results. We, on the other hand, seem to be immune even to shocks like the Bhopal tragedy or the technology embargo on ISRO. I hate to say it but our self-imposed slumber is to a certain extent rooted in our self-interest. I do not expect scientists to be like yogis and be completely above self-interest. At the same time, unless we show some concern for national matters we would have only ourselves to blame if the public becomes disenchanted with us. Leave aside the popularization of science and rural welfare. Our Academies hardly ever articulate with sufficient force even on matters strictly relating to scientific research and technology.

Service to the community may not exactly be popular as it would necessarily cut into our time but then it is like paying tax. Hardly anyone likes paying tax but if everyone cheats on tax, the country's economy would clearly be in the doldrums. I believe the analogy is appropriate. Having lived for two decades in Bombay, I have seen the tension that builds up in slum dwellers who watch with envy the prosperity of those who live in skyscrapers. And when tension builds up beyond a point, there is serious trouble. The lesson is relevant. It is all well for us scientists to lament about our hardships, lack of funds, etc., but unless we do something visible and tangible for our country it is futile to expect public support. We cannot take shelter under the argument that our counterparts in other countries do not do such things. That would be like saying: 'But they don't pay income-tax in Bahamas!'

Once I was in a DST meeting where some of the scientists were pressing for E-mail, declaring that they would all become obsolete if funds for such necessities are not made available. I agree E-mail is needed but should we not also bother to do something pointed and specific for the country and for the less fortunate members of our society? The claim that doing good science is adequate service to the country is, I am afraid, no longer going to wash.

I am sorry if my remarks annoy some readers. But then, from the days of *Mahabharatha*, truth has not been either pleasant or easy to face. To expect public support and funding without quite doing our bit is like expecting a rich harvest of fruits without being concerned about watering the sapling. Indeed one wonders whether we have even bothered to plant the sapling!

G. VENKATARAMAN

Advanced Numerical Research and Analysis Group
P. O. Kanchanbagh
Hyderabad 500 258, India

Science and technology in a poor country

Current Science deserves congratulations for bringing out an excellent collection of articles on basic science in November 10 and 25, 1992 issue, and for seeking response from the readers. The eminent authors have clearly brought out the present strengths and weaknesses of Indian Science and Technology. I wish to add a few more relevant points for consideration of the scientific community. In any discussion on science in India, we forget that we are talking of science in a large country which ranks among the twenty poorest nations of the world on per capita GDP basis[1] and ranks 123 on human development index[2]. Other indicators of our economic and social backwardness—high infant mortality, high illiteracy, etc. are well known to be mentioned again. The scientists, like the other elites of the society, even when reminded, tend to ignore these facts. Since, we think that intellectually we are as good or better than our counterparts in the rich, western world, we refuse to recognize the harsh realities of the poverty of the nation.

The general sentiment of the scientific community is well reflected in C. N. R. Rao's statement 'In spite of the modest support for science and technology the Indian scientific community has hitherto performed well'. Some may like to add 'could have done better, if...'. As pointed out by Rao, science and technology are intimately related to productivity, economic development and international competitiveness. So what should be the goal of science and technology in a poor country? To generate wealth. The questions that should be answered are the following: How much wealth have we created based on indigenous science and technology? Investment in agricultural research has for sure contributed to rural prosperity in many parts of the country. What has been the return on the investment in other branches of science? What percentage GDP is contributed by indigenous technology? An appropriate notional monetary value can be given to the societal gains, such as, in health care or environment where the returns cannot be quantified in monetary terms. The rate of return on research investment is estimated in advanced countries which helps in investment decisions. Further, subcritical funding in many different areas does not contribute to reaching the goal, and hence, brings no returns. Defence-related investment in research should be excluded out of this. While expenditure on higher education contributing to manpower development should be linked to the investment in

science. With this exercise, if the taxpayers can be convinced that the returns on investment in scientific research are high, those controlling the purse strings will be willing to support investment in science. Many outside the scientific community accuse us of spending money which gives no or marginal returns to the society that provides support. Like in other walks of life, scientists also develop vested interest and pursue pseudo-science for personal gains.

The scientists should also realize that the taxpayer pays for their salary and the experiments they perform. In a society with limited resources there are always competing demands. The question remains, should the limited resources be used to provide blackboards in primary schools or a DNA synthesizer? Colleagues say that we should have both, but where are the resources? We face similar choices in personal life. The decisions with personal and public funds should not differ.

All research cannot generate economic returns; while some areas can provide high pay off in short terms. Like commercial organizations, the research laboratories should have a mixed blend of high, medium, low and no pay off investment to achieve an overall return of around 20%. A certain proportion of no immediate pay off research is a must.

All rational societies invest in education and developing skills of their children. The first two or three decades of life are spent on learning the contemporary skills which are then used for earning a living and generating wealth. Research laboratories should follow the same pattern and start generating wealth after initial gestation period of 10–15 years, at best. Technology generation and diffusion is a continuous process. The latter is even more difficult and slower than the former.

The allocation of resources for research should be based on the present economic value of the product or the possible economic growth it can have in the future. As Mashelkar states, we are the largest producers of bicycles, fans and sewing machines. At least 1% of the product value should be invested for their improvement, including the materials used, design and manufacturing. If we recognize that growing population is the most important problem facing the country, it should receive maximum support both for research and implementation.

Looking at the basic research problems pursued by the scientists in the country, at least in life sciences—an area of greater familiarity for me—they are often those which were picked up in the Western laboratories while doing Ph D, post-doctoral or sabbatical work. Peer recognition, both national and international, depends on the ability to build the laboratory facilities to continue similar experiments here. The problems, thus investigated have little relevance in the national context. High-quality science as judged by publications, and presentations are made by those who can have the opportunity to work in Western laboratories every year or alternate years. Career profile of a majority of 'recognized' scientists would reveal that they had several opportunities to work abroad. In contrast, the others who by choice or forced by the circumstances, change to nationally relevant problems find themselves fading from the citation index.

Lastly, coming to the random thoughts on the quality of scientific journals published in India by Ramaseshan. It was a revelation that some 2000 odd scientific journals are published in the country. Ramaseshan has considered about 20 as better of the lot. Considering the speciality journals, I would increase the figure ten-fold to 200. No doubt, this is a high figure. The question we should ask—what is the value of papers published in the remaining 1800 scientific journals published? This is a clear indication of the overall poor quality of science in the country and the resources allocated for such research bring no returns. What have we done to curb the publication of such journals? Should two publications in such journals be recognized for enhancing the junior research fellowship to the senior? The scientific community doing good science is in minority but at the same time influential to guide the destiny of science in the country. It is in its own interest not to be drowned in the trash.

Besides, my understanding is that between 4000 and 5000 scientific meetings are held in the country each year. Most societies hold their meetings annually. Considering the slow pace of research in the country a period 12 months is hardly adequate to produce significant new results. The best papers presented in these meetings are either the review papers or the work carried out abroad by Indian scientists. The local organizers, devote maximum time and effort for the inaugural session which can last anywhere between two hours to the entire morning. The participants also evaluate the meeting by the kind of bag given at the registration desk and the dinners arranged, rather than the scientific content of the papers presented. Often, substantial funds are collected for these extravaganzas from suppliers of laboratory equipment, and consumables.

Colleagues working in elite research centres may not agree with what I have said about the state of science in the country. These perceptions are based largely on interactions with life and agricultural scientists. I hope that things are better in other branches of science.

Poor science even in relevant areas has no value. Good science is important but not enough, unless it is translated into a viable technology which is acceptable, adapted and generates either wealth or social benefits. Taxpayers will not support science for science' sake for very long. Let us demonstrate the actual benefits and not sell the promises.

1. World Development Report 1991, World Bank, Oxford University Press, p. 290.
2. Human Development Report 1991, UNDP, Oxford University Press, p. 202.

C. R. BHATIA

Bio-Medical Group,
Bhabha Atomic Research Centre,
Bombay 400 085, India