new pressures generated by competition, both domestic and international, are more likely to drive the Indian industry closer to industrial research, and this much desirable outcome deserves to be encouraged by suitable modifications to the regulatory framework, which is still powerful and will remain so for some time to come.

S M Datta is in the Hindustan Lever Ltd , Bombay, India

India's emergence as a global R&D platform: The new challenges and opportunities*

R. A. Mashelkar

I consider it to be a matter of great honour and a special privilege to have been invited to deliver this Lala Karamchand Thapar Memorial Lecture. Lala Karamchand was not only a great industrialist but also a great visionary. He believed in the process of value addition to our natural resources through modern industrial processes. In today's context, India's natural resources (and, indeed, its rich biodiversity) and its manpower are its real assets. In keeping with the basic spirit of Lala Karamchand's vision, I am going to speak about the tremendous potential for value addition through our talented manpower (specifically our S&T manpower) for launching India as a major global player in the field of research and technology.

I am fortunate that the Hon'ble Finance Minister Dr Manmohan Singh has agreed to preside over this lecture today. Dr Manmohan Singh set a new national agenda in July 1991 by announcing the new industrial policy and followed it up with astute fiscal policies. With dynamism and vision he has led India on the path of progress by beginning the process of integrating the Indian economy with the global economy. I strongly believe that the integration of Indian economy with the global economy cannot ever be complete unless the integration of our industrial research and technology with the rest of the world also becomes a part of this grand plan. If this is accomplished with speed and determination, then we can see India emerge as a major global R&D platform. I wish to share this exciting vision with you today.

India has been a part of the international scientific network for many decades now. Internationalization of science is not new. Indeed, scientific cooperation is increasing day by day, thanks to the tremendous developments in communication and information technology Whereas in 1978 only 4% of the research papers had transnational authorship, in 1990 this number had risen to over 10%. India continues to sign several bilateral agreements on scientific collaboration, including exchange of scholars, scientific research data, etc. However, most of these agreements emphasize the generation of knowledge for its own sake. Indeed I remember that not until too long ago, while submitting such proposals, one even certified that the joint collaboration was a purely intellectual pursuit and that no intellectual property of any commercial value was likely to arise from it!

My lecture, however, does not deal with the above type of relationship, which is built in the usual rich tradition of science. My focus today is on *research as a business*. It focuses on creation of partnerships with the rest of the world to generate exploitable knowledge, technologies, new products, processes, etc. In other words, it is about wealth creation in India not only through international trade and business but also through export of knowledge-based products and technologies. It emphasizes a major transformation so that we change our image from 'perennial technology seekers' to 'technology providers'. It has an ambitious agenda of 'reverse transfer of technology' to the developed nations. I realize that in this spirit, export of services like software has already begun; however, much of it is still in the form of bodyshopping. To my mind, India's enormous potential has not been tapped so far. This great potential arises due to India's massive S&T infrastructure and its undisputed intellectual resource base.

Thanks to the foresight of the founding fathers of our nation, India today possesses a massive science and technology infrastructure spread across the country. With over 200 universities, 1500 research institutions and 4000 Ph D's being turned out every year, India is in an enviable position as regards the S&T manpower. Right from the time of independence, science and technology has been considered as an instrument of growth and prosperity. Scientific institutions have been set up and nurtured in many diverse sectors. These have included agriculture, atomic energy, electronics, environment, ocean, space, biotechnology, nonconventional energy sources, defence, health and so on. The chain of national laboratories, which was set up after independence, has built several core competencies in large number of areas. All this gives India a marvellous launching pad, on which it can set up a really ambitious agenda of growth. I believe that by the turn of the century, in a list of competitive advantages of which our nation will be proud of, its R&D strengths could be easily on top if we take some actions, many of which I will specify in my lecture.

International trends in globalizing R&D

Industrial R&D collaboration in the developed world has been increasing exponentially. A strong and synergistic pairing of major players in countries such as USA, Japan as well as Europe dominates the scene. Let me review the worldwide scenario briefly for you, before I take up the issue of positioning India in this league of nations.

Take the case of United States first. The R&D spending abroad by US companies is rising much faster than their

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domestic spending. IBM and Hewlett-Packard, for example, are estimated to do nearly 30% of their R&D outside USA. Reciprocally, the number of R&D facilities in USA set up by foreign companies has increased significantly. According to a study, some 250 R&D facilities in the United States are owned by more than 100 foreign parent companies. These are mainly by Japanese, German, British, French and South Korean parent companies.

Several US firms hold R&D facilities in Japan. Development of products for the Japanese markets is the main goal. Improvement of product quality and consumer acceptance is another goal. The hidden agenda is, of course, to gain entry into Japanese R&D. It obviously helps the US firms to improve their market access in Japan.

Let us now move on to Japan itself and see what the game plan is. The last few years have seen a remarkable change in the way Japanese are approaching the issue of globalization of R&D. They are starting with the fundamentals, namely, by beginning to hire foreign scientists in Japan. Indeed, the Japanese companies, known for their conservatism so far, have now begun to recruit foreign researchers based on their skills rather than on their nationality; Fujitsu, Nippon Steel, Sony, Cannon, etc., are good examples of this trend.

The Japanese globalization strategy now includes taking over of R&D intensive corporations and even establishment of R&D centres abroad. Japanese have, in fact, promoted a new concept of *Techno-globalism,* which is being interpreted as 'the strong interaction between the internationalization of technology and the globalization of the economy'. It actually implies 'widening cross-border interdependence between individual technology-based firms as well as economic sectors, especially through the restructuring of high- and medium-tech industry'. Incidentally, it is interesting to note that the intensity of such transnational cooperations and setting up R&D facilities is the highest in high-tech areas, such as electronics, biotechnology, automotive industries, etc.

I can go on to give several examples from Europe too. The European Commission's 'Eureka' Project, which seeks to mobilize the scientific and technological skills of European countries, is a major example.

There is a ferment of activity on collaborative R&D that is sweeping the developed world. I firmly believe that India can become a part of this great game plan on its own terms in the coming decade, provided it understands the forces that are driving globalization of R&D and moves speedily and aggressively.

Driving forces for globalization of industrial R&D

The chain of concept to commercialization necessarily crosses transnational boundaries today. Companies realize that to gain competitive advantage, they have to leverage their capabilities. The idea is to develop synergies and to make one and one equal eleven and not just two! 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. With trade barriers among the countries disappearing fast, companies have to provide the best technology globally to their customers. The concept that technology could be acquired rather than re-invented is gaining momentum. As a part of the global innovation strategy, several companies the world over are scouting for new ideas and patents, which the originator is unable to exploit for a variety of reasons. These companies believe that the surest way of becoming technically strong is through networking with premier organizations in those regions.

There is another interesting and subtle aspect to the whole game. The globalization of R&D is closely linked to globalization of business and consequently to global competition of skills. The competitive advantage in high-technology business increasingly depends on underlying technical skills of the business rather than on particular products. As products' life cycles keep on becomes shorter, skill life cycles becomes 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 they should build up, rather than asking a stereotype question, as to which markets they should enter, and with which products.

In order to acquire a particular new skill and remain world-class in all the core competencies of one's company, an extraordinary technology renewal effort is required. In such a situation, the demands on R&D increase, but the dichotomy is that the corporate investments in R&D decrease because of pressures on profit margins arising out of global competition.

One of the major driving forces is thus the increasing cost of research and resource demands, which even giant multinational companies cannot afford. The companies are concluding that they cannot justify assembling in-house all the various skills and facilities needed to carry out developments, and the pace of change often denies them the time to do so. One dramatic consequence is that today 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. Furthermore, the skills necessary to compete in leading-edge technology over a broad front are rapidly becoming available globally – Brazil's smaller commercial aircraft and Portugal's design and production of moulds for plastics manufacture are good examples.

The focus is shifting to complementing the internal efforts with an increased amount of external technology acquisition on a global basis. Therefore, 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. This new function is global in nature and not restricted to the four walls of a single research laboratory. In some of the companies, as high as 10% of the specialized R&D professionals are devoted to this activity.

Several factors are helping to accelerate the globalization 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 network. Information is the most fluid commodity in the world, most easily and quickly moving from place to place

Consequently, those products, processes and services, which are most fluid and hence able to take the earliest and fullest advantage of information technology are getting globalized rapidly. The internationalization of all professional services is essentially a consequence of this fluidity of information Global information networks are allowing the real-time management and operation of laboratories in any part of the world

Why R&D alliances with India?

Having discussed these driving forces, we can now ask as to why leading companies from the developed world should come to India to forge R&D alliances. First and foremost pertain to the lower costs of doing research in India. This gives India a strong competitive position. Secondly, the high-quality science base prevalent in India in certain select areas is a big attraction, especially when one recognizes that industrial R&D is becoming increasingly science-based.

Thirdly, the companies perceive that such collaborations provide specific mutants of an existing technology or a new technology that is fully adaptable to the distinctive conditions prevailing in India. The fourth factor is the perception of the new environment in the post-liberalization era in which Indian R&D institutes and industrial firms will operate, where factors such as improved freedom and flexibility, better communication and IPR protection, improved consciousness about quality and time of delivery will improve dramatically. The prospects for north–south partnerships in research and technology are thus looking more attractive than ever before.

Let us look at Indian R&D institutes specifically. There is a growing realization among them that technology development is a concurrent, integrated process involving cooperation among the R&D, design, manufacturing and marketing elements. The Indian industry was so far limited in taking a new product or a process to the market-place rapidly on a global scale. Some capable Indian R&D institutes began joining hands with foreign companies who were looking for new ideas and knowledge. These foreign firms were beginning to provide in return not only complementary strengths in product development but also strong financial and marketing inputs to scientific and technological co-operation.

If we see it from the viewpoint of Indian firms, again globalization of industrial R&D is beginning to make sense. Take drug research as an example. With the impending change in the patent laws, Indian drug manufacturers have begun to redefine their strategies, since research on new molecules is expensive and time-consuming. Indeed, introducing a new drug molecule in the market requires around 250–300 million US dollars (more than the present annual investment in R&D by the entire Indian industry!) and takes 10–12 years. In view of this, companies such as Dr Reddy's Laboratories, who specialize in research are already joining hands with the overseas partners for development, since it is development and not research, where the major expenditure in taking a new molecule to the market-place resides.

Going even further, one will now see an increasing trend of Indian and foreign firms setting up joint R&D ventures in India. For instance, you are all aware of the Ranbaxy–Eli Lily tie up that was announced recently. Acquisition and merger of R&D intensive organizations in India will be on cards.

Many leading companies are also moving their R&D centres to India. For example, the well-known Swedish pharmaceutical company ASTRA has already set up a biotechnology R&D Centre in Bangalore. The fifth laboratory of the multinational giant Unilever is being set up in Bangalore. Polaroid Corporation, world's leading instant imaging company, has declared its intentions to start R&D in India as a wholly owned subsidiary. Jack Welch, the chief executive of General Electric (GE), was here in India last month. His statements summarize the new trends quite clearly. He said, 'India is a developing country. But it is a developed country as regards its superb scientific infrastructure. It is for this reason that we wish to shift a part of GE's development effort to India'. The writing is on the wall. We will see several such new initiatives now.

What could India offer?

India can really capitalize on this great movement. Indian R&D laboratories and firms with strong capabilities in research and technology can use several different modes for forming industrial R&D alliances and develop strategies to make research as a business. Let me summarize a few of these below, as I see them.

The first mode is the *innovation sale*, or the sale of an exploitable idea or a concept. Technology follows a growth cycle. It starts with basic research and leads to a laboratory scale work, development at a pilot plant scale, prototyping, etc. It is followed by engineering and eventually results in commercialization. As we move down this *innovation funnel*, the risks, the investments, etc. keep on increasing; at some stage, these costs may be beyond the reach of Indian firms. Innovation sale embodies the true spirit of research as a business. Recently, NCL negotiated successfully licensing of its US patents on a high-performance material with a US firm for an attractive price. Opportunities for such innovation sales will multiply – but only when the innovations are world-class.

A second strategy would be *contract research*. Here a project, or a part of it, is subcontracted by a foreign firm to an Indian publicly funded R&D. Contract research can arise only out of the synergistic strengths of the partners involved. The partnerships again will extend internationally. NCL's work with Oxychem (USA), Neste (Finland), Du Pont (USA) are examples of such contract research.

Contract research could also be for the *custom synthesis* of low-volume, high-value and high-performance compounds. The advantage of India being a low-cost producer with a high intellectual base lies here. IICT in Hyderabad, for instance, is undertaking custom synthesis for Abbott Laboratories in USA.

Then we can have *collaborative research* as a very important vehicle, where synergies of an Indian R&D outfit and a foreign firm are used effectively. Flow of royalties on commercialization can mean significant earning for India.

Technology licensing is another mode. Technology or know-how could be licensed out on an exclusive or a nonexclusive basis. NCL's licensing out a catalyst technology to a leading multinational in Europe is a typical example.

It needs to be realized that the concepts may not necessarily be born in India. R&D results at a certain intermediate stage of evolution could be

acquired from outside and combined with in-house development in India to develop full-blown technologies. Indian firms who are interested in making technology as their business and the Indian R&D institutes could join hands in such ventures. Financial institutes could play a major role here. We have no examples of this happening as yet, but they will surely emerge as technology emerges as a powerful economic driver.

The rich scientific base prevailing in many of our institutions could be extended to impart *knowledge-based consultancy services* to developing countries abroad. These could be, for instance, in the form of setting up R&D laboratories abroad and even managing industrial R&D laboratories abroad. NCL offering services to China in setting up two major industrial R&D laboratories and NCL's recent consultancy work for Ivory Coast in Africa are examples of this. Even the developed countries would want such services. Some of the US companies are already planning to use Indian R&D institutes as a window on knowledge on the rest of the world.

The more successful industrial R&D laboratories in India, who have already undergone the transformation to market-driven and performance-oriented laboratories, would serve as models for laboratories in other parts of the developing world (especially Asia), who wish to undergo a similar transformation. *Institutional twinning* then becomes another form of attractive business. This is an arrangement by which the institutions abroad and leading institutions in India would be interwoven. The twinning arrangement should bring a sizeable income to the Indian R&D institutes through expert fees, training, consultancy, etc. NCL is signing contracts to twin with two chemical laboratories undertaking industrial R&D in Indonesia.

Specialized testing and training could be offered in a variety of ways Certain laboratories in India have world-class facilities and it may be cheaper and advantageous for many developing as well as developed countries to get their specialized training done in India. The excellence of Centre for Cellular and Molecular Biology in Hyderabad, for instance, will be matched by few institutions in the world and the training in molecular biology they could offer would be equivalent to the very best in the world

What could be India's gain?

The foreign companies can associate with Indian R&D outfits synergistically at a fairly early stage of development. The Indian R&D partner can put as his equity his intellectual capital – in the form of research ideas, concepts, etc., and add substantial value to it by joining hands with foreign firms, who can bear the larger development costs. According to Dr Reddy, a leading technocrat and one of the few industrialists who is propagating the theme of *research as a business*, an investment of Rs. 20 crores in drug research can yield Rs. 60 crores from the sale of development to a partner!

Many contract and collaborative research projects involve exchange of technical personnel between the R&D partners. Such an access is invaluable since it results in considerable augmentation in the technical skills and knowledge base of Indian scientists and engineers. This high level expertise later becomes useful in servicing the Indian industries better.

Many multinational firms find it attractive to set up manufacturing base in India itself in view of the high cost economies prevailing in those countries. This would be also true about those products that arise out of the joint R&D done by a foreign firm and an Indian R&D outfit in India. NCL's experience has been that these firms tend to enter into a tolling arrangement with local companies in India. This means again direct benefits to India in view of the expansion of India's manufacturing base, creation of new jobs, etc.

Let me also establish a relationship between technology acquisition and international R&D collaborations. We must realize that the technology acquisition game is becoming more and more complex, since India is no longer being considered as a bottomless pit of demand by the developed world any more. Technology buyers from India are being seen as potential competitors in the world market. Therefore, technology sales are being conditioned with marketing territory restrictions. The age of straightforward technology licensing agreements is also over. It is giving way to technology-cum-market, technology-cum-stakeholding, technology-cum-product swap, etc Technology is available to an Indian buyer only if it fits in with the supplier's global scheme I have a strong feeling that R&D alliances with firms abroad might be one of the many ways in which we can get around the problem of technology acquisition.

Let me share a personal experience with you, where I realized that even in nonstrategic areas, technology may not be available for love or for money. I remember the classic case of IPCL planning the massive petrochemical complex in Gandhar 6–7 years ago. An important part of the product slate was based on alpha olefins. However, in spite of so many years of efforts and continuous pleading with technology suppliers from USA, Europe and Japan, no one so far has been willing to give IPCL this technology. IPCL is now forced to change the product slate. Interestingly, IPCL had begun doing R&D work on alpha olefins in the late eighties. This research was done for a few years and then it was stopped.

It seems to me that if this R&D work had continued, we would have by now moved to at least a pilot plant level, and as it always happens in research, we would have probably got some new leads or competitive strategies, with possibly a strong foreign patent position on alternative processes. Then the technology suppliers themselves would have been willing to join hands on a collaborative R&D and perhaps to supply the technology also!! The real point I wish to make here is that indigenous technology development could be made use of as a powerful strategic weapon to acquire technology and collaborative R&D with foreign technology suppliers can become a part of this game plan!

The progress so far

NCL's experience

Let me share NCL's experience on globalization of research and development. It is interesting that although the new industrial policy was announced in July 1991, NCL had already entered the global market in 1990 by signing an agreement for sale of its catalyst technology with a multinational company from Netherlands It had also won a consultancy contract in China by competing with reputed US consulting companies The intention of transforming National Chemical Laboratory into an International Chemical Laboratory had, in fact, already emerged in the late eighties Why did this transformation take place?

There were several driving forces NCL's success in commercialization of technology in the seventies and early eighties had spurred it into high-tech areas Some of the researchers in NCL were coming out with world-class contributions, which were getting patented abroad There were no takers for these inventions in India and the creative ability of NCL's scientists was getting stifled. The only way to solve this problem was to look at the global R&D markets Thus, the initial process in NCL really began due to 'supply push' rather than a 'demand pull' – to use common jargon. However, as time went on and NCL built on its successes it found that international companies were quite responsive to the idea of looking at NCL as a partner in their global strategic R&D partnerships. Furthermore, the Abid Hussian Committee, which reviewed CSIR and set up targets for its external earnings provided a useful driving force. The reduced government budgets in 1992–95 pushed NCL to a situation where it had no money left for R&D or modernization. Stepping up the external earnings sharply became essential. Strong professional marketing of NCL's capabilities worldwide then became an essential prerequisite for drawing worldwide clients. NCL's hidden agenda was, of course, to create a cadre of scientists and professionals who worked with the international clients and got used to the international benchmarks of 'time' and 'quality'–something which lifted the quality of R&D done at NCL to new heights.

NCL considers itself as a true global R&D platform today. Its global interactions are in the form of contract and collaborative research, technology licensing and technical and consultancy services. NCL recognizes the key determinants of success in global partnerships. Therefore, it pays special attention to the delivery in time of processes and products of international quality, maintenance of confidentiality, protection of intellectual property and strong communication links with the collaborators through flexible and effective mechanisms.

NCL's repeat international customers are a testimony to the fact that it has arrived on the global scene. NCL's services have now been offered both in the developing world and the developed world. Thus, its relationships range from Florafrica in Ivory Coast to General Electric and Du Pont in USA, to JPCID in China. National Chemical Laboratory is already being recognized as an International Chemical Laboratory!

While this is certainly a heady feeling, NCL does recognize that its charter is to serve the nation and make the Indian industry globally competitive. It, therefore, maintains a balanced portfolio, where around two-thirds of the work it undertakes is still with the Indian firms.

National experience

Past two to three years have seen many new initiatives taken by several institutions, who are moving ahead in globalizing their R&D. Let me briefly summarize this movement for you. Let me begin with my own organization, CSIR itself.

Technologies of IICT in Hyderabad on the anti-ulcer drug Omeprazole and anti-AIDS drug AZT have been transferred to a Brazilian company. CDRI in Lucknow has developed an antifertility 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.

Institutions like IICT and NCL synthesize several new molecules, in the course of their research, which could be biologically active. IICT has joint programmes with US companies like Abbott Laboratories, FMC Corporation, etc., where such compounds would be evaluated by these companies for their potential pharmacological activity. NCL has similar arrangements with American Cyanamid. IICT also has external collaborations with National Institute of Health and Parke Davis for testing of natural products extracts based on Indian plants, for their potential pesticidal and pharmaceutical activity.

Indian coastline is globally viewed as an area of immense potential in terms of marine organisms. IICT has a project with Smith Kline & Beecham and NIO in Goa has joint programmes with DuPont and American Cyanamid for screening of marine organisms for their potential drug applications.

International agencies like World Bank, UNEP, WHO, UNIDO have availed the assistance of NEERI in Nagpur on several projects involving environmental protection and management around the world.

Recently, the Tower Testing and Research Station of SERC in Madras bagged an international order for testing two transmission towers of Locweld Inc, Canada, well-known tower fabricators in North America.

NAL in Bangalore is negotiating on a number of high-technology areas in aerospace sector with companies like Boeing. NAL has also 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. NAL has also rendered consultancy services to Vigyan Inc. of the US on the upgradation of the NASA Langley National Transonic Facility Control System

Over the last few years, NRDC has also been reorienting itself to become an international technology transfer organization. It is trying to license indigenous know-how worldwide and execute turnkey projects based on indigenous technologies. For instance, NRDC has recently finished a UNIDO-funded project in Vietnam to set up a natural and synthetic dyes and pigments plant. The technology was developed by RRL in Jammu. NRDC is also making a major effort to provide help on licensing indigenous inventions abroad. Its effort to file worldwide patents for heart valve development by SCTIMST in Trivandrum is a notable example.

Antrix, the marketing arm of the Indian Space Research Organization (ISRO), has won international contracts for studying low earth orbit satellite systems, antenna for hand-held phones, etc. In areas involving cutting edge technology also, Indian R&D outfits are making major strides. Take supercomputers based on massively parallel processing. 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 list is, of course, not exhaustive – but it definitely shows the great momen-

tum that has been gained in recent times in forging global relationships in industrial R&D.

The barriers to progress

Although the case for India to become a part of the global industrial R&D network can be made persuasively, there are several bottlenecks which need to be addressed first before this dream becomes a reality. Partnership involves two or more parties. There are problems and difficulties for the firms abroad as well as for Indian R&D outfits. Let us focus on a few of these.

Firms in the developed world still view cultural barriers as one of the major bottlenecks. They are also not sure as to whether the confidentiality will be maintained and the intellectual property will be well protected. The technology game has become very competitive globally. This has led to an interesting shift in the perspective on the sources of competitive technology. The access to top-class R&D institutions in India will be considered as one such source. In such a situation, the companies do not even want the others to know where they are getting the external technology from. Confidentiality thus becomes a crucial consideration. In government-funded institutions, with well-known pressures on information disclosure and public accountability, it may become difficult to keep confidentiality, unless some fundamental changes are made in view of the nature of the forthcoming business.

Institutions in India are today faced with the problem of reduced budgetary support from the government. Even the best of the R&D institutions will get rapidly obsolete if they are not modernized on an urgent basis. If we want to forge R&D partnerships with foreign firms, say for instance, in the area of drugs, then Good Manufacturing Practices (GMP) becomes a must. This calls for an upgradation of our laboratories, including facilities, controls, manufacture, processing and packing, to ensure that they all meet the stringent requirements of safety, quality and purity characteristics. Creation of GMP-approved laboratories implies significant investments – but if we do not make them, then there is no international business that will be forthcoming!

Many of the institutions have poor skills in patenting (an issue which is so vital that I will deal with it extensively later on), contracting and negotiations. They also suffer from information barriers since they do not have an operating or marketing base in the developed world.

One of the important requirements for success in R&D as a business is the necessity of having an operating and/or marketing base in major markets. Tie-up with technology transfer companies or technology transfer agents in the developed world, therefore, becomes inescapable. Today the word 'agent' has acquired a bad connotation. But if research has to be conducted as an international business, then we may not be able to do away with agents all the time! I wish to emphasize this since we may not at all know the real requirements of the international markets in which we wish to operate, and at the same time these markets may not know about our presence or even our existence!

In this connection it is important to emphasize the crucial role of technology forecasting and techno-market studies. Technology Information, Forecasting and Assessment Council (TIFAC) has already networked the strategy of our R&D institutions, industry and academia to generate more than 100 detailed reports giving an emerging picture of the emerging global possibilities for India. Such activities need to be intensified since they can provide us good leads. R&D institutions abroad work on the basis of exclusivity. The publicly funded R&D institutions in India have been hesitant to offer these conditions. Secondly, most of the laboratories lack a legal back-up. We cannot match the powerful specialist attorneys hired by multinational companies. Companies abroad have professional negotiators on their marketing and acquisition teams. Ignorance of international markets as well as regulations for products and processes makes it difficult for us to do marketing as well as to put a price on our intellectual property. Ignorance of environmental and safety regulations as well as ignorance of occupational health regulations pose additional constraints. Such ignorance can lead to failure of attempts to do technology transfer to the developed world and, worse still, the possibility of getting into public liability cases!

For publicly funded R&D institutions, the requirement of obtaining approvals of multiple government agencies can cause substantial delays. In a competitive environment, the speed of response is of utmost importance. Therefore, all these hurdles must be removed speedily and the institutions given a fair playing ground by debureaucratizing them and giving them full flexibility and freedom.

In certain areas like biotechnology, collaborative programmes entail the exchange of genetic material. The recent government notification on banning the flight of indigenous genetic material to developed countries, though done with a perfectly good intention, will pose difficulties in undertaking time-bound and competitive industrial R&D with foreign partners, where time is the essence. We need to logically and rationally reexamine this issue so that we make sure that we do not lose the benefits arising out of our great biodiversity, but at the same time we can add value and create wealth by exploiting these rich resources through serious international partnerships.

IPR: the vexing issues

I come back now to the issue of patents, which, to my mind, is most vital in the international R&D business. Indeed, skills in patenting, filing, reading and exploiting patents will be most crucial in the years to come. Indian contribution to the pool of international patents is negligible. This has to be increased very substantially. Let me discuss some key issues in this connection.

The fundamental issues will be about the quality of research that we do. The basic criterion for the grant of a patent is that the innovation must have elements of novelty, non-obviousness and utility. How much of the research that we do today, whether basic or applied, meets even some of these basic criteria? Many of the Indian R&D institutions and industrial firms have so far focused on imitative research or reverse engineering. How do we turn them around so that they move on to innovative research or forward engineering?

Creating top-class professionals in patent writing is the first requirement. Today our knowledge about writing and reading patents is very poor. Neither can we properly protect our inventions nor can we understand the implications of the patents granted to our competitors. Thus, we may have a good invention, but we cannot effectively protect it by patents filed abroad as many of the patents written by our professionals could

be easily circumvented. How do we create, within our system, a cadre of top-class professionals who will fight these battles? These are the burning questions

Patent attorneys are one of the highest paid professionals in the West Organizations such as the Certified Institute of Patents Agents in UK produce high-quality patent professionals. An aspirant desirous of making patenting as as his profession has to pass a highly competitive examination, which consists of papers in science, engineering, drafting, infringement and a host of related areas. We have no such system in India. We will have to quickly move on these.

International patenting is an expensive business. In view of the budgetary constraints, a time will shortly come, when it will be difficult for individual institutions to file and maintain large number of patents abroad.

The importance of patents in conducting international research business can be illustrated with the NCL example. Till 1989, NCL did not have a single US Patent, and our foreign earnings had also been very marginal. Ever since 1989, the flow of US patents started. This has resulted in a progressive increase in NCL's foreign contracts as well as our earnings. Incidentally, NCL files the highest number of patents from a single R&D outfit from India today.

We will soon start running into complex difficulties. Let me share again NCL's experience. Exxon and Hoechst today hold nearly 50% of over 400 global patents on metallocenes, a catalyst which will have tremendous impact in future on polyolefin polymers made by the conventional Ziegler – Natta catalysts. Exxon even sues new companies entering this field for violation of their patents to pre-empt any future competitions in this area. NCL is now faced with an interesting difficulty. It has a novel innovation in metallocenes but is finding it difficult to break the fortress of 400 strong patents! This is just an indication of the difficulties we will be facing by the year 2005! We really need to gear ourselves up fast to face these challenges.

In the area of biotechnology, there are special difficulties. India does not have a national facility for depositing micro-organisms, which is internationally accredited. This would mean that if we have to take a patent in this area, we would have to deposit our strains in some of the authorized depositories abroad, like the ATCC. We, therefore, need to create an accredited facility as soon as possible. Signing the Budapest Treaty, therefore, assumes priority.

Some concerns and cautions

The dream and vision that has been portrayed by me could be realized only if the basic premise that we will continue to have strong, viable and relevant S&T base in India remains valid. Some indicators that we see have caused an anxiety in the minds of the scientific community. Over the last 5 years our investments in S&T have declined from 1.1% of GNP to 0.86% of GNP, just at a time when our neighbours like Korea are progressively trying to push their investment up to 4% of GNP. Apart from reduced investments, there is some feeling that there has been a reduced attention paid to issues on science, the needs and the demands of the scientists and so on. Especially important is the feeling that our modern institutes are decaying for want of support and modernization Therefore, the confidence in the scientific community that the nation expects the scientists to be on the centre stage and play a crucial role in nation's development needs to be reinstilled. The government will have to urgently announce plans to revitalize and modernize the Indian S&T force to make it globally competitive and implement these plans.

I wish to emphasize that eventually all efforts on industrial research and development in India must be 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 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 skills are available to the Indian industry too.

In this connection it is rather interesting to see that the Indian industry so far has been lukewarm to the idea of using the Indian S&T talent. In contrast see the statement by the GE Chairman Jack Welsh little earlier, where he compliments the fully developed S&T infrastructure in India and wants to use it for the development programmes of GE! The message is clear The Indian industry will really miss out if they do not establish organic linkages with centres of excellence in India by valuing R&D

The emergence of R&D centres in India by multinationals needs to be viewed in a perspective also. With super attractive remunerations, world-class facilities and cutting edge and challenging problems many top brains from the S&T community will be attracted by these centres It is absolutely essential that the Indian R&D institutes urgently create an intellectually stimulating environment, where young minds could be challenged and performers could be rewarded handsomely.

Internationalization of R&D must lead to wealth creation in India. If only routine services and contract research is offered on comparatively low rates commensurate with our salaries, then we will not achieve these goals. What is important, therefore, is to ensure that we offer globally competitive knowledge and use brain hours rather than man hours while pricing our intellectual property.

We will also have to worry about competitions 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 languages 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.

Next actions

Being a born optimist, I have portrayed this grand and bold vision of India as a global R&D platform. But how do we get there? There are urgent actions that the government, industry and the public R&D institutions need to take in order to make things happen, and happen quickly. In what follows, I suggest 10-point plans for the government, for the industry and for the public R&D institutes.

Government

1. Review and restructure S&T priorities with special emphasis, among other

things, on the global competitiveness of Indian S&T and Indian industry.

2. Enhance in a stagewise manner the national investment in R&D, which has fallen sadly in recent years. Instill a new sense of confidence in the S&T community. Propose plans to minimize brain drain, maximize brain gain and network Indian brain banks around the world.

3. Restructure and debureaucratize the universities and publicly funded R&D institutions, giving them flexibility, freedom of operation and also financial autonomy. Especially examine the relevance and quality of industrial R&D in publicly funded R&D institutes and their relevance in the changing context. Modernize select universities, R&D institutions, etc., in a way that will give them a fair playing ground.

4. Promote measures, including attractive fiscal incentives and innovative government–industry partnerships, to increase the share of the Indian industry in R&D, which is miniscule today.

5. Emphasize technology-led exports as well as export of technology. Create fiscal incentives and simplified procedures for export of technology for industry as well as industrial R&D institutions, similar to those that exist for exporters of goods.

6. Join the Paris Convention as well as the Patent Cooperations Treaty. Also sign the Budapest Treaty.

7. Establish electronic databases exchanging patent information nationwide. The networks spanning transnational boundaries should interconnect all the industrial R&D players in the game.

8. Reform and modernize the patent office (as well as the patent officers) and allied institutions in a massive way. Launch a multipronged attack on patent and IPR illiteracy. Launch a massive mission which will include many simultaneous efforts such as creation of National Patent Promotion Fund, a National Patent Institute, etc.

9. Work out an attractive package of fiscal incentives for international patenting for industry. This could involve suitable tax provisions, writing off of expenses on international patenting, giving special tax concessions to consultancy firms dealing with IPR, etc.

10. Promote measures by which technologies which exploit our resources and skills, rather than our markets, are brought into the country.

Industry

1. Look at technology, rather than just markets, as an instrument of growth. Increase substantially the expenditure on R&D.

2. Use research and academic institutions as 'idea generators' as well as 'window on knowledge' on the rest of the world. Forge organic linkages with them.

3. Create a massive 'demand pull' on the Indian academia and R&D laboratories. Challenge them with tasks and targets.

4. Evolve strategies on technology-led exports as a means of value addition and growth.

5. Bring 'export of technology' on agenda. Make international competitive bids for generation and export of technology by joining with public R&D institutes, whose strengths could be synergistically used.

6. Value 'knowledge' and respect intellectual property. Inculcate patenting culture and build patent literacy within the organization.

7. Identify 'core competencies' and 'enabling technical skills'. Gain visibility and credibility in these areas by creating a strong international patent portfolio.

8. Join in a massive exercise of technology forecasting to determine the long-term trajectories to be followed for competitive strength.

9. Explore opportunities for research as a business worldwide and create new niches by gauging and benchmarking the internal strengths.

10. Participate actively and conscientiously in the effort to take a due share in supporting research and higher education in the country.

R&D institutions

1. Debureaucratize, professionalize and modernize the laboratories and, establish organic linkages with the Indian industry.

2. Enter into and enhance the global business by aggressive marketing and establishing innovative channels of communication. Note that technical personnel abroad of Indian origin are valuable assets. Identify 'champions' in collaborating organizations

3. Recognize the facilitating and promotional role of financial institutions and form R&D institutions/financial institutions/industry nexus.

4. Create incentives and reward systems for S&T personnel undertaking industrial R&D.

5. Engage professionals for technology marketing who can act as innovation facilitators. Whenever feasible, establish commercial arms of laboratories to facilitate marketing.

6. Evolve guidelines for early-stage identification and valuation of IPR and debureaucratize the internal processing. Evolve methodologies and procedures for the capture and formal documentation of IPR.

7. Establish internal assessment mechanisms to assess the elements of novelty, non-obviousness and potential economic benefit, which are the essential pre-requisites of a patent.

8. Undertake a worldwide patent search and techno-market survey prior to initiation of R&D. Undertake technology forecasting exercise and use the forecasts for targeting trajectories of action.

9. Create systems for management and marketing of patent portfolios. Build the cost of patenting into R&D costs, which can be recovered from the contracts.

10. Be market-driven but also drive the markets with innovations of explosive creativity. Move to the path of 'forward engineering' rather than routinely following the path of 'reverse engineering'.

Concluding remarks

I do understand that this has been a long and elaborate lecture, but I deliberately wanted it to be that way. I believe that this is an important point in our history, where we must look at the present as not just a mundane extension of the past but as an exciting launching pad for a great future. I have strong belief that the vision of India as a global R&D platform would materialize, and it would materialize sooner than we expect, provided we move swiftly and with determination

R. A. Mashelkar is in the National Chemical Laboratory, Pune 411 008, India