

Indian R&D Scenario - Some Random Reflections

By

Dr. A. V. Rama Rao

*Former Director, IICT &
Chairman & Managing Director
AVRA Laboratories Pvt. Ltd.
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opportunity to share my views on a subject which was very much dear to Dr Y Nayudamma. Although, I heard of Dr Nayudamma as Director of Central Leather Research Institute (CLRI) and knew of his scientific contributions after I joined National Chemical Laboratory (NCL) in 1960 as a Research Fellow, my first meeting with him was in 1972 at Prof K Venkataraman's residence (the first Indian Director of NCL and my research supervisor) when Dr Nayudamma visited NCL as Director General, Council of Scientific and Industrial Research (DG, CSIR). He was an exception amongst the then breed of scientists in the CSIR as he had succeeded in transforming the art of leather processing into science and finally to technology in this country. During his tenure as DG, CSIR (1971-77), concepts such as input-output analysis of R&D, multi-disciplinary teams, application of science and technology for societal needs, and decentralisation of decision making acquired firm roots. I accept the honour you have bestowed on me with humility and shall make an attempt to share my perceptions on Indian science and the R&D scenario, hopefully in the spirit visualised by the pioneers like late Dr Nayudamma.

Science is not something alien to Indian culture. Our forefathers, beginning from the vedic period and spanning several millennia thereafter, have made highly significant contributions to scientific thoughts, principles and practices. Rig Veda contains the earliest exposition of evolution of the Universe and live systems. Their discoveries in the fields of astronomy, mathematics, medicine, engineering, architecture, physics, chemistry, metallurgy and fermentation technologies are truly awe-inspiring. Archaeological excavations stand testimony to their superior technological skills in the areas of cotton textiles and dyeing (Mohenjadaro exhibit); fabrication of zinc and iron smelters; architectural monuments built to a high degree of practices involving extraction, condensation, distillation, heat and mass transfer principles and a variety of fermented liquors reported to be in everyday use at that time. I do not propose to talk on ancient science of India, for which it may take several days, but I only wish to stress the fact that science, research and development have remained an integral part of our tradition throughout the ages. May be they were relatively dormant during the 200 years of colonial domination, but Indian creativity found its expression even before

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INDIAN R&D SCENARIO - SOME RANDOM REFLECTIONS

I deem it a great honour to have been invited by the Administrative Staff College of India to deliver this prestigious Dr Y Nayudamma Memorial lecture. I am thankful to the Chairman and the Board of Governors of this organisation for this gesture and for giving me an opportunity to share my views on a subject which was very much dear to Dr Y Nayudamma. Although, I heard of Dr Nayudamma as Director of Central Leather Research Institute (CLRI) and knew of his scientific contributions after I joined National Chemical Laboratory (NCL) in 1960 as a Research Fellow, my first meeting with him was in 1972 at Prof K Venkataraman's residence (the first Indian Director of NCL and my research supervisor) when Dr Nayudamma visited NCL as Director General, Council of Scientific and Industrial Research (DG, CSIR). He was an exception amongst the then breed of scientists in the CSIR as he had succeeded in transforming the art of leather processing into science and finally to technology in this country. During his tenure as DG, CSIR (1971-77), concepts such as input-output analysis of R&D, multi-disciplinary teams, application of science and technology for societal needs, and decentralisation of decision making acquired firm roots. I accept the honour you have bestowed on me with humility and shall make an attempt to share my perceptions on Indian science and the R&D scenario, hopefully in the spirit visualised by the pioneers like late Dr Nayudamma.

Science is not something alien to Indian culture. Our forefathers, beginning from the vedic period and spanning several millennia thereafter, have made highly significant contributions to scientific thoughts, principles and practices. Rig Veda contains the earliest exposition of evolution of the Universe and live systems. Their discoveries in the fields of astronomy, mathematics, medicine, engineering, architecture, physics, chemistry, metallurgy and fermentation technologies are truly awe-inspiring. Archaeological excavations stand testimony to their superior technological skills in the areas of cotton textiles and dyeing (Mohenjadaro exhibit); fabrication of zinc and iron smelters; architectural monuments built to a high degree of practices involving extraction, condensation, distillation, heat and mass transfer principles and a variety of fermented liquors reported to be in everyday use at that time. I do not propose to talk on ancient science of India, for which it may take several days, but I only wish to stress the fact that science, research and development have remained an integral part of our tradition throughout the ages. May be they were relatively dormant during the 200 years of colonial domination, but Indian creativity found its expression even before

independence through the contributions made by brilliant personalities like Ramanujam, Bose, Raman and other intellectual giants.

After independence our first Prime Minister, Pandit Nehru felt that science and technology was essential for national development. He had great expectations from scientific research which was reflected in his words at the Indian Science Congress at Allahabad in December 1937.

“Science was the very texture of life without which our modern world would vanish. It was science alone that could solve these problems of hunger and poverty, of insanitation and illiteracy, of superstition and custom and tradition of vast resources running to waste, of rich country inhabited by starving people”.

During the first half of this century a definite relationship between scientific research and economic development was discernible. We tried to emulate this goal and created several educational institutions and research organisations. We were fortunate that at the time of our Independence, we had eminent leaders of science with vision and dedication—S S Bhatnagar, H J Bhabha, P C Mahalanobis and others, who were responsible in building scientific organisations which have now become schools of excellence in selected areas. At that time there was political will and patronage to promote science and technology development in the country. In the address to the 37th session of the Indian Science Congress at Pune in 1950, Jawaharlal Nehru said:

“There is no doubt that in India there is growing realisation of this fact that the politician and the scientist should work in close cooperation. The solution of all social and economic problems depend on this cooperation and no state can afford to ignore this fact”.

Nehru gave a free hand to science planners and allowed them to expand the organisations such as Council of Scientific and Industrial Research (CSIR), Indian Council of Agriculture Research (ICAR), Indian Council of Medical Research (ICMR), Atomic Energy, Space and Defence Research in the country. He also created excellent training centres such as IITs and Regional Engineering Colleges to train young boys and girls in science and engineering to mould them as future leaders.

I belong to the CSIR family since my post-graduation days, first as a research fellow for 5 years, and subsequently as a member of the research staff in various capacities at the National Chemical Laboratory (NCL) and the Indian Institute of Chemical Technology (IICT), lasting for

over three decades. My reflections on Indian R&D scenario, which I am planning to share with you today, will no doubt be drawn largely from my own experiences. Earlier, Dr Nayudamma too belonged to the CSIR, first as a leading leather technologist at CLRI and later as the Director General of the CSIR (1971-76). In my talk therefore there can be minor digressions whenever I attempt to compare my own experiences with the hopes and aspirations which the late Dr Nayudamma had for the research laboratories under the CSIR.

CSIR stands for both Scientific and Industrial research. Science was given first priority, because many of our scientific leaders of pre-independence days believed that good science alone will lead to good technologies. This is true even in today's context. However, basic research often faces hostility in many underdeveloped countries. This is because the pressure on scarce resources is large and peoples expectations are for immediate benefits; hence the tendency to deride long-term fundamental research. In this respect, we are very fortunate that all our Prime Ministers have given ample support and expected Indian scientists to carry out good science for the good of the people. This indicates that CSIR should do science, not for science sake but to have some relevance for national development.

The second purpose of CSIR was to encourage and carry out industrial research. Critics were unsparing during the past 2-3 decades that most of the laboratories under the CSIR have failed to deliver technologies that can be exploited by industry for economic development. In the 50s and 60s, CSIR had drawn people from various Universities and academic institutions from all over the world. Almost all the Directors of the laboratories, although they were good scientists in their own right, failed to identify projects of industrial potential or devoting much time on this aspect as they used to apply their mind and effort to scientific research in their field of specialisation. CSIR also created commodity laboratories for research and technology development in scientific areas. For example, we have a drug research laboratory (CDRI) at Lucknow, a leather research institute (CLRI) at Madras, a food research institute (CFTRI) at Mysore and so on. CSIR also organised regional research laboratories at Hyderabad (the first of its kind), Jammu & Kashmir, Jorhat, Trivandrum, Bhubaneswar and Bhopal, mainly to cater the regional R&D needs.

The post-independence period saw an ordered expansion of the national R&D infrastructure. Financial outlay for research also went up progressively from the millions range to billions of rupees. The major

R&D agencies in the country - CSIR, ICMR, ICAR, DAE, ISRO and DRDO - received funding boost from the government in addition to contractual research funding by Departments of biotechnology, environment, science and technology and others. Funding by industry for technology development also gained ground in the late seventies. Despite these financial augmentations, there always remained the debatable issue of adequacy of R&D funding. Personally, however, I believe that while funding is no doubt important, what distinguishes R&D successes from failures are the scientific calibre of individual scientists, their creativity and intellectual competition, their dedication, persistence and the will to succeed. I will dwell on these qualities in this lecture as we go along.

No doubt, we made an impact on several sectors of the national economy and especially in food production by way of green revolution. Most of the breakthroughs came during the 50s and 60s, in spite of less funding, due to the devotion and hard work of many talented and committed scientists. However, with rapid expansion of the number of scientific institutions and the large amount of manpower that exists in these organisations, the results are not commensurate with the expenditure. Most of the scientists keep on asking for more money year after year pointing out that Government is only spending less than 1% of the GDP on science and technology.

Several committees were appointed from time to time to go into CSIR working and suggest ways and means for improving its performance. I do not wish to go into these recommendations, nor interested in knowing about their implementation but would like to deal with some of the issues facing our scientific institutions and share my thoughts on how to improve the work culture in these organisations. My area of specialisation is organic chemistry and chemical technology and institutes such as NCL, IICT, CDRI, CLRI and several RRLs are intensively involved in this field. I spent more than 25 years of my career at NCL (1960-85) including 5 years as Deputy Director & Head of Organic Chemistry Division, before I moved to RRL-H as Director.

During Dr Venkataraman's time, NCL was known internationally for carrying out good science in chemistry especially in organic chemistry and physical chemistry. It had also made a mark in the chemical engineering science. With much emphasis given by Mrs Gandhi for self-reliance, NCL under the leadership of Dr B D Tilak (1966-78) made a shift towards industrial research. Several projects were identified and some of them came out successfully. For example technology for Acetanilide was transferred to Hindustan Organic Chemicals (HOC) and

Endosulfon to Hindustan Insecticides Limited (HIL). However, two of the major projects initiated in the late 50s dragged on for decades and ultimately failed to be commercialised (Vitamin B6 and Vitamin C). Work on Vitamin B6 was initiated in the organic chemistry division in the year 1959 and pilot plant studies were completed in 1963. The technology was based on an obsolete process (Diels-Alder approach) and after spending time and effort for over 10 years, NCL had to finally admit that it was not easy to compete with the multinationals such as Merck and Roche who were the main producers of Vitamin B6 in the world. When my group in 1981 revived our interest in the project, we could analyse the several mistakes made earlier. We perfected the technology in less than 2 years at lab level and transferred it to M/s Lupin Laboratories, Bombay who scaled up the same at pilot plant level and commercialised the process successfully in 1986. The story of Vitamin C was equally tragic but was not resuscitated due to various reasons. Hindustan Antibiotics Limited (HAL), Pimpri, always blamed NCL for not providing proper technology for this project.

I would like to draw the example of Dr Nayudamma, who had successfully transferred CLRI technologies to various tanners in the country. This is mainly because of the methods he had adopted in those years. He was successful in persuading the cottage industrial sector of the industry - namely the illiterate village tanners - to accept innovations. Dr Nayudamma toured various parts of the country. He was involving the Directors of the cottage industries and important officials in each state and demonstrated to the village tanners modern methods in tanning leather. Dr Nayudamma never believed in charging for the technology transfer. He always allowed every one to directly involve with scientists and the institution to help the small tanners and the industry to benefit from its innovations. This worked out well in the early years to establish modern methods of tanning leather in the country. However, in later years, CLRI's work became obsolete and leather industry made advances much faster than the institute. Similar is the case of Indian Drugs & Pharmaceuticals Limited (IDPL), Hyderabad, which gave birth to basic drug industry and today has become a sick unit. However in recent years CLRI's programme has totally changed and advanced research in tanning is being carried out.

There were many reasons why CSIR laboratories have failed in developing technologies successfully and transferring them to industries. Often we fail to identify the right project which will have a direct bearing to industry. We should realise that no industrialist is interested in implementing technology for any product, however

scientifically interesting, unless he sees money in it. Further, most of our scientists are not fully exposed to the working of a chemical plant and the intricacies involved in implementing technology at the factory floor. Even today, many senior scientists do not know how to source raw materials or their commercial cost. In spite of several odds, some of us have succeeded because we involved ourselves with the industries in identifying the projects, closely interacted with their R&D team, involving marketing personnel wherever required, thereby reducing the time lag between research development and utilization of research results by the industry. Thus, my group at NCL initiated several projects under sponsorship from the Indian drug industry and successfully implemented them on industrial scale. Similar procedures were adopted by my personal group at IICT, which mainly consisted of research fellows and a limited number of scientists. Each research fellow, in the early part of his career, devoted himself in technology development and transfer of technology to industry. I often used to tell the R&D group of the drug industry that if the project succeeds at their end, it will be because of their efforts and if it fails, I take the entire blame. Thus, whenever we have involved the industry and the project was initiated under joint sponsorship, we have succeeded in its implementation within the time frame.

Several commodity laboratories have helped the small scale sector in the early years. However, they failed to make any impact on the major sector of the industry. The case of CDRI is relevant. It is the only laboratory having all the infrastructure for drug development, from medicinal chemistry to clinical trials. In spite of the fact that it has been in existence for over 50 years, not a single novel drug of repute has emerged from its efforts. We are familiar with the statement that to discover a new drug it costs a multinational company at least 250-500 million US dollars but we have spent much more over the years for drug development at CDRI and are hopefully waiting to see some notable examples. My observation, I know, will not be liked by many of my former colleagues in CSIR but I am known for my plain speaking. We may keep mentioning some molecules from time to time as news items including the four new molecules that were released by Sri Rajiv Gandhi as Prime Minister, but they did not make any major headway in the market.

Dr Nayudamma tried to change the management of CSIR laboratories, and brought about several changes in its working and in the selection of senior appointees such as Directors and Deputy Directors of the Laboratories. He also felt the need to take technologies

to the village level and improve the living conditions of the people. He introduced the concept of adoption of the backward district for changing the face of underdeveloped areas by application of science & technology. Karimnagar district in the state of Andhra Pradesh was the first to be adopted and RRL-H was named as the coordinating laboratory. Several other laboratories such as NGRI, CLRI, CFTRI, CBRI and NAL were involved in this task. Dr Nayudamma may have had good intentions, but we failed because no laboratory had taken the concept seriously and also most of the scientists involved were not committed enough to implement any realistic programme. When I took over as Director of RRL-H, I was very keen to study in depth the Karimnagar project and get a first hand information on the on-going activities. My visit to the project site was an eye wash. I found that many of our scientists made several trips to the site but no concrete work was done except spending huge amount on travel. There was nothing worthwhile in continuing this project, hence I had to take an immediate decision to close this project. It is unfortunate that the project had failed not because of any conceptual shortcoming of Nayudamma but because neither the scientists nor the Director of the nodal laboratory took the problem seriously in planning and implementing the project. I later realised that scientists who are at home with test tubes and laboratory ambience are least suited to undertake such work. We should have entrusted that project to some of the social scientists or retired scientists who may be interested in joining the mainstream of villagers and working with them by implementing scientific methods in agriculture, building low-cost houses and setting up of small scale industries.

Dr. Nayudamma always believed in manpower development. He initiated the B.Sc. (Tech.) programme in Leather Technology at the Madras University and training was imparted at CLRI, leading to Bachelor's, Master's and doctoral degree in leather science. The Director of the CLRI is an Honorary Professor and Head of the Department of Leather Technology at the University. In this way CLRI was instrumental in providing the desired manpower to the Indian leather industry.

During my tenure as Director of IICT, I felt the need to train organic chemists in the principles of chemical engineering and lessons in business management and costing, so that they will be better equipped to undertake technology development and to understand the intricacies in process development for chemical industries. At the same time, I also felt the need to expose our chemical engineering graduates to some of the fundamentals of organic synthesis, so that they could

appreciate the chemical conversions and adopt right methodologies in project implementation. I worked out a deal with the Dean and Prof. D. Swaminathan, the then Vice Chancellor at Jawaharlal Nehru Technological University (JNTU), Hyderabad, whereby IICT will select 10 students (5 M.Sc. Organic Chemists and 5 Chemical Engineering graduates) and train them for 3 semesters including one semester in process development, leading to M.Sc. (Tech) degree in Chemical Technology. The only condition I laid down was that the selection of the candidates should be based on all India merit. Prof. Swaminathan agreed and we signed an MOU to implement the project from the following academic year. I also went to the extent of providing scholarship, accommodation and the entire teaching responsibility at IICT. All that JNTU had to do was to conduct examinations and award degrees under their supervision, as IICT is not a teaching institution. I also agreed that some of the best students will be absorbed at Scientist B level in IICT and the rest will be recommended to the Indian Chemical Industry for absorption at an appropriate level. I did see a great demand for such students. In the meantime Prof. Swaminathan became a Member of the Planning Commission and his successor was not prepared to implement the MOU as he wanted to select people only from the state as per JNTU rules, which I could not subscribe to. The whole proposal fizzled out. We do not have people like Prof. Swaminathan who could exert and implement new programmes in the Universities.

CSIR's major contribution is the development of manpower for the National Institutions. The Extra-mural Division of the CSIR selects every year the best among the Masters degree holders in all branches of science and offers them attractive fellowship for a period of 5 years. These fellows are free to choose any institute in the country and also the supervisor of their liking, to carry out Ph.D. programmes in their chosen field of specialisation by registering with various Indian Universities. NCL still remains as a centre of excellence in chemical sciences because of the work carried out mostly by the research scholars. It is these people who never looked at the clock and brought laurels to the organisation. I have been fortunate in having the best fellows who had worked and contributed, both in fundamental research and in technology development, first at NCL and subsequently at IICT. My personal research group worked on various challenging basic research problems covering areas such as anti-tumour agents, immunosuppressants, leukotrienes and other biologically active fatty acids, cyclic peptides including glycopeptides such as vancomycin and chiral synthesis. We published several papers in the best international journals and the same group also extensively contributed to drug

technologies. Many of the young scientists from IICT received CSIR Young Scientist awards in chemical sciences year after year. The same is true for technology awards. Every year IICT bagged some award or the other in the field of Technology for its work in commercialisation of drug and agrochemical technologies. Research fellows from my group, I am happy to say, were members of the team which bagged these technology awards.

Dissatisfied with the way the CSIR was functioning, Sri Rajiv Gandhi in his capacity as President of the CSIR, appointed Abid Hussain Committee in 1986 to review the functioning of CSIR and suggest ways and means to improve its overall performance. The Committee visited several laboratories, interacted with the Directors and several scientists. In my interaction with Mr Abid Hussain and the members of his team, I expressed the need to change the name of the Regional Research Laboratories including RRL, Hyderabad, as these laboratories were not focussing their efforts in any particular area of science or technology specific to the region. I always expressed my feelings that there was nothing regional when it comes to carrying out good science or technology and suggested renaming of RRL-H as National Institute of Chemical Technology as we already have the NCL, dedicated exclusively to chemical sciences. In fact, Abid Hussain Committee recommended changing the name of all RRLs and suggested new names based on their main expertise. The Committee also suggested closing down of RRL-Bhopal, as there was not much work being done. It was only I who had accepted the new name for RRL-H as Indian Institute of Chemical Technology (IICT) effective from 1st April, 1989, but all other RRLs Directors preferred to retain the same name.

One of the most important suggestions made by the Abid Hussain Committee was regarding the laboratory earnings from external cash flow to the extent of 30% of their budget. The Committee's main intention was to improve the laboratories' interaction with industry. No doubt, this has acted as a catalyst to many laboratories for attracting money from outside the CSIR, although the amount earned from private industry remained much low. IICT's earning, under this head, during my tenure as Director was maximum from Indian Chemical industry and the highest among all the CSIR labs.

Several of us have done well, individually as scientists and technologists, by way of our scientific contributions and interaction with industry. However, several major projects initiated through collective efforts within the organisation or inter-laboratory projects did not yield tangible results. This aspect has to be looked into by the

CSIR. Time has come for organisations such as NCL and IICT to break the divisional barriers and evolve an alternative management strategy to bring together all disciplines under one umbrella, and work towards a major goal such as to discover a new drug or a new material, involving organic chemists, biologists, polymer scientists, catalyst group, chemical engineering, and design engineering groups. We should bring about a change in our attitude to meet the emerging national and global challenges. Both NCL and IICT have the strength in these areas and are suited to undertake major projects leading to the discovery of a drug or a new material, rather than remaining as discipline-oriented smaller groups within a regimented ambit.

Dr Nayudamma during his tenure as DG, CSIR introduced the "Scientist-Entrepreneurship scheme" wherein the CSIR scientists could opt for a 3-year leave, to exploit some of the CSIR technologies as entrepreneurs to their advantage. In case they failed in their venture, they can still come back to their organisation and join duty and get all the service benefits, as if they had been on the CSIR rolls. This was a laudable scheme in many respects, because Dr. Nayudamma felt that many of the CSIR projects which were sound but have not seen the light of the day, can be exploited by CSIR scientists for national development. Unfortunately almost all those who opted for this scheme and took leave for 3 years joined back CSIR. The failure of this scheme was due to obvious reasons and I have already dealt with some of these which are associated with the technology development.

When I retired as Director of IICT, I preferred to start my own research laboratory and keep myself busy working amongst youngsters rather than opting for an "Emeritus Scientist" position. I became an entrepreneur and started the AVRA Laboratories Pvt. Limited in the temporary premises provided by Dai-Ichi Karkaria at Nacharam Industrial Estate in Hyderabad with zero investment. AVRA labs came into existence on 15th August, 1995 and has steadily grown during the last 3 years and has since moved to its new establishment at Nacharam, Hyderabad. We are engaged in technology development and custom synthesis for several US based pharma and biotech industries. In addition, we are planning to train youngsters for their Ph.D. degrees in organic chemistry and have undertaken some projects which are relevant to the national health programme.

In the changing world scenario, if we have to perform effectively as scientists and technologists, we have to bring change in our work culture from time to time. Change is essential in our thinking, in our acts and also for the good of the organisation where we work. I always

looked for a change, every 5 years, whether in choosing my projects or the areas of work. As Director of IICT, I have taken several harsh decisions in closing down many on-going projects and impressed on my colleagues to initiate new programmes of national relevance. I inducted several youngsters from all over the world through selection process rather than inbreeding within the organisation. Several of my colleagues in CSIR, and all the three DGs of CSIR under whom I served have rated me as a successful Director. However, on my part I felt that I could achieve only 50 to 60 percent of efficiency in the work culture of the organisation and nowhere nearer to 100 percent, in spite of my best efforts. This is mainly because we still function under rigid personnel and administrative policies not suited to the dynamics of change. We distribute our research resources equally among all the CSIR organisations and also in the same way within the organisation. When it comes to nurturing excellence and backing the right people, we bog down due to various internal problems and do very little on this aspect.

Having spent almost a life time in CSIR and as Director of IICT for 10 years, many people confront me with a question as to how to bring overall efficiency in CSIR, especially in the present context of India being a member of World Trade Organisation and our policy managers expecting a dramatic change in the new millennium from self-sufficiency to the age of discoveries. My answer to this is probably the same as I had suggested to our Honourable Minister of Science & Technology, Mr Kumaramangalam, during Mr Narasimha Rao's stewardship, when he posed a similar question at the Directors conference. I asked him whether there was any need to have CSIR under the changed scenario, stating that CSIR was created at the time of independence on the British model to carry out industrial research as we had no research set up for industry at that time. However, the British Government itself had wound up its CSIR several years back whereas we keep on expanding our organisation. I suggested to him to cut the size of CSIR drastically by gradually closing, at least five labs during every five year plan, and strengthen some of the discipline based institutions such as NCL, NPL, IICT, CCMB, NEERI, CBRI, NAL and commodity labs such as CDRI, CLRI for undertaking excellent scientific research of international standard. They should train the manpower and encourage people to carry out good science in the national interest.

I am of the opinion that a good scientist should be paid on par with his counterparts in international organisations and performance should be rigorously evaluated. Every post should be filled by open advertisement and the present routine promotion at the Senior levels

should be abolished. Every appointment should be for 5 years, on contract. We should train several leaders who could take up senior positions in the growing industry.

It is easy to suggest the closure of several organisations but to implement such an advice is difficult. For this, my advice is as follows: many of these labs are 50 years old and 70% of the staff are over 50 years of age. Some young scientists who are good may be transferred to their respective discipline oriented labs and the numerous R&D agencies in the country and the rest may be paid full salaries till their retirement year, by keeping them at home. Even then it would cost the CSIR much less and more money would become available to strengthen the selected areas. I now feel that these labs may be turned as technology parks in different states. Their infrastructure, such as libraries, lab space, pilot plants, auditoriums can be put to best use by encouraging new entrepreneurs to make use of them for improving their skills. They may be handed over to organisations such as ICICI to manage them. With additional financial inputs from ICICI and other international organisations, we can build excellent technological parks as these labs have spread out in many parts of our country.

Recently I was in China as an invited speaker and was amazed to see how China was making headway in spite of its large population. Their educational and research institutions were in no way different from ours, if at all, they were less advanced compared to our research organisations. But they were trying to bring about changes. They were willing to collaborate with partners from any where in the world. They were encouraging new centres to be started by industrial organisations. I also saw that China has a firm commitment to development. They have only one authority to deal with, whether we like or not. I found that discipline was the fundamental law there. Even young girls could work late in the night safely. They had opened up their markets for global competition way back in 1978 while we have reluctantly followed it in 1991. In spite of the several advantages we have such as language, we have to learn from China some of the lessons in efficiency.

We may have to rewrite our science and technology policy in this changed scenario. It may infringe on our research organisations such as CSIR, ICAR, ICMR. We have to enhance our research funding, which may be by way of a cess on industry and agriculture. We have to modernise our universities and other educational institutions. We have to create centres of excellence in selected universities in certain chosen aspects of basic research, where the best minds of world renown could

pursue their research ideas. Discovery oriented research has to be encouraged on a selected basis with emphasis on quality of work. Efforts should also be made to encourage greater interaction between university and industry. We have to bring change in a major way in selected universities. They should be made truly national in every aspect of work and free from political interference. At least one university in each state should have a Vice Chancellor appointed on merit and preferably from outside the state. All the senior teaching posts (professionals) should be filled by search committees and not by promotion. Students for Masters degree should be selected by all India merit so that true national spirit should be inducted.

The above changes will not be favoured by large sections of vested interests, who have derived gains for the last 4-5 decades. If we want to build world class science and technology to become world player in the economy, we cannot remain as spectators in isolation.

We have to encourage research and development in the private sector. Organisations such as DST and DBT should support liberally some selected projects in the private sector. Although, DST in collaboration with CSIR identified new drug development in the country by setting aside substantial funds for this purpose, such funding is still not available to private pharmaceutical industries, if they do not join hands with public funding organisations. WHO funds for R&D are available to several international private organisations, by inviting research proposals.

During the past 5 years, several corporate bodies mostly from USA and some from Europe are supporting R&D in India in a wide range of subjects such as biotechnology, weather forecasting, polymer science, catalyst development, energy utilisation project and process development in our educational and research organisations. Research funds are flowing in US dollars for projects at our IITs and research institutions. They have initiated major programmes in our R&D organisations because our cost comes to 1/3 compared to what they have to spend in USA or Europe. At the same time we do have talented people to perform equally well. Companies like Monsanto, IBM etc. are setting up new research centres. IBM spent \$25 million to create a centre at IIT, Delhi. Monsanto built an excellent biotechnology centre at Bangalore. More and more organisations are sponsoring research in various institutions to carry out process, research and drug development. Several of them are coming to hire high level managers at dollar salaries. We have to look into all these aspects in the changing world scenario and bring a major change in our S&T policy.

I do realise that whatever I have proposed is a formidable task and a challenge to all of us. But I know that given the will and proper utilisation of our human resources and talent, of which our country has so much in abundance, we could find the right way to lead this country to prosperity and technological leadership in the new century. The world has become a highly competitive place and we know that only the fittest can survive. In spite of the fact that our scientists and technologists are undoubtedly the best in the world, when it comes to their performance, they shy away from competition. Our attitude has to change and change is good not only to the individual but to the nation as a whole. We should compete with the best in the world, some of us may fail but many may succeed, to take this nation to greater levels of excellence and attainment, which we all look forward to in the next millennium.

Distinguished colleagues, I have come to the end of my lecture. Many of you may not agree with what I have said. I am also not sure if Dr Nayudamma were to be alive, whether he would have brought forward some of the changes that I have suggested in the CSIR and Universities. I regarded him as an educationalist and a technologist of high excellence. He tried to introduce innovative methods in teaching and research. He was an idea think-tank man and creator of new and innovative ideas, suggestions and projects. He was never tired of the various possible products and by-products that can be obtained from cotton, turmeric, coconut etc. I would like to quote some of his repeated statements which incidentally reflect his views on many issues.

"I have not applied for any job nor attended any interview for any post at any time"

"I am a farmer by birth but a harijan by profession/adoption"

"Interaction of trinity - industry, university, government - is a *sine qua non* for success in any project"

"You can take the boy out of the village but you may not take the village out of the boy"

"I would like to take anybody as a Godman if he produces a pumpkin and not vibhuti out of nothing"

Friends, whatever I have said is because I love my country and science is my passion, technology development is my mission and I am proud to be a scientist and belong to the CSIR family.