THIRTIETH CONVOCATION ADDRESS

PROGRESS THROUGH PARTNERSHIP: THE EMERGING PARADIGM

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Mr. President, Mr. Chairman, Graduates of the Year, Distinguished Guests, Ladies & Gentlemen.

I consider it to be a great honour and a special privilege to have been invited to be the Chief Guest today to deliver the Convocation Address. This institute is unquestionably the pride of India. This institute has been built assiduously by some of the most eminent men of Indian Science, which include, ofcourse, that intellectual giant Prof Mahalanobis. The rich traditions of scholarship and academic excellence of this institute have been sustained for several decades.

Let me begin by extending my congratulations and my very best wishes to the young graduates. You entered this institute when the decade of nineties had just begun. The world was very different then. As you leave this institute, you will find that the new world that you will now face is a very different one indeed. What a dramatic turn around it has been in the span of just last five years! There has been a sea-change in the economic, political and technological environment the world over. Age old attitudes and mind sets are being discarded everywhere. The wave of change sweeping the country and the world has thrown up myriad of challenges and at the same time it has posed enormous challenges. In this new world,

there will be extraordinary opportunities for those, who are prepared to face these challenge. Indeed only those of us will survive and succeed, who will be able to anticipate the change and also exploit the change. And those who do this will one day lead the change. We should have the ambition of leading the change and make things happen on our own terms. I firmly believe that all this will be possible, if among other things, we will be able to grasp the importance of some vital partnerships that we need to forge to move ahead. Therefore I have chosen the theme of my address today as **Progress Through Partnership : The Emerging Paradigm.**

There are four different partnerships that to my mind are crucially important. The first is the partnership between **diverse disciplines in science and engineering.** The borders between different scientific disciplines and even between engineering and science are disappearing very rapidly. Major advances are taking place at the interface. I will discuss the importance and the essence of such partnerships.

The second partnership is between **science and business** itself. Numerous debates and conferences have taken place on the issue of industry - academia interaction. We have had endless discussions where the same factors have been reiterated again and again. But

in the new context, new models will have to be followed with renewed zeal. I wish to address the issue of this partnership in the new contextual framework.

The third partnership that is emerging is due to the fact that the chain of concept to commercialisation today transcends trans-national boundaries. The word **techno-globalisation** has come to stay. Globalisation of R&D means new types of partnerships. India's superb intellectual infrastructure means that Indian R&D institutions will be attractive partners for global companies. If we understand and exploit this new paradigm of techno-globalisation, then India can become a global R&D platform.

The fourth partnership that I wish to focus on is **partnership with nature.** The partnership between the consumer human race and the producer natural systems as well as the growing realisation of the desirability of compatability between ecology and economics will drive the future. Indeed, if the changing constitutional pre conditions covering equity and social justice and endogeneous choices and economic efficiency with ecologic harmony have to be met, then we wull have no other option but to rededicate ourselves to the cause of forging a partnership with nature.

Let me explain to you my views concerning these four partnerships in some detail.

Partnership Between Disciplines

As I said, the first crucial partnership is between diverse disciplines of science and engineering. When we look around we see that discrete boundaries no longer exist between various natural sciences such as physics, chemistry, biology, mathematics, etc. Explosive advances in adjacent sciences are shaping up the future of core disciplines. New paradigms of "seamless sciences" and even "seamless engineering" are emerging.

Let us take some examples. Take sub-disciplines such as inorganic chemistry, biological chemistry, organic chemistry and physical chemistry. The conceptual boundaries between these disciplines have already vanished. The 1987 Nobel Prize winning work of Lehn, Cram and Pedersen, led to the elucidation of molecular recognition. It led to the whole new area of supramolecular science and engineering, which crucially depends on the emerging discipline of *molecular information engineering.* Subtle organisation of molecular, structural and dynamical features forms the basis of *molecular information engineering.* The chemical, physical, and biological features of chemical species constitute the essence of this highly

inter-diciplinary field. It involves the organic synthetic techniques of receptor construction, metal ion-ligand complexes involving physical chemistry and finally biological processes involving substrate binding and recognition. Its location at the intersection of chemistry, biology and physics makes it a unique example of the emergence of winners through new partnerships.

Partnerships between disciplines are beginning to not only give rise to new vistas in knowledge but also new insights. Let me explain this by taking the simple case of detection of taste. Breathtaking synergistic efforts from diverse disciplines, being interpreted using the theory of chaos, are leading to new ways of taste detection. Let us consider membranes with biological activity. The central question concerns the inter-relationship between the microscopic and macroscopic membrane properties. Properties such as the action potential, spontaneous firing and chaotic behaviour can be viewed now from a system dynamical viewpoint. Thus, for example, the mechanism of oscillatory electrical potential of dioleyl phosphate milipore filter membrane placed between two solutions of different electrolyte concentration can be related to the macroscopic behaviour of interfaces generated due to chemically driven surface tension effects. The system, when subjected to sinusoidal alternating current, synchronizes with the forcing frequency and also

desynchronizes for changing initial conditions. A periodic behaviour in the form of chaos appears in the regime. The appearance of chaos follows the route of quasi-periodicity and analysis of dynamic chaos enables us to use it as a sensor for detecting taste. The simple philosophy followed here is that the substances as received by biological membranes change the membrane potential leading to sustained oscillation and spatio-temporal firing patterns of the neurons, which when transmitted to the cortex and the brain recognize the taste. It is thus possible to use an artificial lipid membrane to convert chemical information to electric currents and construct sensors that identify the taste. The prowess of the synergy of diverse disciplines is at once obvious here. There are several such examples that one can cite.

Forging such partnerships between practioners of different disciplines is not easy. We all live in a world of very high specialization. This automatically implies that we are continuously erecting our own new boundaries, creating our own small clubs and generating our own special language and jargon all the time. Partnership implies interconnectedness. There itself lies the contradiction! Taking care of these contradictions is the biggest challenge we face in forging these partnerships.

The essence of the issue can be highlighted by looking at the partnership between physics and biology. Frauenfelder and Berg edited a special issue of *Physics Today* in 1994 that dealt exclusively with the emerging new relations between physics and biology. They said "interface between physics and biology .... is a cross field endeavour to which physicists can make major contributions. But to do so, they need to learn enough biology to be able to talk with biologists and to distinguish problems that are central from those that are peripheral. Since much of biology is descriptive, the physicist has a strong advantage: It is much easier for a physicist to learn biology than for a biologist to learn physics". This really summarises the essence of the underlying problem in forging these partnerships.

The problem of the language and the cultural barriers between different disciplines is a serious one. Learning the language from another discipline and also teaching the language to a practioner of another discipline is not an easy job. Only those scientists, who have lared to learn other skills and languages from adjacent disciplines will eventually make a mark. It also seems to me that interdisciplinary scientists will have to be great communicators too. They will have to constantly exchange information in a 'jargonless' way and also pass on their infectious enthusiasm by communicating skillfully.

As an engineer myself, I find the vanishing of boundaries between engineering and science absolutely fascinating. A new breed of "engineering scientists" is emerging. I believe that such engineering scientists will be real "compatibilisers" when it comes to forging of new partnerships.

Let me explain the role of an engineering scientist. To do so, I would like to give an analogy with the medical school. We have there basic scientists, who generate new knowledge, but it is knowledge for its own sake. Then we have the hard core practising clinicians, who use the established tools in their everyday practice. But in between these two communities, there are those academic clinicians. They are the ones who understand the language of the basic scientists and they are the ones who know the demands of the profession, as reflected by practising clinicians. What these academic clinicians do is to use the methods of science to develop new tools and new paradigms that the practitioners would find most helpful. They also communicate the needs of these practitioners to the scientists. The academi clinicians thus play this great role of facilitators. To my mind an engineering scientist is like an academic clinician, a facilitator. His task is to look at the continuous advances that take place in basic sciences such as chemistry, biology, physics, etc. He would harness this knowledge to develop new tools, which hard core engineers

would put to use. The richness of the profession, therefore, will depend very critically on the vitality of the engineering scientists and also on the rich variety of skills, tools, etc. that they bring into the profession from adjacent sciences.

The leadership in science tomorrow will rest with those who are daring to travel the intellectual path by recognising the key role of cross-disciplinary partnership between scientists and engineers from different disciplines. Advances will be the sum total of numerous creative ideas and interdisciplinary cooperation. In industry, individuals with diverse scientific and technical backgrounds tend to work together in a mission mode. The driving force for industry is continuous innovation to displace one's own product by oneself- with the well known fear of someone else displacing it otherwise for them. Unfortunately, the concept of interdisciplinary research and development has not gained as much ground in academia, especially in India, as one would have wished. And this is really sad because innovation is not a undimensional process. It is comparable to the intermeshing gears of a clock. The challenge before us is to make this intermeshing happen. This is really the core issue in the partnership between different disciplines.

Science - Business Parnership

The second crucial partnership is between science and business. In India, the partnership between the industry and our own R&D institutions has been very weak. Massive efforts need to be made to strengthen it, since, Indian R&D institutions could play an increasingly important role in the process of global competition, restructuring of the economy and in upgrading the local industry to gear it to face the international competition successfully.

A change of mind sets will be required all around. Our Indian industry will have to champion R&D with a vigour. Apart from willingness to invest in R&D, the Industry should be willing to take risks and should have patience to wait for returns.

The concept of partnership between the productive sector and R&D institutions will have to undergo a dramatic change from the current practice. Publicly funded R&D institutions should be used as *idea generators and providers of new concepts*. Indian industry should be prepared to assume the role of partners, who have the technical, financial and marketing strengths to take ideas to the market place. Industry should not simply look at institutions as super markets, where off the shelf technologies are sold. In the true spirit of partnership, the industry should willingly integrate national R&D

resources into their business strategy. All this would be possible only when we can change the climate for an interaction between our institutions and the industry with an improved communication and understanding, faith in mutual growth and development of healthy working relationships. Today there seems to be a difficulty in forging this partnership, because the institutions and the business units in industry have different cultures. The fact that science has to make an economic sense has not been realised by our institutions. On the other hand the fact that competitive advantage in business will be reached by using cutting edge science and engineering has not been realised by our industry. There are basic incompatibilities which need to be resolved. The institutions have a long term horizon on R&D, whereas the business units have a short term horizon. As regards the financial structure, R&D units are considered as cost centres whereas the business units would want them to be profit making centres. As regards the products emerging from R&D laboratories, these invariably come out as some sort of packages containing knowledge and information, whereas the business units will have to convert these into goods and services, which are saleable. There is even a difference in the orientation between the institutions and the industry. The institutions work on the basis of scientific novelties and perceived needs, whereas the business units work on the basis of

attractiveness in the market and potential for profit. There is a need for both the R&D institutions as well as the business units to change their culture. Only then will we be able to forge these crucial partnerships, which will move the country ahead.

In this context, I might want to seek your indulgence to speak briefly about my own organisation, Council of Scientific and Industrial Research (CSIR). With a chain of 40 laboratories, employing 10,000 highly qualified scientific and technical personnel, CSIR is trying to open up a new chaptter in the partnership with industry by linking its research to market place. We have just released a white paper entitled *"CSIR 2001 : Vision and Strategy"*. It represents a vote for change by the members of the CSIR family. It sets out a new dream and a vision. CSIR has the dream to become a model of organisation for scientific industrial research, which implies that it will do industrial research with cutting edge science rather than doing scientific **and** industrial research with no connection between the two. CSIR wants to be a path-setter in the shifting paradigm of self-financing R&D. It has the vision to become a global R&D platform providing competitive R&D and high quality science based technical services world over.

This vision cannot be achieved unless a close partnership between science and business is forged. CSIR's business strategy would seek

to link and relate its R&D to market palce by studying and analysing technology and market trends and forecasts to identify niche opportunity areas, partners, customers, competitors and markets. CSIR will be evolving a balanced portfoiio of projects; some that are industrially led, cost shared and market driven whilst others that are self propelled and create new processes, products, applications and market. CSIR will be exploring and establishing synergistic alliances, consortia and networks that minimise costs and risks of R&D and optimise on value addition and returns on ouputs.

All of this would necessitate continuous interfacing of CSIR's knowledge workers with the market place, an activity that could be best done through effective business development and marketing systems. CSIR realises that marketing of R&D knowledgebase is different from marketing of physical products and goods or even services. It is best done by persons who are closest to and involved with the generation of the knowledgebase as they are emotionally attached and well versed with diverse nuances and variations of it. Thus **the entrepreneur in a scientist** would be awakened, so that he could venture out in the knowledge marketspace. The strategy to further enhance the marketing of CISR knowledgebase would be to develop, through appropriate training, skills of scientists for diverse aspects of business development and marketing activities. Select

CSIR laboratories will be allowed to set up separate comanies for business development and marketing. With a step jump in ambition, CSIR will even twin with R&D institutions and organisations to realise synergy of business opportunities. The new models of science and business partnerships will hopefully represent the microcosm of change that we are all looking for.

I was truly delighted to see that ISI strongly believes in the value of this science-business partnership and provides specialist help to Indian industry in the areas of statistical quality control and operations research. In the new global competition that the Indian industry will face, quality improvement and productivity enhancements obtained through the rigorous tools provided by ISI, will be a great catalyst for Indian industry. I do hope that ISI will set up new models of science-business partnership for mutual growth.

Global R&D Partnership

The third partnership is between R&D providers and seekers across continents. The chain of concept to commercialisation necessarily crosses transnational boundaries today. Thus many major multinational corporations in USA and Europe, whose R&D budgets are larger than even India's R&D budget, are becoming partners of India's R&D laboratories. For India, rather than remaining a perennial

seeker of technologies from the west, opportunities are opening up for doing even reverse transfer of technology. Why is this new paradigm shift taking place?

Many companies across the world today consider it to be rather unwise to attempt for self-sufficiency in technology development, particularly in an era, where the R&D costs are increasing rapidly. The concept that technology could be acquired rather than re-invented is gaining momentum. As a part of the global innovation strategy, several companies world over are scouting for new ideas and patents. These companies believe that the surest way of becoming technically strong is through net working with premier organisations across the world. In an era of global connectivity through modern information technology, the concept of **virtual laboratory** is gaining ground.

External technology acquisition is assuming importance within leading corporations. R&D departments are increasingly being charged with the job of managing and restructuring the corporation's technology portfolio. Their success is being measured in terms of what they have brought to that portfolio.

Basic skills are gaining importance and the new paradigm is skill based competition. Indeed as product life cycles keep on becoming

shorter, skill-life cycles become longer. The product then is merely an intermediary between company's skills and the market it serves. Rather than being the focus of corporate activity, products are actually transient mechanisms by which the market derives value from a company's skill-base and the company derives value from the market. The high technology companies are therefore asking as to what skills, capabilities and technologies should they build up, rather than asking a stereotype question, as to which markets should they enter, and with which products. The competitive advantage lies in the power and effectiveness of the allied network, which a business team is able to assemble and manage in a short time, rather than in the in-house capability. This stategic shift is shaping up new global partnerships.

Several factors are helping to accelerate these new partnerships through globalisation of industrial R&D, but the most important factor that is helping the process of creation of **seamless laboratories** around the world is the evolution of a global information networks Indeed these networks are allowing the real-time management and operation of laboratories in any part of the world. Thus, companies are seeking to gain a competitive advantage by using the **global knowledge resource** and working with a **global time clock.**

Realisation of the power this major paradigm shift means enormous opportunities for Indian R&D institutes. There are unlimited opportunities that are opening up. I recall with great satisfaction my speaking to the scientists of National Chemical Laboratory when I took over as the Director of his laboratory on 1 June 1989. I said that we should have the dream of converting the National Chemical Laboratory to International Chemical Laboratory (NCL). What I meant was that we should partner on equal terms with some of the biggest giants in the world. The idea was that they will put the capital on the table and we will match it by our intellectual capital. After all India may be a developing country, but it certainly is a developed country as far as its superb intellectual infrastructure is concerned. We are proud that we began the process of global R&D partnerships in NCL in 1989, well before July 1991, when India as a nation formally decided to integrate its economy with the global economy. NCL entered the global market in 1990 by signing an agreement for sale of its catalyst technology with a multinational company from Netherlands. This was the first time such a reverse transfer of technology was taking place in a high tech material. NCL had also won a consultancy contract in China in 1990 by competing with reputed US consulting companies. This initial success led to number of other companies joining hands with NCL. Names like General

Electric, Du Pont, FMC, Ciba Geigy, Oxychem, Exxon, who are all known giants in the international arena, have become NCL's partners. This phenomenon has, of course, spread wider today. Several examples come to my mind.

Let me cite some examples from the CSIR family itself. CDRI in Lucknow has developed an anti-fertility drug, centchroman, and it is now collaborating with a US-based firm on attractive terms. IIP in Dehradun has developed a process for the oxidation of cyclohexane to adipic acid along with an Indian company, Adarsh Chemicals. They have signed an agreement for joint development with ABB Lummus Crest Inc. and Praxair Inc. USA. NAL in Bangalore has partnerships in fatigue research with Boeing, a leading company. NAL has won a global tender for feasibility studies and computer models on aircraft and helicopter wake vortices for the Civil Aviation Authority of the United Kingdom. It is an interesting thought that NAL's work will have a bearing on the frequency of landing of aeroplanes at Heathrow airport in London! Antrix, the marketing arm of the Indian Space Research Organisation (ISRO) has won international contracts for studying low earth orbit satellite systems, antenna for handheld phones, etc. Indian R&D outfits are making major strides elsewhere too. Take supercomputers based on massively parallel processing mode. C-DAC has built up an international reputation with its PARAM

supercomputers. It has already sold its computers to institutions in Britain, Canada, etc. It is trying to set up a commercial arm now so that it could market its products worldwide. It has built strategic alliances with S.G.S. Thomson from Europe, Concurrent system in Japan and Nextore in US in a variety of high-tech computing endeavours. The dream of India as a global R&D platform will be realised sooner than later.

I want to emphasise that we must know where to compete and where to cooperate. Eventually all efforts on industrial research and development in India must be primarily aimed towards making the Indian industry globally competitive. This would imply that the R&D institutes in India will have to draw out a balanced portfolio of business, which includes international collaboration efforts coupled with a major focus on Indian industry. It is also clear that the leading companies from the developed world will seek the very best minds that are available in our publicly funded R&D institutes. But we must also ensure that the same minds are available to the Indian industry too.

We will also have to worry about competition, which will be emerging in Asia itself. Philippines, Taiwan and China are making serious bids to enter the global software industry. In biotechnology, Taiwan and

Singapore are much ahead of us. We also should not underestimate China in the long run as far as process technology is concerned. We have only a narrow window of opportunity before some of these countries cover up their deficiencies like language problems, modern management practice, etc. and surge ahead of us. To seek a lead initially may be easy but to maintain it is going to be tough. If we focus, innovate and keep our ambitions of leadership through technology high, then I see no reason as to why India cannot emerge as a global R&D platform.

Partnership with Nature

Let us come to the fourth partnership viz. the partnership with nature. The society is increasingly beginning to realise the importance of this partnership and it will not forgive any offenders, who do not respect the sanctity of this partnership. There is a growing realisation that the sociocultural roots of our present environmental crisis lie in the paradigms of scientific materialism and economic determinism which fail to recognize the physical limits imposed by ecological systems on economic activity. The future economies must expand within ecosystems which have limited regenerative capacities. Contrary to the neoclassical theory of continuous material growth, economic activities can undermine the potential for development through

over-exploitation of natural resources, and indirectly compromise future production through the discharge of residuals. The old ideas of **quantitative growth** must give way to the idea of **qualitative growth** within the limits of the ecosystems.

The key question is how do we reconcile developmental goals with ecological capabilities? The carrying capacity based planning process, innovative technologies for enhanced material and energy effectivity of production and consumption, structural economic change towards less resource - intensive sectors, and preventive environmental management through increasingly interventionist policies are some of the strategies for reconciling developmental goals with ecological capabilities.

Promotion of environmentally sound technologies warrants large scale technological substitution towards environmentally-benign technologies. Industry as well as R&D institutions will have to change their focus sharply to greener technologies of industrial production, recycle and reuse technologies for end-of-pipe treatment and integrated technologies that minimize cross-media transfer of pollutants thus minimizing overall pollution-induced risks in all environmental components. Emphasis on biotechnology for substitution of non-renewable with renewable resource base would

move the chempresent to biofuture.

In general, there are three broad groups of resources upon which economic activity is based, viz. non-renewable resources, renewable resources, and information. The sectors of economy that deal with non-renewable resources are environmentally the most problematic. Restructuring of the economy by substituting environmentally harmful endeavours with equally productive but environmentally compatible ones could form an important strategy in the economic policy. Developmental planning, henceforth, should aim at raising the levels of both ecologic and economic efficiency by increasing material and energy effectivity in production and consumption in order to minimize the expenses on environmental protection while keeping the cost of natural resource exploitation within acceptable limits.

If partnership with nature has to be given its rightful place, then we need a change in our systems of valuation as well as value systems. For instance, we are well used to the conventional indicators of economic growth measured in terms of Gross National Product, Gross Domestic Product, etc. Should we not think in terms of new indicators such as **Gross Natural Product** or even **Gross Ecological Product?**. Such indicators will not only themselves

measure growth but be indicative of ecologically-sound structural changes in economy. The acceptance of these indicators will also send strong signals about the respect we have for partnership with Nature.

I am happy to say that in a small way, we have already initiated this process. A macro indicator of qualitative growth that is being researched for National Capital Region by CSIR is the Gross Ecological Product (GEP). The concept of GEP essentially involves the deduction of the value of raw material and environmental costs from the GNP. These costs relate to abatement measures and environmental damage caused by residuals. GEP is being estimated by CSIR in Yamuna Basin through the process of Natural Resource Accounting (NRA). If this exercise proves successful, then it might become a universal indicator that could be followed everywhere in the world.

We will have to build a society that believes in partnership with nature. Then only will the consumption will be conscious and restrained. This will require a change of mindsets everywhere. New and different decisions will have to be made in corporate boardrooms as also in national capitals. Such decisions will have to put the needs of the

planets ahead of the profits of the corporation and its shareholders. The Chief Executive Officer of tomorrow will have to view himself as Chief Environmental Officer.

Finally, I firmly believe, that we need to generate a new breed of **ecopreneurs,** who will lead the governance of the globe on the basis of this respect for partnership with nature.

I do hope that all the graduates that are going out in the new challenging world will be involved in atleast one or more of the four partnerships that I have laid out for you. I firmly believe that the next century will belong to Asia and India will have a chance to lead provided we all understand and fully use the dynamics of these four profound partnerships that I have spoken about today.

Let me once again say what a tremendous pleasure and what a great privilege it has been to be amongst all of you. Let me once again congratulate you and express a fond hope that each one of you will reach out to reach not only your own potential, and may I say, even surpass it.