

goals. The challenges of free markets, the growing cries for accountability and the breathtaking pace of advance in modern science, can hardly be met by trumpeting well-worn and often, bankrupt ideas or by philosophical resignation. It is clear that the basic structure of Indian science, built over several decades by many dedicated individuals must be preserved and protected against ill informed and short sighted attack by politicians and bureaucrats. However, the fat must be trimmed and the scientific enterprise in India must gear itself to meet an increasingly difficult future. While diminishing governmental support and the absence of any enthusiasm for research amongst the captains of industry are grim realities that must be addressed, the impending squeeze might afford a good opportunity for introspection. Has

Indian science lived up to our collective expectations in the last thirty years or so? Is there a sound case for major financial inputs into specific areas of science and do we have a realistic hope of achieving hard results of practical value, in a reasonable time frame? Will present management practices in Indian science prove productive in the future? Has the quality of our basic research shown a dramatic upturn during the boom days of the 1980s? In the weeks and months ahead it is hoped that answers to these questions will be forthcoming from a wide cross-section of the scientific community. An informed debate, ironically catalysed by the National Science University proposal, can prove valuable in setting an agenda for the future. The time is ripe for a close look at the conduct of science in India.

Dr Swadesh M. Mahajan of the University of Texas has submitted to the Government of India a proposal for establishing a National Science University. The salient features of this proposal are provided below. For reasons of space Current Science does not reproduce Mahajan's proposal in its entirety.

—Editor

Proposal for a National Science University

Swadesh M. Mahajan

Assessment

India's contribution to the science and technology of the modern era is disappointingly small; high quality research is almost non-existent, major discoveries and inventions have simply passed us by and even minor achievements have been few and far between. Moreover, the situation is not likely to improve in the near future and, in fact, the overall quality of research has actually been on the decline over the last decade. And this is particularly true of the research done by people who have come of age during this period, those very people who will control and shape the future of Indian science.

While the brain-drain may account for a part of the problem, *the primary reasons for this continuing low quality of research must be sought in the underlying structure and organization of the giant Indian scientific establishment which rules over a large number of universities and national institutes and in the prevailing notions in India of how institutions should be run. The scientific establishment is managed by a few extremely powerful*

people who:

- (a) control most of the money,
- (b) are on all important job, promotion, and national committees, and
- (c) decide what are the important scientific areas and directions to explore.

This coterie of science managers must travel ceaselessly to carry out its numerous commitments and, therefore, those who control science have neither the time to visit laboratories nor read scientific papers, not to speak, of course, of doing experiments or themselves writing papers. Yet it is essential for them to give the appearance of being India's leading scientists. They must, thus, go about creating myths to give substance to their pretensions. To do so, they engage in a very egregious form of gimmickry including.

- (a) distributing scientific honors and laurels amongst themselves, and
- (b) giving totally lopsided assessment of our current scientific state with, needless to say, all the exaggerations and untruths, giving a rather favourable impression of that state.

Swadesh M. Mahajan is at the Department of Physics, University of Texas at Austin, USA

And what is ironic and perhaps symptomatic of the malaise-provoking ills of Indian science, they are never held accountable for their consistent 'over promise and under delivery' and are even often kicked upstairs for their established sins.

Thus, the state has arisen in our existing scientific structure where:

(a) it is not *science that brings glory, fame, or fortune; it is scientific administration*, and

(b) it is not *excellence in scientific research that makes one a leader*, but the administrative title of 'Director' (or an equivalent) that 'legitimately' confers leadership upon a person. The director is not only absolutely powerful, but must also be the most important scientist when he is appointed director and for all times to come. No one may have greater scientific stature or ambition than the director whose specific interests take precedence over everyone else's.

This unfortunate state of affairs becomes a self-consistent mode of operation because the director makes use of his immense power and prestige:

(a) to build an empire by recruiting and encouraging people to work for him. These people are usually the director's obedient students. Assistants are hired in preference to those who may be a lot more qualified,
(b) to buy insurance against current or future competition by making it difficult for people of equivalent or higher academic stature or other spirited, bright, and ambitious people to be around. He can do this because of the enormous power he wields.

Thus, there comes into existence an inbred, incestuous group of meek followers and yes men who are beholden to the director and are often leagues below him in talent, intelligence, creativity, and scientific stature. The 'proper' feudal order is established to the detriment of everything and everyone but the boss and his men. And yet, in a sense, it is not even to the advantage of the boss. The place loses most of its independent, bright, and assertive people (often, to the United States), it loses all of its dynamism, creativity and often, ultimately, its productivity. In such a sterile, feudal, and overtly hierarchical set-up, great discoveries do not come as those working in these institutes are rarely inspired to seek the sun and the stars.

Barring a few notable exceptions, the *Indian universities were deemed to be generally unsuitable for conducting high calibre scientific research*. As a result, a momentous decision was made to create a large number of research institutes independent of and totally unconnected to the universities. These places were to provide a haven for our best scientists to pursue knowledge in a 'proper' atmosphere, uncluttered by the usual university 'chores' like teaching undergraduate students. *This in-*

vidious separation, which further impoverished the universities, was a major strategic blunder and has caused as much damage to Indian science as has the feudal character of our scientific establishment (perhaps it has caused even more damage than has the feudalism).

Due to immensely better facilities (wages, housing, research money, technical and clerical help, status and mobility, and a larger concentration of good people), the research institutes (RIs) act as magnets attracting our best people (this is, of course, precisely the reason for the existence of the RIs). *Consequently, the universities, unable to compete with the RIs, fail to attract young and upcoming people* and sometimes even lose their best to the RIs. Today, the universities are saddled with teachers and professors whose intellectual level is shockingly low, as is their desire to work hard to learn to teach to learn. But these are precisely the people who are supposed to train our youngsters, because undergraduate teaching is wholly confined to the universities, and the institutes want to have no part in this! *The insipid and uninteresting teaching leads to a low level of the graduating students who join research programmes*. Most professors in the national institutes bitterly complain about the quality of the products of university education. But hardly any of the institutes themselves have a vigorous and serious teaching programme for post-graduate students. The main tragedy of this structure, then, is that there is no sustained transfer and growth of knowledge as the universities cannot and the institutes just do not teach.

Most institute professors, however, need bodies to man their programme, with the implication that absolutely ill-equipped and ill-treated graduate students are taken into projects which eventually grant them PhDs. The better ones in this lot are absorbed in the institutes, and the rest are shoved back to the universities to 'teach', and thus the rot continues and grows.

This process does not produce scientists, it only produces laboratory assistants, chore boys, and bad teachers. The next generation comes out worse than the preceding one; it is not progressive but retrogressive evolution.

The fate of the institutes is equally tragic. Because of the lack of a built-in regenerative mechanism to continually detect, train and nurture new local talent, a typical national institute succumbs to decay very shortly after its birth. Every institute is formed around a group of talented people and seems to die when the first-generation scientists run out of steam, which they seem to do considerably faster than their Western counterparts. Genuinely creative and productive career-spans are singularly short, both for the scientist and for the institutions they run.

What is needed, therefore, is a complete overhaul of our scientific establishment. The idea of separating the

institutes from the universities is fundamentally flawed; it provides neither nourishment to the young student, nor sustenance to the established scientist. Institutes devoted to basic sciences must become adjoined to the universities or the universities must be built around the institutes. These new universities, born out of a synthesis of the best of the institutes and of the universities, could result in creating a self-sustaining system where science flourishes, and where each new generation, standing on the shoulders of the last, reaches greater and greater heights.

The new university

Nothing short of a revolutionary and massive rehabilitation programme will be needed to bring about these changes. And, even if the 'defeudalization' programme were to begin today, it would take a long time to finish. Well-established universities and institutes are not easily amenable to change. In the meantime, a separate constructive programme is strongly indicated. We believe that at least one 'National Science University' (NSU), which would translate this new philosophy into action, should be instituted as soon as possible. It should serve the dual purpose of providing a model for others to emulate and providing excellent quality education to at least a select group of students. We can no longer afford to condemn our future scientists to the dismal education available in our existing universities; they badly need, and certainly deserve, much better alternatives.

The new university must categorically reject all the feudal values which have plagued our scientific establishments. There will be no more scientific leadership by appointment, no steep concentration of power, no rigid and suffocating hierarchy, no scientific administrators posing and acting as scientists (and hence controlling the fate of science and scientists). Moreover, a scientist's scientific status should be completely independent of his administrative title.

The model university (some extremely preliminary details about the possible size and scope of NSU are given elsewhere) will have a highly interactive collection of select undergraduate and graduate students and the best faculty available. Every possible material and cultural attraction should be provided to attract and keep the best of our scientists. This is not an impossible task. There is a large group of Indian scientists who would wholeheartedly participate in this crucial aspect of nation building if they could work in surroundings more congenial than those provided by the existing Indian institutions. What we want is a place where:

(a) the best of our current scientists teach, train, and inspire the next generation,

(b) our scientists can work in a free democratic set-up, i.e. a large number of essentially equal, independent and competent professionals can compete, cooperate and collaborate with each other to create an exciting scientific environment, an environment which, in a natural fashion, will produce good, well equipped, and even brilliant scientists from our youth.

(c) one's scientific status is not measured by one's administrative title,

(d) scientific leadership is neither absolute nor given by appointment or nomination but emerges in a natural fashion amongst scientists of different age groups and is only comparative and changes with time,

(e) science, its creation, its teaching, and its dissemination is the principal (if not the only) activity; the scientists and the would-be scientists are the principal citizens and everyone else has only a supporting role,

(f) there are absolutely independent career ladders for the scientists and the administrators; no scientist should ever feel the need to become an administrator for more money, facilities, power or prestige. From all points of view, the most desirable position should be that of a Scientist-Teacher,

(g) all principal scientific decisions are made by faculty committees consisting of working scientist; administrators must take care of administrative matters, and the scientists of scientific matters,

(h) theoretical and experimental investigation of a whole spectrum of basic sciences (physics, mathematics, astronomy, chemistry, computer sciences, and biology) is carried out, each discipline must have a critical mass of active and strongly interactive scientists. Although every scientist must be important to the programme, no single scientist should be so important that his departure could be catastrophic.

The only viable criterion of a successful and dynamic temple of learning is that each successive generation should be better than the previous one. A university based on the aforementioned principles and supported at an appropriate level of funding has a good chance of footing the bill. It could easily become a world class university where the faculty will not simply write footnotes to the work of their Western counterparts and where long term excellence is assured by the continual transfer of expertise to the succeeding generations.

Before committing the idea of a national science university (NSU) to action, we realize that a lot of questions need to be answered.

We hope that we have already answered the first relevant question as to how the NSU will be different from the many other universities that dot the Indian map. In fact, the very genesis of the concept of NSU is due to our understanding that the dismal state of Indian science has much to do with the dismal state of our universities. The NSU, a well funded, internally

democratic, nonbureaucratic and highly interactive collection of teachers and students working in congenial, exciting, and comfortable conditions, represents precisely the stuff of which our universities are in short supply. Over the course of time, this model should be embraced by many more universities (new and old) and will be the very instrument that will help change the Indian scientific scene.

A caveat is in order here. Although we expect several other universities of excellence to emerge in years to come, it would be foolish to believe that all universities in the country will meet the NSU criteria. Education, even higher education, cannot have completely uniform standards unless these are uniformly low standards. Any organic higher education structure will be necessarily tiered or hierarchic; only a few institutions can aspire to excellence. Even rich societies cannot (or choose not to) afford to maintain universal excellence. But it is precisely these select institutions which contribute the lion's share to the march of knowledge. The preceding comments automatically lead to the next question: If we can afford only a small number of select institutes, why are we asking for several new NSU-like universities when excellent institutes like the Tata Institute of Fundamental Research (TIFR), and the Indian Institute of Sciences (IISc) already exist? We have already provided part of the answer: Neither of these institutes provides undergraduate education and their commitment to graduate education is, at best, lukewarm.

They also suffer from the host of maladies that we have described earlier. Even their research output (in quality and in quantity) is incommensurate with the sheer raw talent that they manage to attract by virtue of their special status. Much more important, however, is the fact that even institutes of this type are only a handful, are not enough to meet the scientific need of a society which yearns to be self-sufficient. This yearning, moreover, is not some purely mysterious craving for knowledge or some vague philosophical need, but it is the most commonsense, down-to-earth realization that creation and application of scientific knowledge is a necessary condition for us to remain viable in a highly competitive and aggressive world economic order. And in some fields we had better be the first to create knowledge, translate it into products and market and sell these products lest we be continually bullied by the Carla Hills of this world. Our self-respect, even a meaningful existence, is contingent upon our ability to invent, to innovate.

Thus one is thankful that TIFR and IISc exist. Our needs, however, are considerably greater. Only a much larger number of excellent scientific institutions can constitute a critical mass such that we could feel reasonably secure with our technological future. The NSU model will necessarily contain the best features

of our best institutes, but it will go much further. It will aggressively seek young talent, train and hone them in their formative undergraduate years, expose them to our best, and hope that they will be inspired and excited enough to carve scientific destinies which might usher in a new era for their society. The time for beginning our experiment with the NSU is now.

Can we afford such highly expensive ventures as the NSU? In our opinion, the national political leadership of India has already answered this question. Our financial commitment to science is very healthy even in these economically difficult times. The cost of one experimental NSU will be but a drop in the bucket of the science-technology budget. And if this experiment shows signs of success; how could we afford not to have many more? Nothing short of a sound economic future is at stake.

Will NSU become another export house like the IITs? This question has haunted us forever and is likely to do so until the actual results of the experiment become available. There are several indicators, however, that point to the fact that, in the long run, this fear may not be very pertinent. Undoubtedly some of the NSU graduates will go elsewhere seeking fame and fortune, as the citizens of any free society have the right to do. But going abroad for certain periods of time, should never be considered a loss; in fact, it is a necessary and integral part of intellectual growth. What is important is that these graduates, after acquiring additional knowledge and expertise, should spend reasonable chunks of their life serving the society that educated and trained them. It is our experience that, in pure sciences at least, the existence of good and exciting working environments has always served as a magnet for attracting back our best and brightest. Many scientists choose to stay away from India because of the myriad problems associated with our scientific institutions which do not provide a conducive and comfortable research environment. Let us change the turf. Let us change the rules and make doing scientific research in India an exciting and rewarding proposition. Let us help make the economic and social status of a scientist-teacher a bit higher than that of a soap salesman. Let us demonstrate, by clear and loud actions, that our society values research, innovation, invention and discovery. The opening of NSU could be the first major step in this direction. Our belief is that when the dust settles, we would lose only those people who go, not in pursuit of science, but in pursuit of other objectives.

In this connection, there is another issue of considerable importance. A very large number of scientists of Indian origin have more or less settled in the West, particularly in the US. Long and serious conversations with many of them have revealed that they are extremely interested in participating in the building of a sound,

creative, and lasting scientific edifice in India. Many of them would be happy, even excited, to spend a part of the year teaching and interacting with motivated and curious students in addition to collaborating with professors. They promise to bring not only their intellectual expertise but also much needed state-of-the-art scientific equipment, the lack of which often results in fatal delays in completing experiments. It is essential that our scientific institutions provide convenient and ever open channels through which foreign-based Indians can repay some of their debts 'not wholly or in full measure, but very substantially' to the country of their birth. The NSU could and would play a leading role in harnessing this vast reservoir of technical expertise, goodwill, and other valuable resources.

We must go out of our way in stressing that this proposal for NSU is not an arrogant non-resident solution for the ills of Indian science. The need for an NSU-like institution could originate from any one who cares for, and is concerned about, our scientific future. All competent Indian scientists with vision (living in India or living abroad) have an essential commonality of interests and shared objectives. The lackluster scientific scene is no longer acceptable; we must create exciting new alternatives. The daunting task ahead will require every iota of our combined and united will. We must marshal all of our collective strength to set the state of Indian science anew and we must avoid all petty squabbles and such if we are to avoid being consigned to the wards of trivia and inaction.

Requirements

It is essential that NSU be located near a major industrial centre such that the technical infrastructural needs can be adequately met. That requirement will automatically limit the site to a handful of places which are easily accessible by air. This is a must because we plan to have a large number of short- and long-term visiting faculty.

The NSU, with its emphasis on quality education and research has to be of a very moderate size. After a few years of growth, we envisage a total faculty of 100–200 with a proportionate undergraduate population of 800–1500. In addition, we would like to see about 200–400 graduate (PhD) students. The NSU is expected to be fully residential i.e. all students and faculty will be provided on-campus residences. A world-class scientific programme (including recurrent capital cost of new equipment) requires an expenditure of approximately 100,000 dollars (USA) per year per active faculty member. Making appropriate translations for Indian conditions, we feel that an equivalent of about 50,000 dollars (USA) per active member will be needed.

The university will, initially, be limited to basic sciences, i.e. physics, chemistry, biology, and mathematics and computer science. However, every attempt will be made to encourage the faculty, in particular the experimental faculty, to make workable alliances with industry.

Organizational structure

For the NSU to be 'NSU', it must be accorded a certain special status, and it must, in turn, create appropriate internal institutions to justify the privileges given. The NSU must have a separate independent charter, without quotas, and without binding and suffocating rules (internally or externally imposed). The pursuit of science will be the principal activity of NSU, and the pursuers of science will be the principal citizens of NSU; all others will be present only in order to aid the scientist's activities. No scientist in NSU will feel the need to give up active science for an administrative (or similar) position because it brings more money or other tangibles.

Recognition and rewards. In order to keep the creative juices running through students and faculty, it is necessary to reward good work. We will find as many ways as possible to encourage creativity and scientific achievement. These will include financial awards, prizes, medals, media exposure, and intra-NSU ceremonies.

Organizational logic

We suggest the creation of an International Advisory Committee, including in its midst a broad range of funding agencies, which will advise and help to construct forward-looking plans.

Once the NSU is created this committee will retain its integrity and will be in charge of brainstorming and the creation and evaluation of various gameplans suggested by its members, other agencies, and, of course, the faculty.

The faculty of the NSU will retain the principal power for making decisions on all important matters. Again, the idea is not absolutism, but the encouragement of the logic that those involved in the actual doing of science are the repositories of wisdom, which is unavailable to the players peripheral to the core responsibility of NSU. In this sense, it must be stressed that despite the faculty's being in the temple of power, consultation with the International Advisory Committee will be fundamental.

Aside from the core responsibility of the NSU, which is science, there will be an eclectic Management Trust which will be in charge of looking after the various financial aspects of the NSU including investment, creation of new avenues for funding, troubleshooting, and

accounting. The trust should eventually become self-sufficient and should be formed at the intersection of the Academia-Business-Industry nexus. The Management Trust will consist of retired academics, intellectually-oriented politicians, and intellectually-oriented doyens of industry with profound ideas for nation-building. The Management Trust will be the only one of the mentioned agencies that is not a ratifying agency.

Every two years the directorate of NSU, in consultation with faculty, students, interested external sources, and a panel of international academics will issue a 'State of the University' paper in which it will examine whither NSU is going and if that direction is in fulfillment of the basic philosophies, objectives, and modalities laid out in our charter. We must be asked periodically for honest evaluations of each of our departments and of the NSU as a whole.

In keeping with these ideas, NSU will solicit input from far and wide. NSU will maintain contacts with other institutions of excellence based on mutual critical appreciation and the realization that cross-breeding gives rise to newer and more potent strains. This will be done not only to promote the best in scientific achievement, but also to promote a sense of accountability and checks and balances.

Special dispensations

For the greatest success for NSU, we must involve large groups of people in some aspects of its building and maintenance. Naturally, the primary source of expertise and funds will be the people and government of India. We will approach Indians living abroad for foreign

exchange requirements in addition, of course, to contributions to a University Permanent Fund. We will also approach Indians living abroad for donations of equipment and facilities so as to provide our faculty and students with as much freedom as we can to do science.

Another of the special dispensations will be that 20 per cent of the faculty will be mobile. The idea behind this is to encourage connection to and synergy with overseas Indians and overseas institutions. This will also add to the international nature of what we hope will be a world class university.

Some preliminary estimates

We estimate that NSU will require of the order of a 100 crores as start-up cost. Additionally, NSU will require approximately 30 crores/year for operations. The operational costs could come from the revenue generated by investments of a trust of about 300 crores. The following agencies are likely to be the major donors:

- (1) Government of India—we will require an outright government grant.
- (2) Industry/Business—(A mature NSU-industry/business nexus would surely reap results of the type that would benefit both NSU and industry. This is especially true if one concentrates on the long term).
- (3) Non-Resident Indians—(Non-Resident Indians will be called upon, additionally, to make contributions of journals and books. Also, NSU will request these Indians to donate their expertise often in the form of sabbatical visits.
- (4) NSU will also require a land grant; and other sources of revenue in order to ensure maintenance.

The concept of a National Science University

P. N. Srivastava

When India got its independence, we had less than 20 universities and 700 colleges. Today we have about 200 universities (including institutions of national importance and deemed universities). During this period the number of students has increased from about 200,000 to about 4,500,000. The expansion by any standard is very vast. It is a different matter that with the vast development, proper infrastructure could not be created in many institutions with the result that today about one-third of

the universities and colleges are non-viable.

The growth of higher education

The development of higher education since independence can be divided into three phases of about fifteen years each. In the first fifteen years, higher education developed at a rate of about 4–5%. This development could be sustained by India although the growth of economic development was only about 3%. In the middle fifteen years, the rate of growth increased to about 14–15%

P. N. Srivastava is in Nuclear Science Centre, P. B. No 10502, J. N. U. Campus, New Delhi 110 067, India