

EXCELLENCE IN SCIENCE

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HOW does one judge excellence in science? Should it be by the number of Nobel Prize winners? I am quite sure that this would be a mistake. I have known too many extraordinary men of science who have not received the Nobel Prize. While one cannot give a set of qualifications of an individual to be considered as an outstanding person, one almost always knows who the outstanding people are and they are not large in number. We generally see that men of excellence are generally people excited by science and have made major contributions which make an impact in their chosen fields. The quality of papers they publish, the books they write or the journals they favour are quite distinctive. Many of them show sparks of genius (although I must submit that all scientific accomplishments are not based on such sparks of brilliance alone). Institutions of excellence are typically characterized by the unusual men who work there, their attitudes and contributions to science making the institutions unique; more importantly, such institutions generally provide an environment conducive for creative work and almost always have good traditions initiated by men of vision. While there can always be outstanding individuals in all kinds of institutions (purely as a matter of statistics), even the average person in an institution of excellence is far above the average person elsewhere in terms of his attitudes and commitment to excellence. An institution of excellence does not reflect merely the sum of contributions of the individuals in it, but something more. It is here that I am forced to mention that in this country we have very few institutions of excellence and the few that are there, are facing difficulties in surviving. Not all scientists are sympathetic towards such institutions, – an attitude that is equally common towards men of excellence. Some people say that it is a sign of underdevelopment and some others say that such would be the case with an old country like India. I would hate to believe that

either is correct, but I am convinced that we can ill afford this slow extinction or short-life spans of institutions of excellence. We also have to protect and encourage our men of excellence, for they are not infrequently subject to undue pressures and harassment and also to the lure of more attractive positions in the country (which generally go with the absence of research opportunities) or outside the country.

SCIENCE IS INTERNATIONAL

While talking of excellence in science, we have to remind ourselves of the well known statement that science is international while technology is national. The implications of this statement are often forgotten. To me this means, that there is no point doing science which does not come up to standards prevalent in the outside world. We cannot just take satisfaction by saying that we are doing the best we can under the circumstances. We have to compete and there should be no excuses. In the world of science, like in sports, there is no medal for a loser. Policy makers and administrators have to remember this while supporting scientific research in the country.

BASIC VERSUS APPLIED SCIENCE

There have been debates in the country regarding basic *versus* applied science for the past few years, to the detriment of both. This has often led to the downgrading of applied science in some instances or to the undermining of basic sciences in other instances. First rate minds are required for both applied and basic sciences. The real problem seems to be that there is overemphasis on short-range problems and lack of clarity with regard to long-range programmes and problems. The reason that I am mentioning the so-called dichotomy regarding basic *versus* applied science is because we do not seem to have really reached pinnacles of excellence in either of these.

PROMOTION OF EXCELLENCE (BUILDING SCHOOLS OF EXCELLENCE)

I mentioned earlier that it is possible to find men of excellence in almost any kind of institution, but this does not tell us the best way to organize and promote research schools (or groups) of excellence. When one looks at some of our huge scientific organizations in the country, one wonders whether excellence depends upon the large size of an institution. It is a matter of experience that this is not the case. Over organization of science in the country seems to have discouraged individual initiative as well as the emergence of a large number of research groups of excellence. At least in basic sciences, outstanding work is done best in small groups which have sufficient freedom to plan and carry out their work. I get the feeling that this may be true even in applied sciences. It would be difficult for large institutions or laboratories to promote excellence unless they are organized in such a way that scientists still work in small and autonomous groups. The role of a director of a big laboratory should be more like that of a director of an institute of higher learning.

One of the characteristics of modern scientific research is the coming of new and exciting areas of research which often give rise to technological revolutions. For example, some people believe today that genetic engineering will bring about a revolution similar to that of electronics a few years ago. To grow talent in such emerging areas and to support them at the crucial time, are challenges that funding agencies have to respond to. We cannot possibly wait for help from outside to develop our research capabilities in emerging areas. Just as it is essential for us to make a judicious choice of what technologies to develop and what to purchase from outside, in scientific research also we have to make the right decision as to what areas we can and should support and to what extent. This is often difficult and even enlightened funding agencies do not go through this exercise. Thrust areas in basic sciences are to be chosen not only in relation to world trends but also depending on the talent available in the country and possible links between these

areas and the long-term programmes in science and technology in the country.

I believe that we should cultivate schools of excellence in chosen (thrust) areas of science (and avoid omnibus institutions dealing with a broad spectrum of subjects and areas) after ensuring ourselves of the availability of reliable expertise and leadership. One can think of many models for establishing such schools, but two of the models that seem to be relevant are the Max Planck Institutes in FDR and the CNRS Institutes in France. One can visualize many small institutes (some even in very narrowly defined areas) wherein academic people are also directly involved. Typical examples of such areas would be: electronic materials, catalysis, plasma physics, cryogenics, solid state chemistry, lasers, dielectrics, spectroscopy, batteries, photochemistry, enzyme engineering and so on. Interdisciplinary areas could also be encouraged in this manner, but I am afraid that we have a tendency to make a fad of every slogan and have not been able to show restraint and judgement. Interdisciplinary sciences will become a slogan unless we ensure that we have good foundation in basic sciences (like physics and chemistry). It may be through the combined contribution from several sciences, that we may have some real breakthroughs in the years to come.

Many of us advice young scientists to do something challenging—something that will fetch them a Nobel prize. Yet, if we knew what those problems were, we would work on them ourselves. As the saying goes, choosing the right research problems is half the job done. While this may not entirely be true in this country, there is still much truth in the statement. Several instances can be cited where because of the inappropriate choice of the problem or due to absence of facilities, even research carried out competently has not received proper recognition. We have to do something about the scientists being able to be in direct contact with leading workers in frontier research areas being carried out elsewhere. It is extremely difficult for scientists in India to find proper support to participate in good international meetings without going through indignities. Exposure to the science

being carried out in the world at large is essential and funding in this regard has to be made part and parcel of the support for scientific research. It should be noted that there is a growing feeling even in the U.S. that it is no longer (or cannot expect to be) pre-eminent in all fields of science and technology.

PROBLEMS FACED BY UNIVERSITIES

One of the major problems that the scientific community in the country faces today is the increasing depravity of our educational institutions. Funding of universities for science education and research is pathetic and the education sector gets a negligible percentage of the total national investment in S&T or R&D. The infrastructure in these institutions is so hopeless that it may become impossible for us to bring all the educational institutions in the country to ground level in the foreseeable future. Even funding select educational institutions to bring them to world standards may be beyond our reach. These educational institutions co-exist along with the well funded scientific organizations (a situation not different from the co-existence of slums and multistoreyed building in cities). Yet, universities are charged with the task of carrying out frontier research and of training scientists for the future. It is in spite of this terrible situation that some of our brightest men of science have come from our educational institutions.

The situation with regard to funding of research projects has eased in the last few years and it is mainly because of this that some individual scientists have been able to do well in experimental research. It however remains that most educational institutions do not have the absorbing capacity to accept large grants. Even if we were to grant them lots of research projects, the poor infrastructure would not permit them to perform reasonably. I have mentioned all this in relation to excellence in science because I have the feeling that it may be impossible to promote excellence in the country without remedying the existing situation with our educational institutions. After all, scientists receive their training in educational institutions and a large number of them carry out research in them.

Something substantial has to be done without delay if we want to give excellence a chance.

WHERE ARE ALL THE FLOWERS GONE?

Most people seem to agree that we are very short of talented young people in science (below the age of 40 years or so). The number of such talented people in some of the areas is so small that I sometimes get worried about the future of science and technology in the country. Part of the reason may be because many are lured away from science at a young age. I personally feel that the main cause of this is because we have lost one generation (roughly 1962-82) of the most talented, well-trained young scientists in the country, a major proportion of them having settled abroad. We should make sure that we do not miss out another generation. For this purpose, we have to make science a more attractive profession and provide a better atmosphere and improved amenities for young people to work in this country. The government may have to send a large number of young people abroad for training in chosen areas (upto 2-3 years) so that most of them come back. We may also make suitable arrangements for young talented students to spend their vacation in leading laboratories of the country. While the senior scientists in the country have a responsibility to create the atmosphere conducive for pursuing science, the government has to look into the problem of providing better amenities. We cannot possibly depend on the idealism of people alone to take up science as their profession. Typical of the amenities would be proper housing, better social security, medical benefits, subsidy or income-tax relief for subscribing to the membership of professional bodies and academies as well as for buying books and journals. At least the active scientists in the academic sector should get benefits similar to those in other sectors (even the most outstanding professor cannot get a phone and he himself cannot afford to have one).

Recruitment policies in most universities are terrible and doors are really not open for the best men to get in. Lastly, we should not forget that it is the reward system that essentially determines the attitude and performance of people. I would

not like to elaborate on this topic, but it would suffice to say that the recognition given to a good scientist today is to make him an administrator.

Established scientists have a special moral responsibility in making the young to take up science and prosper. We have to show more dedication and commitment (May I also mention nationalism). We have to stop being masochistic.

MANAGEMENT AND INDISCIPLINE

It is well known that enlightened management is essential to nurture institutions and individuals of excellence; it is also true that scientists thrive best where there is least red tape. I will not belabour this point. I would however like to underscore the difficulties in administering institutions today. Even if we bring about the much needed changes in accounting procedures and eliminated bureaucracy, the large-scale indiscipline amongst scientists, teachers and students and particularly the support staff makes it extremely difficult to maintain high standards in running institutions. Many a good scientist and many a good institution have been victims of uncontrollable staff who cannot be expected to do their minimum work or conform to norms of civilized behaviour. How to solve this problem of indiscipline at all levels and bring in some nationalism amongst ourselves, baffles me.

A RECIPE

Let me now comment on the important factors related to the promotion of excellence based on some of my own experience. Some of the crucial steps in building a good institution or a good group seem to be: (i) select the best scientists (without any other consideration); (ii) provide adequate facilities (include young coworkers); (iii) give sufficient freedom and autonomy in the running of research groups; (iv) provide all basic amenities and infrastructure support (housing, secretarial help, travel support for conferences etc.); and (v) provide a dynamic and generous leadership (ignoring personal idiosyncracies) and (vi) encourage and assist in getting research grants and recognitions

at the right time. There is nothing new in this recipe, but unfortunately one sees very few instances where most of these happen.

I shall not elaborate on an important aspect related to excellence in experimental research (at least in physical sciences). This has to do with electricity and water supply, availability of materials, supplies (e.g. liquid nitrogen, and spare parts and so on). These factors are undoubtedly most important in determining the quality of research, but for some reason little attention is paid to them in many of our institutions; part of the problem in educational institutions is the lack of adequate funding.

Even when facilities and equipment are provided, we often get the support too late or/and too little. Sometimes, the money we receive is just not sufficient to carry out research in the area with the sophistication that it requires and we have to compromise. More often than not, Indian scientists have carried out good work in an area several years after a technique has come to the fore. There is no doubt that many of us can do or could have done much better if critical inputs including the right equipment had been made available at the right stage.

In my own career, I have had to wait for years to get the facilities and equipment that I wanted. In one or two areas of my research, I got the equipment when I was no longer that excited in those areas. But, I have been most lucky in that I have received the right kind of encouragement (and recognition) at various stages of my career, often from unexpected sources. The young students who have worked with me have been dedicated and the heads of institutions where I have worked have been most tolerant. The only thing that I am not sure about is whether I have done the best I can and whether I have the ability to cope with the challenges of the times.

To encourage individual excellence in science, there can be no recipe other than what James Conant said long ago; "There is only one proven method of assisting the advancement of pure science—that of picking men of genius, backing them heavily and leaving them to divert themselves".