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ADDRESS BY

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The New Millennium Challenge for Indian Science and Technology

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'The New Millennium Challenge for Indian Science and Technology'

Hon'ble Chancellor, Vice-Chancellor, Distinguished members of the faculty, Proud parents, Graduates of the Year, Distinguished Guests, Ladies and Gentlemen.

I consider it to be a great honour and a special privilege to have been invited to deliver the Convocation Address. This university is unquestionably the pride of India. This university has been built assiduously by some of the most eminent men of India. The rich traditions of scholarship and academic excelience of this Institute have been sustained for several decades. The graduates of this university have done the nation proud. There are enormous expectations from everyone about this university's role in building the new India.

Let me begin by extending my congratulations and my very best wishes to the young graduates. As you leave this university, 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 five years ! There has been a seachange 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 extra-ordinary opportunities for those, who are prepared to face these challenges. 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 making things happen on our own terms.I firmly believe that all this will be possible.

We await the dawn of the next millennium with excitement and anticipation. Around the world today, there is a discussion and debate on designing the future of societies and nations in the new context that is going to emerge. However, dreaming about the next few

centuries ahead of us is a very difficult task; indeed an impossible one. As you know, the knowledge is doubling in approximately 10 years now. The ability to speculate on the future is more difficult now than ever before. Even when the pace of change was nowhere near, what it is today, the forecasts made by some of the brightest minds went so wrong.

Let me recall one such effort. In 1937, the American National Academy of Science organized a study aimed at predicting breakthroughs of the future. Several wise statements about agriculture, synthetic rubber etc. were made. They were essentially based on an imaginative extrapolation of the present. But it missed all the things that happened. It was amusing that in their prediction, there was no mention of nuclear energy, no antibiotic (although it was just 8 years after Fleming), no jet aircraft, no rocketry, nor any use of space! And these are precisely the technologies that have dominated our lives in the last few decades.

Looking Back

Inspite of the hazards of looking into the future, let me make an attempt to size up the challenges that are ahead of us. But first, let me begin by looking back a little bit. As we look back, one finds that Indian gains in the postindependent India are sizeable. We have functioned as a nation in spite of the cultural, social, political, economic and religious diversities and integration of states. We have a vibrant democracy, an independent judiciary, and a diversified and widespread industry. We lacked economic or military clout, yet we contributed significantly to the establishment of an equitable world order.

Inspite of all that we have achieved, several formidable challenges remain: exploding population, widespread poverty, illiteracy, squalor, ruptures & cleavages based on region, religion, language and gender threatening the social fabric, urban congestion, wounded ecosystems, critical power and energy situation. Almost as many Indians are below the poverty line and illiterate as the entire population of India in 1950. Another dimension to the challenge has been added by globalization in terms of both economy and geopolitics. Never before

in the history of mankind, did a country with democratic dispensation had to feed so many poor and teach so many illiterates and also simultaneously compete with the most advanced countries for a place under the sun. We enter the next millenium, therefore, with a great challenge.

Inspite of the problems, we have all the prerequisites to convert them into opportunities. For this, we need a fresh thinking. We need a new vision of India. This vision cannot merely be a derivative of the past. It has to be, of course, based on the reality of the present, but it has to have a boldness, ambition and hope, which is commensurate with the aspiration of this great nation. I am confident that Indian S&T can play a vital role in setting up the new vision and also making it happen.

Indian S& T in the Past

One might ask, as to what gives us this confidence? The strong S&T base of India, in my judgement, gives us this confidence. We go back to the great architect of this base, namely, Pandit Jawaharlal Nehru. To Pandit Nehru, science was not only a tool for economic development but also a means of emancipation of man and qualitative transformation of a stagnant society. The 1958 science policy resolution reflected his own belief beautifully "it is an inherent obligation of a great country like India with its tradition 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".

It was this vision, which spurred the Indian scientists on. If we look back on our achievements, we can say with confidence that the Indian science and technology in the post-independent India has done us proud. Thanks to the *'green revolution'*, India is able not only to feed its millions but has enough to spare and export. The *'white revolution'* has made India the largest milk producer in the world last year.

With a comprehensive defence R&D infrastructure, India is among the few countries of the world, which makes the most sophisticated weapons and weapons systems, including missiles of various

descriptions and multi-barrel rocket systems. It has developed low-level tracking radar, night vision devices, and sophisticated ship sonar systems. An indigenous light combat and a remotely piloted vehicle are at an advanced stage of development. Today, India ranks among the few nations of the world that have a credible capability in space science and technology, including design and construction of satellites and launch vehicle technology. India's capability in nuclear science and technology including nuclear fast breeder reactors has been the result of indigenous efforts. The entire range of technologies from prospecting of raw materials to the design and construction of large nuclear reactors is now available on a self-reliant basis.

There have been other proud moments in Indian science and technology. We had path-breaking developments in parallel computing, breaking into the export market for supercomputers, and India has unveiled the new, PARAM 10000 supercomputer, with a capability of 100 Gigaflops (100,000,000,000 mathematical operations per second). The open frame architecture of CDAC's Param 10000 places India in the League of Nations, which are expanding the frontiers of supercomputing to teraflop range. Presently, only USA, Europe and Japan have such technological capability. Further, India has the status of a world leader in the development of software-based language translation, which finds application in pagers and computers for non-English speaking users. Our software exports are growing with over 50% annual compounded growth rate over the past few years and India has already unravelled the plans to become a software superpower.

The Way Ahead

We can thus feel confident about the future. What should be our policy then? Our policy on science and technology would have to be directed along five lines. The first priority will be to use the great powers of science and technology to meet the basic human needs particularly taking note of locale-specific situations; these would relate to food, health, water, energy, employment, shelter etc. The second would be to use science and technology to create wealth, both by enterprises as well as by individual Indian entrepreneurs. The third would be to embark on a major thrust in emerging knowledge based

areas such as informatics, biotechnology, new and renewable energy sources, new materials and environment-related programmes. In all of these, India can make a major headway and surge ahead of the rest of the world and use this position to its advantage in the global technological scenario. The fourth relates to strategic areas, where for love or for money, technologies will not be available to us. This would involve nuclear energy, defence research and space science and technology. Fortunately, we have built self-reliance and enormous capabilities over the past few decades in all these areas.

What is our stock-in-trade? The world acknowledges the high caliber of Indian scientists, engineers and technologists. The obvious proof of this is the fact that while products of few other Indian enterprises command international prestige and price, the products of our higher educational institutions are in great demand internationally. The contribution of Indians to the growth of science and technology in developed countries has been widely appreciated.

Can we not then garner all these energies and contribute to building the new India in a TEAM INDIA spirit? We certainly can. But for this to happen will also need to ensure that the finest minds, who seek to work on what excites them most, are provided with the environment and opportunity to pursue their interests with the fullest zeal. The government has the prime responsibility to create a great leveraging by using the large base of highly trained manpower created by its institutions of higher learning. The Indian hopes of the next millenium will have to be pinned on this rich resource.

Taking Steep Jumps in Ambition

Even in cases, where we have been successful, we will have to set new benchmarks, new targets and raise our ambitions. Let us take two examples, where Indian success has been acknowledged by the whole world; the first being 'green revolution', the second the 'white revolution' and the third the 'grey revolution', namely India's rapid forays into global software market, where the Indian brains, its 'grey matter' has been used powerfully.

Let us first take 'green revolution' as an example. At a point of time in our history, we went to the western world with a begging bowl for food. Then came the green revolution. It was not merely the innovation by agricultural scientists. Innovative extension models, participation of farmers in the innovation movement and so on were responsible for its success. Indeed a positive policy support, liberal public funding for agricultural research and development and dedicated work of farmers contributed to its success. But what about the future? We have the daunting task of feeding almost 1.5 billion people with about 350 million tons of foodgrains by 2040. The increased production has to be attained with minimal ecological damage, failing per capita arable land, less irrigation water and less fossil fuel based energy sources. This needs an innovative blending of technology and experience. Here,on the one hand, we will need to deploy cutting-edge advances in modern biotechnology, space technology, information technology and renewable energy technology; on the other hand, we will need to take cognizance of the best in India's traditional agricultural wisdom and prudence.

Let me dwell on this a bit further. It is only through the blending of the "gene revolution" with our experience in the 'green revolution', that we can reach our goal of 'evergreen revolution' and also 'nutritional revolution'. The advantage of the gene revolution is that it is relatively scale neutral, and therefore, in principle, it should benefit the big and small farmers alike. It can also reduce a farmer's dependency on chemical inputs such as pesticides and fertilizers.

Sir Francis Bacon had once said: *"it would be an unsound fancy to expect that things which have never yet been done can be done except by methods which have never been tried"*. We therefore require a new approach, and modern biotechnology offers that approach. Indeed, modern biotechnology will offer great opportunity for enhancing genetic potential of crops and other commodities, management of biotic and abiotic stresses, bio-remediation, waste management and organic recycling. India is one of the main centres of agricultural biodiversity and its gene richness can greatly complement the developments in modern biotechnology. Likewise, new developments in GIS, remote sensing and crop modelling provide new opportunities for integrated management of natural resources.

Let us now take 'white revolution'. We have become the highest producers of milk displacing USA to the second position. This was due to the Operation Milk Flood. How did it take place? It was not simply the innovation in animal and dairy science and technology. Great visionary leadership provided by Dr. Kurien, a bold new model of NDDB, novel role of cooperatives etc. made it all possible. But again in the next challenge let us realize that India can beat anyone, when it comes to cumulative numbers. It is the per capita, it is the productivity, it is what we achieve per animal or per physical input per day, per man-hour, where we take a beating. So the next innovation chain in the white revolution will have to focus on this aspect. Also moving up the value chain will become crucial. For example, our exports of milk based value added products are miniscule (0.05% share of global trade), and the next innovation cycle will have to address this issue through innovative technological interventions.

We have a dream to make India a software superpower of the 21st century. A compounded annual growth of 55% in the last five years gives us a hope that we can reach $50 billion export within the next ten years. But for all this to happen, we must move up the value chain. IT companies need to develop innovative and world class software products and not just rely on providing software services. Let us not forget that a tiny country like Israel has IT companies, whose market capitalization is around 60 billion dollars as against around 20 billion dollars of all of the Indian software companies put together; and this is inspite of the fact that the number of software professionals in India is several times higher. We will also have to convert handicaps into opportunities through innovative and daring approaches. For example, certain basic infrastructure is necessary for IT industry to boom. According to the experts, there is a golden opportunity to leap frog several generations of technology and go directly to the latest technologies. In the 1980s France had extremely backward telecom infrastructure. But they directly jumped to the latest technology. Doing this will, of course, require daring and vision and the IT task force set up by the Hon'bie Prime Minister, I am happy to say, has given such a mood and tone.

Blending Indigenous Knowledge and Modern Science

Many societies in the developing world like India have nurtured and refined systems of knowledge of their own, relating to such diverse domains as geology, ecology, botany, agriculture, physiology and health. We are now seeing the emergence of terms such as 'parallel', 'indigenous' and 'civilizational' knowledge systems. Such knowledge systems are also expressions of other approaches to the acquisition and production of knowledge. They were, as yet, neglected by modern science, as the pharmaceutical industry has realized.

The growing dominance of a single view of the natural world as expounded by modern science will undermine these knowledge systems. Further, the process of globalization is threatening the appropriation of elements of this collective knowledge of societies into proprietary knowledge for the commercial profit of a few. These fragile knowledge systems need to be protected and enhanced through national policies and international legislation, while providing its development and proper use for the benefit of its holders.

In particular, a greater awareness about the cultural relationships between various knowledge systems needs to be created. A systematic and in-depth analysis of the parallelism of insights between indigenous and civilizational knowledge systems, on the one hand, and certain areas of modern science concerned with fundamental aspects, on the other will have to be launched. In particular, a strong linkage between the indigenous knowledge holders and scientists will be needed in the new millennium to explore the relationship between different knowledge systems. Some of the greatest opportunities are provided, especially in the Indian context, in the area of traditional medicine.

Creating a New Perspective on Intellectual Property Rights

Increasingly knowledge is being recognised as a source for wealth creation. However, in the new world, it is only proprietary knowledge

that leads to wealth creation. In the world of knowledge based competition, Intellectual Property Rights will emerge as a key strategic tool. In this, India lags behind others and clearly the continued illiteracy in IPR domain will hurt us. Incorporating strong systems on generation of intellectual property, its capture, documentation, protection, evaluation and exploitation will need massive thrust.

The issue of patents in particular, has created a national interest and debate of great dimensions. I thought it might be useful to focus on this specific area. A weak physical infrastructure, inadequate intellectual infrastructure, poor public awareness and delays in framing and implementing government policies are hurting India today. We are behind the rest of the world in patents, both quantitatively and qualitatively partly because of our emphasis on imitative research and partly because of lack of awareness of the power of IPR in assuming a predominant position among institutions and enterprises.

Skills in filing, reading and exploiting patents will be most crucial in the years to come; but our ability to read or write patents is very poor. Neither can we properly protect our inventions nor can we understand the implications of the patents granted to our competitors. Manpower planning for IPR protection needs priority. IPR must be made a compulsory subject matter in the law courses in the universities in India. Our graduates coming out of engineering and technology streams have no idea about IPR, and yet it is these young people, who will have to fight these emerging wars in the knowledge markets. Judicious management of patent information will require well-structured functioning of information creating centres, information documenters and retrievers, information users, IPR specialists and information technology experts.

Renaissance of Indian Science

Basic science is an endless frontier, a uniquely human activity without limits. This pursuit is guided by the spirit of discovering truth and it is universal in outlook. The decline of Indian contribution to this endeavour, both qualitatively and quantitatively, is a matter of deep concern. To build a strong edifice of basic research, new mechanisms, including funding, will have to be set up.

The investment in as well as quality of the Indian basic research in the new millennium will have to undergo sea change. We will aim for world leadership at least in some areas. The new Indian science will be one that leads and not one that follows. It will be based on daring and creativity. Promoting curiosity based basic research with a new sense of adventure would be the Indian endeavour in the next millennium.

Realising science as a social movement and development of scientific temper as part of intellectual, emotional, social and cultural life of our masses demand not merely a governmental program but predominantly a program of action undertaken by leaders in different walks of life, peoples groups and non-govemmental organisations.

One of the hallmarks of the Indian civilization from the very ancient times was to develop harmony with life and nature and to establish the infinite potential of human development. As a long term vision, India should lead the world in establishing and demonstrating the harmony between science and spirituality, in the development and application of science with ethics as the backbone. Scientific temper and true joy of science will be unfolded when the harmony between the science and the mankind's highest quest is achieved.

About Young Innovators

How do we create young scientists who will be ready to face the challenges of the early part of the new millennium? Do we have educational systems in place at all, which will be cater to the millennium challenge? I do not think so. India will have to remould the school science education radically, if we have to build the innovative India of our dreams. Science education will have to be based on the principles of 'learning' in contrast to the prevailing text-book centred *'learning by note'* method. A child will have to become an active participant in the process of learning science through field studies experiments, observation, recording, analysis and discussions. The prevailing discipline-centred approach must give way to a child-centred approach. Science curriculum must relate closely to science and technology experiences of everyday life.

We will have to take into account all the factors that effect the teaching process in the classroom and tackle all of them in an integrated manner. Thus, the total package is concerned not only with curricular innovation but also with teacher training, kits to do experiments with, examination system, school administration, extra curricular inputs, etc. all of which have been suitably modified to form an innovative package. It is only then that we will be able to create the right environment in which a young scientific mind will be able to flower and express itself.

And Finally

We will need a bold national S&T policy, but more than that we need a national innovation policy. A strategy based on a national system of innovation includes S&T, but goes beyond that by seeking in addition to promote changing the ways in which society and economy do things. A bold and visionary *National Innovation Policy,* which invites a creative participation of every individual in nation building has to be launched. I have every hope that we can create the new India of the new millennium, which will not only reach its potential but surpass it.

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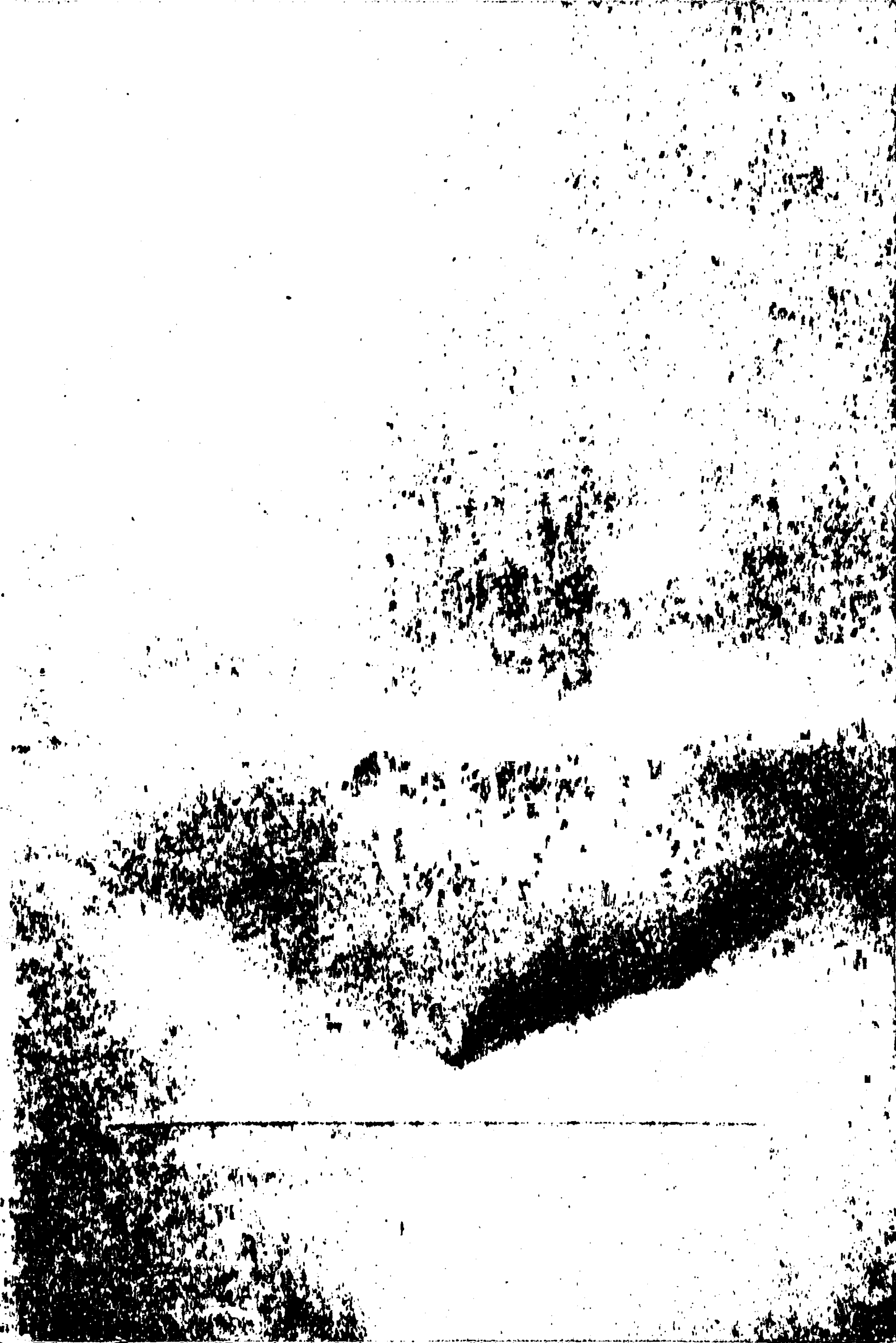

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