple ways too, have it in some form and in some degree. It is the faith that it is the privilege of man to learn to understand, and that this is his mission. If we abandon that mission under stress we shall abandon it forever, for stress will not cease. Knowledge for the sake of understanding, not merely to prevail, that is the essence of our being. None can define its limits, or set its ultimate boundaries."*

_____Vannevar Bush (1870-1974). U.S. electrical engineer & physicist,

*"Science is nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit: and its methods differ from those of common sense only as far as the guardsman's cut and thrust differ from the manner in which a savage wields his club."*

_____T.H. Huxley, English biologist

*"The most exciting phrase to hear in Science, the one that heralds the most discoveries, is not Eureka! But :That's funny…"*

_____Isaac Asimov

*"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world. Science is the highest personification of the nation because that nation will remain the first, which carries the furthest the works of thought and intelligence."*

_____Louis Pasteur (1822-1892)

*"There is one thing even more vital to Science than intelligent methods; and that is, the sincere desire to find out the truth, whatever it may be."*

_____Charles Sanders Pierce

## 1.2 TECHNOLOGY

*"Technology means the systematic application of scientific or other organized knowledge to practical tasks."*

_____John Kenneth Galbraith, American economist and diplomat

*"Technology is a gift of God. After the gift of life, it is perhaps the greatest of God's gifts. It is the mother of civilization, of arts and of sciences."*

_____Freeman John Dyson (b.1923) Eglish Writer, author

*"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."*

_____Richard Feynman

*"Technology makes it possible for people to gain control over everything, except over technology."*

_____John Tudor

*"Once a new technology rolls over you, if you're not part of the steamroller, you're part of the road."*

_____Stewart Brand

## 1.3 FOR FURTHER READING


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# 2. BASIC AND APPLIED RESEARCH: RELATIVE IMPORTANCE AND UTILITY

The explosive growth of scientific knowledge and continuing developments in technology are transforming society. Today, while we are hailing the advent of the Information Age, it is a well-known fact that it is the very breakthrough in the fields of computer science and communication science that knocked open the gate to this age. Obviously, the important role that scientific and technological research has played in the development of human society has been universally recognized. The whole world is emphasizing knowledge, and the role of science and technology as the primary productive forces has consequently increased manifold.

The debate about the relative importance of basic research over applied research or vice versa has always received significant attention among the scientific community. Opinions differ on the issue. Some value applied research more than its basic counterpart, while referring to its application that has led to a large number of inventions and solved many a problem in almost every walk of life. Others tend to disagree and place more value on basic research, considering it a foundation on which every invention is based. It is true that applied research has gained prominence since people seek in it solutions to major global problems, be it over-population, global warming or environmental degradation. Sometimes application has come first and understanding later, but there is no denying the fact that, in a majority of cases, it is the basic research that precedes any invention or technological innovation.

Today, scientific research is a highly controversial issue. Many scientists, technologists, industrialists, planners and policy-makers are commenting and questioning the value of various types of scientific research. Some of the issues being debated are:

- Who should be paying for basic research?
- Should governments spend less of the taxpayer's money on basic research, in order to concentrate more funding on research projects that have potential economic value?
- Should public funds be used to subsidize applied research, being carried out by private industrial companies?
- Is basic research viable and necessary, especially when it comes to developing and underdeveloped countries?
- Should the impetus be to harness and conduct applied research or basic research, and what should be the balance, if any?

As is obvious from the crux of the debate, the issue is primarily focused at the two branches of scientific research, namely basic and applied. Nonetheless, scientific research comprises of more than basic and applied research and can further be broadly categorized as, mission-oriented research, problem-oriented research and industrial research.

## 2.1 WHAT IS BASIC RESEARCH?

Basic research is the extension of scientific and technical knowledge, which are not justified by industrial and commercial intentions. Basic research provides us the necessary knowledge of the intricate mechanisms that sustain life and is at the heart of nearly every major discovery known to man. It is that kind of activity, the output of which is used as an informational input to other inventive activities. It is the attempt of a researcher to access the frontiers of knowledge for the sake of knowledge alone. Nevertheless, ultimately it is the knowledge that pure-research creates, which provides the intellectual material for formulating the applications that we today deploy as technology.

Basic, fundamental or pure-research is driven by a scientist's curiosity or interest in a scientific manner. The main motivation is to expand man's knowledge, not to create or invent something. It can be further defined as, a scientific research performed without any practical end in mind. Basic research is said to be the component of knowledge enterprise most distant from immediate or foreseen commercialization. The discovery of new knowledge and the desire to solve problems is at the core of all research and basic research is at the core of knowledge creation. In a layman's term, a researcher carries out basic research when, he or she thinks that the activity is the best use of his or her time; that the research has value in its own right and that it offers the best prospects of discovering something, presently unknown about the natural universe.

Basic research is that component of knowledge, which does not involve any immediate or foreseen commercialization or commercial viability. The ultimate objective is, therefore, not to serve any pressing need or attend to a current problem, but to aim at discovering knowledge with a universal perspective and a broader horizon. This trait of basic research tends to allows many an invention and technologies to stem from the accumulated knowledge-reservoir built through continued basic research.

One of the most distinguishing characteristics of basic research is that it cannot be easily defined operationally and cannot be tested in advance for utility. In this type of research, the process of innovation is interwoven with the production of new knowledge. Consequently, basic research is righteously termed as the 'mother' of all inventions, because it provides the requisite 'scientific capital' (new scientific knowledge and understanding) that is needed for technological breakthroughs and for finding solutions to important practical problems. Informational input attained from conducting basic research is the essence for instigating inventive activities. More specifically, answers to scientific questions are the building-blocks for technological innovation and further scientific development, and basic research, undoubtedly, is the essential means of gathering such answers.

## 2.2 WHAT IS APPLIED RESEARCH?

Contrary to basic research, applied research may entail new knowledge creation and applications of existing knowledge, but is addressed to clearly defined problems (usually but not always, of companies or industries) and leads to products or services that may be exploited in the near term. Applied research is carried out to find practical solutions for current pressing needs. In essence, the problems of the society in general, and the industry in particular, are assessed and addressed by applied research, which results in the improvement of a product or a system. This research is primarily done because the performer expects to benefit from it in some direct way, such as through a future business return or a direct financial interest.

Applied research is designed to solve practical problems of the modern world, rather than to acquire knowledge for knowledge's sake. The focus of applied research is on defined outcomes i.e. to solve problems, to make decisions and to predict and/or control. It is fundamentally carried out to achieve certain goals and convert the findings of basic research into practical applications. The three predominant characteristics of applied research include:

- Generation of knowledge, which will influence or improve clinical practice
- Potential for contributing to development of theory, and that the
- Researcher has access/control over phenomena being studied

Applied Research is aimed at gaining the knowledge or understanding to meet a specific, recognized need. General examples of applied research would include, using bacteria to inoculate plants against particular diseases, developing computer models of the atmosphere to improve weather forecasting, and creating drug therapies for brain-related illnesses. Further example of what applied researchers may investigate, include ways to:

- Improve agricultural crop-production
- Treat or cure a specific disease
- Improve the energy-efficiency of homes, offices, or modes of transportation

In other words, applied research is work that translates into products, goods, or services that contribute to the GNP. It is the investigation of some phenomena to discover whether its properties are appropriate to a particular need or want. It aims to answer real world questions and not just abstract and theoretical ones. It focuses on solving problems, evaluate projects and make policy or managerial decisions, and plan and forecast. All in all, applied research is an original research just like basic research, but is driven by very specific, practical objectives. Further examples are: research for the formulation of public-policy (education, health, economic, environmental etc); research into how industrial development can take place with simultaneous protection of the environment; research into the provision of adequate, cheap housing; and research around finding cures for diseases.

## 2.3 IMPORTANCE OF BASIC RESEARCH

The importance of basic research is not assessed by the importance of the work being carried out as the probable outcome of the endeavor is not known at the instigation of the research. However, assessing the likelihood of the research's contribution towards important unsolved scientific questions – more specifically known as the 'needs' of science, may be helpful.

Over 200 years ago, at the beginning of 1782, the German physicist and philosopher Christof Lichtenberg wrote in his diary referring to the planet Uranus, which was discovered in 1781:

"*To invent an infallible remedy against toothache, which would take it way in a moment, might be as valuable and more than to discover a new planet... but I do not know how to start the diary of this year with a more important topic than the news of the new planet*".

The question Lichtenberg unreservedly raised, of the relative importance of looking for technical solutions to specific problems, and of searching for new fundamental knowledge, is even more relevant and significant today than it was in his times.

It is inevitably true that the search for fundamental knowledge, motivated by curiosity, is as useful as the search for solutions to specific problems. Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science. One of the fundamental reasons as to why today we have practical computers and did not have them about 100 years ago is because of discoveries in fundamental physics, which formed the basis of modern electronics, developments in mathematical logic, and the need of nuclear physicists in the 1930s to develop ways of counting particles, assuredly, it had nothing to do with the need to develop computers. Today, it is truer than ever that basic research is the pacemaker of technological progress. Technology upon technology originates from fundamental discovery, often unforeseen and unpredicted.

Careful studies indicate that basic research serves as a foundation of the modern technology. The following important contributions in this regard are worth noting:

- It provides the required basic knowledge or acts as a "Scientific Capital", necessary for making the application a reality. It is firmly believed that industrial development would eventually stagnate in the absence of the supporting basic research. This stage is felt only when the "Scientific Capital" runs out.
- Broad based basic research is a prerequisite for solutions to different problems. Solutions are not forced or obtained abruptly. They are preceded by necessary knowledge, often obtained by basic research.
- Basic research provides the foundation of education and basis of training the people working in industry and technological set ups.
- It cultivates scientific climate conducive to understanding the objectives of technology.
- Basic research serves as a source of intellectual standards for applied research.
- It is the net exporter of technique to industry. Techniques such as vacuum technology, cryogenics, x-ray diffraction, radioisotopes, etc. with their origin as techniques of basic research are commonly used in industry these days.

Basic research, therefore, must not be taken as a peripheral activity or to be forced to provide short-term solutions under excessive pressure and/ or limited support. Fundamental research has been well supported by many leading scientists of the world. As Alistar M. Glass notes in his article on fiber optics:

*"Fundamental research in glass science, optics and quantum mechanics has matured into a technology that is now driving a communications revolution"*.

Subjects of great technological and medical importance that originated from basic physical research include among many nuclear magnetic resonance, semiconductors, nano-structures, superconductors and medical cyclotrons.

There is a strong view among experts regarding the out put of research. The proponents of this view suggest that it is the targeted, goal-oriented research that brings about useful products and innovations. Examples from daily life are also cited to support this claim, but it should be kept in mind that numerous examples could also be found which indicated that many a product were developed as a result of basic and fundamental research. Also, funds these days are allocated more towards goal-oriented research and less emphasis is put on basic research. Still, the importance and usefulness of basic research cannot be denied and sustainability of results can only be achieved with an optimal distribution of resources between applied and basic research.

It is a proven fact which history has repeatedly demonstrated, that it is not possible to predict which efforts in fundamental research will lead to critical insights about how to address a particular problem. It is therefore essential, to support a critical number of worthwhile projects in basic research so that key opportunities do not go unrealized and waste. As there is no doubt that basic research aims to complete the blanks in mankind's understanding of how life processes work, there is also no skepticism about the enormously beneficial results that basic research has lead to in terms of its practical applications. The society today reaps enormous benefits from basic research and its applications, which in the form of technologies have saved millions of lives and made many others far more comfortable and meaningful than ever before.

Dr. Allan Bromley of the Atomic Energy of Canada says that the unprecedented boom in the American economy had little to do with new approaches to fiscal management, and all to do with past investments in science. Federal investments in science produce cutting-edge ideas and a highly skilled work-force. Two simple discoveries –the transistor and the fibre-optic cable are at the root of this boom. He added that,

*"Anyone skeptical of this should turn off the computer for a day as see how much work gets done."*

In a nutshell, the importance of basic science can be expressed in the words of Dr. George Smoot of the Lawrence Berkeley National Laboratory:

"*People cannot foresee the future well enough to predict what's going to develop from basic research. If we only did applied research, we would still be making better spears*."

## 2.4 IMPORTANCE OF APPLIED RESEARCH

As mentioned, applied research is aimed at gaining the knowledge or understanding to meet a specific, recognized need, or solve a specific problem. It includes investigations oriented to discovering new scientific knowledge that has specific objectives, for example with respect to systems, products, processes, or services. Finding a better treatment or diagnostic for a disease is also an example of applied research.

Many of the modern day scientists are arguing the viability, significance and importance of applied research against basic research. This argument is augmented by the premise that global overpopulation, pollution and the overuse of natural resources is consistently generating complex problems for the human race and that science should now be directed towards improving the human conditions by providing pragmatic solutions rather than indulging in knowledge seeking endeavors only, which have no immediate direction in sight.

Whatever the argument, one cannot neglect the importance and significance of applied research, be it yesterday, today or tomorrow. Applied research leads to inventions. This process is usually spread over a large span of time and normally a large number of people are involved in attaining invention stage. There have been many historical examples in which applied research has had a major impact on our daily lives. In many cases, the application was derived long before scientists had a good, basic understanding of their underlying science. This phenomena may be illustrated by envisioning a scientist saying to himself, "*I know it works; I just don't really know how it works!*"

The invention of transistor was also a revolutionary application of scientific research and proved to be a major milestone for the electronics industry all over the world. It also proved to be a starting point for the design and manufacture of Integrated Circuit (ICs). Before this discovery, vacuum-tubes were used as the alternate means (as triodes) in electrical devices. Scientific research and experiments also led to many other noteworthy developments in various other fields such as health and medicine. These included developing of vaccines for polio (1953), rabies vaccine (1885), and pencillium (20th Century).

## 2.5 CONCLUSIONS

As is clear from the above-stated deliberations, basic research is performed without thought of practical ends and results in general knowledge, as well as understanding of nature and its laws, whereas applied research aims at giving complete specific answers to important practical problems. In essence, basic research is motivated by curiosity and applied research is designed to answer specific questions. J.J. Thomson, the discoverer of the electron, explicitly outlined the difference between basic and applied research in a speech delivered in 1916:

"*By research in pure science I mean research made without any idea of application to industrial matters but solely with the view of extending our knowledge of the Laws of Nature. I will give just one example of the 'utility' of this kind of research, one that has been brought into great prominence by the War - I mean the use of X-rays in surgery... Now how was this method discovered? It was not the result of a research in applied science starting to find an improved method of locating bullet wounds. This might have led to improved probes, but we cannot imagine it leading to the discovery of the X-rays. No, this method is due to an investigation in pure science, made with the object of discovering what is the nature of electricity".*

*"Applied science leads to reforms, pure science leads to revolutions and revolutions, political or scientific, are powerful things if you are on the winning side*".

The relative importance of 'Basic' and 'Applied' Research is a widely discussed topic of today. It is equally important to note that applied research does not always follow basic research, as was the case in the development of large radar-antennas for applied purposes, which led to basic research in Radar Science and Radio Astronomy, as well as the case of the development of pure materials for technological applications, which stimulated fundamental investigations in Solid-State Physics, but the loop does not necessarily end here. This is not always a one-way street.

People such as James Watt, who was an applied researcher in the field of steam-engines, contributed considerably to the basic fields of mathematics and physics. Virtually, the whole basic field of thermodynamics was developed by applied science. Lavoisier, the founder of modern chemistry, started his career by undertaking two applied projects: lighting the streets of Paris and developing a new process to produce saltpeter. It was these projects that led to and funded his later experiments in which he proved the conservation of mass, and discovered how oxygen functions in combustion. Carnot's work on engines led to the discovery of the second law of thermodynamics. Clausius, building on Carnot's work, proposed the property of entropy. Kelvin's work on engines led to the concept of available energy. Again, working with simple engines, Joule bridged the gap between heat and physical work. Gibbs, combining all of these insights, published signal works in chemistry, widely renowned as fundamental 'basic' discoveries in chemistry.

Evidently, there is a very impressive example of applied work on engines leading to Gibb's insights on chemical equilibria and chemical thermodynamics, including free energies, energies of formation, and all of the mathematical techniques that underlie virtually all of modern chemistry. It is consequently important to note that discoveries do not necessarily take the route from basic to applied.

It is therefore important, to make it clear that all research has objectives, and that all research is aimed at usable results. It may well be that basic research in the main sets its targets within the world of research itself, whereas applied research is aimed at objectives and applications outside the world of research. But the boundary is not at all clear. Much basic research eventually turns out to be applicable, and applied research has often made weighty contributions to the development of research as such. The generally accepted view is that basic research is primarily conducted in universities, whereas applied research is a matter for research institutes and private companies. In fact there is a good deal of applied research carried out in universities, and also basic research in the outside world.

Although interlinked, basic and applied researches have a different orientation to each other. Yet it is the way basic research leads and supports applied research that determines the necessity and usefulness of both kinds of research. It is, however, impossible to say anything about the importance, quality or degree of difficulty of research merely by describing it as either basic or applied research. All research must be judged by its results, and by the degree to which it achieves its objectives. Hence, it is necessary to know the objectives, even if one does not wish to label the research in question in one way or another.

It may also be emphasized at this juncture that experience shows that best results in applied research are obtained in cases where the scientists given the task to carry it out, are knowledgeable and have a sound background in ‘Basic Science’. If their knowledge in basic science is limited and/or narrowly channeled, the ‘applied product’ is expected to have limited utilization. It is, therefore, strongly advisable that ‘applied science’ must be coupled with ‘basic science’ or ‘basic little science’.

## 2.6 MESSAGE FOR DEVELOPING COUNTRIES

The developing world must understand that although basic research is the pacemaker of technological progress, it is not easy to perform. Basic research is characterized by uncertainty, is time consuming and needs gigantic influx of investment both in terms of financial and human resources. However, basic research provides the essential fuel for the science and technology system to run efficiently. It certainly provides new knowledge and opens up avenues for new applications.

Keeping this in mind, developing nations must adopt two paths one after the other. Firstly, they should share their facilities, expertise and equipment with other developed and developing countries. No developing nation is sufficient in the requisite infrastructure of S&T to progress unprecedented, therefore such sharing of resources and expertise is a must. Secondly, whatever basic research developing countries do, they must ensure that the objectives of that research have not been blindly taken from the developed countries. The conditions, environment and dynamics of developing countries are different from those of the developed and therefore, efforts must be made to ensure that adaptation of such research should be in line with the local needs of the country.

Progressive nations further improve systems and products at hand by going back to the basics and carrying out basic research through in-depth study and consequently come out with technological breakthroughs. They essentially do what is inline with the statement of Richter, who once said *“Today’s technology is based on yesterday’s science; today’s science is based on today’s technology”*.

It is hoped that through science-based technology a route to a brighter and prosperous future is made that would improve the condition and overall life of man. Interwoven with this promise are two important elements that need stressing. First, whether science-based technology will provide the necessary answers for all of the people of Earth and make the Earth a more equitable place. The answer to this question will depend more on man’s values and less on his scienctific and technological capabilities. On the other hand, man must become knowledgeable, wise, brave and unselfish enough to forego technologically brilliant ideas when they are more damaging than beneficial.

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# 3. PHYSICS IN OUR LIVES

In the last decades, scientific knowledge and technology have grown at a spectacular rate, and had a dramatic impact on society. There is however, a long and complex way to go between a new scientific discovery and its effects on society. The public will only be aware of such a discovery when it concerns a spectacular new scientific insight and if the media decide to bring it to the people's attention. And then in most cases they rightly will be told at the same time that it may take many years for any practical application of this discovery. But it is precisely these practical applications that have a deep rooted impact on society.

Even if there are no practical applications, scientific discovery still is a cultural enrichment for society. Therefore, science is one aspect of culture. And it would be worthwhile to make this cultural aspect accessible to more and more people. Nevertheless, scientific discoveries only have a substantial impact on society if they ultimately lead to new or improved products, with which we can deal in our day-to-day lives. We need technology for this conversion of science into products. Without technology, most of our durable goods, public utilities, consumables and services would simply not exist. And physics is one of the most important sciences responsible for these developments.

## 3.1 WHAT IS PHYSICS?

The definition of a subject is something very difficult in general. Specially to give a compact definition of a subject like “Physics” which is so vast as the universe itself and so deep and complicated as are the concepts of “Metaphysics”. That is the reason Socrates stressed the definitions and explanations of the terminologies during discussions. For example, Socrates said that we must be clear about:

*“What is godly, what is ungodly; what is beautiful, what is ugly;*
*what is just and what is unjust, what is prudence, what is madness, etc….”,*

before one can engage in meaningful discussion using these words.

Physics does not talk about any of the things mentioned above. Physics does not deal with the abstract concepts and subjective approach about the universe. The beginning of physics goes back to the dawn of history. The prehistoric man acquired practical skills for his survival, which was handed down from generation to generation and formed an ever-enlarging basis for the later cultural development.

The earlier inventions of man appear to have been simple weapons and tools, made first of wood or bone, then of stone, and later of metal. But with time he became more than a weapon and tool-bearing animal. Although he had no written language, prehistoric man acquired an oral one, and came to possess customs and traditions. It is believed that the man's encounter with nature inspired him to think about it.

Man is a curious animal. He could not ignore the fascinating natural phenomena. He was eager to know the reason for lightening, thunders, oceans, rivers, wind storms, etc. He was curious to know what makes the stars shine, why the sun is a source of tremendous light, what is the difference between solids, liquids and gases, etc. All these questions related with the material things and observable phenomena fall in the realm of Physics.

In the beginning, man had not enough accumulated knowledge to understand nature and the universe around him. But man had the capability to correlate observations and find some reasons of physical phenomena, based on superstitions, to satisfy his curiosity. Such philosophical, mythical or religious explanations of the natural phenomena focus the subject called "Metaphysics".

The earlier explanations of physical phenomena were ascribed to mythical gods who played major roles in creating and monitoring the world. These myths, elaborated upon and added to by the men who told and retold them from generation to generation, reflected man's continuing need for guidance and support. His emotional reactions to his environment largely shaped these myths. The world, as early man knew it, turns out to be vastly different from the world we know today.

The change has come in man himself. As he changes, he must approach his world differently. One must be clear about the difference between "Physics" and "Metaphysics". Here we shall not go into further details of metaphysics but concentrate on physics.

To a person born into an age of rapidly evolving technology, physics tends to be associated with the useful technological devices like, T.Vs, refrigerators, aeroplanes, ships, rails, rockets, missiles, bombs, electronic equipments used in medical centers, machines in factories, Computers, etc. But in a complete sense, physics is an intellectual activity rather than being a purely technological one. Physics has explained the energy-mass conversion, time-space relationship, order and disorder, self-organization, chaos, uncertainty, wave-particle and duality, etc.

Physics may be thought of as a knowledge that has been accumulated from observations of physical phenomena, systematized, and formulated in reference to general statements in the form of 'theories' or 'laws', which provide a grasp or a sense of greater understanding of the existing world.

Science (or Physics) looks into the material world objectively. The fact that a scientist observes, or predicts theoretically, can be verified by others, provided the required conditions can be achieved. To elaborate the point, this particular example can be quoted:

Different poets will describe the moon in different ways because of subjective vision, while all the physicists will describe the moon in the same way.

First-hand observation and personal experience with phenomena are an essential elemental role in sciences. Generalization from a specific instance to the universal statement, in terms of only those features that are relevant and significant, is central to the evolution of the desired physical description or scientific theory of the phenomena.

It involves the observation of commonality of an aspect: abstraction of significant features; testing of relevance or irrelevance of detail by careful observation and variation, quantitative measurement with a thorough appreciation of the limits of precision and the sources of error; and a skeptical open-mindedness to the innumerable possibilities of misunderstanding—misinterpretation, confusion, and ambiguity. It is a continuing evolutionary process, and the growth of physics and other sciences is the process of observing, testing, refining, amplifying, and generalizing in this description, which is called a "theory". The objective of this process is a better understanding of the physical world.

Physics does not have rigid beliefs. Any theory which is believed to be true today by all the physicists of the world can be challenged anytime with sufficient and convincible data and arguments. To a physicists the term "absolute truth" is also a relative term. From the physicist's point-of-view, we are absolutely certain of nothing in the real world. There is talk of a "final" theory, a theory of everything. (Right now, we have a sort of patchwork. Quantum mechanics and gravitation are disconnected, for example.) It may happen that we achieve a single theory for all of physics, but we can never be 100% certain that it is totally correct. It could happen that a final theory will be developed, but we will not be certain about the finality. When people talk about a final theory, they are not saying that we will know everything. It would in fact, be a new beginning in the search for further knowledge.

When we start learning physics, we begin with motion. Velocity, acceleration, force, mass, energy, momentum—these are some of the concepts that are found in an elementary physics course. The principles developed apply to the motion of planets, electrons, athletes, owls, glaciers; Physics is really the study of everything in the universe. If someone found valid evidence to support one of those loony ideas like clairvoyance, mental telepathy, pyramid power, crystal power, astrology, auras, ghosts, etc, it would be studied by the physics community. When we say "valid evidence", we mean it has to be convincing to the skeptic level. The "scientific method" is the method of collecting evidence that is convincing even for the skeptic. Normally, this means it must be repeatable. (There might be a few one-time-only events to study, like the comet hitting Jupiter not long ago, but they can be repeated, we repeat them—sometimes a flaw in the experiment is discovered this way.) Also, the experiment must be free of the possibility that the viewers are bring duped. Magicians are full of tricks to make the impossible seem to happen, and there is tacit understanding that the magic act is just that—an act. But when an astrologer or a psychic does his or her "thing", loads of people believe it is the real thing. We guess they are not aware of the fact that these things do not hold up under a thorough scrutiny.

## 3.2 BRANCHES OF PHYSICS

Since physics is the study of the whole universe, therefore, it has been divided into several branches. If we look deeply and carefully, then even chemistry and biology would become the branches of physics. But for the sake of clarity and simplicity we have to classify the study of nature into several subjects. Each one of these subjects has its basis on the principles of physics. For example, a very simple view about chemistry can be that it deals mainly with those reactions among elements and compounds that are due to the electronic structures of atoms and molecules. Similarly, biology is the study of living things, but the behavior, development and evolution of living things are based on laws of physics. For example, our brain sends electronic signals to different organs which work for us. At present we shall assume physics to be a subject different from chemistry, biology, botany, etc. To be specific, we may define physics as the subject which deals with the fundamental forces of nature and constituents of matter over universe. There are several branches of physics, which include: Astronomy, Atomic Physics, Cosmology, Dynamics, Electricity, Electrodynamics, Field Theory, High Energy Physics (also known as Particle Physics), Hydrostatics / Hydrodynamics, Magnetism, Mechanics, Nuclear Physics, Optics, Particle Physics (also known as High Energy Physics), Plasma Physics, Quantum Electrodynamics (also known as Quantum Theory of Light or Quantum Theory of Radiation), Quantum Mechanics, Solid State Physics, Statics, Surface Physics, Thermodynamics, Wave Mechanics etc.

### 3.2.1 Who is a Physicist

In principle, everybody who asks questions about the physical things and physical phenomena around him is a physicist. Yes, a child is also a physicist. Then why only a few persons are called physicists in the world? The answer is simple but important. A physicist is not a person who asks questions momentarily and then forgets; a physicist is a person who remains in search of answers to his questions. He speculates, makes hypotheses, does experiments, forms theories and laws about the working of nature. He remains unsatisfied throughout his life, due to his curiosity and quest for knowledge.

Physics is an organized way of conversing with nature. Physicists ask questions, to which nature responds. For many questions, the answers are almost predictable, but when the question is a particularly good one, the answer can be unexpected and gives us new knowledge of the way the world works. These are the moments physicists live for.

The fundamental ideas of physics underlie all basic sciences: astronomy, biology, chemistry, and geology. Physics also is essential to the applied sciences and engineering that has taken our world from the horse and the buggy to the supersonic jet, from the candle to the laser, from the pony express to the fax, from the beads of an abacus to the chips of a computer.

## 3.3 IMPACT OF PHYSICS ON MAN

The present age is different from the all previous ages only because of the scientific inventions that are in daily use of man. The life of today's man is completely dependent upon machinery and industry. The bicycles, cars, motor vehicles, rails, aeroplanes, electrical appliances in houses, hospitals and offices are all due to the application of physical laws. The industrial revolution is based on technology, which is the application of physics and other branches of science. Life is so much dependent upon technology nowadays that most of the intellectuals, literary persons (poets and writers) and even the scientists are thinking that the use of mechanics has "made man himself like a machine". This is an unpleasant aspect of the technological development. We have discussed that the development of science has been continuously in progress since prehistoric times. The speed of development achieved the greatest impetus by the end of 19th century and, in 20th century, man became able to see into the world of atom and mysteries of galaxies. Man reached the moon and explored the deserts of empty space and expanding galaxies.

Moreover, it is hard to maintain that scientific discoveries have impact on society only if they lead to products. One must think about the impact that Galileo had on thinking and religion, or the impact of quantum mechanics on philosophy and the arts.

## 3.4 PHYSICS IN EVERYDAY LIFE

The most basic of the sciences, physics, is all around us every day. If you have ever wondered what makes lightning, why a boomerang returns, how ice skaters can spin so fast, why waves crash on the beach, how that tiny computer can do complicated problems, or how long does it take light from a star to reach us, you have been thinking about some of the same things physicists study every day.

Physicists like to ask questions. If you like to explore and figure out why things are the way they are, you might like physics. If you have had a back-row seat in a concert, and could still hear, you experienced physics at work! Physicists studying sound contribute to the design of concert halls and the amplification equipment. Knowing more about how things move and interact can be used to manage the flow of traffic and help cities avoid gridlock.

Lasers and radioactive elements are tools in the war against diseases like Cancer. Geophysicists are developing methods to give advance warning of earthquakes. They can explore what is beneath the surface of the earth and are at the bottom of the oceans. The work of physicists made possible the computer chips that are in the digital watch, CD players, electronic games, and hand-held calculators. It is the physics, which shows movies, matches, games and news comes to you in homes through TV and VCR. There are so many examples where physics is in use in our daily lives that cannot all be mentioned in a lecture.

## 3.5 PHYSICS AT WORK

The laboratory of the physicist extends from the edge of the universe to inside the nucleus of an atom. A physicist may work in a laboratory designing materials for the computer-chips of tomorrow, or smashing atomic particles against one another in a quest to understand how the universe began. Physicists have orbited the Earth as astronauts, and plumbed the oceans' depths. Individuals who have studied physics seek to make instruments that diagnose and cure disease, to develop safer and cleaner fuels for our cars and homes, to harness the power of the sea, to calculate the movement of arctic glaciers; and to create smaller, faster electronic components and integrated circuits.

Research physicists work in industry, government, laboratories, hospitals and in university campuses. Some physicists serve in the military, teach in high schools and colleges, design science-museum exhibits, write books and news articles about science, give advice to federal, state, local, and foreign governments, run businesses, even become artists!

## 3.6 CAREERS IN PHYSICS

Physics offers challenging, exciting, and productive careers. As a career, physics covers many specialized fields: from acoustics, astronomy, and astrophysics to medical physics, geophysics, and vacuum sciences. Physics offers a variety of work-activities i.e. lab supervisor, researcher, technician, teacher and manager, etc. Physics opens doors to employment-opportunities throughout the world in government, industry, schools, and private organizations.

### 3.6.1 Elementary or Middle School Teaching

It has been said that children are born scientists. This is best illustrated by the questions they constantly ask. Teaching at the elementary or middle school level presents the challenge of keeping their curiosity alive, while teaching new ideas.

Why do you get electric shocks in cold, dry weather? Does a stick of dynamite contain force? What makes a rainbow? How cold can it get? Individuals who themselves appreciate science often have a special gift for teaching young children. Curiosity about the world around us makes a common bond between children and scientists.

### 3.6.2 Sports

When you watch an athlete, you are observing the principles of physics in the field of motion. The bat hitting the ball, the spiraling football, the bend in the vaulter's pole, and the tension of muscles as a weight is lifted illustrate some of the basic laws of physics, like momentum, equilibrium, velocity, kinetic energy, center of gravity, projectile motion, and friction. Knowing these principles of physics can help an athlete or coach improve performance.

### 3.6.3 Imaging Techniques

Looking inside the body without surgery is one of medicine's most important tools. X-rays, computed tomography, CT scans, and magnetic resonance imaging are used to determine bone damage, diagnose disease, and develop treatments for various illnesses.

Technicians who use imaging equipment need to be familiar with the concepts of x-rays and magnetic resonance, and to be able to determine how much of this powerful technology to use. Imaging technicians usually work at hospitals, medical colleges, and clinics.

### 3.6.4 Automobile Mechanics

Today's automobiles are a far cry from those put on the road by Henry Ford. Computers play a major role in how cars operate. Computers are also used by mechanics to diagnose auto malfunctions. A basic understanding of computer-technology is now essential in almost every career.

### 3.6.5 Environment

The 1990s have been called "Decade of the Environment". Environmental physicists are studying ozone-layer depletion and other problems regarding the atmosphere. They use acoustics to try to reduce noise-pollution. They search for cleaner forms of fuel, study smog and the ways to reduce it, and devise ways in which to dispose of and store nuclear-waste safely.

### 3.6.6 Journalism

Science is one of the most exciting assignments a reporter can have. New discoveries, controversial findings, space research, medical breakthroughs, natural disasters, technological competitiveness, and the environment make up a big part of the news. Reporters who have a background in physics have an advantage in being able to grasp technical issues quickly and communicate easily with researchers. Many major daily newspapers in this country have science sections. In addition, science-reporting is featured on radio and television as well.

## 3.7 FIELDS WHERE PHYSICS IS VITAL

***Engineering***
Electronic, Biomedical, Mechanical, Computer, Civil, Chemical, Environmental, Aeronautical and Instrumentation.

***Non-Technical***
Law, Administration, Business, Journalism, Museums, Sports, Accounting, Marketing, Art, Science communication.

***Consulting***
Industry, Government, Military

***Environmental Science***
Noise control, Pollution control, Conservation, Radiation protection, Environmental monitoring.

***Publishing***
Technical books, Journals, Software.

***Communications***
Telecommunications, Television, Image analysis, Video recording, Photography, Laser Technology.

***Medicine***
Radiation Oncology, Magnetic Resonance Imaging, Radiation Protein, Nuclear Medicine, Diagnostic Instrumentation.

***Computer Science***
Graphics/Software Design, Peripherals Modelling, Artificial Intelligence, Data Processing,, Programming, Computer Games.

***Industry***
Construction, Food, Chemical, Aerospace, Engineering, Agriculture, Consumer Products, Energy, Fuel, Metallurgical, Semiconductors, Textile & Clothing, Transportation, Computers, Electrical, Laser Technology, Materials.

***Education***
Colleges, Universities, Technical Schools, Elementary and Middle Schools.

***Basic Research***
Universities, Technical Schools, National Laboratories, Industrial and Private Laboratories.

***Space and Earth Sciences***
Astronomy, Space Technology, Geophysics, Geology, Atmospheric Sciences, Energy & Resources, Ocean Sciences.

## 3.8 TEACHING SCIENCE (ESPECIALLY PHYSICS)

We have discussed already that the modern societies are completely dependent upon science and technology (S&T). Therefore it is necessary to teach science and technology to younger generations and transfer the current information to the common man in order to uplift his mind and thinking. To enhance the quality of life, we must try to develop our economy, which is impossible without the teaching of S&T. Various types of formal and non-formal education of S&T constitute an essential factor in improving the material and cultural conditions of living. In the present age, we cannot stick to old and ancient cultures rigidly. All over the globe, technology has changed and modified the cultures.

The quality of a nation depends invariably on the quality of its educational system that imparts purpose and visions of the past, present and future to her people. Educational illiteracy is a curse and so is scientific illiteracy. It is now universally admitted that the cultivation of science and technology, economic development and economic prosperity depend upon trained scientific and technical manpower. In fact, the security and survival of any nation depend upon the rapid dissemination of scientific and technical knowledge and skills. It is our education which develops the vision and enlightenment. The educational methods and procedures vary according to age, background, objective, and motivation of the students and learners.

Furthermore, due to its specific subjects, physics teaching has a unique position to make specific contributions to general education. For instance:

- by provoking astonishment, amazement and respect for the incredible beauty of matter and of the forces that reign it
- by explaining the practical meaning of a number of physical notions, with which we are confronted in our day to day life
- by familiarizing people with "neat thinking" and with the "scientific approach", including rigorous observation, experimentation, measuring the world, working with tentative assumptions, challenging assumptions and correcting them according to the new facts, and appreciating the limits of extrapolation. This methodical way of thinking and acting is not only applicable to physics, but also to a number of small or bigger private or professional projects, in which any citizen will sooner or later be engaged!

### 3.9 STUDENT OF PHYSICS

If one likes mathematics and laboratory work, physics offers him many career opportunities. He takes algebra, geometry, trigonometry, and pre-calculus (if it's available) in high school. When he gets into college, he will take more mathematics. Studying mathematics will help him in physics, and physics will help him understand and begin to appreciate the applications of mathematical concepts.

Experiments in schools labs will certainly be more interesting than a cricket match, if one is curious about the principles of nature.

Other fields of science overlap physics. Many parts of biology, chemistry, geology, and engineering use physics.

Graduate students pursuing master's and doctoral degrees concentrate fully on physics. The master's program usually takes two years and may require a research project. An additional five to seven years may be needed to earn a Ph.D. in Pakistan. One of the most important parts of the Ph.D. program is a piece of original research (either theoretical or experimental) conducted with the guidance of a faculty advisor. The student has to put forward his thesis and perhaps publish it in a scientific journal and hence he becomes a physicist. He may find something very new in his course of ideas. A Ph.D. thesis of a student may win a Nobel Prize!

### 3.10 ROLE OF TEACHER IN POPULARISING PHYSICS

Physics can be "popularized" by emphasizing its relevance to life. There are two major aspects of its relevance that can be discussed. First of all, there is the importance of physics in understanding natural phenomena; and secondly, its need in understanding technological developments.

The teacher must arouse curiosity about nature and natural phenomena. For this purpose, he can draw attention to the many marvels of nature. If he and his audience are of a religious bent of mind, the numerous Quranic injunctions to observe and ponder about natural phenomena can also be involved. Having aroused curiosity, the teacher can then go on to show how physics has helped us in understanding many of these phenomena. He should also emphasize that the search for truth is an unending one, and there are many areas that need further investigation, which will continue to provide stimulating challenges for generations of physicists to come.

Principles and processes of physics form the basis of most of the technological devices that have become an important part of our lives. This includes: automobiles, aircraft, cameras, radio, TV, electrical appliances, computers --- and the list can really go on and on. Again, the teacher should emphasize the fact that to gain a real understanding of the functioning of these devices, one must understand physical principles. Besides the devices, there is the underlying technological infra-structure that makes all of these things possible; and for that again, physics forms the base.

### 3.11 ROLE OF PHYSICS IN THE 21$^{ST}$ CENTURY

When we talk about the role of physics in the 21st century, there are two things that should be borne in mind:

1. Principles of physics form the basis of most of the technological development, and therefore, it is not easy to separate out the contribution of physics.

2. In general, many new technologies are highly interdisciplinary in character, bringing together concepts from diverse fields. This again blurs the old boundaries and makes it difficult to isolate the role of any one discipline.

The most dramatic technological development of the 20th century was the proliferation of nuclear weapons. This, more than any other innovation, brought physics and physicists to center-stage in society. Despite continuous efforts during the last half century to put this genie back into the bottle, there are no signs of that happening. The 21st century will, thus, continue to have this technology as one of the major determinants of inter-state relationships. Along with that, the enormous stockpiles of these weapons will continue to represent a serious threat to human society.

Of course, an understanding of the nucleur sciences has also led to the development of many new technologies that have greatly benefited us and that have the potential for bringing many more benefits in the future. Conventional nuclear power from fission-based reactors will continue to play an important role. But potentially, perhaps the most significant development for humanity will be the harnessing of nuclear fusion reactions to generate energy. What is so exciting about this prospect is the fact that fuel for an advanced form of these reactors can be extracted from ordinary water, with a litre of water yielding energy equivalent to more than fifty liters of gasoline. This means that after the development of fusion reactors, we will have a virtually inexhaustible source of energy at our disposal.

Another source of energy with a large and inexhaustible potential is solar energy. It is already harnessed but on a limited scale; for the next century, physicists have the challenge of dealing with the limitations of the present technology and developing new methodologies which will enable a large-scale harnessing of this source.

We have already seen nuclear radiation and radio nuclides applied extensively to the three major aspects of our socio-economic structure: industry, agriculture and medicine. They have also become indispensable tools in many disciplines, as diverse as chemistry, biology, hydrology, oceanography, geology, archaeology, paleontology, environmental science, forensics, genetic engineering and so on. The new century will see an even greater flowering of these applications.

Investigations into superconductivity will lead to many new kinds of applications in areas such as high speed public transportation, efficient energy transport and storage, and a multiplicity of devices requiring intense magnetic fields.

Continuing research in condensed-matter physics promises to yield major dividends in further enhancing the already phenomenal pace of development of computing power.

Lasers have already permeated into countless devices, many of which are found scattered in ordinary homes. Their potential, however, has not yet been fully exploited, and in the next century we can expect to see them being put to many other uses.

Since the discovery of X-rays at the end of the last century, it has been an indispensable diagnostic tool for the medical profession. During the last few decades, many other physical techniques have become a part of the array of diagnostic devices that doctors have now available. These include ultrasound devices, gamma cameras, Single-Photon Emission Computed Tomography (SPECT), positron emission tomography (PET), and magnetic resonance imaging (MRI). The next century will continue to see the power of physics being brought to bear in new ways to illuminate the working of the human body.

It is not just in diagnostics, but for treatment as well that the medical profession has found the great utility of physics and physical devices. Radiotherapy, laser surgery, microsurgical devices, physical implants; all these and many others are already a part of the medical repertoire. In the future we can expect to have a much more extensive range of such applications.

Understanding of physical process within biological organisms – of which the human body is one example - is at present at a relatively primitive stage. The 21st century should see a great upsurge in this area, and with that should come totally new approaches to the old-age problems of maintaining and improving human health.

The recently acquired ability of biologists to understand and manipulate DNA, the control-center of life-processes, has already led to many dramatic applications. But, the full potential of recombinant DNA techniques have played a very important role in the development of the technology and will continue to do so in the future.

Space exploration should become a mature and well-established activity during the next century. This will involve numerous interfaces with physics at all stages of development.

A common element among all of the expected developments described above is the fact that these are based on concepts that have already been developed. From the history of physics we know that the investigation of nature inevitably leads to radically new insights and new concepts. The qualitative change in our understanding of natural phenomena then suggests new ways of harnessing nature for our own purposes. A very pertinent example of such a development is provided by the way an investigation of the structure of matter led to the discovery of the nuclear force and then nuclear fission, a means of liberating that force with all its consequent implications for human society. Just a few years before its actual realization, no one could have predicted such a development. Thus, we should expect the unexpected to arise from the investigations into basic physical phenomena that are going on intensively at present. What impact those new discoveries will have on our understanding of nature, and how that new understanding will affect society at large cannot be predicted.

## 3.12 FOR FURTHER READING


- ‘The Physics of our Universe’, http://www.thinkquest.org/library/site_sum.html?tname=17913&url=17913/
- ‘The Physics of Materials’, http://www.wsi.tu-muenchen.de/Background_info/chap0.pdf

# 4. REFLECTIONS ON SCIENCE AND SCIENTISTS

Scientific research aims at a systematic quest for knowledge. Its purpose is to know and understand the world around us. Its methodology is simple: to define the problem, set up appropriate experiments, collect data, analyze it, and draw conclusions. And then test the conclusions against new observations, in order to modify and improve them. But the conduct of scientific research itself is a legitimate topic to ponder over. Below we give a few quotations, from well-known persons on this subject, for us to think upon:

- "*After all, the ultimate goal of all research is not objectivity, but truth*."
  - Helene Deutsch (1884-1982), U.S. psychiatrist. The Psychology of Women, vol. 1, Preface (1994-45)
- "*Fools make researches and wise men exploit them*"
  - H.G. Wells (1866-1946), British author. A Modem Utopia, ch. 2 sct. 5 . (1905; repr. In The Works of H.G. Wells, vol. 9, 1925).
- "*Data is what distinguishes the dilettante from the artist*."
  - George V. Higgins (b. 1929), U.S. novelist, Guardian (London, 17 June 1988).
- "*If politics is the art of the possible, research is surely the art of the soluble. Both are immensely practical-minded affairs*."
  - Sir Peter Medawar (1915-87), British immunologist. "The Act of Creation," in New Statesman (London, 19 June 1964; repr. In The Rt of the Soluble, 1967).
- "*Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it*."
  - Samuel Johnson (1907-84), English author, lexicographer. Quoted in: James Boswell, Life of Samuel Johnson, 18 April 1775 (1791).
- "*Not many appreciate the ultimate power and potential usefulness of basic knowledge accumulated by obscure, unseen investigators who, in a lifetime of intensive study, may never see any practical use for their findings, but who go on seeking answers to the unknown without thought of financial or practical gain*."
  - Eugenie Clark (b, 1922), U.S. marine biologist, author. The Lady and the Sharks, ch. 1(1969).
- "*To write, it took three months; to conceive, it three minutes; to collect the data, it took all my life*."
  - F. Scott Fitzgerald (1896-1940), U.S. author. The Author's Apology, a letter to the Booksellers' Convention, April 1920 (published in The Letters of F. Scott Fitzgerald, ed. by Andrew Turnbull, 1963), referring to his novel This Side Paradise.
- "*Just as the largest library, badly arranged, is not so useful as a very moderate one that is well arranged, so the greatest amount of knowledge, if not elaborated by our own thoughts, is worth much less than a far smaller volume that has been abundantly and*

*repeatedly thought over*."
- Arthur Schopenhauer (1788-1860), German philosopher. Parerga and Paralipomena, vol. 2, ch. 22. Sct. 25 & 9 (1851).

- "*It seems to me that man is made to act rather than to know: the principles of things escape our most persevering researches*."
  - Frederick The Great, King of Prussia (1712-86), Letter, 30 Sept. 1783, to mathematician and philosopher Jean Ie Rond d' Alembert.
- "*It is a good morning exercise for a research scientist to discard a pet hypothesis every day before breakfast. It keeps him young*."
  - Konrad Lorenz (1903-89), Austrian ethologist. On Aggression, ch. 2 (1963; 1966).
- *"The skeptic does not mean him who doubts, but him who investigates or researches, as opposed to him who asserts and thinks that he has found*."
  - Miguel de Unamuno (1864-1936), Spanish philosophical writer. Essays and Soliloquies, My Religion (1924).
- "*If you steal from one author~ it's plagiarism; if you steal from many, it's research*."
  - Wilson Mizner (1876-1933)~ U.S. dramatist, wit. Quoted in: Alva Johnston, The Legendary Mizners~ ch. 4 (1953).
- "*Researchers have found the first definitive evidence that men and women use their brains differently Men use a minute area in the left side... while women use areas in both sides*."
  - Gina Kolata (b. 1948), U.S. journalist. New York Times (February 16, 1995), report on study conducted at the Yale School of Medicine.
- "*To be sure, nothing is more important to the integrity of the universities... than a rigorously enforced divorce from war-oriented research and all connected enterprises*."
  - Hannah Arendt (1906-75), German- born U.S. political philosopher. Crises of the Republic "On Violence" sct. 1 (1972). "But," Arendt adds, "it would be naIve to expect this to change the nature of modern science or hinder the war effort, native also to deny that the resulting limitation might well lead to a lowering of university standards".
- "*The mythology of science asserts that with many different scientists all asking their own questions and evaluating the answers independently, whatever personal bias creeps into their individual answers is cancelled out when the large picture is put together. This might conceivably be so, if scientists were women and men from all sorts of different cultural and social backgrounds who came to science with very different ideologies and interests. But since, in fact, they have been predominantly university-trained white males from privileged social backgrounds, the bias has been narrow and the product often reveals more about the investigator than about the subject being researched*."
  - Ruth Hubbard (b. 1924), U.S. biologist. "Have Only Men Evolved?", in Women Look at Biology Looking At Women (ed. By Ruth Hubbard, Mary Sue Henifin and Barbara Fried, 1979).
- "*Science has a simple faith, which transcends utility. Nearly all men of science, all men of learning, for that matter, and men of simple ways too, have it in some form and in some degree. It is the faith that it is the privilege of man to learn to understand, and that*

*this is his mission. If we abandon that mission under stress, we shall abandon it forever, for stress will not cease. Knowledge for the sake of understanding, not merely to prevail, that is the essence of our being. None can define its limits, or set its ultimate boundaries*."

- Vannevar Bush (1870-1974), U.S. electrical engineer, physicist. Science is not Enough, "The Search for Understanding" (1967).

**FOR FURTHER READING**


- Brooks H., 1994, *"The Relationship between Science and Technology"*, Research Policy [online], 23, pp 477-486. Available from http://www.compilerpress.atfreeweb.com [Accessed 12 October, 2003].
- Karle J., 2000, *"The Role of Science and Technology in Future Design [online]"*, Nobel e-Museum. Available from http://www.nobel.se/physics/articles/karle/index.html [Accessed 29 November, 2003].
- Papa, C.D., 2002, *"Science and Technology [online]"*, Udine. Available from http://www.wirescript.net/cgibin/HyperNews/get.cgi/cdp9801.html [Accessed 18 September, 2003].

# 5. ADMINISTRATION OF A SCIENTIFIC ORGANIZATION: THE ROLE OF A DIRECTOR

What is our understanding of research in science? How to administer it well and effectively? The subject is fairly complex, as is the field of science. It is generally believed that there are many things in common in different types of administration (business, public, educational, military, scientific). However, experience over the years has shown that management of scientific activities and administration of scientific institutions have basic differences from the conventional types of administration. There appear to be some basic differences, even in the administrative patterns of scientific institutions of different sizes. For example, a small laboratory confronts us mostly with problems of technical/scientific nature, while a bigger research institute has to devote more of its time in dealing with the personnel problems. These differences arise mainly due to the reason that a research institute is not an industrial setup. Its goals and objectives are relatively less clear and are not readily quantifiable, as compared to a business setup. The evaluation of the "output" of a research institute is also relatively much more difficult to assess, when compared with a business organization. These factors are rather complex and interwoven. It is, therefore, difficult to bring down the standard of a research output to a single factor.

Economic globalization, and the world technology revolution, define the context in which all countries have to perform and make technology even more important than in the past. Since technologies develop and change very quickly today, a greater command over technological innovations and the efficient management of R&D organizations is paramount for economic success and, therein, sustainable development. Academic and scientific R&D institutions being the vehicle to sustainable scientific progress, the role of their top science-manager, 'the director', remains significantly decisive in synchronism with global scientific and technological transformations taking place.

To keep it simple, the discussion is limited to the job of a director of a research-oriented science organization. The director is a driving force, with the overall responsibilities of carrying forward the research and development activities and steering these to the predetermined goals. It is extremely important for a successful science administrator to manage "necessary" personnel and financial resources. In many cases, this has to be obtained in "competition" with other groups of researchers, institutes and research organizations. For any research institute, scientists, engineers and technical staff play a pivotal role in its working. Therefore, utmost efforts must be made in not only attracting the best available young scientists and engineers, so as to manage a flow of young blood, but also in hiring or retaining the most experienced and energetic senior scientific and engineering manpower. This blend of youth and experience is a must for a stable and growing research organization. Without doubt, towering figures in science have acted as nuclei in the growth of world famous scientific laboratories. Good scientists not only produce excellent scientific results, but are also expected to attract other good scientists in the country to work for their institutes, preferably as a team with them Therefore, a good science-management of any growing institute must keep this chain reaction active. For this, they have to keep a critical mass of scientists and technical staff, refueling the "core" in a controlled manner, so that it does not become "super" critical. To this end, a careful balance between the change, on the one hand, and the stability of the system, on the other hand, has to be maintained. One of the main tasks of senior scientists, particularly the head of the institute, is to look for bright young scientists in different areas of interest to the institute and to introduce them to research fields of future potential, keeping their own abilities and interests in mind.

Without financial resources, the aims and objectives of a research institute cannot be easily fulfilled. Once the science-management succeeds in securing necessary financial resources, it is equally important to utilize them by employing modem concepts of expenditure management. All this should be based upon carefully worked out priorities of the institute. Once a well thought-out decision is arrived at, the implementation should not be unduly delayed. Of course, during this process of implementation, one has always to keep one's mind open to the new situations arising during the implementation stage. Necessary answers to these questions and solutions to the difficulties so developed have to be worked out.

The Director of the institute plays a key role in the scientific planning and administrative management. It is a must for him to possess a comprehensive knowledge in the field of promotion of science. He has to keep in touch with the government or extra-government bodies and preferably have knowledge of finance and procurement procedure as well. He has to have extremely good relations with various science-communities within and outside the country. A careful balance between his "scientific likes" and internationally-recognized “potential areas of scientific research" has to be maintained. The degree of internal coordination and cohesion of an Institute depends entirely on the personality and character of the Director. At one extreme we have the authoritarian type, with dictatorial tendencies. He treats all his subordinates as slaves, who are given set tasks to carry out. Those who can please him, by whatever dubious means, rise to the top; the rest are condemned. At the other extreme is the anarchic one, where each worker is left to his own, to devise his own ways and means of tackling problems and to report to the Director only as a matter of formality. Both the extremes have their inherent weaknesses and drawbacks. The ideal Director lies somewhere in-between the two extremes. A Director who consults his research workers, formally or informally, at regular intervals about their general progress of work; a Director who knows and sets the direction of work can appreciate the problems encountered by the workers. Such a Director needs vision and wide foresight, someone who is willing to delegate authority.
A director is the most critical link between the mission of the organization and the people who make the achievement of that mission possible. It is his leadership that

provides direction and indeed meaning to the efforts of those assigned to execute the activities that ultimately result in outcome and performance. Utilizing resources at his disposal in the most optimum manner is more than a responsibility – it is a skill, and it is in the mastering of this skill that the greatest amount of accomplishment is possible. However, though this is essential to make him a successful director, it is not sufficient to make him a visionary director. It is only a director who provides vision whose reverence and respect will outlast the duration of his tenure. The factor elevating any director to such a level is as simple as it is undervalued – communication. The right form of communication with the appropriate person at the right time, conveying the ideal message, has the kind of power that influences the thoughts of persons and motivates them to rise above the ordinary, both professionally and personally. It is the substance that makes for those who are remembered by the most number of people long after the seat of authority has been vacated.

To get work out of the employees of the institute, the Director must use the best talent available m a person, and politely and methodically make his colleagues realize shortcomings in their professional expertise and personal abilities. Also, mere forgetting the shortcomings is not enough. Ways and means of overcoming these shortcomings have to be suggested and programmed. These have to be achieved in such a way that the person concerned does not feel offended and a concept of" team work" is created. One of the greatest mistakes a science manager can make is to give preference to his own personal views over those of others (based upon "solid scientific competence").

The management of a research institute must be aware of some characteristic differences existing between the management of a scientific institute and an industrial enterprise. Apart from his scientific abilities, the other important qualification of a Director should be psychological. The Director of a research institute must realize that, like artists, the work of scientists is highly "individual" in nature and cannot be performed to the same depth and degree of perfection by others. Again, scientists have high intellectual levels and are extremely sensitive and innovative. These factors may put considerable demands on the administrative capacity of the Director. He should not only have the ability of getting on with men but, more important, of making them get along with one another. Human nature is such that internal feuds and jealousies amongst colleagues are to be expected in any establishment. In our society, where the upward mobility is not always based on pure merit, these tendencies assume an alarming proportion. It falls in the domain of Director to maintain harmony and vitality in the Institute. All this demands a somewhat exceptional character which may be, but by no means necessarily, will be associated with higher scientific abilities.

The ideal science manager is a person devoted to his mission, having more ideas than he can put into practice, pushing, attracting young scientists and winning the respect of the science community. He should not be a humorless, aggressive and egomaniac bore. He should be imaginative and critical, offering his proposals as to how to optimize procedures or decisions. Last but not the least, he should be competitive, while respecting the work of his colleagues and his administrative partners.

Employees-motivation is another area where the tact and skills of a manager are really tested. Rewards and punishment are two of the important things that keep the employees going. The manager has to be very careful when it comes to evaluating the performance of his/her employees. Good work gone unnoticed will definitely have a negative impact on the performance of the employee and he might not feel up to repeating the same satisfactory performance. In the same way, a poor performance gone scot-free will encourage similar performances in the future. Rewards may range from a small bonus, pay-raise, promotion, or a small tribute, whereas punishment might include a reprimand, a tactfully written letter of admonition, or in extreme cases a demotion.

Some people have gone so far as to declare that scientists are not qualified to run their own organizations. They are certainly not right, if we look at the famous laboratories, such as: Cavendish (Director Lord Rutherford), Los Alamos (Director Openheimer), Goettingen (Director Heisenberg) and last but not least, ICTP (Director Abdus Salam). It is sometimes the case that brilliant scientists or research workers are not always the best of Directors, they are unable to direct or even get on with their fellow workers. In this case, it is advisable to let the scientist pursue independently his research work with a status equal to or even higher than that of the Director, but without powers of a Director. Scientific institutions and consequently science has suffered because the direction of research is considered a matter of prestige. If proper status is accorded to a scientist not directing research, this difficulty will vanish and unsuitable persons might not be put in a position to stultify the work of other besides their own.

Managing the research-oriented science organization requires the top management and especially the director to have deep understanding of issues and challenges pertaining to carrying out the scientific research, and develop and practice the necessary skill to meet them both at internal and external front. These were some of my personal thoughts and reflections that I have accumulated through a long association with scientific research and administration. I have realized through this experience, that it is not always possible to put one's views into practice. The complexities of our bureaucratic working can sometimes be extremely frustrating. Nevertheless one must have a clear vision and well-defined goals, and to achieve those goals one must strive. It is possible that my colleagues have a different perception of a Director's role. Let this publication be a forum, where they can freely express their views on this very important subject.

## FOR FURTHER READING


- *"S&T in the World [online]"*, http://www.terravista.pt/ancora/6116/english/
- 'How to Manage your Organization', http://www.masterviews.com/2003/05/15/how_to_manage_your_organization_powerpoint_presentation_resources_in_a_distributed_and_effective_way.htm

# 6. WHAT DEFINES A 'GENIUS' IN SCIENCE?

According to the Chambers' Twentieth Century Dictionary, the word "genius" means, "the special in-born faculty of any individual: special taste or natural disposition: consummate intellectual, creative, or other power, more exalted than talent: one so endowed: a good or evil spirit, supposed to preside over every person, place, and thing, and especially to preside over a man's destiny from his birth: prevailing spirit or tendency: type or generic exemplification". The Concise Oxford Dictionary of Current English, defines "genius" as "Tutelary spirit of person, place, or institution (good, evil, two opposed spirits or angels working for person's salvation or damnation, also person who powerfully influences one for good or ill); demon(s), supernatural being(s), nation(s), age's, etc., prevalent feeling, opinions, or taste; character, spirit, drift, method, of a language, law, etc.; associations or inspirations of a place; natural ability, special mental endowments; exalted intellectual power, instinctive and extraordinary imaginative, creative, or inventive capacity, person having this; presiding deity; associations, etc., of the place",

What do others think of this word? Here is a collection of some quotations, reflecting a wide spectrum of views of different people in this regard.

- Margaret Fuller (1810-50), U.S. writer, lecturer, Art, Literature and the Drama, "The Moern Drama" (1858),
  *"We know that the nature of genius is to provide idiots with ideas twenty years later"*.

- Louis Aragon (1897-1982), French poet, Treatise on Style, Pt.1. "The Pen"(1928).
  *"Genius, when young, is divine."*

- Benjamin Disraeli (1804-81), English statesman, author. Sidonia, in Coningsby, bk. 3, ch. 1 (1844).
  *"Genius, like truth, has a shabby and neglected mien."*

- Edward Dahlberg (1900-1977), U.S. author, critic. Alms for Oblivion, "For Sale" (1964).
  *"Genius at first is little more than a great capacity for receiving discipline."*

- George Eliot (1819-80), English novelist, editor. Kleismer, in Daniel Deronda, bk. 3, ch. 23 (1876).
  *"Genius lasts longer than Beauty. That accounts for the fact that we all take such pains to over-educate opurselves."*

- Oscar Wilde (1854-1900), Anglo-Irish playwright, author. Lord Henry, in The Picture of Dorian Grey, ch. 1 (1891).

*"Mediocrity knows nothing higher than itself, but talent instantly recognizes genius."*

- Sir Arthur Conan Doyle (1859-1930). English author. The Valley of Fear,, ch. 1 (1915).
  *"One of the satisfactions of a genius is his will-power and obstinacy."*

- Man Ray (1890-1976), U.S. photographer. Letter, 18 May 1941 to his sister. Quoted in : Neil Baldwin, Man Ray (1988).
  *"In every work of genius we recognize our own rejected thoughts: they come back to us with a certain alienated majesty".*

- Ralph Waldo Emerson (1830-82),
  U.S. essayist, poet, philosopher. Essays, "Self-Reliance" (First Series, 1841).
  *"It takes a lot of time to be a genius, you have to sit around so much doing nothing, really doing nothing."*

- English Traits, "Race" (1856).
  *"Unpretending mediocrity is good, and genius is glorious; but a weak flavour of genius in an essentially common person is detestable. It spoils the grand neutrality of a commonplace character, as the rinsings of an unwashed wine-glass spoil a draught of fair water."*

- Gertrude Stein (1874-1946), U.S. author. Everybody's Autobiography, ch.2(1973).
  *"Genius is, to be sure, not a matter of arbitrariness, but rather of freedom, jut as wit, love, and faith, which once shall become arts and disciplines. We should demand genius from everybody, without, however, expecting it."*

- Friedrich Schlegel (1772-1829), German philosopher, critic, writer. Dialogue on Poetry and Literary Aphorisms, "Selected Aphorisms from The Lyceum, aph. 16 (1968; first published 1797),
  *"The hearing ear is always found close to the speaking tongue; and no genius can long or often utter anything which is not invited and gladly entertained by men around him."*

- Oliver Wendell Holmes, Sr. (1809-94), U.S. writer, physician. The Autocrat of the Breakfast-Table, ch. 1 (1858).
  *"Real genius is nothing else but the supernatural virtue of humility in the domain of thought."*

- Simone Weil (1909-43), French philosopher, mystic. Human Personality, published in La Table Ronde (Dec. 1950; repr. In Selected Essays, ed. By Richard Rees (1962).
  *"Every man is a potential genius until he does something."*
- Sir Herbert Beerbohm Tree (1853-1917), English actor-manager. Quoted in: Hesketh Pearson, Beerbohm-Tree ch. 12(1956).

*"A genius can never expect to have a good time anywhere, if he is a genuine article, but America is about the last place in which life will be endurable at all for an inspired writer of any kind."*

- Sumuel Butler (1835-1902), English author, Samuel Butler's Notebooks (1951,p.257).
  *"Men of genius are not quick judges of character Deep thinking and high imaging blunt that trivial instinct by which you and I size people up."*

- Sir Max Beerbohm (1872 –1956),
  British author. And Even Now, "Quia Imperfectum" (1920).
  *"Everybody denies I am a genius – but nobody ever called me one!"*

- Orson Welles (1915-85), U.S. filmmaker. Quoted in: Leslie Halliwell, Halliwell's Filmgoer's Companion (1984).
  *"A man of genius has a right to any mode of expression."*

- Ezra Pound (1885-1972), U.S. poet, critic. Letter, 4 Feb. 1918, to the painter J.B. Yeats (father of W.B. Yeats). Quoted in: Humprey Carpenter, A Serious Character, pt.2, ch. 10 (1988).
  *"The eye of genius has always a plaintive expression, and its natural language is pathos."*

- Lydia M. Child (1802-80), U.S. abolitionist, writer, editor. Letter, 27 April 1843 (published in Letters from New York, vol.1, letter 39, 1843).
  *"I put all my genius into my life; I put only my talent into my works."*

- Oscar Wilde (1854-1900). Anglo-Irish playwright, author. Quoted in: Andre Gide, Journals 1889-1949 (1951), entry for 29 June 1913.
  *"To do easily what is difficult for others is the mark of talent. To do what is impossible for talent is the mark of genius."*

- Henri-Frederic Amiel (1821-81), Swiss philosopher, poet. Journal Intime (1882; tr. by Mrs. Humphry Ward. 1892), entry for 17 Dec. 1856.
  *"Better beware of notions like genius and inspiration; they are a sort of magic wand and should be used sparingly by anybody who wants, to see things clearly."*

- Jose Ortega Gasset (1883-1955), Spanish essayist, philosopher. Notes on the Novel, "decline of the Novel" (1925).
  *"Genius is present in every age, but the men carrying it within them remain benumbed unless extraordinary events occur to heat up and melt the mass, so that it flows forth."*

- Denis Diderot (1713-84), French philosopher. On Dramatic Poetry (1758; rept. in Selected Writings, ed. by Lester G. Crocker, 1966).

*"Genius goes around the world in its youth incessantly apologizing for having large feet. What wonder that, later in life, it should be inclined to raise those feet too swiftly to fools and bores."*

- F.Scott Fitzgerald (1896-1940), U.S. author. The Crack-Up, "Notebook E" (ed.by Edmund Wilson. 1945).
  *"It is personality with a penny's worth of talent. Error which chances to rise above the commonplace."*

- Pablo Picasso (1881-1973), Spanish artist. Quoted in: Jaime Sabartes, Picasso: portraits, etc. souvenirs, ch.9(1946), commenting on genius
  *"Few people can see genius in someone who has offended them."*

- Pablo Picasso (1881-1973), Spanish artist. Remark, 1946, to Francoise Gilot. Quoted in: Francoise Gilot and Carlton Lake, pt.2, Life with Picasso (1964).
  *"Genius is no more than childhood recaptured at will, childhood equipped now with man's physical means to express itself, and with the analytical mind that enables it to bring order into the sum of experience, involuntarily amassed."*

- Robertson Davies (1913-1995), Canadian novelist, journalist. Dylan Thomas and hector Berlioz, in "Saturday Night" (Canada, 9 June 1956; repr. In The Enthusiasms of Robertson Davies, 1990).
  *"What Romantic terminology called genius or talent or inspiration, is nothing other than finding the right road empirically, following one's nose taking shortcuts."*

- Italo Calvino (1923-85), Italian author, critic. Cybernetics and Ghosts, lecture, Nov. 1969, Turin (published in The literature Machine, 1987).
  *"What is genius.....but the power of expressing a new individuality?"*

- Elizbeth Barrett Browning (1806-61), English poet. Letter, 14 Jan. 1843, to author Mary Rusell Mittord (published in Elizabeth Barrett to Miss Mittord, 1954).
  *"Who in the same given time can produce more than others has vigor, who can produce more and better, has talents; who can produce what none else can, has genius."*

- Johann Kaspar Lavater (1741-1801), Swiss divine, poet. Aphorisms on Man, no. 23 (1788).
  *"What I do not like about our definitions of genius is that there is in them nothing of the day of judgment, nothing of resounding through eternity and nothing of the footsteps of the Almighty."*

- Lichtenberg (1742-99), German physicist, philosopher. Aphorisms, Notebook E, aph.92 (written 1765-99; tr. By R.J. Hollingdale, 1990).

*"What makes men of geniuis, or rather, what they make, is not new ideas, it is that idea - possessing them - that what has been said has still not been said enough."*

- Eugene Delaroix (1798-1863), French artist. The Journal of Eugene Delacroi (tr. by Walter pach. 1837), entry for 15 May 1824.
  *"The genius of Einstein leads to Hiroshima."*

- Charles Baudelaire (1821-67), French poet. The Painter of Modern Life, sct. 2, in L'Art Romantique (1869; repr. In Selected Writings on Art and Artists, ed. by P.E. Charvet, 1972).
  *"Thousands of geniuses live and die undiscovered - either by themselves or by others."*

- Virginia Woolf (1882-1941), British novelist. A Room of One's Own, ch.4 (1929).
  *"Saying that a great genius is made, while at the same time recognizing his artistic worth, is like saying that he had rheumatism or suffered from diabetes. Madness, in fact, is a medical term that can claim no more notice from the objective critic than he grants the charge of heresy raised by the theologian, or the charge of immortality raised by the police."*

**FOR FURTHER READING:**

- *'Genius-Definition', http://www.hyperdictionary.com/dictionary/genius*
- "The Infinite Mind: Genius", http://www.lcmedia.com/mind328.htm

## Chapter Two

# HIGHER EDUCATION IN DEVELOPING COUNTRIES: CURRENT SCENARIO AND FUTURE PROSPECTS

# 7. HIGHER EDUCATION IN THE 21$^{ST}$ CENTURY: SOME THOUGHTS

We are at the dawn of a new era, which is dominated by the state of transition from the industrial to an information age. It is characterized by digital networks, software and new media that will bring constant and irrevocable change to the nature of almost every profession. The change will hit un-evolved and unprepared vocations, such as higher education, much harder than others. Thus, the lines drawn by this change will ultimately determine the shape that higher education will adopt in future.

## 7.1 ISSUES AND CHALLENGES FACING HIGHER EDUCATION

We are currently facing a situation in education where both teaching methodology and content are becoming incongruent with reality. A lot of restructuring is needed to accommodate the new realities of the information-age into it.

The current educational models, in most developing countries, promote rote-learning culture. Most of the academic information acquired in this manner, cannot be retained for a much longer period.

A tremendous gulf exists between educational application and the real-world implementation. The skills acquired in the universities are normally found redundant when one enters the practical world. Therefore the graduates, who perform well in the universities, fail to work under actual working conditions. A degree with no experience definitely does not guarantee a job as readily as it had in the past.

In our educational system, the uniqueness of an individual is completely ignored. Many great minds are wasted in an educational system that caters for the mediocre. This is the root cause of a terrible waste of time, talent and potential.

Our education systems are extremely rigid. For pursuing higher specialized studies, pre-requisite subjects have to be undertaken at secondary education level. Counseling for career-selection is not available in our country. If one decides to change direction after completing secondary education, it is extremely difficult unless one starts afresh. This severely constrains one's future career-options.

Higher education is being commoditized in the present era. The major change to befall the universities, over the last two decades, has been the identification as a significant site of capital accumulation, a change in social perception which has resulted in the systematic conversion of intellectual activity into intellectual capital and, hence, intellectual property.

## 7.2 THE TRANSFORMATION OF EDUCATIONAL SYSTEM: ENABLING TECHNOLOGIES AND TRENDS

Globalization and the emerging technologies are going to be the major factors, set to transform the present-day educational system. Broadband Internet is now a reality to offer unprecedented Internet speed. Words like fiber-optic, cable modem, digital subscriber line (DSL) broadcast and satellite are here to stay. The satellites will make connection and communication much easier and will deliver data at much higher speeds.

The 21st century will see significant changes in higher education, and many of these changes will be caused by advancement in technology and emerging trends.

The delivery platform of educational content is shifting away from the barriers of classroom to distance-learning and multimedia environments. We have entered a new era in higher education, one which is rapidly drawing the halls of academia into the age of automation. Automation, the distribution of digitized course-material online, is often justified as an inevitable part of the new "knowledge-based" society. It is assumed to improve learning and increase wider access. With technological breakthroughs, one could have one's pick of whom to learn from. Digital education will not replace the traditional classroom, but the digitization of educational content will provide the learner with a wider choice.

Technology has made important changes, in the current curricula, necessary. The new curricula will force the educators to update their knowledge and relearn a lot of new skills.

The process of Customization of education will continue in the future, adapting to individual learning-styles, something that the classroom in the traditional sense cannot provide.

Certifications will be done directly by the industry, bypassing traditional educational systems. Both industry and consumers will tend to give preference to certification, as it will ensure quality trained workforce, with specialized industry-relevant skills. Certification had its inception in the IT industry and is expected to expand in other fields.

The decentralization of the educational mandate into the hands of private and social sectors is becoming imminent for survival and to be globally competitive. The decentralization will become possible by increasing globalization and elimination of state regulations.

Libraries continue to house printed materials, but most of this material is now available in digital and video format also. This material is accessible 24 hours a day, seven days a week, from anywhere in the world. The universities are going wireless throughout the world, thus enable the students to access required material online.

In the developed world, the present-day higher education is dominated by research and specialization. Students at master level participate in research work and specialize in a certain area. In the educational institutions of our country, emphasis is not on fundamental research work, but on the research done somewhere else in old times. Infrastructure to carry out the research is also not available.

Private and public sectors, in many countries, provide financial aid and funds to the students undertaking research activities at higher level. Same should be done in the developing countries, to promote research at educational institution.

New fields are emerging with advancement in technology. These include biomedical engineering, genetics, biotechnology, telecommunication and many others. Now people from different specialized fields, collaborate and amalgamate their technical expertise to touch those horizons of technology which were not ever thought of before.

### 7.3 CONCLUSIONS & RECOMMENDATIONS

Keeping in view the above discussion, following recommendations can be made:

- The educational curriculum should be updated.
- Distance-learning should be promoted and libraries should be digitized for easy access to knowledge, and career-counseling should be provided.
- The developing countries must provide funds for the infrastructure, necessary for the students in universities to carry out research work.
- Public and private sectors should provide funds to the universities, to promote research-based degrees and diplomas.
- Traditional classrooms must not be entirely replaced by distance-learning because in an ideal educational environment, the educator transfers not only information, but morals, ethics and life skills. Some people always prefer being taught by another human being.
- Specialization and interdiciplinary collaboration among specialized fields should be promoted for development of emerging technologies.
- The higher education in the new age of automation will be very different from what we have now. We must acquire the relevant skills and expertise, if we have to survive in the 21st century.

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# 8. HIGHER EDUCATION IN PAKISTAN: PRESENT SCENARIO AND FUTURE PROSPECTS

Education is vitally important to the progress of any developing country. The widening gap between the developed and underdeveloped countries is not due to lack of resources, but due to the difference in effective use of these assets. Indeed, investment in human capital translates into efficient use of such resources and the most direct form of any such investment is education.

In the changing global scenario of today, the knowledge-economy not only demands highly specialized skills, but also moves faster. People must, therefore, know how to learn, otherwise they will be left behind in all economic and social sectors. Primary and secondary schools aim to provide students with a strong grounding in vital skills, but higher education offers the depth and flexibility needed to thrive in the modern workplace. It also promotes human development by enhancing the capacity of the mind, and creates the freedom to pursue knowledge for its own sake. Nevertheless, acquisition of knowledge equips one with specific understanding and skills, and also conditions attitudes that influence interpersonal relationships.

It is a known fact that every society needs higher education for its development. The outcome of education is the consequence of the integrated efforts of faculty, staff and students, and the system that supports close interaction. These should be organized to derive optimal benefits from the enormous investments that are made in higher education by the society and government, by the lifetime of learning that is devoted by the faculty, and the time and energy put in by the learners.

As a developing country, Pakistan is faced with tremendous obstacles at the social and economic front. Of these, education seems to be the most critical area, considering its pivotal importance and continued negligence right from the country's creation. The state of primary and secondary education has been disturbing, but even more disconcerting is the current scenario of Pakistan's higher education. To build a vibrant Pakistan in the next decades, it is vital that we gear ourselves to produce the leaders, thinkers and problem-solvers, who will help to construct the groundwork for a society that is tolerant and progressive, and would renew the confidence of the nation in the abilities and potential of this country.

## 8.1 IMPORTANCE OF HIGHER EDUCATION

Higher education matters extremely to the pace and process of economic and social development. The potential benefits of higher education include the well-established boost to productivity and income for the people. Beside enhancing the incomes, it also promotes gains at the societal level. These gains are caused by the multiplier effects that emanate from higher education's contributions to entrepreneurship, leadership, and good governance. For these main reasons, it must be viewed as a basic ingredient. Higher education contributes to economic growth and human development, not just by training the workers, but also by utilizing other channels of the development process. It stimulates the accretion and effective utilization of available resources, the creation of environments that are conducive for the formulation of promising and forward-looking policy decisions, and the generation of key national resources in the fields of science and technology.

## 8.2 PRESENT SCENARIO AND SOME STATISTICS

At the time of creation of Pakistan, only one university existed. In the subsequent 50 years of statehood, expanding tertiary education enrollments have outpaced the construction of new colleges and universities. Today, Pakistan has 68 public and private universities and over 1,000 "affiliated" or "constituent" colleges, technical training institutes, teacher training schools, and other specialized institutions. (Table-8.1)

It is no surprise that Pakistan faces immense difficulties in strengthening its higher-education sector in the current economic climate. Pakistan's health, education, and poverty status-indicators are poor in comparison with other countries in the region. Population growth is rapidly increasing and there are escalating deficits in government spending and foreign trade, a great burden of national debt, a tight tax-base, and insufficient levels of direct foreign investment.

These aspects of Pakistan's overall development performance limit its options for higher education reform. Since these problems gravely emphasize the need of more financial resources, it would be wise to devise means to efficiently utilize available resources in order to ultimately strengthen higher education in Pakistan.

**Table-8.1: Educational Statistics (2001-02)**

| Level | Institutions | Enrollment | Teachers |
|---|---:|---:|---:|
| Primary | 169,084 | 19,921,232 | 345,457 |
| Middle | 19,180 | 4,278,392 | 99,098 |
| Secondary | 13,108 | 1,795,444 | 66,522 |
| Higher Secondary | 682 | 86,674 | 16,731 |
| Sec. Vocational | 498 | 88,000 | 6,582 |
| Colleges | 789 | 956,468 | 35,325 |
| Universities | 68 | 1,100,000 | 6,000 |
| Information Technology BCS/MCS | 27 | 22,058 | 337 |

***Source:*** *Ministry of Education, Govt. of Pakistan*

## 8.3 PROBLEMS AND ISSUES

The developing world is home to 85 per cent of world population, but to barely more than half of the world's 80 million higher education students. Relatively few of the approximately 40 million higher education students in developing countries are actually enrolled in genuinely high-quality programs. The rest face many problems. They are taught by a faculty that is poorly compensated, which struggles to provide standard education, due to inadequate facilities and obsolete course-material. All in all, the secondary education system of the country fails to equip the students sufficiently for higher studies. More disconcerting is the fact that, once these ill-equipped students enter the university campus, elements such as, violence, cheating, political activities, corruption and unabated discrimination on all undermines their progress.

Pakistan has been no exception in this regard, coupled with the fact that its governments have never given high priority to the educational sector, spending a smaller percentage of its national budget on education than any of its poor South Asian neighbors. This is further aggravated by the continued recession in the economy. As a consequence, a shaky public higher-education system has emerged, which is deeply under-funded and is therefore incapacitated to pay compensating salaries, purchase requisite stock of supplies, buy books and other published materials for libraries, and maintain a decent infrastructure. The morale and expectation-level of student and faculty alike continuously experience the downward trend. Under the circumstances, it is no surprise that research is also neglected. Politically instigated conflicts interrupt the smooth conduct of the academic tenure and promote the culture of disrespecting class schedules as well.

The most disconcerting element in Pakistan's higher-education system is the substandard quality of the course-content. The outdated and outmoded syllabus is not geared towards equipping the youth of today with the requisite tools of success needed to thrive in the practical world. Courses are seldom formulated with the current and future market-demand in mind, as the concerned authorities themselves are unaware of the same. Furthermore, student career-counseling is not a regular feature in our educational system, which allows for mismanagement and suppression of genuine talent. At the end of the day, all these factors amalgamate to produce educated students who do not have any direction as regards their future career and are usually a misfit in the challenging and changing job-market of our country.

The environment of Pakistan's education system is such that it does not encourage students as well as teachers to consult libraries or latest scientific or nonscientific literature regarding their respective fields. Seminars and workshops are avoided, primarily due to incapacity and lack of command over their subject. Moreover, quality research-work is hampered mostly because of time constraint. Semesters are designed in such a way that teachers as well as students find it extremely difficult to cover all aspects of their course in an effective manner, which results in substandard research work. Generally, the research topics delegated to students are a repetition of the research work already carried out by their supervisors. This practice undermines original thinking and also diminishes the chances of effective researches that may serve as potential solutions for the society's real-life problems. More importantly, the research carried out is in complete isolation to the industrial demands of our country. No mutually beneficial research is carried out in this regard and the motive of conducting research has become that of fulfilling a routine rather than anything else.

Management is yet another weak link in our education system. The administrative staff is usually not oriented with the contemporary means and methods of managerial excellence. The result is a bottlenecked management-system, paving the way for corruption, mismanagement and injustice.

In the higher education system of Pakistan, there is a keen sense of resistance to change, as virtually all the factors of this system want to adhere to their orthodox ways of working. Students are spoon-fed in their tasks and assignments to such an extent that virtually all matters regarding their endeavors are taken care of, without them having to make any effort. Another practice is the handing over of notes to the students for consultation, with the assurance that no queries shall be made outside the scope of this content. All these factors combine to disrupt original and 'out-of-the-box' thinking, forcing Pakistani students to remain entangled in the traditional and obsolete knowledge sphere of yesterday.

**Table-8.2: Education Sector: Investment Plan 2001-11**

| Sub-Sector | Allocation (Million Rs.) | Percentage |
|---|---|---|
| Elementary education | 12,710 | 20 |
| Secondary education | 6,742 | 10 |
| College education | 3,558 | 6 |
| Scholarship and Misc. | 2,842 | 5 |
| Technical education | 12,969 | 21 |
| Literacy programme | 9,040 | 14 |
| Universal education | 14,835 | 24 |
| **Total** | **62,426** | **100** |

**Note:** In addition, provinces will provide Rs. 130 billion through their ADPs.

***Source:*** *Ten-Year Perspective Development Plan, Planning Commission, Govt. of Pakistan*

## 8.4 SOLUTIONS AND RECOMMENDATIONS

It is heartening to note that the government has recently taken salutary initiatives to improve the quality of higher education. Firstly, a high-level National Higher Education Commission has been established. Secondly, the resource-allocation to public universities will be doubled over a period of three years. Thirdly, efforts are being made to develop R&D culture in the country. The Perspective Plan (2001-2011) for the education sector has an outlay of about Rs. 200 billion (Table-8.2).

This action plan, if implemented earnestly, will salvage the damage-inflicted national human capital, resulting in the transformation of our existing system of higher education to world-class standard in a not too distant future.

Contrary to the common belief, a meaningful change in the higher education system is not solely associated with intense infusion of funds, but is equally dependent on the subtle, yet consistent, attitudinal modification of all stakeholders directly or indirectly playing a part in the system. There is thus, a need to alter mindsets, and it doesn't cost much. A few recommendations are made in this regard, as follows:

- The immediate area of concern is the enhancement of academic quality, which involves a thorough and in-depth review of the usefulness of the present syllabi. Course coordinators and content formulators must keep in view the latest developments in the concerned fields of education and must ascertain, anticipate and integrate the current and future market-demand into this content. They must know where the students can be absorbed after graduating, what other work they may be required to do, what qualification and experience employers require for a particular kind of job, as well as the number and type of graduates required by a certain employer.
- More importantly, academic quality cannot be achieved without a committed, empowered and enthusiastic faculty. The need is to provide faculty-members with attractive incentives to discharge their responsibilities. As a first step, their salaries should be de-linked from government pay scales, and performance-based incentives be allowed to them. Moreover, faculty empowerment through greater participation in decision-making and management would also help. Greater emphasis needs to be laid on the qualification of teaching faculty, student teacher ratios, infrastructure and capacity building investment, diversity of student body, proportion of low-income students and evaluation of teachers done by student.
- A clear-cut mechanism must be evolved in which the teachers and supervisors upgrade their professional knowledge, keeping in view the latest developments in science and technology as well as other pertinent fields, so that they may subsequently impart the same knowledge to their students.
- Imperative for quality-assurance and funding for higher education in Pakistan, is a

supportive and facilitative governing body, which must have a catalytic role, rather than an intrusive one.

- The amount of funds, channeled for research purposes, needs to be overviewed and enhanced alongside the improvement in number and quality of research publications, through proper restructuring of semester duration and less interfering role of research supervisors.
- The inculcation of a mentality promoting the use of libraries and resources, by both teachers and students, for a more healthy and original thinking-process would definitely help in the revitalization of the country's education system.
- Public and private universities need to follow a financial transparency system, which involves periodic auditor's statements and adoption of disclosure practices, so as to avoid malpractices and corruption regarding university funds.
- Government grants and endowment funds needed for effective faculty-development and student financial assistance must be overviewed, to ensure progressive professional development of university faculty and equitable provision of educational opportunities to all.
- The integration of scientific and technological organizations and research-based institutions with universities must be initiated, so that practical application of the knowledge achieved by the students can be made possible. Moreover, joint projects with the industry of Pakistan may also be initiated, so that meaningful researches can be conducted and their results can be transformed into concrete and measurable changes in the economy.
- Strict adherence to merit-based procedures for faculty recruitment and promotion, as well as student admission, must be adopted under an explicit and well-defined code of conduct.
- The management and administration of universities needs to orient itself with the modern methodology of management. In this regard, they must be trained to orient themselves in areas such as managerial responsibilities, rules and regulations of universities and institutes, conflict resolution and negotiation skills, as well as the proper and timely exercise of discretionary powers.
- Private-university charters must be thoroughly scrutinized and approved by the governing body and no institution should be allowed to enroll students before approval is granted. Furthermore, same principles of educational, financial and managerial standards must apply to these universities too, and must be regulated by the governing body through a predefined system of checks and balances.
- There is an agreement on the fact that political activity among students arises due to injustices on the part of universities. Strict adherence to the proposed recommendations is expected to root out such injustices and consequently lessen if not eradicate politics in the education system.

The future of higher education rests in the arms of such meaningful and result-oriented changes that must be brought about at the earliest. Thorough consensus of all stakeholders of the society must be integrated in any such policy or decision-making, so that the benefits of this reform may reach the grass-root level of Pakistan's society.

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# 9. TRAINING OF TEACHERS FOR ENSURING QUALITY EDUCATION

Education is the greatest asset of a country. Successful nations are those which make their education meaningful and purposeful. In this regard, the role of the instructor in developing the budding minds of the youth of a nation is momentous. It is, therefore, essential that a country not only lay adequate emphasis on the education and grooming of the youth, but equally stress the development of the requisite understanding and consensus of faculty members according to new concepts and approaches for the teaching of all subjects, in general, and particularly applied sciences subjects and state-of-the-art technologies. No doubt, teacher-training is the most important tool in ensuring quality education to the future workers of tomorrow.

Indeed, it is the collective national responsibility of a country to groom and train its young generation as enlightened future citizens of the state. The future assuredly belongs to them. Therefore, any indolence or slackness in this crucial task can be disastrous for the nation as whole. The grooming and nurturing of the young generation is an onerous responsibility and instructors play a significant role in this regard. The feeling that you are shaping the character and caliber of the future generation is the reward of teaching. There is happiness in moulding and shaping the personality of young students who are the custodians of the future. When the pupils come to you, their minds are only half formed, full of blank spaces and vague notions. You do not merely insert a lot of facts, if you teach them properly; you take the living mind, and mould it. In this way, you get the incomparable happiness of helping to shape a human being. There you act as a role-model and every behavioral pattern and speech manners of yours is always emulated by students unconsciously. Thus, you leave behind indelible imprints on the personality make-up and character of your student.

Laurence Houseman once said, "*A saint is one who makes goodness attractive. Surely, a great teacher does the same thing for education*".

A similar saying of Patricia Cross is that *"The task of the excellent teacher is to stimulate "apparently ordinary" people to unusual effort. The tough problem is not in identifying winners: it is in making winners out of ordinary people."*

When it comes to the point of training of teachers, there are always three major areas that need to be emphasized. These are education, character building and skills. Sherman laid down the following essential characteristics of the 'best' or 'ideal' teacher, as being one with:

- Preparation and organization of detailed course-outlines; establishment of course-objectives; preparation for each class session and definition of evaluation procedures.
- Clarity, which entails clear explanation of concepts; comprehensibility; summarizing of major premises and systematic presentation of material.
- Knowledge i.e. grasp of subject matter; ability to make interrelationships of knowledge-areas clear.
- Enthusiasm, i.e., vocal delivery that is lively and varied; high energy level; pleasure in teaching; love for the subject and deep interest in the subject.
- Stimulation, i.e., creation of interest and thoughtfulness among students; inspiration of intellectual curiosity in students; ability to be interesting; motivating and thought-provoking.

Bearing upon these essentials, a comprehensive teacher-training programme must encompasses modules on Educational Psychology, Guidance & Counseling, Measurement & Evaluation, Teaching Strategies, Research Methodology and Personnel Management Skills. An in-depth analysis and thought-provoking discussions on these subjects would help teachers to improve their emotional intelligence, time-management, team-work, capacity-building and to sharpen inter-personnel skills, like conflict-resolution and negotiation techniques.

History proves that the teachers who used to be most successful in their profession, exhibit three common traits: they are well organized in their planning; they communicate effectively with their students and, above all, they have conviction and commitment. If you (as a teacher) wish to instruct in a systematic manner, then you will devote a substantial proportion of your time and activity to planning: deciding what and how you want your students to learn. The more systematic the teacher, the greater will be the probability of success. Instructional planning or lesson planning is a key to success for an effective teacher. Written lesson-plans make known in advance the priorities about time, learning material, objectives and type of instructions to be imparted. If, as an instructor, you have planned your lecture well, the learning on the part of students will be more meaningful and manageable. This is more applicable in case of teaching applied sciences and technical subjects, such as Telecommunication, Bioinformatics, Physics and Electronics, etc. In this way the students will assimilate the technical processes being taught as a large organized body of knowledge. Communication skill is another essential trait, which an instructor must acquire. Like any other skill, one can achieve proficiency in spoken communication with sincere efforts and sheer practice. As an instructor, you need to come out of your shell and free yourself from inhibition and nervousness with which we all have grown up. The modern teaching method is more interactive and it actively involves the teacher and the taught in critical discussions. Conviction and commitments are the other essential ingredients in the art of effective teaching. Conviction is the belief in your own self and the thoroughness and full grasp of the subject-matter with which you impart knowledge. And that thoroughness and confidence in teaching comes with preparation, devotion to duty and commitment. Commitment is the singleness of purpose to equip students with the latest and state-of-the-art knowledge. This must be the onus on every one of us entrusted with the task of imparting knowledge to the younger generation.

Conclusively, it can be said that a comprehensive teacher–training programme is an opportunity for all instructors to learn the finer aspects of their profession and develop the essential connection with their subject and students, through dedication and commitment. As Albert Einstein very rightly said, *"Setting an example is not the main means of influencing another, it is the only means."*

Sydney Harris once said, *"At its highest level, the purpose of teaching is not to teach - it is to inspire the desire for learning. Once a student's mind is set on fire, it will find a way to provide its own fuel"*.

**FOR FURTHER READING**


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# Chapter Three

# SCIENTIFIC AND TECHNOLOGICAL PROGRESS IN THE DEVELOPING COUNTRIES

# 10. SCIENCE AND TECHNOLOGY IN DEVELOPING COUNTRIES:

## A BRIEF REVIEW OF THE PRESENT STATE AND SOME REMEDIAL STEPS

### 10.1 INTRODUCTORY REMARKS

The history of science can be divided into four broadly defined eras, such as, i) the Greeks era between 450 BC to about 200 BC, which era made great scientific contributions. ii) the Chinese who made useful contributions during the period 600 - 700 AD. iii) the Muslim golden era of science, which shows a continuous strip of about 350 years between 750 to 1100 AD. iv) Another long string of Muslim scientists like Ibn-Rushd, Musa Bin Memoun, Tusi and Ibn-Nafis between 1100 AD to 1350 AD in which names of a few European scientists could also be seen in scientific literature. After 1350 AD, the scientific honours belong mainly to the Western scientists.

Dr. Robert Briffault states that science arose in Europe as a result of a new spirit of enquiry; of new methods of investigation; of the method of experiment, observation and measurement; of the development of mathematics in a form unknown to the Greeks, and thats spirit and those methods were introduced into the European world through the literature of the Arab scientists. The domination of Europeans became more pronounced with the passage of time. The last few centuries (18th, 19th and 20th) completely belong to them and the scientific contribution of scientists from developing countries is almost insignificant.

It is not very difficult to identify the main factors behind such a trend in the under developed/developing countries (particularly from the South). The following factors have contributed to this backwardness:

### 10.2 POLITICAL, ADMINISTRATIVE AND EDUCATIONAL FACTORS

- Low literacy-rate and high growth of population in the countries of the South
- Shortage of scientists and engineers doing research and development in countries of the South.
- Restrictions imposed by developed nations on the acceptance of scholars from the Southern countries, particularly in useful or sensitive scientific areas/fields.
- Dearth of self-motivated scientists / scientific thinkers/ engineers, etc.
- Rulers and the governments of the South kept themselves preoccupied with pursuits other than the development of schools of learning and sciences.

- Political instability and abrupt changes of government, often accompanied by brutal feuds and chaos, and consequent changes in government policies, resulting in adhoc governance and policies that proved detrimental to learning.
- The pursuits of pleasure, luxury and pomp by the rulers also led to their interest and desire in building mausolea for themselves, as monuments of their empires, rather than making investment in the development of the society. The words "Technical Progress" do not seem to exist in their dictionaries.
- The absence of cohesion among the countries of the South affected their progress beyond the point of no return. Contrast e.g. with the cohesion of the Ummah, during the medieval Muslim period, which acted as a unified commonwealth as far as sciences were concerned. The physicist Ibn al-Haitham, could migrate from his native Basra in the lands of the Abbasid caliph to the court of his rival, the Fatimid caliph, receiving high respect and honour, despite political and sectarian differences of the two regimes no less than, these in present days. The dark scientific era of the developing countries from the Muslim world was perhaps triggered by the invasion of the Mongols.
- Dearth of curiosity on the part of scientists of the South.
- The ratio of scientists in proportion to the total population in the Southern countries is very low.
- Extreme shortage of R&D manpower; Pakistan's 30 universities contain 60 mathematicians, while Great Britain, with a population of about a quarter Pakistan's population, has more than 3,000 mathematicians in about 100 universities. Even Singapore, with 2.8 million people, has about 90 mathematicians in its sole university.
- The spending on science and technology in the developing countries does not amount even to 1% of GNP, whereas the United States, the former Soviet Union, Western Europe and Japan are spending nearly about 2-3% of their GNP (of much larger magnitude than those of developing countries) on science and technology. Some other countries are spending even much more.
- Surveys carried out recently show that the scientific output in countries of the South is also way below the norm. According to population and GNP ratios, one out of every 15 research papers in the world should have been written by those belonging to countries of the South, but in fact, the figure is hardly one out of 200.
- Lack of personal interest by rulers in the countries of the South in scientific learning
- The socio-economic factors have forced scientific intelligentsia to migrate to lands that were more fertile. This process of "brain-drain" while reducing the already limited "trained manpower", affected the western scientific pool positively.

## 10.3 IMPORTANCE OF SCIENCE AND TECHNOLOGY IN NATIONAL DEVELOPMENT

Dependence on Science & Technology as an instrument for attainment of national developmental goals, is a phenomenon seen all over the world. The industrial revolution was a classical example of what Science and Technology (S&T) could do for the 'service' sector and for the industrial growth of the nations. As long as science was purely a scholarly pursuit; it attracted only those deeply motivated to carry out scientific work. It was not regarded as a profession, or as an area of large-scale employment. However, when the development of science and technology provided the necessary conditions for creating new products and processes that would be of worth the society, science gradually become a major professional activity, and an area of large-scale employment. Inspite of these evident benefits of S&T, most of the developing countries of the South have been left behind in the move towards the new industrial-revolution. The main reason may be the lack of appropriate planning and implementation mechanism at the national levels. The progress through S&T does not occur accidently, but through deliberate deployment of resources in the right channels and in the right direction. On the one hand, it involves fostering and promoting the development and growth of S&T infrastructure, and on the other hand, it needs well co-ordinated and orchestrated mechanism to utilize our scientific capabilities, in a planned manner, in areas related to our needs of national welfare.

The current level of S&T efforts in the developing countries of the South is much below the requirements and the scientific & technological gap between the developing countries of the South and the developed countries of the North is widening with the passage of time. Therefore, to live in the 21st century with grace, the immediate formulation and implementation of a well thought-out, well-planned science & technology strategy is needed. In the words of Prof. Abdus Salam, "in the conditions of modern life, the rule is absolute: the race which does not value trained intelligence is doomed … today we maintain ourselves, tomorrow science will have moved over one more step and there will be no appeal for the judgement which will be pronounced … on the uneducated. We must arouse the spiritual energies, particularly of the younger generation, for science and technology".

Guided by the same spirit and intitution, Prof. Dr. Abdus Salam, during the 1960's, tried hard to convince the then ruling government of Pakistan to support him in the establishment of a Science Academy in Pakistan that would become the base of S&T activities in the South. He made all out efforts and attempts with all possible data showing the tremendous advantages of S&T to help Pakistan to emerge on the global map of latest advancements and to let Pakistan become a guiding star for countries of the South in their scientific pursuits. The then government, however, did not endorse the idea and Prof. Dr. Salam had to role back his plans, only to be welcomed open heartedly by Govt. of Italy, to set up the Trieste Institute

## 10.4 ROLES REQUIRED TO BE PLAYED FOR S&T DEVELOPMENT IN THE SOUTH BY:

### 10.4.1 Scientists of the South

The quality of the pool of scientific manpower is also an important consideration. For many years, the scientific establishments of the countries of the South could only be described as mediocre if not sub-standard. This mediocre establishments of science have the quality of self-perpetuation; the incompetent scientists are not keen to allow new promising potential to enter their research centres. Mediocre university teachers and research supervisors, in turn, breed mediocre successors.

In this regard, Prof. Dr. Salam, in one of his famous lectures said, "My brothers, as scientists we have rights as well as obligations. We are a few in number, the size of our communities is individually sub-critical. This, however, is not so if we band together in an Ummat-ul-Ilm. For all our quantitative weaknesses, let us not be less ambitious, at least as far as quality is concerned, of which there is no dearth whenever opportunities present themselves. I repeat to you what Jamal Abdul Nasser said: "*Raise your head in pride and self-esteem"*. Recall that in your past, too, there are men like Ibn-al-Haitham, Ibn-Sina, Al-Biruni. Assume that you will be given all the facilities and all the resources you want for pure and applied sciences. Assume that you will have self-governance within your communities and involvement in your society's plans of development.

If China, with a smaller GNP than many of the countries in the South, and with a scientific lead of no more than a few decades, can contemplate achieving the scientific level of USA, of combined Europe and of the USSR, in building the world's fourth largest high-energy accelerator, ahead of Japan; if it can project joining the world Tokamak fusion-reactor project, INTOR, expected to produce fusion power in 15 years and costing 1.5 billion dollars; if the Chinese scientists can build the world's most sensitive gravitational-wave detecting devices - as they had done in 1978 - simply from reproducing the published descriptions of these in the Physical Reviews; if India, with a GNP considerably smaller than many other developing countries, can project radio telescopes, cosmic ray arrays, and are now collaborating with Japan on the first deep underground experiment for proton decay - I do not see any reason why we (other countries of the South) should not also contemplate mounting physics as well as physics-based technological projects on the same scale within its onfines. I do not see why the developing countries could not have the most prestigious institutes in mathematics. If our own manpower is presently short, let such projects hosted by us be thrown open to research collaborations internationally. We will be the ones to benefit from this, besides paying back our due debt to the international science. In the same vein, I would like our countries to join, as full associate members, international enterprises like the fusion INTOR and international earth-watch projects of ICSU. If Greece, with one tenth of the GNP of the Arab countries, and with scant resources in physics manpower, can aspire to join as a full member of the European Organisation for Nuclear Research in Geneva, for an accelerator project which will cost 1/2 billion dollars, designed to produce in the laboratory the heavy photons which our unified theory predicts, I do not see why the Turkish-Arab-Islamic aspiration should be inferior. With ambitions, and with involvement, will come competence, for this is God's promise to all those who strive.

### 10.4.2 Governments in the South

It is essential for the countries of the South to formulate and implement a sound and "workable" science policy as to live with dignity in the new Millennium. A lot has been said and written on this topic, but it is once again emphasised that it would be better to say less and implement more, based upon well thought and well judged policies.

Studies in research and development expenditures in the developed countries have shown that, in order to conduct a modest programme of research in the 1960s, a country had to spend between 0.7 and 3.5 % of its GNP on scientific research and to have 4,000 scientists and engineers working on research and development per million inhabitants. In contrast, countries of the South are generally spending less than 0.5% of their GNP on research and have less than 10 scientists and engineers per million inhabitants. Countries of the South ought to spend at least 1 % of their GNP on research and development in science and technology.

Speaking on this important aspect, Prof. Dr. A. Salam said, "*It is to note that inspite of the material wealth given to us by God, our governments are not convinced to spend any substantial amount on scientific pursuits. The international norms of one to two per cent of GNP would mean expenditures of the order of two to four billion dollars annually for the Arab and the same amount for the countries of the South on research and development, one tenth of this (being) spent on pure science. We need science foundations in our countries, run by the scientists, international higher centres of learning within and without our universities providing generous support, security and continuity for men of science and their ideas.*"

Human capital is a first-order resource that should not be allowed to go waste. The United Kingdom Science and Engineering Research Council awards 5,000 grants for Ph.D training every year. An equal number is awarded by other Research Councils.

It was the earnest desire of Prof. Abdus Salam to build up a Commonwealth of the Countries of the South. Prof. Dr. Salam said, "*today we, the scientists from the countries of the South, constitute a very small community - one hundredth to one-tenth in size, in scientific resources, and in scientific creativity, compared to international norms. We need to bond together to pool our resources, to feel and work as a community, as is indeed* *happening in practice"*. To foster this natural growth, could we possibly envisage from our Governments a moratorium, a compact conferring of immunity, for say the next twenty-five years, during which the scientists from within this commonwealth of science, this, could be treated as a special sub-community with a protected status, so far as internal political and sectarian differences are concerned, just as was the case in the Commonwealth of Muslim Countries in science in the past?

The principal solution for the existing lot of the scientists from the countries of the South in the world today is the adoption of a major national commitment by governments to acquire and enhance scientific knowledge. Japan is a vivid example of a country whose government set itself such a target and succeeded. Mutsushito, emperor of the Meiji dynasty, launched the Meiji Restoration in 1869 and implemented it with a devotion and commitment that led to the rapid growth of Japan as a technological power. From the Japanese example, one can trace elements which had relevance and meaning for nation building. In mobilizing the moral and mental energies of the totality of society, it has been able to make short-term sacrifices for long term gains.

Science is a search for the truth. A poor-quality science is no science; in fact scientific endeavours that lead to half-truths and fallacies are worse than not doing science at all. And, as said earlier, scientific endeavours are international in character and there can not be separate standards. The only standard ought to be an international one. The standard of science will determine the standard of technology, that in turn would determine the standards of living. To promote science to an excellent level, a climate should be created in which quality of research is emphasised much more than the quantity of research.

A most recent example of how important such national political commitment can be is provided by China. In the 1980s, China set herself an ambitious target and hoped to fulfil it through a major modernization programme. The Deng Xiaoping government declared in 1979 that China intended to quadruple its GNP and emulate the North in science and technology by end of the 20th century.

### 10.5 INCENTIVES: A MUST FOR SCIENTIFIC PROGRESS OF A COUNTRY

- **Patronage of Government for Science and Scientists**

It is extremely important that the usefulness of the role of scientists, engineers and technologists in the national development, be recognized at the decision-making level and must be emphasized periodically by the government to ensure continued state-support and patronage of scientists and technologists. The electronic and print media "must" give adequate coverage to scientific and technological activities and also highlight the achievements of individual scientists, engineers and technologists. Eminent scientists, researchers should be invited to the state functions and be introduced to foreign dignitaries as valuable assets of the nation. The learned bodies, scientific societies and professional organisations should be supported and encouraged, both by the public and private sector.

- **Providing Opportunities of Consultation and Participation to Scientists**

While framing policies at national level, the guidance and advice of "Think-Tanks" consisting of eminent, accomplished and active working as well as retired scientists and engineers must be sought. The feasibility studies and technical evaluation of different projects should be carried out, using the indigenous expertise and technical know-how. The head of state/government should periodically invite talented and active scientists to discuss various problems pertaining to S&T fields.

- **Better Service Conditions for Scientists / Researchers/ Teachers**

Scientists are by nature very sensitive people. Therefore, the socio-economic conditions can affect their scientific work. Their salaries and other fringe benefits, such as housing, medical facilities, transportation, education of children, should, therefore, not be less than those enjoyed by the commercial, industrial and corporate sectors. The promotion criteria should invariably be based on merit and performance. Their scientific and technical performance should be given due consideration for recommending promotions instead of just the length of service. The contract jobs should be given with considerably high emoluments to energetic and talented researchers, for project-oriented assignments.

- **Fringe Benefits**

It would be better if scientists, engineers and technologists are allowed to take up advisory and consultancy work. The R&D workers should be given special allowance and extra renumeration. Soft house-building loans and educational stipends must be given to R&D workers in order to facilitate their family-life and ensure better future of their children. The participation of S&T workers in international conferences and meetings be encouraged. Adequate welfare, old-age benefit schemes for the welfare of scientists and engineers should be launched by government, in order to attract talented people to take up scientific careers.

- **Professional Autonomy and Provision of Conducive Environment for Creative work**

It would be a very productive step, if every scientific and technical institute is given a clear delineation of powers from its director's level down to the level of a group leader. This will help in executing different tasks and experiments in a smooth, professional manner. Age old procurement procedures of research-institutes be simplified. The support-facilities, such as libraries, workshops, LAN, WAN, computing facilities, fax/e-mail communication, must be adequately strengthened and simple official procedure be followed in their usage. The scientists and engineers must be facilitated in the import of important scientific equipment, spare parts, specialized journals, etc.

- **Recognition of Meritorious Work in Science and Technology**

It would be very encouraging for scientists if annual awards, prizes, medals accompanied with cash amounts are instituted for outstanding work. It would also be a useful and inducive step if merit prizes/certificates can be awarded to the technicians and craftsmen for excellent productions and innovations. The patents, taken out by scientists and engineers, be allowed to be commercialized by them. The laboratories, research institutions and public places be named after outstanding scientists and technologists who have contributed to science and technology at the national level.

- **Training and Upgrading of the Professional Competence of Scientists and Engineers**

It would be a good investment if adequate number of scholarships and fellowships be made available to the scientists, engineers wishing to continue higher studies in different disciplines of science and technology. Short-term training, pre-service and in-service training programmes may be launched to upgrade the working knowledge and technical talent of the scientists and engineers. Study leave, sabbatical leave, should be liberally allowed to active scientists for the improvement of professional qualifications, and young scientists be helped to secure fellowships, employments in advanced countries.

- **Infrastructural Requirements**

Unfortunately, most of the projects in the of the South have been executed in the technology-free turnkey mode; their execution had no association, no employment of the incipient research and development. Due to this, there is no technical base to provide the design and construction services for most of the projects, nor the competence to upgrade and modify them, if needed.

What is the reason for lack of attention to the concept of attaining future self-sufficiency in manufacture? The answer is uniformly the same: the decision-maker is as a rule a non-technical person; our countries at the best are the paradise of the planner and the administrator. The technologist has no part in decision-making. It is assumed that a technologist is not capable of taking any specialised decisions; he has not the broad vision; he has no training for such a job. It needs to be noticed that in Japan, China, Korea, Sweden and France - all these countries have successful records of self-reliant growth - the most complete accord, participation and involvement exists between the scientists, the technologists, and those who run the development machinery of the state and the industry, with full trust in each other's sphere of specialization.

- **Reduction of Isolation in Science**

Science is becoming an inter-disciplinary activity, involving various areas of knowledge. Completely new fields are emerging, as scientific frontiers are pushed forward. Science is intensively competitive at a global level - more than ever before. Excellence in science can only be seen in terms of being in front – and this calls for a large and sustained financial support, an environment which nurtures, and an infrastructure which provides support. Science depends on a network of supportive structures, such as easy availability of instruments, chemicals, technology, opportunity to interact and to discuss with one's peers. There has to be a critical and viable interactive mass in each concerned field. If this sort of environment is not available, many of our best scientists of the younger generation will have a tendency to go abroad.

Finally, let us say that it is not just the physical isolation of the individual scientist that we suffer from; there is also the isolation from the norms of international science, the gulf between the way the scientific enterprise is run in our countries and in the self-governing manner it is run in the West.

- **Training of Technical Manpower**

The question as to what are the most important inputs for the development of science & technology is indeed the main issue. A number of factors that have often been identified and discussed in this context include proper scientific environment, scientific leadership, supportive management, experimental facilities, funding, manpower, etc. While all these factors do contribute in some measure to the ultimate success or failure of a S&T project, one single factor that is perhaps the most important and yet least mentioned is the intrinsic quality and the training of the manpower engaged in S&T development. Availability of adequately qualified and trained technical manpower is of great importance in carrying out any technical programme. Academic research provides the best means of training and sharpening of intellect. It also provides the seeds for newer applications of science. Thus, a good level of high-quality research in basic science is characteristic of all independent and developed economies. This is also of paramount importance for all countries of the South. All-out efforts should be initiated immediately to produce suitable trained manpower in sufficiently large numbers. It is required not only to make up for the existing deficiencies, but also to cater for the rapidly increasing future requirements. The following suggestions are made in this regard:

i. Dependence on education abroad for high-level scientific and engineering education and training must be done away with. Adequate research funds must be provided to the technical departments of the universities, in addition to their normal teaching budgets.
ii. Appropriate incentives must be given to the university staff for undertaking research

and for supervising M.Phil. and Ph.D. level students.

iii. A series of institutes of science and technology should be established on the pattern of MIT and CALTECH in the U.S.A.

iv. A number of technical training institutes should be established in order to produce suitable trained technicians and para-scientific staff in various disciplines.

It requires more inputs (both fiscal and manpower) if rapid development is aimed at. We should select areas of activities (both academic and applied) that are relevant to the needs of the individual country. In these areas, science, technology and industry must be promoted simultaneously. The funds for scientific research in the developing countries are scarce and are becoming scarcer. It is, therefore, extremely important that available funds are used effectively.

## 10.6 CONSIDERATION OF OTHER SCIENTIFIC & TECHNICAL ASPECTS

It has always been controversial, to what extent the basic and applied research should be carried out in countries with limited financial and/or technical facilities.

The three broad areas of activity viz the scientific research are:

1. *Applied research*, which covers research and application of scientific methodology, in areas such as, health, agriculture, energy, environment, minerals, etc., should be given more emphasis (particularly in the developing countries).
2. *Research in basic sciences*, in various scientific domains (without an application in near future) should also be given due importance. It should not be ignored.
3. *Research and Development (R&D) in technology*, which encompasses R&D efforts aimed at development of improved processes and products in the fields of chemical technology, engineering, transport, telecommunication, micro-electronics, biotechnology, space technology, etc., should get high priority.

The key to national prosperity lies in the effective combination of three factors, namely technology, raw materials and capital. The first, is perhaps, the most important, since the creation and adoption of new scientific techniques, in fact, makes up for some deficiency in natural resources, and reduces the demands on capital. But technology can today grow out of the study of science and its applications.

It has been found that 10-25% of the funding for S&T in USA, Japan, Germany and France is directed towards basic research. The balance is distributed between applied research and R&D in technology, roughly in the ratio 1:3. Therefore, it would be appropriate to distribute S&T funds in the developing countries of the South as follows:

| | | |
|---|---|---|
| Basic Scientific Research | ≈ | 25% |
| Applied Scientific Research | ≈ | 75% |

with 2/3 of the latter giving towards technology development.

This would be helpful in keeping a balance between short-term needs and long term objectives of countries of the South. To build up a sound tradition of original research in countries of the South needs special attention. Certainly, it is a long-term goal, achievable over a period of decades rather than years. It would be appropriate to lay main emphasis, at this stage, on adaptation and transfer of technology already developed elsewhere and to gradually concentrate more and more on original R&D work.

Among the other measures required to be taken is related to the problem of 'Turnkey Projects'. It has been established that during 1978, in the Arab world, more than 400 billion dollars were spent on major hydrocarbons and petrochemicals, civil works including transport, industrial plants including iron and steel, pharmaceuticals, and fertilisers. It is, therefore, emphasised that if we cannot become the "exporters of technology" then we should at least be "wise users of technology" we should not be the "importers of technology". Importing turnkey projects is equivalent to a suicide of the science and technological policy of a country.

Lastly, before concluding this section, one must bear in mind that there are no short cuts in mastering science & technology. Basic science and its creation must become part of our civilisation, a precondition of a mastery of science in application.

### 10.7 CENTRES OF EXCELLENCE AND ESTABLISHMENT OF MAJOR RESEARCH FACILITIES

At present day, scientific developments call for closer interaction among the concerned scientists to ensure free and speedy flow of new information being generated in the centres of learning in the advanced countries. The scientists from countries of the South have been experiencing a sense of growing isolation, because of various constraints that are a source of great frustration.

This was the scenario that provoked Prof. Dr. A. Salam in the 1960's when he requested the then President Ayub Khan to take initiative in allowing the establishment of ICTP, as a base in Pakistan. He was not given permission to do so. The International Centre for Theoretical Physics (ICTP) at Trieste, Italy - now renamed as Abdus Salam International Centre for Theoretical Physics - was created to counter this isolation of the third-world physicists and the experiment has been remarkably successful.

Following a proposal from Prof. Dr. A. Salam, Pakistan took the initiative in 1976 and organised a 3 week International Summer College on Physics and Contemporary Needs in Nathiagali, bringing together a number of experts from the developed countries and a large number of physicists from the developing world, to interact with each other, exchange ideas and develop mutual collaboration. Encouraged by the success of this Summer college, Pakistan Atomic Energy Commission (PAEC) has been holding this college regularly (on annual basis) and 24 such colleges have been held todate.

Charged particle accelerators have been, and continue to be, the most important tools of advanced research and training in practically all the major universities and national laboratories, in both the developed and the major developing countries. Unfortunately, the physics community in the countries of the South has so far remained deprived of such an important facility. In the past, several groups have looked into the feasibility of setting up one or the other type of accelerator facility in the South but, mainly due to paucity of funds, such proposals have not materialised so far.

In view of the important fields, it is proposed that such facilities be established at the earliest in selected countries of the South. Such facilities may be located at "convenient places", preferably closer to the above-mentioned Research Centres. They will, thus, be able to share some of the existing facilities (e.g. library, computers, workshops, etc.) of the nearby Research Centres and at the same time, provide research facilities to scientists, working at the Centres and those from other countries of the South. Decision regarding the exact type, size and other technical features of such accelerators, as well as about their places of location may be taken by a committee of experts that may be set up, once the decision on setting up such facilities has been taken, in principle. It is estimated that capital cost of one such facility would be about US$ 20-30 millions and annual recurring expenditure would be about US$ 3.0 million.

Another area of research, in which the countries of the South are lagging behind, is the utilization of nuclear techniques. Despite the fact that a number of countries of the South, such as Algeria, Egypt, Ghana, Indonesia, Iran, Libya, Malaysia, Pakistan and Turkey have nuclear research reactors, these areas are yet to be fully developed and exploited. Some of these reactors, e.g., in Indonesia are very well equipped from the point of view of experimental facilities, but are under utilised. Since considerable amounts have already been spent on the establishment of these facilities, it is proposed that one of these facilities (e.g. Indonesia) may be developed on the pattern of the Institute Laue-Langvian (ILL), Grenoble, France. This will provide opportunities to scientists from the countries of the South to conduct front-line research, like in the fields of neutron scattering, neutron radiography, radioisotope production, and neutron activation analysis.

### 10.8 FOR FURTHER READING

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# 11. ROLE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH IN DEVELOPMENT: SOME FACTS AND MISCONCEPTIONS

Scientific research is the cardinal tool for mankind to know and reform nature. Activities of scientific research date back to the early stages of human society. Scientists today continuously get familiarized with the universe, understand its objective laws by thinking and practice, and apply the knowledge they have acquired in guiding practice, creation and invention. The remarkable accomplishments of the human race are just monuments of scientific research activities of the past. As Albert Einstein said:

*"The process of scientific discovery is, in effect, a continual flight from wonder"*

The progressive development of the human society has placed an ever-increasing demand on scientific research. On the one hand, the issues for scientific research have become accentuating and complex in an unprecedented manner. Nowadays, the forefront of scientific research is marching towards the untouched areas in leaping bounds in both micro and macroscopic directions. Whether with microscopic particles and nanometer technology in physics or with chromosome and gene in bioscience, scientific research has advanced to create a complex and abstract world, which in turn raises new formidable tasks for scientific research to overcome. All in all, the development of science and technology has given impetus to social progress. Meanwhile the contents and methods of scientific research have also been innovated continuously.

As Sir Isaac Newton, once said:

*"Whoever has undergone the intense experience of successful advances made in (science), is moved by profound reverence for the rationality made manifest in existence"*

Scientific research can be broadly categorized as basic, applied, mission-oriented, problem-oriented and industrial research.

Basic research is the attempt of a researcher to access the frontiers of knowledge for the sake of knowledge alone. It is that kind of activity, the output of which is used as an informational input into other inventive activities. Very briefly, basic research is the extension of scientific and technical knowledge, which are not justified by industrial and commercial intentions. It is that component of knowledge-enterprise most distant from immediate or foreseen commercialization. On the other hand, applied research entails creation of new knowledge and applications of existing knowledge, but is addressed to clearly defined problems and leads to products or services that may be exploited in the near term. It is carried out to find practical solutions for current pressing needs. In essence, the problems of the society in general and the industry in particular are assessed and addressed by applied research, which results in the improvement of a product or a system.

Mission oriented research is primarily a broad-based research, carried out in support of a particular Mission or the achievement of a certain Technological Goal. The ‘Mission’ or the ‘Technological Goal’ could be any broad-based programme, aimed at the developmental work of a certain scientific system or establishment of a proper infrastructure / know how, necessary to make the project ‘Critical’ and workable for the aim with which it was initially started. It may consist of different combinations / phases of “basic” and “applied” research project / sub projects. It is interesting to note that Mission-oriented research does not deal with only applied research, but also greatly contributed in the advancement of basic research with the development of new gadgetry helpful for the generation of new and high-level basic knowledge. Consequently, in Mission Oriented research, the benefit is mutual, i.e. the applied and basic researches help each other. Experience shows that this mutual benefit is maximum when the interpretation of “Mission Relatedness” of “Basic Research was not narrowly defined”.

Problem-oriented research is simply defined as ‘research work carried out to solve a specific problem arisen during a certain research programme’. This is relatively, a narrow research-activity aimed at some difficulty or hurdle faced during a broad research activity. It can also be aimed at solving certain technical fixes. In certain cases it may be required to find out a quick / immediate (on relative time scale) solution to meet certain societal needs. Problem-oriented research is primarily concerned with current issues and problems, as well as the relevant social actors and stakeholders. The primary objective of this type of research is to analyze perceptions of the problems at hand, related models for action and means of knowledge and then to transform these into scientific questions and research strategies. This research claims to bridge the gap between natural sciences, humanities and social sciences, and uses the impetus on predicaments to reach interdisciplinary and/or transdisciplinary approaches. The fundamental goal is to amalgamate scientific analysis with action, keeping in mind the interests of societal decision-makers and stakeholders.

Scientific discoveries coupled with technological developments enable industrial sector to convert the new knowledge so gained to practical applications in an effective manner. Such a conversion of new knowledge to industrial products should preferably take place as early as possible, if an effective edge over other competing industrial set ups is to be achieved. In addition to this, industry carries out its own research programme. This research, carried out by industry under its own programme is generally known as Industrial Research.

Industrial research predates invention, involves highly knowledgeable (men of vision) and is aimed at obtaining ingenious knowledge and new ways that facilitate the emergence of new technology. It is, therefore, clear that it is extremely important to get new and good ideas which enable the industry to (a) improve the quality and usefulness of its products and (b) make them relatively more durable and inexpensive. It clearly indicates that many industrial set ups are well aware of the importance of new/basic knowledge, because it acts as the seed for obtaining a better and more efficient product, which will ultimately result in increased profit and better financial gains for the industry concerned.

Experience shows that there seem to exist (a) "time continuum" from fundamental knowledge to a usable / marketable industrial products, and (b) "diffusion time", a period necessary for the diffusion of "technological innovations". It is interesting to note that both of these durations seem to be getting shorter and shorter with the passage of time. For example:

- The time continuum for the Principle of Photography, was 200 years, while the diffusion time for the same was only 40-50 years
- In the case of Liquid Crystals it took 80 years until the fundamental knowledge was actually converted into products, while it took the Electrical Motor only 40 years
- The time continuum for Nuclear Power and the Transistor is the same i.e. only 5 years, while the diffusion time for the Transistor is an unexpected 15 years
- Transparent Plastics took only 2 years to move from basic knowledge to marketable items
- The time continuum for Nylon is 10 years.

## 11.1 CONTRIBUTION OF INDUSTRY TO RESEARCH

Research and development is an important element of technological innovation, because it helps generate the superior products, processes and services that can give a company a competitive edge. For R & D to lead to profitable growth, it must lead to a technical advance, which in turn must be translated into profits in the world-markets. R & D is a prerequisite for innovation, which is essential for companies to remain competitive in the global village of today.

However, innovation and the resultant technological change do not just happen – they must be paid for through expenditures on research and development. How R&D funds are spent helps determine how scientific knowledge will accumulate and how technological change will be manifested. In other words, total R&D expenditures reveal the perceived economic importance of R&D, relative to all other economic activities of a nation. Of course R&D data alone are not sufficient to analyze the future growth of a field of study or an industrial sector, but they may well be an important input into such analysis.

Most of the nation's civilian research and development is carried out in industry. While "development" has always been the major portion of industrial R&D, industry has made many critically important contributions to "research". But competitive pressures have forced industry to shift R&D efforts toward work with shorter time-horizons. Relatively little industrial R&D now has an anticipated time-to-application longer than five to seven years. This is the case even at Bell Labs and IBM. Hence government support for long-term R&D is now more important than ever. Examining the return on investment in R&D, it is found that the rate of return to industry is around 20%, while the societal rate of return is considerably higher, around 50% (since technology spreads from the firm that introduced it). It is also found that academic research is of great importance in underpinning industrial innovation.

Examples of the industries contribution to research can be drawn from a variety of industries, such as the pharmaceutical, manufacturing and so on. However, the contribution of industry to information-technology, as a field and discipline, are extremely important. There are countless instances of industry's contribution to research which prove the significance of this contribution and its continued positive impact on the realms of scientific and technological research of modern and futuristic times. The society continues to take benefit from the valuable input of the industry towards research.

## 11.2 THE UNPREDICTABLE NATURE OF BASIC RESEARCH

As discussed earlier, the results of most of the basic research work contained unexpected practical applications in store. Such is the uncertain future impact of basic research work that some entirely wrong predictions were made regarding their practical utilization. History of scientific research contains a number of such instances

According to the celebrated scientist Rutherford, "the energy produced by the breaking of the atom would be a very poor kind of thing". He greatly underestimated the application and utility of nuclear energy at that point in time, because basic research had not yet proven the worth of such sources of energy. It is surprising that even Einstein could not possibly foresee how his mass-energy relationship would lead to the release of nuclear energy. He said in the year 1932, "there is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will". Nuclear power generation became a reality quite some time ago, and has since then been playing an important role in meeting the demands of the modern world, proving Albert Einstein's statement wrong. Basic research produced results that were completely unexpected, even to the greatest of the scientists of all times.

Faraday on the other hand, could covertly foresee the practical usefulness and future applied nature of his work on electricity and magnetism. It is said that around 1850, Mr. William Glandstone (the then Chancellor of Ex-Chequer and later Prime Minister) visited

Faraday's laboratory and asked him, *"This is all very interesting, but what good is it?"* Faraday replied, *"Sir, I do not know, but some day you will tax it"*. Faraday's reply was rather a visionary one.

A decade ago, every-one regarded superconductivity as a dead field. But in 1987, Alexs Muller and Georg Bednorz were awarded the Nobel Prize in Physics for the discovery of new kind of superconducting material, with much higher transition temperatures, and it did not fit the model of the Bardeen-Cooper-Schrieffer theory. We still do no fully understand how these materials work, but applications have already begun. Consequently, more basic research still needs to be done, which then may or may not produce expected/ unexpected results, to be later adopted in applied research endeavors.

The uncertain, unpredictable nature of basic research can be judged by the content of the following statements, which show us that basic research simply knocks open the doors to newer horizons and possibilities; something man may not be able to even comprehend before it actually happens. "*Airplanes are interesting toys, but of no military value*"*:* statement of Marechal Ferdinand Foch, Professor of Strategy at the Ecole Superieure de Guerre. "*Louis Pasteur's theory of germs is ridiculous fiction*": statement made by Pierre Pachet, Professor of Physiology at Toulouse in the year 1872 and "No flying machine will ever fly from New York to Paris". Orville Wright made this comment unaware of the potential his work would acquire in later years.

Popular Mechanics said in the year 1949 that, *"computers may weigh no more than 1.5 tons"*. Pocket computers and other compact computer types evidently nullify the validity of this statement. It is seen even today that basic research in this field has broken the boundaries of miniaturization and compactness, and the customer can expect anything and everything in the days to come.

Another such statement was issued by Ken Olson, President of Digital Equipment Corporation, who said in 1977 that *"there is no reason anyone would want a computer in their home"*. Today, there is rarely a reason why one wouldn't want to have a computer at home!

"*This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us*." This is a piece of text from the Western Union internal memo issued in 1876, which seriously underestimated the utility of a device that is an integral part of the conduct of modern livelihood. Surely, at that point in time the applications of telephone were not evident and it was being considered useless. Basic research not only invented the telephone but, at later stages, it improved the system to suit everyday lifestyle of the user, thereby granting it acceptance as one of the most important means of communications.

"*The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?*" This statement was made by David Sarnoff's associates, in response to his urgings for investment in the radio in the 1920s. "*Heavier-than-air flying machines are impossible*." Lord Kelvin, President of the Royal Society said this in 1895, which the Wright Brothers disproved in the nineties. A recollection of events narrated by Apple Computer Inc. founder, Steve Jobs, provides an interesting account of the unpredictable nature of basic research, when he attempted to get Atari and HP interested in his and Steve Wozniak's personal computer. "*So we went to Atari and said, 'Hey, we've got this amazing thing, even built with some of your parts, and what do you think about funding us? Or we'll give it to you. We just want to do it. Pay our salary; we'll come work for you.' And they said, 'No'! So then we went to Hewlett-Packard, and they said, 'Hey, we don't need you. You haven't got through college yet*.'"

"*Professor Goddard does not know the relation between action and reaction and the need to have something better than a vacuum against which to react. He seems to lack the basic knowledge ladled out daily in high schools*", 1921 New York Times editorial about Robert Goddard's revolutionary rocket work; a statement which was made in naivety of the important basic research in this field, which was to follow.

Charles H. Duell, of the Office of Patents said in the year 1899 that, *"everything that can be invented has been invented"*. Obviously, he seriously misjudged the potential of basic and applied science/research. Of course one cannot blame the learned of those times for making such statements. Evidently, the developmental sciences or more specifically basic research conducted during those times was of a different style than that of later days. In the 20th century, tools and concepts of basic research dramatically changed. Huge and complex machines came into being and basic research changed the entire concept of how to do research in science. It is a true fact that discoveries of the 20th century are collectively more than those made in all history before that time. Today, it is said that the discoveries made in the last two decades are far more than those made alone in the 20th century.

The uncertain / unpredictable nature of the curiosity-drive based research-work (i.e. concerning product /practical / main field /area of the final impact) is further illustrated by some more examples summarized in the Table-11.1:

It is also interesting to note that applied form of research (the products that are developed) can somehow be linked to the fundamental research; examples can be given in this regard, as the transistor was developed as a result of research in Condensed Matter Physics, and Magnetic Resource Imaging technology was developed due to investigations in nuclear magnetic moments. A conversation between Socrates and Glaucon can be used to support the claim (see Box-1).

**Box-1**

| | |
|---|---|
| **Socrates:** | "Shall we set down astronomy among the subjects of study?" |
| **Glaucon:** | "I think so; to know something about the seasons, the month and the years is of use for the military purposes, as well as for agriculture and for navigation" |
| **Socrates:** | "It amuses me to see how afraid you are, lest the people should accuse you of recommending useless studies" |

More recently, Frances W. Clarke of the U.S. Geological Survey, in a speech also protested that:

"*Every true investigator in the domain of pure science is met with monotonously recurrent questions as to the practical purport of his studies; and rarely can he find an answer expressible in terms of commerce. If utility is not immediately in sight, he is pitied as a dreamer, or blamed as a spendthrift*."

The return on investment in basic research is not often so immediate. However, over the long term, it can impact substantially, and often when least expected. Indeed, investment in basic research produces a multifarious payback, a clear example of which is the creation of an entire new economy based on information-technology.

## 11.3 THE TECHNOLOGICAL VALUE OF BASIC RESEARCH

It is an established fact that apprehension has always been there regarding the emphasis upon and investment in basic research. This is a mainly due to the uncertainty attached to the focus and expected results of basic research.

The time-line of science and technology indicates that there are certain periods in history where a lot of activity and innovation took place. In this regard, the twentieth century has been a century that can be identified as an era of fast-paced and high-tech innovations. Interestingly enough, this rapid developmental activity of 20th century was seen in almost all areas of science and technology. Be it the field of nuclear physics, organic chemistry, or biotechnology, the world has seen very significant changes in terms of scientific and technological research and their respective applications. During this time-frame, space vehicles were introduced, power plants revolutionized the energy sector, atomic physics experienced the most dynamic (at times destructive) results, and biological sciences were also marked by significant developments. All in all, there is an unending list of activities, and the world actually saw unprecedented changes due to research in science and technology.

**Table-11.1: Scientific Fields and Technological Areas Benefiting From Fundamental Research in Diverse/Unrelated Subjects**

| **Original Research Work or the Basic Emphasis (and / or the Field of Interest)** | **Field / Area which Finally Benefited or the Final Product Resulting due to the Research Work so carried out** |
|---|---|
| Fundamental research in glass science, optics and quantum mechanics | Fibre Optics – Revolutionary Technology in communications |
| Basic Research on Tetrafluoroethylene to aimed at preparing new refrigerants | Teflon – A material with extremely useful industrial application |
| Research work on drug AZT, was carried out to find a remedy against cancer | Useful Progress made in obtaining Anti AID drug |
| Rosenberg's research on the potential effects of electric fields on cell division | Discovery of an important drug against cancer |
| Kendall's work on the harmones of the adrenal gland | Resulted in the identification/ formation of an anti-inflammatory substance |
| Carothers' research work on giant molecules | Let to the invention of Nylone |
| Block and Purcell's fundamental research work in the absorption of radio frequency by atomic nuclear in a magnetic field | The research work led to a very important technique of magnetic /medical resource imaging (MRI) |
| Cohen and Boyer's work on the development of gene splicing | Produced better insulin along with other useful products |
| Haagen – Smit's work on air pollution | Spawned the catalytic converter. |
| Reinitzer's important work on the discovery of liquid crystals | Important contribution in further development of computers (particularly flat panel television screen) and the discovery of laser.<br>Laser, which was initially a laboratory curiosity has found important applications such as the reattachment of a detached retina and the reading of barcodes in supermarkets. |
| Various projects carried out in "Basic Physical Research" | Subjects of great technological and medical importance such as:<br>- Nuclear magnetic resource<br>- Semiconductors<br>- Nanostructures<br>- Super conductors<br>- Making useful … applications<br>- Carrying out medical applications |
| Fundamental Basic Work in Condensed Matter Physics (1920s – 1930s) | Development of Transistors (1950s) |
| Rabi's work on Nuclear magnetic Movements (1938) | Magnetic / medical Resource Imaging (MRI) (1980s) |

## 11.4 REVOLUTIONIZING THE WORLD THROUGH BASIC DISCOVERIES

The importance of basic research in human civilization cannot be emphasized enough. Starting from daily appliances and systems to complex industrial and scientific equipment, systems, disciplines and fields – all owe their celebrated utilization in modern times to basic research.

The link between science and technology can be further illustrated by a number of scientific discoveries that changed the world. Examples of science-based technologies that trace to such discoveries in the fields of electricity and electronics, energy, radiation, chemistry, biomedicine, laser and photonics, and materials include the following:

### 11.4.1 Electrical and Electronic Technologies

Examples include electric discharge tubes, electric lights, electric motors, telephones, radios, televisions, and clean, reliable, technology-tailored electric power, etc. The impact of scientific discovery in this field on advanced technology continues with the miniaturization of electronic devices and computer microprocessing.

### 11.4.2 Energy Technologies

Man's most important energy-sources are science based. They will become more so in the future. Nuclear power came after and not before nuclear physics. It was not technology, but basic science that formulated the understanding and identified the critical reactions in both fission and fusion, which man can harvest for production of useful energy. Plasma physics is central to thermonuclear research and to the applied science, which is needed to enlarge mankind's energy resources. Furthermore, energy-technologies not only involve energy production, but also energy use, energy conservation, energy conditioning, and energy transmission and distribution.

### 11.4.3 Radiation-Based Technologies

Examples include X-rays, which were a result of Roentegen's researches on electrical discharges in gases. The discovery of X-rays further led to a multitude of technologies in medicine and elsewhere. The latter followed the former. Another example is that of Radioactive Tracers, which came from nuclear physics and profoundly impacted society via the many technologies in medicine (nuclear medicine for instance) and biochemistry and molecular biology. Radioisotopes are another example, which are widely used throughout science, technology, and medicine. The ability to detect, measure, understand, and safely use ionizing radiation came from science too. Magnetic Resonance Imaging, another example, came from fundamental work on nuclear magnetic moments in the late 1930's. The MRI captures a deeper insight into the human body by creating a magnetic field around it.

### 11.4.4 Chemistry-Based Technologies

It has correctly been said that of all the branches of science, chemistry is the closest to industry. Chemical synthesis delivers annually about a quarter of a million new compounds, more than 1,000 of which reach the market place. It gave society biodegradable detergents, agricultural, industrial, and medical substances, along with penicillin, vitamins, and hormones. Chemistry-based technologies handed society plastics, fibers, rubbers, coatings, adhesives, items, and polymers. Out of basic research in theoretical, structural, quantum, and computational chemistry on simple, complex, and polymeric molecules, and through the use of a broad spectrum of experimental techniques, grew the industry of plastics, artificial fibers and synthetic rubber. The impact upon the standard of living of society of these comparatively inexpensive materials has been immeasurable. And there is more to come!

### 11.4.5 Physics-Based Technologies

Physics has enormously contributed to the process of development and refinement of not only currently utilized technologies, but also those potentially utilizable technologies, which are termed as the Future Technologies. Physics has contributed tangibly by providing improvement in accuracy of data and its processing, miniaturization of physical and chemical servicing-devices in health care, real-time imaging and analysis, developments towards lighter and more robust devices, developments of in-vivo robotic systems, tools for endoscopic surgery and intelligent implants and physics-based surface engineering in clinical advances. Interesting to note is the fact that physicists invented the computer, the transistor, the laser, and even the World Wide Web.

### 11.4.6 Science-Based Biomedical Technologies

As mentioned earlier, basic research has had a ground-breaking effect on all fields of life, and the same can be said about positive developments in health care. Immunization from diseases that were once life-threatening, introduction of pain killers, and diagnosis and treatment of ailments of various kinds. In addition, it is also the result of basic research that instruments, processes and methods have been developed to facilitate medical care. At the moment, the most advanced methods are being employed and innovations are being made in areas, such as genetic engineering, laser technologies, scanning devices.

### 11.4.7 Laser-Based Technologies

This is an example of scientific knowledge lying dormant until scientific advances, in neighboring areas and technological needs in neighboring fields, made its development inevitable. Today materials for lasers are many and include gases, liquids, and solids. Lasers come in many varieties, power levels, wavelengths (infrared, visible, ultraviolet, and possibly also X-ray), and types (continuous or pulsed). Lasers led to new technology which, in turn, facilitated new science, which again led to new technology and yet again to new science—a continuous interplay that is still unfolding. High-quality lasers and hardware can now be purchased readily, enabling laser-based technology to be used in virtually everything; industry, communications, weapons, information-storage, remote-sensing, and so on. Laser-based technologies are also used in microstructure engineering, microfabrication, semiconductor processing, material deposition and etching, and a host of methods for altering the morphology of a solid surface with special resolution, down to the nanometer scale.

### 11.4.8 Science-Based Materials-Technologies

Materials science is primarily an applied science, which is concerned with the relationship of the structure and properties of materials, whether artificial or natural. Science-based technology gave man the electric light-bulb filament, the transistor, the solid-state laser, composites, ceramics, metals, alloys, and polymers. The applications of materials technologies include electronics, aerospace, medical, motor vehicles, bridges and houses; even small things such as our clothes and shoes, which have a range of natural and synthetic materials involved in their construction, or for that matter used in the manufacture of computers, cameras, hi-tech equipment and other household goods. The list is extensive and includes various metals and their alloys, ceramic materials such as glasses, bricks and porcelain insulators, polymers such as plastics and rubbers, together with semiconducting and composite materials.

## 11.5 BASIC-RESEARCH AND APPLICATIONS: THE FIRST STEP

Since basic science is now very much a part of developing technologies, the term co-evolution of science and society implies the co-evolution of both basic science and industrial science with society. Advances in technology are generally accompanied by social changes, as a consequence of changing economies and ways of carrying out life's various activities. An important issue to discuss is how basic scientific discoveries eventually lead to new technologies and what that may mean to the rational support of basic research and the future of science and technology in the world.

There are tremendous uncertainties in the process that starts with basic research and ends with an economically successful technology. The successful discovery of a new development in research that appears to have technological significance does not ensure the economic success of technologies that may be based on it. Nathan Rosenberg of Stanford University said in this regard that there are great uncertainties regarding the economic success of a technology, even in research that is specifically directed towards a particular technological objective. Uncertainties derive from many sources, such as:

- The failure to appreciate the extent to which a market may expand from future improvement of the technology.

- The fact that technologies arise with characteristics that are not immediately appreciated, and
- Failure to comprehend the significance of improvements in complementary inventions, that is inventions that enhance the potential of the original technology.

It is important to note that many new technological systems take many years before they replace an established technology and that technological revolutions are never completed overnight. They require a long gestation-period. Initially, it is very difficult to conceptualize the nature of entirely new systems that develop by evolving over time.

The road that leads from basic research to application can be illustrated by many examples. We may describe this by two examples of basic scientific findings in a small field of Little Science, namely, low-energy electron collision physics. These examples involve the development of efficient $CO_2$ lasers and the development of gaseous dielectric materials for the transmission and distribution of electricity. These, and innumerable other examples of the translation of scientific findings to technological products, allow us to conclude: what is good science can be good technology.

Looking from another angle, one realizes that laboratory techniques or analytical methods used in basic research, particularly in physics, often find their way either directly, or indirectly via other disciplines, into industrial processes and process-controls largely unrelated either to their original use or to the concepts and results of the research for which they were originally devised. According to Rosenberg, who said in 1991:

*"This involves the movement of new instrumentation technologies... from the status of a tool of basic research, often in universities, to the status of a production tool, or capital good, in private industry."*

Examples are numerous and include electron diffraction, the scanning electron microscope (SEM), ion implantation, synchrotron radiation sources, phase-shifted lithography, high vacuum technology, industrial cryogenics, superconducting magnets (originally developed for cloud-chamber observations in particle physics, then commercialized for 'magnetic resonance imaging' (MRI) in medicine). In Rosenberg's words:

*"The common denominator running through and connecting all these experiences is that instrumentation that was developed in the pursuit of scientific knowledge eventually had direct applications as part of a manufacturing process."*

Also, in considering the potential economic benefits of science, as Rosenberg says:

*"There is no obvious reason for failing to examine the hardware consequences of even the most fundamental scientific research."*

One can also envision ultimate industrial process applications from many other techniques now restricted to the research laboratory. One example might be the techniques for creating selective chemical reactions, using molecular beams.

Clearly, this reciprocal feedback between science and technology is overpopulating the earth with offsprings. This process will undoubtedly continue and, along with it, the shrinking of the time that is required to go from basic research to application. It appears from data that this time may be decreasing virtually to zero. Indeed, this may already be happening in the information and computation technology.

## 11.6 CONCLUSIONS

In the twenty-first century, science must become a shared asset benefiting all people on a basis of solidarity only. Science is a powerful resource for understanding natural and social phenomena and its role promises to be even greater in the future, as the understanding of mankind regarding the growing complexity of the relationship between society and the environment becomes deeper. The continuously increasing need for scientific knowledge in public and private decision-making, including the significant role of science in the formulation of policy and regulatory decisions, has been adequately emphasized and ascertained. It is also agreed and understood that scientific research is a major driving force in the fields of critical importance to mankind and that greater use of scientific knowledge is a prerequisite to development.

Deciphering from the facts in the above narration, it is clear that scientific capacity and infrastructure for continued scientific and technological research lies at the heart of sustainable development and progress in the modern world. Basic research is an unpredictable and uncertain form of scientific research, which ensures newer and improved inventions in science. It is consequently essential that this research must be conducted without bars and limits and should be allowed to progress and prosper in undefined boundaries, so that man may experience better and useful applications in the near future.

The importance for scientific research and education and the need for full and open access to information and data are extremely important considerations in scientific and technological research. It is therefore necessary that a new relationship between science and society must be contemplated, so that humanity may cope with pressing global problems, such as poverty, environmental degradation, inadequate public-health, and food and water security and population-growth. Nevertheless, there is a need for a strong commitment to science on the part of governments, civil society and the productive sector, as well as an equally strong commitment of scientists to the well-being of society.

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# 12. CAPACITY-BUILDING IN PURSUIT OF SUSTAINABLE DEVELOPMENT

One of the primary reasons for the increasing gap in economic progress of the developed and the developing countries is their respective ability to harness their resources in a long-term perspective. Latest research has shown that it is not only important to be equipped with resources, but even more imperative is the capacity to achieve a sustainable level of such assets, so as to maintain and increase the prospect of growth and prosperity.

Although enormous constraints to the achievement of effective capacities to promote sustainable development remain, genuine signs of progress are evident. At present, most of the countries have strategies for either environmental management or sustainable development, and the global community has a reasonable sense of what needs to be done, with respect to capacity-building for sustainable development. Science and technology have been identified as the key areas for achieving the goal of consistent progress. Therefore, it is also extremely important to develop indigenous capabilities and capacities in those areas of science and technology that are of relevance to the developing countries.

Capacity building encompasses the human, scientific, technological, and organizational resource-capabilities of a country. The basic goal of capacity-building is enhancement in the ability to address and assess the policy-choices and modes of implementation among development-options, based on the environmental constraints and potentials, and needs identified by the people of the concerned country.

Within the scope of international cooperation, development-policy should aim at contribution to sustainable development. This also calls for learning-processes on the part of the development-institutions and further development of their services for sustainable development.

The concept of sustainable development ensues from the knowledge that economic and social development and sustainable use of eco-systems are linked with each other. The concept rests on the assumption that it is in the interest of all to design the integration of economic, social and ecological goals. This means that it is not merely an ecological development model, but a comprehensive one. Instead of emphasizing the 'limits of growth', sustainable development focuses on prevention, improving efficiency, integration, innovation and cooperation in a negotiable process based on partnership.

'Capacity-development' stands for a broader approach. Due to the increasing complexity of the range of problems, it is known that targetted group-oriented work, at grass-root level alone, has only a limited outreach. The capacities for action of people and organizations arises not only from their own strategies and strengths, but also from the actions of other actors, the institutional arrangements and general conditions under which they act.

Strategic action in terms of sustainable development demands a way of doing things, which is different from classic sectoral action, not only with regard to the way it comes into being, but also with respect to its content. Action-strategies for sustainable development can focus on a few or many problems. They can be called strategies for sustainable development, poverty-reduction or something quite different. In principle, every strategy can grow into a strategy for sustainable development, provided:

- it takes equal account of economic, social and ecological perspectives, regardless of their sectoral focus;
- it weighs up the short and long-term significance of goals, problems and approaches to solutions; and
- it is embedded in a process which enables the various actors in the government, the private sector and civil society to assume joint responsibility for the strategy.

International cooperation make important contributions to sustainable development, especially if it intervenes at several levels; takes account of the various dimensions of sustainable development; is designed for the long term (while not losing sight of short-term problems); and is in the true sense aimed at 'capacity-development'.

The quality and motivation of the country's trained human resources are of crucial importance to any national system of innovation. Human resource development is too often interpreted as solely tertiary-level education. Governments in the developed countries, generally, look at the issue in a much broader prospective and set out policy-approaches for human resource development and capacity-building at the national level, in ways that take into specific consideration the needs of adult-education and training and technology-education. Therefore, the developing countries can take a leaf out of the book of initiatives by these advanced and more developed nations and take effective measures to develop their own human resources from a strategic point of view.

A sound infrastructure is imperative for development in every field. Be it the establishment of telecommunication, information, and communication centers, or the provision of a conducive legal and regulatory framework, the stakeholders ought to ensure that each one of them plays its respective part in the development process, so as to make it an effort based on the principle of synergy and not on an individualistic one.

The concept of sustainable development requires a complete change of the Research and Development System. Strengthening of autonomous R&D resources in the South is the main condition for the successful transfer of scientific and technical knowledge and for a balanced world. Countries of the North and South are both concerned in the process; some imperative tasks should be the responsibility of one side, others of both. They must be considered as complementary and they have to be conducted in a simultaneous way. Without a common engagement from both parts, there it makes no sense to believe that sustainable development should be reached.

Despite an unquestionable ignorance of Northern scientific institutions about South specificity, there are scientists concerned about the necessary evolution of the research and development system all around the world. Those have to be encouraged to be part of the process. Scientists always have been part of the societal evolution, but they have been used through their results rather than involved in the definition process of developmental models.

Scientific collaboration is having a positive impact on the ability of developing countries to participate in the world of science. Economic growth and social welfare are also benefiting as a result of these activities. However, it is clear that this chain of events works best when some enabling environment is in place at the start of scientific collaboration.

The productivity and return on scientific and technological investments, in developing countries, is most likely lower than the same funds spent in developed countries. It can be observed that scientific spending in advanced countries results in greater economic externalities than funds spent in developing countries. Therefore, it seems an imperative step for the developing countries to allocate adequate funds to the projects aimed at building scientific and technological capacity.

The potential of mutual participation among developing countries hinges on the fact that the activities planned ought to be of equal interest and benefit to each stakeholder. This would then ensure a proportional effort and resource-allocation by the beneficiaries, and thus would ultimately result in the achievement of individual and collective goals. Each member of the society should have a participative control over the allocation and spending of the resources, financial or otherwise.

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# 13. REVITALIZING SCIENTIFIC COMMITMENT FOR DEVELOPMENT IN PAKISTAN

The universality of science as an ever-growing and useful phenomenon is a globally accepted idea. As a vehicle for development and prosperity, science has never deserted mankind. In fact, it has always provided humanity with the means to grow through applicable and implementable solutions for complex problems, and has served continually as an instrument for building the prosperous world that we have today. Science has also contributed to the current environmental, social and economic predicaments faced by humanity at the dawn of the 21st century; however, it is unanimously accepted that it is the use of science and not science itself that have allowed for these global challenges to come up. Needless to say, the importance and significance of science, along with its pivotal role in the development, growth, productivity and prosperity of the world, cannot be undermined at any stage.

## 13.1 BACKGROUND

Keeping in view the centrality of science in the development of the world and acknowledging the many blessings that it has bestowed on humanity, an "International Science-Day" is celebrated globally on the 10th of November. The United Nations Educational, Scientific and Cultural Organization (UNESCO) decided to celebrate this day, in commemoration of to the momentous and significant contributions of science in shaping our world in a progressive manner.

Adding to the knowledge of many is the fact that UNESCO took up this matter formally on the initiative of renowned scientist Dr. Ishfaq Ahmad N.I., H.I., S.I., who was the then Chairman of Pakistan Atomic Energy Commission. Dr. Ishfaq approached the Foreign Office of Pakistan as a first step to arouse awareness on the absence of such a day and the significance associated with it. In his continued efforts for this cause, Dr. Ishfaq approached different United Nations' Departments and Organizations, highlighting the importance of an "International Science Day". In this regard, he also contacted Dr. Atiya Inayatullah, the collaborating force behind the strong Pakistan and UNESCO ties, and apprised her of the situation. COMSATS in its own capacity played a part in this important cause and contacted various pertinent organizations for the promotion of the concept of Science-Day.

Due to Dr. Ishfaq's tireless efforts and effective presentation of the significance of the science-day, UNESCO finally agreed to mark the importance of this pivotal phenomenon with a formal day. The theme for this year's Science Day has justly been denoted as –

Science for Development. Dr. Ishfaq envisioned that this day would not only be a symbolic commemoration of scientific achievements, but would also serve as the base from where planned and continuous scientific ventures may be launched, thereby contributing to and strengthening the scientific base of developing countries, especially Pakistan.

### 13.2 INTERNATIONAL SCIENCE-DAY

The purpose of celebrating an International Science-Day is not to spur typical festivity, but to make good use of the hype created by the celebration of the day, by projecting science in a progressive and positive manner. The idea is to highlight the mammoth contributions of science, in leading mankind to the path of prosperity, and to emphasize the role that science can play, to serve as remedy for the global challenges and problems faced by humanity in the 21st century.

At the International Science-Day, scientific meetings amongst high-level scientists and technical people must be held, in order to ascertain and evaluate present scientific scenarios and pertinent means to develop this phenomenon through active inculcation in the society. The day must serve as a moment of revitalization of the present scientific situation in the light of thorough and meaningful assessment and analysis.

### 13.3 WHAT SCIENCES TO CATER FOR

Science is beneficial and useful to mankind in all its facets, kinds and types. However, since many developing countries, such as our own, have limited human and material resources to work with, therefore a selective approach is required. A priority-list of types of science that must be catered for with full strength and dedicated resources should be devised, in order to achieve maximum, output from scarce resources. For countries like Pakistan, science must bring solutions, to real-life socio-economic and environmental problems and should cater to the needs and requirements of the day and beyond.

For this reason, science must be viewed as need-driven rather than anything else, when it comes to the formulation of priority list for a country. The idea is to understand and keep in mind the needs and wants of the end-users, who shall ultimately benefit from the science being considered. A systematic “need-analysis” of the country needs to be undertaken, whereby key areas of pivotal importance to the society may be quantitatively identified and catered for accordingly.

Any such analysis is not possible through conventional means currently being employed in Pakistan. This is because conventional means are too slow, outdated and outmoded to accurately ascertain the desired results. The need is to inculcate Information Technology and media-channels of the country, so as to correctly and precisely determine the areas of pressing concern.

The nature of science conducted may be either applied or basic in nature. However, basic science without a particular direction will be of no help to the need-based science cause. There must be some vision in mind and some direction in sight, so that the ultimate result may be close to what was envisaged – more than expected, but no less than that.

## 13.4 SCIENCE IN PAKISTAN

Pakistan has absolutely no dearth of talented, skillful and dedicated scientists. Their caliber is deemed no less than that of the scientists from the International community. It is their impressive work that speaks high of their potential and immense talent. Heartening to note is the fact that Pakistani scientists have done considerable work in both basic and applied sciences; however, as they were delegated more work in applied sciences, much of their work has remained concentrated at this front. It is to the credit of these scientists that with the limited amount of human and material resources available, they have successfully completed most of the projects handed over to them. Projects pertinent to health, defense, agriculture and industry were completed in a reasonable fashion; of course better results could have been attained with the provision of proper infrastructure, training, financial resources, etc, but still, the produced results were able to make some headway towards the prosperity and development of the country.

It is common knowledge that the future of a nation lies in its coming generations. To the discomfort of many, Pakistan's breed of young scientists find itself in disarray, as there is no formal platform from where they can be guided with regard to their subjects and particular field of interest and study. There are several academies, in terms of infrastructure, available to cater to their needs, but there is no proper mechanism to allow proper grooming and thorough breeding of these young scientists. These people need guidance, which is not being provided to them in a sustained fashion. One such positive initiative, however, is the "Physics Talent-Contest" which was initiated by the PAEC, and draws huge number of young scientists, specializing in physics from all over the country. The success of this contest, however, must be consolidated in terms of more contests on separate branches of science, such as mathematics, chemistry and biology, so that the simultaneous prosperity of various disciplines of science may be achieved.

Science is a subject that cannot be understood or practically put to implementation in sheer isolation from the external environment. For the true development of science, a conducive environment must be established, whereby variable facets causing uncertainty and imprecision may be tackled. These facets are not only proper facilities and infrastructure, but also requisite socio-economic climatic conditions that affect science in all respects. It is integral to the promotion and prosperity of science that scientists be allowed to travel freely between various countries, regardless of them being friend or foe. International scientific platforms are the key to mutual sharing, learning and projection opportunities; frequent visits to such places allow for thorough understanding to develop through effective communication. This also helps to transform scientists of different countries into ambassadors of peace, which is yet another challenge confronted by many countries today.

It is a general perception that scientists are viewed as mere problem-solvers and are expected to deliver at all times. The need of the hour is to start considering these scientists as human beings as well. In fact, scientists are an even more sensitive breed of human beings and therefore, they must be treated in a preferred manner. Many developed nations owe their status of development to the respect and preference that they give to their educationists and scientists. It is high time that countries like Pakistan realize the need to appreciate, savor and respect the enormous amount of work done by its scientists, and give them their due place in society as highly respectable and dignified, socially and economically sound individuals.

## 13.5 CONCLUSIONS

It is in the interest of our country in particular and the world in general, that new approaches to scientific perspectives be introduced. This is inevitable for the realization of precise and accurate problem-area identification and requisite implementable solutions to social, economic and environmental predicaments, for continued growth and development.

Science is an evolutionary process, not a revolutionary one. Systematic steps amalgamated with proper and thorough planning must be taken to achieve the desired results. However, these results do not have a definite pattern of occurrence. Some results come quickly, while others take their time. It is due to this trait of science that it manages to find itself comfortably inculcated and naturally adjusted in the minds and hearts of targeted people and in the environmental setup offered to it. Nonetheless, dedicated efforts on the part of the government and at individual levels is a prerequisite to all these endeavors. Otherwise the celebration of an “International Science-Day” shall remain no more than an artificial direction-less and spirit-less ceremony.

## 13.6 FOR FURTHER READING


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## Chapter Four

# NEW TECHNOLOGIES: KEY DRIVERS OF PROGRESS AND PROSPERITY

# 14. SUSTAINABLE DEVELOPMENT AND INFORMATION-TECHNOLOGY

Information-Technologies model the reality in such a way that vital information can be efficiently located and made accessible to the decision-makers in a useful and presentable form. There still is a need of standardization of nomenclatures, interchanging of formats and languages, in order to accelerate the communicability of information, so that it may become useful for any decision-maker or for the public.

But at times, this process of standardization or modeling increases the errors in interpreting the reality, which can lead to unsustainable decisions. However, the growing velocity of communication-exchanges and the power of recent information-technologies will probably reduce the standardization-needs in time and allow a communication of less biased information, that is more accurate for a better decision-making process.

## 14.1 INFORMATION IN RELATION TO SUSTAINABLE DEVELOPMENT

The issue of sustainable development is at the heart of society setting the future course of humanity on the planet. This article argues irrespective of technological change -- more powerful computers, satellite monitoring, even artificial intelligence-- the issue of sustainable development will remain essentially the same in the high-tech future. The concept of, as opposed to the term of, "sustainable development" is not new; the profound and complex problems subsumed by the term can be traced back to the earliest human civilizations and to the perennial tension between population-growth and economic development, on the one hand, and the use of natural resources and ecosystems on the other.

The term "sustainable development", however, is a recent invention, having come into common usage recently. For example, the Brundtland Commission, which is responsible for most frequently cited definition of sustainable development, states it to be the process “to meet the needs of the present, without compromising the ability of future generations to meet their own needs".

The concept of sustainable development can be broken into two parts. On the one hand, "sustainability" relates to the question of the "carrying capacity" of the earth, while giving no attention to social issues, particularly those concerning equity and social justice. "Development", on the other hand, would appear to assume and even necessitate continual economic growth and ignore the question of ecological constraints or "carrying capacity". When these two concepts are put together, a very different one emerges, and the result is much more than the sum of the parts.

It is therefore, a multi-dimensional concept, and it must be addressed at various levels simultaneously. Sustainability may be divided into three types: social, ecological and economic. The ecological definition is perhaps the clearest and most straightforward, measuring physical and biological processes and the continued functioning of ecosystems. Economic definitions are sharply contested between those who emphasize the "limits" to growth and carrying capacity and those who see essentially no limits.

In the narrowest sense, global sustainability means indefinite survival of the human species across all the regions of the world... A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival... the broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity.

## 14.2 IMPACT OF INFORMATION-TECHNOLOGY

The development of novel and affordable information and communication technologies, and the emergence of informative society with new economic models, has the potential for making major contributions towards sustainability of the earth's ecosystems. Innovative use of information technology offers substitutes for travel and for the transportation of goods, and a major shift towards less resource-intensive production, consumption, trade, and services. Such changes can significantly reduce the environmental impact of industrial and commercial activities and thus contribute to sustainable development.

Today's information society is being built on technology, knowledge and intelligence. Information technology (IT) empowers both people and machines with it, which is transformed into knowledge and intelligence. Appropriate use of the knowledge by both people and machines contributes to sustainable development. While informed and empowered people know their role as citizens in an environmentally sustainable society, empowered machines have the knowledge to minimize energy, material use, wastes, and pollutants.

Information technology facilitates fast, cheap, equitable, and resource-efficient access to information, accumulated knowledge, learning opportunities, and co-operation support tools for its citizens. Internet, today's cyberspace, facilitates people from across the globe to co-operate and perform various activities of human life. Processing, storage, transmission, and sharing of information in electronic form, without any spatial or temporal constraints, empower people with instant information on desired areas. Information analysis contributes to knowledge and intelligence, which have increasingly become commodities in the information age. As information becomes accessible to anyone, and anywhere, it is becoming a basic economic resource and a structuring factor in today's society.

Miniaturization and innovation in electronics has equipped machines with intelligence and communication-technologies, enabling them to collaborate with each other. By empowering machines, IT offers a high potential for making a positive contribution towards sustainability of our economy and environment, basically by reducing the impacts arising from manufacturing and transportation activities. However, such opportunities are emerging in various other sectors too. The potential of employing IT tools in various sectors to bring about sustainable development is given in the next section.

## 14.3 POTENTIAL OF IT TOOLS IN SELECTED SECTORS

- **Manufacturing**

Using computer-integrated manufacturing (CIM), all-encompassing approaches to managerial and work-based organisational integration in manufacturing are being made. The system can supply important inputs to general business-management, and identify opportunities for less usage of energy, material, and wastes. Computer-aided designing (CAD) can help in reducing product development cycle. Virtual reality simulation can be used to speed up test methods.

- **Transport**

Tele-working and tele-commuting can be acceptable substitutes for local and long-distance travel. Microprocessor engine-control systems can save fossil fuels and reduce pollution. Advanced transport tele-matics (ATT) can improve transport-efficiency and road-safety. Intelligent transport-systems can reduce travel time, improve traffic flow and help to make it safer.

- **Agriculture**

Sustainable food-system benefits the responsible usage of resources by farmers who perform a wide variety of tasks as part of crop management. These tasks can be facilitated by experts system with the knowledge, designed and built with the help of local expertise. Land information-system prepared using geographic information-systems (GIS) and remote sensing can help farmers plan their activity and facilitate decision-making and planning at the local level.

- **Environment**

IT systems can provide improved access to environmental information for citizens, authorities at every level, NGOs, and businesses for environmental monitoring and management. GIS and remote sensing can be used to map resources, land-use patterns and environmental factors. This could help to bring about more effective planning, management, and decision-making with regard to the environment.

- **Education**

Video conferencing and other collaborative working tools can be used to access teachers at distant and remote areas. Multimedia teaching-packages can be used for formal and informal education. On-line courses using Internet can be used, with no constraint on distance separating the teacher and the student.

- **Others**

Saving paper: Electronic information-processing and dissemination can save the forests. Arresting urbanization: Ready and adequate access to information, knowledge, and telecommunications in rural areas would discourage urbanization.

Tele-medicine: Tele-medicine can provide medical care to people in their homes, and to patients in remote areas.

Empowering citizens with information: By creating suitable contents on cyberspace and making it available at info-kiosks in their close proximity, preferably in the local language and covering local issues, will empower citizens with the knowledge to help bring about sustainable development.

## 14.4 VIEWS ON THE ENVIRONMENT

Each of the four major views of the environment—all based on solid assumptions—is described briefly below:

- **Nature is Robust**

The environment is seen to be very forgiving of human impacts and is virtually inexhaustible as a resource-base. Represented graphically, it can be shown by a ball rolling inside a steep-sided basin, where, no matter what changes affect the system, it ultimately returns to the bottom of the basin. In its purest form, this myth views global environmental change in terms of a positive challenge; as new opportunities for human ingenuity. It is assumed that green technology, will prevent, correct, or even restore, any unanticipated damage to the environment. This is essentially an individualist view of the world, in which the invisible hand of markets are seen to be the only necessary regulatory mechanism for the system. This view is broadly supported by many activities in business and industry.

- **Nature is Fragile**

The environment is seen to be vulnerable to irreversible collapse, due to ecological degradation or natural resource exploitation. Graphically, it can be represented by a ball precariously balanced on an upturned bowl. In its purest form, this myth views global environmental changes as a manifestation of the multiple negative human impacts on the environment. It is assumed that a continued advancement along society's current materialist path will ultimately lead to the irreversible destruction of the planet. This view is an egalitarian one and has been embraced by the deep ecologist movement, which suggests that a fundamental transformation of contemporary society is necessary; either through the return to the frugality of traditional societies or through the creation of a universal "earth ethic" with strict moral principles. Fragility images are also used by other groups.

- **Nature is Robust Within Limits**

The environment is believed to be resilient within identifiable limits that must, however, not be surpassed. Graphically, the ball is most likely to remain at the stable point at the centre of its system, but the shallow sides of this depression cannot exclude the ball from being bumped over one of the edges. This view is essentially a hierarchist one, which assumes that ecological degradation and the abundant use of natural resources need to be carefully monitored and managed by a specific body. It assumes that global catastrophe can be avoided through the accurate scientific understanding of ecological limits and the establishment of standard operating procedures. This view is particularly acceptable amongst some governments and the United Nations system, which envisage a type of global bureaucracy to manage the environment. Economic growth can be maintained through rational management.

- **Nature is Chaotic**

The system is seen to be essentially chaotic and unpredictable. Graphically, the ball indiscriminately, moves on a flat plane, devoid of vertical perturbations, continuing on a flat plane forever (there are no edges to fall off). Meaningful or significant change is impossible. This is the most fatal view; life is like a lottery: It is driven by luck, not skill. For obvious reasons, proponents of this view do not often articulate their views, because management strategies, in any common sense of the word, are reduced to just surviving as best one can.

If one of these four views were actually the correct one, it can be assumed that eventually all opponents would be converted to that belief-system simply by experience and the occasional surprise. Yet, among the competing views, although they wax and wane, one never obliterates the others, nor does any view simply fade away - they persist. *Instead, the fact that we continue to be surprised, suggests that the natural world has many ever-changing faces, fitting each of the different views at different times.*

Various groups hold different perspectives on "sustainable development". Each of these views is given as "proof" for the necessity of a particular strategy or action. Opposing interpretations are rejected. Other views are not seen as simply misguided, but are instead perceived to be blatantly wrong and threatening. Many people who adhere to a particular view of the environment --although they might deny this categorization - are so firmly (or blindly) committed to their own view that they refuse to recognize competing views as having any legitimacy. *We need a more open debate on sustainable development; one which is based on the rejection of a single world-view or environmental strategy*. *There is validity in each viewpoint, and each is correct in different contexts*.

## 14.5 THE TRANSLATION-TOOLS OF INFORMATION-TECHNOLOGY

We will concentrate here on 'translation' tools that would have a positive effect on the communication for a more sustainable world.

### 14.5.1 The Information Paradox

The structure of information interchanges everyday on the Internet with a view to the future. Standardization seems to be one of the crucial points of today, immediately. If English is already the main key language of the Internet, the system is evolving to the use of metadata standards in the header of each document, in order to allow the search engines to find the relevant information from the users point of view.

Each language is a model of the reality that reflects its culture. The modelisation of the reality through information accelerates the possibility to manage it. More the real world is modelled, quicker is the management of information and so is the response and further impact on reality. But also, further the answer from the reality, bigger is the risk of error. This information paradox can not be solved, but we will see later that information technology could help to reduce its size.

### 14.5.2 Information Communication Today and Tomorrow

This implies that to allow communication for sustainable development today, it is necessary today to improve:

- Information storage and processing infrastructure
- Communication channels and terminals (80% of the world's population have no access to the telephone)
- Interactive communication efficiency and velocity
- Standardisation (of data, of metadata, of interchange protocols and formats)

The two first points will depend on:

- Reduction of the costs of IT
- Policy of equal distribution between the rich and the poor

The evolution of the IT market shows a drastic reduction of the costs implied (if compared with their performances): telephone terminals and televisions are now accessible for average villages in Africa, radio receivers are accessible to individuals; but computer or Internet terminals are already too expensive for the poorest people, even in the richest countries. The costs of telephone lines are however too high for mainly African users, and already cut them off from the digital information sources.

## 14.6 INFORMATION-TECHNOLOGY—ISSUES AND CHALLENGES

The rapid development and use of information and communication technologies are causing major repercussions on all aspects of the private and public life all over the world. This development is changing the traditional ways of functioning of our contemporary societies and is providing new opportunities and challenges for all. This situation makes it important for developing countries to keep abreast of the new ethical, legal and societal issues and opportunities offered by the Information Society.

### 14.6.1 Societal and Psychological Challenges

- The analysis of impact of IT focuses on both structural changes and changes for the individual at work and on his role as citizen. The main humanistic focus is on possibilities and prerequisites, related to IT, for influencing one's own life-conditions, for social belonging, for a meaningful life-content, and for learning and developing oneself.
- The Information Gap: Looking at our society as a whole, there are noticeable inequalities or "gaps" in the distribution of Information and information-technology. For various reasons, some people appear poised to garner greater benefits from technological advances than others. Observers have pointed to gaps that appear along several dimensions, including socio-economic status, income level, ethnic background, gender lines, or geographic gaps. Domestically, the geographic gap refers to a division between our urban metropolitan areas and rural regions. On an international level, it refers to the inequitable global distribution of technology and information. In other words, some nations have enormous technological prowess and capabilities, while other nations simply do not.

### 14.6.2 Ethical

There are many unique challenges that we face in this age of information. They stem from the nature of information itself. Information forms the intellectual capital from which human beings craft their lives and secure dignity. However, the building of intellectual capital is vulnerable in many ways. The ethical issues involved are many and varied; however, it is helpful to focus on just four.

*Privacy:* What information about one's self or one's associations must a person reveal to others, under what conditions and with what safeguards? What things can people keep to themselves and not be forced to reveal to others?

*Accuracy:* Who is responsible for the authenticity, fidelity and accuracy of information? Similarly, who is to be held accountable for errors in information and how is the injured party to be made whole?

*Property:* Who owns information? What are the just and fair prices for its exchange? Who owns the channels, especially the airways, through which information is transmitted? How should access to this scarce resource be allocated?

*Accessibility:* What information does a person or an organization have a right or a privilege to obtain, under what conditions and with what safeguards?

## 14.7 DISCUSSIONS

As information technology becomes increasingly indispensable for the development of society, the Developing World in particular can least afford to squander the vast opportunities presented by the ongoing information-revolution. Faced with globalisation and the fact that IT has been proved to be the engine of development, the question if the IT is applicable to less developed regions, rather the critical question is how should the developing countries adopt the new information technologies in order to meet the economic development challenges?

Our rationale for participating in the information age is simple and strong: unless and untill developing countries become full actors in the global information, they stand the risk of being excluded from the emerging global economy or suffering severe disadvantage in the competitiveness of their goods and services. Participating in the information-age offers many opportunities for developing countries to "gain time on time"—to leapfrog over past development-deficiencies into the future. A sizable number of developing countries have already made progress in their Internet links that have put them on the global connectivity roadmap.

Development can be seen as an increase of knowledge and skills and creative potentials that can be applied to improve the quality of life. Research shows that low levels of knowledge and inadequate innovative skills at lower, middle and higher levels have contributed to the continuous failures in African countries in all spheres. Information and knowledge are interrelated. Well-informed, knowledgeable and innovative citizens are the main causes for human centered development. Information technology facilitates the flow of knowledge in a modern society. Observing the impact of information-technology on economies, a developing block cannot afford to persist in a state of information-poverty. Information technology, if properly harnessed, will help to bridge the information-gap and will give impetus to faster development in virtually all sectors.

Information technology can improve economic performances, expand and sustain health-services, promote education and research, enhance food-security and gender-balance in development, strengthen and diversify ties with trade partners, invigorate culture and tourism and alleviate man-made crises and natural disasters. In the area of human capital development, for instance, the system of education in many Developing Countries suffers from serious shortcoming, including low teacher-student ratios; limited availability of instructional material; and poor quality of education, related to inadequate funding and inefficient use of available resources.

Information technology offers a wide range of low-cost solutions, for instance, distance education gives its flexibility and suitability for its widely scattered student-bodies, particularly among rural schools where both teachers and students have no access to libraries, reading materials or communication with the outside world. Clearly, although ICT will not bring development overnight, it will certainly permit those who use it to be players in the world economy.

Information technology has created challenges and implicit solutions. The challenges involve adaptation of the technology to needs and the implied solutions are the possibilities of using the technology to attack the perennial problems of underdevelopment: poverty, low-productivity, inequality and environmental degradation. Though there is now a growing recognition of the far-reaching impact of telecommunications and networking on the economies of Developing Countries, a number of problems restrict its diffusion through public institutions. It includes socio-economic problems crippling equal access to information and communication technologies: the resource at the disposal of governments are mostly directed to deal with emergencies, with little left for long-term investments in sectors that could trigger socio- economic development. Education, information and communication are some of the sectors that need immediate attention for development in Developing Countries.

The absence of an efficient telecommunication infrastructure: though most of the countries have established Internet links, access is mostly restricted to the capital cities and it is extremely expensive mainly because of the inefficiency/inavailability of telephone services. Those in rural areas remain electronically isolated. Ironically, as a result of the quantum leap in technology, the inadequate state of telecommunications in many of our countries can be transformed into a great advantage if properly managed. The fact that the telecommunications sector is lacking in both coverage and density means that the country is not over burdened with extensive networks, built on obsolete technology, so they can push to the cutting edge by ensuring that new infrastructure is based on the latest technology. The inadequate policies and incompetence of telecommunications management in most countries blocks achievement of the right to communicate socio-economic development and universal access.

The high cost of computers and software represents another serious impediment. But experts in the field suggest that bare-bone computers and stripped-down software perfectly serviceable for Internet connections, word processing, and graphics can be built today for a price, which is many times lower than current prices. And one way to induce producers to comply with such requirements is 'bulk-purchasing', which should be feasible for the given potential market-size of Developing Countries.

Unfortunately, most developing countries do not have any explicit plans or policies on information technology. The acquisition of information technology and software is a result of isolated initiatives, without preconceived strategies and policies with little coordination and planning. There is thus, a pressing need to devise clear national and regional long-term strategies and policies that cover the acquisition of information-technology, its enabling environment and its applications. The strategies should quantify the investment-requirements of the countries and identify the required changes in institutional, training, legal and regulatory frameworks that will foster the development of the information-societies in the region. Such strategies would also serve as an explicit recognition of the challenges of the information-technology and in instrument for attracting and coordinating donor-assistance in this domain.

Entering into the information-age is not only about getting connected to the Internet and receiving information from the rest of the world. Developing Countries should have the material that will travel in the opposite direction, if they are to be benefitted from the global information-system. Thus, national institutions responsible for data-collection and processing need to be strengthened and their information collection and dissemination structures modernized. The local content of information would need to be developed, even at rural community-levels in as many languages as necessary, according to the given pluri-linguistic and multicultural nature of many Developing Countries. This will encourage participation and speed up information-diffusion to benefit the majority of people. Information exchanges among developing countries would need to be encouraged. Sub-regional information-systems would need to be developed and improved, to provide meaningful backing to national efforts in this area.

Equally important is the question of sustainability. It is pertinent, therefore, to invest in low-cost and locally adapted solutions, such as the use of solar-driven appliances. It is also important to make the users pay, from the very beginning, for the services they receive.

Measures to expedite Developing Countries' entry into the global information-system must also address factors constraining the development of the information-infrastructure. Reviewing the regulatory frameworks is important, to encourage private participation not only in cellular telephony, but also in the operations of the state-owned telecommunication enterprises. Removing legal and regulatory barriers from the use of information and telecommunication technologies would promote interest on the part of the private sector.

## 14.8 CONCLUSIONS

The promises of various socio-technical progresses of information-technology (from the networking to the translation tools) is a chance for global sustainable development, if the society really wants equity and finds a way to solve the possible interest-conflicts mentioned above.

It would be the ideal situation for sustainable development if somebody could speak to anybody using such a language that he/she can be sure to be understood, and take decisions knowing exactly what would be the effects of this decision on the present and future environment or societies.

Developing information-technology is a way to improve the decision-making process to be more reliable and less risky in its results, because it would accelerate the way of making reliable information from ground-measurements, and allow more transparency in the modelling processes. Higher the communication-capacity, higher the potential of humanity's sustainable development. Information-technology gives powerful tools – and no solution - for sustainable development.

## 14.9 FOR FURTHER READING


- *"Sustainable Development and Information Technology', http://www.acca21.org.cn/sd-it.html*
- *"Information Technology for Development", http://www.iospress.nl/html/02681102.html*

# 15. INFORMATION-TECHNOLOGY AND CONTEMPORARY MEDICINE

## 15.1 DEVELOPMENT PHASES OF INFORMATION-TECHNOLOGY

The process of information-exchange has passed through different phases during the long history of human civilisation. In the beginning, useful applications were made of smoke signals, cave drawings and quill pens, with a view to exchange information from person to person and place to place. Centuries afterwards, a significant development in this regard took place with the invention of a printing press, which can perhaps be called the earliest form of “Information Technology”. This was the first solid evidence of the development of a tool for mainly expanding and speeding up the distribution or transfer of information to far-flung areas and to a large number of people and places. Substantial time passed by, till another worth-mentioning development took place in this direction. The development, which followed, changed the whole concept of the process of exchange of information. This important phase in the history of Information-Technology is due to discovery and applications of newly developed tools, such as electricity, telegraph, telephone, wireless, radio, television. It was quite noticeable that history of information went through drastic and sudden changes. Every discovery of a new process or invention of a new tool/gadget was followed by a development in the field of Information Technology. The form/mode of flow of information changed its shape from written words of printing materials to audio signals received through telephone, wireless and radio/fax. Much more comprehensive exchange of information took place in the form of visual signals of television. During this important change in the mode of information-transformation, it was noted that flow of information was making a much greater impact on the recipients, as compared to previous technologies.

No worthwhile further development could be observed in this process for a long time till the development of an important machine, called the ‘computer’. Computers not only transmit information from one place to another and from one source to another, but also, more importantly, with the help of computers the information could be transmitted in a more organized way and could be manipulated/reshaped according to the specific needs. This was perhaps the first useful combination of ‘information’ and ‘technology’, which ultimately resulted in what can be justifiably called, the “Information Age”.

Before we proceed further, let us briefly define the term ‘Information Technology’. The ‘Information’ is a data or fact, that can be stored, retrieved and manipulated. A simple definition of ‘technology’ can be given as: the application of scientific knowledge to design, produce and use products and to develop new/better devices/ services with a view to enhancing the human potential and capabilities (refer to Figure-15.1).

**INFORMATION-TECHNOLOGY**

**Information:** Data or Fact that can be stored, retrieved and manipulated.

**Technology:** The Application of Scientific Knowledge to Design, Produce and Use Products and services for the purpose of extending the Human Potential to improve and control the Natural and Human made Environment.

**Information-Technology:** A Set of Tools, systems, techniques and knowledge developed to solve problems invoving and utilizing information.

**Figure-15.1: Definitions of 'Information', 'Technology' and 'Information Technology'**

"Information Technology", can thus simply be defined as a set of tools, products, processes, techniques, expertise, which can be used to solve problems involving and utilizing information. Information Technology can also help in the further refinement of the flow of information during the retrieval and utilization of information.

## 15.2 MAIN DISCIPLINES OF IT

Information Technology is actually not a single subject, rather it consists of a number of disciplines. There are three main disciplines, namely: Information Systems, Computer Science and Information Engineering (Figure-15.2) **[1]**. Information-Technology deals with both software and hardware. Also, the subject matter is both machine-oriented and people-oriented.

### 15.2.1 Information-Systems

A simple definition of an "Information-System" is the system that studies the effects computing systems may have on people, set-ups and organizations. On the other hand, "Computer Science" and "Information Engineering" are relatively technology-oriented disciplines. The "Information Systems" deal with questions such as why some systems are more successful than others and using this knowledge to plan new systems which are likely to be the most successful. In these studies, it is assumed that the systems are

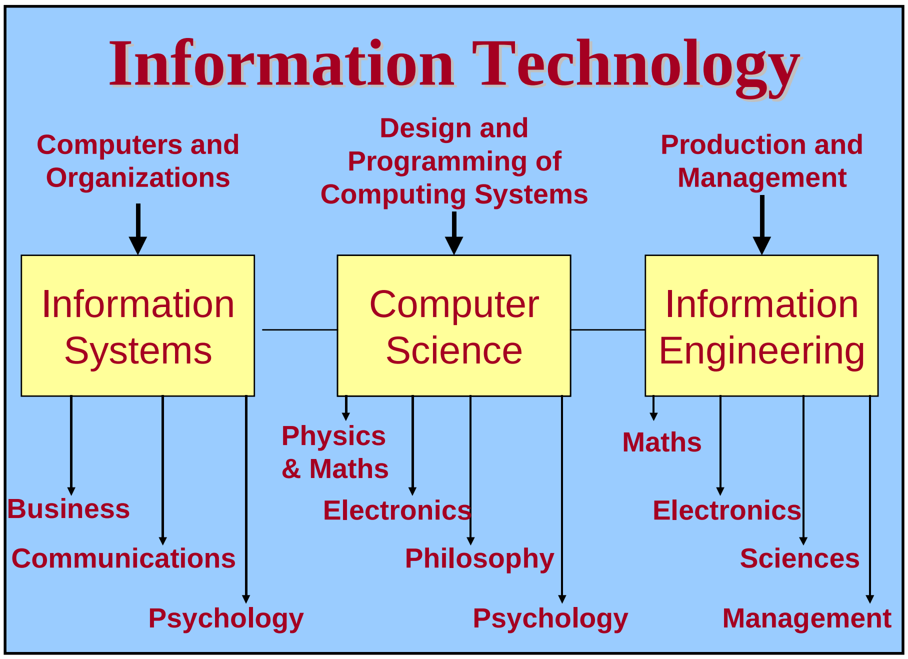


**Figure-15.2: Information Technology, its main Disciplines, and the Basic Subjects.[1]**

technically sound and the emphasis is to find out the best possible steps to integrate these systems into a work-place, according to the maximum satisfaction of the actual users. From the foregoing brief description of an "Information System", it is quite clear that this branch of "Information Technology" deals very little with the programming and is concerned more with the human and business aspects (Figure-15.2). It may also be pointed out that the mathematical requirement in the study of "Information Systems" is relatively minimum, when compared with the other two disciplines of Information Technology, i.e. Computer Sciences and Information Engineering, where knowledge of Physics and Mathematics plays an important role.

### 15.2.2 Computer Sciences

This branch of Information-Technology deals with the devising, building and programming of Computing-Systems. To this end, one has to study not only the underlying computer-hardware but also be well-versed with software aspects, i.e. the programming of the systems. The study of Computer Science is based upon five essential subjects, namely, Physics, Mathematics, Electronics, Philosophy and Psychology (Figure-15.2). In psychology, the knowledge of a subject known as Human-Computer- Interaction (HCI) plays an important role. The HCI is an extremely important factor in the design of a computer-system. Therefore, this branch of computer-science requires not only deep study of computing discipline but also takes into account human psychology and perception. Based on these two important factors, the design of a computer system is made which is not only technically sound but also is user-friendly. Of course, programming is an important part of computer science. However, experience shows that programming is only a part and not everything. Through programming, we carry out different types of tasks on a system and make it work according to certain instructions pertinent to a particular job / assignment. Certainly, programming is an extremely important part of computer-science as can be judged from the following statement:

"Programming is to computing as chemistry laboratories are to chemistry" However, as mentioned earlier, there is much more in computer science than mere programming.

### 15.2.3 Information Engineering

"Information Engineering" mainly deals with industrial application of Information Technology. Normally, information and telecommunication-engineering work on combined knowledge, based upon electronics, communication, computer engineering, signal processing and mathematics, etc (Figure-15.2). Now-a-days, electronic systems carry out functions such as computing, processing and analyzing, storing, distributing and displaying the required information. Important examples of information, telecommunication and engineering are: Internet, a CD player, video recorder, a Tele-text, a cell phone.

From the foregoing discussion, it is quite clear that engineering aspects in information-technology are fairly different from its scientific aspects. It is particularly worth mentioning that the main focus of engineering is on the practical application of technology i.e. to carry out design and production in industrial environment. It is, therefore, clear that engineering aspects of information technology are based on scientific/mathematical knowledge, as well as on technology and management.

## 15.3 WHY INFORMATION TECHNOLOGY?

In the twenty-first century, cost-effective communication-infrastructure and information-systems are not just luxuries, but a necessity. In fact, they are strategic factors critical to the development-process and to poverty-reduction. Information Technology has become the "Knowledge Tool" which is essential for the management of a country's economics. By involving IT, governments can transport, store, retrieve and disseminate information far more efficiently and hence improve the productivity of their nations.

Information Technology is perhaps one of the most dynamic and creative branches of present technologies. Experience shows that there is a continuous supply of new

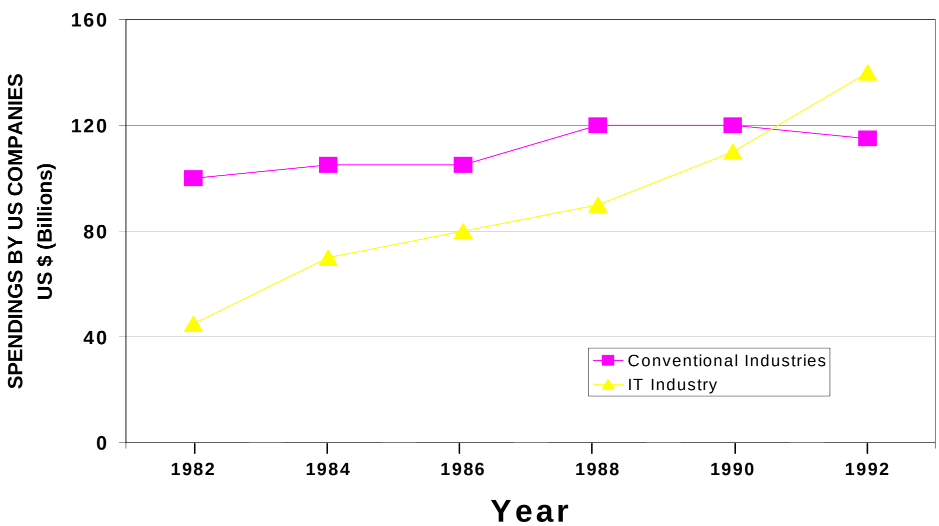


**Figure-15.3: Variation of Spendings by U.S. Companies on 'Conventional Industries' and 'Information Technology' in Different Years in the Past**

problems. These problems are not only new, but also time-targeted. Not only that these problems are to be solved immediately but it becomes even more complicated because both technology and problems keep on changing with time. Apart from having a thorough knowledge of their fields, information-technology people are required to work alongwith experts in other professions. This is particularly true when the problems so arising belong to non-computing areas. All this shows that working in the field of information-technology, one never feels static. The challenges not only keep on changing, but also growing. Information technology is, therefore, particularly suitable to those who have creative minds and who love to face new challenges of this extremely fast developing technology of modern era. If, on the other hand, you can synchronize your thinking and work with the extremely dynamic nature of information technology, it is ensured that you will be offered unimaginable opportunities in the respective field.

It is interesting and remarkable that information-technology is not only extremely pervasive but also its history is recent. There is no doubt that in a short span of time information technology has reduced this world to a global village. Previously existing physical boundaries in education, commerce and communications have almost vanished. New scholarly, economic, political and spiritual alliances have been forged, due to the role played by information technology to access and retrieve the required information from widely distributed and diverse sources. Multinational companies and world-wide businesses exist due to the extremely useful role played by information technology. This is because of its enhanced communication-capability, increased access and streamlined financial operations. This has resulted in what we call today "High-Tech Industry". This stage of development owes a lot to the dramatic surge in the development of information-technology tools, systems and processing and some of the novel uses/ applications of the valuable information obtained by using information-technology. This entirely new segment of commerce has taken birth and has revolutionized the whole process of business and economy.

It may be mentioned at this juncture that cellular phones, personal computers, world-wide access, satellite delivery systems – some of the tools of information-technology used presently - are rapidly becoming interwoven in the fabric of our life style. Some of the important changes that have taken place include, information-access in terms of time and scope, change of mode of information according to the format one requires, and to learn, work and play according to time and place of our preference. In short, the impact of information-technology is enormous on our day-to-day living. It has changed the way we think and live.

Revolutionary advances in IT reinforce economic and social changes that are transforming business and society. A new kind of economy, the "information economy", is emerging, where trade and investment are global and compete with knowledge, networking and agility. A corresponding new society is also emerging, with pervasive information-capabilities that make it substantially different from an industrial society: much more competitive, more democratic, less centralized, better able to address individual needs, and more friendly to the environment. A hundred years ago, strong industrial sector meant an economically strong country. Today, information-revolution plays a pivotal role in any country's economic success.

In 1991, as the graph indicates (Figure-15.3), information-age capital-spending by US companies exceeded industrial-age spending for the first time. The same year, annual sales of personal computers exceeded 50 million units, as compared to 35 millions passenger cars world-wide. Using the right tools, companies can bring about efficiencies in their organizations. Entire enterprises, large and complex industries can only function smoothly if they are equipped with the right IT related tools. For example, financial-market transaction-volume, credit cards, e-commerce, online travel reservations, could not be possible without the use of information technology.

Technology is changing the today's world around us. And if we do not adapt the changes, we would be left behind.

## 15.4 PROLOGUE

The past few years have seen enormous changes in the way information is gathered, stored, moved, manipulated, analyzed, and disseminated. These developments in

Information Technology (IT) provide opportunities for both government and the private sector to rethink how they produce and deliver products and services, and in many cases to rethink what their basic function should be. Although the opportunities are exciting, there are also significant challenges for making new technology and ideas function. Two of the key challenges are: coping with the investment of time, resources, and stress to put changes in place, and dealing with the need for wide collaboration and cooperation, especially in a government context.

Information Technology deals with the mechanisms of managing information i.e. the mechanisms for gathering, storing, protecting, moving, manipulating, analyzing, and disseminating information. Although the phrase “information technology” generally brings to mind the stunning recent advances in electronic-technology, changes in storage and sharing of information have been going on for a long time. Printing, telegraph, telephone, radio, and television all expanded people’s ability to share information remotely, across times or across distances.

Recent and continuing developments in computers have enormously increased the ability to store information and to share it remotely. In addition, advances in computer software now permit various kinds of manipulation, analysis, and even problem-solutions to be done by computers through the techniques of artificial intelligence and expert systems.

Using information-technology is not simply a matter of replacing paper with computer-files, and person-to-person meetings with remote access to information and services. Therefore, Information Technology is moving to provide quicker, interactive access to information and services.

Point-of-Contact Data-Entry: Public-sector organizations as well as private-sector companies record data and information almost constantly. Generally, the information process involves -- one to record information and one to provide the information. Even other thought much of this information is destined to become part of an electronic record, a large part of the initial gathering of information is handled through pencil and paper recording of notes and other data, followed by transcription into an electronic form for further use.

Point-of-contact data-entry refers loosely to the practice of getting information directly from where it exists to where it needs to be stored/used. Therefore, organizations all over the world are implementing an amazing variety of innovative approaches to point-of-contact data entry, using information technology in one way or another. All of these approaches have saved time and resources, and in many cases have produced more accurate information.

Patient Care Notes: It is an already practiced phenomenon that hospitals place computer-terminals at the point of care (patients' bedsides) to allow nurses to enter information directly, thereby eliminating time to walk back to the nursing station, and reducing transcription errors. In addition to this, some point-of-care terminal can be linked to equipment, which monitors patient's vital-signs, so that accuracy and timeliness is further improved.

Information is critical to the provision of health care, and coping with that information is one of the major challenges that health-care providers face. The most primitive part of the health-care system is the part which helps individuals and families make wiser choices regarding their own care. Even in this challenging area, some communities are making progress. Some key examples of information technology at work in specific health-care facilities and communities include:

- Remote monitoring of patients at home
- Public access to personal-health information and assistance to common questions
- Access by specialists to images and other patient information, to assist physicians in remote or under-served areas
- Access by doctors in their offices to information on hospital patients
- Point-of-care data-gathering, instead of transcribing from hand-written notes
- Reduction of administrative expenses and errors from handling paper-based claims and managing inventory

This science has made the world smaller and allowed people to come nearer is now such an overworked truism that one would be hesitant to repeat it, except for the fact that the statement now means so much more than the ordinary speaker can actually visualise. We all know, and hear constantly repeated, that faster means of travel and communication have turned the whole world into a global village, and means of communication have become incredibly speedier and easier. But today has really revolutionised human life is the fact that these exciting developments in quicker communication are no longer limited to the affluent few, but have been brought within reach of the average citizen.

With the introduction of e-mail, communication costs and time have nose-dived. A person can press a few keys and send a letter to the other end of the world within hours or even minutes. Slow, unreliable postal mail is being replaced by instant, electronic and faster communication. and all at a cost of just few rupees.

Similarly, Internet connections have now made it possible to talk at length at a negligible cost with persons thousands of miles away. A video camera fitted at each end even makes it possible to see the speakers, so that negotiations can be carried out on a more personal level, and misunderstandings could be eliminated.

In the field of contemporary medicine, information technology is introducing fantastic advances that will soon change the entire present concept of health-care. One of the new developments made possible by information technology is Tele-medicine, among the true miracles of contemporary medicine. A patient living in Pakistan can now get himself examined and treated , without ever leaving his own country, by a doctor practising in any part of the world. Photographs and video films of the patient's injuries, abnormal growths, or other symptoms and problems are transferred within minutes to a foreign doctor for his expert assessment and treatment. X-ray films, ECTG charts, echocardiograms, and all other readings can be instantly conveyed to help the doctor to make as reliable a diagnosis as if the patient had been physically checked up by him. The extent of the closeness made possible through I.T. between patient and the far away physician can be imagined from the fact that a patient in one country can place a stethoscope on his chest and the doctor in another country can hear the sound via electronic channels, and there and then form his opinion about the nature and extent of the malady.

All this ads up to the opening of a wonderful new chapter of hope and relief in the lives of suffering humanity. It is no longer necessary in every case for the patient to go abroad for specialized treatment, when the same is available over the Internet. Forbidding travel- costs can now be eliminated and precious foreign exchange preservedas well as travel time is saved.

But what is even more important and gladdening is the prospect that patients who, because of the condition of health, might have found it painful or difficult to travel, can now obtain the best medical attention right inside their homes. This is a particularly great boon for people living in remote, inaccessible areas often deprived of health-facilities. Efforts are being made to take Tele-medicine to these far-flung places. A pilot project, for instance, has been set up in Skardu, while another is being established in the congested, neglected town of Gujar Khan.

Medical Transcription is another major step in international cooperation in the medical field. Doctors in the States like to maintain up-to-date files on their patients' visits: the physician's own observations on the patient's apparent condition, the latter's account of his symptoms, results of the examination carried out on that occasion, medication continued stopped, or changed, and all other relevant information. The doctors, used to pass on the data daily to local computer-firms to convert to text, but charges for these services were very high. An arrangement has now been made by Pakistani I.T. companies to obtain the voice files from the American doctors, it also saves time, as done in those hours when it is night in America, but daylight in Pakistan, so that when the work is sent back, it reaches on the morning of the very next working day.

For Pakistan, medical transcription creates wide employment-opportunities. Young doctors, particularly, can avail of the chance of useful and gainful employment in a rapidly developing field. The country's benefitted by the inflow of foreign exchange.

*WEB M.D.* is a very useful I.T. offering. This particular website makes possible direct discussion with doctors and specialists in different areas of medicine. *The Web Med-Conference* is an Internet website, where doctors of any specific field can "chat" with each other to exchange notes and share experiences, findings.

*Dentistry:* Information technology helps bring down medical costs in almost every field by the utilization of cheaper Third World skill and labour. The foreign dental surgeon can now transmit tooth x-rays and jaw impressions over the internet and get dentures made in Pakistan for less than half the cost that would be entailed in their making over there. For our technicians this means more occupational opportunities and the chance of earning good money. For the country it means another avenue of earning fastest.

*Ophthalmology:* similarly, the foreign eye-specialists will find it more economical to get glasses made in a Third World country where labour is cheap, and needs simply to transmit the required lens number and other specifications by computer, in order to get the spectacles manufactured speedly.

*Medical E-commerce* is another valuable source of foreign exchange for the country. Foreign orders for our medical supplies and equipment can be obtained and accepted speedily over the Internet and businesses can be expanded.

*Medical education*: Medical education was never more direct and vivid for the student than it is today, only due to information technology. Boring lectures and books describing the functions of the various organs of the body are being replaced by graphic videos showing the actual or simulated working of these parts in an easily, and immediately, comprehensible way. Gone are the days when students struggled to obtain unavailable and expensive books, and pored over them trying to memorize the dreary information they contained. Medical libraries are available in C.D. form to make study simpler and more effective, accessible and standards of medical knowledge it is hoped will consequently rise. Medical colleges throughout the advanced world are utilizing information-technology for teaching and examining students. The Royal College for Physicians and Surgeons has also adopted a system for examining the students on the Internet.

Information-Technology is the most momentous development of the preceding century and promises to revolutionize life in the future. Contemporary medicine making use of I.T can usher in a wonderful new era of international combined effort, which can lead to a golden age of cheaper, faster, better and safer medical care.

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# 16. INFORMATION-TECHNOLOGY IN THE ISLAMIC WORLD: PRESENT SCENARIO AND FUTURE PROSPECTS

The Muslim World as a whole falls far behind the West, particularly in the sector of Information Technology (IT). Unfortunately, we are in the pool of those countries which could be regarded as 'have-nots' of the digital world. The rapid advances made elsewhere also mean that the gap would be widening with the passage of time. To understand the pace of development, it would be useful to recall Moore's law which has proven to be true during the last two decades: it states that the processing power of computer-chip doubles after every 18 months. This is only one facet of the technical advances. There is a vast variety of other technical breakthroughs, which are changing the world around us in ways unimagined a few years ago. The connectivity of the people and businesses of the world through the internet is changing the way people think, work and do business. The currents and undercurrents of these phenomenal changes should not be underestimated; certainly should not be ignored.

It may well not be too late to realize the importance of the on-going Information-revolution and, without further hesitation, to go steam ahead. The starting points are, of course, the development of infrastructures: telephone lines, fibre-optic backbones, satellite channels, alongwith other hardware/software requirements and capacity building to generate & absorb the technological advances. These infrastructures and facilities will have to be provided to as large a section of population as possible. The revenues spent on these tools would ultimately help us achieve our long-awaited renaissance, since it is through these channels that we could hope to improve literacy-rate and economic performance.

## 16.1 INFORMATION-TECHNOLOGY IN MUSLIM COUNTRIES: PRESENT SCENARIO

Information-technology is one of the most important and promising technologies of the present world. Muslim countries simply cannot ignore this field, which is relatively new, yet involves working at the cutting edge of technology. It is now an important part of our daily living. It can be found in cars, in super markets and even in automatic machines of day-to-day use. It has a wide spectrum of applications, having science and engineering at one end, and diverse fields such as commerce, psychology, medicine, art and music at the other end of the spectrum. In addition to the above diverse applications, it has an added attraction for young graduates, to obtain financially rewarding and challenging careers with banks, large industrial complexes, computer companies and government departments. It is, thus, clear that Muslim countries should make all out efforts to acquire and master this important technology without further wastage of time. Proper planning ahead would not be possible without having knowledge of the prevailing situation of information-technology related development and status in Islamic World. This section attempts to present a comprehensive picture of IT in the Islamic World, with a regional perspective and country-wise status wherever possible.

Unfortunately, the situation in Muslim countries does not seem to be very healthy. There is no doubt that some countries are making serious efforts to master this technology and to make useful applications. However, whatever the activities and limited achievements of the Muslim countries may be, they are not well documented. Some scanty available documentation is either out of date and /or is unreliable. The attempt is, however, made to present a collection of IT related facts and figures concerning the Muslim countries, which the author was able to acquire/collect, using internet, existing literature on information technology and through personal contacts with colleagues in various countries. The limited data, so collected, concerns the following countries: Malaysia, Indonesia, Turkey, Iran, UAE, Pakistan, Jordan, Saudi Arabia, Egypt, Bangladesh, Palestine, Qatar, Lebanon.

If we analyze the power supply and telecommunication infrastructure in Islamic countries, it would be evident that very few countries have strong and modern telecommunication lines. The strong and emerging candidates in this area, based on their currently installed systems and growth-rates, include Saudi Arabia, Lebanon, Turkey, Malaysia, Qatar, UAE, Iran, Kuwait, Jordan and Pakistan. In Africa, the communication and information infrastructure has improved dramatically over the past 5 years. The Internet, satellite television, cellular phones and itemized billing are now widespread all over the continent. What might have been unthinkable a decade ago is still a dream for the majority of Africans (those who do not live in the capital cities and are not part of the elite). Access to telephones is still very scarce on the continent: there are only about 14 million lines installed, less than the number of phones in Manhattan (USA) or Tokyo. And most of the lines are concentrated in the urban areas, while over 70% of the population is rural. Likewise, cellular phone-coverage is usually confined to the capitals and secondary cities. As Internet Service-Providers are usually concentrated in the capital cities, it is a long-distance call to the Internet for most of the public (predominantly rural).

Most of the Islamic Countries lack a skilled work-force. The human resources development efforts in IT are not that much streamlined and there is a critical shortage of IT professionals due to lack of trained personnel, and brain-drain / emigration of experts to the developed countries. The Islamic countries that have good literacy ratios and some that have started investing in IT training and education include Turkey, Qatar, Lebanon, Jordon, Malaysia, and Pakistan.

In the hardware area, majority of the Islamic Countries import the computers and peripherals, with 70-80% assembling being done locally. One or two countries like Malaysia have local production capacity; even that is very small in proportion.

On the software side, the major Islamic markets are catching up. With available skilled workers, many software houses have been successfully developing software for the domestic and export markets. Some have succeeded in winning partnerships and development-contracts from the developed countries, due to the lower labour-costs and other comparative advantages. The list may include Turkey, Pakistan, Malaysia, Indonesia, UAE and Saudi Arabia. Others in the Muslim countries mainly Africans, are still dependent upon the outside world to meet their domestic software needs. Many have not yet even started computerization of domestic systems, due to lack of resources.

Internet is one field that is growing fast and gaining acceptance in the Islamic Countries. The access quality might not be good, due to the absence of required infrastructures; more and more countries, but, are getting online, even the ones in the least developed areas of Africa. This is a healthy sign, as the Internet alone could make the IT more accessible to this part of the world. The basic issues might include the content side of Internet and censorships.

After gaining some ground in the fields of internet, human resource development, and software, the Islamic countries can well jump into prospective sector of IT services, an area which has still not caught the attention of IT entrepreneurs. The available data in this area is also very limited to portray a reasonable picture of the current state of affairs. It may be concluded that this sector is still under development.

Overall, the Islamic countries are still in the development stage, as far as IT is concerned. Efforts can be seen emerging in the major countries to install and upgrade at least the basic infrastructures (electricity, telecommunications, computers, internet), which are the pre-requisites for starting the IT revolution. A few have already started investing in Human Resource Development and internet technologies, while the areas like software, hardware and IT services still need lots of attention and efforts to develop reasonably.

## 16.2 SOME RECENT POSITIVE INITIATIVES TAKEN BY THE MUSLIM COUNTRIES

### 16.2.1 Silicon Valley of Malaysia

The Malaysian government has unveiled an ambitious plan to transform Malaysia into a digital economy. The Vision 2020, as it is called, aims at making Malaysia a “knowledge-rich” country in a span of 20 years. To make this vision a reality, rubber tree and oil plantations around Kuala Lumpur have been turned into Eco-friendly smart cities, namely Cyberjaya and Putrajaya. Putrajaya is the new IT savvy government center, while

Cyberjaya is expected to be the most advanced IT city in South East Asia. They are officially referred to as “Multimedia Super Corridor” (MSC). The idea is that MSC would enable Malaysia to become a global player in the information-based economy.

Many major global players have already signed up for MSC status. Large corporations like Intel, Microsoft, Siemens, IBM, Ericsson, Oracle, Sun Microsystems, are just a few of the IT leaders that are already its members. The government of Malaysia is offering extremely attractive incentives to foreign companies. Tax holiday for ten years; unlimited import of “knowledge” workers; censorship-free Internet, coupled with the most advanced infrastructure available, are some of the attractions to the foreign investments.

Multimedia Super Corridor is connected to a fibre-optic backbone with 2.5 to 10 GBit bandwidth. The network supports multiprotocols including ATM, Frame Relay, ISDN, TCP/IP. Along with providing this infrastructure, the government has also promised reliability and performance-guarantee at par with international standards. At the same time, the Government of Malaysia wants to transform itself into an IT savvy government. To achieve its goal, it has formed “Media Development Corporation”(MDC). MDC’s goal is to assist and invite IT companies in the MSC zone, and help them setup and run offices there. It is also assisting in forming strategic partnerships with the government for the IT transformation. Companies like SUN Microsystems, Oracle, Japan’s NTT (Nippon Telephone & Telegraph), are already part of the MDC conglomerate.

This kind of interaction with the private sector is unique. Here, the government is actually working with the private sector and is asking for its help in defining and implementing the new Malaysia. The Malaysian government is focusing on the following seven projects, to transform themselves in the new Millennium:

- Smart Schools
- Telemedicine
- Multipurpose smart card (ID, Drivers License, Passport, Health Record, Credit Card, etc.)
- Paperless e-Government
- R&D clusters
- Borderless Marketing
- Worldwide manufacturing web

If these initiatives remain on track and start delivering, Malaysia is sure to become a world leader in information technology. They will soon be at par, or even ahead of Western Europe and North America. We can learn a lot from them.

### 16.2.2 Dubai Internet City (DIC)

Dubai Internet City (DIC) is being established to "create the infrastructure, environment and attitude that will enable new economic enterprises to operate locally, regionally and globally with significant competitive advantages." It is the world's first free-trade zone for IT, e-business and media companies and is expected to be operational before the end of year 2000. It is the perfect location for the entire range of new economy industries. Global Internet-focused companies like IBM, Microsoft, Sun, CISCO, Yahoo and Infosys, and more have been invited to set up regional offices and global software development centres at the Dubai Internet City. Also, global e-commerce companies are expected to join soon.

Some of the highlights are as follows:

- World-class technical infrastructure: high bandwidth, low-cost telecom infrastructure and secure, high-speed support infrastructure.
- State-of-the-art urban infrastructure: cost-competitive, flexible office space and world-class housing, medical and education facilities.
- Access to talent pool: large pool of high-skill, low-cost knowledge workers.
- Straight-forward laws and regulations: easy and fast company registration laws, hassle-free immigration process and straight-forward legal procedures.
- Gateways to markets: access to regional markets in Middle East, North Africa and Indian Subcontinent.
- Supportive environment: Government is backing e-business initiatives, business incubators, venture-capital funds and e-education programs.

The technical infrastructure at DIC is of world class. It will offer high bandwidth, low-cost state-of-the-art telecom infrastructure, with redundant connections, to Internet primary-backbone providers. Top international companies will provide the complete spectrum of technical infrastructure, such as data-centers and server-farms. DIC will also have Science & Technology Park that will house an R&D center for new technology initiatives and take up developmental projects for the industry.

Dubai Internet City will offer ready-to-operate, modern, full serviced offices-space that caters for the needs of new economy companies. Companies can look forward to competitively priced offices, with flexible lease agreements. The offices will offer leading-edge technology and provide wired and wireless networks.

### 16.2.3 Pakistan's IT Initiatives

Since 1990, Pakistan has tried to implement pro IT policies in the country. Rules and regulations were passed under various governments that helped & promoted IT-culture in the country. For example, providing tax breaks for software companies, establishment of ISPs in the private sector, duty-free import of IT related equipment, etc. These activities have been intensified manifold in the past year or so. The present government desires to see the private sector lead in IT based business-opportunities. This government would like to concentrate on providing legal cover and making the environment more conducive for development of Information-Technology.

In the mid nineties, the Pakistan Government allowed internet-service providers to launch the services in the private sector. Within five years, there are now over sixty ISPs operating in the country. They are not only providing jobs to thousands of people, but are also allowing citizens access to the internet at an affordable cost. Around the same time, the government also established Pakistan Software Export Board. The sole aim of the board was to introduce Pakistani software-industry in the international market and to facilitate local companies to get leverage world-wide, with the result that there are now over 300 software houses in the country. They are not only doing software developmental work within Pakistan, but are also exporting their services to companies world-wide, including, USA, Canada, UK, Germany. The industry giants like Microsoft, Cisco, Oracle and NCR have already established offices in the country.

Recently, the government of Pakistan has placed IT as one of its top priorities. A separate IT and Telecom Division has been established within the Ministry of Science and Technology. The new division has been charged with the task of making Pakistan an IT savvy country. Within six months of its inception, it has already had an impact on the IT scene. Pakistan's first IT Policy has also been approved. However, the efforts can only be fruitful and successful if the government is sincere and all hurdles in the implementation are removed.

### 16.2.4 Tunisia's IT Initiatives

The Tunisian capital, Tunis, is listed by the current issue of French business-magazine "Capital" as the world's key "new economy" capital. The magazine says in its October 2000 issue - "Tunisia is, along with South Africa, an exception on the African continent. Even in the remotest corners of the country, the internet is accessible at the price of a local phone call." It adds that "last year, in suburban Tunis, the government launched a communication technology park . Six firms have already been implanted there, including start-ups. So, to be sure not to run out of skilled labor, the Tunis high commercial studies institute has established a teaching cycle in information-technologies and e-commerce."

The Tunisian business community is regularly encouraged by Tunisian President Ben Ali to tap the resources offered by new information-technologies. During the last few weeks, Tunisia has launched the "e-Dinar", a virtual currency used in transactions over the web. One immediate use of the currency, last month, was the payment of registration fees of remote students in a number of institutes of higher education. The setting up of six new private internet-service providers was also recently announced in Tunisia. Secondary schools, universities, research institutions and medical centers are already connected to the worldwide web. Work is in hand to connect all primary schools to the internet.

## 16.3 INFORMATION-TECHNOLOGY IN MUSLIM WORLD: FUTURE PROSPECTS

In today's world, success is highly dependent on the capacity to generate and absorb knowledge and technologies. As is evident from the facts given in the earlier sections of this paper, technological advances are taking place with lightening speed and the major contributors and beneficiaries of the technological age belong to the West and developed regions of the world. The reasons are apparent; their willingness and readiness to accept the change and the ability to exploit it to their advantage.

Information-technology, now the mother of all scientific and technological innovations, is no exception. It is bearing fruits for the nations that have embraced it at the right time. IT is one of the few technologies that can be as friendly to less advantaged countries as it is to the developed ones. It carries equal, even more ripe, opportunities for an LDC like Ghana as it does for any developed country like US, Canada or UK. The only thing that is required on the part of developing and / or Islamic countries is the commitment and effort to prepare and launch themselves in the enabling direction for embracing these technologies.

Based on projected statistics, there will be over 320 million internet users by the year 2002, of which, 68 % would be in North America and Western Europe alone, while only 13.5% would be in the rest of the world (a mere 43 million users). Out of these, there will be less than 4 million from the Islamic countries. Barring the efforts by Malaysia, United Arab Emirates and Pakistan, there is hardly any good example of rising IT economy. This is a dismal situation. It requires urgent attention of leaders of the Islamic World.

Here, the proper approach would be to base the future prospects of the Islamic World as a whole and / or individual countries on the existing scenario or current state of affairs as presented in the previous section. The section, however, does not provide a reliable and sound launching pad for drawing any trend-lines or making any predictions about what is to come for the Islamic World, say, in the next five years. The reasons, as have already been mentioned, are the absence of authentic and up-to-date figures with similar set of parameters and units of measurements for different countries and / or IT indicators—the factors that are imperative for making any comparisons and forecasts. Keeping all the limitations in mind, I have tried to present a qualitative picture here, which is based on the current scenario of selected countries. Some of the countries having good foundations for the development of IT and positive growth-rates in different IT sectors, under favourable policy-environment and government approach, economy take off, or other positive signals, have been marked as emerging countries.

Overall, the situation does not seem too rosy, yet the silver lining can be found here and there. The pre-requisites for a better picture and for aspiring future leadership in this sector include major overhauling of quite a few areas.

The changes taking place are so fast that governments around the world are finding it difficult to cope with the emerging situation. It is because of this fact that some governments (US, Malaysia, Canada, etc.) are asking their private sectors to lead the way. They are also working with the private sectors to re-form and re-equip themselves for an 'IT ready government'. The job of the government is now changing. They are now concentrating more on monitoring and policing the activities. This is exactly what Islamic governments need to do. Instead of trying to do all IT related activities themselves, they should let the private-sectors grow and thrive. Some of the preliminary steps that are necessary to have a prosperous nation well equipped with IT are mentioned below:

- Setting up of Smart Schools & Universities.
- Re-structuring the Telecom Sector
- Promoting e-business & e-commerce
- Declaration of IT as an industry

These steps may take years or even decades to become functional and effective. Unless we think ahead, our future in the 'Information-Age' is not secure.

### 16.4 SOME RECOMMENDATIONS FOR DEVELOPMENT OF INFORMATION-TECHNOLOGY IN ISLAMIC COUNTRIES

- Development of world-class "enabling infrastructure" for IT Industry that is both efficient and cost-effective, to provide equitable access to national and international networks and markets
- Develop an extensive pool of academically and technically skilled IT manpower at all levels to meet the local and export needs
- Revolutionize the way people communicate and access information, by encouraging the growth of Internet and competition
- Promote extensive use of IT applications in Government, trade, industry, homes, agriculture, education, health, and other sectors with widespread use of internet
- Promote and encourage both local and foreign investors to ensure the development of IT sector (Software, Hardware and services industries) in Islamic countries and the use of IT products and services

- Create strong domestic and international markets through linkages and marketing networks for local IT products and Services
- Revitalize, emphasise and support the country's manufacturing and R &D potential
- Make the governments in Islamic countries a facilitator and an enabler, to provide maximum opportunities to the private sector to lead the thrust in development of IT.
- To develop an enabling legislative and regulatory framework for IT related issues.
- Ensure continuous development through learning and global sharing
- Take advantage of the available expertise and technology-assistance from within the Islamic Bloc. The developed world is already on the move and is draining the developing world of its valuable human capital, which if retained can both administer and advance the IT applications to our own advantage.

## 16.5 ISSUES AND CHALLENGES OF THE INFORMATION-AGE

The rapid development coupled with the increasing use of information and communication technologies is causing major repercussions on all aspects of private and public life, in all countries. This development is transforming the traditional ways of functioning of our contemporary societies and is providing new opportunities and challenges for all. This situation makes it important for Islamic countries to keep abreast of the new ethical, legal and societal issues and opportunities offered by the Information Society, which would facilitate Islamic Block participation in, and contribution to, the new digital world.

Globalization of the information-society, through educational and behavioral changes, is promoting a more open society with better sharing of information-resources and its sources, new collaboration and group-work patterns, new cognitive tools, and cultural diversity. Sound governmental initiatives, action plans, policies and strategies implemented at the national, regional and international levels are required, in order to prepare the transition to an Information Society.

Some of the major challenges confronted by the Muslim World include:

- Challenges to Academia
- Societal and Psycho-social Challenges
- Ethical Issues of the Information Age
- Legal, Regulatory and Public Policy Issues
- Economics Perspective
- Information-Systems (IS) / Information-Technology (IT) Management Issues in the Public Sector

## 16.6 CONCLUSIONS

As information technology becomes increasingly indispensable for the development of society, the developing world and Islamic countries can least afford to squander the great opportunities presented by the ongoing information-revolution. Faced with globalization and the fact that IT has been proved to be the engine of development, the question is no longer if IT is applicable to less developed regions, rather the critical question is how should the developing countries adopt the new information-technologies in order to meet the economic development challenges?

The Islamic World's rationale for participating in the information age is simple and strong: unless Islamic Countries become full actors in the global information, they run the risk of being excluded from the emerging global economy or suffering severe disadvantages in the competitiveness of their goods and services. Participation in the information-age offers many opportunities for Islamic countries to "gain time on time"— to leapfrog over past developmental deficiencies into the future. A sizable number of Islamic countries have already made progress in their Internet links that have put them on the global connectivity map.

Development can be seen as an increase of knowledge and skills and creative potentials that can be applied to improve the quality of life. Research shows that low levels of knowledge and inadequate innovative skills at lower, middle and higher levels have contributed to the continuous failures in African countries in all spheres. Information and knowledge are interrelated: well-informed, knowledgeable and innovative citizens are causes for human-centred development. Information-technology facilitates the flow of knowledge in modern society. Observing the impact of information-technology on economies, the Islamic Block cannot afford to persist in a state of information-poverty. Information-technology, if properly harnessed, will help to bridge the information gap and will give impetus to foster development in virtually all sectors. Information-technology can improve economic performance, expand and sustain health-services, promote education and research, enhance food-security and gender-balance in development, strengthen and diversify ties with trade partners, invigorate culture and tourism. It can also alleviate man-made crises and natural disasters. In the area of human-capital development, for instance, the systems of education in many Islamic countries suffer from serious shortcomings, including low teacher-student ratios; limited availability of instructional material; and, poor quality of education, related to inadequate funding and inefficient use of available resources. Information-technology offers a wide range of low-cost solutions, through for instance, distance-education that gives its flexibility, and suitability for its widely scattered student bodies, particularly among rural schools where both teachers and students have no access to libraries, reading materials or communication with the world outside. Clearly, although ICT will not bring development overnight, it will certainly permit those who use it to be players in the world economy.

Information-technology has created challenges and implicit solutions. The challenges involve adaptation of the technology to needs and the implied solutions are the possibilities of using the technology to attack the perennial problems of underdevelopment: poverty, low-productivity, inequality and environmental degradation. Though, there is now growing recognition of the far-reaching impact of telecommunication and networking on the economies of Islamic countries, a number of problems restrict its diffusion through public institutions. These include socio-economic problems, crippling access to the information and communication technologies. The resources at the disposal of governments are mostly directed towards dealing with emergencies, with little left for long-term investments in sectors that could trigger socio- economic development. Education, information and communication are some of the sectors that need immediate attention for long-term development in Islamic countries.

The absence of an efficient telecommunication infrastructure poses serious problems. Although most of the countries have established Internet links, access is mostly restricted to the capital cities and it is extremely expensive, mainly because of the inefficiency of telephone services. Those in rural areas remain electronically isolated. Ironically, as a result of the quantum leap in technology, the inadequate state of telecommunications in many of our countries can be transformed into a great advantage if properly managed. The fact that the telecommunication-sector is lacking in both coverage and density means also that the country is not burdened with extensive networks, built on obsolete technology. They can push to the cutting edge, by ensuring that *new infrastructure is based on the latest technology*. The inadequate policies and incompetence of telecommunication management in most countries block achievement of socio-economic development.

The high cost of computers and software represents another serious impediment. The experts in the field suggest that bare-bone computers and stripped-down software perfectly serviceable for Internet connections, word processing, and graphics can be built today for a price, which is many times lower than current prices. And one way to induce producers to comply with such requirements is 'bulk-purchasing', which should be feasible, given the potential market-size of Islamic countries.

Unfortunately, most of the Islamic countries do not have any explicit plans or policies on information-technology. The acquisition of information technology and software is a result of isolated initiatives, without preconceived strategies and policies, with little coordination and planning. Thus, there is a pressing need to devise clear national and regional long-term strategies and policies that cover the acquisition of information-technology, its enabling environment and its applications. The strategies should quantify the investment-requirements of the countries and identify the required changes in institutional, training, legal and regulatory frameworks that will foster the development of the information-societies in the region. Such strategies would also serve as an explicit recognition of the challenges of the information-technology and as an instrument for attracting and coordinating donor assistance in this domain.

Entering into the information age is not only about getting connected to the Internet and receiving information from the rest of the world. Islamic countries should have the material that will travel in the opposite direction, if they are to benefit from the global information system. Thus, national institutions responsible for data-collection and processing need to be strengthened and their information collection and dissemination structures to be modernized. The local content of information would need to be developed even at rural community level, in as many languages as necessary, given the pluri-linguistic and multicultural nature of many Islamic countries. This will encourage participation and speedy information-diffusion to benefit the majority of Muslims. Islamic-to-Islamic countries information-exchanges would need to be encouraged. Sub-regional information systems would need to be developed and improved, to provide meaningful backing to national efforts in this area.

Equally important is the question of sustainability. It is pertinent, therefore, to invest in low-cost and locally adapted solutions, such as the use of solar-driven appliances. It is also important to make the users pay, from the very beginning, for the services they receive.

Measures to expedite the Islamic countries' entry into the global information-system must also address factors constraining the development of the information-infrastructure. Reviewing the regulatory frameworks is important to encourage private participation, not only in cellular telephony, but also in the operations of the state-owned telecommunication enterprises. Removing legal and regulatory barriers to the use of information and telecommunication technologies would promote interest on the part of the private sector.

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# 17. INFORMATION-TECHNOLOGY PROWESS: ROAD TO PROSPERITY FOR MUSLIM COUNTRIES

In this world of increased competition, a country's success depends on its ability to optimally utilise its existing resources, as well as to enhance them. Thus, the inability of any country to access and to make full use of the latest information, in various fields, makes it vulnerable to the threat of extinction. The fast-paced development of science and technology has made it even more critical for nations to be aware of, and to pursue a path based on development of science and technology. The leaders in these fields are the Western countries. The cardinal reason for this adeptness is apparent; their eagerness and vision to sustain their growth-process through an effective use of information.

When we try to elucidate the rationale behind the present technological revolution, the main impetus comes up in the form of ***Information-Technology***. It implies that those nations who have engaged themselves in this field of Information Technology have achieved the objective of sustainable growth, while others have lagged far behind. It is also imperative to note that the use of latest information-tools is as consequential for the developing countries as it is for the developed ones. Therefore, a and relentless effort commitment is required from the Muslim countries, in order to reap the benefits of this information-age.

The number of Internet users provides us with one of the prime indicators for comparison between the utilisation of IT tools by the Muslim countries and that by the developed countries. The estimated figures show that, by the year 2002, out of the 320 million Internet users around the world, 68% will belong to the West and USA, while users in the Muslim countries will only form approximately 1.2% of this number. This is a very alarming situation, as it shows the lack of awareness and even ignorance on the part of these Muslim countries. Therefore, drastic and concrete measures need to be taken, in order to survive this threat of information-challenge.

The rapidly changing scenario of today's world ought to produce a sense of urgency among the Muslim countries regarding the use of IT tools. One way of adopting the right strategy for the future will be to initiate collaborative activities between the public and the private-sectors. Only this kind of arrangement would allow the government to concentrate on formalising policies and monitoring the activities, while the private sector would focus on carrying out the research and developmental projects. This arrangement will also ensure that the *Human Resource* of the Muslim countries will be employed in the mainstream-activities of sustainable development, and skilled manpower could also be attracted. It would also reduce the increasing threat of *Brain Drain* in these nations.

The ongoing information-revolution brings with it an intense atmosphere of competition. *Globalisation* is even more strengthened by this fast-paced IT based development-process. Until and unless Muslim countries realise the importance of acquiring and utilising the skill of IT tools, their survival will faced a serious threat.

Among the challenges of Information Technology is the fear of adopting it as a source of information access, information utilisation, and information dissemination. IT needs to be recognised and approached as a separate industry and discipline, and should be given its due share of importance in the eyes of decision-makers. As information-access and dissemination are the order of the day, therefore, immediate and solid steps need to be taken to promote this field. A proper application of IT principles will guarantee an abridgement of distance between various sectors, and will also ensure that development-process seeks a faster lane of prosperity.

Information-Technology can also contribute towards improvement of the overall economic standard of our societies. Promoting research and developmental activities in various fields like health, education, tourism, culture, and gender-development can serve this purpose very well.

Information and Communication are two fields that deserve immediate attention by the Muslim countries. These two areas are currently considered to be the backbone of the process of sustainable development, and should therefore be the main areas for the application of resources. These two are also dependent on each other, as the absence of an effective telecommunication-structure hampers the IT modes like Internet. In fact, if we analyse the reason for an expensive and low-quality Internet facility in these Muslim countries, the main problem is that of inefficiency of the telecommunication infrastructure. In addition, personal computers and supporting software are either very costly or are not readily available in these countries, thus making it extremely difficult for the users.

Embracing the challenges of information age is not only limited to the usage of Internet. Steps need to be taken to ensure that information dissemination is carried out at all levels of the community, either rural or urban. This will protect the right of all citizens, in addition to being the impetus to an overall sustainable national development.

There are a number of steps that can achieve the purpose of transforming IT from a mere technological field to the status of “solution-provider” for numerous problems of Muslim countries. Some of these are:

- Removal of any legal and regulatory barriers on the use of IT
- Establishing institutions which emphasise and impart IT-related education
- Declaration of IT as a full-fledged industry
- Creation of an effective liaison between public and private sectors
- Revamping the Telecommunication sector
- Focusing on the promotion of e-Commerce

In the light of the above discussion, it can be concluded that the advent of Information-Technology has given a totally new angle to the competition between countries of the world. It is high time for all the Muslim countries to allocate their energies and resources to face the modern challenge of Information-Technology. By doing so, they may guarantee long-term survival and growth; in case of failure to address the situation immediately, their existence will be subjected to a constant threat.

**FOR FURTHER READING**


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# 18. ROLE AND IMPORTANCE OF BIOTECHNOLOGY IN THE MODERN WORLD

## 18.1 ABSTRACT

Biotechnology has assumed great importance in the modern times. Although its role cannot be denied by any country, its relative importance for the socio-economic uplift of the developing countries is even greater. Be it the areas of food; medicine and health; or the industry and environment, biotechnology and its allied fields can play a major role, in terms of improving the processes and in producing the desired output. This article mainly discusses the importance and role of biotechnology in various fields of life, and also the opportunities and challenges it faces.

Biotechnology promises to offer new opportunities for diversification of the economic activity, by solving most persistent environmental problems. It can be done by ecological rehabilitation and pollution abatement and by improving the quality of life in most of the countries for developing new agricultural and pharmaceutical products, both for export and domestic consumption. It also offers the potential for dealing with medical problems associated with tropical and other diseases. In essence, appropriate use of the biotechnological research would improve the overall quality of life in a global way. Biotechnology is neither a new discipline nor a specific field of technology; in fact it is a whole range of new techniques that are increasingly influencing and enhancing one another and also improving the effectiveness of established tools.

## 18.2 USES OF BIOTECHNOLOGY

Although the use of biotechnology is found in a variety of fields, but it has had a profound impact on the areas of industry, medicine and very importantly for developing countries, in the area of agriculture.

Biotechnology, to many, is all about genetically modified foods and cloning also it is proving its worth in the application and industrial production, offering clear environmental and economic advantages over conventional methods.

### 18.2.1 Biotechnology in Industry

Biotechnology has and still is continuing to impact the overall industry. In an industrial context, “clean” is a relative term; any change that reduces consumption of raw material and energy or reduces waste, including recycling is “Cleaner” or more “environment-friendly”. There are ways of evaluating technologies and their alternatives in terms of their relative cleanliness throughout the production-process and the life of the product. More generally with Industrial Biotechnology the focus has shifted from remedy to prevention of environmental degradation.

Cleaner industry may be a relative notion, but one thing is obvious; the urgent task of reducing emissions does not imply economic loss. Indeed, with Biotechnology, the environment and the economy can actually reinforce each other. It would not only improve industrial sustainability, but would also help to ensure that the link between industry and pollution is broken once and for all.

### 18.2.2 Biotechnology in Medicine

During the course of the past few years, Biotechnology has had an enormous effect in the fields of healthcare and medicine. This included development of health-programs to overcome major communicable diseases and in improving initiatives to assist in specific treatment of, and protection from, major non-communicable diseases and also in the manufacture of recombinant DNA-products, Insulin, Interferon, Human Growth-Hormone, etc. The apparent paucity of projects that directly address the role of biotechnology in health, in the developing world, is indeed a part of a problem-based approach, rather than pre-occupation with the development of specific technologies.

### 18.2.3 Biotechnology in Agriculture

In the agriculture-sector, it is expected that the ambivalent results of the "Green-Revolution" will be experienced for a second time, but with significantly enhanced social impact. But, in contrast to the green-revolution, which focused on three main food-crops (Rice, Wheat and Maize), the new Biotechnology can be used to improve the characteristics of all target-plants. With that the genuine subsistence like cassava or sweet-potatoes could also be effected.

**Table - 18.1: Global Area of Transgenic Crops, 1996 to 2000**

(Millions of hectares / acres)

| Year | Area (Hectares millions) | Acres (millions) |
|---|---|---|
| 1996 | 1.7 | 4.3 |
| 1997 | 11.8 | 27.5 |
| 1998 | 27.8 | 69.5 |
| 1999 | 39.9 | 98.6 |
| **2000** | **44.2** | **109.2** |

Note: Increase of 11 % , 4.3 million hectares or 10.6 million acres , between 1999 and 2000 .

Source : James , C. , 2000

Furthermore, Biotechnology can also contribute significantly to a pattern of agriculture, which is more sustainable and ecologically sound, as well as, to the reforestation of desert or erosion-prone areas.

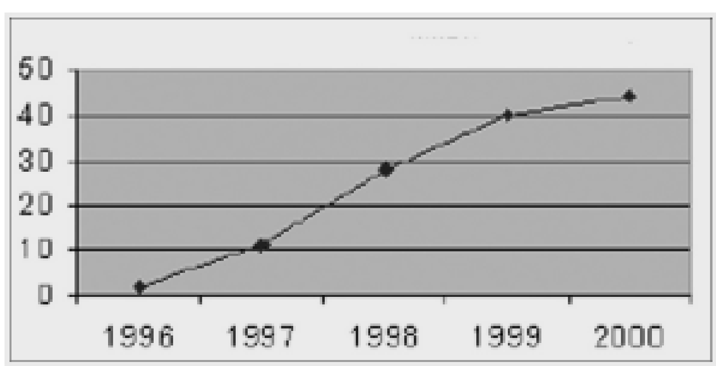
Critics stress the fact that the present direction of development of agrarian Biotechnology is dominated by the research-agenda of the industrialized countries. Thus, the main concern is not the realization of the potential offered by the new techniques to combat hunger and malnutrition in a highly specific and target-oriented way, but almost exclusively the profit interests of Northern companies, commercializing the products of Biotechnology.

The products based on plant-biotechnology that have or will soon be commercialized are generated primarily through either of two pathways: (i) some products are developed through identification of natural variants or through chemical or genetic mutation and subsequent breeding strategies; (ii) others are developed using methods of molecular biology. These two pathways for product-development are complementary and each has its own advantages.

### 18.3 MARKET-INTRODUCTION STRATEGIES

For those candidates that meet functionality criteria, market-introduction strategies must be devised traits that are used in place of, or in conjunction with chemical inputs, such as fertilizers and pesticides, or traits that enhance yields are typically used to increase the market-share of the seed, or to increase the market share of the seed sales. The product is a seed and it is produced through normal foundation seed-multiplication channels.

**Figure-18.1: Global Area of Transgenic Crops, 1996 to 2000 (million hectares)**




Source: James , C. , 2000

To benefit from the research investment the developer must, either market seeds directly or negotiate a royalty with a seed-company, or in the case of herbicide-resistant crops, benefit by increasing sale of chemical.

Despite these challenges, the commercialization of products based on plant-biotechnology is accelerating. Examples of current or incipient products, include: tomatoes and peppers developed using another culture-based breading; and herbicide-resistant corn and soyabean leaves that have been selected through mutation – breading protocols. Other crops, such as, high-corn, and high oleic acid and low poly un-saturated fatty acid oil seeds, have been developed. Their yields have been augmented through the application of advanced analytical screens and molecular breeding-technologies.

Finally, a number of transgenic products have been or are nearing commercial introduction. The commercial success of these products will ultimately depend upon the development of regulatory frameworks that are well defined and scientifically based upon the public-acceptance of transgenic plant-products, and upon the economic benefits that the products bring to all participants in the value-chain, including trait-developers, seed-companies, traders, distributors, ingredient manufactures and consumers.

## 18.4 ROLE OF BIOTECHNOLOGY IN DEVELOPING COUNTRIES

There is also uncertainty about the ability of developing countries and those with economies in transition, to participate in the Biotechnological revolution. Some of the uncertainty has largely been stimulated by the claims that the technology is suited to the needs and conditions of the rich economies of the West.

Its appropriateness to the developing countries has been questioned. The questions in this issue is whether or not technology is appropriate or in-appropriate for developing countries, has been clouded with conventional thinking of the process of technological change as linear. The linear view of technological change, essentially advocates that countries take a step-by-step entry into a technology, differs across countries and sectors. They are determined by factors, such as, prior accumulated knowledge and experience in similar technological areas, and technical and financial flexibility to manage the high scientific intensity, associated with the technology. In such sectors as agriculture and pharmaceuticals, where Biotechnology is maturing fast, barriers to entry are reducing for developing countries. The growth and accumulation of scientific knowledge are giving rise to major technological and commercial breakthroughs, involving a shift away from the established trajectories. These developments have stimulated the emergence of different institutional arrangements, in each of the sectors.

The developing countries of the world are faced with the dual challenge of a rapidly growing population and threatened agricultural resource-base. About 700 million of the

4.5 billion people, currently living in the developing countries, suffer from under-nutrition. And by the year 2025, farmers in these countries will need to produce sufficient food, at most affordable prices, for additional 2.5 billion people. While increased food-production cannot solve the hunger problem, It is an essential requirement. Moreover, the agriculture-sector is so large in most of these countries that growth in agriculture is the most effective, and often the only viable strategy for achieving the overall economic growth, which can help reduce poverty. For example, in China and India, over 60% of the population is employed in agriculture-sector and this percentage is even higher in most of Africa. The highest fertility-rates exist in the rural areas of these countries, and hundreds of millions of additional people will join those already dependent on agriculture for their livelihood.

Plant-biotechnology has the potential to help shift the balance towards greater use of science, technology and informed management; towards the more efficient use of inputs; and the sustainable use of natural recourses. Harnessing the power of biotechnology and directing it towards these objectives, will require effective technology-transfer, at a reasonable cost. Developing countries must have sufficient bio-technological capacity, to integrate these new tools and products with in the public-sector plant-research and programs of crop-improvement that serve the vast majority of farmers, who have small holdings and limited purchasing power.

In several developing countries, there is also an emerging private-sector crop-biotechnology industry, which produces hybrid seeds for commercial farmers; micro-propagation to produce seedlings for commercial farmers, and produces horticultural crops for domestic sale and export. However, the current capacity in molecular Biology Research of these companies is limited, and they rely heavily on technical advances generated in the public-sector or by foreign partners.

Fortunately, there is an international network of publicly supported agricultural research-institutions that has a significant record of accomplishment, in producing and delivering crop-varieties to farmers in developing countries. Apart from sub-Saharan Africa, where the conventional strategies of plant-breeding at national agricultural research-agencies still need strengthening. The key components of this system are already in place and provide a sound foundation for bringing the benefits of plant-biotechnology to most developing countries. Improved cultivars generated by this system, already accounts for over 70% of the area, unplanted to rice and wheat in Asia, and over the past 20 years, the proportion of this region's population, affected by under-nutrition, has declined from about 40% to 20%. Steady progress is also being made with maize, sorghum, millet, potatoes, cassava, beans, cowpeas, chickpeas and ground-nuts.

## 18.5 POLICY FOR DEVELOPMENT OF BIOTECHNOLOGY

Well-established policies for Biotechnology are a major factor for successful integration of biotechnology in crucial sectors of society. Effective broad-based biotechnology policy-framework will enable the countries to develop the technologies and policies according to their own needs, ability and opportunities.

It is, therefore important, for the developing and under-developed countries, to start the process to seriously understand, assess, use and evaluate new biotechnology. It is also important for the countries to prioritize their research-efforts, so that the existing scarce resources are used efficiently. In this regard, Government of Pakistan has taken a major initiative by establishing National Commission on Biotechnology, headed by a renowned Biotechnologist, Dr. Anwar Nasim, who is one of the few torch bearers in the field of biotechnology, in Pakistan . The Commission will primarily be working in the areas of Human-Resource Development, upgradation of research-facilities, and will help undertake projects in agriculture and health-sectors. Socioeconomic inputs, such as efficient resource-utilization, employment, equity, income-distribution, and sustainability are also important for sound planning and setting priorities.

Biotechnology policies are also greatly linked to the access of genetic resources, a subject greatly discussed nowadays in a number of international fora. The countries in the region must carefully assess these international trends and develop efficient national policies and regulations. Though policies for Bio-safety and Biotechnology are well in practice, a remaining dominant problem facing the region is the human-capacity to ensure adequate policy-implementation.

## 18.6 FURTHER CHALLENGES

The socio-political ramifications of Biotechnologies in developing countries are extremely complex. Not only do they vary from sector to sector of a nation's economy, they are also different for various segments of its population. Generalizations, therefore, have scant pertinence. In order to circumscribe the subject more concretely, the following discussion will limit itself to agriculture, with the main emphasis falling on adequate food-production. In particular, this aspect is a timely consideration, because over the next quarter-century, grave problems of food-security will effect hundreds of millions of people. Yet, to date this prospect, seems not to have aroused the concern it calls for.

It is widely accepted that the agricultural systems within the developing countries will have to meet most of the growing food and industrial needs of the people of LDCs over the coming decades. It is estimated that for rice alone, a 20% increase in productivity is required by the year 2025, to keep pace with growing demand. The scale and urgency of the situation is compounded by several additional factors. Increased crop-production in the LDCs has traditionally been achieved by bringing more land under-cultivation. For example, the area committed to cultivation of the tropical root-crop—cassava—has increased 43% since 1970, while production-per-hectare has risen only by 20% over the same time.

Such activities are unsustainable and undesirable, as they will result in severe depletion of the world's remaining natural eco-systems. The tropical and sub-tropical regions contain approximately 80% of the world's bio-diversity, the loss of which would have disastrous consequences for future crop-production and pharmaceutical development. In fact, it is now considered that most of the world's high quality farmland is already under-cultivation, especially in Asia, where land and population pressure is the greatest. In some regions, the available farmland is actually decreasing, as prime agricultural areas are lost to urban spread, soil-erosion and desertification.

It is clear that significant increase in production from the agricultural systems, in the LDCs, must be generated and sustained over the coming decades. This must be obtained largely from the land already under-cultivation. Achieving these aims on the scales required is a daunting prospect.

## 18.7 CONCLUSIONS

Biotechnology can help developing countries meet their rapidly increasing demand for more food, and contribute towards their economic development. To realize this potential, research capacities in biotechnology are being established and strengthened at the national levels, and within international organizational research-centers. New strategies are also being formulated and tested for developing more effective calculated laboratories between the network of public-sector institutions and the expanding biotechnology-industry.

As for most complex issues, there is no single simple remedy. Biotechnology is not a panacea for world's hunger. However, when combined with traditional breading, good agricultural practices and sound economic policies, it can be an important factor in achieving improved standards of health and economic security, for all over the globe. Are the new technologies effectively directed to those who need it most, or are these only going to benefit the already affluent, remains a significant question. It is essential that we do not proceed to a situation, comparable to that for the treatment of AIDS, where the costs of high technology cures make them applicable only to those infected in North and having completely failed to address the epidemic as a whole, providing no hope to victims in the LDCs, where the disease is spreading out of control.

How the potential of the human imagination should be sutured, guided, interpreted and ultimately directed and controlled with respect to Biotechnology, is a question of profound socio-economic and ethical dimensions. It deserves to be discussed, contemplated and digested at all levels of society.

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# 19. BIOTECHNOLOGY FOR DEVELOPING WORLD

## 19.1 INTRODUCTION

Biotechnology is the next wave of revolution. The term biotechnology was coined in 1919 by Karl Ereky. Biotechnology is the application of science and engineering to the direct or indirect use of living organism.

Biotechnology refers to using living organisms or systems to produce useful substances or to using biological technologies to improve plants, animals, or processes. Although the word “biotechnology” is relatively new, using biological agents isn’t. Yeasts, moulds, and bacteria have been used for years, to make fermented foods like beer, wine, and bread, and to preserve foods, such as by turning milk into cheese and yoghurt. The newer technologies include: the techniques of recombinant-DNA, gene transfer; embryo manipulation and transfer; plant regeneration; tissue culture; monoclonal antibodies; and bioprocess engineering. It can offer enormous benefits to mankind, from an improved environment to better crop-yield, from better health to more effective healthcare.

Biotechnology has brought us to the brink of world of engineered products that are based in the natural world rather then chemical and industrial processes. Different traits can be introduced to crops using GM-technology to increase disease-resistance, improve nutritional value and increase crop survival in drought, flood or forest conditions

The research tools that have generated these technologies have also opened new fields of research. Genomics, the sequencing of the entire genetic makeup of species is advancing fast. New genome projects include several species that are important in agriculture. It has been proved that related species share most of their genes. They also have, to a large degree, common gene-orders along the chromosomes. Therefore, the complete sequencing is not necessary in all species. For example, the rice genome that is almost completely sequenced can be used as a model in molecular biology research on other cereal crop species. Such research directs much of current biology, and is expected to yield new insight with potential to improve disease management, better stress tolerance, and better resource utilization in both livestock and crop production.

Some of the biotechnological applications are primarily relevant or only in industrial forms of agriculture. However, an increasing range of biotechnology-related research outputs respond to needs and demands in the small-scale farm-sector.

Modern agricultural biotechnologies are being used in livestock, fish, cultivated plants, and also in food-technology. The key components of modern biotechnology include:

- *Micropropagation*: e.g. through tissue culture for multiplication;
- *Genomics:* the molecular characterization of all species;
- *Bioinformatics*: the assembly of data from genomic analysis into accessible forms;
- *Diagnostics*: the use of molecular characterization to provide more accurate and quicker identification of pathogens and other deleterious factors in grains, other plant material, animals, food and feed-stuffs;
- *Molecular breeding*: the identification and evaluation of desirable traits in breeding-programmes with the use of marker-assisted selection;
- *Transformation*: the introduction of single genes conferring potentially useful traits into crop, livestock, fish and tree species;
- *Applied Functional Agrobiodiversity*: the use of valuable crop-associated organisms to improve the nutrition and protection of crop-plants; they may be used directly as organisms, or as sources of valuable chemicals and the genes that code for them;
- *Vaccine technology*: use of modern immunology to develop recombinant-DNA vaccines for control of lethal diseases.

Developing countries have consistently demanded access to modern biotechnology and the international community has promised to contribute to transfer such technology both technically and financially

## 19.2 CURRENT AND EMERGING MODERN BIOTECHNOLOGIES

Today "biotechnology in farm animals" basically includes techniques in reproductive and molecular biology intended to enhance performance, efficiency and health for sustainable production of animal. Cloning and transgene technology will open new horizons both for biomedicine and for many agricultural applications, particularly in the area of product diversification.

### 19.2.1 DNA Technologies in Animal Genetics and Breeding

Animal diseases are a major and increasingly important factor reducing livestock productivity in developing countries. Use of DNA biotechnology in animal-health may contribute significantly to improved animal disease-control, thereby stimulating both food-production and trade of livestock.

Somatotropins (growth hormones) may be the first products of biotechnology to significantly influence animal agriculture. Originally available, only from pituitary glands of animals, somatotropin now can be produced in pure form and in large quantities at relatively low cost through recombinant DNA technology. It have impressive effects on growth, feed-efficiency, and can dramatically increase milk-production in dairy cattle.

Artificial insemination and frozen semen allow embryo manipulation (including embryo collection and transfer) to be used successfully with cattle. Embryo-transfer techniques can be used to produce “litters” of calves from a single superior mother that would otherwise produce only one calf at a time.

Infectious diseases remain the leading cause of death and reduced productivity in livestock. Biotechnology offers the potential to produce powerful vaccines for foot-and-mouth disease, scours, shipping fever, and other animal illnesses. Along with superior vaccines, biotechnology-techniques using monoclonal antibodies are being developed to detect animal diseases, estrus and pregnancy, and aflatoxin15 in livestock feed. Recombinant DNA can be used to make “probes” to diagnose disease, and monoclonal antibodies can be used to diagnose diseases, monitor drug-efficacy, and develop therapeutic treatments and vaccines.

Biotechnology can be employed to assess and improve the safety, freshness, color, flavor, texture, taste, nutritional characteristics, and shelf-life of aquacultural food products.

Enzymes can improve the nutrient availability from feedstuff, lower feed costs and reduce output of waste into the environment. Prebiotics and probiotics or immune supplements can inhibit pathogenic gut microorganisms or make the animal more resistant to them. Administration of recombinant somatotropin (ST) results in accelerated growth and leaner carcasses in meat animals and increased milk production in dairy cows.

Immunomodulation can be used for enhancing the activity of endogenous anabolic hormones. In poultry nutrition, possibilities include the use of feed enzymes, probiotics, single cell protein, and antibiotic feed-additives. The production of tailor-made plant-products for use as feeds and free from anti-nutritional factors through recombinant DNA technology is also a possibility.

### 19.2.2 Health Biotechnology

Traditional medicines depend largely upon plants and animal products. Modern pharmaceuticals have evolved from the traditional medicines. Recombinant technology, which uses bacteria, yeast, animal and plant cells to manufacture valuable protein-based medicines, which is expected to offer significant benefit to global health by producing valuable therapies in sufficient quantities and at affordable prices for poorer countries.

Extensive DNA, RNA and protein data on humans and infectious organisms responsible for millions of deaths each year in developing country are stored in databases that can be accessed, free of charge, from anywhere in the world over the Internet. Bioinformatics has the power to transform vast amounts of data into valuable medical insights for preventing and treating both infectious and non-communicable disease. Without having to invest heavily in the technologies used to produce them, developing countries can take advantage of these data and apply the power of bioinformatics to local health problems.

The global incidence of Sexually Transmitted Infections (STIs) is high and is rising rapidly. it has been estimated that 333 million people acquire an STI other than HIV/AIDS annually. Biotechnology is enabling the development of a number of new forms of female-controlled protection against STIs, such as recombinant vaccines, monoclonal antibodies and new approaches to the development of vaginal microbicides, which are discreet, topically-applied barriers to infection. Advances in this area could have a significant impact on women's health, and reduce the spread of STIs among the general population.

Many diagnostics used in developing countries are cumbersome, time-consuming and costly. Molecular diagnostics use tools such as, the polymerase chain-reaction (PCR), monoclonal antibodies and recombinant antigens, to detect the presence of infections or other disease conditions

Medical research, in future is expected to be the application of procedures, such as, gene-therapy and stem cell therapy for curing diseases. Perhaps the most demanding aspect of gene therapy will be availability of harmless vectors and targeting of corrective gene to the desired cell or tissue. There have been encouraging advances in stem-cell therapy for treatment of spinal cord injuries and diabetes. The exciting future medical biotechnology and genetic engineering research holds both promises and challenges.

### 19.2.3 Agricultural Biotechnology

Agricultural biotechnology can be used to help farmers in developing counties, produce more by developing new crop-varieties that are drought-tolerant, resistant to insects and weeds and able to capture nitrogen from the air.

The bioengineering of plants with economic advantage can help many developing countries transform arid-zones into food factories. Crop-productions from arid lands can benefit from genetic improvement of cultivated species and their resistance to environmental stress. Agricultural biotechnology is full of entrepreneurial opportunities for networking the technological transformation of developing-world, to designing solutions, to devising bioclean industrial processes, to enhancing soil-fertility, to increasing crop-yield, and to engaging in molecular farming.

Biotechnology can also make the food-farmers produce more nutritious food by increasing the vitamin-A, iron and other nutrients in the edible portion of the plant. In fact, researchers announced recently that they had succeeded in genetically modifying rice to provide more iron and vitamin-A. The next step is to test the new rice for its effects on human-health and environment.

Globally, transgenic varieties are now grown on more than 58.7 million hectares (145 million acres) in countries such as: Argentina, Australia, Brazil, Canada, China, India, Mexico, the Philippines, South Africa, and the United States. Nearly one-quarter of that hectarage is farmed by over 5 million resource-poor farmers in developing countries.

Present applications in agriculture include: conventional breeding, tissue-culture and micropropagation, molecular breeding or marker-assisted selection, plant disease-diagnostics, genetic engineering and the production of GM crops, exploitation of heterosis vigor, development of new hybrids and planting material with desirable traits, and the "omics" sciences (e.g., genomics, proteomics, and metabolomics.)

A number of multi-institutional projects have also been launched, in developing countries, including the development of transgenics for resistance to geminiviruses in cotton, mungbean, and tomato, resistance to rice tungro disease, resistance to bollworms in cotton, development of a nutritionally enhanced potato with a balanced amino acid composition, and development of molecular methods for heterosis breeding.

The first GM crop to be released for commercial cultivation is Bt cotton. The average Bt cotton farmer will reduced pesticide sprayings for the Asian bollworm from 20 to 6 times per year and will produce a kilogram of cotton for 28% less cost than the farmer using non-Bt varieties

Possible developments of saline resistant and water stress resistant plants can provide hope to green degraded and semi arid lands of the world. Biotechnology will help reduce use of agro chemicals water and fertilizers.

### 19.2.4 Environmental Biotechnology

Contamination of water, air and soil, largely the result of human activity, has had an undeniable impact on human-health. Bioremediation and biosensing harness the ability of microbes and plants to degrade and detect pollutants, and represent a potentially cheap and sustainable form of waste disposal. Conventional chemical sewage treatments can be augmented by use of beneficial bacteria and other microorganisms to kill pathogens. A low cost alternative to conventional sewage treatment is being used in southern China. The system uses floating rafts called restorers to supply beneficial microorganisms to a canal contaminated with human waste transforming the sewage canal into wetland featuring 20 species of native Chinese plants.

## 19.3 BIOTECHNOLOGY IN DEVELOPING COUNTRIES: INITIATIVES

A number of developing countries, particularly in Asia and Latin America, have invested considerably in biotechnology R&D. Publicly funded research institutions and a few private companies in developing countries have established projects and programmes in biotechnology R&D. The nature of the activities and the level of investment in the technology vary from one country to another and from one sector to another.

Developing Countries are at different stages with respect to biotechnological development and applications. The Czech Republic, Hungary and Poland are leading actors in several areas related to biotechnology, while countries such as Romania and Bulgaria have begun to develop their biotechnology-industry. The main areas of focus of biotechnology R&D in central and eastern Europe are development of vaccines and diagnostics, and also more general application in the food-sciences.

Some countries in the Asian region have identified priorities and are targeting their biotechnology R&D to address specific needs or objectives. For example, China has focused its biotechnology efforts on the development of two-line hybrid rice, transgenic cotton, and recombinant drugs for a number of critical diseases. A target-directed non-viral vector-system, which can efficiently transfer exogenous genes into a tumor cell in vivo and significantly inhibit the growth of the tumor, has been developed, thus, achieving a major breakthrough in the area of gene therapy.

In Latin America, leading actors in biotechnology include Argentina, Brazil and Cuba. Argentina is one of the major exporters of genetically modified crops. Cuba and Brazil have also invested considerably in the genetic engineering of crops for export. In 1998, the Government of Cuba allocated a budget of over US$ 50 million to biotechnology R&D, with emphasis on the development of genetically modified crops and products. The country's biotechnology R&D activities are conducted and coordinated by the Centre for Genetic Engineering and Biotechnology (CIGB) and the Centre for Molecular Immunology (CMI).

## 19.4 BIOTECHNOLOGY IN DEVELOPING COUNTRIES: ISSUES AND CHALLENGES

For most people in developing countries, a better standard of living depends on increasing productivity in agriculture. Biotechnology research, together with appropriate policies, better infrastructure and traditional research methods, can bring benefits to millions of poor farmers and consumers.

Biotechnology applications in agriculture are in their infancy. The rapid progress in genomics will transform plant, tree and livestock breeding. Marker assisted selection will assist breeding for resistance to complex traits such as drought tolerance. This is an area of great potential benefit for tropical crops, which are often grown in harsh environments and on poor soils.

Biotechnology in agriculture includes issues and challenges that may be:

- Non-controversial and with proven merits and relevance, such as cell and tissue-cultures, diagnostics and vaccine in animal production,
- Controversial (particularly genetic engineering), raising concern about ethics, implications for the environment (biosafety), the healthiness of the food (food safety), and for corporate power through control of the technology.
- What are the challenges that will constrain the realization of the opportunities?

### 19.4.1 Food Security and Poverty Reduction

Hunger and famine are caused by structural problems, and therefore, cannot be dealt merely as a technological issue. Conventional technologies of increasing food production are still underutilised in many food deficit areas. We have to consider seriously both current and potential contributions from new technologies. Whether transgenic crop-varieties (genetically modified plants, GMPs) can contribute to food security in poor countries is disputed. Both structural and biological constraints need to be considered.

Structurally the problem is the decline in funding of public plant-breeding. The field is dominated by private industries that can only survive by making technology for the commercial sector. Thus it should not be surprising that available GMPs are less relevant in the subsistence farm sector.

The biological constraint is related to the fact that current methods of genetic engineering can only deal with single genes, while yield basically depends on a complex of many genes. Also in developing countries, generation intervals are generally longer for all animal species of interest than in developing countries. How can DNA technologies be used to reliably realise intense and accurate selection and short generation intervals and to enable genetic improvement of these many locally adapted breeds, to contribute to the required livestock development?

There is rapid progress in the preparation of sufficiently dense DNA-Marker (microsatellite) linkage maps to assist in the search for genetic traits of economic importance. Can these linkage maps be used to develop strategies of Marker-Assisted Selection (MAS) and Marker-Assisted Introgression (MAI) to meet breeding the goals of developing country? How should this be approached ? Given the limited financial resources, how might work for the developing country breeding programmes strategically utilise the rapidly accumulating functional genomic information of other species such as humans, mice and drosophila (fruit fly)?

The structural constraint can be overcome by public funding of technology for the non-commercial sector. One example is the “golden rice”. It has little commercial potential but is believed to have a great humanitarian potential (reduction in vitamin-A deficits). Many ideas of such kind of “pro-poor” biotechnology are discussed for poverty alleviation and meeting the food requirements of the poorer countries. Most of them suggest better tolerance of stress (drought, saline soil, diseases an pests). Improved nutritional quality, called biofortification, includes vitamine-A (the golden rice) but also other ideas related to food quality.

### 19.4.2 The Lack of Capacity

Few developing countries have been able to access the technology and build national competence to any significant extent. Countries like China, Brazil, Argentina, India and Cuba, are strong in certain fields of biotechnology. Many developing countries do not have sufficient resources for research and development of their genetic and bio-resources, hence they are dependent on developed industrial countries for a so called technology-transfer.

### 19.4.3 Insufficient Investment

There is declining public sector investment in agricultural research, whereas modern biotechnologies are resource-hungry. This will result, as it has done for human health, in lack of attention to the crops and problems that do not present a sufficient market for the private sector. The justification of spending on biotechnology is also disputed. Will it help overcoming constraints to food production and contribute to poverty alleviation, or will it only divert resources that could be better spent on conventional approaches?

### 19.4.4 Fear and Confusion

The heated and often polarized debate, in Europe that is now being taken up in USA on the potential risks of so-called GMOs, is a cause of fear and confusion for many developing countries. The hazards of GMOs to biodiversity and human and animal health are now acknowledged by sources within the UK and US Governments. Particularly, serious consequences are associated with the potential for horizontal gene-transfer. These include the spread of antibiotic resistance marker-genes that would render infectious diseases untreatable; the generation of new viruses and bacteria that cause diseases; and harmful mutations, which may lead to cancer.

It is damaging the readiness and abilities of some developing countries to invest in and/ or use biotechnologies that would be of great value to those countries. It affects the degree to which NARS are able to raise resources to invest in modern biotechnologies, and the degree to which the developed world development-agencies are allowed to assist developing countries take advantage of the technologies. It could also impact on the trade potentials with products produced using some of the modern biotechnologies.

### 19.4.5 Insufficient Trained Scientists and Technicians

In order for the problems of developing country receive focused attention, with the required understanding of the needs and capabilities of the farmers and sufficient two-way communication along the research continuum, there do need to be large groups of trained scientists and technicians, active in the national research-systems. They need to be able to assist in the setting of national policies and to be active in the securing of the resources needed.

### 19.4.6 Access to Technology

The question is how to access proprietary technology from the developed world for the benefit of the developing world, to produce public goods that the poor can afford At least some of the technologies needed will be subject to issues of intellectual property-rights. There will be proprietary technology used in the developed world that can be used readily to meet needs of developing countries.

Developing countries are rich in biological resources, but they feel that they are being exploited since they do not have enough knowledge for intelligent resource-utilization and contemporary manufacturing and marketing. Thus, ironically they loose any benefits they could get out of their biological resources.

The technology of genetic modification, includes patented methods (enabling technology) and patented gene(s). Often a single product depends on a range of different patents. But rights-holders are usually willing to waive their patent rights in case of philanthropic use of the product(s). That means dividing the market into non-commercial and commercial segments. Subsistence-crops grown by small-scale farmers in developing countries are seen as "non-commercial" and may have access to technology, free of charge. That is promised for the vitamin-A enriched "golden rice" that is expected to be released for cultivation in a few years. But the patents are not cancelled. Patents are waived depending on where and for what purpose it is being used. The issue of control and ownership of technology, therefore, remains as a source of concern and an issue in policy debates.

As an alternative to legal protection commercial biotechnology companies are developing "technology-protection systems". Genetically modified varieties are often believed to be equipped with "terminator genes", preventing farmers from producing their own seeds. One form of technology-protection, exploits molecular techniques that provide a switch mechanism to prevent further use of a variety or the use of a particular trait. In technical jargon these methods are called "Genetic Use Restriction Technologies" or GURTs. The molecular switch mechanism can be used:

1. To disrupt essential processes in seed development resulting in sterile seeds, or
2. To prevent the expression of an added trait so that it would not appear in the plant.

Main motivation for providing seeds with GURTs mechanisms is in the case of sterile seeds to prevent farmers from saving seeds and in the case of trait expression, to prevent unlicensed use of an added trait. It is for intellectual property protection (alternative to patent) or for biosafety (prevent spread of transgenes to other varieties or to wild relatives).

It is, however, uncertain whether such technology will ever be commercially applied. Since it is purely for protection, it adds costs but does not add any productive value. The technology is highly controversial and is met with particular skepticism in developing countries.

### 19.4.7 Trade

In case of export-crops the use of genetically modified varieties also depends on market acceptability. There are countries where such research methods are prohibited and where genetically modified food is considered too risky for their own populations to consume.

### 19.4.8 Biosafety (Environment and Human Health)

Concerns about environment and food safety are supposed to be taken care of by procedures of testing and control elaborated in the Cartagena Protocol on Biosafety. Most developing countries have signed the protocol, but few have so far ratified it. Most developing countries, and particularly the least developed countries lack the capacity to implement the Cartagena Protocol and depend on the financial and technical support that is stated as a necessity in the protocol itself.

Basic tests do not need to be repeated in all countries, but each country must be able to critically assess tests made by others, and do additional testing if deemed necessary because of local circumstances. The risk of uncontrolled spread of transgenes to wild species or to local varieties of the same species depends on local flora and on the local farming, and seed supply system.

### 19.4.9 Laws and regulations

Developing countries also realize that they lack laws and capacity to make and enforce the needed laws. In some cases the adoption of new technology is put on hold because the regulatory framework is not in place. The agricultural policies of developing countries should enable and facilitate the safe and effective development, introduction and uptake of valuable new technologies. These would need to include aspects of biosafety, and the protection of consumers and the environment.

### 19.4.10 Local Resources and Policies of Utilization and Protection

Many developing countries are rich in genetic resources and want to exploit those resources for economic development in a sustainable way. This leads to policies of conservation of the biological diversity, to programmes of research on those resources, and to a desire for technology utilisation. However, such programmes mainly exist outside their country, most often in industrial countries. That leads to policies on bioprospecting and "Material Transfer" to ensure that any commercial use of genetic resources from the country is based on agreements that include articles on sharing of benefits.

### 19.4.11 Social and Ethical Issues

The attitude of Islam towards biological sciences is based on an encouragement of a comprehensive knowledge of all aspects of sciences including biological sciences. The rapid advancement of biotechnology raises many ethical and religious issues. These technologies need to be fenced with ethical norms. Some contemporary people think that Holy Quran prohibits scientific intervention with the genetic sack of animals because it is a part of the portion marked off by Satan to lead them astray from the path of God. God's justice in the world is denied if biotechnology is utilized to increase the control of rich nations and groups over the common biological resources of the creation. God's justice is broken if biotechnology becomes a tool for genetic discrimination against vast groups of people. And God's justice is violated if biotechnology imposes on women dangerous and exploitative reproductive techniques. The peace in God's world is violated by all those who use biotechnology to perfect military means for spreading diseases and death.

The integrity of creation is damaged if biotechnology is utilized by commercial pressures to manufacture new life forms that are valued only as economic commodities. The integrity of creation is attacked if biotechnology is used to reduce the rich diversity of human life and to threaten the uniqueness of each individual. The integrity of creation is undermined if new organisms are created and released into the environment irresponsibly.

There is a need for a collective Islamic effort that restricts biotechnology to effect mankind in ways that respects man without victimizing him, does not transgress what god has forbidden and cautioned against. Its goeal must be to help people attain a better and perfect life

## 19.5 MODES OF BUILDING RELEVANT COMPETENCE IN DEVELOPING COUNTRIES

The gaps and needs vary from country to country, but include short term needs of strengthening the capacity to manage current and pressing issues, and longer term needs of establishing in-country capacity to educate needed expertise on the technical subjects and on the related legal, social and political issues.

### 19.5.1 Biotechnology Advisory Boards

States need institutions that can advice governments on biotechnology related legal, regulatory and policy issues. Such institutions exist in some countries, but need support, in order to develop adequate capability. A parallel building of capacity in other institutions is therefore necessary.

### 19.5.2 Policy and Law

Institutions that are responsible for management of genetic resources need to be guided by the policies on biodiversity collection and international exchange. This includes capacity to negotiate terms, including sharing of benefits. Environment law need to be formulated or further developed in many countries.

### 19.5.3 Biosafety

Responsible decision-making on importation of GM-food, or the introduction of GM-technology depends on professional assessment of biosafety issues according to the Cartagena Protocol. Short-term courses should be arranged for senior policy-makers and regulators from developing countries, and on risk assessment and gene ecology for senior scientists, and on risk assessment for NGO/Civil society leaders. This kind of training is urgently needed and would be helpful for many countries.

### 19.5.4 The Cartagena Protocol on Biosafety

In January 2000 a protocol on Biosafety (The Cartagena Protocol), successfully negotiated in Montreal, was adopted as an attachement to the Convention on Biological Diversity. The Cartagena Protocol takes into account “the limited capabilities of many countries, particularly developing countries, to cope with the nature and scale of known and potential risks associated with living modified organisms”. It devotes one article to Capacity-Building (Article-22) and one article to Financial Mechanisms and Resources (Article-28), where the needs of the developing country Parties, in particular the least developed are explicitly mentioned. More than 130 governments have agreed to implement the precautionary principle, and to ensure that biosafety legislations at the national and international levels take precedence over trade and financial agreements at the WTO.

Similarly, delegates to the Codex Alimentarius Commission Conference, in Chiba Japan, March 2000, have agreed to prepare stringent regulatory procedures for GM foods that include pre-market evaluation, long-term monitoring for health impacts, tests for genetic stability, toxins, allergens and other unintended effects(56). The Cartegena Biosafety Protocol has now been signed by 68 Governments, in Nairobi in May, 2000.

### 19.5.5 Capacity-Building through Education

The biotechnology industry grew out of universities. Universities and educational institutes do not have the capacity and resources to educate needed expertise in biotechnology and biotechnology related social sciences. This means lack of professionals for the growing needs for biotechnological development, but it also means lack of high caliber scientists for critical assessment, and well-informed debates on biotechnology issues and challenges

These shortcomings imply the need to building in-country capacity to educate and empower expertise for the country, and the building capacity to undertake independent research on strategic technology and policy issues. It will enable the country to assess technology needs and potentials in the country, use relevant technology elements in national research and development; formulate and enforce policies, laws and regulations; negotiate contracts with industries; participate on equal terms in international collaboration on research; development and policy-making.

### 19.5.6 Establishing a Biotechnology Centre

In order to work with issues that cut across established department borders a biotechnology center (establishment) would provide necessary structure for collaborating among universities and other institutions from with-in or outside the country. A Biotechnology centre could therefore, have sections or groups working on the interaction of the biotechnology and law, ethics, and social sciences. Having such expertise and research in the Biotechnology centre would ease the cross-disciplinary communication, in both research and teaching. The proposed objectives could be achieved through institutional collaboration involving a designated university in a developing country and a partner university in an industrial country.

### 19.5.7 National Centers of Excellence in Biotechnology: Selected Examples

There are many public centres of biotechnology around the world. These centres play or could play important roles in building the capacities of developing countries and countries with economies in transition.

There are a number of national centres of excellence in biotechnology in the Latin America region. These include the Oswaldo Cruz Foundation (FIOCRUZ) in Brazil, the Centre for Genetic Engineering and Biotechnology (CIGB) in Cuba, the Biotechnology Institute at the Autonomous University of Mexico (IBT-UNAM) in Mexico, and also the Centre for Research and Advanced Studies (CINVESTAV) in Irapuato, Mexico.

In Africa, although a growing number of biotechnology activities are conducted in national public universities there are few centres dedicated to biotechnology R&D. The latter is largely undertaken by departments in universities and national agricultural research bodies. Some of the universities have established units or programmes that are now dedicated to biotechnology R&D. Many of these have not yet grown into centres of excellence.

Asia has a growing number of centres of excellence in biotechnology. Thailand's National Centre for Genetic Engineering and Biotechnology (BIOTEC) is one of the leading biotechnology institutes in the region. Founded in 1983 with funding from the Government of Thailand, the Centre has implemented many national and regional research projects and programmes.

In central and eastern Europe the Agricultural Biotechnology Centre (ABC) in Hungary, is a centre of excellence in agricultural biotechnology. Established in 1986 by the Ministry of Agriculture of Hungary, ABC has grown into a regional centre engaged in cutting-edge scientific research in various areas of agricultural biotechnology.

A number of well-established and relatively dynamic international research centres now engaged in agricultural biotechnology R&D were identified. The International Rice Research Institute (IRRI), a member of the Consultative Group on International Agricultural Research (CGIAR), is one such centre. In the 1980s, UNIDO took the lead in the creation of the International Centre for Genetic Engineering and Biotechnology (ICGEB), with headquarters in Trieste, Italy. The ICGEB is engaged in the building of national capacity in industrial, agricultural, pharmaceutical, animal and human health biotechnology. It now has more than 30 affiliated centres around the world. The International Centre for Tropical Agriculture (CIAT) in Colombia, the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico, the International Potato Centre (CIP) in Peru, and the International Livestock Research Institute (ILRI) in Kenya are among the leading international public biotechnology R&D institutes.

In the area of biotechnology policy, leading actors include the International Service for National Agricultural Research (ISNAR). ISNAR was established in 1979 to support the institutional development of agricultural research in developing countries.

### 19.5.8 Labeling Biotechnology Food for Customer Awareness

Labeling of biotech foods is required to protect consumers and increase consumer choice. Labeling of a new food should be provided to inform consumers of genetically modified or biotechnology processed foods, and the significant changes in nutritional value, safety, or usage of such products. In addition, labeling is without value unless it is accompanied by focused consumer education, about genetically modified products and their possible advantages and disadvantages, in the context of local needs and environment. It is important to spread correct information and to stimulate a sound debate of potential benefits and risks related to the use of such techniques.

## 19.6 CONCLUSIONS

Modern biotechnologies will not solve all the problems of food insecurity and poverty. But they could provide key components to solutions if given the chance, and if steered by a set of appropriate policies.

The capacity to search, assess, acquire or develop, and utilize biotechnology is one of the most important factors accounting for differences in nations' competitiveness in the technology. It is the existence or absence of that capacity in developing countries that will determine whether they engage effectively in the application of biotechnology to address their national needs. The capacity is articulated in human skills; the existence of dedicated centres or programmes; the availability of adequate financial resources; the formulation of systemic and long-term policies; the existence of scientific and technological infrastructure; and appropriate institutional structures and linkages (for example, within and between research bodies, and between research and industry) for biotechnology R&D.

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## Chapter Five

# SUSTAINABLE DEVELOPMENT LED BY SCIENCE AND TECHNOLOGY

# 20. TOWARDS SUSTAINABLE DEVELOPMENT THROUGH SCIENCE AND TECHNOLOGY

In a world increasingly challenged by economic, social and environmental problems that spill across political, cultural and demarcated boundaries, concrete and implementable solutions are the need of the hour. In the wake of such urgency, sustainable development is perhaps the most sought-after concept, envisaged to be the sovereign remedy for global predicaments.

Keeping in view the centrality of sustainable development as a solution for global issues and problems, many countries, organizations and agencies have convened countless meetings, conferences and summits over the years. The movement of sustainable development first became a part of the international agenda in 1972, at the UN Conference on Human Environment, held in Stockholm, Sweden. Principle 21 of the Stockholm Declaration, one of the most significant outcomes of the conference, held states responsible for actions that cross over borders harming other states. Prompted by a chain of following events, the UN General Assembly called the "Earth Summit" at Rio de Janeiro, Brazil, in 1992, marking the 20th anniversary of the Stockholm meeting. The most significant achievement of this summit was the preparation of a comprehensive document known as 'Agenda 21', which identified priority actions and guidelines dealing with domestic, social and economic policies, international economic relations and cooperation on global common issues for the achievement of sustainability of human society.

The Tokyo, Montrae and Doha declarations followed in Rio's lead, while the very latest of international efforts to address sustainable development was the World Summit on Sustainable Development held in Johannesburg, some months back. The official agenda for the summit was to review the achievements that had been made since the last "Earth Summit" at Rio de Janeiro, consolidate the implementation of "Agenda 21" of the same summit and determine progress in this regard. Contrary to the general opinion, Johannesburg was not a complete failure in terms of matters discussed and resolutions issued. Some improvements were certainly seen. Although the issues under discussion were politically colored, it must be said that the summit was not a failure; instead it was a useful step forward in the struggle to attain global sustainable development. At Johannesburg, issues identified from the Rio summit were discussed in greater depth than ever before and from varied angles; however, as the pre-summit expectations were exceptionally high, the summit is deemed to have failed according to many.

## 20.1 NEED FOR SUSTAINABLE DEVELOPMENT

As an instant reaction, one tends to ponder why this concept of Sustainable Development is deemed so important and what justifies the need for it. The answer is simple. It is a known fact that economic and social progress & prosperity are the essence of a nation's developmental objectives. Natural resources are exploited and utilized to achieve maximum benefits for socio-economic uplift and prosperity. However, the unabated exploitation of natural reserves for economic benefits, and consistent damage to the delicate ecological setup of the planet, have caused many devastating phenomena, such as acid rains, deforestation, deplition of ozone-layer, pollution and global warming, to occur, which have had a negative impact on every developmental endeavor initiated at ecology's expense. Therefore, the only way in which consistent growth and development can be achieved is by maintaining harmony with the ecological equilibrium, which implies sustainable development. Nevertheless, sustainable development today is analyzed in great depth and includes not only lesser environmental degradation and pollution, but also reduced poverty, illiteracy, disease, war, corruption, and gender equality. In short, it addresses all those concepts that are environmentally, socially and economically undesirable.

The dilemma, i.e. to figure out the essential means through which sustainable development can be achieved, remains unresolved at this juncture. However, the answer lies in the problem itself. The issues faced by the developing and developed nations of today are mainly pertinent to: i) fight against disease; ii) population growth and urbanization; iii) the digital/information divide; iv) coping with climate change; v) confronting the water-scarcity crisis; vi) preventing soil degradation; vii) preserving forests, fisheries and bio-diversity, and viii) building a new ethic of global stewardship. However, if analyzed closely, these problems seem to be more at the heart of the developing rather than the developed states, who on the other hand, being the major users of natural resources and consequent pollutors of air and water, bear the heavy responsibility of reconciliation.

What caused such alarming dilemmas to materialize in the first place? Without a doubt, unabated industrial revolution across the globe is to be primarily blamed for such persistent and irreparable damage. And the backbone of this very revolution was, nonetheless, science and technology. S&T were the tools effectively used to develop means and methods for excessive exploitation of natural resources, without much concern for the equilibrium of the ecology. It was the use of S&T that allowed depletion of ozone-layer through CFCs and carbon emissions. Undoubtedly, it was S&T that paved the way for the development of huge and easy-to-use machines that today facilitate the clearing of miles and miles of natural forest-cover. It was through S&T that, today, industries producing diversified products are also discharging hazardous waste-materials, which degrade the natural environment. Furthermore, S&T have led to the existence of the core-factors causing global warming and abrupt climatic changes and new and tough diseases for mankind to deal with. The industrial revolution, with its many ill effects on the environment, is also the primary factor causing economic and social imbalances within and among the countries of the world. Developmental gaps have forced poverty to rise and have in turn initiated the struggle for “survival of the fittest”. which has led to degradation of ethical responsibilities towards the society and environment.

## 20.2 SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY

Nevertheless, to date, scientific knowledge and appropriate technologies are still considered central to resolving the economic, social and environmental problems that make current development paths unsustainable. The extracts of many global summits and conferences suggest that the transition towards sustainable development is inconceivable without science, engineering and technology, as these are the groundwork for addressing immediate human and social needs, while preserving the Earth’s fragile life-support systems. Their propagation and essential implementation, keeping in view their pivotal importance, is the means of achieving true sustainable development, because it is not S&T itself that is responsible for the global predicaments of today, but the *wrong use of S&T* in that particular manner, which has allowed such environmental, social and economic issues to come up. Indeed, S&T are mere tools whose implementation determines the ensuing results. The need is to amalgamate and analyze natural sciences suitably with social sciences, so as to correctly interpret the consequences of particular S&T applications, as well as, implementable solutions for prospective side-effects.

It is an accepted fact that science and technology serve as the key players in the systematic bridging of the development-gap between the nations of the South and the North. S&T are rightly considered to be vital for creating wealth and improving the quality of life in contemporary society. They are increasingly recognized to be central to the social, environmental and economic origins of ‘sustainability’ challenges, and to the prospects for successfully dealing with them. Science and technology brought us the everyday technologies that preserve our foods, cool our houses and make life much easier for us. They played a crucial role in bringing about the increases in agricultural yields and distribution-systems that have helped to keep most of the world from famine. Prevention of disease would have been a remote concept, had science and technology not invented breakthrough cures and preventive techniques. The industrial revolution was man’s necessity and is the root of many wonderful, useful and integral products, services, means and methods, which have made human beings much more productive, efficient and progressive.

Sustainability is a slow process, and it treats different socio-economic problems in an interconnected manner. However, the relationship between different phenomena is not necessarily positive. It may be that while sustainable development is achieved in a few areas of concern, others may deteriorate or remain unchanged for the time being. Whatever the case, science and technology are the crux of sustainability and form the true development-engine in underdeveloped as well as developed parts of the world. It is high time that the strategists of the world bring forward scientists and researchers to take part in strategic decision-making processes affecting the global environment, so that S&T may be practically inculcated in the policies and future plans.

## 20.3 GLOBAL CONCEPTIONS ON S&T FOR SUSTAINABLE DEVELOPMENT

The latest notion among global planners and strategists for achieving true sustainable development is "WEHAB", which is an abbreviation of the pressing issues governing sustainable development, namely Water, Energy, Health, Agriculture and Bio-diversity. Credit must be given to the United Nations for adamantly pursuing the cause of global sustainable development and for the introduction of such useful terminologies, which serve as a good starting point for further improvement. However, after due consideration of the pivotal nature of these issues, one must realize that other aspects, such as globalization, gender inequality and poverty also stand as towering challenges to the realization of true global sustainable development. As of today, the global strategists are addressing all problems, yet in isolation from one another and in neglect of the interlinked nature and relationship of their occurrence and persistence.

The need today is to chalk out the strategic path, through which S&T can be effectively used for the betterment of mankind and the human race, through minimal infliction of negative aspects on the three pillars of sustainability, i.e., society, environment and economics. Promoting transitions toward sustainability in the 21st century will require much more than improvements in the production and effective use of science and technology, which will be essential components of most of the solutions. S&T must be used in a manner, whereby the ill effects of its implementation are contained and controlled and are not allowed to spread and plunder unabatedly.

## 20.4 PREMISE FOR S&T POLICY FRAMEWORK

Science and technology has the potential of producing the most wondrous alternative energy systems, enhancing agricultural productivity (potential applications of which are bio-technology, genetic engineering, superconductivity, impressive recycling and recovery techniques), introducing low-energy catalytic routes, integrated transport-systems, efficient urban-design systems, energy and material conservation, etc.; in theory and in practice, there is no limit to what S&T is capable of delivering. But all that science and technology, that innovative potential must be universally available and pro-actively sought after, in order to yield a sustainable environment. A coherent and concrete policy within the context of the three pillars of sustainable development – economic, social and environmental--integrated with the possible role of science and technology is therefore essentially required today for the realization of global sustainable development. Consequently, a S&T policy framework must evolve and build around the following aspects:

- ***Define Focus:*** In the light of confronted and potential global challenges, any S&T policy for sustainable development must have two directives. First, that the developing and developed countries seek new ways of achieving an environmentally benign economic structure. And second, that an internationally cooperative mutuality develops, whereby all major trading blocs, competing ideologies, developed and developing regions, recognize the need for equal partnership involvement in seeking and furthering the benign environmental trajectory.

- ***Plan for the Future Generations:*** The fruits of sustainable development are to be equally reaped by the next generations, which have as much right to Earth's natural resources as the generation of today. And to cater to the needs of these coming generations, we must have the requisite knowledge and tools to precisely determine and predict future climatic conditions, population-growth, food-requirement & growth and related issues. Currently, our projections are not very precise, because of the lack of necessary knowledge and tools for accurate prediction and assessment. The need, therefore, is not unlimited growth, but to determine how much exactly to produce in a given span of time and under certain conditions, so that the future generations are efficiently catered for and are not deprived of their share of natural resources. New methods of scientific prediction, therefore, need to be invented, so as to determine the exact amount of world's available resources and precise impact of various exploitative activities on these resources.

- ***Keep an Out-of-the-Box Approach Towards S&T:*** All in all, a comprehensive S&T application must be supplemented by the discovery of new sciences, which augment the precision capabilities of existing tools and techniques. New approaches need to be assessed and various scientific areas, especially social sciences, need to be viewed with a different perspective altogether, so that new parameters for measuring social, economic and environmental factors may be developed and efficiently put to use. Nonetheless, effective management of resources certainly helps in conservation and efficient use of these precious assets. Methods such as e-management or smart-management must also be introduced for true sustainable development at individual and collective levels.

- ***Thoroughly Inculcate the Societal & Human Aspect:*** Another major factor to consider in any S&T policy for sustainable development remains the establishment of a positive, cooperative and peaceful environment, where everyone enjoys an "equitable" standard of living. These developments, however, are suppressed by the sole presence of poverty, which remains to date one of the most important hurdles on the way towards realizing global sustainable development. Nevertheless, there is no substitute for the need to inculcate the "basic human ingredient" of caring and mutual respect amongst the people of the world for the actualization of intended plans. It is, therefore, only through these elements that the nations of the developed and developing regions can "feel for the need" of sustainable development and will be able to commit themselves practically towards the achievement of this idea.

Science, technology and innovation can offer much more than anticipated, if they are embedded within a more equitable and acceptable socio-economic framework. The conventional approach to S&T must be modified and revised, so that different disciplines may come together to collectively work towards the realization of this important goal.

- ***Determine Local Solutions for Local Problems:*** Local predicaments need local remedies; therefore original and adaptable solutions must be encouraged, so that requisite results may be achieved. It has taken Europe and North America several centuries to reach the level where they are today. However, no policy should envision the development standards of these regions as the benchmark for sustainable development, as socially, morally and ethically, these areas remain extensively perturbed.

- ***Define Roles and Responsibilities of Developing and Developed Nations Alike:*** The developing and the developed nations, who keep on shifting the burden of implementation on one another, must also review their attitudes with thorough consideration for their own benefits and the benefits of the entire global community. The developing nations demand greater leverage and more time in the use of natural resources and a lower standard in respect of pollution-control, through the use of non-renewable energy, so that they may be able to reach close to the developmental levels of the already developed nations. On the other hand, developed nations shift the burden on to the developing countries by asking them to be more conscious about pollution-control, so that they may violate the "unwritten agreement" of the use of non-renewable energy, which otherwise undermines their plans for development.

Nonetheless, it is in the interest of "sustainable development for all" that the developed countries assume their responsibility for taking up measures to ensure future economic and social growth of the poor world and, above all, be honest and sincere in the fulfillment of their commitments in this regard. In short, for the South the "means" for sustainable development is a pre-requisite, while for the North, the "will" to commit to global sustainable development is the key. It has already been ten years since the last "Earth Summit" and the promised results of this event are yet to be fully realized. The need today is to recognize that the world is running out of time and patience, and to sit down and redo our "theoretical planning". It is about time that concrete steps for implementation are formulated and put in place, before the strategists of the world are confronted with problems worse than those at hand.

## 20.5 CONCLUSIONS

Finally, it can be safely said that there is no other way forward for developed or developing regions, but through sustainable development. The need today is to fully engage S&T

with societal wants, so that all stakeholders may be involved in a meaningful dialogue leading in this direction. Thorough integration of S&T in the educational-system is envisaged to allow for better public understanding of sustainability issues. Moreover, greater investments in S&T are bound to bridge the developmental gap between the countries of the South and the North. Surely, sustainable development cannot be brought about in isolation or segregation; therefore, S&T capacity-building at the international, regional and sub-regional levels must be synchronized to achieve maximum benefits. The introduction of clean and adaptable technologies in targeted areas is expected to provide the necessary results and, more importantly, strategic partnerships between the public and private S&T sectors, which will also produce requisite outcomes.

In the world of today, sustainable development is not just an environmental demand; it is a developmental necessity, and the only concrete and comprehensive tool for achieving this necessity is science and technology.

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# 21. SCIENTIFIC KNOWLEDGE AND SUSTAINABLE DEVELOPMENT

The world today is being shaped by progress in scientific knowledge and technology. Advancement in scientific knowledge has led to incredible innovations that have benefited mankind significantly. Cures have been discovered for many ailments and our life-expectancy has increased markedly. Agricultural output has risen considerably in many parts of the world, to meet growing needs of the population. Technological developments have created the opportunity to free mankind from exhausting labour.

In addition to the demonstrable benefits, the applications of scientific development have also led to environmental degradation and technological disasters. In order to keep the planet inhabitable, the nations and scientists of the world must recognize their duty to use scientific knowledge in a responsible manner.

Today, while exceptional advances in technology are foreseen, there is a need for informed democratic debate on the use of scientific knowledge. The scientific community and the decision-makers should strengthen the public trust and support for science through such a debate. Advancing the objectives of international peace and common welfare of humankind should be the highest and most noble goals of our society. Greater interdisciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with ethical, social, cultural, environmental, gender, economic and health issues.

As a result of structural differences among countries, regions, social groups and between the sexes, most of the benefits of science are unevenly distributed. The scientific knowledge has become a crucial factor for prosperity and its distribution has become more inequitable. The major distinction between the poor and the rich, be it people or countries, is not only possession of fewer resources, but also elimination of the benefits of scientific knowledge. Enhancing the role of science, for a more equitable, prosperous and sustainable world, requires a long-term commitment of all stake-holders, public and private, through greater investment, appropriate review of investment-priorities, and sharing of scientific knowledge.

The scientific knowledge, based on comprehensive inquiry into nature and society, provides educational, cultural and intellectual enrichment and leads to technological advances and economic benefits. For sustainable progress, lasting peace and equity, the efforts for scientific research must be consistent with the needs, aspirations and values of humankind and with proper respect for nature and future generations.

Promoting fundamental and problem-oriented research is essential for achieving endogenous development and progress. There is a need to give recognition to the key role of scientific research in the acquisition of knowledge, in the training of scientists and in education of the public. The international character of fundamental research should be strengthened by significantly increasing support for long-term research-projects and for international collaborative projects, especially those of global interest. In order to reap propagating benefits from scientific research, a balance must be established between immediate and long-term objectives.

Scientific research funded by the private sector has become a crucial factor for socio-economic development, but this cannot exclude the need for publicly funded research. For the achievement of true benefits, both private and public sectors should work in close collaboration and must complement each other in the financing of scientific research.

The dissemination and sharing of scientific knowledge are crucial parts of the research-process. In order to facilitate access to sources of scientific knowledge, especially by the developing countries, there is a need of increased collaboration between scientists, research-institutions and other relevant non-governmental organizations on international level.

The countries that have the necessary expertise must promote dissemination and transfer of knowledge through training of scientists worldwide. As access to data and information is essential for undertaking scientific work and for translating the results of scientific research into tangible benefits, publication of such results should be carried out.

It is the duty of the scientific community to collaborate and promote harmony and a culture of peace and to work for the solidarity of mankind. Cooperation among the scientists throughout the world is important for global peace and security. This could promote disarmament and a dialogue between representatives of governments, civil society and scientists for reducing military spending and the orientation of science towards military applications.

Scientific and technological development must be directed towards ‘safe’ and ‘clean’ production, efficient use of resources and environmentally benign products. For responsible applications of science and technology, scientists must assess the safety of new technologies in an impartial and objective way before implementation. The objective should be a strategic step towards sustainable development, through the integration of economic, social, cultural and environmental dimensions.

Science-education is an elementary requirement for ensuring sustainable development. For a country to have the capacity to provide for the basic needs of its population, education in the fields of science and technology is a strategic necessity. The basic principles of peace and coexistence should be a part of education at all levels. In the developing countries, there is a need to strengthen scientific research in higher education and postgraduate programmes, taking into account national priorities.

The practice of scientific research and the use of acquired knowledge should always aim at the welfare of humankind. It should focus on the reduction of poverty and preserving the global environment. A free flow of information on all possible uses and consequences of new discoveries and technologies should be promoted, so that ethical issues can be debated in a suitable way. It is the social responsibility of scientists to maintain high standards of scientific integrity and quality-control, and share their knowledge. All scientists should commit themselves to high ethical standards.

Equal access to science is a social requirement for human development. There is a need to address the difficulties encountered by disadvantaged groups and especially women, in pursuing a career in the fields of science and in participatory decision-making in science and technology related issues.

Every human being has a right to equitable healthcare facilities. The complex problems of poor health and increasing inequalities in health between different countries and between different communities, within the same country, have to be addressed by the governments and scientists of the world. This can be accomplished by using scientific and technological advances and by developing long-term partnerships between all stakeholders.

## 21.1 IMPORTANT CONSIDERATIONS & CONCLUSIONS

There are certain important aspects that the scientific community and decision-makers must give serious thought to. They must consider:

- where the natural sciences stand today, where they are heading and what their social impact has been;
- cooperation between the scientific community of the world must be encouraged and science must become a shared asset, benefiting all people, on the basis of solidarity that scientific research and its applications may yield significant returns towards economic growth and sustainable human-development, including poverty-alleviation;
- that use of scientific knowledge can considerably improve human health-conditions
- that some applications of science can be detrimental to the environment, individuals and the society, and therefore must be practiced responsibly;
- that the contribution of science is indispensable to the cause of peace and development and to the global safety and security;
- application of science should be in line with appropriate ethical requirements, developed on the basis of informed public-debate; and
- that the public should be provided access to science-education without any kind of discrimination.

Encapsulating the afore-mentioned discussion, it may be concluded that the sciences should be at the service of humanity, as a whole, and should contribute to providing everyone a better quality of life and a sustainable and healthy environment for present and future generations.

## 21.2 FOR FURTHER READING


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# 22. DEVELOPMENT LED BY SCIENCE AND TECHNOLOGY–AS SEEN THROUGH COMSATS

## 22.1 SCIENCE IN EARLY CENTURIES

The history of science is witness to four eras in terms of the major contributions. The Greeks (450 BC to about 200 BC), the Chinese (600-700 AD), and the Muslim golden era of science showing continuous dominance for about 350 years between 750 to 1100 AD and another long string of achievements from 1100 AD to 1350 AD. After 1350 AD, the scientific honors belong mainly to the western scientists, as a result of a new spirit of enquiry. The domination of Europeans became more pronounced with the passage of time. The last few centuries completely belong to them and the scientific contribution of scientists from developing countries is relatively insignificant. The main factors behind such a trend contributing to this backwardness in the under developed/developing countries are lack of political will, administrative factors, low literacy-rate and high population-growth, shortage of research and development scientists and engineers, and restrictions imposed by developed nations on the acceptance of scholars from the Southern countries, particularly in useful/sensitive scientific areas/fields.

## 22.2 EMERGENCE OF THE CONCEPT OF INTEGRATION OF SCIENCE AND TECHNOLOGY IN NATIONAL DEVELOPMENT

Dependence on science and technology as an instrument for attainment of national developmental goals is a phenomenon that has grown in importance over the years. The industrial revolution was a classical example of what Science and Technology (S&T) could do for the services sector and for the industrial growth of nations. The current level of S&T efforts in the developing countries of South is dismal, because of the reasons highlighted above. It has been realized that the role of governments in the process of development is irreplaceable. Thus, the need is for a canalised mechanism, through which scientific heads would frame and execute objective-oriented policies. To live through the challenges of the 21$^{st}$ century with success, the immediate formulation and implementation of a well thought-out, well-planned science and technology strategy, in the developing world, is imperative.

## 22.3 ROLE OF THIRD-WORLD ACADEMY OF SCIENCES (TWAS) IN PROMOTION AND DEVELOPMENT OF SCIENCE

The Third-World Academy of Sciences (TWAS) is a unique institution, which has gained a prominent position among major players of the field, due to its revolutionary ideas and programmes. The institution first thought of the idea of scientific and technical exchanges between the countries of South, considering the increasing inhibition of advanced countries to share their know-how with less developed countries. TWAS, by continual and concerted efforts, tried to hammer out some ways and means to pool the natural and human resources available in the countries of the South, and steer ahead to attain advancement in their particular fields of interest. These attempts were aimed at sensitizing the political leadership in the South to place science and technology at the top of their development agenda, and to increase funding for research and development.

## 22.4 ESTABLISHMENT OF COMSATS

Realizing that a common and independent platform is needed to mobilize the political will, the President of Third-World Network of Scientific Organizations (TWNSO) and Third-World Academy of Sciences (TWAS) called for joint efforts by government of the South, the World Bank and inter-governmental organizations of the UN system. In the south, a network of 20 international research and training centres were to be established, aiming at excellence in areas of frontier sciences, technology and environmental sciences, which are most likely to have strong impact upon the economic and social development of the South.

The proposal was endorsed by Heads of Governments of Non-Aligned countries in a meeting in Belgrade (1989) and also received support from a number of Heads of States who responded positively to the letters written by Dr. Abdus Salam, the then President of TWAS and TWNSO. After a string of consultations, it transpired that the quickest and most feasible way of establishing the first nodes of the Network would be to upgrade a number of existing competent centres of the developing countries to become International Centres of Excellence, with the support of international community combined with the necessary commitments from host governments.

The foundation conference of COMSATS was convened in Islamabad on October 4&5, 1994 at Islamabad, Pakistan. The representatives of heads of states or government from 36 countries that attended the conference included 22 ministers of science and technology. A number of international organizations also sent their representatives. Management of the Network of Centres of Excellence was set as the major function of COMSATS. The main objective of the Network of Centres of Excellence is to build human resources capacity in the emerging sciences through providing high-level training and research opportunities, so as to provide scientific solutions to complicated developmental problems (R &D), to prevent brain drain, to provide a framework for S&T assessment and management, and to provide a focus for international cooperation.

The Commission, therefore, induces cooperation in Science and Technology amongst the member states in the South and provides support to various initiatives meant to bring socio-economic uplift in the third world. It is a very new but upcoming forum of the developing countries. So far, 21 countries have become its members. International aid-giving agencies, such as TWAS, TWNSO, UNESCO, UNIDO, UNDP, World Bank, are also collaborating with COMSATS in its mission of fostering science and technology in the developing countries, particularly in the South.

## 22.5 COMSATS PROGRAMMES AND ACHIEVEMENTS (OCTOBER, 1994-2000)

### 22.5.1 Network of International Science and Technology Centres of Excellence

The Expert Committee of Third-World Academy of Sciences (TWAS) has selected 13 centres, which are acting as first nodes of the network in scientific fields. Through mutual exchange, COMSATS promotes networking of each node with its counterparts in the South and encourages co-operation among all network-members. A system is being developed for the up-gradation of the selected centres, in order to bring them at par with their counterparts in the developed world. The tools that are used to promote networking and exchange include training-programmes (workshops / seminars), joint R&D and technology transfer, and expert exchange.

### 22.5.2 Programmes in the Field of Information Technology

Of all the advanced sciences, information technology leads in providing opportunities, better than any other industry in the world. Considering the outstanding contributions of IT to the new techno-economic paradigm, COMSATS has taken IT as the priority-area for development. The projects launched include:

- ***COMSATS Internet Services (CIS)***
  This project was initiated in 1995 to serve as a vehicle for providing access to huge information-reservoir globally. Being one of the pioneers of Internet-technologies in Pakistan, CIS is now helping researchers, decision-makers, industry and the business community by connecting them to the world. CIS has a presence in seven cities i.e. Islamabad, Lahore, Peshawar, Faisalabad, Sialkot, Karachi and Gilgit, having more than 15,000 subscribers. Its services range from dial-up access of 56 kbps to high-speed dedicated line (for individual users) to corporate clients with 24 hours customer-support. The quality-services have earned COMSATS the name of one of the best and prestigious Internet Services providers in Pakistan. To facilitate access to research and educational institutes, CIS offers 50% discount on all its services. CIS also conducts network-training programmes. High-end network training, like CISCO certification, is being provided to the users and engineers.

- ***COMSATS Institute of Information Technology (CIIT)***

he project was taken in hand in April 1998, with an aim to impart high-level education and to produce quality manpower matching the requirements of the international IT industry. CIIT started with conducting short professional courses and one-year post-graduate diploma in IT. In 1999, Bachelors and Masters level courses in information-technology were started. Recently the Government of Pakistan has approved the charter of CIIT, granting university-status to the institute. The Post-graduate diploma and short professional courses are running parallel with degree courses. In addition to the training program, CIIT is also involved in software development and has completed successfully quite a few development projects, to the satisfaction of the clients.

- ***IT Centres in Member Countries***

Following the huge success of CIS and CIIT in Pakistan, a plan is underway to establish Information Technology Centres in other member countries. COMSATS, in partnership with OIC committee on Science and Technology (COMSTECH), is setting up IT Centres in common member countries. The Karachi center was inaugurated on 8$^{th}$ June 2000, while the Syrian Centre would hopefully be operating later this year. The IT centres in member countries aim to train manpower in the latest technologies, and to deliver other services, like software development and export, internet connectivity and research.

### 22.5.3 Programmes Being Developed in the Field of Renewable-Energy Technologies

Renewable energy systems use resources that are constantly replaced and are usually less polluting. The sources of renewable energy include solar, wind, and geothermal energy (getting energy from the heat in the earth), trees and plants, rivers, and even garbage. COMSATS programmes in this field include: Biomass energy utilization, direct Solar Energy, and Micro-hydel Energy. The major work done by COMSATS include:

- ***Biomass Energy***

COMSATS, under the project-support from UNESCO is installing Biogas plants in rural areas of Pakistan. Initially, the gas produced is being used for heating and cooking purposes, with an advantageous output of fertilizers. The project, which utilizes cattle-dung as an input, is being implemented with technical input from Pakistan Council of Appropriate Technology (PCAT). So far, Biogas plants have been installed at 4 sites in Dhok Uthal, Simly Dam Road, Islamabad.

- **Solar Thermal Energy Power-Plant**

COMSATS' project to set up a 1 Mega Watt solar-thermal power plant in Pakistan has won UNESCO funds. COMSATS now awaits the release of the grant, soon after which the project will be implemented.

- ***Micro-Hydel and Wind-Power Plants***

COMSATS, in collaboration with China and local community organizations, plans to initiate a programme to install the micro-hydel and wind-power plants in the remote areas of Sindh and Balochistan, which are off the national grid.

#### 22.5.4 COMSATS Postgraduate Scholarship Programme

COMSATS has started the scholarship programme to financially support higher education for the scientists and promising youth of the member states. Postgraduate scholarships program has been implemented with the support of COMSATS Centres of Excellence and other training institutes / organizations having working linkages with COMSATS. The scholarships have initially been announced to the following establishments:

i. HEJ Research Institute of Chemistry, Karachi University, Karachi, Pakistan
ii. International Centre of Climate and Environmental Sciences (ICCES), Beijing, China.
iii. COMSATS Institute of Information Technology (CIIT), Islamabad, Pakistan
iv. National University of Science and Technology (NUST), Islamabad, Pakistan
v. Damascus University, Syria
vi. Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad.

#### 22.5.5 Workshops/Seminars

COMSATS provides a platform to learn, share, and upgrade skills of the scientists of the member states in different science and technology fields, through conducting professional workshops and technical trainings. Workshops have been organized at both national and international level, with internationally renowned resource-persons, for the benefit of the developing region. The following workshops/seminars/conferences have been arranged so far:

i. Workshop on Laser Technology – Islamabad (July 1996)
ii. Pre-Donor Conference – Islamabad, (July 1997)
iii. Workshop on Mathematical Modelling: Application and Uses - Islamabad, 1998
iv. Numerical Weather-Prediction Model Workshop – Islamabad, 1997
v. Numerical Weather-Prediction Model Workshop – Islamabad, 1998
vi. Numerical Weather-Prediction Model – Dec 6-10, 1999 – Beijing (China)
vii. Use of Spectroscopic Techniques in Structural Organic Chemistry 15-17 Feb. 2000, Karachi, Pakistan
viii. Round Table Meeting on South-South Cooperation on Convergence - Information Technology, Telecommunication and Media - 28th Feb 2000, Islamabad, Pakistan
ix. ISO 14000 Implementation in Industry - 7-9 March 2000, Islamabad, Pakistan
x. CIS-CISCO Workshop on New technology routers, August 2000, Islamabad - Pakistan

### 22.5.6 COMSATS Technology-Exchange Programme for Small and Medium Enterprise (SME) Development

COMSATS facilitates transfer of successful technologies among Member States, to strengthen the technological base of the industrial economy. COMSATS facilitates contact between the interested parties at both ends i.e. the donor and the recipient member-countries for creating joint ventures.

- ***COMSATS Expo – Chinese Technology Exhibition***
  A technology showcase was organized in Lahore, Pakistan, from October 12-14, 1999, displaying Chinese technologies. The event acted as a platform for Pakistani and Chinese entrepreneurs, facilitating their direct contact and providing them an opportunity to explore potential areas for joint business ventures. COMSATS received around 500-700 inquiries/registrations for the event that attracted about 3000 people representing the local industry from all over Pakistan. Approximately 120 one-to-one meetings were arranged between the entrepreneurs, the follow up for which is still on. In addition, seven technology-seminars were conducted during the event, to provide technology details and organizational background of the Chinese exhibitors. The programme extension is planned in the coming years, by organizing similar showcases in the member states. The next exhibition is planned for July 2001in Tanzania

### 22.5.7 Distance-Learning Programme

Distance learning or distance education is yet another means of providing quality training in a range of subjects accessible to maximum possible number of people around the world. COMSATS distance-learning programme aims to provide educational opportunities to remote areas by making use of latest Internet technologies.

COMSATS has taken up jointly a pilot project with Allaince Francaise, French Linguistic Centre in Islamabad, to initiate online French language training-program in Pakistan. The project is of 3 years duration, during which online classes of French language will be conducted for students in the remote areas, by setting up distance-learning centres in various cities of Pakistan, starting with the places where COMSATS Internet Services are functioning. After testing of this pilot project, more distance-learning programmes would be introduced in technical subjects.

### 22.5.8 Programmes in the Field of Biotechnology

Biotechnology is a collection of scientific techniques, including genetic engineering, that are used to improve or modify plants and microorganisms. Scientists are also looking at ways to use biotech to deliver more nutrients and better taste in our foods.

The technology has improved the quality of seed-grains and the ability to produce bigger harvests from currently cultivated land, leading to increased income for the farmer. COMSATS plans to launch some programmes using biotechnology in the near future.

- ***Tissue-Culture Research Project***
  COMSATS, in collaboration with National Agricultural Research Centre, Pakistan (NARC), has taken up a project to test tissue-culture technology applications for producing potato seeds. The project, aimed at producing disease-resistant and high-yielding potato seeds is progressing satisfactorily.

### 22.5.9 Online Scientific and Technical Information Resources

COMSATS plans to launch online database to facilitate access to major scientific database and literature for the scientists of the COMSATS Network. A Scientific and Technical Information Centre has been set-up at HEJ Research Institute of Chemistry, Karachi. This will host major scientific databases (initially Bio-sciences and Chemical sciences) that can be used for research and development work in the South.

### 22.5.10 Scientific Publications

COMSATS' quarterly journal "Science Vision" that was started in 1995 is being circulated in about 27 countries, including Pakistan, and has gained recognition among the eminent scientists and scientific and technological institutions of international repute. An international abstracting agency prints abstracts of the scientific research papers from this journal. So far, 137 papers have been published in the journal, including those printed in Vol.6, No.1 for July-September, 2000. All the published issues have recently been made available online for easy access by the developing world's scientists. www.sciencevision.org.pk

### 22.5.11 Financial Support for Scientific Activities/Travel/Study Grants

COMSATS has taken a new initiative of sponsoring/ co-sponsoring scientific activities of organizations / institutions / individuals. This scheme provides financial support, specifically for holding workshops/ seminars / other training programmes, travel grants for participation in international conferences, and research/ study grants. The countries of Pakistan, Ghana, Sri Lanka, Bangladesh, Iran, Uganda and a few others have benefited so far.

### 22.5.12 Experts/Scholars Exchange Programmes

COMSATS facilitates exchange of experts amongst member states. The scientists of the developing world are offered fellowships to work at centres of excellence, or other establishments, linked with COMSATS for short tenured academic / research activity in various fields of science and technology. This exercise promotes knowledge-sharing, regional networking and offers scientists an opportunity to participate in the development of the third world.

### 22.5.13 COMSATS Membership Campaign

Through the diplomatic missions based in Islamabad, COMSATS has invited the developing states in the south to join COMSATS as member. The possibilities of collaboration in science and technology between COMSATS and the following potential member-countries have been discussed. The countries contacted so far include: Oman, Iraq, U.A.E, Brunei Darusssalam, Somalia, Yemen, Palestine, Turkey, Mynamar, Kuwait, Mauritius, Malaysia, Indonesia, Nepal, Maldives, Qatar, South Africa, Saudi Arabia, Azerbaijan, Algeria.

The Diplomatic representatives of the countries that were approached, expressed the desire to work closely with COMSATS for introducing applications of science and technology like Information Technology, Biotechnology in their countries, for the development of the region. COMSATS has been assured that the requests of arranging COMSATS meetings with the State Authorities in their respective countries would be granted in the near future.

### 22.5.14 International Co-operation

COMSATS keenly follows and participates in the international developmental activities. Various efforts have been made to initiate collaboration in S&T, to create a widespread network of cooperation for the benefit of the south. The two-fold objective includes exploring avenues for co-operation with the international agencies in north and south, to integrate efforts for science and technology related development of the region, and to secure financial support for developmental initiatives of COMSATS also for the project-proposals submitted by the member countries or Centres of Excellence.

Working linkages are being developed with UN Asian Pacific Centre for Transfer of Technology (APCTT), International Council for Science (ICSU), UNIDO, TWAS, TWNSO, Academies of Sciences in member countries, COMSTECH (OIC Committee on Science and Technology), ISESCO, UNESCO, IDRC & ICIMOD, World Bank, JAICA, GTZ, and UNEP.

### 22.5.15 TWAS Co-ordinating Office at COMSATS Secretariat

COMSATS has been vested with the responsibility to look after the interest of the third-world countries in this region, covering the field of Science and Technology. An MOU has been signed between COMSATS and the Third-World Academy of Sciences (TWAS), Trieste, Italy, to strengthen co-ordination and dissemination of scientific and technological information to third-world countries as well as to promote use of science and technology for socio-economic development in the region. A co-ordinating office of TWAS/TWNSO has been established in COMSATS Secretariat, Islamabad. The TWAS co-ordinating office would attend to the requests for scientific and technological information, as required by the member countries of the two organizations.

A part of the TWAS coordinating office is dedicated to Prof. Dr. Abdus Salam, to display some of his valuable scientific publications, honours diplomas and medals from academics of the world as well as renowned institutions of North and South, and records of his achievements.

## 22.6 CONCLUDING REMARKS

The topic of establishment of S&T in the third-world countries has been under consideration for many years. Conferences were convened, detailed discussions were held, various reviews were expressed and, finally, elaborate plans were drawn up, only to go into cold storage and nothing came out at all. The countries of the region are still lagging behind. The reason for the stalemate points towards the indifferent attitude and lack of real interest to ensure the much needed enthusiastic effort in the scientific world of today. COMSATS has proved, beyond any doubt, during its infancy since 1994 that this past history would never be repeated and would continue to demonstrate progress physically to show concrete results of progress on ground. Many precious plans had fallen prey to the lust of power of the rulers. COMSATS would try hard not to repeat this fate again. It has accepted a challenge that would be met with the sincere support of its members.

All the progress achieved by COMSATS, so far, was the result of the support of the member states without which it would not have been possible at all. The extent of enthusiasm gained by COMSATS in a short period, since its inception in 1994, bears evidence to the immense trust put in it by the members. The spirit of mutual cooperation and help within the ambit of COMSATS would definitely lead the third world to share our experience in the advancement of science and technology and win a prominent position in the comity of advanced and industrialized countries.

The one-window dispensation of problems and procurement of knowledge has been globally experimented successfully, and that one window has emerged now in the

South in the shape of COMSATS. Let the needy simply approach it and the rest would follow in joint efforts.

## 22.7 FOR FURTHER READING


- *'10 Years of COMSATS'*, www.comsats.org.pk

# 23. SUSTAINABLE DEVELOPMENT SINCE RIO DE JANEIRO EARTH SUMMIT AND DEVELOPING COUNTRIES

Sustainable development is a concept that has received much attention over the years. It has grown and expanded to embrace the ideas and needs of all nations and has in many ways initiated consensus and dialogue for avenues where it was most needed. The spirit of sustainable development lies in considerate use of resources that allows availability for future generations. It caters for a stable relationship between human activity and the natural world. The effort, therefore, is innately global, understands interdependencies and recognizes the human face of the challenges that exist.

Another manner in which it can be defined is that it is a process that focuses on improving the quality of life for all of the Earth's citizens bearing in mind the capacity of the environment. It requires an understanding that inaction has consequences and that we must find innovative ways to change institutional structures and influence individual behaviour. It is about taking action, changing policy and practice at all levels, from the individual to the international**[1]**.

A less generic definition is given by the World Bank that says that *"sustainable development means basing developmental and environmental policies on a comparison of costs and benefits and on careful economic analysis that will strengthen environmental protection and lead to rising and sustainable levels of welfare"***[2]** .

The first large-scale intense effort to bring the world together on the issue of sustainable development, that came twenty years after the UN Conference on the Human Environment, Stockholm in 1972, was at Rio de Janeiro. The UN Conference on Environment and Development (UNCED), informally known as the Earth Summit was an unprecedented UN conference not only in terms of the number of people that attended, but also in terms of the scope of its concerns. It attracted the attention of people from all walks of life and enjoyed the wide support of nations that encouraged their governments to participate in the Summit. A total of 172 governments participated.

Many important international documents and Conventions came out of the Earth Summit. These included Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity. Later, a Convention on Desertification and the UN Convention on the Law of the Sea were also initiated. The ambitious message of the Summit was a call for a change of attitudes and approach to make possible the changes that were needed in moving towards sustainable development.

It was no doubt a most important, yet daunting undertaking as ultimately it was not the words of the declaration, but the actions in line with the declaration that would determine the level of success achieved. Now twelve years on and with the World Summit on Sustainable Development at Johannesburg having taken place in 2002, we have the opportunity to look back and ascertain whether promises were indeed converted into actions.

Agenda 21 was perhaps one of the most important documents that the international community ever sanctioned, despite the compromises and negotiated changes which were made in the original text for it to be adopted by all. Even today, it serves as a reference point and guideline to efforts of sustainable development. It is a powerful vision of a long term nature with the objective of balancing the economic and social needs of humanity with earth's resources and ecosystems. There is a general agreement that the Earth Summit was successful in putting sustainable development on the map and bringing related issues to the forefront of global debate.

There have been several achievements in the years following the Rio conference. It has been recorded that over 6,000 cities and towns have created their own "local Agenda 21" to guide long term planning processes, while many countries have prepared National Agenda 21 documents. The UN Commission on Sustainable Development, which was set up as a monitoring body for the implementation of Agenda 21, has met every year since 1993 and has been successful in initiating many multi-stakeholder dialogues. Several conferences have sparked from the Earth Summit, which include the 1994 Conference on Population and Development in Cairo, the 1995 Social Summit in Copenhagen, the 1995 Women's Conference in Beijing, the 1996 Habitat II Conference in Istanbul and of course the 2002 World Summit on Sustainable Development. These conferences have helped to keep issues of sustainable development alive and have forced focus on achieving results.

The Global Environment Facility (GEF) was launched in 1991 just prior to Rio. With World Bank, UNDP and UNEP as its implementing agencies, it has become the main source of multilateral lending to developing countries and countries in transition for global environmental projects. This is highlighted by the fact that in its first ten years GEF provided $4.2 billion to projects and was able to obtain $11 billion in co-financing. In 1998 the fund was replenished when 36 countries pledged $2.75 billion to GEF.

Principles from Agenda 21 have also permeated into declarations of the World Trade Organization that has now recognized the need for open and non-discriminatory multilateral trading systems. At the 2002 International Conference on Financing for Development in Monterrey, donor countries promised a total of $30 billion in additional resources for sustainable development through 2006.

The UN Framework Convention on Climate Change that was put forth at Rio entered into force in 1994 and has 165 signatories. In 1997 at Kyoto, efforts produced the now famous Protocol that has been signed by 84 governments. Similarly the UN Convention on Biological Diversity which was also opened for signature at Rio, came into force in 1993 and was ratified by 183 nations. In 2000, the Cartagena Protocol on Biosafety was introduced to ensure the safe use of modern biotechnologies and the risks of trans-boundary movement of living modified organisms. This has been ratified by 17 countries.

Furthermore, the Earth Summit provided strength to the Basel Convention on hazardous wastes, administered by UNEP in 1989. In 1995 the treaty helped to outlaw the export of toxic waste from developed countries to developing countries that often do not have the technology for safe disposal of such substances. In 1998 an international treaty under the auspices of FAO and UNEP was adopted by 100 governments that would facilitate sharing of information on trade in hazardous chemicals and pesticides. In 2001, countries agreed on the Stockholm Convention on Persistent Organic Pollutants that concentrated on the elimination of 12 harmful chemicals that are famous as the “dirty dozen”.

The Forest Principles which were adopted at Rio proved to be the basis for the Intergovernmental Panel on Forests that met for two years and was successful in adopting over 100 action proposals in 1997. To help monitor implementation the Panel became the Intergovernmental Forum on Forests at the Earth Summit +5 in 1997and held its first session in 2001.

The Montreal Protocol of 1987, that was positively benefited by the Rio process, was strengthened in 1996, after which the total consumption of chlorofluorocarbons declined from 1.1 million tons in 1986 to 156,000 tons in 1998**[3]**.

However, with these achievements, there is universal recognition that for the goals outlined in Agenda 21 and subsequent targets set forth at WSSD to be realized, efforts need to be redoubled. In order to provide a complete picture, it is therefore important to take into account the difficulties, the slow progress and the challenges that still need to be faced.

For example, with regard to the UN Framework Convention on Climate Change that was mentioned earlier, most industrialized countries did not meet their voluntary goal of reducing emissions of greenhouse gases to 1990-levels by the year 2000. Similarly, the Kyoto Protocol has faced difficulties, as it can only enter into force when ratified by 55 countries representing 55% of industrialized country emissions. Only two industrialized countries have ratified the Protocol.

At other occasions funds have hindered the achievement of objectives. The UN Convention to Combat Desertification addresses the extremely important issue of arid and semi-arid lands where the lack of or inadequacy of water affects the livelihood and food supply of over 900 million people worldwide, especially in Africa. This convention however, is facing problems in implementation due to limited resources available**[4]**.

The important question to ask with regard to sustainable development is where does humanity stand? According to the Framework Paper of the Working Group on WEHAB for WSSD the situation appears to be far from ideal. The following statistics are reflected in the Paper:

Poor natural resource management has left ecosystems and water resources fragile. About 1.2 billion people still have no access to safe drinking water and 2.4 billion do not have adequate sanitation services. The world loses 2 million of its children each year from water-related diseases. The ever increasing competition for water, increase in population and requirements of water for food production are challenges that will only get more complicated in the future.

In energy today some 1.7 to almost 2 billion people in the world that largely reside in rural areas have no access to electricity. Another 2 billion are acutely undersupplied. Even with modern technology in the 21st Century, one third of the global population still depends on traditional fuels of wood, dung and agricultural residues to meet their needs. Relying on wood puts further pressure on the environment. This poverty-environment nexus is an issue for which solutions need to be designed that best suit the local situation. This is an area where renewable energy technologies have great benefits to offer.

Health is another area highlighted during and after WSSD. The challenge however is evident – more than 2 million children under the age of five lose their lives annually from diseases that can be prevented by available vaccines. Some 28,000 young children die every single year in developing countries. Pneumonia is the deadliest of all and kills more children than any other infectious disease. HIV/AIDS, malaria and tuberculosis also remain avoidable diseases that cause most deaths in low-income countries. Science and technology has a great role to play in this regard but S&T must be made to reach those developing countries where it is needed the most, but where generation of knowledge is weakest.

Agriculture and biodiversity are aspects of sustainable development where several challenges are being faced in the current scenario. Some 70% of poor people in developing countries live in rural areas and are directly or indirectly dependent on agriculture for their incomes. Similarly, some 900 million of 1.2 billion people living in extreme poverty not only live in rural areas but are highly dependent on biodiversity and functioning ecosystems for their survival. Alleviating poverty in such areas often requires new job opportunities based on biodiversity. The issues of poverty reduction, food production and income generation are closely linked and are influenced by infrastructure, technology, trade and policy.

In view of these challenges, there are quarters in the global development sector that believe that WSSD was not able to produce the kind of strong outcomes that are needed to substantially address these issues. However, several important aspects were brought to the notice of the global community through the WSSD process. One of the important deliverables of Johannesburg was that it provided a platform for an honest review of progress or lack thereof and made Governments speak about political will for sustainable development. The voices from developing countries that were weak at Rio were much more louder at Johannesburg.

During WSSD that lasted from 26 August to 4 September 2004 in Johannesburg, developing countries called for efficiently applying resources in a transparent and accountable manner. Much attention was drawn to the foreign debt that burdens developing countries and constitutes one of the biggest impediments in their journey towards sustainable development. Disappointment was expressed on the amount of progress achieved thus far and breaking away from status quo was strongly put forth.

In his statement at the Ministerial Segment of WSSD, Professor G.O.P. Obasi, Secretary General of the World Meteorological Organization, outlined hard realities and stressed that unless solutions were genuine, sustainable development would remain unattainable. He said that ten of the warmest years that have ever occurred were the 1990s and that the 20th Century was the warmest over the last 1,000 years. The year 1998 was the warmest and 2001 the second warmest since records began in 1860. Furthermore, the overall global ozone decline during the last 25 years compared to pre-1970s averages is about 6%. This of course has serious implications. He added that the amount of freshwater available to each person in Africa is about one-quarter of what it was in 1950, while in Asia and South America it is now only about one-third of the 1950 amount. According to the statistics in his speech, glaciers and mountain-ice that are sources of freshwater are wasting as the global temperature increases and the global mean sea-level is expected to rise by 9cm to 88cm. This would no doubt especially threaten the Small Island Developing States.

President Vicente Fox Quesada of Mexico urged participants to place sustainable development in the framework of equity and justice, with an effective battle that would alleviate poverty and provide for a dignified life of respect and opportunity to all people. This in essence was at the core of all messages from developing countries that were shared at the Summit. Dr. Bassem I. Awadallah, Minister of Planning and the head of the Jordanian Delegation, chose to describe the effort as a choice of destiny that rests on an ethical vision of the Earth Charter. H.E. Eltigani Adam El Tahir, Minister of Environment and Physical Development, Sudan expressed concern over the drastic drop in Official Development Assistance (ODA) and underscored the benefits of cooperation and mutual understanding. This concern was echoed in many other speeches by the heads of state of developing countries.

President Maumoon Abdul Gayoom of the Maldives presented the disturbing facts: *"Globalization has increased in pace and scale, with the promise that a rising tide of prosperity will lift all the boats. Sadly, most still remain moored to poverty, faced with the threat of sinking. Over 1.2 billion people still live in absolute poverty. Nearly 3 billion don't have access to safe sanitation….11 percent of the world's reefs are now permanently lost… Low-lying nations are at greater risk than ever before. Time, the most precious non-renewable resource, is running out. From floods to droughts, from advancing deserts to receding glaciers, and from the rising seas to the loss of biodiversity, the writing is on the wall. How long can we pretend not to see?...... Time may not be on our side. But science, technology, and wisdom can be made to be. And so can be simple common sense."*

The struggle of each day for the people of developing countries was aptly portrayed by H.E. Benjamin William Mkapa, President of the United Republic of Tanzania: *"Agenda 21 was designed to achieve a balance between the needs of people and their environmental, balance between the basic requirements of the living, and our inescapable, collective obligations to future generations. But the poor, the hungry and the diseased cannot be expected to put the preservation of their environment above their struggle to survive this very day. So they mine soil nutrients, cultivate steep slopes, cut trees for wood fuel, and overgraze range lands. Many of them know this is harmful to the environment. But, for them, it is not the quality of life that is at stake, it is life itself. For them, sustainability is a secondary concern, the primary one is to get the wheel of development turning, and turning faster"*.

A strong voice was that of H.E. R.G. Mugabe, President of Zimbabwe: *"Your Excellencies, we must examine why, 10 years after Rio, the poor remain very much with us, poorer and far more exposed and vulnerable than ever before. Our children suffer from malnutrition, hunger and diseases, compounded now by the deadly HIV-Aids pandemic. No, the World is not like it was at Rio; it is much worse and much more dangerous. Today Rio stands out in history as a milestone betrayed…. the betrayal of the collective agenda we set at Rio is a compelling manifestation of bad global governance, lack of real political will by the North and a total absence of a just rule of law in international affairs"*.

Mr. Jose G. Justiniano Sandoval, Minister of Sustainable Development and Planning and Head of the Economic and Social Ministerial Council of Bolivia stressed: *"When we fight against corruption we also expect corporate responsibility and transparency. When we create conditions for direct foreign investment, we expect more reinvestment than remittances. When we pay environmental costs, we demand cooperation. Without responsibility from all and for all there is no sustainability, Mr. President. The Implementation Plan that shall emerge from Johannesburg shall also become our responsibility. We should call it Responsibility 21, as a renewed commitment to accelerate the implementation of Agenda 21."*

President Stjepan Mesic of Croatia accurately described the complexities of the predicament: *"Let me note, however, that we are faced with global interconnected problems. They require simultaneous, global approach and common solutions. It is high time to create a unique concept which will ensure the survival of our planet, of the human species and of our civilizations built over centuries with all its specific facets. We can save everything, but also destroy everything."*

While Dr. Sam Nujoma, President of Namibia provided the focus towards better solutions: *"Let me stress that the commitment to the principle of common but differentiated responsibility is not an abdication of duty by the developing countries. Rather, and rightly so, it is a recognition of the varying capacities among states to address the challenges of sustainable development. It is also an acknowledgement of the unequal benefits nations derive from the global environment and the need to rectify this."*

The positive responses from developed countries included those from Japan, Sweden and Germany. Prime Minister Junichiro Koizumi of Japan committed on behalf of his Government to provide no less than 250 billion yen in education assistance and cooperation in the area of environment-related capacity building by training 5,000 people from overseas over a five year period as they recognize that the strength of human resources plays a critical role in sustainable development. He further extended emergency food aid amounting to US$ 30 million to save children in southern Africa from famine. Japan can also claim its due credit for the production of the Kyoto Protocol.

Mr. Göran Persson, Prime Minister of Sweden placed responsibility on industrial countries to take the lead by changing their own production and consumption, and by promoting the exchange of technologies with developing countries. To stimulate such actions, he committed on behalf of the Swedish Government an additional contribution of 10 million euros to the Global Environment Facility.

On a similar note, German Federal Chancellor, Mr. Gerhard Schroder highlighted Germany's success in cutting $CO_2$ emissions by 19% and its pledge to provide 500 million euros to promote cooperation in renewable energies.

The regional level roundtable meetings held in preparation for WSSD helped to highlight the diversity of developing countries and the fact that solutions needed to be local, adaptable, acceptable and in line with the spiritual and cultural environment for them to be sustainable and successful.

Developing countries share many defining characteristics and yet differ at many social, economic and political levels. Developing countries collectively have seen a decrease in absolute poverty but have seen an increase in income inequality. People of many of these countries are still dependent on subsistence living, are the first hit by environmental imbalances, lack access to adequate information, institutions of justice and social safety nets. Rapid urbanization has created a new face of poverty – urban slums where health and sanitation are in alarming conditions. Migration and rapid population growth have complicated pollution and waste disposal issues. Food security that has links with economic security remains as fragile if not more than it was a decade ago.

One of the aspects that has and must continue to receive due attention is that issues of all sectors and all nations are interdependent. The environmental problems of one country become the climate change problem of another, changes in trade policy becomes the economic crash of another, the political instability of one country becomes the refugee problem of another. At the national level, issues often have multi-sectoral implications. For example, shortage of adequate water supplies have an impact on agriculture, health, environment, energy, biodiversity, food security, exports and an array of micro level concerns. Solutions therefore cannot be devised in isolation and without consideration of their multiplier effects.

Discussions at the pre-WSSD regional roundtables produced a number of credible recommendations regarding certain pressing areas in the realm of sustainable development. Poverty eradication and empowerment of the poor, of course, was placed high on the list. Economic development and the creation of livelihood opportunities are important in poverty alleviation efforts but needs to occur with a focus on bringing about social and income equalities. It was recommended that Governments must establish fiscal policies that progressively tax high-income groups, provide funds for human resource development and ensure empowerment of the poor, with added emphasis on women and vulnerable groups. National and regional financial institutions and mechanisms need to be encouraged to facilitate access to micro-credit or other micro-finance schemes that increase self-reliance and decrease dependence.

Globalization has meant an increased interaction at the regional and international level. Where this process has had its benefits, there is no doubt that it has adversely affected indigenous processes, traditions and livelihoods. To combat these negative and often invasive impacts, it was recommended that new and energetic efforts be made for gender equality, preservation of cultures and diversity and human development. Furthermore, international laws must be designed so as to reduce the harmful outcomes of globalization, such as pollution, disposal of toxic materials and the adverse pressure of free trade on developing and struggling economies.

Perhaps the most sound investment that developing countries can make is in capacity building coupled with education, training and public awareness. Emphasis must be laid on the roles of young people as inheritors of today's problems. In this regard it is of critical importance that partnerships are established between the private sector and academic institutions where the private sector would provide funds for scholarships and workshops. At the other end, the education and technical sector can provide the training and skill set that the private sector needs to forge economic development. There is great benefit in bringing about south-south collaborations for this front. At the national level it is imperative to build a healthy and trusting relationship between universities and research and development institutes on one hand and the industrial and service sector on the other.

Technology transfer is another important factor in capacity building and has come to be recognized as a tool that could not only help improve production activity in the manufacturing sector, but also the agriculture sector, service sector and environmental and natural resource management. Technology has the potential to solve complex problems and the flexibility to be molded to meet any unique local needs. It is important therefore to ensure that adequate incentives and rewards for the development of sound and environmentally friendly technologies are developed, while maintaining a balance that facilitates wide access to useful technologies.

When asked, the poorest of the poor in developing countries will probably not show much interest for concepts that relate to economic, social, intellectual and political advancement that are debated and discussed in avenues of sustainable development. They cannot be blamed. Each day is a struggle of survival for them, a battle that they can lose, a constant reminder that hunger and death is a distinct reality. For these people what is beyond themselves is hardly of relevance or importance. Food security therefore, would perhaps be their foremost priority. With a trend of rapid population-growth in developing countries, there is immense pressure on natural resources for food production. Therefore, there is a need to ensure finances and increased focus on agriculture related research and development. It has also been recognized that indigenous methods and species and the utilization of organic farming must be widely promoted as they contribute to qualitative and quantitatively better food production.

A pervasive factor in sustainable development is the availability of finances for the initiatives and efforts being advocated and implemented. Donor countries were reminded at WSSD of their commitment agreed upon by the United Nations of achieving the Official Development Assistance (ODA) target of 0.7% of their GDP. But apart from urgently calling for donor countries to play their role, it is vital to provide more support to mobilize financial resources through specialized trust funds or debt for nature swap schemes**[5]**.

Key outcomes of WSSD include support for the establishment of a world solidarity fund for the eradication of poverty and the extensive participation of civil society in the Summit. Some 8,000 civil society participants attended WSSD that represented all major groups. Heartening was the fact that the concept of partnerships between governments, businesses and civil society was given a large boost by the Summit itself and the Plan of Implementation that came out of it. Over 220 partnerships, with $253 million in resources were identified in advance of the Summit and around 60 partnerships were announced during the Summit by a variety of countries**[6]**.

The world today is faced with complex problems that call for well thought and well planned solutions that are adoptable, flexible and affordable. Though sustainable development lies at the heart of global debate, unless it lies at the heart of global action it will only remain a vision of what could have been. We must remember that sustainable development is only achievable through sustained effort.

In the words of the Secretary General in his address to the Johannesburg Summit:

*"Let there be no more disguising the perilous state of the earth, or pretending that conservation is too expensive, when we know the cost of failure to act is far greater."*

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# 24. SCIENCE AND TECHNOLOGY FOR DEVELOPMENT: IMPORTANCE OF REGIONAL COOPERATION

Rapid globalization and the emergence of a technology-driven economy have changed the world notably. The developing countries of the South have entered the third millennium, facing mammoth challenges hindering their efforts to make economic progress and sustainable development. Issues such as the worldwide lowering of trade-barriers, integration of capital-markets, decentralization of production-processes, and the extraordinary advancements in information and communication technology, merge to suggest a very different agenda for international development-cooperation, whether South-South or North-South.

Science and technology are now the principal tools for bringing about the changes needed to meet the ever-increasing requirements of the human-race. These are also considered to be the major factors that will assist in dictating the new world-orders of the future. Advancement in science and technology depends on the broad sharing of information and knowledge. It is, therefore, essential that the flow and exchange of information and experiences be enhanced and sustained, especially in R&D activities and resultant lessons learnt. This will, on the one hand, promote the advancement and dissemination of knowledge, while on the other hand, helping to improve human relations and mutual understanding.

The developing world contributes meagerly to modern science and technology. Yet, if acquired and utilized appropriately, the new trends in science and technology offer tremendous potential for solving many of the problems hampering economic progress in the developing world. It is, therefore, crucial that the developing countries utilize science and technology in a manner that addresses their own pressing needs. It is also necessary to promote scientific and technological cooperation in the regional and international arena, and more importantly, among developing countries.

To increase the cooperation amongst developing countries and between developed and developing countries, several challenges must be met. The primary challenge is the trouble that the international community confronts while attempting to mobilize requisite resources. Cut-throat competition in technological invention and innovation has evolved due to the New World Order, which is essentially technology-oriented and calls out to bestow economic power and honor on nations that are technologically advanced. Therefore, technology becomes an essential element which is strictly protected, thus causing cooperation to subside. Other challenges that affect scientific and technological cooperation at the inter-regional and international levels include:

i. the establishment of distinct structures of higher education and research within various countries, due to the blind pursuit of scientific and technological development policies under the flag of nationalism; even though these structures lacked the bare minimum resources required for proper functioning, they were still created;
ii. the scientific and technological policies that are being pursued in most countries, when assessed from a practical viewpoint, usually turn out to be steps taken in isolation. Moreover, these initiatives are neither entirely integrated into national economic and social developmental plans, nor into bilateral and multilateral cooperation programmes;
iii. barriers of language and international travel, coupled with the difficulty to travel and communicate, besides the dubious nature of financially challenged publishing facilities, allow for isolation to spread; and
iv. there is a dearth of reliable data on the existing and projected scientific and technological potential of many countries.

Additionally, duplication, overlapping mission and under-optimization along with irrational mismanagement of resources at hand, and the failure to clearly define national objectives are also pertinent reasons.

Despite the seemingly unconquerable challenges, there is no doubt that science and technology cooperation amongst developing countries and between developed and developing countries has bright prospects. The needs of the developing countries demand optimal efforts, on the one hand, and on the other, opportunities for creating additional capacities and new developments related to science and technology. Key areas in this regard include biotechnology, microelectronics and new materials, where jointly undertaking the scientific and research and technological innovation would greatly benefit the developing countries. Indeed, the development of such new technologies is a painstaking and expensive process; yet their assimilation, adoption and application to the production would be cost-effective. However, this has to be done through leap-frogging over immediate levels of technology.

A sustained mechanism of sharing research-resources could bring developing countries much closer to their target of maintaining a critical minimum of investment required. This would also allow for minimizing the duplication of effort in some other areas as well.

The developing regions of the South enjoy common environmental and thermohygrometric conditions. Due to these similarities, specialized technical know-how in the fields of agriculture and agro-foods can be effectively shared. Moreover, common solutions to common problems in the exploration of prospects in different sectors can also be expanded. Effective collaboration of these countries in areas of water-resource management, energy, disease-diagnosis and control, key-crop production, and functional, nutritional and commercial viability-enhancement in agro-based products can be realized. It can also be safely said that the key areas for cooperation between the countries of the South are biotechnological and agricultural research. As these regions face many common problems, the results of the research may have a wider application and could help more than one country. As research in the realms of the stated fields is complicated and expensive, it is advisable that the concerned countries should share their resources and work collectively on endeavors of mutual interest.

Any strategy for future cooperation, amongst the countries of the South, must be initiated with their resolution, and will continue with the political will to rise to the challenges they have identified for themselves. For this, the concerned countries must adopt and pursue policies of non-secrecy to other parts of the developing world, show their willingness to propagate and further the local and regional South-South collaboration in science and technology, and commit themselves to solidarity in the collective augmentation of capacities and acquiring of necessary technologies.

Any cooperation, thus envisioned, must be founded on a medium to long-term vision, based on a choice of the priority-sectors and on mutually agreed specific actions, to be taken to attain the stated objectives.

As a matter of fundamental importance, it is also imperative that the focus remain on regional centres for the encouragement of science and technology in the concerned countries. Such centres, if utilized as genuine centres of excellence, would not only reduce brain-drain in these countries, but will also enjoy the benefits of assistance from expatriate experts of developing countries who are residing outside their native lands. Such international consultative forums can also be used to augment South-South cooperation in S&T.

Given the similarities of economic and environmental conditions, in most of the developing countries, South-South cooperation in the realms of science and technology assuredly has the potential to produce the desired results. However, the focus must always remain on identifying critical areas of collaboration, which may include sectors of common interests, such as food and agriculture, new and renewable energies, public health and information & communication technologies. In this regard, priority-areas demanding concrete and urgent actions include: science and technology policies, human-resource development; institutional capacity-building; the promotion of exchange of information, identification of stakeholders, involving the North in collaborative efforts; identification of clusters of common interest, and maintaining impetus on the classical approach to the cooperation. The role of the centres of excellence in minimizing brain-drain could be pivotal and effective; however it must be realized that any South-South or North-South collaboration must initially overcome the financial constraints restraining the realization of cooperation in its true spirit. No headway can be achieved in cooperation unless the political will and determination is present to share and mobilize their resources for greater cooperation in science and technology for sustained development

Undoubtedly, a much more elaborate follow-up, monitoring and evaluation system of the cooperative activities of South-South and North-South collaboration must be weighed and assessed. Projects and programmes must be practically assessed, so that reasonable clarity as to the identified objectives and their corresponding results may be attained. Efforts must also be channeled towards the promotion of the needs for South-South and North-South cooperation, augmented by the success-stories of various organizations, enterprises, institutions, countries and regions.

The equation is now quite obvious for developing countries: it calls for a proactive approach and resolute determination. It is now upto us to take concrete steps, join hands, integrate our efforts and set the right direction. Regional cooperation in the field of science and technology promises a prosperous future and in it lies the safeguarding of the national interests and solutions for present-day problems.

**FOR FURTHER READING**


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