A given alone. If the object is to promote maximal vitamin A retention and not just to capture children then the time of vaccination is an inappropriate choice for vitamin A administration.

If 11 per cent of infants receiving massive vitamin A dose along with vaccination are going to develop visible signs of intracranial tension, there is the very real danger that the EPI programme will suffer because of poor compliance. EPI is of proven benefit; massive vitamin A oral dose in infancy, to say the least, is of doubtful value. We certainly should not allow an excellent programme of indisputable value to be ruined by a dubious 'fellow traveller'.

Latham[6] had recently pointed out that whatever effect vitamin A administration is claimed to have had on child mortality may be largely explained by reduction in deaths following on measles. Measles vaccination is a far more certain way of bringing this about than vitamin A administration. It will be unwise to do anything which will reduce the acceptability of EPI by the community.

One-third of infants in South Asia are of low-birth-weight to start with and show signs of psychomotor deficits at birth. Our attempt must be to help them overcome these initial handicaps. Subjecting these poor infants to repeated episodes of increased intracranial tension could contribute to further retardation of their brain development. A significant part of overall development of the brain takes place in the post-natal period.

Before any procedure is recommended for adoption, especially on a public health scale, its safety must be established beyond reasonable doubt. We have no studies whatsoever on the effects of repeated episodes of raised intracranial tension on the development of the brain in the post-natal period, especially in infants who start their lives with psychomotor deficits as a result of intrauterine growth retardation.

It is strange that a wholly unnecessary procedure, the safety and validity of which have not been adequately tested and proven and which could undermine the confidence of poor communities in EPI, is sought to be promoted by some agencies and commercial interests. Surely there must be more legitimate and less hazardous ways of expanding the market for favoured commercial products. Why pick on defenceless infants of poor countries for such unethical (mis)adventures?

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C. Gopalan is in the Nutrition Foundation of India, B-37, Gulmohar Park, New Delhi 110 049, India

Technology development trends in India: Past, present and future

R. B. Subramanyam

The recent liberalization policies of the Government of India aimed at rapid economic growth of the nation through extensive foreign investments in almost all sectors and the emphasis on global competitiveness have raised several questions in regard to indigenous technology development and its relevance to the present day context. A review, therefore, of the technology development policies of the past in comparison to the current trends will perhaps be not only useful but also necessary to enable us to plan our future programmes. Many such articles and reviews have already appeared in print and this is yet another attempt to bring to focus the various issues involved so that there can be a serious debate leading to productive and meaningful guidelines and policies for the future.

It is needless to emphasize that a good and progressive 'democracy' calls for a well-informed and knowledge-based governmental intervention at the appropriate time in the 'Affairs of the Nation' be it relating to its industrial growth and economic progress, scientific and technological development, agriculture, alleviation of poverty or even political stability. While this canvas of far-flung activities, each apparently quite distinct from the other, is very vast, undoubtedly, simultaneous and comprehensive development of all these areas and many more is vital for the healthy growth of a nation. The task of making the right decision at the right time is understandably extremely difficult and can be achieved only through periodic reviews and adjustment of 'Policy decisions' to suit our domestic needs keeping in view the changing global economic and political environment. I sincerely hope that the views expressed and the suggestions made in regard to only one small but vital area, viz. 'Technology development', will catalyse further discussions and debate and eventually provide a knowledge base to our policy-makers to make necessary corrective adjustments. If this limited objective is achieved through this article and 'Tomorrow's citizens' do not blame us for the path that we have chalked out for them, I shall consider the time that I have spent writing it, worth its while.

This article is primarily based on my three decades of experience in the fields of basic and applied research, technology development and production of reactive metals. Since my entire career so far has

been only in the Departments of Atomic Energy and Defence Research. I have chosen authentic examples and case studies only from these two departments to illustrate and support the viewpoints expressed on 'Approach to technology development'.

Approach to R & D in the Department of Atomic Energy

I joined the Metallurgy Division of the Bhabha Atomic Research Centre [then known as the Atomic Energy Establishment, Trombay (AEET)] in 1957 as an Engineering Trainee of the first batch of the just then started 'Training School'. It was a time when the Department of Atomic Energy, the youngest scientific department, under the dynamic and visionary leadership of Homi J. Bhabha, was growing at a pace unheard of in any other well-established scientific departments of the Government of India. To say the least, the growth rate of the department in the first two decades was phenomenal and mind boggling It is interesting to note that Homi Bhabha, who started his career as a cosmic-ray physicist (considered as a secluded branch of science even today) could and did take such a deep-rooted interest in the entire range of science and engineering disciplines. It was his strong conviction that 'nuclear energy' could play a dominant and peaceful role in the welfare of mankind and to master this limitless energy, there is a need to build up expertise in every branch of science and engineering associated however remotely, with it. It is this conviction, coupled with the staunch and undaunted support that he received from Pandit Jawaharlal Nehru (another visionary son of India, who firmly believed rapid industrialization and technology development for self-reliance as absolutely vital for the healthy growth of the nation) that provided the Atomic Energy Department with near-total autonomy and almost unlimited resources for 'Research and Development' in the formative years and for large-scale production of nuclear and allied materials later, when the indigenous capability for the same became available.

The only 'slogan' that we heard in those days was that of 'self-reliance' and self-reliance at any cost. I must, at this juncture, once again, emphasize the visionary role played by Homi Bhabha in instilling this 'Mantra' into everyone of us working in the department but for which the country could not have acquired the level of competence that we now witness in a wide range of 'high tech' disciplines related to the Peaceful Uses of Nuclear Energy.

While on the one hand, scientists were given all the encouragement to build, in-house, all the equipment required for their R & D work (for which excellent fabrication facilities such as the 'Central workshops' and the 'Technical Physics Division' were created quite early in the programme), on the other, massive financial support and technical assistance was also provided to the Indian industry to develop and build sophisticated equipment and components for the Atomic Energy Programme in general and those connected with heavy water production and Nuclear Power Plant construction in particular. Transfer of knowledge and technology to interested and knowledgeable entrepreneurs/industry was encouraged for which, at least in the early years none talked about 'know-how fees' or 'technology transfer fees'. The mission was to provide the benefits of atomic energy to the Nation at the earliest by all possible means. This policy of self-reliance and encouragement of indigenous industry by the DAE units was remarkably successful and later became a role model to follow for the Departments of Space and Defence Research. 'Self-reliance' means doing everything needed for the programme either in-house or within the country and as far as possible utilizing indigenous raw materials, equipment and skills. I can with some authority state that the 'mantra' of 'self-reliance' was the most appropriate at that point of time since I was witness to some of the events that directly favoured this policy. For example, the massive technical help and support that the DAE received from the USA during the fifties and early sixties was short-lived with changing Indo-US political relationship. The same was the case with the help and support that we received from Canada which was abruptly cut-off after the Pokhran experiment.

Therefore, it was only the comprehensive approach of self-reliance that paid rich dividends and eventually put us at par with the nations claiming supremacy in the field of atomic energy. For the benefit of those readers who are not very familiar with the level of competence that has been achieved in this field, it is relevant to point out that India has the capability of designing and constructing nuclear power plants of 200 MW(e) capacity on 100% indigenous basis entirely with Indian raw materials, equipment and skills.

Development of defence-related technologies

The Defence Research & Development Organization (DRDO), with many laboratories spread throughout the country, has been carrying out R & D in practically every conceivable area of concern to defence. Subjects that are addressed by DRDO laboratories range from (a) missile systems to material sciences, (b) combat vehicles to computer sciences, (c) explosives to electronics, (d) combat aircraft to camouflaging sciences etc. In recent years, defence research has caught the imagination of the entire world with many success stories like the development of advanced ballistic missiles, sophisticated equipment for the Army such as the Main Battle Tank, world class anti-tank ammunition, advanced radar equipment for the aero-space and a wide range of electronic defence equipment comparable to the best in the world. Interestingly, for the development of these products and several others not mentioned here, the country neither sought nor received help from any external agency.

Indigenous development of space technologies

In more recent times, the country has witnessed outstanding developments in the field of 'space sciences', the benefits of which have flown down even to the remotest village in the country through satellite communication and television. Contributions of our space scientists towards many other areas like weather forecasting, satellite mapping for variety of scientific applications etc., though less known to the common man, have enlarged our knowledge base and understanding of many vital areas. Thanks to the massive support received from the Central Government, the country's Space Programme, despite many initial setbacks, has now reached the take-off stage with indigenous capabilities for design and manufacture of launch vehicles, satellites and control instrumentation well-established. Like in

the case of atomic energy and defence research, the many success stories of our Space Programme are truly Indian in origin with very little help provided by the nations considered as leaders in this field. With the momentum already gained after the recent success of the PSLV launch and with continued support from the Government, our space scientists will surely be in a position to design and build satellite launch vehicles with cryogenic engines entirely on their own.

R & D philosophy – the past and the present

A careful scrutiny of the strategies for development adopted by the Departments of Atomic Energy, Space and Defence Research interestingly reveals many common factors. This is perhaps so since all the scientific secretaries who were and currently are at the helm of affairs in these Departments hold Homi J. Bhabha in the highest esteem and have opted to implement similar, if not identical policies of self-reliance and active support to industries' participation in all their development/production programmes, doing so with a remarkable degree of success. The success of the R & D programmes in these three areas can perhaps also be attributed to the fact that Government had given them full support and unfettered freedom to develop a wide range of high-tech products entirely within the country with the full realization that no help will ever come forth from developed nations in these areas of strategic importance.

Foreign technologies and their implications on indigenous development

Coming back to the subject of technology development as applicable to the general industrial sector, it is interesting to note that almost all our industrial development activity (barring a few isolated cases related to Atomic Energy, Space and more recently Defence as mentioned above) has occurred with foreign collaboration and tie-ups. Perhaps, soon after independence, with a view to achieving rapid industrialization, this policy of foreign collaboration and tie-up was necessary. But unfortunately the same policy continued for several decades and continues even today with even the checks and balances that existed earlier having been removed with the current liberalized approach. A dispassionate analysis will indicate that the success stories of Atomic Energy, Space and Defence have come out of total commitment to self-reliance without examining other options, if any, available to them. On the other hand no such commitment existed, nor does it exist even today in respect of other industrial areas. Besides, there has always been a feeling and this feeling continues even today, that our scientific and engineering R & D community is incapable of providing technological solutions to the problems faced by our industry. Thus, a gap always existed between the R & D establishments within the country and the industrial sector. There were none like Homi Bhabha to dispel such misgivings and to insist on firm tie-ups between indigenous technology development and production. Thus, technology development in the national laboratories and parallely, establishment of industries with foreign collaboration became the way of life in almost all sectors. This unfortunately went unchecked for decades, perhaps partly due to lack of well-informed knowledge-based decision making capability at the highest level while making crucial decisions on major projects. I would also not like to rule out the role of vested interests for this sad state of affairs.

Having said this, may I ask whether scientists and technologists can escape from their responsibility by merely stating that their work is not recognized nor accepted by the industry? Perhaps not. But, without going into the reasons in detail, one can easily see that R & D institutions remain isolated from the needs of the industry and one can venture to say that conditions of cold war exist even today between these two vital limbs of our nation-building activity in so far as the general industrial sector is concerned.

Till very recently, until the unleashing of the liberalization policy advocating global competitiveness cutting across all areas of development and production activities, most of the national laboratories were carrying on with their work in total isolation under a well-protected environment. Good publications in international journals were considered as adequate return for the investments made by the Government. Nor was any demand made by either the government or the industry for a cost-benefit analysis on the R & D investments. Even in isolated instances where excellent technologies became available due to sustained efforts of some dedicated scientists, this was mostly ignored on one pretext or the other by the industry due to the bias in favour of foreign technology nurtured over several decades. It is true that starting from scratch, it always takes considerable time and effort to reach the level of confidence required for building cost effective industries. However, if there had been a periodic debate and strong demands made by the industry/government, certainly at least in some areas indigenous technologies could have blossomed into full-scale commercial plants and we as Indians could have taken pride to say that these plants and technologies have come entirely out of our own efforts. Even if these technologies are not comparable to the best in the world, with time, undoubtedly, we would have upgraded our technologies so that by now at least in some areas these could have become the best in the world. Unfortunately, this scenario never took place.

For a country to become a strong and vibrant industrialized nation, R & D institutions and industry should learn to work in perfect harmony each respecting the role of the other and each seeking help from the other. The R & D institutions must know the needs of the industry and try to provide advanced technological options to them. The industry on the other hand should make demands on the R & D institutions in terms of development of cost-effective technologies, provide adequate financial support in the form of sponsored research projects and also learn to wait for the results of indigenous development rather than rush to seek a foreign collaborator. To receive and appreciate sound technological help, the industries should preferably have applied R & D wings of their own in their field of activities with competent scientific personnel manning them. This will certainly help and profitably enhance the benefits of interactions with other R & D institutions in the country. I had already talked about knowledge based governmental intervention and I strongly believe that the Government has to play this vital role of bringing the industry and the R & D institutions together and encourage each to work with the other. Our late Prime Ministers, Smt. Indira Gandhi and Shri Rajiv Gandhi tried, perhaps in vain, to

propagate concepts such as 'Development of appropriate technologies' and 'Technology missions'. It is most unfortunate that these ideas, which could have played a vital role in bringing the R & D institutions and the industry together to build a strong and powerful nation did not, for a variety of reasons, catch on. For this failure should we blame the scientific community or the bureaucracy or the lack of political will at various levels to aggressively implement the policies? Maybe I should leave this matter to the better judgement of the readers.

Role of Indian consultancy engineering companies in technology development

With the rapid industrialization after independence, a host of consulting engineering companies came to the forefront and played a key-role in the nation-building activity. As already stated, almost all the major industries set up in the country during the fifties through eighties were based on imported know-how. The role of the Indian consulting engineering companies was therefore, by and large limited to the design and construction of civil works and utilities and project management and implementation. While the path followed by the Indian consulting engineering companies was not only correct but also appropriate considering the level of engineering expertise available with them at that point of time (say during the first two decades after independence) similar methods followed by them since then (say from mid-seventies onwards) should not have been encouraged. The consulting engineering companies unfortunately did not keep in touch with the technology developments taking place within the national laboratories nor did they play any link-role between the Industry and the Laboratory. Had they spent a part of their time, energy and financial resources in such activities they could have brought many Indian technologies to the forefront. Unfortunately, our Government also did not make it mandatory for our consulting engineering companies (at least the large and profit-making ones in the public sector) to play this vital function. The R & D institutions are busy developing good technologies and publishing papers. They would much rather work in frontier areas of research to achieve international recognition rather than divert their resources, meagre as they are, to areas of immediate relevance to the Industry or the Nation since they are not too sure whether our Industry will accept home-grown technologies developed on laboratory/pilot plant scale. Our consulting engineering companies are busy, as they have been in the past, assisting the Indian Industry to set up projects based on imported technologies. Our industry as already stated, is yet to accept indigenous technologies for a variety of reasons.

A vast country like ours with hundreds of problem areas cannot rest on its laurels from a few success stories. The gap between the research institutions and the Industry on the one hand and between the research institutions and the consulting engineering companies on the other must be bridged. Even today, our consulting engineering companies fight shy of upscaling laboratory/pilot plant data generated by the laboratories, providing process and technology guarantees and encouraging Indian entrepreneurs to accept home-grown technologies for commercial exploitation. Like the scientists in the laboratory who are happy with publishing good-quality papers and earning recognition in the international scientific community, our consulting engineering companies are quite happy and content to play the secondary role of a local consultant to translate the drawings of a foreign consultant into factories. While hitting out so hard on the scientific and the engineering community, I am quite conscious of the fact that I too belong to the same group and that a person in a glasshouse normally does not throw stones. But I consider it necessary to exaggerate a little in order to drive home the point and deliver the message loud and clear.

Future strategy towards technology development

Having made such remarks, it would be foolish on my part to end this article without some positive suggestions. In my opinion, the country today possesses every conceivable talent in practically all branches of science, engineering and technology. Our scientists are second to none in the world and this can easily be verified from the quality and number of publications they bring out year after year as well as their demonstrated capabilities in the fields of Atomic Energy, Space and Defence. Our consulting engineering companies, over the years, have achieved international level of competence through execution of several major projects not only in India but also in several developing/developed countries. Indian entrepreneurship has also matured over the years and the captains of our industry have now the business acumen and financial backing needed to undertake even very large projects. Therefore, if only we can find a way to bring all these three essential limbs of the 'nation building activity' together, I do not see why India cannot, say in the next decade or two, become a leader in many fields rather than remain as an 'also ran' nation.

For achieving anything, planning should precede action. Let me therefore share with you the following action plan and seek your reactions:

(a) Our R & D institutions, in addition to basic and fundamental research in frontier areas of science and technology, must commit at least half their resources towards developing appropriate need based technologies, however mundane they may appear to be on the surface so that the country's immediate needs are met. They should also establish direct links with the industries, producing goods and services relevant to their R & D field, solve their day-to-day problems and provide them with improved technologies for achieving higher productivity and better quality products. Our R & D institutions should establish joint professional teams in association with consulting engineering companies and the Industry to recommend R & D projects of immediate relevance to the industry/nation. These teams should monitor the progress of the projects, carry out techno-economic assessment and bring in the concept of cost-awareness amongst the working scientists and eventually effect 'ToT' to Industry with scale-up designs and technology/process guarantees coming from the consulting engineering company that has been associated with this activity from the R & D stage.

(b) Our Industry should identify the laboratories engaged in R & D activities relevant to their field, refer their technology-related problems to them for solutions and also sponsor R & D programmes on 'technology upgradation' that can bring forth improvements in productivity and quality of their products. Our Industry must be made to understand that

its products and services can become cost-effective and reach the global markets only when it learns to upgrade its technologies with *indigenous* R & D effort specifically designed and executed to suit our domestic conditions. The fact that hardly any country in the world would ever part with their latest and the most cost-effective technology for love or money needs to be driven home hard till it is appreciated and accepted by our Industry.

(c) Our consulting engineering companies must play a dominant role and act as a vital link between the R & D institutions and the Industry by adopting a laboratory or a group of laboratories working in their field of expertise, sponsoring wherever necessary joint development projects, monitoring closely their progress and eventually helping the laboratory in ToT to Industry by carrying out detailed engineering of the scaled-up version of the project and by providing process guarantees to the Industry.

Conclusions

What I have stated above, I sincerely hope, looks simple, straightforward and logical. But, will the various linkages get established and the events happen on their own? I am afraid not. For various reasons discussed in this article, our R & D institutions, Industry and the consulting engineering companies have got accustomed to living and working entirely in their own worlds, blissfully ignorant of each other's needs. To get them together, some external pressure is necessary and this can only be in the form of Governmental intervention through appropriate legislation. In a democratic society, legislation alone cannot and will not bring forth the desired results. It should be matched with appropriate 'implementing and monitoring devices' with necessary checks and balances. 'DGTD' which was in existence ever since independence till very recently, could have and should have played this role. Unfortunately it functioned merely as a clearing house for import licenses and foreign collaboration agreements. Their rapport with research institutions, if any, was insignificant. All the same, if the Government is bent upon making our country as Number 1, in some chosen fields at least by the first decade of the 21st century, it is time now to think about the means of achieving our goals, make adjustments in our policies relating to 'technology development' and 'industrialization' and act firmly and decisively.

May I once again submit that 'self-reliance' at least in strategic sectors is as relevant today as it was in the fifties considering some of the recent global political developments. Trade wars of the future can be fought only with innovative, home-grown, cost-effective technologies and products. In order to achieve this, knowledge-based, timely and effective Governmental intervention in the 'Affairs of the Nation' is absolutely necessary and no responsible Government can leave this task entirely to the so-called market-forces. We have the resources and the capabilities to lead the world in many spheres. What we need is the will to work cohesively with a spirit of understanding keeping the national goals above our individual needs.

R. B. Subramanyam is in the Defence Metallurgical Research Laboratory, Kanchanbagh, Hyderabad 500 258, India

Armenia: A travelogue

R. N. Iyengar

When the Department of Science and Technology (DST), Government of India, asked me whether I would like to go to Armenia to participate in an international conference on earthquakes, my feelings were mixed. DST informed that I may be the first scientist from India to visit Armenia after it came out of the Soviet Union. This of course gave me a feeling of imagined importance but when some of my colleagues wondered where on earth could be Yerevan, I felt quite awkward. Before I went to Yerevan my knowledge of Armenia was limited to what I had seen in Madras, the Armenian street and an outlandish church and of course the Spitak earthquake of 1988 which killed 25,000 people This earthquake is one of the best documented and well researched events in earthquake engineering literature. Thus when I left Delhi for Moscow on 28 September, 1993, I was looking forward to a strictly professional experience, but what was in store for me was quite unexpected.

Air India to Moscow

The flight to Moscow was only name sake Air India. The aircraft did have a few Indian crew; but they served only the first and business class passengers. In the economy class the service was wholly by Russians and this dampened the enthusiasm of many who had expected the quality of service that Air India claims to provide. The Ilyushin aircraft took off beautifully and sailed smoothly all the way. However, lack of oxygen demo and a casual attitude to safety belt regulations did not quite induce the assurance that makes for an enjoyable, anxiety-free journey at least among the Indian passengers.

At Moscow I was supposed to be received by a person from the Russian Academy of Sciences, but there was no sign of anyone even remotely interested in me other than taxi drivers. The business man from Delhi who exports alcohol to Russia, had already warned me about the uncertainties and lawlessness in Moscow. With only two hundred dollars in my pocket I was in no mood either to hire a taxi or to venture out to a bus in the first snow of the season. After phoning up the Indian Embassy and loitering in the airport for about an hour, I ventured