higher than that of research institutions funded by CSIR and DAE.

Arunachalam *et al.*[2] based their analysis on more than 42,000 papers published by Indian scientists in 2300 journals indexed in the SCI during 1989–92. This study revealed that Indian contribution to world scientific literature is showing a decline as India came down from the 8th position in 1980 to 12th position during 1989–92. Chemistry and physics account for bulk of research publications from India, followed by engineering and clinical medicine. Again, the most productive Indian journal was *Current Science* followed by *Indian Journal of Chemistry* and *Pramana – Journal of Physics*. This analysis gave a macroscopic view of science in India as reflected by the literature covered by the SCI and did not rate universities/research institutions as reported by Mehrotra and Lancaster[1].

Basu and Nagpaul[5] made a bibliometric assessment of India's scientific publications based on the SCI for 1990 and 1994 in their report, published by NISTADS, New Delhi. This is one of the most comprehensive surveys of Indian scientific research publications and covers 4000 journals including 12 from India indexed in the SCI. The report gives detailed analysis on disciplines, specializations, institutions, states and rankings of 3000 Indian research institutions on a floppy disk. The top 50 institutions are rated on the basis of research output and impact factor. IISc, Bangalore occupies the top position with highest output and high impact. Out of the Indian universities, Aligarh Muslim University occupies the top slot in the category: small output–high impact. It shows the quality of research based on impact factor only. Surprisingly, BARC, Trombay and BHU are listed in the category: high output–low impact, while NPL, New Delhi has a very poor rating in research and is classified in the low output–low impact category along with PAU, Ludhiana, Kurukshetra University and M.D. University, Rohtak. IISc occupies the top position among 25 research institutions of India in most of the field of science and technology. BHU, Delhi University, Hyderabad University, Pune University and IITs find a slot among the top 25. Among the Indian states, Maharashtra produces the highest percentage of research papers followed by West Bengal, UP and Delhi.

Aparna Basu *et al.*[6] published their brief report, which was circulated in January at Pune, the venue of 87th Indian Science Congress. It was based on 5000 + journals covered by the SCI. The conclusions of this survey are contrary to the frequently expressed views[7–9] about the health of Indian science. It claims that there has been no fall in the output of scientific papers published from India annually and indexed in the SCI over the last 10 years, despite the fact that the SCI covered journal use by Indians has fallen from a steady 45–50% to 28% at present. The number of Indian journals covered by the SCI fell from 36 in 1980 to 11 during 1997–98. One may believe the conclusions of this survey with an iota of doubt.

Among the top 20 most productive institutions, IISc, BARC and TIFR, Mumbai occupy the first three positions followed by BHU. There are only 6 universities among the top 20 institutions during 1997–98 compared with 14 in the first survey[1]. It clearly shows a sharp decline of research output in Indian universities during the last two decades. While the research productivity of some national level institutions has remained steady, the universities are losing ground due to poor funding *vis-à-vis* research organizations, e.g. DAE, Space and Defence. None of the universities from Punjab occupies a slot among the top 20 institutions of India.

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S&T in India

This is in the context of G. Padmanaban's article on recent trends in S&T in India (*Curr. Sci.*, 2000, **78**, 381–382). I agree wholeheartedly with his observations and would like to add a few comments from the perspective of an IIT.

Prospective employers who frequent the campus here are mainly interested in what software courses the students have taken – not their specializations. So after a few cursory questions on their subject, all engineers from Electrical to Agriculture and Mining find themselves recruited for the same type of desk jobs. Is this what we rationalize as 'Borderless Science and Seamless Technology'? Then who does the actual engineering and production?

For some years we have been noticing the apathy of students to doing experiments involving working with their hands. As one who has worked with hardware all his life, I now find it difficult to attract and enthuse students for growing new materials, studying phenomena and making devices that work. No doubt the work is painstaking and even frustrating at times. But the same students with a PC will toil away all day (and night in air-conditioned rooms) on some simulation which may have little relevance to actual science and technology. And, what is worse, all the software is borrowed.

The IITs face questions regarding the high cost of education provided to students who on completion queue up for US visas. Studies by DST have shown that not more than 25% of students go abroad; an appreciable number no doubt, but in no way more than half as projected by the press. The IITs are however hard pressed to maintain their quality since up to 75% of their budgets are to pay salaries and very limited funds are left for upgrading equipment. *Some years ago I found that the annual budget of TIFR, Mumbai was greater than that of the then 5 IITs combined. Comparisons are invidious, but are they not unavoidable?*

This brings me to the Holy Trinity of Indian science. Without casting any doubt about the importance of the work undertaken by them, is it not self-defeating when the students are left to get their training in universities which have primitive facilities. The wheel is coming full circle now with organizations such as defence research complaining about the lack of adequately trained man power.

The powers-that-be in Indian science come out with brave statements such as 'there is no dearth of money in India for good science'. My experience has been to the contrary. It may take up to ten years to convince scientists-turned-bureaucrats that some technology is worth pursuing. A project on Metallorganic Vapour Phase Epitaxy, now widely recognized for its quality and versatility, which I submitted in 1979 was finally funded in 1989. By then 3 other laboratories had started working on it, attesting to the importance of the technology, but we are at least ten years behind time.

A few crores of rupees for the Holy Trinity is peanuts. One does not grudge the funding if it is related to their objectives. BARC suddenly announced in the early eighties the development of the technology for space quality solar cells – this has never been heard of since. Two laboratories belonging to the same organization and in close proximity suddenly realized the importance of X-ray reflectivity for surface studies and spent a few crores of rupees each in setting up laboratories. However, all their work is on borrowed samples because sample preparation has been overlooked!

In a poor country like India, setting up 'central' or 'national' facilities when universities are starved of funds is proving counter-productive. Three Pelletrons may have been a good 'buy' but what the electronics community required was an Ion Implanter! The last half of the 20th century saw R&D driven by solid state electronics more than any other field – the chip revolution permeated all fields of S&T relying on measurement and control. But the facilities set up have been totally inadequate.

Apart from the Trinity we have other departments such as the Department of Electronics, setting up a chain of laboratories (another empire?) around the country. The DOE, set up as a regulatory authority, perhaps had some work in the license-permit Raj of the seventies – should India have colour TV, etc. But with the revolution in modern electronics and communication, most of the work in these laboratories is redundant and they are actually looking for funding from private industry. Much of the 10% per increase in budget per year over 30 years is spent on setting up impressive buildings. Is it not time that these departments be rationalized and merged with the Department of Science & Technology?

We welcome the grand success of the NRIs, especially in S&T. They have converted their professional success into becoming entrepreneurs. But when an NRI, after funding a management centre in his own name, turns around and says that we should stop all M Tech and research programmes in IITs and concentrate on producing B Techs for the US market, it is time to question this short-sightedness and/or motives.

If the USA is shifting some of its manufacturing base outside, it is for good economic reasons. However it has come to realize that a 'service economy' is not the hallmark of a Great Power. As Padmanaban has pointed out, India has a long way to go in removing poverty, illiteracy and meeting the basic needs of food, water, sanitation and housing. Fortunately or unfortunately these cannot be done 'on-line'.

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Shrimp embryo cryobanking is now possible

For developing marine shrimp industry all over the world through aquaculture technology, there are two major constraints that we come across. One is the non-availability of sufficient shrimp spawners to produce seed at the desired time. Even in the event of availability of spawners, their maintenance and management becomes extremely difficult and expensive. Therefore, to ease this problem there is an urgent need to evolve a suitable technology for cryobanking of viable gametes, so that shrimp production can be made sustainable according to the need. The second constraint that is encountered by the industry is the large-scale mortality of juvenile shrimps during transportation from the hatchery site to remote rural areas where shrimp farming is being done. Sometime casualties can also be due to infection, disease or pollution. This problem could be relieved to some extent by developing a technology for storage of quality eggs, embryos and nauplii, in a viable but dormant condition. Hence, there is an urgent need to devise the technique of preservation of viable embryos and larvae under low freezing temperatures to ensure the interest and confidence of shrimp industries.

Although sperm cryopreservation has been carried out successfully in a number of commercially important aquatic species, particularly in some teleost fish[1] and also shell fish[2], the technology is still not at the stage of advanced commercial application that is seen in domestic mammals. The first successful attempt at the cryopreservation of embryos of sea urchin was reported by Asahina and Takahashi[3]. Later Zell[4] and Erdahl and Graham[5] have reported preliminary attempts to freeze the eggs of rainbow trout. Studies have been carried out to cryopreserve the embryos of Japanese medaka *Oryzias letipes*[6], rainbow trout *Oncorhynchus mykiss*[7] and zebra fish *Brachydanio rerio*[9]. In recent years a few attempts have also been made