EVERYMAN'S SCIENCE

Vol. XLVIII No. 3 (Aug '13 – Sept '13)

EDITORIAL ADVISORY BOARD

Prof. Swapan Kumar Datta *(New Delhi)*

Prof. Premendu Prakash Mathur *(Bhubaneswar)*

Dr. R. L. Bharadwaj *(Agra)*

Prof. Rajneesh Dutt Kaushik *(Haridwar)*

Prof. Amarendra Kumar Sinha *(Jaipur)*

Dr. Mohan Khedkar *(Amravati)*

Dr. Pitamber Prasad Dhyani *(Almora)*

Dr. Subhash Chandra Yadav *(Varanasi)*

Prof. Lalit Mohan Manocha *(Vallabh Vidyanagar)*

Prof. D. S. Hooda *(Guna)*

Dr. Surya Kant Tripathi *(Lucknow)*

Prof. Parimal C. Sen *(Kolkata)*

Dr. Sanjeev Ramachandra Inamdar *(Dharwad)*

Prof. Surinder Pal Khullar *(Chandigarh)*

COVER PHOTOGRAPHS

Past General Presidents of ISCA

1. Prof. A. K. Saha (1980)
2. Prof. A. K. Sharma (1981)
3. Prof. M. G. K. Menon (1982)
4. Prof. B. Ramachandra Rao (1983)
5. Prof. R. P. Bambah (1984)
6. Prof. A. S. Paintal (1985)

For permission to reprint or reproduce any portion of the journal, please write to the Editor-in-Chief.

EDITORIAL BOARD

Editor-in-Chief
Dr. Ashok Kumar Saxena

Area Editors

Dr. (Mrs.) Vijay Laxmi Saxena
(Biological Sciences)

Dr. Pramod Kumar Verma
(Earth Sciences, Engineering & Material Sciences)

Dr. Manoj Kumar Chakrabarti
(Medical Sciences including Physiology)

Dr. Arvind Kumar Saxena
(Physical Sciences)

Dr. (Mrs.) Vipin Sobti
(Social Sciences)

General Secretary (Membership Affairs)
Er. Nilangshu Bhushan Basu

General Secretary (Scientific Activities)
Prof. Arun Kumar

Editorial Secretary
Dr. Amit Krishna De

Printed and published by Dr. Ashok Kumar Saxena on behalf of Indian Science Congress Association and printed at Seva Mudran, 43, Kailash Bose Street, Kolkata-700 006 and published at Indian Science Congress Association, 14, Dr. Biresh Guha Street, Kolkata-700 017, with Dr. Ashok Kumar Saxena as Editor.

Annual Subscription : **(6 issues)**

Institutional ₹ 200/- ; Individual ₹ 50/-

Price : ₹ 10/- per issue

CONTENTS

EDITORIAL

GEOSCIENCE FOR EVERYONE

The journey of Geology to Earth System Sciences has witnessed enormous changes. The subject Geology mainly dealing with study of earth, in its modern 'avtar' as Earth System Sciences has encompassed earth and its environment along with planetary studies. The subject Geology characterized by indispensable field studies has now practically turned to an instrument based science. The technology like remote sensing, GPS, GIS, high resolution microscopy, advanced core recovery system etc. have changed the entire face of geoscientific understandings.

Geoscience education is now truly inter-disciplinary with physical, chemical and computational sciences deeply integrated to it. Field education traditionally has been an integral component of geoscience curricula, however during the past few decades, geoscience departments have moved toward a broader theoretical and laboratory-intensive focus. Just to breath, however, many software are available that simulate field in laboratory.

Generally, environmental concerns are attempted to be explained by green house emissions and/or solar activities. The geoscience, however, provides a new look in to it through mantle plume movements, earth rotation, gravity instability etc. It is only geoscience that relates crustal dynamics and environmental changes.

The advanced sensors providing hyperspectral and radar data have taken geoscientists to reach the unreachable places and have opened up vista of new research. High resolution microscopy and laser based composition analysis have added nano dimension to the subject. Advances in geophysics have provided better images of earth interior and have added to the exploration technology. Laboratory simulation of mega tectonic structures have added to our understanding of global tectonics including prediction of earthquakes. Geoscience along with many other disciplines in science & technology face an exponential increase in amount of data generated through observation, experiment and large scale high resolution 3-D numerical simulation.

The science of mapping and map making has undergone tremendous changes. The concept of Geographic Information System along with GPS enabled devices have yielded colour coded, multi layered, location based information system. The objects are represented by points, lines and polygons that may have vector components representing dynamic nature of data. The attribute data is easily integrated with vector data tagged with location photographs sent through real time online GPS enabled camera. The whole system has emerged as a value addition and good support for e-governance.

Planetary Geoscience is new window for extra terrestrial study and research. With its ambitious missions like Mission Moon, Mission Mars etc. India is now amongst front runners in this field. Highly advanced sensors deployed onboard satellites and associated robotic samplers have provided deep insight into the geoscientific knowledge of other planets and, thus have added to the understanding of evolution of earth and solar system, in general.

The hydrogeology, medical geology, gemmology etc. are of direct relevance to society. Study and research in exploration, conservation and augmentation of water resources is indispensable component of geologists role in societal upliftment. Rocks and minerals as medicinal ingredients are open field for research. Gem cutting and polishing industry provides local employment and entrepreneurship.

As in many other areas, gender imbalance is evident in geoscience practitioners also. Though there is sign of improvement, at the current rate of increase, women will not achieve parity in the geosciences for approx. another 50 years.

Geoscience is an interesting, challenging and truly interdisciplinary subject with its extraordinary wide domain. Initially confined within the earth, now it has universe as its limits. The journey of geoscience started with rocks and minerals is now dealing with cosmic signals. Geoscience works for everyone and geoscience is for everyone.

Prof. Pramod K. Verma
Scientific Advisor, Govt. of M.P.
Director General, Madhya Pradesh Council of
Science & Technology, Bhopal

We shall require a substantially new manner of thinking if mankind is to survive.

— Albert Einstein

PRESIDENTIAL ADDRESS

BASIC RESEARCH AS AN INTEGRAL COMPONENT OF A SELF-RELIANT BASE OF SCIENCE AND TECHNOLOGY

Prof. M.G.K. Menon, Ph.D. (Bristol) D.SE, F.A.SE, F.N.A, F.R.S.

I am deeply grateful to the Indian Science Congress Association for the honour they have done me in electing me as president for the year 1981-82.

DEDICATION

This address is dedicated to two great Indian scientists who have been past Presidents of the Indian Science Congress Professor Sir C.V. Raman and Dr. Homi Bhabha who presided over the sessions in 1929 and 1951 respectively; and to two other great scientists, Prof. Cecil Powell and Lord Blackett. Prof. Powell had visited India many times and addressed the Indian Science Congress at its Agra (1956) session. Lord Blackett had also visited India many times, the first time being for the New Delhi (1947) session of the Indian Science Congress presided over by Jawaharlal Nehru. I had the great privilege of knowing each of them personally and closely. They had very different backgrounds, personalities, and experiences, but each reflected excellence, and the distilled essence of science and scientific method, in all facets of their lives. It is from them that I have learnt a large part of the history, philosophy and method of Science; and a great deal of what I have to say today will reflect this.

** General President, 69th Indian Science Congress held during January, 1982 at Mysore.

FOCAL THEME

I have chosen, as the focal theme for this Session of the Science Congress, the subject of "Basic Research as an Integral Component of a Self-reliant Base of Science and Technology", covering aspects relating to its role, relevance, support and areas of thrust. I selected this theme intentionally, because for some time now, I have felt that, in response to meeting needs arising from the immediate and serious problems that we face as a society and a nation, understanding relating to the importance of basic Science and research on fundamental aspects, and support for it, is gradually diminishing.

We are well aware of the many conflicting demands on our national economy. There is the already large population, which is continuing to grow, and there are the obvious requirements of food and nutrition, health, housing, clothing and education and providing employment that have to be met. We are now facing major problems in the area of energy which was the subject of the Presidential address of Prof. A. K. Saha at the 67th (Jadavpur) Session of the Indian Science Congress. In the current world situation, there are the growing and grim demands of national security. There are then the requirements of industrialization and of providing gainful employment. From time to time we are faced with natural calamities like floods, droughts, cyclones and the like, which constitute sudden and unexpected stresses on the national economy. All of these demand significant allocations from the national exchequer and call for immediate attention and solution. Indeed at the 1947 Session of the Indian Science Congress held at Delhi, the president of the Indian Science Congress Jawaharlal Nehru said, "For a hungry man or a hungry woman, truth has little meaning. He wants food. And India is a hungry, starving country, and to talk of Truth and God, and even of many of the fine things of life, to the millions who are starving is a mockery. We have to find food for them, clothing, housing, education, health and so on, all the absolute necessities of life that every human man should possess. So Science must think in terms of the few hundred million persons in India. "In the face of this, it would not be unusual for the decision makers to regard basic research as a non-priority item. But Jawaharlal Nehru, in spite of the connotation that might be put on what I have just quoted, supported Science in the fullest measure; and as scientists we have cause to be deeply grateful to him for his abiding interest in Science, and his vision and wisdom in creating the powerful base that we possess today; he understood fully that science is not cake but the bread and the staff of life of our type of civilization.

Having stated what is obvious, that we face immediate major problems that confront society on a day-to-day basis, I would ask whether these urgent priority tasks in the sectors of food, energy, health, employment and proper utilization of natural resources etc., can be dealt with without recourse to a self -reliant base of science and technology in the country. And the answer is a definite NO. To me it is clear that we are allowing problems of the present and immediate to overwhelm us, to such an extent that the much smaller effort required to ensure that, in the long run, we can significantly ride above such situations, is being lost sight of.

The purpose of my address is to point out that there are certain philosophical, cultural and intellectual aspects of basic research that are not well-appreciated, but which underpin in an essential manner the very concept of self-reliance. And for basic research to flourish it needs an appropriate environment and climate as much as financial support.

S&T COMPONENT OF THE SIXTH PLAN

Last year, a major exercise was carried out to formulate the Sixth Five Year Plan of the country for the period 1980-85. I had the privilege of chairing a Working Group constituted by the Planning Commission to prepare the draft chapter on Science and Technology for the plan document. In starting on this task, I went back to the Scientific Policy Resolution adopted by the Government on 4 March 1958. (I have, for convenience of readers, reproduced this resolution in full, as an appendix to the written text of this address.) This was a most remarkable document adopted by this country, through the visionary foresight of Jawaharlal Nehru. In its operative part, it says,

> "Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by putting forward out utmost effort into the development of Science that we can bridge the gap. It is an inherent obligation of a great country like India with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of Science, which is probably mankind's greatest enterprise today".

Indeed, with the great support given by Jawaharlal Nehru from the time of Independence, vigorous measures were taken for the development of Science through larger financial allocations; from Rs. 20 crores for Plan and Non-plan of the First

Five Year Plan (1951-56), this allocation has gone up to Rs. 3367 crores in the Sixth Plan (1980-85). There has been a significant increase in the number of universities, institutes of technology, agricultural universities; a large number of National Laboratories have been set up under various agencies covering the entire spectrum of Science, engineering, technology and medicine. There has been widespread application of Science to national problems in the areas of agriculture, health, industry, energy, communications and so on; impressive returns have been obtained in many cases. There is today a significant infrastructure for Science and Technology in the country; a stock of scientific and technical manpower which also is large at first sight, being estimated at 2.5 million; and many major achievements in the form of accomplishments of tasks that have been clearly assigned. Indian scientists are well-recognized and regarded on an international plane.

In spite of all this, taking note of the spirit of the Scientific Policy Resolution, which I had just quoted in its operative part, the unambiguous and clearly laid down policy of attaining self-reliance and the large and important position that India has in the community of nations, the working group asked itself : "how far have we gone bridging the gap and in participating fully in the march of Science" : and it came to the conclusion that "while significant advances have taken place on the Science and Technology front in India over the past three decades, the gap between what obtains in the country and in other advanced countries, in terms of infrastructure and capabilities, has significantly widened... There are many gaps in important fields and in the ranks of leadership and in excellence."

THE NURTURING OF SCIENCE

I am personally of the view which is shared by a large number of my distinguished colleagues in the scientific community of this country, with whom I have had extensive discussion, that the concepts of excellence is being lost, that centers of excellence in the country are finding it difficult to survive because of lack of appreciation concerning issues of an administrative and financial nature and what might be referred to as personnel and labour aspects, particularly in terms of the laws of the land and the attitudes taken by our judiciary; our brilliant students have very few positions for training and further research at outstanding centers. Our educational institutions which have the responsibility for generating our scientific manpower have been sadly neglected in terms of support, even on a selective basis. Those who would potentially be the great scientists of the furture are drifting to professions other than Science, or are moving abroad where better opportunities exist. The Working Group on Science and Technology for the Sixth Plan has expressed its deep concern over all of these issues. There is, therefore, need for a much wider appreciation and debate on these issues, since they are indeed fundamental and serious.

I have asked myself : "Under what auspices could questions of this type be publicly posed, leading to a greater debate on the problems and solutions". In terms of scientific bodies, there is the Science Advisory Committee to the Cabinet (SACC), the creation of which the Prime Minister announced at the last Indian Science Congress session at Varanasi ; SACC has met several times over the past year, and has concerned itself with some of these basic issues. There are the academies of Science and other professional societies. And then there is the Indian Science Congress Association which covers the broadest spectrum of scientific disciplines and whose membership today stands close to 7400. I believe that the issues we are considering are so important that they must be debated in all these forums.

I have noticed that the Indian Science Congress, in its session for quite some time now, has discussed many areas of national life where Science has relevance and finds significant application. This is important. I also believe that the approach of selecting one broad area of national relevance and importance as a focal theme, on which scientists from different areas of Science can focus their attention will lead to coordinated, interdisciplinary and integrated efforts. In all of this there is the basic assumption that the scientific base in strong, and itself needs no attention; and therefore our attention should be profitably concentrated on "application of Science". If, however, the base of Science in the country is weak or unsound or not getting the support and climate that it needs for its own growth and development then Science as a force for development will obviously not be very effective. It is this question to which I wish to address myself : "how is Science itself to be nurtured and developed in a manner in which it can be a successful component of development ?"

It will be seen that the focal theme essentially covers three components : the concept of a base of Science and Technology; the concept of self-reliance; and within this framework the role and relevance of basic research; other aspects that we will consider are support and areas of thrust in respect of basic research.

SCIENCE AND TECHNOLOGY : GENERAL ASPECTS

The world of today is largely the product of developments that have taken place in the field of Science and Technology; no doubt other social, cultural and economic aspects have influenced and made possible the self-sustaining exponential growth of Science and Technology that has taken place. These developments have occurred over the past few hundreds of years since the scientific and industrial revolutions took place. It must be remembered that Science did grow but declined in many earlier civilizations, and did not attain the present self-sustaining character that we see around. The present developments were nucleated in what are the great industrial centers of the world today; as a result these areas were able to make rapid progress in the material sense, to become the highly developed countries. 97% of the world's research and development is carried out in these developed countries and only 3% in the less developed countries.

At this point I am reminded of what Cecil Powell said when he was arguing in the early 1950s for support for basic research in Europe. At that time the United States was vigorously moving into the field of high energy elementary particle Physics, and European physicists were trying to obtain support for a common European accelerator and high energy physics which today exists as CERN (European Council for Nuclear Research). Cecil Powell then said : "In the long run, it is most painful, and very expensive, to have only a derivative culture and not one's own, with all that it implies in independence in thought, self-confidence and technical mastery. If we left the development of Science in the world to the free play of economic factors alone, there would inevitably result a most undesirable concentration of Science and Scientists in too few centers, those rich in Science becoming even richer, and those poor, relatively poorer". This was as between Europe and America then. The disparity that exists is infinitely greater between the developing and developed countries. The UN Conference on Science & Technology for Development was held in Vienna in August 1979 precisely to seek ways to reduce this disparity, so as to lead to a New International Economic Order.

The spectacular, and highly visible, material developments that have taken place as a result of advances in Science and the rapid succession of technological innovations in the areas of industry, agriculture, medicine, transportation, communications, energy etc. are there for all to see. High speed jet engines and wide-bodied aircraft have resulted in mass transporatation which has made the world a small place physically; the advent of the Space Age and of geo-stationary satellites, and the developments of modern electronic techniques have resulted in world-wide radio and

TV broadcasting and telecommunications, which have made the earth a small place in terms of communications, transmittal of ideas and human expectations; advances in medical science, with modern antibiotics and other miracle drugs, as also our greatly increased basic understanding of Biology at the molecular and cellular levels have had a profound impact on world population (with reduction in death rate and rapid rise in population), treatment of disease and the promise of an unending chain of new possibilities; modern high-yielding varieties have enabled food production to keep pace in some sense with the expanding populations; the developments in modern electronic techniques have made it an all-pervasive technology, affecting entertianment, industry, defence, communications, space technology, computer and information sciences and the like. All of this has resulted in rising expectations the world over, and a feeling of euphoria that Science and Technology is a magic wand to bring about development. The point that needs to be emphasized is that *Science and Technology is not a magic wand*. We must explode the myth that Science is a great external solver of all problems. Lord Blackett in the first Jawaharlal Nehru Memorial Lecture given in 1967 had said : "Science is no Magic Wand to wave over a poor country to make it a rich one".

We have also to remember that Science and Technology should not be looked upon as a separate entity to be separately accountable for development. In this connection, Casimir has remarked "Science and Technology *cannot* be applied to development. Science and Technology are an essential part of development. One does not apply one's lungs to respiration, nor one's heart to the circulation of blood nor one's legs to waking. If we regard Science and Technology as a crutch, it will at best provide a halting gait. If we regard them as a transplanted heart, they will sooner or later be rejected by the receiver". Science, and Technology which is based on a basic understanding (in contrast to pure implementation of a well-defined set of technical tasks) cannot be imported nor be regarded as an external entity. It has to be an integral part of all our activities.

SELF-RELIANCE

We have to recognize that India is a large country of sub-continental dimensions, with a population close to 700 million. The very size of our country, and the diversity and complexity of the problems we encounter, which are quite different from those of smaller developing countries, demand self-reliance. The Prime Minister, Mrs. Indira Gandhi, has remarked : "Self-reliance must be at the very heart of S & T planning. There can be no other strategy for a country of our size and endowments. While we all readily pay obeisance to this concept, there are too many and too frequent lapses. Considerations like security, the time factor, performance guarantee and costs often compel us to buy advanced technology from the international market. But in the ultimate analysis, neither true defence nor true development can be bought or borrowed. We have to grow them ourselves". She has further said : "Self-reliance does not mean making everything ourselves but acquiring the capacity to do so when things come to a head".

The pathway to self-reliance is not to set out to rediscover independently what has already been discovered, nor to invent what has already been invented. It implies the ability to analyse problems, and to define tasks and objectives; to obtain information/know-how etc. which is needed from wherever it is available, but on a specific basis; to have self-confidence to develop whatever needs to be developed; and most important, the ability to start from a base which may be a mix of indigenous and imported know-how to move into the future on an internationally contemporary basis through innovation and original thinking. Self-reliance should also not be confused with self-sufficiency. Self-reliance demands a national commitment and political will; and involves many facts such as technology policy; management and technical skills etc. But clearly a crucial element of self-reliance, in a world whose economy and life styles are dominated by scientific and technological advances, has to be a self-reliant base of S & T. And this base cannot be built without at the same time doing significant basic research; for that is the only way to generate basic understanding which is not restricted to specific knowledge in an area, but provides the ability to attack and solve problems over a wide spectrum; and it is this ability that basic research more than anything else develops to the highest degree. Aspects to basic research and the qualities that it demands are dealt with a little later.

THE INNOVATION CHAIN

I would now like to consider the place of Science and Technology within the overall framework of the productive sector. It was Lord Blackett who, in the first Jawaharlal Nehru Memorial Lecture, outlined the importance of ensuring the integrity of various links in what he referred to as the "innovation chain", if investments at various points of the chain are to be fruitful. "Innovation chain" is a term that has been used to signify the whole process from fundamental research (which is concerned with the discovery of new facts and the understanding of nature and hitherto unknown principles), through applied research (which involves definite practical objectives), to the building of prototypes in laboratories, to the development of a small number of items in batches on a pilot plant basis to test our production techniques (and analogous pilot plant operation for testing the feasibility and economics of process techniques), to devising processes to suit available skills and equipment and the use of items that are most easily and cheaply available, to the final emergence of marketable products or of services; in the fields of agriculture and medicine, the intermediate steps would be of field trials and liaison with the producers and users of the products. It is important to recognize that scientific research represents only the few steps in this long and expensive chain. A high level of research and development *alone* is not sufficient to ensure successful innovation; the industrial and commercial elements of the chain are equally vital. Actually, research and development claims generally only a small part of the total costs of successful innovation. On the average, it is estimated that about 5-10% of the total launching costs of a successful new product goes into the research and development leading up to the basic innovation; and about 10-20% goes into the engineering development and design of the project. The remaining 70-85% is needed for the tooling costs for first production, and for the initial manufacturing and marketing expenses.

Thus, the British textile material "Terylene" was invented in a research laboratory running at less than $ 60,000 a year. When Imperial Chemical Industries obtained the UK commercial rights for this invention, it then spent the equivalent of around $ 11 million on pilot plant development; and for the first major commercial production, the new plant cost around $ 40 million. The economic factors involved in the various elements of this innovation chain have to be well understood if the investments on research and development are to be profitable, and not lead to frustration.

If on the basis of careful perspective planning, one can define end-requirements well in advance, particularly in the major economic sectors, then resources-human and financial — can be deployed wisely and in time on research and other aspects, with the clear-cut expectation that investments will be forthcoming in the later elements of the innovation chain in the productive sector, to make use of the scientific effort that has gone before. In the absence of such perspective planning, and the linkages between the productive sector and the R&D sector, as also policies arising from pressures relating to immediacy of requirements which have enabled technology to come in easily, the investments on Science and Technology, particularly on applied R&D, have often appeared to be unproductive, though the tasks defined for them had been accomplished; and this has been a frustrating experience for scientists. This has also led to the question that the scientific community is very often asked. "So much money has been allocated for Science; what have we got in return?" It is essential to realize that returns will be forthcoming only if adequate investments are made in the different downstream steps of the innovation chain, and time elements that are relevant are kept in mind; we have to remember that long gestation periods are involved in the fructification of S&T efforts. And applied R&D, design and development work should not be initiated in areas where no chance of fruition exists, whatever be the reason.

There is often a tendency to use the wide umbrella term "Science and Technology" under which many different facets are subsumed. This has resulted in a great deal of confusion in defining investments, effort etc., that relate to the different components of Science and Technology. We have already seen that the largest resources — human and financial — in the productive sector, whether it be in agriculture, industry, transportation etc., have to be in the later stages of the innovation chain. Though these productive activities are based on Science and Technology, and they absorb the larger part of the output of trained technical personnel emerging from the educational institutions, they cannot be, (and are not), treated as the S&T sector. The latter is concerned with research (pure and applied), design and development. As already stated, applied research and development can fructify only when there are clear-cut end-objectives and needs, and appropriate guarantees and linkages to ensure utilization through investment in the productive sector. The largest part of the budget of the S&T sector in the country has so far gone into the areas of applied research and development, whether they be in the areas of atomic energy, space Science and Technology, defence or through the Councils dealing with Scientific and Industrial Research, Agricultural Research or Medical Research. In each of these areas, there is only a relatively small amount which goes into basic research. However, because of the overall allocations for Science and Technology, under which umbrella title basic research is also subsumed, it is generally assumed that it is also well looked after. But this has not been the case in real terms, and particularly in the context of the headlong advances that Science and Technology have been making and the completely new areas that are being opened out on an international plane.

A RESTATEMENT OF THE BACKGROUND

In what I have said up to now I have covered several different facets of the scenario that a policy maker in the field of Science and Technology is confronted with. It would be good if I attempted at this stage to draw together the threads of my discussion into some simple statements. First, Indian planning since Independence has sought to work towards the objective of self-reliance; and this is the banner under which we have been marching all these years. Whilst we have many individual achievements in Science and Technology to our credit, and today we produce a very significant part of all that we need for daily life within the country, yet we must admit that we still have a long way to go in attaining true self-reliance. In a world that has been fashioned by Science and Technology, and of which we are a part, it is quite clear that national self-reliance implies a self-reliant base of Science and Technology. For Science and Technology to fructify in terms of meaningful national development, it has to be ensured, on the one hand, that there are investments downstream, to ensure that know-how that is generated through applied research and development is transformed in a productive manner for the benefit of society; and on the other, that where large investments are involved in the Science and Technology sector, as is the case of applied research and development, this is done only in areas where, on the basis of long-range planning, it is clear that there are needs and users. We are, of course, aware of many instances where users project their needs much too late for national S&T to respond or make any useful contribution; and usually these instances relate to large projects. This should not be permitted.

The quality of excellence in all that we do can come about only if support is given to sectors such as basic research in the same manner as in sectors such as exports where the highest international standards alone will ensure competitiveness. I shall now pursue in the remaining part of my talk, the role and relevance of basic research in promoting innovation and excellence.

BASIC RESEARCH : ITS ROLE AND RELEVANCE

In January 1966, in the last speech that he gave in his life, Homi Bhabha, addressing the International Council of Scientific Unions in Bombay remarked

> "What the developed countries have and the underdeveloped lack is modern Science and an economy based on modern technology. The problem of developing the underdeveloped countries is therefore the problem of establishing modern Science in them and transforming their economy to one based on modern Science and Technology. An important question which we must consider is whether it is possible to transform the economy of a country to one based on modern technology developed elsewhere without at the same time establishing modern Science in the country as a live and vital force. If the answer to this important question is in the negative — and I believe our experience will show that it is — then *the problem of establishing Science as a live and vital force in society is an inseparable part of the problem of transforming an industrially underdeveloped to a developed country".*

At this point, let us consider the important question Bhabha raised : Is it possible to transform the economy of an industrially underdeveloped country to one based on modern technology developed elsewhere without at the same time establishing modern Science in the country as a live and vital force? Bhabha answered it in unequivocal terms on the basis of his experience in India for quarter of a century.

Bhabha has returned to India with an internationally established reputation as a theoretical physicist of the first order. Working during the years of the second world war at the Indian Institute of Science, this outstanding theoretical physicist began thinking of the need to establish modern Science in India, of the needs of energy for economic development, the great potential that nuclear power was likely to offer in this regard within a couple of decades, and the enormous possibilities of leapfrogging in the process of development through modern sophisticated techniques. He did not, however, approach these possibilities in the manner which foreign collaborations are normally embarked upon. He first proceeded to build a base of fundamental research by setting up the Tata Institute of Fundamental Research; he did this because he had become aware of the shortcomings of Science in India in some of the modern areas such as nuclear Physics, high energy Physics and so on, and felt that in these areas where so much fundamental and exciting work was going on, India should not be left out. He was also clear that in setting up such an institution, it would be necessary to introduce modern concepts of administration and research management, which would lead to an atmosphere and environment conducive to its being a pace-setter for the growth of Science and self-confidence, and be the base from which major ventures could be undertaken. Lord Penney writing on Homi

Bhabha in the Biographical Memoirs of Royal Society has stated, "In the 21 years since the Institute was inaugurated in Bombay to Bhabha's death in 1966, the Tata Institute of Fundamental Research has grown to be one of the finest research institutes in the world". In the letter that he wrote to the Sir Dorab Trust outlining the proposal for setting up the Tata Institute of Fundamental Research, Homi Bhabha showed that he was also clear about the long-range fall-out and the imperative of self-reliance in a strategic area. In a visionary and prophetic sentence he marked "Moreover, when nuclear energy has been successfully applied for power production, in say a couple of decades from now, India will not look abroad for its experts but will find them ready at hand".

Since Bhabha conceived of the Tata Institute of Fundamental Research, many new areas have developed right at the frontiers of Science, for example in modern Biology, with unambiguous indications of relevance, applications and growth. It is clear that we need to grow many more such institutions, and particularly in close coupling with the educational system.

Then Bhabha went on to develop the atomic energy programme; and he selected physicists, chemists, engineers and biologists who would work not on a purely imitative basis or by reverse engineering, but on the basis of an understanding of the basic elements in their areas, whether it related to materials, structures, heat transport, spectroscopy, chemical reactions and so on. It is this strength of basic understanding which characterizes the Indian nuclear programme, and which has enabled it, in spite of many hurdles encountered more recently in the area of international cooperation, to stand on its own feet. At the dedication of the new buildings of the Tata Institute of Fundamental Research in January 1962 by Jawaharlal Nehru, Bhabha had remarked : "The support of such (basis) research and, of an institution where such research can be carried out effectively, is of great importance to society for two reasons. First of all, and paradoxically, it has an immediate use, in that it helps to train and develop, in a manner in which no other mental discipline can, young men of the highest intellectual calibre in a society, into people who can think about and analyse problems with a freshness of outlook and originality which is not generally found. Such men are of the greatest value to society, as experience on the last war showed; for many of the applications of Science, which were crucial to the outcome of the war, were developed by men who, before the war, were devoting their time to the pursuit of scientific knowledge for its own sake. Radar and atomic energy are two examples of fields in which a vast body of established basic knowledge was developed into technology of immense practical importance, largely through the application in war time of the efforts of those who might be called "pure" scientists. Bhabha further said : "It is not an exaggeration to say that this Institute was the cradle of our atomic energy programme".

I have just conveyed to you what one of our great scientists Homi Bhabha, who made his reputation by accomplishing basic research of the highest quality, and who was responsible for promoting much else in national development in the fields of atomic energy and electronics, felt about the importance of basic research. I fully concur with all that he had to say.

ASPECTS OF PURE AND APPLIED RESEARCH AND LINKAGES BETWEEN VARIOUS CONCERNED INSTITUTIONS

I would now like to put down for clarity certain specific aspects concerning various forms of research activity, and their respective roles and relevance. Research is often categorized as pure research and applied research. The fundamental difference lies in the motivation. The motivation in the case of pure research is the desire to know something, whereas in the case of applied research it is the desire to do something. The words pure, fundamental or basic are often used synonymously.

Basic research is concerned with discovery of new knowledge and with increasing our understanding of natural phenomena. It ultimately leads to a clearer and sharper definition of the laws which govern nature. Basic research is not directed towards the solution of immediate practical problems. Basic research, by definition, is at the frontiers of our knowledge; and the quality of work and achievements have to be judged by the entire international scientific community. Quite clearly those who would accomplish such research have to possess capabilities necessary for work at the frontiers of science on a competitive international basis. In contrast, applied research has very definite practical objectives. It can and should be a highly creative process involving originality, imagination and inventiveness. In a desirable situation, these qualities, in the case of applied research, should be of the same magnitude as for basic research. It is not the degree of creativity that distinguishes basic from applied research but the clear practical direction that applied research aims at. In contrast, design and development relates to the effective and economical execution of a task that has been shown to be feasible on the basis of applied research and past experience.

Another important aspect of fundamental research is its essential place in the system of education. In its broadest sense, education involves the totality of effort related to acquiring new knowledge, preserving it in suitable form, and transmitting it to future generations, together with the thought processes involved. Very often, with obvious unfortunate consequences, the mere process of handling over knowledge as a dead, inanimate object is considered to be education; this happens in many of the educational institutions in India that stress uniformity and learning by rote. The only way in which teaching can be brought out of this rut of routine, pedantic transmission of facts is by ensuring the accomplishment of significant research that leads to a tradition of penetrating and independent inquiry. Such research may be pure or applied, but must be of high quality and encourage innovativeness.

Education is primarily the responsibility of the universities, and quite clearly there must be basic research at the universities if education has to have any quality. The question, however, can be asked whether all the basic research that needs to be done can be done within the universities; and I believe, the answer to that question will be in the negative in today's context. The reason is that a lot of basic research today involves rather large expenditures, major facilities and infrastructural support, close links with technology and interdisciplinary efforts. This could involve accelerators, telescopes, major facilities for biological research and so on. These are best located and managed in separate research institutions, which will need autonomy and a culture necessary for them to manage large technical facilities and conduct interdisciplinary programmes. However, in my view, such institutions could be within, or should be calculated with educational institutions, so that the research institution participates in the university activities and *vice-versa*.

We must recognize that different kinds of institution are appropriate for various categories of activities, and what is important is to establish associations and linkages between them for mutual benefit. For example, a university associated with a government or industrial laboratory may acquire thereby the stimulation of constant contact with applied problems and also have available to it the large-scale facilities that are necessary and have been developed for applied research. Correspondingly, the government or industrial laboratory acquires increased contact with the very talented enthusiastic young students and the openness of the university environment. What is required in such a linkage is not purely in terms of financing of research in the university by the government or industrial laboratory, but mutuality in participation. Mutuality cannot come about in wholly unequal relationships. It is for this reason that the weakening of our university research capabilities, through lack of support, is reducing the possibilities of such mutually highly beneficial linkages.

I can now particularize the scenario to the national plane. We have a large number of universities throughout the country. In their vicinity there are major research institutions coming under the purview of the Atomic Energy and Space Commissions, the Council of Scientific and Industrial Research, the Defence Research and Development Organization, the Indian Council of Medical Research, Indian Council of Agricultural Research and Department of Science and Technology, the various surveys such as Survey of India, Geological Survey of India, Botanical Survey of India, Zoological Survey of India, as also major industrial units, some with excellent R&D facilities. There is, however, very little that is being done to establish strong interconnections between the University system and this infrastructure. There are a variety of schemes that I can think of which can be used for this purpose. The most classical is the use of university staff as consultants by industry and national institutions. This must be made compulsory. Such consultancy provides the academic community with opportunities to get acquainted with important industrial research problems which challenge the scientific imagination. The consultants can be used for probing areas that are new and unfamiliar to the company or laboratory, as well as for giving lectures to the staff. (It is, in fact, my experience that very few lectures are given in most government or industrial research laboratories, which is a pity, since Science thrives and grows only through open, critical discussions.) Through these interactions the academic community can be exposed to the industrial environment, its problems and its attitudes. Conversely, it is important to provide visiting professorships, adjunct professorships, participation in university activities through advisory committee etc. to those from industrial and other national institutions. These provide opportunities from scientists from governmental or industrial laboratories to keep in touch with a broad spectrum of intellectual activity that a university represents and to widen their horizons.

There are a variety of such mechanisms to bring about better linkages that could be of mutual benefit; I have just indicated a few possibilities. Whilst some forms of collaboration have been worked out, it is nowhere near what can be achieved.

To my friends in the scientific community I would like to emphasize the point that basic research does not mean any research that is carried out which does not qualify as applied research. Basic research is characterized by high quality and innovation. It is subject to a system of peer review, and must arise from a deep inner urge to find out. It must, in the ultimate, be competitive at a truly international level. In this connection, I would like to recount a fable by Prof. Karl Popper : "Suppose that someone wished to give his whole life to Science. Suppose that he therefore sat down, pencil in hand, and for the next twenty, thirty, forty years recorded in notebook after notebook everything that he could observe. He may be supposed to leave out nothing : today's humidity, the racing results, the level of cosmic radiation and the stock market prices and the look of Mars, all would be there. He would have complied the most careful record of nature that has ever been made; and, dying in the calm certainty of a life well spent, he would of course leave his notebooks to the Royal Society. Would the Royal Society thank him for the treasure of a lifetime of observation? It would not. The Royal Society would treat his notebooks exactly as the English bishops have treated Joanna Southcott's box. It would refuse to open them at all, because it would know, without looking, that the notebooks contain only a jumble of disorderly and meaningless items". The reason is that as Paul Weiss has said: "The primary aim of research must not just be more facts and more facts, but more facts of strategic value".

I must confess that there is a considerable amount of so-called basic research done in this country, which falls in the category of that described in Karl Popper's fable; very large numbers of Ph.D's seem to emerge from our education system on this basis; reputations have been built up through the publication of hundreds of papers only to fool the untutored. All that is done is mere data collection on a routine basis, without any urge whatsoever to really understand something new about nature. This is not to decry data gathering, because it is no doubt useful and necessary, for its only on the basis of data that one can build up models, hypotheses, theories and so on. However, it is necessary that the data gathering process be treated as a means in an innovative manner, and must relate to analytical and interpretative research. It must be motivated by a deep desire to know.

NEED FOR CENTRES AND SCHOOLS OF EXCELLENCE

It is quite clear that basic research is carried out by, and around, gifted individuals. This is true of any creative human enterprise such as music, art, dance and so on. It is well-known that, apart from the innate gifts that an individual may possess, there is a very important component which an individual derives from the environment, particularly that close to him, and more particularly from a gifted teacher. It is this concept which has been the basis of the "guru-shishya" relationship in Indian education, and of the great "gharanas" of our country in music and dance. One can, in our country and abroad, trace great accomplishments and individuals to great schools, and establish a genealogy based on teacher-pupil links. This is certainly true of Science.

In the autobiographies of great scientists, one repeatedly comes across phrases which trace their own achievements to the influence of outstanding teachers. For example, Liebig was a pupil of the great French chemist Gay-Lussac, the discoverer of some of the fundamental laws of the behaviour of gases, and Gay-Lussac was in turn a pupil of Berthollet. Liebig has remarked "The course of my whole life was determined by the fact that Gay-Lussac accepted me in his laboratory as a collaborator and pupil". Liebig, in turn told his student Kekule, who later became famous for his contribution to the structure of organic compounds, specially the ring structure of benzene : "If you wish to be a chemist, you must be willing to work so hard as to ruin your health". This was to emphasize the importance of hard work as a prime element in Science. From Liebig one can trace several successive generations of scientists, containing more than 60 exceptionally distinguished names, and including more than 30 Nobel Laureates. The Deutsches Museum in Munich gives the genealogy of 17 Nobel Laureates who were members of a teacher-pupil family descended from Von Baeyer. One of these was Otto Warburg who has remarked "the most important event in the career of a young scientist is the personal contact with the great scientists of his time. Such an event happened to me in my life when Emil Fisher accepted me, in 1903, as a co-worker in Protein Chemistry". Warburg's student was Hans Krebs who also won Nobel prize and has remarked "If I ask myself how it came about that one day I found myself in Stockholm, I have not the slightest doubt that I owe this good fortune to the circumstances that I had on outstanding teacher at the critical stage of my scientific career. He set an example in the methods and qualities of first research". The essential point we have to keep in mind is that distinction develops if nurtured by distinction. It is attitude rather than knowledge which is the only basis on which exceptionally hard work that is ultimately required, does get put in. An important element of attitude that a great teacher imparts is that of humility, and from it flows a self-critical mind and the continuous effort to learn and to improve. One can trace in the history of Science great schools and centers as at Paris, Gottingen, Cambridge, Oxford, Berkeley and so on.

It is of course true that there are many individuals who are prodigies or geniuses in their own right, and do not trace their links with any existing school. In India, scientists like Srinivasa Ramanujan, C.V. Raman, J.C. Bose fall in this category. However, such an individual, given the right opportunities, will very often be the starting point of a genealogy of excellence. One can trace many of the first rate scientists in India to schools nucleated by C.V. Raman, Meghnad Saha, S.N. Mitra, Homi Bhabha and so on. However, it takes time and an appropriate environment with long-range support, to ensure full flowering of any such school. Unfortunately, in India, what should have been points from which whole generations of excellence came forth, dried up too early. Homi Bhabha has remarked "It is the duty of people like us to stay in our own country and build up outstanding schools of research such as some other countries are fortunate to possess". His other phrases, in this connection, were: "Build up in time an intellectual atmosphere approaching what we knew in Cambridge and Paris"; and again would have an electrifying effect on the development of Science in India".

It must be remembered that very often an individual by himself tends to get lost, unless one was dealing with a genius like Einstein or Dirac or in India Ramanujan. We have to recognize the importance of an overall supportive environment and of team work. Jacques Monod has commented in his Nobel Lecture on the importance to him of a Rockefeller Fellowship which gave him an opportunity to work at the California Institute of Technology in the laboratory of the Nobel Laureate Morgan : "This was a revelation to me — a revelation of what a group of scientists could be like when engaged in creative activity, and sharing it in constant exchange of ideas, bold speculations and strong criticisms".

It is very clear that most human beings never stretch themselves to the limits of their abilities. It is the outstanding teacher who attracts the finest students; and, in the overall intellectual environment that the team represents, the individuals are pushed to the very limits of their intellectual capability, each deriving strength from the other in a resonant and supportive manner. It is this that we should aim at creating in the country. This, however, demands both the highest standards in selection and flexibility in management.

Under the banner of equality and democracy, circumstances operate powerfully against the development of excellence in Science; very often I fear we have too much of equality and too little promotion of excellence. This is not a matter which is the responsibility of Government alone, though it also has some responsibility in terms of the rules and regulations that it frames for general administration and makes applicable uniformly to scientific activities. The primary responsibilities is of the scientific community, which must recognize excellence as something precious, which requires the entire effort of the community to cultivate and nurture, and not something to be destroyed through envy and jealously, and for the petty considerations of individuals and groups.

LOUIS PASTEUR : THE OPPORTUNITIES FOR BASIC RESEARCH IN THE IMMEDIATE ENVIRONMENT

I would like to spend a few minutes on what we could learn profitably from the life and work of a great scientist whose work I have always admired, since I have felt that it has so much relevance to our circumstances and for the choice of areas for research. The scientist I speak of is Louis Pasteur, who took his doctorate with dissertations in both

Physics and Chemistry, and then carried out an impressive series of investigations on the relation between optical activity, crystalline structure and chemical composition in organic compounds. His work opened the way to a consideration of the disposition of atoms in space, and his early memoirs constitute the founding documents of Stereochemistry. From Crystallography and Structural Chemistry, Pasteur moved to the controversial and inter-related topics of fermentation and spontaneous generation. These were then empirical areas like cooking is today, but converted to areas of Science through the work of Pasteur. This came about because he was appointed Professor of Chemistry at the Faculty of Sciences at Lille, which was newly established with the objective of bringing science to the service of local industry. While resisting any emphasis on applied subjects at the expense of basic Science, Pasteur strongly supported the goal of linking industry and the Faculty of Sciences. His work in the area of fermentation (traced to the brewing industry in life) was based on his earlier interest in optical activity. He promoted specific living micro-organism, and was responsible for the sterilizing procedures called "pasteurization"; he laid the foundation for the germ theory of disease, which was thereafter developed rapidly by others notably Joseph Lister. For a period of almost 30 years he worked in succession on silk worm diseases, where he achieved remarkable success, and on the etiology and prophylaxis of a range of infectious diseases, anthrax, fowl cholera, swine erysipelas and rabies. He developed one treatment directly applicable to a human disease, namely for rabies. It is interesting that all of these problems that Pasteur encountered were in his immediate vicinity and interest in them evolved from his own basic research in which he displayed great experimental ingenuity. His approach was fundamental and resulted in the formulation of new biological principles. We have only to look at the range of problems that we encounter in our environment, whether in the area of population, communicable diseases, agricultural production, meteorology, energy, and so on to realize that there are challenges to excite the keenest minds in our vicinity and in our surroundings. To meet these challenges one would have to devise new techniques, new instruments, new insights and approaches which could as easily open a window into the hitherto unknown areas of nature, leading to work at the frontiers of Science and contributing to the world pool of knowledge, without necessarily being dictated by fashions set elsewhere in the world. And there are areas of Pure Science such as Astronomy in which we possess locational advantages where work of the highest order is possible with relatively small investment. This is true of mathematical and theoretical areas.

ILLUSTRATIVE AREAS OF THRUST

I would now like to cover, on a broad illustrative basis, certain areas of thrust in basic research which are of great interest scientifically, and where one can also see very clearly, relevance in terms of possible tangible fruits in the not too distant future.

Let us look at the field of food production. The history of agriculture goes back over a period of many thousands of years, since man shifted from his role as a food gatherer to a cultivator. Farming could be successfully carried out in the rich and fertile river valleys such as those of the Euphrates and Tigris, the Changjiang and the Indus. Based on a certain amount of logic, experience and common sense, coupled with knowledge concerning the movement of the suns and stars which define the seasons and Weather, and which could be regarded as rudimentary Science, agriculture developed in a rather empirical fashion since its earliest days up to relatively recently. However, the situation radically altered over the past century to make agriculture a highly Science-based area of production. Remarkable success has been achieved in increasing yields of many plant varieties, through an understanding of aspects of genetics and breedings, of nutrient requirements and of pest control. This success owes very significantly to the inputs that could be provided in the form of water and fertilizer which were available cheaply so long as energy was available cheaply. Whilst the production outputs grew significantly this has not been the case with production efficiency in terms of energy. India had a good base in the Agricultural Sciences when the process of modernization to increase yields in Indian agriculture was initiated around two decades ago, forced largely under the pressures of a large and growing population and the need to produce adequate food to avoid very heavy imports that would otherwise be needed, with consequent problems of both availability and high foreign exchange . This modernization and increase in food production depended on an agricultural strategy similar to that adopted in the Western countries, which was essentially energy-intensive. This was an appropriate strategy at that time before the energy crisis of the 1970's. It was essential to tide over the immediate problem of raising food production to a level of self-sufficiency. It is on this basis that currently India has a production of around 135 million tones of foodgrains. India had no choice but to initiate the energy-intensive agricultural, so-called green revolution, as the Prime Minister, Mrs. Gandhi, has stated :

> "It was a time of acute grain shortage, and the point was how do we immediately double the production of wheat. And so we went all out, and that is how we have been able to survive all this time, even through droughts".

This strategy and similar improvements in many crops such as rice, pulses, oilseeds, and many cash crops will and must continue, to enable us to meet the immediate problems of demand and to avoid or reduce imports. The question, however, is what should be the strategy in the long run.

First and foremost there is the question of energy. Oil is still a significant item of import, and has been subject to several increases in price in recent past, making a total price increase of twentyfold over the last 8 years. Oil is a non-renewable source, and with expanding world population and industrialization, rising standards of living and human expectations, one must accept the fact that it will become more scarce with time and more expensive, and dependence on it in any major way can only make us vulnerable. It is, therefore, important to see whether agriculture strategies cannot be developed which will make lesser demands on chemical fertilizers which are oil-based, and lesser demand on energy for agricultural operations. In the short run we must certainly produce more fertilizer. Even though India today is the fourth largest producer and consumer of fertilizer nitrogen in the world, the country is faced with a gap which will increase to 4 million tones by the end of the Sixth Five Year Plan and to a much larger figure by the end of the century. The imports of large quantities of oil, food grains, edible oils and fertilizers can be supported in the short-term through loans and have to take place to meet immediate needs. But what of the long-term? Consider the case of fertilizer. The question is whether we can turn to methods of providing nitrogen to plants without depending wholly on chemical fertilizers, where nitrogen is fixed through the intensive use of energy. We must remember that until recently our agriculture has survived for thousands of years depending on the renewable sources for nitrogen existing in our soil. Can we extend the host range of nitrogen fixing organisms and identify new bacteria and other micro-organisms which will fix nitrogen ? Can we transfer the nitrogen fixing genes to a wide range of micro-organisms through the process of genetic engineering ? These could then form symbiotic or non-symbiotic association with crop plants like cereals, in addition to the pulses. This immediately takes us into problems of genetic engineering, microbiology and soil sciences using nitrogen fixation concepts right at the frontiers of modern Life Sciences.

Another extremely important area of Basic Science from the viewpoint of agriculture, and of energy, is the area of photobiology. All biomass on the earth is produced through the process of photosynthesis, in which using the sun's energy, carbon dioxide and water can be converted to carbohydrate and oxygen; and additionally, nitrogen, sulphur and so on can be incorporated. The final efficiency of the process, when one considers large-scale biomass production, tends to be only of the order of 0.02%. The question is can we improve this efficiency? And this takes us into areas of "whole-plant Physiology and Biochemistry". Further, a detailed study of the various elements involved in photosynthesis might enable us to mimic some of the reactions artificially, so that one can photochemically produce hydrogen from water. It is expected that in time this will become an important source of energy.

Energy today has assumed very important dimensions from the viewpoint of both availability and cost. In India, half of the energy used is non-commercial energy, which means burning up of wood, agricultural residues and animal dung. This is leading to serious deforestation and desertification. Possibilities exist for improving the whole area of forestry through the techniques of tissue culture, nutrient inputs, genetic engineering and nitrogen fixation techniques, as discussed earlier in the case of crop plants. We can also consider production of varieties like sugarcane and tapioca, which make extremely good use of the sun's energy, and these could then be converted to produce ethanol which is a basic chemical building block.

We are aware of the problems of diseases in plants, and that these are larger by a factor of ten in the tropics compared to the temperate zone. Pesticides are being used but have their own problems relating to the environment and health. Strategies relating to integrated pest management are called for and these will involve work in insect physiology at the frontiers of our present knowledge.

There is no question that the success of the green revolution owes significantly to the farmers and peasants who were responsible to recognizing the potential of the new strategies and implementing these with success. However, it is important to point out that the so-called green revolution could never have come about but for the scientific discoveries and scientific data accumulated over the period of time prior to the breakthrough. As I have already mentioned these strategies will and must continue; and there will be many aspects of research that will need to be conducted in the agricultural institutes and universities which will relate to practical aspects to meet the felt needs of the farmer. But these by themselves are not going to solve the complex problems that we are going to encounter in our Seventh Plan and beyond. To solve these problems we need new approaches.

There was a symposium on "Basic Sciences and Agriculture" organized under the auspices of the Indian National Science Academy in 1975. The proceedings of this Symposium bring out in great detail the variety of possibilities for new quantum jumps in productivity in the field of agriculture. These possibilities are based on basic research in varied fields such as plant physiology and photosynthesis, biological nitrogen-fixation, new work in genetics and genetic engineering and so on. New institutions, centers and programmes need to be supported in these areas; and the potential rewards from this basic research are likely to be so great that we must go ahead even at the risk of failure. But whilst such symposia are held, and valuable and feasible recommendations are made, the follow-up tends to be not commensurate with the importance and urgency of the problems. In my view, this is the opportune time when we should be thinking and planning for the new agriculture that we require in a decade from now and undertake the basic researches that will enable this to happen.

In recent decades we have been witnessing a major revolution in the field of Life Sciences. This has primarily been brought about through an increased understanding of biological systems at the cellular and molecular levels. This would not be the place to go into the details of these spectacular changes that have come about in out understanding and in our capabilities. These capabilities, coming under the broad heading of biotechnologies, relate to the fields of tissue culture, developments in the field of recombinant DNA technology or genetic engineering, plasmid and gene transfers, developments relating to hybridomas and aspects relating to enzyme engineering, immunology, photosynthesis etc. Apart from the fact that these are areas of Science where there is great excitement and significant new developments are taking place continuously, it also turns out that these are areas with great practical application.

We are now aware of the formation of companies based on biotechnologies, originally started by life scientists who had developed and worked out these techniques, and now significantly backed by major oil companies and pharmaceutical and chemical companies; these new companies are in the several hundred million dollar category. The beneficiary areas are those of agriculture, medicine, energy and industry. For example, in agriculture one is considering the possibility of genetically changing plants to give them resistance to pests, drought and saline soils; to make them convert sunlight more efficiently; and to persuade them to fix nitrogen from the air rather than relying on expensive fertilizers. Even without going as far as genetic engineering, considerable developments are taking place through conventional plant breeding and protoplast fusion. In forestry, there are new efforts relating to large-scale propagation of trees from cells taken from leaves and growing baby trees in test tubes. Biological processes are being developed for a whole range of chemicals such as ethanol, ethylene glycol, ethylene oxide, lubricants, olefins and paraffins, various fine and ultra-pure chemicals etc. In the area of medicine many products are likely to be extracted from blood by genetic engineering including albumin, urokinase etc.; and this technique may be used to produce a number of vaccines such as those for animals for swine dysentery, and safer foot-and-mouth vaccine and vaccines for human use against hepatitis and possibly malaria. Hormones such as human growth hormone (HGH) and insulin which control various activities in different tissues of the body, and interferon which is part of the body's immune system, are all products being worked on for production through genetic engineering techniques.

It is clear that with the range of problems that we have in areas of agriculture, animal and human health, population control, energy and the production of a range of interesting chemicals and pharmaceutical products the new biotechnologies will play an increasingly important role. These technologies are science-based, and if one is going to embark on them and to participate in their development, particularly for applications of great interest to our country, we will have to encourage and support significantly research and development in educational institutions which alone can generate the needed scientific manpower, as also in major national institutions of research which will need to be set up where major facilities for work in such areas can be well provided.

I shall now cover briefly some areas of Basic Science that are relevant to high technologies. There is today, a large gap between Basic Science and engineering in our country. We have to recognize that with regard to areas of high technology, our industry is behind that of the advanced countries by at least a decade in terms of sophistication. In the advanced countries, sophisticated industries operating in the areas of high technology are able to interact rapidly with research scientists working in their fields in educational institutions and various research laboratories to make rapid use of the discoveries that are taking place. What are these areas of high technology? They are primarily the areas of : lasers; cryogenics (up to liquid helium temperatures); micro-technologies going down sub-micron levels; high temperature technologies; high pressure technologies; electro-optics and opto-electronics; new materials and so on. It is important to recognize that in all these technologies the innovative capabilities relating to work in Science at the frontiers are required. If one does not have ongoing basic research to cover these areas, it would be very difficult even to identify meaningful areas of application, to define what can be indigenously developed and that which needs to or could be imported, and ensure systems engineering in the country. One can, for specific applications, certainly import equipment and systems for use as black boxes, or make some of these under licence in the country. But the rate of change in these areas is so significant that one will be permanently trailing in cost and economics of production, and in international competitiveness, in many areas where we have advantages otherwise. These also happen to be areas on which a very large number of Indian scientists and technologists are working abroad and it is unlikely that one can bring them back except through opportunities for similar work in India.

In more concrete terms let me illustrate the scenario in the fields of electronics and materials sciences.

In electronics particularly since the second world war, a continuing revolution has been taking place, the origin of which was basic scientific research relating to the applications of quantum mechanics to understand solid state phenomena. This resulted in the invention of the transistor, and thereafter through a series of integrated circuits to the very large-scale integrated circuits in common use today where one talks of 256,000 bit memory chips, and achieving by the end of the decade million bit memory chips.

What is clear is that many apparently separate fields are merging together to form an enormously new and powerful whole. Advances in computer and communication technology are bringing about an inseparable union of these two fields. The development of these technologies is now mutually dependent. Large volume data to and from computers are transmitted over communication lines. Equally, telecommunication systems are becoming increasingly electronic with the introduction of electronic switching systems; it is the switching side which had remained largely mechanical and electromechanical up to now. In addition, a new development of great importance for high density traffic will be the use of optical fibre-based telecommunication, where the light source will be a solid state laser. A further important development is that the communication format will become mostly digital. The shift from analog to digital systems will further merge the computer and communication fields.

The electronic revolution is bringing about an information revolution. Computers which were once considered to be large central machines meant primarily for large volume routine computation or for advanced research, are now becoming all-pervasive, with a continuous spectrum ranging from the pocket or hand-held calculator up to the largest computer. A major development has been the advent of the microprocessor. It is the evolution of the silicon chip technology that has enabled this progress in capability, lowered cost and increased areas of application; and as this chip technology continues to evolve, the distinction between micro, mini and large computers will depend less on size and storage capacity, and more on how they are used. Computer cost and size have diminished over the years while computation speed has increased substantially; further increases in speed are expected. Computers now under development will store much greater amounts of information at less than one percent of current costs. One of the major areas to work over the future will relate to software. As a result of all these, the information revolution will permeate society on a very general basis.

Information is the key to development and progress. Until recently transfer of information had been effected mechanically through persons, through mail and printed matter; and communication systems were largely mechanical or electro-mechanical. These involved bulk transport of matter, and mobility in physical space obviously had its limitations. In the future, information transfer will essentially be through electrons or coded electromagnetic waves. What will be needed are appropriate terminal devices at the points from where information is sent out and where it is received.

Apart from the aspects that I have already mentioned, major advances have taken place in microwave technology, radars, lasers, video systems and broadcasting, transducers, industrial control, inertial guidance and many other areas in electronics.

Let us now consider the area of materials. In the past we were content with making use of materials that were readily available. Present industrial needs demand new materials, with specific properties; this is particularly true for the high technology areas such as aerospace, nuclear and electronics engineering etc. The availability of suitable materials will define the progress possible in these fields. Factors that have to be taken into account are restricted availability and increasing costs of energy, as well as of many relatively scarce non-renewable resources.

In the area of discovery and extraction of raw materials, the new developments will be based on increased scientific knowledge about the earth, particularly based on the theory of plate tectonics, new systems, for airborne profiling of the terrain, new technology in marine geology and geophysics to explore the ocean potentials (for gas oil, minerals) particularly in the continental margins, and the use of remote-sensing techniques.

A substanital effort is needed to develop substitute materials, such as high strength polymers and ceramics in place of energy-intensive or scarce materials. Similar substitution efforts will cover replacement of stainless steel by iron-aluminium alloys, or whole platinum by platinum-coated parts; use of recycled materials in asphalt pavements etc. Composite materials are often stronger, lighter and more durable than conventional materials, and their use can lead to significant savings; examples are of fibre reinforced plastics, carbon fibre which is stronger than steel, and ferroics with 3-dimensional or 2-dimensional connectivities; in the case of these new materials, aspects relating to their life and of failure (under stress and environmental conditions) need careful investigation. In view of the problems relating to the high cost and decreasing availability of oil-based raw materials, possibilities need to be explored of organic materials extracted from plants, and particularly those that grow well on poor lands. In many cases, instead of new classes of alloys, material scientists hope to meet specific requirements by modifying the internal structures in metals through precise control of the steps in fabrication. Thus high-strength micro alloy steels may be increasingly used in automobiles because they save weight. It is now known that all materials can be made amorphous. Amorphous materials have unique properties (distinct from those of crystalline materials), and these properties can be exploited to advantage; examples are the use of amorphous semiconductors such as silicon, and of metallic glasses, that will find important applications for transformer winding etc. Mention should be made of the challenges in the area of superconducting materials, particularly the possibility of high temperature superconductors. Diamond is the hardest metal known; can we develop super-hard materials ? Other possibilities in the field of materials include : synthetic polymers (plastics and synthetic rubber); low cost polymer materials with improved properties; ceramics, particularly silicon ceramics; materials based on directional solidification; power metallurgy techniques to get near-net shapes; new methods for detecting wear, and new surface treatments particularly using laser and electron beams. This is only an illustrative list but indicative of a high tempo of development that will continue to yield materials of interest for transportation, aerospace, electronics and other high technology applications. But these are areas that can be developed only through an understanding of the Physics and Chemistry of condensed matter, and the most advanced multifaceted instrumentation to probe compositions, structures, surfaces and so on.

In this part of my talk I have attempted to give both the philosophy as well as details of some fields which could be regarded as areas of thrust in agriculture, biotechnology, and in high technology areas such as electronics and materials. It would be a very elaborate exercise to do this in detail to cover all areas of Science. And I shall, therefore, not attempt this in this talk. I would like to stress that my list is illustrative and not comprehensive.

SELECTION OF AREAS OF THRUST

It would be to some interest to consider the rationale that one could employ for selecting areas of thrust for basic research. Firstly, the area must be one which is clearly regarded as in the front line of development, or likely to be so. It must be an area where one can build an effort which is viable and critical on the basis of resources that can be provided by a country such as ours. It should also be an area where there already exist interested individuals who are deeply motivated and of the highest quality, whose work should be supported and strengthened; it is always necessary to ensure a minimum size for research groups so that advantage can be taken of a high level interactive community, it is also desirable to have several groups working in the field in the country who could interact amongst each other by exchange of personnel, through discussions, and for whom major and expensive facilities can be provided on a common basis. Finally, it would be desirable if the concerned area has clear possibilities for relevant application, that would be supported by other work in complementary areas of applied research and development, where larger sums of money are generally available for infrastructural aspects. In the absence of such criteria, the tendency is to look at each project or programme on it own merits, as it is put forward, and to spread the available resources over a wide range of projects that get approved, without leading to a critical mass or thrust in any particular set of areas, it is the responsibility of the scientific community to discuss these issues and put forward its views on how the scientific effort should be focused so as to make the greatest impact at a select number of points across the whole scientific front. It is, of course, clear that resources must be available for the support of individuals of the highest quality, who may wish to put forward programmes of their own, which do not come within any such planning exercise. The system must have the capacity to recognize such situations, and the flexibility to ensure that such support is provided.

It is worthwhile to emphasize that there have been spectacular advances in the field of instrumentation that have transformed the entire experimental approach in Science. The days have gone when scientists had to take readings, record them and make graphs etc. using the data. Today, practically every instrument is a "smart" instrument with attached microprocessors which enable the data to be automically reduced to desired formats and then display or print them. Interactive display are also in use in a variety of situations. There are a whole host of new techniques for analysis of minute quantities of materials at the levels of parts per billion or parts per trillion impurities in solids. We can look at atoms directly with high voltage high resolution electron microscopy, under realistic conditions including dynamic changes. A variety of techniques can be brought to bear simultaneously on a single problem giving insights from different angles. A laboratory equipped with these modern instrumentation facilities is capable of obtaining data for a highly complex nature and proceeding then to the building up of hypotheses to enable further planning of experiments, all in a matter of a few hours or a few days, whereas working with the older approaches that many of us used two or three decades ago, and that are available in our laboratories, one would need time period, of half-a-year or a year for this. It is extremely important that instrumentation facilities right at the front line be provided on a selected basis in the country.

ROLE OF THE PROFESSIONAL BODIES SUCH AS THE ACADEMIES AND INDIAN SCIENCE CONGRESS IN FOSTERING BASIC RESEARCH

Scientific academies, professional societies and those concerned with the publication of scientific and technical journals have an exceedingly important role to play in setting standards of excellence for scientific research. This is primarily because Science can only advance through open critical discussion and debate. Scientific work must be presented to the widest possible audience. Indeed in the earlier period, scientists made serious efforts to communicate with each other by extensive correspondence so as to get different views to bear on their own work and thinking. Today, this is largely accomplished through meetings and publication of scientific results in journals. It is not surprising that the tremendous growth of Science that has taken place over the past few hundred years is also related to the advent of printing and the increased ability to travel and interact. A principal objective of scientific academies and professional societies/institutions should be to arrange for such scientific discussions. Indeed, in all scientific institutions, there must be a conscious effort to have regular programmes of lectures, seminars and discussions, where the work being carried out it presented and critically assessed. Science does not believe in secrecy. Science also does not believe in hierarchy and the youngest listener has the fullest right to question and criticize what may have been put forward by senior and distinguished scientists. Indeed, this must be encouraged, for it is more than likely that the younger colleague has the more original approach, whereas it is the more senior scientist who has greater experience, information and skills. In the case of papers sent to scientific journals they ought to be objectively and critically referred so that only sound work gets published. In the absence of good journals of Science in the country, the tendency is to publish abroad; this has is any case been so because of the undue importance attached within the country to publications in journals abroad. The scientific and professional societies of the country must come together to ensure that the major part of the scientific work done in India, and certainly the best work, is published in this country. Professor Raman has remarked, "while the foundation of the scientific reputation of a country is established by the quality of work produced in its institutions, the superstructure is reared by the national journals which proclaim their best achievements to the rest of the world. Manifestly the edifice of Science in India is incomplete.... It is true that the spirit of Science and its service are international, but it is not also true that every nation has its own Academies, learned societies, magazines and journals ? India will have to organize and develop her national scientific institutions before she can enter into the comity of international scientists."

It is for this reason that a special effort is being made during the Sixth Plan period to consolidate and strengthen the professional academies and societies in India to play this role.

On this occasion. Let me say something more particular about the Indian Science Congress.

The Indian Science Congress was established in 1914 with the first objective being defined as "to advanced and promote the cause of Science in

India". In fact in the detailed account relating to the Indian Science Congress Association it is stated that it was "Established in 1914 to convince people and Government that Science plays a vital role in the life of the nation". It is very clear from these objectives and the manner in which the Indian Science Congress is structured, that it is largely patterned on the British Association for the Advancement of Science which had its first meeting in York 150 years ago. It may be of some interest for those of us concerned with the Indian Science Congress to go back to the origins of the British Association which can be traced back to Charles Babbage, credited as the father of the computer, and to David Brewster, the well-known optical physicist and the inventor of the kaleido-scope. I recount this background intentionally for the reason that it throws light on the manner in which Science has changed with time and also on how we should organize ourselves in the future to promote the cause of Science.

Babbage who was on a visit to Germany in 1827, at the invitation of the great Alexander Von Humboldt attended a meeting in Berlin of the Deutscher Naturforscher Versammlung. This society had arisen from the idea of having "a great yearly meeting of the cultivators of Natural Science and medicine from all parts of the German fatherland". Babbage was greatly impressed by the meeting. At that time he was, in fact, very depressed about the state of Science in his country, and had written a book entitled *"Reflection on the Decline of Science in England"*. On return from Germany, Babbage wrote an article in the Edinburgh journal of Science, edited by David Brewster, on the German meeting which he had just attended. This struck a sympathetic chord amongst many in Britain. Brewster worked up the idea of having such a meeting in Britain and what it could do. He stated that it would make, "the cultivators of Science acquainted with each other, to stimulate one another to new exertions—to bring the objectives of Science more before the public eye and to take measures for advancing its interests and accelerating its progress" and further "to revive Science from its decline, and the scientific arts from their depression; to instruct the government when ignorant, and stimulate when supine; to organize more judiciously our scientific instructions, and the public boards to which scientific objects are entrusted,... to raise scientific and literary men to their just place in society". These views would hold good as the objectives of the Indian Science Congress today.

I would also like to remind you that some of the great discoveries of Science were reported originally at the British Association for the Advancement of Science. These included : J.J. Thomson's announcement of his discovery of the electron (1899); the demonstration by Crookes of the properties of Cathode rays (1879); the discovery of a new gas Argon by William Ramsay (1894); the ideas of James Joule on the mechanical equivalent of heat (1843); Clark Maxwell's first reports on molecular physics, and ideas on the Maxwell distribution (1873); Fitzgerald's report on the discovery by Hertz of the electromagnetic waves predicted by Maxwell (1888); Millikan's measurement of the unit charge on the electron (1909); etc. Additionally, many of our scientific units originated with the British Association: the joule; the ohm, the dyne and the erg; the CGS system of measurement etc. I am more than aware that all this occurred in the historical days, just when Science started on its present dizzy exponential growth. Today most discoveries are reported over the radio and in the daily press, and discussed at highly specialized thematic meetings. They are no longer reported at the British Association for Advancement of Science, nor will they be at the Indian Science Congress. (We should of course remind ourselves that Prof. Raman reported at the January 1929 (Madras) Science Congress, in his Presidential Address, the work done in Calcutta over the previous year which resulted in the discovery of the Raman Effect.).

There is no reason, however, why topics of major scientific interest and excitement should not form part of our discussion at the Indian Science Congress which happens to be the largest single gathering of scientists in the country, covering the whole range of Sciences. The Indian Science Congress should not be a place for reporting of routine measurements or for discussing pedestrian details of Science policy. It should be a forum to generate a sense of enthusiasm and elan in the scientific community. With its coverage of a wide spectrum of scientific disciplines it can arrange for panel discussions on interdisciplinary aspects where some of the major thrusts occur for as C. V. Raman has remarked: "History of Science has shown that real fundamental progress is always due to those who had ignored the boundaries of Science and who treated Sciences as a whole". This was a man interested in the colour of the sky and of the sea, in crystals and diamonds, in the theory of vision and of hearing; in the theory of musical instruments and much else.

Basic research always happens to be an area of innovation, originality and excitement. And the Science Congress should attempt to focus in this direction if it is to be dynamic and relevant and excite the young minds.

An aspect which the scientific community must always keep in mind is that, if Science is to grow and flourish, it must attract to Science some of the finest minds of the country. This can happen if one can convey to the potential young scientists a sense of excitement and the possibility of new discoveries. It is the young minds who are characterized by the greatest originality, and it is this generation which is capable of putting in exceptionally hard work. A very important reason for strong support to research in the educational system is that it is here that we find the truly young generation, in the student community. Some deliberate measures are called for to see that the best and well-trained amongst them are provided adequate incentives to take up research as a career, and that areas are defined and supported that best serve national interests and priorities towards which such talent can be directed or encouraged to work on. The Indian National Science Academy awards each year the Young Scientists Medal, which is presented by the Prime Minister at the Indian Science Congress Session. This is an attempt to focus attention on work of high quality accomplished by very young Indian scientists. Particular efforts are also being made in the Sixth Plan to involve young scientists directly on a more active basis in scientific research and development.

CONCLUDING REMARKS

In conclusion, I would like to restate some of the aspects that I have covered in this address that I regard as important, and also which call for action both on the part of the scientific community as well as decision makers at various levels.

Indian Science and Technology have been placed on a relatively firm footing through major efforts since Independence. We are now at a take-off point, but the question is whether we will seize this opportunity. A large part of the resources allocated have been in the areas of applied research and development, and in these, wherever clear-cut lacks have been assigned, Indian Science and Technology has invariably produced the results expected of it. What is important is that, on the basis of perspective planning, the needs and investments in the productive sector are clearly defined, well in advance, so that the appropriate scientific effort can be initiated right now to meet those requirements. Furthermore, there is no point in undertaking applied research and development on an *ad hoc* basis, without a clear appreciation that investments will take place downstream which can make use of the scientific effort.

The World of today is quite clearly a world characterized by Science and Technology. In the future it will be characterised even more so.

Technologies relating to areas across a whole spectrum of agriculture, health, energy, industry and so on are becoming increasingly science-based, and for any meaningful efforts in applied research and development it is essential that we have in the country the appropriate background of basic understanding. This, as well as its role in the system of education and the creation of manpower in the country with innovative capabilities, demands the execution of basic research across a wide spectrum. Applied sciences and technology are forced to adjust themselves to the highest intellectual standards that are developed in the Basic Sciences. This influence works in many ways : for example, some students trained in basic research come into industry; again, the techniques which are developed and applied to meet the most stringent requirements of basic research at the frontiers of human capability serve to create new technological methods for industry.

There is total national agreement on the importance of self-reliance. The problems we encounter are large in magnitude, and many are local specific; we have to find solutions for these ourselves, and it is for this that innovative thinking, characteristic of basic research, acts as a pace-setter. All of this is inherent in the Scientific policy Resolution. What we need to do is to aim steadfastly at implementing this Resolution in its true spirit.

Basic research needs to be supported first in the educational institutions which have been allowed to run down sadly in recent years. Much greater support is required to build up the infrastructural capabilities, at least on a selected basis, in educational institutions. Apart from this, basic research must form an integral part of other research bodies. In many areas of agricultural, industrial and defence research, faced with the problems of the immediate, there is a tendency for decision makers to insist that everything is directed at solving felt needs of the users. I have very often emphasized that in the case of the Council of Scientific and Industrial Research, the word "scientific" precedes the word "industrial"; and in fact the organization can be effective for industrial research only by carrying out scientific research. This is equally true in areas of agriculture, of medicine, of defence and so on.

We have to recognize that basic research has to comply with international standards of performance and excellence; and is centered around the most gifted individuals. The environment under which such individuals work, and attract outstanding pupils and create centers of excellence, is not the environment of factories or of Government departments. Apart from the financial support needed for nurturing such centers of excellence, there is the need to support them in generating the culture where such growth can take place. In this respect, the situation has deteriorated in recent years.

Many of our activities today on the scientific scene relating to the educational sector, the national laboratories, the industrial sector and Government departments are largely compartmentalised. There is need for much greater linkages amongst these, which are not difficult to implement but are largely missing because of administrative and financial bottlenecks.

The future of Science will depend on attracting some of the finest minds of the country to scientific research. The importance of enthusing and nurturing the potential young scientists of the country needs no emphasis. Professional bodies have an important role to play in this regard as also in that of popularization of Science.

It is clear that resources both human and financial will not be available to cover the total spectrum of Science and Technology on a viable basis. We have to be selective in the thrust areas that we choose to concentrate on. Many of these can and will relate to problems in our immediate environment, which offer opportunities not only for work at the frontiers of Science but also for work that could have relevance for large sectors of national development.

The value of basic research does not lie only in the discoveries it leads to which are international. There is more to it. It affects the whole intellectual life of a nation by determining its way of thinking, and the standards by which actions and intellectual production are judged; an atmosphere of creativity is established which penetrates every cultural frontier. It is fundamental research which sets the standards of modern scientific thought. As C. V. Raman has remarked : "Unless the real importance of Pure Science and its fundamental influence in the advancement of all knowledge are realized and acted upon, India cannot make headway in any direction and attain her place among the nations of the world. There is only one solution for India's economic problems and that is Science and more Science and still more Science".

ACKNOWLEDGEMENT

I would like to thank Prof. R. R. Daniel, Dr. H. K. Jain, Dr. P. J. Lavakare, Dr. P.M. Bhargava, Prof. C. N. R. Rao and Dr. S. R. Valluri for their suggestions relating to coverage of the focal theme; and Dr. B. P. Pal and Dr. S. Varadarajan for their valuable and constructive comments on the manuscript of this Address.

I am deeply grateful to Dr. (Mrs) Manju Sharma for all the assistance she has given me in preparing this talk; and but for her and my dedicated staff Shri C. V. Subramaniam, Shri V. P. Gera, Shri R. C. Gupta, Shri Mohan Lal and Shri C. Radhakrishnan, this talk would never have been prepared in time; my thanks are due to all of them.

ANNEXURE

Government of India : Scientific Policy Resolution

New Delhi, the 4th March, 1958.

No. l31/Cf/57. The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of Science and its applications.

2. The dominating feature of the contemporary world is the intense cultivation of Science on a large scale, and its application to meet a country's requirements. It is this, which for the first time in man's history, has given to the common man in countries advanced in Science, a standard of living and social and cultural amenities, which were once confined to a very small privileged "ture to an extent never possible before. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given to civilization a new vitality and a new dynamism.

3. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare state has grown. It is characteristic of the present world that the progress towards the practical realization of a welfare state differs widely from country to country in direct relation to the extent of industrialization and the effort and resources applied in the pursuit of Science.

4. The wealth and prosperity of a nation depend on the effective utilization of its human and material resources through industrialization. The use of human material for industrialization demands its education in Science and training

in technical skills. Industry opens up possibilities of greater fulfillment for the individual. India's enormous resources of manpower can only become an asset in the modern world when trained and educated.

5. Science and Technology can make up for deficiencies in raw materials by providing substitutes, or, indeed, by providing skills which can be exported in return for raw materials. In industrialising a country, a heavy price has to be paid in importing Science and Technology in the form of plant and machinery, highly paid personnel and technical consultants. An early and large-scale development of Science and Technology in the country could therefore greatly reduce the drain on capital during the early and critical stages of industrialization.

6. Science has developed at an ever-increasing pace since the beginning of century. So that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by putting forward our utmost effort into the development of Science that we can bridge the gap. It is an inherent obligation of a great country like India with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of Science, which is probably mankind's greatest enterprise today.

7. The Government of India have accordingly decided that the aims of their scientific policy will be

    1. to foster, promote and sustain, by all appropriate means, the cultivation of Sciences, and scientific research in all its aspects — pure, applied and educational;
    2. to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation;
    3. to encourage and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in Science and education, agriculture and industry, and defence;
    4. to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;
    5. to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom; and
    6. in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The Government of India have decided to pursue and accomplish these aims by offering good conditions of service to scientists and according them an honoured position, by associating scientists with the formulation of policies, and by taking such other measures as may be deemed necessary from time to time.

SHIFTING CULTIVATION : A PRACTICE OF DEFORESTATION OR SUSTAINABLE DEVELOPMENT

Sudeep Kumar* and Debendra Kumar Biswal**

Today the issue of food insecurity has been a serious concern for the global community. There are some communities like the primitive tribal groups who do not have even the basic amenities for their survival. Shifting cultivation, variously known as rotational bush-fallow agriculture, swidden cultivation or slash-and-burn cultivation is an ancient form of agriculture still practiced in many parts of India including the Central region.

On the one hand, the government has enacted strict forest and land laws to curb shifting cultivation, which is based on the ideas of one school of natural and behavioural scientist, who believe that this primitive form of agriculture results in serious environmental problems. Accordingly, the developmental efforts for the tribal groups have been prepared with a vision of "sustainability". The only strategy is to pursue the practitioners for other forms of livelihood. On the other hand, among the shifting cultivators like Bonda and Kutia Kondhs in Orissa, it was observed from the site selection, cutting, burning and cropping that it is an ingenious system of organic multiple cropping which is well adapted to local conditions in moist forest and hill tracts, where the monetary and energetic output-input ratios is higher than other form of agriculture. The efforts of the government, both central and state government for the development of the primitive tribal groups who are practicing shifting cultivation is wrong both in policy as well as in social-philosophical-humane level.

Using both primary as well as secondary data this paper is an attempt to get a picture of the meaning and applicability of the word 'sustainabile development' for the shifting cultivator primitive tribal groups in Orissa. It was found that the philosophical and the practical view of life and livelihood hidden in the customs and traditions of the tribal groups practicing shifting cultivation have the strong justification over the modern laws of the so called civilized people.

INTRODUCTION

Shifting cultivation, a primitive system of agriculture, the first step in transition from food gathering and hunting to food production is nearly 9000 years old agricultural practice and believed to have started during Neolithic period. It is prevalent not only in India but in other countries of Asia, Africa, South America and Australia. This is extensively practised by the tribals throughout the tropical and subtropical region. Conventionally, shifting cultivation has been interpreted as an inefficient (economically) and destructive (ecologically) form of agriculture[4, 5, 6]. Since the

* Department of Research and Publications, Xavier Institute of Social Service, Ranchi-834001 Email : skg74@ rediff mail.com.

** Centre for Anthropological Studies, Central University of Orissa, Koraput, Orissa-764020, Email : debendrabiswal@ rediffmail.com

British period of ruling, the shifting cultivators have been a target for the government, environmentalists, anthropologists and surely the policy makers, how to stop or if possible to give an alternative livelihood to the practitioners of this so called "unethical", "anti-environmental", "anti-developmental", "anti-social" primitive form of agriculture. More recently, shifting cultivation is viewed as an inflexible static system (institutionally) ill-suited for adapting to changes brought about by modernity. This latter view, as illustrated in World Bank (1992), holds that it slows agricultural production and causes ecological degradation. In the recent studies and policies, almost all the questions and issues raised revolve around two major issues; firstly, Population, productivity and deforestation and secondly, development projects and displacement of the tribal groups practicing shifting cultivation. It is also proved that Shifting cultivation and poverty has a vice versa relationship. Under the most recent policies of the Ministry of Agriculture and Forestry, four targets are identified for a sustainable livelihood among the practitioners of shifting cultivation. These are (i) Ensuring food security, ii) Commercialization of agricultural productions, (iii) Shifting cultivation stabilization for poverty reduction, and (iv) Sustainable forest management[12]. On the other hand, anthropological and sociological interpretations have seen this agricultural practice as a tradition and basic for the livelihood of a community. The practitioners have the better understanding of the environment than others and thus, nothing to do with environmental issues associated with it[2, 7, 8, 9, 10, 11]. Therefore, it is essential to examine whether shifting cultivation is a destructive, inefficient and inflexible static system of agriculture.

SHIFTING CULTIVATION : MEANING AND EXTENT

As different from settled cultivation, shifting cultivation involves traditionally established conventionality and rituals. The shifting cultivation is generally practiced in the following sequence : 1. Selecting a forest patch and clearing the vegetation normally in December and January, 2. Burning of the vegetation (without stumps and roots) in February and March, 3. Sowing of seeds, by dibbling, generally of cereals, vegetables and oil seeds in April–May, 4. Continuing cultivation for a few years, 5. Abandoning the cultivated site and shifting to other forest sites and Returning to the former site, and once again practice shifting cultivation on it. In India, Shifting cultivation has been a traditional cultivation practice in hilly terrains, especially amongst the tribal communities. About 5.0 million tribal families are practising this system on 4.37million hectare of land covering 11 states (Table-1).

Table-1
Shifting cultivation in different states of India

State	Tribal Families (Million)	Total Area (Million hectare)
Andhra Pradesh	0.11	0.15
Arunachal Pradesh	0.43	0.21
Assam	0.31	0.31
Bihar	0.23	0.19
Madhya Pradesh	0.19	0.38
Manipur	0.36	0.26
Meghalaya	0.61	0.47
Mizoram	0.40	0.19
Nagaland	0.19	0.12
Orissa	2.00	1.60
Tripura	0.19	0.49
Total	**5.02**	**4.37**

Source **:** Shifting cultivation in India, ICAR

In Orissa, Shifting cultivation is an age-old practice, which is locally known as the *podu* cultivation. About 5298 sq. kms. area annually is under this primitive agriculture practice in Orissa. Shifting cultivation is prevalent in Kalahandi, Koraput, Kandhamal and other southern and western districts, covering 119 blocks. The tribal communities, viz. *Kondha*, *Kutia Kondha*, *Dongaria Kondha*, *Lanjia Sauras*, *Paraja*, *Godaba*, *Koya*, *Didayi*, *Bonda*, *Juanga* and *Pauri Bhuyan*, *Peranga* and *Erenga Kolha* are involved in this practice. Many festivals and other such rituals revolve around the *podu* fields, because the tribals view *podu* cultivation not just as a means of their livelihood, but as a way of life. Orissa is estimated to have the highest amount of land under shifting cultivation among the states of India (Table-2).

Table 2
Estimates of area under shifting cultivation in Orissa

Source of Information	Estimates of area under shifting cultivation in Orissa
FSI, 1999	5,29,800 hectares under active shifting cultivation in the year of Survey
N. Pattnaik, 1993	37,00,000 hectares of shifting cultivation area
A Decade of Forestry, GOO, 1995	26,49,000 hectares of shifting cultivation
Forest Enquiry Report, GOO, 1959	30,72,000 hectares of shifting cultivation approximately

Estimates of the area under shifting cultivation in Orissa range from 5298 sq. km. to 37,000 sq. km.(Table 2). That these areas were traditionally under shifting cultivation is clear from a number of reports from the colonial period. Even the Forest Enquiry Committee Report of 1959 mentioned those 12,000 sq. miles (almost 30,720 sq. km.) of land in Orissa was under shifting cultivation. Almost all tribal communities in Orissa practice shifting cultivation. Forest Enquiry Report, GOO, 1959 says that 30, 72,000 hectares of land is under shifting cultivation.

POLICIES TO CHECK SHIFTING CULTIVATION IN ORISSA

In Orissa, keeping in view of the extent of the area and population affected by shifting cultivation, the State Government has attempted to tackle the problem by controlling or nationalizing the practice. The colonization programme was introduced during the sixties in the problem areas to divert the primitive tribes to settled agriculture by providing cultivable land, necessary inputs and residential accommodation. During the first four plans, a number of colonies have been established in the tribal areas. However, in most of the areas the scheme has not achieved the desired results. Besides the colonization scheme, the programme of rational land use on watershed basis has been taken up by the State Government through Soil Conservation Department. The programmes included the following : (a) Providing land to the tribals who was willing to give up cultivation on steep slopes. (b) Plantation of economic species useful for tribal community. (c) Introduction of conservation farming to allow tribal people to obtain higher production from crop land. (d) Utilization of steep slopes for production of timber. Under the above scheme a suitable watershed in the shifting cultivation area is selected and rational land use programme is executed on the existing catchment. A schematic land classification of watershed management units together with land use programmes was recommended for watershed areas for rationalization of shifting cultivation. The above programme was first started in selected catchments of Koraput district on pilot basis and then it was extended to other problem areas in Phulbani, Kalahandi and Keonjhar districts. However, these programmes were inadequate in view of the vast population and the area affected by shifting cultivation. In June 1987, Ministry of Agriculture, Government of India, floated a pilot scheme for control of shifting cultivation. It has two fold objectives i.e. restoring ecological balance in the hill areas and improving socio-economic conditions of tribal *podu* practicing families by weaning them away from *podu* cultivation with 100% Central Assistance. Besides, the ICAR and the World Bank have recommended for several strategies to reduce shifting cultivation. These are: (a) to promote forestry on upper reaches with silvi-pasture development. (b) to break middle slope length for annual or perennial fruit trees and inter-crop, and (c) to put lower slopes under agricultural crops. As an alternative to shifting cultivation, SALT 1, SALT 2 and SALT 3 are to be demonstrated on pilot basis.

SUSTAINABILITY OF THIS PRACTICE

The shifting cultivation is considered devastative and dis-advantageous as it not only causes harm to the ecosystem but also exerts negative impact on economy. Some of the evil effects of such cultivation are; it helps the springs to dry up, results in soil erosion, destroys valuable timber, responsible for causing very heavy floods, and silting the tanks and fields and damage to crops.

The forests of Orissa are mostly of deciduous type though the mangrove patches of coastal areas are a pride for the state. The forests are Sal-dominant in many areas, but miscellaneous forests and Teak forests are also found. During the last fifty years, the forest cover of Orissa has been drastically reduced. For instance, the forest area in 1962 was about 65868.9 sq. km. which was reduced to 57184 sq. km. in 1997 as per legal status though satellite pictures suggested a much lower figure i.e., 46941 sq. km.(30.1%) (Forest Survey of India, *State of Forest Report 1997*, p.29). In tribal districts 25760 sq. km. (1993) of forests were reduced to 25424 sq. km. in 1997 (*State of Forest report 1997*,p.61). Forests land and water not only support the sustenance of one another, but also support the existence of life on earth. It is through the balanced utilisation of these vital resources that man is able to lead a healthy and harmonious life. Among the various man-made factors/developments (like mining, industrial use, timber extraction, etc.) responsible for spoiling this harmonious relationship between natural resources and human life, shifting cultivation has been alleged to be a significant one. In its destructive role, it affects land, water and forests in the following ways; destruction of rich forest cover, degradation of land though soil erosion and decreasing the availability of floral, Waste which, due to the presence of a good forest cover, used to enrich the soil fertility and affecting the catchment areas of rivers and hill streams in a number of ways like decrease in rainfall and ground water level and increasing siltification and consequent burial of river channels due to soil erosion.

FAO (1982) defined deforestation as a complete cleaning of trees and their replacement by other use of the land ('alienation')[3]. Many studies have contradicted with FAO that tribals/ practitioners of shifting cultivation are not deforesting but they are part of conservation[14, 15]. Cultivation on such hill sides without fertilizer inputs results in a progressive decline in soil fertility and thus justifies sustainability of land use in these areas[18, 16, 17, 19]. It is also argued that researches about the impact of shifting cultivation on the forests often overlook the fact that shifting cultivators are more than just farmers; they are also carpenters, fisherman, hunters and gatherers[21, 22, 23, 20]. Increase in population has been cited as a major cause of the sorry state of shifting cultivation and livelihood in many parts of the world. They feel that pressure in these areas will worsen with an increase in population. However, contrary to this popular belief, population increase is not always the culprit for deforestation. A review of 70 different studies from around the world found that the impact of population increases on tropical hill side resources has actually been quite varied. Aerial photographs and ground surveys from hilly areas of Kenya, Nepal and Rwanda show that tree cover increased with population growth.

With reduction in *podu* cycle from 20–30 years to 3-5 years, the land under shifting cultivation looses its nutrients and the topsoil. With reduction in crop yield, the families start moving to other virgin areas. Frequent shifting from one land to the other has affected the ecology of these regions, declined the area under natural forest, caused fragmentation of habitat and disappearance of native species including invasion by exotic weeds. The area having *podu* cycle of 3 and 5 years is more vulnerable to weed invasion compared to *podu* cycle of 15-20 years. Reduction in the cycles of *podu* adversely affected the recovery of soil fertility, and the nutrient recycling by the ecosystem. Repeated short-cycle *of podu* has created forest-canopy gaps, which can be seen as thin forests from a distance. In shifting cultivation, once the fertility of the land is declined, it is abandoned and another area is selected for clearing and farming. The former area is reverted to forests and remained uncultivated for years together. Though the tribal agro-ecosystems are well satisfied in shifting cultivation and efficiency of shifting cultivation in terms of energy and economy is superior to that of settled agriculture provided it is done in 15-20 year cycle. *Podu* cultivation in short cycle has been detrimental to the ecosystem.

The flora and fauna have been affected variously due to loss of forests. The impacts of deforestation can be categorised as under : General : Invasive weeds have taken over some parts of the deforested areas. These weeds do not allow regeneration of forest crops. Similarly, mature timber trees have become scarce and wild life has been reduced drastically. Shifting cultivation and/or overexploitation has also reduced the availability of forest tubers, bamboo and *dabaghas* (*per. comm*.,). Similarly, among the wild life bison and tiger etc. are almost out of sight and in villages. Species-specific: Impacts on individual species are due to two reasons: insecure livelihood and negligence of the Forest Department.

Though shifting cultivation is considered as an evil agricultural practice, the cost-benefit analysis shows that the livelihood, food security and socio-cultural events of the concerned communities have a wider edge than the environmental issues associated with it. The word 'sustainability' is not merely rooted in the environmental management, but also on other issues of survival of a community. A sustainable development is one in which the resources are extracted but NOT exhausted. It manages economic growth to such a way as to do no irreparable damage to the environment. It is based upon the principle that given enough time nature is able to recycle its conservable resources. By balancing the economic requirements of a society with ecological concerns it seems too satisfy the needs of the people without endangering the prospects of the future generations. Thus, the word "SUSTAINABILITY" or "SUSTAINABLE GROWTH" has infiltrated discussions of long run economic policy in the last few years. Here, the developments in all sectors have been seen as a self-defeating process. Thus, people are in search of alternative development process. Sustainability is a key concept in the alternative development paradigm that has been advocated. Sustainable development is a development process that not only generates economic growth but also distributes its benefits equitably, that regenerates the environment rather than destroying it, that empowers people rather than materialising them. The basic principles of sustainability for promoting ecologically-sound agriculture, proposed and pursued by M.S. Swaminathan (1991 : 29-31) include (I) Land, (II) Water, (III) Energy, (IV) Nutrient supply, (V) Genetic diversity (VI) Pest management (VII) Post harvest systems (VIII) Systems approach and (IX) Location-specific research and development along with monitoring, equity in conservation and no less pivotal and vitally significant areas of biodiversity, food and ecological security.

In a study by KCDS, Bhubaneswar (OTELP, 2007) in four districts; Kandhamal, Kalahandi, Koraput and Gajapati it found that each household takes about 0.68 ha. known as the *podu* of forest land under shifting cultivation which provides food security for 4-5 months (September-January) (Table-3).

Table 3
Area under Shifting Cultivation by Households (Ha)

District	Area under shifting cultivation per Household	Type of crops grown
Gajapati	0.52	Millets, pumpkin, pulses
Kalahandi	0.47	Millets and pulses
Kandhamal	0.60	Millets, pulses, turmeric, vegetables
Koraput	0.55	Millets, pulses, pumpkin

In a similar study by the authors among the Kutia Kondhs of Phulbani district in Orissa, it was observed from the official documents that alternate livelihood systems consistent with sustainable forest land use are promoted to reduce *Podu*. Give pattas before anything else. Then help to intensify cultivation in a small portion of the shifting range. In addition, offer to lease or buy-back the pattas thus facilitating a voluntary movement away from reduced fallow unsustainable shifting cultivation and also providing alternative sustenance[13]. However, it was found that around 80 percent of the land holding is under shifting cultivation, from which they produce 200 varieties of cereals and 30 varieties of pulses. Though it is their main source of livelihood, they are also dependent upon livestock, forest produces and Minor Forest Products (MFPs). According to Kutia Kondhs Development Authority (KKDA), 8435 sq. km. of land is under shifting cultivation which is around 23% of the total lands of this district. It is significant from the sustainable perspective is that the site selection is done after taking into consideration the soil fertility, distance from the villages, legality from the forest department and the availability of drinking water. During slashing, they could collect fruits of some indigenous forest plants, seeds of these fruits are eaten as nuts. Some flowers collected during this process are used in off seasons. Seeds of *sal trees* and brooms collected are sold in the market. There is no use of modern agricultural implements. The important agricultural implements used are plough, yoke, dibbling rods, web, tiny mattock, hoe and sickle. The hand weapons include axe, bow and arrow. After once or twice cultivating the land, the site is abandoned for natural vegetation. The fallow period/ *Nellatu* is the gap between two successive clearing of forest followed by cultivation is maximum up to 7 years. However, in the past, fallowing was of long duration (up to 10 years).

CONCLUSION

Both the strategies; to reduce shifting cultivation and to achieve sustainability in the shifting cultivation tribal areas seems to be difficult as shifting cultivation has a vice versa relationship with socio-cultural, economic and temporal aspects of the communities. For example, poverty and livelihood is deeply rooted in this form of agriculture and without wiping out poverty it is difficult to imagine of sustainability. In Orissa, there are different projects developed to reduce shifting cultivation and to bring out sustainability. Because of the important impact of climate change on agricultural landscapes, and its recognized implications for food security, agricultural production and GDP, these projects are of great relevance to the first, second and third of these targets. 13 measures to achieve these targets have been identified, including improvement of land use planning and surveying methods, establishment of technical support at the village cluster level, and capacity building. However, after seeing at this practice, it can be said that the philosophical and the practical view of life and livelihood hidden in the customs and traditions of the tribal groups practicing shifting cultivation have the strong justification over the modern laws of the so called civilized people. That, in its ideal nature shifting cultivation is a technique for the utilisation and development available/reclaimable land for cultivation under unfavourable geographical conditions. That, it is the 'civilised people' of the plains who have deprived the tribal of their resources and have forced them to search for an alternative place of sustenance in the hill-forests, thus leading to shifting cultivation.

REFERENCES

1. Govt. of Orissa, H & T. W. Deptt. (1991), Control of Shifting Cultivation scheme, Orissa, Annual Action Plan 1991-92 (unpublished), (1990).
2. K. J. Pelzer, Pioneer settlement in the Asiatic Tropics: studies in land utilization and agricultural colonization in southeastern Asia. 1945. *American Geographical Society*, New York.
3. FAO, Forest Resources of Tropical Asia. 1982. Rome, Italy.
4. Izikowitz, 1951.Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
5. Schlippe, 1551. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
6. Freeman, 1955. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
7. Simoons, 1958. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
8. Wettess, 1960. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
9. Concklin, 1954. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
10. Leach, 1959. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
11. Anderson, 1975. Cited in 'the study of shifting cultivation' by H. C. Conklin. *Current Anthropology*, **2**, 1, 1961.
12. B. Das, Shifting cultivation among the tribes of Orissa. 2006. Orissa Review, July, 2006.
13. Biswal. Ecology and health : a comparative study among the Kutia Kondhs and Gonds in Orissa. 2009. Unpublished Thesis, Department of Anthropology, University of Delhi.
14. P. H. Nye, and Greenland, D. J. The soil under shifting cultivation. 1960. Technical communication No. 51, Commonwealth bureau of soils, Harpenden. Commonwealth Agricultural Bureau, Bucks, England.
15. P. A. Sanchez, Soils of the humid tropics. 1981.Studies in Third World Societies, 14, college of Williams and mary, Virginia, USA.
16. S. C. Chin, Agricultural and resource utilization in a low land rainforest Kenyah community. 1985
17. J. D. Freeman, Report on the Iban. London School of Economics, 1970. monographs on Social anthropology, no. 41. Athlone Press, University of London, England.
18. D. H. Janzen, *Science*, **182**, 1212-1219, 1973.
19. R. E. Seavoy, *Annual Asso. Amer. Geography*, **63** *:* 218-225, 1973.
20. R. Gianno, 1986. The exploitation of resinous products in a lowland Malayan Forest. Cited in 'Do shifting cultivators deforest', by S. C.

Chin, in V. Shiva (ed.) Forest Resources : Crisis and Management (1992), Natraj Publisher : Dehradun.

21. Fox-Worthy, 1922. Minor forest products of the Malay Peninsula. Cited in 'Do shifting cultivators deforest', by S. C. Chin, in V. Shiva (ed.) Forest Resources : Crisis and Management (1992), Natraj Publisher: Dehradun.

22. Pringle, 1970. Rajahs and rebels. Cited in 'Do shifting cultivators deforest', by S. C. Chin, in V. Shiva (ed.) Forest Resources : Crisis and Management (1992), Natraj Publisher : Dehradun.

23. Chin, 1985. 'Do shifting cultivators deforest', in V. Shiva (ed.) Forest Resources : Crisis and Management (1992), Natraj Publisher : Dehradun.

BIOCHEMISTRY OF TOXICOLOGY

Jyoti D. Vora and Padma Srinivasan

Industrialization, Globalization, rapid growth of economies, all dreams of productivity and profitability etc. have exposed mankind and other living species to great levels of toxicity in the environment. The effects of growth have taken a toll on health leading to various diseases and hazards. Toxicology, a detailed study of the effects of such toxins in the environment is a useful and effective aid to study causes in detail, suggest remedies as also to eradicate the hazards. This understanding enables implementation of various preventive, managerial and curative measures with reference to toxins in various systems of medicine, pharmacology, food science, forensic sciences, and environmental sciences and also in industrialization during the development of sustainable eco-friendly manufacturing processes. The following review details all aspects involving the biochemical perspective of the science of toxicology.

Toxicology (literally translated into "Study of toxicity") is the study of the adverse effects of chemical, physical or biological agents on living organisms and the ecosystem, including the prevention and amelioration of such adverse effects. Exposure of humans and other organisms to toxicants may result from many activities : intentional ingestion, occupational exposure, environmental exposure, as well as accidental and intentional (suicidal or homicidal) poisoning.

A toxin can be defined as a colloidal proteinaceous substance which is capable of immunoglobulin (antibody) formation. Toxins generally exert their effects on interacting with membrane receptors or by absorption and mobilization into body tissues. Only a specific part of the toxin's entire structure known as the Toxicophore that is responsible for its toxicity in the living system.

Toxicity is the adverse end product of a series of events that is initiated by exposure to chemical, physical or biological agents. Toxicity can manifest itself in a wide array of forms, from mild biochemical malfunctions to serious organ damage and death.

A vital fundamental rule used in assessing the severity of a toxicant is the Dose-effect response. It postulates that the relationship between exposure and adverse effects can be established by measuring the adverse effects of a toxin relative to an increasing dose. Thus it is said that "The Dose Makes the Poison."

The broad scope of toxicology, from the study of fundamental mechanisms to the measurement of exposure, including toxicity testing and risk analysis, requires an extensively interdisciplinary approach. This approach utilizes the principles and methods of other disciplines, including molecular biology, chemistry physiology, medicine, computer science and informatics.

Thus, the various subdisciplines of toxicology as a science are as follows :

- **Environmental Toxicology :** It deals with the study of chemicals which contaminate

* Department of Biochemistry & Food Science and Quality Control, Ramnarain Ruia College, Matunga, Mumbai-400019, India. E-mail : drjyotivora@yaho.co.uk

food, air, water, soil and other natural resources. It deals with the lethal effects of various toxic chemicals on plant, animal and human life.

- **Clinical toxicology :** It is concerned with the diseases and illnesses associated with the short-term or long-term exposure to toxic chemicals.
- **Forensic Toxicology :** It is used to establish the cause and effect relationships between the exposure of a drug/ chemical and the lethal effects from that exposure.
- **Occupational (Industrial) toxicology :** It is concerned with the health effects from exposure to chemicals in the workplace. This field grew out of the need to protect workers from hazardous chemicals and to make their work environment safe.
- **Regulatory toxicology :** This field gathers and evaluates existing toxicological information to establish concentration- based standards of safe exposure.
- **Food toxicology :** This field is involved in delivering a safe and edible supply of food to the consumer. This field also aids in setting up permissible limits of contaminants in food products like pesticides and heavy metals.
- **Descriptive toxicology :** It is concerned with gathering toxicological information from animal experimentation. These types of experiments are utilized to establish dose-effect relationships.
- **Analytical toxicology :** It identifies the toxicant through analysis of body fluids and tissues, stomach contents, etc. Hair is generally used to detect long-term exposure to drugs of abuse.
- **Mechanistic toxicology :** It deals with the observations of how toxic substances cause their effects.
- **Systemic Toxicity :** This field deals with the toxic effects as a result of absorption and distribution of a toxicant to a site distant from its entry point. Most chemicals that produce systemic toxicity do not cause the same degree of toxicity in all organs, but usually demonstrate major toxicity to one or two organs which are referred to as the target organs of toxicity for that chemical.
- **Immunotoxicity :** Immunotoxicity is defined as adverse effects on the functioning of the immune system that result from exposure to chemical substances. Altered immune function may lead to the increased incidence or severity of infectious diseases or cancer, since the immune system's ability to respond adequately to invading agents is suppressed. These toxins exert their mechanism of action by inducing hypersensitivity, asthma, rhinitis etc.
- **Preventive toxicology :** This field encompasses the multiple disciplines of toxicology in the identification, characterization, mode of action and toxicological manifestations of frequently encountered environmental and industrial toxins; so as to evaluate the efficacy of measures by which these toxins can be eliminated from the very source from which they are derived.
- **Adaptive toxicology :** In the context of toxicology, the process whereby a cell or organism responds to a xenobiotic so that the cell or organism will survive in the new environment that contains the xenobiotic without impairment of function. It studies the actual mechanisms by which a toxicant can exhibit tolerance in the human system and also the implications by which may occur on accumulation.

- **Inhalation toxicology :** This field deals with the toxic manifestations of inhalable toxins, i.e. toxins which exert their mechanism of action by absorption through the respiratory epithelium. Such toxicants are predominantly quite smaller in size and include metal dust, aerosols, and other micro-molecules which can easily diffuse via the alveolar sacs into systemic circulation. This procedure is mainly used in the evaluation of toxicity of gaseous components like industrial air pollutants and is also used in the assessment of various aerosols and oils which are used therapeutically for treatment of lung disorders.

Toxicity may be acute or chronic, and may vary from one organ to another as well as with age, genetics, gender, diet, physiological condition, or the health status of the organism. As opposed to experimental animals, which are highly inbred, genetic variation is a most important factor in human toxicity since the human population is highly out bred and shows extensive genetic variation. Even the simplest measure of toxicity, the LD_{50} (the dose required to kill 50% of a population under stated conditions) is highly dependent on the extent to which the above variables are controlled. LD_{50} values, as a result, vary markedly from one laboratory to another.

Consequences of toxicity include the following parameters :

- Whether damage is reversible or irreversible often depends upon the repair and regenerative ability of the target tissue. It also depends on the nutritional status of the affected subject.
- Exposure to neurotoxins may reduce the age at which neurologic and behavioural deficits appear. This occurs by the rapid induction of formation of lesions which normally occurs at a much slower rate during the process of ageing.
- Allergic reactions may develop to nearly all drugs. Can proceed to systemic anaphylaxis if not monitored or treated appropriately.

However, in spite of all these concerns, the human body (especially the liver) is highly capable of elimination of these "unusual metabolites" or xenobiotics via integrated detoxification pathways. The liver as the organ of detoxification has the following vital roles in the process of detoxification, like :

- Filtration of blood to selectively imbibe toxins within itself and thus prevent them from entering the circulatory system.
- Solubilization of hydrophobic toxins into bile.
- Enzymatic disintegration of unwanted metabolites.

The detoxification pathway initiated by the liver can be precisely divided into three distinct steps :

Phase 1 : This is the first enzymatic defense against any foreign chemical. In this pathway toxins are converted into a more reactive form by certain redox reactions mediated by integral cytochrome p450 class of enzymes. This renders the toxin more susceptible to biodegradation via Phase 2 mechanisms. The activity of the p450 enzymes depends upon the genetic profile of the individual and their efficacy generally decreases as a consequence of ageing. About 1-20 molecules of the toxin are detoxified per second by these enzymes. There is a formation of abundant free radicals in this pathway, thus many antioxidative coenzymes like NADH, FADH, Biotin and cofactors like Vitamins A, C, E, are utilized.

Phase 2 : This is the conjugation pathway in which the "activated" (more reactive form) of the toxin produced in phase 1 is conjugated with moieties like Glutathione, Glucouronic acid, and Acetyl CoA, various amino acids, etc; so as to make the toxin greatly hydrophilic. This renders it most suitable for excretion via urine or bile.

Phase 3 : In which the soluble, harmless intermediate of the toxin is actively transported outside cells *via* ABC (ATP Binding Casette) transporters, which are specialized channels involved in detoxification mechanisms at the cellular level. This mechanism provides a barrier against xenobiotic entry. The passive diffusion of xenobiotics through the cell membrane may result in the destruction of membrane integrity as this diffusion would be a thermodynamically unfavorable pathway.

Thorough biochemical understanding of the detoxification pathway of the liver gives rise to an easier approach to clinical detoxification, whereby the body's natural mechanisms are strengthened rather than the usage of synthetic extrinsic pharmacological substances solely for the detoxification procedures.

Symptoms of adverse toxicity include the following observations :

- Breath has a characteristic odour (arsenic poisoning-garlic odour).
- Dilation and increased photosensitivity of pupils.
- Hair loss.
- Convulsions.
- Coma.
- Change in skin colour (observed in CO and nitrite poisoning).
- Change in skin texture (hyperkeratosis, blisters, etc.).

POISON CONTROL CENTRES

A poison control centre is a medical facility that is able to provide immediate, free, and expert treatment advice and assistance over the telephone in case of exposure to poisonous or hazardous substances. Poison control centres answer questions about potential poisons in addition to providing treatment management advice about household-products, medicines, pesticides, plants, bites and stings, food-poisoning, and fumes. More than 72% of poison exposure cases are managed simply by phone, greatly reducing the need for costly emergency room and doctor visits.

In India, to provide information on management of various poisonings and treatment protocols all over the country, a National Poisons Information Centre has been set up in the Department of Pharmacology at AIIMS, New Delhi which provides round-the-clock, 7 days-a-week, 365 days service on telephone. The centre can be reached at the following numbers : Tel. No. : 26589391, 26593677, Fax: 26850691, 26862663.

Adverse toxicity is treated by the following measures after complete characterization of the lethal effects. These strategies aim at completely eliminating or reducing the severity of the adverse effects caused due to overexposure of the toxicant. The measures include :

- Identification and removal of the source of the toxin.
- Usage of certain agents or methods which inhibit/minimize the absorption of the toxin (e.g. gastric lavage using activated carbon as a decontaminating agent).
- Biotransformation of the toxin by using methods/ agents which may increase biliary or urinary excretion of the toxin; like increasing the pH of urine by administration of sodium carbonate to ensure thorough excretion of acidic toxins.
- Supportive therapy (like increasing ventilation which is significant in CO poisoning).
- Using specific therapeutic agents (e.g. antivenins like Polyvalent snake antivenom against the venom of viper species of snakes, chelators like EDTA that form insoluble complexes which can be rapidly excreted)

CONCLUSION

The study of toxicology thus serves society in many ways, not only to protect humans and the environment from the deleterious effects of toxicants but also to facilitate the development of more selective toxicants such as anticancer and other clinical drugs and pesticides. It must be noted that toxicity is a quantitative concept, almost any substance being harmful at some doses but, at the same time, being without harmful effect at some lower dose. Between these two limits there is a range of possible effects, from subtle long-term chronic toxicity to immediate lethality. Toxicology thus aids us in the critical understanding of dose-response relationships, which is fundamental for the development of newer and safer detoxification strategies.

REFERENCES

1. http://www.swissmedic.ch
2. Toxins and Poisons-Mechanisms of Action: Prof. MU Dr. Sixtus Hynie, DrSc.
3. http://www.lef.org/protocols
4. Principles of Environmental Toxicology: Gregory Möller, Ph.D., University of Idaho.
5. http://pmep.cce.cornell.edu
6. www.atsdr.cdc.gov
7. www.Tuberose.com

HEALTHCARE SETTINGS : EPICENTER OF NOSOCOMIAL INFECTIONS

Pranay Jain and Priyanka Sharma*

Nosocomial infections or hospital acquired infections are endogenous or exogenous infections which a patient acquires either during hospitalization or soon after discharge from the hospital. Hospitals and hospital-like settings tend to gather many sick under one roof and hence, serve as a reservoir of numerous infectious agents. These overcrowded healthcare settings with inability to maintain hygienic conditions are threat not only to the patients but also to the healthcare workers. Increasing population of immune-compromised patients including the aged-ones, unsafe medical care, surgical procedure, injections, transplants are some of the major causes of spread of nosocomial infections. Nosocomial infections have severe adverse effects. It leads to emotional stress, functional disability and even death in certain cases. Mortality caused by nosocomial infections in India is more than any other form of accidental death. It also prolongs the hospital stays and adds to the economic burden of managing the underlying disease. The active cooperation of the Healthcare workers for better implementation of the existing preventive and control measures along with the technical advances will contribute much to fight against the nosocomial infections.

The overcrowding of the healthcare settings with the patients and the inability to maintain hygienic conditions contributes much to the spread of nosocomial infections. Prevalence of such conditions has made healthcare settings an epicenter of the infectious agents. As a result, patients undergoing a treatment of any particular ailment develop a secondary infection which at times is more serious than the existing ailment. Increasing population of immunocompromised patients including the aged-ones, aggressive medical interventions including antimicrobial treatments and surgical procedures, rising population of antimicrobial resistant strains due to selective pressures and changing environmental conditions are the major factors contributing to the spread of nosocomial infections.

* Deptt. of Biotechnology, UIET, Kurukshetra University, Kurukshetra, India, E-mail: drpranayjain@gmail.com

1.0. DEFINITION : NOSOCOMIAL INFECTIONS

If a patient either during hospitalization or after discharge from the hospital develops an endogenous or exogenous infection which was neither present nor incubating at the time of admission to the hospital. Such an infection is known as nosocomial infection (NI) or hospital acquired infection (HAI)[1].

Nosocomial infections can be caused by the endogenous microflora of one's own body, can be acquired from contact with the hospital staff or from the other patients in the hospital.

Shorter stay of the patients in the healthcare units prevents the early detection of this infection. Also, it becomes difficult to diagnose whether the infection source was endogenous or exogenous. The average postoperative stay nowadays is 5 days which is shorter than the 5-to 7-days incubation period for *S. aureus* surgical wound infections[3]. The symptoms of the infection become visible only after the patients are discharged[1].

2.0. FREQUENCY OF NOSOCOMIAL INFECTIONS

There has been a global increase in nosocomial infections in the healthcare settings and these infections have contributed much in increasing the morbidity and mortality rates[1]. Also they prolong the hospital stays and add to the economic burden of managing the underlying disease.

It is estimated that 5-10 per cent of all the hospitalized patients develop hospital acquired infections ,i.e., of every 100 hospitalized patients at any given time, 5-7 in developed and 10 in developing countries will acquire at least one nosocomial infections[6].

On the basis of monthly reports (more than 270 institutions report) of hospital acquired infections from a non random sample of US hospitals which was received by CDC's National nosocomial infections surveillance (NNIS) system, it was concluded that the rate of nosocomial infections increased by 36% from 7.2 in 1975 to 9.8 in 1995 due to progressively shorter inpatient stays[1]. The estimated nosocomial rate in USA was 4.5% in 2002, corresponding to 9.3 infections per 1000 patient-days.

The rate of nosocomial infections is as low as 1 per cent in developed countries like Europe and America whereas in parts of Asia, Latin America and Sub-Saharan Africa the rate of nosocomial infections is more than 40 per cent[9]. In India, Nosocomial infection rate is at over 25 per cent which means nosocomial infection develops in 1 patient in every 4 patients admitted to the hospital. Tikhomirov, 1987 highlighted the severity of nosocomial infections by concluding that over 1.4 million patients all over the world will have nosocomial or hospital acquired infections at any particular time[11].

According to a study conducted in a tertiary teaching hospital in Goa[12], out of 498 patients followed, 103 people developed 169 nosocomial infections. 26.63% suffered from Urinary tract infection, which was found to be the most common nosocomial infection, followed by surgical site infection (23.67%), wound infection (23%) and nosocomial pneumonia (18.34%). Nosocomial phlebitis and septicemia, respectively, accounted for 4.73% and 3.55% of the total Nosocomial Infections[8].

Nosocomial infections are often associated with some or the other invasive support measures like central intravenous lines (CVL), urinary tract catheters and mechanical ventilators. Records have shown that ninety one percent of blood infections were in patients with central intravenous lines (CVL), ninety five percent of pneumonia cases developed in patients undergoing mechanical ventilation, and seventy seven percent of urinary tract infections were in patients with urinary tract catheters[4].

Reintubation, genetic syndromes, immuno-deficiency, and immunosuppression in pediatric patients are some of the factors that contribute to the development of ventilator-associated pneumonia (VAP)[4].

In pediatric patients, the risk factors contributing to development of nosocomial urinary tract infections include bladder catheterization, prior antibiotic therapy and cerebral palsy[4].

Catheter hub colonization, exit site colonization, catheter insertion after one week of life, disruption of catheter dressing and extremely low birth weight (less than 1000 g) at the time of catheter insertion increases the risk of catheter-associated bloodstream infections in newborn child[4].

3.0. EPIDEMIOLOGY OF NOSOCOMIAL INFECTIONS

Nosocomial infections are most commonly caused by viral, bacterial, and fungal pathogens. While majority (nearly 60%) of nosocomial infections are caused by aerobic gram-negative bacilli only 30 per cent of nosocomial infections are caused by gram positive bacteria and anaerobes account for only 3 per cent of nosocomial infections. The remaining 7 per cent of the nosocomial infections are caused by either fungi or viruses. Group A *Streptococci* was the major nosocomial pathogen in Semmelweis's era. For the next half a century, gram-positive cocci were major nosocomial pathogens, particularly *Streptococci* and *Staphylococcus aureus*. The pandemic of 1940s to 1950s, when *S. aureus* phage type 94/96 was prime causative agent of most of the hospital acquired infections was the peak point of gram-positive cocci infections. It is the time when the penicillin-resistant *Staphylococci* emerged as the major nosocomial infection agents. Thereafter came the period of 1970s, where gram-negative bacilli, particularly *Pseudomonas aeruginosa* and *Enterobacteriaceae* were the chief causative agent of all the nosocomial infections[3, 6].

The source of the microorganisms causing nosocomial infection can be both endogenous and exogenous. Endogenous flora refers to the microflora of the patients own body whereas exogenous microflora can come from invasive devices[1].

Although the microorganisms causing the nosocomial infections are continuously evolving but the predominant sites of nosocomial infections have not change. The anatomic site of infection specifies the microorganism causing nosocomial infection[2].

In NNIS data analysis (2003), it was found that gram-negative bacilli were associated with majority of ICU infections along with 71 per cent of the total urinary tract infections, 65 per cent of the pneumonia and 24 per cent of the bloodstream infections[2].

A study was conducted in 12 intensive care units (in seven hospitals) of seven Indian cities by the International Nosocomial Infection Control Consortium, which observed 10,835 patients hospitalized for a total of 52,518 days for nosocomial infection. The observed patients acquired 476 infections in the hospital of which 46 per cent were *Enterobacteriaceae*, 27 per cent *Pseudomonas* and 3 per cent of *S. aureus* and 8 per cent *candida* spp.[8].

In 2001, A six month study conducted in the intensive care units of AIIMS Delhi found that 140 of 1,253 patients (11%) had 152 hospital acquired infections, 21 per cent of the infections were caused by *P. aeruginosa*, 23 per cent *S. aureus*, 16 per cent *Klebsiella*, 15 per cent *Acinetobacter baumannii* and 8 per cent infection were *E. coli* borne. The majority of the total isolates (71%) were gram-negative bacteria. Another similar study conducted on burn patients at Post Graduate Institute of Medical Education and Research (PGIMER) in Chandigarh revealed that up to 59 burn patients out of 71 (83%) had hospital acquired infections. When the pathogens were isolated from wounds and blood, 35 per cent of the pathogens were *S. aureaus*, 24 per cent *P. aeruginosa*, and 16 per cent were Beta-haemolytic *Streptococci*[8].

A survey done on 110,709 pediatric ICU patients reported nosocomial infection in 6,290 patients. Nosocomial infections of bloodstream, pneumonia and urinary tract were the three major types of nosocomial infection that were recorded. Each of these infections is associated with use of invasive devices. Twenty eight percent of the infections were bloodstream infections caused by primarily by coagulase-negative *Staphylococcus* (38%), *Enterococcus* (11%), and *S. aureus* (9%). Twenty one percent of the patients developed pneumonia. *P. aeruginosa* (22%), *S. aureus* (17%), and *Haemophilus influenza* (13%) were the three major causative agents of hospital acquired pneumonia. Fifteen percent of the patients developed urinary tract infection which was caused by gram-negative enteric organisms for about fifty percent of all urinary tract infections. There were three main pathogens which were found associated with the urinary tract nosocomial infections and these were *Escherichia coli*, *C. albicans* (14%), and *P. aeruginosa* (13%)[1] (Table-1).

Table–1 : Types of nosocomial infections[2]

Common types of nosocomial infections	Commonly associated nosocomial microorganisms	Treatment related factors contributing to infection
Urinary tract infection	Gram-negative pathogens, *Escherichia coli, Proteus mirabilis, Klebsiella* spp., and *P. aeruginosa, Enterobacter* and *Enterococci* (gram-positive). *Candida* spp.	Use of catheter to measure output Disconnection of catheter from drainage tube Duration of catheterization; insertion of catheter late in hospital stay Retrograde flow of urine from drainage bag
Surgical site infections	*S. aureus*, coagulase-negative *Staphylococci, Enterococcus* spp., *Enterobacter* spp., *P. aeruginosa, Escherichia coli*	Foreign material (including drains and sutures) Skin antisepsis Duration of operation Intraoperative contamination Duration of preoperative hospital stay Hypothermia during operation Duration of surgical scrub Antimicrobial prophylaxis Preoperative preparation(wash/shave) Surgical technique Reintubation
Ventilator-associated pneumonia	*P. aeruginosa, S. aureus, Haemophilus influenza*	Supine head position Aspiration of gastric contents Nasogastric tube Use of paralytic agents Duration of mechanical ventilation
Intravascular device-related bloodstream infections	Coagulase-negative *Staphylococci, Enterococcus, S. aureus.* *Candida albicans*	Heavy colonization on skin at site of insertion Location in internal jugular or femoral vein Length of time in place Contamination of catheter hub Type of infusate Total parenteral nutrition Location of insertion
Gastrointestinal tract infections	*Clostridium difficile*, Rotavirus.	Antibiotic use Nasogastric intubation

3.1. NOSOCOMIAL INFECTIONS AS OPPORTUNISTIC INFECTION

Opportunistic infections are those infections which infect the person with weak immune system or immunocompromised patients. These are secondary infections which attack the body when its immune system is already busy fighting other chronic illness or when the immune system is compromised due to malnutrition, fatigue, HIV infection, chemotherapy, skin damage, antibiotic treatment or some immunosuppressing agents like corticoids, etc. and hence is vulnerable to attack by infectious agents.

In last twenty years, the infections of opportunistic fungi have emerged as a cause of death and poor health in many patients. Earlier, majority of the opportunistic fungal mycoses was caused by *Aspergillus* spp. and *Candida* spp. But during the past decade, infections by some of the uncommon opportunistic fungal microorganisms have also been reported which includes *Trichosporon* (yeast), *Fusarium* spp. (filamentous fungi), *Penicillium mameffei* (endemic dimorphic fungi), zygomycetes and a variety of dematiaceous moulds[5].

4.0. CAUSES OF SPREAD OF NOSOCOMIAL INFECTIONS

Unsafe medical care is the prime cause of spread of nosocomial infections, specially, in underdeveloped and developing countries[1]. Recently, strong evidences suggesting the unsafe healthcare facilities to be an important factor in transmitting HIV have been found[7].The reason for the widespread of nosocomial infections are as follows :

- Crowding of patients in a hospital or healthcare setting increase the chances of spreading an infection[7].
- The risk of nosocomial infection increases with age and illness as they decrease the immune strength[7].
- An invasive treatment may pave a way for the entry of the infectious agents inside the body[7]. The increasing use of invasive devices like mechanical ventilators, urinary catheters and central intravenous lines is the key factor contributing to the spread of nosocomial infections specially if used without proper training or laboratory support[1].
- Rapidly increasing antibiotic resistance among the microorganisms has increased the difficulty of healthcare workers to combat the deadly infection[7]. Up to 60 per cent of hospital infections are caused by drug-resistant microbes and in 35 to 40 per cent of the infections the microorganism is resistant to the best drug commonly used to treat that infection. The excessive use of broad spectrum antibiotics has led to the development of antibiotic resistance among the microorganisms[1]. Vancomycin-resistant *Enterococci* (VRE) and methicillin-resistant *S. aureus* (MRSA) are the major gram-positive nosocomial micro-organisms and *P. aeruginosa*, *Klebsiella*, and *Enterobacter* that harbor chromosomal or plasmid-mediated beta-lactamase enzymes are major gram-negative antimicrobial resistant pathogens of concern[3].

  The development of resistance to antibiotic acyclovir and ganciclovir in Herpes virus is major threat to immunocompromised patients, particularly HIV-infected patients[3]. The WHO report on infectious diseases states that due to emerging co-infection with HIV, the cases of visceral leishmaniasis are increasing at an alarming rate in countries like India and Sudan and in certain parts of India, over 60 per cent of visceral leishmaniasis cases no longer respond to the first- line drug[1].

  Candida spp. with intrinsic resistance to azole antifungal agents (e.g., *C. krusei*) and to amphotericin B (e.g., *C. lusitaniae*) has emerged as grave concern in oncology units[3].
- The frequent use of unnecessary injections (eg., routine injections of vitamins like vitamin B-12 or an antibiotic such as carbapenems) should be avoided. In the developing countries more than 50 per cent of the needles, syringes or both are reused i.e. are unsafe[10]. As a consequence nearly 80,000 to 160,000 new HIV infections occur annually in Sub-Saharan Africa. Much more cases of HBV and HCV occur annually because of unsafe injections[9].
- The emergences of new pathogenic agents have further aggravated the existing problems[1].

- Besides the above mentioned causes of nosocomial infection spread, poor infection prevention practices, improper use of limited resources and lack of supervision are major causes of nosocomial infections in developing countries[1].

5.0. EFFECTS OF NOSOCOMIAL INFECTIONS

The effects of nosocomial infections can be very severe. They can lead to emotional stress, functional disability and even death in certain cases. Mortality caused by nosocomial infections in India is more than any other form of accidental death. It is one of the five major cause of death of infants in India and the maternal mortality rate is as high as 450 deaths per 1, 00,000 live births with wide regional disparities[1, 7].

Nosocomial infection prolongs the hospital stays and hence increases the expense of the treatment. The worst part is that the nosocomial infections have affected those countries the most which have limited healthcare facility, limited resources and least capability to afford the expensive medication[1].

6.0. TYPES (OR SITES) OF NOSOCOMIAL INFECTIONS

Surgical site infections, urinary tract infections and lower respiratory (pneumonia) infections are the most frequent types of nosocomial infections occurring in developing countries[1] whereas in developed countries the sequence is somewhat different. The nosocomial infections of urinary tract and respiratory tract are more prevalent in US as compared to the surgical site infections[9].

As much as 80 per cent of all the nosocomial infections are urinary tract infections, surgical site infections, pneumonia or bacteraemia. Rest of the 20 per cent of the nosocomial infections are gastrointestinal tract, bone, joints, severe burns, eyes and genital tract infections[6].

6.1. URINARY TRACT INFECTION

The rate of urinary tract nosocomial infection accounts for 35 per cent of all the nosocomial infections but costs the least in terms of economics, mortality and morbidity. Its occurrence is very high in the patients who have an indwelling catheter or have had a kidney transplant. A catheter is associated with nearly 80 per cent of all the hospital acquired urinary tract infections[2].

6.2. SURGICAL SITE INFECTION

Surgical site infections accounts 40 per cent of all the hospital acquired infections. They prolong the hospital stay, have expensive treatment and have higher rates of morbidity and mortality[2].

6.3. VENTILATOR-ASSOCIATED PNEUMONIA

Ventilator-associated pneumonia is defined as the pneumonia that develops within 48 hrs of tracheal intubation. It accounts for 15 to 20 per cent of all the nosocomial infections but costs highest in terms of economics, mortality and morbidity. Those patients who are critically ill or those who are receiving continuous mechanical ventilation have a high risk of getting infected with ventilator associated pneumonia. Approximately 9 to 27 per cent of the intubated patients develop ventilator-associated pneumonia and nearly 25 to 60 per cent of these are not able to survive[2].

6.4. INTRAVASCULAR DEVICE-RELATED BLOODSTREAM INFECTIONS

Intravascular device-related bloodstream infections account for approximately 15 per cent of all nosocomial infections. Although bloodstream infections such as septicemia and bacteremia can develop from the infection at other types of infections on some other site in the body but nearly half of them are caused by central venous catheters[2].

6.5. GASTROINTESTINAL TRACT INFECTIONS

Rotavirus infection is the major threat to the children especially, younger than three years. It causes acute gastroenteritis in hospitalized children. *Clostridium difficile* is the most important bacterial cause of nosocomial infections in gastrointestinal tract and is often suspected in the patients with diarrhea and recent medical history of antibiotic use (especially, Cephalosporin and Clindamycin)[4].

7.0. VICTIMS OF NOSOCOMIAL INFECTION

The susceptibility to nosocomial infections varies from person to person. Aged patients are more susceptible to nosocomial infections because of low nutritional status, decreased immunity and underlying diseased condition[1, 3]. As a result, as much as three times higher infection rates are observed in the patients of intensive care units (I.C.U.) as compared to elsewhere in the hospitals[3]. On the other hand, young with a healthy lifestyle and good health have a stronger immune system and hence, are less susceptible to nosocomial infections.

The risk of nosocomial infection can be classified as follows depending upon the age, general health and the type of treatment being carried out on the patient :

Minimal risk-is assigned to those patients with a strong immune system and not undergoing an invasive procedure.

Medium risk-is assigned to older patients and those undergoing an invasive procedure such as surgeries and transplantations or implantation of invasive medical devices such as mechanical ventilators, urinary catheters and central intravenous lines.

High risk-individuals undergoing surgical invasive procedures such as organ transplantation and the immunocompromised people such as HIV patients are under high risk of infections. ICU patients, cancer patients and patients with multiple trauma or severe burns are also assigned high risk factor[1, 3].

8.0. PREVENTION AND CONTROL OF NOSOCOMIAL INFECTIONS

In 1840s, Ignaz Semmelweis emphasized on controlling the infection transmissions in hospitals by stating the importance of hand washing by healthcare workers between the patients[3]. Scheckler *et al*., 1998 had stated that approximately one third of the nosocomial infections are preventable. In 1985, a study on the efficacy of nosocomial infection control conducted by the centers for disease control and prevention's (CDC's) showed that the rate of nosocomial infections reduced by one third by the following four infection control components:

- An effective hospital epidemiologist,
- One infection control practitioner for every 250 beds,
- Active surveillance mechanisms, and
- Ongoing control efforts.

The various measures to prevent nosocomial infections are as follows:

Improved national surveillance: It is mandatory to develop efficient surveillance systems for surveillance of nosocomial infections that occur in inpatient as well as outpatient facilities where much healthcare is now given[3]. Surveillances target those infections which are difficult to treat and are expensive in terms of mortality, morbidity and economics[2].

Improved epidemiologic tools: Aseptic techniques and hand washing are the foremost preventive measures. Weinstein RA. in 1991stated that in ICUs, Asepsis is often ignored in the rush of crisis care. Pulsed-field gel electrophoresis has become an important tool in investigating the multi-drug resistant pathogens[3].

Risk adjustment: Robert A. Weinstein, 1998 has emphasized on the need to "risk adjust" infection rates so that inter-hospital comparisons are valid. The development of noninvasive infection resistant devices and implementation of the existing infection control measures help in preventing and controlling the nosocomial infections[3].

Improved invasive devices: Most of our successes in controlling nosocomial infections rely on the development of non invasive monitoring devices or improved invasive devices or minimally invasive surgical tools[3].

Antibiotic control: Microorganisms are increasingly becoming resistant to the antibiotics and therefore, depleting the antimicrobials available for their treatment. Judicial use of the available antibiotics and proper implementation of the infection preventive measures can be the effective measures to limit the antimicrobial resistance among the pathogens. Aggressive antibiotic control programs are mandatory to combat nosocomial infections[3]. Combination therapy in antimicrobial use is recommended in most of the surveys[6].

Development in therapeutics: Physicians should give necessary value to the results of microbiology laboratories. Development of new diagnostic techniques should be encouraged and all the healthcare settings, whether small or large ones should have the required facilities to conduct a range of diagnostic tests. Also, the essential vaccination programs should be efficiently implemented. According to a current schedule, one-third of world's unimmunized children are in India and not even half of the all the Indian children are fully immunized. Vaccination against the vaccine-preventable diseases would promote the health and reduce the mortality and morbidity rates. It will prevent the spread of epidemics, reduce the expenses on healthcare, save on the use of antibiotics and also prevent the spread of antibiotic resistance among microorganisms[8].

Occupational safety : Care should be taken when using needles, scalpels and handling sharp instruments after procedures. Also the disposal of these instruments should be carefully done to avoid infection by any blood borne pathogen. Puncture-resistant bags must be used for placing sharp articles to be disposed or to be transported to the reprocessing area for sterilization before reuse. The use of mouthpieces and resuscitation bags or other ventilation devices is recommended over mouth-to-mouth resuscitation[2].

Apart from these, personnel education programs, environmental control, patient isolation, hand-washing guidelines, wearing gloves, gowns, mask, eye protection and face shields are some of the standard preventive measures[2].

9.0. CONCLUSION

Healthcare settings are the reservoir of numerous infectious agents because of the presence of many patients with different infectious agents under one roof. These are threat not only to the patients but also to the healthcare workers. A healthy human body has its own ways and means to protect itself against the invading microorganisms. It offers physical and chemical barriers to the infection causing microorganisms. But the surgical procedures pave a way for the easy entry of infectious agents into the body. Therefore, immunization, maintenance of proper hygienic conditions, sterilization of soiled equipments and other articles, increased national surveillances and development of non invasive procedures are some of the measures to prevent the nosocomial infections. The active cooperation of the Healthcare workers for better implementation of the existing preventive and control measures along with the technical advances will contribute much to fight against the nosocomial infections.

REFERENCES

1. World Health Organization, Removing Obstacles to Healthy Development, 1999, 1-68, World Health Organization, Geneva, Switzerland.
2. Lori L. Alexander, CME Resource, 2007.
3. Robert A. Weinstein, *Emerg Infect Dis*, **4**, 1998.
4. Ayesha Mirza, http://emedicine.medscape.com/article/967022-clinical#a0216.
5. A.H. Groll and T.J. Walsh, *Clin Microbiol Infec*, **7** (Supplement 2), 8-24, 2001.
6. Eugenie Bergogne-B£rezin, Dominique Deere and Marie-Laure Joly-Guillou, *J Antimicrob Chemoth*, **32**, Suppl. A, 39-47, 1993.
7. G. Ducel, J. Fabry, L. Nicolle, Prevention of hospital-acquired infections, World Health Organization, A Practical Guide, 2002, 2nd ed., 30-62, WHO Press, Malta.
8. Nirmal K. Ganguly, N.K. Arora, Sujith J. Chandy, Mohamed N. Fairoze, J.P.S. Gill, Guru A. Dev, Usha Gupta, Shah Hossain, Sadhna Joglekar, P.C. Joshi, Manish Kakkar, Anita Kotwani, Ashok Rattan, H. Sudarshan, Kurien Thomas, Chand Wattal, Alice Easton, Ramanan Laxminarayan, *Indian J Med Res*, **134**, 281-294, 2011.
9. JC Saha, *Faridpur Med. Coll. J.*, **5**(1), 1-2, 2010.
10. Simonsen, Bulletin of the World Health Organization **77**(10), 789–800, 1999.
11. Eugene Tikhomirov, *Chemiotherapia* **6**(3), 148–151, 1987.
12. US Kamat, AMA Ferreira, R Savio, DD Motghare, *Indian J. Community Med*, **33**, 89-92, 2008

THE AGING PROCESS : ACCELERATORS AND DECELERATORS

Nivedita Acharjee

The aging process needs no formal introduction. It is characterized by the impaired sensory system, slowed nerve transmission and adverse changes in the skeletal, digestive, respiratory, renal, reproductive, circulatory and immune systems. Psychological, social and stress issues are also considerable in the aging process. In the modern lifestyle, we all are suffering from premature aging problems and age-related disorders and always search for easy solutions of the aging phenomena. The present day markets are flooded with anti-aging treatments which induce irreparable side-effects in several instances. Food habits responsible for premature aging have been initially discussed in the present report and the remarkable age fighting properties of some natural foods have been pointed out.

WHAT IS AGING ?

Aging is a highly individualized phenomenon which can be classified chronologically (number of years lived), physiologically (age by body function) and functionally (ability of social contribution). There are two types of aging; intrinsic aging—age-related changes are dictated by the genetic makeup—and extrinsic aging, due to lifestyle and environmental factors. Nobel Laureate Dr. Linus Pauling started taking high doses of vitamin C in 1965 and died in 1994 at the age of 93. Dr. Pauling believed that his death was delayed due to vitamin C intake and explained that people can have extra 12-18 years of life by taking 3200 to 12000 mg of Vitamin C per day. Humans are one of the few animals that cannot produce vitamin C and must get it from external source. The increased demands of aging require regular intake of vitamin C since it is water soluble and quickly excreted by kidneys.

Some natural foods have the inherent ability to counteract the aging phenomena to a great extent[1]. Most people don't understand the importance of optimizing their insulin levels, as insulin is the major accelerant of aging. This one crucial step, combined with nutritional typing and the inclusion of nature's anti-aging miracle foods in diet, can dramatically improve our health and longevity. In order to delay aging, in addition to paying attention to the maintenance of skin, we must also pay attention to our daily diet. Then, what kinds of food have such an effect? The present report aims to focus the causes of premature aging and summarize the scientifically proven anti aging benefits of some easily available fruits, vegetables, spices and other ingredients.

It is also important to know in this context that anything discussed in this article might be the healthiest food in the world, but if your body gives an allergic signal to avoid it, it is typically best to honor the body's wisdom.

Let us initially get a very brief introduction to the physical theories of aging:

1. **Program theory** : Cells replicate for a specific number of times and then die.
2. **Error theory** : DNA structure alteration with age leads to transcription and translation malfunction and hence leads to aging.

* Department of Chemistry, Jalpaiguri Government Engineering College, Jalpaiguri-735102,
E-mail : nivedita_acharjee@rediffmail.com

3. **Cellular theory** : Cells function improperly due to normal wear and tear.
4. **Free-radical theory** : Lipids in cell membranes are exposed to radiation or free radicals which rupture the membrane and the cell dies.
5. **Nutritional model theory** : 50-60% less feeding of animals than it eats by own leads to longer life expectancy. Lean mass results in better health.
6. **Collagen theory**: Aging of collagen causes hypertension and organ malfunctions.
7. **Mutating auto-immune theory** : As cells age, mutations and secretions are viewed as foreign particles by the body. This solicits immune response, shuts cell down and the entire organ malfunctions.
8. **Neuro-aging theory** : Nervous system degenerates resulting in the hormone release changes which decline the cell function.

Scientists believe that the combination of several theories leads to the aging process and none of these theories have been universally accepted.

THE TWO MAIN AGE ACCELERANTS

1. Sweets, junk and processed foods : The biggest offender present in junk food is the trans fat which enhances inflammation and ages us from inside out by nibbling away our telomeres. Telomeres are the caps which protect our chromosomes. Every time a chromosome divides, its telomere shortens. Shorter is the telomere, less efficient the chromosome and we lose our ability to regenerate the organs. Telomere length is the measure of how well our body is aging. Trans fats also add years to our age due to their odd molecular shape which begins to change cell-to cell signaling and membrane fluidity. In 1985, scientists discovered telomerase[2]. This enzyme extends telomeres, rebuilding them to their former lengths. In most of our cells, the enzyme is turned off before we're born and stays inactive throughout our lives. Using genetic engineering, scientists reactivated the enzyme in human cells grown in the laboratory. Could reactivating telomerase in our cells extend the human lifespan? Unfortunately, the exact opposite—an untimely death from cancer—could occur. If telomerase is present in sufficient amounts, it permits cells to keep multiplying. Many labs have shown that the apparent increase in telomerase is a common feature of human tumor cells e.g. promotion of mammary carcinomas in aging mice[3], increased epidermal tumors in mice etc[4]. Magalhães *et al*[5] reviewed several arguments both in favor and against the use of telomerase as an anti-ageing therapy. Telomerase has the property to immortalize human cells which suggests that telomerase can be used as an anti-ageing therapy. However, the authors have raised doubts since results from human cells expressing telomerase have also suggested that telomerase may promote tumorigenesis. Though telomerase may be used in regenerative medicine and to treat specific diseases, it is unlikely to become a source of anti-ageing therapies.

Sugar, trans fats and starches cause insulin to surge and trigger an inflammatory response leading to wrinkles before time and speed up the aging process. This also affects brain chemicals and lead to mood swings and depression. The high fat content in junk food requires high amount of blood and enzymes for digestion. Consequently, major portion of blood in the body is diverted to the intestine and the person feels drowsy and suffers from reduced concentration to respond. Junk food contains excessive amount of low-density lipoproteins and cholesterol that get deposited on the inner linings of blood vessels. This leads to formation of plaques and the heart is required to put extra effort for pumping blood through the arteries leading to heart diseases and atherosclerosis. Excess sugar in blood causes trouble by an age- accelerating process called glycosylation and the skin loses its natural repair mechanism, explains Shawn Talbott, a nutritional biochemist and author of "The Metabolic

Method" (Current Book 2008). This makes the skin elastic and wrinkle faster. Easy processed foods and snacks contain monosodium glutamate (MSG) and sodas contain aspartame. Aspartame is a neuron excitoxin which excites brain cells to death and imparts many neurological side effects. Artificial fruit juices are not low calorie foods as advertized; rather they are artificially sweetened by high fructose corn syrup (HFCS) which are not rapidly metabolized into energy like glucose. HFCS gets trapped in the liver, leading to fatty liver, Type II diabetes or cancer. Recently researchers[6] have published online in Federation of American Societies for Experimental Biology (FASEB) journal by a mice study in 2010 that sodas and processed foods have high levels of phosphates which accelerate signs of aging. This may also increase age-related complications like chronic kidney disease, cardiovascular calcification and severe muscle and skin atrophy.

2. UV rays : UV wavelengths are classified as UVA, UVB, or UVC, with UVA the longest of the three at 320-400 nanometers (nm, or billionths of a meter). UVB ranges from 290 to 320 nm. Most UVC is absorbed by the ozone layer and does not reach the earth. Both UVA and UVB, however, penetrate the atmosphere and play an important role in conditions such as premature skin aging, eye damage (including cataracts), and skin cancers. The signs include dryness, wrinkles, loss of elasticity and sagging. UVA radiation is the major contributor since there is more UVA radiation reaching the earth's surface. Sunburn (or erythema) is redness of skin, which is due to increased blood flow in the skin caused by dialation of the superficial blood vessels in the dermis as a result of UV exposure. Tanning takes place due to increase in the number of pigment cells which enhance the activity of an enzyme tyrosinase, then, new melanin is formed and the number of melanin granules increases throughout the epidermis.UVB is 1000 to 10000 times more efficient than UVA in terms of sunburn induction and skin cancer respectively.

NATURAL FOODS AS AGE DECELERATORS

ANTI AGING FRUITS

Normally, an oxygen molecule (O_2) absorbs four electrons and is eventually safely converted into water. But if an oxygen molecule only takes up one or two electrons, the result is one of a group of highly unstable molecules called reactive oxygen species (ROS) that can damage many kinds of biological molecules by stealing their electrons. Cell damaging free radicals are the main culprits for illnesses and development of visual signs of aging (e.g. appearance of fine lines, age spots, wrinkles and dryness of the skin). The major anti aging benefits of different fruits have been listed in Table 1.

Table 1: Anti Aging benefits of fruits

Fruit	Anti Aging Benefit	Supportive Research studies (R)
Grapes	Dark skinned *grapes* contain a natural anti-pathogenic compound resveratrol (R1). A recent review examined the human studies which have explored the physiological benefits of resveratrol. Grapes contain lots of fiber, vitamins (especially Vit. E), minerals, essential fatty acids and antioxidants. Grapes have anti inflammation, cancer prevention (R3), blood sugar control, blood pressure and cholesterol reduction properties (R4). The regenerative property of grapes moisturizes the skin and helps to maintain the elasticity of the skin.	R1 : L. Camont, *et. al.*, *Analytica Chimica Acta*, **634**, 121–128, 2009. R2 : J. M. Smoliga, *et. al.*, *Mol. nutr. Food. Res*, **55**, 1129–1141, 2011. R3 : K. J. Jung, *et. al.*, *Cancer Letters*, **233**, 279-288, 2006. R4 : D. Bagchi, *et. al.*, *Toxicology*, **148**, 187–197, 2000.

Fruit	Anti Aging Benefit	Supportive Research studies (R)
Oranges	*Oranges* (R5) are filled with Vitamin C, a natural and powerful antioxidant to kill free radicals and toxins throughout our system. Bits of white part covering the fleshy part of orange should be eaten since they contain fiber to fight free radicals and nutrients like calcium for bone strengthening.	R5 : C. S-Moreno, *et. al.*, *Am J Clin Nutr*, **78**, 454–460, 2003.
Water melon	Watermelon protects the skin from sunburn, offers nutritional support for male fertility and helps to decrease the risk of prostate, ovarian, cervical and pharyngeal cancers (R6). Zinc in water melon cleanses toxins particularly from the bladder and kidney. *Water melon* is a natural anti aging food with 90% water, vitamins A, B, C, E, and minerals zinc, selenium and essential fats which fight against free-radicals (R7). Watermelons have very high glutathione (R8, R9) content.	R6:http://www.newsfinder.org/site/more/watermelon_may_be_cancer_ killer/ R7 : I. Tlili, *et. al.*, *Journal of Food Composition and Analysis*, **24**, 307-314, 2011. R8 : A. Pompella, *et. al.*, *Biochemical Pharmacology*, **66**, 8, 1499–1503, 2003. R9:http://www.drlam.com/book/chapter3.asp [Chapter 3, Secret 2, Anti aging nutritional supplements, Dr. Lam]
Cucumber	*Cucumber*, an excellent anti-aging food, is loaded with mineral silica, ionic potassium, magnesium and vitamin C. Cucumber is required for a smooth and glowing skin, hydration of skin, joints and tissues. New research (R10) is linking the lignans present in cucumbers with reduced risk of cardiovascular diseases and the breast, uterine, ovarian and prostate cancers.	R10 : N.M. Saarinen, *et. al.*, *Mol Nutr Food Res*, **51**, 857-866, 2007
Guava	Guava leave extract have anti-bacterial (R11) and anti-inflammatory properties to treat sunburns and eczemas.	R11 : M. D. M. Hoque, *et. al*, *Foodborne Pathogens and Disease*, **4**, 481-488, 2007.
Pineapple	*Pineapple* contains 85% water, vitamins B1, B2, B12, C, carotene, iron, zinc, copper, potassium, calcium, magnesium, iodine, manganese, and bromelain. Bromelain is a composition of enzymes, which has anti-inflammatory (R12) properties that reduces swelling and redness on the skin.	R12 : L. P. Hale, *et. al.*, *Inflamm Bowel Dis*, **16**, 2012–2021, 2010.
Papaya	*Papaya* is a valuable fruit for fighting against wrinkles and blemishes. Papaya is rich in vitamin A, E, C enzymes, and antioxidants, which cleans the skin. Papain (R13) is a proteolytic enzyme in papaya, which promotes skin renewal and cellular turnover. Although, cellular turnover normally takes 30 days, when you use papaya it helps to exfoliate the skin revealing new, softer cells. Papain removes wrinkles and smoothes out skin because new cells contain collagen, which keeps it healthy, youthful and taunt.	R13 : http://skinfopedia.com/Papain; http://www.dermalinstitute.com/us/library/20_article_Methods_of_ Exfoliation.html.
Apples	*Apples* provide a wide range of phytonutrients such as catechins, quercetin, phloridzin and chlorogenic acid, which act as antioxidants (R14) to fight disease.	R14 : K. Wolfe, *et. al.*, *J Agric Food Chem*, **51**, 609-614, 2003.

Glutathione is a naturally occurring amino acid that is obtained from food and made by every cell in a human body. Blood glutathione level drops 17% between ages 40 and 60 and low glutathione levels leads to chronic diseases. A study suggested that a compound citrulline, found naturally in water melon plays a key role in heart health[7]. The researchers fed high saturated fat and cholesterol rich diets to two mice groups. One group was given water containing 2% watermelon juice and the other group received the same amount of water supplemented with a solution containing same amount of carbohydrate as in water melon. 30% less weight, 50% less plaque in arteries and elevated levels of citrulline was found in the group receiving pure water melon juice.

Oxidative stress is one of the main causes of aging. Anthocyanins also aid our brain in the production of dopamine, a chemical that is critical to coordination, memory function, and your mood. Anthocyanins in *blueberries* appear to combat oxidative stress. Scientists have noted the ability of apples to slow down the aging process in fruit flies[8]. The flies were deliberately exposed to oxidants and those receiving a diet rich in apple polyphenol had 3% increased life span.

ANTI-AGING VEGETABLES AND LEAFY GREENS

Table 2 : Anti Aging benefits of vegetables/leafy greens

Vegetable/leafy greens	Anti Aging Benefit	Supportive Research studies (R)
1. Spinach	Spinach has a very high ORAC (R15) (Oxygen radical absorbance capacity) score and hence destroys the damage producing free radicals in our body. *Spinach* and other leafy greens such as turnip greens, collard greens and lettuce are great sources of vitamin C, K, zinc and beta-carotene. These help to protect the vision from macular degeneration, the leading cause of blindness in adults 65 or older. According to a study (R16), spinach may be beneficial to retard age related central nervous system and cognitive behavioral deficits and neurodegenerative diseases. Spinach provides folate which dramatically improves the short-term memory and lowers the risk for heart disease and cancer.	R15 : G. Cao, *et. al.*, *Free Radic Biol Med*, **14**, 303–311, 1993. R16 : J. A. Joseph, *et. al, The Journal of Neuroscience*, **18**, 8047-8055, 1998.
2. Turnip and Radish	*Turnip* and *radish* (R17) help to fight against toxins which cause degeneration of cells and aging.	R17:http://www.renewforanewyou.com index.php?module= pagesmith& uop= view_page&id=7
3. Neem	Drugs.com (R18) notes that *neem* (R19) tree parts contain an anti-inflammatory agent. The *Indian Academy of Science* asserts that neem features antifungal, antibacterial, antioxidant and antiviral qualities. The fatty acids in neem seed oil have an emollient effect on skin and reduces fine lines. In a clinical study (R20) researchers found that fatty acids in neem provide protection against UV light, the main cause of photoging.	R18 : http://www.drugs.com/npp/neem.html R19 : I. Hashmat, *et. al.*, *International Research Journal of Biological Sciences*, **1**, 76-79, 2012. R20 : E. Boelsma, *et. al.*, *Am. J. Clin. Nutr*, **73**, 853-864, 2001.

Vegetable/leafy greens	Anti Aging Benefit	Supportive Research studies (R)
4. Broccoli	*Broccoli* contains high amount of isothiocyanates, antioxidants and vitamin B6, C, E, flavonoids, calcium and chromium. Broccoli decreases the risk of certain cancers (R21) including prostate, bladder, colon, pancreatic, gastric and breast cancer.	R21 : A. Shibata, *et. al.*, *Br. J. Cancer,* **66**, 673-679,1992.
5. Mushrooms	*Mushrooms* help decrease cancer risks, lower blood pressure, and are rich in chromium for anti-aging (R22) benefits.	R22 : M. Elmastas, *et. al.*, *Journal of Food Composition and Analysis*, **20**, 337-345, 2007.
6. Tomatoes	Packed with the antioxidant lycopene, *tomatoes* (R23) reduce inflammation.	R23: R. Ilahy, *et. al.*, *Journal of Food Composition and Analysis*, **24**, 588-595, 2011
7. Carrot and Sweet Potatoes	*Carrot* and *sweet potatoes* (R21) are potent sources of Vitamin A, B and C as well as calcium and potassium. Alliance of aging research (R9) suggests that adults should take 10 mg to 30 mg per day of beta carotene for life. One cup of carrot juice equals 24.2 mg and one medium sweet potato equals 10 mg. Heavy cooking destroys beta-carotene.	
8. Cauliflower and Cabbage	*Cauliflower* and *cabbage* are rich in glutathione (R9). Dr. Garnett Cheney (R24) at Stanford University treated 63 ulcer patients with one quart of raw cabbage juice per day and 60 of those showed pronounced healing.	R24: G. Cheney, California Medicine, **70**, 10-15, 1949.

ANTI-AGING SPICES

Table 3 : Anti Aging benefits of spices

Spices	Anti Aging Benefit	Supportive Research studies (R)
1. Garlic and Onion	*Garlic* and *onion* fight the aging process by preventing cell degeneration, colon cancer (R25) and heart diseases. When garlic is cut, allin is converted to the beneficial allicin (R26) and hence fresh garlic should be chopped and then eaten after few minutes. Jarred, powdered or dried garlic don't give all the benefits of fresh garlic. As the antioxidant allicin of the garlic digests in our body, it produces sulfenic acid, which reacts with dangerous free radicals (R27) than any other compound.	R25: E. Dorant, *et. al.*, *Br. J. Cancer,* **67**, 424-429, 1993. R26: H. Fujisawa, *et. al.*, *J. Agric. Food Chem*, **56**, 4229–4235, 2008. R27: A. Rabinkov, *et. al.*, *Biochimica et Biophysica Acta*, **1379,** 233-244,1998.

Spices	Anti Aging Benefit	Supportive Research studies (R)
2. Ginger	Ginger contains active phytonutrient ingredients "gingerols (R28)" and "shaogaols" which give a distinctive flavor, neutralize stomach acids, enhance the digestive juice secretion and tone the digestive tract muscles. Researchers (R29) believe that gingerols are responsible for reducing nausea and vomiting by blocking body's reflex to vomit. Denmark researchers have discovered that ginger can block the effects of prostaglandins, which are substances that cause inflammation of brain blood vessels leading to migraines. Ginger inhibits the action of several genes i.e. cytokines and chemokines and act as non-steroidal inflammatory drugs (R30).	R28 : P. S. Variyar, *et. al.*, *Journal of Food Composition and Analysis*, **13**, 219-225, 2000. R29 : Q' Qiu-hai, *et. al.*, *Chin Med J*, **123**, 478-484, 2010. R30 : R. Grzanna, *et. al.*, *J. Med Food*, **8**, 125-132, 2005.
3. Turmeric	Same as the other antioxidant giants like tea, berries and pomegranates, the active ingredient of *turmeric* is curcumin (R31) which shows anti-inflammatory, antioxidant and cancer preventing properties. A Jawaharlal Nehru University (R32) study focused the antiaging effects of curcumin in aged rat brain regions. One of the comprehensive summaries (R33) of turmeric studies to date published concluded that turmeric outperforms several pharmaceuticals against chronic diseases and virtually induces no side effects. It also helps to create the master antioxidant glutathione (R8, R9).	R31: H. Hatcher, *et. al.*, *Cellular and Molecular Life Sciences*, **65**, 1631–1652, 2008. R32: K. Bala, *et. al.*, *Biogerontology*, **7**, 81-89, 2006. R33: J. A. (Jim) Duke, *Alternative and Complementary Therapies*, 229-234, 2007.
4. Cloves	Of all spices, *cloves* receive highest ORAC (R34) score, meaning it is the highest in antioxidants.	R34:http://www.oracvalues.com/sort/orac-value

OTHER ANTI-AGING FOODS

Obtained through the leaves of the plant Camellia sinensis, *green tea*, and the least processed of all the tea species is prepared by quickly steaming or heating the leaves so that they retain the green colour. Tea contains polyphenols and the most potent is catechins which have anti-cancer and anti-aging properties. Studies have shown that green tea affects the DNA and more specifically the length of telomere.

Regular intake of protein can promote the growth of subcutaneous muscle and makes it plump and elastic which slows down the aging process. Good sources of protein are *meat* and *fish*. When it comes to anti-aging diet, lean fish is preferred which supplies omega 3 fats. Omega 3 fatty acids in fish oil show the anti-aging benefits. As the body ages, it ceases to produce Coenzyme Q-10[9]. A diseased heart shows severe deficiencies of this nutrient. One pound of sardine fish provide 30 mg of Coenzyme Q-10 which is the recommended anti-aging dose for the healthy people, over 50 years old. Fish, chicken and dairy products contain Vitamin B12. 500 mcg-1000 mcg per day in older people is more appropriate for anti- aging purposes. However, one should be aware of fishes containing mercury and pesticides.

A single true free range chicken egg contains essential amino acids, highest quality proteins, choline for brain, nervous and cardiovascular systems and naturally occurring vitamin D. However, there are critical nutritional differences between these eggs and commercially framed eggs. Allergic reactions to eggs are generally caused by the changes that occur in the cooking process. Raw egg eating helps to preserve many perishable nutrients. Raw egg whites contain a glycoprotein called avidin that is effective to bind protein and cooking deactivates avidin. One can expect biotin (vitamin B7) deficiency from raw egg whites. However, egg yolks have one of the highest concentrations of biotin found in nature. Therefore, eating the whole raw egg, yolk and white doesn't lead to biotin deficiency.

Yoghurt is rich in calcium to prevent the age-related problems of the intestine. Glutathione levels can be increased through *whey protein* intake which has been carefully processed from grass fed organic cows to preserve the amino acid precursors. Many people believe that *nuts* are full of calories. However, nuts are a good source of essential omega 3 fatty acids. Especially walnuts are known for their anti aging properties and are good sources of minerals. Sprouts are rich in vitamins and minerals and contain easily absorbable hormones effective for anti aging. By increasing cereals intake in the daily diet such as whole grain, barley, nuts, oats and brown rice helps to have healthier skin.

CONCLUSION

Many of the external causes of aging skin are determined by the health and lifestyle decisions we make every day. Making unhealthy choices can cause prematurely aging skin, and this makes us older, faster, both internally and externally. In the present scenario, junk food is one of the major causes of premature aging which is characterized by the free radical accumulation in body. Consumption of fruit and vegetables, as well as grains, has been strongly associated with reduced risk of age-related functional decline and cardiovascular diseases, cancer, diabetes, Alzheimer disease, and cataracts. This has been experimentally established by researchers all over the world. In addition to that, David Blanchflower[10] of the University of Warwick (UK) concluded in a review of 80,000 cases that high level of fruit and vegetable consumption improves not merely physical health but also elevates life satisfaction, happiness and mental stamina.

REFERENCES

1. A. V. Everitt, S. N. Hilmer, J. C. Brand-Miller, H. A. Jamieson, A. S. Truswell, A. P. Sharma, R. S. Mason, B. J. Morris, D. G. Le Couteur, *Clin Interv Aging*, **1**, 11-31,2006.
2. S. Cohen, M. Graham, G. Lovrecz, N. Bache, P. Robinson, R. Reddel, *Science*, **315**, 5820, 1850–1853, 2007.
3. S. E. Artandi, S. Alston, M. K. Tietze, N. E. Sharpless, S. Ye, R. A. Greenberg, D. H. Castrillon, J. W. Horner, S. R. Weiler, R. D. Carrasco, R. A. DePinho, *Proc Natl Acad Sci U S A*, **99**, 8191-8196, 2002.
4. E. González-Suárez, E. Samper, A. Ramírez, J. M. Flores, J. Martín-Caballero, J. L. Jorcano, M. A. Blasco, EMBO J, **20**, 2619-2630, 2001.
5. J. P. de Magalhães, O. Toussaint, *Rejuvenation Research*, **7**, 126-133, 2004.
6. M. Ohnishi, M. S. Razzaque, *FASEB J*, **24**, 3562-3571, 2010.
7. A. Poduri, D. L. Rateri, S. K. Saha, S. Saha, A. Daugherty, *The Journal of Nutritional Biochemistry*, **24**, 882-886, 2013.
8. C. Peng, H. Y. Chan, Y. Huang, H. Yu, Z. Y. Chen, *Journal of Agricultural and Food Chemistry*, **59**, 2097-2106, 2011.
9. L. Ernster, G. Dallner, *Biochimica et Biophysica Acta*, **1271**, 195–204, 1995.
10. D. Blanchflower, http://wrap.warwick.ac.uk/53081/1/WRAP_Oswald_twerp_996.pdf.

KNOW THY INSTITUTIONS

INDIAN INSTITUTE OF PETROLEUM, DEHRADUN

THE ORGANIZATION

CSIR-Indian Institute of Petroleum (IIP), an ISO 9001 (2008) accredited organization, was established in 1960, by Govt. of India, as one of the constituent laboratories under Council of Scientific & Industrial Research (CSIR). It is a premier National Laboratory engaged in Research and Development activities mostly in the downstream sector of Petroleum Industry. Its charter includes functions, amongst others, to undertake R&D work in petroleum refining, natural gas, renewable and petrochemicals; utilization of petroleum products in IC engines and in industrial & domestic combustion; to provide technical and analytical services to petroleum refining & related industry including technology transfer; to develop human resources for the hydrocarbon and related industries by training their personnel through specialized training courses and assisting the Bureau of Indian Standards (BIS) in formulating standards for petroleum products equipments and devices using these products. Over the years IIP has developed more than 70 technologies/Processes/ Products, a large number of them commercialized.

TECHNOLOGIES MAJOR PROCESSES LICENSED

CORE COMPETENCE

- Crude evaluation and physicochemical characterization of petroleum products
- Molecular level characterization of petroleum and related products
- Separation processes
- Catalyst and conversion processes

- IC engine studies including emissions and alternative fuels studies Industrial and domestic combustion
- Renewable Fuels & Lubricants
- Process development for petrochemicals and intermediates and for bio-catalytic processes.
- Development of additives and specialty chemicals for hydrocarbon sector
- Tribological studies
- Simulation, modelling and process design

TECHNOLOGIES READY FOR COMMERCIALIZATION REFINING

- Oxidative desulphurization of diesel
- Adsorptive desulphurization of FCC Gasoline and diesel
- Catalyst and process for removal of hydrogen sulphide from (fuel) gas streams with simultaneous production of sulphur
- Regenerative process for removal of sulphur-dioxide form lean gas streams
- Super critical propane Deasphalting
- Re-extraction technology for Dearomatization of middle distillate
- Polymer modified bitumen
- Recovery of CO from flue gas by adsorption and absorption 2 route
- Ultra-low deep desulphurization
- Isomerization of light naphtha
- Light naphtha to LPG and gasoline (NTGG)
- Deep catalytic cracking (DCC)

BIOFUELS & BIOLUBRICANTS

- Biodiesel from vegetable oils, waste oils and fats
- Biolubricants from vegetable oils, starch and cellulose, Glycerol

SPECIALTY CHEMICALS, ADDITIVES AND CATALYST

- Microcrystalline wax from crude oil tank bottoms
- Petroleum based electrode pitches
- Specialty carbon materials
- Pour point depressants and VI improvers
- Specialty chemicals and products from *Jojoba* oil
- Production of Grade-A Helium
- Additives for fuels antioxidants, lubricity improvers
- Multifunctional additives (MFA) for fuels
- Sweetening catalyst THOXCATES

BIO-PROCESSES

- Biosurfactant for recovery of oil from crude oil tank
- bottom sludge
- Bioethanol production from biomass by microorganism

KNOWLEDGE GENERATION

- Research Papers 2000
- Patents Granted 240

TRAINING PROGRAMMES

Developing human resource for hydrocarbon and related industries has been one of the major activities of IIP since its establishment and has maintained its leading role in imparting training to personnel from petroleum refining, petrochemical and related industries and Government bodies.

TECHNOLOGY AWARDS

CSIR-IIP has the distinction of bagging the prestigious CSIR Technology Awards (in Chemical Sector, Physical Science including Engineering, Business Development and Technology Marketing) since its institution in 1990 as listed below :

- Production of Benzene/Toluene through Sulfolane Extraction (1990)
- Bimetallic Pt-Re Reforming Catalyst (1992)
- Shield for Process Technology Food Grade Hexane (1993)
- Low Air Pressure Film Burner (1994)

- Business Development and Technology Marketing (1996)
- Sulfolane Production Technology (1997)
- Visbreaking Technology (1998)
- Propane Deasphalting of Petroleum Residue (1999)
- Shield for Process Technology NMP based LOBS Production Technology (2000)
- Food and Petroleum Grade Hexane using NMP (2001)
- Development of Comb Type Polymeric Wax Crystal Modifier and Dewaxing
- Aid and Additives for Production of LOBS (2006)
- Development of New Catalyst for Sweetening of Lighter and Heavier Petroleum Fractions (2007)
- Innovative Technology for Up-grading Fuel Oil Components in to Premier Refining Products (2009)
- Business Development and Technology Development Marketing (2011)
- Further, IIP has also received FICCI, ICMA and NRDC awards for some of the above technologies.

ACADEMY OF SCIENTIFIC AND INNOVATIVE RESEARCH (AcSIR)

Post Graduate Research Programme in Engineering (PGRPE)

- Advanced Petroleum Science and Technology
- Two Year Postgraduate Programme at CSIR-IIP
- Four Semester Course of 69 credits
- 10 seats per year
- Four students of I batch Appointed as Junior Scientist

MAJOR FACILITIES

Analytical

- FTIR, SEM, XRD, High resolution GC-MS
- TG-DTA, NMR-500, HPLC, SFC, UV-Vis, DSC, CFPP
- Low resolution GC-MS, AAS, ICP-AES
- GC SCD, GC PFPD
- Polarized Light Optical Microscope
- Asphalt Rheometer
- Nottingham Asphalt Tester, Marshal Stability Tester
- Bitumen Rolling Thin Film oven Apparatus

Pilot Plant

- Visbreaking Pilot Plant Unit
- Delayed Coking Pilot Unit
- Biodiesel Pilot Plant
- Biomass Fast Pyrolysis Unit
- Bioreactors
- Waste Plastic Unit
- Bench Scale Fixed bed Sweetening Unit
- Pilot Plant for Gas Desulphurization Studies
- Two Column PSA Unit
- Single Column Micro-adsorber Unit
- Gas Isotherm Measurement Unit

Automotive Division (For all categories of vehicles)

- Two/Three Wheeler Chassis Dynamometer
- Chassis Dynamometer for LCV including Passenger Cars
- Constant Volume Sampler (CVS) & Emission Analyzers for CO, NOx, HC & PM
- Transient Dynamometer (to be commissioned shortly)
- On-board Emission Analyzer
- Engine Dynamometer
- CAT1 H2/ 1G2
- Spray Imaging System
- Meterlogy
- CLR-38
- CFR Engine
- STAR-CD CFD Software

Tribology (Lubricant Testing Facilities)

- Amsler Wear Testing M/c
- FZG Gear Test Rig
- Timken Wear& Lubricant Tester
- Pin on Disc M/c
- IAE Gear Test Rig

Grease Test Facilities

- IP Roller Bearing Test Rig
- Evaporation Loss of Grease
- Leakage Tendency of Greases
- Emcor Rust Test Rig
- Roll Stability of Greases Gear Wear Tester

Nanotribology

- Particle Size and Zeta Potential Analyzer
- Ultrasonic Probe

Contact :

Director,
Indian Institute of Petroleum
Dehradun-248005, INDIA
Phone : +91-135-2525704 (Off.)
Mobile : +91-9412916301

Conferences / Meetings / Symposia / Seminars

National Conference on Adaptation and Mitigation Strategies of Climate Change for Sustainable Livelihood, 5–7th March, 2014, Cooch Behar, West Bengal.

Theme Areas :

- Climate Resilient Resource Management
- Crop improvement and Crop Management
- Sustainable Livelihood Management
- Education, training, law, policy and Strategies

Contact : Dr. Bidhan Roy, Organizing Secretary, Department of Genetics and Plant Breeding, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Bihar 736 165, West Bengal, Ph : 09434117057
E-mail : bcroy10@yahoo.com.

22nd Annual International Conference on Composites/Nano Engineering (ICCE-22), July 13 – 19, 2014, Malta.

Topics :

- Bio Nano, Energy Materials
- Green Engineering
- Natural Fibers
- Chemistry of materials and Computational materials.

Contact : Prof. David Hui, Department of Mechanical Engineering, University of New Orleans, New Orleans, LA–70148, Tel : (504) 280 6652, Fax : (504) 280 6192
Email : dhui@uno.edu, Website : www.icce-nano.org

S & T ACROSS THE WORLD

COULD BOUNCING DROPLETS HELP US SORT OUT THE NATURE OF REALITY ?

The strange, beautiful behavior of tiny liquid droplets may be related to the seemingly non-sensical laws governing nature at the smallest scales, physicists say. A paper published on-line Aug. 13, 2013 in the journal *Physics of Fluids* presents equations for how liquid droplets can bounce and "walk" over pools of the same fluid without falling in. Physicists say the droplets are guided by waves they themselves make in the pool—a situation reminiscent of a theory devised long ago to explain the baffling behaviors of subatomic particles.

Known as pilot-wave theory, it fell out of favor, but never went away. "This walking droplet system represents the first realization of a pilot-wave system," said John Bush, a mathematician at the Massachusetts Institute of Technology. But unlike the case with the tiny realms that pilot-wave theory was devised to explain, the droplets are "plainly visible," he added. "It gives us the first opportunity to view pilot-wave dynamics in action." The new work is an outgrowth of research a few years ago by Yves Couder, a physicist at Université Paris Diderot, who first reported the behavior of the roughly millimeter-sized droplets.

Couder's findings fed into an old debate. In the early 1900s, physicists contested how to explain subatomic particles' strange behavior, such as their tendency to behave both as particles and waves. This is perplexing because waves are not traditionally considered physical objects— they're oscillations. And particles acting like waves defies common sense. For instance, waves interfere with each other: if you drop two stones in a pond, their outward-moving waves will alter each other's appearance as they meet. Individual objects can't "interfere" with each other like that, one would think. But subatomic particles, such as photons, or particles of light, do—and they don't even have to be moving at the same time. Their mutual "Interference" can be seen in the patterns they form when they strike a surface and the landing locations are marked. Pilot-wave theory, proposed by Louis de Broglie in the 1920s, reconciled these problems by proposing that moving particles are borne along on some sort of wave, like driftwood on the tide. But no one ever quite explained what that wave was. The theory ultimately gave way to the so-called Copenhagen interpretation on quantum mechanics, which prevails today. It gets rid of the carrier wave—but with it the common-sense notion that a particle travels a definite path. It holds that tiny particles have no definite location or trajectory until a measurement take place, an idea that, if not terribly satisfying, at least solves the problems at hand mathematically.

Enter Couder's research. He placed an oil-filled tray on a surface that was vibrating not quite strongly enough to produce waves. When a droplet of the same fluid was placed on the surface, a cushion of air between the drop and the bath prevented the drop from merging. The droplet then bounced on the surface. The bouncing caused waves, which in turn propelled the droplet along. Initial experiments suggested that the droplets acted like waves in some circumstances—much as subatomic particles do. The more recent paper looked at the droplet trajectories in further detail. "Our recent article is the culmination of work spearheaded by my student, Jan Molacek, who developed a theoretical model to describe the dynamics of bouncing and walking droplets by answering questions such as : Which droplets can "bounce? Which can walk? In what manner do they walk and bounce? When they walk, how fast do they go?"

The paper compared Molacek's developments to the results of experiments performed by Øistein Wind-Willassen, from the Danish Technical University, on an experimental rig designed by

Bush's student, Dan Harris. "Molacek's work also led to a trajectory equation for walking droplets, which is currently being explored by my graduate student Anand Oza," Bush said. "Our next step is to use this equation to better understand the emergence of quantization and wave-like statistics, both hallmarks of quantum mechanics"—behavior at the smallest scales. Interestingly, pilot-wave theory is similar to a view proposed by great physicist Isaac Newton three centuries ago. He maintained that particles of light generate waves as skipping stones do, and that these waves in turn affect the motion of the particles. In this picture, the substance forming the actual waves was "the aether"—a hypothetical fluid-like substance then believed to fill space. Physicists concluded much later that there is no aether.

(*Courtesy : American Institute of Physics and World Science*)

LIGHTNING HELPS SHAPE MOUNTAINS, STUDY FINDS

Lightning strikes cause rocks to explode, a process that help shapes mountain landscapes in southern Africa and perhaps elsewhere, a study has found.

Its authors say the findings prove mountains are a lot less stable than we think, and overturn previous assumptions that icy conditions created angular rock formations. In a world where mountains are crucial to food security and where mountains are crucial to food security and water supply, this has major implications, especially in the context of global warming, they add.

The findings are published in the advance online edition of the research journal *Geomorphology*. Researchers Jasper Knight and Stefan Grab from Wits University in South Africa said they used a compass to prove lightning caused some of the angular rock formations in the Drakensburg. Southern Africa's highest mountain range.

Normally, a compass needle points to near the North Pole. "But when you pass a compass over a land's surface, if the minerals in the rock have a strong enough magnetic field, the compass will read the magnetic field of the rock, which corresponds to when it was formed." said Knight.

"In the Drakensburg, there are a lot of basalt rocks which contain a lot of magnetic minerals, so they've got a very strong magnetic signal, " he added. And if you pass a compass over an area where a lightning strike occurred, the needle will suddenly swing around.

Lightning "can, for a short time, partially melt the rock and when the rock cools down again, it takes on the magnetic imprint of today's magnetic field, not the magnetic field of millions of years ago when the rock was originally formed, "Knight explained. "It's a very useful indicator" to identify exactly where lightning struck.

Knight and Grab mapped out where lightning struck the Drakensburg and found that lightning controls the evolution of the mountain landscapes because it helps to shape the summit areas–the highest areas–with a blasting effect. Previously, angular formations were assumed to result from changes typical of cold environments, such as fracturing due to frost. Water enters cracks in rocks and when it freezes, it expands, splitting the rocks.

Knight and Grab said they're challenging centuries-old assumptions about what causes mountains to change shape. Many people have considered mountains to just sit there "to be affected by cold climates over these long periods of time, "Knight said.

"This evidence suggests that is completely wrong. African mountain landscapes sometimes evolve very quickly and very dramatically over short periods of time. These are actually very sensitive environments and we need to know more about them."

It's also useful to try to determine how much debris these blasts move around, which can shift huge boulders by tens of meters of yards, he added. "We can identify where the angular, broken-up material has come from, trace it back to source, and determine the direction and extent to which the debris has been blasted on their side. Of course we know from the South African Weather Service how many strikes hit the land's surface," allowing an estimate over how much material moves, over what area and how often, he added.

The stability of the land's surface has important implications for the people living in the valleys below the mountain, he went on. "If we have lots of debris being generated it's going to flow down slope and this is associated with hazards such as landslides," said Knight.

Mountains are also linked to food security and water supply. In Lesotho, a country crucial to South Africa's water supply, food shortages are leading to overgrazing, expesing the rock surface and making mountain landscapes even more vulnerable to weathering by lightning and other processes. Knight hopes the new work will help to put in place monitoring and systems to counteract some of the effects. "The more we increase our understanding, the more we are able to do something about it."

THE INDIAN SCIENCE CONGRESS ASSOCIATION
14, DR. BIRESH GUHA STREET, KOLKATA–700 017

YOUNG SCIENTIST'S AWARD PROGRAMME : 2014-2015

To encourage Young Scientists, The Indian Science Congress Association has introduced a number of awards in different disciplines. These awards carry a sum of ₹ 25,000/- besides a Certificate of Merit.

1. Applications are invited from members (Life & Annual) of the Association who have paid their subscription on or before **July 15, 2014**. The upper age limit of the candidates for the award is 32 years as reckoned on **December 31, 2014**.
2. Four copies of full length paper along with four copies of the abstract (not exceeding 100 words) must reach the office of the General Secretary (Membership Affairs) not later than **August 16, 2014**. At the top of each copy of the paper and its abstract, the name of the Section under which the paper is to be considered should be indicated. For details of Sections see http://www.sciencecongress.nic.in/html/youngsc.htmlare.
3. Along with the Four copies of paper, Four copies of the Application Form (to be downloaded from ISCA website http://www.sciencecongres.nic.in) with brief bio-data of the candidate (not exceeding 2 pages), list of publications, with copies of reprints of already published papers if any and a soft copy of the duly filled application form with scanned copies of enclosures (excluding reprints), full length paper, abstract and bio data in the form of a CD must also be sent simultaneously along with the hard copies.
4. The Paper submitted must be **single author paper** and the research work should have been carried out in India and this has to be certified by the Head of the Institution from where the candidate is applying.
5. The candidate should give an undertaking that the paper being submitted has not been published in any journal or presented in any other Conference/Seminar/Symposium or submitted for consideration of any award.
6. A Young Scientist can present only one paper in any one Section (and not a second paper on the same or any other topic in any other Section).
7. A person who has already received Young Scientist Award in any section once will not be eligible to apply for the above Award in the same or any other section.
8. Incomplete Application will not be considered.
9. The papers submitted will be subjected to verification for authenticity.
10. Full length paper will be evaluated by experts and the selected Six Young Scientists in each section will be invited to make oral presentation of their paper during 102nd Indian Science Congress. The selected candidates will be provided admissible travelling allowances by the ISCA.
11. The final selection for the Awards will be made by a duly constituted committee and the awards will be given during the Valedictory Session of 102nd Indian Science Congress session.
12. Application submitted for the above award will not be returned.
13. The last date for receiving papers at ISCA Headquarters is **August 16, 2014**

All correspondences should be made to : **The General Secretary (Membership Affairs), The Indian Science Congress Association, 14, Dr. Biresh Guha Street, Kolkata-700017. Tel. Nos. (033) 2287-4530/2281-5323 Fax No. 91-33-2287-2551, E-mail : iscacal@vsnl.net, Website : http://www.sciencecongress.nic.in**