

G. RAM REDDY MEMORIAL LECTURE

**'ON BUILDING INNOVATIVE INDIA OF THE TWENTY FIRST CENTURY'**

By

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1. It is a special honour and a privilege to deliver the 8<sup>th</sup> annual G. Ram Reddy Memorial Lecture. I appreciate this opportunity to pay my tributes to a great thinker and a visionary. I feel further gratified, when I see the list of illustrious speakers, who had delivered this lecture in the past. Dr. Ram Reddy's dream was to create a new India that 'will lead and not follow'. This India has to be an innovative India. I am going to speak about building that innovative India of the twenty first century.
2. Everyone recognizes that twenty first century is the 'Century of Knowledge'. Nations, which have developed mastery in the production of knowledge, its dissemination, its conversion into wealth and social good and its protection have assumed a leadership position in the world today. But it must be recognized that knowledge without innovation is of no value. It is through the process of innovation alone that new knowledge can be created. It is innovation, which converts knowledge into wealth and social good.
3. India was a leader in innovation several centuries ago. Indeed, since the Indus Valley Civilisation of about 5000 years ago, innovation has been the part of the Indian culture and the basis of its civilization. Our innovations were diverse and pioneering. They included remarkable town planning, the use of standardized burnt bricks for dwelling houses and interlinked drainage systems. They included wheel-turned ceramics and solid-wheeled carts. The dockyard at Lothal is regarded as the largest maritime structure ever built by a bronze-age community. The discovery of zero and the decimal-place value system by Indians dates back to the Vedic Period. Our pioneering work in algebra, trigonometry and geometry was truly outstanding. Indian innovations in medicine, especially in Ayurveda, not only aimed at the cure of diseases but more importantly, on the preservation of health. The innovations in surgery included pioneering efforts in laprotomy, lithotomy and plastic surgery. The iron pillar at Delhi, which testifies to the achievements in metallurgy some 1500 years ago, is truly inspirational even today. Indian civilization was characterized by scientific thought, capabilities and techniques, at levels far more advanced than others.

4. In spite of this great heritage and record of accomplishments, why did India fall behind in the ensuing centuries? When the scientific and industrial revolutions took place in the west a few hundred years ago, there was a period of stagnation in India. Lack of development over this period was a result of a hierarchical approach, irrational subjective thinking, and build up of superstitions and superficial ritualism. The earlier great traditions were allowed to decay. A highly feudalistic structure of society developed. It was in this state of its society that India came under the colonial domination. During early part of the twentieth century, some development in science did happen because of the efforts of some outstanding Indians, who worked over three quarters of the century prior to Indian independence. They include names such as Sir C.V.Raman, S. Ramanujan, P.C. Ray, J.C.Bose, S.N.Bose and so on, a spectacular array of thinkers. These were the products of the ferment in the Indian society, which had motivated the freedom struggle. But by and large, compared to other nations, inhibition and imitation in the society was evident during a substantial part of the twentieth century. We lost the leadership position. This cannot continue into the twenty first century. We must regain this position with determined action.
  
5. We have now an opportunity to start the resurgence of an innovative India today. What do we need to do? We need to build new social, legal and economic structures that will support innovation. We need to make the symbol of 'I' in 'India' to stand for 'Innovation'. I am convinced that just as we had launched a freedom movement, which freed us from the stronghold of foreign powers, we must launch an 'Indian Innovation Movement' now, so that India can assume its rightful place in the comity of nations. And the time to do it is now, at the dawn of the new millennium.
  
6. Our confidence in building the new innovative India of our dreams stems from our major successes in the arena of many technological innovations, which have made such a difference to the nation. Some prominent examples include the blue (space), green (agriculture), white (milk) and grey (software) revolutions. Let us just take one example. The Indian space program, for example, has designed and sent into space a series of satellites that, among other things, comprise the largest domestic communication system in the Asia-Pacific Region. It has also developed

a range of launch vehicles, the most recent being a geo-synchronous launch vehicle with an 1800 kg payload. These developments have helped in the application of space technology for national needs in communication, meteorology, broadcasting, and remote sensing. All of this has been achieved in a relatively cost-effective manner – the Indian space program’s current annual budget is equivalent to US \$450 million while NASA’s budget, in comparison, is over \$15 billion. Other innovations serving specific Indian needs include C-DOT digital switches, CorDECT cost-effective wireless-local-loop products, the Simputer, which is a low-cost computer and the Param supercomputer. The last is an example of “denial-driven innovation,” illustrating that India has the potential to tackle highly advanced technological issues, given the proper motivation.

7. The landscape of technology innovation in India is not static. It is continuously evolving. It has undergone a number of positive developments over the past decade. Let us reflect on some of these. There has been a paradigm shift that is reflected in a move from research as an end in itself to research coupled with technology development, with this linkage being increasingly driven by socio-economic needs. The perspective has also shifted from primarily a local or national focus to a global one, with the globalization of R&D being a major driving force. This has resulted in some major transitions: for example, the pharmaceutical sector that was based on formulations of imported drugs in the 1960s has slowly enhanced its innovative capabilities and is now gearing up to compete with the global players. Realising the power of Indian intellect, we have seen more than 100 top companies from abroad set up their R&D centers here in India.
8. Technology entrepreneurship has begun to establish itself. While creation of high-technology start-ups has been dominated so far by information technology services and software, there is also activity in knowledge-intensive sectors such as biotechnology and IT-hardware. There is also an emergence of innovative models of entrepreneurship. The TeNeT group at IIT Madras, for example, has spun off – with faculty, student and alumni involvement – a series of firms that are engaged in a range of activities from IT product development to provision of technology-based services.

9. What are India's major strengths in technological innovation? On the human resource front, India has the largest pool of qualified engineers in the world, the 7<sup>th</sup> largest pool of R&D personnel, and a large cadre of expatriate scientists, technologists, and entrepreneurs, who are increasingly engaged with their home country. On the institutional front, India's assets include numerous institutions of higher learning as well as an impressive array of research centers and laboratories that focus on a large range of scientific and technical problems. India has a huge domestic market, with potential customers numbering a few hundred millions. We have an economy that has grown at almost 6% per year over the last decade, not many countries have done so. There are exceptional leaders within the government, academia, and the business domain who are promoting and catalyzing institutional transformation (both revolutionary and evolutionary) in a range of ways. There are increasing numbers of individuals, both within the country as well as outside it, who serve as role models for technology entrepreneurship.

10. What is the new direction that the Indian technological innovation needs? Our technology innovations must be now redirected for solving the major problems that the nation faces today. Let me illustrate this by taking only one issue. We have about 200 million adults that cannot read and write. Our illiteracy is reducing only at the rate of 1.5% per annum. We have constraints of trained teachers. The use of conventional methods of learning is from alphabets to words, which requires 200 hours of instruction. If these conventional methods are used, then we will need 20 years to attain a literacy level of 95%. This is too long. We, therefore, must find out new innovative ways of solving the problem.

11. Look at what the great doyen of Indian IT industry, F.C Kohli has done. He has developed a Computer-based Functional Literacy (CBFL) method. It focuses on the reading ability. It is based on the theories of cognition, language and communication. In this method, the scripted graphic patterns, icons and images are recognized through a combination of auditory and visual experiences by using computers. The method emphasizes learning of words rather than

alphabets. While the method focuses on reading, it acts as a trigger for people to learn to write on their own.

12. Based on this method, Kohli's team has developed innovative methodologies using IT and computers to build reading capability. This experiment was first conducted in Medak village near Hyderabad. Without a trained teacher, the women started reading the newspaper in Telugu in 8 to 10 weeks. Thereafter, Kohli's team has carried out more experiments at several centers. Over 20,000 adult participants have become literate now.

13. We can ask a simple question. If all this is computer based, then is it not too expensive for a country like India? Kohli has an innovative solution to that too. His team has developed these lessons to run on Intel 486s and earlier versions of Pentium PCs modified to display multimedia. There are around 200 million of such PCs in the world that are obsolete. They have been discarded. By using these PCs, the cost of making one person literate would be less than Rs.100. With CBFL, Kohli says he can increase the literacy to 90 to 95% within 3 to 5 years, instead of 20 years. It is this kind of innovation and innovative approach to problem solving that can transform India.

14. Innovative India of the future must be compassionate. It should continuously look at the problems of the poor. Let me focus on one such problem. Millions of women draw water from wells. They feel fatigued and sometimes they need to rest to catch their breath. But all this time, they had to keep holding the rope with a water-filled bucket or vessel tied to it. Even if they momentarily lost their grip, the bucket fell back into the well. All their effort went waste. Although communities have devised ways of retrieving a fallen bucket out of well, for example, by using hooks tied to another rope, this did not prevent the bucket falling into the well. This was the situation until an illiterate artisan came on the scene. When posed with this challenge, he solved this problem by attaching a small lever on the pulley. The lever did not get in the way while pulling on the rope, but the moment the tension on the rope slackened, the lever pressed against it and arrested the downward movement. This kept the water-filled bucket in its position. Now an old lady could take rest, chat and then resume the pulling operation. Thousands of such pulleys

are now being installed all across the Gujrat Villages. These designs will spread to the rest of India soon. Can you imagine the relief this will bring to millions of poor women, who draw water from wells in India everyday.

15. The question we should ask ourselves is why is it that the design of a pulley to draw water from the well remain unchanged for two thousands years. Indeed, a more general question is this. Why do such problems that affect millions of people every day not get solved through the use of existing scientific models? In the example of this pulley, we should remember that navigators had used a similar concept while pulling the ropes in setting oars in the boats. Further, a chain pulley system in the construction industry also was using similar concepts. Thus the concept was not new. But its application in a real life problem did not happen. New innovative India of our dreams must carry that compassion so that the problems of the poor can be solved. We must harness the talent of the scientists so that value can be added to the local, indigenous ability.

16. For all this to happen, we must create a new value system, where problem solving for the poor and the disadvantaged becomes a national mission. Those who contribute to this mission must be made into the national heroes. That is why an illiterate artisan, who developed this pulley system was acknowledged and rewarded by the National Innovation Foundation that was set up under my Chairmanship last year. We need more such innovations, which will solve the problems of the poor.

17. How can we change our mindset and value systems? Technologies developed by local artisans, craftsmen, potters, farmers, weavers, etc. are considered as traditional. These technologies are never included in the fabric of modern technology. How can we bring about this change? I tried an experiment in Pune during the Indian Science Congress in January 2000. As President of the Science Congress, I said let this Science Congress be 'knowledge congress'. Let it be 'people's congress'. We will show that we value people's knowledge. We had several grass root innovators participate in our science exhibition. They demonstrated their technologies. None of them spoke English. We had a session, where they made a presentation on their technologies in local languages to around

2000 scientists. They stood on the same platform from which the Nobel Laureates spoke. I must say that they got a bigger applause than even the Nobel Laureates. I believe the scientists, for the first time, realised the power of innovation that takes place in the field. They also saw the innovative and creative abilities of those, who were unadulterated by the modern day educational system. This realization must now turn to a respect and then to meaningful partnership.

18. National Innovation Foundation (NIF) is helping to build such respect and partnership. NIF recognizes the innovations by grass root innovators, be they farmers, slum dwellers, artisans, school dropouts and so on. NIF set up a national innovation competition two years ago. To begin with, in the first year, there were less than one thousand entries, which increased to sixteen thousand in the second year! Our President Dr. A.P.J. Abdul Kalam gave away the prizes for the winners. Many of them were illiterate or semi-literates. The winners during the last year included an eighth standard dropout, who developed a complex robot. The winners included a farmer, who developed a cardamom variety, which today has over 80% share of the market in Kerala. The winners included again an illiterate individual, who had developed a disease resistant pigeon pea variety, which became a big winner. These disadvantaged individuals had shown to us as to what they can do by working in laboratories of life by using their powers of observation, analysis and synthesis. It is time that we sing a song for these heroes and salute this part of India, which is as vast as it is innovative. Others recognize them but we do not. Let me give an example.

19. What do global giants like General Electric and Motorola have in common with a humble tiffin delivery network comprising 3500 dabbawallas, who deliver 1.5 lakh lunch boxes to citizens in Mumbai each day? The dabbawallas have the six sigma rating or an efficiency rating of 99.999999, which means one error in one million transactions! This rating has been given to them by Forbes Global, the famous American business weekly. But we did not recognize them. Look at the innovation that these largely illiterate dabbawallas have done. Their secret lies in a coding system devised over the years. Each dabba is marked in an indelible ink with an alphanumeric code of about 10 characters. In terms of price and the reliability of delivery, say compared to a Federal Express System,

dabbawallas remain unbeatable. Their business models have become a class room study in some management institutes. By giving this one example, all that I am trying to convey is that the innovative potential of the people does not plummet to zero, when the people are illiterate or semi-literate. They necessarily have to innovate to survive and to succeed.

20. Our new innovative India will have to be built by concentrating on our youth, which represents the national strength, vitality and vigour. If properly moulded, the youth can become the champion of our culture, custodian of our national pride and a trustee of the freedom of the country. But the process of such moulding requires the right type of education right from childhood. Our youth must imbibe the spirit of a true innovator. Innovators are those who do not know that it cannot be done. Innovators are also those who see what everyone else sees, but think of what no one else thinks. Innovators refuse status quo, they convert inspirations into solutions and ideas into products. Building such innovators will require an all-pervasive attitudinal change towards life and work – a shift from a culture of drift to a culture of dynamism, from a culture of idle prattle to a culture of thought and work, from diffidence to confidence, from despair to hope. Revival of Indian creativity and the innovative spirit needs to be made into a national movement today.

21. How can we induce creative thinking amongst our young people? The young budding inventors can learn a lot from the legendary career of an inventor like Thomas Alva Edison. As we know, Edison was granted a record of 1,093 patents for inventions ranging from light bulb, typewriter and electric pen to his phonograph and motion-picture camera. His work methods reveal that the real keys to unlocking creativity are an open-minded approach to learning and perseverance. Edison used his creativity not only for developing new inventions but also for bringing them to the market and winning out financially over competitors.

22. When Edison died in 1931, he left 3500 note books which read like a turbulent brainstorm. It shows Edison's mind at work spanning most of his six-decade career. They offer fresh clues as to how Edison, who received virtually no formal education, could achieve such an astounding unrivalled record of inventiveness.

The notebooks illustrate how Edison conceived his ideas from their earliest inceptions and show in great detail how he developed and implemented them.

23. How do ideas get generated? Curiosity provides the stimulus for the production of ideas. Curiosity prompts us to ask questions and explore further. As Einstein said " He who cannot wonder, cannot feel curious about things around him, is as good as dead, a snuffed-out candle". Edison was curious and therefore he could generate new ideas.
24. Edison felt that his lack of formal education was, in fact, a 'blessing'. This enabled him to approach his work with far fewer assumptions than his more educated competitors, who included many theoretical scientists, renowned doctorates and engineers. He approached any idea or experience with wild enthusiasm and was prepared to try anything out of ordinary material.
25. When an experiment failed, Edison would always ask what the failure revealed and would enthusiastically record what he had learnt. He had an enormous talent for appropriating ideas that may have failed in one instance and using them for something else. Whenever he succeeded with a new idea, he would review his notebooks to rethink ideas and inventions abandoned in the past in light of what was recently learnt. He would often jot down ideas others had come up with in other fields.
26. The lessons that we learn from Edison's life are simple. First, challenge the assumptions continuously. Do not have a preset or prejudiced mind. Let the windows of your mind be always open. Second, patience and perseverance pays. Third, nothing is final. Strive for creating products that are better than the best. And displace your products yourself. Finally, you can learn more from your failures than you can from your successes. So do not be afraid to fail. Take risks. Indeed, risk taking must become a part of the national innovation policy.
27. In science, only those are remembered, who say either the first word in science or the last word in science. India has not done it often enough. Why? Because, among other things, we have not dared, risked, gambled or deliberately funded

risky research. While I was the Director of National Chemical Laboratory, I decided to fund risky research by creating a 'Kite Flying Fund'. I said, we will support ideas, which aim to attain some unattainable goals, meet some stretched targets, or follow novel strategies in problem solving, that have never been used before. Here the chance of success may be one in one thousand. This fund generated a lot of excitement. I remember a fierce competition among scientists, where many innovative ideas sprang up.

28. When I moved to CSIR, we used the 'Kite Flying Fund' concept at NCL to create a 'New Idea Fund'. We invited the entire chain of laboratories to submit ideas, which had explosive creativity, and where the chance of success may again be even one in thousand. During the last 5 years we have received over 350 new ideas but we have funded only 15 of them; we are so tough on our criteria on what constitutes explosive creativity. This initiative has spurred our scientists to aim for increasingly higher level of innovation in CSIR and even individual laboratories are setting up such funds now.

29. We must also understand that the challenge is not only that of funding risky ideas, but also spotting and funding mavericks, who have the potential to create breakthroughs. Such unusual innovators refuse to preserve status quo. Whereas standard science management practices tend to avoid conflicts, such people create conflicts. They bring in unusual spontaneity and exceptionality to the table. Their incentives are personal and emotional. They are not institutional or financial. Such innovators are sometimes extremely intense. Great innovators like Carother, who developed world's first synthetic fibre nylon, committed suicide. Diesel, who invented diesel engine, also committed suicide. Managing such intense and creative people requires a subtle understanding of the pain of creation that such people undergo day in and day out.

30. The difficulty with science is often not with the new ideas, but in escaping the old ones. A certain amount of irreverence is essential for creative pursuit in science. I believe that if we promote that irreverence in Indian science, by change of personal attitudes, change of funding patterns, creating that extra space for risk taking, respecting the occasional mavericks and rewarding the risk takers, then not

only will the fun & joy of doing science will increase, but also Indian science will make that difference, that “much awaited” difference.

31. I would like to end by emphasizing that the future of India can be built by remembering and practicing three things, which are encapsulated in the world ‘TI’. Firstly, TI stands for ‘Think India’. We must have India in our hearts and minds. As someone had said, India’s response to WTO should be WTI, that is, ‘We Think for India’. The second meaning of TI is ‘Team India’. We all must work as a team, breathe as a team and strive forward as a team. TI also stands for ‘Total Innovation’. This means making India truly innovative by changing its social, legal and economic structures. The most important pledge we should take today is that, we should make the national symbol in ‘I’ in ‘India’ stand for ‘Innovation’. If we ‘Think India’, work with the spirit of ‘Team India’ and push forward the movement on ‘Total Innovation’, then I am confident that India will find its rightful place in the comity of nations, which is right at the top.