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SEVENTEENTH BIRBAL SAHNI MEMORIAL LECTURE

Why basic science?

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यो ब्रह्माणं विदधाति पूर्वं यो वै वेदांश्च प्रहिणोति तस्मै।
तं ह देवं आत्मबुद्धिप्रकाशं मुमुक्षुर्वै शरणमहं प्रपद्ये।।

Svetasvatara Upanishad—Ch. VI, Sl. 18.

He who at the beginning of creation projected Brahma (universal consciousness), who delivered the Vedas unto him, whose light turns the understanding towards the Atman, desirous of salvation, I resort for refuge.

ॐ असतो मा सद्गमय।
तमसो मा ज्योतिर्गमय।
मृत्योर्मा अमृतं गमय।
ॐ शांतिः शांतिः शांतिः।

Brhadaranyaka Upanishad—1-3-28.

Lead us from untruth to truth, from darkness to light, from death to immortality. Om! Peace... Peace... Peace.

Basic research should be looked upon neither as something which has to be of practical use nor as an ornament to Society. Indeed, it is a pillar on which culture rests. In basic research it is the quality of the work which is more important than the topic of study. Convincing Society of the importance of learning basic sciences in the universities and conducting researches is important in itself. In fact, universities have been patrons of basic researches in all branches of sciences, not only in India, but also in the more advanced countries, and quite rightly so. Therefore, in the control of basic research in mathematics, physical sciences and in the biological sciences, we must recognize the responsibility of Society to Science. There is no such thing as a "scientific society" as, invariably, society appreciates only our gadgets and not profound ideas for further research. Science, if one may say so, is the most successful example of international cooperation. Unlike religion or sport, there is, relatively, less competition except where hi-technology is involved. While we can buy technological know-how, research ideas in the basic sciences have to be generated by individuals working independently or, in small teams in a cloistered and creative atmosphere.

In business, as in science, creativity is known to thrive in unfettered and possibly undisciplined efforts. Nevertheless, it is difficult to convince aid-giving bodies that any investment in basic research should not be measured by the number of patents claimed or the number of industries that have developed round a particular set of experiments. There are many instances of how a basic research finding was found to have relevance to a later discovery, sometimes two or three decades later, and acknowledged as a pioneering effort.

HISTORICAL

A basic question is why did not technology develop in the ancient past. The Greeks did not use technology as a tool to master the world or as labour saving devices. Archimedes and Hero had contributed to mechanical inventions but they hardly made any attempts to employ these gadgets for industrial production. Plutarch's opinion about the many inventions of Archimedes is worthy of our attention: "Archimedes possessed so high a spirit, so profound a soul, and such treasures of scientific knowledge that, though these inventions had now obtained him the renown of more than human sagacity, he yet would not design to leave behind him any commentary or writing on such subjects, but repudiating as sordid and ignoble the whole trade of engineering and every sort of art that leads itself to mere profit, he placed his whole affection and ambition in those purer speculations where there can be no reference to the vulgar needs of life".

Archimedes had constantly apologised for his inventions and looked upon them as mere amusements, as diversions, as useless toys. In such an intellectual climate then obtaining, technology had little chance to develop. The Greeks did not objectify nature sufficiently as they had not developed the experimental method. In fact, they did not concern themselves with the idea of controlling and conquering nature, they were content developing imaginative conjectures of hypotheses about nature.

The discovery of Nature

Later, in the middle ages, nature became objectified—first, as an object of aesthetic contemplation and second, as an object of exploration and finally, as an object of exploitation. It was Francis Bacon (1561-1626) who played the role of a spokesman for the new science, introducing the experimental method in science. Bacon announced at the end of the 16th Century *knowledge is power* (not technology is power) and this caught the imagination of the Western intellectual tradition in the centuries to come. Indeed, the ancient Hindu philosophers, and prophets also considered knowledge to be a supreme form of intellectual attainment. One has only to look into our past. We had the Buddha, Adi Sankara, Ramanuja, Madhwa and many others whose creativity made human history in this land of Paramacharyas. They all functioned in an atmosphere of scholarship and high thinking. Bacon argued: "the wisdom we have derived principally from the Greeks is but like the boyhood of knowledge and has the characteristic property of boys; it can talk but it cannot generate, for it is fruitful of controversies but barren of works".

The quantification of Nature

The credit for quantification of nature must go to Galileo Galilei (1564-1642). Galileo explored mathematically the empirical world discovered by the Rennaissance. But it must be said that mathematics was only an instrument for formulation of results and not a method for acquisition of new knowledge. It was realized that the method of acquiring knowledge was experimental. The basic difference between Bacon's experimental method and Galileo's was that, whereas Bacon urges starting with facts and experiments and induce theories from them, Galileo insisted that we must start with imaginative hypotheses and at the end subject them to empirical tests. Similar eulogies about the value of imagination came from Einstein: "Imagination is more important than knowledge. Knowledge is limited, imagination embraces the world, stimulating progress, giving birth to evolution".

The Newtonian Era

In the 17th and 18th Centuries quantification of nature was given by Isaac Newton (1647-1727) as evidenced by the book of nature, Newton's *Philosophiae Naturalis Principia Mathematica* (1687). One century later after Newton's *Principia* appeared, based on Newtonian mechanics, a mechanistic model of the universe appeared. Whatever was not quantifiable was considered either non-existent or unimportant. It was at that point of time that science completed its task for technology and technology prepared itself to start its conquest and subjugation of nature. It is generally assumed that technology is "indifferent" containing no metaphysics. This is not quite correct. Technology, as of now, is a historical phenomenon born of a certain idea of nature, of a certain idea of progress, of a certain preconception about the deterministic structure of the world, related to specific social ideals and specific vision of the ends of human life. Therefore, it has elements of traditional meta-physics.

It is interesting to record here some of the views of Jean-Jacques Rousseau (1712-78). He effectively argued that civilization has imposed on us artificial needs. The pursuit of these needs has alienated man and deprived him of his humanity. The tyranny of artificial needs is the greatest malady of mankind because it has fundamentally impoverished the individual life of man. Rousseau advocated individual salvation by defying and opting out from the artificial needs imposed by society and civilisation. Man according to him must return to nature working for liberation from the web of artificial needs and phoney relationships of the technological civilization. Nature for Rousseau was an imaginary matrix, the ideal state where the symbiosis of the individual with the outside and with his inner essence takes place. It is, therefore, not an object but a subject.

Before we return to a further consideration of technology vis-a-vis, science, we could consider some of the revolutionary thinking that has taken place in some areas of Biology in the last three decades. I will choose two areas which have made very significant progress in basic science. This will give us an idea of the dynamism in-built in the pursuit of knowledge for knowledge's sake.

GENETIC ENGINEERING

Today, man has acquired the basic knowledge to manipulate hereditary material. The discoveries in this area have been breath-taking and man expects much good and bad to come out of this. Application of genetic engineering for commercialization with the many techniques born out of basic research is leading towards spectacular industrialization. To cite just one example, the synthetic production of insulin. Here, therefore, is an enigma of what promise it holds for homo sapiens in the years to come in changing our ecosystems. All these swift developments came from in-depth studies on the genetic material, DNA, a simple macro-molecule of universal occurrence in living systems. The currently investigated recombinant DNA technology forms the background of genetic engineering and biotechnology. Genetic engineering itself is the outcome of the vast new fundamental science of molecular biology.

From the observational methods of the 19th century by great biologists like Charles Darwin, Carl Linnaeus and Jean Baptiste Lamarck, it was the celebrated Johann Gregor Mendel who brought in the concept of experimental biology and quantification of his results on the mysteries of inheritance. In fact, Mendel had laid the foundation of modern genetics. In the forties biochemical studies were intensified by frontline biochemists like Oswal T. Avery, C. M. MacLoed and M. McCarty, followed by some classical work on the chemical nature of the substance that could be responsible for the phenomenon of bacterial transformation which resulted in identifying the DNA as the genetic material worthy of all attention. Hot on the heels was the work of Arthur Kornberg, N. D. Zuider, J. Lederberg, A. D. Hershey, M. Chase and H. G. Khorana, that led to the understanding of the genetic macro-molecule DNA and its synthesis. The classical work of George W. Beadle and F. L. Tatum on the bread mould *Neurospora crassa* has also to be mentioned while considering biochemical pathways in protein synthesis.

The Genetic Code

Once established that the DNA molecule was the genetic material, J. W. Watson and F. C. Crick, by their classical experiments proposed a model for the DNA molecule. The Watson-Crick double-helix model gave the first picture of the hereditary substance and how it carried all the information necessary for the determination of the several characteristics of any organism and that it was capable of replicating itself and longitudinally separating itself into two complementary strands of two DNA molecules, quantitatively and qualitatively similar to the parent molecule.

Thus was born the language of genetics, the genetic code, which gave the central role to the DNA which carried coded information and played an important part in the synthesis of polypeptide molecules. The subject of molecular genetics or Molecular Biology had taken root. Studies were initiated on viruses and their manner of reproduction. All DNA viruses, on entry into the host cell, assumed control over the host DNA and made it synthesize viral DNA but in the case of RNA viruses, they entered the cell with the help of an enzyme reverse transcriptase formed one strand of DNA which was complementary to the viral DNA. With this strand of DNA as template and DNA polymerase enzyme, a double-stranded DNA molecule emerged. Today, transfer of DNA from one organism to another has become possible. In plant materials, whole protoplasts have been removed from one cell and transferred to another. The story of introducing the insulin gene from the mouse into the *Escherichia coli* plasmid was the outcome of all these transplantation experiments and recombinant DNA technology, or what is called Genetic Engineering. This applied science has come to be recognized as a first step in tailoring human needs through microbial genetical manipulations.

Revolutionary discoveries

These revolutionary discoveries in science, be it in the physical or biological sciences, will remain as shining examples of creativity. The physicist talks of decay of fundamental particles, they also mention of short to long half-life among isotopes. So too, in technology we see new generation instruments emerging at short intervals, in computers, jet planes, automobiles, and even in soild state TV sets. Indeed, we have these short-lived gadgets only to be superceded by more efficient ones.

Not so, in the breakthrough discoveries. The Raman Effect, the Chandrasekhar Limit, the structure of the DNA molecule by Watson and Crick, the earlier laws of heredity by Mendel, Einstein's relativity, Khorana's contributions to the understanding of the DNA and its synthesis, to mention a few, will remain classics for all time. It has always been a matter of pride to nations when such pacemakers appear on the scientific scene from time to time. It is they that matter, they are the salt of the earth and humanity owes them a deep debt of gratitude.

ULTRAMICROSCOPIC VIRUSES

Turning our attention to some of the exciting ideas that have come after the epoch making discovery by W. M. Stanley in the late thirties, it all started with a study of the tobacco mosaic virus (TMV). He purified and isolated TMV which appeared as long needle-shaped crystals which were infective. Stanley called them liquid crystals or paracrystals. Later work showed that the ultimate TMV particle was a rigid rod-shaped nucleo-protein of the ribose nucleic acid type (RNA) and that the nucleic acid component was the core of the rods and was really the infective part. Several other plant viruses were subsequently isolated and characterised but not all were rod-shaped like TMV, indeed, many were true crystalline forms with a 3-dimensional regularity. Furthermore, the infective nucleic acid could be tagged on to anomalous protein and whole virus molecule was reconstituted and they were infective. Many other discoveries followed, like the unravelling of the ultimate structure of the virus molecule and showing them to be single or double stranded structures. The amino acid sequences, nucleotide composition etc., have all contributed to our understanding of the complexity of the disease producing agents. The TMV has been the most worked upon virus and in it each protein unit is a coiled polypeptide chain containing 158 amino acids, whose sequences have been worked out. The nucleic acid thread contains more than 5000 nucleotides. Therefore, the varying symptoms produced by different strains of a virus must derive directly from either the synthesis of nucleic acid, or, through other proteins than the structural ones, coded for by parts of the nucleic acid other than those producing the structural protein. However, the ability to code for structural protein is not alone enough to confer pathogenicity. This is illustrated by the smallest particle size virus known as the 'satellite' virus. This virus has possibly few nucleotides to spare after coding for its structural protein and it not only fails to cause symptoms but also fails even to multiply unless aided by the large Tobacco necrosis virus with which it is constantly associated in nature.

On the subject of virus multiplication, the main emphasis is on derangement of the mucleic acid metabolism of the host plant. The infecting virus particle may be 'disrobing' and releasing its nucleic acid somewhere in the cell. Then, nucleotides get polymerized to duplicate the virus mucleic acid and it then codes for its structural protein, encloses the nucleic acid in the protein to give the complete virus particles. All these discoveries bring us to the basic question of the origin of viruses. How do plant viruses which appear "inert" nucleoproteins with no signs of "life", as we understand life and living, become aggressively pathogenic once inside the host cell? How do they shed their protein coat outside the cell wall and enter the host cell as a "naked" nucleic acid? Once inside the host cell how do they become dynamic so as to command the host cell to produce more nucleic acid. How do they combine with the host protein to form the entire viral nucleoprotein?

TEACHING OF SCIENCE

F. H. Westheimer (Emeritus Professor of Chemistry, Harvard University, Cambridge, Mass) under the caption: "Are our Universities Rotten at the 'Core' has given much food for thought in dissemination of knowledge in science at various levels. The Harvard University faculty instituted a 'Core-Committee' to give a 'Core' knowledge for all college students before they graduate and join the society of educated men and women". This core curriculum was considered as minimizing science and, therefore, the majority of students graduating from Harvard were, in a sense, uneducated because they knew almost no science. The essential concept that emerged on analysing the problem was that learning in science is primarily vertical or intensive, whereas that in the humanities was primarily horizontal or extensive.

Requirements for teaching Science

Many of the American colleges and universities require the equivalent of only about two half-courses in sciences for graduation and therefore, they watered down courses. In Columbia University science requirement is intended to provide students the opportunity to learn what scientists do, how they think, what kinds of questions they consider, what procedures they develop to evaluate the results of their research, and in what forms they present their knowledge. How scientists think is not talking about science says Westheimer. Their curriculum has no word about atomic energy or metallurgy or medicine or agriculture or chemical synthesis or genetics or immunology or infinite series or any real subject in science or mathematics. In contrast to its modern requirements, Harvard's curriculum in 1849-50 include a course in science or mathematics, or both, in every semester of every year!

Teaching about advances in Science

In the intellectual advances in science in the last 50 years, long after Copernicus, Galileo, Newton, Lavoisier, Darwin, Mendel, Pasteur, there have been many contributions to add to the intellectual heritage of mankind. The great discovery of atomic fission was not published until 1939. Says Westheimer: "But the advances in science in the last half-century have scarcely been confined to nuclear physics. The first practical digital computer was invented during World War II. The discoveries in solid-state physics have revolutionized computers, phonographs, TV sets, etc. The discovery of penicillin and the many antibiotics has benefited modern medicine. Lasers are used in many situations, for eye surgery, for drilling holes in diamond and saffires and in a multitude ways. But the greatest intellectual revolution for the last 40 years has taken place in biology. Can anyone, asks Westheimer, be considered educated today who does not understand a little of molecular biology? If we are to teach molecular biology it will be necessary to teach some organic chemistry, and that in turn, demands a background of general chemistry." This sequence in subjects is typical of the 'Vertical structure' of learning in the sciences. As mentioned earlier, all these discoveries led to the determination of the structure of proteins and nucleic acids thus leading to the determination of the genetic code and to a methodology of synthesizing genes. Asks Westheimer: "Should not college students learn something about some of these scientific advances even at a price- and it is a real price—of knowing less literature and history at graduation? Which will be easier to learn without instruction in later life: more Shakespeare or molecular biology? Graduates from prestigious institutions become legislators, educators, lawyers, judges and business-executives. In every situation if they know enough science it would provide them with a background for future learning."

The Core Curriculum: Intensive and extensive subjects

The reasons for scientists voting for a 'Core' curriculum which ignored the teaching of a minimum quantum of basic science have been attributed, by Westheimer, to a general resistance among scientists in teaching anyone who does not want to learn. To this he suggests the remedy lies in selecting those eager to learn science in preference to those that show resistance. He adds that "if universities demanded some real science from their students, the high schools have to exphasize the importance of working toward better preparation in sciences and mathematics. The result will not be instantaneous, but in a generation we would have much better education. If scientists try to teach non-scientists molecular biology without Chemistry, or to teach quantum theory without mathematics, they are unlikely to succeed. If they are deliberately made easy, they are almost devoid of content. If they cover only a specialized field, they necessarily give no sense of the sweep of science." This is equally true of teaching biology to-day, you have to have a good background of biochemistry, biophysics and biometrics.

RELEVANCE OF BASIC RESEARCH

In 1945 Vannevar Bush published a book—"Science—The Endless Frontier". There he concluded: "On the wisdom with which we bring science to bear against the problems of the coming years depends in large measure our future as a nation". Bush's famous report to President Truman noted the contributions science had made to winning World War II, and argued that the economic battles that lay ahead in 1945 would also require, a major effort in research and development if the United States were to prosper. Erich Bloch has summarised many of the issues under the caption "Basic Research: The Key to Economic Competitiveness"

The result of the message of Bush was clear. It meant the continuing of the wartime effort in basic research through the creation of a new agency, the National Science Foundation and this was launched in 1950. The main plank of the foundation was to support basic research and education in the sciences and engineering. The clarion call was to strengthen American Science and Engineering base by the collection of people, facilities and equipment. It was at once realized that the nation could not prosper without sustained investment in science and engineering education and research in the American universities. Their main goals were as follows:

1. Intrinsic intellectual value
2. To accomplish a specific government mission such as defense or health
3. To make the nation's economy more competitive

In implementing these laudable objectives, the first goal of intrinsic intellectual value has been given top priority as evidenced by the support given to advances in any field of science and engineering. In other words, they have sought excellence in every one of the scientific activities the nation has undertaken in post-war years. The second goal is important for both the developed and developing nations. The third goal is relevant to both situations because it envisages boosting the economic competitiveness of a nation.

Funding of research

This can only be done by a very balanced funding of basic and applied research. It boils down to this. Those nations that have attained an economically dominant position are most anxious to safeguard their pre-eminent position in science, technology and industrial excellence while maintaining their defense preparedness at as high a level as possible. However, this leadership position resulting in a lion's share of world economy is getting gradually eroded and top three or four nations are being overtaken in this race by newly emerging economic powers in the world. They are steadily progressing not because of any great advantage in natural resources but because of sustained research in both basic and applied sciences. Let there be no ambiguity in understanding this new challenge for a change in world order. It is generally recognized that competitiveness can be improved by automated production systems in industries and judicious combination with meaningful research projects. This has come to be recognized as a far more reliable method of maintaining excellence in national products than trade barriers or protectionist policies. Bloch goes on to say that "any society that wishes to remain competitive in the modern world must do three things:

1. It must support basic research adequately
2. It must educate enough new scientists and engineers
3. It must invest sufficiently in research facilities and equipment

The record in all these areas Bloch says in less than it should be considering their R and D effort

i) The United States has not invested in R and D in recent decades at the rate that sustained growth in a modern society requires. We have slipped from our position of leadership... while our competitors have been pushing ahead... in key technological areas,
ii) The preparation of US federal research support that goes for military purposes is high and rising."

"When military research is eliminated from the comparison, our effort in R and D is significantly less, as a fraction of GNP, than the effort made in Japan and Germany. An encouraging trend, however, has been the increasing fraction of federal support for R and D that is going for basic research. Development expenditures are, quite properly, being left to industry".

Basic research spinoff

Block concluded: "While industry and state governments are deeply involved, basic research and education in science and engineering is a well-established responsibility of the federal government. Basic research produces knowledge that is available to all, not just the organization that pays for the research. Investment in science and engineering has been the source of much of our economic progress over the past four decades. It continues to be the best single way that we can provide the jobs and national wealth that we must have in decades to come. Our science and engineering base, however, needs renewed attention—Science and Technology can provide the means to meet the challenge of international economic competition in the decades ahead, but only if we find the resources to strengthen our effort markedly. The most basic considerations of national welfare demand that we do no less"

THE BIRTH OF TECHNOLOGY

We will now pass on to some general considerations about Technology, its antecedents and precedents. Technology is a part of our intellectual heritage and is an intrinsic component of our society. Technology is power in the modern context and it will be difficult to redirect its course. We can only shift our aim and vision to a model of symbiosis between man and nature based on qualitative and not quantitative criteria. This will need bringing about changes in our economic and social structures.

The Greek ideal of knowledge as enlightenment and source of all progress has been mentioned earlier. The progress of man is concerned here as the progress of his spirituality, and tool making is conceived as a function of this progress. The intellectual conception of technology, rooted in the Aristotelian definition of man conceived as a rational animal, emphasizes the abstract cognitive elements in the make-up and the development of man. The rational and intellectual elements are, then, defining characteristics and the point of departure. Technology in this scheme of things is but contaminated science.

Science vs Technology contrasted

If we contrast the two views, pragmatic and the intellectual, in the pragmatic approach the distinction between science and technology is blurred; the autonomous status of human knowledge is subordinated to a larger scheme of biological survival. In the intellectual approach, on the contrary, the autonomous cognitive status of human knowledge is strongly emphasized. Because of the paramount importance of pure knowledge in man's progress, technology is but a shadow of science, devoid from and congnitively dependent on science. In the pragmatic approach, technology is identified with the tools essential for survival, and is thereby elevated to a sublime height. In the intellectual approach, technology is considered as a cognitive phenomenon, and is thereby deemed trivial, derivative, parasitic. Neither of these two approaches attempts to spell out the distinctive features of technological knowledge as contrasted with other forms of knowledge. Neither seems to grasp the peculiar dialogue which goes on between technology and society. There is probably a third approach, the dialectical approach. In this approach, technology is not a thing-in-itself. It is, and always has been, a continuous dialogue concerning society, its needs and aspirations, and the technical means potentially contained in technology for satisfying those needs and fulfilling those aspirations. The nature of technology cannot be understood without understanding the nature of this dialogue. Indeed, the place of technology in the scope of human knowledge is determined by the nature of dialogue concerning the aspirations of society and the potentials of technology. It is in this sense that we can stress on the dialectical approach to technology.

To analyse these views further, it is a mistake to think of technology as entirely autonomous, although it has secured for itself a great deal of autonomy. It would also be a mistake to think that the technological system is self-justifying in its own terms. The present ecological crisis and fundamental rethinking of technology's role in the society of the future is the *prima facie* illustration of this point. We are going to abandon many technological developments even though the existing technological order justifies their future development. We may have to introduce many new technologies for which there is no need in the existing technological system. Are we going to evolve and invent new forms of technological knowledge which are either unneccessary or simply go against the grain of the existing technological system? We will have to do these things because we are in the process of changing the nature of the dialogue concerning the needs of society and the potentials of technology.

In science we investigate the reality presented to us, the empirical reality, the world around us. In technology, on the other hand, we create a reality according to our designs; this is the man-made reality. Our scientific pursuits are "what there is"; our technological pursuits are based on our ability to construct objects according to our desires. In short, science concerns itself with "what is" whereas technology is concerned with "what is to be". In science we have reality first and then its description; whereas, in technology, we have description or design first, and only afterwards reality.

The process of establishing correspondence between reality and its description in science is known as establishing the truth. Therefore, to establish the correspondence in science is to match description with reality. In technology also a correspondence is established with the only difference that we start with a description with reality, an object. Thus, the classical problem of the quest for truth consists of establishing correspondence between reality and description as in technology. But there is one difference, we do not call the objects satisfying this correspondence as true, but instead call them valid or adequate for the purpose.

Truth and Reality in Science and Technology

In science, reality and truth are assigned an *a priori* position, the process goes from reality to its description. In technology description or blue-print is given first, object or reality is at the end and the process of arriving at the object is called invention, and it is considered as valid. The basic problems of truth in science are centered on reality. By redefining, the basic problem of truth in technology is centered on the notion of the "possible" in the technical sense. Therefore, the validity of technological designs is a function of the scope of the possible, i.e., broadening of the end power of technology is by enlarging the scope of the possible. In other words, the vital characteristic of technology is to attempt to turn the technically possible into the technologically possible.

BASIC DISCOVERIES, TECHNOLOGY AND APPLIED SCIENCE

Technology is thought of as applied science. Scientific theories produce basic explanations about nature, and technology derives practical applications from science. Funding agencies often justify support to fundamental scientific research on the basis of potential technological dividends in the offing. The production of electricity from nuclear energy is one such instance although nuclear material can lead on to destructive and devastating weapons. Yet, technological advance of the late nineteenth and early twentieth centuries developed independently, without scientific research and understanding preceding them. Before fundamental principles of thermodynamics and aerodynamics were understood, the steam engine, the automobile and the aeroplane were developed. Nevertheless, these stray technological landmarks have no validity in the present age as science and technology have very close interaction.

As mentioned earlier, biotechnology and genetic engineering have their base in basic discoveries in unravelling the mysteries of life process and the emergence of the genetic code. Likewise, the simple, yet elegant, experiments conducted by Went on the factors that influenced the coleoptile to bend with unidirectional incident light were a landmark in understanding the phenomenon of growth in plants. The basic discovery of the indole compounds as one of the growth factors in plants brought in its trail a whole host of new growth substances from kinins to gibberellins. Indeed, these basic concepts led on to the recognition of totipotency in isolated plant cells and the new sub-discipline of tissue culture was born. One can go on multiplying these instances in every branch of the basic sciences. For purposes of the present lecture topic, I started with the title "Why Basic Sciences?" This may raise many eyebrows and if, in what I have covered, I have not created convincing evidences justifying the title, I will probably give it a twist to make my intentions more positive and challenging and say "Why not Basic Sciences?". It adds to national pride whenever there is a breakthrough. Fortunately, we have in our country a few centres of basic researches in classical botany. One such is this institute established by my great guru Professor Birbal Sahni. You are the custodians of this legacy. In you rests the onus of keeping its flag flying high. Do not surrender your rights, maintain your status and individuality in the field of Palaeobotany. Never allow incursions into your academic autonomy within limits of motivation and discipline. I place a high premium on loyalty to the cause and the institution, as they are precursors to success. I wish you all a very bright future in your chosen field of specialization. There is enough room for expansion of your research activities within the framework of Palaeobotany without looking for support from other disciplines for, fashion subjects come and go but classics remain as bastions of academic pursuits of excellence.

As all of you are highly motivated academics, I would like to end up by an Upanishadic exhortation addressed to Acharyas and Vidyarthis on the basic concept of sharing knowledge. May you keep this exhortation before you and spread your knowledge, gathered through your researches, to the universities and other centres of learning in Bharat.

श्रद्धया देयम्। अश्रद्धयाः देयम्। श्रिया देयम्।
ह्रिया देयम्। भिया देयम्। संविदा देयम्।।

Taittiriya Upanishad

Gifts should be given with faith; it should never be given without faith; it should be given in plenty, with modesty, with sympathy.

HARI OM!